Exploring the addition of an acoustic survey to the summer Gulf of Maine shrimp survey

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Project Title:

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Goals and objectives / related projects:

This project attempted to test whether an acoustic component could be successfully added to the annual summer survey for Northern Shrimp, *Pandalus borealis*. The summer shrimp survey is conducted by the National Marine Fisheries Service, Maine Department of Marine Resources, and commercial shrimp fishermen. It consists of 15-minute bottom trawl tows conducted in a stratified, random design with station density per stratum weighted by the historical presence of shrimp. Relying on a trawl survey means only a small portion of the total bottom is surveyed, due to time constraints and limited areas where a net can be towed. Additionally, it is impossible to know whether a high-catch tow represents a tow that passed through the center of a medium sized school, or one that passed through the edge of a much larger school. Acoustic survey techniques are generally not hampered by rough, untowable bottom and have the potential to cover areas more rapidly and completely than an equal amount of time spent conducting trawl surveys. Adding an acoustic component to the annual survey has the potential to greatly inform the results of the tow samples and to conduct surveys in areas that cannot be assessed using a bottom trawl.

Partnerships:

The project was principally a partnership between the Maine Department of Marine Resources (Dan Schick and Lessie White); Gulf of Maine Research Institute (Shale Rosen); and the captain and crew of F/V Tenacious: including captain Proctor Wells and mates Jason Wells and Bert Wells. Shale Rosen (Gulf of Maine Research Institute) spent one day aboard the F/V Bad Penny

(Kelo Pinkham, captain and Morgan Pinkham, mate) to verify catches being used to direct acoustic surveys. Rachel Gallant, Northeast Consortium's Fisheries Specialist, conducted a site visit and participated in surveys on October 7.

Approach and work plan:

Six nights of acoustic surveys were conducted. Four nights were conducted between July 30 and August 4. The remaining two nights (October 7 and 8) were delayed as project participants awaited arrival of a different frequency transducer (described below). Surveys were conducted in areas where significant quantities of shrimp were caught the previous day in the joint State-Federal Summer Gulf of Maine shrimp survey's tows. Vessels participating in the trawl survey included the R/V Gloria Michelle and F/V Bad Penny.

A chart indicating the survey track paths and nearby Northern Shrimp summer survey stations is shown below:

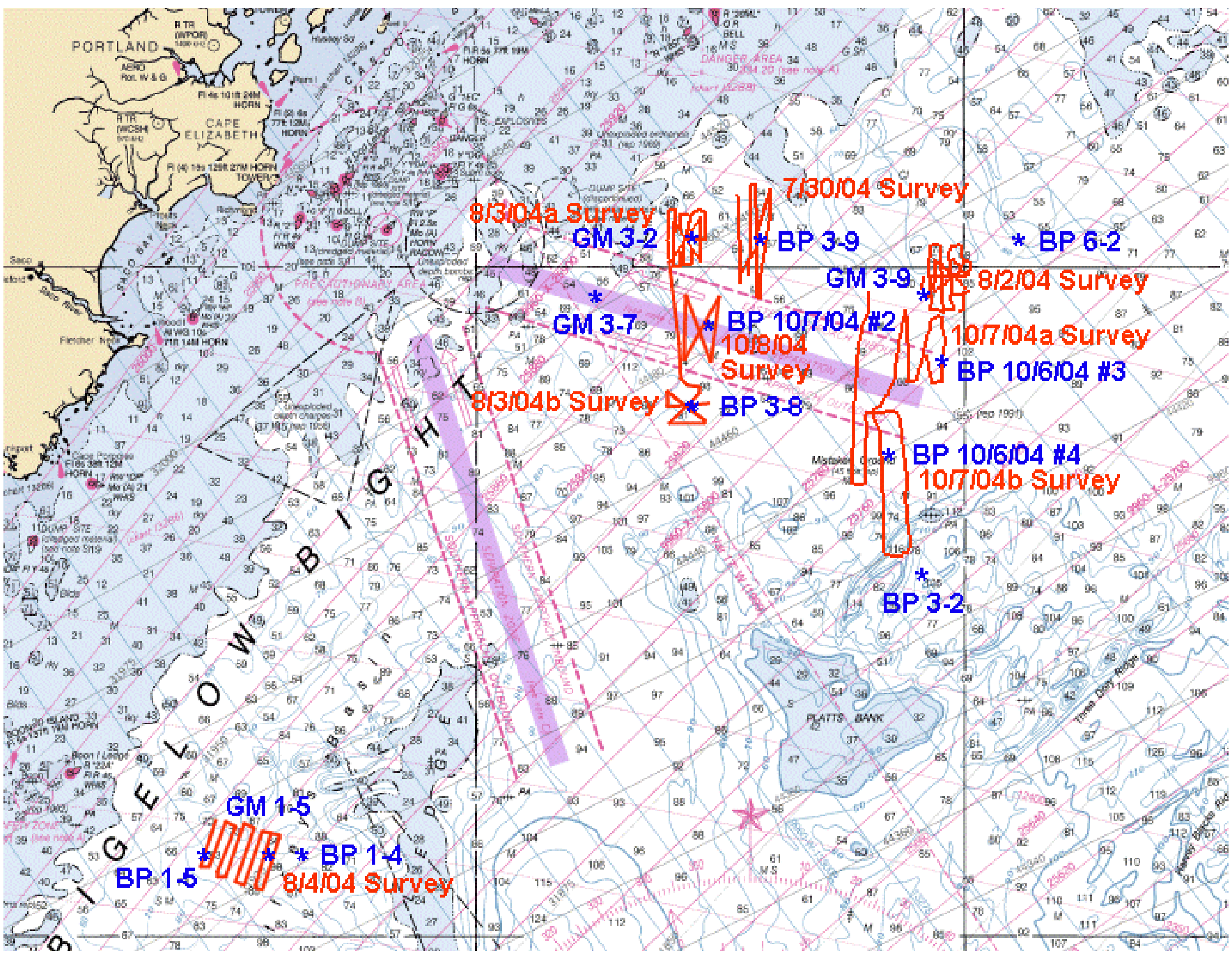

Figure 1. Area of operations. Red lines represent vessel's track path while conducting acoustic surveys. Blue asterisks represent nearby survey stations for summer shrimp survey.

Work was conducted at night because Northern Shrimp come off bottom at night to feed, and should therefore be accessible to acoustic survey methods.

A summary of the areas surveyed is presented in tabular form below:

Date	Center of Survey Area Latitude	Longitude	Duration (minutes)	Average Speed (knots)	Distance Traveled (kilometers)	Area Surveyed (square kilometers)
07/30/04	43:31.324	69:42.559	320	5.7	56.5	19.4
08/02/04	43:29.452	69:30.681	318	5.1	50.1	16.9
08/03/04a *	43:31.314	69:46.767	237	5.9	43.4	12.3
08/03/04b *	43:23.784	69:46.696	74	6.8	16.1	8.7
08/04/04	43:03.807	70:14.136	203	6.7	42.1	25.6
10/07/04a *	43:26.441	69:32.428	184	5.5	31.2	20.2
10/07/04b *	43:21.354	69:34.854	264	5.5	44.4	36.3
10/08/04	43:27.233	69:45.920	316	5.9	57.1	13.3

* Surveys were conducted in two separate locations on 08/03/04 and 10/07/04.

Equipment and methods:

Suveys were conducted aboard the F/V Tenacious, a 46-foot Wesmac stern trawler. Survey speed was five to seven knots, depending on sea state. Speed had to be reduced in seas of greater than three feet in order to collect satisfactory acoustic data.

For the first four nights of survey the acoustic equipment consisted of a FEMTO Electronics, Ltd. DE9320 digital echosounder configured to operate simultaneously at 40 and 120 kHz connected to a FEMTO dual frequency transducer operating at 40 and 120 kHz frequencies. The system was calibrated in July 2004 prior to surveys, and was found to be operating adequately although concern was expressed about its consistency for yielding quantitative biomass estimates. For the qualitative goals of this investigation (identifying presence/absence and relative amounts of shrimp) this level of inconsistency was not a concern.

The transducer was mounted on a towing body, which was deployed off the vessel's port stabilizer. This positioned the transducer approximately three meters off the vessel's hull and two meters below the water surface. A photograph of the towing body and transducer is provided below:

Figure 2. Towed body used to deploy transducers for acoustic surveys.

Project participants experimented with the addition of a 75 kHz frequency system on surveys conducted October 7 and 8. This was a completely independent system, consisting of a FEMTO DE9320 digital echosounder configured for 75 kHz and a FEMTO 75 kHz single-frequency transducer. The transducer was mounted on the same towing body, directly behind the 40/120 kHz transducer.

Acoustic data were logged using the HDPS (Hydroacoustic Data Processing System) software provided by FEMTO. Data were logged directly to the hard drive of a Pentium II class personal computer. Position information was supplied to the logging software by a Garmin GPSMap 182, a WAAS differential corrected unit with manufacturer-reported position accuracy of 3 meters 95% of the time.

Obtaining a source of clean 120 volt ac power on the vessel proved problematic. The first night's surveys include a large amount of interference from the vessel's DC to AC inverter (manufacturer and model unknown). For the second night of surveys, a different inverter (Schumacher model PI-750) and automatic voltage regulating uninterruptible power supply (Belkin F6C550-AVR) were used to supply power. Although the interference was changed by this setup, it was not eliminated and a portable generator (Honda EU2000i), which supplies true sine wave AC current was used on all remaining surveys. Representative echograms (visual representations of the acoustic data) for the three power sources are presented below:

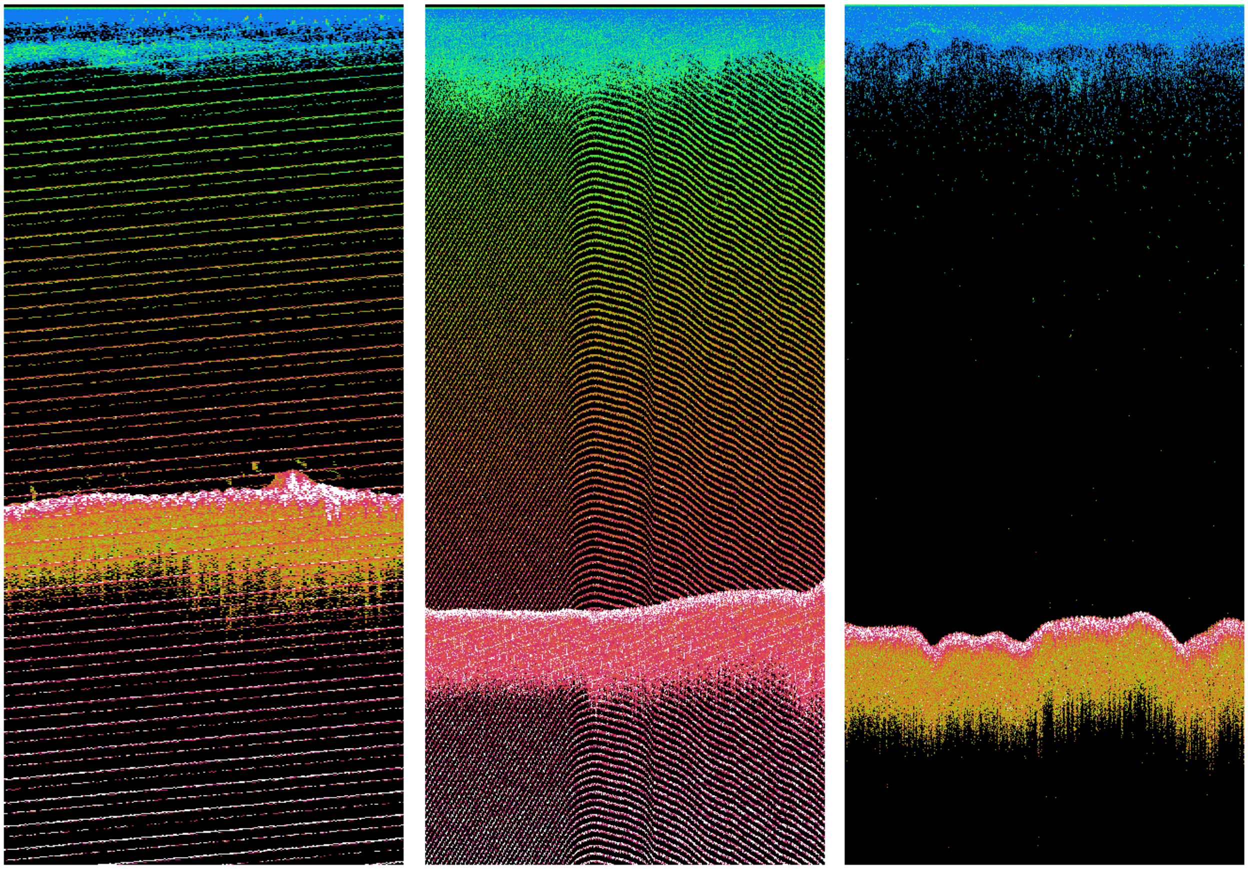

Figure 3. Echograms showing electrical interference signatures when power was supplied by the existing inverter on F/V Tenacious (left), Schumacker inverter (center) and Honda generator (right).

Survey tracks were designed in an ad-hoc fashion at sea, taking into account wind and wave direction and the vessel captain's instincts on bathymetric features where shrimp were most likely to be found (Wells has been a long time participant in the Gulf of Maine shrimp fishery). In all cases surveys were centered around a station where a vessel participating in the summer shrimp survey caught 25 kilograms or more of shrimp per 15 minute tow either one or two days previous (refer to Figure 1.). The first transect was begun approximately one nautical mile before the station, and was continued at least an equal distance beyond the station. Subsequent transects were laid out in either a parallel fashion or a modified hourglass, whereby the survey track crossed the trawl survey station from multiple directions. Examples of these designs are illustrated below:

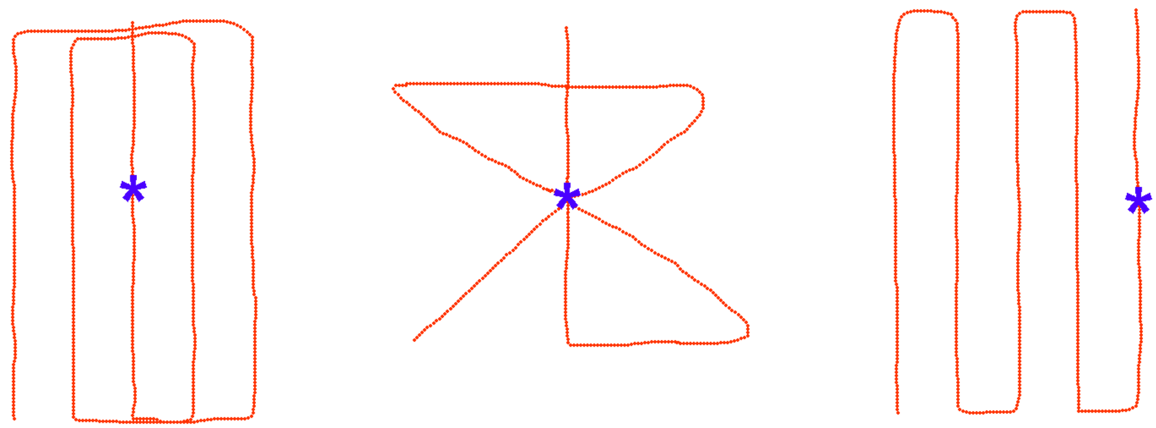

Figure 4. Designs used for vessel survey tracks. The spiral parallel design used (left) gives the most even coverage, but only intersects the station (marked with an asterisk) from one direction and double samples some regions. The hourglass design (center) gives a less even coverage, but intersects the station from three directions. A more typical parallel design (right) progresses in only one direction, and leaves a large area adjacent to the station unsurveyed unless the first survey transect is started before the station.

Results

Despite operating in areas Northern Shrimp were known to be present (based upon trawl samples taken earlier the same day), no acoustic signal that could be identified as belonging to shrimp was observed. A scattering layer near the surface was observed within 20-30 meters of the surface on all nights, however depth and temperature data collected during trawling operations on the R/V Gloria Michelle and F/V Bad Penny indicate it is unlikely that shrimp were present this close to the surface. Most likely this scattering layer is near-surface plankton.

Oceanographic data indicate there was a strong thermocline present during the period of surveys. Apollonio et al. (1986) demonstrated that Pandalus borealis in the Gulf of Maine do not generally migrate through a well-developed thermocline. Trawl surveys conducted by the Maine Department of Marine Resources indicate Pandalus borealis are generally found in areas with bottom temperatures of 8 degrees C water or less (Schick, personal communication). Oceanographic conditions at the time of the acoustic surveys inducated water as warm as 8 degrees C was present at a depth of 37-38 meters. It seems therefore unlikely that shrimp would have been present in depths shallower than 37 meters.

Acoustic surveys of Pandalus montagui in Eastern Hudson Strait, Canada indicated this species of shrimp (which is also present in the Gulf of Maine) migrated off bottom as light levels decreased in late afternoon, at a vertical ascent rate of 2.75 meters per minute (Crawford et al. 1992). In the 100-200 meter deep waters surveyed in the Gulf of Maine, shrimp demonstrating a similar vertical rate of ascent would take one half to one hour to reach the 20 to 30 meter depth where scattering was observed.

The presence of the scattering layer before dark and its position above the thermocline leads the project partners to conclude it is most likely not composed of shrimp. Targets identified as shrimp in acoustics surveys conducted by the Department of Fisheries and Oceans in Easter

Hudson Strait were also visible on the acoustic echograms near bottom even at night (Crawford et al. 1992). In contrast no shrimp targets were observed near bottom at any time during Gulf of Maine surveys.

Discussion

The project partners reviewed their strategy and protocols after completing the first several nights of surveys without observing shrimp on the acoustic echograms. The following steps were taken in an attempt to explain and remedy the problem of not seeing shrimp acoustically:

1. Adding a third frequency of data acquisition (75 kHz).

2. Scrutinizing data collected just off bottom, including using a transducer better suited to detecting backscatter near bottom.

3. Verifying the system was capable of identifying biological targets in the water column and near bottom.

4. Verifying the locations and amount of shrimp caught in the trawl survey were being accurately relayed to the acoustic survey team.

The acoustic signature of a material or organism depends greatly upon the frequency at which the acoustic signal is generated. The frequencies used on the first four nights of surveys (40 and 120 kHz) were chosen to be consistent with the 120 kHz frequency used successfully by Crawford et al. (1992) and the 38 kHz frequency used by Rose and Hiscock (1999) to survey *Pandalus* genus shrimp (the difference between biological targets' acoustic signatures at 40 kHz and 38 kHz should be negligible). In order to see if a change in frequency would improve the project's ability to detect shrimp a separate 75 kHz system was installed and logged data simultaneously with the 40/120 kHz system. The 75 kHz system was run simultaneously with the 120 kHz frequency of the dual frequency system on October 7 and 8. Coincidentally the 40 kHz channel stopped functioning when the 75 kHz system was added to the towed body. This may have been the result of damage to the transducer or its cable when the towed body was modified to carry the 75 kHz transducer.

The 75 kHz transducer used has been used successfully by researchers at the Gulf of Maine Research Institute to discriminate targets near bottom, and should have been able to detect shrimp if they were present just off the bottom. The 40/120 kHz dual frequency transducer was designed to detect targets in the water column and suffers from significant sidelobes, which can make it impossible to resolve targets just off the bottom. However since the 75 kHz system did not detect a significant amount of backscatter near the bottom, it is unlikely the four initial nights of survey missed detecting shrimp because of their proximity to bottom.

Although the calibration raised concerns about the ping-to-ping consistency of the dual frequency transducer's performance, this should not have affected its ability to detect acoustic targets. In fact acoustic targets believed to be Atlantic herring (*Clupea harengus*) were observed on the 120 kHz channel during the survey conducted October 7. These targets ranged from being adjacent to bottom to more than 40 meters off bottom.

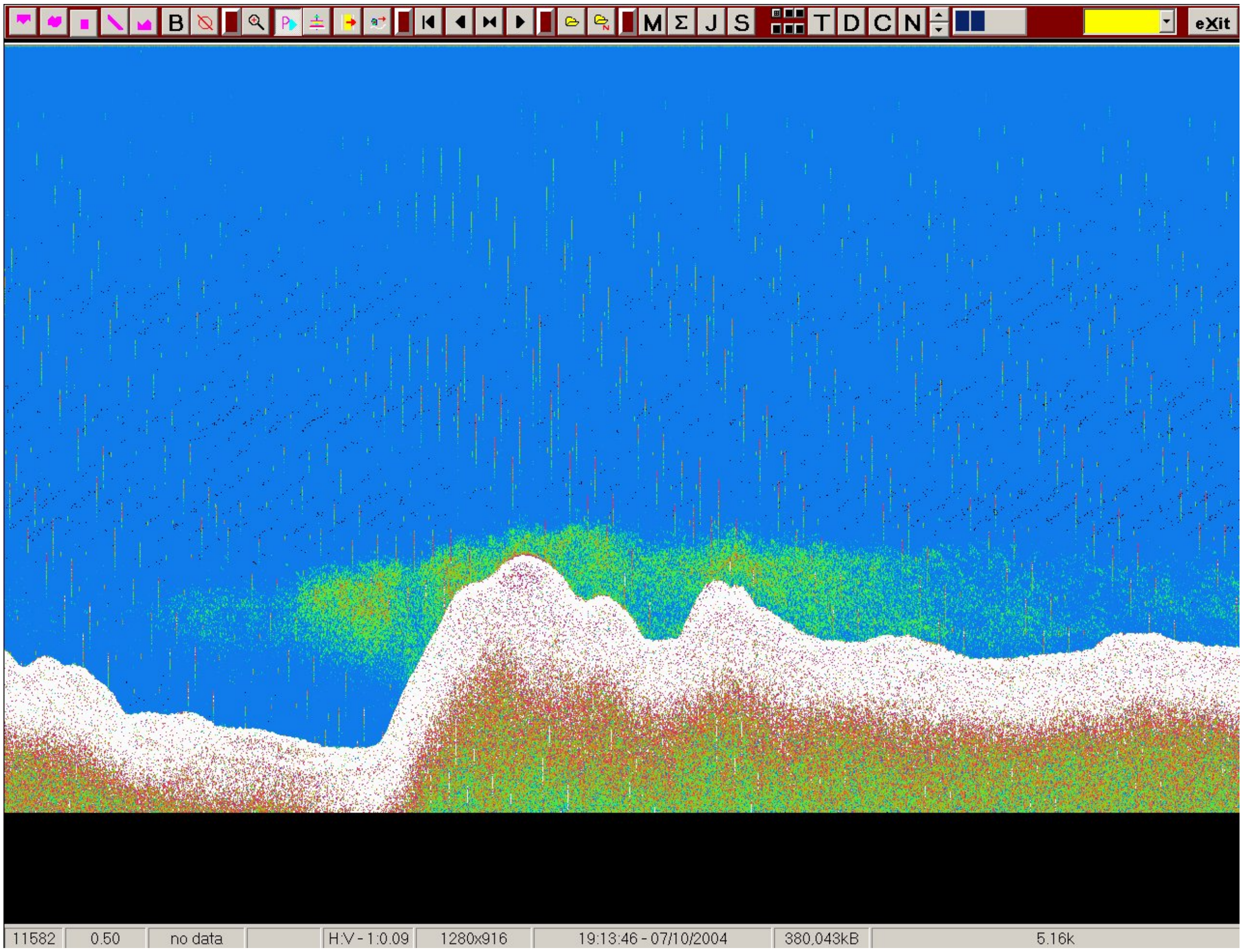

Figure 5. Echogram of 120 kHz data collected 10/7/04 showing targets believed to be herring (green and red cloud at center of screen just off bottom). The light blue background and vertical spikes are interference noise resulting from running the system at the same time as the 75 kHz system.

In order to verify that catch weights and positions were being accurately relayed to the acoustic survey vessel, the physical catch data sheets from trawl surveys conducted 10/6/04 by the F/V Bad Penny were transferred at sea to the F/V Tenacious, which conducted acoustic surveys of the two areas with highest catch rates (42.9 and 49.0 kg per 15 minute tow). Additionally Shale Rosen (the acoustic technician present on all acoustic surveys) served as an observer and technician on the F/V Bad Penny during one day of trawl sampling on October 6 to verify the catch amounts and locations were being logged as understood. All indications are that information being relayed from the trawl survey vessels to the acoustic survey vessel was accurate and miscommunication about catch amounts and locations of areas of high shrimp presence was not the cause of a failure to locate them acoustically.

Several potential explanations remain for the project’s failure to detect shrimp acoustically. The most likely one seems to be a threshold minimum density for acoustic techniques to detect shrimp. There may simply not have been enough shrimp present in any of the locations for their schools to scatter the acoustic signal a sufficient amount to be detectable above background levels. Crawford et al. (1992) report that concentrations of shrimp were detected by their acoustic equipment, but that dispersed shrimp could not be identified acoustically.

Catch rates reported by Crawford et al. (1992) ranged from 0.05 to 2133.5 kg of shrimp per 30-minute tow (standard swept area of 54,185 square meters). The highest catch rate reported in an area where Gulf of Maine acoustic surveys were carried out was 382 kg (standardized to 30 minutes and 13,890 square meters swept area).

Impacts and applications:

This project was unsuccessful in demonstrating the ability of the acoustic equipment tested to identify and assess shrimp in the Gulf of Maine. While other equipment and techniques (different frequencies and multibeam systems for example) might be effective in discriminating shrimp near the bottom or in the water column, results from this project indicate the tools and techniques tested in this study were not suited to assessing shrimp in the Gulf of Maine.

Literature cited:

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Rose, G.A., and W. Hiscock. 1999. Trends in spring and winter research CPUE of shrimp in Hawke Channel, 1994-1998. Canadian Atlantic assessment Res. Doc. 99/154