NATIONAL MARINE FISHERIES SERVICE NORTHEAST SUPPLEMENT
04-105-05-02-NEC
January 15, 2004

Science and Technology
Standards and Protocols for Surveys 04-105
NOAA Protocols for Fisheries Acoustic Surveys and Related Sampling 04-105-05

NOAA PROTOCOLS FOR FISHERIES ACOUSTICS SURVEYS AND RELATED SAMPLING IN THE NEFSC

NOTICE: This publication is available at: http://www.nmfs.noaa.gov/directives/.

OPR: NEC **Certified by: NEC (J.Boreman)**
Type of Issuance: Renewed March 2013

SUMMARY OF REVISIONS: 2013-Technical revisions made.

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[Approving Authority name] Date
[Approving Authority title]

Protocols for Fisheries Acoustics Surveys and Related Sampling

Northeast Fisheries Science Center

04-105-05-02-NEC

Prepared by:

Michael Jech
The Advanced Sampling Technology Group

Last Updated:

March 5, 2013

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Introduction

This document provides data collection and operational protocols for acoustical surveys of Atlantic herring (*Clupea harengus*) at the Northeast Fisheries Science Center (NEFSC).

This document is arranged as follows. Center-specific background is given to provide information on NEFSC personnel and general support. Five general categories are defined: system calibration and performance, acoustical backscattering measurements, target strength, acoustical-biological conversions, and sampling (survey) design. Acoustical background and general information for each section and the topics “Definition & Importance”, “Error”, and “Considerations” are given in the acoustics National Protocol and are not repeated here. The Methods section details specific methods for each of these categories.

Center Background

NEFSC

The Northeast Fisheries Science Center (NEFSC) fisheries acoustics group currently has two FTEs affiliated with the Survey Branch. One FTE is funded on a congressional budget “line-item” and one FTE is funded through the NOAA-Fisheries Advanced Sampling Technology Working Group. The NEFSC fisheries acoustics group focuses on estimating Atlantic herring (*Clupea harengus*) spawning stock biomass with an annual six-week survey conducted in the fall.

The Atlantic herring acoustical survey employs a systematic parallel design, with inter-transect spacing set at 8 or 10 nautical miles (nmi). The transect spacing is consistent within a survey, but has changed among surveys, which is primarily due to logistic constraints. The extent of the survey encompasses the spawning stock biomass in the Georges Bank and southern Gulf of Maine regions. The s_A values along transects are used to derive relative indices of the herring abundance. The s_A values are extrapolated to the surveyed region using geostatistical methods. The s_A values are converted to abundance by calculating mean herring lengths from trawl catches, converting the mean lengths to target strength (TS) using a generic Atlantic herring TS-Length regression. Biomass estimates are derived by scaling the abundance estimates by an empirical length-weight relationship. Age-based estimates are derived from the age composition of the trawl catches.

Methods

Calibration and System Performance

Calibration

Techniques

Software

NEFSC Protocols

The NEFSC uses the Simrad Lobe program (date of last revision: 2010) to calibrate the EK60 echo sounder. The calibration software version and the echo sounder firmware version are documented for all calibrations.

Standard values

Table 1 provides a list of standard values for calibration. The copper spheres are the primary spheres for the 18 and 38-kHz systems, and the 38.1-mm WC sphere is the primary sphere for the 70, 120, and 200-kHz systems. However, the 38.1-mm WC sphere has been used for all frequencies except 12 kHz. The copper spheres are preferred for the 18 and 38-kHz systems because they provide 8-10 dB of signal-noise improvement.

Table 1. Calibration standard values used at the NEFSC. Calibration sphere measurements are the sphere diameter. 'Cu' denotes a copper calibration sphere, and 'WC' denotes a tungsten carbide with 6% cobalt binder sphere.

Frequency [kHz]	Calibration Sphere	EK500 Minimum Target Range [m]	Nominal TS [dB]*
18	64-mm Cu 38.1-mm WC	20 20	-34.4 -42.7
38	60 mm Cu 38.1-mm WC	10 10	-33.6 -42.3
70	38.1 mm WC	10	-41.1
120	23 mm Cu 38.1-mm WC	10 10	-40.4 -40.0
200	38.1-mm WC	10	-39.9

On-axis sensitivity

NEFSC Protocols

The NEFSC acoustics manual (NEFSC_aqstx-acoustics_manual.doc) details on-axis calibration protocols. The tolerance of the 38-kHz on-axis calibration is ±0.4 dB (G_0: ±0.2 dB).

Transceiver settings are equivalent to those used during the survey.

Beam pattern measurements

NEFSC Protocols

The NEFSC acoustics manual (NEFSC_aqstx-acoustics_manual.doc) details beampattern measurement protocols. The NEFSC does not modify the offset or beamwidth parameters based on the Lobe program. This is due to the concern that the beam pattern parameters derived by the Lobe program are not based on independent measurements of the beam pattern. The Lobe program relies on the angular offsets provided by the EK500 and transducer, which is not an independent measure of the true angular positions.

Transceiver settings are equivalent to those used during the survey.

s_A Calibrations

NEFSC Protocols

The NEFSC acoustics manual (NEFSC_aqstx-acoustics_manual.doc) details s_A calibration protocols. The tolerance of the 38-kHz S_v calibration is ±0.4 dB (s_A: ±0.2 dB).

Transceiver settings are equivalent to those used during the survey.

Oceanographic Data

NEFSC Protocols

A vertical temperature and salinity (CTD) profile is collected prior to calibrations that are conducted offshore. For inshore calibrations, such as those that are conducted at the Woods Hole Oceanographic Institution's pier, either CTD profiles or the 3-m temperature and salinity hull-mounted sensor are used for the physical data. CTD profiles encompass the calibration depths. Refer to the Sampling->Oceanographic Data section for details on operating the CTD.

Temperature and salinity measurements are compared between the CTD profiler and hull-mounted sensors during the calibrations.

Considerations

Remediation

If the 38-kHz gain or s_A values are outside of the tolerances defined above, the survey will not commence until the cause of the error is resolved. The Simrad manual (Simrad, 1996) provides diagnostic tests to evaluate the EK60 echo sounder.

If temperature and salinity measurements are not comparable between the CTD profiler and hull-mounted sensors, the Fisheries Oceanography Investigation (FOI) and the ship's electronic technician should be contacted to determine the cause of the discrepancy.

<u>System Performance</u>

Techniques

NEFSC Protocols

The 'test' values and passive noise values for the Simrad EK60 echo sounder are documented for every calibration and at the beginning of each survey 'leg' (two to three week portion of a survey). Test and passive noise values are documented for all frequencies.

During the survey, individual target locations in the acoustic beam (EK60 TS Detection Menu) are evaluated to ensure that individual target locations appear in all quadrants.

Considerations

Remediation

Survey operations should be suspended if the ‘Test’ values are out of tolerance and the cause of the errors diagnosed. The Simrad manual provides diagnostic and evaluation procedures (Simrad, 1996). After the problem is resolved, the survey can continue.

If individual targets do not appear in all quadrants, survey operations should be suspended and the problem diagnosed. After the problem is resolved, the survey can continue.

Data Management

The calibration Lobe data, EK60 data, and associated meta-data are stored on board until such time is appropriate for downloading to a shore-based computer. The EK60 data are stored on an SCS server, which is RAID configured to minimize potential loss of data. These data are archived by the Data Management Service branch at the NEFSC after the data are downloaded to shore.

Volume Backscattering Measurements (E_i)

Data Collection

Techniques

Echo Sounder Parameters

NEFSC Protocols

Echo-sounder parameters are set relative to the goals of the survey and in some cases are a compromise between data quality and preferred values, where data quality has paramount priority.

Transceiver settings for the Simrad EK60 echo sounder are provided in Table 2. The gain is obtained from the echo sounder calibration (Calibration section). Simrad provides the power and two-way integrated beam pattern and these values are not modified unless a transducer is changed. The sound speed and sound attenuation are not modified from the default values for the fall Atlantic herring survey. The bandwidth value is set according to the Simrad recommendations. The pulse durations for all frequencies is set to 1 ms as per the recommendation of Demer et al. (1999) for improving acoustical discrimination of individual targets using multi-frequency methods. The 1 ms pulse duration was chosen for the 38-kHz echo sounder as the optimal setting for the depth ranges encountered during the fall Atlantic herring survey (maximum range of approximately 500 m) and the vertical resolution of the integrated data.

Table 2. EK60 parameter settings. “Transducer Depth” is the depth of the transducer from the sea surface. “Absorption” is the acoustic attenuation coefficient. “Bandwidth” is the receiver bandwidth setting. “Max. Power” is the maximum transmit power. “Two-way Beam” is the two-way integrated beam angle. “Gain” is the 40logR-TVG gain setting. “Sa Correction” is the areal backscatter gain factor. “Alongship” and “Athwartship” are the main axes of the split-beam transducer, where alongship is parallel to the keel of the vessel and athwartship is in the orthogonal (i.e., abeam) direction. “Sensitivity” is the parameter for converting electrical to mechanical angles. “Beam width” is the angular width of the acoustic beam at the 3-dB (half-power) points. “Offset” is the angular offset of the acoustic axis. “Ping interval” is the interval between successive transmissions. “Vertical Res.” is the vertical resolution of the volume backscatter (S_v) data.

	18 kHz	**38 kHz**	**70 kHz**	**120 kHz**	**200 kHz**
Transducer Type	ES18-11	ES38B	ES70-7C	ES120-7C	ES200-7C
Transducer Depth (m)	0.0	0.0	0.0	0.0	0.0
Absorption (dB km^{-1})	2.1	8.1	21.5	40.5	60.7
Pulse Duration τ (ms)	1.024	1.024	1.024	1.024	1.024
Bandwidth (kHz)	1.57	2.43	2.86	3.03	3.09
Max. Power (W)	1000	1000	1000	500	300
Two-way Beam (dB)	-17.3	-20.8	-20.9	-20.9	-20.8
Gain	22.88	24.07	24.74	26.29	26.64
Sa Correction	-0.69	-0.70	-0.33	-0.33	-0.52
Sensitivity Alongship	13.9	21.9	23.0	23.0	23.0
Sensitivity Athwartship	13.9	21.9	23.0	23.0	23.0
Beam width Alongship	10.9	7.0	6.9	6.5	6.26
Beam width Athwartship	10.9	7.0	6.9	6.5	6.23
Alongship Offset	0.0	0.00	0.00	0.00	0.00
Athwartship Offset	0.0	0.00	0.00	0.00	0.00
Ping Interval (sec)	1	1	1	1	1
Vertical Res. – (m)	0.192	0.192	0.192	0.192	0.192

The echo sounder is calibrated with the same transceiver settings used during the survey, and the transceiver settings are not modified during the survey.

Software

NEFSC Protocols

The echo sounder firmware version and the post-processing software (SonarData, Echoview) version are documented for every survey.

GPS

NEFSC Protocols

The primary Global Positioning System (GPS) data used for the acoustical surveys are the differential GPS values.

Oceanographic Data

NEFSC Protocols

Sea-surface temperature and salinity data are collected continuously during the survey. These are a standard set of data regularly collected by the Scientific Computer System (SCS).

Vertical temperature and salinity (CTD) profiles are conducted at the beginning and end of each transect.

Vertical CTD profiles are also conducted immediately prior to or immediately after every deployment or set of deployments. If multiple deployments are to be conducted in the same area and over a short time frame (e.g., less than 12 hours), whether to conduct a single CTD or multiple profiles is left to the discretion of the scientific watch chief.

The Fisheries Oceanography Investigation (FOI) maintains the CTD instrumentation and is responsible for CTD data management. The FOI provides training for CTD operation at the beginning of each survey 'leg'. All scientific personnel participate in the training at least once during the survey.

<u>Detection Probability</u>

Techniques

Thresholding

NEFSC Protocols

No threshold is set for data acquisition. The post-processing S_v threshold was chosen for Atlantic herring by evaluating the relationship of S_A as a function of S_v threshold (Figure 1). An S_v threshold of –66 dB was chosen as the optimal value to retain volume backscattering by Atlantic herring while reducing backscatter by other organisms.

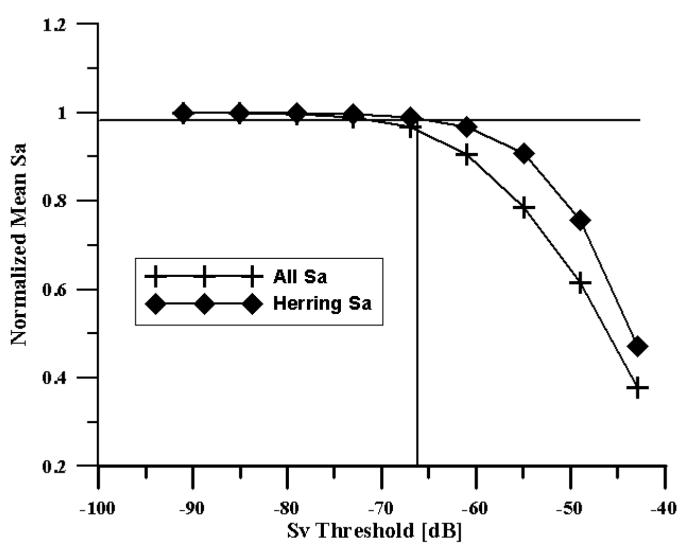

Figure 1. Normalized water column S_A and Atlantic herring S_A as a function of S_v threshold. Data were collected during September 1999 on Georges Bank.

Range

NEFSC Protocols

Currently we do not have protocols to account for range or signal to noise affects.

Acoustic Dead Zones: Near surface and near bottom

NEFSC Protocols

No S_v data are eliminated during data collection.

When post-processing the S_v data, a constant depth below the surface is chosen where data above this depth (i.e., near-surface data) are eliminated from analyses (this depth is commonly called the 'bubble layer'). The minimum depth is set to 10 m for the 18, 38, and 120-kHz echo sounders. The depth for the 18, 38, and 120-kHz systems was chosen based on: 1) the hull-mounted transducers are located approximately 3 to 6 m below the surface, 2) the near field of the 38 kHz transducer is approximately 4 m, 3) a consistent depth is desired to compare data among the frequencies, and 4) under normal survey conditions, surface noise (*e.g.*, bubbles) do not penetrate deeper than 10 m.

During data collection and post-processing of the S_v data, a constant distance above the bottom where data below this depth are eliminated from analyses (this distance is commonly called the 'backstep') is selected. The 'backstep' is set to 0.5 m for all frequencies. This distance was chosen based on observations of the S_v data and the EK60 and Echoview bottom-detection algorithms.

For post-processing the S_v data, we use Echoview's bottom-detection algorithm to select the echoes from the seabed. Echoview bottom-detection parameters are:

i. Bottom detection algorithm: Maximum Sv with backstep
ii. Minimum Sv for good pick: -50.00 dB
iii. Discrimination Level: -40.00 dB
iv. Backstep range: -0.50 m

The bottom detection is obtained from the 120 kHz data and applied to all frequencies. After the 120-kHz bottom detection has been completed using Echoview's algorithm, all echograms are visually inspected for improper bottom detections. Improper bottom detections are manually corrected using Echoview post-processing software.

As an independent check of the bottom detection algorithm and subsequent visual inspection, a 1 m layer adjacent to and above the bottom detection line (including backstep) is created using Echoview's 'virtual echogram' module. S_v values within this layer greater than an S_v threshold of –45 dB (note this threshold is not equivalent to the post-processing threshold) may indicate improper bottom detections or may indicate backscattering by fish. These Sv values are exported and used to visually inspect echograms for a final determination of improper bottom detection.

Animal Behavior

NEFSC Protocols

Currently we do not have protocols to account for animal behavior effects on S_v measurements.

Vessel Noise and Avoidance

NEFSC Protocols

Sound range measurements were conducted on the FRV Delaware II in January 2003 at the Canadian Naval Sound Range in Halifax, Nova Scotia and in 2007 at the AUTEC range in the Bahamas. Reports from the sound rangings and a summary of the data were generated and are available from the NEFSC fisheries acoustics group.

Currently we do not have protocols for investigating vessel noise effects on S_v measurements.

Currently we do not have protocols for monitoring vessel noise during surveys.

Multiple scattering and shadowing

NEFSC Protocols

Currently we do not have protocols for determining when non-linear scattering effects are significant or for correcting S_v measurements due to multiple scattering and shadowing.

<u>Classification</u>

Techniques

Single Frequency

NEFSC Protocols

The NEFSC utilizes multiple frequencies for subjective classification of Atlantic herring (Refer to the next section).

Multiple Frequency

NEFSC Protocols

Each echo sounder is calibrated according to the calibration protocols (Calibration Section). The 38-kHz data are the primary data for Atlantic herring density and abundance estimates used in assessments. Data processing and post-processing protocols established for the 38-kHz data apply to all frequencies used for analysis. However this does not imply that all parameter settings are equivalent among echo sounders. Calibration and data collection parameters may differ among systems. For near-bottom data, a common bottom-detection line is applied among all frequencies. For near-surface data, the deepest 'bubble layer' will generally limit application of multi-frequency analyses.

Atlantic herring are objectively classified as described in Jech and Michaels (2006). Briefly, an objective algorithm is applied to the 18, 38, and 120-kHz data and then visually scrutinized to confirm backscatter attributed to herring.

Biological Sampling

Trawls

NEFSC Protocols

For the Fall Atlantic herring survey on Georges Bank, pre-determined trawl locations are defined. These trawl locations were chosen based on spatial distributions of Atlantic herring during acoustical surveys from 1999-2002. Trawl hauls are conducted within ±5 nautical miles (nmi) of these locations. Other trawl locations are determined on an *ad hoc* basis. Selecting *ad hoc* trawl locations is at the discretion of the scientific watch chief, and is based on the experience of the scientific personnel and the goals of the survey.

For other sites in the Gulf of Maine, trawl locations are determined on an *ad hoc* basis. Selecting *ad hoc* trawl locations is at the discretion of the scientific watch chief, and is based on the experience of the scientific personnel and the goals of the survey.

The pelagic trawls used during acoustical surveys are the Irish herring mid-water rope trawl (IHMRT) made by Swan Nets of Gloucester, MA and the polytron mid-water rope trawl (PMRT) made by Superior Trawl of Point Judith, RI. Maintenance details for the trawls are given in "NEFSC_midwater_trawl_maintenance.PDF". The chief boatswain is provided a copy of this document before sailing.

Trawl catch data are processed according to the Ecosystems Survey Branch (ESB) protocols (refer to the Bottom Trawl Survey Protocol), with modifications for the acoustical surveys and sampling Atlantic herring. The primary trawl catch processing software is the Fisheries Scientific Computer System (FSCS). The two components of FSCS that are modified for acoustical surveys are the 'Trawl Event' and the sampling station designation.

The 'Trawl Event' electronically documents meta-data information pertinent to the trawl. The FSCS manual provides standard operating procedures for the trawl event and the bridge officers are responsible for operating the trawl event. Five modifications of the trawl event for acoustical surveys are:

i. The "Station Number" and the "Tow Number" are set equivalent to the acoustical deployment number.
ii. The "Start Event" button is clicked when the net begins streaming.
iii. The "Start Trawl" button is clicked when the doors enter the water.
iv. The "Stop Trawl" button is clicked when the doors come out of the water.
v. The "Stop Event" button is clicked when the net is on the deck.

The ESB defines a 'station' as a coordinated set of activities associated with a bottom trawl. The fisheries acoustics group does not follow this convention. During acoustical surveys, a 'deployment' is defined as a single activity or event, deployment numbers are sequential throughout the entire survey, and each deployment receives a sequential number. For example, a CTD conducted prior to a trawl is given a separate deployment number from the trawl. The start of the mid-water trawl is defined as when the doors enter the water, and the end is defined as when the doors exit the water. This start and end distinctions are due to the fact that the net is able to encounter and catch fish and other organisms as soon as the doors are set.

Procedures for setting and retrieving the pelagic trawl are provided in the "NEFSC_aqstx-biology_manual.doc" document. The manual provides procedures for the bridge and scientific staff.

Net mensuration sensors are attached to the net during trawling activities to: provide real-time evaluation of the net performance, ensure proper net configuration, and document net performance. Net mensuration data are collected with Vemco MiniLog temperature-depth probes, and a Simrad FS70 scanning sonar.

Two Vemco minilog temperature-depth probes are attached to the net, one on the headrope and one on the footrope, as the net is being set. The probes record temperature and depth at 5-second intervals. Each probe is initialized immediately prior to the trawl.

Upon retrieval of the net, the data are downloaded to a shipboard computer, and downloaded to a shore-based computer at the end of the survey.

The Simrad FS70 is the primary instrument used for evaluating the real-time performance of the net. A trawl is not to be conducted if the FS70 is inoperable. The FS70 is a 'third-wire' system that contains a scanning sonar and a temperature-depth recorder. The FS70 requires an armored conducting cable and winch. Prior to sailing, the ship's electronic technician will connect the FS70 and ensure that it is operational. As the net is being set, the FS70 is placed in the 'kite' near the headrope, and upon retrieval the FS70 is removed from the kite and stored. Because the FS70 is the primary instrument for determining that the net is properly set, a display is located on the bridge and in the trawl winch operator room.

The FS70 display is constantly monitored by scientific and bridge personnel during the trawl to ensure that the net is 'fishing' properly and is not on the bottom. After the net has reached 'fishing' depth, at approximately 5-minute intervals or each time the depth of the net is modified, the data and time (in GMT), vessel speed, shaft RPM, temperature at the net, depth of the headrope, door and wing spreads, vertical mouth opening, and horizontal opening are recorded to a paper form. These data are then entered in a spreadsheet and archived at the conclusion of the survey.

Trawl catch sampling and sub-sampling protocols for length, weight, age, and other biological variables are based on the standard protocols set by the NEFSC – except for Atlantic herring. For more details on the standard protocols refer to the NEFSC Trawl Survey Protocol, and the NEFSC Fisheries Scientific Computing System (FSCS) manual. The catch, including herring, is processed using the FSCS system.

Sampling and sub-sampling Atlantic herring protocols are:

i. Approximately 150 individual Atlantic herring are randomly chosen from the entire herring catch as a sample. If there are fewer than 150 individuals, all herring are sampled.
ii. For all 150 herring, individual lengths and individual weights are measured.
    a. Fish length is recorded as fork length (FL) to the nearest millimeter [mm]. If the electronic board does not measure to the nearest mm, use a manual measuring board.
    b. Fish weight (mass) is recorded to the nearest gram [g].
iii. At least once per survey, fork lengths and total lengths (TL) should be measured, in addition to the other measurements, to maintain a time series of the FL-to-TL relationship.
iv. For 'age&growth', food habits, and maturity data the following sub-sampling is conducted:
    a. One herring per centimeter [cm] length class below 25 cm is sampled.
    b. Three herring per cm length class greater than or equal to 25 cm are sampled.
    c. The cm length class is defined as between 5 mm below and 4 mm above the length class designation. For example, the 25 cm length class is bounded by 245 and 254 mm (24.5 to 25.4 cm).
    d. Only the herring sub-sampled for age&growth are frozen whole for later otolith extraction by the Age and Growth Branch at the NEFSC.

v. At the conclusion of processing the catch, the data are loaded into Oracle.

The document "NEFSC_aqstx-biology_manual.doc" details procedures for biological sampling.

Underwater video.

NEFSC Protocols

Underwater video methods and techniques are currently experimental and currently we do not have protocols for underwater video measurements.

Bottom Tracking

NEFSC Protocols

Refer to the 'Volume Backscattering Measurements->Detection Probability -> Acoustic Dead Zones' section for protocol details.

<u>Performance Degradation</u>

Techniques

Noise

Acoustical

NEFSC Protocols

The ship's electronic technician maintains a list of all acoustical systems on board. This list documents operating frequency, manufacturer, model, and serial number. We have established which systems interfere with the scientific EK60 echo sounders. These systems are the bridge Simrad ES60 echo sounder (dual 50 and 200 kHz), the bridge Raytheon recording depth sounder (38 kHz), and the Acoustic Doppler Current Profiler (ADCP) operating in 'wideband' mode. After the vessel has left port, the Raytheon recording depth sounder is turned off during acoustical surveys. The ADCP is not operated during acoustical surveys. The 50-kHz signal from the ES60 has been determined to interfere with the EK60 38-kHz echo sounder. The ES60 operating mode is switched to '200 kHz only' during acoustical surveys.

Electrical

NEFSC Protocols

Electrical interference has not been an issue during acoustical surveys.

Bubble Attenuation

NEFSC Protocols

Currently we do not have protocols for adjusting S_v measurement due to bubble attenuation during survey operations.

We remove backscattering by surface bubbles that extend below the 'bubble layer' from S_v data during post-processing by encompassing these areas using Echoview regions and defining these regions as 'Bad Data'. The 'bad data' designation eliminates this data from analysis.

Transducer Motion

NEFSC Protocols

Currently we do not have protocols for adjusting S_v measurements due to transducer motion.

Currently we do not have protocols for objective decisions for suspending survey operations based on sea state or vessel motion. The decision to slow the vessel or to suspend operations due to sea-state is based on the judgment of the scientific watch chief.

Bio-fouling

NEFSC Protocols

Prior to sailing, the bridge officers and deck crew often conduct diving operations on the ships. If feasible, the divers are requested to inspect and, if necessary, clean the hull-mounted transducers before each survey.

Considerations

Remediation

In some cases, we are not able to eliminate acoustical interference during data collection (*e.g.*, the Simrad ITI sensors cause 'spikes' in the 38 kHz data during trawl activities). For these data, the noise is manually removed during post-processing using Echoview regions specified as 'Bad Data'. This designation eliminates those data from analysis.

If results of cavitation, bubble attenuation, or transducer motion are observed on any echo sounder (e.g., blank spots in the echogram), the survey is conducted at a slower speed. If the vessel speed drops below 6 knots, survey operations are suspended. The decision to slow the vessel or suspend operations is at the discretion of the scientific watch chief.

Data Management

During the survey, volume backscattering data are stored on the Scientific Computer System (SCS) system. Hard drives on this server are in a RAID configuration to minimize the potential for data loss.

S_v data are downloaded to a shore-based computer at the end of each survey 'leg'. Volume backscattering data are archived by the Data Management Service (DMS).

Target Strength (σ_i)

Models

Techniques

Theoretical

NEFSC Protocols

The use of theoretical models is experimental. Currently we do not have protocols for integrating theoretical models in survey estimates.

Empirical

NEFSC Protocols

Currently we do not have protocols for implementing empirical models of Atlantic herring from the Gulf of Maine in survey estimates.

Validation

NEFSC Protocols

Currently we do not have protocols for validating theoretical or empirical models.

<u>Data Collection</u>

Techniques

Echo sounder Parameters

NEFSC Protocols

Currently we do not have protocols for collecting or processing acoustic data for target strength.

Software

NEFSC Protocols

The Echoview version is documented for every survey.

In situ data

NEFSC Protocols

Currently we do not have protocols for collecting *in situ* target strength data. The NEFSC is investigating methods and instrumentation for collecting *in situ* target strength data.

GPS

NEFSC Protocols

The primary Global Positioning System (GPS) data used for the acoustical surveys are the differential GPS values.

Oceanographic Data

NEFSC Protocols

Sea-surface temperature and salinity data are collected continuously during the survey. These data are a standard set of data regularly collected by the Scientific Computer System (SCS).

Vertical temperature and salinity (CTD) profiles are conducted at the beginning and end of each transect.

Vertical CTD profiles are also conducted immediately prior to or immediately after every deployment or set of deployments. If multiple deployments are to be conducted in the same area and over a short time frame (e.g., less than 12 hours), whether to conduct a single CTD or multiple casts is left to the discretion of the watch chief.

The Fisheries Oceanography Investigation (FOI) maintains the CTD instrumentation and is responsible for CTD data management. The FOI provides training for CTD operation at the beginning of each survey ‘leg’. All scientific personnel participate in the training at least once during the survey.

<u>Detection Probability</u>

Techniques

NEFSC Protocols

The beam width and directivity response function for each transducer are provided by the transducer manufacturer (Simrad) and are documented for each survey. During calibration exercises, beam pattern measurements are evaluated for proper echo strength compensation.

Thresholding

NEFSC Protocols

No threshold is set during data acquisition. The display threshold on the EK60 does not affect data collect.

Acoustic Dead Zones: Near Bottom and Near Surface

NEFSC Protocols

Near-surface and near-bottom limitations are equivalent for target strength and S_v data. The 'Volume Backscattering Measurement->Detection Probability->Acoustic Dead Zones' section provides detailed protocols.

Animal Behavior

NEFSC Protocols

Currently we do not have protocols for incorporating animal behavior in target strength measurements.

Vessel Noise

NEFSC Protocols

The 'Volume Backscattering Measurements->Detection Probability->Vessel Noise and Avoidance' section provides details on vessel noise. Currently we do not have protocols for incorporating vessel noise in analysis of TS measurements.

Density Requirements

NEFSC Protocols

Currently we do not have protocols for incorporating density dependencies on target strength measurements.

Single Frequency

NEFSC Protocols

Currently we do not have protocols for incorporating single frequency methods in analyzing target strength data.

Multiple Frequency

NEFSC Protocols

Currently we do not have protocols for incorporating multiple frequency methods in analyzing target strength data. We are investigating the potential for incorporating multi-frequency methods described by Demer et al. (1999) to improve target strength measurements.

<u>Classification</u>

Techniques

Single Frequency

NEFSC Protocols

Currently we do not have protocols for classification of individual targets using single frequency target strength data.

Multiple Frequency

NEFSC Protocols

Currently we do not have protocols for classification of individual targets using multiple frequency target strength data.

Biological Sampling

Trawls

NEFSC Protocols

Verification of the species composition of individual targets is equivalent to methods used for S_v data. The ‘Volume Backscattering Measurements->Classification->Biological Sampling->Trawls’ section provides detailed protocols for biological sampling.

Underwater video.

NEFSC Protocols

The use of underwater video methods and instrumentation are experimental. Currently we do not have protocols for underwater video methods.

Bottom Tracking

NEFSC Protocols

Seabed detection protocols are equivalent for target strength and S_v data. Detailed protocols are provided in the ‘Volume Backscattering Measurements->Detection Probability->Acoustic Dead Zones’ section.

<u>Performance Degradation</u>

Techniques

Noise

Acoustical

NEFSC Protocols

Acoustical noise protocols are equivalent for the target strength and S_v data. The ‘Volume Backscattering Measurements->Performance Degradation-Noise->Acoustical’ section provides detailed methods.

Electrical

NEFSC Protocols

Electrical noise protocols are equivalent for the target strength and S_v data. The ‘Volume Backscattering Measurements->Performance Degradation->Noise-Electrical’ section provides detailed methods.

Bubble Attenuation

NEFSC Protocols

Currently we do not have protocols for adjusting or correcting target strength measurements due to bubble attenuation. During post-processing, backscattering by surface bubbles is removed from TS data using Echoview regions defined as ‘Bad Data’. This designation eliminates these data from analysis.

Transducer Motion

NEFSC Protocols

Currently we do not have protocols for adjusting TS measurements due to transducer motion.

Currently we do not have protocols for objective decisions for suspending survey operations based on sea state or vessel motion. The decision to slow the vessel or suspend operations is at the discretion of the scientific watch chief.

Bio-fouling

NEFSC Protocols

Prior to sailing, the bridge officers and deck crew often conduct diving operations on the ships. If feasible, the divers are requested to inspect and, if necessary, clean the hull-mounted transducers before each survey.

Considerations

Remediation

If results of cavitation, bubble attenuation, or transducer motion are observed on any echo sounder (e.g., blank spots in the echogram), the survey is conducted at a slower speed. If the vessel speed drops below 6 knots, survey operations are suspended. The decision to slow the vessel or suspend operations is at the discretion of the scientific watch chief.

Data Management

During the survey, target strength data are stored on the Scientific Computer System (SCS) backup server. Hard drives on this server are in a RAID configuration to minimize the potential for data loss.

Target strength data are downloaded to a shore-based computer at the end of each survey ‘leg’. Target strength data are archived by the Data Management Service (DMS).

Sampling

Survey Design (A_i)

Techniques

Vessel Speed

NEFSC Protocols

Survey vessel speed while conducting transects is optimally 10 knots. The minimum vessel speed for conducting transects is 6 knots. If excessive vessel motion is observed at six knots, operations should be suspended until the sea state reduces.

Currently we do not have objective criteria for reducing vessel speed or suspending survey operations based on excessive performance degradation.

GPS

NEFSC Protocols

The primary Global Positioning System (GPS) data used for the acoustical surveys are the differential GPS values.

Numerical Density to Biomass Density (D_i)

Techniques

Target Strength to Length Regression

NEFSC Protocols

Interpretation and derivation of target strength to length regressions are beyond the scope of these protocols. Target strength data collection methods are detailed in the 'Target Strength Measurements' section. Fish length measurements and biological data collection methods are detailed in the 'Volume Backscattering Measurements -> Classification->Biological Sampling->Trawls' section.

Length-Weight Regression

NEFSC Protocols

Interpretation and derivation of length-weight regressions are beyond the scope of these protocols. Fish length and weight measurements and biological data collection methods are detailed in the 'Volume Backscattering Measurements->Classification -> Biological Sampling->Trawls' section.

Oceanographic Data

Techniques

CTD profiles

NEFSC Protocols

Fisheries Oceanography Investigation (FOI) maintains the CTD instrument manufacturer, identification number, firmware version, processing software and version and is responsible for calibrating and maintaining CTD instrumentation.

Water samples are collected twice every 24 hours and the water stored for laboratory analysis of salinity. These data are used to ensure data quality throughout the survey.

Vertical temperature and salinity (CTD) profiles are conducted at the beginning and end of each transect.

Vertical CTD profiles are also conducted immediately prior to or immediately after every deployment or set of deployments. If multiple deployments are to be conducted in the same area and over a short time frame (e.g., less than 12 hours), whether to conduct a single CTD or multiple casts is left to the discretion of the watch chief.

Data collection and archiving protocols are established by FOI. Prior to each survey, the FOI conducts training for operating the CTD hardware and software. All scientific personnel involved with collecting CTD data attend training at least once during the survey.

Surface temperature and salinity

NEFSC Protocols

Sea-surface temperature and salinity sensors and data are part of the Scientific Computer System (SCS). NOAA Marine and Aviation Operations (NMAO) are responsible for maintaining on-board instrumentation and sensors. The ship's electronic technicians document the manufacturer, model numbers, and identification numbers of temperature and salinity sensors.

For acoustical surveys, the hull-mounted sensors at 3-m depth provide the primary sea-surface temperature and salinity data.

Scientific Computer System (SCS)

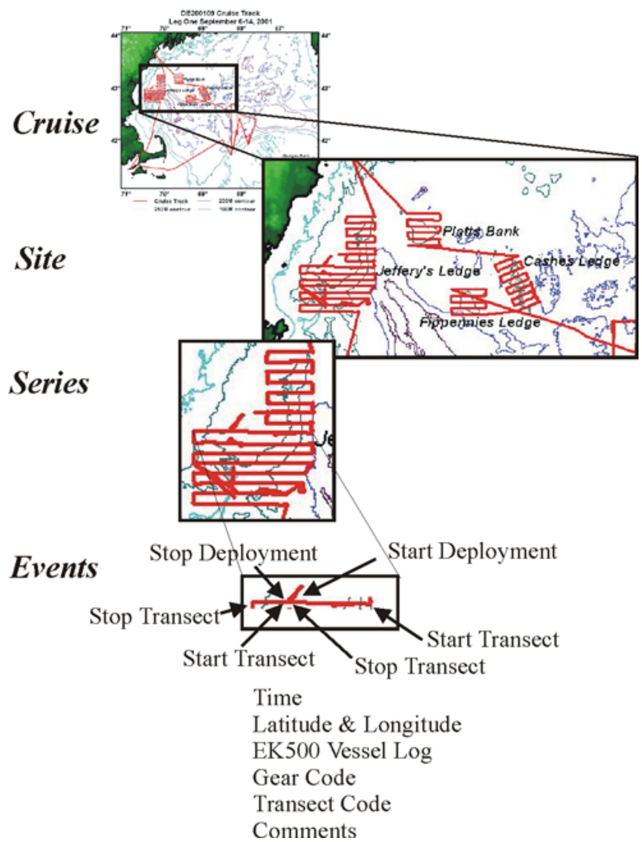

Figure 5. Pictorial overview of the hierarchical NEFSC acoustical event log.

Techniques

Event Log

NEFSC Protocols

The Scientific Computer System (SCS) is a shipboard system that logs data from electronic sensors throughout the vessel. Within the SCS framework, SCS event logs are created for specific surveys. The acoustical event log electronically documents events in order to coordinate the acoustical data with other scientific operations, such as CTD and trawl deployments. At the conclusion of a survey, the event log data are audited and entered in an Oracle database. In addition to the electronic log, a 'hardcopy' paper form is filled out with equivalent information. This paper log is updated each time the SCS event log is updated.

Prior to sailing, an acoustical SCS event log is created by modifying an existing acoustical event log template. The survey code is set to the current survey, and the event log is saved to a new file. The file name of the SCS acoustical event log is used to define the directory where the data are stored.

During the survey, the acoustical SCS event log is constantly monitored and updated for all events by the scientific personnel. The watch chief is responsible for event log quality and for training personnel in the use of the event log.

SCS data

NEFSC Protocols

The following sensor data are pertinent to the acoustical survey and should be collected:

a. Date and time (GMT)
b. GPS (differential)
c. Doppler Speed Log (bridge speed log)
d. Motion Sensor

Prior to sailing, the ship's electronic technician is contacted to ensure these data are stored. At the end of the survey, copies of the SCS data are requested from the ship's electronic technician.

Data Management

At the conclusion of each 'leg' of the survey, the SCS and SCS event log data are downloaded to a shore-based computer for storage and archiving. The SCS data are archived by the ship's electronic technician, the NEFSC, and the fisheries acoustics group.

Archival and management of CTD data are the responsibility of the Fisheries Oceanography Investigation.

Modifications to Protocols

Changes to operational protocols will be at the discretion of the NEFSC Science Director who may approve such changes directly or specify a peer review process to further evaluate the justification and impacts of the proposed changes.

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