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INTRODUCTION

Fisheries acoustics data have been used for decades to estimate fish densities and abundances in fisheries assessments (Simmonds and MacLennan 2005) and ecosystem investigations (Trenkel et al. 2011). Acoustic signals travel through water at a speed of approximately 1500 m s^{-1} and can propagate 1000s of kilometers, so the entire water column can be sampled quickly and continuously from vessels, buoys, or other platforms. Active acoustic methods transmit a pulse of sound and echoes from targets such as fish, zooplankton, thermo- or pycnoclines, and the sea bed which are detected and recorded by the echo sounder. Passive acoustic methods listen for sounds generated by geological (e.g., earthquakes), meteorological (e.g., rain and wind), and biological (mammals and fish) sources. Because acoustic signals are so effective and efficient at sampling the aquatic environment, instrumentation and methods to utilize these signals are ubiquitous in marine and freshwater systems (Horne and Jech 2005).

Acoustic data are here defined as narrow-band, volume backscatter (S_v, dB re m^{-1}) collected at multiple frequencies with the Simrad EK500 scientific echo sounder (Bodholt et al. 1989) from 1998 to 2002 and the Simrad EK60 (Andersen 2001) scientific echo sounder from 2003 to 2012. Volume backscatter is the cumulative acoustic energy within a sampling volume (i.e., acoustic beam or cone) and is proportional to the density of targets within that volume. Volume backscatter can be used as a relative index of density and abundance, or it can be scaled to numeric (i.e., "absolute") density, abundance, and biomass (Simmonds and MacLennan 2005), and as such, is the primary acoustic variable used in fisheries applications.

Acoustic data at the Northeast Fisheries Science Center (NEFSC) have been collected during dedicated acoustic surveys for Atlantic herring (*Clupea harengus*) on the National Oceanic and Atmospheric Administration (NOAA) Ship *Delaware II* since 1998 (Jech and Michaels 2006; Jech and Stroman 2012); and during other surveys from the NOAA Ship *Albatross IV* from 1998 to its decommissioning in 2008, and from the NOAA Ship *Henry B. Bigelow* since its commissioning in 2007. These data were acquired on the vessels, downloaded to data servers at the NEFSC, and archived at the NEFSC by the Data Management Systems (DMS) division. Postprocessing of acoustic data collected during the acoustic herring surveys is described elsewhere (Jech et al. 2000, 2002; Jech and Michaels 2006; Jech and Stroman 2012). Postprocessing of data collected on the *Albatross IV* and *HB Bigelow* began in 2011.

Acoustic data collected on the *Albatross IV* and *HB Bigelow* have primarily been collected during the NEFSC bottom trawl surveys. Acoustic data were rarely collected during other surveys on the *Albatross IV* and occasionally during other surveys on the *HB Bigelow*. The bottom trawl surveys are conducted during winter, spring, and fall (the winter survey was discontinued in 2008) and are the primary fisheries-independent surveys in mid-Atlantic and New England waters. The bottom trawl survey typically begins near Cape Hatteras, North Carolina, and works northward covering the continental shelf to Nova Scotia, Canada in about an 8-10 week period. The general strategy of data acquisition was to begin recording data when the vessel departed port and end recording when the vessel returned to port. This strategy was, in general, successful. There were, however, numerous times when data were not recorded, or sufficient data were not recorded, or the data were lost. Beginning in 2014, EK60 acoustic data will be archived by NOAA's National Geophysical Data Center (NGDC).

The impetus to process these data was to evaluate whether acoustic data could be useful for estimating the abundance of Atlantic herring and whether these data could be used in an assessment. Atlantic herring catches during the fall bottom trawl survey are a primary data source for the herring assessment, thus data collected during the fall bottom trawl surveys were selected to process. Additionally, data were processed from the first occurrence of Atlantic herring in the trawl catches to the end of the survey. In general, Atlantic herring are caught from Georges Bank and Cape Cod, MA, northward, so data from Cape Hatteras to Cape Cod were not processed. However, the methods for each year and vessel can be applied to the remaining fall survey data.

METHODS

Postprocessing methods for each year and vessel are described. Each section is separated into Acquisition and Postprocessing subsections. The Acquisition section details instrumentation, acquisition parameter settings, and calibration information. The Postprocessing section details postprocessing methods applied to the data.

The beginning and end dates for each year are those for when acoustic data were processed, which do not necessarily correspond to the full extent of the bottom trawl survey. The beginning date was selected by finding the first occurrence of Atlantic herring in a bottom trawl catch and then data were postprocessed from the beginning of that "leg" of the survey. The end date is the end of each survey.

Methods Common to All Data

Postprocessing methods consisted of selecting data to exclude and include, removing noise (acoustic, electric, mechanical, bubble), detecting the echo from the sea floor (i.e., bottom detection), correcting erroneous bottom detections, applying classification algorithms, visually scrutinizing the data for species identification (Reid et al. 1998; Reid 2000), and importing summary data into an Oracle relational database. All postprocessing, with the exception of the final import to Oracle, was done with Myriax Echoview software (v5.x+, GPO Box 1387 Hobart, Tasmania, Australia, www.echoview.com).

Echo sounders were calibrated using the standard target method (Foote et al. 1987). Every attempt was made to calibrate prior to, during, or immediately following each survey. The echo sounders on the *HB Bigelow* were calibrated for each survey beginning in 2008, and the data in 2007 were calibrated earlier in the year during acceptance sea trials. The echo sounders on the *Albatross IV* were sporadically calibrated, and gain settings were often based on calibrations done prior to or after the surveys were completed, sometimes separated by years. Among year comparisons are difficult for the *Albatross IV* data, as the echo sounders were not calibrated often. 38-kHz calibration gains for the HB Bigelow varied by ±0.1 dB, which is highly consistent among years.

Unless otherwise noted, data were collected to 500 m depth. Data were set relative to the ocean surface. Data shallower than 10 m (i.e., the "bubble layer") and within 0.5 m of the sea floor were eliminated from analysis. The 10-m layer was chosen to eliminate the transducer depth offset (the depth of the transducer relative to the sea surface), the transmit pulse (i.e., transducer "ring down"), and bubbles from the analysis. Echoes from the sea bed were eliminated from analysis because they are orders of magnitude greater than those from fish or zooplankton and inclusion of any part of the sea-bed echo can greatly skew density estimates. An offset from the bottom detection was used to minimize the acoustic "dead zone" (Ona and Mitson 1996). This is the zone where it is difficult to separate echoes from fish or zooplankton from the sea-bed echo. Atlantic herring can be located on or near the bottom, so a 0.5-m offset was selected to maximize herring detection while minimizing the dead zone. The "Maximum Sv" bottom-detection algorithm with -50 dB minimum $S_{v,}$ and -40 dB discrimination level was used to detect the echo from the sea floor. Bottom detection was done on the 120-kHz data and applied to the other data (i.e., the same bottom detection was used for all frequencies), unless there were no 120-kHz data. In cases where there were no 120-kHz data, bottom detection was done on the 38-kHz data and applied to the other frequencies. Erroneous detections were visually inspected for all frequencies and manually corrected. Bottom detections were exported to text files.

After data were cleaned and classified, S_v echograms were visually scrutinized (i.e., examined) for Atlantic herring. In most years, multi-frequency analyses were conducted, and the resulting composite echogram was used for estimating herring abundance. This composite echogram is labeled "fish" throughout this document because it highlights swimbladder-bearing fish and minimizes S_v from other organisms. Visual scrutiny was necessary for an accurate estimate of herring abundance because the classification algorithms highlighted S_v from herring as well as from species that have similar acoustic characteristics. Experience from scrutinizing data during the Atlantic herring acoustic surveys (Jech and Michaels 2006) was applied to these data. This experience was based on comparing midwater trawl catch composition to acoustic backscatter patterns. The midwater trawl provides optimal data for comparison to acoustic data, whereas the bottom trawl samples a small volume within a few meters of the bottom. Secondary to experience, bottom-trawl catch composition aided in identifying S_v due to Atlantic herring. In some cases, especially for in-shore areas, bottom-trawl catch composition was not useful for deciphering S_v in the water column, so identification relied on experience. In Echoview, regions were created by digitally drawing, via mouse clicks on the digital echogram images, polygons. These polygons were labeled, and the vertices of these polygons were exported to text files.

The composite "fish" S_v data were exported to a generic HAC data file. An Echoview "EV" file was created for each HAC data file, and the bottom detections and region vertices were imported. This conversion was done to significantly decrease computational time for generating area backscatter (NASC). Finally, nautical area scattering coefficient (NASC, m^2 nmi^{-2}, MacLennan et al. 2002) values at 0.5 nmi intervals (Equivalent Distance Sampling Unit, EDSU, MacLennan et al. 2002) were exported from Echoview to text files and then imported to a relational database in Oracle (Oracle Corp., 500 Oracle Parkway, Redwood Shores, CA USA, www.oracle.com).

Cruise-specific tables are presented for each survey (Tables 1-15), and a summary table (Table 16) condenses the different methods and calibration gains applied to the data.

1998 – *Albatross IV*

Acquisition

Table 1 provides data acquisition parameters and settings. Although the EK500 had a12-kHz system, no data were collected at this frequency. The EK500 echo sounder was not calibrated for this survey. The gain and parameter settings were set from the calibration done in June 1996.

Postprocessing

Anomalously large S_v values (i.e., "spikes") were ubiquitous and needed to be removed to prevent unrealistic herring density estimates. These "spikes" were due to interference from other acoustic instrumentation and were multiple samples long (vertical extent) but had a duration of only 1 transmission (i.e., ping). The difference (in dB) between successive pings at each depth interval was used to highlight spikes, and S_v values with differences greater than 10 dB were removed (set to -999.0 dB) from analysis (T. Ryan, Pers. Comm.; Anderson et al. 2005).

Data were synchronized between frequencies by matching time (±300 sec) for each transmission. A 3x3 kernel was applied by convolution to smooth the S_v data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1.

After removing noise spikes, synchronization, and smoothing, the 38- and 120-kHz S_v data were used to classify acoustic backscatter by using the "dB-differencing" method (Madureira et al. 1993; Kang et al. 2002). For each pixel, 120-kHz S_v was subtracted from 38-kHz S_v (ΔS_v), and pixels with ΔS_v less than 10 dB were classified as generic "fish." These fish pixels were applied to the 38-kHz S_v data (without the 3x3 convolution kernel applied), and these data were visually scrutinized (Jech and Michaels 2006) for Atlantic herring (Figure 1).

1999 – *Albatross IV*

Acquisition

Table 2 provides data acquisition parameters and settings. Although the EK500 had a 12-kHz system, no data were collected at this frequency. The EK500 echo sounder was not calibrated for this survey. The gain and parameter settings were set from the calibration done in June 1996.

Postprocessing

Anomalously large S_v values (i.e., "spikes") were ubiquitous and needed to be removed to prevent unrealistic herring density estimates. These "spikes" were due to interference from other acoustic instrumentation and were multiple samples long (vertical extent) but had a duration of only 1 transmission (i.e., ping). The difference (in dB) between successive pings at each depth interval was used to highlight spikes, and S_v values with differences greater than 10 dB were removed (set to -999.0 dB) from analysis (T. Ryan, Pers. Comm.; Anderson et al. 2005).

Data were synchronized between frequencies by matching time (±300 sec) for each transmission. A 3x3 kernel was applied by convolution to smooth the S_v data. The kernel values summed to 1, with the center value equal to 0.2, and the surrounding values equal to 0.1.

After removing noise spikes, synchronization, and smoothing, the 38- and 120-kHz S_v data were used to classify acoustic backscatter by using the "dB-differencing" method (Madureira et al. 1993; Kang et al. 2002). For each pixel, 120-kHz S_v was subtracted from 38-kHz S_v (ΔS_v), and pixels with ΔS_v less than 10 dB were classified as generic "fish." These fish pixels were applied to the 38-kHz S_v data (without the 3x3 convolution kernel applied) and these data were visually scrutinized (Jech and Michaels 2006) for Atlantic herring (Figure 2).

2000 – *Albatross IV*

Acquisition

Table 3 provides data acquisition parameters and settings. Although the EK500 had a12-kHz system, no data were collected at this frequency. The EK500 echo sounder was not calibrated for this survey. The gain and parameter settings were set from the calibration done in June 1996.

Postprocessing

Most of the data were noise free, but upon occasion anomalously large S_v values (i.e., "spikes") occurred and needed to be removed to prevent unrealistic herring density estimates. These "spikes" were due to interference from other acoustic instrumentation and were multiple samples long (vertical extent) but had a duration of only one transmission (i.e., ping). The difference (in dB) between successive pings at each depth interval was used to highlight spikes and S_v values with differences greater than 10 dB were removed (set to -999.0 dB) from analysis (T. Ryan, Pers. Comm.; Anderson et al. 2005).

Data were synchronized between frequencies by matching time (±300 sec) for each transmission. A 3x3 kernel was applied by convolution to smooth the S_v data. The kernel values summed to 1, with the center value equal to 0.2, and the surrounding values equal to 0.1.

After removing noise spikes, synchronization, and smoothing, the 38- and 120-kHz S_v data were used to classify acoustic backscatter by using the "dB-differencing" method (Madureira et al. 1993; Kang et al. 2002). For each pixel, 120-kHz S_v was subtracted from 38-kHz S_v (ΔS_v), and pixels with ΔS_v less than 10 dB were classified as generic "fish." These fish pixels were applied to the 38-kHz S_v data (without the 3x3 convolution kernel applied), and these data were visually scrutinized (Jech and Michaels 2006) for Atlantic herring (Figure 3).

2001 – *Albatross IV*

Acquisition

Table 4 provides data acquisition parameters and settings. Although the EK500 had a12-kHz system, no data were collected at this frequency. The EK500 echo sounder was not calibrated for this survey. The parameter settings are unknown for this cruise, but based on parameter settings for cruises before and after this cruise, it is assumed that the parameters settings are based on a calibration done in March 2001.

Postprocessing

The noise "spikes" were absent, so no "de-spike" algorithm was applied.

Data were synchronized between frequencies by matching time (±300 sec) for each transmission. A 3x3 kernel was applied by convolution to smooth the S_v data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1.

After synchronization and smoothing, the 38- and 120-kHz S_v data were used to classify acoustic backscatter by using the "dB-differencing" method (Madureira et al. 1993; Kang et al. 2002). For each pixel, 120-kHz S_v was subtracted from 38-kHz S_v (ΔS_v), and pixels with ΔS_v less than 10 dB were classified as generic fish. These fish pixels were applied to the 38-kHz S_v data (without the 3x3 convolution kernel applied) and these data were visually scrutinized (Jech and Michaels 2006) for Atlantic herring (Figure 4).

2002 – *Albatross IV*

Acquisition

Table 5 provides data acquisition parameters and settings. Although the EK500 had a12-kHz system, no data were collected at this frequency. The EK500 echo sounder was not calibrated for this survey. The gain and parameter settings are unknown for this cruise, but based on settings for cruises before and after this cruise the gain and parameter settings were set from a calibration done in April 2002.

Postprocessing

Although the transmission interval was set at 2 seconds (Table 5), the functional transmission interval was about 6 seconds. The cause of this discrepancy is unknown. However, the effects on the data were that there were fewer pings per 0.5-nmi interval, the algorithm to remove noise spikes decimated the 120-kHz data too much to be useful, and the 120-kHz data were too noisy to be useful, so the 120-kHz data were not used for quantitative analysis. Fortunately, the 38-kHz data were not noisy, so the unfiltered and unsmoothed 38-kHz data were used directly for scrutinizing and generating the "fish" echogram (Figure 5).

2003 – *Albatross IV*

Acquisition

Table 6 provides data acquisition parameters and settings. The Simrad EK500 was replaced by a Simrad EK60 during the winter repair period in 2003. The EK60 echo sounder was not calibrated for this survey. The gain and parameter settings were based on the factory default settings for the transducer types. The 120-kHz data appeared to be "bad" (i.e., the data values were low and there was overwhelming noise), so they were not postprocessed or used for analysis.

Postprocessing

Most of the data were noise free, but upon occasion anomalously large S_v values (i.e., "spikes") occurred and needed to be removed to prevent unrealistic herring density estimates. These "spikes" were due to interference from other acoustic instrumentation and were multiple samples long (vertical extent) but had a duration of only one transmission (i.e., ping). The difference (in dB) between successive pings at each depth interval was used to highlight spikes, and S_v values with differences greater than 10 dB were removed (set to -999.0 dB) from analysis (T. Ryan, Pers. Comm.; Anderson et al. 2005).

Because the 120-kHz data were unusable, a modified version of the Jech and Michaels (2006) method was applied to the 18- and 38-kHz S_v data ("modified presence/absence" method). A threshold of -66 dB was applied to the 18- and 38-kHz S_v data. The EK60 digitally samples the acoustic signal based on the transmit pulse duration, and the range (i.e., vertical) resolution is different when different pulse durations are used. Because the pulse durations were different for the 18- and 38-kHz S_v data (Table 6), in order to analyze the data, the vertical resolution was set equivalent between the 18- and 38-kHz S_v data. This was done by computing the unweighted mean S_v for each transmission, where the averaging was done in the linear domain, for each 1-m vertical interval. A 3x3 kernel was applied by convolution to smooth the 1-m vertical resolution S_v data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1.

The 18- and 38-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 1-m vertical resolution 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 1-m vertical resolution 38-kHz S_v data where both the 18- and 38-kHz echograms had values greater than -66 dB (Figure 6). The "fish" echogram was visually scrutinized for Atlantic herring.

2004 – *Albatross IV*

Acquisition

Table 7 provides data acquisition and processing parameters and settings. The EK60 echo sounder was not calibrated for this survey. The gain and parameter settings for the 18-kHz echo sounder were based on factory default settings. The gain and parameter settings for the 38-kHz echo sounder were incorrectly modified during data acquisition. Corrected gain and parameter settings based on a calibration done in 2008 were applied to the 38-kHz data during processing. The 120-kHz data appeared to be "bad" (i.e., the data values were low, and there was overwhelming noise), so they were not postprocessed or used for analysis.

Postprocessing

The noise spikes were absent, so no "de-spike" algorithm was applied.

Because the 120-kHz data were unusable, a modified version of the Jech and Michaels (2006) method was applied to the 18- and 38-kHz S_v data ("modified presence/absence" method). A threshold of -66 dB was applied to the 18- and 38-kHz S_v data. The EK60 digitally samples the acoustic signal based on the transmit pulse duration, and the range (i.e., vertical) resolution is different when different pulse durations are used. Because the pulse durations were different for the 18- and 38-kHz S_v data (Table 7), in order to analyze the data, the vertical resolution was set equivalent between the 18- and 38-kHz S_v data. This was done by computing the unweighted mean S_v for each transmission, where the averaging was done in the linear domain, for each 1-m vertical interval. A 3x3 kernel was applied by convolution to smooth the 1-m vertical resolution S_v data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1.

The 18- and 38-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 1-m vertical resolution 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 1-m vertical resolution 38-kHz S_v data where both the 18- and 38-kHz echograms had values greater than -66 dB (Figure 7). The "fish" echogram was visually scrutinized for Atlantic herring.

2005 – *Albatross IV*

Acquisition

Table 8 provides data acquisition and processing parameters and settings. The EK60 echo sounder was not calibrated for this survey. The gain and parameter settings for the 18-kHz echo sounder were based on factory default settings. The gain and parameter settings for the 38-kHz echo sounder were incorrectly modified during data acquisition. Corrected gain and parameter settings based on a calibration done in 2008 were applied to the 38-kHz data during processing. The 120-kHz data appeared to be "bad" (i.e., the data values were low, and there was overwhelming noise), so they were not postprocessed or used for analysis.

Postprocessing

The noise spikes were absent, so no "de-spike" algorithm was applied.

Because the 120-kHz data were unusable, a modified version of the Jech and Michaels (2006) method was applied to the 18- and 38-kHz S_v data ("modified presence/absence" method). A threshold of -66 dB was applied to the 18- and 38-kHz S_v data. The EK60 digitally samples the acoustic signal based on the transmit pulse duration, and the range (i.e., vertical) resolution is different when different pulse durations are used. Because the pulse durations were different for the 18- and 38-kHz S_v data (Table 8), in order to analyze the data, the vertical resolution was set equivalent between the 18- and 38-kHz S_v data. This was done by computing the unweighted mean S_v for each transmission, where the averaging was done in the linear domain, for each 1-m vertical interval. A 3x3 kernel was applied by convolution to smooth the 1-m vertical resolution S_v data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1.

The 18- and 38-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 1-m vertical resolution 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 1-m vertical resolution 38-kHz S_v data where both the 18- and 38-kHz echograms had values greater than -66 dB (Figure 8). The "fish" echogram was visually scrutinized for Atlantic herring.

2006 – *Albatross IV*

The 18- and 38-kHz EK60 echo sounders were calibrated in March; however, no data were recorded for 2006.

2007 – *Albatross IV*

Acquisition

Table 9 provides data acquisition and processing parameters and settings. The EK60 echo sounder was not calibrated for this survey. The gain and parameter settings for the 18-kHz echo sounder were based on a calibration done in 2006. The gain and parameter settings for the 38-kHz echo sounder were incorrectly modified during data acquisition. Corrected gain and parameter settings based on a calibration done in 2008 were applied to the 38-kHz data during processing. The 120-kHz data appeared to be "bad" (i.e., the data values were low, and there was overwhelming noise), so they were not postprocessed or used for analysis.

Postprocessing

The noise spikes were absent, so no "de-spike" algorithm was applied.

Because the 120-kHz data were unusable, a modified version of the Jech and Michaels (2006) method was applied to the 18- and 38-kHz S_v data ("modified presence/absence" method). A threshold of -66 dB was applied to the 18- and 38-kHz S_v data. The EK60 digitally samples the acoustic signal based on the transmit pulse duration, and the range (i.e., vertical) resolution is different when different pulse durations are used. Because the pulse durations were different for the 18- and 38-kHz S_v data (Table 9), in order to analyze the data, the vertical resolution was set equivalent between the 18- and 38-kHz S_v data. This was done by computing the unweighted mean S_v for each transmission, where the averaging was done in the linear domain, for each 1-m vertical interval. A 3x3 kernel was applied by convolution to smooth the 1-m vertical resolution S_v data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1.

The 18- and 38-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 1-m vertical resolution 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 1-m vertical resolution 38-kHz S_v data where both the 18- and 38-kHz echograms had values greater than -66 dB (Figure 9). The "fish" echogram was visually scrutinized for Atlantic herring.

No Global Positioning System (GPS) data were recorded with the acoustic data, so latitudes and longitudes were imported to the Echoview EV files. GPS data were collected as part of the vessels Scientific Computer System (SCS). These data were imported and synchronized with the acoustic data via time stamps for each transmission and GPS coordinate with Echoview's GPS import function.

2007 – *Henry B. Bigelow*

Acquisition

Table 10 provides data acquisition parameters and settings. The EK60 echo sounder was not calibrated for this survey. Gain and parameter settings for all frequencies were set from a calibration done during the initial sea trials done earlier in the year.

Postprocessing

Noise spikes were absent, so no "de-spike" algorithm was applied. The data were collected without any transducer depth offset, so the "bubble layer" line was set to 4 m, which accounted for a 6-m transducer depth and gave a total layer depth of 10 m.

A threshold of -66 dB was applied to the S_v data and a 3x3 kernel was applied by convolution to smooth the data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1. The 18-, 38-, and 120-kHz S_v data were analyzed as in Jech and Michaels (2006) ("presence/absence" method). Briefly, the 18-, 38-, and 120-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 38-kHz S_v data where the 18-, 38-, and 120-kHz echograms had values greater than -66 dB (Figure 10). The "fish" echogram was visually scrutinized for Atlantic herring. The 200-kHz Sv data were not used for analysis.

2008 – *Albatross IV*

Acquisition

Table 11 provides data acquisition parameters and settings. The EK60 echo sounder was calibrated for this survey, and gain and parameter settings were set from this calibration. The calibration confirmed that the 120-kHz data were "bad" (i.e., the data values were low, and there was overwhelming noise), and they were not postprocessed or used for analysis.

Postprocessing

The noise spikes were absent, so no "de-spike" algorithm was applied.

Because the 120-kHz data were unusable, a modified version of the Jech and Michaels (2006) method was applied to the 18- and 38-kHz S_v data ("modified presence/absence" method). A threshold of -66 dB was applied to the 18- and 38-kHz S_v data. The EK60 digitally samples the acoustic signal based on the transmit pulse duration, and the range (i.e., vertical) resolution is different when different pulse durations are used. Because the pulse durations were different for the 18- and 38-kHz S_v data (Table 11), in order to analyze the data, the vertical resolution was set equivalent between the 18- and 38-kHz S_v data. This was done by computing the unweighted mean S_v for each transmission, where the averaging was done in the linear domain, for each 1-m vertical interval. A 3x3 kernel was applied by convolution to smooth the 1-m vertical resolution S_v data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1.

The 18- and 38-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 1-m vertical resolution 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 1-m vertical resolution 38-kHz S_v data where both the 18- and 38-kHz echograms had values greater than -66 dB (Figure 11). The "fish" echogram was visually scrutinized for Atlantic herring.

2008 – *Henry B. Bigelow*

Acquisition

Table 12 provides data acquisition parameters and settings. The EK60 echo sounder was calibrated immediately prior to this survey. Gain and parameter settings for all frequencies were set from this calibration.

Postprocessing

Noise spikes were absent, so no "de-spike" algorithm was applied. The data were collected without any transducer depth offset, so the "bubble layer" line was set to 4 m, which accounted for a 6-m transducer depth and gave a total layer depth of 10 m.

A threshold of -66 dB was applied to the S_v data, and a 3x3 kernel was applied by convolution to smooth the data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1. The 18-, 38-, and 120-kHz S_v data were analyzed as in Jech and Michaels (2006) ("presence/absence" method). Briefly, the 18-, 38-, and 120-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 38-kHz S_v data where the 18-, 38-, and 120-kHz echograms had values greater than -66 dB (Figure 12). The "fish" echogram was visually scrutinized for Atlantic herring. The 200-kHz Sv data were not used for analysis.

2009 – *Henry B. Bigelow*

Acquisition

Table 13 provides data acquisition parameters and settings. The EK60 echo sounder was calibrated immediately prior to this survey. Gain and parameter settings for all frequencies were set from this calibration.

Postprocessing

Noise spikes were absent, so no "de-spike" algorithm was applied. The data were collected without any transducer depth offset, so a 6-m transducer offset was incorporated into the S_v echograms, and the "bubble layer" line was set to 10 m.

A threshold of -66 dB was applied to the S_v data, and a 3x3 kernel was applied by convolution to smooth the data. The kernel values summed to 1, with the center value equal to

0.2 and the surrounding values equal to 0.1. The 18-, 38-, and 120-kHz S_v data were analyzed as in Jech and Michaels (2006) ("presence/absence" method). Briefly, the 18-, 38-, and 120-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 38-kHz S_v data where the 18-, 38-, and 120-kHz echograms had values greater than -66 dB (Figure 13). The "fish" echogram was visually scrutinized for Atlantic herring. The 70- and 200-kHz Sv data were not used for analysis.

2010 – *Henry B. Bigelow*

Data during 2010 were only collected to 50 m, rendering them unusable for analysis.

2011 – *Henry B. Bigelow*

Acquisition

Table 14 provides data acquisition parameters and settings. The EK60 echo sounder was calibrated immediately prior to this survey. Gain and parameter settings for all frequencies were set from this calibration.

Postprocessing

Noise spikes were absent, so no "de-spike" algorithm was applied. The data were collected without any transducer depth offset, so a 6-m transducer offset was incorporated into the S_v echograms, and the "bubble layer" line was set to 10 m.

A threshold of -66 dB was applied to the S_v data and a 3x3 kernel was applied by convolution to smooth the data. The kernel values summed to 1, with the center value equal to 0.2 and the surrounding values equal to 0.1. The 18-, 38-, and 120-kHz S_v data were analyzed as in Jech and Michaels (2006) ("presence/absence" method). Briefly, the 18-, 38-, and 120-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 38-kHz S_v data where the 18-, 38-, and 120-kHz echograms had values greater than -66 dB (Figure 14). The "fish" echogram was visually scrutinized for Atlantic herring. The 70- and 200-kHz Sv data were not used for analysis.

2012 – *Henry B. Bigelow*

Acquisition

Table 15 provides data acquisition parameters and settings. The EK60 echo sounder was calibrated immediately prior to this survey. Gain and parameter settings for all frequencies were set from this calibration.

Postprocessing

Noise spikes were absent, so no "de-spike" algorithm was applied. The data were collected without any transducer depth offset, so a 6-m transducer offset was incorporated into the S_v echograms, and the "bubble layer" line was set to 10 m.

A threshold of -66 dB was applied to the S_v data, and a 3x3 kernel was applied by convolution to smooth the data. The kernel values summed to 1, with the center value equal to

0.2 and the surrounding values equal to 0.1. The 18-, 38-, and 120-kHz S_v data were analyzed as in Jech and Michaels (2006) ("presence/absence" method). Briefly, the 18-, 38-, and 120-kHz echograms were compared where identically-located pixels between each echogram that had S_v values greater than -66 dB were highlighted. The locations of these highlighted pixels were applied to the 38-kHz S_v data to generate the fish echogram. In other words, the "fish" echogram was the 38-kHz S_v data where the 18-, 38-, and 120-kHz echograms had values greater than -66 dB (Figure 15). The "fish" echogram was visually scrutinized for Atlantic herring. The 70- and 200-kHz Sv data were not used for analysis.

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Table 1. Data acquisition parameters and settings for acoustic data collected during the 1998 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "Transducer Depth" is the depth of the transducer from the sea surface. "Absorption" is the acoustic attenuation coefficient. "Pulse Length" is the pulse duration setting for the EK500, and τ is the pulse duration. "Bandwidth" is the receiver bandwidth setting. "Max. Power" is the maximum transmit power. "Two-way Beam Angle" is the two-way equivalent beam. "Sv Gain" and "TS Gain" are the gain settings. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data in the pelagic and bottom echograms.

Vessel Code	AL199811 (AL-98-11)	
NEFSC Survey Code	199804 (9804)	
Begin Date	20 October 1998	
End Date	10 November 1998	
Simrad Echo Sounder	EK500	
	38 kHz	**120 kHz**
Transducer Type	ES38-12	ES120
Transducer Depth (m)	3.5	3.5
Absorption (dB km^{-1})	10	38
Pulse Length: τ (ms)	Medium: 1	Long: 1
Bandwidth	Auto	Auto
Max. Power (W)	1000	1000
Two-way Beam Angle (dB)	-15.8	-20.7
S_v Gain	21.5	26.5
TS Gain	23.9	21.0
Sensitivity Alongship	12.5	21.0
Sensitivity Athwartship	12.5	21.0
Beam width Alongship	11.7	7.3
Beam width Athwartship	11.7	7.3
Alongship Offset	-0.07	-0.05
Athwartship Offset	-0.24	-0.26
Ping Interval (sec)	2	2
Vertical resolution – pelagic (m)	0.5	0.5
Vertical resolution – bottom (m)	0.1	0.1

Table 2. Data acquisition parameters and settings for acoustic data collected during the 1999 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "Transducer Depth" is the depth of the transducer from the sea surface. "Absorption" is the acoustic attenuation coefficient. "Pulse Length" is the pulse duration setting for the EK500, and τ is the pulse duration. "Bandwidth" is the receiver bandwidth setting. "Max. Power" is the maximum transmit power. "Two-way Beam Angle" is the two-way equivalent beam. "Sv Gain" and "TS Gain" are the gain settings. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data in the pelagic and bottom echograms.

Vessel Code	AL199911 (AL-99-11)	
NEFSC Survey Code	199908 (9908)	
Begin Date	7 September 1999	
End Date	10 November 1999	
Simrad Echo Sounder	EK500	
	38 kHz	**120 kHz**
Transducer Type	ES38-12	ES120
Transducer Depth (m)	4.86	4.86
Absorption (dB km^{-1})	10	38
Pulse Length: τ (ms)	Medium: 1	Long: 1
Bandwidth	Auto	Auto
Max. Power (W)	1000	1000
Two-way Beam Angle (dB)	-15.8	-20.7
S_v Gain	21.5	26.5
TS Gain	23.9	21.0
Sensitivity Alongship	12.5	21.0
Sensitivity Athwartship	12.5	21.0
Beam width Alongship	11.7	7.3
Beam width Athwartship	11.7	7.3
Alongship Offset	-0.07	-0.05
Athwartship Offset	-0.24	-0.26
Ping Interval (sec)	2	2
Vertical resolution – pelagic (m)	0.5	0.5
Vertical resolution – bottom (m)	0.1	0.1

Table 3. Data acquisition parameters and settings for acoustic data collected during the 2000 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "Transducer Depth" is the depth of the transducer from the sea surface. "Absorption" is the acoustic attenuation coefficient. "Pulse Length" is the pulse duration setting for the EK500, and τ is the pulse duration. "Bandwidth" is the receiver bandwidth setting. "Max. Power" is the maximum transmit power. "Two-way Beam Angle" is the two-way equivalent beam. "Sv Gain" and "TS Gain" are the gain settings. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data in the pelagic and bottom echograms.

Vessel Code	AL200006 (AL-00-06)	
NEFSC Survey Code	200005 (0005)	
Begin Date	18 September 2000	
End Date	21 October 2000	
Simrad Echo Sounder	EK500	
	38 kHz	**120 kHz**
Transducer Type	ES38-12	ES120
Transducer Depth (m)	4.86	4.86
Absorption (dB km^{-1})	10	38
Pulse Length: τ (ms)	Medium: 1	Long: 1
Bandwidth	Auto	Auto
Max. Power (W)	1000	1000
Two-way Beam Angle (dB)	-15.8	-20.7
S_v Gain	21.5	26.5
TS Gain	23.9	21.0
Sensitivity Alongship	12.5	21.0
Sensitivity Athwartship	12.5	21.0
Beam width Alongship	11.7	7.3
Beam width Athwartship	11.7	7.3
Alongship Offset	-0.07	-0.05
Athwartship Offset	-0.24	-0.26
Ping Interval (sec)	2	2
Vertical resolution – pelagic (m)	0.5	0.5
Vertical resolution – bottom (m)	0.1	0.1

Table 4. Data acquisition parameters and settings for acoustic data collected during the 2001 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "Transducer Depth" is the depth of the transducer from the sea surface. "Absorption" is the acoustic attenuation coefficient. "Pulse Length" is the pulse duration setting for the EK500, and τ is the pulse duration. "Bandwidth" is the receiver bandwidth setting. "Max. Power" is the maximum transmit power. "Two-way Beam Angle" is the two-way equivalent beam. "Sv Gain" and "TS Gain" are the gain settings. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data in the pelagic and bottom echograms.

Vessel Code	AL200110 (AL-01-10)	
NEFSC Survey Code	200109 (0109)	
Begin Date	17 September 2001	
End Date	23 October 2001	
Simrad Echo Sounder	EK500	
	38 kHz	**120 kHz**
Transducer Type	ES38-12	ES120
Transducer Depth (m)	4.86	4.86
Absorption (dB km^{-1})	10	38
Pulse Length: τ (ms)	Medium: 1	Long: 1
Bandwidth	Auto	Auto
Max. Power (W)	1000	1000
Two-way Beam Angle (dB)	-15.8	-20.7
S_v Gain	24.0	24.4
TS Gain	23.9	24.5
Sensitivity Alongship	12.5	21.0
Sensitivity Athwartship	12.5	21.0
Beam width Alongship	11.7	7.3
Beam width Athwartship	11.7	7.3
Alongship Offset	0.00	0.00
Athwartship Offset	0.00	0.00
Ping Interval (sec)	2	2
Vertical resolution – pelagic (m)	1.0	1.0
Vertical resolution – bottom (m)	0.1	0.1

Table 5. Data acquisition parameters and settings for acoustic data collected during the 2002 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "Transducer Depth" is the depth of the transducer from the sea surface. "Absorption" is the acoustic attenuation coefficient. "Pulse Length" is the pulse duration setting for the EK500, and τ is the pulse duration. "Bandwidth" is the receiver bandwidth setting. "Max. Power" is the maximum transmit power. "Two-way Beam Angle" is the two-way integrated beam angle. "Two-way Beam Angle" is the two-way equivalent beam. "Sv Gain" and "TS Gain" are the gain settings. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data in the pelagic and bottom echograms.

Vessel Code	AL200210 (AL-02-10)	
NEFSC Survey Code	200209 (0209)	
Begin Date	1 October 2002	
End Date	25 October 2002	
Simrad Echo Sounder	EK500	
	38 kHz	**120 kHz**
Transducer Type	ES38-12	ES120
Transducer Depth (m)	4.86	4.86
Absorption (dB km^{-1})	10	38
Pulse Length: τ (ms)	Medium: 1	Long: 1
Bandwidth	Auto	Auto
Max. Power (W)	1000	1000
Two-way Beam Angle (dB)	-15.8	-20.7
S_v Gain	24.0	24.4
TS Gain	23.9	24.5
Sensitivity Alongship	12.5	21.0
Sensitivity Athwartship	12.5	21.0
Beam width Alongship	11.7	7.3
Beam width Athwartship	11.7	7.3
Alongship Offset	0.00	0.00
Athwartship Offset	0.00	0.00
Ping Interval (sec)	2	2
Vertical resolution – pelagic (m)	1.0	1.0
Vertical resolution – bottom (m)	0.1	0.1

Table 6. Data acquisition parameters and settings for acoustic data collected during the 2003 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data.

Vessel Code	AL200305 (AL-03-05)		
NEFSC Survey Code	200306 (0306)		
Begin Date	20 September 2003		
End Date	1 November 2003		
Simrad Echo Sounder	EK60		
	18 kHz	**38 kHz**	**120 kHz**
Transducer Type	ES18-11	ES38-12	ES120-7
Transducer Depth (m)	4.86	4.86	4.86
Absorption (dB km^{-1})	2	7.8	38.6
Pulse Duration τ (ms)	2.048	1.024	0.256
Bandwidth (kHz)	1.19	2.43	8.7
Max. Power (W)	2000	1000	1000
Two-way Beam Angle (dB)	-17.0	-15.8	-20.7
Gain	22.9	22.21	25.1
Sa Correction	0.0	-0.46	-0.1
Sensitivity Alongship	13.9	12.5	21.0
Sensitivity Athwartship	13.9	12.5	21.0
Beam width Alongship	11.0	12.4	7.3
Beam width Athwartship	11.0	12.6	7.2
Alongship Offset	0.0	0.00	0.00
Athwartship Offset	0.0	0.00	0.00
Ping Interval (sec)	2	2	2
Vertical resolution – (m)	0.384	0.192	0.048

Table 7. Data acquisition parameters and settings for acoustic data collected during the 2004 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data.

Vessel Code	AL200409 (AL-04-09)		
NEFSC Survey Code	200407 (0407)		
Begin Date	20 September 2004		
End Date	28 October 2004		
Simrad Echo Sounder	EK60		
	18 kHz	**38 kHz**	**120 kHz**
Transducer Type	ES18-11	ES38-12	ES120-7
Transducer Depth (m)	6.2	6.2	6.2
Absorption (dB km^{-1})	2	9.8	37.3
Pulse Duration τ (ms)	2.048	1.024	0.256
Bandwidth (kHz)	1.19	2.43	8.71
Max. Power (W)	2000	1000	1000
Two-way Beam Angle (dB)	-17.0	-15.5	-20.8
Gain	22.9	22.2	25.1
Sa Correction	0.0	-0.63	0.0
Sensitivity Alongship	13.9	12.5	21.0
Sensitivity Athwartship	13.9	12.5	21.0
Beam width Alongship	11.0	12.0	7.1
Beam width Athwartship	11.0	12.0	7.1
Alongship Offset	0.0	0.00	0.00
Athwartship Offset	0.0	0.00	0.00
Ping Interval (sec)	2	2	2
Vertical resolution – (m)	0.384	0.192	0.048

Table 8. Data acquisition parameters and settings for acoustic data collected during the 2005 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data.

Vessel Code	AL200508 (AL-05-08)		
NEFSC Survey Code	200510 (0510)		
Begin Date	3 October 2005		
End Date	5 November 2005		
Simrad Echo Sounder	EK60		
	18 kHz	**38 kHz**	**120 kHz**
Transducer Type	ES18-11	ES38-12	ES120-7
Transducer Depth (m)	6.2	6.2	6.2
Absorption (dB km^{-1})	2.6	9.8	37.3
Pulse Duration τ (ms)	2.048	1.024	1.024
Bandwidth (kHz)	1.19	2.43	3.03
Max. Power (W)	2000	1000	1000
Two-way Beam Angle (dB)	-17.0	-15.5	-20.8
Gain	22.9	22.2	25.7
Sa Correction	0.0	-0.63	0.0
Sensitivity Alongship	13.9	12.5	21.0
Sensitivity Athwartship	13.9	12.5	21.0
Beam width Alongship	11.0	12.0	7.1
Beam width Athwartship	11.0	12.0	7.1
Alongship Offset	0.0	0.00	0.00
Athwartship Offset	0.0	0.00	0.00
Ping Interval (sec)	2	2	2
Vertical resolution – (m)	0.384	0.192	0.192

Table 9. Data acquisition parameters and settings for acoustic data collected during the 2007 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data.

Vessel Code	AL200707 (AL-07-07)	
NEFSC Survey Code	200709 (0709)	
Begin Date	15 October 2007	
End Date	6 November 2007	
Simrad Echo Sounder	EK60	
	18 kHz	**38 kHz**
Transducer Type	ES18-11	ES38-12
Transducer Depth (m)	6.2	6.2
Absorption (dB km^{-1})	2.7	9.8
Pulse Duration τ (ms)	2.048	1.024
Bandwidth (kHz)	1.19	2.43
Max. Power (W)	2000	1000
Two-way Beam Angle (dB)	-17.0	-15.5
Gain	23.43	22.2
Sa Correction	-0.46	-0.63
Sensitivity Alongship	13.9	12.5
Sensitivity Athwartship	13.9	12.5
Beam width Alongship	10.85	12.0
Beam width Athwartship	10.92	12.0
Alongship Offset	-0.01	0.05
Athwartship Offset	0.0	0.01
Ping Interval (sec)	1	1
Vertical resolution – (m)	0.384	0.192

Table 10. Data acquisition parameters and settings for acoustic data collected during the 2007 fall bottom trawl survey on the NOAA Ship *Henry B Bigelow*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data.

Vessel Code	HB200711 (HB-07-11)			
NEFSC Survey Code	200711 (0711)			
Begin Date	6 November 2007			
End Date	16 November 2007			
Simrad Echo Sounder	EK60			
	18 kHz	**38 kHz**	**120 kHz**	**200 kHz**
Transducer Type	ES18-11	ES38B	ES120-7C	ES200-7C
Transducer Depth (m)	0.0	0.0	0.0	0.0
Absorption (dB km^{-1})	1.7	6.5	45.2	81.2
Pulse Duration τ (ms)	1.024	1.024	1.024	1.024
Bandwidth (kHz)	1.57	2.43	3.03	3.09
Max. Power (W)	2000	2000	500	120
Two-way Beam Angle (dB)	-17.3	-20.8	-20.9	-20.8
Gain	23.09	23.98	26.47	26.54
Sa Correction	-0.64	-0.65	-0.41	-0.55
Sensitivity Alongship	13.9	21.9	23.0	23.0
Sensitivity Athwartship	13.9	21.9	23.0	23.0
Beam width Alongship	10.2	7.04	6.9	6.9
Beam width Athwartship	10.5	7.05	6.9	7.0
Alongship Offset	0.0	0.06	0.00	0.00
Athwartship Offset	0.0	-0.01	0.00	0.00
Ping Interval (sec)	1	1	1	1
Vertical resolution – (m)	0.192	0.192	0.192	0.192

Table 11. Data acquisition parameters and settings for acoustic data collected during the 2008 fall bottom trawl survey on the NOAA Ship *Albatross IV*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End Date" are the beginning and ending dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "Transducer Depth" is the depth of the transducer from the water line. "Absorption" is the attenuation coefficient. "Pulse Duration" is the pulse duration (τ) in ms. "Bandwidth" is the receiver bandwidth in kHz. "Max. Power" is the maximum transmit power. "Two-way Beam Angle" is the two-way equivalent beam. "Gain" is the gain setting and "Sa Correction" is the Sa correction 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 a parameter for converting electrical to mechanical angles. "Beam width" is the total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data.

Vessel Code	AL200803 (AL-08-03)	
NEFSC Survey Code	200807 (0807)	
Begin Date	6 October 2008	
End Date	31 October 2008	
Simrad Echo Sounder	EK60	
	18 kHz	**38 kHz**
Transducer Type	ES18-11	ES38-12
Transducer Depth (m)	6.2	6.2
Absorption (dB km^{-1})	2.7	9.8
Pulse Duration τ (ms)	2.048	1.024
Bandwidth (kHz)	1.19	2.43
Max. Power (W)	2000	1000
Two-way Beam Angle (dB)	-17.0	-15.5
Gain	22.9	21.03
Sa Correction	0.0	-0.63
Sensitivity Alongship	13.9	12.5
Sensitivity Athwartship	13.9	12.5
Beam width Alongship	11.0	12.0
Beam width Athwartship	11.0	12.0
Alongship Offset	0.0	0.0
Athwartship Offset	0.0	0.0
Ping Interval (sec)	1	1
Vertical resolution – (m)	0.384	0.192

Table 12. Data acquisition parameters and settings for acoustic data collected during the 2008 fall bottom trawl survey on the NOAA Ship *Henry B Bigelow*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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 Resolution" is the vertical resolution of the volume backscatter (S_v) data.

Vessel Code	HB200807 (HB-08-07)			
NEFSC Survey Code	200812 (0812)			
Begin Date	7 October 2008			
End Date	14 November 2008			
Simrad Echo Sounder	EK60			
	18 kHz	**38 kHz**	**120 kHz**	**200 kHz**
Transducer Type	ES18-11	ES38B	ES120-7C	ES200-7C
Transducer Depth (m)	0.0	0.0	0.0	0.0
Absorption (dB km^{-1})	1.9	7.3	43.5	70.6
Pulse Duration τ (ms)	1.024	1.024	1.024	1.024
Bandwidth (kHz)	1.57	2.43	3.03	3.09
Max. Power (W)	2000	1000	500	300
Two-way Beam Angle (dB)	-17.3	-20.8	-20.9	-20.8
Gain	22.90	23.93	25.95	26.32
Sa Correction	-0.73	-0.65	-0.34	-0.54
Sensitivity Alongship	13.9	21.9	23.0	23.0
Sensitivity Athwartship	13.9	21.9	23.0	23.0
Beam width Alongship	10.5	7.04	6.43	6.26
Beam width Athwartship	10.2	7.05	6.75	6.23
Alongship Offset	-0.08	0.06	-0.13	-0.09
Athwartship Offset	0.13	-0.01	0.00	-0.12
Ping Interval (sec)	1	1	1	1
Vertical Resolution – (m)	0.192	0.192	0.192	0.192

Table 13. Data acquisition parameters and settings for acoustic data collected during the 2009 fall bottom trawl survey on the NOAA Ship *Henry B Bigelow*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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.

Vessel Code	HB200905 (HB-09-05)				
NEFSC Survey Code	200904 (0904)				
Begin Date	28 September 2009				
End Date	19 November 2009				
Simrad Echo Sounder	EK60				
	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})	2.3	8.7	21.5	37.8	54.6
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)	2000	1000	1000	500	300
Two-way Beam (dB)	-17.3	-20.8	-20.9	-20.9	-20.8
Gain	22.82	24.07	26.71	26.03	26.6
Sa Correction	-0.75	-0.66	-0.35	-0.34	-0.42
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)	2	2	2	2	2
Vertical Res. – (m)	0.192	0.192	0.192	0.192	0.192

Table 14. Data acquisition parameters and settings for acoustic data collected during the 2011 fall bottom trawl survey on the NOAA Ship *Henry B Bigelow*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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.

Vessel Code	HB201105 (HB-11-05)				
NEFSC Survey Code	201104 (1104)				
Begin Date	7 October 2011				
End Date	11 November 2011				
Simrad Echo Sounder	EK60				
	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})	2.5	9.1	21.5	35.9	51.1
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	23.01	24.2	26.00	26.29	26.48
Sa Correction	-0.62	-0.70	-0.34	-0.47	-0.60
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

Table 15. Data acquisition parameters and settings for acoustic data collected during the 2012 fall bottom trawl survey on the NOAA Ship *Henry B Bigelow*. "Vessel Code" is the cruise code for the vessel, which combines the vessel code, year, and the sequential cruise number for that year. "NEFSC Survey Code" is the code used to reference the trawl data in the Northeast Fisheries Science Center (NEFSC) database. "Begin Date" and "End date" are the begin and end dates for when the acoustic data were collected and do not necessarily correspond to the full extent of the bottom trawl survey. "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 Angle" is the two-way equivalent beam. "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 total 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.

Vessel Code	HB201206 (HB-12-06)				
NEFSC Survey Code	201204 (1204)				
Begin Date	24 September 2012				
End Date	11 November 2012				
Simrad Echo Sounder	EK60				
	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

Table 16. Summary of postprocessing methods and calibration gain settings for the NOAA Ship *Albatross IV* (AL IV) and NOAA Ship *Henry B Bigelow* (HB). Spike removal and time synchronization are described in the text. Classification methods are: Method 1 is “dB-differencing” between the 38 and 120 kHz Sv data; Method 2 is visual inspection only; Method 3 is a modified method from Jech and Michaels (2006) (“modified presence/absence”); and Method 4 is the method from Jech and Michaels (2006) (“presence/absence”).

Year	**Vessel**	**Echo Sounder**	**Spike Removal**	**Time Sync**	**Classification**	**Frequencies (kHz)**	**Notes**	**38-kHz Sv gain (dB)**
1998	AL IV	EK500	Yes	±300 sec	Method 1	38, 120		21.5
1999	AL IV	EK500	Yes	±300 sec	Method 1	38, 120		21.5
2000	AL IV	EK500	Yes	±300 sec	Method 1	38, 120		21.5
2001	AL IV	EK500	None	±300 sec	Method 1	38, 120		24.0
2002	AL IV	EK500	None	None	Method 2	38		24.0
2003	AL IV	EK60	Yes	None	Method 3	18, 38		22.2
2004	AL IV	EK60	None	None	Method 3	18, 38		22.2
2005	AL IV	EK60	None	None	Method 3	18, 38		22.2
2006	AL IV	EK60	---	---	---	---	No data	
2007	AL IV	EK60	None	None	Method 3	18, 38		22.2
2007	HB	EK60	None	None	Method 4	18, 38, 120, 200		24.0
2008	AL IV	EK60	None	None	Method 3	18, 38		22.9
2008	HB	EK60	None	None	Method 4	18, 38, 120, 200		23.9
2009	HB	EK60	None	None	Method 4	18, 38, 70, 120, 200		24.1
2010	HB	EK60	---	---	---	18, 38, 70, 120, 200	Data collected to 50 m	
2011	HB	EK60	None	None	Method 4	18, 38, 70, 120, 200		24.2
2012	HB	EK60	None	None	Method 4	18, 38, 70, 120, 200		24.1

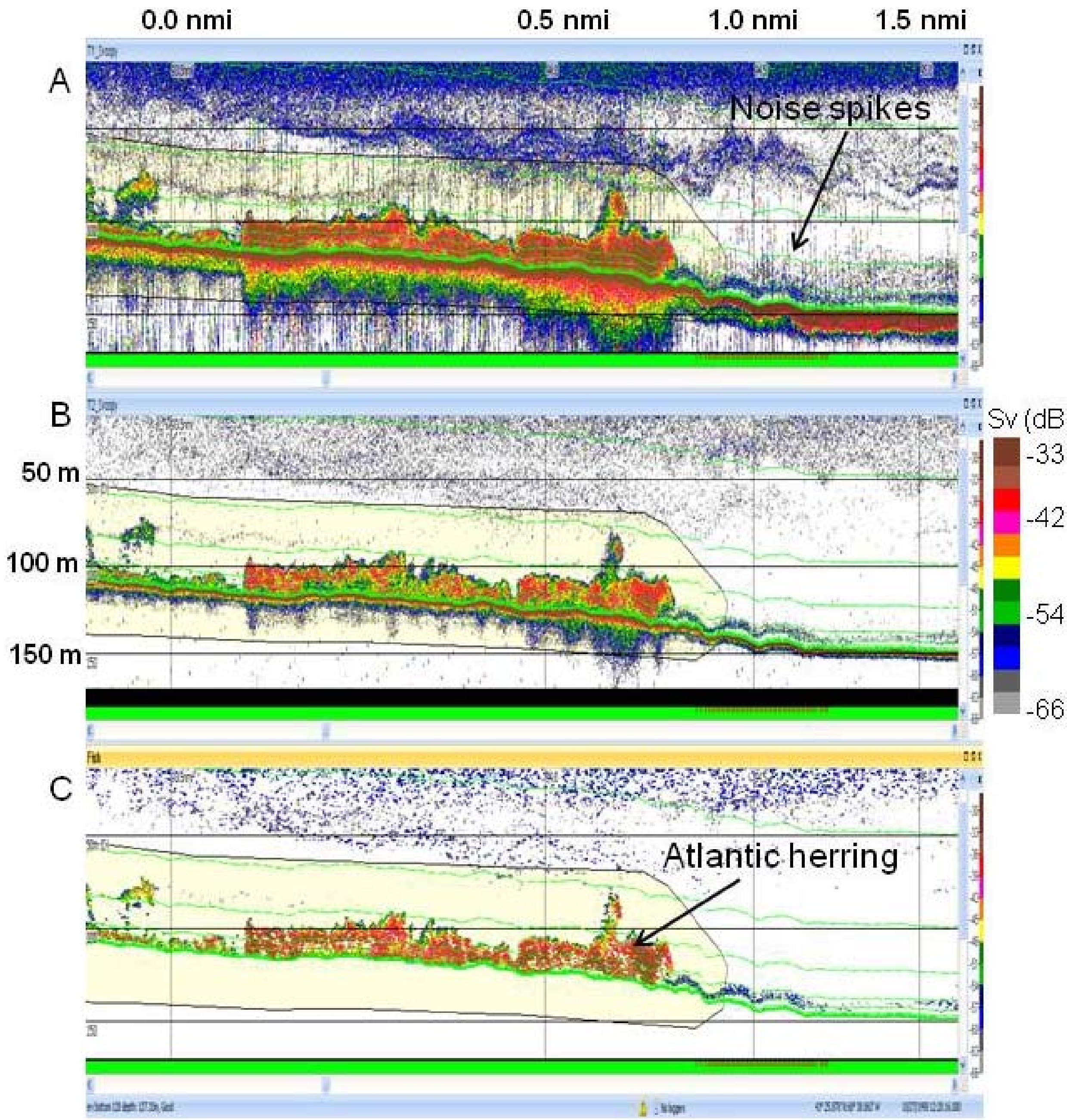

Figure 1. Volume backscatter (S_v) echograms at 38 kHz (A), 120 kHz (B), and "fish" (C) on 27 October 1998, 1200 GMT from the NOAA Ship *Albatross IV*. The large object is an aggregation of Atlantic herring (*Clupea harengus*). Noise spikes are evident in the 38-kHz echogram. The fish echogram (C) is derived from echograms (A) and (B) via the dB-differencing method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

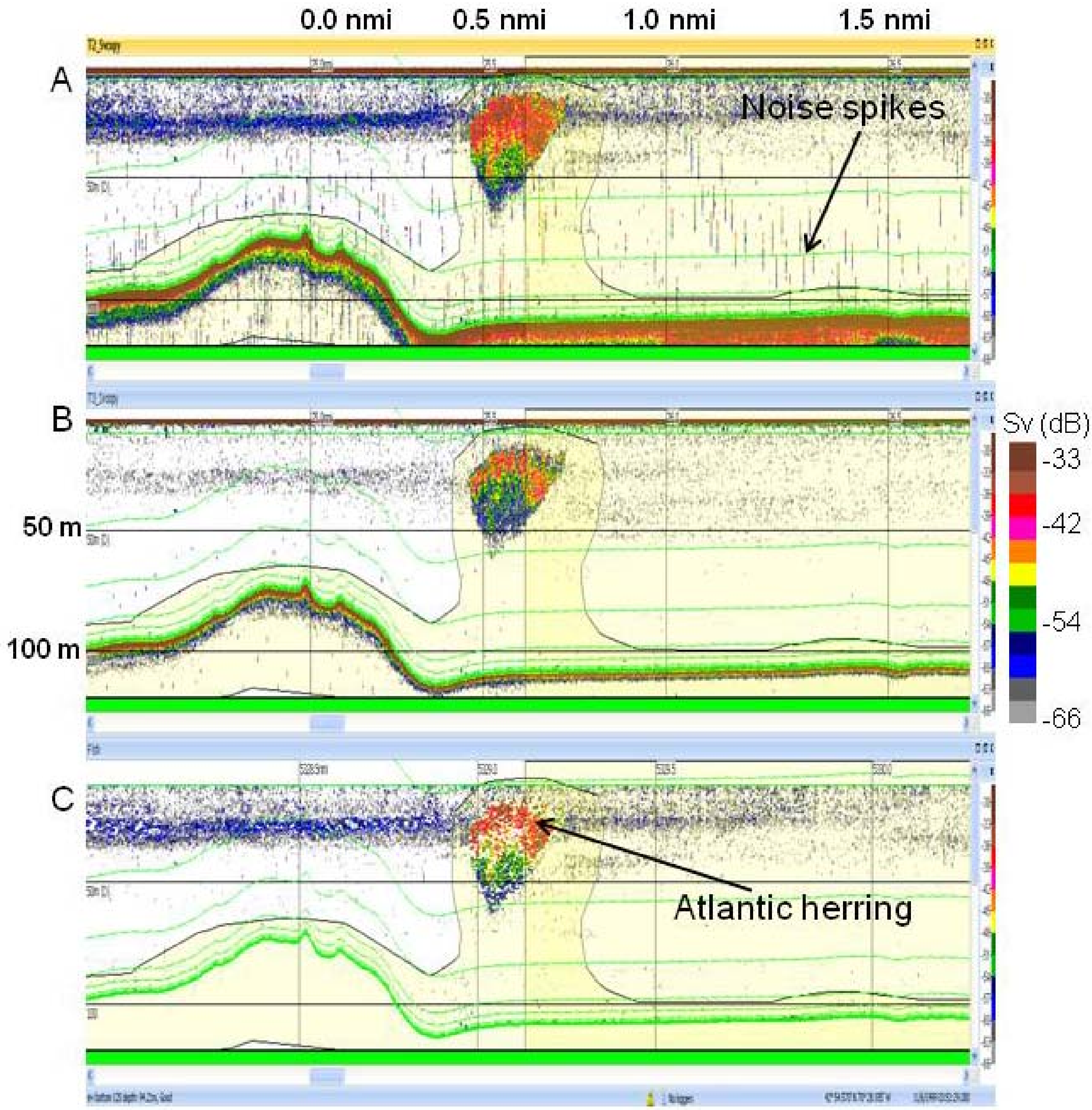

Figure 2. Volume backscatter (S_v) echograms at 38 kHz (A), 120 kHz (B), and "fish" (C) on 6 November 1999, 0400 GMT from the NOAA Ship *Albatross IV*. The large object is an aggregation of Atlantic herring (*Clupea harengus*). Noise spikes are evident in the 38-kHz echogram. The fish echogram (C) is derived from echograms (A) and (B) via the dB-differencing method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

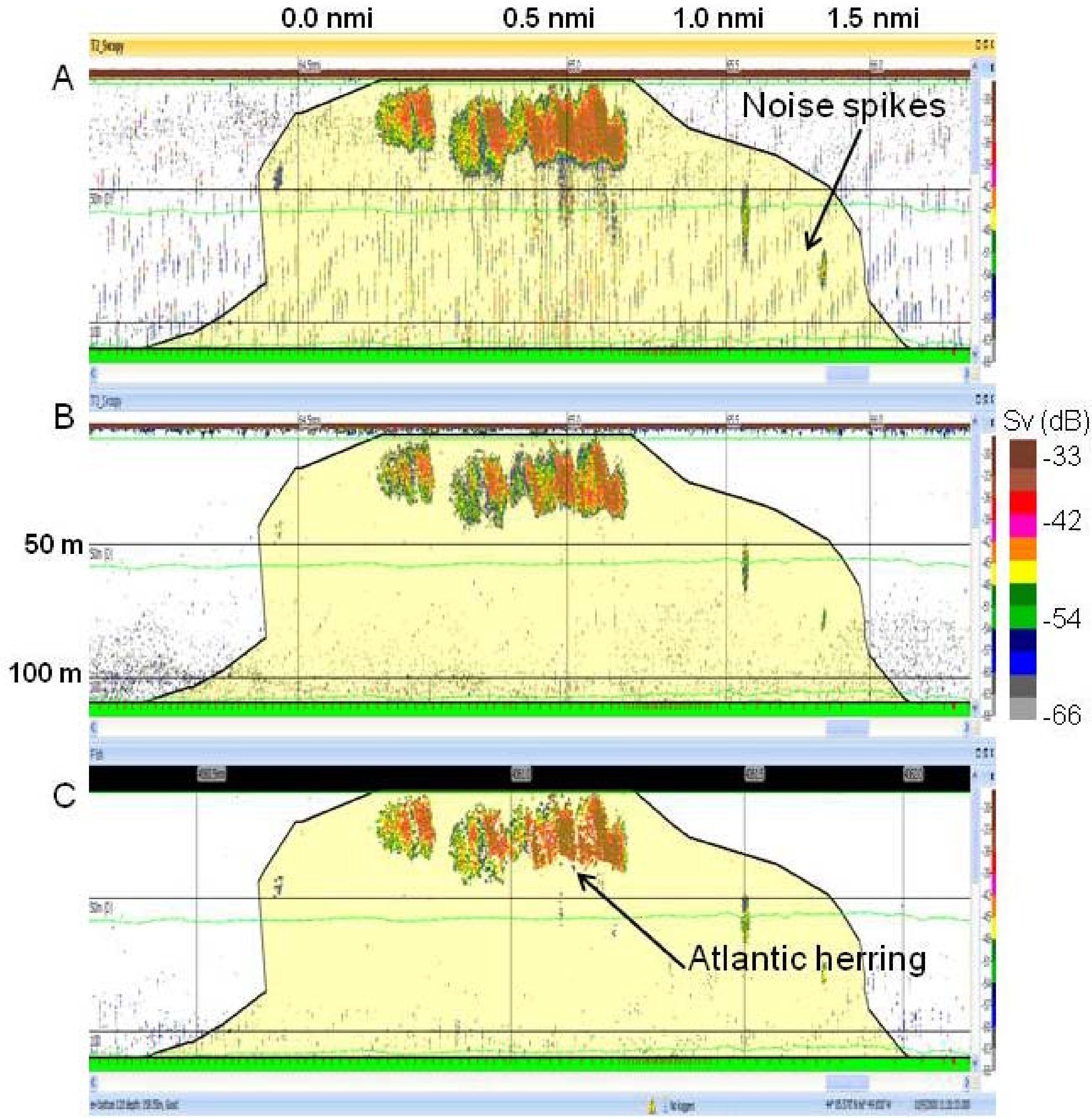

Figure 3. Volume backscatter (S_v) echograms at 38 kHz (A), 120 kHz (B), and "fish" (C) on 9 October 2000, 1130 GMT from the NOAA Ship *Albatross IV*. The large object is an aggregation of Atlantic herring (*Clupea harengus*). Noise spikes are evident in the 38-kHz echogram. The fish echogram (C) is derived from echograms (A) and (B) via the dB-differencing method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

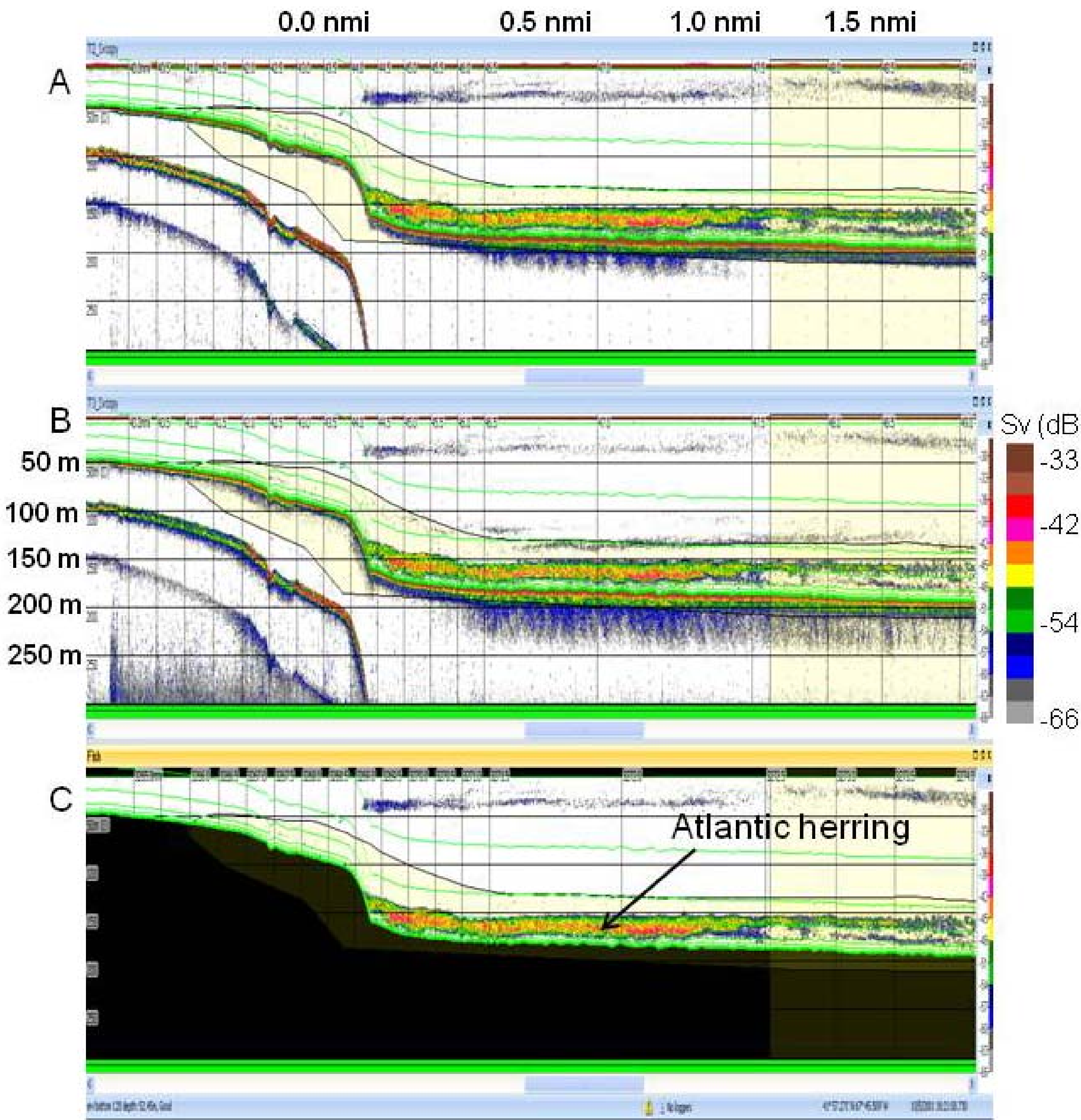

Figure 4. Volume backscatter (S_v) echograms at 38 kHz (A), 120 kHz (B), and "fish" (C) on 6 October 2001, 0030 GMT from the NOAA Ship *Albatross IV*. The large object is an aggregation of Atlantic herring (*Clupea harengus*). The fish echogram (C) is derived from echograms (A) and (B) via the dB-differencing method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

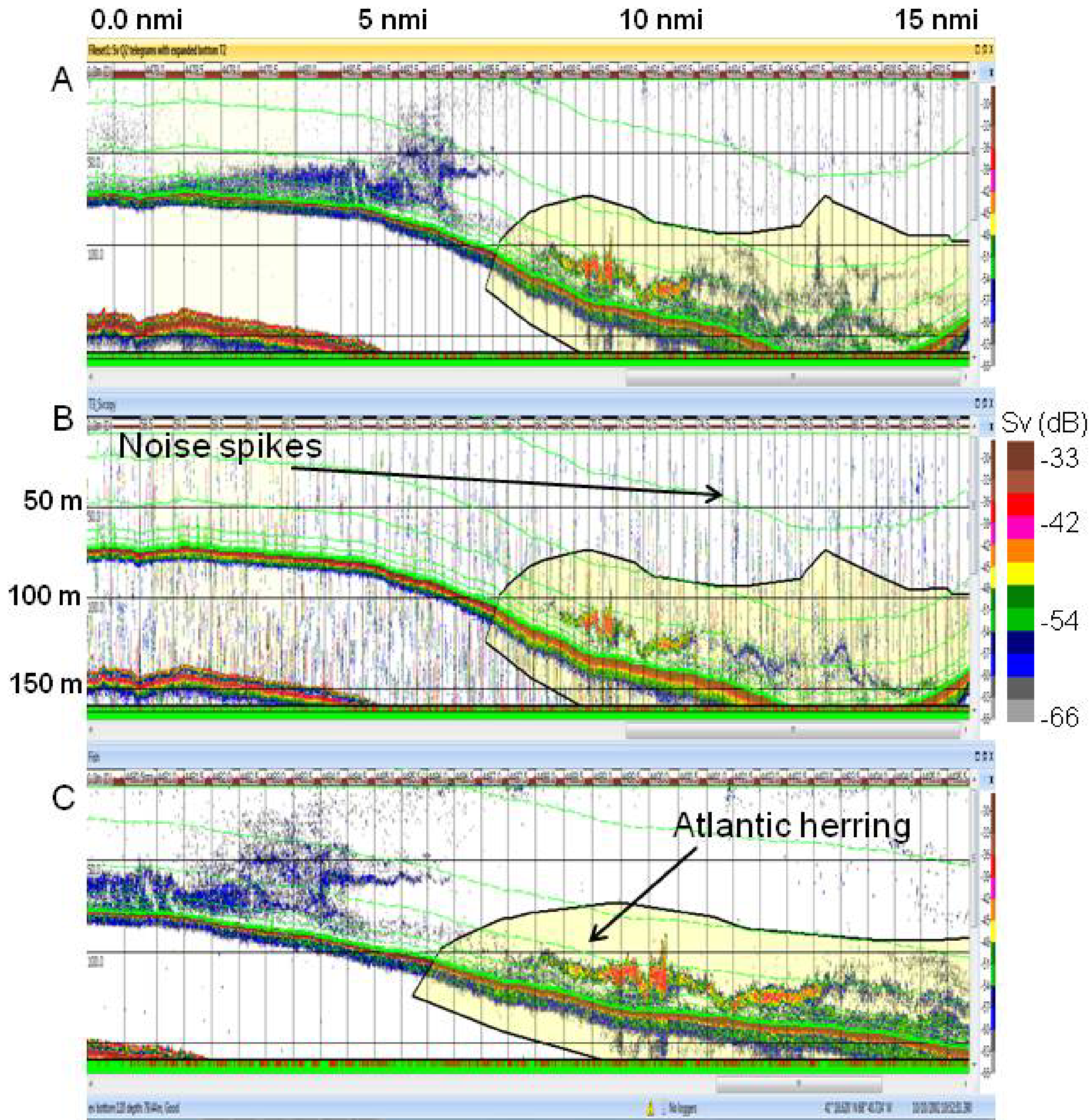

Figure 5. Volume backscatter (S_v) echograms at 38 kHz (A), 120 kHz (B), and fish (C) on 10 October 2002, 1100 GMT from the NOAA Ship *Albatross IV*. The large object is an aggregation of Atlantic herring (*Clupea harengus*). Noise spikes are dominant in the 120-kHz echogram. The fish echogram (C) is derived from the 38-kHz echogram (A). The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

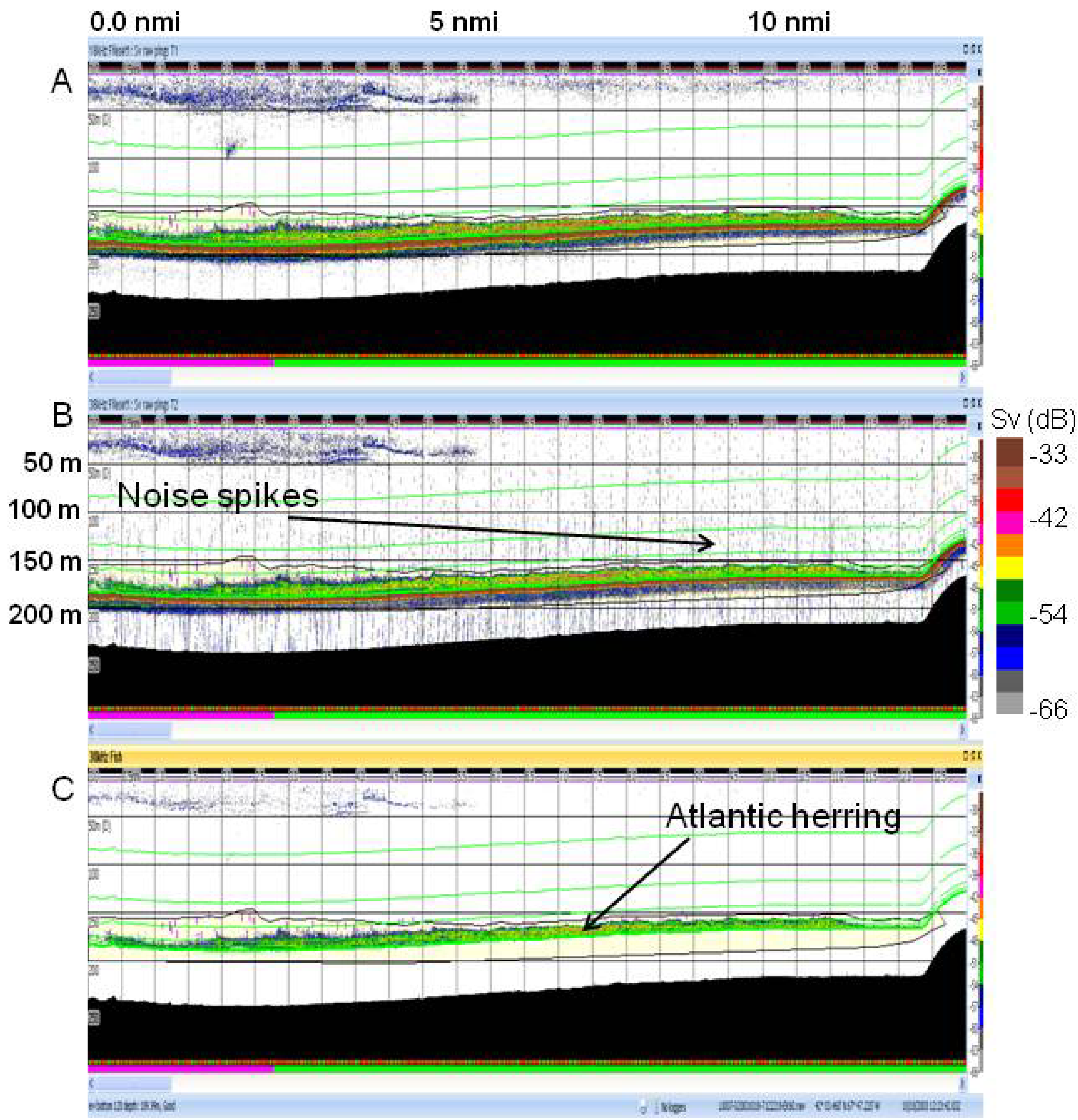

Figure 6. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), and fish (C) on 18 October 2003, 1230 GMT from the NOAA Ship *Albatross IV*. The object near the sea bed is an aggregation of Atlantic herring (*Clupea harengus*). Noise spikes are evident in the 38-kHz echogram. The fish echogram (C) is derived from echograms (A) and (B) via the modified presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

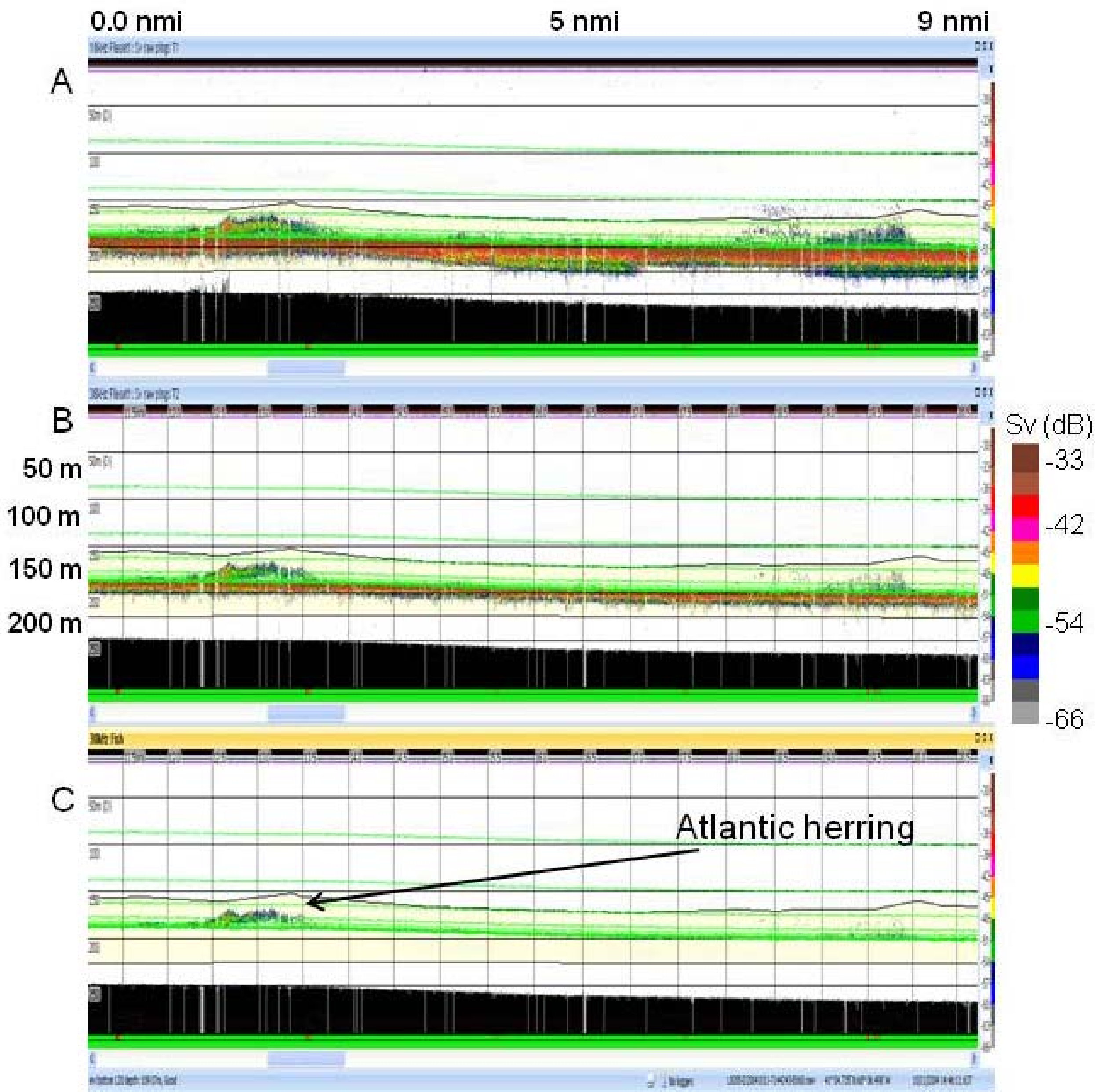

Figure 7. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), and fish (C) on 11 October 2004, 1500 GMT from the NOAA Ship *Albatross IV*. The object is an aggregation of Atlantic herring (*Clupea harengus*). The fish echogram (C) is derived from echograms (A) and (B) via the modified presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

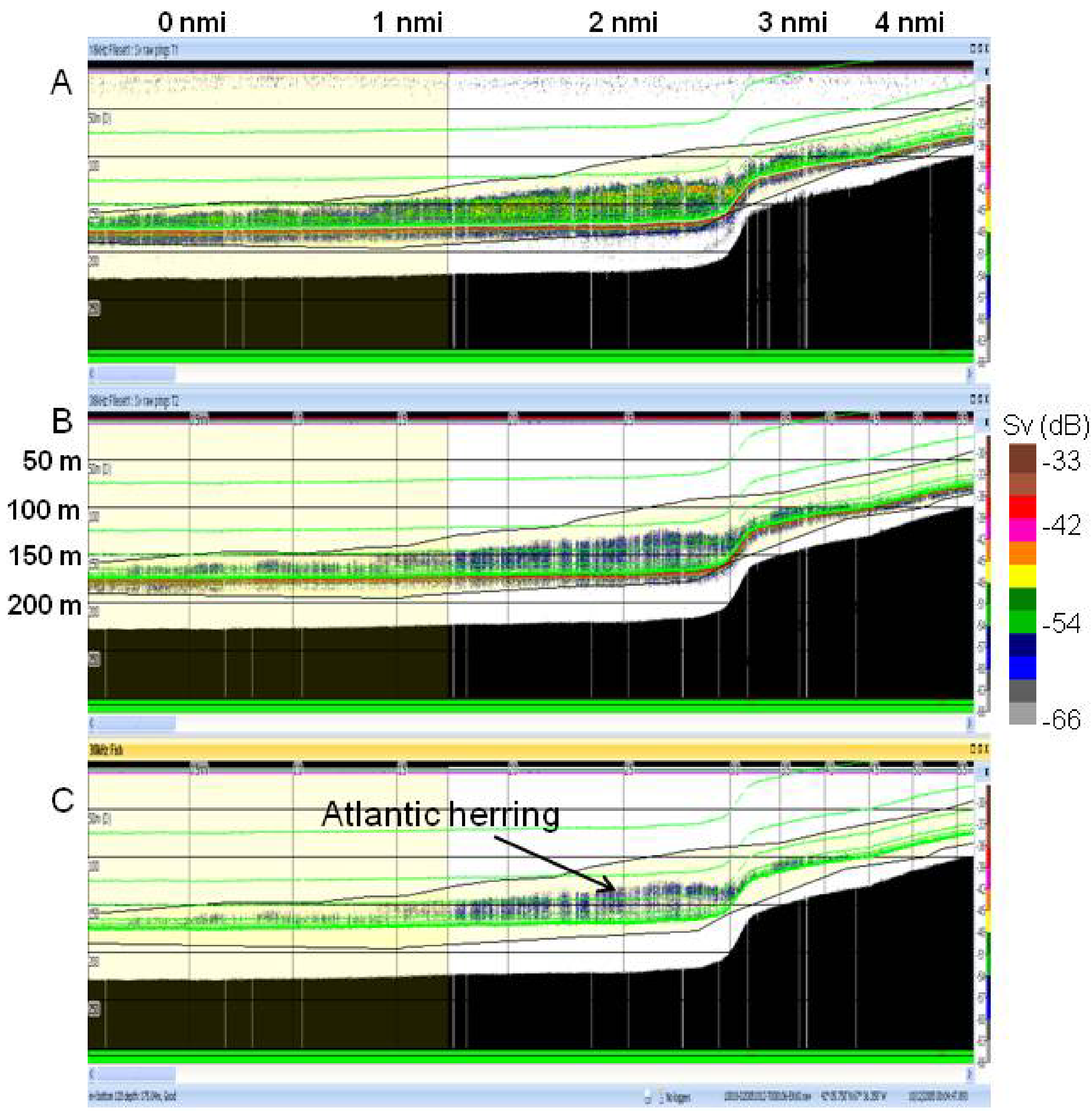

Figure 8. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), and fish (C) on 12 October 2005, 0030 GMT from the NOAA Ship *Albatross IV*. The large object is an aggregation of Atlantic herring (*Clupea harengus*). The fish echogram (C) is derived from echograms (A) and (B) via the modified presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

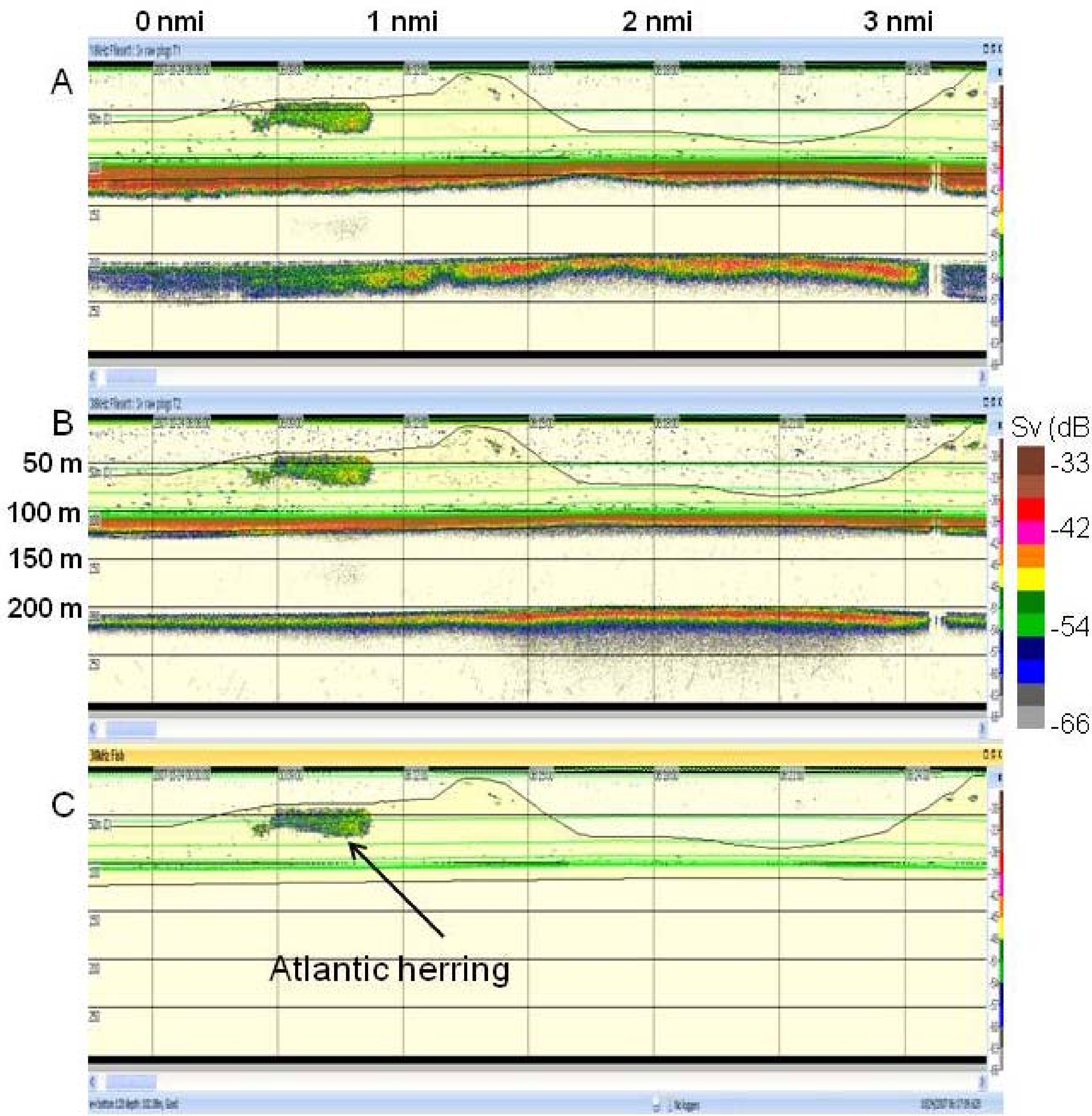

Figure 9. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), and fish (C) on 24 October 2007, 0600 GMT from the NOAA Ship *Albatross IV*. The large object is an aggregation of Atlantic herring (*Clupea harengus*). The fish echogram (C) is derived from echograms (A) and (B) via the modified presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

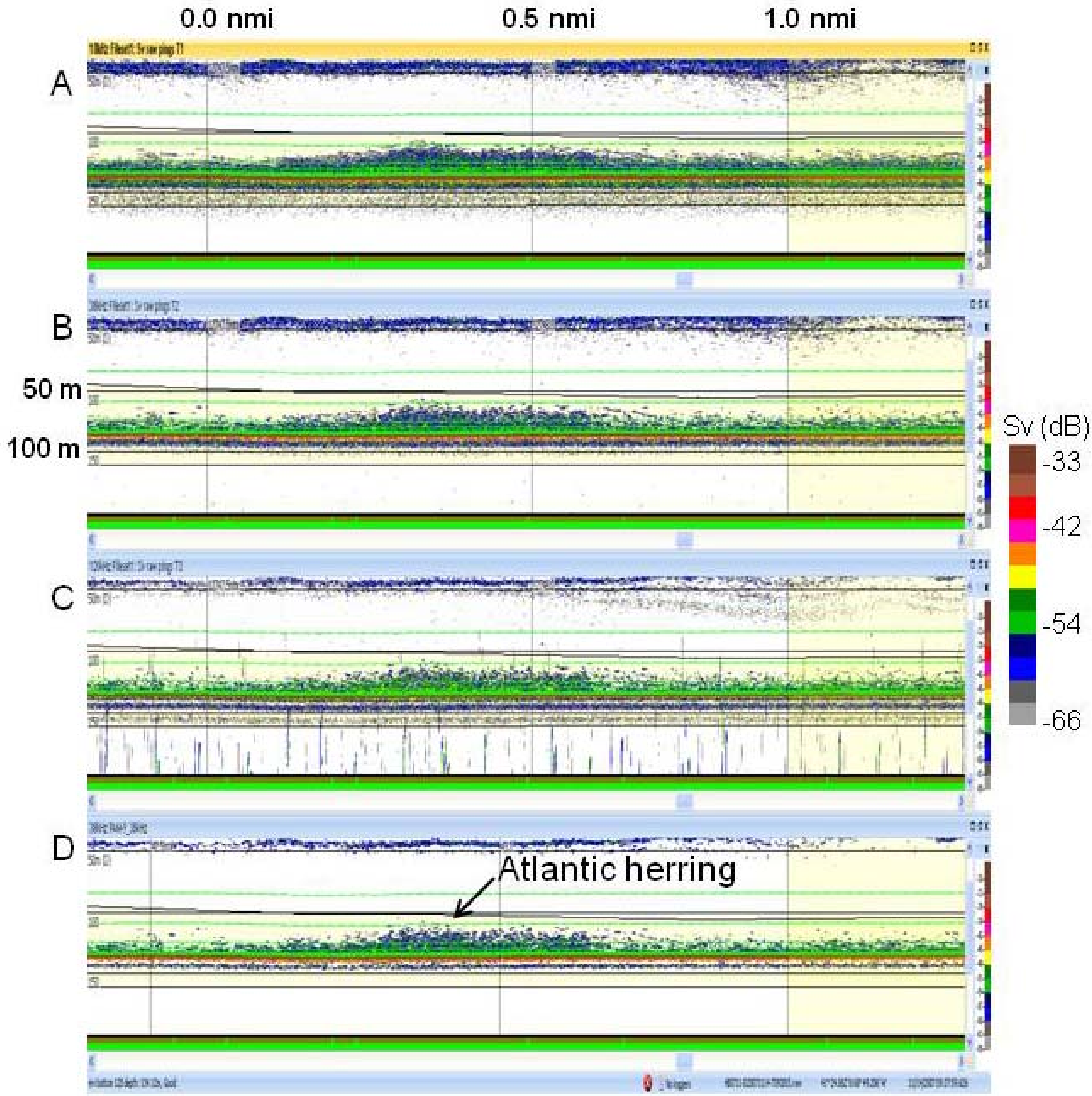

Figure 10. Volume backscatter (S_V) echograms at 18 kHz (A), 38 kHz (B), 120 kHz (C), and fish (D) on 14 November 2007, 0900 GMT from the NOAA Ship *HB Bigelow*. The object near the sea bed is an aggregation of Atlantic herring (*Clupea harengus*). The fish echogram (D) is derived from echograms (A), (B), and (C) via the presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

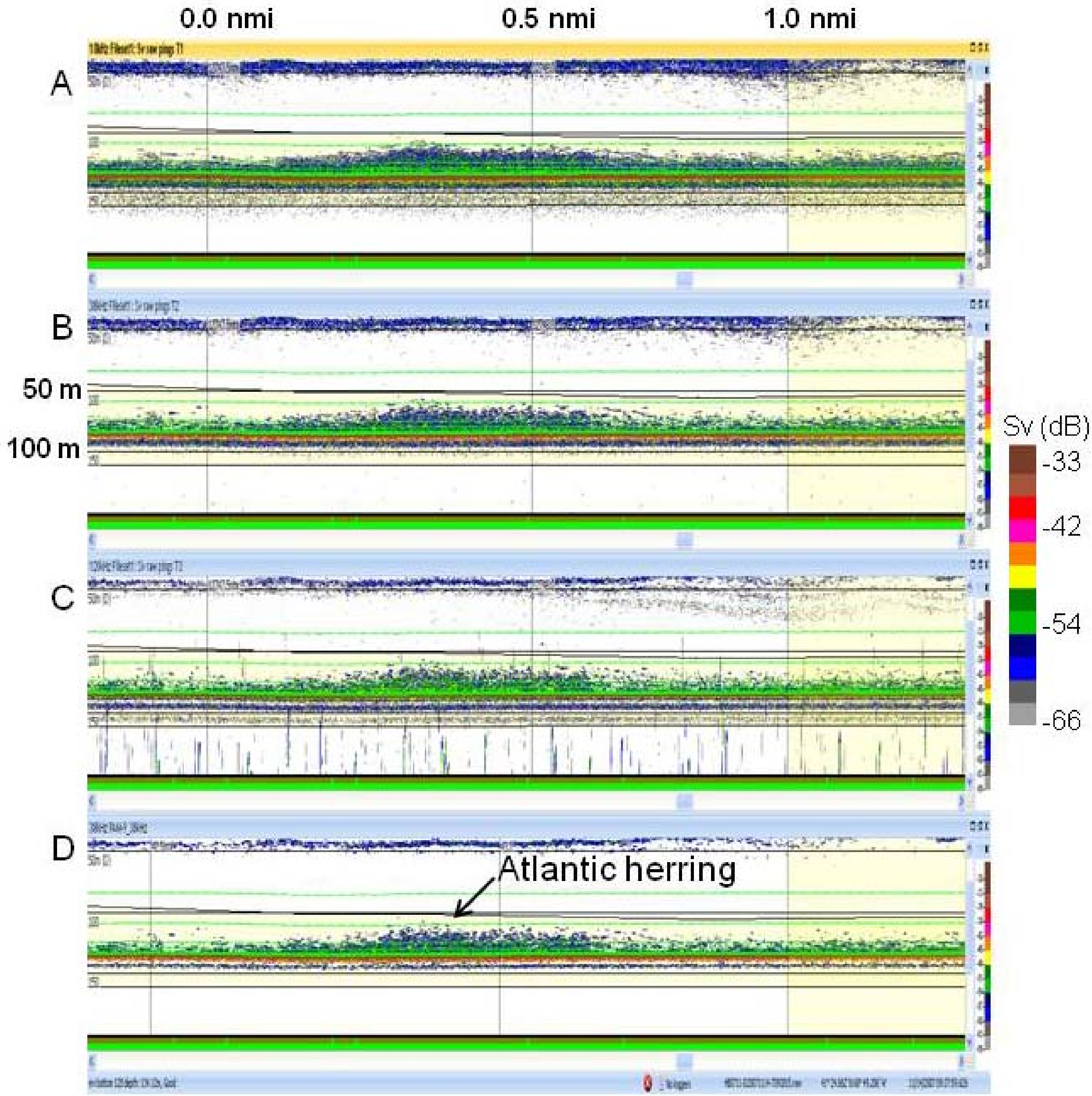

Figure 11. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), and fish (C) on 28 October 2008, 0015 GMT from the NOAA Ship *Albatross IV*. The large object is Atlantic herring (*Clupea harengus*). The fish echogram (C) is derived from echograms (A) and (B) via the modified presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

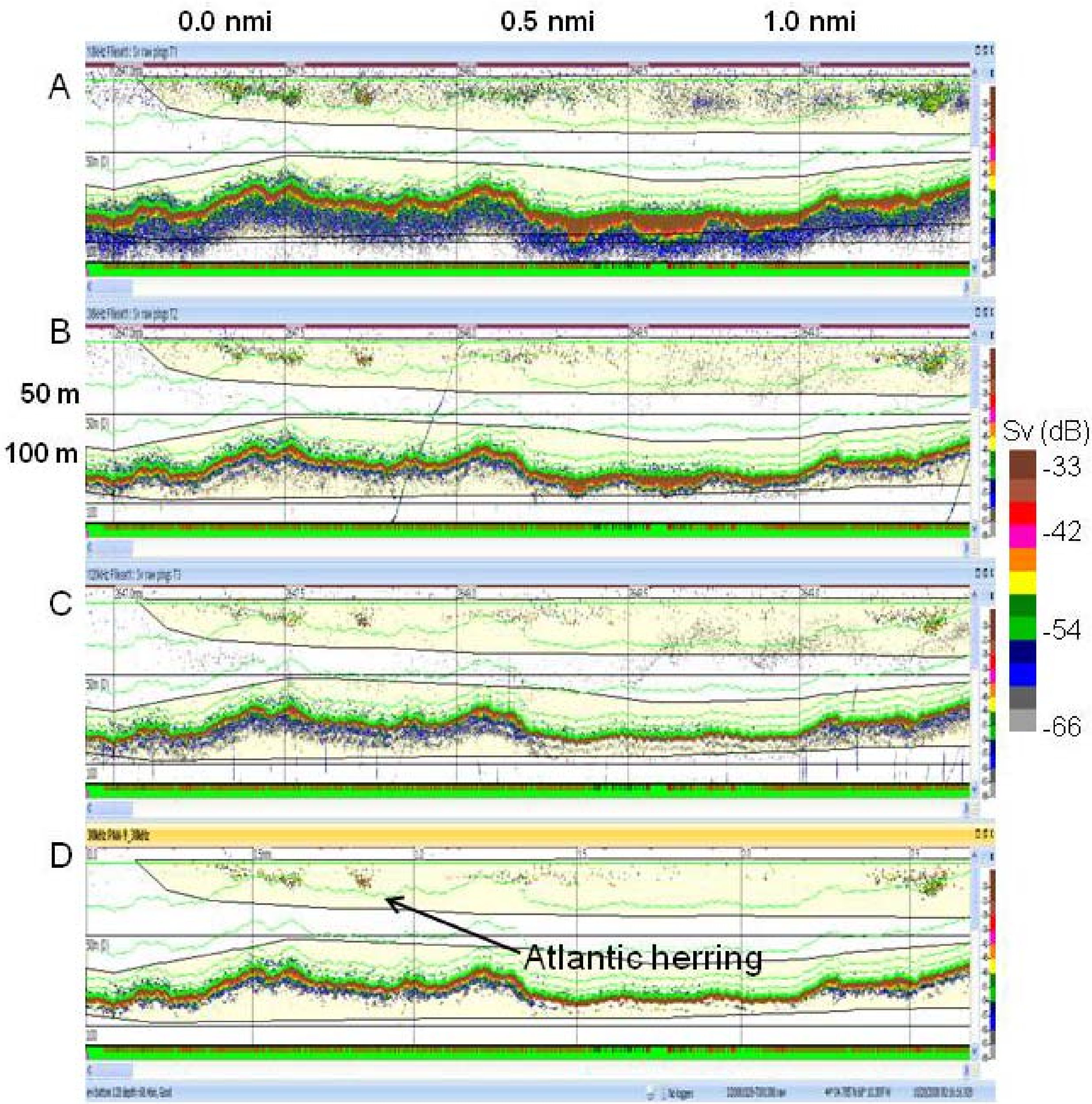

Figure 12. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), 120 kHz (C), and fish (D) on 28 October 2008, 0015 GMT from the NOAA Ship *HB Bigelow*. The large object is Atlantic herring (*Clupea harengus*). The fish echogram (D) is derived from echograms (A), (B), and (C) via the presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

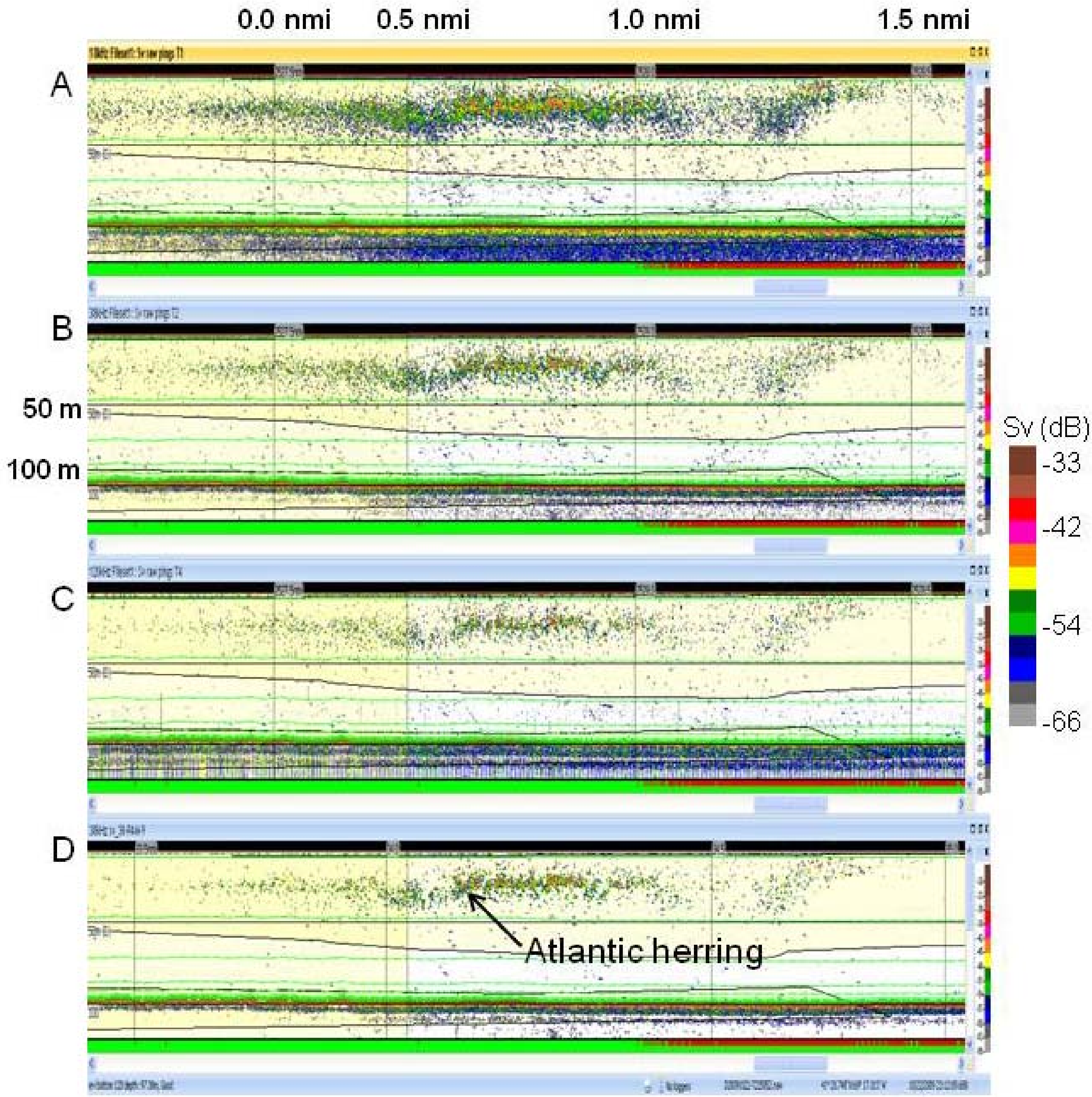

Figure 13. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), 120 kHz (C), and fish (D) on 22 October 2009, 2300 GMT from the NOAA Ship *HB Bigelow*. The large object is Atlantic herring (*Clupea harengus*). The fish echogram (D) is derived from echograms (A), (B), and (C) via the presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

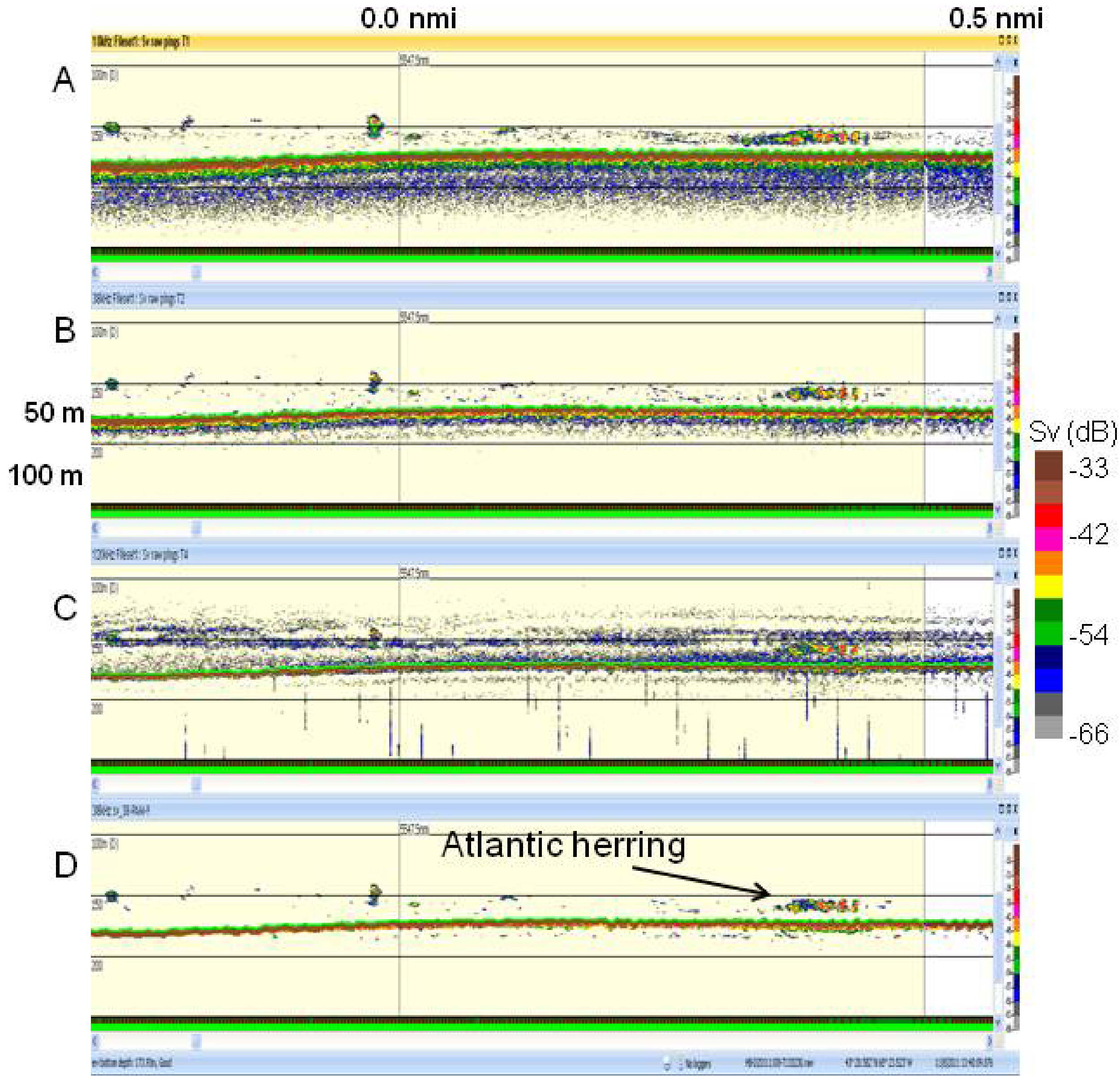

Figure 14. Volume backscatter (S_v) echograms at 18 kHz (A), 38 kHz (B), 120 kHz (C), and fish (D) on 8 November 2011, 1330 GMT from the NOAA Ship *HB Bigelow*. The object is Atlantic herring (*Clupea harengus*). The fish echogram (D) is derived from echograms (A), (B), and (C) via the presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

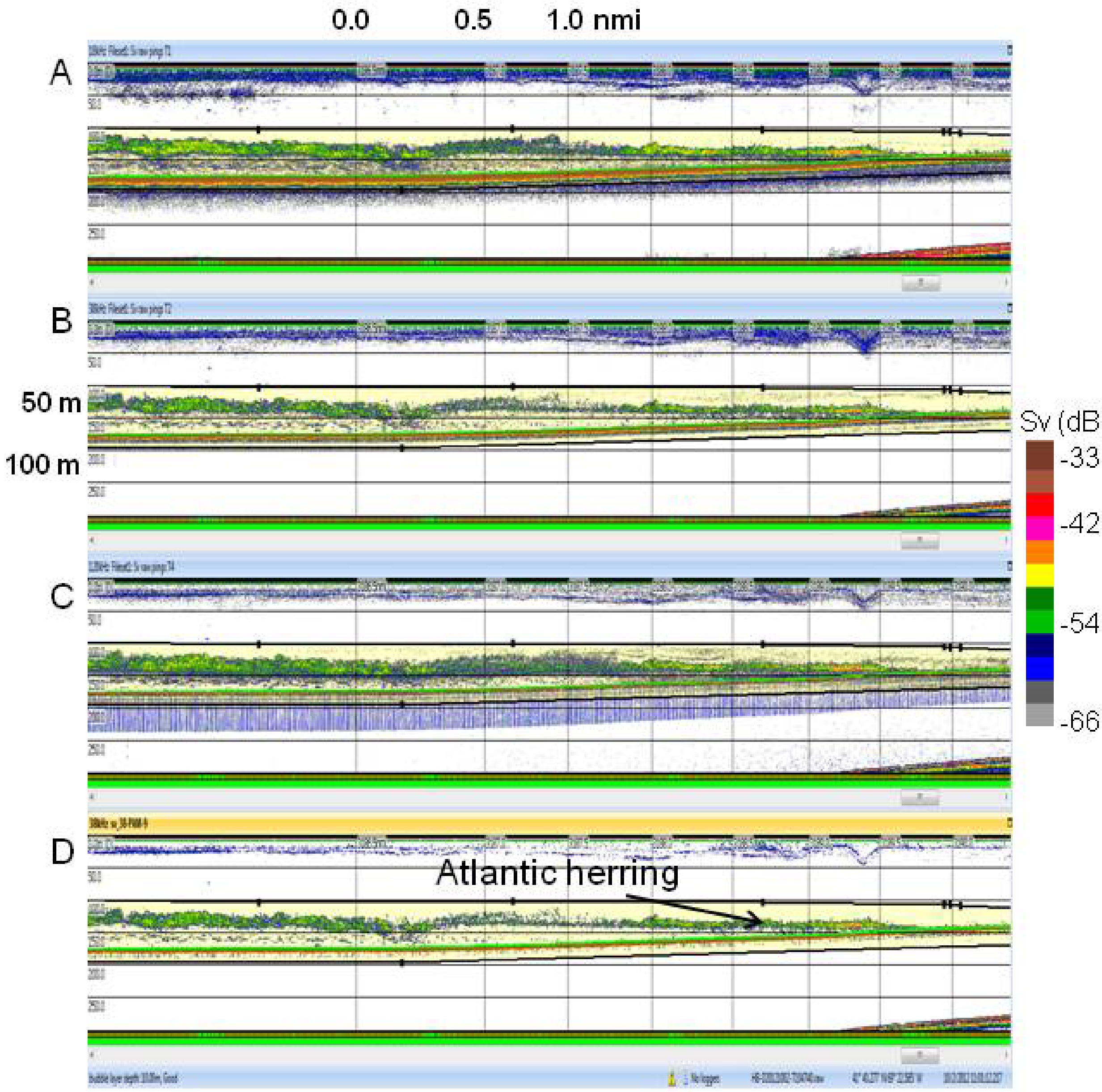

Figure 15. Volume backscatter (Sv) echograms at 18 kHz (A), 38 kHz (B), 120 kHz (C), and fish (D) on 2 October 2012, 1100 GMT from the NOAA Ship *HB Bigelow*. The object is Atlantic herring (Clupea harengus). The fish echogram (D) is derived from echograms (A), (B), and (C) via the presence/absence method. The vertical bars are at 0.5 nmi intervals, and the horizontal bars are at 50 m intervals. Regions are denoted by the translucent yellow polygons.

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