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Investigation of the Vertical Distribution, Movement and Abundance of Fish in the Vicinity of Proposed Tidal Power Energy Conversion Devices

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SUMMARY

The inner the Bay of Fundy, in particular Minas Passage, has been identified as one of the primary locations in eastern Canada for the installation of tidal in-stream energy conversion (TISEC) devices. The interaction of fish populations with TISEC devices and the long term impact of these interactions is a major source of uncertainty in the development of tidal energy. In addition, the prevalence and natural behaviour of fishes at many potential development sites, including Minas Passage, is poorly understood. Unfortunately, the physical characteristics of the Passage, water clarity, and tidal currents/flow precludes effective use of many conventional fish monitoring tools such as video for close-in turbine interaction studies and the deployment of trawling gear. Conventional Simrad EK60 split-beam echosounding (120 kHz) was employed in Minas Passage during eight seasonally distributed 1 to 2 tidal cycle duration acoustic surveys to investigate fish spatial-temporal distributions and behaviours both in the FORCE turbine test sites near Black Rock and extending across the adjacent wider Passage. Split-beam surveys were complemented with a 2-D Simrad-Mesotech MS 2000 multi-beam (200 kHz) sonar and custom software for the extraction of relative volume backscatter, a still experimental but emerging fish detection technology (Melvin et al. 2003). Two new acoustic monitoring technologies, namely the CodaOctopus 3-D multi-beam sonar (375 kHz) for short range turbine interaction studies and the ASL bottom mounted echosounder (125 kHz) for long-term point site monitoring were also evaluated.

The best quality and most reliable Minas Passage fish data were obtained from the split-beam system. Extensive, calibrated split-beam results are presented in graphic and tabular form for both the acoustic volume backscatter (S_v) and target strength (TS) regimes. Briefly, backscatter levels in both the Channel and near the initial TISEC test site peaked strongly in June, the culmination of an upward trend initiating in March. These observations are consistent with the late spring - early summer influx of herring (mainly adult) and other seasonally transient species. August backscatter levels were measurably lower but subsequently rose modestly until November, consistent with the anticipated late summer and fall sea-going exodus of anadromous young-of-the-year spring-spawning species through the Channel. Backscatter levels declined during mid-winter prior to the influx of spring-spawning herring. This interpretation was also supported by the split-beam analysis of fish target strengths (TS's) with strongest mean TS's in May and August when migratory fish species may be moving though the Passage. Column biomass estimates ranged from < 1 to 7.5 tons/km^2 on employing a backscatter to biomass conversion appropriate to herring. Acoustic backscatter levels delineated seasonally complex and sometimes contrasting patterns of vertical fish distribution in the Channel and in the shallower test site area, patterns which appeared to be additionally influenced by diel fluctuations in ambient light levels and by tidal phase. Mid-water column fish concentrations observed at the test site could potentially interact with tidal turbines. Backscatter vs. depth data from these surveys should assist evaluation of potential fish stock interactions with future tidal turbine configurations. September 2010 observations of the in-place OpenHydro turbine by both survey systems revealed strong, seemingly buoyant acoustic wakes proceeding from the downstream side of the turbine although normal turbine operation was unlikely at this time.

Quantification of both the split-beam and multi-beam systems was seriously hampered by tidal turbulence generated backscatter (bubbles) affecting the top 10 - 20 m of the water column and frequently deeper. This effect was most prominent in the test site area except near slack tide.

Bubble cloud effects proved especially intractable in the MS 2000 multi-beam analysis in spite of custom tools employed to minimize their effect along with the effects of radiated vessel noise and cross instrument acoustic interference. When reliable multi-beam fish data could be extracted, results were generally consistent with those of the more noise immune split-beam system.

Sea tests of the CodaOctopus 3-D sonar and ASL Profiler were restricted to less turbulent waters than Minas Passage. The Coda sonar displayed a maximum detection range in the order of 30 m for acoustic test targets representative of individual adult herring – and, by inference, lesser ranges for many smaller fishes of interest in Minas Passage. While the Coda unit was suitably packaged for autonomous underwater deployment, such operation was characterized by high power consumption, critical operational adjustments, firmware signal processing of uncertain quantitative characteristics, and excessively high levels of real-time signal decimation. The system was also very costly for a high risk environment. These characteristics in combination appeared to make the Coda unit unsuited for the autonomous monitoring of fish stocks or for the monitoring of the full (OpenHydro) turbine aperture from a spatially remote bottom deployment. The unit might have some potential for short range turbine aperture observations if mounted on the turbine superstructure itself with remotely supplied power and high speed (fiber-optic), real-time data and control links to shore.

The ASL profiler, trial deployed on bottom in a high speed tidal channel in Passamaquoddy Bay, performed well, obtaining a continuous, low noise full water column (approx. 50 m) profile of fish backscatter including an apparent marine mammal detection. The unit is low cost, self-contained, and engineered for autonomous operation with sufficiently modest power requirements and ample data storage to make multi-month deployments feasible. While probably unsuited to close-range turbine aperture monitoring, such a unit, properly housed and protected, has potential for continuous, fixed-location, high vertical resolution monitoring of water column backscatter levels including transitory events in Minas Passage or elsewhere.

TABLE OF CONTENTS

LIST OF FIGURES

1. INTRODUCTION

1.1 Context

The inner Bay of Fundy has been identified as one of the key locations for the installation of tidal in-stream energy conversion (TISEC) devices. Based on a NRC technical report summarizing 3-D modeling and assessment of tidal current energy resources (Durand et al. 2008), the potential power generation capacity in Minas Passage exceeds all other areas in the Bay of Fundy. The Passage is also home to a diverse assemblage of fishes, marine mammals, and invertebrate species. Currently there are in excess of 50 species of fish and invertebrates (commercial and non-commercial) inhabiting or passing through Minas Passage on an annual basis. Knowledge of when these species are present in the Passage, how these species are distributed vertically and horizontally in the water column, whether they are long term or transient inhabitants, and, especially, their reaction/behaviour when encountering an artificial underwater structure is critical to our understanding of the risks associated with the safe deployment of tidal turbine devices and the large scale development of TISEC-based tidal power.

The physical characteristics of the passage, especially water clarity, and tidal currents/flow which preclude use of the more conventional suite of biological monitoring tools, including video and bottom trawls, illustrate the advantages of acoustic sensing techniques. An earlier pre-installation trial acoustic survey in the same general area (Melvin et al. 2009) disclosed high levels of acoustic backscatter in the upper half of the water column. This appeared to arise from tide rip associated bubble cloud aeration, especially that extending westward from the vicinity of Black Rock on ebb tidal flows. While surface turbulence/aeration backscatter can, and did, obscure biological targets in the upper water column there was no detectable associated attenuation of acoustic backscatter echoes from the lower portions of the water column. This implies that targets lying outside the turbulence zones (i.e. multiple bubble clouds) can be reliably detected and quantified acoustically.

Advancement of TISEC technology in the Bay of Fundy has taken a sequential approach beginning with the identification of potential development sites, establishment of a Minas Passage test site just west of Black Rock, Nova Scotia by the Fundy Ocean Research Centre for Energy (FORCE) via a 20 year Crown lease, and the initial test deployment of an OpenHydro turbine unit at one of four defined near-shore test berths on 12th November 2009. Unfortunately, communication via acoustic telemetry with this device was lost soon after deployment and a camera survey in March 2010 appeared to indicate two turbine blades missing. On turbine removal on the 16th December 2010 all blades were missing. At the time of preparation of this report (late 2013), no additional turbine deployments have been attempted.

The present report is intended as a stand-alone document. Therefore, the authors have drawn freely from their earlier reported materials, as appropriate, including a published technical report (Melvin & Cochrane 2012) based on the initial (16th Sept. 2010) Minas Passage survey. Where analyses and conclusions have since evolved, appropriate modifications have been made.

1.2 Project Chronology

The Offshore Energy Environmental Research Association (OEER) and the Offshore Energy Technical Research Association (OETR) are twin not-for-profit organizations incorporated in 2006 by grants from the Nova Scotia Department of Energy to support ocean-related environmental research including the impacts of renewable energy technologies. As of 1st April 2012 the OEER and OETR have been amalgamated as the Offshore Energy Research Association of Nova Scotia (OERA). On 15th May 2009 the Associations issued a call for Expressions of Interest (EOI) concerning "Research on Tidal marine Energy". A DFO response to the EOI outlined a program to investigate fish interactions with tidal turbines, the program which subsequently evolved into that currently reported.

The Project chronological progression from start to finish is summarized in APPENDIX 1. Specific dates pertaining to the project's progress including contract awarding, formal changes in focus, survey timing, and reporting are identified. Existing technical reports and other readily accessible communications arising from this project are listed in Section 8.

1.3 Reporting

1.3.1 Progress Reports

The Joint Project Agreement (JPA) governing this work mandated periodic reporting to the OEER/OETR as a pre-condition for receiving Project Progress Payments.

Formally submitted Project Progress Reports:

6 October 2010 – Progress Report treating seagoing and laboratory trials of the Coda Octopus 3-D sonar and a brief overview of the initial 16 Sept.2010 site survey.

21 February 2011 – Progress Report treating some initial analysis of the 16 Sept. 2010 survey, both split-beam and multi-beam, including innovative approaches to 2-D multi-beam processing.

1 June 2011 – Progress Report primarily treating improvements to 2-D multi-beam processing, especially computation of beam-specific "Integrated Beam Width Factors" and the quantitative effects of signal "thresholding" in connection with volume backscattering strength estimation.

01 January 2012 – Progress Report primarily treating 4 combined split-beam/multi-beam Minas Passage fish surveys conducted in the period 22 Aug. – 22 Nov. 2011.

1.3.2 Final Report

30 November 2013 - The present document marks the end of the project and represents the final report covering all aspect of the study from the beginning in 2010 to the completion in 2013.

2. OBJECTIVES

The original Project objectives in abridged form as stated in the negotiated and revised proposal of 16th Sept. 2009 – "Project Synopsis/ Overview" were: "… to image fish trajectories about Minas Passage TISEC turbines using bottom-mounted sonar with a 3-D viewing field with the objective of observing and quantifying the distribution and abundance of fish in the water column and their ability to detect and avoid turbines." Also stated was "The sonar of primary interest is the CodaOctopus EchoScope II, one of the very few proven 3-D imaging sonars." The project was to extend over 3 years starting in the fall of 2009 with year 1 devoted to a "proof of concept". Under "Scientific and Technical Objectives and Outcomes", it was stated: "Critical parameters extractable from the acoustic analysis include fish densities as functions of height above bottom and the phase of the tidal cycle - both in the presence of and remote from the turbine; the frequency of fish transiting the turbine aperture; any fish trajectory deviations apparently induced by turbine presence; and species information from resolved target shapes, echo amplitudes, or other characteristics." More simply stated, it was proposed to first evaluate and, if deemed suitable, utilize the CodaOctopus Echoscope II 3-D sonar to image fish trajectories close to the mouth of an operating tidal turbine with the objective of determining the degree to which fish actively avoided the operating device. More remote from the turbine, and possibly within the same contiguous field of view, one would seek to quantify the "undisturbed" characteristics of fish abundance and vertical distribution. Our philosophy/methodology for sonar based turbine monitoring is elaborated in APPENDIX 2.

A major shift in Project direction (APPENDIX 1) occurred in the summer of 2010 when the planned usage of the Coda 3-D imaging sonar was judged impractical due to a combination of inadequate sonar performance; difficulty in satisfying power consumption requirements; and the challenges, risks, and costs associated with emplacing an autonomous bottom package within the necessary stringent spatial and orientational constraints in an extremely harsh environment. Nor, under close examination, did the alternative of placing short-term, more conventional acoustic systems on-bottom, wired to a surface vessel seem practical. There was also growing concern as to the normal functionality and future operational status of the deployed OpenHydro turbine unit since operational telemetry was not being received.

The consequent "New Directions" document of 6 Aug. 2010 defined two modified objectives:

1) To better understand the detailed physical acoustical operational environment and fish distributions in the immediate vicinity of Minas Passage TISEC device(s) i.e. turbines.

2) To place bounds on fish avoidance of the TISEC device(s).

Objective 1 would be met by surface vessel-based, conventional fisheries acoustic grid surveys around the turbine test site using a Simrad EK60 split-beam echosounder and a Simrad-Mesotech MS 2000 multi-beam sonar. Usage of both systems, based at DFO's St. Andrews Biological Station, had previously been proven in Minas Passage. The survey component would satisfy the original Project objective of better defining fish distributions and behaviours near TISEC test sites. Furthermore, fish density - with anticipated seasonal, tidal, and diel dependencies, could be intensively explored with at least one fully established, highly quantifiable acoustic instrument (split-beam echosounder).

The path to objective (2) was less well defined. One tentative methodology was use of two ASL bottom-mounted echosounders, one deployed near-turbine and a second simultaneously deployed more remotely. Comparison of bottom sounder-derived fish densities might reveal signs of any "long-range" turbine avoidance but monitoring within the potentially more critical "local" avoidance zone (i.e. at ranges from the turbine comparable to the turbine aperture) would remain out-of-reach.

As circumstances unfolded, an acceptable DFO vessel charter was not arranged until Aug. 2011 (the anticipated use of a DFO CCGS *J. L. HART* replacement vessel working out of St. Andrews did not materialize). Only a single acoustic survey of the turbine site (Sept. 2010) could be arranged before an inoperative OpenHydro unit was removed in Dec. 2010 with uncertain prospects for the emplacement of a similar or alternative turbine unit within the remaining Project time frame. Therefore, the post-2010 Project reduced to achieving Objective (1) with, at most, a demonstration/evaluation of a bottom-mounted ASL profiler in Minas Passage. Purchase of an appropriate single ASL unit using DFO resources was contemplated by the Saint Andrews Biological Station and this unit might be made available for limited Minas Passage testing.

3. METHODOLOGY

3.1 Study Area

Minas Passage, located in the inner Bay of Fundy, is a relatively narrow channel, approximately 12 km long and 5 km wide, that allows the flow of tidal waters into and out of Minas Basin (Fig. 1). The passage is characterized by strong, predominately lunar semi-diurnal (M_2) period tides of average 10 m amplitude with spring tide peaks of more than 13 m and with associated tidal currents ranging from 6 - 8 knots (3.0 - 4.1 m/s) during maximum flow (Tides & Currents Software, Version 1.05). On specific surveys tidal currents were estimated to exceed 11 knots for short periods near spring tide peak flow at the test site. Water depths in the Passage exceed 135 m, but at the OpenHydro turbine test site range from 28 – 41 m depending upon the tide. Detailed physical characteristics of the Passage are available in several published reports (Durand et al. 2008, AECOM 2009).

3.2 CodaOctopus 3-D Imaging Sonar

A sonar unit demonstrated in Bedford Basin by Coda Octopus, and their distributor ROMOR Ltd. personnel, in the summer of 2009 was observed to have a capacity for high spatial resolution 3-D imaging at high pulse repetition rates suggesting its potential suitability for 4-D (X, Y, Z, t) delineation of fish targets (i.e. the tracing of discrete fish trajectories near the intake apertures of tidal turbines, provided effective fish detection ranges of the order of 50 m could be achieved). Unlike recently developed, heavy, ship-based, lower frequency 3-D sonars such as the Simrad MS70, the Coda sonar appeared sufficiently compact and suitably packaged to allow autonomous bottom deployment from a small vessel. A single CodaOctopus Echoscope II sonar unit was procured for evaluation at BIO in the fall of 2009 with special cooperation from the manufacturer. A description of the Coda Octopus Echoscope II sonar, its field and laboratory testing at BIO, its subsequent field evaluation in Passamaquoddy Bay, and conclusions as to its possible applicability to fish behavioural studies in the immediate proximities of TISEC devices are treated in APPENDIX 3.

Because of the technical limitations of the sonar unit discerned through the laboratory and field trials outlined in APPENDIX 3, the high cost of long-term Coda rental, and the high monetary value of the sonar head (> $200 K) considered in the light of the non-negligible probability of loss or damage inherent in autonomous Minas Passage deployments - it was concluded that alternative directions should to be pursued. Our tests of the Coda sonar do not completely rule-out the Coda sonar as a useful fish monitoring and possibly turbine avoidance detection tool if deployed under the following conditions:

1) The imaging sonar were mounted directly on the turbine superstructure in a manner such that the sampling geometry could be precisely pre-set or adjusted remotely to allow extraction of observations within ranges of a few 10’s of meters of the sonar head. At these ranges fish targets of primary interest could be detected at the signal-to-noise ratios required for quantification, and/or fish trajectories could be monitored over all of - or over an appreciable fraction of - the turbine intake aperture to enable direct enumeration of fish transits.

2) A sonar-to-shore fiber-optic control and data link were available thereby enabling sonar performance to be remotely monitored and adjusted in real-time and data sent to shore for display and analysis

3) Ample electrical power could be directly supplied from shore permitting long duration (i.e. multi-month) observations. Fish species composition , abundance , and behaviour including turbine avoidance likely vary with tides, diurnal light levels, and with season therefore requiring extended and continuous observation times to discern.

When the unfeasibility of utilizing the Coda sonar as initially envisioned became apparent the Program was redirected toward studies of the Minas Passage fish populations with special emphasis on the FORCE Test Area on the north side of the Passage. This work conducted using more conventional ship-based acoustic technologies constitutes the bulk of the subsequent program and is treated below.

3.3 ASL Acoustic Water Column Profiler

The “New Directions” response document of 6 Aug. 2010 (APPENDIX 1) identified the possible use of bottom-mounted echosounders in the vicinity of the test sites as an investigative monitoring tool. An ASL Environmental Sciences (based Victoria BC) Acoustic Water Column Profiler was procured (non-OEER funding) by DFO’s St. Andrews Biological Station for exploratory stock assessment. It was planned to conduct a field deployment based assessment of this instrument in or near Minas Passage in the fall of 2012 as an integral part of the present Project. However, unanticipated weather and vessel scheduling constraints precluded deployment prior to the official Project termination on 31 Oct. 2012. In consideration of the fact that OEER funds had already been expended both to adapt the earlier CODA sonar triangular bottom platform to accommodate the new ASL instrument and to gear-up for the trial deployment, DFO completed a trial of the device in a strong tidal channel in Passamaquoddy Bay in late November 2012 at no additional cost to the Project. The report on this deployment appears in APPENDIX 4.

Overall, the 125 kHz bottom-mounted ASL instrument performed reasonably well in a strong tidal environment displaying sufficient sensitivity and dynamic range to detect fish (and a possible marine mammal) at water depths of the order of 50 m, depths consistent with those encountered at the Minas Passage test site. There was little indication of excessive flow noise or serious spurious responses. Battery capacity exists or is readily expanded to allow multi-month deployments at quite useful time and depth resolutions. The ASL instrument is reasonably inexpensive (approx. $ 25 k/unit single channel), a potential virtue considering the risks attendant with any extended instrumental deployment in Minas Passage. More complex (and expensive) autonomous echosounders have also recently appeared on the market including bottom-mounted split-beam echosounders – so several factors need be considered to select the appropriate instrument for a given objective and given deployment environment.

Bottom-mounted echosounder technologies would seemingly be of utility in monitoring a few representative locations between traditional grid surveys using more conventional ship-based scientific systems. Long term deployments would allow seasonal biological cycles to be reliably resolved, enable the separation of tidal origin vs. diel biological effects, as well as enable the detection of any strong transitory events. Calibrated multiple instruments suitably employed spatially around an active turbine might also directly detect “long range” fish avoidance provided the effects were reasonably pronounced.

3.4 Ship-based Acoustic Surveys

3.4.1 Vessel Platform and Acoustic Survey Systems

Commencing on 19th Sept. 2010 and extending to 25 & 26th June 2012 a series of nine (9) moving vessel acoustic surveys were conducted in Minas Passage. The charter vessel *FUNDY SPRAY* (Fig. 2), a 15.4 m, 38 gross ton small passenger vessel owned and operated by the Huntsman Marine Science Center in St. Andrews, N.B. was employed for all surveys. Two active acoustic systems were deployed: (i) a split-beam echo-sounder operating at 120 kHz (Simrad EK60) and (ii) a 2-D 200 kHz multi-beam sonar (Kongsberg-Mesotech MS 2000, hardware wise also formerly designated as the SM 2000). Acoustic transducers for both the EK60 echosounder and the MS 2000 sonar were pole-mounted (Fig. 3) and deployed at about 1.5 m depth off the starboard side of the vessel. This enabled delineation of both a narrow vertical cone beneath the vessel (split-beam, 7^o conical beam angle) as well as a port-starboard fan swath (multi-beam, 180^o fan swath, beam angles approx. $2.5^°$ along fan x $1.5^°$ out-of-fan). While the transducer configuration was similar to that utilized on the earlier trial survey of Melvin et al. (2009), the comparatively more substantial transducer support boom supplied by the Charter vessel enabled safe profiling to at least 12 knots and measurably contributed to the overall success of the undertaking. The ship's navigation differential GPS unit provided NEMA 083 positional serial data streams to both the EK60 and the MS 2000. Time was extracted from the computer clocks. System-specific software was used for data logging; Simrad ER60 for the EK60 echo-sounder and Simrad MS 2000 Version 1.4.2 for the multi-beam sonar. Ping rate was set at 1.0/s for both systems with an intentional very slight offset in ping rates to minimize the possibility of the two systems interfering with each other in a continuous manner over an extended time period.

3.4.2 Survey Description

3.4.2.1 Initial Survey Methodology

The primary goal of the initial survey was to monitor fish distributions in the vicinity of the Minas Passage turbine (OpenHydro) over a complete tidal cycle. On this survey, just over 6 hours of simultaneous 120 kHz split-beam and 200 kHz multi-beam data were collected. Upon reaching the test site the transducers were lowered to slightly below hull depth, fixed into position, and the acoustic systems activated. Data collection in the vicinity of the turbine began on the 16th of September 2010 at 12:16 GMT, about 2 hours after local high tide, and ended at 18:35 GMT, 2 hours past local low tide - earlier than planned due to deteriorating weather (Fig. 4).

The first step was to verify the exact position of the turbine relative to the co-ordinates (45^o 21.897' N 64^o 25.5762' W) provided by the developer. After the supplied turbine location was successfully verified by sonar, several experimental passes were made over the device to determine the best approach direction given the system's orientation, tidal currents, and weather conditions (Fig. 5). Subsequently, a series of 7 survey transects were established approximately 100 m apart, 3 north and 3 south of the predominately east-west line passing over the turbine (Fig. 1). These transects extending in the direction of the general prevailing current approximately paralleled the northern shoreline. The transects, which varied in length from 900 m to 1400 m, were surveyed sequentially and continuously until about 18:30 GMT when the vessel undertook several final passes over the turbine before heading to port for shelter. Additional acoustic data more remote from the turbine site were collected on the transit to Parrsboro. All data acquisition ended at 19:03 GMT.

The EK60 system settings for the September 16, 2010 survey are presented in Table 1. Table 2 summarizes the location, time, tidal phase, and transect length. Table 3 summarizes the backscatter for each transect occupied throughout the day. Although the duration of true slack water in Minas Passage is very short, one hour before and after low tide (16:32 GMT) was considered slack tide for this report and the subsequent analyzes. In total, data from 25 individual transects were collected with both the EK60 scientific echo-sounder and the MS 2000 multi-beam sonar (Fig. 6). All data were checked for completeness and archived on DVD prior to analysis.

3.4.2.2 Subsequent Survey Methodologies

The tidal turbine was removed after the 16 Sept. 2010 survey; no alternative TISEC unit was installed during the project period. While this precluded further observations of fish interactions with the turbine, it did afford an extended window to observe baseline conditions. For subsequent surveys it was considered expedient to utilize the basic 7-line grid pattern established on the initial survey, supplementing this with two additional adjacent transect lines, one about 100 m north of and parallel to the earlier grid and the other about 100 m to the south of the original grid. The new 9-line grid transects were denoted T0 to T8 (Table 4) from nearest-shore to furthermost off-shore (i.e. northernmost to southernmost) with lines T1 to T7 representing the grid of the initial survey after modest adjustments to equalize line lengths (Fig. 7). It was also considered prudent to tie in the 9-line intensive survey grid covering the vicinity of the turbine test berths with additional transects sampling the wider fish distribution cross-channel. To this end three (3) additional survey lines were defined, “X1, “Y1”, and “X2” (also Table 4). Line X1 extended from the easterly end of T8 generally south-westward across Minas Passage to about the 30 m bathymetric contour on the southern coastline. Line Y1 followed the approximate 30 m contour along the south coast to the start of the return transect X2 which paralleled X1 and extended through the western end of T8 north-eastward to terminate at the western end of T0.

Grid surveys started at the western end of T0 and each successive transect of the 9-line grid was occupied in numerical order, alternating survey direction on each successive line until arriving at the eastern end of T8. Ensuing cross-channel line X1 terminated near the Passage southern coastline followed by Y1 east-to-west and then the return line X2 arriving at the west end of T0 (i.e. the survey origin). The overall strategy was to repeat successive “grids” over the duration of a survey, the duration being either 1 or 2 tidal cycles as the vessel could only return to port near high tide. On several occasions extreme tidal currents or equipment problems forced deviations from the regular pattern. In addition, on the 25 – 26th June 2012 survey some cross-channel lines were intentionally skipped for an extended time period to better define the temporal characteristics of extremely high fish concentrations encountered on the close-spaced portion of the grid.

On single (1) tidal cycle surveys, the vessel departed Parrsboro on an early morning high tide and returned on the evening high tide the same day. This normally permitted the completion of 3 complete grids plus the close-spaced portion of a 4th grid – sometimes more. Single tidal cycle surveys were limited to daylight data acquisitions. Two-tidal cycle surveys enabled more efficient use of ship time, with surveys extending into Grids 10 to12 with good coverage of both day and night time conditions. A significant amount of time (~2 hours) was normally expended to set-up and debug equipment on arriving on-site, and to conduct CTD profiles off Black Rock prior to initiating survey. For CTD profiles, temperatures and salinities were averaged from the surface to about 15 m depth and then used to compute acoustic sound speeds and absorption coefficients.

For the EK60 split-beam sounder settings such as pulse length, power, and ping rate were fixed similar to the 2010 survey, however factors affecting the transducer and speed of sound were adjusted according to pre survey calibrations and water parameters at the time of surveying. For the

MS 2000 multi-beam the maximum acquisition range was set to either 50 or 75 m for both the close-spaced grid and for Y1, and to either 100 or 150 m for X1 and X2. The sonar pulse length varied with maximum range setting, ranging from 100 μs for 50 m range to 325 μs for 150 m range.

3.5 Analysis: Ship-based Surveys

3.5.1 Data Handling and Initial Processing

3.5.1.1 General

Data handling and initial processing of information from the two acoustic systems differed significantly. Both the EK60 and the MS 2000 collect relatively large volumes of data that must be scrutinized and edited to identify fish and non-fish targets prior to quantitative analysis. For the EK60 a commercial editing and analytical software package, Echoview Version 4.9 and 5.3 by Myriax, were used for all data analysis. Calibration parameters characteristic of the system and the environment were checked and updated if necessary (Table 1, Table 5). Similar survey-oriented software was not available for analyzing the MS 2000 data and the analyses was conducted using analytical tools developed by the authors.

The split-beam and multi-beam systems provide complementary information that may improve the identification of fish-like targets from background noise in the editing phase of the analysis. The MS 2000 multi-beam sonar’s 180° beam fan samples a much larger water volume than the narrow 7° vertical beam of the EK60, potentially permitting a superior statistical description of shallow depth fish distributions as well as sparsely distributed fish schools and aggregations. The EK60, in contrast, is an inherently more sensitive system which should yield higher signal-to-noise ratio information on weakly scattering fish in the deeper portions of the water column. The echosounder is specifically designed for accurate fisheries quantification with standardized calibration protocols and compatibility with widely accepted commercial analytical software. In contrast, the MS 2000 remains largely an experimental system for fisheries applications, is presently somewhat less well characterized quantitatively, and with analysis restricted to methodologies and software developed “in-house”. In regard to the MS 2000 much of what follows constitutes original approaches to extracting information from a multi-beam system.

3.5.1.2 Initial Data Reduction

EK60

For the EK60 echosounder little data reduction or compression was applied prior to analysis, the exception being rejection of files containing no information or transects of no interest. Data files were first loaded into Echoview as one continuous survey track for scrutinizing. Once loaded, the sections of the file related to specific transects were defined as “regions” and labelled accordingly. Table 2 identifies the individual transects and labels of the September 16, 2010 survey while Table 5 summarizes the characteristics and physical parameters of the survey series conducted between August 2011 and June 2012. Details for individual transects are provided in APPENDIX 5 and the transect locations within the passage in Fig. 7. Initially two range boundaries were established for the editing of the EK60 data, the first 1.5 m below the transducer (120 kHz) face (acoustic near field zone) and the second 0.5 m above the sounder-detected bottom. All backscatter outside this vertically (i.e. top and bottom) bounded zone was excluded from further analysis. Fixed vertical intervals (1 m for the 2011/2012 surveys and 5 m for the 2010 survey) were established for depth specific analyses. Extraneous acoustic targets such as the turbine superstructure and turbine-associated turbulence were identified and excluded from fish backscatter calculations.

MS 2000

Multi-beam sonars synthesize a contiguous fan of narrow sonar beams using signal amplitude and phase information acquired by a large array of discrete receive transducers. The MS 2000 multi-beam can acquire field data in either raw elemental, non-beamformed form, i.e. data from the individual receive array transducers are stored for later off-line beamforming, or the array data can be beamformed in real time by company proprietary software and stored in the resultant reduced form. For this study raw elemental data (i.e. non-beamformed ".smb" output format) was selected to enable the use of our quantitatively better understood in-house developed beamformers (Cochrane et al. 2003) as well as to provide greater analytical flexibility in post-processing. For the Sept. 2010 survey, data were first beamformed in post-processing in successive groups of 1000 pings to facilitate trials with differing analytical concepts. All subsequent surveys were beamformed in units corresponding to individual grid survey transects. The earlier Sept. 2010 data were eventually also reprocessed in transect units for consistency. The Sept. 2010 data files were additionally beamformed using a non-linear algorithm (Cochrane 2002) to determine if the alternative technique might improve fish detection. While cursory inspection showed that the non-linear processing did yield visually less noisy appearing fan sections, the technique did not clearly reveal additional fish echoes. Consequently, it was decided to use only "normal" linear beamforming because of its inherently superior quantification potential.

3.5.1.3 Data Processing

EK60

General: Data processing was essentially the same for the single 2010 survey and the 2011/2012 surveys. Once the regions (transects) were defined in the data files and the vertical analysis intervals identified, a third variable depth boundary was manually established defining the upper margin of a layer that included all valid observations lying below the surface bubble/turbulence backscatter zone. This required careful scrutinizing of the echogram to separate areas of surface backscatter noise from areas containing potentially un-obscured fish targets. An additional boundary was established at 10 m to investigate the distribution of backscatter associated with the surface layer. Figure 8 illustrates the boundary layers and demonstrates the subjective nature of assigning this boundary. Depth intervals of 5 m for the 2010 survey and 1 m for the most recent surveys were established between the sea surface and the varying depth of the bottom boundary for subsequent quantification. Backscatter for the entire water column and the vertical intervals were estimated following standard acoustic procedures in the Echoview software. Output options for backscatter included volume backscattering strength (S_v), Nautical Area Scattering Coefficient (NASC), area backscattering coefficient (ABC), and **area** backscattering strength (S_a). Most estimates of backscatter for the EK60 were expressed in NASC or S_a units where the difference between S_a and

NASC is simply a scaling factor (MacLennan et al. 2002). A total of 26 transects were extracted from the echogram data in September 2010 compared with 512 for the 2011/2012 surveys, and subjected to analysis and variable output (APPENDIX 5).

TS estimates: The Echoview acoustic editing software contains a module that uses standard algorithms to detect individual targets based on a series of input parameters. The output is the target strength distribution of those reflectors which meet the selection criteria. Although the detection of single targets during vessel transit is far more difficult than when stationary due to reduced target redundancy, and generally leads to the selection of fewer echoes, it is still possible. However, it should be noted that the selection of targets is very sensitive to the threshold values used to determine whether an echo originates from a single or multiple target(s) within a sample layer. Information on the distribution of target strength for high probability single-target echoes can be used to infer fish size and possibly species.

Acoustic transect files were edited in Echoview to remove unwanted noise then subjected to the single target detection algorithm contained within the virtual echogram module. Individual fish targets were identified in the water column within the boundaries defined as the surface (noise removed) and the bottom as described above. Slight refinements in the detections parameters were implemented between the 2010 survey analysis and the 2011/12 survey series which reduced the number of targets detected modestly. Target detection parameters for each time period within the Echoview editing software were defined as follows:

	2011/2012 Surveys	Sept 2010
TS Threshold (dB) :	-55.00	-60.00
Pulse length determination Level (dB):	6.00	6.00
Minimum normalized pulse length:	0.70	0.60
Maximum normalized pulse length:	1.20	1.50
Maximum beam compensation (dB):	6.00	6.00
Maximum Standard deviation minor-axis (degrees):	0.60	0.60
Maximum Standard deviation minor-axis (degrees):	0.60	0.60

Detailed data on range, angular position, compensated and uncompensated TS for each target were exported to an MS Excel (CSV) file for analysis. These data were subject to further filtering following the criteria established by (Peña 2008). Only targets within a low signal-to-noise region of the acoustic beam based on a target-beam composition of -3 dB and maximum within beam offset of 3° from the acoustic axis were selected for the analysis. This resulted in a reduction of targets by approximately 50%. Each target was then assigned to 10 m depth intervals to investigate variability in TS with depth. TS was converted to backscatter ($\sigma_{bs} = 10^{TS/10}$), averaged in the linear domain, then converted to mean TS (TS= 10 log σ_{bs}). Day time was defined as 1 hour after sunrise and before sunset, while night was 1 hour after sunset and 1 hour before sunrise. The two hour transition periods at dawn and dusk were not included in the day/night analysis.

MS 2000 Multi-beam

Several approaches were explored in the quantitative analysis of MS 2000 data. The initial approach was an exploratory implementation of direct echo counting or enumeration to make maximum use of the large ping-to- ping ensonification volumes provided by the multi-beam. In the end, the vast bulk of our analysis relied on the extraction of Volume Backscattering Strength in a manner somewhat analogous to that employed for the EK60 echosounder but requiring adaptation for the complex synthetic beam patterns of the multi-beam and further efforts to suppress extraneous noise which was markedly more prevalent than with the single beam system.

Time Base: Recorded MS 2000 data were time-stamped from the time base of the logging computer. On data playback this time base displayed both an offset and, in some cases, a linear offset drift from the EK60 time base. For the initial Sept. 2010 survey, when observations of the OpenHydro turbine were conducted, a specialized algorithm harmonized MS 2000 time to EK60 time to within 2 s over the entire logging period. For subsequent surveys, analyses proceeded on the basis of spatially-defined transects making harmonized timing less critical but EK60 and MS 2000 data times were usually harmonized to within 60 s.

Fish Densities from Echo Enumeration: Fish concentrations (fish/m^3) as functions of depth can be estimated by, first, the direct counting or enumeration of manually identified fish echoes for contiguous depth intervals over a predefined number of successive fan sections (i.e. pings), followed by division of the total accumulated fish counts for specific depth intervals by the total "effectively" ensonified water volumes (explained below) for the same depth intervals. The advantage of a manual direct counting approach is that operator experience enables the rejection of false fish echoes arising either from spatially extended or diffuse bubble clouds, from recognizable extraneous noise bursts, or from the more continuous noise background especially at longer profiling ranges. This largely overcomes the fundamental weakness of the alternative Volume Backscattering Technique outlined below where either all sources of noise are accepted, or else specialized algorithms are developed and employed to recognize and reject specific types of false signals. In practice, manual target selection is achieved by simply mouse clicking on visually identified fish echoes over successive fan sections. For each selected echo, port-starboard echo position and depth are computed from mouse-selected screen coordinates and converted to echo latitude, longitude, and depth using GPS vessel course (i.e. direction of travel) as a first estimate to vessel heading (directional orientation). The approximation of vessel heading in this manner is not particularly accurate within strong tidal streams, but the only measure available (vessel heading is not utilized for any results presented in this current Report). A supplementary ping-by-ping file of maximum usable profiling ranges is also generated by mouse clicking on the nearest point on bottom including the leading edge of any artificial bottom structures. Normally, fish echoes are not discernible at ranges greater than the transducer to first bottom arrival (echo) distance on all fan beams including beams at inclinations far removed from the vertical. At profiling ranges exceeding the transducer to bottom distance, continuous high-level bottom-scattered energy arrives at the receive transducer array elements and dominates the beam-forming process. This intense bottom-scattered energy contaminates or masks otherwise legitimate low-level signals originating within the water column in inclined fan beams at profiling ranges greater than the minimum transducer to bottom range. Some of the interfering energy arises from normal beam side lobe leakage but the effect is usually exacerbated by non-linear processes such as signal clipping and anomalous array elemental interactions.

The direct counting methodology, while possessing high discrimination for legitimate fish targets, has three fundamental weaknesses all effectively addressed or side-stepped by the more standard Volume Backscattering Strength technique:

1) The difficulty of defining "effectively" sampled water volumes on a ping-by-ping basis: While the port-starboard beam fan swath is well defined for imaging purposes, the fore-aft angular detection space is not. The fore-aft beam response declines in amplitude gradually and systematically on moving either fore or aft of the nominal central plane of the fan swath. Consequently, it is inescapably subjective to determine whether a fish echo of given strength lies "inside" or "outside" any arbitrarily established fore-aft angular sampling boundary. Stronger fish echoes will be clearly discerned at greater angular distances from the central swath plane.

2) The laborious nature of target-by-target manual echo identification making application to the full quantity of data constituting a typical fisheries acoustic survey impractical – unless, perhaps, the human operator can be removed and automated target recognition algorithms employed. Consequently, it proved feasible to apply this methodology to only a few representative data selections from the initial Sept. 2010 data set.

3) The failure of the methodology when fish are aggregated into sufficiently tight schools that individual fish echoes cannot be confidently resolved.

The theory, implementation, and limitations of the direct counting approach are more fully discussed in APPENDIX 6.

Volume Backscattering Strength: Volume backscattering strength (abbreviated VBS – symbol S_v) is a standard quantitative measure of backscatter widely employed in conventional single beam acoustic fish surveys including those conducted using split-beam sounders like the Simrad EK60. By strict definition VBS is a measure of the acoustic intensity returned or "backscattered" from 1 m^3 of ensonified water, observed at a (mathematically) reduced reference range (by convention 1 m), using a unit intensity ensonifying source, the quantity expressed in logarithmic decibel form: $S_v = 10 \log(s_v R_1)$ where s_v, the "volume backscattering coefficient", is the relevant intensity and R_1 the unity reference distance (see Clay & Medwin 1977 for a fuller development of acoustic terminology and relevant concepts). Our practice is to use the symbols "S_v" or "VBS" to refer to backscatter measures in either decibel or linear form but qualified by the terms "linear form" or "linearized" S_v when the linear form (i.e. s_v) is implied. Even for conventional single beam (including split-beam) echosounders, VBS is a challenging quantity both to measure accurately and to interpret properly in terms of real-world fish densities and biomass distributions (MacLennan & Simmonds 1992, Clay & Medwin 1977). When VBS extraction is applied to multi-beam systems, quantification and interpretational challenges are multiplied (Cochrane et al. 2003, Foote et al. 2005) due to multiple and differing synthesized beam patterns, a susceptibility to extraneous noise, and, importantly, the difficulty of characterizing fish target strengths at variable and generally non-dorsal ensonification angles as further discussed below.

Computationally, linear form VBS at a given observation range - or equivalently at any instant in time after sonar pulse transmission - reduces to a numerical quantity consisting of the suitably scaled, 2-way propagation loss corrected, squared amplitude of the backscattered echosounder signal, divided by the volume of water instantaneously "effectively" ensonified. The authors have published fairly rigorous techniques for extracting VBS from the Simrad MS 2000 (formerly denoted the SM 2000) multi-beam (Melvin et al. 2003, Cochrane et al. 2003). These techniques have been extended in APPENDIX 7 to accommodate use of the narrow-beam (1.5°) transmit transducer in Mills Cross configuration with the receive array in the present multi-beam configuration. Relative-only VBS estimates have been extracted from the Minas Passage MS 2000 data sets as the system is uncalibrated. Absolute sonar system calibrations using the narrow beam transmit transducer would require measurements in a specialized facility not available locally. Multi-beam VBS analysis possesses two inherent advantages over visual target counting:

1) VBS has a precise mathematical/physical definition permitting the development of objective, fully automated processing codes which permit rapid assessment of large datasets.

2) Since VBS is a lumped energy-based signal measure rather than a target enumeration measure, aggregated targets do not require resolution into discrete echoes for assessment. This is important when fish targets are schooled.

It is essential to understand that multi-beam linearized VBS vs. depth profiles constitute a precise proxy for fish densities only if the mix of targets (i.e. fish) remains invariant with depth and if all relevant fish components possess acoustic target strengths independent of depth and of ensonification angle - which is never exactly true in reality. Vertical beam echosounders have the advantage that fish ensonification angles remain near dorsal. In contrast, our multi-beam derived VBS estimates for a given depth combine data from a number of beams at varying angles from the vertical, an angular mixture which varies with depth. At off-dorsal ensonification angles, fish azimuthal orientation relative to the ensonification direction is also a determinate of VBS. For these reasons multi-beam derived profiles of VBS vs. depth obtained using sonar beams inclined off-vertical may differ from those derived from vertical split-beam systems; nor can such multi-beam derived profiles be as confidently interpreted in terms of real vertical changes in fish density. Also, simple multi-beams like the MS 2000, unlike systems with split-beam capability, cannot supply independent estimates of acoustic target strength to reduce ambiguity in deducing fish densities from measured VBS levels.

VBS-based studies of fish in Minas Passage using MS 2000 multi-beam data presented several additional challenges. First, VBS is a lumped measure of backscatter from all sources including both fish and difficult to exclude, deep-penetrating bubble clouds highly prevalent in the tide-rips of the area. Secondly, VBS is observed to contain large noise components arising both from EK60 sounder interference and from the vessel's propulsion system. Automated processing algorithms have been developed to minimize this noise (APPENDIX 7), both by employing signal thresholding to minimize weak, fairly continuous noise sources, and by employing noise blanking in an attempt to identify and eliminate discrete noise bursts on individual echogram fan sections prior to their quantification. These noise suppressions algorithms have proven to be of limited effectiveness. Nevertheless, we do believe that multi-beam derived VBS profiles properly chosen and scrutinized in light of the above limitations can still inform one as to the gross characteristics of water column biomass distribution as well as furnishing important clues as to how these distributions may vary spatially (both vertically and horizontally), in response to tides and light levels, and even seasonally.

There is one inherent advantage to multi-beam vs. EK60 derived VBS estimates: For the matched sampling rates employed in Minas Passage, over a given length of survey profile the multi-beam non-redundantly samples a larger total water volume than the split-beam system. This arises from the multi-beam's 180° angular fan spread combined with reduced along track overlap between beam samples due to the multi-beam's 1.5° along-track beamwidth vs. 7° for the split-beam system. In consequence, the multi-beam when operating under good signal-to-noise conditions may afford superior time-spatial resolution of fish distributions to the split-beam system.

Starting with the 22 August 2011 survey and continuing to the end of the field program MS 2000 VBS vs. depth profiles were generated at 1 m depth intervals with correction for transducer draft. The single survey line or transect was used as the basic analysis unit (i.e. a spatial analysis unit in contrast to a temporal analysis unit as employed for much of the specialized analysis of the initial survey). Acoustic absorption corrections were applied to the multi-beam data consistent with survey-specific measured temperatures and salinities. Subsequently, signal thresholding was also applied and "Ring", "Arc", and "Spoke" noise removal algorithms added and refined as outlined in APPENDIX 7. The initial 10 Sept, 2010 data were eventually reprocessed in a manner consistent with the latter collected data sets.

4. RESULTS AND DISCUSSION

4.1 EK60 Split-beam Sonar

4.1.1 Backscatter levels

The initial step in the analysis of the EK60 data was to examine the backscatter throughout the water column including the near-surface backscatter "noise" below 1.5 m believed to originate from tidal turbulence associated bubble clouds. Immediately obvious are the large declines in individual transect backscatter, averaging 99.65%, and ranging from 98.10% to 99.97%, when the surface noise zones were removed from the September 2010 analysis (Table 3). For the 2011/12 surveys this is equivalent to the zone identified as fish in Table 6. While the amount of backscatter attributed to turbulence/ aeration is generally less when considered over the entire year it still ranges from 63 to 99% at the test site and 74 to 96% in the channel. This clearly illustrates the significance of the backscatter that is attributed to surface bubble entrainment – the degree of which varies dramatically throughout the tidal cycle. It should be noted that high winds were encountered during the 2010 and August 2011 surveys which likely contributed to additional aeration of the surface waters. Peak near-surface backscatter amplitudes and the deepest vertical penetrations of the bubble noise (i.e., backscatter) generally correspond to the period of maximum tidal flows, however, spatial differences were observed between transects for all surveys. Fortunately, although the surface noise was relatively strong there was no evidence of acoustic shading of the water column or of the bottom below the noise in the 2010 data.

Details of the water column backscatter from individual transects are provided in Table 3 for the 2010 survey and in APPENDIX 5 for the 2011/12 surveys. However, because the results from the

2010 survey have already been reported (Melvin and Cochrane 2012) we will focus our discussion on the results from the 2011/12 surveys. Differences in observations/ conclusions will be identified if, and when, they exist between the two study periods. In addition, our discussions will concentrate on general observations related to the spatial and temporal distribution and abundance of fish. Our approach will be to begin with a general overview of the data/observations then move into more specific details of our findings. Given the large amount of data collected over the year there are additional opportunities to explore a number of hypotheses or relationships in the future.

Over a period of about 10 months, eight surveys were conducted in Minas Passage that covered the FORCE test site and the adjacent channel. Each survey was divided into a series of grids where each grid included 9 transects over the test site and 3 representing the channel (Table 4). The date, time, number of transects and physical characteristics of the water for each survey are described in Table 5. Mean S_a by survey for the entire water column, for the water column below 10 m, and then edited to retain only fish (i.e., non-turbulence related backscatter) are presented in Table 6. A summary of the mean acoustic backscatter from the test site and the channel expressed in terms of S_v, NASC, ABC and S_a from fish-like targets observed during each of the 8 surveys in Minas Passage is presented in Table 7. In addition, **an estimate of fish biomass based on a Target Strength (TS) weight value of -35.5 dB (characteristic of a 28 cm herring) is provided.** It is important to note that the biomass presented must not be considered as an absolute value. Biomass in tonnes is presented as an understandable measure and is derived from the primary backscatter units (S_v , NASC, ABC and S_a). It is a relative term that can be compared from survey to survey and between areas.

Examination of biomass estimates by survey reveals distinct differences between the amount of fish at the test site and in the channel, and that estimated biomass varies both spatially and temporally (Table 5). In August, September and November the observed biomass is greater in the channel than at the test site while in May and June the opposite occurs. During the winter periods, January and March, there is essentially no difference in estimated biomass between the two areas. This relationship is best illustrated in Fig. 9 which displays the monthly biomass estimates for the test area and the channel. The figure shows that there are no significant differences ($P < 0.01$) between areas for October, January and March with the test site having more fish than the channel in late summer early fall, but less fish in May and June. The outstanding data point is November where the estimate is much larger in the channel than at the test site. This point was checked and is valid, but it is also the result of a single dense school of fish that appears in one transect during the survey. Without the one transect encountering a school of fish the November biomass estimate is not significantly different from that observed at the test site.

In summary the mean monthly backscatter from the surveys indicates a relatively consistent pattern of fish-like backscatter at both the test site and in the channel. Beginning in August there is a gradual increase until about November then a decline during the cold winter months and finally a rapid increase in May with a maximum in June. This is generally consistent with the known migration and distribution of fishes in the upper Bay of Fundy. During the late summer early fall the anadromous fishes, adults and juveniles, leave the freshwater to begin the marine phase of their life cycle. Many likely linger in the upper Bay of Fundy before moving into deep water at the onset of winter. With the beginning of spring the anadromous fishes return to the area and there is also an increase in the abundance of Atlantic herring known to spawn in the inner Bay of Fundy between May and July, thereby increasing the backscatter associated with fish.

One question that always arises from point estimates (i.e., single estimate for the month) is the degree of data compatibility from year-to-year. We have only a single survey from 2010 that is comparable in the design and coverage to the 2011/12 surveys. The September 2010 survey covered the majority of the test area of the September 2011 survey – the exception being that both the 2011 farthest north and farthest south transects were not included in the 2010 survey. Comparing the two surveys shows that there is no significant difference ($P < 0.01$) between the mean biomass (backscatter) in September 2010 and 2011 (Fig. 10).

Unfortunately, a survey could not be undertaken every month of the year due to weather and vessel availability and what occurs during these interim periods is only speculative. If funds become available effort should be made to fill in the gaps, either from existing data sources or additional studies. The fact that there appears to be some consistency between years (albeit one survey) suggests that the data would be comparable. There also appears to be some consistency in backscatter with season.

4.1.2 Vertical Distribution

The acoustic surveys conducted in Minas Passage over the year provide extensive information on the abundance and vertical distribution of fish-like targets. Because of the large volumes of data available when the backscatter is assessed at 1 m intervals for the entire water column, the information is presented graphically rather than in tabular form. However, the numeric backscatter at any depth and for any transect are available if required. In essence, the data are presented in two forms for each of the 8 surveys. The first series of graphs illustrates the proportion of backscatter and area backscattering coefficient (ABC) for the entire survey separated into the test area and the channel. The initial graph is restricted to only water depths consistent with the test area when presenting data for both the test area and the channel Fig. 11a), while the second graph illustrates the same parameters for the full depth of the channel (Fig. 11b) using the channel data alone. Thereafter, the backscatter for each completed survey grid is presented for the channel (Fig. 11c) and for the test area (Fig. 11d) in terms of proportion of backscatter and the ABC. All estimates are based on the mean backscatter/1 m interval. The same representation is used for each of the eight surveys conducted during this study (Figs. 11 to 18).

Immediately evident from the figures is that there are clear bands of distribution throughout the water column where fish are concentrated. The vertical distribution is also variable from survey-to-survey and by grid, and not necessarily consistent between the test area and the channel even for common depths. For the August 22 survey the distribution of fish by depth was different between the test area and the channel (Fig. 11a). Peak backscatter in the test area occurred near the surface (< 3 m), about 10 m, and between 16 and 22 m, while in similarly shallow areas of the channel the peaks occurred between 10 – 15 m and 20 – 22 m. Overall, backscatter was greater in the channel than at the test site. Examination of the full channel depth range (Fig. 11b) disclosed another peak at about 50 - 60 m which coincides with the increased slope at the channel break. Specific grids undertaken during the survey illustrate how the distribution pattern can change with time and tidal phase. Most surveys began on the falling tide. In the channel, peak backscatter distribution appears to move closer to the surface from Grid 1 to Grid 2, then back to an intermediate (40 – 60 m) depth (Fig. 11c) suggesting that fish may move closer to the surface with changing tide. At the test site the observations show strong backscatter between 12 and 20 m, declining to about 35 m during the ebb tide. This would imply that fish are moving out with the tide (Fig. 11d). In the other 3 Grid's (phases of the tide) at the test site acoustic backscatter was distributed evenly throughout the water column, except Grid 2 where two dominant peaks occurred at 10 and 22 m. These peaks are the result of a few small individual aggregations of targets in the test area.

Similar results were observed during the September 19 survey where the overall backscatter distribution showed major modes in the shallow water (~5 m) and between 14 and 28 m (Fig. 12a). Backscatter distribution was consistent between the test area and the channel, except for a spike that occurred at 49 m in the former. This depth is near bottom at the break between the test area and the channel. Overall backscatter was much greater in the channel than at the test site for most depth intervals (Fig. 12a). In the channel another major peak/spike was observed near bottom at about 115 - 118 m (Fig. 12b) during Grid 3. The increased backscatter in the channel occurred in Grid 3 during the early phase of the flood tide (Fig. 12c). It was not uncommon to document an increase in backscatter in this area (i.e. depth) during several of the surveys conducted over the year. At the test site the pattern was slightly different when the backscatter was examined by Grid (Fig. 12d). A peak was observed between 15 and 25 m but the greatest backscatter even at these depths occurred during Grid 1 (ebb tide) and Grid 4 (flood tide). Fish-like targets were more abundant and more broadly dispersed throughout the water column below 15 m than in the other Grids (Fig. 12d). A spike in backscatter occurred at 49 m in Grid 2 reflecting a small school of fish observed in the deeper water of one of the transects near the channel break.

Backscatter in the channel decreased but increased in the test area in October observations (Fig. 9). Overall the backscatter was distributed through the water column with multiple peaks occurring in both areas (Fig. 13a & b). The largest proportion of backscatter was observed in the top 12 m at the test site and in the top 40 m in the channel. The backscatter at both locations was approximately equal. A slight increase in backscatter was also observed near the channel bottom at ~130 m (Fig. 13b). Looking at the backscatter distribution in the channel by Grid, it is difficult to detect any pattern, except that the majority of fish-like targets occur at depths less than 35 m and that far more backscatter was observed during Grid 1 and Grid 3 (Fig. 13c). A similar observation was made at the test site where the majority of backscatter occurred in the top 22 m and was dominated by Grid 1 (ebb tide) and Grid 4 (flood tide) (Fig. 13d).

During the November 22 survey the majority of backscatter was found above 10 m at both the test site and in the Channel (Fig. 14a). Below 10 m the backscatter was relatively constant on a proportional bases with the overall backscatter greater in the channel than at the test site for all depths (Fig. 14a). No increase in backscatter was observed near bottom in the channel (Fig. 14b). Backscatter was also relatively constant throughout the water column in the channel from Grid to Grid with the majority occurring in the upper 15 m (Fig. 14c). Although relatively consistent for Grid 1 and 2 there was a significant increase in backscatter between 18 and 32 m for Grid 3 at the test site (Fig. 14d).

When the overall mean backscatter for the January 25 survey was examined it showed what might be considered as an unusual pattern that oscillates at about 3 m vertical intervals at both the test site and in the channel - with more backscatter being associated with the latter (Fig. 15a). A similar oscillating pattern is observed throughout the deeper waters in the channel, although there is a slight increase in backscatter in the deepest waters near bottom (Fig. 15b). The pattern is likely due to the relatively small amount fish present in the area during the extreme conditions of winter and a more uniform distribution of backscatter in the water column. The peaks and troughs represent the variability in presence of organisms as a function of changing tidal depths over a 24 hour period. Note this is the first 24 hour survey to be conducted and distributions are likely confounded by the day/night cycles. Examination of the mean backscatter by grid reveals some patterns consistent with earlier surveys in that peak backscatter occurs at less than 15 m depth in the channel (Fig. 15c). However, beyond the shallow water the pattern is similar for most Grids between 40 and 100 m, peaking near 40 m then slowly decreasing with increasing depth. There are also some Day/Night differences in the amount of total backscatter. Grids 4 and 5 with the highest mean backscatter represent night sampling suggesting there may be some movement up into the water column at night. The situation is slightly different at the test site with the peak backscatter occurring around 30 m for two daytime Grids (1 & 2) and a large concentration of backscatter near bottom (Fig. 15d).

The second 24 hour survey was conducted on March 19 and produced a backscatter distribution pattern similar to the previous survey. Oscillating waves of backscatter were observed throughout the water column without any easily identifiable depth of maximum concentration (Fig. 16a & b). Overall backscatter was also low at this time of year (winter) at the test site and also in the channel (Fig. 9). For the individual Grids several peaks were identified. In the channel spikes occurred at 5, 22, and 42 m depths with a broad distribution of increased backscatter occurring in Grid 1 between 30 and 70 m. Excluding the occasional peaks, the mean backscatter by grid decreased slightly with depth in the channel (Fig. 16c). Backscatter distribution in the water column differed at the test site (Fig. 16d). Increased backscatter was observed near the surface, between 18 and 35 m, as well as several spikes at water depths > 35 m for several of the Grids undertaken during the 24 hr survey.

The May survey represents a period of time when mean biomass densities had increased from the winter lows, especially at the test site (Fig. 9). This was the first survey where the estimated water column biomass at the test site was statistically ($P < 0.01$) greater than that in the channel. Unlike the previous two surveys distinct vertical distribution patterns began to appear again. Figure 17a, which shows the mean backscatter (ABC) in 1 m intervals, depicts the majority of backscatter above 10 m in the water column for both the test site and the channel (Fig. 17a). An additional peak is seen at 30 – 34 m at the test site and at about 51 – 54 m in the channel. Examination of the Grids indicates the consistency of the surface distribution throughout the entire survey in the channel and the influence of a single transect for the generation of the 50 - 54 m peak on Grid 4 (Fig. 17c). At the test site the majority of backscatter was observed near the surface for most survey Grids; however, the distribution between 20 and 40 m was more variable depending upon the Grid. The strongest backscatter occurred at 32 m for Grid 4, but minor peaks were observed between 20 and 35 m in several other Grids (Fig. 17d).

The highest biomass observed during the 1 year study occurred on June 25, 2012. Biomass in the test area again was statistically ($P < 0.01$) greater than the channel (Fig. 9). Overall the vertical distribution of backscatter in the channel and at the test site was relatively similar from the surface to just over 40 m (Fig. 18a). Below 40 m multiple peaks in backscatter, extending to over 100 m were observed in the channel (Fig. 18b). The large peak at 45 m is associated with a school of fish off bottom near the channel break. This 24 hr survey serves to illustrate how extreme the distributional variability of backscatter (i.e. fish) can be extending over just two tidal cycles spanning the day-night transition. The backscatter layer between 20 and 40 m shows up in both the channel and the test area for the Grids, but it is primarily the product of Grid 1 for the former and Grids 5 and 6 for the latter (Fig. 18c & d). Several strong layers resulting from other Grids were also observed below 40 m in the channel (Fig. 18c). At the test site the backscatter was dominated by 3 Grids (5, 6, and 7) with distinctly different backscatter vertical distributions: Grid 5 had a range between 28 and 38 m, Grid 6 between 18 and 35 m and Grid 7, between 18 and 15 m (Fig. 18d). These Grids represent the change from day to night with Grid 5 occurring during the day, Grid 6 late day/sunset, and Grid 7 night (Fig. 18d, 3-D backscatter plot for Grid 6 shown in Fig. 19). Assuming the backscatter is associated with fish, then the change in distribution at the test site likely represents the upwards diel movement of fish in the water column at night.

In summary the data presented illustrate that the distribution and abundance of fish-like targets can be monitored and quantified using acoustic technology. Over the year-long study we have found the vertical distribution and strength of acoustic backscatter to vary with depth, tidal phase, season, day/night, and survey Grid. The extent of this variability appears to be related to the quantity of fish in the area and likely the species present. In some cases the fish-like targets seem to remain at about the same depth as the tide level changes, while in other Grids they maintain a constant depth off bottom. Generalizing the observations, at the test site there are 3 main layers or zones of backscatter; the upper water column (< 10 m from the surface), the middle water column (15 - 35 m), and the near bottom (> 45 m). At these depths a significant proportion of the backscatter can and will interact with a proposed tidal power unit. The actual proportion can be calculated from the existing data and will of course depend upon the vertical position of the turbine. Maximum backscatter at the test site occurs in May, June, and possibly July (no surveys) with estimates greater than in the Channel during this period. In August and September the backscatter at the test site was much lower than in the channel. In November backscatter at the test site and in the channel are about equal. The water column distribution of backscatter in the channel can be either consistent with or significantly different from that observed at the test site depending upon the month and timing of the survey grid.

An extensive amount of data were collected during this study that will help developers and regulatory agencies evaluate the potential impact of tidal power development in Minas Passage. In this report we have provided only general statements about the distribution and abundance of fish-like scatterers. The data can, however, be used to address specific development configurations once they are known. It must be stressed that sampling covered a total of only 8 days in an entire year at somewhat irregular intervals and that a number of large gaps exist in the data. Additional studies are needed to examine the months for which there were no surveys and how variable the observations are from day-to-day. Another critical factor in the analysis is the lack of ground-truthing. **While the estimates of backscatter will not change, the extension of these data to biomass is purely speculative based on knowledge of the area.** New studies should incorporate sampling to identify the acoustic targets.

4.1.3 Target Strengths (TS)

4.1.3.1 Results and Discussion

Target strength in the simplest terms is the ability of a target like fish to return an echo. More specifically it is defined as the ratio of the incident acoustic intensity to the reflected acoustic intensity, referenced to a distance of 1 m from the target, as follows:

$TS = 10 \text{ Log } (I_r / I_i)$

where

I_r = reflected acoustic intensity at the reference distance

I_i = incident acoustic intensity

In essence, it is the proportion of energy reflected by a target relative to the incident energy transmitted from an echosounder or sonar. Knowledge of target strength enables one to convert a measure of received acoustic energy like Volume Backscattering Strength into the number of or volume density of targets within an acoustic beam. For fish possessing a swim bladder, greater than 90% of the reflected energy is a function of size and shape of this organ. Target strength is a function of the size, structure, and physical properties of the target which for aquatic organisms include biological conditions of the specific target, and to a lesser extent the properties of the enclosing environmental medium. An identical target observed by a multi-frequency echo-sounder will have different TS values for each frequency. In this study a 120 kHz transducer was deployed for all surveys. System calibrations were based on the TS of a 38.1 mm tungsten carbide sphere. The standard TS/Length equation for a fish is;

TS = Slope Log (Length) - intercept

where

Slope = slope of the TS-length relationship usually fixed at 20
Length = fish length (cm)
Intercept = intercept of the TS-length relationship.

Additional parameters have been incorporated into other TS equations to account for maturity stage and depth of fish targets (Ona 2003). Generally speaking, for fish the stronger the TS of a target the larger the fish after inter-specific differences are taken into consideration.

In general, acoustic targets greater than -60 dB and less than -30 dB are considered fish with TS being dependent upon the fish length and species. Unfortunately, the information collected in Minas Passage to date does not permit any reliable identification of species, yet species within the observed TS dB ranges are known to occur in the area at the time of sampling. Any reference to species is purely speculative. Given the observed TS distributions it is likely that the targets with a TS < -52 dB represent relatively small fish in the order of 10 cm or less (e.g. young of the year gaspereau or herring). TS distributions in the range of -51 to -47 dB are characteristic of juvenile clupeids in the 15 - 20 cm range (e.g. juvenile herring - age 1+). A TS in the range of -46 to -41 dB represents larger and likely adult fish such as herring, gaspereau, or smelt. The few targets with a TS > -40 dB are most probably one of several groundfish species known to occur in the area or a migratory shad/striped bass.

In this study we explored the variations in mean TS of individual targets by survey (season) and by vertical distribution at the FORCE test site and the broader channel in Minas Passage. A major limitation of the study was the absence ground-truthing of the observed fish-like targets at the time of surveying. That being said the operation of most conventional sampling gear is extremely difficult in the rapid moving waters of the Passage. Without this information all inferences regarding fish species are based on literature values and previous knowledge of the species and size present in the area. A fish study by CEF Consultants between 2009 and 2010 monitored the seasonal distribution of fishes in the Passage (CEF 2011). Based on their findings the dominant species present throughout the summer months was herring, with catches of mackerel, gaspereau, smelt, lumpfish, flounder and dollar fish. Occasional larger species such as striped bass and shad were also reported.

The TS distribution of individual targets by survey month indicated a broad distribution ranging from the upper to the lower threshold detection boundaries of -30 to -60 dB (Fig. 20). Multiple modes reflecting different fish species or size of fish can be seen in the histograms, except for the winter period – November through March. From August to November there is a general decline in the number or proportion of higher TS targets suggesting the departure of larger fish from the area. In May the proportion of higher TS targets increases into June, and likely remains at about the same level in July (no survey), thereby completing the annual cycle (Fig. 20). During the winter months the frequency appears to be uni-modally distributed around a mean TS of between -51 to -49 depending upon the month. These low TS's are generally considered characteristic of small or otherwise poorly reflecting fishes.

Mean TS by survey was found to differ significantly during certain periods of the survey year (Fig. 21). Overall TS decreased significantly ($P < 0.05$) from -44.57 dB in August to September reaching a low in October. Targets in this TS range lie in the size range of juvenile herring. Thereafter the TS gradually increased over the winter months (November through March) remaining in the general range characteristic of juvenile fish. Between March and May the mean TS jumped significantly ($P < 0.05$) implying the influx of larger fish, although a large number of smaller targets were still present in the area. This may be characteristic of adult anadromous fishes moving through the Minas Channel to ascend their natal rivers. The TS decreased significantly ($P < 0.05$) from May to June with a mean TS similar to that observed in August (Table 8). Unfortunately no surveys were conducted in December, February, April, or July.

Examination of the distribution of mean TS for each survey by 10 m depth intervals serves to illustrate the variability of TS by season and by depth including the depths associated with the test site and the deeper channel. Observations above 60 m are generally considered characteristic of the test-site while those deeper characterize the channel. For the spring and summer surveys there appears to be two modes or peaks in the vertical distribution of stronger mean TS, one between 10 and 40 m depending upon the tide and another in the deeper waters at depth greater than 100 m (Fig. 22). The winter months (November through March) consistently show the strongest mean TS as originating from targets below 100 m, however even these are weaker by a couple of dB than those observed at similar depths during the summer. This would imply that, overall, larger fish are more prevalent in the spring/summer than during the winter. During the spring/ early summer (May and June surveys), and even late summer, the mean TS around the 20 - 40 m peak is similar or slightly higher than the TS observed at depth > 100 m. However, as fall progresses (September/October) this pattern changes such that the larger TS (i.e. fish) are observed primarily in the deeper areas of the channel. This pattern persists over the winter although the mean TS's during this period are weaker. There also appears to be a weak TS peak at 50 – 60 m in most surveys that corresponds roughly with the transition (channel edge) from the test site to the channel.

To investigate seasonal patterns in mean TS the monthly data by 10 meter depth intervals were overlaid in two figures. The first figure represents water depths consistent with the FORCE test site and the second depths associated with the deep channel water (Figs. 23 & 24 respectively). It should be noted that in this analysis the data were not split into the test site and channel, so mean TS was determined from all targets within a depth interval regardless of its location. Figure 23, which illustrates the TS distribution for water depths associated with the test site, shows two mean TS general modes; September/October and May. The one exception is the 0 – 10 m interval where there is a real decrease in the September mean TS. This interval was subject to intensive removal of backscatter (fish and noise removed because of uncertainty) due to the extreme levels of background noise (turbulence) in the near surface zone. Error estimates for each depth interval and month are provided in Table 8. Mean TS at all water depths were consistently lower (more weakly scattering targets) throughout the winter months. There also appears to be a relationship between the monthly modes and the water depths (20 – 40 m) associated with peak backscatter and larger fish (Fig. 23). Water depths associated with the channel showed a similar pattern with peaks in the mean TS occurring in September and May declining during the summer and winter months (Fig. 24). A general increase in mean TS with depth within surveys is also evident for the deeper waters (> 60 m). This implies that fish size may vary (increase) vertically with the highest TS occurring in the deepest waters of the channel during September/October and May.

Day/night TS comparisons were examined for the three surveys which were conducted over a 24 hour period; January 25, March 19, and June 26, 2012, representing three seasons (Winter, Spring and Summer). The results clearly show distinct differences between the seasons (Fig. 25). In the January survey there is essentially no difference in the mean TS with depth, except in the 81 – 90 m and 121 – 130 m depth intervals. Overall there is no significant difference ($P < 0.05$) between day and night mean TS (Table 9). The highest TS's were observed in the deeper depth intervals. The low TS suggests that the majority of targets are likely small fish, including in the deeper waters where the mean TS was around -47 dB both day and night. The March survey shows a slightly different picture. Statistically there is a difference ($P < 0.05$) in the total mean TS between night and day with the night targets generally being stronger than during the day (Table 9 and Fig. 25). At most depth intervals TS differs from night to day. It is also evident that there are two water depths where mean TS is much stronger at night relative to the day time observations. The mean TS of individual targets at depth intervals 21 – 30 m and 91 – 110 m increases by about 3 and 6 dB from day to night respectively (Fig. 25). Fish may be moving up into the water column from bottom (acoustic dead zone) or moving through the passage at night as a function of tidal phase. In fact both scenarios may be true where the larger targets in the channel may represent fish moving off bottom while those around 20 – 30 m depth may be in transit.

June represents a period when a variety of fishes, both summer resident and transient species, would be expected to be in the upper Bay of Fundy, consequently an increase in mean TS of the individual targets. Although there was a marked difference between day and night mean TS with water depth overall there was no significant difference ($P > 0.05$) when the entire water column is examined.

This would imply that the same fish are present, but their distribution changes from day to night. Unlike the other 24 hr surveys, there was a decrease in mean TS between 20 and 40 m from day to night. Below 50 m the decrease was from night to day is consistent with earlier observations. The exception to this observation was in the deep water of the channel at depths > 120 m. Overall mean TS was stronger at night in June than in March or January implying larger or a different species of fish in the water column.

4.1.3.2 Summary

The results of the TS analysis clearly illustrate that there are temporal and spatial differences in the mean TS in Minas Passage. Two peak periods stand out as having the strongest mean TS implying the presence of larger fish; August and May, although the August TS is much larger than the May. These two periods correspond to the approximate time when migratory fish should be moving through the passage. Surprisingly, the mean TS in June is not significantly different ($P > 0.05$) from March and the mean may have been influenced by a large number smaller targets (e.g. Juvenile herring), given the nearly factor of 4 greater number of targets detected. The lowest mean TS was observed in October at a time when most fish would have moved out of the area to over-wintering areas. The mean TS for September through March would suggest small fish occurring throughout most of the fall and winter. Mean TS was also found to vary with depth. Overall TS was found to general increase with depth regardless of the season and especially in the channel waters below 50 m.

Although filters were established between -55 and -30 dB for the extraction of individual targets there is a clear seasonal pattern in TS distributions over the surveys. From August to October there is a decline in the proportion of stronger targets until November when these targets (> -42 dB) have all but disappeared. This general absence of stronger targets continues throughout the winter months until May (no surveys in April) when they appear again and likely continue to be present throughout the summer. Assuming the TS distribution is reflective of fish size, the pattern is consistent with the expected seasonal movement of fish into the area. During the late spring, summer and early fall, larger fish would be expected to be in the passage transiting to/from rivers (anadromous species) or feeding. With the onset of winter many of the larger fish would be expected to leave the area.

Temporal and spatial differences in mean day/night TS were observed in Minas Passage during the study period. The first of three 24 hour surveys indicated that during January there was no significant difference ($P < 0.05$) between day and night TS. By March this changed slightly with a statistical difference in overall mean TS and mean TS for most depth intervals, with the night targets being stronger than the day. In June the situation changed again with marked differences in the mean TS for specific depth internals, but not for the overall water column. These observations are consistent with the diel movements of the fish known to be present in Minas Passage at the time of the survey. During the winter most of the larger fish would have moved to deeper waters outside Minas Channel and the majority of fishes are likely juvenile and small, although there may be some resident larger fish in the deep channel waters. By spring there is some indication of movement of the larger of the fish present moving off bottom at night in the deeper waters. The concentration of targets between 20 - 30 m is still relative small in size (based on TS) compared to those in the deep waters. June is a dynamic period for fish in the inner Bay of Fundy as large and small migrants move into and transit the area, but there is no overall difference in mean TS. This would suggest the same fish are present but there distribution changes between day and night. Below 40 m the pattern is characteristic of natural cycles with larger fish moving up in the water column. The peak in mean TS between 20 and 40 m is likely herring which during the day are found in the water column. At night they are traditionally found feeding very near the surface, possibly in the acoustically unobservable zone above the transducer depth.

4.2 MS 2000 Multi-beam Sonar

4.2.1 General

The extended time period from the initial Sept. 2010 survey to the next survey in Aug. 2011 afforded time to experiment with multi-beam processing algorithms using the initially acquired dataset. Data were most commonly viewed as single fan sections (Fig. 26) but alternative display options such as aerial multi-ping sections (Fig. 27) were also explored. Fan sections did reveal distinct and often abundant fish targets in the upper 10 - 20 m of the water column over a significant portion of the initial survey with these targets often displaying short range aggregation tendencies (Fig. 26 - right of center). Other fish-like target echoes were occasionally observed at deeper levels to bottom (depths are reported relative to the transducer depth of about 2 m). Apparent bubble/turbulence clouds frequently extended from the surface to, on occasion, depths of 20 m or more (see backscatter distribution above), similar to observations from the earlier pilot survey (Melvin et al. 2009). Differences in character between backscatter arising from fish aggregations and those arising from bubble clouds were sometimes subtle suggesting any attempt to construct fully automated algorithms to identify fish targets would be problematic. Isolated fish-like echoes around or just below the periphery of bubble clouds which could represent either fish attracted to areas of downwelling or, alternatively, simply small detached areas of bubbles were particularly difficult to classify on both the multi-beam sonar and the split-beam sounder. The former being more difficult as editing/filtering tools were not available on the commercial market.

4.2.2 Fish Density

4.2.2.1 Results

Estimation of fish density (fish/m^3) using manual target enumeration was explored using two differing turbine-transiting profiles on the initial Sept. 2010 survey. Profile 1 consisted of 1700 fan sections collected between 12:33:11 to 13:01:11 GMT on Sept 16, 2010, and encompassed most of survey line T4a while moving west-to-east against a strong ebb flow. Profile 2 consisted of 529 fan sections collected between 16:08:53 to 16:17:37 GMT and mostly coincided with line T4f while moving west-to-east just prior to the end of the ebb cycle (slack low tide interval). Profile 1 fish echoes appeared particularly numerous around a 15 m depth mode. For this profile, coordinates of approximately 31,400 individual fish echoes were logged for an average of 18.5 fish echoes per fan section. Profile 2 was characterized by markedly lower visual fish densities in the same depth range, only 1450 fish targets being observed for an average of about 2.7 echoes per section. While average water depth was modestly lower on Profile 2 (~ 41 m) than on Profile 1 (~ 45 m) due to differences in location and varying tidal phase, considerably lower Profile 2 fish densities were still very apparent.

Fish densities were computed for 2 m vertical bins extending from the 2 m transducer depth to a maximum profiling range defined by the minimum transducer to bottom distance, for successive groups of 100 pings: For each 2 m depth bin, individual ping "effective" ensonified water volumes were calculated using the hybrid analytical-numerical integration outlined in APPENDIX 6 and summed over the specific 100 ping interval. Total fish counts summed for each 2 m depth interval over the same 100 ping interval were then divided by the corresponding total ensonified water volume appropriate to the relevant depth bin to yield fish density as a function of depth. Selected examples of fish density analyses are shown in Figs. 28(A) and 29(A), both for 100 ping sequences recorded on two differing portions of the ebb tide cycle, the first, covering a period when visually discerned fish targets in the 15 m depth range appeared especially numerous.

4.2.2.2 Virtues and Limitations of Direct-Counting

A few remarks regarding direct-counting will be made at this point: The direct-counting methodology as presented remains valid regardless of the degree of along profile ping-to-ping ensonification overlap - or even in the total absence of overlap. Nor does the technique require tracking specific targets between successive ensonifications to eliminate counting redundancies – an uncertain process as our multi-beam does not incorporate beam stabilization. In the methodology presented the fundamental uncertainty arises from the assignment of an "effective" fore-aft (out-of-fan) beam width to define the ensonified water volume in which target echoes are being observed and counted on a specific transmission. Proper choice of an "effective" beam width depends on the signal-to-noise ratio required to reliably discern a fish echo above ambient background. This in turn will depend upon fish target strength, observation range, the level and character of the ambient background noise including target "clutter" from bubble clouds as well as operator subjective factors. Therefore, at least a factor of 2 uncertainty in fish densities is likely – which considered in combination with the laborious nature of the implementation, limits its usefulness as a general purpose tool. Nevertheless, the "human component" offers potentially strong rejection of bubble cloud backscatter, of interference from the simultaneously operating split-beam sounder, and other transient noise bursts in a manner not unlike the manual "editing-out" of unwanted bubble clouds during the EK-60 processing.

The plotted fish density profiles of Figs. 28A and 29A have been scaled to a nominal 1° (unitary) out-of-fan beamwidth. A single realistic or "effective" - as opposed to "nominal" - beamwidth, as discussed above and in more detail in APPENDIX 6, is difficult to assign but may be of the order of 3.75°. In this case actual fish densities will be reduced from those plotted by a factor of $\sin(3.75^{\circ}/2)/\sin(1^{\circ}/2) \sim 3.75$.

4.2.3 Volume Backscattering Strength

4.2.3.1 Volume Backscatter - Initial Survey

Volume Backscattering Strength, S_v, in linear form, is directly proportional to target density provided all targets backscatter identically. An example of S_v extraction, both with and without beam pattern corrections, using the same 100 ping data series used to generate Fig. 28(A) is shown in Fig. 28(B). The similarities between fish density and S_v vs. depth profiles between 10 and 20 m are to be noted. The principal difference between these two measures is that the S_v profile of Fig. 28(B) includes backscatter contributions from surface bubble clouds while for the fish density profile of Fig. 28(A) any such bubble cloud contributions have been largely eliminated by the manual target selection process. Fortuitously, in the example shown the bubble cloud backscatter appears confined to sufficiently shallow depths that deeper fish origin S_v levels, are only modestly affected. The comparison data series collected near the end of the ebb tide cycle, when fish densities in the vicinity of 15 m depth appeared significantly lower is shown in Fig. 29(B). It should be noted that a high degree of noise reduction must be applied to these data and results are very sensitive to the “fine tuning” of the noise suppression parameters. More sophisticated noise removal algorithms have been utilized for the VBS data presented in APPENDIX 8 than employed for S_v analysis in Figs. 28 & 29.

Inspection of S_v vs. depth over the duration of the initial survey (Sept. 2010) showed an apparent systematic variation of the strength of the fish layer which tended to persist around 15 m depth. Figure 30 shows a plot of peak amplitudes of S_v (linear form) vs. time, manually scaled from plots analogous to those of Figs. 28 & 29 for the scattering layer displaying a modal peak around 15 m extending over the full duration of the survey (only “peak” fish layer S_v amplitudes could be reliably separated from the bubble cloud scatter in the majority of cases, background bubble noise levels precluded any effective numeric vertical echo integration). The simultaneous tidal amplitude sinusoid is also shown.

While an S_v peak broadly centered in the 15 m depth range was a reasonably persistent feature in the survey, S_v levels for the profiles used to produce Fig. 30 peaked sharply between about 12:35 and 13:15 GMT – a roughly 40 min time interval centered about 2 hr 34 min into the ebb tide cycle. Fish were present earlier but in markedly lower concentrations, as well as present later in lower and generally declining concentrations extending over the remainder of the ebb tide cycle. On examining the locations of survey tracks associated with the time-varying fish concentrations displayed in Fig. 30 it did appear that concentrations were consistently lower on transects north (shoreward) of the turbine. However, this may well have been a consequence of when these transects were steamed rather than a general function of their geographic location.

Some fish were present below the 15 m modal layer but in much lower concentrations than the peak values observed around 15 m. Below 15 m, the limited set of concentrations derived from direct counting probably constitute the more reliable data on vertical fish distributions since the S_v data are more prone to any contamination by residual bubble clouds extending below 15 – 20 m and from other noise of non-fish origin. Dominant species, hence target strength distributions, may also systematically vary between shallow and deeper fish concentrations. Target strengths as well as fish concentrations determine S_v levels. Species interpretation is difficult using a multi-beam in isolation since target strengths are not easily extracted nor is our multi-beam system calibrated in an absolute sense to allow this. Fortunately, for this survey we do have EK60 target strengths as well as limited ground-truth in the form of 9 trawl samples taken in the Minas Passage area on the 16 & 17th Sept. 2010 by CEF Consultants (CEF Consultants 2011) during a parallel combined trawl/acoustics survey. Eight (8) of 9 trawl samples were dominated by herring, the trawl yielding the highest herring concentration was a set west of the turbine site in relatively shallow water (60 m) with a headline depth between 9.1 and 18.3 m and with sampling centered 2 hr 33 min into the ebb tide cycle (essentially the same tidal phase when our acoustic concentrations peaked). However, the trawl sampling was on the **night** time ebb tide while our observations were conducted on the preceding **day** ebb cycle. Nevertheless, it seems reasonable to conclude that the multi-beam was seeing mainly herring.

The significantly enhanced herring flux observed over an approximately 40 min interval is interesting. The average prevailing upper water column current would be of the order of 2.5 m/s. Assuming fish moving predominately passively at these current magnitudes, the along-channel spatial dimension or extent of the enhanced concentration would be of the order of 2400s x 2.5 m/s = 6000 m. Note that the highest fish concentrations appear to have moved out of the survey area prior to maximum ebb flow (13:30 GMT ignoring local effects). Were herring utilizing ambient tidal currents to systematically move out of Minas Basin long term, or will they, perhaps, be advected back on the next flood tide at a different point along the cross-Channel profile? If herring concentrations are being repetitively and largely passively advected by the tides the cumulative probability of encounters with TISEC devices could be substantially enhanced. Note that in the present case, at 13:26 GMT, near the end of the period of highest fish density, the physical top of the OpenHydro turbine intake, was 19 m below surface. Since tidal height was declining during the preceding period of highest fish density, most of the observed fish flux would have passed over the top of the turbine thereby minimizing the potential for any interactions.

Little is known about herring spatial aggregation in and around the Minas Passage TISEC test sites. One possibility is that herring aggregated on or near bottom during the preceding high tide slack water and were vertically re-distributed when near-bottom ebb flow currents reached a certain critical threshold. Such a threshold might be related to the onset of intense whole water column turbulence and the rapid generation and growth of deep penetrating bubble clouds. The ~40 min. interval might correspond to the time required to sweep any vertically redistributed fish out of the most turbulent area of the passage. This would be consistent with the generally observed pattern of herring tending to aggregate near or on bottom during the day normally moving up in the water column at night.

4.2.3.2 Volume Backscatter – Total Survey Period

The volume backscatter from the MS 2000 was computed for each survey. APPENDIX 8 shows the computed linear form S_v vs. Depth profiles for all 9 surveys on a systematic grid-by-grid, transect-by-transect basis, excepting the initial survey where lines were steamed on a more ad-hoc basis. Primary analytical parameters utilized are listed as well as the underlying field-collected data files for future reference.

One systematic difference between the split-beam and multi-beam analysis should be pointed out: The cross-channel transect X2 in the multi-beam analysis terminates at the west end of T0 whereas in the split-beam analysis it terminates at the west-end of T8. Consequently, the split-beam analysis achieves a more complete separation of the test site from the more southern portion of the channel by eliminating the short slice across the test site. While this analytical difference should be noted we do not believe it to be of consequence in the results which follow. The primary comparisons of multi-beam and split-beam data are, in any case, limited to the test site profiles T0 – T8.

On examination of the collected VBS profiles several facts are evident:

1) Within the test site grid, bubble plume backscatter is both prevalent and dominant in the upper 10 - 20 m of the water column and often considerably deeper. The exception is within 90 min. or so of high and low tide slack water when the action of bubble plumes is frequently more modest and sometimes virtually non-existent. Contributions from bubble plume backscatter remain quite apparent in the VBS vs. depth profiles even after application of noise reduction algorithms. Bubble clouds are also frequently apparent in the cross channel transects but markedly less prevalent for the south shore coastal transect Y1.

2) VBS levels computed for depths below those strongly affected by bubble clouds are also frequently enhanced when tidal currents are strongest. To make headway against strong tidal flows the survey vessel must increase propeller rpm's. This leads to a major increase in noise, especially "spoke" noise. While much of this noise is recognized and removed by specialized processing algorithms, enough remains to lend a typically "irregular" appearance to deeper VBS profiles as increasing TVG compensation with depth progressively boosts the effect of these non-fish origin noise sources. While noise of vessel or flow origin is typically much lower when steaming lines (sometimes essentially drifting) with the current under high flow conditions, the vessel does tend to remain fixed over a very restricted parcel of water leading to both brief and highly redundant acoustic samples which can yield biased or non-representative transect VBS estimate.

3) Intense scattering events can be quite transitory. During the 25 – 26 June survey, a relatively brief pre-sunset period displayed much higher backscattering levels in the test site area than observed during any portion of the other eight (8) surveys.

Subsequent analysis proceeded from the individual transect VBS vs. depth profiles of APPENDIX 8. The residual noisy character of this data even after application of noise reduction algorithms seemingly precluded "bulk" utilization of these computed profiles. Rather, the VBS profiles were utilized selectively by locating events which appeared to stand out from the ever changing noise background following a systematic methodology as follows:

1) The VBS vs. depth profiles of APPENDIX 8 were systematically examined visually; transect-by-transect, grid-by-grid, survey-by-survey, for both the test site and cross-channel, to find depth intervals displaying enhanced backscatter not obviously arising from known noise sources. A resultant list of flagged survey lines and relevant depth ranges deemed to possibly display fish-origin backscatter is tabulated in Table 10.

2) Each entry in Table 10 was further examined by visual reference to successive fan section echograms to better infer the origin of the enhanced acoustic levels. Backscatter of likely fish origin was denoted "Y" in the "Verified" column.

3) Positively "Verified" backscatter entries were carried forward to Table 11 (Note: The less certain March 2012 Grid 6 T0 – T8 data entry was not carried forward). The Table 11 expanded entries include estimates, scaled from the APPENDIX 8 VBS vs. depth plots, of

both the peak backscatter levels within the designated depth intervals, and a rough visual estimate of the average VBS (i.e. S_v) level within the same depth interval (more precise estimates might be extracted from computed numeric S_v levels, but approximate levels should suffice for the current purpose). Also tabulated are: a) tidal phase at the mid-survey time of the listed intervals obtained by linear interpolation from the on-line Canadian Hydrographic Service listings of high and low tides times for Cape Sharp, and b) sun angle above the horizon for the mid-survey time computed for the OpenHydro turbine location using algorithms detailed by Meeus (1988).

4) In Table 11, estimates of depth-integrated S_v (entry "Int. Av.") were computed for the listed depth interval, followed by - **for transects lying within the test site grid only (lines T0 – T8)** - the average integrated S_v per survey transect over the **full duration** of the survey (entry "Sum/Total Lines"). The latter quantity was to serve as a rough, survey-specific, comparative measure of the average integrated backscatter present per test site survey line – all test site transects assumed to be the same length. It was computed by summing the integrated backscatter detected over all test site survey transects (survey-specific sum of the quantities in the column denoted "Int. Av. x No. Survey Lines" divided by the total number of test site lines surveyed (column "Total Lines")). Only the test site grid was analysed in this manner since broad scattering layers at > 60 – 70 m depth on the cross channel transects would unlikely be consistently detectable by the multi-beam. In addition, for any deep scattering layers the highly variable bathymetry across-channel should be properly accounted for by a more exacting along line x depth integration – Int. Av. $S_{v\,,}$ as above employed, is not the same as Av. Int. S_v when bathymetry varies along transect: The simpler averaging applied in deriving the former quantity gives undue weight to S_v contributions from the physically deeper portions of the transect (the same criticism applies to the test site estimates above, but since most layers are shallow, bathymetric induced effects should be small compared to other uncertainties).

Summary inspection of Table 10 reveals that many observed backscattering enhancements for the MS 2000 are spurious i.e. arising from noise not fish – at least to the extent this can be discerned from detailed examination of the echograms. On moving to the higher confidence backscatter entries of Table 11 the exceptional nature of the backscatter events on the June 2012 survey is readily seen, the average integrated backscatter per (test site) grid transect being almost an order of magnitude higher than that observed on any other survey. Also observed is the fact that no "verified" backscatter enhancements occurred during hours of darkness even though 3 surveys extended through the night time period. While the "unverified" observations from March 2012 Grid 6 T0 – T8 did occur at night, the fish scatterers, if indeed real, were dispersed over an unusually wide depth range, 10 – 45 m, for the test site. In Table 11 the average depths for scattering layers, un-weighted for the number of transects on which a given layer was observed, is: test site transects, top: 16.6 m, bottom 28.5 m; cross-channel transects, top 16.7 m, bottom 36.3 m; the south coast line Y1 not being considered. Since these all represent daylight entries, and since the average depths to the tops of the scattering layers are virtually identical for test site and cross channel lines (the average depths of the lower boundaries are also not greatly discordant) – would suggest illumination to be a controlling factor (it will be remembered that the multi-beam may be incapable of reliably discerning scattering layers at depths > 60 - 70 m depth under noisy conditions and probably not > 75 – 100 even under the best conditions).

The role of illumination in controlling vertical fish distributions is also suggested by examination of the June 2012 Grid 7 T0 – T8 S_v profiles of APPENDIX 8. One observes an apparent progressive, upward migration of an intense, almost certainly herring origin layer, from 15 - 20 m depth on transects T1 & T2 to 10 m or less on transects T6 and T7. Local sunset occurred on line T5. Were the herring moving onto the surface in response to approaching darkness? Interestingly, while the fish layer at times appears embedded in strong plume-like near-surface backscatter - as might be expected near maximum ebb flow - the fish layer itself remains distinctly discernible. On examining the preceding Grid 5 & 6 surveys the apparent same intense layer was centered at depths of about 35 and 25 m respectively. These earlier grid observations provide strong confirmation that a persistent fish layer was in systematic and progressive upward motion at least several hours prior to sunset, the Grid 7 transects detailing only the end-point of this process. These observations illustrate how the multi-beam sonar can resolve transitory phenomena and where, perhaps, a more rigorous "editing-out" of all plume backscatter could have also removed important details of a superimposed fish behavioural phenomenon.

4.2.3.3 Comparison of Multi-beam and Split-beam Data

Comparison of split-beam biomass density estimates (proportional to split-beam vertically integrated, linear form S_v assuming a herring population of invariant size distribution) with multi-beam average S_v levels per transect is instructive. The analyses are confined to the test site where multi-beam delineated scattering layers could be reliably detected to typical bottom depths. A plot of multi-beam, average integrated S_v per survey line vs. survey month is shown in Fig. 31. The Fig. 31 data are extracted from Table 11 and restricted to post Sept. 2010 test site only grid surveys. Several comments regarding the analyses are listed below:

1 The relevant ordinate for the 22 Nov. 2011 survey has been entered as a "0" since no fish layers were unambiguously detected by the multi-beam.

2) The corresponding ordinate for the less systematic 16 Sept. 2010 survey would be 3.36 vs. the plotted 0.82 for the more regular 19 Sept. 2011 survey.

3) If the less certain fish detections for March 2012 Grid 6 were included, the plotted March ordinate would rise from 0.11 to 1.62 – a significant change. While EK60 split-beam detections (below) lend no support for significant fish densities on Grid 6 – for the purposes of Fig. 31 it is best that this conclusion rest on the interpretation of the multi-beam data alone.

4) For the Nov. 2011 survey, multi-beam data was available for **Grid 1 only**, while the split-beam system subsequently detected high fish concentrations on Grid 3 of the same survey.

The multi-beam data of Fig. 31 is best compared to the split-beam "test site" data of Fig. 9. Both systems clearly detected the very high fish (almost certainly herring) concentrations on the final June 2012 survey. However, the lower concentrations characterizing the earlier surveys appear greatly underestimated by the multi-beam system. It must be remembered that Fig. 31 data were limited to visually "obvious" (i.e. isolated) selected events while Fig. 9 data were derived from the complete processed dataset. It might be concluded that most fish targets surveyed by the multi-beam system were sufficiently well dispersed in the water column, or, if aggregated within layers, displayed sufficiently weak backscatter to be masked by background noise thereby precluding their inclusion in Table 11.

Due to the susceptibility of the MS 2000 to several known sources of noise as well as our current inability to fully eliminate the strong and highly variable backscatter contributions from bubble clouds it would appear prudent to rely upon results from the much less noise prone, fully calibrated, and better data-edited split-beam system for the bulk of survey identification and quantification of fish concentrations in Minas Passage. The current multi-beam data is best utilized for consistency checks with the split-beam observations on the infrequent occasions when high signal amplitudes (i.e. well above residual noise levels) are present and also for use in select situations where the multi-beam's inherently greater volumetric sampling capability can effectively enhance observational spatial/time resolutions in delineating transitory or highly spatially localized phenomena (such as rapid herring migrations to surface at dusk).

In retrospect, it is possible that improved multi-beam performance for the purpose of VBS extraction might have been obtained if the range settings employed in the deep channel had been retained for use in the test area. In the MS 2000 firmware a longer profiling range automatically invokes a longer transmit pulse length and a narrower receive bandwidth, both of which would conspire to produce enhanced signal-to-noise ratios in the presence of broad band background noise such as that generated by propeller cavitation, flow noise, and perhaps far out-of-band EK60 interference. However, longer pulses and attendant narrower bandwidths would, in theory, **not** alter the overall signal-to-noise situation for vertically integrated VBS when the noise component originates from bubble cloud backscatter. One disadvantage of longer pulses is that the **instantaneous** signal level contrast between a fish (point target) and from a surrounding homogeneous bubble cloud (**diffusely** scattering medium) is reduced. In consequence longer transmit pulses would tend to make fish echoes less visible on multi-beam fan sections when superimposed on a diffusely scattering bubble cloud background. Because of this reduction in instantaneous signal level contrast any signal thresholding applied to suppress the bubble background would become less efficient and more difficult to adjust. However, if broad band "spoke" noise, originating for say from ship radiated noise, constitutes the dominant noise background use of longer pulses could be quite advantageous.

It is instructive to provide some survey-by-survey comparisons of the two survey systems with special emphasis on the multi-beam events included in Table 11. One limitation is that while multi-beam backscatter profiles are presented on a transect-by-transect basis (APPENDIX 8), comparable profiles for the split-beam are only presented on a grid-by-grid basis (Figs. 11 – 18). Nevertheless, a degree of comparison is possible.

22 August 2011 Survey

Test Site: The multi-beam observed enhancement on Grid 1 T5 – T8 from 15 – 25 m depth (Table 11) appeared to have a clear counterpart in the split-beam lumped Grid 1 profile of Fig. 11d.

However, the split-beam observed sharp spikes on Grid 2 at about 10 and 23 m respectively appeared to have no obvious counterpart on the split-beam profiles of APPENDIX 8

Cross-Channel: The multi-beam observed enhancements on Grid 1 X1 & X2 from 15 – 28 m depth appeared on the split-beam as two close-spaced separate layers or spikes in the same depth range (Fig. 11c).

The split-beam did show significant enhanced backscatter on Grid 3 in the 25 – 80 m range which was **not** selected as a possible multi-beam enhancement in Table 10. Re-examination of the relevant Grid 3 multi-beam profiles of APPENDIX 8 did reveal a possible enhancement but it remained unclear whether this necessarily arose from fish or, alternatively, may have arisen from residual bubble plume scattering prominent at the shallower end of the stated depth range or the increasing effect of residual "spoke" noise at the deeper end of the range. Multi-beam noise levels on Grid 3 were high as a consequence of near maximum flood current. While such multi-beam features can be labelled as "possibly" real when compared to lower noise split-beam data, this level of confidence was not reached on examination of the multi-beam data in isolation.

19 September 2011 Survey

Test Site: Multi-beam selected enhancements on Grid 4 T4 – T8 around 15 – 25 m depth clearly show on the split-beam (Fig. 12d). A similar split-beam observed enhancement in this depth range on Grid 1 may be present on the multi-beam but the higher noise levels and bubble scattering near maximum ebb flow make its reality uncertain.

Cross-Channel: Multi-beam reported enhancements on Grids 1 & 2, and, most strongly, on Grid 3 (17 – 28 m) are clearly reflected only in the split-beam Grid 3 profile of Fig. 12c at the corresponding depth range although split-beam profiles for Grids 1 & 2 do show a few spikes in the vicinity of 20 m.

03 October 2011 Survey

Test Site: The tabulated multi-beam Grid 4 T6 – T8 enhancement at about 7 – 15 m depth appears present on the split-beam Grid 4 (Fig. 13d). Split-beam Grid 4 levels appear much higher than Grid 1 & 2 levels in the same depth range. The fairly high Grid 1 split-beam levels (2 - 15 m) are not clearly observed on the multi-beam.

Cross-Channel: The multi-beam reported a Grid 3 X2 transect enhancement from 15 – 30 m (Table 11). Split-beam Grid 3 levels are also highest in this depth range (Fig. 13c) but appear composed of two main layers. Any reflection of the split-beam delineated broad, low amplitude peak from 30 – 75 m depth on Grids 1 & 3 seems obscured by noise on the corresponding multi-beam profiles.

22 November 2011 Survey

Test Site: Only Grid 1 was surveyed with the multi-beam and no clear enhancements were tabulated. The split-beam system did observe fish on Grid 1 at < 10 m depth (Fig. 14d) - perhaps also present in the multi-beam data but not reliably separable from the bubble backscatter as peak ebb flow approached.

Cross-Channel: No multi-beam lines were run due to equipment failure.

Unfortunately multi-beam equipment problems precluded comparisons with the seemingly quite significant split-beam observed Grid 3 enhancements from ~ 15 to 40 m both at the test site and in the Channel (Fig. 14c & d).

25 - 26 January 2012 Survey

Test Site: Backscatter levels were generally low on both systems. The multi-beam showed a slight enhancement on Grid 8 T6 – T8 between 14 - 22 m depth (Table 11) that was only delineated because noise levels were exceptionally low at the approach of low tide slack water. The split-beam did show a very modest peak in this depth range (Fig. 15 d). Most observed split-beam scattering was on Grids 1 & 2, broadly in the 10 - 50 m depth range with the Grid 1 scattering peaking at just over 30 m depth. All of the split-beam observed scattering was of quite low level and not confidently discernible on the multi-beam.

Cross-Channel: Levels remained quite low on the multi-beam. Highest split-beam backscatter occurred on Grid 4 broadly between 30 - 110 m depth and peaking from 60 - 70 m but levels were very low (Fig. 15c). Multi-beam profiles for Grid 4 did display higher levels in this depth range than for the preceding and the following grids but amplitudes remained sufficiently low to preclude confident selection.

19 – 20 March 2012 Survey

Test Site: Again backscatter levels were quite low on both systems. Multi-beam Grid 4 profiles T7 & T8 displayed low level enhancements between 4 - 12 m and 17 - 30 m (strongest) depths (Table 11). As in the preceding survey these peaks were discernible on the multi-beam system only because of the exceptionally low noise levels occurring near low tide slack water. The split-beam did not clearly discern the Grid 4 shallower enhancement but did show the deeper (Fig. 16d). Significantly, the multi-beam Grid 6 T0 - T8, 10 - 45 m depth possible fish layer of Table 10 did not stand out on the split-beam suggesting its exclusion from Table 11 was the correct choice.

Cross-Channel: No multi-beam layers were identified.

31 May 2012 Survey

Test Site: The multi-beam Grid 1, especially transect T0, seemed to show intense compact schools near-bottom in the 40 – 48 m depth range but these features did not appear on the lumped Grid 1 split-beam analysis (Fig. 17d). It is possible these features were, in reality, diffractions associated with the very hard 3-D bottom and were eliminated as “bottom” on the split-beam analysis. In rougher portions of the test site it was not uncommon to observe fish-like echoes within bottom depressions which could be real or, alternatively, arise from bottom diffractions including high profile bathymetric features lying just off the survey transect. The split-beam did record high backscatter at < 5 m depth on Grids 2 & 5. The multi-beam did show very high backscatter at < 10 m depth on some Grid 5 transects but this was likely a noise effect arising from coincident maximum flood current. The high level split-beam observed peak on Grid 4 from 30 – 34 m depth was not clearly seen in the multi-beam. The narrow depth range of this feature might suggest as origin an intense localized feature. Any such intense highly localized feature may well have been eliminated as a noise burst in the automated multi-beam processing.

Cross-Channel: No multi-beam selections were tabulated. The split–beam did record fish echoes in the < 10 m depth range on Grids 1, 2 & 4 a dubious depth range for multi-beam comparison (Fig. 17c). The multi-beam did show some enhancement at < 10 m on Grid 4 on X1 & X2. The high level split-beam observed peak on Grid 1 at about 54 m depth was not seen in the multi-beam. Again the narrow depth range might suggest a single intense localized feature.

25 – 26 June 2012 Survey

Test Site: The multi-beam appears to see fish on Grid 1, T0 – T8 from 25 – 56 m; split-beam observations reveal only a minor, thin layer from 23 - 28 m suggesting the multi-beam layer to be spurious. Real time cruise notes reported Grid 1 fish targets on both the multi-beam and split-beam – but the latter did not show-up in a significant manner on quantitative analyses.

Very intense layers on Grids 5, 6 & 7 were observed on both systems (Fig. 18d). Grid 5 and Grid 6 layers were seen at similar depths (allowing for the differing transducer draft corrections). Curiously, the Grid 7 layer was much broader on the multi-beam than on the split-beam – multi-beam Grid 7 transects T4 & T5 agreeing reasonably well with the split-beam but transects T0 – T3 not so. Multi-beam profiled fish layers on Grid 7 transects T0 – T2 were discernible but superimposed on a strong bubble plume backscatter background. Were the corresponding split-beam fish layers manually edited out with the plume backscatter in analysis? While both systems appear to show a herring layer rising toward surface over Grids 5, 6 & 7, the multi-beam Grid 7 transect-by-transect delineation of the end-point of the apparent vertical migration is noteworthy as it seems to show a herring layer merging onto the water surface as darkness approached. If this interpretation is correct, it serves as an example of how the high sampling volume of the multi-beam can enable high degree of time resolution of a transitory phenomenon.

Cross-Channel: Multi-beam Grid 1 lines X1 (especially) & X2 both are tabulated as showing modest enhancements in the 20 – 55 m depth range. The multi-beam fan sections on careful inspection also show numerous fish echoes and compact schools. The Grid 1 split-beam data below 30 m also suggest some type of enhancement (Fig. 18c). However, the many sharp “spike” features on the split-beam grid analyses do not clearly show up on the corresponding multi-beam profiles. Could the multi-beam noise reduction algorithms have been overly aggressive in eliminating legitimate high amplitude localized signal bursts?

4.3 Turbine Observations

During the 10 Sept. 2010 survey the OpenHydro turbine was imaged by both acoustic systems; the MS 2000 multi-beam (Fig. 32) clearly outlined its circular shape and its supporting base. Some fish echoes could be observed to within about 5 m of the turbine on both systems. Observations of turbine-proximate fish echoes on MS 2000 fan sections were largely restricted to waters immediately above the turbine as strong diffraction fringes generated by the turbine shroud effectively obscured water column regions immediately adjacent to the turbine nacelle openings. EK60 echograms in particular revealed prominent acoustic wakes on the down-stream current side of the turbine with a hint, perhaps, of some close-in flow disturbance also on the intake side. Any proximate intake-side effect is difficult to separate from diffractions from the superstructure (Fig. 33). Near slack tide, down-stream wakes angled steeply upward toward the surface suggesting a buoyant nature, conceivably originating from turbine or turbine enclosure induced aeration or cavitation. On multi-beam sections, wakes on the outlet side of the turbine were also frequently visible – perhaps less dramatic in appearance then those recorded by the EK60 (see above) due to the multi-beam's lower sensitivity – but curiously, in some cases, suggesting the form of hollow circular arcs in 3-D space. Hollow arcs generated from turbulent interactions with the outer enclosing shroud alone, would be consistent with all turbine blades being absent at the time of observation – a hypothesis not inconsistent with what is definitely known about the structural failure of the turbine blades. Regardless of whether some turbine blades were still in operation, the presence of acoustically-visible, intense outflow wakes and possible near-intake acoustic disturbances should be taken into account in any future attempts to monitor turbine-proximate fish using sonars mounted on or close-to the turbine superstructure.

4.4 Summary

The data presented above, combined with the multi-beam sonar observations, illustrate that acoustic technology can be used to monitor and quantify fish distribution and movement from the surface at high flow sites. In general the observations were consistent with those of the EK60 split-beam system. Some limitations are imposed during extreme flow phases of the tide when surface aeration and turbulence penetrate to near bottom, thereby prohibiting the detection of fish targets. Strong winds further increase the depth of surface noise. It should also be noted that vessel /flow noise at high propeller rpm's, consistent with peak flow periods limited the detection of fish-like targets beyond 75 – 100 m. However for most phases of the tide a large portion of the water column can be monitored.

5. DISSEMINATION AND TECHNOLOGY TRANSFER

To date, preliminary results from the 2010 initial survey have been published in the Canadian Technical Report Series (Melvin & Cochrane 2012). Plans exist to publish the essence of this report in the refereed literature. Both authors are presently members of the FORCE Fundy Advanced

Sensor Technology (FAST) Science Advisory Board, thereby well positioned to bring experience garnered from this study to bear toward the selection, mounting, and deployment of new sonar sensors in further studies of fish distributions and abundances at active or potential Bay of Fundy TISEC sites.

6. CONCLUSIONS

This report, including the appendices, summarizes the extensive data collected during the study and is sufficiently detailed to allow interested individuals to pursue further general investigations to the transect level. Additional information can be extracted from the dataset, but requires specialized software. Those interested can make a special request to the authors. The following conclusions were drawn from 9 surveys undertaken between 2010 and 2012 from simultaneous deployment of single and multi-beam acoustic systems in Minas Passage. The observations are based on a single survey (2010) with the OpenHydro turbine in place and 8 surveys (2011 - 2012) conducted over a year to elucidate temporal, spatial and diel variability of fish-like targets in the water column at the FORCE test site. The weak link in this analysis is that no ground-truthing of the targets was undertaken to confirm species or fish size. Our general conclusions are as follows.

1) Surface waters in Minas Passage, especially near the test site, are extremely turbulent and often highly aerated, the extent depending upon the tidal flow and the wind. The aerated layer is continually changing and usually extends to a water depth of approximately 10 - 20 m, however during certain phases of the tide it can extend from the surface to the bottom for a short period of time. The thickness of the aerated zone also appears to broaden with increasing winds. The acoustic detection of fish-like targets within intensely backscattering bubble clouds and plumes within the aerated zone is not reliable using the techniques employed in this study.

2) Conventional surface acoustic technology can be used to detect fish distribution and abundance throughout the water column below the bubble-dominated surface turbulent zone. There are, however, uncertainties in the detection of individual fish in or near the surface waters and within the variably aerated layer as noted above.

3) Combining single beam with multi-beam observations, the latter non-redundantly ensonifying larger water volumes, enhances the ability to detect and to define layers of fish, especially near-surface. Several cases were identified during processing where fish or layers of fish were detected by one system and not the other. The systems generally complement each other, helping to verify otherwise uncertain targets. Unfortunately, considerable work is required to optimize any multi-beam sonar, including the MS 2000, for the most reliable extraction of volume backscattering (e.g. calibration, data editing, and noise suppression). Single targets near the surface aerated zones were difficult to discern.

4) Fish-like targets were identified year round at the FORCE test site and in the channel although the quantity varied by season and from survey to survey. Beginning in August acoustic backscatter attributed to fish gradually increased until about November, then

declined during the cold winter months before a rapid increase in May with an observed yearly maximum in June. This is generally consistent with the known migration and distribution of fishes in the upper Bay of Fundy. Biomass estimates ranged from < 1 t/km^2 to 7.5 t/km^2 assuming herring as the target species.

5) The vertical distribution and strength of acoustic backscatter was found to vary with depth, tidal phase, season, day/night cycle, and survey Grid; with the extent of this variability apparently related to the quantity of fish in the area and likely the species present. In general, observations indicate the existence of 3 main layers or zones of backscatter; namely the upper water column (< 10 m from the surface), the middle water column (15 - 35 m), and the near bottom (> 45 m) at the test site. The precise modal depth varied depending upon tidal phase. A deep layer was also observed near bottom in the channel.

6) Given the range of water depths present and the approximate height of a tidal turbine, fish occurring in the middle water column (15 – 35 m) layer will likely interact with a tidal turbine positioned on the FORCE test site.

7) Target strength analysis clearly illustrate that there are temporal and spatial differences in the species composition and size distribution of fish in Minas Passage. Two periods stand out as displaying the strongest mean TS - implying the presence of larger fish; August and May, although the August mean TS is much larger than that in May. These two periods correspond to the approximate time when migratory fish should be moving through the Passage.

8) Mean day/night TS observed in Minas Passage during the study period indicate temporal and spatial differences during certain periods of the year. The first 24 hour survey in January showed no significant difference ($P < 0.05$) between day and night TS. By March a statistical difference in overall mean TS and mean TS by depth interval was found for most depth intervals, with the night targets being stronger than the day. In June the situation changed again with marked differences in the mean TS for specific depth internals, but not for the overall water column. These observations are consistent with the diel movements of the fish known to be present in Minas Passage at the time of the survey.

9) There are definite differences between the EK60 and the MS 2000 datasets with respect to detection levels, range, and quantification. S_v estimates from the MS 2000 were relatively but not absolutely calibrated and thus could not be converted to absolute biomass. The MS 2000 sonar was not optimized to detect volume backscattering from deeper targets nor fully normalized to compare backscattering between widely separated depth intervals. Furthermore, the MS 2000 was markedly more sensitive to background/ambient noise which reduced detection depths at the higher survey vessel speeds used during peak flow periods. The multi-beam was also more sensitive to cross-system acoustic interference. Regardless, when both systems detected fish, peak backscatter occurred at the same depth intervals.

10) In the original survey of 2010 there appeared to be a distinct period during the ebb tide when fish preferentially transited out of the basin. This pattern was further observed on

several surveys over the yearlong study, particularly during periods when fish appeared more abundant in the area.

11) Overall, the mean density of fish was relatively low at the time of surveying based on the observed volume backscatter (**S_v**) levels from the EK60. However, there were indications that extensive layers of fish did pass through the area on specific transects, potentially representing much higher densities for short periods of time.

12) Currently the MS 2000 system requires the development of improved analytical tools if the same or similar multi-beam sonar systems are to be used as quantitative monitoring instruments in noisy environments or in highly aerated waters as occur in Minas Passage. A number of editing tools and noise removal algorithms were developed for this study and are contained in the in-house analytical software. However, automated removal of bubble cloud backscatter as well as other noise sources is, at present, only partial while alternative manually-based editing or target selection techniques are too laborious for extensive application to multi-beam data sets. If multi-beam technologies are to be used as fish monitoring tools much improved and fully automated, methods must be developed. Considerable room also exists for the improvement of multi-beam performance apart from the post-processing. This includes synchronization of simultaneously running sounders to reduce some types of cross interference, choice of less noisy vessel platforms, and choice of multi-beam operational parameters (pulse widths and bandwidths) better optimized for VBS estimation as opposed to high resolution individual fish visualization.

7. RECOMMENDATIONS

The present study provides a general overview of fish abundance, distribution, and vertical movement based on surface/vessel mounted split and multi-beam acoustic systems. There are, however, a number of limitations imposed on data collections using this approach. Minas Passage is located in a relative isolated region of the Bay of Fundy and chartering a suitable vessel can be challenging and expensive for extended field operations. Split-beam technology provides a tried and tested method to quantify fish, while the multi-beam sonar encompasses a broader area and larger volumetric sample, but is far more sensitive to background noise associated with, in part, the vessel. During peak flow periods, at least, fish at greater than 60 – 70 m depth become difficult to detect, being lost in the background noise. Both systems must contend with the surface turbulence and the potential loss of signal due to shading (not encountered in earlier studies). However, by far the most difficult editing task is the separation of fish or aggregations of fish that occur with the bubble zone. On several occasions fish could be tracked moving into or within the turbulence zone, yet separating noise from fish was virtually impossible.

While intriguing patterns of fish behaviour have been revealed in this study they represent only a few point estimates scattered throughout the year. Furthermore, there were several months of the year where no surveys were conducted. If funding becomes available, surveys similar to those presented here should be conducted to complete the annual cycle. Observations from this study can be used to undertake a first estimate of the impact of tidal power development however further and more numerous sampling will be required to draw definitive conclusions about potential impacts of TISEC devices on the behaviour and mortality of upper Bay of Fundy fish stocks.

Regarding equipment to monitor, split-beam echosounders are likely to provide the best estimate of the abundance and distribution of fish at existing and proposed test sites in the near future as most of the analytical tools for processing the data already exist. However, in the longer term multi-beam sonars will provide the same information, but with greater coverage, enhanced distributional information, behavioural patterns/reactions and visual displays of the fish and marine mammals occupying and transiting proposed development sites. Multi-beams sonar still has some development to achieve this objective, especially in terms of reasonably priced post-processing tools, before it can become a commonly used monitoring tool for evaluating environmental impacts. It is encouraging that multi-beam sonars specifically engineered and optimized for fish detection and quantification are now appearing in the marketplace and it is anticipated that their performance will be much enhanced for these specific applications and their attendant working environments. However, better quantification of the existing “general purpose” multi-beam sonars and their beam patterns is both possible and recommended to generate more accurate vertical profiles of S_v and to enable more precise inter-comparison with complementary data from split-beam systems.

Many of the challenges associated with surface deployment and vessel noise would be overcome through the bottom deployment of upward looking acoustic equipment, either hardwired into a power/communication supply or as a self-contained autonomous unit mounted to a retrieve platform. The small number and brevity of Minas Passage sampling surveys provided fragmentary scientific data, coupled with a measure of informed speculation in order to ensure an adequate and representative description of the fish ecosystem composition, its functioning, and, especially, its vulnerabilities. Preliminary experiments in high flow areas indicated that equipment such as the ASL acoustic water column profiler can be successfully deployed for several months at a time and collect continuous information on the occurrence of fish-like targets and their distribution Appendix 4).

The authors would recommend the deployment of an autonomous, stationary, bottom-mounted echosounder to extend monitoring into the inter-survey periods. This continuous, longer-term acoustic monitoring tool would have several innate advantages even in the absence of the detailed spatial and target strength data possible from ship-based surveys:

1) The ability to ascertain if “spot” vessel-based acoustic surveys are representative of longer term ecosystem conditions, especially in regard to fish densities, and fish vertical distributions, and repetitive behaviours.

2) The ability to separate tidal current induced fish behaviours from those induced by diurnal variations in ambient light levels i.e. linked to time of day.

3) The detection of significant “transient” biological events – if they exist.

Biological sampling of the water column (e.g. trawling) to ground-truth targets is definitely required to support acoustic-based interpretation. Current speculation on fish is based on the limited information available for the area. Individual target TS data can be useful in identifying fish species, but without supporting ground-truthing it often remains too ambiguous for confident species identification. Trawl surveys recently conducted in the general Minas Channel area seldom sampled below about 20 m depth resulting in our current knowledge of fish distributions being highly biased toward the near-surface region. Further research in this area in required.

While observation of fish densities in the general vicinity of turbines can at best place upper limits on turbine fish transits, acoustic methodologies employing surface vessels are unlikely to detect active turbine avoidance by fish occurring within several meters of the intakes. This critical proximate to the turbine constitutes a challenging observational region for conventional shipboard systems where individual fish echoes are normally obscured by strong acoustic beam side lobe scattering and multi-beam array sensor overloads from the turbine structure and where stable positioning and sufficiently long observation times are also difficult to achieve – not to mention the compounding problem of additional fish avoidance from noisy vessels. If fish are repelled at ranges of 10’s to hundreds of meters by noise radiated from tidal turbines some potential for vessel-based detection may exist. Accurate and dependable delineation of avoidance would seemingly require acoustic systems to be mounted directly on the turbine structure, looking outward at optimum observation angles, with hard-wired power and telemetry to shore. The practicalities of mounting (and recovering) general purpose scientific instrumentation on turbine structures should be addressed. It should be noted that even if turbine fish transits can be eventually quantified, ecosystem impacts can only be accurately evaluated if additional transit mortality data are available. However, even in the absence of the latter parameter, quantification of fish avoidance should enable a **reduced upper bound** to be placed on potential fish mortality compared to that derived from utilization of fish densities and turbine flow rates alone.

The proposed deployment of a retrievable scientific platform will help to evaluate the performance, durability, data quality, and limitations of a multitude of monitoring equipment from both the engineering and practical aspects. Development and installation of the scientific platform should be encouraged. During the testing, further development of analytical capabilities should be undertaken for several systems that show promise (e.g., multi-beam sonars, ASL Water Profiler, etc.).

8. PUBLICATIONS

8.1 Technical Reports

Preliminary analysis of data collected on the initial Minas Passage Project acoustic survey of 16 Sept. 2010 has been published in the Canadian Technical Report Series:

Melvin, Gary D. and Cochrane, Norman A. 2012. A Preliminary Investigation of Fish Distributions Near an In-Stream Tidal Turbine in Minas Passage, Bay of Fundy. Can. Tech. Rep. Fish. Aquat. Sci. 3006: vi + 43 p.

8.2 Other Public Communications

N. A. Cochrane and G. D. Melvin (2010) Vertical Distribution, Movement & Abundance of Fish near Tidal Turbines – Results, Challenges & Lessons Learned. PPT Presentation at OEER/FORCE Tidal Power Workshop, Wolfville, NS Oct. 13 – 14, 2010, on-line: http://www.offshoreenergyresearch.ca/Portals/0/Norman%20Cochrane_wait%20for%20NSPI.pdf

9. EXPENDITURES OF OEER/OETR FUNDS

The contents of this section have been forwarded to the OERA under a separate cover.

10. EMPLOYMENT SUMMARY

Contrary to initial expectations no students were employed in this project. Delays and uncertainties in charter vessel procurement shifted the routine field work where students could potentially be employed into the fall and winter of 2011 and into the spring of 2012, conflicting with the standard academic term and student availability. In consequence, most of the field program and routine off-loading of data was performed by DFO regular and term technicians. The incremental cost of DFO technical support, including modest applicable field overtime costs have been charged against the project. The subsequent data analysis was non-routine requiring specialized expertise and software development beyond the expected technical level of a short term student placement. Analysis was personally performed by the Project PI's as a pre-agreed DFO in-kind project contribution.

Also contrary to original plans local fishing vessels could not be utilized since few local boat owners were willing to obtain a "Passenger" or "Commercial" (non-fishing) license for their vessels to satisfy Transport Canada regulations for the conduct of non-fishing related operations. Vessel charters were awarded to the Huntsman Marine Science Centre, St. Andrews, NB on the basis of formal cost-competitive bids.

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TABLES

Table 1. EK60 sounder calibration settings used for the 16 Sept. 2010 Minas Passage acoustic survey.

Calibration Settings	Applied	Datafile
Absorption Coefficient (dB/m)	0.04095	0.03744
Sound Speed (m/s)	1493.89	1493.89
Transmit Power (W)	500	500
Two-way beam angle (dB re 1 Steradian)	-20.8	-20.8
Transducer gain (dB)	26.31	25.7
Sa Correction (dB)	-0.34	0
Transmit pulse length (ms)	1.024	1.024
Frequency (kHz)	120	120
Minor-axis 3dB beam angle	6.45	7.1
Major-axis 3dB beam angle	6.45	7.1

Table 2. Summary of acoustic transects conducted in Minas Passage on 16 Sept. 2010. Transects are numbered from north to south. Transect 4 passes directly over the turbine.

Transect	Date	Sounder Frequency	Start Time (GMT)	End Time (GMT)	Tide Phase	Start Time (Local)	Start Lat	Start Lon	End Lat	End Lon	Transect Length (m)
T1a	20100916	120	15:07:52.50	15:13:55.83	E	12:07:52	45.3672	-64.4225	45.3694	-64.43441	958
T1b	20100916	120	18:01:04.45	18:04:57.16	F	15:01:04	45.3693	-64.43419	45.3670	-64.42213	965
T2a	20100916	120	14:53:56.28	15:07:05.95	E	11:53:56	45.3686	-64.4352	45.3663	-64.42245	1045
T2b	20100916	120	17:30:41.89	18:00:19.41	F	14:30:41	45.3662	-64.42165	45.3687	-64.43519	1132
T3a	20100916	120	14:47:16.97	14:52:38.22	E	11:47:16	45.3654	-64.42279	45.3681	-64.43546	1039
T3b	20100916	120	17:24:23.58	17:29:52.35	S	14:24:23	45.3679	-64.43591	45.3656	-64.42229	1083
T4a	20100916	120	12:26:54.61	13:02:02.45	E	09:26:54	45.3669	-64.43287	45.3635	-64.42056	1113
T4b	20100916	120	13:02:12.95	13:07:38.72	E	10:02:12	45.3637	-64.4206	45.3666	-64.43417	1123
T4c	20100916	120	13:08:56.78	13:33:28.08	E	10:08:56	45.3664	-64.43378	45.3645	-64.42338	901
T4d	20100916	120	14:19:19.98	14:45:51.39	E	11:19:19	45.3658	-64.43742	45.3646	-64.4235	1213
T4e	20100916	120	15:16:19.95	15:32:56.83	E	12:16:19	45.3673	-64.43637	45.3646	-64.42327	1097
T4f	20100916	120	16:04:38.95	16:17:14.08	S	13:04:38	45.3653	-64.43875	45.3643	-64.42293	1396
T4g	20100916	120	16:49:35.28	16:59:13.28	S	13:49:35	45.3654	-64.43833	45.3639	-64.42225	1395
T4h	20100916	120	16:59:52.31	17:23:22.02	S	13:59:52	45.3640	-64.4226	45.3671	-64.43582	1124
T4i	20100916	120	18:09:15.39	18:29:01.44	F	15:09:15	45.3645	-64.41874	45.3652	-64.42757	784
T4j	20100916	120	18:29:16.45	18:31:39.08	F	15:29:16	45.3652	-64.42767	45.3644	-64.42365	351
T5a	20100916	120	13:34:20.63	13:38:44.86	E	10:34:20	45.3639	-64.42401	45.3660	-64.4357	945
T5b	20100916	120	15:36:02.97	15:41:39.27	E	12:36:02	45.3640	-64.42381	45.3662	-64.4358	960
T5c	20100916	120	16:18:20.16	16:26:17.58	S	13:18:20	45.3638	-64.42398	45.3661	-64.43571	948
T6a	20100916	120	13:40:04.41	14:11:43.58	E	10:40:04	45.3653	-64.4363	45.3627	-64.42435	1059
T6b	20100916	120	15:43:37.88	15:56:52.03	S	12:43:37	45.3653	-64.43633	45.3625	-64.42434	983
T6c	20100916	120	16:27:35.66	16:35:58.58	S	13:27:35	45.3651	-64.43634	45.3625	-64.42434	972
T7a	20100916	120	14:13:24.17	14:17:31.89	E	11:13:24	45.3618	-64.42533	45.3645	-64.43749	970
T7b	20100916	120	15:58:26.63	16:03:52.41	S	12:58:26	45.3613	-64.4253	45.3647	-64.43759	1020
T7c	20100916	120	16:37:22.66	16:48:38.25	S	13:37:22	45.3619	-64.42534	45.3649	-64.43753	1015

Table 3. Summary of Volume backscattering strength (S_v), Nautical Area Scattering Coefficient (NASC), Area backscattering coefficient (ABC), and Area backscatter Strength (S_a) for each transect with and without the surface noise.

Transect	Noise Included				Noise Excluded				
	Mean Sv	NASC	Area Backscatter Coefficient	Area Backscatter Strength	Mean Sv	NASC	Area Backscatter Coefficient	Area Backscatter Strength	Percent Excluding
T1a	-54.60	6454.6	0.000026	-45.88	-82.21	7.234	0.0000002	-67.75	0.650
T1b	-54.22	6892.8	0.000146	-38.35	-86.71	3.357	0.0000001	-71.09	0.053
T2a	-54.29	7056.0	0.000191	-37.19	-79.24	11.864	0.0000003	-65.60	0.144
T2b	-54.95	5801.3	0.000150	-38.25	-85.16	4.814	0.0000001	-69.52	0.075
T3a	-54.61	6311.8	0.000042	-43.79	-82.30	8.190	0.0000002	-67.21	0.455
T3b	-54.84	5752.5	0.000164	-37.86	-86.48	3.419	0.0000001	-71.01	0.048
T4a	-52.24	9417.5	0.000148	-38.29	-73.66	40.432	0.0000009	-60.28	0.632
T4b	-52.59	8845.2	0.000135	-38.71	-75.38	31.324	0.0000007	-61.39	0.540
T4c	-52.81	8353.7	0.000148	-38.29	-75.25	27.481	0.0000006	-61.95	0.430
T4d	-57.10	2942.4	0.000114	-39.44	-76.16	24.921	0.0000006	-62.38	0.508
T4e	-58.28	2238.5	0.000163	-37.89	-79.56	12.648	0.0000003	-65.32	0.180
T4f	-61.42	1112.5	0.000194	-37.13	-83.28	6.009	0.0000001	-68.56	0.072
T4g	-51.97	9362.4	0.000160	-37.96	-81.89	7.672	0.0000002	-67.50	0.111
T4h	-53.42	6384.0	0.000025	-45.98	-83.75	5.431	0.0000001	-69.00	0.500
T4i	-51.79	6395.1	0.000014	-48.42	-82.63	4.847	0.0000001	-69.49	0.782
T4j	-50.73	9488.7	0.000220	-36.57	-83.09	3.249	0.0000001	-71.23	0.034
T5a	-56.59	3487.8	0.000068	-41.66	-73.01	55.982	0.0000013	-58.86	1.903
T5b	-59.04	1801.2	0.000081	-40.92	-82.72	6.315	0.0000001	-68.34	0.181
T5c	-53.53	6301.7	0.000052	-42.85	-84.48	4.202	0.0000001	-70.11	0.188
T6a	-53.46	7008.6	0.000204	-36.89	-76.56	21.939	0.0000005	-62.93	0.249
T6b	-61.29	1086.7	0.000205	-36.88	-76.87	24.807	0.0000006	-62.40	0.280
T6c	-52.05	8814.1	0.000133	-38.75	-85.05	3.744	0.0000001	-70.61	0.065
T7a	-55.04	4904.9	0.000146	-38.34	-79.02	13.697	0.0000003	-64.98	0.217
T7b	-63.80	619.9	0.000218	-36.61	-85.93	3.347	0.0000001	-71.10	0.036
T7c	-52.51	8231.0	0.000217	-36.63	-85.27	3.673	0.0000001	-70.69	0.039

Table 4. Standard Minas Channel survey transects.

Along-Cannel Line	North-West End		South-East End	
	N	W	N	W
T0	45 22.229	64 26.057	45 22.067	64 25.326
T1	45 22.175	64 26.081	45 22.018	64 25.349
T2	45 22.130	64 26.100	45 21.971	64 25.365
T3	45 22.093	64 26.117	45 21.939	64 25.381
T4	45 22.021	64 26.151	45 21.862	64 25.414
T5	45 21.969	64 26.173	45 21.812	64 25.434
T6	45 21.918	64 26.194	45 21.761	64 25.458
T7	45 21.864	64 26.219	45 21.702	64 25.484
T8	45 21.809	64 26.242	45 21.647	64 25.507
X1	45 19.970	64 26.995	45 19.950	64 26.178
Across-Channel Line	**North-East End**		**South-West End**	
	N	W	N	W
Y1	45 21.647	64 25.507	45 19.950	64 26.178
Y2	45 22.229	64 26.057	45 19.970	64 26.995

Table 5. Summary of Acoustic Surveys conducted in Minas Passage between August 22, 2011 and June 25, 2012.

Survey	Start Date	Start time (hh:mm:ss)	End Time (hh:mm:ss)	Day/Night	Max Tide (m)	Transects	Grids	Channel	Temp (C^{o})	Salinity (ppt)	Sound Speed (m/s)
1	20110822	11:45:18	21:28:30	D	10.25	45	4	3	15.41	30.82	1503.3
2	20110919	10:55:27	20:22:39	D	10.14	45	4	3	15.70	31.30	1508.6
3	20111003	09:55:59	20:14:49	D	11.17	46	4	3	N/a	N/a	N/a
4	20111122	14:22:38	22:35:59	D/N	11.12	46	3	3	10.30	30.90	1485.9
5	20120125	18:32:58	16:15:18	D/N	11.49	96	9	9	3.57	30.07	1458.7
6	20120319	14:23:30	13:33:06	D/N	11.23	95	12	11	2.50	30.70	1454.5
7	20120531	12:09:40	23:12:16	D	11.25	57	5	4	9.51	31.52	1483.6
8	20120625	09:08:26	23:15:05	D/N	11.22	82	9	7	11.66	31.12	1491.4

Table 6. Summary of acoustic backscatter (area backscattering strength – S_a) for the entire water column, for the water column below 10 m, and finally with all turbulence removed (fish) observed during a yearlong study at the FORCE test site and adjacent channel in Minas Passage, Nova Scotia.

		Backscatter						Proportion Backscatter			
Survey	Survey	Test Area			Channel			Test Area		Channel	
Number	Month	Water Column	Below 10m	Fish	Water Column	Below 10m	Fish	Top	Fish	Top	Fish
		Sa (dB)	Sa (dB)	Sa (dB)	Sa (dB)	Sa (dB)	Sa (dB)	10m		10 m	
1	August	-43.112	-51.217	-67.630	-43.517	-54.435	-64.248	0.96	0.01	0.79	0.24
2	September	-47.857	-59.061	-66.176	-47.715	-54.660	-62.116	0.82	0.20	0.53	0.54
3	October	-47.702	-57.334	-63.428	-55.452	-61.288	-62.806	0.68	0.37	0.50	0.60
4	November	-45.994	-54.731	-61.988	-45.437	-50.759	-59.060	0.85	0.25	0.74	0.29
5	January	-40.111	-47.969	-61.866	-40.956	-48.805	-60.579	0.86	0.08	0.90	0.04
6	March	-43.786	-51.248	-63.574	-50.409	-59.222	-64.106	0.71	0.30	0.59	0.48
7	May	-45.327	-53.812	-58.981	-53.234	-65.888	-62.109	0.68	0.35	0.66	0.61
8	June	-41.416	-48.753	-56.871	-44.379	-51.238	-58.106	0.74	0.26	0.54	0.45

Table 7. Summary of the mean acoustic backscatter from the test site and the channel expressed in S_v, NASC, ABC and S_a from fish-like targets observed during each of the 8 surveys in Minas passage. The estimated biomass is based on a TS weight of -35.5. Note that all transects are included in the estimate of the mean. Individual surveys are broken down into grids in Table and individual transects in APPENDIX 5.

Survey Number	Date	Number Transects	Mean Volume Backscattering Strength (Sv)		Mean Nautical Area Scattering Coefficient (m2.nmi2)		Mean Area Backscattering Coefficient (m2/m2)		Mean Area Backscattering Strength (ABS)		Estimated Biomass (tonnes/km2)	
			Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel
1	22/08/2011	45	-82.5119	-81.0933	7.438	16.207	0.000000173	0.000000376	-67.6304	-64.2480	0.612	1.334
2	19/09/2011	45	-81.3939	-79.5173	10.397	26.479	0.000000241	0.000000614	-66.1760	-62.1158	0.856	2.180
3	03/10/2011	46	-78.7081	-80.6556	19.575	20.328	0.000000454	0.000000472	-63.4278	-63.2641	1.611	1.673
4	22/11/2011	46	-76.6750	-76.3926	28.603	53.519	0.000000664	0.000001242	-61.7807	-59.0598	2.355	4.406
5	26/01/2012	96	-76.1104	-76.7360	28.711	31.148	0.000000666	0.000000723	-61.7645	-61.4106	2.363	2.564
6	19/03/2012	95	-78.5202	-81.5342	18.930	16.744	0.000000439	0.000000388	-63.5735	-64.1063	1.558	1.378
7	31/05/2012	57	-74.2366	-80.0018	54.494	26.522	0.000001264	0.000000615	-58.9815	-62.1088	4.486	2.183
8	25/06/2012	82	-71.9057	-75.2197	91.900	66.663	0.000002132	0.000001547	-56.7118	-58.1061	7.565	5.488

Table 8. Summary of mean target strength estimates for each survey apportioned into 10 meter depth intervals. Note all calculations were undertaken in the linear domain.

	Depth Interval													
	0-10	**11-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	**81-90**	**91-100**	**101-110**	**111-120**	**121-130**	**Total**
Aug-11														
Number of Targets	1	21	23	56	61	20	26	23	18	27	35	17	8	336
Mean TS (dB)	-40.21	-44.78	-43.24	-45.89	-47.52	-49.60	-43.50	-47.50	-46.17	-44.44	-42.08	-39.89	-45.56	-44.57
Standard Error (dB)	-	-0.954	-1.791	-0.985	-0.806	-0.904	-2.424	-1.367	-1.297	-2.051	-1.674	-1.650	-1.785	0.634
Sep-11														
Number of Targets	3	96	140	108	116	66	101	123	104	152	112	51	47	1219
Mean TS (dB)	-52.17	-44.74	-44.29	-45.35	-47.17	-47.01	-47.35	-44.87	-44.28	-41.48	-39.95	-41.21	-38.69	-47.39
Standard Error (dB)	1.528	0.396	0.488	0.768	0.637	0.815	0.632	1.046	0.811	0.804	0.735	0.975	0.907	0.675
Oct-11														
Number of Targets	10	50	69	112	161	107	74	55	49	64	43	29	15	838
Mean TS (dB)	-44.61	-43.12	-44.38	-45.54	-46.26	-46.17	-47.09	-43.73	-41.49	-42.95	-39.33	-39.31	-36.31	-48.32
Standard Error (dB)	1.049	0.803	0.780	1.585	0.641	0.856	0.823	1.223	1.204	0.870	1.316	1.103	1.339	0.648
Nov-11														
Number of Targets	71	424	906	1497	1618	1698	1573	1285	1137	854	548	195	50	11856
Mean TS (dB)	-42.30	-48.24	-48.71	-48.51	-48.43	-48.33	-48.40	-47.64	-47.12	-44.68	-44.70	-46.39	-44.41	-46.90
Standard Error (dB)	1.010	0.290	0.177	0.250	0.226	0.263	0.149	0.355	0.249	0.416	0.391	0.366	0.724	0.562
Jan-12														
Number of Targets	89	663	1752	2438	2188	1413	1061	892	554	323	145	47	10	11575
Mean TS (dB)	-49.63	-50.00	-50.20	-50.25	-50.22	-50.54	-50.31	-49.72	-49.38	-49.08	-45.78	-47.59	-48.22	-46.80
Standard Error (dB)	0.389	0.197	0.196	0.201	0.130	0.100	0.105	0.198	0.187	0.200	0.984	1.314	1.074	0.556
Mar-12														
Number of Targets	23	181	561	676	603	241	167	140	95	70	42	10	2	2811
Mean TS (dB)	-47.69	-49.33	-48.69	-49.31	-49.83	-49.22	-49.55	-49.57	-48.30	-46.52	-44.92	-48.70	-48.57	-45.81
Standard Error (dB)	1.056	0.336	0.607	0.301	0.216	0.518	0.329	0.442	1.086	1.087	0.890	0.760	0.610	1.136
May-12														
Number of Targets	22	25	56	161	151	48	21	15	29	43	27	11	8	617
Mean TS (dB)	-44.84	-42.70	-38.21	-37.64	-45.29	-42.41	-44.01	-41.24	-44.77	-41.84	-39.53	-42.27	-44.26	-40.48
Standard Error (dB)	1.225	1.658	2.277	1.445	1.203	1.264	1.796	2.555	1.273	1.132	1.083	1.511	1.388	0.898
Jun-12														
Number of Targets	17	320	1248	1816	1690	925	665	493	448	419	287	91	56	8475
Mean TS (dB)	-47.47	-47.34	-44.28	-44.46	-45.23	-47.85	-49.18	-51.21	-47.49	-45.03	-41.92	-45.65	-41.76	-45.45
Standard Error (dB)	1.250	0.629	1.101	0.540	1.613	0.643	0.467	0.619	0.739	0.534	0.679	0.656	0.774	0.480

Table 9. Summary of the Day/Night mean target strength estimates apportioned into 10 m depth intervals for each of the 3 surveys which were conducted over a 24 hour period. The total column includes all water depths. Note that all calculations were undertaken in the linear domain then converted to dB's.

	Depth Interval													
	0-10	**11-20**	**21-30**	**31-40**	**41-50**	**51-60**	**61-70**	**71-80**	**81-90**	**91-100**	**101-110**	**111-120**	**121-130**	**Total**
January 25 (Day)														
Number of Targets	33	193	595	765	598	293	198	167	115	51	25	4	2	3039
Mean TS (dB)	**-49.00**	**-49.64**	**-49.76**	**-49.91**	**-50.17**	**-50.28**	**-50.41**	**-49.79**	**-50.22**	**-49.61**	**-47.02**	**-50.42**	**-46.26**	**-49.930**
Standard Error (dB)	0.826	0.425	0.446	0.504	0.239	0.232	0.203	0.271	0.186	0.296	0.856	0.975	2.309	0.175
January 25 (Night)														
Number of Targets	49	362	890	1248	1160	786	675	578	348	238	103	38	7	6482
Mean TS (dB)	**-50.01**	**-50.18**	**-50.29**	**-50.34**	**-50.22**	**-50.64**	**-50.33**	**-49.95**	**-49.51**	**-49.24**	**-46.40**	**-49.70**	**-50.39**	**-50.104**
Standard Error (dB)	0.235	0.105	0.179	0.171	0.185	0.134	0.132	0.259	0.193	0.184	1.406	0.498	0.578	0.088
March 19 (Day)														
Number of Targets	12	83	350	407	325	98	65	59	43	20	18	6	1	1487
Mean TS (dB)	**-46.56**	**-49.63**	**-49.63**	**-49.41**	**-49.61**	**-50.13**	**-50.16**	**-50.44**	**-47.34**	**-49.68**	**-50.47**	**-49.12**	**-49.28**	**-49.531**
Standard Error (dB)	0.826	0.425	0.446	0.504	0.239	0.232	0.203	0.271	0.186	0.296	0.856	0.975	2.309	0.189
March 19 (Night)														
Number of Targets	5	57	122	188	200	106	70	49	25	22	16	3	0	863
Mean TS (dB)	**-48.42**	**-49.18**	**-46.53**	**-49.21**	**-50.34**	**-49.06**	**-49.08**	**-49.08**	**-49.43**	**-44.17**	**-42.77**	**-50.04**	**-**	**-48.438**
Standard Error (dB)	2.862	0.454	1.478	0.483	0.178	0.795	0.554	0.655	0.745	1.764	1.003	0.278	-	0.429
June 26 (Day)														
Number of Targets	13	250	902	1115	944	409	281	217	192	177	119	31	22	4672
Mean TS (dB)	**-47.39**	**-47.38**	**-43.36**	**-43.09**	**-48.47**	**-49.19**	**-55.08**	**-54.33**	**-53.36**	**-45.28**	**-42.15**	**-48.52**	**-39.95**	**-45.321**
Standard Error (dB)	1.344	0.711	1.213	0.614	1.324	1.580	0.349	0.497	0.545	0.839	0.757	0.845	1.090	0.502
June 26 (Night)														
Number of Targets	4	67	318	652	694	498	384	276	256	242	168	60	34	3660
Mean TS (dB)	**-47.72**	**-47.01**	**-48.54**	**-48.41**	**-42.81**	**-46.91**	**-47.29**	**-49.74**	**-45.57**	**-44.86**	**-41.76**	**-44.68**	**-43.53**	**-45.541**
Standard Error (dB)	10.869	1.222	0.807	0.881	2.075	0.445	0.507	0.757	0.811	0.666	0.972	0.748	0.810	0.872

Table 10. Survey lines displaying possible fish concentrations with verification status.

Date	Lines	No. Lines	Top m	Bot m	Verified	Comments
16 Sep. 2010	T4a, T4b, T4c	3	12	20	Y	
	T6a	1	35	50	N	Fish 15 to 20 m
	T4i, T4j	2	20	30	N	Turbine superstructure
22 Aug. 2011	G1 T5 - T8	4	15	25	Y	
	G1 X1 & X2	2	10	28	Y	Strong fish schools at excellent SNR
	G2 X1 & X2	2	12	20	N	Some fish but spoke noise quite strong
	G3 Y1	1	12	21	Y	Strong fish schools at good SNR
19 Sep. 2011	G1 X1 & X2	1	15	28	Y	Reliably detected fish on X1 only!
	G2 X1	1	20	30	Y	May be real but not absolutely certain
	G2 X1 & X2	2	30	55	N	Probably not real
	G3 T7	1	10	40	N	Very high noise
	G3 X1 & X2	2	17	28	Y	
	G4 T4	1	12	24	Y	Strong layer of fish good SNR
	G4 T5	1	15	25	Y	Strong layer of fish present
	G4 T6 - T8	3	15	25	Y	Strong layer of fish
03 Oct. 2011	G1 X1 & X2	2	60	100	N	Noise
	G3 X2	1	15	30	Y	Fish present - noise high - probably real
	G4 T6 - T8	3	7	15	Y	Probably real but bubble noise high
	G4 T0 - T8	9	35	47	N	Noise
	G4 X1	1	70	92	N	Noise
22 Nov. 2011	G1 T7	1	33	42	N	Spoke noise
25 - 26 Jan. 2012	G1 Y1	1	45	55	N	Mostly spoke noise
	G2 T1 - T7	7	25	55	N	Some fish 15 - 20 m odd profiles
	G6 T1 - T7	7	25	50	N	Spoke noise
	G6 Y1	1	32	38	N	Plumes, noise at range
	G7 Y1	1	34	38	N	Plumes, noise at range, some fish
	G8 T6 - T8	3	14	22	Y	Noisy but there, T7 best
	G10 T0	1	30	47	N	Spoke and other noise
19 - 20 Mar. 2012	G1 Y1	1	32	38	N	Only noise
	G2 T1	1	17	27	N	Surface connected plume under ship
	G4 T7 - T8	2	4	12	Y	Weak echoes, good SNR, prob. real
	G4 T7 - T8	2	17	30	Y	Large number weak echoes, good SNR
	G6 T0 - T8	9	10	45	?	May be fish - could be spoke noise
	G8 T4 - T8	5	38	53	N	Spoke noise
	G12 T2 - T4	3	20	50	N	T2 esp. plumes, maybe some fish
31 May 2012	G1T0	1	40	48	Y	Intense compact schools near bottom
	G1 X2	1	55	92	N	Very noisy esp. "spoke noise"
	G3 X2	1	45	63	N	Very noisy
	G5 T4 - T7	4	27	52	N	Spoke noise & detached plumes deep

25 - 26 Jun. 2012	G1 T0 - T8	9	25	56	Y	G1T4 cluster ~ 30m fairly noisy
	G1 X1	1	20	55	Y	Individual echoes & schools
	G1 X2	1	20	55	Y	Individual echoes & schools
	G1 X2	1	85	99	N	Noise
	G2 T1	1	10	30	N	Deep penetrating plume event
	G3 Y1	1	40	42	N	Reality of fish layer not obvious
	G4 T2 esp.	1	15	30	N	Mainly plumes above 30 m
	G4 T0 - T6	7	30	55	N	Spoke noise mainly, occasional fish
	G5 T1 - T8	8	28	40	Y	Intense layers of fish above 40 m
	G6 T0 - T8 esp. T3	9	18	32	Y	Intense layers of fish above 35 m
	G7 T1 - T6	6	10	25	Y	Fish layer verified to move to surface
	G9 T4 - T7	4	35	52	N	Some fish 10 -13 m but not near bottom
	G9 Y1	1	45	49	N	Peak is spurious

Table 11. Verified fish layers with roughly estimated contribution to total backscatter.

Date	Lines	No.	Top m	Bot m	Peak (e-07)	Ave. (e-07)	Int. Av (e-07)	Int. Av. x No. Lines (e-07)	Total Lines	Sum/Total Lines (e-07)	Tide Deg.	Sun Deg.
16 Sep. 2010	T4a, T4b, T4c	3	12	20	4.6	3.5	28.0	84.0	25	3.36	74.2	29.7
22 Aug. 2011	G1 T5 – T8	4	15	25	0.9	0.6	6.0	24.0	36	0.67	104.4	41.9
	G1 X1 & X2	2	10	28	0.5	0.3	5.4				131.9	49.6
	G3 Y1	1	12	21	1.2	0.8	7.2				249.3	45.4
19 Sep. 2011	G1 X1	1	15	28	1.2	0.8	10.4		36	0.82	130.2	30.5
	G2 X1	1	20	30	0.6	0.4	4.0				180.8	42.8
	G3 X1 & X2	2	17	28	2.1	1.4	15.4				281.5	39.3
	G4 T4	1	12	24	1.1	0.8	9.6	9.6			321.3	26.4
	G4 T5	1	15	25	1.6	0.8	8.0	8.0			327.7	24.3
	G4 T6 - T8	3	15	25	0.6	0.4	4.0	12.0			336.8	21.2
03 Oct. 2011	G3 X2	1	15	30	0.6	0.4	6.0		36	1.33	240.5	39.6
	G4 T6 - T8	3	7	15	2.8	2.0	16.0	48.0			322.9	21.3
25 - 26 Jan. 2012	G8 T6 - T8	3	14	22	0.5	0.4	3.2	9.6	83	0.12	174.1	4.6
19 - 20 Mar. 2012	G4 T7 - T8	2	4	12	0.3	0.2	1.6	3.2	104	0.11	193.9	17.1
	G4 T7 - T8	2	17	30	0.4	0.3	3.9	7.8			193.9	17.1
31 May 2012	G1 T0	1	40	48	2.2	1.2	9.6	9.6	45	0.21	348.7	35.9
25 - 26 Jun. 2012	G1 T0 - T8	9	25	56	1.4	0.5	15.5	139.5	80	20.22	49.7	13.3
	G1 X1	1	20	55	0.6	0.5	17.5				82.3	24.8
	G1 X2	1	20	55	0.3	0.2	7.0				100.0	31.2
	G5 T1 - T8	8	28	40	10.6	6.0	72.0	576.0			5.7	30.6
	G6 T0 - T8	9	18	32	5.5	3.8	53.2	478.8			46.0	16.2
	G7 T1 - T6	6	10	25	6.4	4.7	70.5	423.0			92.1	1.1

FIGURES

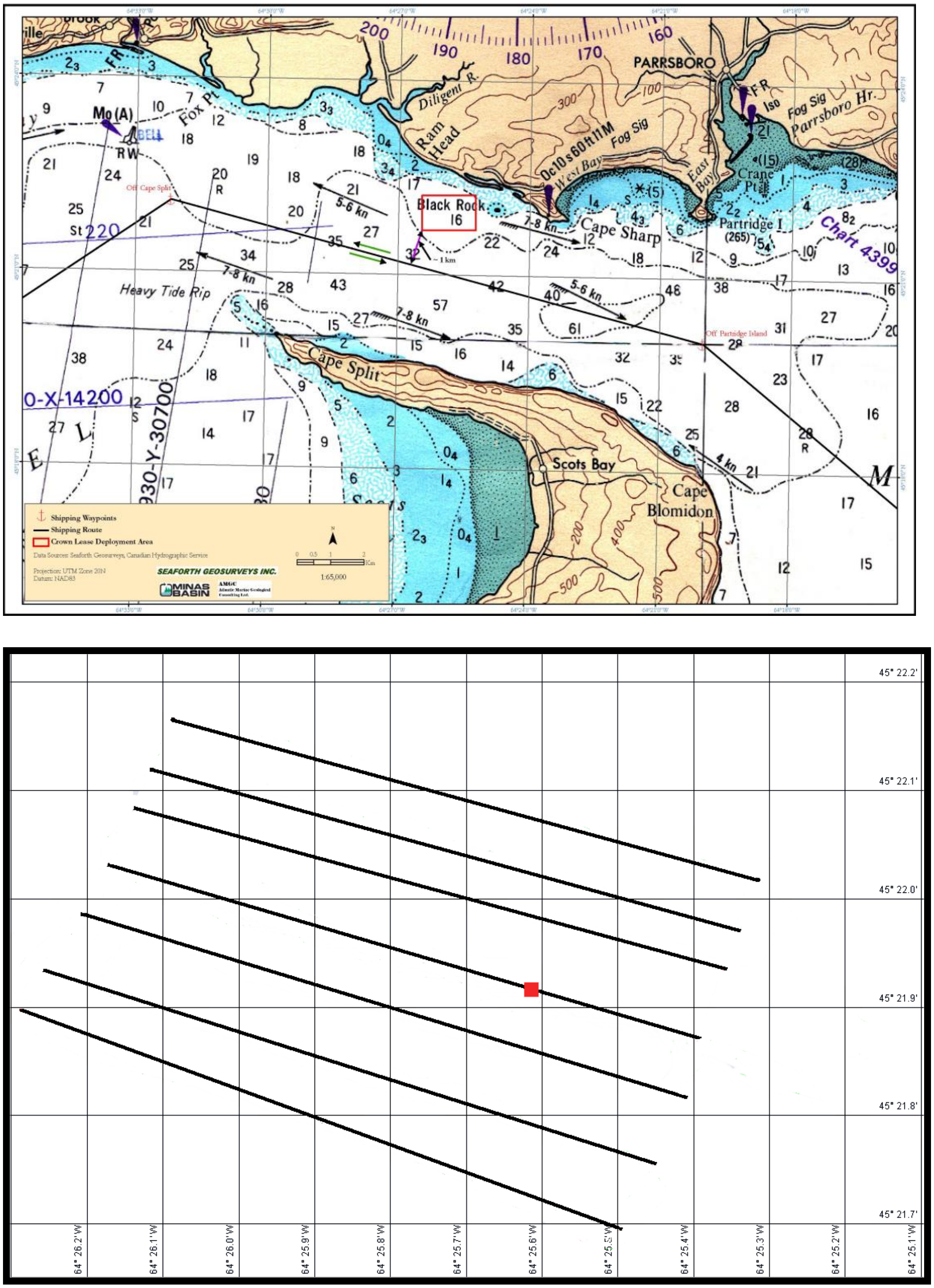


Figure 1. Minas Passage bathymetry with detail of original survey grid and location of OpenHydro tidal turbine.

Figure 2. The Huntsman Marine Science Centre R/V *FUNDY SPRAY* approaching the wharf in Parrsboro Nova Scotia.

Figure 3. Boom-mounted acoustic transducer package attended by DFO Research Scientist G. Melvin. The orange unit at top is the 120 kHz Simrad EK60 split-beam transducer. Immediately below it lies the 200 kHz Kongsberg-Mesotech MS 2000 narrow beam, linear transmit transducer. Near bottom is the circular arc MS 2000 receive transducer.

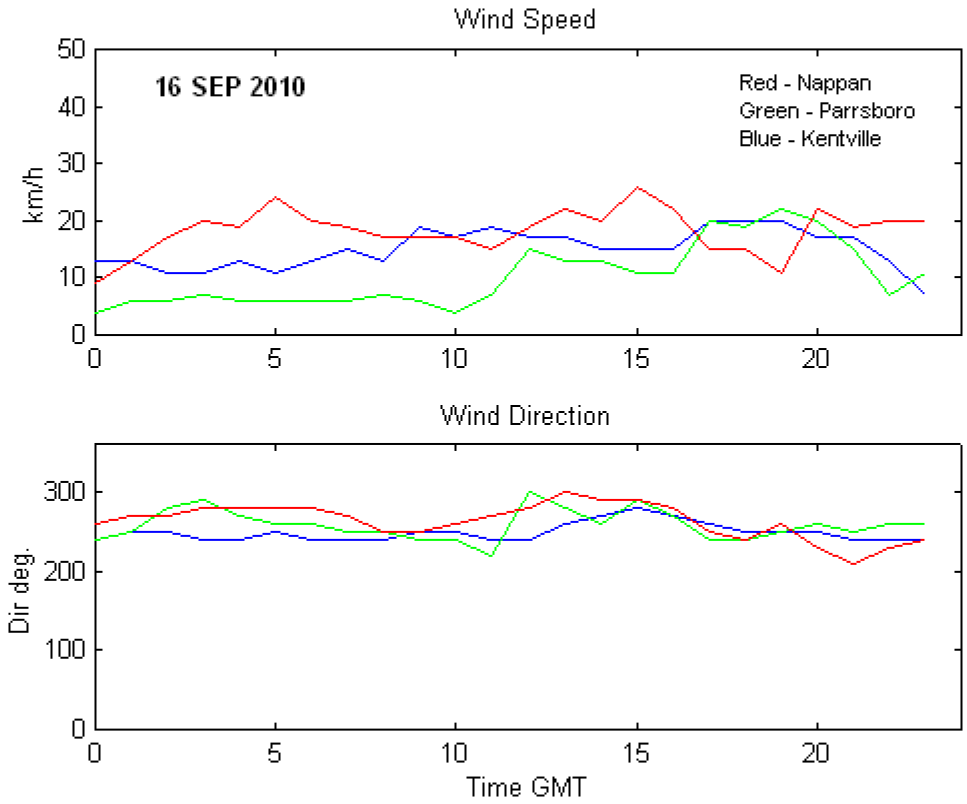
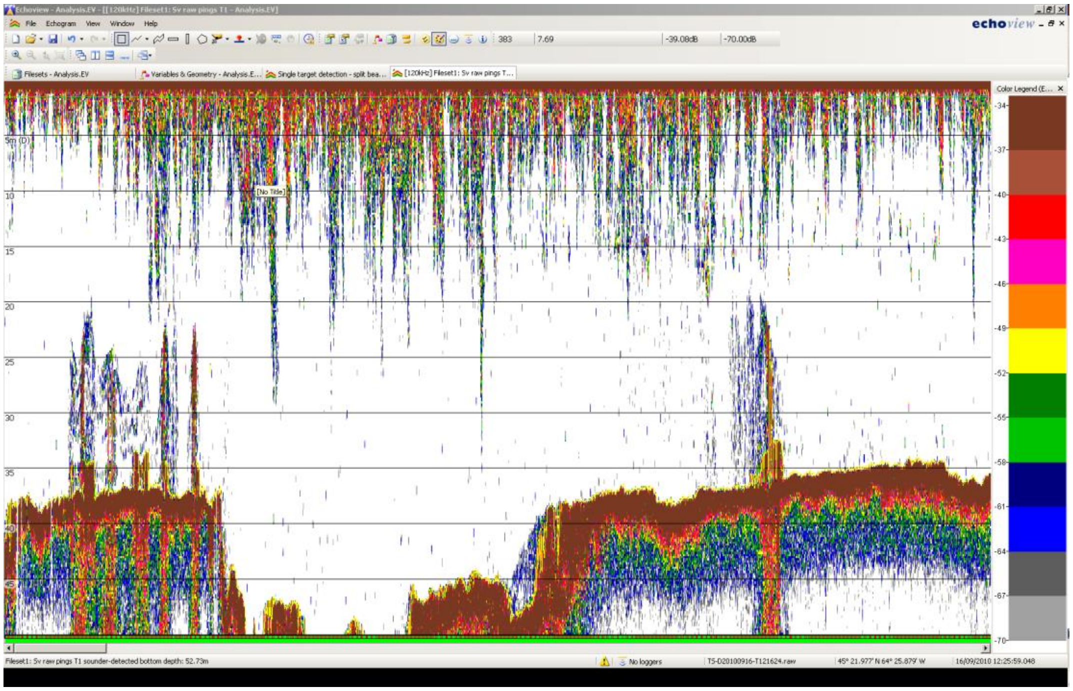


Figure 4. Wind speed and direction for three locations in the vicinity of Minas Passage on 16 Sept. 2010. Source: Environment Canada, National Climate Data and Information Archive.



Fileset1: Sv raw pings T1 sounder-detected bottom depth: 52.73m

T5-D20100916-T121624.raw

45° 21.977' N 64° 25.879' W

16/09/2010 12:25:59.048

Figure 5. Echogram from the EK60 echosounder showing several passes over the turbine (LHS) prior to commencing the survey and a single pass over the turbine during the first transect (RHS).

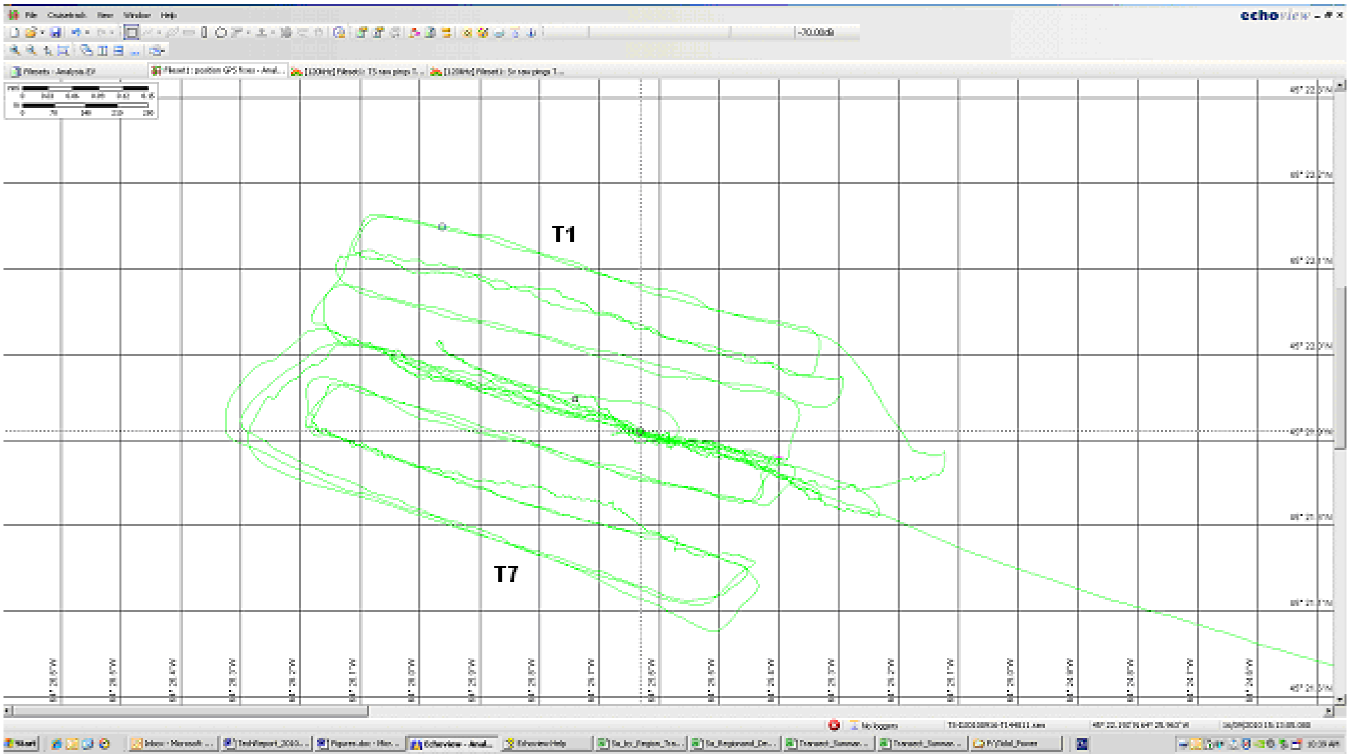


Figure 6. Vessel track and transects for the survey conducted on 16 Sept. 2010 in Minas Channel. Note transects are numbered from north to south as 1 to 7 with transect 4 including the turbine (designated by cross hairs).

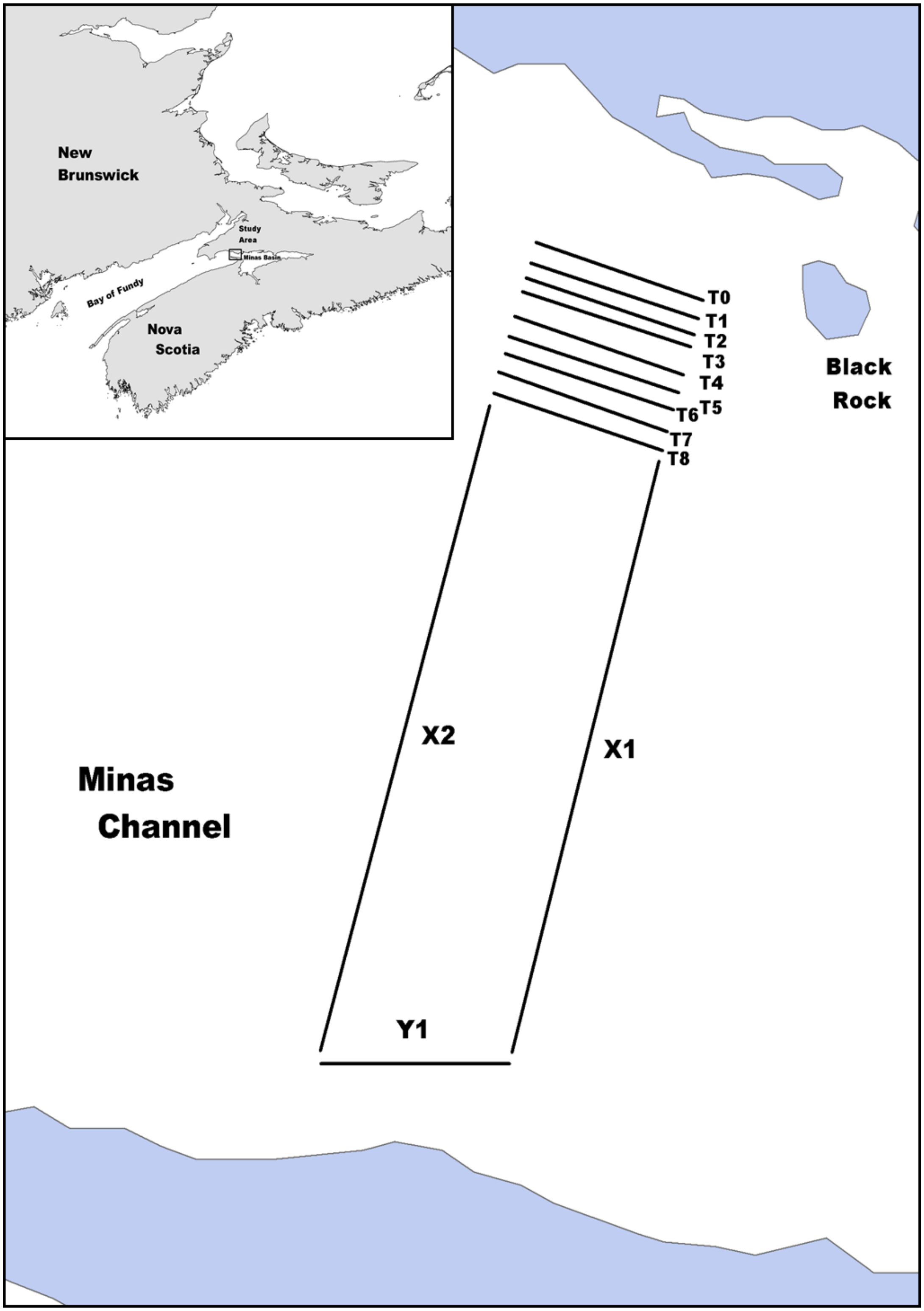


Figure 7. Location of the acoustic transect coverage for the test area and channel in Minas Passage

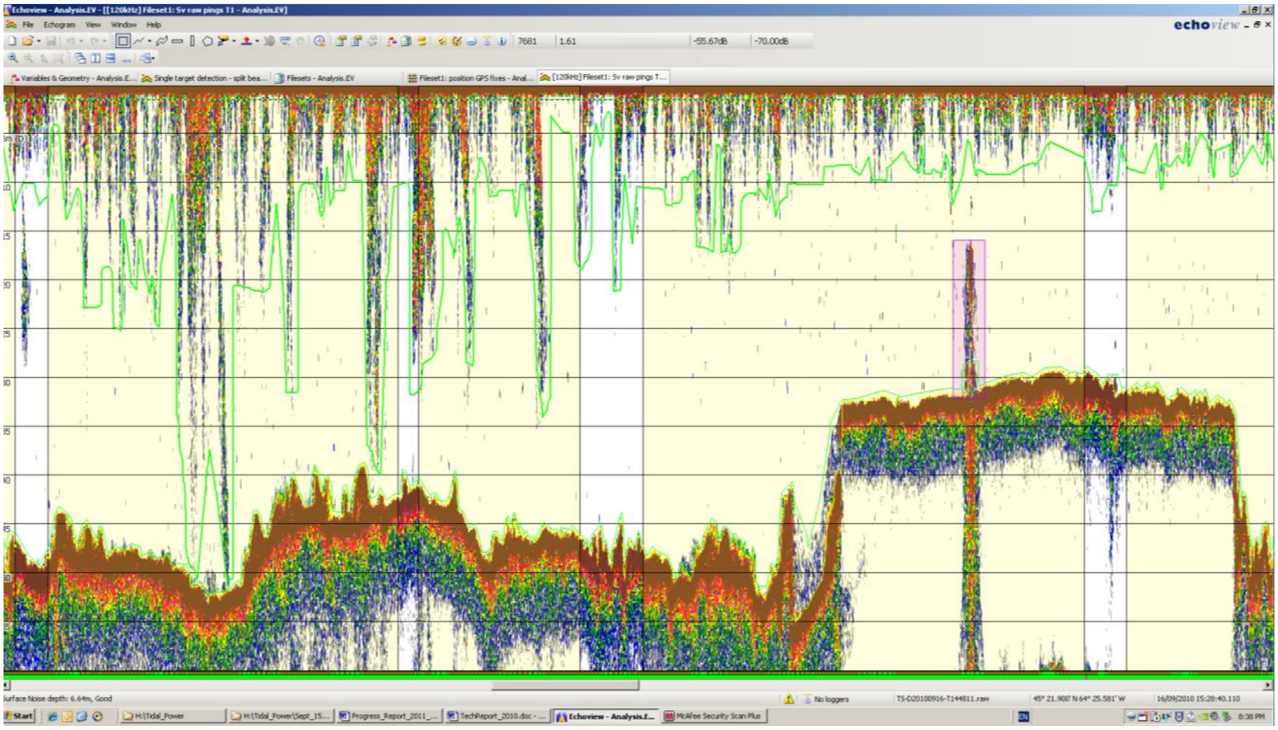


Figure 8. EK60 echogram illustrating the surface, surface noise, and bottom boundaries (green). The yellow shading defines the transects and the pink shading the area associated with the turbine.

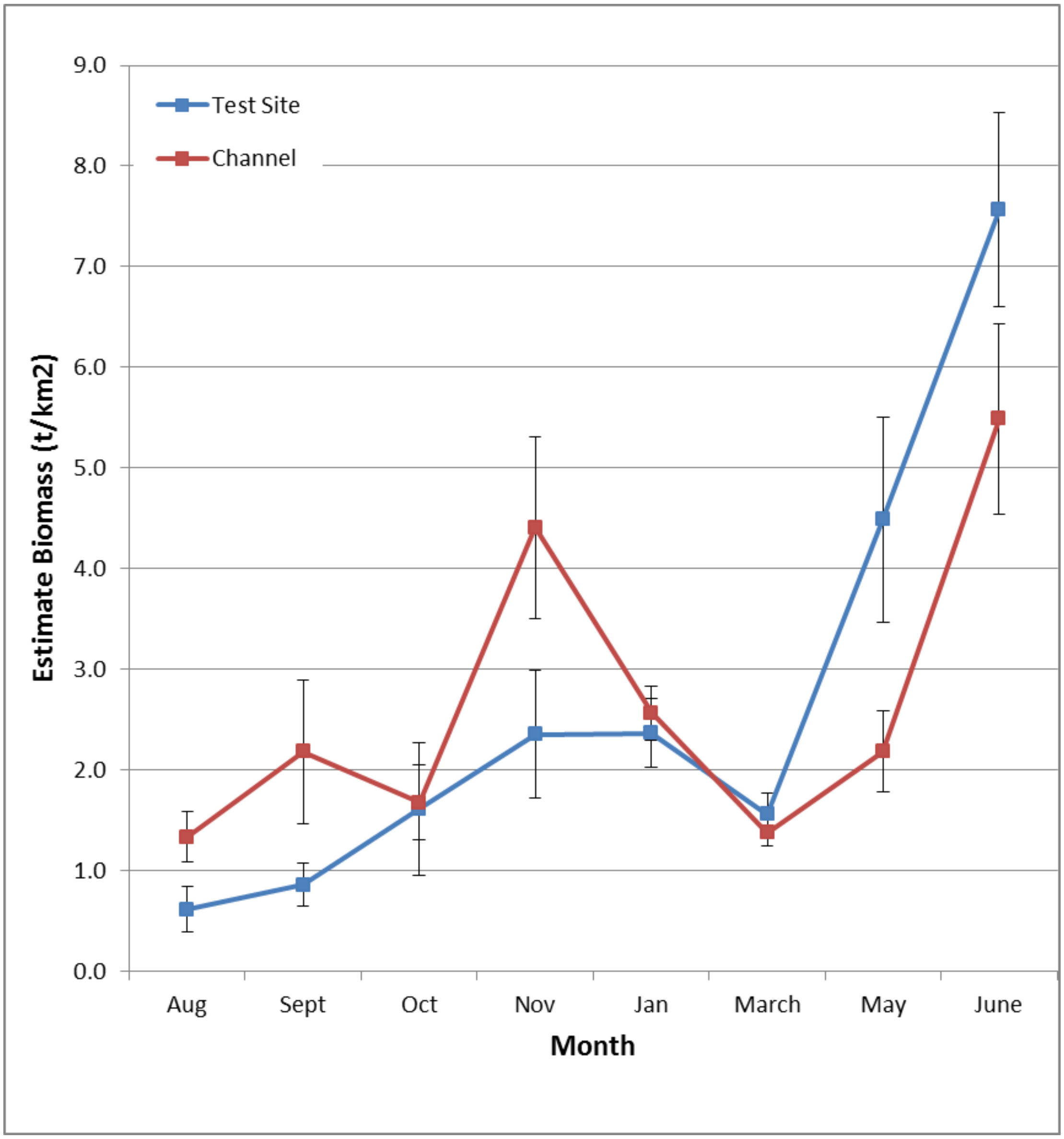


Figure 9. Monthly estimate of biomass (t/km^2) at the test site and in the channel based on the TS for Atlantic herring. Error bars represent 2 standard errors.

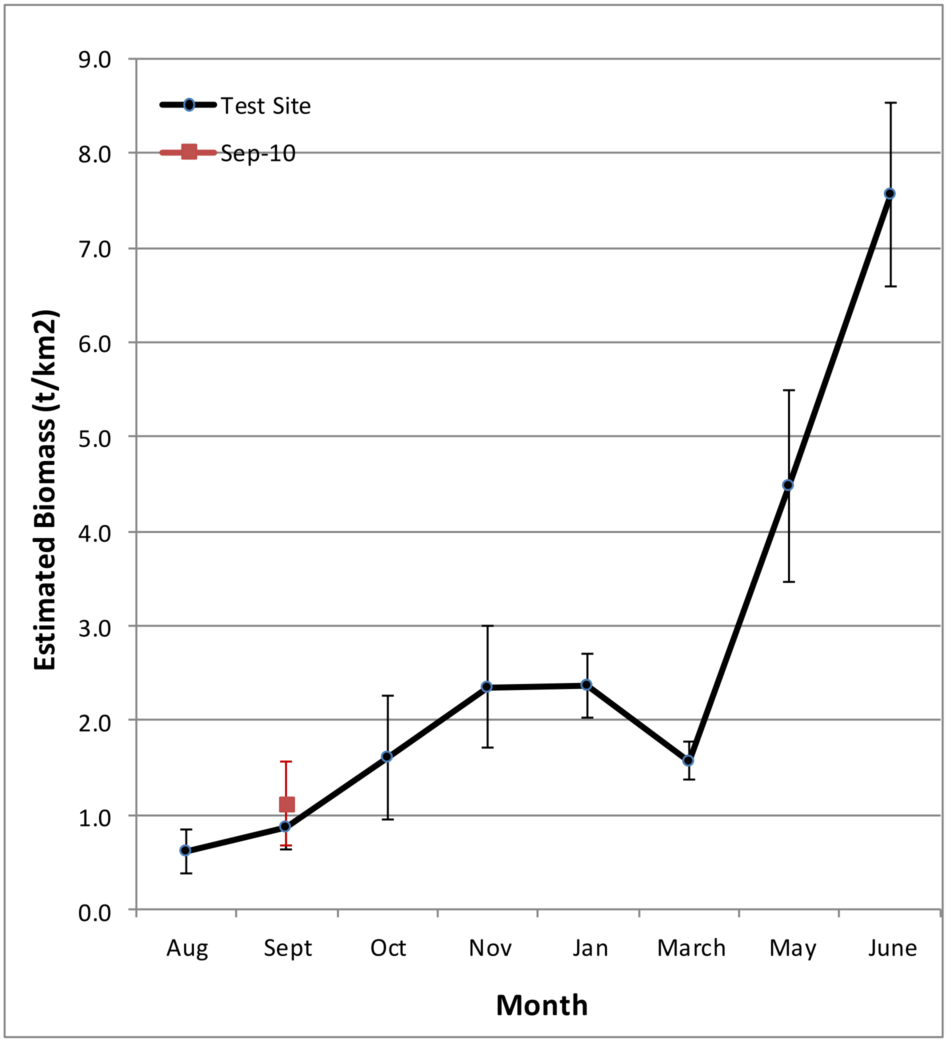


Figure 10. Comparison of monthly estimate of biomass (t/km^2) at the test site during the current and the single survey conducted in September 2010 based on the TS for Atlantic herring. Error bars represent 2 standard errors.

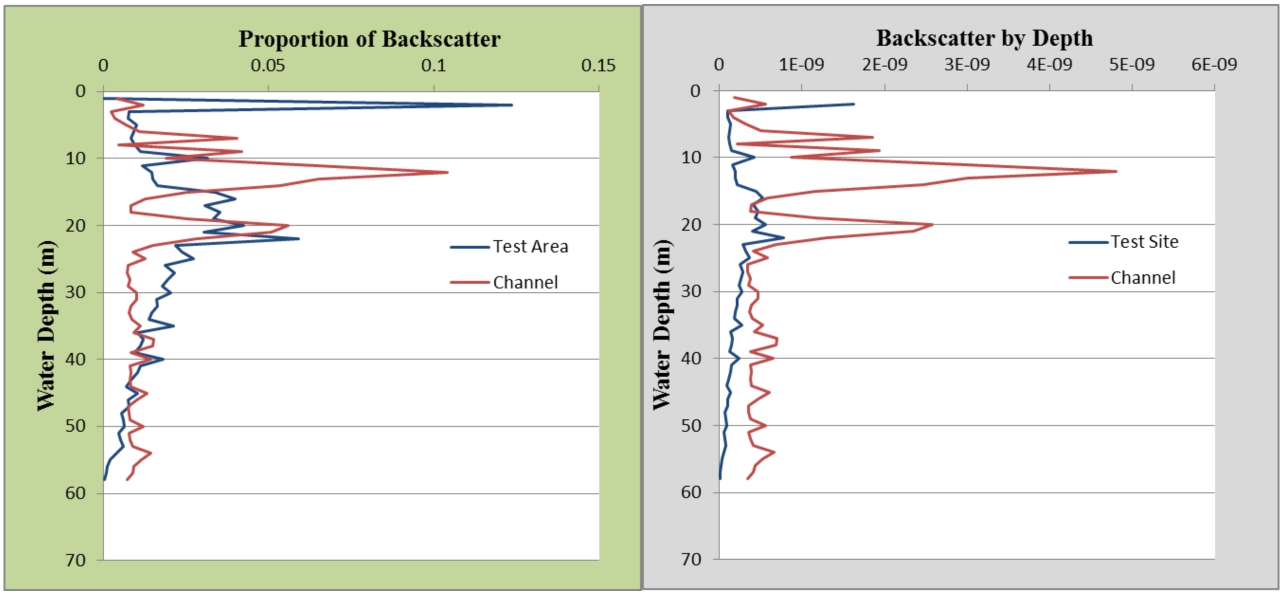


Figure 11a. Summary of the proportion (left) and actual (right) backscatter on August 22, 2011 for the test area and the channel to the test site water depths.

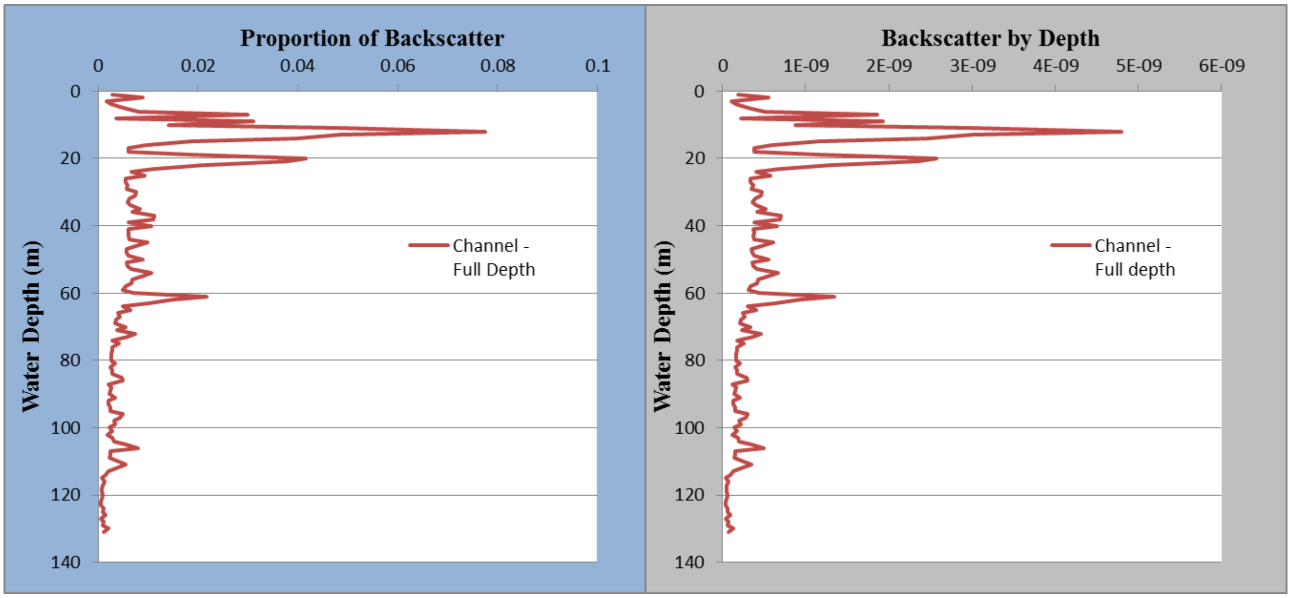


Figure 11b. Summary of the proportion (left) and actual (right) backscatter by depth on August 22, 2011 for the channel from the surface to bottom.

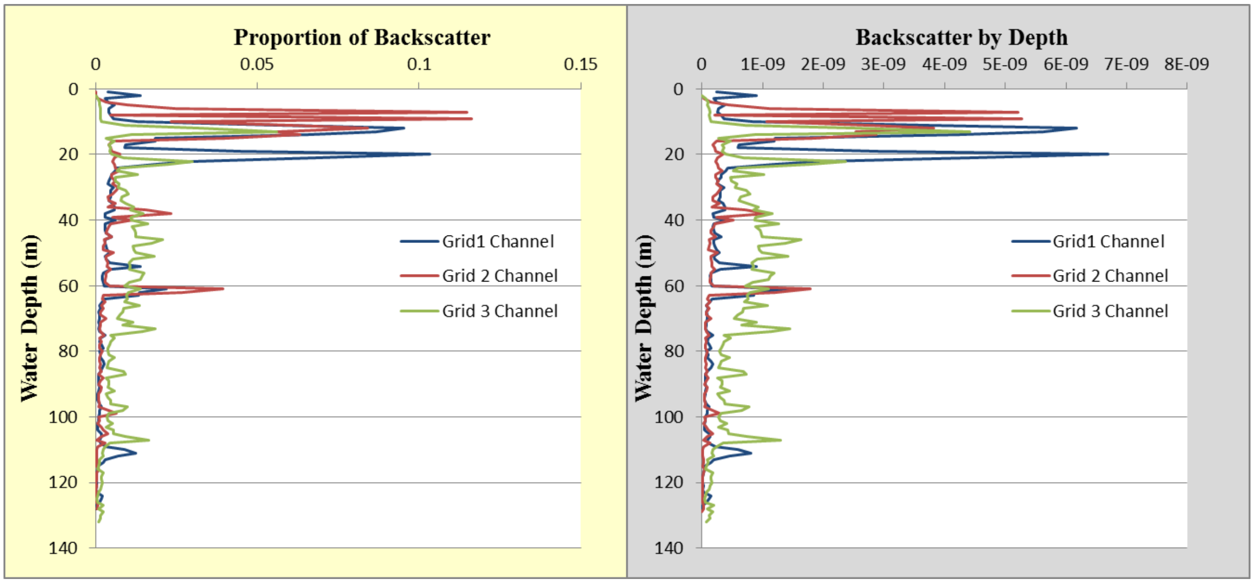


Figure 11c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the August 22, 2011 survey.

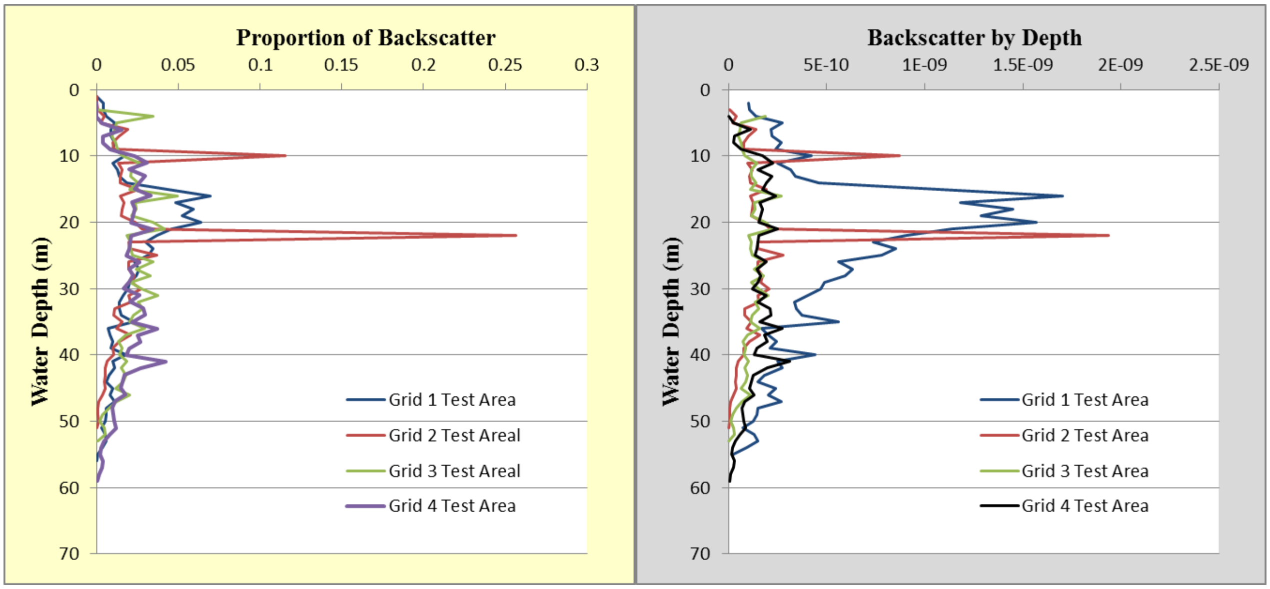


Figure 11d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the August 22, 2011 survey.

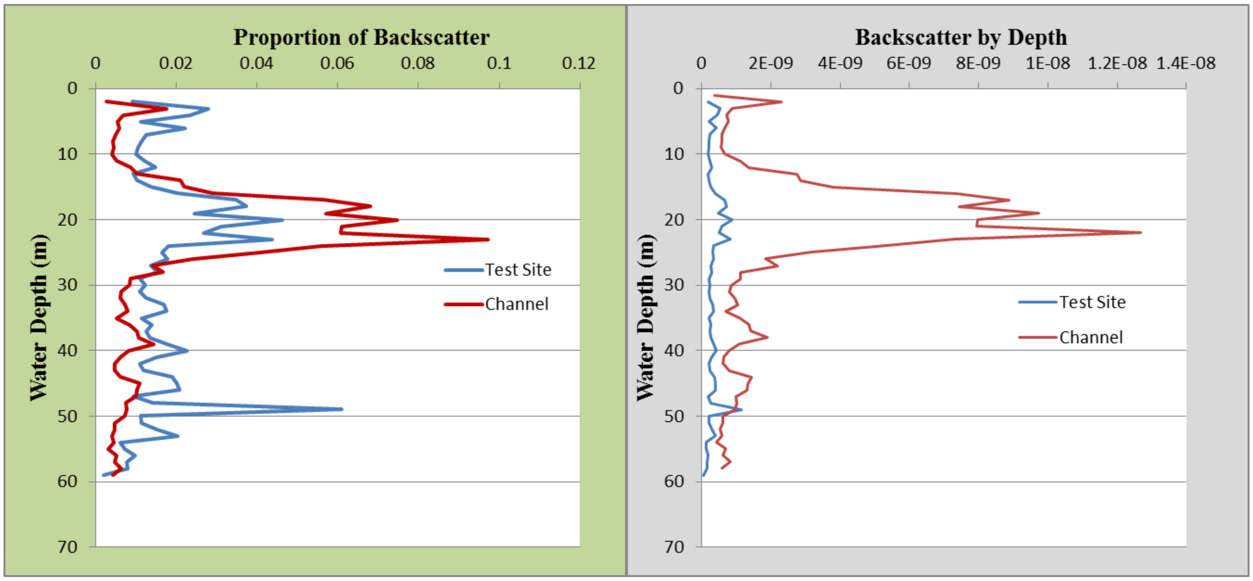


Figure 12a. Summary of the proportion (left) and actual (right) backscatter on September 19, 2011 for the test area and the channel to the test site water depths.

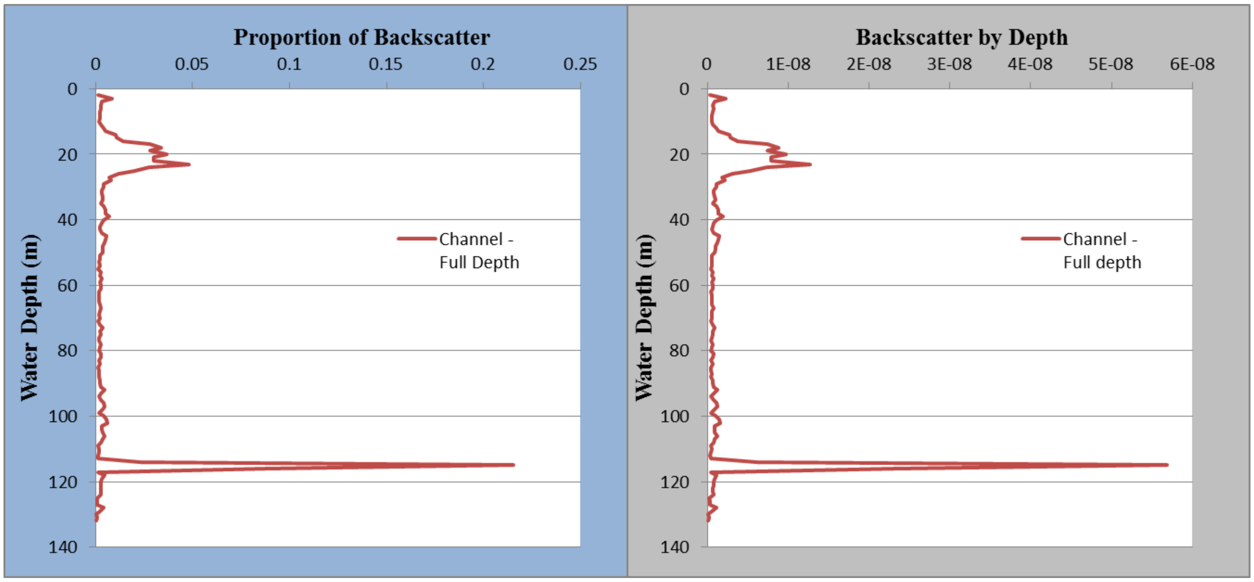


Figure 12b. Summary of the proportion (left) and actual (right) backscatter by depth on September 19, 2011 for the channel from the surface to bottom.

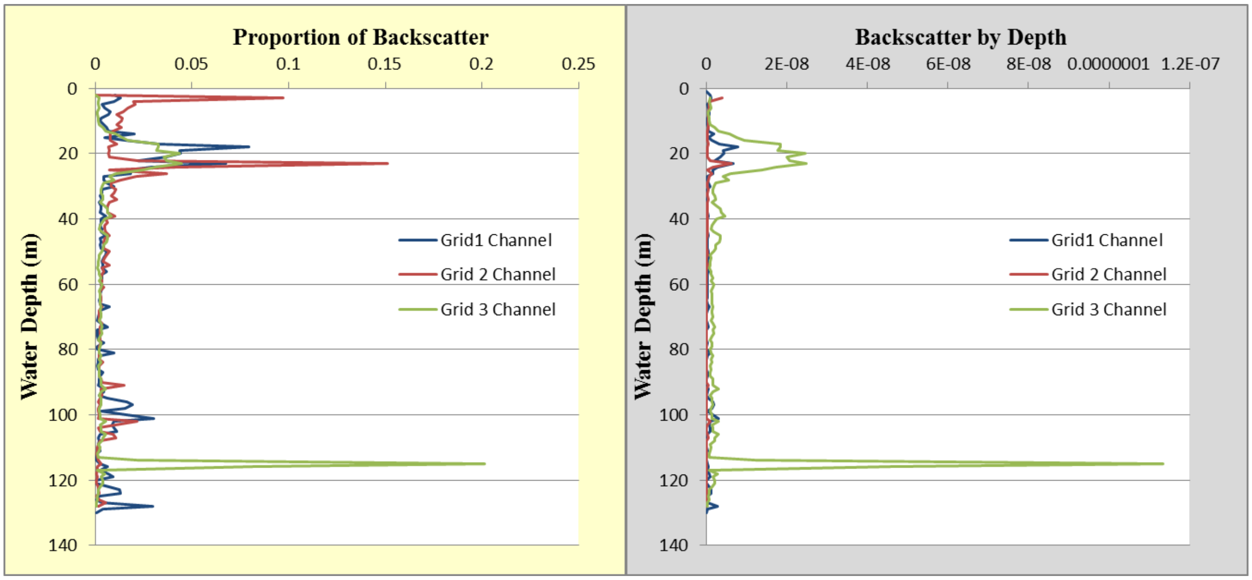


Figure 12c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the September 19, 2011 survey.

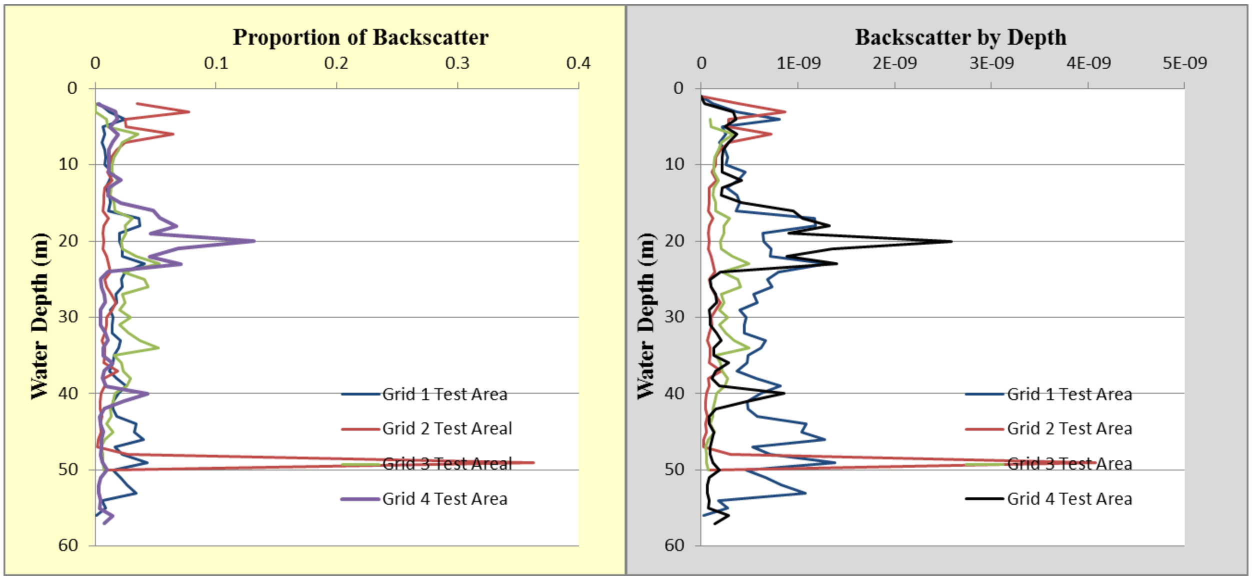


Figure 12d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the September 19, 2011 survey.

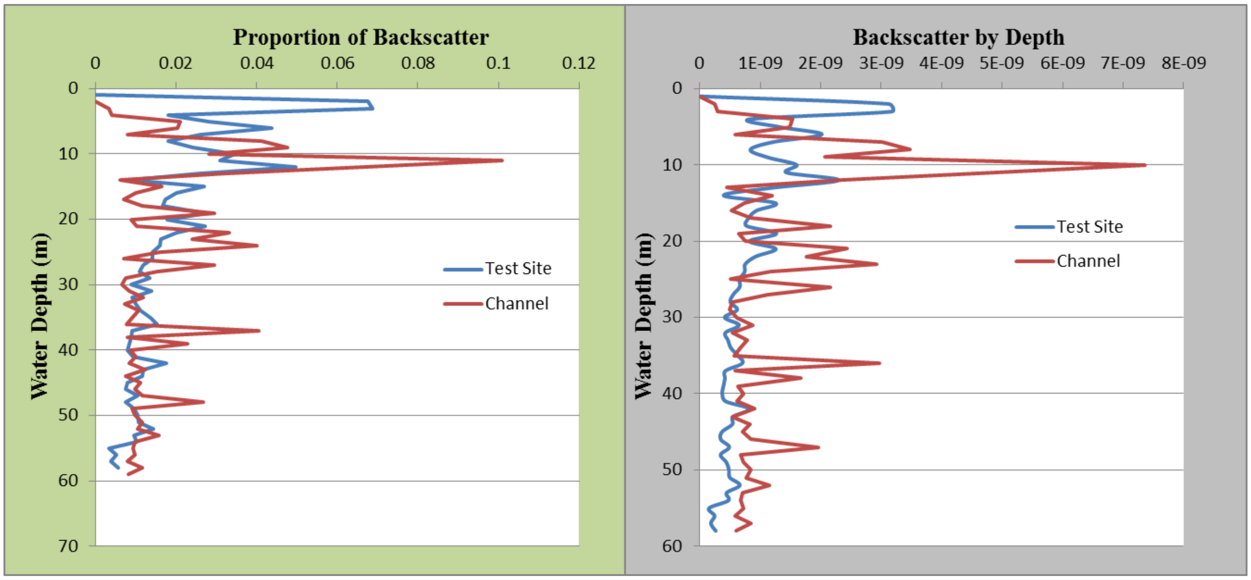


Figure 13a. Summary of the proportion (left) and actual (right) backscatter on October 3, 2011 for the test area and the channel to the test site water depths.

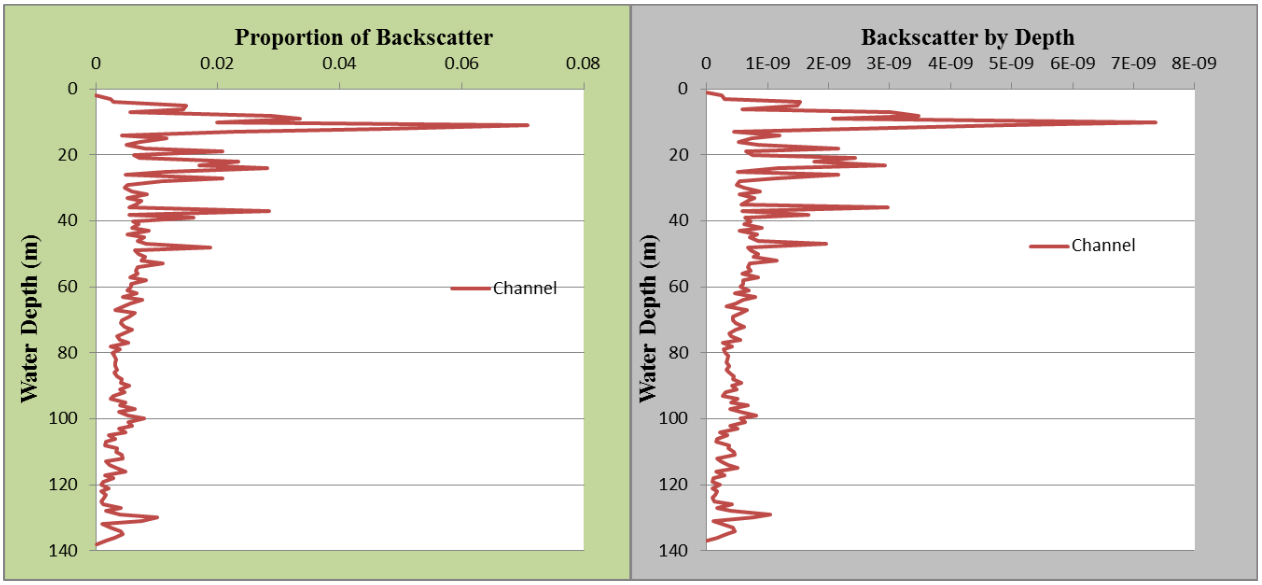


Figure 13b. Summary of the proportion (left) and actual (right) backscatter by depth on October 3, 2011 for the channel from the surface to bottom.

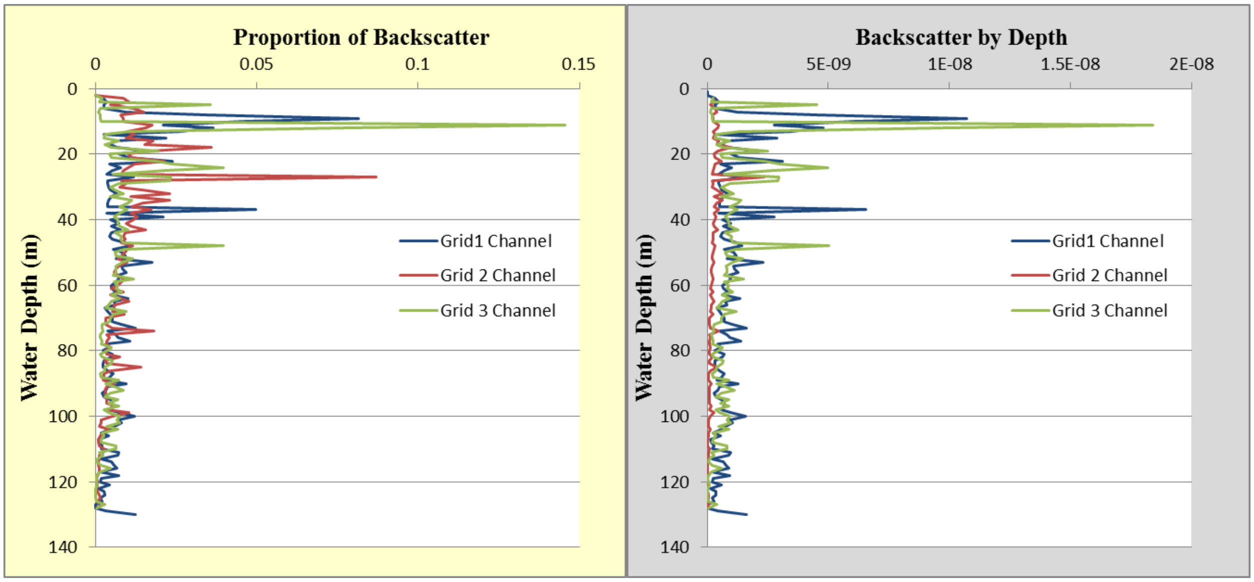


Figure 13c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the October 3, 2011 survey.

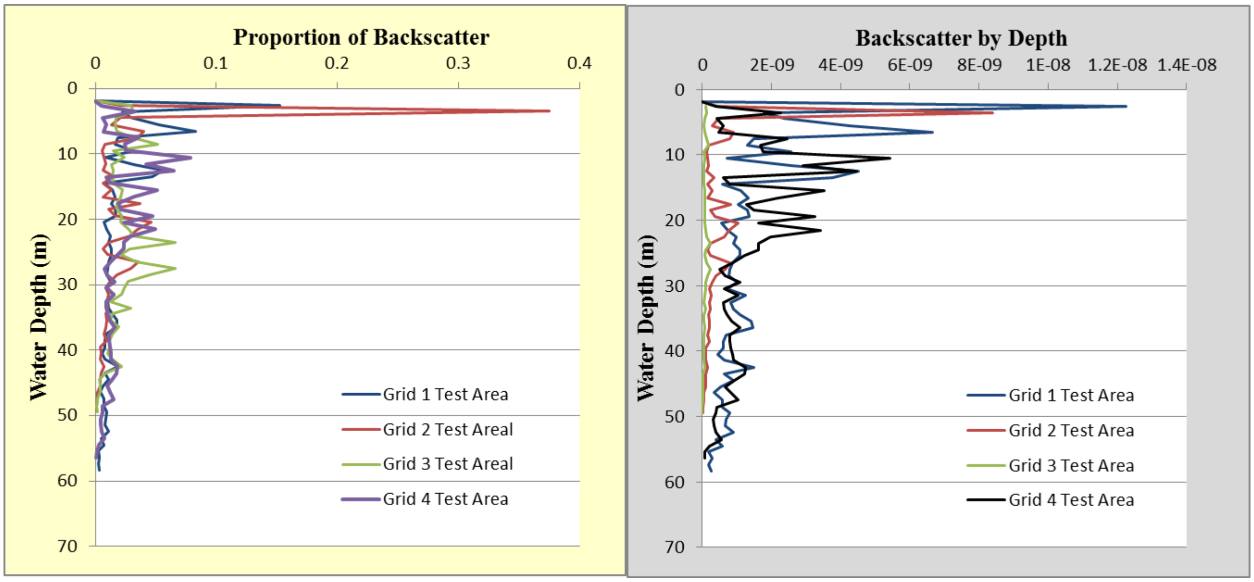


Figure 13d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the October 3, 2011 survey.

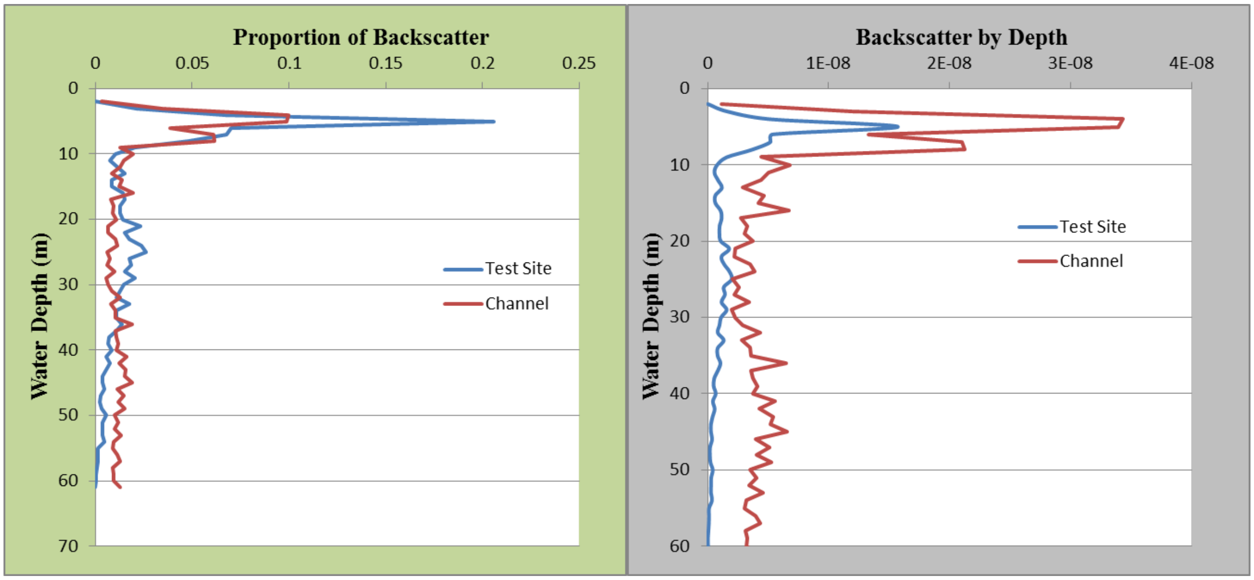


Figure 14a. Summary of the proportion (left) and actual (right) backscatter on November 22, 2011 for the test area and the channel to the test site water depths.

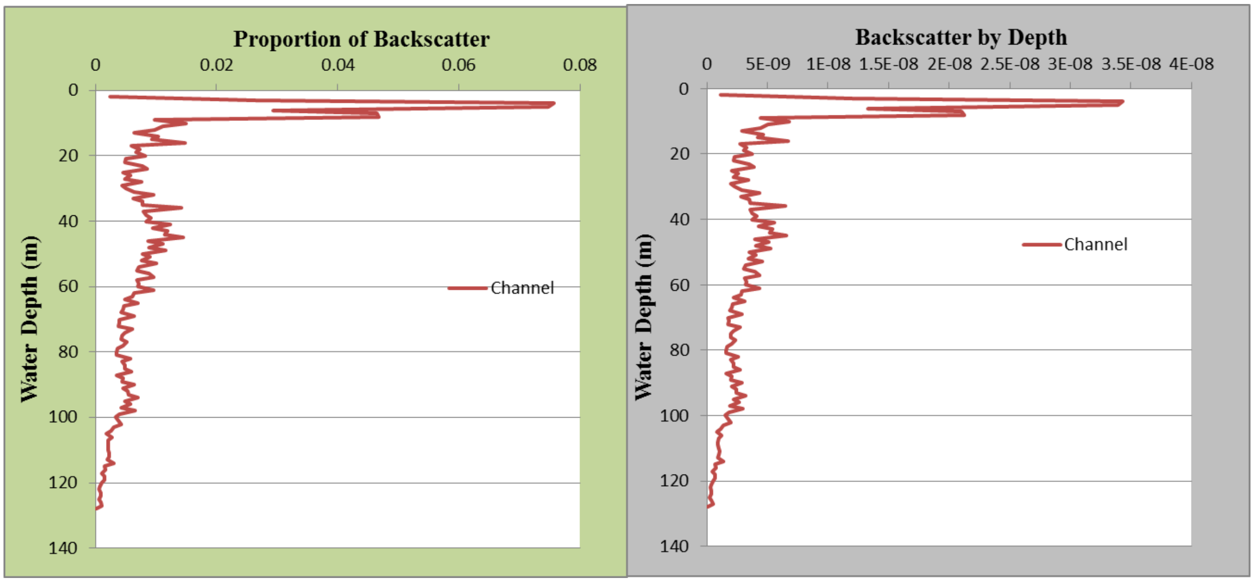


Figure 14b. Summary of the proportion (left) and actual (right) backscatter by depth on November 22, 2011 for the channel from the surface to bottom.

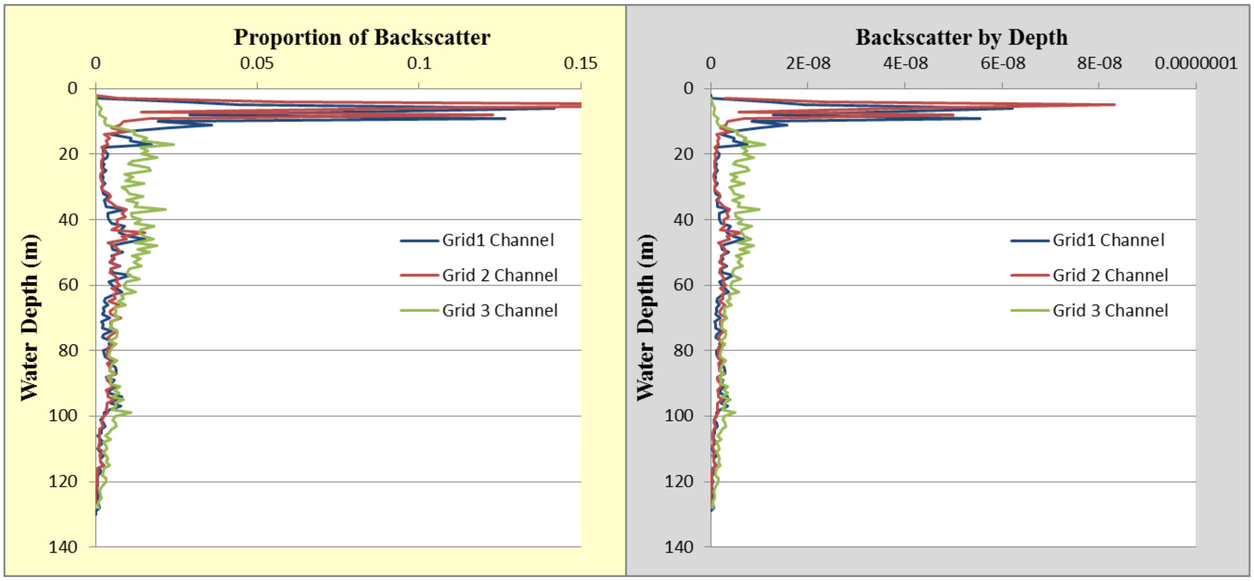


Figure 14c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the November 22, 2011 survey.

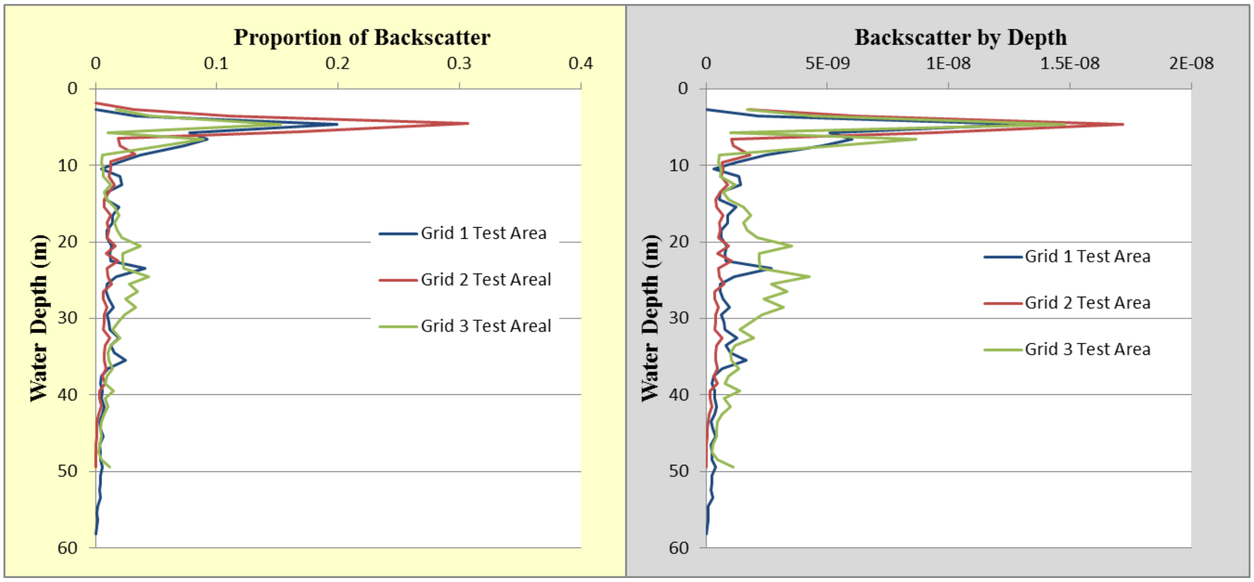


Figure 14d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the November 22, 2011 survey.

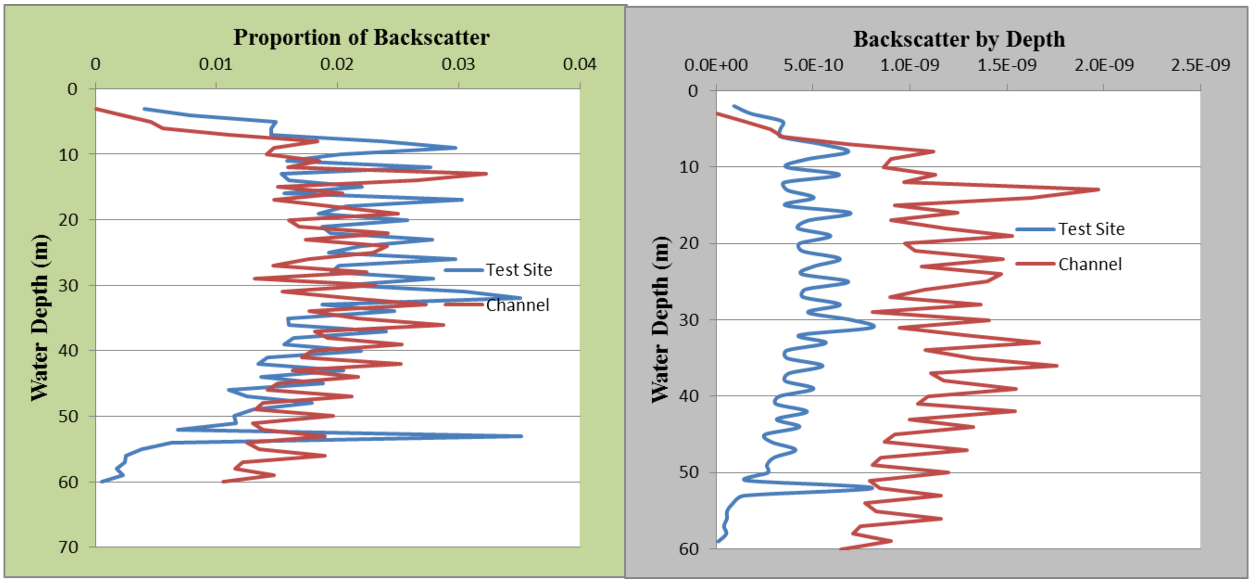


Figure 15a. Summary of the proportion (left) and actual (right) backscatter on January 25, 2012 for the test area and the channel to the test site water depths.

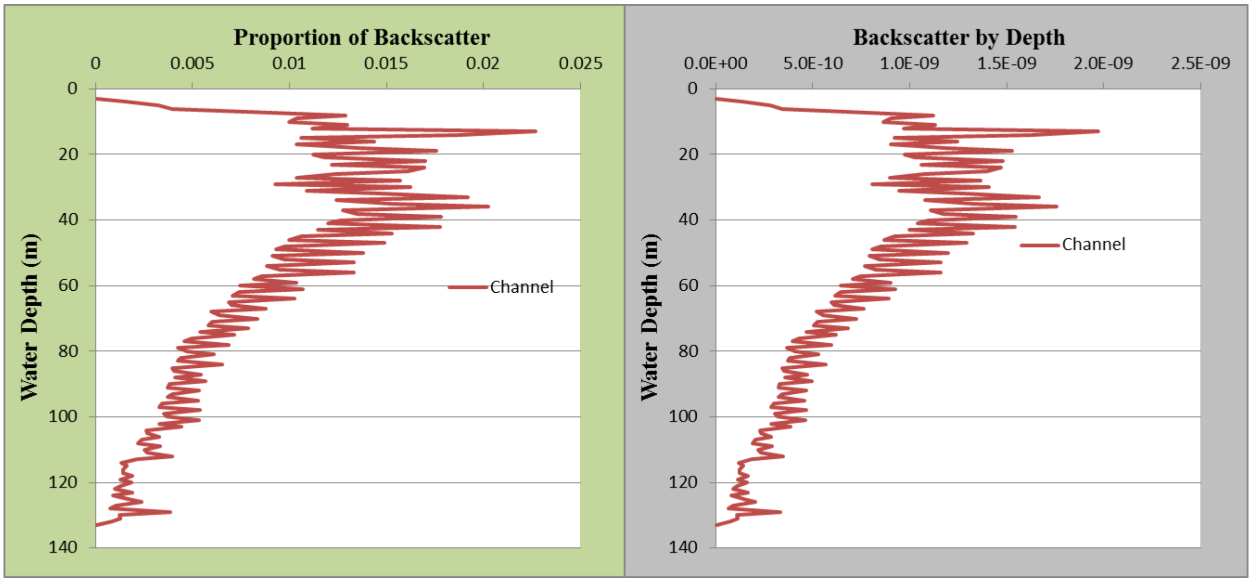


Figure 15b. Summary of the proportion (left) and actual (right) backscatter by depth on January 25, 2012 for the channel from the surface to bottom.

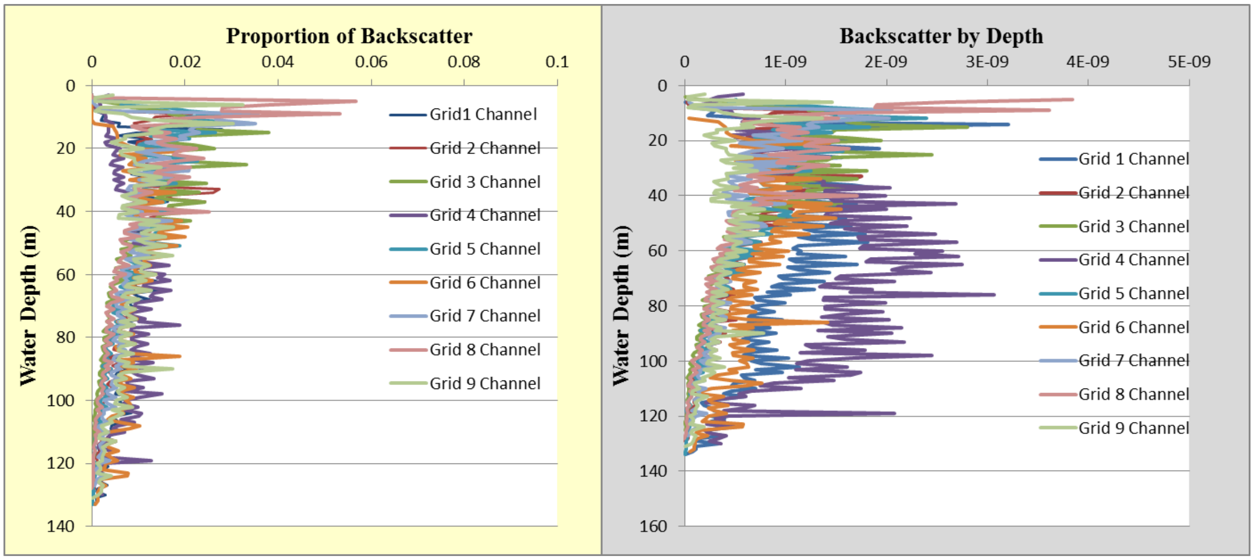


Figure 15c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the January 25, 2012 survey.

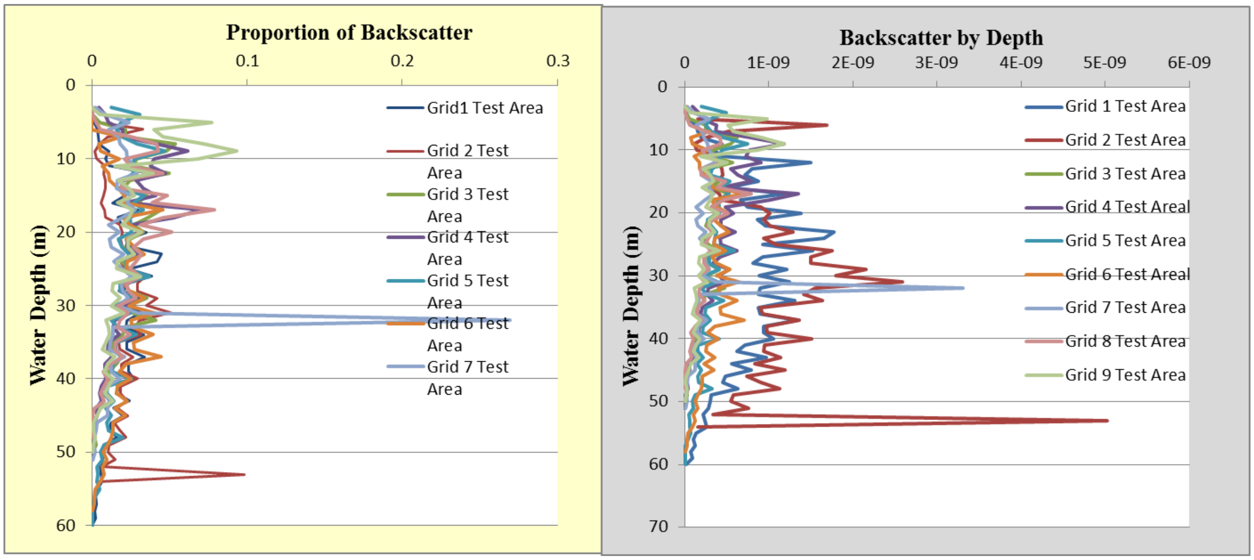


Figure 15d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the January 25, 2012 survey.

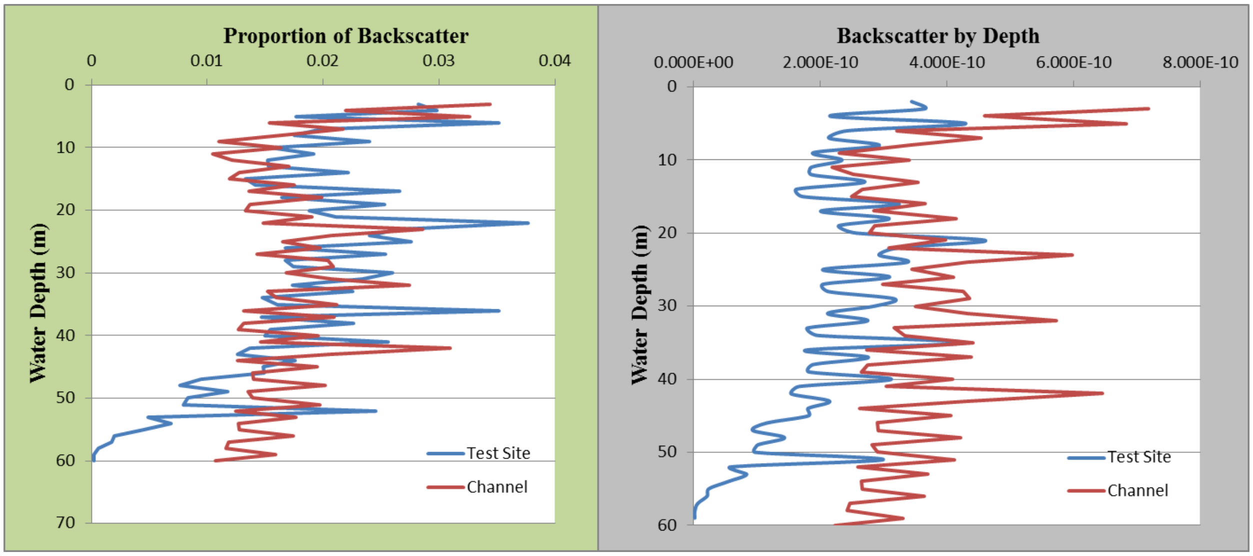


Figure 16a. Summary of the proportion (left) and actual (right) backscatter on March 19, 2012 for the test area and the channel to the test site water depths.

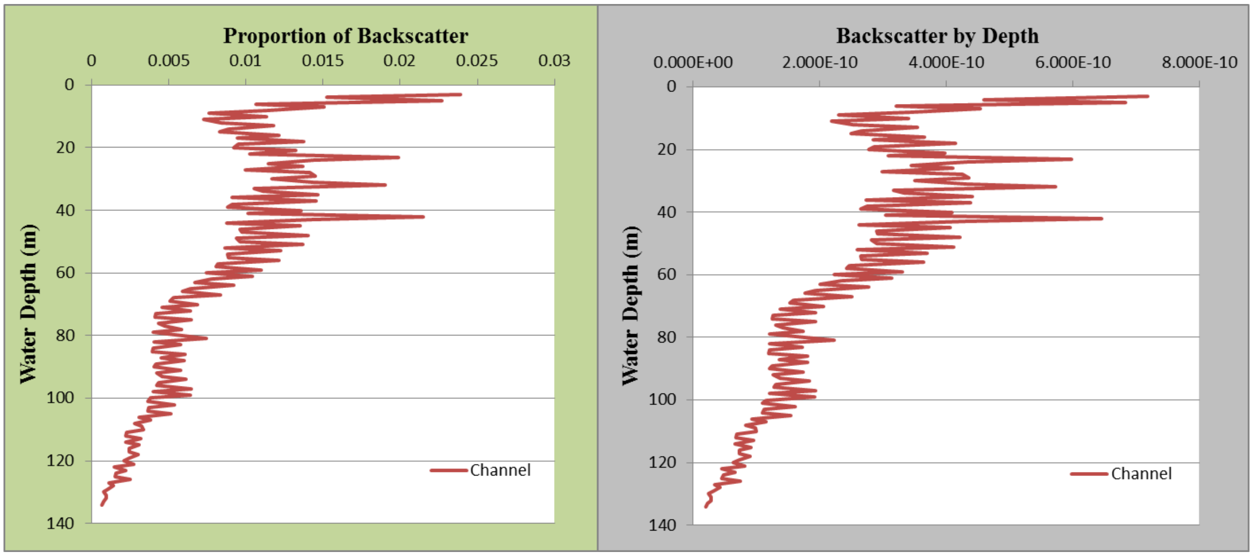


Figure 16b. Summary of the proportion (left) and actual (right) backscatter by depth on March 19, 2012 for the channel from the surface to bottom.

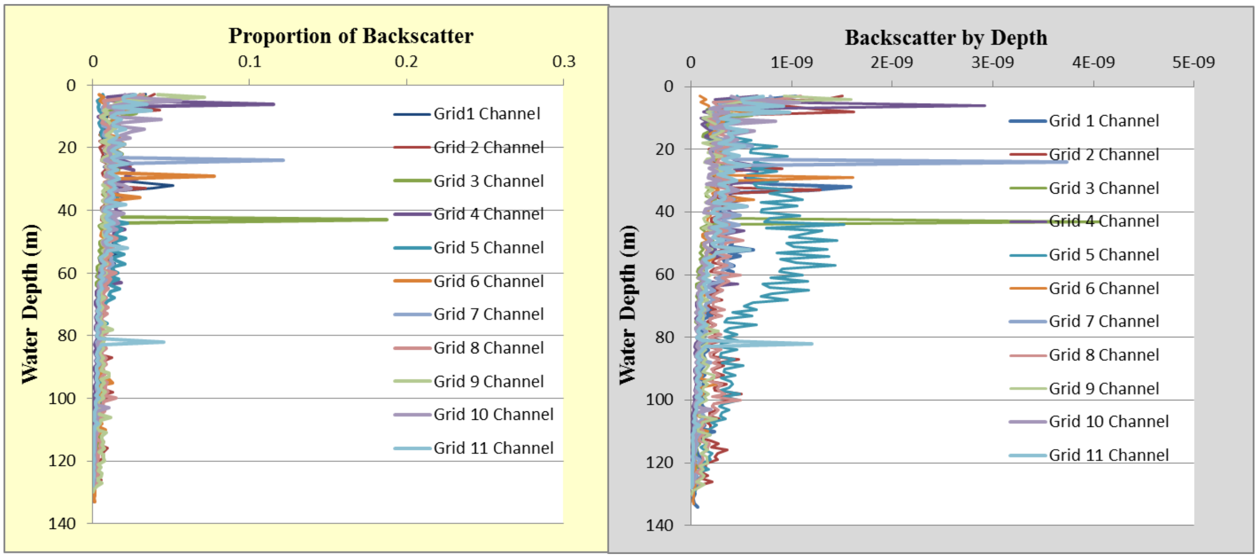


Figure 16c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the March 19, 2012 survey.

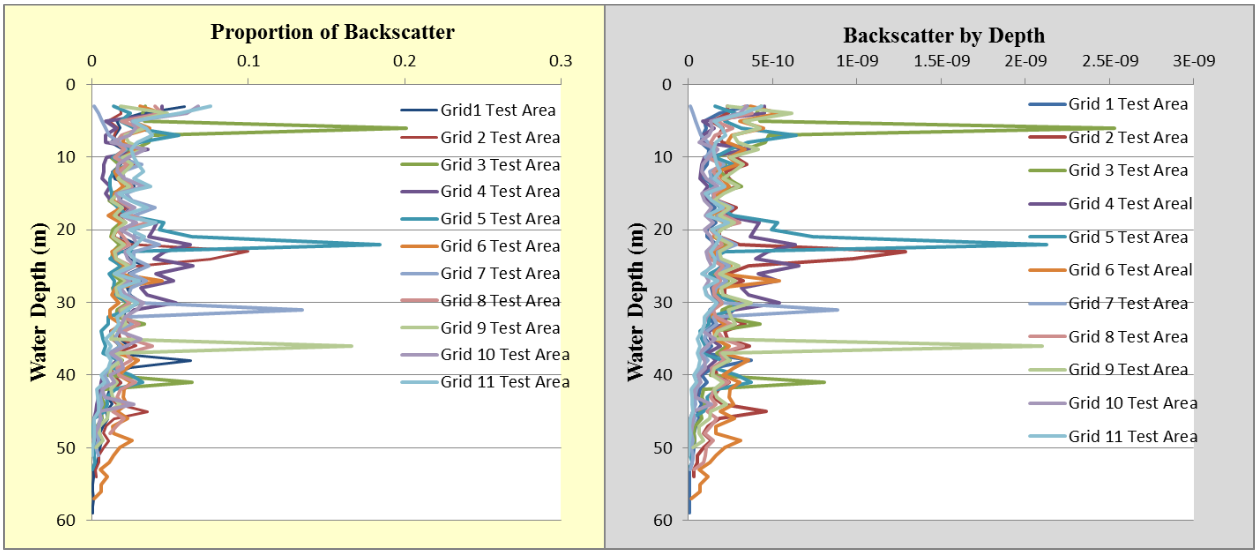


Figure 16d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the March 19, 2012 survey.

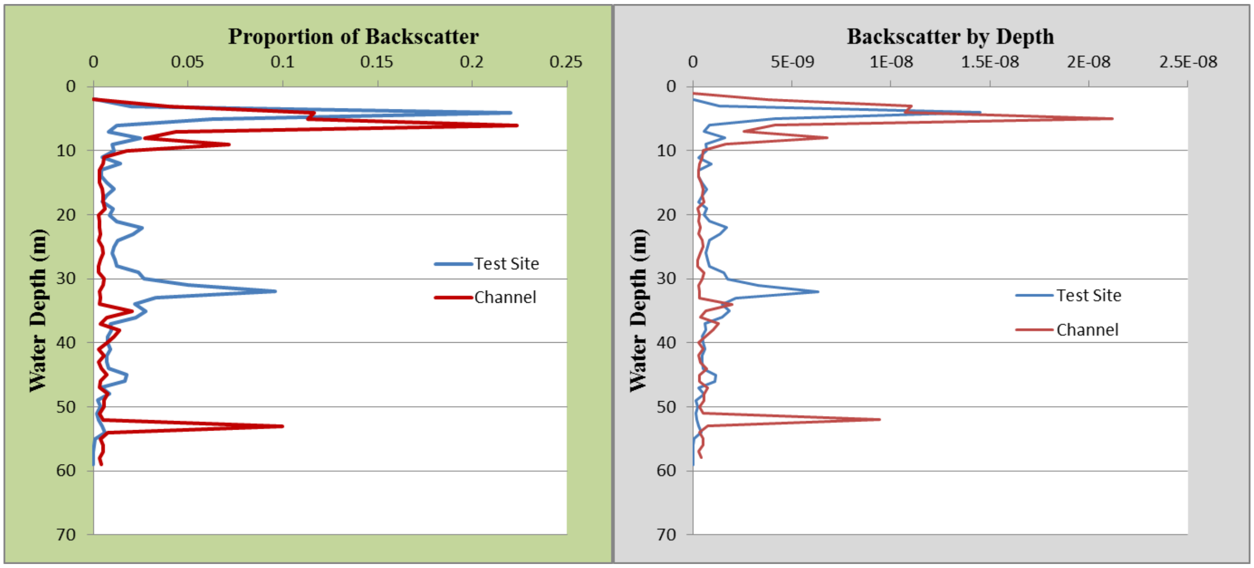


Figure 17a. Summary of the proportion (left) and actual (right) backscatter on May 31, 2012 for the test area and the channel to the test site water depths.

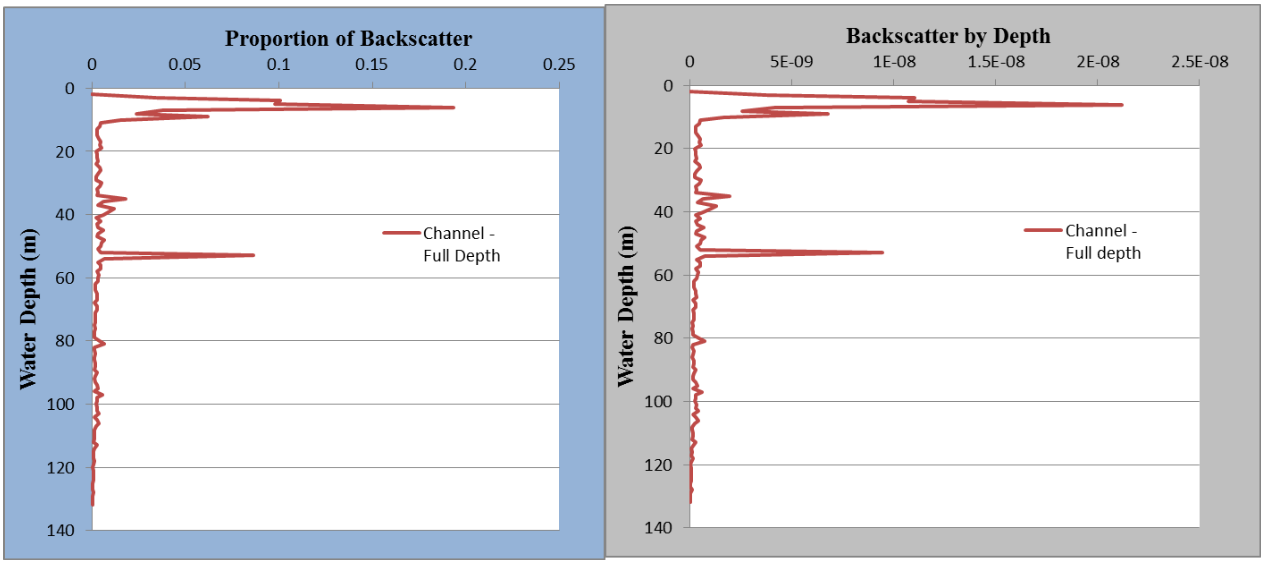


Figure 17b. Summary of the proportion (left) and actual (right) backscatter by depth on May 25, 2012 for the channel from the surface to bottom.

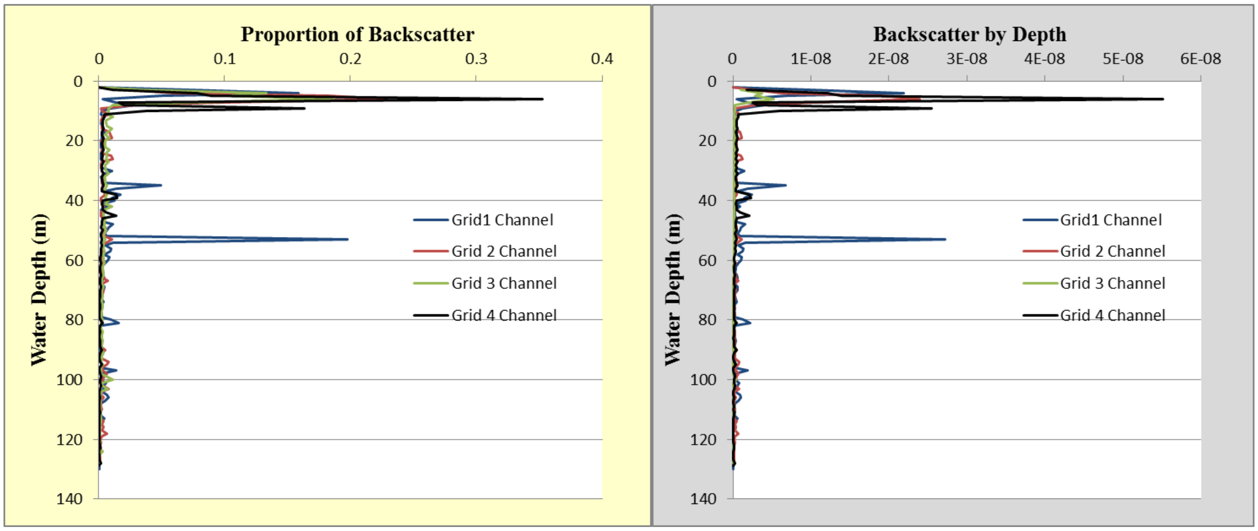


Figure 17c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the May 31, 2012 survey.

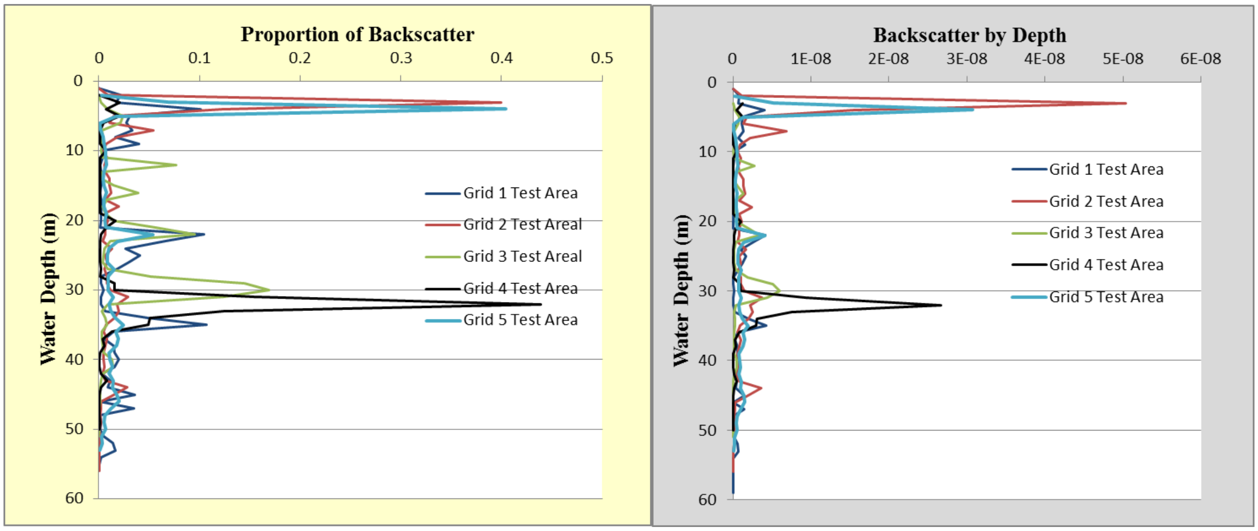


Figure 17d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the May 31, 2012 survey.

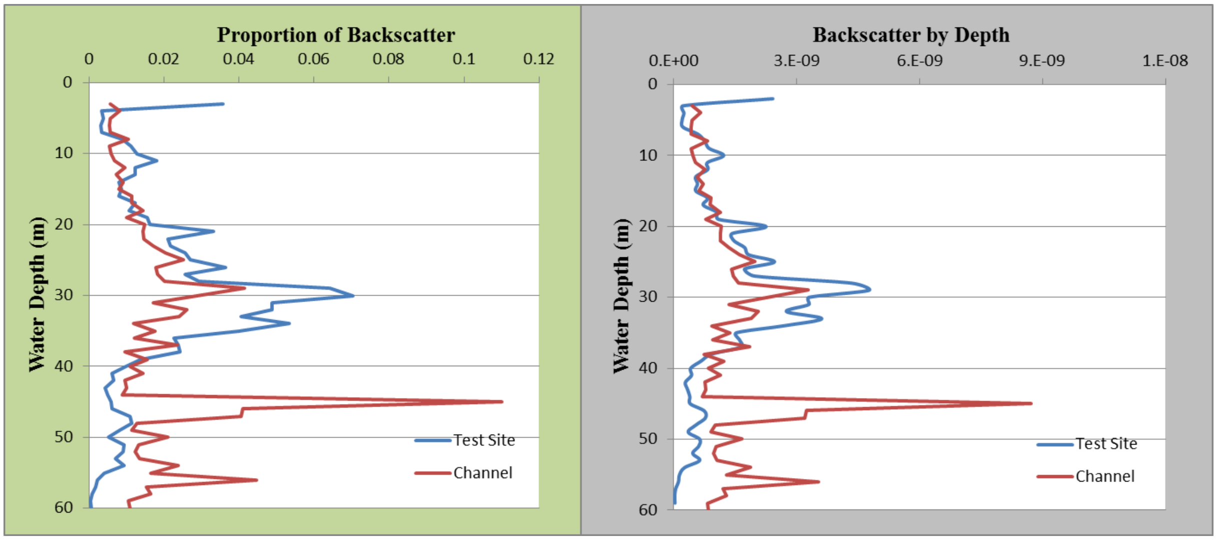


Figure 18a. Summary of the proportion (left) and actual (right) backscatter on June 25, 2012 for the test area and the channel to the test site water depths.

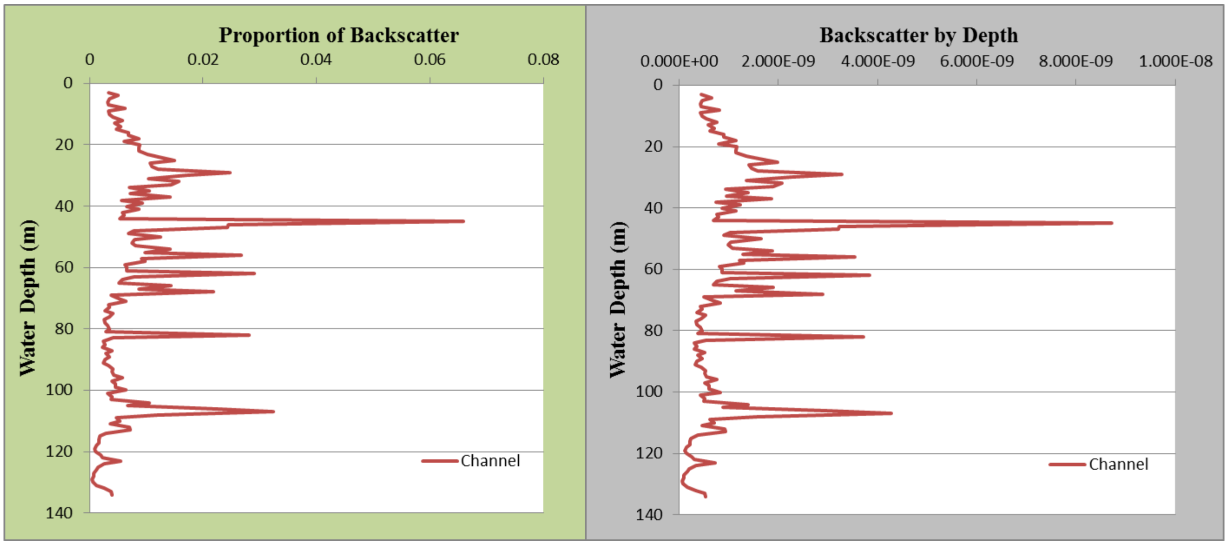


Figure 18b. Summary of the proportion (left) and actual (right) backscatter by depth on June 25, 2012 for the channel from the surface to bottom.

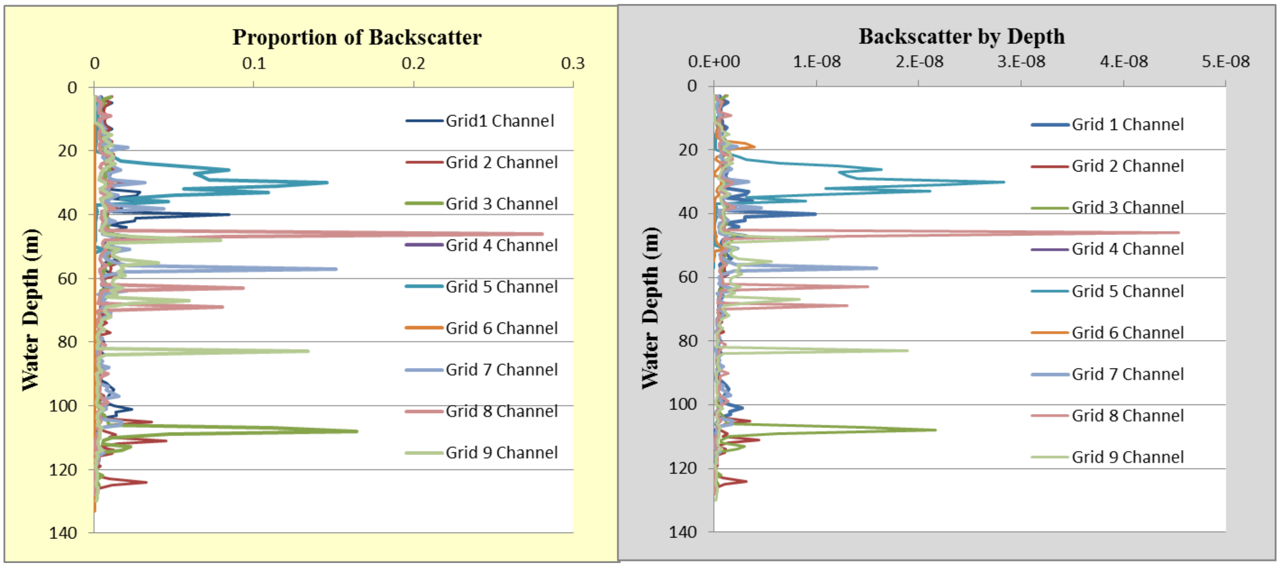


Figure 18c. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the channel for the June 25, 2012 survey.

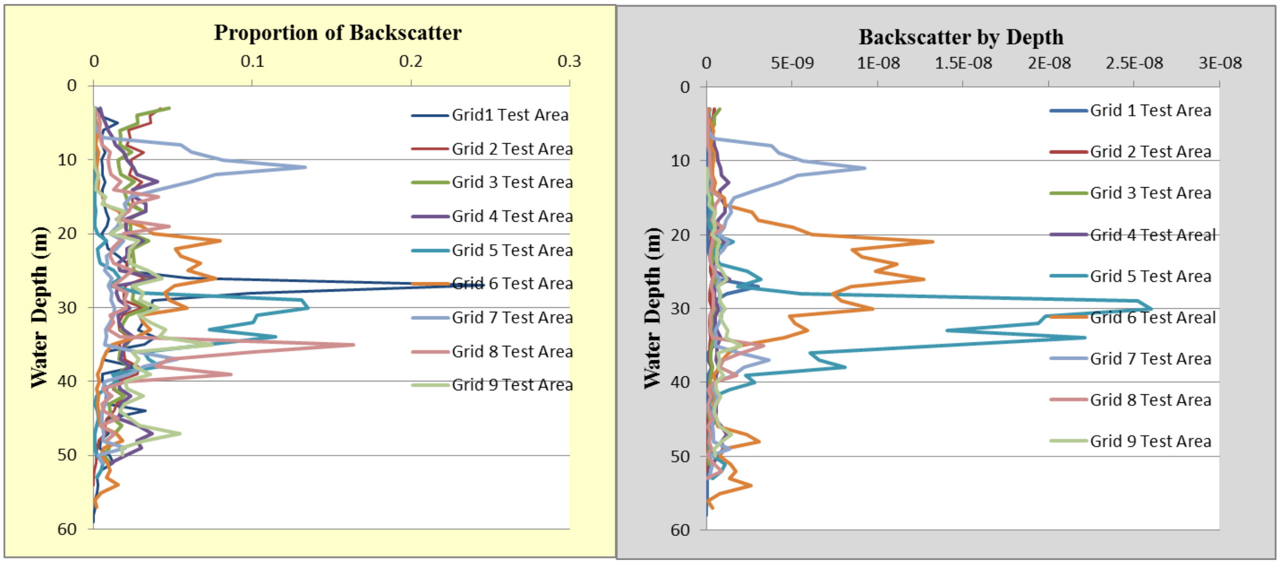


Figure 18d. Proportion of backscatter (left) and actual backscatter (right) by depth and grid within the test area for the June 25, 2012 survey.

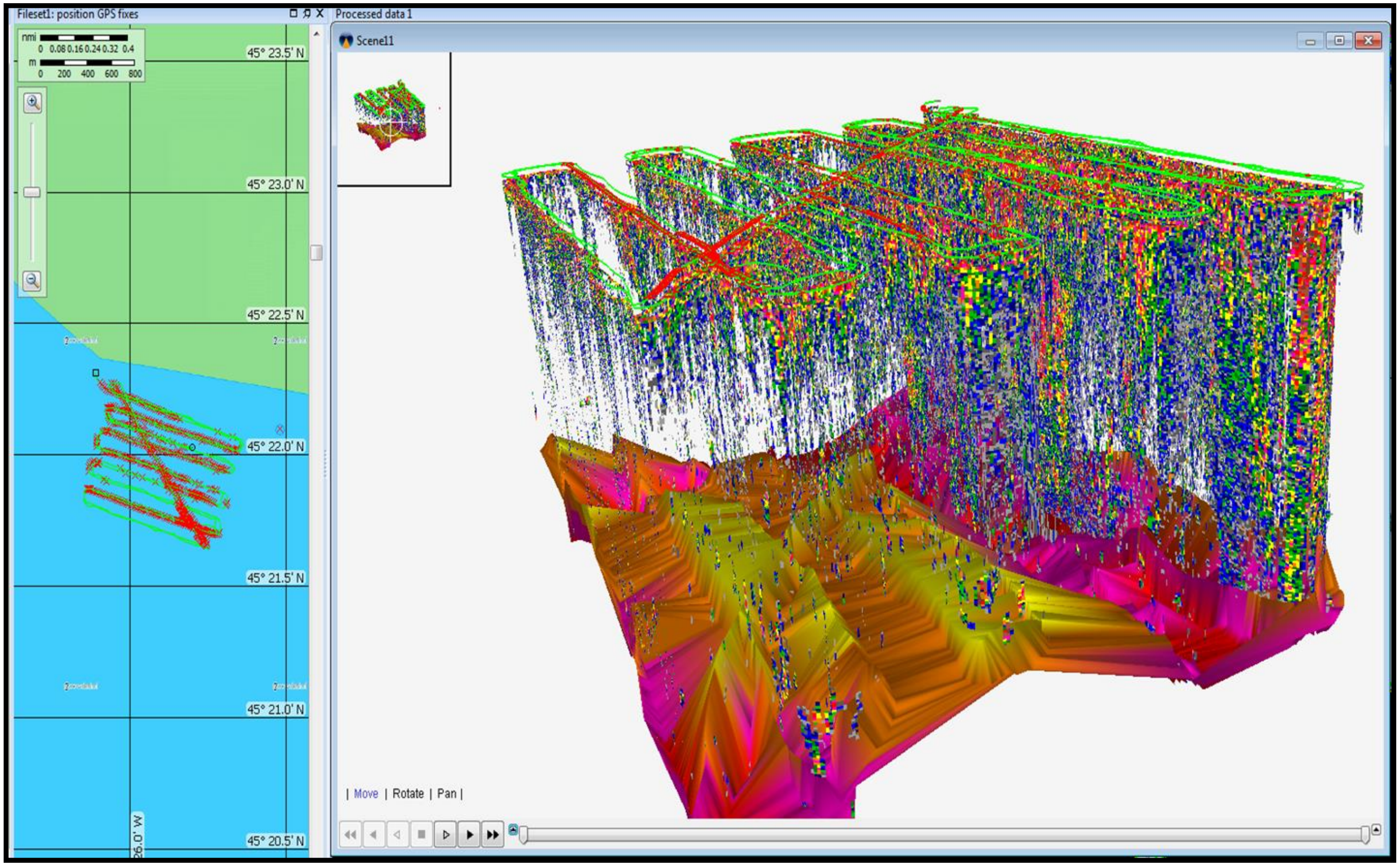


Figure 19. A test site 3-D backscatter curtain derived from Grid 6 split-beam transects of the June 25, 2012 survey. At grid initiation (transect T0 LHS expanded view) bubble plume backscatter extending downwards from the surface is relatively weak and shallow. The bubble backscatter deepens and intensifies as successive transects are steamed on an increasing ebb current. Another group of scatterers, almost certainly herring, are concentrated near mid-water column most prominently in the central and latter grid transects.

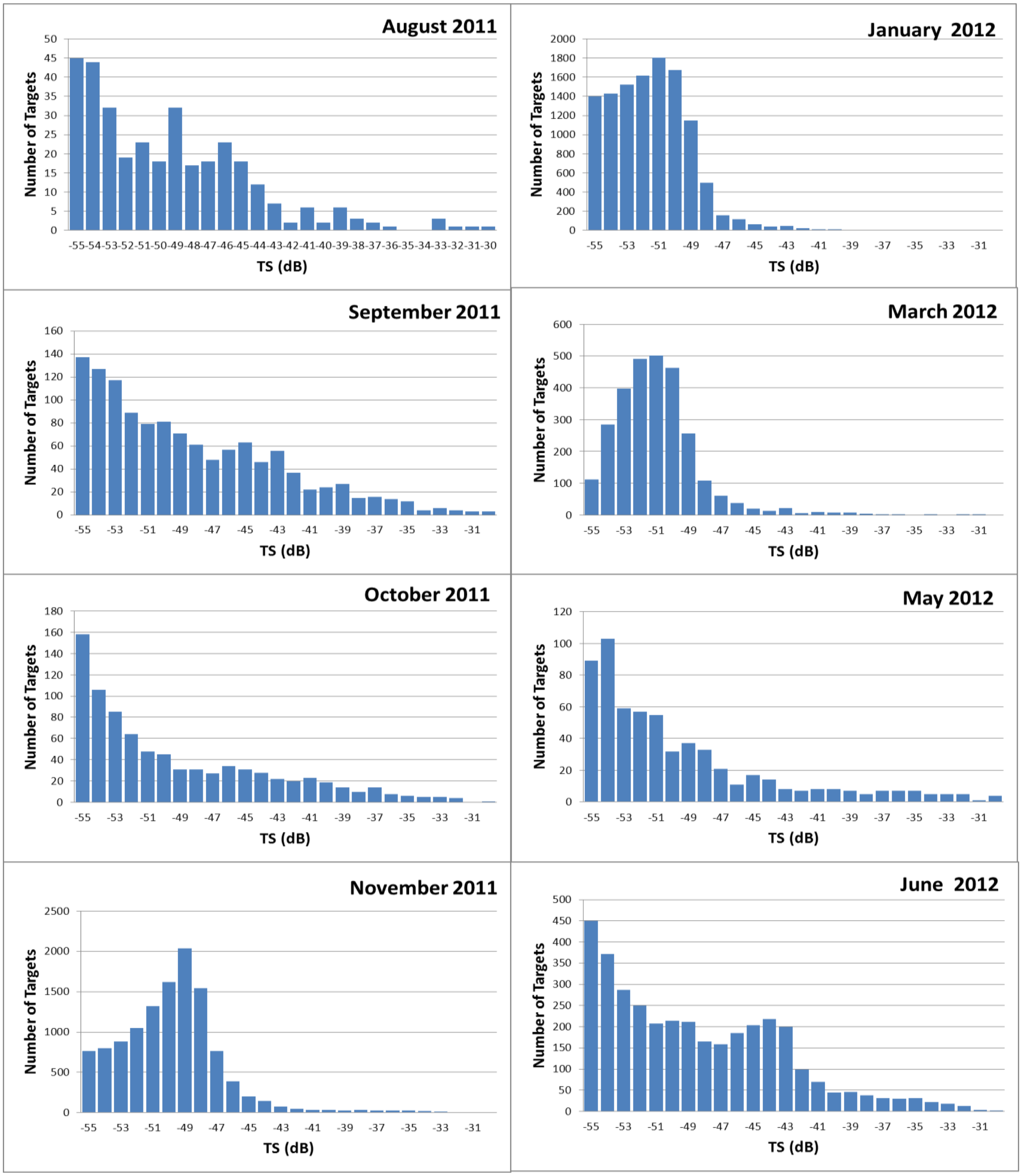


Figure 20. Overall frequency distribution of target strength of individual targets for each survey conducted between 2011 and 2012 in Minas Passage. Summary includes individual targets from all transects.

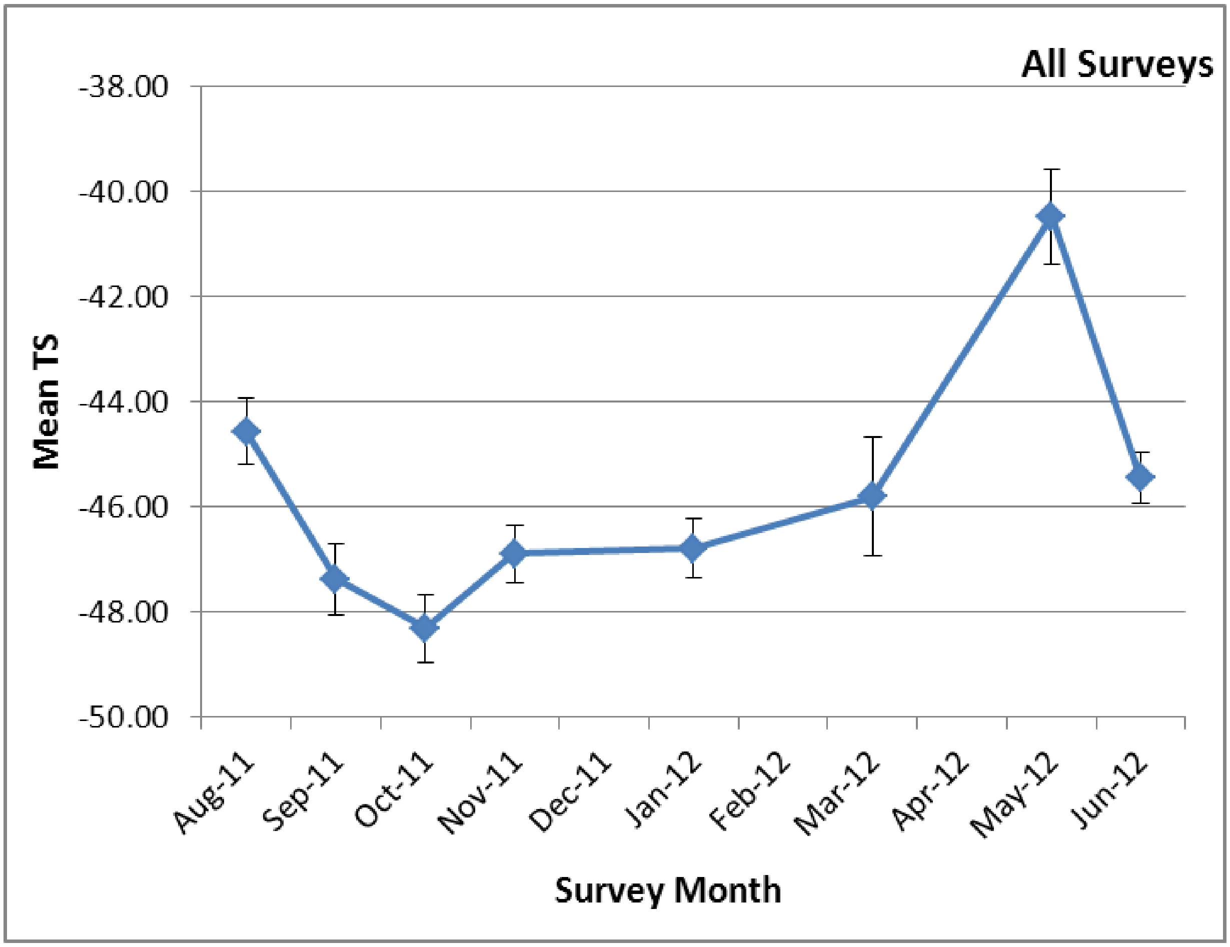


Figure 21. Summary of the mean TS for individual targets from all transects and all depths. No surveys were conducted in December, February or April. Error bars are two standard errors.

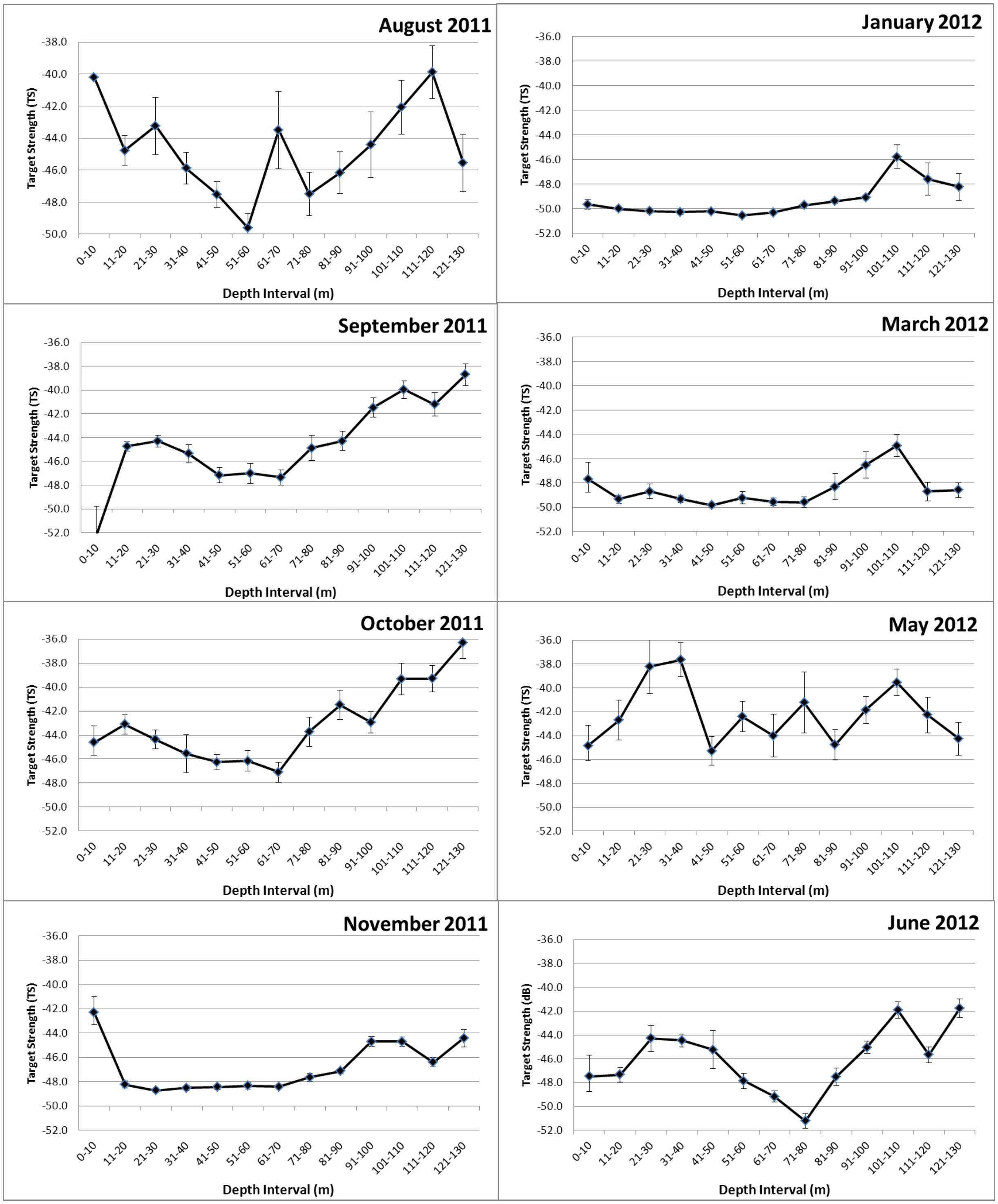


Figure 22. Distribution of mean target strength (single targets) by 10 m depth intervals from the surface to bottom for all surveys conducted in Minas Passage between 2011 and 2012. The error bars represent two standard errors.

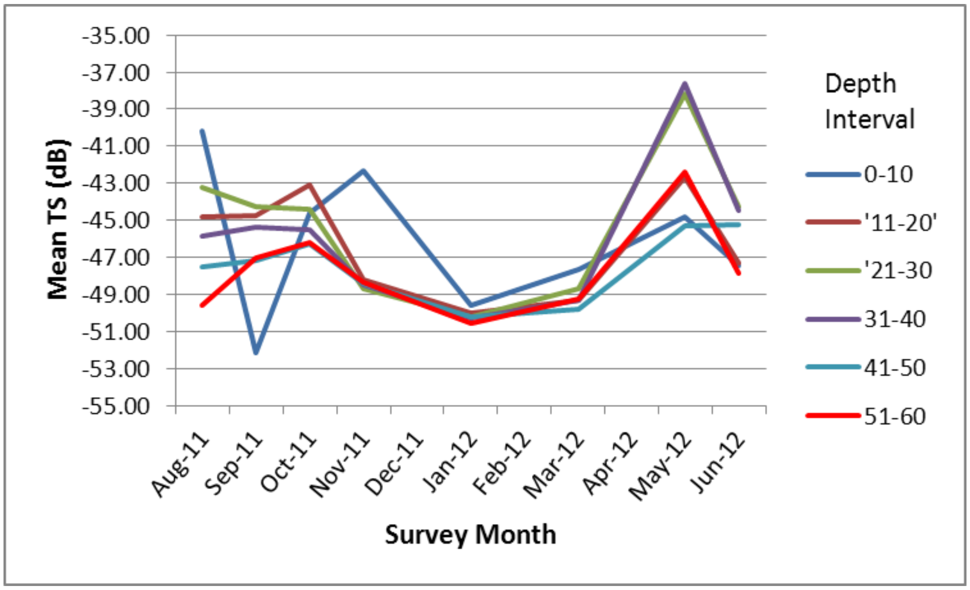


Figure 23. Mean TS by 10 m depth intervals from 0 – 60 m and survey month for all transects. Depth range corresponds to approximately those at the test site. No surveys were conducted in December, February or April. Standard errors are presented in Table 8.

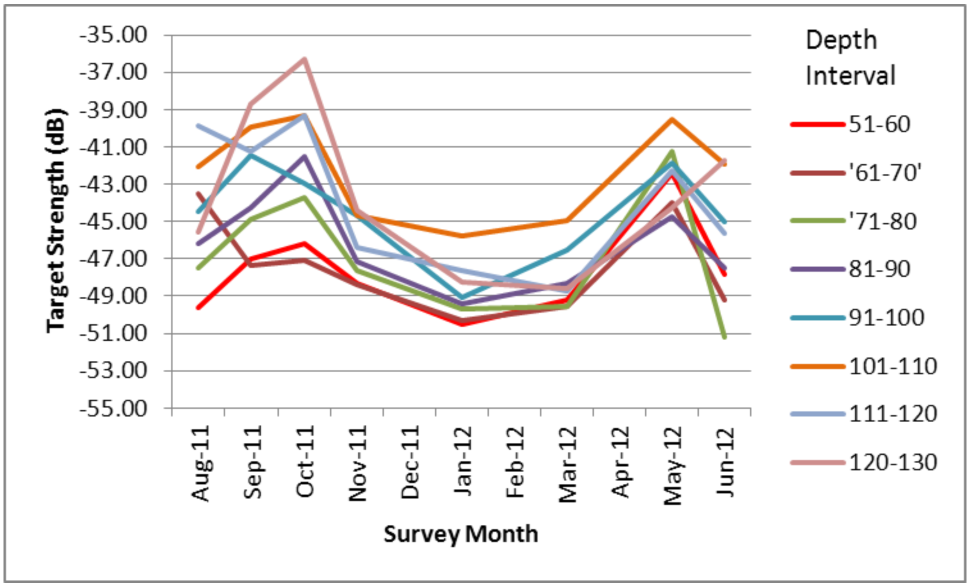


Figure 24. Mean TS by 10 m depth intervals from 61 – 130 m and survey month for all transects. Depth range corresponds to approximately those in the Channel. No surveys were conducted in December, February or April. Standard errors are presented in Table 8.

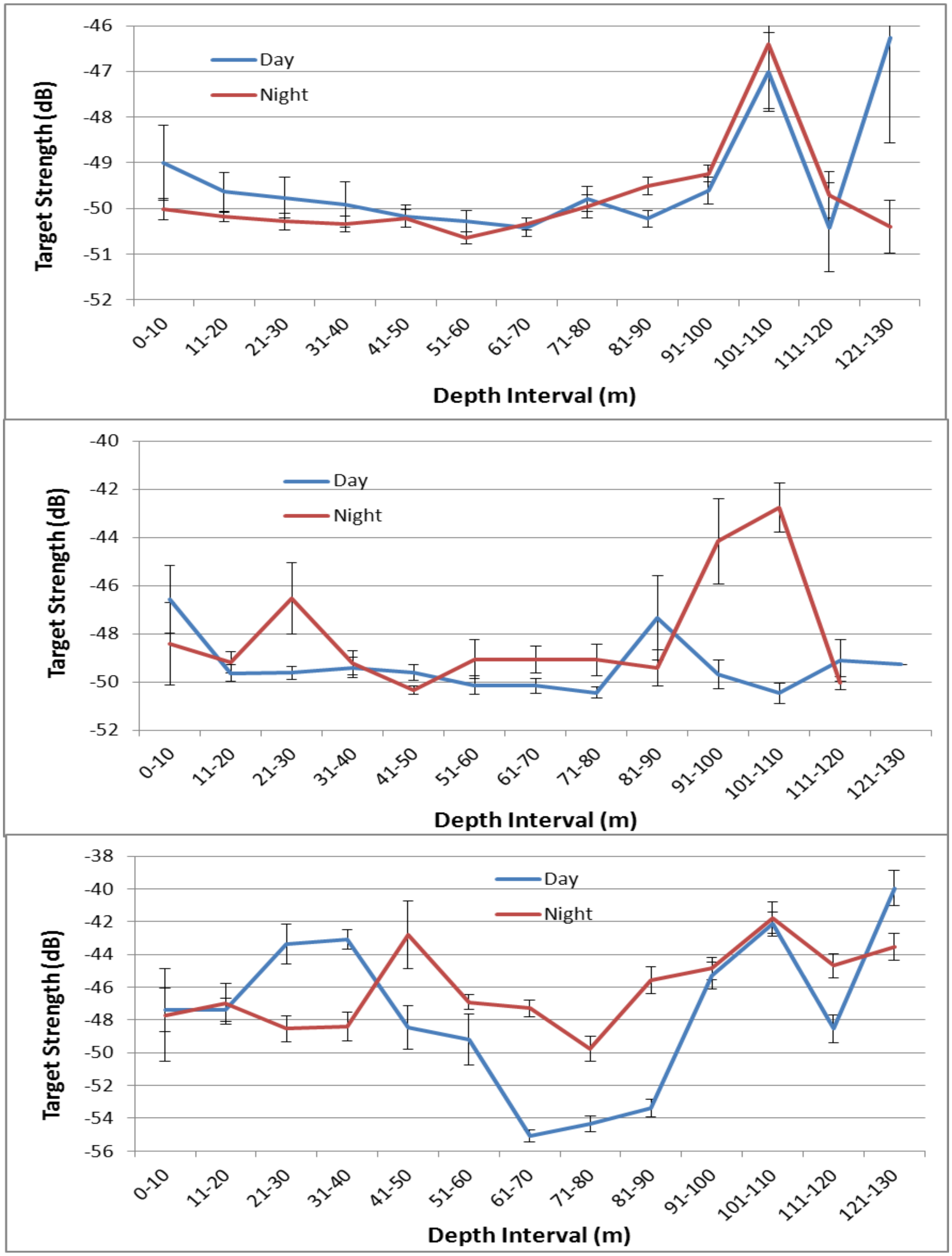


Figure 25. Mean individual target strength estimates by 10 depth interval for acoustic surveys conducted in January (top), March (centre) and June (bottom) of 2012 in Minas Passage.

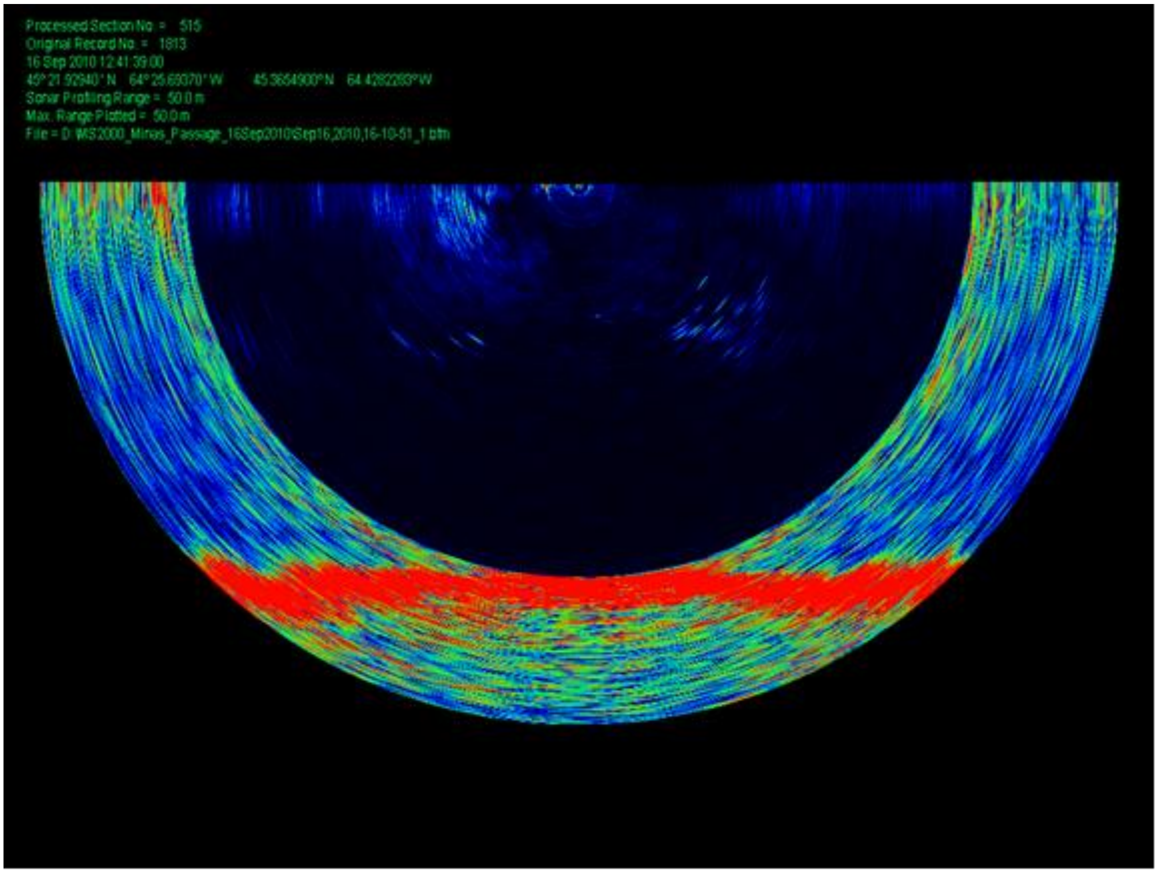


Figure 26. Simrad MS 2000 multi-beam 2-D fan section. Range to outer edge of coloured semicircle is 50 m. The red horizon is the bottom at a depth of 36 m. Intense scattering off the bottom interferes with all synthesized beams limiting the maximum effective water column profiling range to the distance from transducer to the nearest point on bottom. Around 15 m depth a heterogeneous layer of discrete fish targets can be observed. Above the fish can be seen water column scattering of bubble cloud origin extending downward from the surface.

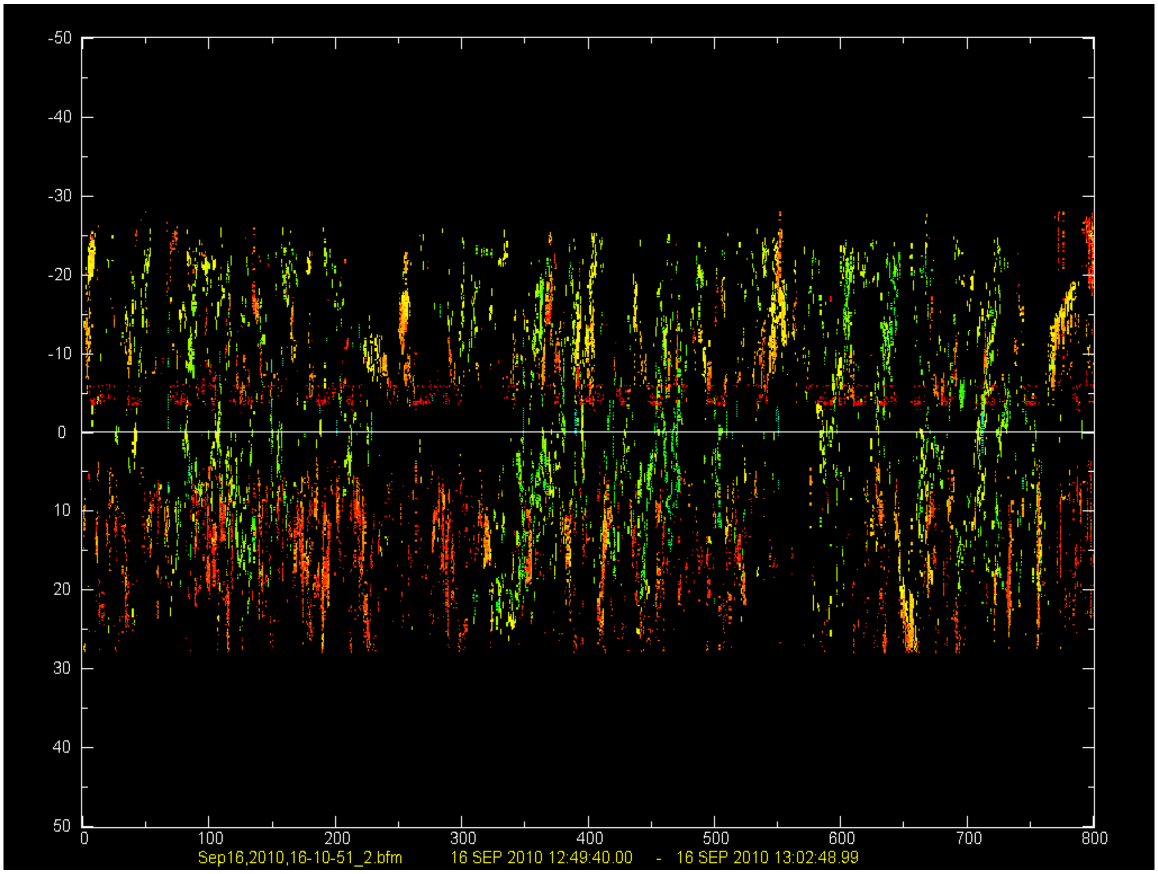


Figure 27. Aerial view of observed Simrad MS 2000 multi-beam field of view, looking downwards, over pings 1 to 800 of beamformed file Sept16,2010,16-10-51_2.bfm. Data series extends from 12:49:40 to 13:02:49 GMT, 16 Sept. 2010. This recording was conducted while the vessel steamed a loop just east of the turbine when shallow fish targets were especially numerous on the strong ebb tide cycle. Data are reproduced out to a maximum radial range of 28 m from the transducer. Negative to positive Y axis values correspond to Port and Starboard distances respectively from the transducer in meters. The X axis shows ping number. Depth is colour-encoded, ranging from red at surface to blue at depth. Shallow bubble clouds show up as shades of red to yellow while fish near 15 m depth appear in green. A few deeper fish targets or acoustic artefacts show up as blue.

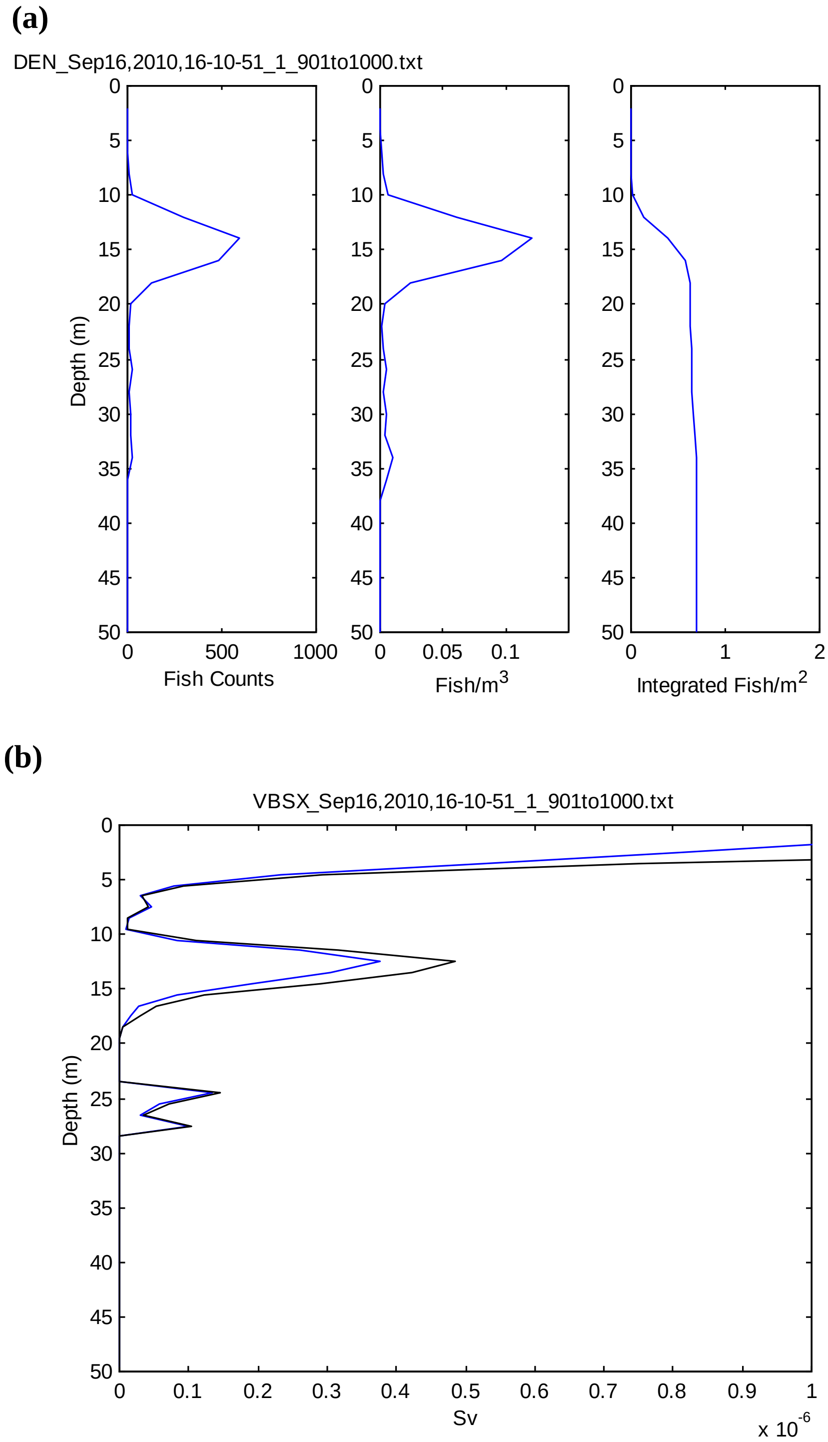


Figure 28. Comparison of (a) fish density vs. depth from direct counting and (b) volume backscattering strength component vs. depth for an identical 100 ping section extending from ping 901 to ping 1000 of beamformed file: Sep16,2010,16-10-51_1.bfm: Black – VBS corrected beam patterns, Blue – VBS uncorrected for beam patterns. VBS is plotted in linear form. Data shown was gathered immediately east of turbine between 12:48:01 and 12:49:39 GMT on the strong portion of the ebb tide cycle.

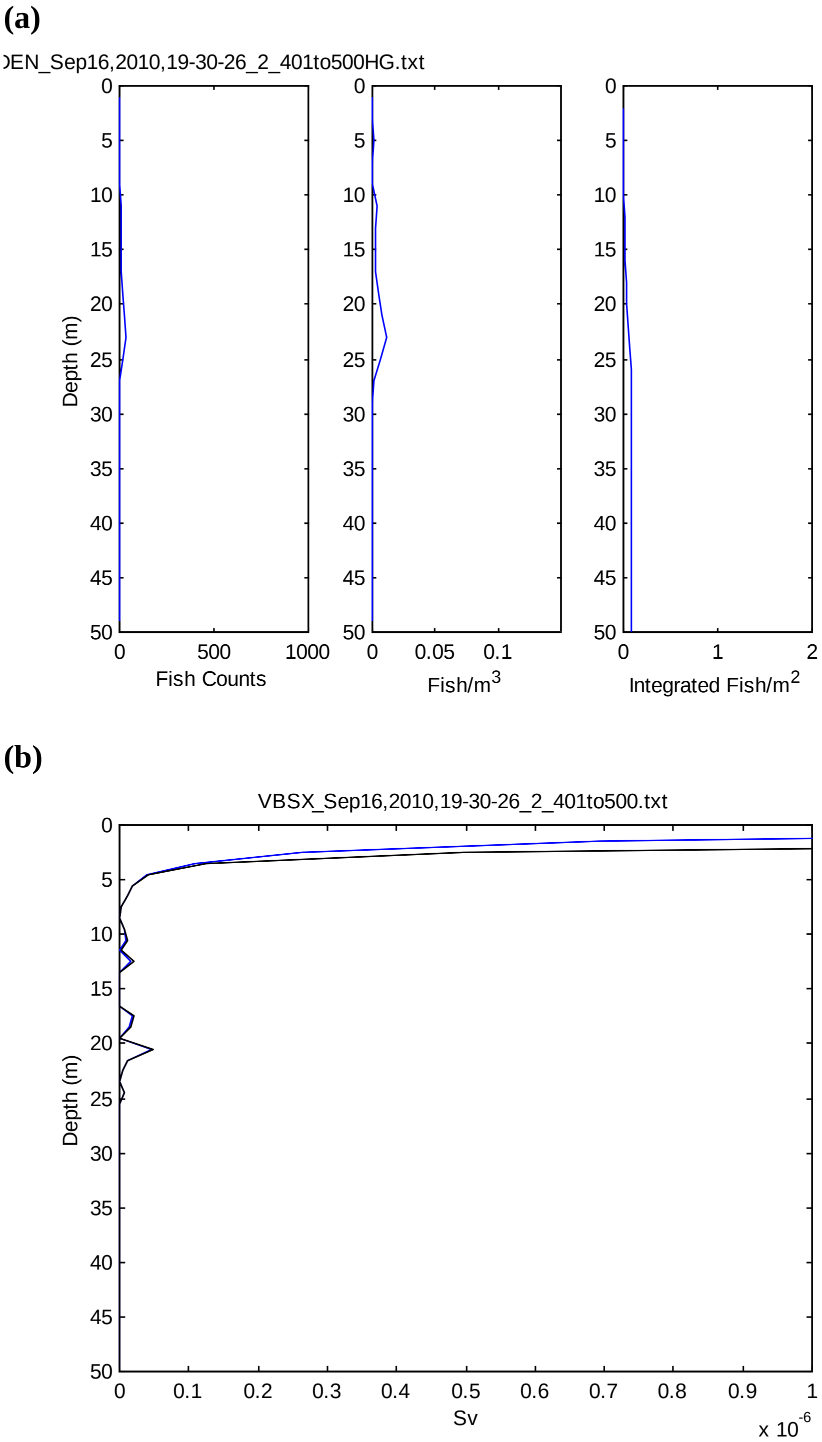


Figure 29. Comparison of (a) fish density vs. depth from direct counting and (b) volume backscattering strength component vs. depth for an identical 100 ping section extending from ping 401 to ping 500 of beamformed file: Sep16,2010,19-30-26_2.bfm: Black – VBS corrected beam patterns, Blue – VBS uncorrected for beam patterns. VBS is plotted in linear form. Data shown was gathered immediately east of turbine between 16:15:31 and 16:17:09 GMT near the end of the ebb current cycle. Horizontal axis scaling matches that of Fig. 28.

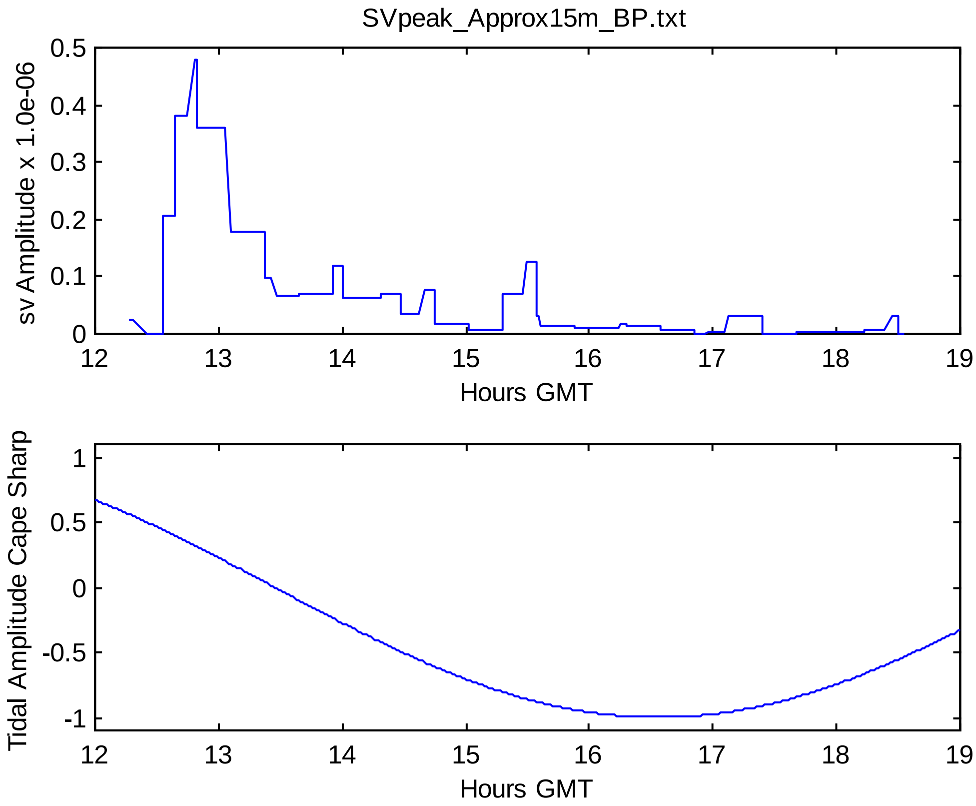


Figure 30. (Top) Peak S_v amplitude (linear form, scaling arbitrary) of ~15 m depth layer vs. time. Multi-beam beam pattern corrections have been employed. (Bottom) A sinusoidal approximation to Cape Sharp tidal amplitudes. Plotted observation period extends from 12:16:43 to 18:33:10 GMT.

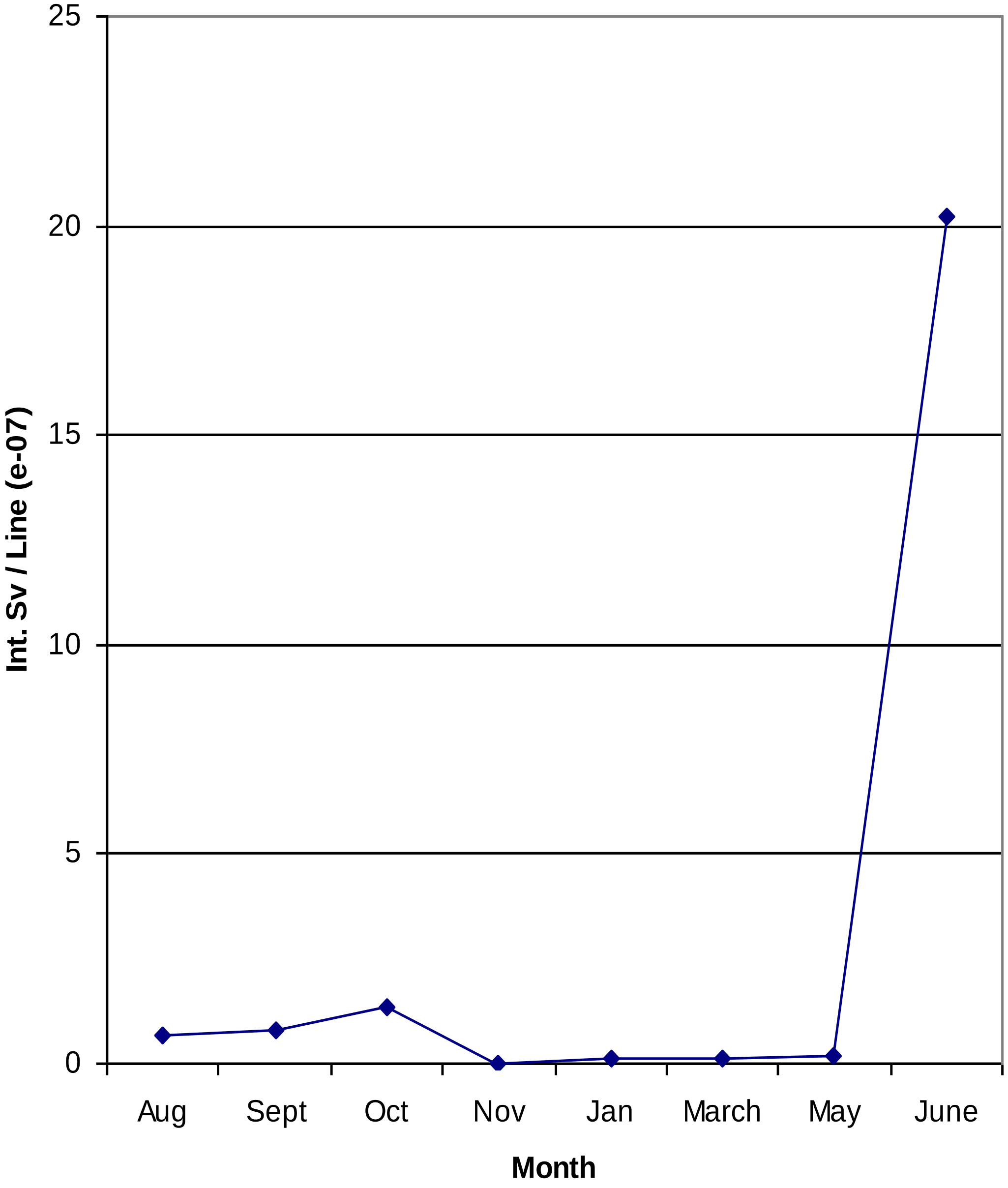
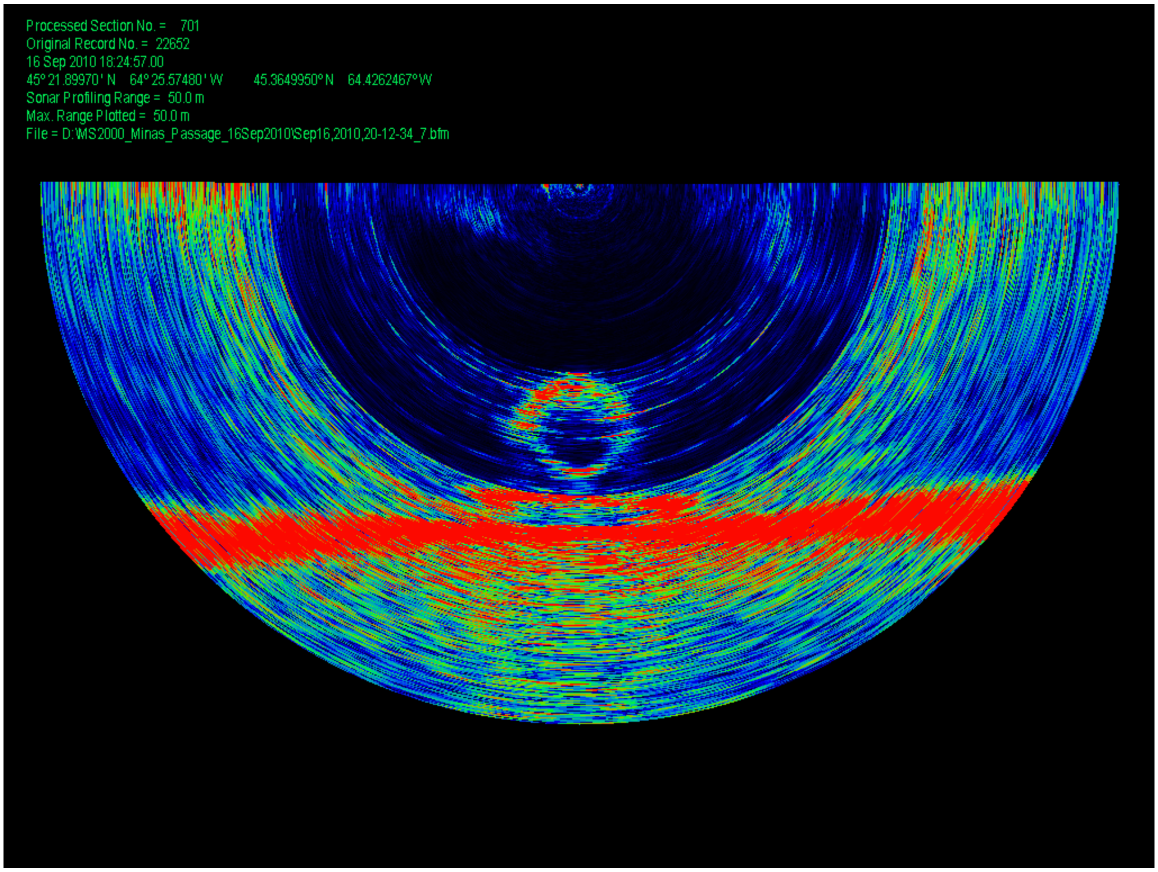


Figure 31. Average depth integrated, linear form S_v per test site line using MS 2000 multi-beam sonar for post 16 Sept. 2010 surveys.



```
Processed Section No. =    701
Original Record No. =  22652
16 Sep 2010 18:24:57.00
45° 21.89970' N    64° 25.57480' W        45.3649950° N    64.4262467° W
Sonar Profiling Range =  50.0 m
Max. Range Plotted =  50.0 m
File = D:\MS2000_Minas_Passage_16Sep2010\Sep16,2010,20-12-34_7.bfm
```

Figure 32. Simrad MS 2000 section showing OpenHydro turbine and its supporting base. Note interference in all synthesized beams from intense backscatter originating from the turbine structure.

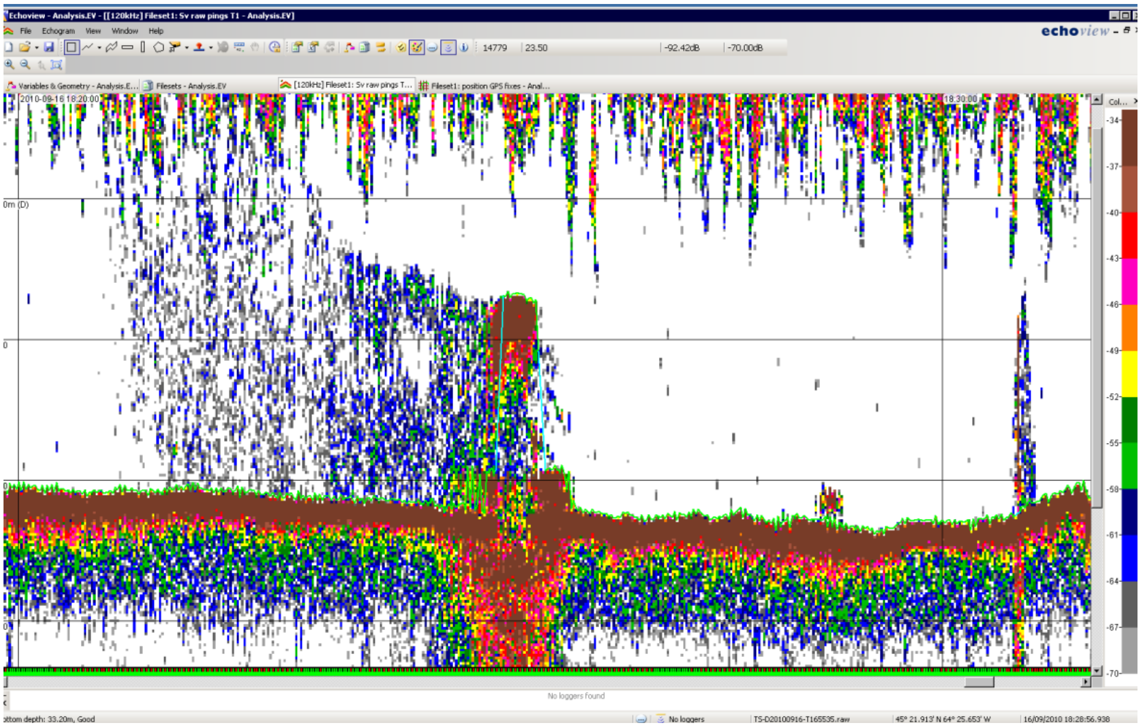


Figure 33. EK60 echogram showing an acoustically visible wake apparently ascending to the surface on transect over turbine (near center). Bubble clouds can also be observed extending down from surface. Vessel was moving slowly east to west against the flood tide.

APPENDIX 1: PROJECT CHRONOLOGY

The specific Project chronology developed as follows:

10th July 2009 – Reception of formal notification of EOI acceptance from the Joint OEER/OETR Tidal Area Sub-committee.

17th August 2009 – Submission of a formal 3-yr Project Proposal with Norman A. Cochrane and Gary D. Melvin as Co-principal Investigators (PI's), and with Peter C. Smith as Project Management Coordinator. Coda Octopus Ltd. and their local agent ROMOR Atlantic Ltd. were named Project Partners. Scientific objectives will be outlined below.

6th October 2009 – Formal notice of project acceptance received from the OEER/OETR. DFO internal funding allowed initial phase, project-related scientific work with the Coda Octopus sonar to commence in September 2009.

3rd March 2009 – The effective start date of a negotiated OEER/OEER/DFO Joint Project Agreement (JPA) with P. Smith as DFO Project Authority. The JPA provided an official Project framework and defined the financial and other obligations of all parties. Final signatures were obtained on the 8th April 2010.

22 – 23 July 2010 – Final field trials of the Coda Octopus imaging sonar were conducted in fish weirs in Passamaquoddy Bay.

27th July 2010 – The OEER/OETR were notified by the PI's of their assessment of the infeasibility on technical grounds of proceeding as originally planned using the Coda sonar as the primary observation/quantification tool. The PI's requested that alternative Project options be considered. At a subsequent meeting on 4th August 2010 involving DFO the OEER/OETR, FORCE, and Nova Scotia Power Ltd. (NSPL), the OEER/OETR requested that DFO to submit a "New Directions" revised project plan document.

6th August 2010 – A "New Directions" response document was submitted by DFO to the OEER/OETR. Initially planned direct imaging of near-turbine fish trajectories using a Coda sonar would be replaced by wider area, more conventional ship-based acoustic studies of fish populations in Minas Passage with emphasis placed on active turbine site(s). An existing DFO split-beam sounder and a 2-D multi-beam system, both based at DFO's St. Andrews Biological Station (SABS) would be employed. Possible use of a commercial bottom-mounted upward looking echosounder to study fish distributions near turbine sites was also tentatively proposed. An applicable budget was submitted by DFO on August 12th.

13th August 2010 – Conditional acceptance of "New Directions" document by the OEER/OETR.

16th September 2010 - The first Project split-beam/multi-beam survey of Minas Passage commenced utilizing a vessel charter provided by NSPL. This was to constitute the only DFO-conducted Minas Passage acoustic survey conducted with a tidal turbine present.

22nd August 2011 – 25th June 2012 – Eight (8) combined split-beam/multi-beam surveys were conducted in Minas Passage during this interval and comprise the bulk of the Project field data collection.

31st October 2012 – Formal end of OEER/OETR Project funding

19th – 30th November 2012 – Experimental deployment of ASL bottom-mounted echosounder on recoverable rigid bottom frame in tidal passage in Passamaquoddy Bay. Results to be included in the Final Report.

APPENDIX 2: SONAR TURBINE MONITORING

If tidal turbines are capable of inducing mortality on fish passages, the cumulative mortality would be reduced if fish utilize available sensory cues to detect and avoid passage through the turbine aperture. Risking considerable over simplification one might conceptualize a “box type” fish-turbine interaction/mortality model characterized by three physical regions:

1) A far field region in which fish movement and fish density is undisturbed by the turbine.

2) A closer adjustment region in which fish perceive the turbine and its directional bearing and move systematically to avoid it. Systematic fish avoidance reactions would result in a region of decreasing volumetric fish density as the turbine aperture is approached axially.

3) A near-field region beyond the “point-of-no-return” where all fish entering this region will be eventually swept through the turbine aperture.

One assumes that the close-in region will characterized by more chaotic fish motions but, additionally, a somewhat uniform volumetric *Turbine Aperture Fish Density*. The numeric flux of fish (fish/s) passing through the turbine will be assumed equal to the product of the *Turbine Aperture Fish Density* and the total turbine flow rate. This latter statement implicitly assumes fish motions to be sufficiently chaotic that no overall organized motion of the fish mass occurs relative to the local water flow. This is an assumption that cannot at this point be conclusively proven and which constitutes a major uncertainty in the model but, nevertheless, makes the overall problem tractable.

One proceeds by defining:

Fish Mortality Rate (fish/s) - The numerical fish mortality per unit time from the operation of one specific turbine

Natural Fish Density (fish/m^3) – Representative ambient fish density at the water column depth of the turbine but at a location sufficiently remote as to not be influenced by the turbine presence

Turbine Flow Rate (m^3/s) – Sea water flow rate through turbine (variable)

Turbine Avoidance Factor (unitless) – Fractional reduction in water column fish density from the undisturbed or “Natural” density to that density existing at or beyond the “point-of-no-return” i.e. the point sufficiently close to the turbine that all fish at or beyond this point will be swept through the turbine (i.e. *Turbine Avoidance Factor* = 1 – *Turbine Aperture Fish Density* / *Natural Fish Density*)

Turbine Mortality Factor (unitless) - The average probability of mortality, including delayed mortality, for a fish passing through the turbine

It is now possible to postulate a time dependent, rate relationship for turbine fish mortality of the form:

Fish Mortality Rate = *Turbine Fish Flux* x *Turbine Mortality Factor*

= *Turbine Aperture Fish Density* x *Turbine Flow Rate*
x *Turbine Mortality Factor*

= *Natural Fish Density* x (1 - *Turbine Avoidance Factor*)
x *Turbine Flow Rate* x *Turbine Mortality Factor*

All the above factors must be assumed functions of tidal current speed (largely defined by tidal phase and amplitude) and all but *Natural Fish Density* are also functions of turbine size and construction, and, probably, the instantaneous electro-mechanical loading of the turbine.

Until the *Turbine Mortality Factor* can be measured or estimated from future studies lying beyond the scope of this Project, the numeric *Fish Mortality Rate* remains indeterminate. Rather, this Project as originally proposed, seeks both a measure of *Natural Fish Density* (preferably as a function of depth or height above bottom, tidal phase, light level, season, and species) and, especially, a measure of the *Turbine Avoidance Factor* (as a function of tidal phase, and perhaps species). *Turbine Fish Flux* might also be directly accessible to Coda sonar measurement, during the short temporal spans projected for near-turbine sonar measurement.

Some variables above might be elucidated by independent means. In particular *Turbine Flow Rate* can probably be predicted fairly accurately from engineering analysis or monitored real-time operational turbine parameters (rpm's) and *Natural Fish Abundance* could in principle be approximated from conventional surveys over representative spatial regions remote from the turbine, although much wider temporal time spans should be considered than contained within the scope of the original proposal. The central goal of the originally conceived project was measurement of the *Turbine Avoidance Factor* (probably a strong function of flow rate), which if measured over even a relatively short temporal series of observations, might be usefully used in conjunction with an evolving knowledge (obtained by independent means) of longer term of *Natural Fish Abundance*'s to estimate *Turbine Fish Flux*. The latter quantity when time-integrated over, for instance, an annual seasonal cycle of fish abundances would place an upper bound (assuming an extreme *Fish Mortality Factor* of unity) on absolute annual fish mortality. Annual fish mortality estimates could eventually be scaled downwards as knowledge of the *Turbine Mortality Factor* is gleaned from future studies or estimated from engineering and operational parameters specific to the turbine.

Limitations of the above approach are many, for instance: 1) Turbine avoidance may be highly fish species dependent with the species mix varying seasonally. Species is not easily discerned from observations using a Coda-like sonar in isolation. 2) The *Turbine Avoidance Factor* will almost certainly vary with turbine construction and size. However, there does remain the possibility that observed avoidance for some species may be virtually total, an exceedingly important observation if such were to occur with implications for a wide variety of turbine types.

Fish avoidance of turbines may be either “local” i.e. the avoidance process is confined to a spatial region comparable to the dimensions of the intake aperture and, in principle, could be elucidated by simultaneous imaging of the water space somewhat forward of the turbine as well as immediately adjacent to the turbine intake (the preferred situation for our Coda sonar-based studies) or, alternatively, “long-range”, that is occurring at ranges large compared to the turbine aperture – or some combination of the two. As above implied, in the case of “local” avoidance it would be most advantageous to image as one contiguous space both:

a) the undisturbed fish environment forward of the turbine, i.e. a region in which fish trajectories move with the prevailing tidal flow sufficiently forward of the intake that the water flow (as opposed to the fish embedded within the flow) is essentially undisturbed by the presence of the turbine itself (thereby removing ambiguities in interpretation)

b) the aperture region where fish trajectories physically enter the turbine.

This ideal observational situation would necessitate the observing sonar to be careful positioned and orientated and also for the same sonar to possess sufficient observation range, angular and range resolution, and pulse repetition rate to gather the required spatial/temporal information. In contrast, elucidation of “long-range” avoidance would require simultaneous, or near-simultaneous, determinations of fish density at more than one location. However, this particular case might offer possibilities for partial or full discernment from more remotely placed, less critically oriented conventional fisheries echosounders or sonars located on-bottom or perhaps even operated from surface platforms (see also **CONCLUSIONS AND DISCUSSION APPENDIX 3** in regard to the CodaOctopus sonar system**).**

A few more specific remarks are in order regarding the sonar-based measurement of volumetric fish densities as discussed above. Fish density estimates are potentially obtainable by several differing techniques. One approach is by mapping time-dependent fish trajectories in 3-D space to ranges of several 10’s of meters from the turbine. If avoidance is “local” a “far” region might be observed where fish move largely passively with the water flow and where the water flow itself does not significantly diverge around the turbine superstructure. Under these circumstances the *Natural Fish Density* will be given by the observed fish flux /m^2 for a plane normal to the flow divided by the time-spatial trajectory(s) derived average fish velocity. Such a computation could be a complex process if the detectability of fish trajectories were to display significant range or target orientation biases (leading to strong target scintillations). The “near” *Turbine Aperture Fish Density* might be similarly derived by counting and quantifying the trajectories of fish passing through the turbine intake aperture. If trajectory velocities were to prove difficult to determine close-in due to complex fish motions but aperture transits could still be enumerated, the required fish density might be approximated by dividing the observed total aperture fish flux by the independently measured flow rate of the turbine. An alternative approach to fish density estimation would be the use of sonar-derived Volume Backscattering Strength (VBS) as treated in the **CONCLUSIONS AND DISCUSSION APPENDIX 3**; while a quite different signal energetic-based measure, VBS is not without its own quantification and interpretational problems especially as applied to multi-beam type sonar systems.

The Project Proposal acknowledged severe limitations in our current knowledge of fish abundances and behaviours in Minas Passage. Virtually any sonar imaging near turbine test sites (however limited) would enhance our understanding of fish abundance and distribution (primarily vertical) changes linked to seasonal, tidal, and diel light cycles. The inherent risks associated with utilizing yet unproven sonar technology for the scientific imaging of fish targets was also recognized in the “Project Synopsis/ Overview”: “If the Echoscope II technology does not prove feasible (to be determined the first year) an alternate plan will utilize the bottom platform instrumented with more conventional fisheries split-beam and/or 2-D multi-beam acoustic technology, some components of which are currently owned by DFO at BIO/SABS.” The prevailing thought being that if direct Coda sonar-based turbine avoidance measurements were to prove unfeasible options might exist to study turbine avoidance using more conventional acoustic systems temporarily placed on-bottom in close proximity to turbines while remaining directly cabled to a surface vessel.

APPENDIX 3: CODA OCTOPUS 3-D IMAGING SONAR

1. SYSTEM DESCRIPTION

The Coda Octopus Echoscope II is a 375 kHz true 3-D imaging sonar: Pulses emitted from a single wide beam radiator are reflected from targets of interest and subsequently received on a 48 x 48 element planar array. The receive array data is synthesized into a 2-D 128 x 128 array of 1° (stated in manufacturer correspondence) contiguous and partially overlapping beams (16,384 beams total). The Coda beam array subtends a 50 x 50° pyramidal cone in space. Beams can be formed up to a 20/s rate, dependent on the chosen maximum profiling range selectable from 1 to 200 m. Maximum specified range resolution is 1 cm. The physical system consists of a 38 x 30 x 15.2 cm sonar head containing both a small transmit transducer and the much larger 2-D planar array for receive beamforming. The head weighs about 22 kg in air, and the standard unit is rated to 600 m depth. The Coda sonar is distinguished from other semi 3-D sonars consisting of two orthogonal 2-D multi-beams which offer a more limited capability to distinguish targets in 3-D space.

The sonar head is connected by a 3 m cable to a Digital Interface Unit (DIU), essentially a PC in a pressure case, which serves as the head controller and provides real-time sonar data storage. A power supply unit coupled to the DIU supplies 26 V DC at 4 – 6 amps. During normal operation the DIU is connected by a standard 10BaseT Ethernet cable to a surface PC which enables operating parameters to be adjusted and allows real-time sonar imagery to be displayed.

The Echoscope II's characteristics are optimized for engineering inspection and surveillance applications with a sophisticated 3-D mosaic capability. Less clear at project inception was the unit's adaptability to scientific studies of moving fish. Scientific usage demands precise quantification of signal amplitudes, requiring well defined and documented control of transmit levels and receiver gains, including TVG, as well as high degrees of stability and linearity over wide dynamic ranges. There must also exist systematic and standardized calibration methodologies and provision for rapid system self-verification. It did appear that fairly standard TVG corrections were applied to the Coda sonar returns, and that transmit levels and receiver gains were user adjustable at least in a relative manner – decibel readouts suggesting some potential for quantification. However, system properties and the precise nature of available adjustments were not well documented for the critical quantitative scientific end user – clearly not the primary market sector envisioned for this sonar. For versatility in field deployment it was possible to disconnect the top-end PC from the DIU post-start up and to record data to the DIU for a preset time interval, a capability necessary for the autonomous recording of fish echoes while the sonar sits stably on bottom without a physical link to surface.

A major limitation of the Coda sonar for scientific applications concerned data storage. Because 16,384 independent beams were synthesized for each transmitted pulse it was impossible to store or to display all the synthesized beam data using the supplied standard PC interface. Rather, and acceptable for many engineering oriented structural visualization tasks, data streams from individual beams were decimated to a single (i.e. one) amplitude-range reading, optionally either the maximum amplitude range bin and corresponding range encountered on that beam, or the (F)irst amplitude value on the beam rising (A)bove a user set (T)hreshold ("FAT") and its corresponding range. These severely restricted beam descriptors were stored as amplitude & range target pairs, ping-by-ping, in standardized XTF format along with ancillary data. Several user-adjustable settings allowed limited control of the process. These included minimum and maximum target range selection gates to eliminate undesired signal detections or "clutter" arising from either close-range fixed object reflections such as the sonar mounting structures, portions of the observation vessel, and any proximate water surface; or from distant unwanted objects such as a range-bounding wharf, or sea-bottom or sea-surface reflections arriving from beyond the desired target observation range. Side lobe and noise suppression controls seemingly allowed suppression of beam artifacts arising from strong reflectors well off the central axes of the beams of interest – although their precise mechanisms of action and effects on signal amplitudes remained unclear. Obvious drawbacks of the overall system architecture were that sonar gains, thresholds, range gating, and signal optimization controls must be set correctly prior to the initiation of any data acquisition. Real-time data decimation and recording offered no flexibility to change or to optimize these parameters on playback. In addition, there remained the fundamentally intractable problem of one strong in-beam target preventing detection of weaker targets in the same beam or preventing the detection of stronger beam targets at ranges exceeding that of the initial threshold detection.

Software systems supplied by the manufacturer permitted collected data playback and visual graphical inspection of the same in a variety of colour-coded display modes (range, depth, amplitude etc.) either as time and frame annotated continuous video streams or as frame-by-frame stills. Graphical displays could be rotated in 3-D and viewed in a variety of perspectives. Precise frame-specific (x, y, z) coordinates of mouse-selected scatterers (targets) and their related acoustic amplitudes could be extracted. Such pre-packaged software, central to many primary structural engineering applications, would appear applicable to the identification of and subsequent manual time-spatial delineation of any fish trajectories potentially appearing in the field data.

2. CODA PROGRAM AND RESULTS

2.1 Approach

The initial objective was determining the Coda Octopus Echoscope II's capability for fulfilling the intended mission in the intended environment. This involved considerations of basic sonar performance and optimal configuration as outlined above as well as the practicalities of accurately and efficiently emplacing, orienting, and safely recovering a sonar within the required observational range of a working turbine, supplying sufficient electrical power over an adequate operational duration, and processing the resultant data streams where only limited system-specific software tools currently exist, and these not specifically optimized for fisheries applications. Addressing the initial objective reduced to tasks involving system familiarization, initial basic sonar sea trials, laboratory tests of system power consumption and required voltage stabilities under various operational conditions, integrating and mounting system components for autonomous seabed operation, seabed platform deployment and recovery tests, and full seabed trials.

Due to the high replacement value of the Coda sonar ($ 200 – 300 K) it was concluded that autonomous deployment in Minas Passage should not be risked until prior tests had established:

1) A reasonable probability of the sonar being able to detect and track typical individual fish targets to a least 30 m range, the minimal range required to image water volumes extending across the 10 m diameter turbine intake from near-bottom vantage points beside or forward of the turbine base.

2) That the sonar mounting and deployment platform would be stable and recoverably in Minas Passage (i.e. initial Minas Passage deployment platform tests conducted without the mounted sonar).

A series of at sea, laboratory, platform deployments and field trials were conduct between September 2009 and July 2010 to evaluate the CODA Octopus Echoscope II capabilities and laminations before consideration would be given to testing in Minas Passage. A brief description of the trials in chronological order follows below.

2.2 Sea Tests at BIO

Sept. 2009 - Sonar evaluation trials began with a series of stationary, cabled Coda sonar deployments in the BIO marina working from the deck of the *SIGMA-T*. For mechanical stability the sonar was mated to a buoyancy dual-float package similar to that shown in Fig. A3-1 with a heavy under-slung weight allowing submersion to a controlled depth from the vessel's A-frame. Sonar power was direct-wired from an on-deck DC power supply. Real-time software adjustments of signal gains and thresholds proved critical to obtaining any recognizable imagery. Some acquired digital data was forwarded to Project Partner Coda Octopus to verify proper system performance and for further advice.

Oct. 14 & Oct. 16, 2009 - Further marina trails were conducted to optimize system performance. An approximate -42 dB target strength ping-pong ball (roughly simulating the dorsal aspect target strength of a medium sized herring) was suspended in the sonar observation field at 10 m horizontal range. After considerable adjustments of the sonar controls both the calibration target and a tensioning weight suspended below the target were sighted (side-lobe suppression firmware options had to be activated to see anything). Both acoustic targets scintillated strongly in strength over a 2 hour observation period and not infrequently completely dropped from visibility.

Oct. 31, 2009 – Sonar tests were moved from the marina to the Bedford Basin side of the BIO wharf (Fig. A3-1) where targets could be deployed at horizontal ranges exceeding 10 m in water of 8 – 9 m depth. The sonar refused to operate. Excessive voltage drops along a new and longer power cable were suspected since DC currents up to 10 A were drawn for short periods during the normal sonar start-up sequence.

Nov. 4 & 5, 2009 - The sonar deployment geometry of Oct. 31st was repeated. After more start-up problems, a directly facing concrete jetty wall was imaged at about 35 m range. Target tests were conducted using the ping-pong ball target. Both target and sonar were suspended near mid-water column. The target was observed first at 20 m and then at 34 m range. Over several hours the quality of the 34 m range imagery progressively deteriorated as the local sea state increased. A 2nd weaker acoustic target consisting of a 0.75" diameter tungsten carbide sphere (TS = -45.8 dB at 375 kHz) could not be positively observed at 34 m range. Many additional signal returns were present with amplitudes comparable to that of the -42 dB target, these appearing and disappearing (i.e. scintillating) from ping-to-ping with no apparent systematic long term motion (i.e. they did not appear to arise from fish or other systematically moving water column targets). Most were probably artefacts related to side reflections from the adjacent wharf and/or from the top and bottom of the water column. It was concluded that a moving and likely scintillating amplitude fish target of roughly similar average target strength (-42 dB) at these ranges would not be reliably identified and tracked under these circumstances. Special side lobe suppression options for the sonar had to be activated to detect the present target at 34 m range. It was uncertain how the implementation of these real-time signal processing options otherwise affected the echoes of interest.

Nov. 10, 2009 - To observe sonar performance in deeper open waters with the possibility of seeing natural fish targets, the sonar was deployed in tow configuration from *SIGMA-T* in about 25 m of water north of the BIO jetty. The sonar head was towed at about 2 kts while mounted on the streamlined neutrally buoyant package with the receive transducer array pointed along the tow direction but angled down 30° from the horizontal. The effects of signal thresholds and side lobe suppression algorithms were examined and several digital recordings obtained. While the sea bottom was readily imaged no fish echoes were conclusively observed.

Nov. 12, 2009 – Stationary target tests were again conducted from *SIGMA-T* at the BIO wharf using the -42 dB target deployed at 18 m range. Correct side lobe suppression settings were again critical to visibility of target. Digital recordings of target echoes were conducted and again shared with Coda Octopus.

Based on the above trials it was considered advisable that further tests be conducted in an environment where fish targets were abundant (e.g. fish weirs). By this time (mid-November) weirs near the St. Andrews Biological Station were being dismantled for winter season but tests would be possible the coming summer. Specific sonar tests from the DRDC acoustic calibration Barge could be conducted during the winter if required.

2.3 Laboratory Tests

In the fall of 2009 lab tests confirmed the inadequacy of BIO's ADCP type alkaline cell battery packs (initially suggested as a power source by Coda) to power the sonar - the Coda sonar high current drains moved the cells into an extremely inefficient portion of their discharge curve. In

Jan. 2010 a 40 amp-hr 24 v Deep Sea Light & Power Sea Battery which could more efficiently handle the required current drain was purchased. However, a series of lab tests in Feb. 2010, including immersion in a water bath to simulate typical ambient battery temperatures to be encountered in Minas Passage, disclosed that the Coda sonar would only operate reliably, as a total system, over a narrow voltage range, the video link shutting down at less than 26 V. Correspondence with Coda also revealed the possibility of sonar system damage if the input voltage fell below a critical threshold. It was concluded that the battery supplies could not be used directly but must be re-engineered with an additional solid-state module to supply a modest voltage boost and proper voltage regulation. The sonar voltage sensitivity also had implications for powering the units from conventional DC power supplies utilizing long connecting cables, where fluctuating current demands would induce corresponding varying voltage drops along-cable. A 2nd SeaBattery (purchased March 2010) should provide sufficient energy reserve to allow sonar acquisitions over about one tidal cycle with use of the proper solid state voltage regulation module. Voltage stabilization requirements precluded immediate tests on bottom using the DRDC Barge. In the interim the sonar was returned to the manufacturer until a course of action was decided.

2.4 Bottom Platform Release Trial

May 11, 2010 – The completed Coda bottom platform (Fig. A3-2) was crane-deployed to bottom from the BIO wharf and the integrated surface recovery float successfully released on acoustic command using a platform-integrated TELEDYNE BENTHOS SR-50 “Smart Release”. The next platform test could be in Minas Passage without the sonar mounted in order to test platform stability on bottom and the reliability of acoustic release telemetry during maximum tidal current.

2.5 St. Andrews Weir-based Tests

July 22, 2010 – Coda sonar field tests commenced at the St. Andrews Biological Station (SABS) marina. Observations of stationary acoustic target tests were conducted from the 24 ft. Roseborough *SALAR* to verify proper sonar operation using the approx. -42 dB target, initially at 3 m range and then at 17 m. The sonar was subsequently transported to a herring weir on the north coast of White Island (44° 59.105’ N 66° 54.072’ W). Observations were conducted from *SALAR* while tied to the inside of the weir enclosure (Figs. A3-3 & A3-4). Seining of the weir (i.e. removal of fish) in ~6 m of water had just been completed. The area was sheltered and presented a reasonably calm sea-surface. No fish-like targets travelling in obvious coherent trajectories were seen but bottom bathymetry was observable. Occasional water column backscattering patches were observed, these appeared most likely sonar artefacts rather than real targets. A few isolated fish echoes were observed on *SALAR*’s 200 kHz vertical beam echo-sounder. A Coda digital data acquisition was attempted but did not record successfully. Length sampling of the seined catch showed herring ranging from 13.5 to 16.0 cm length, with a 15 cm length mode and one outlier at 18 cm.

July 23, 2010 - Additional target work was conducted in the SABS marina with the standard target placed at 17 m range. The sonar was then transported to a weir on Eastern Wolf Island (44° 58.441’ N 66° 41.741’ W). The *SALAR* tied-up to the outside of the weir and observations were conducted through the weir mesh in about 26 m water depth (near high tide). The main weir enclosure had not yet been seined. Four to five seals were also visually observed inside the weir enclosure. The sonar was operated with 4 – 60 m and 4 – 70 m signal range gates at an ensonification rate of 5 pings/s. Weir poles lining the enclosure could be observed on the sonar. Toward the central part of the enclosure at approximately 20 m range an extended irregular wall-like structure with a constantly changing surface topography was observed (Fig. A3-5). It was assumed this wall defined the facing outer boundary of a dense fish mass filling at least the central portions of the weir. Rotation of the 3-D sonar image in post-processing showed the wall to consist of a thin shell curved away from the sonar head position (Fig. A3-6). The outer periphery of the curved “wall” could, on occasion, be observed out to about 40 m. The outer shell had a “blobby” appearance but the individual “blobs” showed little convincing ping-to-ping continuity even though the larger scale geometry of the wall varied in a slow systematic manner. No individual fish echoes which could be reliably tracked over more than 2 - 3 successive pings were observed. Occasionally strong and spatially extended echoes, apparently arising from diving seals, could be tracked ping-to-ping but disappeared when they moved through or behind the “wall”. Two digital recordings documenting these phenomena were conducted. Two frames from one video at close time separation showing what is believed to be a moving seal appear in Fig. A3-7.

To further document these phenomena the beam of a 200 kHz Simrad EK60 scientific echo-sounder with a 7° circular beam transducer was directed horizontally toward the center of the enclosure. The resultant EK60 echogram revealed a virtually solid, unresolved mass of scatterers starting abruptly at 20 – 25 m range from the vessel and ending abruptly at about 50 m range – which may represent the far side of the weir or, at least, the enclosed fish mass within the weir. No “shell” structure, as observed with the Coda, was evident. It is conjectured that the Coda sonar-observed structure was a result of the first-above-threshold (FAT) echo detection scheme, each sonar beam yielding a single detection at the near edge of the encountered fish mass. The Eastern Wolf Island seining sample showed herring between 14 and 18 cm length with a 15.5 cm length mode.

3. CONCLUSIONS AND DISCUSSION

Following the Coda sea-tests in Passamaquoddy Bay and with further consideration of the sonar trials conducted in Bedford Basin and the laboratory measurements at BIO it was concluded that the Coda sonar tests to date had not convincingly demonstrated this device to be an adequate and practical instrument for its envisioned use to track fish trajectories proximate to a tidal turbine in Minas Passage. Our reasoning is summarized as follows:

1) **Inadequate sensitivity** - Following the St. Andrews Coda sonar trials it was concluded that no tests to date had convincingly demonstrated that fish trajectories could be tracked over extended regions of 3-D space at ranges of at least 30 m as required for

useful Minas Passage turbine observations. Reasoning: While an approx. -42 dB artificial target could occasionally be imaged to about 34 m that accomplishment required very careful system adjustment. Many fish of interest in Minas Passage would possess target strengths < -42 dB. At the Coda sonar operational frequency of 375 kHz, real fish targets viewed closer to side as opposed to "normal" dorsal aspect would be expected to display complex backscattering patterns characterized by a high variability of apparent target strength with ensonification angle. Considering normal fish motions the result would be strongly scintillating targets with numerous signal "drop-outs" and consequent poorly defined spatial trajectories. If sporadic fish echoes were indeed observed in the Coda weir deployments, their degree of target amplitude scintillation combined with the sonar's FAT detection scheme and an applied 20 log R vs. the theoretically preferable 40 log R discrete target TVG function rendered any tracking of individual fish echoes impossible. The inability to track individual fish trajectories at the St. Andrews Weir tests would suggest similar difficulties for Minas Passage. In fact, no reliably trackable fish echoes were identified over the entire series of evaluation tests.

2) **Critical system adjustment** - Very careful sonar set-up in terms of range gating and heavy use of side lobe suppression signal processing in real-time were required to detect -42 dB test targets at ranges of 30 m or more. For a real turbine, strong side lobe interference might be expected from reflections off the turbine or its mounting structures at similar ranges to potential fish targets. Such interference would not be easily range gated-out using the FAT processing, and "blind" sonar set-up planned for Minas Passage; consequently, this would lead to inevitable losses of real fish echoes.

3) **Critical deployment geometries** - Accurate tracking of fish trajectories relative to a turbine requires simultaneous imaging of the turbine aperture (mouth) together with a large volume of water adjacent and immediately forward of the aperture. This demands precise control over both the position and the orientation of the sonar bottom platform. Physical emplacement of a Minas Passage bottom platform presents many difficulties even with the necessary assistance of short baseline acoustic positioning and real-time orientation telemetry. These problems are accentuated by both the intense tidal streams affording but a short (possibly even non-existent) slack current deployment window, and the necessary safety precautions when working extremely close to a turbine. There has been little accumulated experience at BIO in achieving such tasks in comparable environments, consequently this task would involve a steep learning curve and a high risk of equipment loss or damage.

4) **Low recording endurance -** The laboratory-measured heavy electrical power drain of the Coda system would limit continuous autonomous deployments to a maximum duration of one tidal cycle – a serious operational constraint. To achieve even this objective, solid state DC voltage control and regulation would have to be added to the system to efficiently utilize the power supplied by 2 SeaBatteries.

5) **Interpretational challenges -** Apart from any active turbine avoidance by fish, fish trajectories about turbines will be strongly influenced by the variable flow around the

high hydrodynamic drag devices. Therefore, the mere observation of systematically curved fish trajectories around turbines does not by itself necessarily imply active fish avoidance. One specific consequence of active avoidance would be a reduction in volumetric fish density near the turbine mouth, i.e. "beyond the point of no return", compared to the corresponding volumetric density at a remote reference location. The ratio of the two volumetric densities defines a quantitative measure of this process, the *Turbine Avoidance Factor* (APPENDIX 2).

Expanding upon "Interpretational challenges" above a potentially superior proxy for fish volume density would be sonar derived acoustic Volume Backscattering Strength (VBS). A VBS-based approach would be especially advantageous if individual fish trajectories and fish fluxes in either the "near" or "far" turbine regions were to prove difficult to discern. VBS is proportional to backscattered acoustic energy per unit volume of water, which for similar fish ensonification angles and fish mixes would be proportional to volumetric fish density. VBS estimation, even relative as opposed to absolute if performed by the same instrument, has the analytical simplicity of not requiring the tracking of fish trajectories. Nevertheless, discrete simultaneous target tracking, if possible, would be advantageous in verifying fish echoes to be the primary source of backscatter and to enable comparative measurements of fish densities by fairly independent means. If employing VBS, one must ensure that complex fish motions close to the turbine manifesting in an expanded range of observed fish orientations do not induce unacceptable biases in sonar-derived VBS levels. CODA sonar performance for potential quantitative VBS estimation remains an unknown. Clearly the difficulties noted elsewhere in the extraction of accurate VBS – even relative VBS – from the 2-D MS 2000 multi-beam would be corresponding multiplied for a fully 3-D system like the CODA. The detailed functioning and quantitative impacts of the specialized CODA noise and side-lobe reduction firmware, use of which experiment has shown to be seemingly necessary to discern weak targets within the sonar imaging field, remain large unknowns.

Very long range turbine avoidance - as opposed to "local" avoidance - might in principle be detectable by comparing volumetric fish densities (or VBS levels) reasonably close to the turbine - but not necessarily beyond the "point-of-no-return" - with simultaneous densities (or VBS levels) from a second, more remote "undisturbed" sonar. If VBS levels are to be compared, both sonars need be calibrated and beam orientations reasonably well matched. However, since we are comparing fishes densities at two well separated points by two different systems, precise localization of targets and trajectories becomes less important and one is likely to be better served by a lower frequency 2-D multi-beam or even a single beam system rather than the CODA with its inherent limitations. The key point of this discussion is that the use of sonar to derive reliable information about fish avoidance of turbine regardless of the methodologies or conceptual models employed is unlikely to be either "simple" or "straightforward" – except perhaps if the avoidance is essentially "total" or if the avoidance extends to sufficiently long ranges from the turbine that it might be detected and quantified by simpler more conventional acoustic systems.

FIGURES (APPENDIX 3)

Figure A3-1. Coda Octopus Echoscope II sonar mounted on adjustable-depth flotation package being deployed from *SIGMA-T* alongside BIO wharf.

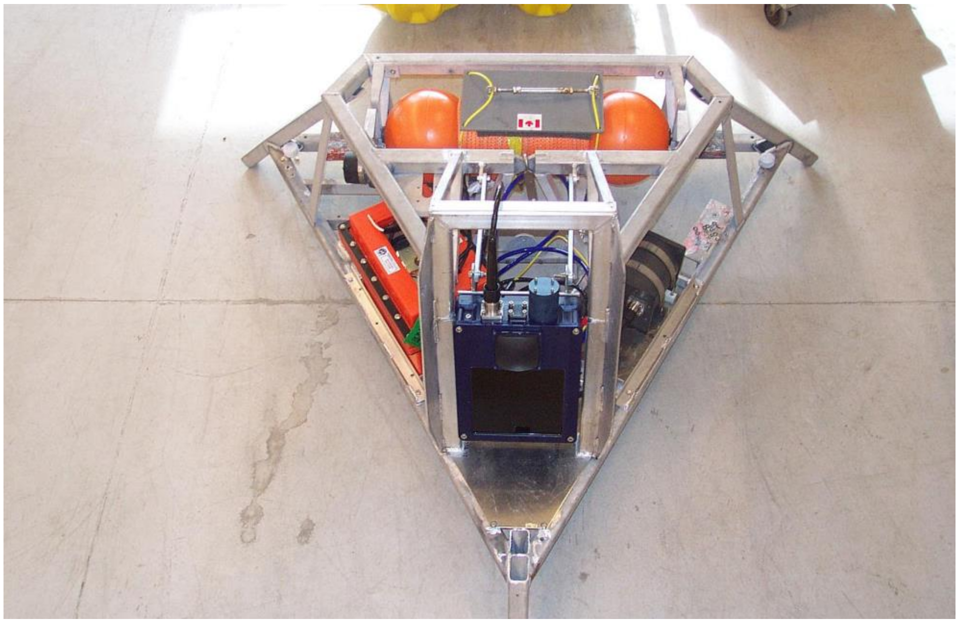


Figure A3-2. Bottom-mount package with Coda sonar installed (sonar head at front). SeaBattery is orange rectangular object on left (also provision for mounting 2nd battery). DIU electronics is opposite battery on right. Acoustically released recovery float with associated line constitutes the orange dumbbell-shaped object near platform rear.

Figure A3-3. *SALAR* inside White Island fish weir during Coda sonar test in Passamaquoddy Bay, NB.

Figure A3-4. Top end control computer for Coda sonar during test in White Island fish weir. Bottom bathymetry is displayed on screen while supply at right provides power to sonar head and DIU.

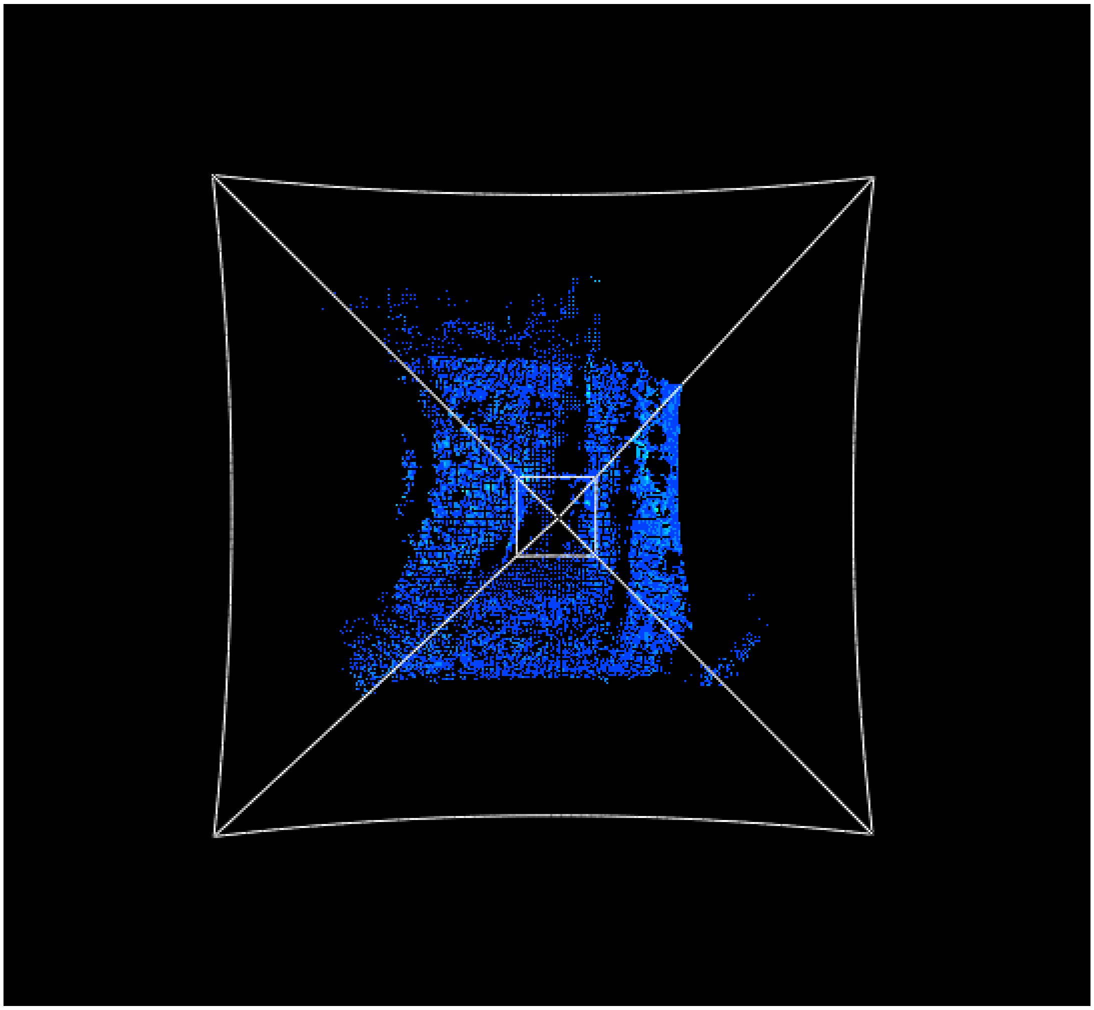


Figure A3-5. Coda sonar playback frame with colour-coded signal intensity from Eastern Wolf Island, Passamaquoddy Bay fish weir. Sonar is just below surface pointed downward about 25° from the vertical and looking into the weir enclosure. Eye and sonar position are at the cross-hairs. Vertical structures on right of image and extending into the distance arise from a series of weir poles defining the RHS of the inner weir enclosure. The level bottom is at the bottom of the frame. Left of center is a mass of herring extending down from the surface in bowl-shaped wall. LHS of herring mass lies outside sonar's 50 x 50° total field of view.

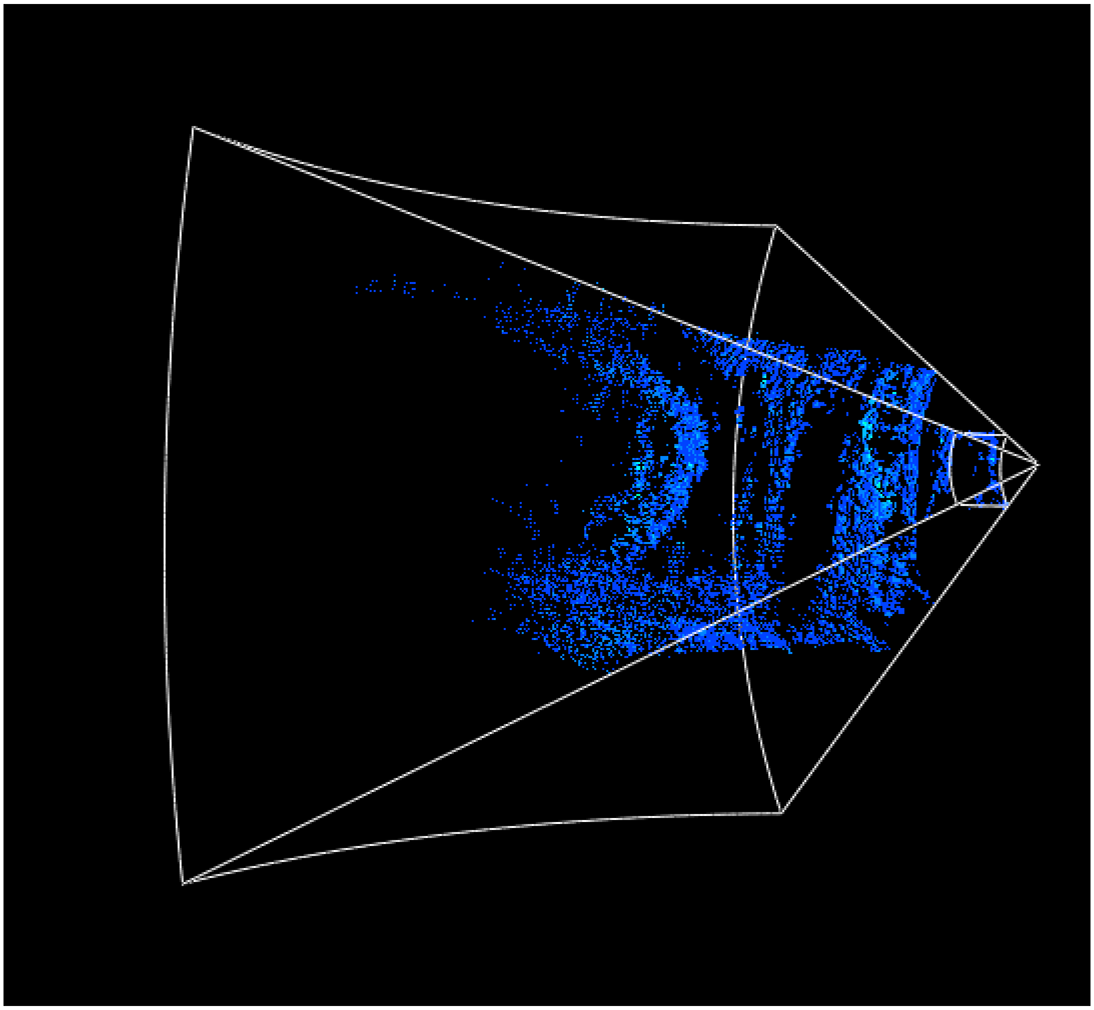


Figure A3-6. Coda sonar frame identical to previous figure rotated to the right in 3-D so that sonar is at point of cone while the eye views straight on. The side of the weir is observed in a less oblique perspective, and the level bottom is clearly seen. The bowl-shaped mass of fish in rotated perspective is now seen to constitute a thin outer shell starting at about 20 m range with virtually no penetration into the interior of the fish mass.

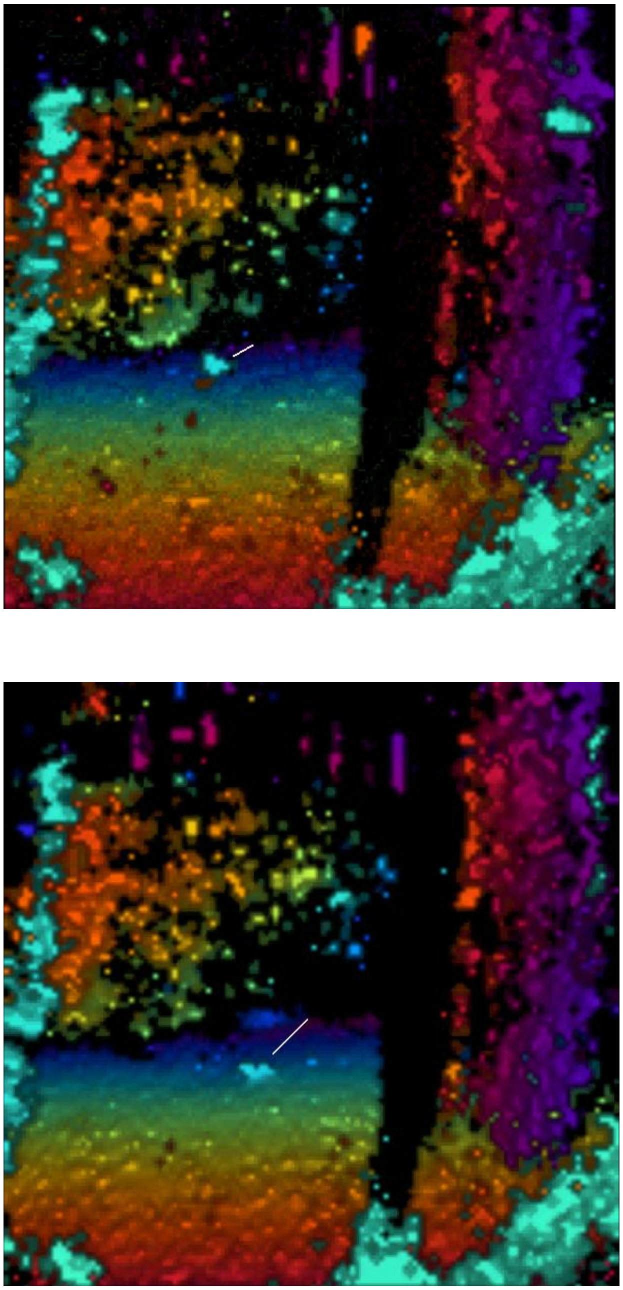


Figure A3-7. Two video frames of Coda Sonar field showing herring aggregation in White Island weir. Image fields are comparable to those in Figs. A3-5 & A3-6 but are repetitively colour-coded in range. White lines point to a suspected seal moving near-bottom behind school. Frames are separated by 2 s. Other objects of similar colour are in near-field foreground well removed in range from the seal target.

APPENDIX 4: TRIAL DEPLOYMENT OF AN AUTONOMOUS ASL WATER COLUMN PROFILER IN A HIGH TIDAL FLOW AREA

1. INTRODUCTION

A major difficulty in deploying scientific acoustic technology in remote locations is powering the equipment over an extended period of time. Power demands for most available technologies require connection to surface/shore sources, alternative battery power sufficing for only a relative short period of time. The ASL multi-channel Acoustic Zooplankton Fish Profiler (AZFP) was specifically developed to maximize battery powered endurance thereby enabling field deployments in the order of months. The unit is a self-contained, battery powered, single beam echosounder expandable to up to 4 acoustic channels. Our current system configuration consists of two 7^o 125 kHz transducers that can be orientated in differing directions. Operationally we have deployed the unit for up to 2 months at ping rates of 1/s utilizing a single battery pack.

Many tidal development sites are remote without facilities to connect in-situ instrumentation to a power source. This makes the ASL Profiler potentially ideal for sites such as Minas Passage. However, given the strong tidal flows the profiler was initially tested in an alternative high flow channel to investigate its performance prior to any Minas Passage deployment. Several test deployments were conducted off the biological Station in St Andrews and in Western Passage, Passamaquoddy Bay, the latter an area with currents of up to 3 m/s during specific tidal phases. Unfortunately, due to weather and vessel scheduling a deployment in Minas Passage was never undertaken. The results presented below are from the test deployments.

2. DEPLOYMENT/MOUNTING

The AZFP was mounted on a triangular bottom platform developed at BIO for deployment in high flow areas. The platform has a low profile and is designed to incorporate additional ballast weight of up to 500 kg when deployed in strong currents. The self-contained platform is deployed via a vessel-mounted small crane or boom attached to an acoustic release (Fig. A4-1). The platform is lowered to the bottom and the release triggered leaving the platform seated on the bottom with no physical connection to the surface. After the test period has elapsed the platform is retrieved following a somewhat similar approach, except in reverse. A Teledyne Benthos SR-50 smart release mounted on the platform releases a floatation spool wound with high strength rope to establish physical contact with the surface (Fig. A4-1). After surface command releases the retrieval mechanism and the float dumbbell has risen to the surface with the attached retrieval rope (Fig. A4-2), the surface vessel retrieves the float and lifts the platform onto the vessel with a crane. The data are then downloaded for analysis from the ASL unit (Fig. A4-3) either through a direct cable connection or by removal of the memory card.

3. DEPLOYMENT LOCATION

To evaluate the performance of the ASL profiler and the platform deployment/retrieval mechanism in deep rapid flowing water, the Acoustic Zooplankton Fish Profiler was deployed north of Cummings Cove in the Western Passage for 8 days on November 19, 2012. The maximum water depth was 60 m with water currents exceeding 3.0 m/s depending on the tide. The transducers were nominally oriented such that one pointed directly upward toward the surface while the other was orientated about 5^o above the horizontal to investigate fish near bottom. The actual in-situ orientations of the transducers would be dependent on how the platform was seated on bottom. The platform was deployed and retrieved by the DFO vessel *VIOLA M. DAVIDSON* using its onboard crane.

4. METHODS

Prior to deployment the data collection parameters must be defined and communicated to the ASL unit. The system parameters, data collection rates, ranges and times are set via a direct-wired interface using system-specific software. The parameters assigned for this deployment can be seen in Fig. A4-4 as they appeared on the interface software. The unit was set to record for 10 days, transmitting at a 1/s rate for the entire deployment. The range on the vertical transducer (looking up) was set to 75 m (maximum water depth 60 m) and the range for the horizontal transducer (looking sideways) set to 100 m. The two channels were programmed by the manufacturer to ping alternately to prevent mutual interference. A new data storage file was generated every 3600 pings (i.e. every hour) to minimize data loss in the event of a problem. In excess of 192 data files were generated during the deployment period.

Standard deployment procedures were used to place the platform on-bottom in Western Passage. The deployment cable/rope was attached to an acoustic release from which the platform could be decoupled on command. Once the unit touched bottom the release was triggered to enable the rope and acoustic release to be retrieved. A UDB-9000 Universal deck box with associated hydrophone was used to trigger the acoustic release. Unfortunately, the first attempt at release was unsuccessful and the platform had to be pulled back to the surface and the ship re-positioned before another release was attempted. On the second attempt, the hydrophone was lowered well below the hull of the ship and the release was successful. As this was our first deep water deployment a safety line was also mounted on the triangle platform in case the (retrieval) acoustic release could not be triggered. The unit was deployed north of Cummings Cove in the Western Passage at coordinates 44° 56.390’ N and 67° 00.000’ W in a depth of 54 m at approximately 1030 hours, local time.

The unit remained on-bottom for 7 days before the vessel returned to the deployment site. A recovery attempt was made on the 26th of November at approximately 12:30 hours; however, it was unsuccessful. The dumbbell buoy released successfully and returned to the surface; however, due to strong tidal flow the float submerged again once it reached the end of its tether. Tidal flow forces on the dumbbell float were sufficient to pull the float under. This could be a concern if vessel time were limited. The unit was easily retrieved the following day during a slack tide period.

5. RESULTS

The results from this short qualitative study clearly illustrate the range of observations obtainable by the ASL acoustic profiler under medium flow, low turbulence conditions. Schools, small aggregations and individual fish-like targets were observed during the deployment. Two transducers were deployed with the unit, one facing upward looking from the bottom to the surface and the other looking approximately horizontal from the platform across the bottom. The results for the vertical profile will be presented first followed by the horizontal observations.

Figures A4-5 to A4-8 provide examples of the water column including near surface distributions of fish-like targets, which in this area are likely juvenile herring. The echograms also illustrate how the types of distributions, their depths, and their school configuration (i.e., size and density) change over time reflecting the tidal phase and flow. In Fig. A4-5 the fish are sparsely distributed about mid-water column whereas an hour later they have formed more of an aggregation (Fig. A4-6). Two hours later they have formed small dense pods and move up slightly in the water column. By 16:00 most of the aggregations have moved up in the water column to near the surface (Fig. A4-8).

Surface turbulence from the research vessel and interference from our acoustic modem are clearly visible (Fig. A4-9). The yellow band at ping 2200 was generated when we communicated with the acoustic release to ensure the platform was still in place after a few days deployment. About a minute later the vessel wake was detected by the ASL unit as the air saturated surface water drifted over the unit. The resultant dark surface protrusion 3 - 5 m below remained present for about 5 minutes (Fig. A4-9). Strong winds have been known to saturate the surface waters and create surface generated turbulence extending several meters below the surface, especially when the wind is against the tidal flow. Figures A4-10 and A4-11 illustrate the extent and variability of the turbulence observed in Western Passage. Aggregations of fish are visible in both echograms near the surface (Fig. A4-10) and a few hours later near the bottom, although their general configuration has changed. In addition, Fig. A4-11 illustrates what appears to be a marine mammal, likely a seal diving toward fish near bottom. Finally, Fig. A4-12 shows the triggering of the acoustic release and the research vessel wake near the surface. As noted earlier the unit was not actually retrieved until about 24 hours after its release was triggered.

The horizontal transducer was oriented about 5° above the horizontal (i.e. the bottom) to detect any fish-like targets near the bottom. However, the actual observation angle is dependent upon the bottom characteristics and how the platform orientates itself when deployed. We had no mechanism to determine either how the platform was sitting or the heading of the horizontal transducer. In this deployment it is evident that the beam or the beam's side lobes intersect the bottom in such a manner that the signal is overloaded and to varying degrees clipped out to about 28 m. A second reflection occurs at about 58 m (Fig. A4-13) probably representing reflected energy from the water surface originating from the beam side lobes or scattered from the bottom. Outside the contaminated ranges multiple fish-like individual targets (possibly groundfish) can be seen during certain phases of the tide (Fig. A4-14). Strong reflectors, likely larger fish, can sometimes be discerned within the contaminated ranges. Note that the assumed marine mammal detected in Fig. A4-11 appears in the horizontal transducer within a few seconds of being detected in the upward looking transducer. In this case the animal is approaching the transducer then turns away at about 50 m while remaining close to bottom (Fig. A4-15).

Although the ASL profiler is not split-beam, movement within the horizontal acoustic beam can sometimes be detected. The echogram from November 27 between 10:00 and 11:00 shows fish as they pass/drift across the acoustic beam (Fig. A4-16). However, at about ping 1400 the fish all appear to move in a consistent direction as if spooked or following the water flow. The actual direction of the water flow is unknown as the orientation of the platform could not be determined. In order to ensure that retrieval of the platform was possible if the acoustic release malfunctioned, a 100 m length drag line was deployed across channel from the platform. This line drifted slightly above bottom so it could be captured with a hook if required. The echogram from November 21 shows a portion of the line as it apparently drifts in front of the transducer at ranges of 30 – 60 m (Fig. A4-17). Virtually no fish-like targets were observed during this period.

The ASL profiler continued to record data up to and including the time it was retrieved and placed on board the research vessel (Fig. A4-18). Once on board the ASL unit was opened, the power disconnected and the flash card removed for data downloading and archiving.

6. DISCUSSION/SUMMARY

The ASL acoustic water profiler has the potential to become a valuable tool in monitoring the distribution and abundance of fish and marine mammals at proposed tidal power development sites. The unit is a programmable, self-contained, and seemingly dependable acoustic logging system that can be deployed for an extended period of time. Depending upon profiler settings it should be possible to have the equipment record data for 6 months or more on a single battery pack. However, for this length of deployment some compromises would have to be made regarding repetition rate-range resolution of samples or activation period. From our experience it would be better to collect data on a monthly basis, retrieving the system at 30 - 40 day intervals, then redeploying. This would ensure the system is working as expected, maximize data collection/resolution, and minimize data loss in the event of an unexpected software/hardware failure.

The data presented in this report provides a few examples of how the ASL might be used in the context of monitoring and the types of data that can be collected over an extended time period. The results illustrate the quality of data available and the detection capabilities of the system for fish, marine mammals, and inanimate objects (rope) using two identical transducers. The system is capable of supporting up to 4 channels which could be used various ways: 1) Increasing the number of beam orientations available for monitoring 2) Operating beams at differing acoustic frequencies, thereby providing information on target frequency response which may assist in identifying species 3) Providing 4-quadrant split-beam operation. This would allow estimation of target strengths for individual acoustic targets and the detection of within-beam target movement both vertical and horizontal in a vertically oriented beam (similar capabilities to the Simrad EK-60 shipboard split-beam system). Split-beam systems are also much easier to calibrate than single beam systems.

As with any acoustic system, ground-truthing of acoustic targets is critical to understanding and quantifying observations. Without direct knowledge of the potential targets present and their size at the time of sampling all estimates of abundance and/or biomass must be considered biased and subject to considerable error. Frequency response and target strength estimates can help to reduce such error, but the interpretation of the observations and species will depend on the experience of the scientist and knowledge of the area. If the ASL is to be deployed for environmental studies it should be combined with a target sampling program to assist in the identification of targets.

Quantification of the backscatter from the ASL at the moment is difficult due to the absence of standard calibration procedures; consequently the backscatter levels can only be used in a relative sense, assuming the system remains stable between deployments and over time. Calibration experiments are planned for the late summer of 2013. It should also be noted that a self-contained Simrad EK60 split-beam system with similar capabilities is scheduled for release in the next few months.

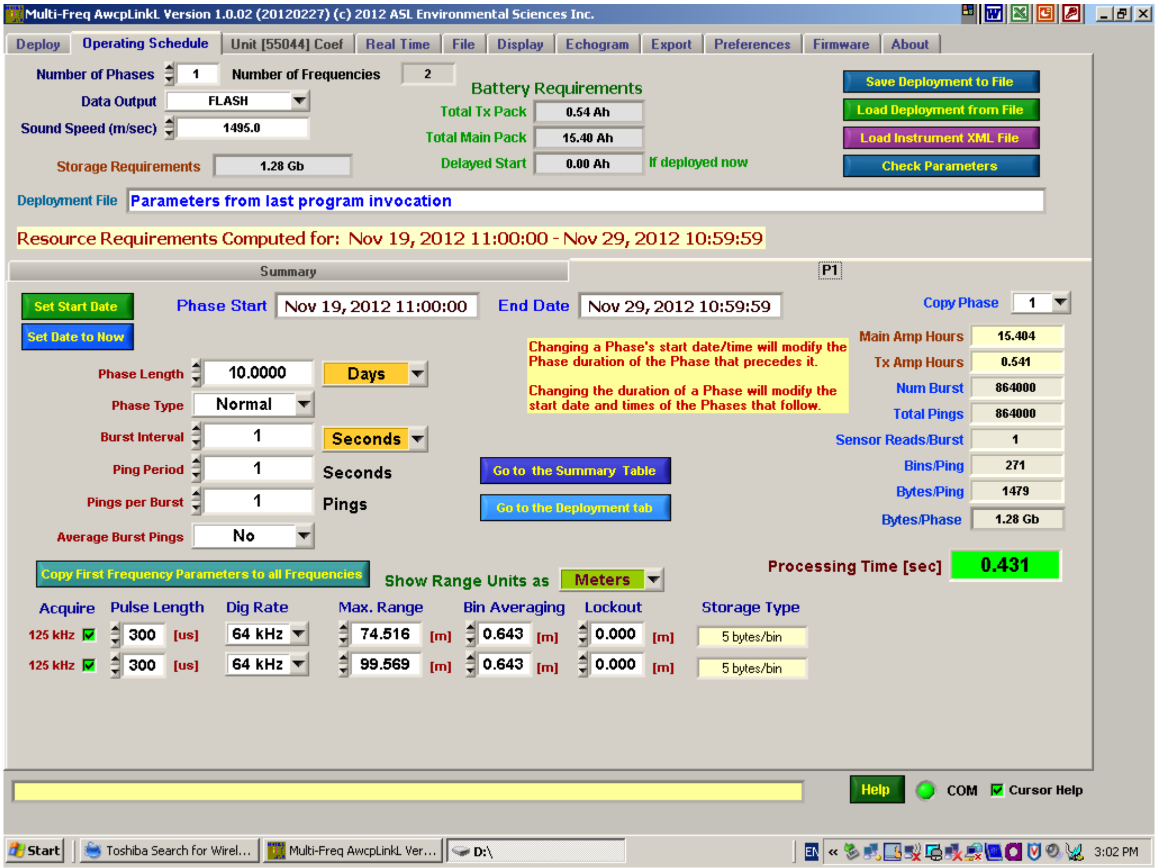
In summary we have found the ASL to be a versatile and dependable acoustic tool for the monitoring of fish distribution and abundance. The system overcomes one of the critical problems associated with deployment of electronics in remote areas, namely power for extended operation. The self-contained nature and long-term operational capacity make it (or similar systems) ideal for monitoring at potential tidal power development sites. However, there are still a number of studies/experiments that remain to be conducted to maximize its observational potential. Calibration is required if quantitative data are to be extracted. Deployment methods and platform orientation monitoring techniques need to be developed to ensure that observational conditions are known and optimized. Split-beam and multi-frequency applications should investigate target strengths and their frequency responses for various species/targets. Ground-truthing of targets at specific sites will be necessary to determine what biological species are present and their size distributions. Finally new analytical software should be developed to maximize the analytical output capabilities of the system and to efficiently summarize observations.

FIGURES (APPENDIX 4)

Figure A4-1. The ASL water profiler deployment platform illustrating the positioning of the unit, acoustic release, retrieval dumbbell, and deployment line (blue rope).

Figure A4-2. Acoustic retrieval mechanism for the ASL deployment platform. The picture illustrates the acoustic release connection to the dumbbell.

Figure A4-3. Close-up of the ASL water column profiler illustrating the communication port and the transducer connecting cables.



Number of Phases: 1

Number of Frequencies: 2

Data Output: FLASH

Sound Speed (m/sec): 1495.0

Storage Requirements: 1.28 Gb

Battery Requirements

Total Tx Pack: 0.54 Ah

Total Main Pack: 15.40 Ah

Delayed Start: 0.00 Ah If deployed now

Deployment File: Parameters from last program invocation

Resource Requirements Computed for: Nov 19, 2012 11:00:00 - Nov 29, 2012 10:59:59

Phase Start: Nov 19, 2012 11:00:00

End Date: Nov 29, 2012 10:59:59

Copy Phase: 1

Changing a Phase's start date/time will modify the Phase duration of the Phase that precedes it.

Changing the duration of a Phase will modify the start date and times of the Phases that follow.

Phase Length: 10.0000 Days

Phase Type: Normal

Burst Interval: 1 Seconds

Ping Period: 1 Seconds

Pings per Burst: 1 Pings

Average Burst Pings: No

Main Amp Hours: 15.404

Tx Amp Hours: 0.541

Num Burst: 864000

Total Pings: 864000

Sensor Reads/Burst: 1

Bins/Ping: 271

Bytes/Ping: 1479

Bytes/Phase: 1.28 Gb

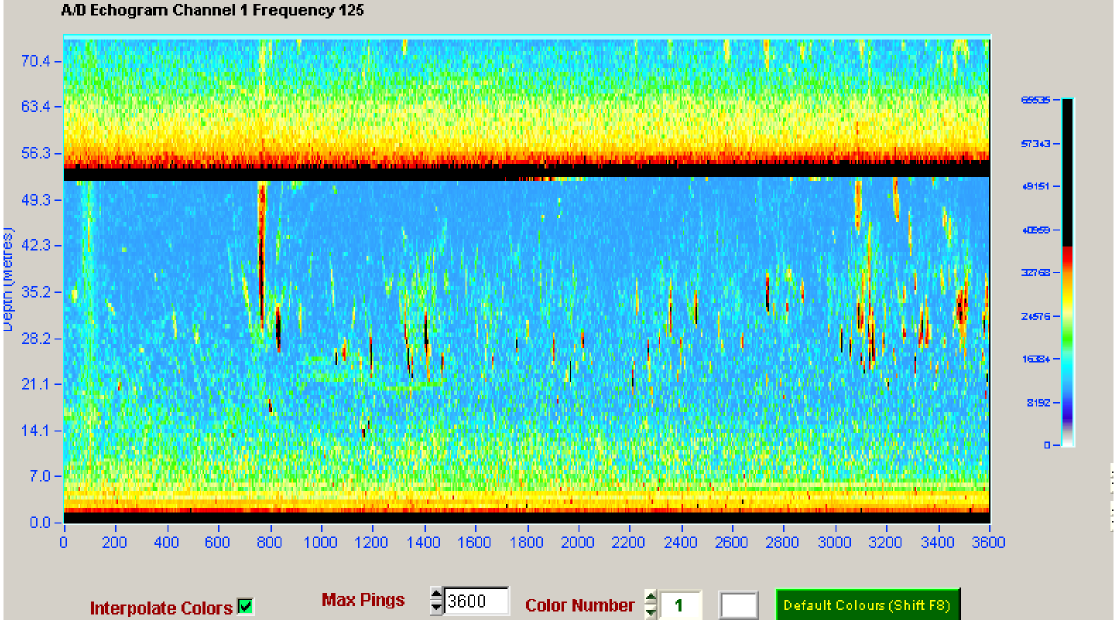
Processing Time [sec]: 0.431

Show Range Units as: Meters

Acquire	Pulse Length	Dig Rate	Max. Range	Bin Averaging	Lockout	Storage Type
125 kHz ☑	300 [us]	64 kHz	74.516 [m]	0.643 [m]	0.000 [m]	5 bytes/bin
125 kHz ☑	300 [us]	64 kHz	99.569 [m]	0.643 [m]	0.000 [m]	5 bytes/bin

Figure A4-4. ASL software parameter screen showing the settings for the Western Passage deployment.

Vertical Profiles (Channel 1)


A/D Echogram Channel 1 Frequency 125

Interpolate Colors ☑ Max Pings 3600 Color Number 1

Figure A4-5. ASL echogram (Nov. 19/12 1100 - 1200) from the upward looking transducer (Channel 1) in Western Passage. Spike-like targets are characteristic of small groups of juvenile herring. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~53 m is the water surface.

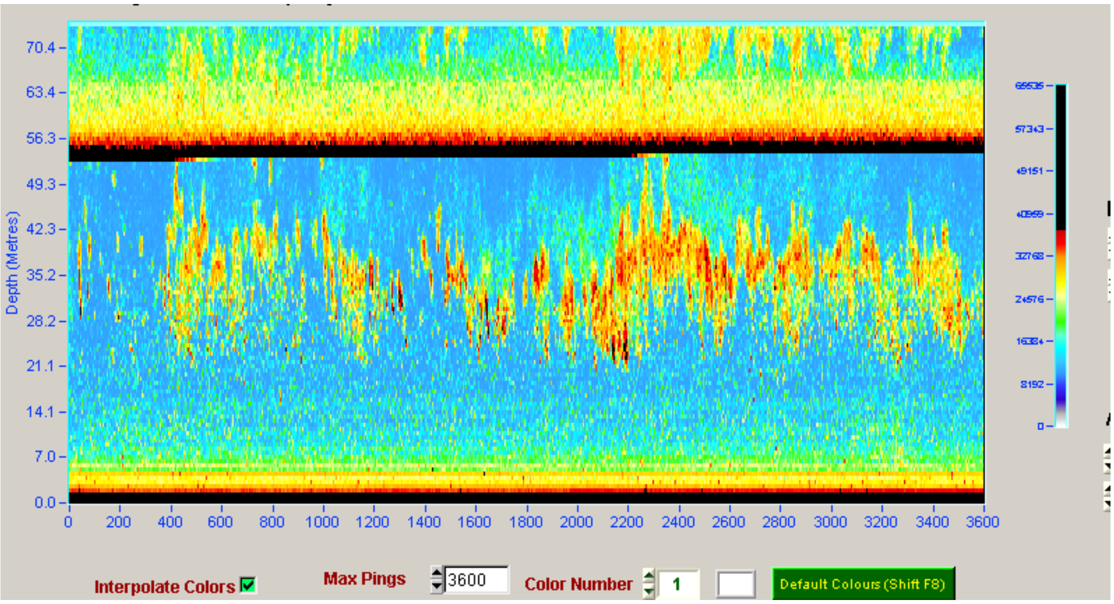

Interpolate Colors ☑ Max Pings 3600 Color Number 1

Figure A4-6. ASL echogram (Nov. 19/12 1200 - 1300) from the upward looking transducer (Channel 1) in Western Passage. School-like targets are characteristic of small juvenile herring. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~54 m is the water surface.

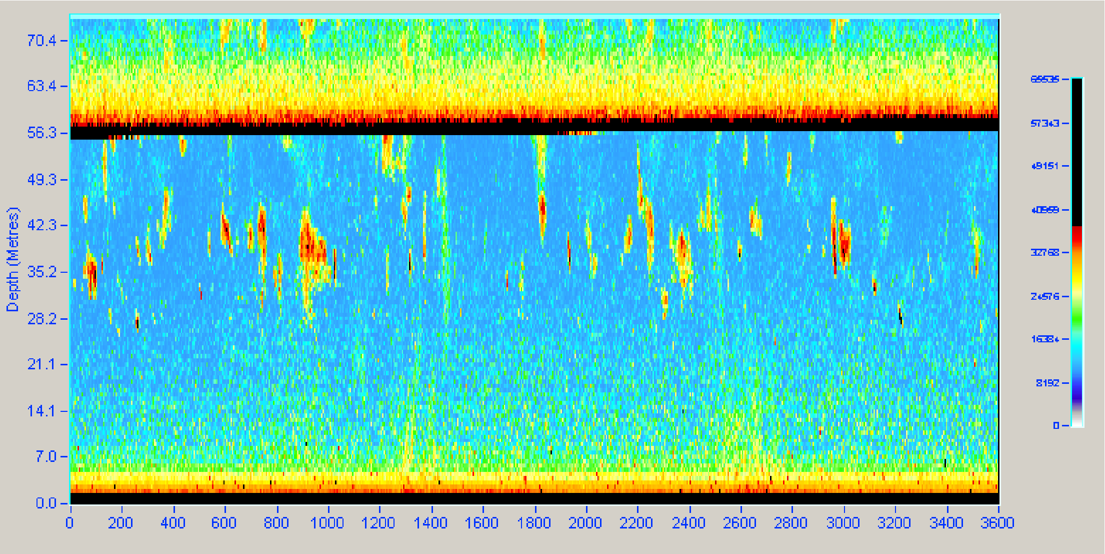


Figure A4-7. ASL echogram (Nov. 19/12 1400 - 1500) from the upward looking transducer (Channel 1) in Western Passage. Small aggregations characteristic of juvenile herring. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~56 m is the water surface.

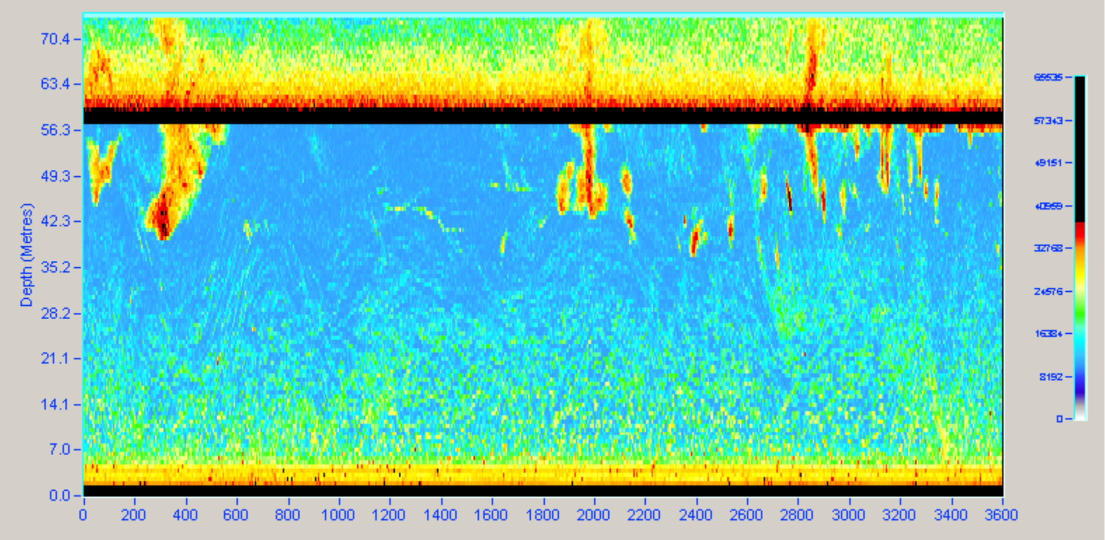


Figure A4-8. ASL echogram (Nov 19/12 1600 - 1700) from the upward looking transducer (Channel 1) in Western Passage. Small aggregations characteristic of juvenile herring near the surface. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~56 m is the water surface.

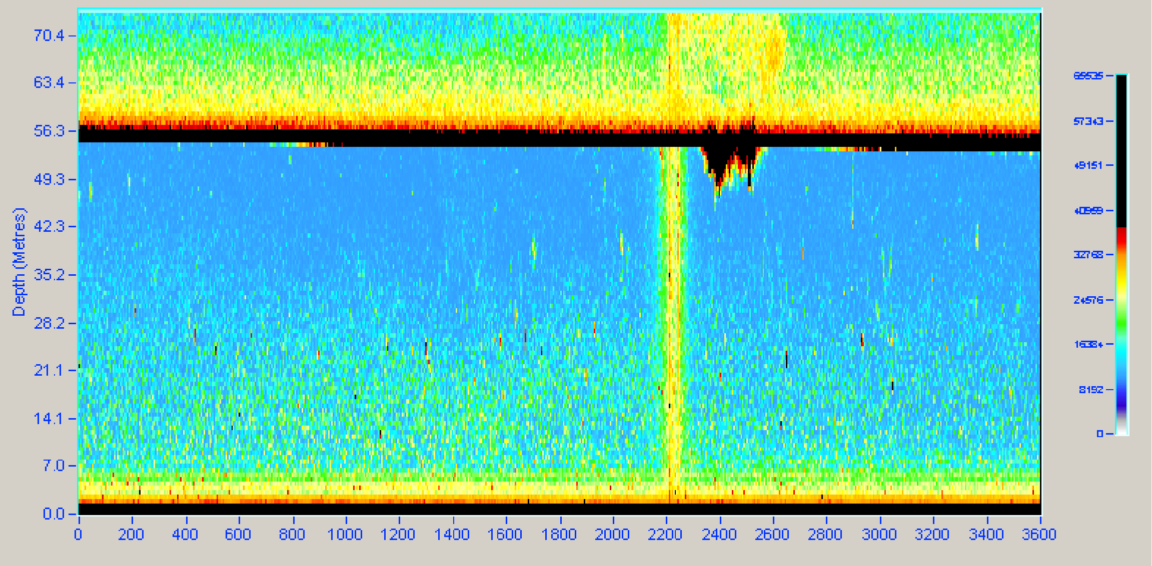


Figure A4-9. ASL echogram (Nov 21/12 0900 - 1000) from the upward looking transducer (Channel 1) in Western Passage. The yellow band represents acoustic interference from communication and the dark area vessel prop turbulence. Few fish were observed during this hour. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~56 m is the water surface.

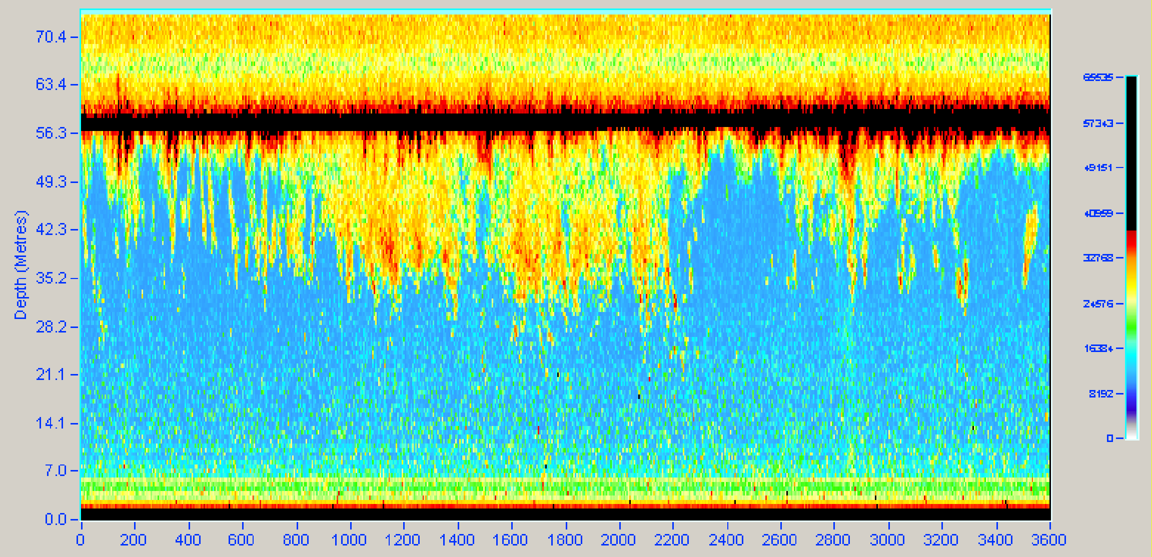


Figure A4-10. ASL echogram (Nov 25/12 0800 - 0900) from the upward looking transducer (Channel 1) in Western Passage. Note the surface noise likely originating from wind generated turbulence. Schools of fish are observed below the turbulence at about 35 - 49 m. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~56 m is the water surface.

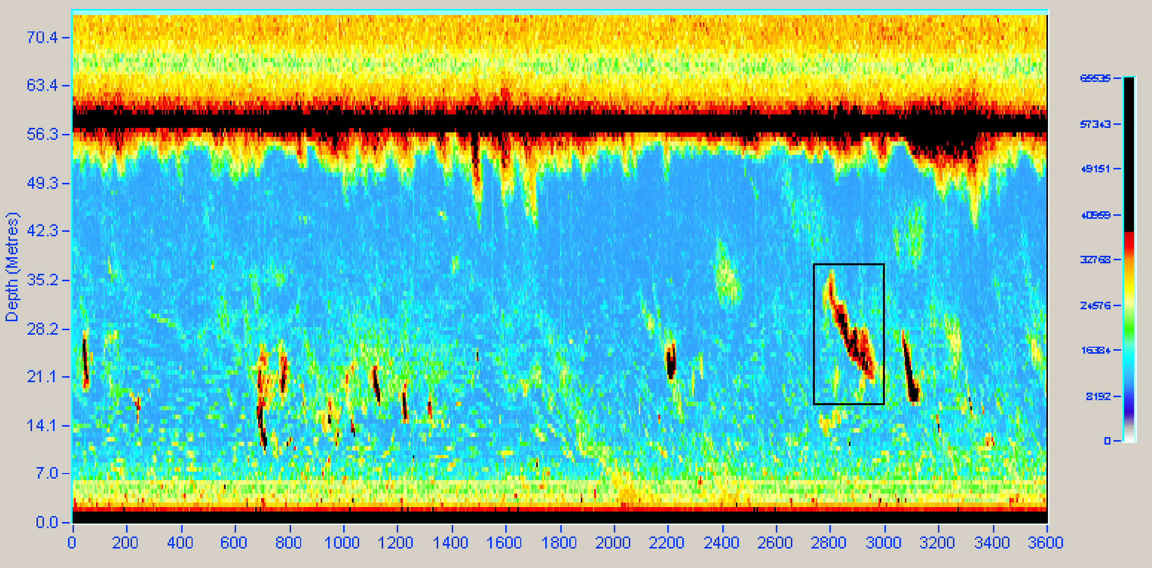


Figure A4-11. ASL echogram (Nov 25/12 1000 - 1100) from the upward looking transducer (Channel 1) in Western Passage. Another example of wind generated surface noise. Fish are located at 14 – 28 m. The target in the box may be a marine mammal diving. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~56 m is the water surface.

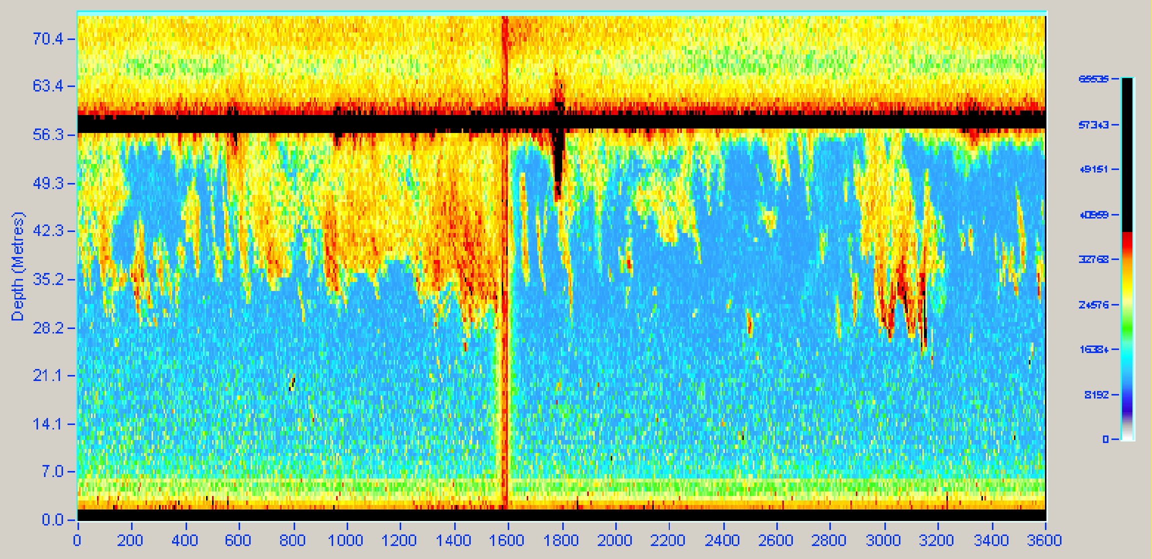


Figure A4-12. ASL echogram (Nov 26/12 0900 - 1000) from the upward looking transducer (Channel 1) in Western Passage. The band is the signal to release and the dark protrusion from the surface the vessel wake. Aggregations of fish were seen between 28 and 50 m. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. The dark band at ~56 m is the water surface.

Horizontal Profiles (Channel 2)

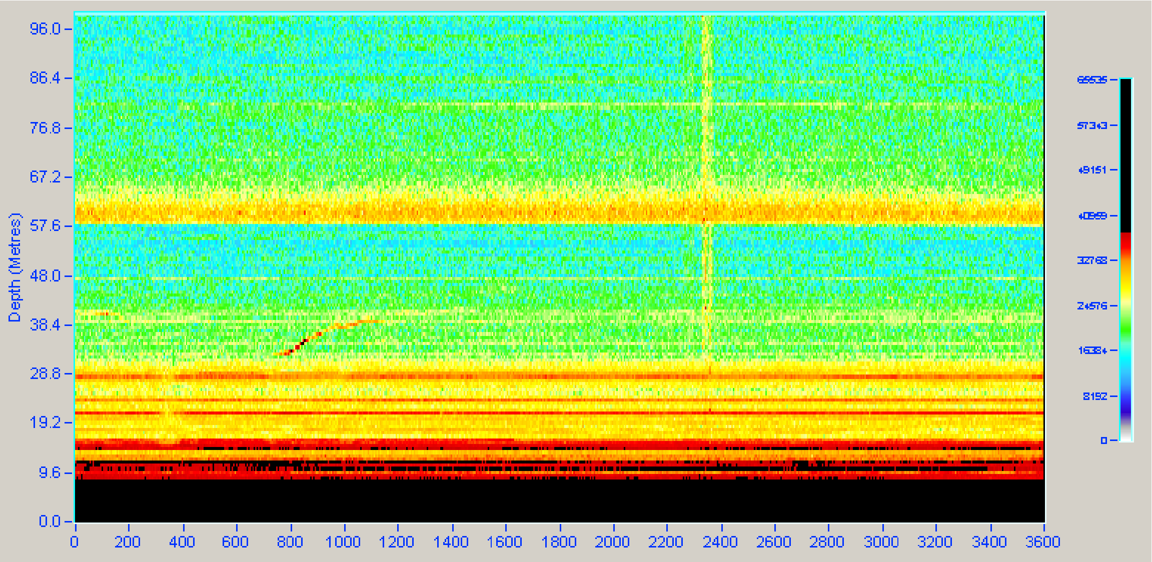


Figure A4-13. ASL echogram (Nov 19/12 1600 - 1700) from the horizontal looking transducer (Channel 2) in Western Passage. The echogram illustrates the background reflections near or on bottom, a safety rope for retrieval, and the communication interference. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. Bottom reflections and multiple echoes limit observations out to about 28 m. The range is set to 100 m.

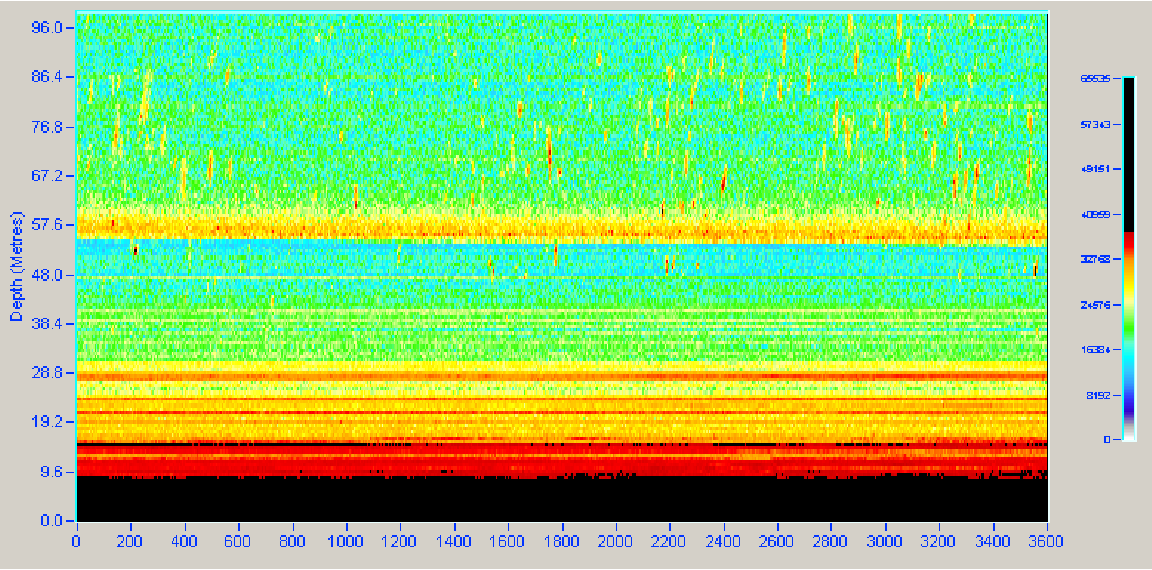


Figure A4-14. ASL echogram (Nov 22/12 1000 - 1100) from the horizontal looking transducer (Channel 2) in Western Passage. The echogram illustrates multiple targets near bottom 40 - 100 m from the transducer. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. Bottom reflections and multiple echoes limit observations out to about 28 m. The range is set to 100 m.

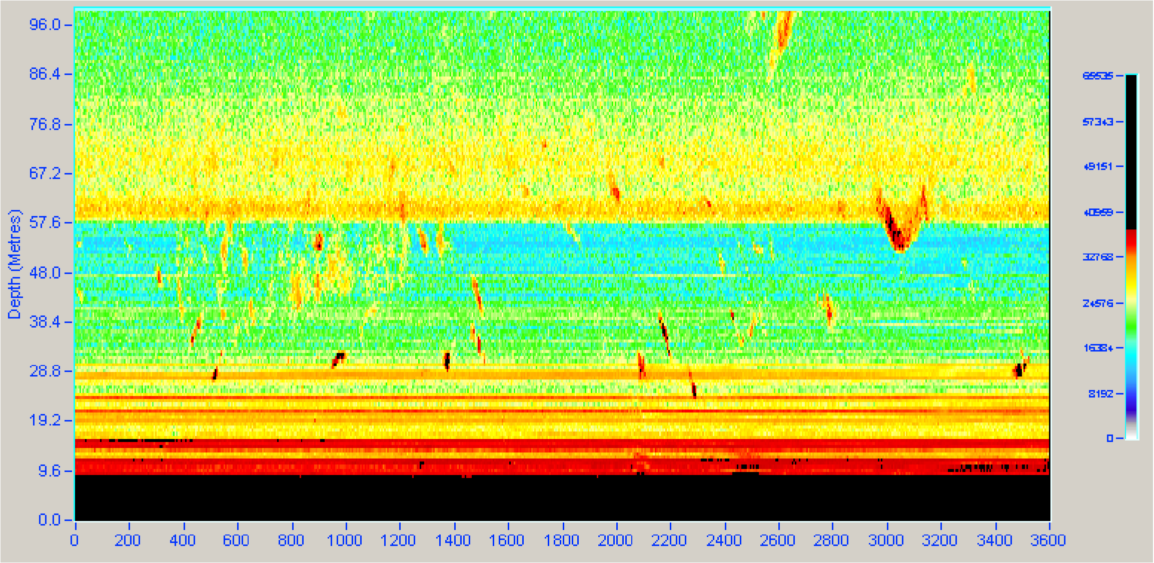


Figure A4-15. ASL echogram (Nov 25/12 1000 - 1100) from the horizontal looking transducer (Channel 2) in Western Passage. The echogram shows multiple strong acoustic targets near bottom 25 - 100 m from the transducer. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. Bottom reflections and multiple echoes limit observations out to about 25 m. The range is set to 100 m.

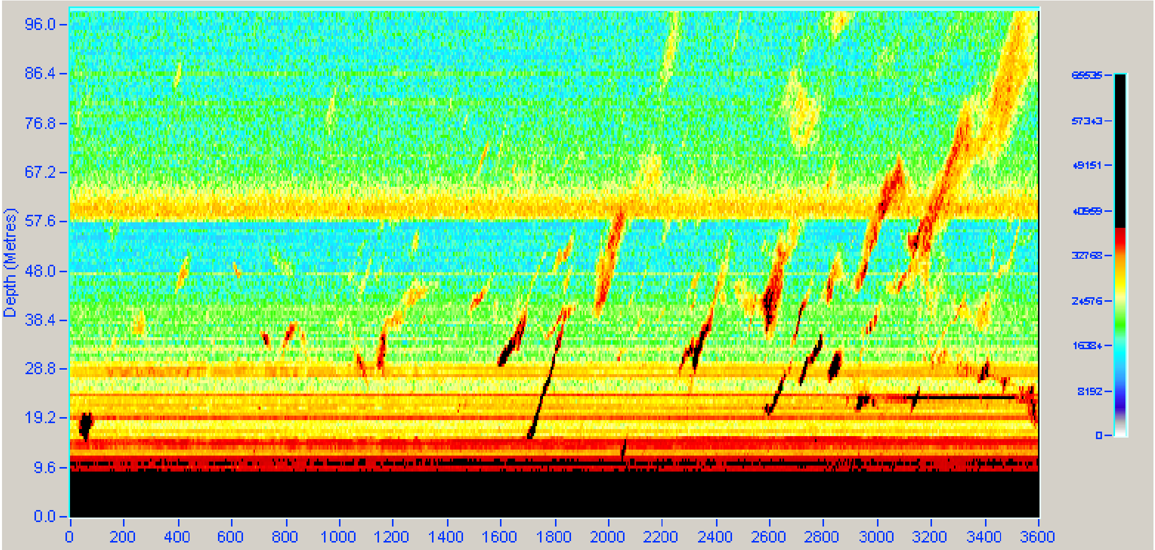


Figure A4-16. ASL echogram (Nov 27/12 1000 - 1100) from the horizontal looking transducer (Channel 2) in Western Passage. The echogram shows multiple strong acoustic targets near bottom moving away from the transducer. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. Bottom reflections and multiple echoes limit observations out to about 25 m, although in this case targets are seen up to 15 m from the transducer. The range is set to 100 m.

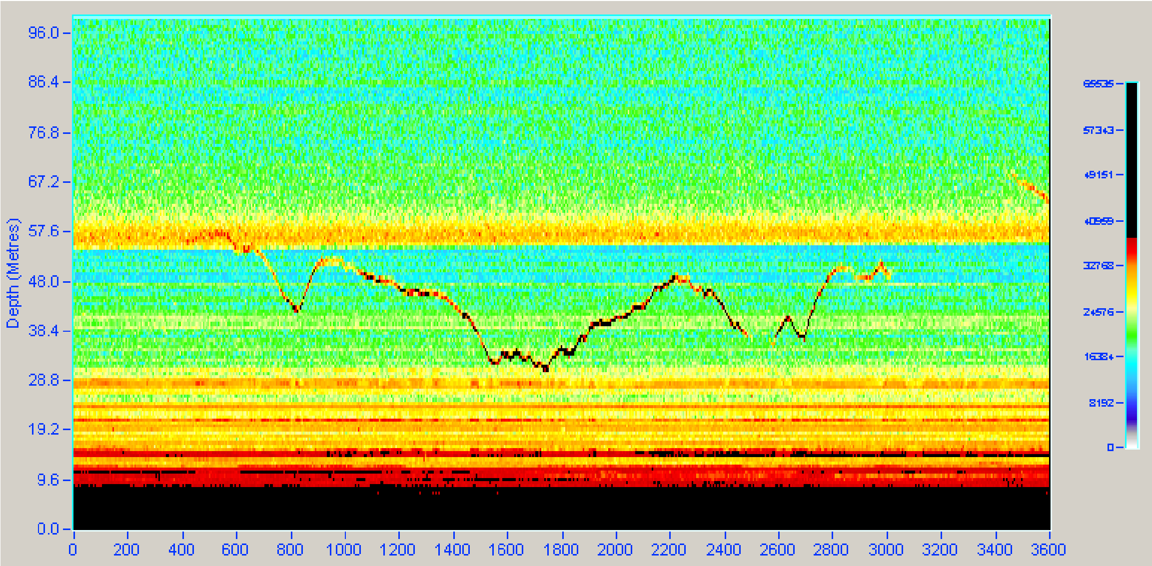


Figure A4-17. ASL echogram (Nov 21/12 0200 - 0300) from the horizontal looking transducer (Channel 2) in Western Passage. The echogram shows the safety line deployed for retrieval in the event the acoustic release malfunctioned. The line drifted in front of the transducer during certain phases of the tide. No fish were observed during this period. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. Bottom reflections and multiple echoes limit observations out to about 28 m from the transducer. The range is set to 100 m.

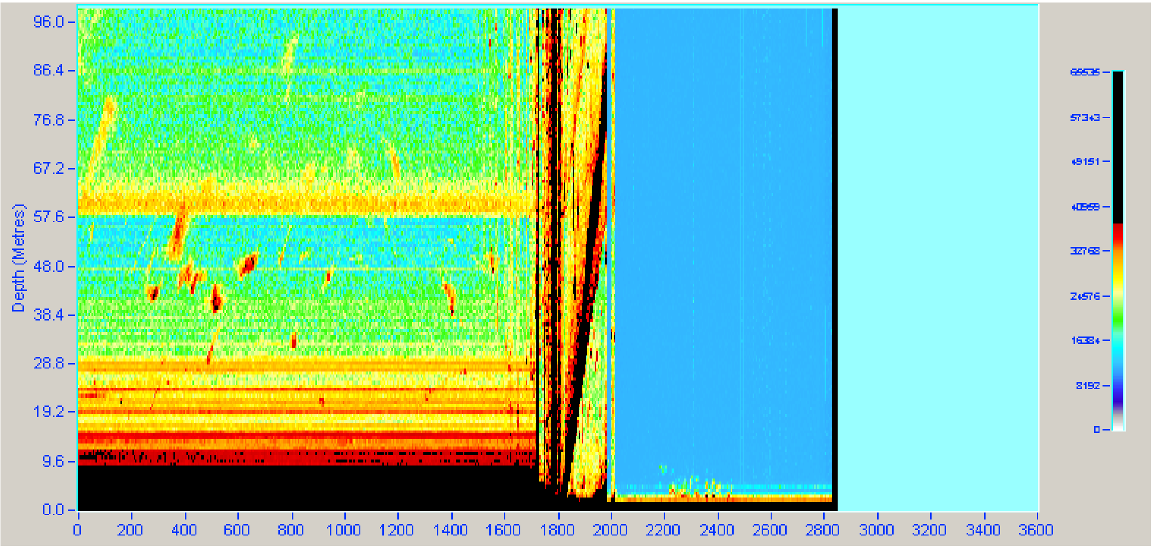


Figure A4-18. ASL echogram (Nov 27/12 1100 - 1130) from the horizontal looking transducer (Channel 2) in Western Passage. The echogram shows the retrieval of the platform and the surface recording in air before it was turned off. No fish were observed during this period. The y-axis represents the range from the transducer and the x-axis sequential pings from 0 - 3600. Fish targets were observed until the platform was lifted off bottom. The range is set to 100 m.

APPENDIX 5: EK60 TRANSECT-BASED ACOUSTIC BACKSCATTER FOR ALL SURVEYS

Below are listed several standard acoustic backscatter measures and mean tidal heights computed for each survey on:

1) A grid-by-grid basis – Grids are further broken down to "Test Site" and "Channel"

2) A transect-by-transect basis – Separate tables are provided for acoustic measures computed stating at 2 m and 10 m below the transducer and for acoustic measures computed after manually editing out the surface bubble dominated region.

Table A5-1 Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the August 22, 2011 survey. The estimated biomass is based on a TS weight of -35.5. Note that N/A indicates that the no data are available for the area.

Depth	Grid	Start Time	End Time	Mean Tide	Number Transects	Mean Sv Test Site	Mean Sv Channel	Mean NASC Test Site	Mean NASC Channel	Mean ABC Test Site	Channel	Mean BSC Test Site	Channel
2	1	11.76	15.06	550.8	12	-62.159	-69.748	1170.4	276.4	0.00002715	0.00000641	-45.662	-51.929
	2	15.07	16.84	327.3	12	-59.427	-68.773	1879.4	358.3	0.00004360	0.00000831	-43.605	-50.803
	3	16.85	19.39	519.8	12	-56.651	-57.607	3361.2	5118.3	0.00007798	0.00011875	-41.080	-39.254
	4	19.55	21.48	960.2	9	-54.319	N/A	6809.1	N/A	0.00015798	N/A	-38.014	N/A
10	1	11.76	15.06	550.8	12	-68.142	-80.794	250.6	20.3	0.00000581	0.00000047	-52.356	-63.259
	2	15.07	16.84	327.3	12	-77.542	-82.292	24.2	12.6	0.00000056	0.00000029	-62.511	-65.326
	3	16.85	19.39	519.8	12	-73.354	-67.712	52.1	432.7	0.00000121	0.00001004	-59.178	-49.983
	4	19.55	21.48	960.2	9	-66.648	N/A	323.9	N/A	0.00000752	N/A	-51.240	N/A
SU	1	11.76	15.06	550.8	12	-80.081	-81.307	12.9	19.5	0.00000030	0.00000045	-65.253	-63.438
	2	15.07	16.84	327.3	12	-83.728	-80.220	5.6	18.0	0.00000013	0.00000042	-68.834	-63.793
	3	16.85	19.39	519.8	12	-81.992	-81.928	8.5	11.1	0.00000020	0.00000026	-67.053	-65.893
	4	19.55	21.48	960.2	9	-86.864	N/A	2.8	N/A	0.00000006	N/A	-71.937	N/A

Table A5-2. Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the Sept 19, 2011 survey. The estimated biomass is based on a TS weight of -35.5. Note that all transects are included in the estimate of the mean.

Depth	Grid	Start Time	End Time	Mean Tide	Number Transects	Mean Sv Test Site	Mean Sv Channel	Mean NASC Test Site	Mean NASC Channel	Mean ABC Test Site	Channel	Mean BSC Test Site	Channel
2	1	10.92	13.57	693.0	12	-64.117	-81.284	741.099	19.736	0.00001719	0.00000046	-47.646	-63.392
	2	13.59	15.53	241.6	12	-75.850	-79.932	43.377	26.598	0.00000101	0.00000062	-59.972	-62.096
	3	15.54	18.77	332.6	12	-60.749	-61.504	1341.045	2141.850	0.00003111	0.00004969	-45.070	-43.037
	4	18.77	20.38	857.6	9	-64.316	N/A	698.571	N/A	0.00001621	N/A	-47.903	N/A
10	1	10.92	13.57	693.0	12	-71.162	-81.845	118.578	15.108	0.00000275	0.00000035	-55.605	-64.553
	2	13.59	15.53	241.6	12	-82.287	-84.670	7.919	8.155	0.00000018	0.00000019	-67.358	-67.230
	3	15.54	18.77	332.6	12	-74.718	-68.068	41.834	418.927	0.00000097	0.00000972	-60.130	-50.124
	4	18.77	20.38	857.6	9	-75.161	N/A	45.711	N/A	0.00000106	N/A	-59.745	N/A
SU	1	10.92	13.57	693.0	12	-79.429	-81.967	15.656	16.618	0.00000036	0.00000039	-64.398	-64.139
	2	13.59	15.53	241.6	12	-83.680	-83.783	6.968	11.078	0.00000016	0.00000026	-67.914	-65.900
	3	15.54	18.77	332.6	12	-82.680	-76.386	6.362	51.741	0.00000015	0.00000120	-68.309	-59.207
	4	18.77	20.38	857.6	9	-81.005	N/A	12.599	N/A	0.00000029	N/A	-65.342	N/A

Table A5-3. Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the October 3, 2011 survey. The estimated biomass is based on a TS weight of -35.5. Note that all transects are included in the estimate of the mean.

Depth	Grid	Start Time	End Time	Mean Tide (cm)	Number Transects	Mean Sv		Mean NASC		Mean ABC		Mean BSC	
						Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel
2	1	9.93	13.10	693.0	12	-68.285	-77.740	279.4	45.0	0.00000648	0.00000104	-51.883	-59.815
	2	13.11	15.25	241.6	12	-68.653	-84.907	242.2	6.8	0.00000562	0.00000016	-52.502	-67.997
	3	15.27	17.08	332.6	12	-68.644	-70.263	194.0	240.9	0.00000450	0.00000559	-53.467	-52.526
	4	17.11	20.25	882.0	10	-58.951	-71.688	2211.2	233.2	0.00005130	0.00000541	-42.899	-52.667
10	1	9.93	13.10	693.0	12	-74.453	-80.198	57.3	21.2	0.00000133	0.00000049	-58.766	-63.080
	2	13.11	15.25	241.6	12	-73.989	-84.690	56.5	6.0	0.00000131	0.00000014	-58.828	-68.545
	3	15.27	17.08	332.6	12	-85.295	-76.268	3.5	51.3	0.00000008	0.00000119	-70.924	-59.243
	4	17.11	20.25	882.0	10	-68.515	-77.690	201.3	52.8	0.00000467	0.00000122	-53.306	-59.121
SU	1	9.93	13.10	693.0	12	-75.389	-79.720	42.6	26.0	0.00000099	0.00000060	-60.053	-62.203
	2	13.11	15.25	241.6	12	-80.205	-84.907	14.1	6.8	0.00000033	0.00000016	-64.844	-67.997
	3	15.27	17.08	332.6	12	-86.253	-79.924	3.6	20.7	0.00000008	0.00000048	-70.820	-63.194
	4	17.11	20.25	882.0	10	-78.850	-78.611	18.0	42.9	0.00000042	0.00000100	-63.785	-60.016

Table A5-4. Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the November 22, 2011 survey. The estimated biomass is based on a TS weight of -35.5. Note that all transects are included in the estimate of the mean.

Depth	Grid	Start Time	End Time	Mean Tide (cm)	Number Transects	Mean Sv		Mean NASC		Mean ABC		Mean BSC	
						Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel
2	1	14.38	18.42	633.4	12	-59.961	-63.605	1866.1	863.3	0.00004330	0.00002003	-43.635	-46.983
	2	18.42	20.19	160.5	12	-69.486	-74.288	177.4	97.8	0.00000412	0.00000227	-53.855	-56.443
	3	20.20	22.60	360.9	12	-61.511	-60.093	1208.9	2736.2	0.00002805	0.00006348	-45.521	-41.973
10	1	14.38	18.42	633.4	12	-69.198	-76.717	192.9	48.7	0.00000448	0.00000113	-53.491	-59.473
	2	18.42	20.19	160.5	12	-74.128	-79.946	49.6	21.5	0.00000115	0.00000050	-59.386	-63.013
	3	20.20	22.60	360.9	12	-68.657	-63.815	192.4	1015.5	0.00000446	0.00002356	-53.502	-46.278
SU	1	14.38	18.42	633.4	12	-77.310	-76.972	23.5	46.8	0.00000054	0.00000109	-62.637	-59.641
	2	18.42	20.19	160.5	12	-77.283	-76.902	23.8	50.8	0.00000055	0.00000118	-62.581	-59.287
	3	20.20	22.60	360.9	12	-75.421	-75.474	34.5	63.0	0.00000080	0.00000146	-60.962	-58.355

Table A5-5. Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the January 25, 2012 survey. The estimated biomass is based on a TS weight of -35.5. Note that all transects are included in the estimate of the mean.

				Mean		Mean		Mean		Mean		Mean	
Depth	Grid	Start Time	End Time	Tide	Number	Sv		NASC		ABC		BSC	
				(cm)	Transects	Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel
2	1	18.55	20.93	1048.2	12	-56.520	-55.942	4504.9	6645.6	0.00010452	0.00015418	-39.808	-38.120
	2	20.93	23.03	550.3	12	-49.300	-59.352	21198.9	2622.1	0.00049184	0.00006084	-33.082	-42.158
	3	0.15	23.88	163.3	12	-61.740	-64.490	1079.8	891.0	0.00002505	0.00002067	-46.012	-46.846
	4	0.56	3.31	209.9	12	-62.839	-56.751	770.1	6832.1	0.00001787	0.00015851	-47.479	-37.999
	5	5.74	7.49	1121.0	12	-64.978	-62.032	633.6	1622.9	0.00001470	0.00003765	-48.327	-44.242
	6	7.51	9.92	915.7	12	-53.651	-55.925	8207.3	5746.3	0.00019042	0.00013332	-37.203	-38.751
	7	9.95	11.65	440.8	12	-53.667	-59.613	7276.3	2507.7	0.00016882	0.00005818	-37.726	-42.352
	8	11.68	13.04	178.3	12	-59.360	-63.386	1780.5	1129.1	0.00004131	0.00002620	-43.840	-45.818
	9	13.08	14.93	225.4	12	-61.107	-59.761	1178.7	2931.3	0.00002735	0.00006801	-45.631	-41.674
	10	15.48	16.26	640.0	3	-50.197	N/A	17701.4	N/A	0.00041069	N/A	-33.865	N/A
10	1	18.55	20.93	1048.2	12	-68.368	-66.855	240.8	516.4	0.00000559	0.00001198	-52.528	-49.215
	2	20.93	23.03	550.3	12	-52.565	-72.130	8459.5	122.4	0.00019627	0.00000284	-37.071	-55.466
	3	0.15	23.88	163.3	12	-66.961	-75.672	277.3	46.7	0.00000643	0.00000108	-51.916	-59.648
	4	0.56	3.31	209.9	12	-72.373	-60.080	67.4	2842.7	0.00000156	0.00006595	-58.058	-41.808
	5	5.74	7.49	1121.0	12	-77.153	-75.581	31.2	63.6	0.00000072	0.00000148	-61.404	-58.310
	6	7.51	9.92	915.7	12	-60.903	-65.975	1370.2	568.7	0.00003179	0.00001319	-44.977	-48.796
	7	9.95	11.65	440.8	12	-57.952	-74.679	2299.7	64.2	0.00005335	0.00000149	-42.728	-58.269
	8	11.68	13.04	178.3	12	-67.560	-78.070	208.5	29.9	0.00000484	0.00000069	-53.153	-61.583
	9	13.08	14.93	225.4	12	-70.758	-65.152	103.5	743.1	0.00000240	0.00001724	-56.197	-47.634
	10	15.48	16.26	640.0	3	-57.898	N/A	2505.3	N/A	0.00005813	N/A	-42.356	N/A
SU	1	18.55	20.93	1048.2	12	-75.568	-75.432	40.1	54.1	0.00000093	0.00000126	-60.314	-59.009
	2	20.93	23.03	550.3	12	-72.100	-76.701	53.2	28.1	0.00000124	0.00000065	-59.083	-61.863
	3	0.15	23.88	163.3	12	-76.981	-76.951	25.1	34.2	0.00000058	0.00000079	-62.355	-61.002
	4	0.56	3.31	209.9	12	-77.440	-76.906	24.5	41.4	0.00000057	0.00000096	-62.459	-60.177
	5	5.74	7.49	1121.0	12	-77.930	-76.966	28.8	32.0	0.00000067	0.00000074	-61.757	-61.298
	6	7.51	9.92	915.7	12	-77.804	-75.779	18.4	21.7	0.00000043	0.00000050	-63.703	-62.972
	7	9.95	11.65	440.8	12	-75.585	-77.882	25.8	19.1	0.00000060	0.00000044	-62.227	-63.537
	8	11.68	13.04	178.3	12	-76.735	-78.763	26.5	24.9	0.00000061	0.00000058	-62.115	-62.387
	9	13.08	14.93	225.4	12	-77.529	-76.173	23.9	24.8	0.00000055	0.00000058	-62.568	-62.392
	10	15.48	16.26	640.0	3	-82.492	N/A	5.5	N/A	0.00000013	N/A	-68.980	N/A

Table A5-6. Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the March 19, 2012 survey. The estimated biomass is based on a TS weight of -35.5. Note that all transects are included in the estimate of the mean.

Depth	Grid	Start Time	End Time	Mean Tide (cm)	Number Transects	Mean Sv		Mean NASC		Mean ABC		Mean BSC	
						Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel
2	1	14.39	15.79	902.1	12	-64.115	-79.522	787.1	31.7	0.00001826	0.00000073	-47.385	-61.339
	2	15.81	17.97	509.7	12	-63.153	-74.171	955.0	104.2	0.00002216	0.00000242	-46.545	-56.165
	3	17.99	19.88	165.9	11	-61.196	-75.482	1340.9	48.1	0.00003111	0.00000112	-45.071	-59.519
	4	19.91	21.51	266.4	12	-75.777	-80.128	39.0	24.7	0.00000090	0.00000057	-60.436	-62.420
	5	21.53	23.18	651.2	12	-56.135	-63.894	3591.8	1164.3	0.00008333	0.00002701	-40.792	-45.684
	6	0.23	2.73	1077.4	12	-58.338	-69.593	2638.9	306.6	0.00006123	0.00000711	-42.131	-51.479
	7	2.75	4.10	917.0	12	-61.022	-71.718	1504.4	141.7	0.00003490	0.00000329	-44.571	-54.833
	8	4.13	6.18	542.8	12	-62.988	-58.257	967.8	2376.8	0.00002245	0.00005514	-46.487	-42.585
	9	6.21	7.87	188.2	12	-60.003	-75.800	1824.3	52.3	0.00004233	0.00000121	-43.734	-59.163
	10	7.89	9.28	208.8	12	-69.596	-82.318	183.7	13.7	0.00000426	0.00000032	-53.704	-64.991
	11	9.29	11.10	491.3	12	-70.988	-76.932	116.0	51.1	0.00000269	0.00000118	-55.699	-59.264
	12	11.13	13.55	983.9	7	-52.497	N/A	9298.2	N/A	0.00021573	N/A	-36.661	N/A
10	1	14.39	15.79	902.1	12	-79.604	-81.677	17.4	16.8	0.00000040	0.00000039	-63.947	-64.092
	2	15.81	17.97	509.7	12	-67.518	-79.238	286.1	26.3	0.00000664	0.00000061	-51.780	-62.139
	3	17.99	19.88	165.9	11	-64.406	-82.514	517.4	11.3	0.00001200	0.00000026	-49.207	-65.799
	4	19.91	21.51	266.4	12	-77.491	-82.160	19.2	13.1	0.00000044	0.00000030	-63.519	-65.180
	5	21.53	23.18	651.2	12	-61.265	-68.411	870.1	369.0	0.00002019	0.00000856	-46.949	-50.675
	6	0.23	2.73	1077.4	12	-68.086	-77.296	227.0	48.2	0.00000527	0.00000112	-52.785	-59.514
	7	2.75	4.10	917.0	12	-78.540	-81.239	22.0	19.0	0.00000051	0.00000044	-62.917	-63.561
	8	4.13	6.18	542.8	12	-69.470	-78.992	180.6	27.5	0.00000419	0.00000064	-53.778	-61.945
	9	6.21	7.87	188.2	12	-63.229	-82.381	703.4	11.3	0.00001632	0.00000026	-47.873	-65.822
	10	7.89	9.28	208.8	12	-73.132	-82.466	63.6	10.9	0.00000148	0.00000025	-58.310	-65.975
	11	9.29	11.10	491.3	12	-81.277	-81.829	8.6	13.7	0.00000020	0.00000032	-66.993	-64.988
	12	11.13	13.55	983.9	7	-60.463	N/A	1176.4	N/A	0.00002729	N/A	-45.639	N/A
SU	1	14.39	15.79	902.1	12	-80.734	-81.247	15.1	20.5	0.00000035	0.00000048	-64.562	-63.222
	2	15.81	17.97	509.7	12	-77.459	-80.228	24.9	21.9	0.00000058	0.00000051	-62.388	-62.941
	3	17.99	19.88	165.9	11	-76.954	-82.238	22.1	14.2	0.00000051	0.00000033	-62.896	-64.830
	4	19.91	21.51	266.4	12	-77.844	-81.653	23.2	16.7	0.00000054	0.00000039	-62.690	-64.107
	5	21.53	23.18	651.2	12	-78.639	-80.331	14.6	18.0	0.00000034	0.00000042	-64.687	-63.790
	6	0.23	2.73	1077.4	12	-80.014	-82.767	14.9	13.2	0.00000035	0.00000031	-64.620	-65.135
	7	2.75	4.10	917.0	12	-79.503	-81.639	19.1	19.4	0.00000044	0.00000045	-63.543	-63.474
	8	4.13	6.18	542.8	12	-79.450	-81.012	14.8	17.7	0.00000034	0.00000041	-64.628	-63.863
	9	6.21	7.87	188.2	12	-76.622	-82.070	26.2	14.6	0.00000061	0.00000034	-62.154	-64.696
	10	7.89	9.28	208.8	12	-80.213	-82.325	13.8	13.7	0.00000032	0.00000032	-64.958	-64.967
	11	9.29	11.10	491.3	12	-80.713	-82.171	12.7	14.2	0.00000029	0.00000033	-65.306	-64.822
	12	11.13	13.55	983.9	7	-76.528	N/A	28.1	N/A	0.00000065	N/A	-61.851	N/A

Table A5-7. Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the May 31, 2012 survey. The estimated biomass is based on a TS weight of -35.5. N/A indicates that no transects were conducted in the gird. Note that all transects are included in the estimate of the mean.

				Mean		Mean		Mean		Mean		Mean	
Depth	Grid	Start Time	End Time	Tide	Number	Sv		NASC		ABC		BSC	
				(cm)	Transects	Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel
2	1	12.16	14.06	976.8	12	-67.503	-78.240	353.5	45.4	0.00000820	0.00000105	-50.861	-59.775
	2	14.08	16.44	591.7	12	-69.014	-63.694	212.5	685.4	0.00000493	0.00001590	-53.072	-47.985
	3	16.46	18.17	256.8	12	-60.582	-83.269	1530.4	12.2	0.00003551	0.00000028	-44.497	-65.473
	4	18.19	20.06	265.2	12	-68.606	-75.550	203.6	75.7	0.00000472	0.00000176	-53.257	-57.553
	5	20.08	23.20	735.9	9	-56.144	N/A	4020.1	N/A	0.00009327	N/A	-40.303	N/A
10	1	12.16	14.06	976.8	12	-76.423	-81.159	34.1	20.7	0.00000079	0.00000048	-61.019	-63.176
	2	14.08	16.44	591.7	12	-73.646	-82.866	62.0	11.0	0.00000144	0.00000026	-58.423	-65.922
	3	16.46	18.17	256.8	12	-66.417	-86.679	312.8	4.1	0.00000726	0.00000010	-51.392	-70.181
	4	18.19	20.06	265.2	12	-72.328	-83.564	72.7	8.5	0.00000169	0.00000020	-57.731	-67.029
	5	20.08	23.20	735.9	9	-64.855	N/A	414.3	N/A	0.00000961	N/A	-50.171	N/A
SU	1	12.16	14.06	976.8	12	-76.250	-79.803	40.6	31.6	0.00000094	0.00000073	-60.255	-61.349
	2	14.08	16.44	591.7	12	-71.481	-79.386	101.0	27.9	0.00000234	0.00000065	-56.301	-61.882
	3	16.46	18.17	256.8	12	-76.028	-83.858	33.1	10.6	0.00000077	0.00000025	-61.152	-66.086
	4	18.19	20.06	265.2	12	-72.859	-78.574	77.6	35.9	0.00000180	0.00000083	-57.445	-60.789
	5	20.08	23.20	735.9	9	-77.705	N/A	20.1	N/A	0.00000047	N/A	-63.308	N/A

Table A5-8. Summary of the grid mean acoustic backscatter for 2 m, 10 m, and edited surface from the test site and the channel expressed in S_v, NASC, ABC and S_a observed during the June 25, 2012 survey. Diagonal transects through the test site are labelled ZX. The estimated biomass is based on a TS weight of -35.5. N/A indicates that no transects were conducted in the gird. Note that all transects are included in the estimate of the mean.

				Mean		Mean		Mean		Mean		Mean	
Depth	Grid	Start Time	End Time	Tide	Number	Sv		NASC		ABC		BSC	
				(cm)	Transects	Test Site	Channel	Test Site	Channel	Test Site	Channel	Test Site	Channel
2	1	8.13	12.01	871.0	7	-60.645	-75.749	1699.8	78.4	0.00003944	0.00000182	-44.041	-57.401
	2	12.43	14.41	217.5	12	-61.913	-77.336	1168.0	42.4	0.00002710	0.00000098	-45.670	-60.074
	3	14.54	16.96	333.3	12	-66.726	-62.212	317.3	1662.4	0.00000736	0.00003857	-51.330	-44.138
	4	17.01	18.86	868.3	7	-55.189	N/A	5285.8	N/A	0.00012264	N/A	-39.114	N/A
	5	20.41	21.36	1051.4	9	-59.957	N/A	1962.9	N/A	0.00004554	N/A	-43.416	N/A
	6	21.47	23.17	856.7	9	-59.988	N/A	1801.3	N/A	0.00004179	N/A	-43.789	N/A
	7	0.07	23.81	441.2	12	-54.578	-67.111	6405.7	547.9	0.00014862	0.00001271	-38.279	-48.958
	8	1.99	4.04	253.2	12	-63.564	-71.269	691.2	192.3	0.00001604	0.00000446	-47.949	-53.506
	9	4.15	7.99	782.4	12	-52.831	-57.033	8679.7	5914.9	0.00020138	0.00013723	-36.960	-38.625
10	1	8.13	12.01	871.0	7	-73.678	-78.396	69.6	37.6	0.00000162	0.00000087	-57.916	-60.589
	2	12.43	14.41	217.5	12	-67.594	-77.092	254.0	37.4	0.00000589	0.00000087	-52.297	-60.617
	3	14.54	16.96	333.3	12	-76.149	-68.545	29.1	324.5	0.00000067	0.00000753	-61.712	-51.233
	4	17.01	18.86	868.3	7	-63.172	N/A	663.6	N/A	0.00001540	N/A	-48.126	N/A
	5	20.41	21.36	1051.4	9	-66.791	N/A	345.7	N/A	0.00000802	N/A	-50.958	N/A
	6	21.47	23.17	856.7	9	-68.169	N/A	233.9	N/A	0.00000543	N/A	-52.655	N/A
	7	0.07	23.81	441.2	12	-58.344	-71.376	2237.2	155.7	0.00005191	0.00000361	-42.848	-54.422
	8	1.99	4.04	253.2	12	-72.441	-74.298	71.5	86.3	0.00000166	0.00000200	-57.800	-56.985
	9	4.15	7.99	782.4	12	-60.539	-64.318	1116.6	1112.1	0.00002591	0.00002580	-45.866	-45.884
SU	1	8.13	12.01	871.0	7	-74.422	-78.712	53.0	36.2	0.00000123	0.00000084	-59.105	-60.760
	2	12.43	14.41	217.5	12	-77.236	-77.553	26.0	40.4	0.00000060	0.00000094	-62.201	-60.286
	3	14.54	16.96	333.3	12	-77.470	-77.241	27.2	35.1	0.00000063	0.00000081	-61.997	-60.892
	4	17.01	18.86	868.3	7	-77.808	N/A	22.0	N/A	0.00000051	N/A	-62.917	N/A
	5	20.41	21.36	1051.4	9	-67.100	N/A	323.7	N/A	0.00000751	N/A	-51.244	N/A
	6	21.47	23.17	856.7	9	-69.166	N/A	172.0	N/A	0.00000399	N/A	-53.991	N/A
	7	0.07	23.81	441.2	12	-71.024	-72.190	89.3	131.1	0.00000207	0.00000304	-56.835	-55.170
	8	1.99	4.04	253.2	12	-75.311	-74.545	32.5	88.2	0.00000075	0.00000205	-61.222	-56.889
	9	4.15	7.99	782.4	12	-75.354	-76.216	25.0	48.7	0.00000058	0.00000113	-62.373	-59.467
ZX	15	21.36	23.25	819.0	2	-68.508	N/A	84.8	N/A	0.00000197	N/A	-57.062	N/A

Table A5-9-1.1. Summary of acoustic backscatter from **2 m** below the transducer to bottom by individual transect for the August 22, 2011 survey in Minas Passage. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20110822	-64.4273	45.3690	11.76	11.90	8.77	42.58	960.9	526	Day	781	-58.34618	2685.9	0.0000623	-42.054
"T0_2"	20110822	-64.4267	45.3688	15.07	15.19	7.42	37.31	1107.7	445	Day	325	-61.83021	1055.0	0.0000245	-46.112
"T0_3"	20110822	-64.4260	45.3687	16.85	16.93	4.35	36.85	873.0	261	Day	386	-58.35311	2320.9	0.0000538	-42.688
"T0_4"	20110822	-64.4264	45.3688	19.55	19.69	8.37	41.45	1145.7	501	Day	835	-54.35567	6553.2	0.0001520	-38.180
"T1_1"	20110822	-64.4299	45.3685	11.92	11.99	4.43	48.20	1092.9	266	Day	755	-56.30158	4868.1	0.0001129	-39.471
"T1_2"	20110822	-64.4324	45.3691	15.20	15.31	6.42	42.89	1268.2	384	Day	320	-58.41242	2664.7	0.0000618	-42.088
"T1_3"	20110822	-64.4292	45.3683	16.95	17.10	8.97	43.27	974.6	535	Day	407	-54.63883	6408.4	0.0001487	-38.277
"T1_4"	20110822	-64.4295	45.3685	19.74	20.06	19.30	47.71	1057.6	1143	Day	892	-55.38749	5948.2	0.0001380	-38.601
"T2_1"	20110822	-64.4308	45.3680	12.02	12.18	9.62	48.96	685.6	576	Day	726	-66.32611	491.7	0.0000114	-49.428
"T2_2"	20110822	-64.4253	45.3668	15.35	15.41	3.68	39.41	564.9	220	Day	317	-58.41329	2447.8	0.0000568	-42.457
"T2_3"	20110822	-64.4270	45.3671	17.12	17.21	5.25	40.60	1084.9	312	Day	420	-62.00754	1102.3	0.0000256	-45.922
"T2_4"	20110822	-64.4264	45.3671	20.09	20.19	6.43	45.47	1124.8	385	Day	953	-51.54049	13744.6	0.0003189	-34.964
"T3_1"	20110822	-64.4337	45.3679	12.32	12.42	5.95	47.14	1253.5	357	Day	688	-62.57571	1122.9	0.0000261	-45.842
"T3_2"	20110822	-64.4304	45.3672	15.42	15.52	5.97	41.40	1213.8	358	Day	315	-56.27553	4206.6	0.0000976	-40.106
"T3_3"	20110822	-64.4301	45.3671	17.22	17.36	8.22	42.16	1069.3	492	Day	439	-63.01991	906.5	0.0000210	-46.771
"T3_4"	20110822	-64.4289	45.3668	20.27	20.57	18.35	46.92	1081.0	1090	Day	957	-58.96444	2567.0	0.0000596	-42.251
"T4_1"	20110822	-64.4292	45.3656	12.42	12.68	15.40	38.92	1091.5	921	Day	644	-69.61413	183.3	0.0000043	-53.712
"T4_2"	20110822	-64.4291	45.3656	15.53	15.64	6.25	34.18	955.6	374	Day	315	-63.20108	704.9	0.0000164	-47.864
"T4_3"	20110822	-64.4284	45.3654	17.37	17.44	4.50	34.27	1062.5	268	Day	451	-60.50988	1313.5	0.0000305	-45.160
"T4_4"	20110822	-64.4283	45.3653	20.60	20.71	6.42	40.31	1120.5	382	Day	970	-57.51945	3076.0	0.0000714	-41.465
"T5_1"	20110822	-64.4309	45.3650	13.21	13.32	6.42	37.44	1144.8	381	Day	535	-72.07309	100.1	0.0000023	-56.340
"T5_2"	20110822	-64.4330	45.3654	15.67	15.76	5.40	37.05	1091.0	323	Day	315	-61.56454	1113.8	0.0000258	-45.877
"T5_3"	20110822	-64.4306	45.3649	17.47	17.64	10.27	34.73	1041.9	615	Day	480	-65.75318	398.0	0.0000092	-50.346
"T5_4"	20110822	-64.4301	45.3648	20.73	20.99	15.33	40.29	1112.3	911	Day	995	-56.41802	3961.4	0.0000919	-40.366
"T6_1"	20110822	-64.4298	45.3639	13.35	13.62	16.07	34.80	1051.5	955	Day	488	-69.2135	179.8	0.0000042	-53.797
"T6_2"	20110822	-64.4282	45.3635	15.77	15.88	6.42	32.02	1118.7	375	Day	317	-60.9027	1121.1	0.0000260	-45.849
"T6_3"	20110822	-64.4293	45.3637	17.65	17.72	4.40	33.31	1061.3	247	Day	493	-61.97629	910.7	0.0000211	-46.751
"T6_4"	20110822	-64.4283	45.3634	21.02	21.12	6.32	38.76	1033.6	372	Day	1004	-52.73821	8893.9	0.0002063	-36.854
"T7_1"	20110822	-64.4322	45.3635	13.65	13.74	5.45	35.99	1000.8	327	Day	471	-66.10776	380.1	0.0000088	-50.546
"T7_2"	20110822	-64.4330	45.3635	15.88	15.97	5.38	34.81	1060.6	321	Day	319	-59.21351	1798.2	0.0000417	-43.797
"T7_3"	20110822	-64.4318	45.3632	17.75	18.04	17.42	34.15	1288.1	1022	Day	544	-54.13937	5674.4	0.0001317	-38.806
"T7_4"	20110822	-64.4315	45.3631	21.15	21.36	12.45	40.56	1189.4	738	Day	1016	-57.84477	2871.8	0.0000666	-41.763

Table A5-9-1.1 Continued

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time	End Time	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_1"	20110822	-64.4349	45.3630	13.74	13.90	9.43	34.97	724.0	560	Day	447	-64.60776	521.8	0.0000121	-49.170
"T8_2"	20110822	-64.4300	45.3619	15.98	16.09	6.33	35.27	1138.6	380	Day	323	-59.2595	1802.9	0.0000418	-43.785
"T8_3"	20110822	-64.4335	45.3626	18.05	18.08	1.53	33.41	370.2	92	Day	550	-51.08456	11216.3	0.0002602	-35.846
"T8_4"	20110822	-64.4303	45.3618	21.37	21.48	6.45	42.66	911.5	357	Day	1020	-51.28855	13665.8	0.0003171	-34.989
"X1_1"	20110822	-64.4297	45.3483	14.15	14.51	21.27	72.81	3073.1	1271	Day	374	-69.7779	330.3	0.0000077	-51.156
"X1_2"	20110822	-64.4315	45.3444	16.10	16.37	16.27	70.54	3117.8	972	Day	338	-70.10402	296.8	0.0000069	-51.620
"X1_3"	20110822	-64.4298	45.3479	18.08	18.53	27.47	69.94	4083.5	1627	Day	632	-55.35499	8785.0	0.0002038	-36.908
"Y1_1"	20110822	-64.4416	45.3360	14.51	14.56	2.83	59.85	710.0	170	Day	369	-79.68836	27.7	0.0000006	-61.918
"Y1_2"	20110822	-64.4427	45.3334	16.38	16.48	6.02	40.11	939.1	360	Day	345	-74.4928	61.4	0.0000014	-58.461
"Y1_3"	20110822	-64.4437	45.3314	18.54	18.64	6.32	32.75	1106.5	378	Day	650	-78.53186	19.8	0.0000005	-63.379
"X2_1"	20110822	-64.4354	45.3601	14.57	15.06	29.35	54.15	4206.1	1751	Day	331	-66.9482	471.3	0.0000109	-49.612
"X2_2"	20110822	-64.4418	45.3527	16.48	16.84	21.30	62.80	4094.6	1269	Day	378	-65.77197	716.6	0.0000166	-47.792
"X2_3"	20110822	-64.4426	45.3502	18.65	19.39	44.55	66.74	3609.3	2635	Day	785	-56.42652	6550.1	0.0001520	-38.182

Table A5-9-1.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the August 22, 2011 survey in Minas Passage. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20110822	-64.4273	45.3690	11.76	11.90	8.77	42.58	960.9	526	Day	781	-63.4604	674.0	0.0000156	-48.058
"T0_2"	20110822	-64.4267	45.3688	15.07	15.19	7.42	37.31	1107.7	445	Day	325	-79.8806	13.0	0.0000003	-65.195
"T0_3"	20110822	-64.4260	45.3687	16.85	16.93	4.35	36.85	873.0	261	Day	386	-85.7016	3.4	0.0000001	-71.083
"T0_4"	20110822	-64.4264	45.3688	19.55	19.69	8.37	41.45	1145.7	501	Day	835	-68.1107	223.5	0.0000052	-52.852
"T1_1"	20110822	-64.4299	45.3685	11.92	11.99	4.43	48.20	1092.9	266	Day	755	-60.9295	1402.6	0.0000325	-44.876
"T1_2"	20110822	-64.4324	45.3691	15.20	15.31	6.42	42.89	1268.2	384	Day	320	-76.4726	34.0	0.0000008	-61.031
"T1_3"	20110822	-64.4292	45.3683	16.95	17.10	8.97	43.27	974.6	535	Day	407	-79.9896	15.3	0.0000004	-64.502
"T1_4"	20110822	-64.4295	45.3685	19.74	20.06	19.30	47.71	1057.6	1143	Day	892	-75.7741	45.4	0.0000011	-59.773
"T2_1"	20110822	-64.4308	45.3680	12.02	12.18	9.62	48.96	685.6	576	Day	726	-75.2242	53.2	0.0000012	-59.089
"T2_2"	20110822	-64.4253	45.3668	15.35	15.41	3.68	39.41	564.9	220	Day	317	-71.3476	99.6	0.0000023	-56.361
"T2_3"	20110822	-64.4270	45.3671	17.12	17.21	5.25	40.60	1084.9	312	Day	420	-82.6258	7.7	0.0000002	-67.478
"T2_4"	20110822	-64.4264	45.3671	20.09	20.19	6.43	45.47	1124.8	385	Day	953	-84.0842	6.3	0.0000001	-68.335
"T3_1"	20110822	-64.4337	45.3679	12.32	12.42	5.95	47.14	1253.5	357	Day	688	-75.872	43.8	0.0000010	-59.933
"T3_2"	20110822	-64.4304	45.3672	15.42	15.52	5.97	41.40	1213.8	358	Day	315	-74.4143	52.3	0.0000012	-59.162
"T3_3"	20110822	-64.4301	45.3671	17.22	17.36	8.22	42.16	1069.3	492	Day	439	-85.0979	4.6	0.0000001	-69.749
"T3_4"	20110822	-64.4289	45.3668	20.27	20.57	18.35	46.92	1081.0	1090	Day	957	-73.3064	78.6	0.0000018	-57.392
"T4_1"	20110822	-64.4292	45.3656	12.42	12.68	15.40	38.92	1091.5	921	Day	644	-79.9603	13.5	0.0000003	-65.042
"T4_2"	20110822	-64.4291	45.3656	15.53	15.64	6.25	34.18	955.6	374	Day	315	-85.6498	3.1	0.0000001	-71.452
"T4_3"	20110822	-64.4284	45.3654	17.37	17.44	4.50	34.27	1062.5	268	Day	451	-87.3651	2.1	0.0000000	-73.152
"T4_4"	20110822	-64.4283	45.3653	20.60	20.71	6.42	40.31	1120.5	382	Day	970	-75.8373	36.4	0.0000008	-60.729
"T5_1"	20110822	-64.4309	45.3650	13.21	13.32	6.42	37.44	1144.8	381	Day	535	-77.7719	21.3	0.0000005	-63.066
"T5_2"	20110822	-64.4330	45.3654	15.67	15.76	5.40	37.05	1091.0	323	Day	315	-85.9786	3.2	0.0000001	-71.331
"T5_3"	20110822	-64.4306	45.3649	17.47	17.64	10.27	34.73	1041.9	615	Day	480	-87.8301	1.9	0.0000000	-73.541
"T5_4"	20110822	-64.4301	45.3648	20.73	20.99	15.33	40.29	1112.3	911	Day	995	-76.2312	33.3	0.0000008	-61.126
"T6_1"	20110822	-64.4298	45.3639	13.35	13.62	16.07	34.80	1051.5	955	Day	488	-78.6603	15.8	0.0000004	-64.361
"T6_2"	20110822	-64.4282	45.3635	15.77	15.88	6.42	32.02	1118.7	375	Day	317	-85.7269	2.8	0.0000001	-71.901
"T6_3"	20110822	-64.4293	45.3637	17.65	17.72	4.40	33.31	1061.3	247	Day	493	-85.8784	2.8	0.0000001	-71.827
"T6_4"	20110822	-64.4283	45.3634	21.02	21.12	6.32	38.76	1033.6	372	Day	1004	-76.2143	31.8	0.0000007	-61.318
"T7_1"	20110822	-64.4322	45.3635	13.65	13.74	5.45	35.99	1000.8	327	Day	471	-80.1462	11.7	0.0000003	-65.659
"T7_2"	20110822	-64.4330	45.3635	15.88	15.97	5.38	34.81	1060.6	321	Day	319	-82.025	7.3	0.0000002	-67.724
"T7_3"	20110822	-64.4318	45.3632	17.75	18.04	17.42	34.15	1288.1	1022	Day	544	-69.2725	133.8	0.0000031	-55.080
"T7_5"	20110822	-64.4315	45.3631	21.15	21.36	12.45	40.56	1189.4	738	Day	1016	-84.7249	4.7	0.0000001	-69.583

Table A5-9-1.2. Continued.

Transect		Mid	Mid	Start	End	Duration	Mean	Transect	Transect	Day/night	Tide	Sv	NASC	Area	Area
Number	Date	Longitude	Latitute	Time	Time	(min)	Height	Length	Pings		Height	mean		Backscattering	Backscattering
							(m)	(m)			(cm)			Coefficent	Strength
"T8_1"	20110822	-64.4349	45.3630	13.74	13.90	9.43	34.97	724.0	560	Day	447	-77.8422	19.2	0.0000004	-63.515
"T8_2"	20110822	-64.4300	45.3619	15.98	16.09	6.33	35.27	1138.6	380	Day	323	-86.9775	2.4	0.0000001	-72.603
"T8_3"	20110822	-64.4335	45.3626	18.05	18.08	1.53	33.41	370.2	92	Day	550	-65.683	297.2	0.0000069	-51.615
"T8_5"	20110822	-64.4303	45.3618	21.37	21.48	6.45	42.66	911.5	357	Day	1020	-57.8557	2455.4	0.0000570	-42.444
"X1_1"	20110822	-64.4297	45.3483	14.15	14.51	21.27	72.81	3073.1	1271	Day	374	-79.6623	30.2	0.0000007	-61.539
"X1_2"	20110822	-64.4315	45.3444	16.10	16.37	16.27	70.54	3117.8	972	Day	338	-82.4132	15.5	0.0000004	-64.444
"X1_3"	20110822	-64.4298	45.3479	18.08	18.53	27.47	69.94	4083.5	1627	Day	632	-67.4364	482.7	0.0000112	-49.509
"Y1_1"	20110822	-64.4416	45.3360	14.51	14.56	2.83	59.85	710.0	170	Day	369	-79.8627	23.1	0.0000005	-62.706
"Y1_2"	20110822	-64.4427	45.3334	16.38	16.48	6.02	40.11	939.1	360	Day	345	-82.225	8.3	0.0000002	-67.144
"Y1_3"	20110822	-64.4437	45.3314	18.54	18.64	6.32	32.75	1106.5	378	Day	650	-79.7419	11.4	0.0000003	-65.786
"X2_1"	20110822	-64.4354	45.3601	14.57	15.06	29.35	54.15	4206.1	1751	Day	331	-84.1388	7.7	0.0000002	-67.487
"X2_2"	20110822	-64.4418	45.3527	16.48	16.84	21.30	62.80	4094.6	1269	Day	378	-82.2415	14.1	0.0000003	-64.845
"X2_3"	20110822	-64.4426	45.3502	18.65	19.39	44.55	66.74	3609.3	2635	Day	785	-64.9894	804.1	0.0000187	-47.292

Table A5-9-1.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the August 22, 2011 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time	End Time	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20110822	-64.4273	45.3690	11.76	11.90	8.77	42.58	960.9	526	Day	781	-78.4884	11.5	0.0000003	-65.740
"T0_2"	20110822	-64.4267	45.3688	15.07	15.19	7.42	37.31	1107.7	445	Day	325	-83.7563	5.2	0.0000001	-69.200
"T0_3"	20110822	-64.4260	45.3687	16.85	16.93	4.35	36.85	873.0	261	Day	386	-85.7606	3.4	0.0000001	-70.980
"T0_4"	20110822	-64.4264	45.3688	19.55	19.69	8.37	41.45	1145.7	501	Day	835	-85.4583	3.5	0.0000001	-70.855
"T1_1"	20110822	-64.4299	45.3685	11.92	11.99	4.43	48.20	1092.9	266	Day	755	-82.3652	7.0	0.0000002	-67.897
"T1_2"	20110822	-64.4324	45.3691	15.20	15.31	6.42	42.89	1268.2	384	Day	320	-79.343	17.0	0.0000004	-64.042
"T1_3"	20110822	-64.4292	45.3683	16.95	17.10	8.97	43.27	974.6	535	Day	407	-74.7088	48.7	0.0000011	-59.474
"T1_4"	20110822	-64.4295	45.3685	19.74	20.06	19.30	47.71	1057.6	1143	Day	892	-86.2905	3.4	0.0000001	-70.969
"T2_1"	20110822	-64.4308	45.3680	12.02	12.18	9.62	48.96	685.6	576	Day	726	-77.5737	28.7	0.0000007	-61.767
"T2_2"	20110822	-64.4253	45.3668	15.35	15.41	3.68	39.41	564.9	220	Day	317	-85.4953	3.7	0.0000001	-70.713
"T2_3"	20110822	-64.4270	45.3671	17.12	17.21	5.25	40.60	1084.9	312	Day	420	-83.4895	6.3	0.0000001	-68.332
"T2_4"	20110822	-64.4264	45.3671	20.09	20.19	6.43	45.47	1124.8	385	Day	953	-88.7477	2.1	0.0000000	-73.183
"T3_1"	20110822	-64.4337	45.3679	12.32	12.42	5.95	47.14	1253.5	357	Day	688	-82.8407	8.6	0.0000002	-66.982
"T3_2"	20110822	-64.4304	45.3672	15.42	15.52	5.97	41.40	1213.8	358	Day	315	-84.9567	4.3	0.0000001	-70.007
"T3_3"	20110822	-64.4301	45.3671	17.22	17.36	8.22	42.16	1069.3	492	Day	439	-85.1554	4.7	0.0000001	-69.583
"T3_4"	20110822	-64.4289	45.3668	20.27	20.57	18.35	46.92	1081.0	1090	Day	957	-85.4169	4.3	0.0000001	-69.970
"T4_1"	20110822	-64.4292	45.3656	12.42	12.68	15.40	38.92	1091.5	921	Day	644	-82.0549	8.4	0.0000002	-67.109
"T4_2"	20110822	-64.4291	45.3656	15.53	15.64	6.25	34.18	955.6	374	Day	315	-85.8392	3.2	0.0000001	-71.324
"T4_3"	20110822	-64.4284	45.3654	17.37	17.44	4.50	34.27	1062.5	268	Day	451	-87.3146	2.2	0.0000001	-72.832
"T4_4"	20110822	-64.4283	45.3653	20.60	20.71	6.42	40.31	1120.5	382	Day	970	-85.0523	4.0	0.0000001	-70.376
"T5_1"	20110822	-64.4309	45.3650	13.21	13.32	6.42	37.44	1144.8	381	Day	535	-77.7345	23.1	0.0000005	-62.700
"T5_2"	20110822	-64.4330	45.3654	15.67	15.76	5.40	37.05	1091.0	323	Day	315	-85.9706	3.4	0.0000001	-71.004
"T5_3"	20110822	-64.4306	45.3649	17.47	17.64	10.27	34.73	1041.9	615	Day	480	-87.7192	2.2	0.0000001	-72.919
"T5_4"	20110822	-64.4301	45.3648	20.73	20.99	15.33	40.29	1112.3	911	Day	995	-86.8721	2.5	0.0000001	-72.415
"T6_1"	20110822	-64.4298	45.3639	13.35	13.62	16.07	34.80	1051.5	955	Day	488	-80.734	10.9	0.0000003	-65.968
"T6_2"	20110822	-64.4282	45.3635	15.77	15.88	6.42	32.02	1118.7	375	Day	317	-85.7651	3.1	0.0000001	-71.420
"T6_3"	20110822	-64.4293	45.3637	17.65	17.72	4.40	33.31	1061.3	247	Day	493	-85.6122	3.3	0.0000001	-71.149
"T6_4"	20110822	-64.4283	45.3634	21.02	21.12	6.32	38.76	1033.6	372	Day	1004	-88.1178	1.9	0.0000000	-73.584
"T7_1"	20110822	-64.4322	45.3635	13.65	13.74	5.45	35.99	1000.8	327	Day	471	-81.0118	10.3	0.0000002	-66.210
"T7_2"	20110822	-64.4330	45.3635	15.88	15.97	5.38	34.81	1060.6	321	Day	319	-81.8146	8.4	0.0000002	-67.111
"T7_3"	20110822	-64.4318	45.3632	17.75	18.04	17.42	34.15	1288.1	1022	Day	544	-87.6659	1.7	0.0000000	-74.067
"T7_5"	20110822	-64.4315	45.3631	21.15	21.36	12.45	40.56	1189.4	738	Day	1016	-88.7415	1.8	0.0000000	-73.886

Table A5-9-1.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time	End Time	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_1"	20110822	-64.4349	45.3630	13.74	13.90	9.43	34.97	724.0	560	Day	447	-82.0503	7.2	0.0000002	-67.792
"T8_2"	20110822	-64.4300	45.3619	15.98	16.09	6.33	35.27	1138.6	380	Day	323	-87.1829	2.5	0.0000001	-72.351
"T8_3"	20110822	-64.4335	45.3626	18.05	18.08	1.53	33.41	370.2	92	Day	550	-83.1119	3.9	0.0000001	-70.489
"T8_5"	20110822	-64.4303	45.3618	21.37	21.48	6.45	42.66	911.5	357	Day	1020	-89.7095	1.4	0.0000000	-75.005
"X1_1"	20110822	-64.4297	45.3483	14.15	14.51	21.27	72.81	3073.1	1271	Day	374	-80.3203	27.1	0.0000006	-62.009
"X1_2"	20110822	-64.4315	45.3444	16.10	16.37	16.27	70.54	3117.8	972	Day	338	-87.5156	5.1	0.0000001	-69.258
"X1_3"	20110822	-64.4298	45.3479	18.08	18.53	27.47	69.94	4083.5	1627	Day	632	-82.9429	11.3	0.0000003	-65.824
"Y1_1"	20110822	-64.4416	45.3360	14.51	14.56	2.83	59.85	710.0	170	Day	369	-80.2757	24.0	0.0000006	-62.549
"Y1_2"	20110822	-64.4427	45.3334	16.38	16.48	6.02	40.11	939.1	360	Day	345	-76.7268	34.9	0.0000008	-60.921
"Y1_3"	20110822	-64.4437	45.3314	18.54	18.64	6.32	32.75	1106.5	378	Day	650	-80.5203	11.9	0.0000003	-65.598
"X2_1"	20110822	-64.4354	45.3601	14.57	15.06	29.35	54.15	4206.1	1751	Day	331	-84.5197	7.5	0.0000002	-67.609
"X2_2"	20110822	-64.4418	45.3527	16.48	16.84	21.30	62.80	4094.6	1269	Day	378	-82.5956	14.0	0.0000003	-64.882
"X2_3"	20110822	-64.4426	45.3502	18.65	19.39	44.55	66.74	3609.3	2635	Day	785	-82.7619	10.1	0.0000002	-66.285

Table A5-9-2.1. Summary of acoustic backscatter from **2 m** below the transducer to bottom by individual transect for the September 19, 2011 survey in Minas Passage. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20110919	-64.4288	45.3691	10.92	11.09	9.70	42.57	1043.6	570	Day	937	-61.7641	1222.4	0.0000284	-45.473
"T0_2"	20110919	-64.4291	45.3692	13.59	13.70	6.38	37.47	994.1	375	Day	314	-68.6312	221.4	0.0000051	-52.894
"T0_3"	20110919	-64.4277	45.3691	15.54	15.60	3.58	36.78	793.6	210	Day	249	-69.8349	164.7	0.0000038	-54.179
"T0_4"	20110919	-64.4284	45.3694	18.77	18.83	3.53	42.50	876.6	207	Day	560	-69.6804	197.2	0.0000046	-53.396
"T1_1"	20110919	-64.4280	45.3678	11.11	11.21	5.95	45.90	999.1	349	Day	909	-56.8957	4043.6	0.0000938	-40.277
"T1_2"	20110919	-64.4277	45.3679	13.72	13.81	5.77	41.48	1001.7	339	Day	292	-74.6221	61.7	0.0000014	-58.444
"T1_3"	20110919	-64.4274	45.3680	15.67	15.83	9.38	41.42	1083.1	551	Day	259	-65.7086	479.6	0.0000111	-49.537
"T1_4"	20110919	-64.4277	45.3681	18.88	19.18	17.83	48.15	1046.1	1047	Day	624	-66.6351	450.4	0.0000104	-49.809
"T2_1"	20110919	-64.4289	45.3675	11.25	11.44	11.15	45.69	1032.7	654	Day	876	-63.9688	789.7	0.0000183	-47.371
"T2_2"	20110919	-64.4299	45.3679	13.84	13.95	6.07	42.47	987.7	356	Day	272	-74.3935	66.6	0.0000015	-58.112
"T2_3"	20110919	-64.4309	45.3679	15.85	15.93	5.00	42.82	930.1	294	Day	270	-70.1903	176.6	0.0000041	-53.874
"T2_4"	20110919	-64.4304	45.3676	19.20	19.26	3.73	48.99	944.9	219	Day	682	-64.4706	754.3	0.0000175	-47.570
"T3_1"	20110919	-64.4285	45.3666	11.45	11.54	5.42	43.78	1015.2	318	Day	841	-72.0326	118.2	0.0000027	-55.619
"T3_2"	20110919	-64.4281	45.3667	13.97	14.06	5.78	39.57	980.5	340	Day	255	-79.2618	20.2	0.0000005	-63.288
"T3_3"	20110919	-64.4272	45.3665	15.98	16.15	10.15	40.63	746.4	596	Day	280	-67.5257	309.5	0.0000072	-51.438
"T3_4"	20110919	-64.4284	45.3668	19.35	19.60	15.03	47.29	1013.6	881	Day	804	-67.0127	405.5	0.0000094	-50.265
"T4_1"	20110919	-64.4300	45.3656	11.59	11.81	13.47	39.14	1034.0	789	Day	800	-68.179	256.5	0.0000060	-52.253
"T4_2"	20110919	-64.4309	45.3661	14.10	14.20	5.67	36.35	998.5	332	Day	241	-85.7714	4.1	0.0000001	-70.167
"T4_3"	20110919	-64.4310	45.3659	16.29	16.37	5.13	38.51	1050.8	299	Day	293	-61.3371	1220.1	0.0000283	-45.481
"T4_4"	20110919	-64.4307	45.3660	19.62	19.69	4.38	43.95	1028.6	250	Day	893	-62.1407	1157.0	0.0000268	-45.711
"T5_1"	20110919	-64.4288	45.3646	11.91	12.00	5.25	33.64	936.0	306	Day	761	-69.467	164.0	0.0000038	-54.198
"T5_2"	20110919	-64.4299	45.3648	14.22	14.33	6.70	32.82	1155.5	390	Day	229	-83.3486	6.5	0.0000002	-68.187
"T5_3"	20110919	-64.4287	45.3646	16.43	16.67	14.72	33.47	1078.5	845	Day	307	-61.8023	952.5	0.0000221	-46.556
"T5_4"	20110919	-64.4290	45.3647	19.77	19.98	12.73	39.53	1021.5	747	Day	973	-72.0608	106.0	0.0000025	-56.091
"T6_1"	20110919	-64.4311	45.3642	12.03	12.26	13.47	36.06	1025.4	785	Day	702	-76.0694	38.4	0.0000009	-60.499
"T6_2"	20110919	-64.4318	45.3643	14.34	14.43	5.57	34.32	979.7	325	Day	219	-88.5803	2.1	0.0000000	-73.225
"T6_3"	20110919	-64.4244	45.3627	16.71	16.86	9.38	37.13	1654.5	540	Day	324	-56.6774	3439.5	0.0000798	-40.980
"T6_4"	20110919	-64.4312	45.3642	20.00	20.07	4.22	42.08	977.4	241	Day	1033	-58.4297	2603.6	0.0000604	-42.189
"T7_1"	20110919	-64.4307	45.3631	12.28	12.37	5.33	34.85	978.2	310	Day	648	-78.8435	19.6	0.0000005	-63.421
"T7_2"	20110919	-64.4298	45.3628	14.46	14.55	5.67	33.00	983.1	332	Day	212	-87.7256	2.4	0.0000001	-72.541
"T7_3"	20110919	-64.4328	45.3635	16.98	17.19	12.25	30.47	720.6	484	Day	339	-73.0998	64.3	0.0000015	-58.261
"T7_4"	20110919	-64.4301	45.3629	20.13	20.29	9.57	41.16	1028.6	560	Day	1062	-76.5127	39.6	0.0000009	-60.368
"T8_1"	20110919	-64.4316	45.3621	12.40	12.60	12.07	35.92	1070.4	704	Day	582	-79.4483	17.6	0.0000004	-63.894
"T8_2"	20110919	-64.4324	45.3624	14.58	14.67	5.53	32.26	987.1	322	Day	209	-84.0848	5.4	0.0000001	-68.999
"T8_3"	20110919	-64.4322	45.3623	17.25	17.32	4.27	36.60	1104.0	246	Day	359	-54.7678	5262.6	0.0001221	-39.133
"T8_4"	20110919	-64.4322	45.3623	20.30	20.38	4.42	41.59	1002.0	254	Day	1087	-64.9492	573.6	0.0000133	-48.759

Table A5-9-2.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"X1_1"	20110919	-64.4293	45.3482	12.65	13.03	22.97	72.91	3054.7	1343	Day	470	-80.8561	25.8	0.0000006	-62.228
"X1_2"	20110919	-64.4297	45.3482	14.68	15.00	19.22	70.86	3488.8	1121	Day	210	-83.3889	14.0	0.0000003	-64.885
"X1_3"	20110919	-64.4295	45.3497	17.32	17.75	25.55	74.31	3361.8	1482	Day	391	-58.491	4533.8	0.0001052	-39.780
"Y1_1"	20110919	-64.4431	45.3333	13.03	13.12	4.87	37.45	1172.0	286	Day	422	-84.717	5.4	0.0000001	-68.982
"Y1_2"	20110919	-64.4373	45.3350	15.00	15.15	9.28	55.50	1558.0	545	Day	216	-80.8142	19.8	0.0000005	-63.371
"Y1_3"	20110919	-64.4382	45.3314	17.75	17.83	5.08	39.98	1039.3	299	Day	428	-79.1869	20.8	0.0000005	-63.169
"X2_1"	20110919	-64.4423	45.3518	13.12	13.57	27.00	60.43	4400.6	1572	Day	368	-79.6926	28.0	0.0000006	-61.880
"X2_2"	20110919	-64.4406	45.3550	15.15	15.53	22.75	60.60	3893.0	1322	Day	230	-77.5453	46.0	0.0000011	-59.720
"X2_3"	20110919	-64.4417	45.3528	17.84	18.77	55.88	62.53	5365.7	3226	Day	492	-61.5848	1871.0	0.0000434	-43.624

Table A5-9-2.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the September 19, 2011 survey in Minas Passage. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20110919	-64.4288	45.3691	10.92	11.09	9.70	39.67	1043.6	570	Day	937	-65.7851	394.2	0.0000091	-50.388
"T0_2"	20110919	-64.4291	45.3692	13.59	13.70	6.38	34.56	994.1	375	Day	314	-76.7828	26.7	0.0000006	-62.078
"T0_3"	20110919	-64.4277	45.3691	15.54	15.60	3.58	33.88	793.6	210	Day	249	-85.2996	3.7	0.0000001	-70.697
"T0_4"	20110919	-64.4284	45.3694	18.77	18.83	3.53	39.59	876.6	207	Day	560	-84.7027	5.0	0.0000001	-69.316
"T1_1"	20110919	-64.4280	45.3678	11.11	11.21	5.95	43.01	999.1	349	Day	909	-65.0588	510.8	0.0000119	-49.262
"T1_2"	20110919	-64.4277	45.3679	13.72	13.81	5.77	38.58	1001.7	339	Day	292	-84.3138	5.4	0.0000001	-69.056
"T1_3"	20110919	-64.4274	45.3680	15.67	15.83	9.38	38.51	1083.1	551	Day	259	-86.1943	3.5	0.0000001	-70.945
"T1_4"	20110919	-64.4277	45.3681	18.88	19.18	17.83	45.25	1046.1	1047	Day	624	-82.0641	10.8	0.0000003	-66.018
"T2_1"	20110919	-64.4289	45.3675	11.25	11.44	11.15	42.79	1032.7	654	Day	876	-73.3206	75.8	0.0000018	-57.549
"T2_2"	20110919	-64.4299	45.3679	13.84	13.95	6.07	39.57	987.7	356	Day	272	-77.4636	26.7	0.0000006	-62.080
"T2_3"	20110919	-64.4309	45.3679	15.85	15.93	5.00	39.91	930.1	294	Day	270	-86.125	3.7	0.0000001	-70.697
"T2_4"	20110919	-64.4304	45.3676	19.20	19.26	3.73	46.08	944.9	219	Day	682	-87.2718	3.3	0.0000001	-71.138
"T3_1"	20110919	-64.4285	45.3666	11.45	11.54	5.42	40.88	1015.2	318	Day	841	-77.7572	25.9	0.0000006	-62.211
"T3_2"	20110919	-64.4281	45.3667	13.97	14.06	5.78	36.67	980.5	340	Day	255	-85.8391	3.6	0.0000001	-70.835
"T3_3"	20110919	-64.4272	45.3665	15.98	16.15	10.15	37.73	746.4	596	Day	280	-85.0276	4.4	0.0000001	-69.880
"T3_4"	20110919	-64.4284	45.3668	19.35	19.60	15.03	44.39	1013.6	881	Day	804	-82.1056	10.5	0.0000002	-66.153
"T4_1"	20110919	-64.4300	45.3656	11.59	11.81	13.47	36.24	1034.0	789	Day	800	-78.2975	19.9	0.0000005	-63.354
"T4_2"	20110919	-64.4309	45.3661	14.10	14.20	5.67	33.46	998.5	332	Day	241	-86.2942	2.9	0.0000001	-71.755
"T4_3"	20110919	-64.4310	45.3659	16.29	16.37	5.13	35.63	1050.8	299	Day	293	-79.4119	15.1	0.0000004	-64.553
"T4_4"	20110919	-64.4307	45.3660	19.62	19.69	4.38	41.04	1028.6	250	Day	893	-70.616	134.7	0.0000031	-55.050
"T5_1"	20110919	-64.4288	45.3646	11.91	12.00	5.25	30.75	936.0	306	Day	761	-80.2316	10.5	0.0000002	-66.126
"T5_2"	20110919	-64.4299	45.3648	14.22	14.33	6.70	29.93	1155.5	390	Day	229	-88.2178	1.6	0.0000000	-74.253
"T5_3"	20110919	-64.4287	45.3646	16.43	16.67	14.72	30.57	1078.5	845	Day	307	-75.6946	29.7	0.0000007	-61.620
"T5_4"	20110919	-64.4290	45.3647	19.77	19.98	12.73	36.62	1021.5	747	Day	973	-79.0385	17.0	0.0000004	-64.041
"T6_1"	20110919	-64.4311	45.3642	12.03	12.26	13.47	33.17	1025.4	785	Day	702	-80.8369	10.0	0.0000002	-66.342
"T6_2"	20110919	-64.4318	45.3643	14.34	14.43	5.57	31.42	979.7	325	Day	219	-88.7294	1.5	0.0000000	-74.513
"T6_3"	20110919	-64.4244	45.3627	16.71	16.86	9.38	34.23	1654.5	540	Day	324	-69.0831	155.5	0.0000036	-54.427
"T6_4"	20110919	-64.4312	45.3642	20.00	20.07	4.22	39.17	977.4	241	Day	1033	-70.4883	131.5	0.0000031	-55.154
"T7_1"	20110919	-64.4307	45.3631	12.28	12.37	5.33	31.96	978.2	310	Day	648	-80.4671	10.4	0.0000002	-66.163
"T7_2"	20110919	-64.4298	45.3628	14.46	14.55	5.67	30.10	983.1	332	Day	212	-88.3652	1.6	0.0000000	-74.372
"T7_3"	20110919	-64.4328	45.3635	16.98	17.19	12.25	27.68	720.6	484	Day	339	-84.7976	3.3	0.0000001	-71.205
"T7_5"	20110919	-64.4301	45.3629	20.13	20.29	9.57	38.26	1028.6	560	Day	1062	-82.9583	7.2	0.0000002	-67.742
"T8_1"	20110919	-64.4316	45.3621	12.40	12.60	12.07	33.02	1070.4	704	Day	582	-80.977	9.6	0.0000002	-66.505
"T8_2"	20110919	-64.4324	45.3624	14.58	14.67	5.53	29.36	987.1	322	Day	209	-88.9115	1.3	0.0000000	-75.049
"T8_3"	20110919	-64.4322	45.3623	17.25	17.32	4.27	33.70	1104.0	246	Day	359	-68.9434	157.7	0.0000037	-54.367
"T8_5"	20110919	-64.4322	45.3623	20.30	20.38	4.42	38.68	1002.0	254	Day	1087	-72.0127	91.3	0.0000021	-56.741

Table A5-9-2.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"X1_1"	20110919	-64.4293	45.3482	12.65	13.03	22.97	70.02	3054.7	1343	Day	470	-81.2392	21.1	0.0000005	-63.110
"X1_2"	20110919	-64.4297	45.3482	14.68	15.00	19.22	67.96	3488.8	1121	Day	210	-83.548	12.0	0.0000003	-65.559
"X1_3"	20110919	-64.4295	45.3497	17.32	17.75	25.55	71.42	3361.8	1482	Day	391	-65.0569	893.2	0.0000207	-46.835
"Y1_2"	20110919	-64.4431	45.3333	13.03	13.12	4.87	34.55	1172.0	286	Day	422	-85.0203	4.0	0.0000001	-70.317
"Y1_3"	20110919	-64.4373	45.3350	15.00	15.15	9.28	52.61	1558.0	545	Day	216	-84.7889	6.8	0.0000002	-68.014
"Y1_7"	20110919	-64.4382	45.3314	17.75	17.83	5.08	37.08	1039.3	299	Day	428	-84.4917	4.9	0.0000001	-69.431
"X2_1"	20110919	-64.4423	45.3518	13.12	13.57	27.00	57.53	4400.6	1572	Day	368	-80.4818	20.3	0.0000005	-63.279
"X2_2"	20110919	-64.4406	45.3550	15.15	15.53	22.75	57.70	3893.0	1322	Day	230	-86.024	5.7	0.0000001	-68.807
"X2_3"	20110919	-64.4417	45.3528	17.84	18.77	55.88	59.63	5365.7	3226	Day	492	-68.1708	358.7	0.0000083	-50.798

Table A5-9-2.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the September19, 011 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20110919	-64.4288	45.3691	10.92	11.09	9.70	39.67	1043.6	570	Day	937	-79.8095	11.41187	0.0000003	-65.771
"T0_2"	20110919	-64.4291	45.3692	13.59	13.70	6.38	34.56	994.1	375	Day	314	-85.6936	3.840002	0.0000001	-70.502
"T0_3"	20110919	-64.4277	45.3691	15.54	15.60	3.58	33.88	793.6	210	Day	249	-84.626	5.067312	0.0000001	-69.297
"T0_4"	20110919	-64.4284	45.3694	18.77	18.83	3.53	39.59	876.6	207	Day	560	-85.0483	4.790131	0.0000001	-69.541
"T1_1"	20110919	-64.4280	45.3678	11.11	11.21	5.95	43.01	999.1	349	Day	909	-75.991	31.34357	0.0000007	-61.383
"T1_2"	20110919	-64.4277	45.3679	13.72	13.81	5.77	38.58	1001.7	339	Day	292	-80.2337	15.95853	0.0000004	-64.315
"T1_3"	20110919	-64.4274	45.3680	15.67	15.83	9.38	38.51	1083.1	551	Day	259	-85.9181	4.077876	0.0000001	-70.241
"T1_4"	20110919	-64.4277	45.3681	18.88	19.18	17.83	45.25	1046.1	1047	Day	624	-86.7829	3.722395	0.0000001	-70.637
"T2_1"	20110919	-64.4289	45.3675	11.25	11.44	11.15	42.79	1032.7	654	Day	876	-78.9565	17.94119	0.0000004	-63.806
"T2_2"	20110919	-64.4299	45.3679	13.84	13.95	6.07	39.57	987.7	356	Day	272	-78.4693	24.85916	0.0000006	-62.390
"T2_3"	20110919	-64.4309	45.3679	15.85	15.93	5.00	39.91	930.1	294	Day	270	-86.0835	4.013653	0.0000001	-70.310
"T2_4"	20110919	-64.4304	45.3676	19.20	19.26	3.73	46.08	944.9	219	Day	682	-86.0529	4.675991	0.0000001	-69.646
"T3_1"	20110919	-64.4285	45.3666	11.45	11.54	5.42	40.88	1015.2	318	Day	841	-79.7892	17.78309	0.0000004	-63.845
"T3_2"	20110919	-64.4281	45.3667	13.97	14.06	5.78	36.67	980.5	340	Day	255	-84.9819	5.148205	0.0000001	-69.228
"T3_3"	20110919	-64.4272	45.3665	15.98	16.15	10.15	37.73	746.4	596	Day	280	-84.9166	4.959277	0.0000001	-69.391
"T3_4"	20110919	-64.4284	45.3668	19.35	19.60	15.03	44.39	1013.6	881	Day	804	-84.1889	6.693907	0.0000002	-68.088
"T4_1"	20110919	-64.4300	45.3656	11.59	11.81	13.47	36.24	1034.0	789	Day	800	-79.3077	15.58341	0.0000004	-64.418
"T4_2"	20110919	-64.4309	45.3661	14.10	14.20	5.67	33.46	998.5	332	Day	241	-86.5672	3.332652	0.0000001	-71.117
"T4_3"	20110919	-64.4310	45.3659	16.29	16.37	5.13	35.63	1050.8	299	Day	293	-84.7678	4.538646	0.0000001	-69.776
"T4_4"	20110919	-64.4307	45.3660	19.62	19.69	4.38	41.04	1028.6	250	Day	893	-75.9037	40.06646	0.0000009	-60.317
"T5_1"	20110919	-64.4288	45.3646	11.91	12.00	5.25	30.75	936.0	306	Day	761	-80.8979	11.16274	0.0000003	-65.867
"T5_2"	20110919	-64.4299	45.3648	14.22	14.33	6.70	29.93	1155.5	390	Day	229	-88.1032	2.170391	0.0000001	-72.980
"T5_3"	20110919	-64.4287	45.3646	16.43	16.67	14.72	30.57	1078.5	845	Day	307	-84.4417	3.871481	0.0000001	-70.466
"T5_4"	20110919	-64.4290	45.3647	19.77	19.98	12.73	36.62	1021.5	747	Day	973	-79.1591	18.73592	0.0000004	-63.618
"T6_1"	20110919	-64.4311	45.3642	12.03	12.26	13.47	33.17	1025.4	785	Day	702	-80.3238	13.70242	0.0000003	-64.977
"T6_2"	20110919	-64.4318	45.3643	14.34	14.43	5.57	31.42	979.7	325	Day	219	-88.5612	2.060066	0.0000000	-73.206
"T6_3"	20110919	-64.4244	45.3627	16.71	16.86	9.38	34.23	1654.5	540	Day	324	-81.1151	8.754482	0.0000002	-66.923
"T6_4"	20110919	-64.4312	45.3642	20.00	20.07	4.22	39.17	977.4	241	Day	1033	-80.7493	12.77707	0.0000003	-65.281
"T7_1"	20110919	-64.4307	45.3631	12.28	12.37	5.33	31.96	978.2	310	Day	648	-81.2626	11.07026	0.0000003	-65.903
"T7_2"	20110919	-64.4298	45.3628	14.46	14.55	5.67	30.10	983.1	332	Day	212	-87.712	2.408271	0.0000001	-72.528
"T7_3"	20110919	-64.4328	45.3635	16.98	17.19	12.25	27.68	720.6	484	Day	339	-84.6513	2.968146	0.0000001	-71.620
"T7_5"	20110919	-64.4301	45.3629	20.13	20.29	9.57	38.26	1028.6	560	Day	1062	-82.8249	8.799582	0.0000002	-66.900
"T8_1"	20110919	-64.4316	45.3621	12.40	12.60	12.07	33.02	1070.4	704	Day	582	-81.4369	10.9086	0.0000003	-65.967
"T8_2"	20110919	-64.4324	45.3624	14.58	14.67	5.53	29.36	987.1	322	Day	209	-86.6588	2.936181	0.0000001	-71.667
"T8_3"	20110919	-64.4322	45.3623	17.25	17.32	4.27	33.70	1104.0	246	Day	359	-77.2664	19.01085	0.0000004	-63.555
"T8_5"	20110919	-64.4322	45.3623	20.30	20.38	4.42	38.68	1002.0	254	Day	1087	-80.7376	13.13088	0.0000003	-65.162

Table A5-9-2.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"X1_1"	20110919	-64.4293	45.3482	12.65	13.03	22.97	70.02	3054.7	1343	Day	470	-81.2916	23.1787	0.0000005	-62.694
"X1_2"	20110919	-64.4297	45.3482	14.68	15.00	19.22	67.96	3488.8	1121	Day	210	-83.5052	13.56232	0.0000003	-65.022
"X1_3"	20110919	-64.4295	45.3497	17.32	17.75	25.55	71.42	3361.8	1482	Day	391	-76.8868	51.35322	0.0000012	-59.239
"Y1_2"	20110919	-64.4431	45.3333	13.03	13.12	4.87	34.55	1172.0	286	Day	422	-84.7102	5.455933	0.0000001	-68.976
"Y1_3"	20110919	-64.4373	45.3350	15.00	15.15	9.28	52.61	1558.0	545	Day	216	-82.9661	11.94809	0.0000003	-65.572
"Y1_7"	20110919	-64.4382	45.3314	17.75	17.83	5.08	37.08	1039.3	299	Day	428	-82.6295	9.066221	0.0000002	-66.771
"X2_1"	20110919	-64.4423	45.3518	13.12	13.57	27.00	57.53	4400.6	1572	Day	368	-80.8276	21.22076	0.0000005	-63.077
"X2_2"	20110919	-64.4406	45.3550	15.15	15.53	22.75	57.70	3893.0	1322	Day	230	-85.1665	7.724727	0.0000002	-67.466
"X2_3"	20110919	-64.4417	45.3528	17.84	18.77	55.88	59.63	5365.7	3226	Day	492	-73.6639	94.80392	0.0000022	-56.577

Table A5-9-3.1. Summary of acoustic backscatter from **2 m** below the transducer to bottom by individual transect for the October 3, 2011 survey in Minas Passage. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20111003	-64.4283	45.3689	9.93	10.07	8.02	45.60	982.6	320	Tran1	937	-67.72466	331.8909	0.0000077	-51.135
"T0_2"	20111003	-64.4289	45.3694	13.11	13.24	8.02	37.43	971.4	321	Day	314	-71.11644	124.773	0.0000029	-55.384
"T0_3"	20111003	-64.4282	45.3689	15.27	15.34	4.10	36.31	1006.5	164	Day	249	-69.05541	194.5499	0.0000045	-53.455
"T0_4"	20111003	-64.4279	45.3690	17.11	17.18	3.98	38.72	991.3	159	Day	560	-58.43655	2392.119	0.0000555	-42.557
"T1_1"	20111003	-64.4265	45.3677	10.15	10.18	2.37	49.21	630.5	94	Tran1	909	-66.75372	447.9371	0.0000104	-49.833
"T1_2"	20111003	-64.4288	45.3682	13.29	13.36	4.30	41.76	980.7	172	Day	292	-59.85163	1862.295	0.0000432	-43.644
"T1_3"	20111003	-64.4284	45.3681	15.36	15.45	5.57	40.85	998.6	223	Day	259	-86.39952	4.033568	0.0000001	-70.288
"T1_4"	20111003	-64.4300	45.3685	17.22	17.64	25.47	44.56	1155.6	1018	Day	624	-71.9355	123.0086	0.0000029	-55.446
"T2_1"	20111003	-64.4289	45.3675	10.25	10.50	14.57	48.57	1028.8	582	Tran1	876	-73.96068	84.09508	0.0000020	-57.097
"T2_2"	20111003	-64.4285	45.3674	13.39	13.57	10.78	40.98	1029.8	431	Day	272	-71.12173	136.4397	0.0000032	-54.996
"T2_3"	20111003	-64.4284	45.3673	15.47	15.53	3.75	39.48	985.6	150	Day	270	-86.73342	3.609803	0.0000001	-70.770
"T2_4"	20111003	-64.4284	45.3674	17.65	17.71	3.82	42.82	1041.9	152	Day	682	-58.67074	2506.239	0.0000581	-42.355
"T3_1"	20111003	-64.4296	45.3670	10.53	10.62	5.05	47.06	1006.4	202	Tran1	841	-64.04176	799.755	0.0000186	-47.315
"T3_2"	20111003	-64.4294	45.3670	13.59	13.66	4.13	39.84	1024.0	165	Day	255	-79.03144	21.4631	0.0000005	-63.028
"T3_3"	20111003	-64.4293	45.3669	15.55	15.65	5.75	38.89	1022.9	230	Day	280	-81.4579	11.98076	0.0000003	-65.560
"T3_4"	20111003	-64.4280	45.3666	17.86	18.56	42.08	44.42	1278.9	1682	Day	804	-69.73672	203.4419	0.0000047	-53.261
"T4_1"	20111003	-64.4294	45.3657	10.66	10.93	15.97	40.97	1035.6	638	Tran1	800	-68.30246	261.0695	0.0000061	-52.177
"T4_2"	20111003	-64.4297	45.3657	13.70	13.87	10.00	34.78	1058.6	400	Day	241	-79.8085	15.6668	0.0000004	-64.395
"T4_3"	20111003	-64.4298	45.3657	15.67	15.73	3.80	33.27	1005.2	152	Day	293	-87.79329	2.383465	0.0000001	-72.573
"T4_4"	20111003	-64.4291	45.3654	18.60	18.66	3.65	38.35	1000.7	146	Day	893	-57.49916	2939.731	0.0000682	-41.662
"T5_1"	20111003	-64.4303	45.3648	10.96	11.04	4.85	38.55	1001.1	194	Tran1	761	-69.54171	184.6289	0.0000043	-53.682
"T5_2"	20111003	-64.4302	45.3649	13.89	13.96	4.30	31.86	1011.4	172	Day	229	-83.42782	6.23692	0.0000001	-68.395
"T5_3"	20111003	-64.4300	45.3647	15.75	15.85	5.95	31.79	1013.6	238	Day	307	-74.71731	46.25032	0.0000011	-59.694
"T5_4"	20111003	-64.4287	45.3644	18.74	19.36	37.15	37.49	1350.0	1485	Day	973	-69.80806	168.9005	0.0000039	-54.069
"T6_1"	20111003	-64.4295	45.3637	11.09	11.46	21.82	37.05	1092.4	872	Day	702	-69.32748	186.4471	0.0000043	-53.639
"T6_2"	20111003	-64.4309	45.3641	14.01	14.19	10.83	32.29	1046.3	433	Day	219	-84.52481	4.910672	0.0000001	-69.434
"T6_3"	20111003	-64.4307	45.3639	15.87	15.93	3.83	31.51	990.6	153	Day	324	-78.05697	21.2424	0.0000005	-63.073
"T6_4"	20111003	-64.4303	45.3638	19.40	19.44	2.83	38.00	1018.5	113	Day	1033	-60.92125	1324.651	0.0000307	-45.124
"T7_1"	20111003	-64.4312	45.3629	11.49	11.56	4.55	36.96	993.0	182	Day	648	-71.445	114.2027	0.0000026	-55.768
"T7_2"	20111003	-64.4312	45.3631	14.21	14.29	4.63	31.63	1027.8	184	Day	212	-82.7482	7.239703	0.0000002	-67.748
"T7_3"	20111003	-64.4312	45.3631	15.95	16.07	6.83	32.83	1030.2	273	Day	339	-81.8184	9.308165	0.0000002	-66.656
"T7_4"	20111003	-64.4300	45.3629	19.50	19.83	20.15	39.93	988.1	805	Day	1062	-66.97302	345.5374	0.0000080	-50.960

Table A5-9-3.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_1"	20111003	-64.4311	45.3620	11.62	12.02	23.82	38.36	1106.9	952	Day	582	-70.26592	155.5077	0.0000036	-54.427
"T8_2"	20111003	-64.4319	45.3623	14.32	14.45	7.78	32.27	935.7	311	Day	209	-86.53204	3.090997	0.0000001	-71.444
"T8_3"	20111003	-64.4313	45.3621	16.09	16.15	3.70	33.37	989.9	148	Day	359	-59.95452	1453.378	0.0000337	-44.721
"T8_4"	20111003	-64.4309	45.3621	19.88	19.93	3.05	41.33	993.1	122	Day	1087	-52.51193	9990.146	0.0002318	-36.349
"X1_1"	20111003	-64.4295	45.3489	12.17	12.53	21.85	73.12	3023.0	873	Day	470	-76.46195	71.17236	0.0000017	-57.822
"X1_2"	20111003	-64.4307	45.3456	14.50	14.79	17.33	66.82	3358.9	693	Day	210	-84.54201	10.12056	0.0000002	-66.293
"X1_3"	20111003	-64.4312	45.3449	16.17	16.44	15.80	65.41	3544.0	631	Day	391	-80.58828	24.6219	0.0000006	-62.432
"X1_4"	20111003	-64.4301	45.3478	19.97	20.25	16.80	80.32	3032.1	671	Day	1102	-71.42308	249.449	0.0000058	-52.375
"Y1_1"	20111003	-64.4411	45.3309	12.53	12.63	5.70	35.10	1503.3	228	Day	422	-80.41435	13.75246	0.0000003	-64.961
"Y1_2"	20111003	-64.4425	45.3305	14.79	14.88	5.25	27.58	1012.4	210	Day	216	-82.12559	7.286988	0.0000002	-67.719
"Y1_3"	20111003	-64.4433	45.3306	16.44	16.56	7.58	29.40	1058.7	303	Day	428	-84.81638	4.179592	0.0000001	-70.134
"X2_1"	20111003	-64.4430	45.3497	12.63	13.10	28.07	62.13	4397.6	1122	Day	368	-77.18183	51.23663	0.0000012	-59.249
"X2_2"	20111003	-64.4422	45.3518	14.89	15.25	21.27	58.43	4410.9	850	Day	230	-86.13922	6.126594	0.0000001	-68.473
"X2_3"	20111003	-64.4408	45.3537	16.57	17.08	30.47	60.07	4305.0	1218	Day	492	-65.70938	695.3483	0.0000161	-47.923

Table A5-9-3.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the October 3, 2011 survey in Minas Passage. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20111003	-64.4283	45.3689	9.93	10.07	8.02	45.60	982.6	320	Tran1	937	-75.399	46.9	0.0000011	-59.635
"T0_2"	20111003	-64.4289	45.3694	13.11	13.24	8.02	37.43	971.4	321	Day	314	-76.5298	28.3	0.0000007	-61.826
"T0_3"	20111003	-64.4282	45.3689	15.27	15.34	4.10	36.31	1006.5	164	Day	249	-87.8148	2.0	0.0000000	-73.279
"T0_4"	20111003	-64.4279	45.3690	17.11	17.18	3.98	38.72	991.3	159	Day	560	-79.2052	16.0	0.0000004	-64.317
"T1_1"	20111003	-64.4265	45.3677	10.15	10.18	2.37	49.21	630.5	94	Tran1	909	-71.6264	122.5	0.0000028	-55.465
"T1_2"	20111003	-64.4288	45.3682	13.29	13.36	4.30	41.76	980.7	172	Day	292	-65.3317	427.5	0.0000099	-50.035
"T1_3"	20111003	-64.4284	45.3681	15.36	15.45	5.57	40.85	998.6	223	Day	259	-86.1284	3.5	0.0000001	-70.950
"T1_4"	20111003	-64.4300	45.3685	17.22	17.64	25.47	44.56	1155.6	1018	Day	624	-77.1395	30.5	0.0000007	-61.497
"T2_1"	20111003	-64.4289	45.3675	10.25	10.50	14.57	48.57	1028.8	582	Tran1	876	-75.9031	45.0	0.0000010	-59.811
"T2_2"	20111003	-64.4285	45.3674	13.39	13.57	10.78	40.98	1029.8	431	Day	272	-81.0181	11.3	0.0000003	-65.822
"T2_3"	20111003	-64.4284	45.3673	15.47	15.53	3.75	39.48	985.6	150	Day	270	-86.383	3.1	0.0000001	-71.389
"T2_4"	20111003	-64.4284	45.3674	17.65	17.71	3.82	42.82	1041.9	152	Day	682	-72.4157	86.3	0.0000020	-56.985
"T3_1"	20111003	-64.4296	45.3670	10.53	10.62	5.05	47.06	1006.4	202	Tran1	841	-68.6153	232.2	0.0000054	-52.687
"T3_2"	20111003	-64.4294	45.3670	13.59	13.66	4.13	39.84	1024.0	165	Day	255	-80.8756	11.3	0.0000003	-65.832
"T3_3"	20111003	-64.4293	45.3669	15.55	15.65	5.75	38.89	1022.9	230	Day	280	-82.4011	7.7	0.0000002	-67.489
"T3_4"	20111003	-64.4280	45.3666	17.86	18.56	42.08	44.42	1278.9	1682	Day	804	-77.2852	29.4	0.0000007	-61.659
"T4_1"	20111003	-64.4294	45.3657	10.66	10.93	15.97	40.97	1035.6	638	Tran1	800	-74.8095	47.1	0.0000011	-59.615
"T4_2"	20111003	-64.4297	45.3657	13.70	13.87	10.00	34.78	1058.6	400	Day	241	-79.475	13.1	0.0000003	-65.180
"T4_3"	20111003	-64.4298	45.3657	15.67	15.73	3.80	33.27	1005.2	152	Day	293	-87.9144	1.8	0.0000000	-73.871
"T4_4"	20111003	-64.4291	45.3654	18.60	18.66	3.65	38.35	1000.7	146	Day	893	-75.0371	41.1	0.0000010	-60.202
"T5_1"	20111003	-64.4303	45.3648	10.96	11.04	4.85	38.55	1001.1	194	Tran1	761	-80.0613	13.0	0.0000003	-65.197
"T5_2"	20111003	-64.4302	45.3649	13.89	13.96	4.30	31.86	1011.4	172	Day	229	-82.5477	5.7	0.0000001	-68.752
"T5_3"	20111003	-64.4300	45.3647	15.75	15.85	5.95	31.79	1013.6	238	Day	307	-87.2225	2.0	0.0000000	-73.439
"T5_4"	20111003	-64.4287	45.3644	18.74	19.36	37.15	37.49	1350.0	1485	Day	973	-77.2852	23.8	0.0000006	-62.573
"T6_1"	20111003	-64.4295	45.3637	11.09	11.46	21.82	37.05	1092.4	872	Day	702	-76.7376	26.6	0.0000006	-62.091
"T6_2"	20111003	-64.4309	45.3641	14.01	14.19	10.83	32.29	1046.3	433	Day	219	-83.7759	4.4	0.0000001	-69.903
"T6_3"	20111003	-64.4307	45.3639	15.87	15.93	3.83	31.51	990.6	153	Day	324	-87.5946	1.8	0.0000000	-73.864
"T6_4"	20111003	-64.4303	45.3638	19.40	19.44	2.83	38.00	1018.5	113	Day	1033	-72.2703	76.9	0.0000018	-57.485
"T7_1"	20111003	-64.4312	45.3629	11.49	11.56	4.55	36.96	993.0	182	Day	648	-80.4411	11.3	0.0000003	-65.809
"T7_2"	20111003	-64.4312	45.3631	14.21	14.29	4.63	31.63	1027.8	184	Day	212	-82.1067	6.3	0.0000001	-68.354
"T7_3"	20111003	-64.4312	45.3631	15.95	16.07	6.83	32.83	1030.2	273	Day	339	-87.2237	2.0	0.0000000	-73.257
"T7_5"	20111003	-64.4300	45.3629	19.50	19.83	20.15	39.93	988.1	805	Day	1062	-70.9664	110.5	0.0000026	-55.911

Table A5-9-3.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_1"	20111003	-64.4311	45.3620	11.62	12.02	23.82	38.36	1106.9	952	Day	582	-77.8078	21.7	0.0000005	-62.971
"T8_2"	20111003	-64.4319	45.3623	14.32	14.45	7.78	32.27	935.7	311	Day	209	-86.8205	2.2	0.0000001	-72.952
"T8_3"	20111003	-64.4313	45.3621	16.09	16.15	3.70	33.37	989.9	148	Day	359	-81.2835	8.2	0.0000002	-67.223
"T8_5"	20111003	-64.4309	45.3621	19.88	19.93	3.05	41.33	993.1	122	Day	1087	-59.853	1490.6	0.0000346	-44.611
"X1_1"	20111003	-64.4295	45.3489	12.17	12.53	21.85	73.12	3023.0	873	Day	470	-79.5258	31.4	0.0000007	-61.382
"X1_2"	20111003	-64.4307	45.3456	14.50	14.79	17.33	66.82	3358.9	693	Day	210	-84.2578	9.5	0.0000002	-66.555
"X1_3"	20111003	-64.4312	45.3449	16.17	16.44	15.80	65.41	3544.0	631	Day	391	-83.2806	11.6	0.0000003	-65.683
"X1_4"	20111003	-64.4301	45.3478	19.97	20.25	16.80	80.32	3032.1	671	Day	1102	-76.5566	69.0	0.0000016	-57.958
"Y1_2"	20111003	-64.4411	45.3309	12.53	12.63	5.70	35.10	1503.3	228	Day	422	-81.4262	8.4	0.0000002	-67.080
"Y1_3"	20111003	-64.4425	45.3305	14.79	14.88	5.25	27.58	1012.4	210	Day	216	-81.3858	6.2	0.0000001	-68.445
"Y1_7"	20111003	-64.4433	45.3306	16.44	16.56	7.58	29.40	1058.7	303	Day	428	-84.2164	3.5	0.0000001	-70.893
"X2_1"	20111003	-64.4430	45.3497	12.63	13.10	28.07	62.13	4397.6	1122	Day	368	-79.6991	25.0	0.0000006	-62.357
"X2_2"	20111003	-64.4422	45.3518	14.89	15.25	21.27	58.43	4410.9	850	Day	230	-86.0503	5.4	0.0000001	-69.015
"X2_3"	20111003	-64.4408	45.3537	16.57	17.08	30.47	60.07	4305.0	1218	Day	492	-72.0516	140.2	0.0000033	-54.877

Table A5-9-3.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the October 3, 2011 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20111003	-64.4283	45.3689	9.93	10.07	8.02	45.60	982.6	320	Tran1	937	-80.0591	17.30114	0.0000004	-63.964
"T0_2"	20111003	-64.4289	45.3694	13.11	13.24	8.02	37.43	971.4	321	Day	314	-78.5533	18.06075	0.0000004	-63.778
"T0_3"	20111003	-64.4282	45.3689	15.27	15.34	4.10	36.31	1006.5	164	Day	249	-85.9945	3.92049	0.0000001	-70.412
"T0_4"	20111003	-64.4279	45.3690	17.11	17.18	3.98	38.72	991.3	159	Day	560	-81.9666	8.905826	0.0000002	-66.848
"T1_1"	20111003	-64.4265	45.3677	10.15	10.18	2.37	49.21	630.5	94	Tran1	909	-73.164	68.09695	0.0000016	-58.014
"T1_2"	20111003	-64.4288	45.3682	13.29	13.36	4.30	41.76	980.7	172	Day	292	-76.7139	29.32529	0.0000007	-61.672
"T1_3"	20111003	-64.4284	45.3681	15.36	15.45	5.57	40.85	998.6	223	Day	259	-86.3995	4.033568	0.0000001	-70.288
"T1_4"	20111003	-64.4300	45.3685	17.22	17.64	25.47	44.56	1155.6	1018	Day	624	-76.8316	34.02967	0.0000008	-61.026
"T2_1"	20111003	-64.4289	45.3675	10.25	10.50	14.57	48.57	1028.8	582	Tran1	876	-76.0549	45.97412	0.0000011	-59.720
"T2_2"	20111003	-64.4285	45.3674	13.39	13.57	10.78	40.98	1029.8	431	Day	272	-75.3672	46.35264	0.0000011	-59.684
"T2_3"	20111003	-64.4284	45.3673	15.47	15.53	3.75	39.48	985.6	150	Day	270	-86.7334	3.609803	0.0000001	-70.770
"T2_4"	20111003	-64.4284	45.3674	17.65	17.71	3.82	42.82	1041.9	152	Day	682	-81.0084	10.16999	0.0000002	-66.272
"T3_1"	20111003	-64.4296	45.3670	10.53	10.62	5.05	47.06	1006.4	202	Tran1	841	-78.2053	24.34619	0.0000006	-62.481
"T3_2"	20111003	-64.4294	45.3670	13.59	13.66	4.13	39.84	1024.0	165	Day	255	-79.0178	21.39089	0.0000005	-63.043
"T3_3"	20111003	-64.4293	45.3669	15.55	15.65	5.75	38.89	1022.9	230	Day	280	-81.4579	11.98076	0.0000003	-65.560
"T3_4"	20111003	-64.4280	45.3666	17.86	18.56	42.08	44.42	1278.9	1682	Day	804	-78.7638	20.91175	0.0000005	-63.141
"T4_1"	20111003	-64.4294	45.3657	10.66	10.93	15.97	40.97	1035.6	638	Tran1	800	-78.0719	19.86186	0.0000005	-63.365
"T4_2"	20111003	-64.4297	45.3657	13.70	13.87	10.00	34.78	1058.6	400	Day	241	-80.1355	14.11787	0.0000003	-64.847
"T4_3"	20111003	-64.4298	45.3657	15.67	15.73	3.80	33.27	1005.2	152	Day	293	-87.7933	2.383465	0.0000001	-72.573
"T4_4"	20111003	-64.4291	45.3654	18.60	18.66	3.65	38.35	1000.7	146	Day	893	-78.9578	16.45631	0.0000004	-64.182
"T5_1"	20111003	-64.4303	45.3648	10.96	11.04	4.85	38.55	1001.1	194	Tran1	761	-69.6748	160.6838	0.0000037	-54.285
"T5_2"	20111003	-64.4302	45.3649	13.89	13.96	4.30	31.86	1011.4	172	Day	229	-83.4278	6.23692	0.0000001	-68.395
"T5_3"	20111003	-64.4300	45.3647	15.75	15.85	5.95	31.79	1013.6	238	Day	307	-86.4138	3.078407	0.0000001	-71.462
"T5_4"	20111003	-64.4287	45.3644	18.74	19.36	37.15	37.49	1350.0	1485	Day	973	-78.2241	19.48696	0.0000005	-63.447
"T6_1"	20111003	-64.4295	45.3637	11.09	11.46	21.82	37.05	1092.4	872	Day	702	-76.4076	28.851	0.0000007	-61.743
"T6_2"	20111003	-64.4309	45.3641	14.01	14.19	10.83	32.29	1046.3	433	Day	219	-84.5248	4.910672	0.0000001	-69.434
"T6_3"	20111003	-64.4307	45.3639	15.87	15.93	3.83	31.51	990.6	153	Day	324	-87.9656	2.117983	0.0000000	-73.086
"T6_4"	20111003	-64.4303	45.3638	19.40	19.44	2.83	38.00	1018.5	113	Day	1033	-80.1796	12.84638	0.0000003	-65.257
"T7_1"	20111003	-64.4312	45.3629	11.49	11.56	4.55	36.96	993.0	182	Day	648	-75.1496	44.02765	0.0000010	-59.908
"T7_2"	20111003	-64.4312	45.3631	14.21	14.29	4.63	31.63	1027.8	184	Day	212	-82.7482	7.239703	0.0000002	-67.748
"T7_3"	20111003	-64.4312	45.3631	15.95	16.07	6.83	32.83	1030.2	273	Day	339	-87.4624	2.415024	0.0000001	-72.516
"T7_5"	20111003	-64.4300	45.3629	19.50	19.83	20.15	39.93	988.1	805	Day	1062	-71.1748	114.4945	0.0000027	-55.757

Table A5-9-3.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_1"	20111003	-64.4311	45.3620	11.62	12.02	23.82	38.36	1106.9	952	Day	582	-76.5643	30.26688	0.0000007	-61.535
"T8_2"	20111003	-64.4319	45.3623	14.32	14.45	7.78	32.27	935.7	311	Day	209	-86.532	3.090997	0.0000001	-71.444
"T8_3"	20111003	-64.4313	45.3621	16.09	16.15	3.70	33.37	989.9	148	Day	359	-87.2546	2.274721	0.0000001	-72.776
"T8_5"	20111003	-64.4309	45.3621	19.88	19.93	3.05	41.33	993.1	122	Day	1087	-76.8028	24.81393	0.0000006	-62.398
"X1_1"	20111003	-64.4295	45.3489	12.17	12.53	21.85	73.12	3023.0	873	Day	470	-79.3392	35.71417	0.0000008	-60.817
"X1_2"	20111003	-64.4307	45.3456	14.50	14.79	17.33	66.82	3358.9	693	Day	210	-84.542	10.12056	0.0000002	-66.293
"X1_3"	20111003	-64.4312	45.3449	16.17	16.44	15.80	65.41	3544.0	631	Day	391	-82.2297	16.67	0.0000004	-64.126
"X1_4"	20111003	-64.4301	45.3478	19.97	20.25	16.80	80.32	3032.1	671	Day	1102	-77.2203	59.90174	0.0000014	-58.571
"Y1_2"	20111003	-64.4411	45.3309	12.53	12.63	5.70	35.10	1503.3	228	Day	422	-80.4144	13.75246	0.0000003	-64.961
"Y1_3"	20111003	-64.4425	45.3305	14.79	14.88	5.25	27.58	1012.4	210	Day	216	-82.1256	7.286988	0.0000002	-67.719
"Y1_7"	20111003	-64.4433	45.3306	16.44	16.56	7.58	29.40	1058.7	303	Day	428	-84.8164	4.179592	0.0000001	-70.134
"X2_1"	20111003	-64.4430	45.3497	12.63	13.10	28.07	62.13	4397.6	1122	Day	368	-79.2917	30.05089	0.0000007	-61.566
"X2_2"	20111003	-64.4422	45.3518	14.89	15.25	21.27	58.43	4410.9	850	Day	230	-86.1392	6.126594	0.0000001	-68.473
"X2_3"	20111003	-64.4408	45.3537	16.57	17.08	30.47	60.07	4305.0	1218	Day	492	-76.6471	42.57842	0.0000010	-60.053

Table A5-9-4.1. Summary of acoustic backscatter from **2 m** below the transducer to bottom by individual transect for the November 22, 2011 survey in Minas Passage. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20111122	-64.4284	45.3692	14.38	14.52	8.27	45.62	971.4	495	Day	998	-71.94036	125.7789	0.0000029	-55.349
"T0_2"	20111122	-64.4286	45.3691	18.42	18.52	5.67	35.65	1100.9	1096	Day	179	-67.59608	267.2392	0.0000062	-52.076
"T0_3"	20111122	-64.4296	45.3695	20.20	20.28	4.83	35.11	1244.7	919	Tran2	221	-65.08602	469.202	0.0000109	-49.631
"T1_1"	20111122	-64.4293	45.3685	14.54	14.63	5.33	49.74	1052.9	201	Day	975	-66.12166	523.6361	0.0000121	-49.155
"T1_2"	20111122	-64.4288	45.3683	18.53	18.60	4.18	39.14	986.0	846	Day	170	-65.78185	445.6304	0.0000103	-49.855
"T1_3"	20111122	-64.4290	45.3684	20.30	20.43	7.78	40.23	1113.9	1576	Tran2	237	-75.10932	53.4677	0.0000012	-59.064
"T2_1"	20111122	-64.4281	45.3673	14.63	14.97	20.17	48.54	1058.9	1208	Day	932	-57.5199	3703.446	0.0000859	-40.659
"T2_2"	20111122	-64.4282	45.3673	18.62	18.73	6.63	38.86	1041.5	1341	Day	162	-67.22552	317.3092	0.0000074	-51.330
"T2_3"	20111122	-64.4285	45.3674	20.44	20.49	3.02	38.73	939.2	611	Tran2	253	-79.67751	17.97773	0.0000004	-63.798
"T3_1"	20111122	-64.4297	45.3671	14.99	15.05	3.25	47.31	955.6	194	Day	890	-55.55305	5677.134	0.0001317	-38.804
"T3_2"	20111122	-64.4299	45.3670	18.75	18.82	4.30	37.70	974.0	872	Day	156	-68.0678	253.528	0.0000059	-52.305
"T3_3"	20111122	-64.4292	45.3669	20.51	20.64	7.77	38.59	1037.6	1570	Tran2	271	-78.24358	24.92583	0.0000006	-62.378
"T4_1"	20111122	-64.4285	45.3654	15.12	15.79	39.92	39.88	1227.6	2391	Day	799	-60.83159	1419.428	0.0000329	-44.824
"T4_2"	20111122	-64.4311	45.3660	18.84	18.94	6.28	35.13	785.0	1270	Day	150	-72.92727	77.17521	0.0000018	-57.470
"T4_3"	20111122	-64.4254	45.3647	20.65	20.76	6.65	30.52	1297.9	1024	Tran2	291	-75.76461	34.88578	0.0000008	-60.918
"T5_1"	20111122	-64.4305	45.3650	15.82	15.87	3.20	37.70	960.9	192	Day	713	-59.14331	1979.261	0.0000459	-43.380
"T5_2"	20111122	-64.4282	45.3645	18.99	19.04	3.42	27.71	634.5	689	Day	146	-74.76889	39.82643	0.0000009	-60.343
"T5_3"	20111122	-64.4315	45.3651	20.77	20.89	7.67	33.28	794.4	1550	Tran2	316	-74.50827	50.79742	0.0000012	-59.287
"T6_1"	20111122	-64.4300	45.3640	15.96	16.39	26.02	36.79	1196.0	1558	Day	634	-60.26815	1490.87	0.0000346	-44.611
"T6_2"	20111122	-64.4307	45.3640	19.09	19.20	6.57	31.31	1006.4	1330	Day	144	-72.81326	70.60787	0.0000016	-57.856
"T6_3"	20111122	-64.4304	45.3639	20.91	20.96	2.73	30.67	982.2	550	Tran2	338	-68.74555	176.4485	0.0000041	-53.879
"T7_1"	20111122	-64.4307	45.3631	16.39	16.46	4.13	35.36	1085.2	183	Day	570	-59.8924	1562.169	0.0000362	-44.408
"T7_2"	20111122	-64.4310	45.3630	19.22	19.31	5.42	30.27	1021.5	1095	Day	145	-72.59056	71.84457	0.0000017	-57.781
"T7_3"	20111122	-64.4319	45.3632	20.99	21.24	14.95	32.83	1063.6	3027	Tran2	371	-61.04701	1111.818	0.0000258	-45.885
"T8_1"	20111122	-64.4313	45.3623	16.46	17.52	63.23	34.66	1157.4	2769	Day	348	-66.78205	313.4557	0.0000073	-51.383
"T8_2"	20111122	-64.4309	45.3621	19.34	19.46	7.27	32.90	1188.5	1451	Day	148	-74.2281	53.55661	0.0000012	-59.057
"T8_3"	20111122	-64.4253	45.3608	21.26	21.41	8.70	41.42	1626.7	1298	Tran2	414	-53.00328	8940.954	0.0002074	-36.831
"X1_1"	20111122	-64.4308	45.3486	17.52	17.84	19.43	71.09	3269.5	3830	Day	295	-64.42219	1106.868	0.0000257	-45.904
"X1_2"	20111122	-64.4310	45.3445	19.46	19.73	16.18	65.79	3375.0	3275	Day	157	-73.1034	138.77	0.0000032	-54.922
"X1_3"	20111122	-64.4316	45.3438	21.41	21.71	17.90	81.39	2775.3	3619	Tran2	469	-67.35841	644.4697	0.0000150	-48.253
"Y1_1"	20111122	-64.4507	45.3310	17.97	18.02	2.63	27.52	428.3	532	Day	240	-61.60206	820.2528	0.0000190	-47.205
"Y1_2"	20111122	-64.4499	45.3313	19.83	19.86	1.60	26.92	353.5	325	Tran2	175	-83.51971	5.160186	0.0000001	-69.218
"Y1_3"	20111122	-64.4502	45.3321	21.71	21.82	6.52	31.15	1155.1	118	Night	527	-71.47808	95.54172	0.0000022	-56.543
"X2_1"	20111122	-64.4424	45.3515	18.02	18.42	24.17	60.22	4331.2	4882	Day	207	-65.92858	662.7356	0.0000154	-48.132
"X2_2"	20111122	-64.4423	45.3515	19.86	20.19	19.93	59.36	4304.4	4030	Tran2	194	-72.33762	149.3668	0.0000035	-54.602
"X2_3"	20111122	-64.4395	45.3490	21.82	22.60	46.98	64.61	4228.8	9489	Night	623	-55.71583	7468.567	0.0001733	-37.613

Table A5-9-4.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the November 22, 2011 survey in Minas Passage. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20111122	-64.4284	45.3692	14.38	14.52	8.27	45.62	971.4	495	Day	998	-76.3743	37.3777	0.0000009	-60.619
"T0_2"	20111122	-64.4286	45.3691	18.42	18.52	5.67	35.65	1100.9	1096	Day	179	-71.4495	85.38185	0.0000020	-57.031
"T0_3"	20111122	-64.4296	45.3695	20.20	20.28	4.83	35.11	1244.7	919	Tran2	221	-82.4854	6.596542	0.0000002	-68.152
"T1_1"	20111122	-64.4293	45.3685	14.54	14.63	5.33	49.74	1052.9	201	Day	975	-80.0389	17.83501	0.0000004	-63.832
"T1_2"	20111122	-64.4288	45.3683	18.53	18.60	4.18	39.14	986.0	846	Day	170	-68.2391	201.4302	0.0000047	-53.304
"T1_3"	20111122	-64.4290	45.3684	20.30	20.43	7.78	40.23	1113.9	1576	Tran2	237	-79.5777	15.31501	0.0000004	-64.494
"T2_1"	20111122	-64.4281	45.3673	14.63	14.97	20.17	48.54	1058.9	1208	Day	932	-63.5441	772.859	0.0000179	-47.464
"T2_2"	20111122	-64.4282	45.3673	18.62	18.73	6.63	38.86	1041.5	1341	Day	162	-73.5332	58.99075	0.0000014	-58.637
"T2_3"	20111122	-64.4285	45.3674	20.44	20.49	3.02	38.73	939.2	611	Tran2	253	-81.7154	8.92513	0.0000002	-66.839
"T3_1"	20111122	-64.4297	45.3671	14.99	15.05	3.25	47.31	955.6	194	Day	890	-65.0052	535.2974	0.0000124	-49.059
"T3_2"	20111122	-64.4299	45.3670	18.75	18.82	4.30	37.70	974.0	872	Day	156	-71.8236	84.1456	0.0000020	-57.095
"T3_3"	20111122	-64.4292	45.3669	20.51	20.64	7.77	38.59	1037.6	1570	Tran2	271	-82.0527	8.22288	0.0000002	-67.195
"T4_1"	20111122	-64.4285	45.3654	15.12	15.79	39.92	39.88	1227.6	2391	Day	799	-70.0119	137.0932	0.0000032	-54.975
"T4_2"	20111122	-64.4311	45.3660	18.84	18.94	6.28	35.13	785.0	1270	Day	150	-82.7038	6.27764	0.0000001	-68.367
"T4_3"	20111122	-64.4254	45.3647	20.65	20.76	6.65	30.52	1297.9	1024	Tran2	291	-82.7209	5.190918	0.0000001	-69.192
"T5_1"	20111122	-64.4305	45.3650	15.82	15.87	3.20	37.70	960.9	192	Day	713	-74.5129	45.30377	0.0000011	-59.784
"T5_2"	20111122	-64.4282	45.3645	18.99	19.04	3.42	27.71	634.5	689	Day	146	-85.9263	2.171286	0.0000001	-72.978
"T5_3"	20111122	-64.4315	45.3651	20.77	20.89	7.67	33.28	794.4	1550	Tran2	316	-82.8936	5.598887	0.0000001	-68.864
"T6_1"	20111122	-64.4300	45.3640	15.96	16.39	26.02	36.79	1196.0	1558	Day	634	-69.75	131.5085	0.0000031	-55.155
"T6_2"	20111122	-64.4307	45.3640	19.09	19.20	6.57	31.31	1006.4	1330	Day	144	-86.4015	2.302007	0.0000001	-72.724
"T6_3"	20111122	-64.4304	45.3639	20.91	20.96	2.73	30.67	982.2	550	Tran2	338	-79.7945	10.24895	0.0000002	-66.238
"T7_1"	20111122	-64.4307	45.3631	16.39	16.46	4.13	35.36	1085.2	183	Day	570	-74.1846	45.00825	0.0000010	-59.812
"T7_2"	20111122	-64.4310	45.3630	19.22	19.31	5.42	30.27	1021.5	1095	Day	145	-86.0807	2.36755	0.0000001	-72.602
"T7_3"	20111122	-64.4319	45.3632	20.99	21.24	14.95	32.83	1063.6	3027	Tran2	371	-72.2415	63.89843	0.0000015	-58.290
"T8_1"	20111122	-64.4313	45.3623	16.46	17.52	63.23	34.66	1157.4	2769	Day	348	-79.0924	14.17038	0.0000003	-64.831
"T8_2"	20111122	-64.4309	45.3621	19.34	19.46	7.27	32.90	1188.5	1451	Day	148	-84.5316	3.78136	0.0000001	-70.568
"T8_3"	20111122	-64.4253	45.3608	21.26	21.41	8.70	41.42	1626.7	1298	Tran2	414	-59.524	1607.923	0.0000373	-44.282
"X1_1"	20111122	-64.4308	45.3486	17.52	17.84	19.43	71.09	3269.5	3830	Day	295	-74.0471	107.1123	0.0000025	-56.047
"X1_2"	20111122	-64.4310	45.3445	19.46	19.73	16.18	65.79	3375.0	3275	Day	157	-78.3014	36.83626	0.0000009	-60.682
"X1_3"	20111122	-64.4316	45.3438	21.41	21.71	17.90	81.39	2775.3	3619	Tran2	469	-71.5801	219.8693	0.0000051	-52.923
"Y1_2"	20111122	-64.4507	45.3310	17.97	18.02	2.63	27.52	428.3	532	Day	240	-79.3661	9.741925	0.0000002	-66.458
"Y1_3"	20111122	-64.4499	45.3313	19.83	19.86	1.60	26.92	353.5	325	Tran2	175	-83.1689	3.934524	0.0000001	-70.396
"Y1_7"	20111122	-64.4502	45.3321	21.71	21.82	6.52	31.15	1155.1	118	Night	527	-75.0392	31.29032	0.0000007	-61.391
"X2_1"	20111122	-64.4424	45.3515	18.02	18.42	24.17	60.22	4331.2	4882	Day	207	-78.8812	29.12529	0.0000007	-61.702
"X2_2"	20111122	-64.4423	45.3515	19.86	20.19	19.93	59.36	4304.4	4030	Tran2	194	-79.6779	23.84848	0.0000006	-62.570
"X2_3"	20111122	-64.4395	45.3490	21.82	22.60	46.98	64.61	4228.8	9489	Night	623	-59.4106	2795.414	0.0000649	-41.880

Table A5-9-4.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the November 22, 2011 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20111122	-64.4284	45.3692	14.38	14.52	8.27	45.62	971.4	495	Day	998	-75.5276	49.39805	0.0000011	-59.408
"T0_2"	20111122	-64.4286	45.3691	18.42	18.52	5.67	35.65	1100.9	1096	Day	179	-77.6858	20.38554	0.0000005	-63.252
"T0_3"	20111122	-64.4296	45.3695	20.20	20.28	4.83	35.11	1244.7	919	Tran2	221	-79.4325	16.8535	0.0000004	-64.078
"T1_1"	20111122	-64.4293	45.3685	14.54	14.63	5.33	49.74	1052.9	201	Day	975	-80.8765	14.91825	0.0000003	-64.608
"T1_2"	20111122	-64.4288	45.3683	18.53	18.60	4.18	39.14	986.0	846	Day	170	-80.4219	11.82512	0.0000003	-65.617
"T1_3"	20111122	-64.4290	45.3684	20.30	20.43	7.78	40.23	1113.9	1576	Tran2	237	-75.6064	46.61757	0.0000011	-59.659
"T2_1"	20111122	-64.4281	45.3673	14.63	14.97	20.17	48.54	1058.9	1208	Day	932	-77.7513	20.48195	0.0000005	-63.231
"T2_2"	20111122	-64.4282	45.3673	18.62	18.73	6.63	38.86	1041.5	1341	Day	162	-79.2304	16.56038	0.0000004	-64.154
"T2_3"	20111122	-64.4285	45.3674	20.44	20.49	3.02	38.73	939.2	611	Tran2	253	-81.4905	11.42009	0.0000003	-65.768
"T3_1"	20111122	-64.4297	45.3671	14.99	15.05	3.25	47.31	955.6	194	Day	890	-77.7646	21.56479	0.0000005	-63.007
"T3_2"	20111122	-64.4299	45.3670	18.75	18.82	4.30	37.70	974.0	872	Day	156	-79.5764	13.55646	0.0000003	-65.023
"T3_3"	20111122	-64.4292	45.3669	20.51	20.64	7.77	38.59	1037.6	1570	Tran2	271	-81.1764	12.20262	0.0000003	-65.480
"T4_1"	20111122	-64.4285	45.3654	15.12	15.79	39.92	39.88	1227.6	2391	Day	799	-77.2302	20.80294	0.0000005	-63.164
"T4_2"	20111122	-64.4311	45.3660	18.84	18.94	6.28	35.13	785.0	1270	Day	150	-74.9572	43.44402	0.0000010	-59.966
"T4_3"	20111122	-64.4254	45.3647	20.65	20.76	6.65	30.52	1297.9	1024	Tran2	291	-77.1605	24.46441	0.0000006	-62.460
"T5_1"	20111122	-64.4305	45.3650	15.82	15.87	3.20	37.70	960.9	192	Day	713	-78.5282	13.54192	0.0000003	-65.028
"T5_2"	20111122	-64.4282	45.3645	18.99	19.04	3.42	27.71	634.5	689	Day	146	-83.9028	4.450948	0.0000001	-69.860
"T5_3"	20111122	-64.4315	45.3651	20.77	20.89	7.67	33.28	794.4	1550	Tran2	316	-74.5845	47.25829	0.0000011	-59.600
"T6_1"	20111122	-64.4300	45.3640	15.96	16.39	26.02	36.79	1196.0	1558	Day	634	-76.9955	20.04485	0.0000005	-63.325
"T6_2"	20111122	-64.4307	45.3640	19.09	19.20	6.57	31.31	1006.4	1330	Day	144	-80.5292	10.74933	0.0000002	-66.031
"T6_3"	20111122	-64.4304	45.3639	20.91	20.96	2.73	30.67	982.2	550	Tran2	338	-80.3074	10.71682	0.0000002	-66.044
"T7_1"	20111122	-64.4307	45.3631	16.39	16.46	4.13	35.36	1085.2	183	Day	570	-77.1136	18.86953	0.0000004	-63.587
"T7_2"	20111122	-64.4310	45.3630	19.22	19.31	5.42	30.27	1021.5	1095	Day	145	-72.8738	63.43444	0.0000015	-58.322
"T7_3"	20111122	-64.4319	45.3632	20.99	21.24	14.95	32.83	1063.6	3027	Tran2	371	-77.9535	17.12358	0.0000004	-64.009
"T8_1"	20111122	-64.4313	45.3623	16.46	17.52	63.23	34.66	1157.4	2769	Day	348	-75.9935	31.72303	0.0000007	-61.331
"T8_2"	20111122	-64.4309	45.3621	19.34	19.46	7.27	32.90	1188.5	1451	Day	148	-76.4399	29.70099	0.0000007	-61.617
"T8_3"	20111122	-64.4253	45.3608	21.26	21.41	8.70	41.42	1626.7	1298	Tran2	414	-69.0186	124.2007	0.0000029	-55.404
"X1_1"	20111122	-64.4308	45.3486	17.52	17.84	19.43	71.09	3269.5	3830	Day	295	-76.8656	56.50983	0.0000013	-58.824
"X1_2"	20111122	-64.4310	45.3445	19.46	19.73	16.18	65.79	3375.0	3275	Day	157	-75.8111	71.11403	0.0000016	-57.825
"X1_3"	20111122	-64.4316	45.3438	21.41	21.71	17.90	81.39	2775.3	3619	Tran2	469	-74.081	120.5629	0.0000028	-55.533
"Y1_2"	20111122	-64.4507	45.3310	17.97	18.02	2.63	27.52	428.3	532	Day	240	-81.4962	7.073373	0.0000002	-67.849
"Y1_3"	20111122	-64.4499	45.3313	19.83	19.86	1.60	26.92	353.5	325	Tran2	175	-83.741	4.750267	0.0000001	-69.578
"Y1_7"	20111122	-64.4502	45.3321	21.71	21.82	6.52	31.15	1155.1	118	Night	527	-75.793	31.87834	0.0000007	-61.310
"X2_1"	20111122	-64.4424	45.3515	18.02	18.42	24.17	60.22	4331.2	4882	Day	207	-74.8709	76.85206	0.0000018	-57.488
"X2_2"	20111122	-64.4423	45.3515	19.86	20.19	19.93	59.36	4304.4	4030	Tran2	194	-75.1199	76.51276	0.0000018	-57.508
"X2_3"	20111122	-64.4395	45.3490	21.82	22.60	46.98	64.61	4228.8	9489	Night	623	-77.0675	36.41731	0.0000008	-60.732

Table A5-9-5.1. Summary of acoustic backscatter from **2 m** below the transducer to bottom by individual transect for the January 26, 2012 survey in Minas Passage. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120125	-64.4285	45.3693	18.55	18.65	5.97	46.09	1025.3	1233	Day	1155	-54.85745	6492.052	0.0001506	-38.221
"T0_2"	20120125	-64.4279	45.3691	20.93	21.02	5.40	40.22	997.5	324	Tran2	763	-46.86775	35660.04	0.0008274	-30.823
"T0_3"	20120125	-64.4307	45.3696	23.05	23.10	2.95	37.42	587.4	176	Night	243	-63.48883	722.3672	0.0000168	-47.757
"T0_4"	20120126	-64.4271	45.3689	0.56	0.62	3.47	34.92	875.5	208	Night	100	-74.28728	56.09087	0.0000013	-58.856
"T0_5"	20120126	-64.4280	45.3690	5.74	5.80	3.85	45.85	967.4	231	Night	1092	-70.84763	162.5928	0.0000038	-54.234
"T0_6"	20120126	-64.4277	45.3690	7.51	7.60	5.15	43.77	971.0	308	Night	1077	-56.26901	4454.195	0.0001033	-39.857
"T0_7"	20120126	-64.4289	45.3695	9.95	10.02	4.18	37.97	822.1	251	Night	608	-54.96589	5215.6	0.0001210	-39.172
"T0_8"	20120126	-64.4275	45.3689	11.68	11.74	4.07	34.70	955.8	244	Tran1	230	-56.7287	3176.218	0.0000737	-41.326
"T0_9"	20120126	-64.4266	45.3687	13.08	13.14	3.83	34.34	893.2	230	Day	150	-66.05651	366.9868	0.0000085	-50.698
"T0_10"	20120126	-64.4273	45.3688	15.48	15.54	3.78	40.25	1037.1	227	Day	548	-49.09018	21393.99	0.0004964	-33.042
"T1_1"	20120125	-64.4288	45.3682	18.68	18.75	4.00	51.31	1018.1	239	Day	1147	-59.52135	2469.387	0.0000573	-42.419
"T1_2"	20120125	-64.4289	45.3681	21.04	21.11	4.02	45.04	975.0	240	Tran2	738	-43.05184	96131.73	0.0022304	-26.516
"T1_3"	20120125	-64.4290	45.3683	23.15	23.21	3.65	40.78	983.7	219	Night	224	-58.15737	2686.872	0.0000623	-42.052
"T1_4"	20120126	-64.4285	45.3682	0.64	0.75	6.72	39.85	1075.8	402	Night	102	-74.18953	65.46353	0.0000015	-58.185
"T1_5"	20120126	-64.4287	45.3682	5.87	5.97	6.37	50.70	985.7	382	Night	1107	-73.7021	93.16639	0.0000022	-56.652
"T1_6"	20120126	-64.4291	45.3680	7.61	7.68	4.22	48.67	1035.4	253	Night	1067	-51.30323	15538.96	0.0003605	-34.431
"T1_7"	20120126	-64.4298	45.3684	10.05	10.12	4.52	42.39	1122.3	271	Night	579	-50.37893	16744.19	0.0003885	-34.106
"T1_8"	20120126	-64.4287	45.3683	11.76	11.82	3.97	39.83	980.8	238	Tran1	218	-61.05218	1347.233	0.0000313	-45.050
"T1_9"	20120126	-64.4283	45.3682	13.15	13.27	7.08	40.17	1039.9	424	Day	154	-71.90505	111.6449	0.0000026	-55.867
"T1_10"	20120126	-64.4295	45.3685	15.64	16.15	30.47	46.31	1244.1	1827	Day	644	-54.44318	7176.02	0.0001665	-37.786
"T2_1"	20120125	-64.4282	45.3673	18.78	18.98	12.02	49.85	1307.7	468	Day	1138	-56.7449	4546.366	0.0001055	-39.768
"T2_2"	20120125	-64.4284	45.3675	21.14	21.29	9.32	45.25	1031.1	558	Tran2	705	-51.2073	14771.03	0.0003427	-34.651
"T2_3"	20120125	-64.4287	45.3674	23.22	23.31	5.12	39.26	1013.7	306	Night	209	-64.61421	584.833	0.0000136	-48.675
"T2_4"	20120126	-64.4292	45.3673	0.78	0.86	4.57	39.84	1018.1	274	Night	107	-73.17586	82.64789	0.0000019	-57.173
"T2_5"	20120126	-64.4301	45.3675	5.97	6.06	5.18	50.27	1247.5	310	Night	1114	-58.65488	2953.323	0.0000685	-41.642
"T2_6"	20120126	-64.4289	45.3676	7.76	7.92	9.22	48.79	1059.0	552	Night	1042	-51.74435	14071.97	0.0003265	-34.861
"T2_7"	20120126	-64.4279	45.3674	10.19	10.30	6.52	41.91	1026.9	390	Night	542	-50.41571	16415.22	0.0003809	-34.192
"T2_8"	20120126	-64.4288	45.3674	11.84	11.91	4.20	38.20	1023.4	252	Tran1	206	-61.04431	1294.474	0.0000300	-45.224
"T2_9"	20120126	-64.4284	45.3675	13.29	13.36	3.90	38.95	1006.1	234	Day	162	-73.27771	78.93409	0.0000018	-57.372
"T2_10"	20120126	-64.4272	45.3671	16.21	16.26	2.75	44.66	814.3	164	Day	728	-48.94681	24534.08	0.0005692	-32.447
"T3_1"	20120125	-64.4312	45.3675	18.98	19.03	2.87	50.92	738.9	172	Day	1122	-52.03258	13745.42	0.0003189	-34.963
"T3_2"	20120125	-64.4300	45.3670	21.30	21.37	3.85	43.39	1003.4	231	Tran2	670	-53.32141	8703.457	0.0002019	-36.948
"T3_3"	20120125	-64.4297	45.3669	23.32	23.38	3.55	39.21	1000.8	213	Night	195	-56.66209	3644.598	0.0000846	-40.728
"T3_4"	20120126	-64.4291	45.3669	0.88	1.00	7.02	39.07	1019.6	420	Night	114	-70.61088	146.2932	0.0000034	-54.693
"T3_5"	20120126	-64.4292	45.3669	6.11	6.21	5.78	49.08	1004.1	347	Night	1124	-77.47226	37.85821	0.0000009	-60.563
"T3_6"	20120126	-64.4302	45.3671	7.94	8.00	3.45	48.83	1003.2	207	Night	1023	-53.28686	9873.457	0.0002291	-36.400

Table A5-9-5.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T3_7"	20120126	-64.4298	45.3671	10.31	10.38	4.07	40.73	1002.2	244	Night	517	-51.32547	12938.81	0.0003002	-35.226
"T3_8"	20120126	-64.4295	45.3669	11.92	11.99	4.07	38.91	984.3	244	Tran1	196	-54.53663	5900.687	0.0001369	-38.636
"T3_9"	20120126	-64.4292	45.3670	13.38	13.47	5.82	38.78	1021.3	348	Day	169	-74.14183	64.40584	0.0000015	-58.256
"T4_1"	20120125	-64.4301	45.3658	19.07	19.22	9.03	44.18	933.6	541	Day	1108	-54.97255	6059.356	0.0001406	-38.521
"T4_2"	20120125	-64.4293	45.3656	21.39	21.56	9.80	37.18	1031.5	587	Tran2	636	-54.70638	5421.877	0.0001258	-39.003
"T4_3"	20120125	-64.4297	45.3655	23.40	23.50	5.83	33.27	1024.0	349	Night	179	-67.70761	243.0971	0.0000056	-52.487
"T4_4"	20120126	-64.4297	45.3655	1.05	1.12	4.12	32.81	1008.2	246	Night	126	-71.98824	89.45741	0.0000021	-56.829
"T4_5"	20120126	-64.4298	45.3655	6.23	6.29	4.15	43.26	984.9	248	Night	1129	-64.37573	680.7637	0.0000158	-48.015
"T4_6"	20120126	-64.4294	45.3657	8.05	8.26	12.97	41.25	1040.8	777	Night	994	-52.20912	10689.98	0.0002480	-36.055
"T4_7"	20120126	-64.4295	45.3656	10.41	10.53	7.15	34.13	1021.0	428	Night	484	-56.02273	3676.094	0.0000853	-40.691
"T4_8"	20120126	-64.4293	45.3655	12.01	12.08	4.38	31.68	991.7	263	Tran1	186	-66.51938	304.3643	0.0000071	-51.511
"T4_9"	20120126	-64.4294	45.3655	13.49	13.55	3.38	32.43	981.0	203	Day	178	-73.53288	61.96304	0.0000014	-58.424
"T5_1"	20120125	-64.4304	45.3650	19.26	19.33	3.82	41.24	1006.4	228	Day	1089	-61.70731	1199.769	0.0000278	-45.554
"T5_2"	20120125	-64.4311	45.3652	21.57	21.64	4.03	36.27	1032.7	241	Tran2	601	-50.89668	12716.42	0.0002950	-35.301
"T5_3"	20120125	-64.4304	45.3648	23.51	23.57	3.63	31.35	1005.4	218	Night	165	-68.81236	177.6206	0.0000041	-53.850
"T5_4"	20120126	-64.4302	45.3649	1.17	1.29	7.28	31.80	1012.9	436	Night	138	-73.57237	60.20346	0.0000014	-58.549
"T5_5"	20120126	-64.4296	45.3648	6.35	6.45	6.07	41.46	1028.5	364	Night	1133	-71.95174	114.0059	0.0000026	-55.776
"T5_6"	20120126	-64.4306	45.3647	8.31	8.37	3.80	39.01	1093.0	227	Night	964	-55.82351	4398.996	0.0001021	-39.911
"T5_7"	20120126	-64.4308	45.3648	10.54	10.60	3.70	33.21	1017.4	222	Night	460	-53.75544	6028.433	0.0001399	-38.543
"T5_8"	20120126	-64.4305	45.3650	12.10	12.17	4.05	31.11	1010.6	242	Tran1	178	-58.34087	1965.014	0.0000456	-43.411
"T5_9"	20120126	-64.4301	45.3648	13.59	13.72	7.68	32.09	1025.3	461	Day	192	-68.81341	181.7788	0.0000042	-53.749
"T6_1"	20120125	-64.4307	45.3640	19.37	19.57	11.75	41.15	1052.8	702	Day	1064	-60.26331	1669.245	0.0000387	-44.120
"T6_2"	20120125	-64.4300	45.3640	21.74	21.94	11.70	33.99	1080.7	701	Tran2	539	-55.0219	4610.158	0.0001070	-39.708
"T6_3"	20120125	-64.4304	45.3639	23.59	23.69	5.63	31.02	1006.2	337	Night	152	-66.37728	307.8578	0.0000071	-51.461
"T6_4"	20120126	-64.4304	45.3637	1.56	1.62	3.62	30.90	1040.0	217	Night	185	-62.56748	737.3644	0.0000171	-47.668
"T6_5"	20120126	-64.4300	45.3634	6.46	6.53	4.22	40.10	1001.4	253	Night	1135	-64.93033	555.3976	0.0000129	-48.899
"T6_6"	20120126	-64.4299	45.3639	8.42	8.67	15.30	37.90	1081.3	918	Night	927	-55.64571	4452.623	0.0001033	-39.859
"T6_7"	20120126	-64.4302	45.3639	10.63	10.76	8.15	32.39	1045.7	488	Night	433	-57.13386	2700.861	0.0000627	-42.030
"T6_8"	20120126	-64.4302	45.3638	12.18	12.25	4.33	29.67	974.3	260	Tran1	169	-64.78572	424.8359	0.0000099	-50.063
"T6_9"	20120126	-64.4302	45.3637	13.74	13.80	3.65	29.80	974.7	219	Day	206	-57.62249	2220.692	0.0000515	-42.880
"T7_1"	20120125	-64.4310	45.3629	19.59	19.66	4.00	40.79	1014.0	239	Day	1041	-60.58876	1535.065	0.0000356	-44.484
"T7_2"	20120125	-64.4315	45.3631	21.97	22.03	3.77	33.73	1028.3	225	Tran2	495	-51.64696	9948.752	0.0002308	-36.367
"T7_3"	20120125	-64.4309	45.3631	23.70	23.76	3.90	30.44	1025.9	234	Night	142	-60.4948	1170.541	0.0000272	-45.661
"T7_4"	20120126	-64.4314	45.3631	1.68	1.93	15.00	33.91	1167.4	899	Night	219	-60.47073	1311.325	0.0000304	-45.168
"T7_5"	20120126	-64.4306	45.3629	6.57	6.66	5.60	41.67	1016.9	336	Night	1135	-73.49644	80.29148	0.0000019	-57.298
"T7_6"	20120126	-64.4326	45.3635	8.72	8.80	4.35	38.10	1071.3	261	Night	885	-53.72615	6962.749	0.0001615	-37.917
"T7_7"	20120126	-64.4317	45.3632	10.78	10.85	4.22	32.99	1072.0	253	Tran1	405	-61.02245	1123.604	0.0000261	-45.839
"T7_8"	20120126	-64.4311	45.3630	12.27	12.34	3.97	30.68	1011.7	238	Tran1	162	-61.87127	859.3946	0.0000199	-47.003
"T7_9"	20120126	-64.4312	45.3631	13.93	14.10	10.27	32.30	1042.2	615	Day	238	-67.03989	275.2407	0.0000064	-51.948
"T8_1"	20120125	-64.4313	45.3622	19.70	19.96	15.42	40.41	1140.5	924	Day	1010	-57.89591	2827.757	0.0000656	-41.830

Table A5-9-5.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_2"	20120125	-64.4319	45.3623	22.07	22.28	12.85	34.36	1236.0	770	Tran2	452	-57.19357	2826.296	0.0000656	-41.833
"T8_3"	20120125	-64.4314	45.3620	23.79	23.88	5.43	32.85	1014.2	325	Night	131	-68.95135	180.2735	0.0000042	-53.786
"T8_4"	20120126	-64.4308	45.3619	1.98	2.03	3.20	34.91	973.5	191	Night	254	-55.35689	4382.277	0.0001017	-39.928
"T8_5"	20120126	-64.4311	45.3621	6.68	6.75	4.30	42.48	967.0	258	Night	1134	-62.51855	1025.192	0.0000238	-46.237
"T8_6"	20120126	-64.4314	45.3620	8.86	9.13	16.35	38.16	1086.0	979	Night	837	-56.81653	3423.135	0.0000794	-41.001
"T8_7"	20120126	-64.4311	45.3621	10.91	11.03	7.68	33.61	1028.3	460	Tran1	368	-63.52368	643.6127	0.0000149	-48.259
"T8_8"	20120126	-64.4311	45.3620	12.36	12.43	4.60	32.04	1050.2	275	Tran1	157	-62.63887	752.0343	0.0000174	-47.583
"T8_9"	20120126	-64.4312	45.3618	14.11	14.17	3.58	37.57	1050.4	215	Day	259	-53.49216	7246.99	0.0001681	-37.743
"X1_1"	20120125	-64.4304	45.3476	19.97	20.26	17.57	77.83	3108.7	1028	Day	955	-59.15411	4076.158	0.0000946	-40.242
"X1_2"	20120125	-64.4297	45.3476	22.31	22.62	18.05	66.63	3483.9	1081	Night	380	-58.9897	3623.882	0.0000841	-40.753
"X1_3"	20120126	-64.4314	45.3448	23.90	0.14	-1425.70	65.78	3400.6	857	Night	115	-62.57031	1568.732	0.0000364	-44.389
"X1_4"	20120126	-64.4306	45.3449	2.20	2.52	19.37	77.22	3326.0	1161	Night	325	-56.7852	6977.961	0.0001619	-37.908
"X1_5"	20120126	-64.4309	45.3462	6.78	7.04	15.30	77.58	3316.4	917	Night	1128	-64.82658	1100.5	0.0000255	-45.929
"X1_6"	20120126	-64.4298	45.3479	9.14	9.44	18.17	71.56	3282.9	1089	Night	771	-58.68857	4171.806	0.0000968	-40.142
"X1_7"	20120126	-64.4302	45.3471	11.04	11.28	14.15	66.76	3313.3	848	Tran1	329	-61.32552	2120.452	0.0000492	-43.081
"X1_8"	20120126	-64.4306	45.3461	12.45	12.66	12.72	66.46	3346.1	762	Tran1	148	-61.83204	1878.751	0.0000436	-43.606
"X1_9"	20120126	-64.4328	45.3399	14.31	14.45	8.42	82.52	2010.4	504	Day	300	-67.64708	611.4572	0.0000142	-48.481
"Y1_1"	20120125	-64.4472	45.3347	20.28	20.37	5.72	46.49	1151.1	342	Tran2	911	-55.01983	6308.034	0.0001464	-38.346
"Y1_2"	20120125	-64.4440	45.3322	22.62	22.67	3.43	29.06	1140.0	206	Night	336	-59.57047	1382.853	0.0000321	-44.937
"Y1_3"	20120126	-64.4451	45.3322	0.15	0.22	4.43	27.45	908.3	265	Night	106	-68.40711	170.7379	0.0000040	-54.022
"Y1_4"	20120126	-64.4446	45.3309	2.54	2.63	5.60	30.67	1128.6	336	Night	377	-75.7997	34.7672	0.0000008	-60.933
"Y1_5"	20120126	-64.4440	45.3323	7.05	7.11	3.28	38.88	797.7	196	Night	1119	-63.91343	680.6233	0.0000158	-48.016
"Y1_6"	20120126	-64.4463	45.3328	9.46	9.50	2.20	34.26	826.9	132	Night	728	-54.65128	5059.986	0.0001174	-39.303
"Y1_7"	20120126	-64.4446	45.3324	11.29	11.34	3.23	30.16	1042.7	193	Tran1	299	-60.78048	1086.149	0.0000252	-45.986
"Y1_8"	20120126	-64.4439	45.3322	12.66	12.74	4.73	28.55	1082.1	284	Tran1	145	-66.3614	284.4007	0.0000066	-51.806
"Y1_9"	20120126	-64.4447	45.3329	14.48	14.55	4.00	33.48	794.9	240	Day	325	-69.15668	175.2459	0.0000041	-53.908
"X2_1"	20120125	-64.4428	45.3504	20.39	20.93	31.90	67.68	4489.1	1911	Tran2	838	-54.84844	9552.554	0.0002216	-36.544
"X2_2"	20120125	-64.4420	45.3518	22.67	23.03	21.52	59.40	4461.9	1289	Night	288	-59.52003	2859.595	0.0000663	-41.782
"X2_3"	20120126	-64.4419	45.3526	0.22	0.55	19.80	58.65	4396.3	1186	Night	99	-64.32624	933.603	0.0000217	-46.643
"X2_4"	20120126	-64.4408	45.3477	2.67	3.31	38.50	74.20	4285.3	2306	Night	472	-53.75092	13483.69	0.0003128	-35.047
"X2_5"	20120126	-64.4436	45.3478	7.12	7.49	22.50	62.64	5036.4	1349	Night	1102	-59.41696	3087.702	0.0000716	-41.449
"X2_6"	20120126	-64.4427	45.3510	9.51	9.92	25.03	64.31	4391.6	1500	Night	673	-55.39312	8007.247	0.0001858	-37.310
"X2_7"	20120126	-64.4421	45.3522	11.35	11.65	18.55	58.67	4357.0	1112	Tran1	265	-57.67778	4316.555	0.0001001	-39.994
"X2_8"	20120126	-64.4419	45.3525	12.75	13.04	17.45	58.10	4319.8	1046	Day	144	-63.10843	1224.088	0.0000284	-45.467
"X2_9"	20120126	-64.4422	45.3496	14.56	14.93	22.28	64.58	3751.9	1336	Day	372	-55.41125	8007.133	0.0001858	-37.310

Table A5-9-5.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the January 26, 2012 survey in Minas Passage. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120125	-64.4285	45.3693	18.55	18.65	5.97	46.09	1025.3	1233	Day	1155	-64.2501	616.596	0.0000143	-48.445
"T0_2"	20120125	-64.4279	45.3691	20.93	21.02	5.40	40.22	997.5	324	Tran2	763	-49.0287	17353.53	0.0004026	-33.951
"T0_3"	20120125	-64.4307	45.3696	23.05	23.10	2.95	37.42	587.4	176	Night	243	-70.8899	103.2227	0.0000024	-56.207
"T0_4"	20120126	-64.4271	45.3689	0.56	0.62	3.47	34.92	875.5	208	Night	100	-76.2519	27.47788	0.0000006	-61.955
"T0_5"	20120126	-64.4280	45.3690	5.74	5.80	3.85	45.85	967.4	231	Night	1092	-78.8277	21.35481	0.0000005	-63.050
"T0_6"	20120126	-64.4277	45.3690	7.51	7.60	5.15	43.77	971.0	308	Night	1077	-61.3015	1141.587	0.0000265	-45.770
"T0_7"	20120126	-64.4289	45.3695	9.95	10.02	4.18	37.97	822.1	251	Night	608	-61.3283	950.3477	0.0000220	-46.566
"T0_8"	20120126	-64.4275	45.3689	11.68	11.74	4.07	34.70	955.8	244	Tran1	230	-59.6573	1243.809	0.0000289	-45.397
"T0_9"	20120126	-64.4266	45.3687	13.08	13.14	3.83	34.34	893.2	230	Day	150	-81.7453	7.587806	0.0000002	-67.544
"T0_10"	20120126	-64.4273	45.3688	15.48	15.54	3.78	40.25	1037.1	227	Day	548	-60.0338	1378.221	0.0000320	-44.952
"T1_1"	20120125	-64.4288	45.3682	18.68	18.75	4.00	51.31	1018.1	239	Day	1147	-71.3648	136.2522	0.0000032	-55.001
"T1_2"	20120125	-64.4289	45.3681	21.04	21.11	4.02	45.04	975.0	240	Tran2	738	-44.8746	51918.48	0.0012046	-29.192
"T1_3"	20120125	-64.4290	45.3683	23.15	23.21	3.65	40.78	983.7	219	Night	224	-58.7901	1865.383	0.0000433	-43.637
"T1_4"	20120126	-64.4285	45.3682	0.64	0.75	6.72	39.85	1075.8	402	Night	102	-76.6737	29.50426	0.0000007	-61.646
"T1_5"	20120126	-64.4287	45.3682	5.87	5.97	6.37	50.70	985.7	382	Night	1107	-78.5592	25.62561	0.0000006	-62.258
"T1_6"	20120126	-64.4291	45.3680	7.61	7.68	4.22	48.67	1035.4	253	Night	1067	-54.1931	6670.25	0.0001548	-38.103
"T1_7"	20120126	-64.4298	45.3684	10.05	10.12	4.52	42.39	1122.3	271	Night	579	-54.0184	5871.108	0.0001362	-38.658
"T1_8"	20120126	-64.4287	45.3683	11.76	11.82	3.97	39.83	980.8	238	Tran1	218	-67.4649	245.6924	0.0000057	-52.441
"T1_9"	20120126	-64.4283	45.3682	13.15	13.27	7.08	40.17	1039.9	424	Day	154	-78.8176	18.18574	0.0000004	-63.748
"T1_10"	20120126	-64.4295	45.3685	15.64	16.15	30.47	46.31	1244.1	1827	Day	644	-66.0527	409.5006	0.0000095	-50.222
"T2_1"	20120125	-64.4282	45.3673	18.78	18.98	12.02	49.85	1307.7	468	Day	1138	-65.6197	494.2203	0.0000115	-49.406
"T2_2"	20120125	-64.4284	45.3675	21.14	21.29	9.32	45.25	1031.1	558	Tran2	705	-56.1692	3876.129	0.0000899	-40.461
"T2_3"	20120125	-64.4287	45.3674	23.22	23.31	5.12	39.26	1013.7	306	Night	209	-69.8195	140.3283	0.0000033	-54.873
"T2_4"	20120126	-64.4292	45.3673	0.78	0.86	4.57	39.84	1018.1	274	Night	107	-77.883	22.32441	0.0000005	-62.857
"T2_5"	20120126	-64.4301	45.3675	5.97	6.06	5.18	50.27	1247.5	310	Night	1114	-73.6867	77.90357	0.0000018	-57.429
"T2_6"	20120126	-64.4289	45.3676	7.76	7.92	9.22	48.79	1059.0	552	Night	1042	-57.459	3153.568	0.0000732	-41.357
"T2_7"	20120126	-64.4279	45.3674	10.19	10.30	6.52	41.91	1026.9	390	Night	542	-51.7774	9698.994	0.0002250	-36.478
"T2_8"	20120126	-64.4288	45.3674	11.84	11.91	4.20	38.20	1023.4	252	Tran1	206	-70.7586	109.1906	0.0000025	-55.963
"T2_9"	20120126	-64.4284	45.3675	13.29	13.36	3.90	38.95	1006.1	234	Day	162	-81.8941	8.617558	0.0000002	-66.991
"T2_10"	20120126	-64.4272	45.3671	16.21	16.26	2.75	44.66	814.3	164	Day	728	-54.4038	5728.188	0.0001329	-38.765
"T3_1"	20120125	-64.4312	45.3675	18.98	19.03	2.87	50.92	738.9	172	Day	1122	-71.3093	136.7636	0.0000032	-54.985
"T3_2"	20120125	-64.4300	45.3670	21.30	21.37	3.85	43.39	1003.4	231	Tran2	670	-63.5622	671.031	0.0000156	-48.077
"T3_3"	20120125	-64.4297	45.3669	23.32	23.38	3.55	39.21	1000.8	213	Night	195	-66.3761	309.5517	0.0000072	-51.438
"T3_4"	20120126	-64.4291	45.3669	0.88	1.00	7.02	39.07	1019.6	420	Night	114	-77.3536	24.60588	0.0000006	-62.435
"T3_5"	20120126	-64.4292	45.3669	6.11	6.21	5.78	49.08	1004.1	347	Night	1124	-78.7127	23.79801	0.0000006	-62.580
"T3_6"	20120126	-64.4302	45.3671	7.94	8.00	3.45	48.83	1003.2	207	Night	1023	-68.7869	232.514	0.0000054	-52.680

Table A5-9-5.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T3_7"	20120126	-64.4298	45.3671	10.31	10.38	4.07	40.73	1002.2	244	Night	517	-55.94	3590.034	0.0000833	-40.794
"T3_8"	20120126	-64.4295	45.3669	11.92	11.99	4.07	38.91	984.3	244	Tran1	196	-68.6229	182.772	0.0000042	-53.726
"T3_9"	20120126	-64.4292	45.3670	13.38	13.47	5.82	38.78	1021.3	348	Day	169	-79.7745	13.96114	0.0000003	-64.896
"T4_1"	20120125	-64.4301	45.3658	19.07	19.22	9.03	44.18	933.6	541	Day	1108	-64.0599	611.7669	0.0000142	-48.479
"T4_2"	20120125	-64.4293	45.3656	21.39	21.56	9.80	37.18	1031.5	587	Tran2	636	-62.0012	792.5258	0.0000184	-47.355
"T4_3"	20120125	-64.4297	45.3655	23.40	23.50	5.83	33.27	1024.0	349	Night	179	-77.4359	19.63381	0.0000005	-63.415
"T4_4"	20120126	-64.4297	45.3655	1.05	1.12	4.12	32.81	1008.2	246	Night	126	-77.3692	19.57148	0.0000005	-63.429
"T4_5"	20120126	-64.4298	45.3655	6.23	6.29	4.15	43.26	984.9	248	Night	1129	-75.5471	42.33529	0.0000010	-60.078
"T4_6"	20120126	-64.4294	45.3657	8.05	8.26	12.97	41.25	1040.8	777	Night	994	-64.1824	546.5609	0.0000127	-48.969
"T4_7"	20120126	-64.4295	45.3656	10.41	10.53	7.15	34.13	1021.0	428	Night	484	-66.0941	276.5544	0.0000064	-51.927
"T4_8"	20120126	-64.4293	45.3655	12.01	12.08	4.38	31.68	991.7	263	Tran1	186	-78.2645	15.2043	0.0000004	-64.525
"T4_9"	20120126	-64.4294	45.3655	13.49	13.55	3.38	32.43	981.0	203	Day	178	-78.4143	15.1513	0.0000004	-64.540
"T5_1"	20120125	-64.4304	45.3650	19.26	19.33	3.82	41.24	1006.4	228	Day	1089	-72.0765	88.74715	0.0000021	-56.863
"T5_2"	20120125	-64.4311	45.3652	21.57	21.64	4.03	36.27	1032.7	241	Tran2	601	-62.7544	645.5434	0.0000150	-48.246
"T5_3"	20120125	-64.4304	45.3648	23.51	23.57	3.63	31.35	1005.4	218	Night	165	-78.3319	14.75893	0.0000003	-64.654
"T5_4"	20120126	-64.4302	45.3649	1.17	1.29	7.28	31.80	1012.9	436	Night	138	-76.2036	24.55289	0.0000006	-62.444
"T5_5"	20120126	-64.4296	45.3648	6.35	6.45	6.07	41.46	1028.5	364	Night	1133	-78.8666	18.70526	0.0000004	-63.625
"T5_6"	20120126	-64.4306	45.3647	8.31	8.37	3.80	39.01	1093.0	227	Night	964	-72.4343	76.24396	0.0000018	-57.523
"T5_7"	20120126	-64.4308	45.3648	10.54	10.60	3.70	33.21	1017.4	222	Night	460	-68.8206	142.3935	0.0000033	-54.810
"T5_8"	20120126	-64.4305	45.3650	12.10	12.17	4.05	31.11	1010.6	242	Tran1	178	-75.5459	27.74885	0.0000006	-61.912
"T5_9"	20120126	-64.4301	45.3648	13.59	13.72	7.68	32.09	1025.3	461	Day	192	-80.3866	9.488154	0.0000002	-66.573
"T6_1"	20120125	-64.4307	45.3640	19.37	19.57	11.75	41.15	1052.8	702	Day	1064	-76.6794	30.66513	0.0000007	-61.478
"T6_2"	20120125	-64.4300	45.3640	21.74	21.94	11.70	33.99	1080.7	701	Tran2	539	-64.5421	393.2717	0.0000091	-50.398
"T6_3"	20120125	-64.4304	45.3639	23.59	23.69	5.63	31.02	1006.2	337	Night	152	-80.0327	9.833515	0.0000002	-66.418
"T6_4"	20120126	-64.4304	45.3637	1.56	1.62	3.62	30.90	1040.0	217	Night	185	-77.6217	17.04434	0.0000004	-64.029
"T6_5"	20120126	-64.4300	45.3634	6.46	6.53	4.22	40.10	1001.4	253	Night	1135	-78.2707	20.58443	0.0000005	-63.210
"T6_6"	20120126	-64.4299	45.3639	8.42	8.67	15.30	37.90	1081.3	918	Night	927	-68.8391	168.2316	0.0000039	-54.086
"T6_7"	20120126	-64.4302	45.3639	10.63	10.76	8.15	32.39	1045.7	488	Night	433	-71.5841	72.90579	0.0000017	-57.717
"T6_8"	20120126	-64.4302	45.3638	12.18	12.25	4.33	29.67	974.3	260	Tran1	169	-79.4137	10.67529	0.0000002	-66.061
"T6_9"	20120126	-64.4302	45.3637	13.74	13.80	3.65	29.80	974.7	219	Day	206	-71.5858	65.13824	0.0000015	-58.207
"T7_1"	20120125	-64.4310	45.3629	19.59	19.66	4.00	40.79	1014.0	239	Day	1041	-78.4463	20.19165	0.0000005	-63.293
"T7_2"	20120125	-64.4315	45.3631	21.97	22.03	3.77	33.73	1028.3	225	Tran2	495	-65.3252	324.9904	0.0000075	-51.226
"T7_3"	20120125	-64.4309	45.3631	23.70	23.76	3.90	30.44	1025.9	234	Night	142	-78.6849	13.07308	0.0000003	-65.181
"T7_5"	20120126	-64.4314	45.3631	1.68	1.93	15.00	33.91	1167.4	899	Night	219	-78.5951	15.41412	0.0000004	-64.466
"T7_5"	20120126	-64.4306	45.3629	6.57	6.66	5.60	41.67	1016.9	336	Night	1135	-77.8318	23.8883	0.0000006	-62.563
"T7_6"	20120126	-64.4326	45.3635	8.72	8.80	4.35	38.10	1071.3	261	Night	885	-69.3667	149.9515	0.0000035	-54.585
"T7_7"	20120126	-64.4317	45.3632	10.78	10.85	4.22	32.99	1072.0	253	Tran1	405	-71.2455	80.75766	0.0000019	-57.273
"T7_8"	20120126	-64.4311	45.3630	12.27	12.34	3.97	30.68	1011.7	238	Tran1	162	-76.0127	24.45008	0.0000006	-62.462
"T7_9"	20120126	-64.4312	45.3631	13.93	14.10	10.27	32.30	1042.2	615	Day	238	-77.2792	19.57358	0.0000005	-63.428
"T8_1"	20120125	-64.4313	45.3622	19.70	19.96	15.42	40.41	1140.5	924	Day	1010	-76.3674	32.21905	0.0000007	-61.264

Table A5-9-5.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_2"	20120125	-64.4319	45.3623	22.07	22.28	12.85	34.36	1236.0	770	Tran2	452	-68.5199	159.591	0.0000037	-54.315
"T8_3"	20120125	-64.4314	45.3620	23.79	23.88	5.43	32.85	1014.2	325	Night	131	-77.337	19.75446	0.0000005	-63.388
"T8_4"	20120126	-64.4308	45.3619	1.98	2.03	3.20	34.91	973.5	191	Night	254	-64.3436	426.0982	0.0000099	-50.050
"T8_5"	20120126	-64.4311	45.3621	6.68	6.75	4.30	42.48	967.0	258	Night	1134	-77.4781	26.53791	0.0000006	-62.106
"T8_6"	20120126	-64.4314	45.3620	8.86	9.13	16.35	38.16	1086.0	979	Night	837	-68.2858	192.708	0.0000045	-53.496
"T8_7"	20120126	-64.4311	45.3621	10.91	11.03	7.68	33.61	1028.3	460	Tran1	368	-79.0211	13.815	0.0000003	-64.941
"T8_8"	20120126	-64.4311	45.3620	12.36	12.43	4.60	32.04	1050.2	275	Tran1	157	-77.8091	17.1363	0.0000004	-64.006
"T8_9"	20120126	-64.4312	45.3618	14.11	14.17	3.58	37.57	1050.4	215	Day	259	-62.1658	773.3895	0.0000179	-47.461
"X1_1"	20120125	-64.4304	45.3476	19.97	20.26	17.57	77.83	3108.7	1028	Day	955	-70.3216	279.3992	0.0000065	-51.883
"X1_2"	20120125	-64.4297	45.3476	22.31	22.62	18.05	66.63	3483.9	1081	Night	380	-74.2819	94.22988	0.0000022	-56.603
"X1_3"	20120126	-64.4314	45.3448	23.90	0.14	-1425.70	65.78	3400.6	857	Night	115	-75.4535	70.90878	0.0000016	-57.838
"X1_4"	20120126	-64.4306	45.3449	2.20	2.52	19.37	77.22	3326.0	1161	Night	325	-59.7492	3159.778	0.0000733	-41.348
"X1_5"	20120126	-64.4309	45.3462	6.78	7.04	15.30	77.58	3316.4	917	Night	1128	-79.0691	37.14453	0.0000009	-60.646
"X1_6"	20120126	-64.4298	45.3479	9.14	9.44	18.17	71.56	3282.9	1089	Night	771	-71.8858	177.3882	0.0000041	-53.856
"X1_7"	20120126	-64.4302	45.3471	11.04	11.28	14.15	66.76	3313.3	848	Tran1	329	-77.5505	44.49145	0.0000010	-59.862
"X1_8"	20120126	-64.4306	45.3461	12.45	12.66	12.72	66.46	3346.1	762	Tran1	148	-77.5453	44.32287	0.0000010	-59.879
"X1_9"	20120126	-64.4328	45.3399	14.31	14.45	8.42	82.52	2010.4	504	Day	300	-75.8029	84.39752	0.0000020	-57.082
"Y1_1"	20120125	-64.4472	45.3347	20.28	20.37	5.72	46.49	1151.1	342	Tran2	911	-70.4336	150.0333	0.0000035	-54.583
"Y1_2"	20120125	-64.4440	45.3322	22.62	22.67	3.43	29.06	1140.0	206	Night	336	-74.079	35.44094	0.0000008	-60.850
"Y1_3"	20120126	-64.4451	45.3322	0.15	0.22	4.43	27.45	908.3	265	Night	106	-74.6738	28.53617	0.0000007	-61.791
"Y1_4"	20120126	-64.4446	45.3309	2.54	2.63	5.60	30.67	1128.6	336	Night	377	-82.9204	4.980455	0.0000001	-69.372
"Y1_5"	20120126	-64.4440	45.3323	7.05	7.11	3.28	38.88	797.7	196	Night	1119	-79.1312	16.24368	0.0000004	-64.238
"Y1_6"	20120126	-64.4463	45.3328	9.46	9.50	2.20	34.26	826.9	132	Night	728	-69.2792	133.4726	0.0000031	-55.091
"Y1_7"	20120126	-64.4446	45.3324	11.29	11.34	3.23	30.16	1042.7	193	Tran1	299	-75.2742	28.32024	0.0000007	-61.824
"Y1_8"	20120126	-64.4439	45.3322	12.66	12.74	4.73	28.55	1082.1	284	Tran1	145	-78.6164	12.16225	0.0000003	-65.495
"Y1_9"	20120126	-64.4447	45.3329	14.48	14.55	4.00	33.48	794.9	240	Day	325	-77.4821	19.59042	0.0000005	-63.424
"X2_1"	20120125	-64.4428	45.3504	20.39	20.93	31.90	67.68	4489.1	1911	Tran2	838	-63.6099	1119.778	0.0000260	-45.854
"X2_2"	20120125	-64.4420	45.3518	22.67	23.03	21.52	59.40	4461.9	1289	Night	288	-69.6942	237.5881	0.0000055	-52.587
"X2_3"	20120126	-64.4419	45.3526	0.22	0.55	19.80	58.65	4396.3	1186	Night	99	-77.2849	40.77195	0.0000009	-60.241
"X2_4"	20120126	-64.4408	45.3477	2.67	3.31	38.50	74.20	4285.3	2306	Night	472	-57.2573	5363.36	0.0001244	-39.051
"X2_5"	20120126	-64.4436	45.3478	7.12	7.49	22.50	62.64	5036.4	1349	Night	1102	-72.3367	137.4319	0.0000032	-54.964
"X2_6"	20120126	-64.4427	45.3510	9.51	9.92	25.03	64.31	4391.6	1500	Night	673	-62.4027	1395.125	0.0000324	-44.899
"X2_7"	20120126	-64.4421	45.3522	11.35	11.65	18.55	58.67	4357.0	1112	Tran1	265	-72.6049	119.8166	0.0000028	-55.560
"X2_8"	20120126	-64.4419	45.3525	12.75	13.04	17.45	58.10	4319.8	1046	Day	144	-78.1145	33.31336	0.0000008	-61.119
"X2_9"	20120126	-64.4422	45.3496	14.56	14.93	22.28	64.58	3751.9	1336	Day	372	-60.595	2125.446	0.0000493	-43.070

Table A5-9-5.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the January 26, 2012 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120125	-64.4285	45.3693	18.55	18.65	5.97	46.09	1025.3	1233	Day	1155	-74.5352	52.75796	0.0000012	-59.122
"T0_2"	20120125	-64.4279	45.3691	20.93	21.02	5.40	40.22	997.5	324	Tran2	763	0	0	0.0000000	0.000
"T0_3"	20120125	-64.4307	45.3696	23.05	23.10	2.95	37.42	587.4	176	Night	243	-75.0984	34.94248	0.0000008	-60.911
"T0_4"	20120126	-64.4271	45.3689	0.56	0.62	3.47	34.92	875.5	208	Night	100	-76.4377	31.35654	0.0000007	-61.382
"T0_5"	20120126	-64.4280	45.3690	5.74	5.80	3.85	45.85	967.4	231	Night	1092	-79.4905	19.55945	0.0000005	-63.431
"T0_6"	20120126	-64.4277	45.3690	7.51	7.60	5.15	43.77	971.0	308	Night	1077	-77.8785	25.05738	0.0000006	-62.356
"T0_7"	20120126	-64.4289	45.3695	9.95	10.02	4.18	37.97	822.1	251	Night	608	-76.5451	8.398331	0.0000002	-67.103
"T0_8"	20120126	-64.4275	45.3689	11.68	11.74	4.07	34.70	955.8	244	Tran1	230	-78.8752	7.254872	0.0000002	-67.739
"T0_9"	20120126	-64.4266	45.3687	13.08	13.14	3.83	34.34	893.2	230	Day	150	-81.9386	8.32623	0.0000002	-67.140
"T0_10"	20120126	-64.4273	45.3688	15.48	15.54	3.78	40.25	1037.1	227	Day	548	-74.503	24.17934	0.0000006	-62.510
"T1_1"	20120125	-64.4288	45.3682	18.68	18.75	4.00	51.31	1018.1	239	Day	1147	-74.0846	61.25679	0.0000014	-58.473
"T1_2"	20120125	-64.4289	45.3681	21.04	21.11	4.02	45.04	975.0	240	Tran2	738	0	0	0.0000000	0.000
"T1_3"	20120125	-64.4290	45.3683	23.15	23.21	3.65	40.78	983.7	219	Night	224	-76.9287	23.12606	0.0000005	-62.704
"T1_4"	20120126	-64.4285	45.3682	0.64	0.75	6.72	39.85	1075.8	402	Night	102	-76.92	32.06463	0.0000007	-61.285
"T1_5"	20120126	-64.4287	45.3682	5.87	5.97	6.37	50.70	985.7	382	Night	1107	-78.307	29.15371	0.0000007	-61.698
"T1_6"	20120126	-64.4291	45.3680	7.61	7.68	4.22	48.67	1035.4	253	Night	1067	-75.5541	33.99881	0.0000008	-61.030
"T1_7"	20120126	-64.4298	45.3684	10.05	10.12	4.52	42.39	1122.3	271	Night	579	-73.9934	25.05052	0.0000006	-62.357
"T1_8"	20120126	-64.4287	45.3683	11.76	11.82	3.97	39.83	980.8	238	Tran1	218	-76.7872	19.21873	0.0000004	-63.508
"T1_9"	20120126	-64.4283	45.3682	13.15	13.27	7.08	40.17	1039.9	424	Day	154	-78.3958	22.62127	0.0000005	-62.800
"T1_10"	20120126	-64.4295	45.3685	15.64	16.15	30.47	46.31	1244.1	1827	Day	644	-76.2137	25.85274	0.0000006	-62.220
"T2_1"	20120125	-64.4282	45.3673	18.78	18.98	12.02	49.85	1307.7	468	Day	1138	-75.4584	42.25398	0.0000010	-60.086
"T2_2"	20120125	-64.4284	45.3675	21.14	21.29	9.32	45.25	1031.1	558	Tran2	705	-69.0453	105.0669	0.0000024	-56.130
"T2_3"	20120125	-64.4287	45.3674	23.22	23.31	5.12	39.26	1013.7	306	Night	209	-77.0808	23.98855	0.0000006	-62.545
"T2_4"	20120126	-64.4292	45.3673	0.78	0.86	4.57	39.84	1018.1	274	Night	107	-77.5838	29.05167	0.0000007	-61.713
"T2_5"	20120126	-64.4301	45.3675	5.97	6.06	5.18	50.27	1247.5	310	Night	1114	-79.0515	23.48722	0.0000005	-62.637
"T2_6"	20120126	-64.4289	45.3676	7.76	7.92	9.22	48.79	1059.0	552	Night	1042	-77.8044	14.49182	0.0000003	-64.734
"T2_7"	20120126	-64.4279	45.3674	10.19	10.30	6.52	41.91	1026.9	390	Night	542	-76.5314	9.794111	0.0000002	-66.435
"T2_8"	20120126	-64.4288	45.3674	11.84	11.91	4.20	38.20	1023.4	252	Tran1	206	-77.9581	19.74764	0.0000005	-63.390
"T2_9"	20120126	-64.4284	45.3675	13.29	13.36	3.90	38.95	1006.1	234	Day	162	-75.2728	45.207	0.0000010	-59.793
"T2_10"	20120126	-64.4272	45.3671	16.21	16.26	2.75	44.66	814.3	164	Day	728	-77.7209	16.35356	0.0000004	-64.209
"T3_1"	20120125	-64.4312	45.3675	18.98	19.03	2.87	50.92	738.9	172	Day	1122	-74.3518	60.45003	0.0000014	-58.531
"T3_2"	20120125	-64.4300	45.3670	21.30	21.37	3.85	43.39	1003.4	231	Tran2	670	-69.6993	118.277	0.0000027	-55.616
"T3_3"	20120125	-64.4297	45.3669	23.32	23.38	3.55	39.21	1000.8	213	Night	195	-76.9827	19.0328	0.0000004	-63.550
"T3_4"	20120126	-64.4291	45.3669	0.88	1.00	7.02	39.07	1019.6	420	Night	114	-77.232	30.52366	0.0000007	-61.499
"T3_5"	20120126	-64.4292	45.3669	6.11	6.21	5.78	49.08	1004.1	347	Night	1124	-78.4375	28.07824	0.0000007	-61.861
"T3_6"	20120126	-64.4302	45.3671	7.94	8.00	3.45	48.83	1003.2	207	Night	1023	-77.5784	28.20296	0.0000007	-61.842

Table A5-9-5.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscatterin Coefficent	Area Backscattering Strength
"T3_7"	20120126	-64.4298	45.3671	10.31	10.38	4.07	40.73	1002.2	244	Night	517	-74.0176	30.42043	0.0000007	-61.513
"T3_8"	20120126	-64.4295	45.3669	11.92	11.99	4.07	38.91	984.3	244	Tran1	196	-76.2499	28.38955	0.0000007	-61.813
"T3_9"	20120126	-64.4292	45.3670	13.38	13.47	5.82	38.78	1021.3	348	Day	169	-79.5683	17.00204	0.0000004	-64.040
"T4_1"	20120125	-64.4301	45.3658	19.07	19.22	9.03	44.18	933.6	541	Day	1108	-73.8355	49.79836	0.0000012	-59.373
"T4_2"	20120125	-64.4293	45.3656	21.39	21.56	9.80	37.18	1031.5	587	Tran2	636	-69.317	72.50087	0.0000017	-57.741
"T4_3"	20120125	-64.4297	45.3655	23.40	23.50	5.83	33.27	1024.0	349	Night	179	-77.5866	20.9098	0.0000005	-63.141
"T4_4"	20120126	-64.4297	45.3655	1.05	1.12	4.12	32.81	1008.2	246	Night	126	-152.679	69.05254	0.0000016	-122.209
"T4_5"	20120126	-64.4298	45.3655	6.23	6.29	4.15	43.26	984.9	248	Night	1129	0	0	0.0000000	0.000
"T4_6"	20120126	-64.4294	45.3657	8.05	8.26	12.97	41.25	1040.8	777	Night	994	-78.6747	12.49678	0.0000003	-65.377
"T4_7"	20120126	-64.4295	45.3656	10.41	10.53	7.15	34.13	1021.0	428	Night	484	-76.5207	10.7976	0.0000003	-66.012
"T4_8"	20120126	-64.4293	45.3655	12.01	12.08	4.38	31.68	991.7	263	Tran1	186	-78.3917	16.12659	0.0000004	-64.269
"T4_9"	20120126	-64.4294	45.3655	13.49	13.55	3.38	32.43	981.0	203	Day	178	-78.7296	16.74062	0.0000004	-64.107
"T5_1"	20120125	-64.4304	45.3650	19.26	19.33	3.82	41.24	1006.4	228	Day	1089	-75.1413	40.88417	0.0000009	-60.229
"T5_2"	20120125	-64.4311	45.3652	21.57	21.64	4.03	36.27	1032.7	241	Tran2	601	-70.0922	75.5537	0.0000018	-57.562
"T5_3"	20120125	-64.4304	45.3648	23.51	23.57	3.63	31.35	1005.4	218	Night	165	-78.2491	16.99596	0.0000004	-64.041
"T5_4"	20120126	-64.4302	45.3649	1.17	1.29	7.28	31.80	1012.9	436	Night	138	-75.992	32.26883	0.0000007	-61.257
"T5_5"	20120126	-64.4296	45.3648	6.35	6.45	6.07	41.46	1028.5	364	Night	1133	-78.4119	24.26271	0.0000006	-62.496
"T5_6"	20120126	-64.4306	45.3647	8.31	8.37	3.80	39.01	1093.0	227	Night	964	-77.9296	17.43088	0.0000004	-63.932
"T5_7"	20120126	-64.4308	45.3648	10.54	10.60	3.70	33.21	1017.4	222	Night	460	-77.0853	13.94079	0.0000003	-64.902
"T5_8"	20120126	-64.4305	45.3650	12.10	12.17	4.05	31.11	1010.6	242	Tran1	178	-76.8219	21.27911	0.0000005	-63.065
"T5_9"	20120126	-64.4301	45.3648	13.59	13.72	7.68	32.09	1025.3	461	Day	192	-77.1693	23.14248	0.0000005	-62.701
"T6_1"	20120125	-64.4307	45.3640	19.37	19.57	11.75	41.15	1052.8	702	Day	1064	-77.8871	22.67316	0.0000005	-62.790
"T6_2"	20120125	-64.4300	45.3640	21.74	21.94	11.70	33.99	1080.7	701	Tran2	539	-74.5297	25.70057	0.0000006	-62.245
"T6_3"	20120125	-64.4304	45.3639	23.59	23.69	5.63	31.02	1006.2	337	Night	152	-78.665	15.58261	0.0000004	-64.419
"T6_5"	20120126	-64.4304	45.3637	1.56	1.62	3.62	30.90	1040.0	217	Night	185	-76.7954	23.2271	0.0000005	-62.685
"T6_4"	20120126	-64.4300	45.3634	6.46	6.53	4.22	40.10	1001.4	253	Night	1135	-78.2781	23.66943	0.0000005	-62.603
"T6_6"	20120126	-64.4299	45.3639	8.42	8.67	15.30	37.90	1081.3	918	Night	927	-79.548	9.297046	0.0000002	-66.661
"T6_7"	20120126	-64.4302	45.3639	10.63	10.76	8.15	32.39	1045.7	488	Night	433	-79.7611	8.515838	0.0000002	-67.043
"T6_8"	20120126	-64.4302	45.3638	12.18	12.25	4.33	29.67	974.3	260	Tran1	169	-78.881	13.8813	0.0000003	-64.921
"T6_9"	20120126	-64.4302	45.3637	13.74	13.80	3.65	29.80	974.7	219	Day	206	-79.6072	10.9449	0.0000003	-65.953
"T7_1"	20120125	-64.4310	45.3629	19.59	19.66	4.00	40.79	1014.0	239	Day	1041	-80.1743	13.38151	0.0000003	-65.080
"T7_2"	20120125	-64.4315	45.3631	21.97	22.03	3.77	33.73	1028.3	225	Tran2	495	-76.6506	15.18223	0.0000004	-64.532
"T7_3"	20120125	-64.4309	45.3631	23.70	23.76	3.90	30.44	1025.9	234	Night	142	-76.3544	24.21218	0.0000006	-62.505
"T7_4"	20120126	-64.4314	45.3631	1.68	1.93	15.00	33.91	1167.4	899	Night	219	-78.2635	17.32735	0.0000004	-63.958
"T7_5"	20120126	-64.4306	45.3629	6.57	6.66	5.60	41.67	1016.9	336	Night	1135	-77.1063	33.71194	0.0000008	-61.067
"T7_6"	20120126	-64.4326	45.3635	8.72	8.80	4.35	38.10	1071.3	261	Night	885	-78.4716	14.05694	0.0000003	-64.866
"T7_7"	20120126	-64.4317	45.3632	10.78	10.85	4.22	32.99	1072.0	253	Tran1	405	-71.1401	77.46595	0.0000018	-57.454
"T7_8"	20120126	-64.4311	45.3630	12.27	12.34	3.97	30.68	1011.7	238	Tran1	162	-75.1919	33.60131	0.0000008	-61.081
"T7_9"	20120126	-64.4312	45.3631	13.93	14.10	10.27	32.30	1042.2	615	Day	238	-79.0111	13.93471	0.0000003	-64.904
"T8_1"	20120125	-64.4313	45.3622	19.70	19.96	15.42	40.41	1140.5	924	Day	1010	-79.0302	17.42599	0.0000004	-63.933

Table A5-9-5.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_2"	20120125	-64.4319	45.3623	22.07	22.28	12.85	34.36	1236.0	770	Tran2	452	-77.6533	15.45771	0.0000004	-64.453
"T8_3"	20120125	-64.4314	45.3620	23.79	23.88	5.43	32.85	1014.2	325	Night	131	-76.8548	25.2043	0.0000006	-62.330
"T8_4"	20120126	-64.4308	45.3619	1.98	2.03	3.20	34.91	973.5	191	Night	254	-76.5509	15.69844	0.0000004	-64.386
"T8_5"	20120126	-64.4311	45.3621	6.68	6.75	4.30	42.48	967.0	258	Night	1134	-78.313	21.48215	0.0000005	-63.024
"T8_6"	20120126	-64.4314	45.3620	8.86	9.13	16.35	38.16	1086.0	979	Night	837	-76.0093	20.11191	0.0000005	-63.310
"T8_7"	20120126	-64.4311	45.3621	10.91	11.03	7.68	33.61	1028.3	460	Tran1	368	-79.919	11.35914	0.0000003	-65.791
"T8_8"	20120126	-64.4311	45.3620	12.36	12.43	4.60	32.04	1050.2	275	Tran1	157	-77.8444	18.28699	0.0000004	-63.723
"T8_9"	20120126	-64.4312	45.3618	14.11	14.17	3.58	37.57	1050.4	215	Day	259	-75.8271	22.3206	0.0000005	-62.858
"X1_1"	20120125	-64.4304	45.3476	19.97	20.26	17.57	77.83	3108.7	1028	Day	955	-77.1319	54.49598	0.0000013	-58.981
"X1_2"	20120125	-64.4297	45.3476	22.31	22.62	18.05	66.63	3483.9	1081	Night	380	-78.2256	35.85143	0.0000008	-60.800
"X1_3"	20120126	-64.4314	45.3448	23.90	0.14	-1425.70	65.78	3400.6	857	Night	115	-77.3797	45.58036	0.0000011	-59.757
"X1_4"	20120126	-64.4306	45.3449	2.20	2.52	19.37	77.22	3326.0	1161	Night	325	-77.7338	38.85943	0.0000009	-60.450
"X1_5"	20120126	-64.4309	45.3462	6.78	7.04	15.30	77.58	3316.4	917	Night	1128	-78.5972	41.9681	0.0000010	-60.116
"X1_6"	20120126	-64.4298	45.3479	9.14	9.44	18.17	71.56	3282.9	1089	Night	771	-78.659	32.75079	0.0000008	-61.193
"X1_7"	20120126	-64.4302	45.3471	11.04	11.28	14.15	66.76	3313.3	848	Tran1	329	-78.0107	39.62523	0.0000009	-60.365
"X1_8"	20120126	-64.4306	45.3461	12.45	12.66	12.72	66.46	3346.1	762	Tran1	148	-77.7175	44.02502	0.0000010	-59.908
"X1_9"	20120126	-64.4328	45.3399	14.31	14.45	8.42	82.52	2010.4	504	Day	300	-78.7417	39.03203	0.0000009	-60.431
"Y1_1"	20120125	-64.4472	45.3347	20.28	20.37	5.72	46.49	1151.1	342	Tran2	911	-73.3026	68.20958	0.0000016	-58.006
"Y1_2"	20120125	-64.4440	45.3322	22.62	22.67	3.43	29.06	1140.0	206	Night	336	-77.1629	15.53697	0.0000004	-64.431
"Y1_3"	20120126	-64.4451	45.3322	0.15	0.22	4.43	27.45	908.3	265	Night	106	-74.8546	34.04784	0.0000008	-61.024
"Y1_4"	20120126	-64.4446	45.3309	2.54	2.63	5.60	30.67	1128.6	336	Night	377	-82.1696	7.38918	0.0000002	-67.659
"Y1_5"	20120126	-64.4440	45.3323	7.05	7.11	3.28	38.88	797.7	196	Night	1119	-78.6275	18.98159	0.0000004	-63.562
"Y1_6"	20120126	-64.4463	45.3328	9.46	9.50	2.20	34.26	826.9	132	Night	728	-76.6729	16.50602	0.0000004	-64.168
"Y1_7"	20120126	-64.4446	45.3324	11.29	11.34	3.23	30.16	1042.7	193	Tran1	299	-75.0139	30.37825	0.0000007	-61.519
"Y1_8"	20120126	-64.4439	45.3322	12.66	12.74	4.73	28.55	1082.1	284	Tran1	145	-74.0496	43.01047	0.0000010	-60.009
"Y1_9"	20120126	-64.4447	45.3329	14.48	14.55	4.00	33.48	794.9	240	Day	325	-76.4476	26.4368	0.0000006	-62.123
"X2_1"	20120125	-64.4428	45.3504	20.39	20.93	31.90	67.68	4489.1	1911	Tran2	838	-77.0369	39.74168	0.0000009	-60.352
"X2_2"	20120125	-64.4420	45.3518	22.67	23.03	21.52	59.40	4461.9	1289	Night	288	0	0	0.0000000	0.000
"X2_3"	20120126	-64.4419	45.3526	0.22	0.55	19.80	58.65	4396.3	1186	Night	99	-156.457	65.37705	0.0000015	-122.581
"X2_4"	20120126	-64.4408	45.3477	2.67	3.31	38.50	74.20	4285.3	2306	Night	472	-74.5398	75.41308	0.0000017	-57.570
"X2_5"	20120126	-64.4436	45.3478	7.12	7.49	22.50	62.64	5036.4	1349	Night	1102	-77.9051	36.84963	0.0000009	-60.681
"X2_6"	20120126	-64.4427	45.3510	9.51	9.92	25.03	64.31	4391.6	1500	Night	673	-77.6265	31.77431	0.0000007	-61.324
"X2_7"	20120126	-64.4421	45.3522	11.35	11.65	18.55	58.67	4357.0	1112	Tran1	265	-78.2539	30.79159	0.0000007	-61.461
"X2_8"	20120126	-64.4419	45.3525	12.75	13.04	17.45	58.10	4319.8	1046	Day	144	-77.2084	43.67809	0.0000010	-59.942
"X2_9"	20120126	-64.4422	45.3496	14.56	14.93	22.28	64.58	3751.9	1336	Day	372	-78.8483	24.51144	0.0000006	-62.451

Table A5-9-6.1. Summary of acoustic backscatter from **2 m** below the transducer to bottom by individual transect for the March 19, 2012 survey in Minas Passage. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120319	-64.4274	45.3688	14.39	14.46	3.90	45.03	908.2	233	Day	994	-80.6613	16.7	0.0000004	-64.127
"T0_2"	20120319	-64.4283	45.3690	15.81	15.91	5.77	43.14	1026.9	345	Day	706	-64.0595	730.2	0.0000169	-47.711
"T0_3"	20120319	-64.4283	45.3693	17.99	18.08	5.50	38.04	975.4	330	Day	217	-61.0151	1297.7	0.0000301	-45.213
"T0_4"	20120319	-64.4280	45.3690	19.91	19.99	5.32	35.12	1061.5	318	Day	179	-74.4576	54.2	0.0000013	-59.002
"T0_5"	20120319	-64.4288	45.3692	21.53	21.60	3.97	36.27	1019.1	237	Tran2	456	-68.0936	242.5	0.0000056	-52.498
"T0_6"	20120320	-64.4284	45.3689	0.23	0.29	3.23	43.00	1000.7	193	Night	1044	-57.1772	3550.4	0.0000824	-40.842
"T0_7"	20120320	-64.4277	45.3689	2.75	2.81	3.60	45.74	998.7	215	Night	997	-68.9625	250.3	0.0000058	-52.359
"T0_8"	20120320	-64.4279	45.3691	4.13	4.23	5.85	43.13	1026.4	351	Night	730	-60.0726	1828.1	0.0000424	-43.725
"T0_9"	20120320	-64.4280	45.3690	6.21	6.30	5.25	38.32	993.0	314	Night	253	-59.7562	1746.9	0.0000405	-43.922
"T0_10"	20120320	-64.4283	45.3691	7.89	7.96	4.50	35.11	990.0	269	Night	160	-78.4285	21.7	0.0000005	-62.974
"T0_11"	20120320	-64.4282	45.3693	9.29	9.37	4.48	35.46	963.0	269	Night	343	-84.5475	5.4	0.0000001	-69.050
"T0_12"	20120320	-64.4271	45.3693	11.13	11.18	3.25	36.24	899.7	195	Tran1	784	-48.9036	20105.1	0.0004665	-33.312
"T1_1"	20120319	-64.4290	45.3682	14.47	14.54	4.00	48.59	986.7	240	Day	981	-63.3698	963.9	0.0000224	-46.505
"T1_2"	20120319	-64.4290	45.3682	15.92	15.99	3.70	46.93	995.0	222	Day	681	-54.7229	6818.6	0.0001582	-38.008
"T1_3"	20120319	-64.4289	45.3684	18.10	18.17	4.18	42.12	988.2	250	Day	204	-56.5167	4048.6	0.0000939	-40.272
"T1_4"	20120319	-64.4286	45.3682	20.01	20.08	4.37	38.98	1028.4	262	Day	189	-78.9294	21.5	0.0000005	-63.021
"T1_5"	20120319	-64.4290	45.3684	21.62	21.73	6.40	40.46	1010.4	384	Tran2	483	-75.0953	54.0	0.0000013	-59.025
"T1_6"	20120320	-64.4288	45.3683	0.34	0.61	16.05	46.66	1071.8	962	Night	1068	-71.3285	148.1	0.0000034	-54.639
"T1_7"	20120320	-64.4289	45.3684	2.82	2.88	3.90	50.14	986.2	234	Night	985	-61.7708	1437.5	0.0000334	-44.769
"T1_8"	20120320	-64.4293	45.3683	4.24	4.30	3.70	47.67	989.9	222	Night	706	-56.0405	5112.7	0.0001186	-39.258
"T1_9"	20120320	-64.4290	45.3684	6.31	6.37	3.48	43.09	970.9	209	Night	240	-51.2706	13862.7	0.0003216	-34.926
"T1_10"	20120320	-64.4288	45.3684	7.98	8.03	3.27	40.20	993.1	196	Night	165	-66.9002	353.8	0.0000082	-50.857
"T1_11"	20120320	-64.4280	45.3681	9.40	9.49	5.72	40.41	1037.7	342	Tran1	366	-81.4208	12.6	0.0000003	-65.356
"T1_12"	20120320	-64.4293	45.3683	11.24	11.55	18.97	44.16	1123.4	1137	Day	842	-73.6824	81.5	0.0000019	-57.233
"T2_1"	20120319	-64.4283	45.3673	14.56	14.62	4.03	47.41	933.0	241	Day	968	-58.3368	2997.2	0.0000695	-41.578
"T2_2"	20120319	-64.4287	45.3674	16.01	16.17	9.20	46.56	1035.0	551	Day	648	-70.7228	169.9	0.0000039	-54.043
"T2_3"	20120319	-64.4287	45.3674	18.20	18.33	7.63	41.45	1028.6	458	Day	189	-57.4801	3191.8	0.0000741	-41.305
"T2_4"	20120319	-64.4289	45.3675	20.11	20.19	4.73	38.45	1009.7	283	Day	201	-76.5823	36.4	0.0000008	-60.734
"T2_5"	20120319	-64.4290	45.3674	21.75	21.82	4.02	38.79	1015.8	240	Tran2	510	-69.9249	170.1	0.0000039	-54.037
"T2_6"	20120320	-64.4283	45.3673	0.64	0.69	3.22	44.67	1013.0	192	Night	1084	-54.6708	6568.4	0.0001524	-38.170
"T2_7"	20120320	-64.4284	45.3673	2.90	2.96	3.70	48.95	1006.8	222	Night	975	-61.8312	1384.1	0.0000321	-44.933
"T2_8"	20120320	-64.4295	45.3677	4.31	4.47	9.52	47.89	1200.1	571	Night	678	-71.4827	146.7	0.0000034	-54.681
"T2_9"	20120320	-64.4284	45.3674	6.39	6.51	7.02	43.11	1010.8	420	Night	225	-65.7041	499.6	0.0000116	-49.359
"T2_10"	20120320	-64.4289	45.3675	8.05	8.12	4.43	40.24	1004.3	266	Night	169	-70.623	150.3	0.0000035	-54.576
"T2_11"	20120320	-64.4291	45.3676	9.51	9.58	4.25	39.59	1007.7	255	Tran1	387	-80.762	14.3	0.0000003	-64.786
"T2_12"	20120320	-64.4282	45.3673	11.58	11.63	3.10	42.27	981.7	186	Day	894	-53.9459	7344.7	0.0001704	-37.685

Table A5-9-6.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T3_1"	20120319	-64.4293	45.3669	14.64	14.70	3.77	47.21	982.0	226	Day	954	-58.8002	2682.4	0.0000622	-42.060
"T3_2"	20120319	-64.4299	45.3672	16.19	16.25	3.37	46.87	975.1	202	Day	615	-68.9679	256.2	0.0000059	-52.259
"T3_3"	20120319	-64.4295	45.3669	18.35	18.41	3.88	40.70	989.2	233	Day	177	-59.336	2044.2	0.0000474	-43.240
"T3_4"	20120319	-64.4294	45.3669	20.21	20.28	4.47	37.51	1037.7	268	Day	213	-75.1508	49.4	0.0000011	-59.410
"T3_5"	20120319	-64.4289	45.3670	21.84	21.97	7.95	39.46	1014.6	477	Tran2	538	-74.4523	61.0	0.0000014	-58.491
"T3_6"	20120320	-64.4281	45.3669	0.79	1.09	17.95	46.61	1146.3	1075	Night	1100	-68.7137	270.1	0.0000063	-52.029
"T3_7"	20120320	-64.4295	45.3669	2.97	3.04	3.75	48.47	995.2	224	Night	962	-58.4374	2993.8	0.0000695	-41.583
"T3_8"	20120320	-64.4297	45.3671	4.49	4.55	3.53	47.60	971.6	212	Night	645	-70.7839	171.3	0.0000040	-54.008
"T3_9"	20120320	-64.4294	45.3669	6.52	6.57	3.25	41.10	960.9	195	Night	212	-74.4576	63.5	0.0000015	-58.319
"T3_10"	20120320	-64.4294	45.3669	8.14	8.20	3.60	38.71	971.5	215	Night	177	-61.9218	1071.9	0.0000249	-46.043
"T3_11"	20120320	-64.4288	45.3669	9.62	9.71	5.52	38.22	1016.9	331	Tran1	412	-81.5317	11.6	0.0000003	-65.708
"T3_12"	20120320	-64.4279	45.3668	11.77	12.55	47.12	43.95	1717.7	2824	Day	1009	-60.0629	1867.0	0.0000433	-43.633
"T4_1"	20120319	-64.4295	45.3656	14.72	14.80	4.63	42.60	1000.7	278	Day	939	-73.1237	89.4	0.0000021	-56.829
"T4_2"	20120319	-64.4296	45.3657	16.28	16.45	10.07	39.54	1028.1	603	Day	581	-67.466	305.5	0.0000071	-51.495
"T4_3"	20120319	-64.4293	45.3657	18.45	18.57	7.38	34.51	1028.3	442	Day	164	-72.6857	80.1	0.0000019	-57.307
"T4_4"	20120319	-64.4300	45.3658	20.32	20.41	5.23	32.97	1011.7	313	Day	229	-74.756	47.5	0.0000011	-59.575
"T4_5"	20120319	-64.4291	45.3657	22.01	22.06	3.38	33.25	894.0	203	Tran2	571	-70.9142	116.1	0.0000027	-55.696
"T4_6"	20120320	-64.4289	45.3655	1.13	1.20	3.77	40.30	1016.5	226	Night	1106	-53.3223	8083.2	0.0001875	-37.269
"T4_7"	20120320	-64.4292	45.3655	3.05	3.12	3.75	41.85	973.8	225	Night	949	-58.8772	2336.0	0.0000542	-42.660
"T4_8"	20120320	-64.4290	45.3656	4.58	4.74	9.82	39.74	1027.4	588	Night	612	-69.6133	187.3	0.0000043	-53.621
"T4_9"	20120320	-64.4295	45.3656	6.60	6.72	7.35	35.60	1008.0	440	Night	197	-73.7923	64.1	0.0000015	-58.277
"T4_10"	20120320	-64.4296	45.3657	8.22	8.30	4.80	33.40	1008.2	288	Night	185	-81.0186	11.4	0.0000003	-65.781
"T4_11"	20120320	-64.4298	45.3659	9.74	9.81	4.30	34.16	1013.5	258	Tran1	438	-81.2466	11.0	0.0000003	-65.911
"T4_12"	20120320	-64.4294	45.3654	12.60	12.66	3.13	38.65	971.3	188	Day	1082	-47.3506	30663.0	0.0007114	-31.479
"T5_1"	20120319	-64.4303	45.3648	14.82	14.88	3.60	41.62	988.1	215	Day	924	-68.3912	259.8	0.0000060	-52.198
"T5_2"	20120319	-64.4307	45.3650	16.47	16.53	3.48	37.11	988.4	208	Day	548	-71.7847	106.0	0.0000025	-56.090
"T5_3"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000	0.000
"T5_4"	20120319	-64.4309	45.3650	20.43	20.51	4.52	32.27	1121.8	271	Day	246	-77.7709	23.2	0.0000005	-62.683
"T5_5"	20120319	-64.4303	45.3649	22.10	22.25	9.12	32.23	1030.1	546	Tran2	604	-70.9146	112.5	0.0000026	-55.833
"T5_6"	20120320	-64.4297	45.3648	1.25	1.50	15.03	38.89	1103.5	901	Night	1106	-68.7471	223.7	0.0000052	-52.849
"T5_7"	20120320	-64.4305	45.3649	3.13	3.19	3.68	41.61	1016.3	221	Night	938	-62.2243	1074.7	0.0000249	-46.032
"T5_8"	20120320	-64.4306	45.3648	4.76	4.82	3.20	38.34	941.8	192	Night	579	-65.7467	440.1	0.0000102	-49.910
"T5_9"	20120320	-64.4304	45.3649	6.74	6.80	3.42	34.04	1004.7	205	Night	185	-76.7451	31.0	0.0000007	-61.425
"T5_10"	20120320	-64.4305	45.3649	8.31	8.37	3.22	31.84	967.2	192	Night	193	-82.0719	8.5	0.0000002	-67.042
"T5_11"	20120320	-64.4298	45.3648	9.83	9.93	6.12	31.79	1018.7	366	Tran1	461	-80.3288	12.7	0.0000003	-65.306
"T5_12"	20120320	-64.4283	45.3645	12.78	13.47	41.72	36.57	1661.9	2501	Day	1130	-63.675	676.3	0.0000157	-48.043
"T6_1"	20120319	-64.4302	45.3640	14.89	14.97	4.72	40.03	996.3	283	Day	906	-79.3403	20.1	0.0000005	-63.317
"T6_2"	20120319	-64.4300	45.3640	16.56	16.75	11.60	36.74	1036.5	695	Day	506	-73.6211	68.8	0.0000016	-57.970
"T6_3"	20120319	-64.4301	45.3639	18.70	18.86	9.18	31.96	1013.9	550	Day	147	-76.4523	31.2	0.0000007	-61.406
"T6_4"	20120319	-64.4307	45.3639	20.53	20.61	4.80	31.01	1000.8	287	Day	262	-77.4589	24.0	0.0000006	-62.544

Table A5-9-6.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent
"T6_5"	20120319	-64.4296	45.3638	22.27	22.35	5.00	31.29	1009.1	300	Tran2	637	-52.4383	7693.6	0.0001785
"T6_6"	20120320	-64.4297	45.3638	1.53	1.59	3.95	38.99	967.0	236	Night	1102	-56.504	3758.4	0.0000872
"T6_7"	20120320	-64.4298	45.3638	3.21	3.28	4.22	40.01	1019.8	253	Night	923	-59.7113	1842.9	0.0000428
"T6_8"	20120320	-64.4301	45.3639	4.84	5.05	12.27	38.27	1040.1	735	Night	541	-72.9373	83.9	0.0000019
"T6_9"	20120320	-64.4303	45.3640	6.83	6.96	8.27	33.28	1011.1	495	Night	174	-74.8419	47.0	0.0000011
"T6_10"	20120320	-64.4304	45.3639	8.38	8.47	4.87	31.37	1001.6	292	Night	202	-82.1131	8.3	0.0000002
"T6_11"	20120320	-64.4306	45.3641	9.95	10.02	4.15	32.62	1018.2	249	Tran1	488	-77.8053	23.3	0.0000005
"T6_12"	20120320	-64.4301	45.3637	13.50	13.55	2.93	38.46	1025.0	176	Day	1146	-55.811	4349.7	0.0001009
"T7_1"	20120319	-64.4310	45.3630	14.99	15.05	3.62	39.94	1000.2	217	Day	890	-80.4486	15.5	0.0000004
"T7_2"	20120319	-64.4312	45.3631	16.77	16.82	3.10	34.85	995.1	186	Day	473	-72.6025	82.5	0.0000019
"T7_3"	20120319	-64.4312	45.3631	18.88	18.94	3.70	31.48	1006.2	221	Day	142	-79.871	14.0	0.0000003
"T7_4"	20120319	-64.4310	45.3631	20.63	20.71	4.58	31.49	1035.3	275	Day	278	-74.6544	46.5	0.0000011
"T7_5"	20120319	-64.4314	45.3630	22.39	22.67	16.97	33.74	1188.9	1016	Tran2	691	-58.1071	2248.5	0.0000522
"T7_6"	20120320	-64.4310	45.3631	1.66	1.81	9.28	40.09	970.2	556	Night	1095	-68.8984	222.7	0.0000052
"T7_7"	20120320	-64.4314	45.3631	3.29	3.35	3.32	40.09	979.6	199	Night	908	-60.1214	1680.1	0.0000390
"T7_8"	20120320	-64.4314	45.3632	5.06	5.12	3.50	36.22	991.8	210	Night	504	-63.7803	653.8	0.0000152
"T7_9"	20120320	-64.4310	45.3632	6.98	7.04	3.48	32.63	998.1	209	Night	165	-72.0507	87.7	0.0000020
"T7_10"	20120320	-64.4309	45.3632	8.49	8.54	3.37	31.25	1001.8	202	Night	212	-79.9619	13.6	0.0000003
"T7_11"	20120320	-64.4306	45.3630	10.05	10.16	6.55	32.24	1011.1	392	Tran1	516	-80.3029	13.0	0.0000003
"T7_12"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000
"T8_1"	20120319	-64.4306	45.3621	15.07	15.17	5.73	41.87	1005.5	344	Day	870	-76.6993	38.6	0.0000009
"T8_2"	20120319	-64.4312	45.3622	16.86	17.07	12.75	37.13	1043.0	764	Day	432	-74.4402	57.6	0.0000013
"T8_3"	20120319	-64.4315	45.3622	18.98	19.12	8.38	32.78	1003.8	503	Day	139	-78.5813	19.6	0.0000005
"T8_4"	20120319	-64.4313	45.3621	20.73	20.81	4.80	32.37	1010.5	287	Day	295	-74.6219	48.1	0.0000011
"T8_5"	20120319	-64.4312	45.3619	22.69	22.74	3.15	35.39	978.7	189	Tran2	737	-48.483	21627.6	0.0005018
"T8_6"	20120320	-64.4310	45.3618	1.93	2.00	4.13	42.15	1011.0	247	Night	1081	-62.9301	925.2	0.0000215
"T8_7"	20120320	-64.4306	45.3619	3.37	3.44	4.57	42.31	985.1	273	Night	893	-65.2819	540.5	0.0000125
"T8_8"	20120320	-64.4310	45.3620	5.15	5.38	13.33	38.56	1032.1	800	Night	463	-72.8553	86.1	0.0000020
"T8_9"	20120320	-64.4313	45.3622	7.08	7.21	8.23	34.43	1005.6	493	Night	158	-79.6765	16.0	0.0000004
"T8_10"	20120320	-64.4314	45.3621	8.56	8.64	4.70	32.81	998.6	281	Night	222	-80.1292	13.7	0.0000003
"T8_11"	20120320	-64.4314	45.3621	10.17	10.24	3.98	33.67	1007.1	239	Tran1	541	-61.8835	940.6	0.0000218
"T8_12"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000
"X1_1"	20120319	-64.4299	45.3467	15.19	15.41	12.92	75.33	3276.1	774	Day	835	-78.5297	45.6	0.0000011
"X1_2"	20120319	-64.4306	45.3470	17.11	17.40	17.15	71.69	3275.8	1028	Day	363	-73.7425	130.5	0.0000030
"X1_3"	20120319	-64.4301	45.3472	19.19	19.44	14.58	67.28	3226.0	874	Day	140	-82.2929	17.1	0.0000004

Table A5-9-6.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"X1_4"	20120319	-64.4307	45.3466	20.85	21.08	14.27	66.87	3274.1	855	Day	329	-78.5369	40.4	0.0000009	-60.285
"X1_5"	20120319	-64.4304	45.3465	22.78	23.06	17.17	73.85	3297.4	1028	Tran2	790	-63.1021	1558.2	0.0000362	-44.419
"X1_6"	20120320	-64.4306	45.3466	2.06	2.27	12.57	77.48	3229.6	753	Night	1067	-70.1077	325.8	0.0000076	-51.216
"X1_7"	20120320	-64.4302	45.3462	3.47	3.68	12.35	76.90	3323.9	740	Night	861	-77.8767	54.0	0.0000013	-59.017
"X1_8"	20120320	-64.4300	45.3475	5.38	5.67	17.32	72.89	3288.7	1038	Night	400	-75.8132	82.4	0.0000019	-57.187
"X1_9"	20120320	-64.4301	45.3472	7.22	7.46	14.10	68.73	3269.5	845	Night	150	-81.1206	22.9	0.0000005	-62.749
"X1_10"	20120320	-64.4304	45.3465	8.66	8.86	12.53	67.14	3295.4	751	Night	245	-82.1689	17.6	0.0000004	-63.899
"X1_11"	20120320	-64.4304	45.3469	10.27	10.51	14.27	68.86	3249.5	855	Tran1	587	-81.2587	22.2	0.0000005	-62.879
"Y1_1"	20120319	-64.4432	45.3319	15.41	15.46	3.23	38.66	1170.9	193	Day	803	-83.6245	7.2	0.0000002	-67.752
"Y1_2"	20120319	-64.4435	45.3328	17.50	17.57	3.68	35.72	1084.3	220	Day	303	-79.9921	15.4	0.0000004	-64.463
"Y1_3"	20120319	-64.4419	45.3326	19.46	19.52	3.47	34.00	874.3	208	Day	146	-71.7186	98.6	0.0000023	-56.404
"Y1_4"	20120319	-64.4426	45.3326	21.10	21.20	5.85	32.88	1077.6	350	Day	365	-83.7791	5.9	0.0000001	-68.609
"Y1_5"	20120319	-64.4427	45.3327	23.10	23.18	5.00	35.62	1108.1	300	Tran2	841	-84.4089	5.6	0.0000001	-68.892
"Y1_6"	20120320	-64.4428	45.3326	2.29	2.36	4.28	41.49	1099.4	257	Night	1051	-73.2689	84.2	0.0000020	-57.089
"Y1_7"	20120320	-64.4433	45.3326	3.70	3.76	3.65	40.55	1108.2	219	Night	830	-68.4162	251.7	0.0000058	-52.337
"Y1_8"	20120320	-64.4431	45.3327	5.70	5.76	3.88	35.84	1096.2	233	Night	355	-53.6422	6678.2	0.0001549	-38.098
"Y1_9"	20120320	-64.4431	45.3327	7.48	7.55	3.95	33.99	1139.6	236	Night	148	-73.7313	62.1	0.0000014	-58.417
"Y1_10"	20120320	-64.4435	45.3328	8.89	8.97	4.60	31.43	938.0	276	Night	271	-83.0823	6.7	0.0000002	-68.109
"Y1_11"	20120320	-64.4420	45.3326	10.54	10.66	7.17	35.89	1141.2	429	Tran1	642	-83.4165	7.0	0.0000002	-67.866
"X2_1"	20120319	-64.4419	45.3519	15.47	15.79	19.30	64.79	4374.8	1157	Day	761	-78.205	42.2	0.0000010	-60.090
"X2_2"	20120319	-64.4425	45.3508	17.59	17.97	22.55	61.85	4396.0	1351	Day	260	-72.037	166.8	0.0000039	-54.124
"X2_3"	20120319	-64.4425	45.3510	19.56	19.88	19.22	56.96	4375.9	1152	Day	160	-79.323	28.7	0.0000007	-61.767
"X2_4"	20120319	-64.4421	45.3519	21.20	21.51	18.58	58.91	4332.8	1114	Day	411	-79.6117	27.8	0.0000006	-61.910
"X2_5"	20120319	-64.4400	45.3486	23.20	0.17	-1382.13	61.25	5819.4	3468	Night	956	-61.3629	1929.0	0.0000448	-43.492
"X2_6"	20120320	-64.4429	45.3494	2.37	2.73	21.23	63.99	4739.2	1272	Night	1025	-67.3321	509.8	0.0000118	-49.271
"X2_7"	20120320	-64.4419	45.3524	3.78	4.10	19.17	66.37	4410.4	1148	Night	783	-73.7993	119.3	0.0000028	-55.580
"X2_8"	20120320	-64.4425	45.3508	5.79	6.18	23.68	64.79	4396.1	1419	Night	301	-68.7794	369.9	0.0000086	-50.664
"X2_9"	20120320	-64.4423	45.3519	7.56	7.87	18.33	57.81	4415.9	1099	Night	151	-75.4011	71.8	0.0000017	-57.781
"X2_10"	20120320	-64.4422	45.3514	8.98	9.28	18.02	58.85	4318.1	1080	Night	305	-81.8015	16.8	0.0000004	-64.104
"X2_11"	20120320	-64.4407	45.3537	10.67	11.10	25.68	58.96	4439.5	1540	Tran1	715	-73.1185	123.9	0.0000029	-55.413

Table A5-9-6.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the March 19, 2012 survey in Minas Passage. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120319	-64.4274	45.3688	14.39	14.46	3.90	45.03	908.2	233	Day	994	-83.0892	7.8	0.0000002	-67.405
"T0_2"	20120319	-64.4283	45.3690	15.81	15.91	5.77	43.14	1026.9	345	Day	706	-65.7432	403.6	0.0000094	-50.286
"T0_3"	20120319	-64.4283	45.3693	17.99	18.08	5.50	38.04	975.4	330	Day	217	-63.9063	526.5	0.0000122	-49.131
"T0_4"	20120319	-64.4280	45.3690	19.91	19.99	5.32	35.12	1061.5	318	Day	179	-80.8735	9.6	0.0000002	-66.542
"T0_5"	20120319	-64.4288	45.3692	21.53	21.60	3.97	36.27	1019.1	237	Tran2	456	-85.0167	3.8	0.0000001	-70.504
"T0_6"	20120320	-64.4284	45.3689	0.23	0.29	3.23	43.00	1000.7	193	Night	1044	-68.8619	196.0	0.0000045	-53.421
"T0_7"	20120320	-64.4277	45.3689	2.75	2.81	3.60	45.74	998.7	215	Night	997	-78.9345	20.8	0.0000005	-63.167
"T0_8"	20120320	-64.4279	45.3691	4.13	4.23	5.85	43.13	1026.4	351	Night	730	-63.6498	653.3	0.0000152	-48.194
"T0_9"	20120320	-64.4280	45.3690	6.21	6.30	5.25	38.32	993.0	314	Night	253	-63.2795	614.0	0.0000142	-48.463
"T0_10"	20120320	-64.4283	45.3691	7.89	7.96	4.50	35.11	990.0	269	Night	160	-80.7318	9.9	0.0000002	-66.401
"T0_11"	20120320	-64.4282	45.3693	9.29	9.37	4.48	35.46	963.0	269	Night	343	-84.0403	4.7	0.0000001	-69.654
"T0_12"	20120320	-64.4271	45.3693	11.13	11.18	3.25	36.24	899.7	195	Tran1	784	-57.4473	2190.4	0.0000508	-42.940
"T1_1"	20120319	-64.4290	45.3682	14.47	14.54	4.00	48.59	986.7	240	Day	981	-80.8418	14.4	0.0000003	-64.759
"T1_2"	20120319	-64.4290	45.3682	15.92	15.99	3.70	46.93	995.0	222	Day	681	-59.4396	1909.0	0.0000443	-43.537
"T1_3"	20120319	-64.4289	45.3684	18.10	18.17	4.18	42.12	988.2	250	Day	204	-58.4154	2117.8	0.0000491	-43.086
"T1_4"	20120319	-64.4286	45.3682	20.01	20.08	4.37	38.98	1028.4	262	Day	189	-80.6986	11.4	0.0000003	-65.789
"T1_5"	20120319	-64.4290	45.3684	21.62	21.73	6.40	40.46	1010.4	384	Tran2	483	-83.8274	5.8	0.0000001	-68.714
"T1_6"	20120320	-64.4288	45.3683	0.34	0.61	16.05	46.66	1071.8	962	Night	1068	-78.0345	26.2	0.0000006	-62.163
"T1_7"	20120320	-64.4289	45.3684	2.82	2.88	3.90	50.14	986.2	234	Night	985	-76.9227	36.9	0.0000009	-60.676
"T1_8"	20120320	-64.4293	45.3683	4.24	4.30	3.70	47.67	989.9	222	Night	706	-63.1675	824.3	0.0000191	-47.184
"T1_9"	20120320	-64.4290	45.3684	6.31	6.37	3.48	43.09	970.9	209	Night	240	-54.4577	5418.5	0.0001257	-39.006
"T1_10"	20120320	-64.4288	45.3684	7.98	8.03	3.27	40.20	993.1	196	Night	165	-77.2755	26.0	0.0000006	-62.197
"T1_11"	20120320	-64.4280	45.3681	9.40	9.49	5.72	40.41	1037.7	342	Tran1	366	-82.4533	7.9	0.0000002	-67.348
"T1_12"	20120320	-64.4293	45.3683	11.24	11.55	18.97	44.16	1123.4	1137	Day	842	-77.7179	26.4	0.0000006	-62.137
"T2_1"	20120319	-64.4283	45.3673	14.56	14.62	4.03	47.41	933.0	241	Day	968	-74.6064	58.8	0.0000014	-58.651
"T2_2"	20120319	-64.4287	45.3674	16.01	16.17	9.20	46.56	1035.0	551	Day	648	-77.0694	32.6	0.0000008	-61.209
"T2_3"	20120319	-64.4287	45.3674	18.20	18.33	7.63	41.45	1028.6	458	Day	189	-62.1037	888.1	0.0000206	-46.860
"T2_4"	20120319	-64.4289	45.3675	20.11	20.19	4.73	38.45	1009.7	283	Day	201	-81.5144	9.3	0.0000002	-66.680
"T2_5"	20120319	-64.4290	45.3674	21.75	21.82	4.02	38.79	1015.8	240	Tran2	510	-82.5785	7.3	0.0000002	-67.695
"T2_6"	20120320	-64.4283	45.3673	0.64	0.69	3.22	44.67	1013.0	192	Night	1084	-64.8863	513.0	0.0000119	-49.244
"T2_7"	20120320	-64.4284	45.3673	2.90	2.96	3.70	48.95	1006.8	222	Night	975	-78.1791	26.8	0.0000006	-62.057
"T2_8"	20120320	-64.4295	45.3677	4.31	4.47	9.52	47.89	1200.1	571	Night	678	-77.203	32.7	0.0000008	-61.195
"T2_9"	20120320	-64.4284	45.3674	6.39	6.51	7.02	43.11	1010.8	420	Night	225	-69.8186	157.7	0.0000037	-54.365
"T2_10"	20120320	-64.4289	45.3675	8.05	8.12	4.43	40.24	1004.3	266	Night	169	-75.7554	36.9	0.0000009	-60.672
"T2_11"	20120320	-64.4291	45.3676	9.51	9.58	4.25	39.59	1007.7	255	Tran1	387	-81.8964	8.8	0.0000002	-66.902
"T2_12"	20120320	-64.4282	45.3673	11.58	11.63	3.10	42.27	981.7	186	Day	894	-62.3764	854.6	0.0000198	-47.027

Table A5-9-6.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T3_1"	20120319	-64.4293	45.3669	14.64	14.70	3.77	47.21	982.0	226	Day	954	-80.8741	13.8	0.0000003	-64.940
"T3_2"	20120319	-64.4299	45.3672	16.19	16.25	3.37	46.87	975.1	202	Day	615	-73.6757	71.9	0.0000017	-57.780
"T3_3"	20120319	-64.4295	45.3669	18.35	18.41	3.88	40.70	989.2	233	Day	177	-63.8908	575.4	0.0000133	-48.746
"T3_4"	20120319	-64.4294	45.3669	20.21	20.28	4.47	37.51	1037.7	268	Day	213	-81.5424	8.9	0.0000002	-66.844
"T3_5"	20120319	-64.4289	45.3670	21.84	21.97	7.95	39.46	1014.6	477	Tran2	538	-83.3106	6.3	0.0000001	-68.334
"T3_6"	20120320	-64.4281	45.3669	0.79	1.09	17.95	46.61	1146.3	1075	Night	1100	-74.7835	55.3	0.0000013	-58.918
"T3_7"	20120320	-64.4295	45.3669	2.97	3.04	3.75	48.47	995.2	224	Night	962	-79.9487	17.6	0.0000004	-63.878
"T3_8"	20120320	-64.4297	45.3671	4.49	4.55	3.53	47.60	971.6	212	Night	645	-78.319	25.1	0.0000006	-62.343
"T3_9"	20120320	-64.4294	45.3669	6.52	6.57	3.25	41.10	960.9	195	Night	212	-77.1358	27.6	0.0000006	-61.938
"T3_10"	20120320	-64.4294	45.3669	8.14	8.20	3.60	38.71	971.5	215	Night	177	-64.5035	469.2	0.0000109	-49.631
"T3_11"	20120320	-64.4288	45.3669	9.62	9.71	5.52	38.22	1016.9	331	Tran1	412	-81.5415	9.1	0.0000002	-66.739
"T3_12"	20120320	-64.4279	45.3668	11.77	12.55	47.12	43.95	1717.7	2824	Day	1009	-68.8879	200.1	0.0000046	-53.332
"T4_1"	20120319	-64.4295	45.3656	14.72	14.80	4.63	42.60	1000.7	278	Day	939	-79.4035	17.1	0.0000004	-64.013
"T4_2"	20120319	-64.4296	45.3657	16.28	16.45	10.07	39.54	1028.1	603	Day	581	-74.2837	50.7	0.0000012	-59.295
"T4_3"	20120319	-64.4293	45.3657	18.45	18.57	7.38	34.51	1028.3	442	Day	164	-78.8889	14.8	0.0000003	-64.656
"T4_4"	20120319	-64.4300	45.3658	20.32	20.41	5.23	32.97	1011.7	313	Day	229	-81.18	8.2	0.0000002	-67.207
"T4_5"	20120319	-64.4291	45.3657	22.01	22.06	3.38	33.25	894.0	203	Tran2	571	-81.0919	8.5	0.0000002	-67.070
"T4_6"	20120320	-64.4289	45.3655	1.13	1.20	3.77	40.30	1016.5	226	Night	1106	-61.1521	1067.7	0.0000248	-46.061
"T4_7"	20120320	-64.4292	45.3655	3.05	3.12	3.75	41.85	973.8	225	Night	949	-78.9585	18.5	0.0000004	-63.664
"T4_8"	20120320	-64.4290	45.3656	4.58	4.74	9.82	39.74	1027.4	588	Night	612	-80.6122	11.9	0.0000003	-65.596
"T4_9"	20120320	-64.4295	45.3656	6.60	6.72	7.35	35.60	1008.0	440	Night	197	-76.9895	23.8	0.0000006	-62.581
"T4_10"	20120320	-64.4296	45.3657	8.22	8.30	4.80	33.40	1008.2	288	Night	185	-81.7222	7.4	0.0000002	-67.675
"T4_11"	20120320	-64.4298	45.3659	9.74	9.81	4.30	34.16	1013.5	258	Tran1	438	-81.1183	8.7	0.0000002	-66.943
"T4_12"	20120320	-64.4294	45.3654	12.60	12.66	3.13	38.65	971.3	188	Day	1082	-55.1762	4011.0	0.0000931	-40.312
"T5_1"	20120319	-64.4303	45.3648	14.82	14.88	3.60	41.62	988.1	215	Day	924	-81.0484	11.4	0.0000003	-65.783
"T5_2"	20120319	-64.4307	45.3650	16.47	16.53	3.48	37.11	988.4	208	Day	548	-78.9376	16.0	0.0000004	-64.299
"T5_3"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000	0.000
"T5_4"	20120319	-64.4309	45.3650	20.43	20.51	4.52	32.27	1121.8	271	Day	246	-78.3247	15.4	0.0000004	-64.475
"T5_5"	20120319	-64.4303	45.3649	22.10	22.25	9.12	32.23	1030.1	546	Tran2	604	-79.4178	11.9	0.0000003	-65.576
"T5_6"	20120320	-64.4297	45.3648	1.25	1.50	15.03	38.89	1103.5	901	Night	1106	-78.841	17.4	0.0000004	-63.943
"T5_7"	20120320	-64.4305	45.3649	3.13	3.19	3.68	41.61	1016.3	221	Night	938	-79.461	16.4	0.0000004	-64.197
"T5_8"	20120320	-64.4306	45.3648	4.76	4.82	3.20	38.34	941.8	192	Night	579	-75.7322	34.9	0.0000008	-60.912
"T5_9"	20120320	-64.4304	45.3649	6.74	6.80	3.42	34.04	1004.7	205	Night	185	-79.1301	13.7	0.0000003	-64.974
"T5_10"	20120320	-64.4305	45.3649	8.31	8.37	3.22	31.84	967.2	192	Night	193	-82.5939	5.7	0.0000001	-68.821
"T5_11"	20120320	-64.4298	45.3648	9.83	9.93	6.12	31.79	1018.7	366	Tran1	461	-80.4288	9.3	0.0000002	-66.667
"T5_12"	20120320	-64.4283	45.3645	12.78	13.47	41.72	36.57	1661.9	2501	Day	1130	-70.7367	103.9	0.0000024	-56.178
"T6_1"	20120319	-64.4302	45.3640	14.89	14.97	4.72	40.03	996.3	283	Day	906	-81.9138	8.9	0.0000002	-66.859
"T6_2"	20120319	-64.4300	45.3640	16.56	16.75	11.60	36.74	1036.5	695	Day	506	-79.7593	13.1	0.0000003	-65.175
"T6_3"	20120319	-64.4301	45.3639	18.70	18.86	9.18	31.96	1013.9	550	Day	147	-81.8358	6.8	0.0000002	-68.041
"T3_1"	20120319	-64.4307	45.3639	20.53	20.61	4.80	31.01	1000.8	287	Day	262	-77.1513	19.1	0.0000004	-63.534

Table A5-9-6.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T6_5"	20120319	-64.4296	45.3638	22.27	22.35	5.00	31.29	1009.1	300	Tran2	637	-63.7182	426.4	0.0000099	-50.047
"T6_6"	20120320	-64.4297	45.3638	1.53	1.59	3.95	38.99	967.0	236	Night	1102	-80.3321	12.4	0.0000003	-65.421
"T6_7"	20120320	-64.4298	45.3638	3.21	3.28	4.22	40.01	1019.8	253	Night	923	-79.9138	14.1	0.0000003	-64.862
"T6_8"	20120320	-64.4301	45.3639	4.84	5.05	12.27	38.27	1040.1	735	Night	541	-80.2583	12.3	0.0000003	-65.448
"T6_9"	20120320	-64.4303	45.3640	6.83	6.96	8.27	33.28	1011.1	495	Night	174	-80.2904	10.2	0.0000002	-66.263
"T6_10"	20120320	-64.4304	45.3639	8.38	8.47	4.87	31.37	1001.6	292	Night	202	-83.6839	4.3	0.0000001	-69.999
"T6_11"	20120320	-64.4306	45.3641	9.95	10.02	4.15	32.62	1018.2	249	Tran1	488	-78.9417	13.5	0.0000003	-65.030
"T6_12"	20120320	-64.4301	45.3637	13.50	13.55	2.93	38.46	1025.0	176	Day	1146	-61.8972	848.2	0.0000197	-47.060
"T7_1"	20120319	-64.4310	45.3630	14.99	15.05	3.62	39.94	1000.2	217	Day	890	-82.0042	8.7	0.0000002	-66.962
"T7_2"	20120319	-64.4312	45.3631	16.77	16.82	3.10	34.85	995.1	186	Day	473	-72.3564	67.2	0.0000016	-58.068
"T7_3"	20120319	-64.4312	45.3631	18.88	18.94	3.70	31.48	1006.2	221	Day	142	-83.6309	4.4	0.0000001	-69.925
"T7_4"	20120319	-64.4310	45.3631	20.63	20.71	4.58	31.49	1035.3	275	Day	278	-73.5526	44.7	0.0000010	-59.844
"T7_5"	20120319	-64.4314	45.3630	22.39	22.67	16.97	33.74	1188.9	1016	Tran2	691	-63.5282	492.2	0.0000114	-49.424
"T7_6"	20120320	-64.4310	45.3631	1.66	1.81	9.28	40.09	970.2	556	Night	1095	-81.7157	9.3	0.0000002	-66.653
"T7_7"	20120320	-64.4314	45.3631	3.29	3.35	3.32	40.09	979.6	199	Night	908	-76.2622	32.7	0.0000008	-61.200
"T7_8"	20120320	-64.4314	45.3632	5.06	5.12	3.50	36.22	991.8	210	Night	504	-78.7183	16.3	0.0000004	-64.213
"T7_9"	20120320	-64.4310	45.3632	6.98	7.04	3.48	32.63	998.1	209	Night	165	-72.5768	58.6	0.0000014	-58.663
"T7_10"	20120320	-64.4309	45.3632	8.49	8.54	3.37	31.25	1001.8	202	Night	212	-81.5488	7.0	0.0000002	-67.885
"T7_11"	20120320	-64.4306	45.3630	10.05	10.16	6.55	32.24	1011.1	392	Tran1	516	-80.8646	8.6	0.0000002	-67.021
"T7_12"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000	0.000
"T8_1"	20120319	-64.4306	45.3621	15.07	15.17	5.73	41.87	1005.5	344	Day	870	-79.759	15.4	0.0000004	-64.462
"T8_2"	20120319	-64.4312	45.3622	16.86	17.07	12.75	37.13	1043.0	764	Day	432	-80.7381	10.6	0.0000002	-66.096
"T8_3"	20120319	-64.4315	45.3622	18.98	19.12	8.38	32.78	1003.8	503	Day	139	-82.7576	5.7	0.0000001	-68.817
"T8_4"	20120319	-64.4313	45.3621	20.73	20.81	4.80	32.37	1010.5	287	Day	295	-73.5774	46.1	0.0000011	-59.710
"T8_5"	20120319	-64.4312	45.3619	22.69	22.74	3.15	35.39	978.7	189	Tran2	737	-52.3507	6868.2	0.0001593	-37.976
"T8_6"	20120320	-64.4310	45.3618	1.93	2.00	4.13	42.15	1011.0	247	Night	1081	-70.0523	145.4	0.0000034	-54.719
"T8_7"	20120320	-64.4306	45.3619	3.37	3.44	4.57	42.31	985.1	273	Night	893	-80.1491	14.3	0.0000003	-64.795
"T8_8"	20120320	-64.4310	45.3620	5.15	5.38	13.33	38.56	1032.1	800	Night	463	-79.5811	14.5	0.0000003	-64.730
"T8_9"	20120320	-64.4313	45.3622	7.08	7.21	8.23	34.43	1005.6	493	Night	158	-82.4371	6.5	0.0000002	-68.217
"T8_10"	20120320	-64.4314	45.3621	8.56	8.64	4.70	32.81	998.6	281	Night	222	-82.4089	6.1	0.0000001	-68.463
"T8_11"	20120320	-64.4314	45.3621	10.17	10.24	3.98	33.67	1007.1	239	Tran1	541	-82.0557	6.9	0.0000002	-67.962
"T8_12"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000	0.000
"X1_1"	20120319	-64.4299	45.3467	15.19	15.41	12.92	75.33	3276.1	774	Day	835	-80.6039	25.3	0.0000006	-62.322
"X1_2"	20120319	-64.4306	45.3470	17.11	17.40	17.15	71.69	3275.8	1028	Day	363	-79.1298	33.5	0.0000008	-61.089
"X1_3"	20120319	-64.4301	45.3472	19.19	19.44	14.58	67.28	3226.0	874	Day	140	-83.0991	12.5	0.0000003	-65.370

Table A5-9-6.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"X1_4"	20120319	-64.4307	45.3466	20.85	21.08	14.27	66.87	3274.1	855	Day	329	-80.6586	21.8	0.0000005	-62.960
"X1_5"	20120319	-64.4304	45.3465	22.78	23.06	17.17	73.85	3297.4	1028	Tran2	790	-66.6299	616.6	0.0000143	-48.445
"X1_6"	20120320	-64.4306	45.3466	2.06	2.27	12.57	77.48	3229.6	753	Night	1067	-76.5105	66.9	0.0000016	-58.092
"X1_7"	20120320	-64.4302	45.3462	3.47	3.68	12.35	76.90	3323.9	740	Night	861	-82.3845	17.1	0.0000004	-64.003
"X1_8"	20120320	-64.4300	45.3475	5.38	5.67	17.32	72.89	3288.7	1038	Night	400	-81.9857	17.7	0.0000004	-63.865
"X1_9"	20120320	-64.4301	45.3472	7.22	7.46	14.10	68.73	3269.5	845	Night	150	-82.1371	16.0	0.0000004	-64.303
"X1_10"	20120320	-64.4304	45.3465	8.66	8.86	12.53	67.14	3295.4	751	Night	245	-82.5546	14.2	0.0000003	-64.836
"X1_11"	20120320	-64.4304	45.3469	10.27	10.51	14.27	68.86	3249.5	855	Tran1	587	-83.0678	12.9	0.0000003	-65.225
"Y1_1"	20120319	-64.4432	45.3319	15.41	15.46	3.23	38.66	1170.9	193	Day	803	-85.1207	4.1	0.0000001	-70.255
"Y1_2"	20120319	-64.4435	45.3328	17.50	17.57	3.68	35.72	1084.3	220	Day	303	-80.9046	9.7	0.0000002	-66.478
"Y1_3"	20120319	-64.4419	45.3326	19.46	19.52	3.47	34.00	874.3	208	Day	146	-84.3416	4.1	0.0000001	-70.193
"Y1_4"	20120319	-64.4426	45.3326	21.10	21.20	5.85	32.88	1077.6	350	Day	365	-84.7633	3.6	0.0000001	-70.805
"Y1_5"	20120319	-64.4427	45.3327	23.10	23.18	5.00	35.62	1108.1	300	Tran2	841	-84.6978	4.0	0.0000001	-70.287
"Y1_6"	20120320	-64.4428	45.3326	2.29	2.36	4.28	41.49	1099.4	257	Night	1051	-84.6861	4.9	0.0000001	-69.438
"Y1_7"	20120320	-64.4433	45.3326	3.70	3.76	3.65	40.55	1108.2	219	Night	830	-86.6764	3.0	0.0000001	-71.552
"Y1_8"	20120320	-64.4431	45.3327	5.70	5.76	3.88	35.84	1096.2	233	Night	355	-80.0975	11.7	0.0000003	-65.651
"Y1_9"	20120320	-64.4431	45.3327	7.48	7.55	3.95	33.99	1139.6	236	Night	148	-82.1445	6.8	0.0000002	-67.997
"Y1_10"	20120320	-64.4435	45.3328	8.89	8.97	4.60	31.43	938.0	276	Night	271	-82.548	5.6	0.0000001	-68.852
"Y1_11"	20120320	-64.4420	45.3326	10.54	10.66	7.17	35.89	1141.2	429	Tran1	642	-83.5879	5.3	0.0000001	-69.134
"X2_1"	20120319	-64.4419	45.3519	15.47	15.79	19.30	64.79	4374.8	1157	Day	761	-80.6491	21.1	0.0000005	-63.107
"X2_2"	20120319	-64.4425	45.3508	17.59	17.97	22.55	61.85	4396.0	1351	Day	260	-78.1198	35.8	0.0000008	-60.809
"X2_3"	20120319	-64.4425	45.3510	19.56	19.88	19.22	56.96	4375.9	1152	Day	160	-80.8427	17.4	0.0000004	-63.945
"X2_4"	20120319	-64.4421	45.3519	21.20	21.51	18.58	58.91	4332.8	1114	Day	411	-81.9986	13.8	0.0000003	-64.931
"X2_5"	20120319	-64.4400	45.3486	23.20	0.17	-1382.13	61.25	5819.4	3468	Night	956	-66.7396	486.2	0.0000113	-49.477
"X2_6"	20120320	-64.4429	45.3494	2.37	2.73	21.23	63.99	4739.2	1272	Night	1025	-75.2031	72.8	0.0000017	-57.723
"X2_7"	20120320	-64.4419	45.3524	3.78	4.10	19.17	66.37	4410.4	1148	Night	783	-78.3483	36.8	0.0000009	-60.687
"X2_8"	20120320	-64.4425	45.3508	5.79	6.18	23.68	64.79	4396.1	1419	Night	301	-76.6295	53.2	0.0000012	-59.087
"X2_9"	20120320	-64.4423	45.3519	7.56	7.87	18.33	57.81	4415.9	1099	Night	151	-82.9044	11.0	0.0000003	-65.932
"X2_10"	20120320	-64.4422	45.3514	8.98	9.28	18.02	58.85	4318.1	1080	Night	305	-82.3017	12.9	0.0000003	-65.239
"X2_11"	20120320	-64.4407	45.3537	10.67	11.10	25.68	58.96	4439.5	1540	Tran1	715	-79.8388	22.8	0.0000005	-62.767

Table A5-9-6.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the March 19, 2012 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120319	-64.4274	45.3688	14.39	14.46	3.90	45.03	908.2	233	Day	994	-81.8339	12.6	0.0000003	-65.337
"T0_2"	20120319	-64.4283	45.3690	15.81	15.91	5.77	43.14	1026.9	345	Day	706	-77.7277	21.3	0.0000005	-63.051
"T0_3"	20120319	-64.4283	45.3693	17.99	18.08	5.50	38.04	975.4	330	Day	217	-76.516	18.0	0.0000004	-63.790
"T0_4"	20120319	-64.4280	45.3690	19.91	19.99	5.32	35.12	1061.5	318	Day	179	-77.612	25.1	0.0000006	-62.354
"T0_5"	20120319	-64.4288	45.3692	21.53	21.60	3.97	36.27	1019.1	237	Tran2	456	-84.7741	5.0	0.0000001	-69.317
"T0_6"	20120320	-64.4284	45.3689	0.23	0.29	3.23	43.00	1000.7	193	Night	1044	-76.8826	27.0	0.0000006	-62.039
"T0_7"	20120320	-64.4277	45.3689	2.75	2.81	3.60	45.74	998.7	215	Night	997	-78.9776	22.8	0.0000005	-62.760
"T0_8"	20120320	-64.4279	45.3691	4.13	4.23	5.85	43.13	1026.4	351	Night	730	-78.0091	17.0	0.0000004	-64.050
"T0_9"	20120320	-64.4280	45.3690	6.21	6.30	5.25	38.32	993.0	314	Night	253	-76.7123	19.4	0.0000005	-63.460
"T0_10"	20120320	-64.4283	45.3691	7.89	7.96	4.50	35.11	990.0	269	Night	160	-80.1072	14.4	0.0000003	-64.754
"T0_11"	20120320	-64.4282	45.3693	9.29	9.37	4.48	35.46	963.0	269	Night	343	-84.6087	5.3	0.0000001	-69.070
"T0_12"	20120320	-64.4271	45.3693	11.13	11.18	3.25	36.24	899.7	195	Tran1	784	-79.303	13.4	0.0000003	-65.089
"T1_1"	20120319	-64.4290	45.3682	14.47	14.54	4.00	48.59	986.7	240	Day	981	-80.5771	16.3	0.0000004	-64.212
"T1_2"	20120319	-64.4290	45.3682	15.92	15.99	3.70	46.93	995.0	222	Day	681	-77.4454	20.2	0.0000005	-63.286
"T1_3"	20120319	-64.4289	45.3684	18.10	18.17	4.18	42.12	988.2	250	Day	204	-75.0301	29.4	0.0000007	-61.658
"T1_4"	20120319	-64.4286	45.3682	20.01	20.08	4.37	38.98	1028.4	262	Day	189	-80.5128	14.6	0.0000003	-64.689
"T1_5"	20120319	-64.4290	45.3684	21.62	21.73	6.40	40.46	1010.4	384	Tran2	483	-83.6349	7.1	0.0000002	-67.820
"T1_6"	20120320	-64.4288	45.3683	0.34	0.61	16.05	46.66	1071.8	962	Night	1068	-80.4291	15.4	0.0000004	-64.463
"T1_7"	20120320	-64.4289	45.3684	2.82	2.88	3.90	50.14	986.2	234	Night	985	-77.1242	37.4	0.0000009	-60.616
"T1_8"	20120320	-64.4293	45.3683	4.24	4.30	3.70	47.67	989.9	222	Night	706	-74.8128	36.8	0.0000009	-60.684
"T1_9"	20120320	-64.4290	45.3684	6.31	6.37	3.48	43.09	970.9	209	Night	240	-74.5776	25.6	0.0000006	-62.262
"T1_10"	20120320	-64.4288	45.3684	7.98	8.03	3.27	40.20	993.1	196	Night	165	-79.4725	15.5	0.0000004	-64.431
"T1_11"	20120320	-64.4280	45.3681	9.40	9.49	5.72	40.41	1037.7	342	Tran1	366	-81.4957	12.4	0.0000003	-65.400
"T1_12"	20120320	-64.4293	45.3683	11.24	11.55	18.97	44.16	1123.4	1137	Day	842	-77.6575	29.2	0.0000007	-61.688
"T2_1"	20120319	-64.4283	45.3673	14.56	14.62	4.03	47.41	933.0	241	Day	968	-80.6718	15.0	0.0000003	-64.593
"T2_2"	20120319	-64.4287	45.3674	16.01	16.17	9.20	46.56	1035.0	551	Day	648	-78.3657	23.7	0.0000006	-62.594
"T2_3"	20120319	-64.4287	45.3674	18.20	18.33	7.63	41.45	1028.6	458	Day	189	-74.6599	36.9	0.0000009	-60.670
"T2_4"	20120319	-64.4289	45.3675	20.11	20.19	4.73	38.45	1009.7	283	Day	201	-81.4225	11.5	0.0000003	-65.724
"T2_5"	20120319	-64.4290	45.3674	21.75	21.82	4.02	38.79	1015.8	240	Tran2	510	-80.1946	14.4	0.0000003	-64.748
"T2_6"	20120320	-64.4283	45.3673	0.64	0.69	3.22	44.67	1013.0	192	Night	1084	-79.9176	16.6	0.0000004	-64.133
"T2_7"	20120320	-64.4284	45.3673	2.90	2.96	3.70	48.95	1006.8	222	Night	975	-78.8552	24.3	0.0000006	-62.489
"T2_8"	20120320	-64.4295	45.3677	4.31	4.47	9.52	47.89	1200.1	571	Night	678	-80.4729	16.1	0.0000004	-64.287
"T2_9"	20120320	-64.4284	45.3674	6.39	6.51	7.02	43.11	1010.8	420	Night	225	-77.7699	23.7	0.0000005	-62.606
"T2_10"	20120320	-64.4289	45.3675	8.05	8.12	4.43	40.24	1004.3	266	Night	169	-79.2389	19.1	0.0000004	-63.530
"T2_11"	20120320	-64.4291	45.3676	9.51	9.58	4.25	39.59	1007.7	255	Tran1	387	-80.7981	14.3	0.0000003	-64.782
"T2_12"	20120320	-64.4282	45.3673	11.58	11.63	3.10	42.27	981.7	186	Day	894	-74.3337	51.8	0.0000012	-59.204

Table A5-9-6.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T3_1"	20120319	-64.4293	45.3669	14.64	14.70	3.77	47.21	982.0	226	Day	954	-80.9083	15.1	0.0000004	-64.550
"T3_2"	20120319	-64.4299	45.3672	16.19	16.25	3.37	46.87	975.1	202	Day	615	-77.6532	29.1	0.0000007	-61.701
"T3_3"	20120319	-64.4295	45.3669	18.35	18.41	3.88	40.70	989.2	233	Day	177	-78.3778	15.2	0.0000004	-64.530
"T3_4"	20120319	-64.4294	45.3669	20.21	20.28	4.47	37.51	1037.7	268	Day	213	-81.0844	11.8	0.0000003	-65.634
"T3_5"	20120319	-64.4289	45.3670	21.84	21.97	7.95	39.46	1014.6	477	Tran2	538	-81.7998	10.6	0.0000002	-66.105
"T3_6"	20120320	-64.4281	45.3669	0.79	1.09	17.95	46.61	1146.3	1075	Night	1100	-79.1893	20.4	0.0000005	-63.253
"T3_7"	20120320	-64.4295	45.3669	2.97	3.04	3.75	48.47	995.2	224	Night	962	-81.2805	13.2	0.0000003	-65.130
"T3_8"	20120320	-64.4297	45.3671	4.49	4.55	3.53	47.60	971.6	212	Night	645	-82.3122	10.3	0.0000002	-66.199
"T3_9"	20120320	-64.4294	45.3669	6.52	6.57	3.25	41.10	960.9	195	Night	212	-77.1314	32.2	0.0000007	-61.261
"T3_10"	20120320	-64.4294	45.3669	8.14	8.20	3.60	38.71	971.5	215	Night	177	-78.3108	21.8	0.0000005	-62.956
"T3_11"	20120320	-64.4288	45.3669	9.62	9.71	5.52	38.22	1016.9	331	Tran1	412	-81.5362	11.7	0.0000003	-65.671
"T3_12"	20120320	-64.4279	45.3668	11.77	12.55	47.12	43.95	1717.7	2824	Day	1009	-75.7762	37.3	0.0000009	-60.629
"T4_1"	20120319	-64.4295	45.3656	14.72	14.80	4.63	42.60	1000.7	278	Day	939	-79.5544	19.6	0.0000005	-63.413
"T4_2"	20120319	-64.4296	45.3657	16.28	16.45	10.07	39.54	1028.1	603	Day	581	-77.559	22.3	0.0000005	-62.870
"T4_3"	20120319	-64.4293	45.3657	18.45	18.57	7.38	34.51	1028.3	442	Day	164	-75.2829	38.5	0.0000009	-60.489
"T4_4"	20120319	-64.4300	45.3658	20.32	20.41	5.23	32.97	1011.7	313	Day	229	-81.4979	9.4	0.0000002	-66.598
"T4_5"	20120319	-64.4291	45.3657	22.01	22.06	3.38	33.25	894.0	203	Tran2	571	-79.4676	15.1	0.0000004	-64.550
"T4_6"	20120320	-64.4289	45.3655	1.13	1.20	3.77	40.30	1016.5	226	Night	1106	-81.5931	9.2	0.0000002	-66.713
"T4_7"	20120320	-64.4292	45.3655	3.05	3.12	3.75	41.85	973.8	225	Night	949	-79.2142	18.6	0.0000004	-63.644
"T4_8"	20120320	-64.4290	45.3656	4.58	4.74	9.82	39.74	1027.4	588	Night	612	-81.1773	11.2	0.0000003	-65.858
"T4_9"	20120320	-64.4295	45.3656	6.60	6.72	7.35	35.60	1008.0	440	Night	197	-75.8329	35.8	0.0000008	-60.802
"T4_10"	20120320	-64.4296	45.3657	8.22	8.30	4.80	33.40	1008.2	288	Night	185	-80.9922	11.6	0.0000003	-65.707
"T4_11"	20120320	-64.4298	45.3659	9.74	9.81	4.30	34.16	1013.5	258	Tran1	438	-81.2641	11.1	0.0000003	-65.882
"T4_12"	20120320	-64.4294	45.3654	12.60	12.66	3.13	38.65	971.3	188	Day	1082	-73.5487	43.0	0.0000010	-60.008
"T5_1"	20120319	-64.4303	45.3648	14.82	14.88	3.60	41.62	988.1	215	Day	924	-80.9161	14.2	0.0000003	-64.836
"T5_2"	20120319	-64.4307	45.3650	16.47	16.53	3.48	37.11	988.4	208	Day	548	-79.9968	13.3	0.0000003	-65.115
"T5_3"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000	0.000
"T5_4"	20120319	-64.4309	45.3650	20.43	20.51	4.52	32.27	1121.8	271	Day	246	-78.3988	19.7	0.0000005	-63.392
"T5_5"	20120319	-64.4303	45.3649	22.10	22.25	9.12	32.23	1030.1	546	Tran2	604	-80.394	11.0	0.0000003	-65.951
"T5_6"	20120320	-64.4297	45.3648	1.25	1.50	15.03	38.89	1103.5	901	Night	1106	-81.7538	9.6	0.0000002	-66.517
"T5_7"	20120320	-64.4305	45.3649	3.13	3.19	3.68	41.61	1016.3	221	Night	938	-80.7318	12.7	0.0000003	-65.314
"T5_8"	20120320	-64.4306	45.3648	4.76	4.82	3.20	38.34	941.8	192	Night	579	-81.8899	8.9	0.0000002	-66.846
"T5_9"	20120320	-64.4304	45.3649	6.74	6.80	3.42	34.04	1004.7	205	Night	185	-78.9174	17.3	0.0000004	-63.968
"T5_10"	20120320	-64.4305	45.3649	8.31	8.37	3.22	31.84	967.2	192	Night	193	-81.928	8.9	0.0000002	-66.847
"T5_11"	20120320	-64.4298	45.3648	9.83	9.93	6.12	31.79	1018.7	366	Tran1	461	-80.3579	12.8	0.0000003	-65.285
"T5_12"	20120320	-64.4283	45.3645	12.78	13.47	41.72	36.57	1661.9	2501	Day	1130	-79.3901	12.9	0.0000003	-65.256
"T6_1"	20120319	-64.4302	45.3640	14.89	14.97	4.72	40.03	996.3	283	Day	906	-81.4035	12.0	0.0000003	-65.549
"T6_2"	20120319	-64.4300	45.3640	16.56	16.75	11.60	36.74	1036.5	695	Day	506	-80.3746	12.5	0.0000003	-65.363
"T6_3"	20120319	-64.4301	45.3639	18.70	18.86	9.18	31.96	1013.9	550	Day	147	-79.494	14.6	0.0000003	-64.707
"T6_4"	20120319	-64.4307	45.3639	20.53	20.61	4.80	31.01	1000.8	287	Day	262	-77.7433	21.5	0.0000005	-63.015

Table A5-9-6.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T6_5"	20120319	-64.4296	45.3638	22.27	22.35	5.00	31.29	1009.1	300	Tran2	637	-78.1365	15.4	0.0000004	-64.478
"T6_6"	20120320	-64.4297	45.3638	1.53	1.59	3.95	38.99	967.0	236	Night	1102	-86.2066	3.4	0.0000001	-71.067
"T6_7"	20120320	-64.4298	45.3638	3.21	3.28	4.22	40.01	1019.8	253	Night	923	-80.4006	13.7	0.0000003	-64.988
"T6_8"	20120320	-64.4301	45.3639	4.84	5.05	12.27	38.27	1040.1	735	Night	541	-81.9814	9.6	0.0000002	-66.541
"T6_9"	20120320	-64.4303	45.3640	6.83	6.96	8.27	33.28	1011.1	495	Night	174	-80.1239	12.7	0.0000003	-65.307
"T6_10"	20120320	-64.4304	45.3639	8.38	8.47	4.87	31.37	1001.6	292	Night	202	-81.9612	8.7	0.0000002	-66.945
"T6_11"	20120320	-64.4306	45.3641	9.95	10.02	4.15	32.62	1018.2	249	Tran1	488	-79.7069	15.1	0.0000004	-64.551
"T6_12"	20120320	-64.4301	45.3637	13.50	13.55	2.93	38.46	1025.0	176	Day	1146	-81.0598	9.5	0.0000002	-66.574
"T7_1"	20120319	-64.4310	45.3630	14.99	15.05	3.62	39.94	1000.2	217	Day	890	-82.1651	10.4	0.0000002	-66.187
"T7_2"	20120319	-64.4312	45.3631	16.77	16.82	3.10	34.85	995.1	186	Day	473	-73.0457	69.1	0.0000016	-57.951
"T7_3"	20120319	-64.4312	45.3631	18.88	18.94	3.70	31.48	1006.2	221	Day	142	-82.0815	8.0	0.0000002	-67.340
"T7_4"	20120319	-64.4310	45.3631	20.63	20.71	4.58	31.49	1035.3	275	Day	278	-74.6823	46.7	0.0000011	-59.649
"T7_5"	20120319	-64.4314	45.3630	22.39	22.67	16.97	33.74	1188.9	1016	Tran2	691	-75.1952	35.7	0.0000008	-60.819
"T7_6"	20120320	-64.4310	45.3631	1.66	1.81	9.28	40.09	970.2	556	Night	1095	-81.7436	10.5	0.0000002	-66.117
"T7_7"	20120320	-64.4314	45.3631	3.29	3.35	3.32	40.09	979.6	199	Night	908	-80.6387	12.5	0.0000003	-65.377
"T7_8"	20120320	-64.4314	45.3632	5.06	5.12	3.50	36.22	991.8	210	Night	504	-79.7267	13.2	0.0000003	-65.150
"T7_9"	20120320	-64.4310	45.3632	6.98	7.04	3.48	32.63	998.1	209	Night	165	-73.3533	56.8	0.0000013	-58.804
"T7_10"	20120320	-64.4309	45.3632	8.49	8.54	3.37	31.25	1001.8	202	Night	212	-80.1704	13.1	0.0000003	-65.184
"T7_11"	20120320	-64.4306	45.3630	10.05	10.16	6.55	32.24	1011.1	392	Tran1	516	-80.5572	12.3	0.0000003	-65.445
"T7_12"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000	0.000
"T8_1"	20120319	-64.4306	45.3621	15.07	15.17	5.73	41.87	1005.5	344	Day	870	-79.3818	20.5	0.0000005	-63.237
"T8_2"	20120319	-64.4312	45.3622	16.86	17.07	12.75	37.13	1043.0	764	Day	432	-80.6378	12.2	0.0000003	-65.464
"T8_3"	20120319	-64.4315	45.3622	18.98	19.12	8.38	32.78	1003.8	503	Day	139	-79.2705	16.4	0.0000004	-64.203
"T8_4"	20120319	-64.4313	45.3621	20.73	20.81	4.80	32.37	1010.5	287	Day	295	-74.6522	48.4	0.0000011	-59.501
"T8_5"	20120319	-64.4312	45.3619	22.69	22.74	3.15	35.39	978.7	189	Tran2	737	-74.7808	17.5	0.0000004	-63.913
"T8_6"	20120320	-64.4310	45.3618	1.93	2.00	4.13	42.15	1011.0	247	Night	1081	-78.1807	21.8	0.0000005	-62.964
"T8_7"	20120320	-64.4306	45.3619	3.37	3.44	4.57	42.31	985.1	273	Night	893	-79.9056	16.3	0.0000004	-64.213
"T8_8"	20120320	-64.4310	45.3620	5.15	5.38	13.33	38.56	1032.1	800	Night	463	-81.3146	10.6	0.0000002	-66.073
"T8_9"	20120320	-64.4313	45.3622	7.08	7.21	8.23	34.43	1005.6	493	Night	158	-80.555	12.7	0.0000003	-65.297
"T8_10"	20120320	-64.4314	45.3621	8.56	8.64	4.70	32.81	998.6	281	Night	222	-81.1838	10.7	0.0000002	-66.056
"T8_11"	20120320	-64.4314	45.3621	10.17	10.24	3.98	33.67	1007.1	239	Tran1	541	-78.4458	19.2	0.0000004	-63.507
"T8_12"	0	0.0000	0.0000	0.00	0.00	0.00	0.00	0.0	0	Night	0	0	0.0	0.0000000	0.000
"X1_1"	20120319	-64.4299	45.3467	15.19	15.41	12.92	75.33	3276.1	774	Day	835	-80.2788	30.2	0.0000007	-61.541
"X1_2"	20120319	-64.4306	45.3470	17.11	17.40	17.15	71.69	3275.8	1028	Day	363	-80.0661	29.0	0.0000007	-61.728
"X1_3"	20120319	-64.4301	45.3472	19.19	19.44	14.58	67.28	3226.0	874	Day	140	-82.6316	15.7	0.0000004	-64.379

Table A5-9-6.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"X1_4"	20120319	-64.4307	45.3466	20.85	21.08	14.27	66.87	3274.1	855	Day	329	-80.8934	23.3	0.0000005	-62.675
"X1_5"	20120319	-64.4304	45.3465	22.78	23.06	17.17	73.85	3297.4	1028	Tran2	790	-79.9213	24.2	0.0000006	-62.498
"X1_6"	20120320	-64.4306	45.3466	2.06	2.27	12.57	77.48	3229.6	753	Night	1067	-82.4948	16.3	0.0000004	-64.210
"X1_7"	20120320	-64.4302	45.3462	3.47	3.68	12.35	76.90	3323.9	740	Night	861	-82.1696	19.7	0.0000005	-63.401
"X1_8"	20120320	-64.4300	45.3475	5.38	5.67	17.32	72.89	3288.7	1038	Night	400	-81.8953	19.3	0.0000004	-63.500
"X1_9"	20120320	-64.4301	45.3472	7.22	7.46	14.10	68.73	3269.5	845	Night	150	-81.5227	20.8	0.0000005	-63.170
"X1_10"	20120320	-64.4304	45.3465	8.66	8.86	12.53	67.14	3295.4	751	Night	245	-82.1883	17.6	0.0000004	-63.902
"X1_11"	20120320	-64.4304	45.3469	10.27	10.51	14.27	68.86	3249.5	855	Tran1	587	-82.4115	17.0	0.0000004	-64.053
"Y1_1"	20120319	-64.4432	45.3319	15.41	15.46	3.23	38.66	1170.9	193	Day	803	-83.5451	7.4	0.0000002	-67.631
"Y1_2"	20120319	-64.4435	45.3328	17.50	17.57	3.68	35.72	1084.3	220	Day	303	-79.9381	15.8	0.0000004	-64.364
"Y1_3"	20120319	-64.4419	45.3326	19.46	19.52	3.47	34.00	874.3	208	Day	146	-84.2179	5.6	0.0000001	-68.886
"Y1_4"	20120319	-64.4426	45.3326	21.10	21.20	5.85	32.88	1077.6	350	Day	365	-84.0825	5.5	0.0000001	-68.922
"Y1_5"	20120319	-64.4427	45.3327	23.10	23.18	5.00	35.62	1108.1	300	Tran2	841	-84.392	5.6	0.0000001	-68.830
"Y1_6"	20120320	-64.4428	45.3326	2.29	2.36	4.28	41.49	1099.4	257	Night	1051	-84.9193	5.8	0.0000001	-68.741
"Y1_7"	20120320	-64.4433	45.3326	3.70	3.76	3.65	40.55	1108.2	219	Night	830	-86.881	3.6	0.0000001	-70.831
"Y1_8"	20120320	-64.4431	45.3327	5.70	5.76	3.88	35.84	1096.2	233	Night	355	-80.5788	12.3	0.0000003	-65.454
"Y1_9"	20120320	-64.4431	45.3327	7.48	7.55	3.95	33.99	1139.6	236	Night	148	-82.5796	8.0	0.0000002	-67.287
"Y1_10"	20120320	-64.4435	45.3328	8.89	8.97	4.60	31.43	938.0	276	Night	271	-83.1215	6.7	0.0000002	-68.097
"Y1_11"	20120320	-64.4420	45.3326	10.54	10.66	7.17	35.89	1141.2	429	Tran1	642	-83.4283	7.1	0.0000002	-67.833
"X2_1"	20120319	-64.4419	45.3519	15.47	15.79	19.30	64.79	4374.8	1157	Day	761	-80.5991	23.9	0.0000006	-62.558
"X2_2"	20120319	-64.4425	45.3508	17.59	17.97	22.55	61.85	4396.0	1351	Day	260	-80.7186	21.0	0.0000005	-63.132
"X2_3"	20120319	-64.4425	45.3510	19.56	19.88	19.22	56.96	4375.9	1152	Day	160	-80.6156	21.2	0.0000005	-63.077
"X2_4"	20120319	-64.4421	45.3519	21.20	21.51	18.58	58.91	4332.8	1114	Day	411	-80.7284	21.4	0.0000005	-63.038
"X2_5"	20120319	-64.4400	45.3486	23.20	0.17	-1382.13	61.25	5819.4	3468	Night	956	-78.5452	24.1	0.0000006	-62.518
"X2_6"	20120320	-64.4429	45.3494	2.37	2.73	21.23	63.99	4739.2	1272	Night	1025	-81.5411	17.5	0.0000004	-63.907
"X2_7"	20120320	-64.4419	45.3524	3.78	4.10	19.17	66.37	4410.4	1148	Night	783	-79.0472	34.8	0.0000008	-60.923
"X2_8"	20120320	-64.4425	45.3508	5.79	6.18	23.68	64.79	4396.1	1419	Night	301	-80.6799	21.6	0.0000005	-63.000
"X2_9"	20120320	-64.4423	45.3519	7.56	7.87	18.33	57.81	4415.9	1099	Night	151	-82.175	15.0	0.0000003	-64.576
"X2_10"	20120320	-64.4422	45.3514	8.98	9.28	18.02	58.85	4318.1	1080	Night	305	-81.7731	17.0	0.0000004	-64.048
"X2_11"	20120320	-64.4407	45.3537	10.67	11.10	25.68	58.96	4439.5	1540	Tran1	715	-81.0134	18.5	0.0000004	-63.662

Table A5-9-7.1. Summary of acoustic backscatter from **<u>2 m</u>** below the transducer to bottom by individual transect for the May 31, 2012 survey in Minas Passage. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120531	-64.4253	45.3686	12.16	12.22	3.47	43.64	758.6	205	Day	1045	-72.2293	112.5733	0.0000026	-55.831
"T0_2"	20120531	-64.4279	45.3690	14.08	14.23	9.38	42.40	1024.7	557	Day	779	-65.9697	462.2518	0.0000107	-49.696
"T0_3"	20120531	-64.4279	45.3690	16.46	16.55	5.27	37.10	1014.0	313	Day	334	-74.3270	59.04527	0.0000014	-58.633
"T0_4"	20120531	-64.4278	45.3691	18.19	18.25	4.10	35.23	987.3	244	Day	215	-68.1198	234.1366	0.0000054	-52.650
"T0_5"	20120531	-64.4270	45.3688	20.08	20.16	4.70	37.33	1004.9	279	Day	468	-54.4836	5730.692	0.0001330	-38.763
"T1_1"	20120531	-64.4294	45.3684	12.23	12.31	4.80	50.59	969.6	285	Day	1039	-66.8546	449.9171	0.0000104	-49.814
"T1_2"	20120531	-64.4292	45.3684	14.27	14.32	2.88	47.20	990.1	171	Day	754	-70.9954	161.7794	0.0000038	-54.256
"T1_3"	20120531	-64.4289	45.3684	16.57	16.63	3.90	41.69	986.6	231	Day	319	-56.2002	4310.109	0.0001000	-40.000
"T1_4"	20120531	-64.4292	45.3684	18.27	18.34	4.47	40.22	1027.6	265	Day	218	-68.3218	255.139	0.0000059	-52.277
"T1_5"	20120531	-64.4294	45.3684	20.19	20.41	12.93	42.95	1032.6	767	Day	502	-68.6436	253.013	0.0000059	-52.313
"T2_1"	20120531	-64.4279	45.3672	12.34	12.42	4.58	48.59	1003.0	272	Day	1032	-67.4678	375.1809	0.0000087	-50.603
"T2_2"	20120531	-64.4286	45.3673	14.35	14.54	11.53	46.12	1024.2	684	Day	726	-70.8148	164.7809	0.0000038	-54.176
"T2_3"	20120531	-64.4289	45.3675	16.65	16.76	6.13	40.77	1023.0	364	Day	304	-65.8313	458.8777	0.0000106	-49.728
"T2_4"	20120531	-64.4284	45.3674	18.36	18.42	3.90	39.43	1008.6	232	Day	222	-74.0532	66.83366	0.0000016	-58.095
"T2_5"	20120531	-64.4284	45.3674	20.45	20.52	3.67	42.15	1018.6	218	Day	545	-65.1618	553.4935	0.0000128	-48.914
"T3_1"	20120531	-64.4302	45.3671	12.44	12.52	4.55	48.71	999.7	270	Day	1023	-62.2890	1239.328	0.0000288	-45.413
"T3_2"	20120531	-64.4294	45.3669	14.57	14.63	3.53	46.09	1016.6	209	Day	697	-74.0739	77.75631	0.0000018	-57.438
"T3_3"	20120531	-64.4295	45.3670	16.93	16.99	3.72	40.40	995.2	220	Day	272	-53.0303	8665.517	0.0002010	-36.967
"T3_4"	20120531	-64.4295	45.3670	18.44	18.51	4.45	38.76	996.0	264	Day	227	-67.0751	327.598	0.0000076	-51.192
"T3_5"	20120531	-64.4303	45.3671	20.56	21.01	26.78	43.09	1175.5	1588	Day	612	-65.8194	486.378	0.0000113	-49.475
"T4_1"	20120531	-64.4288	45.3654	12.56	12.63	4.78	41.68	958.9	282	Day	1012	-68.3006	265.6548	0.0000062	-52.102
"T4_2"	20120531	-64.4289	45.3656	14.67	14.88	12.92	38.27	1015.4	766	Day	661	-70.9625	132.1533	0.0000031	-55.134
"T4_3"	20120531	-64.4301	45.3658	17.00	17.11	6.70	34.66	1147.9	397	Day	261	-76.7774	31.37315	0.0000007	-61.379
"T4_4"	20120531	-64.4294	45.3656	18.53	18.59	3.72	32.45	994.6	221	Day	233	-79.2046	16.79615	0.0000004	-64.093
"T4_5"	20120531	-64.4294	45.3655	21.07	21.13	3.60	36.60	1003.6	213	Day	679	-52.9609	7978.336	0.0001851	-37.326
"T5_1"	20120531	-64.4307	45.3650	12.66	12.73	4.05	41.64	977.9	240	Day	1001	-65.5529	499.7209	0.0000116	-49.358
"T5_2"	20120531	-64.4312	45.3651	14.95	15.01	3.47	37.70	953.5	206	Day	622	-68.9553	206.6778	0.0000048	-53.192
"T5_3"	20120531	-64.4310	45.3650	17.13	17.20	3.82	32.48	1064.2	227	Day	251	-79.3501	16.26039	0.0000004	-64.234
"T5_4"	20120531	-64.4307	45.3649	18.61	18.69	4.60	32.24	1032.6	273	Day	240	-78.4021	20.07752	0.0000005	-63.318
"T5_5"	20120531	-64.4290	45.3646	21.28	22.19	54.73	35.37	1703.9	3246	Day	821	-67.5753	266.4332	0.0000062	-52.089
"T6_1"	20120531	-64.4296	45.3638	12.75	12.85	6.05	40.01	1004.2	359	Day	988	-69.7033	184.6582	0.0000043	-53.681
"T6_2"	20120531	-64.4301	45.3639	15.04	15.32	16.52	35.89	1029.6	980	Day	582	-73.8058	64.39091	0.0000015	-58.257
"T6_3"	20120531	-64.4303	45.3639	17.22	17.32	6.05	31.33	1006.9	359	Day	241	-72.4251	77.27012	0.0000018	-57.465
"T6_4"	20120531	-64.4301	45.3638	18.70	18.76	3.80	30.75	1015.1	225	Day	247	-62.5909	729.875	0.0000169	-47.712
"T6_5"	20120531	-64.4297	45.3637	22.22	22.28	3.60	36.60	992.5	213	Day	927	-52.5346	8800.142	0.0002042	-36.900
"T7_1"	20120531	-64.4314	45.3632	12.88	12.94	3.48	40.99	997.7	207	Day	976	-78.7275	23.68222	0.0000005	-62.601

Table A5-9-7.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T7_2"	20120531	-64.4317	45.3633	15.36	15.42	3.97	34.81	1012.2	235	Day	539	-64.2467	564.3355	0.0000131	-48.830
"T7_3"	20120531	-64.4314	45.3632	17.34	17.40	3.78	32.09	991.7	224	Day	233	-79.7617	14.61341	0.0000003	-64.697
"T7_4"	20120531	-64.4310	45.3630	18.78	18.86	4.87	31.84	1054.0	289	Day	257	-76.8616	28.26743	0.0000007	-61.832
"T7_5"	20120531	-64.4298	45.3629	22.34	22.91	34.08	38.94	1382.0	2021	Day	996	-66.7192	357.2215	0.0000083	-50.816
"T8_1"	20120531	-64.4298	45.3619	12.97	13.13	9.32	42.33	999.8	553	Day	959	-77.6853	31.08771	0.0000007	-61.419
"T8_2"	20120531	-64.4314	45.3622	15.45	15.71	15.15	36.40	1037.4	899	Day	503	-73.0278	78.12679	0.0000018	-57.417
"T8_3"	20120531	-64.4312	45.3621	17.42	17.52	5.98	33.32	1008.7	355	Day	226	-70.1027	140.2365	0.0000033	-54.876
"T8_4"	20120531	-64.4309	45.3619	18.87	18.94	3.75	33.68	1030.1	222	Day	266	-69.7467	153.8975	0.0000036	-54.473
"T8_5"	20120531	-64.4303	45.3619	23.14	23.20	3.87	41.44	1000.4	229	Tran2	1073	-51.8166	11755.52	0.0002727	-35.643
"X1_1"	20120531	-64.4299	45.3475	13.17	13.46	17.35	76.70	3264.2	1029	Day	921	-77.8794	53.86672	0.0000012	-59.032
"X1_2"	20120531	-64.4303	45.3472	15.72	15.99	15.98	70.81	3290.7	948	Day	448	-73.3052	142.5826	0.0000033	-54.804
"X1_3"	20120531	-64.4304	45.3468	17.53	17.75	13.13	69.03	3208.9	779	Day	217	-81.0938	23.12913	0.0000005	-62.703
"X1_4"	20120531	-64.4312	45.3453	18.98	19.36	22.53	67.97	3262.4	1337	Day	300	-72.6287	159.9211	0.0000037	-54.306
"Y1_1"	20120531	-64.4393	45.3326	13.52	13.54	1.45	45.92	462.8	86	Day	888	-87.2627	3.71715	0.0000001	-70.643
"Y1_2"	20120531	-64.4434	45.3327	16.00	16.07	3.85	35.00	1124.9	229	Day	414	-59.2430	1795.939	0.0000417	-43.802
"Y1_3"	20120531	-64.4434	45.3326	17.77	17.84	4.13	32.72	1086.0	245	Day	212	-86.3897	3.238058	0.0000001	-71.242
"Y1_4"	20120531	-64.4432	45.3327	19.43	19.56	7.62	33.79	1107.5	451	Day	349	-81.6477	9.964615	0.0000002	-66.360
"X2_1"	20120531	-64.4419	45.3516	13.60	14.06	27.62	67.98	4356.3	1638	Day	838	-75.7154	78.58184	0.0000018	-57.392
"X2_2"	20120531	-64.4422	45.3515	16.09	16.44	20.77	61.69	4361.0	1231	Day	375	-73.5396	117.6917	0.0000027	-55.637
"X2_3"	20120531	-64.4423	45.3520	17.86	18.17	18.98	58.80	4373.2	1126	Day	211	-83.9104	10.29991	0.0000002	-66.217
"X2_4"	20120531	-64.4414	45.3536	19.59	20.06	28.63	59.98	4325.1	1698	Day	408	-76.5465	57.26046	0.0000013	-58.766

Table A5-9-7.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the May 31, 2012 survey in Minas Passage. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120531	-64.4253	45.3686	12.16	12.22	3.47	43.64	758.6	205	Day	1045	-73.4475	69.5	0.0000016	-57.926
"T0_2"	20120531	-64.4279	45.3690	14.08	14.23	9.38	42.40	1024.7	557	Day	779	-68.6325	203.3	0.0000047	-53.264
"T0_3"	20120531	-64.4279	45.3690	16.46	16.55	5.27	37.10	1014.0	313	Day	334	-79.0249	15.7	0.0000004	-64.382
"T0_4"	20120531	-64.4278	45.3691	18.19	18.25	4.10	35.23	987.3	244	Day	215	-67.3077	218.4	0.0000051	-52.953
"T0_5"	20120531	-64.4270	45.3688	20.08	20.16	4.70	37.33	1004.9	279	Day	468	-73.6449	54.7	0.0000013	-58.968
"T1_1"	20120531	-64.4294	45.3684	12.23	12.31	4.80	50.59	969.6	285	Day	1039	-80.7942	15.3	0.0000004	-64.498
"T1_2"	20120531	-64.4292	45.3684	14.27	14.32	2.88	47.20	990.1	171	Day	754	-74.72	57.0	0.0000013	-58.784
"T1_3"	20120531	-64.4289	45.3684	16.57	16.63	3.90	41.69	986.6	231	Day	319	-65.1686	442.0	0.0000103	-49.891
"T1_4"	20120531	-64.4292	45.3684	18.27	18.34	4.47	40.22	1027.6	265	Day	218	-67.583	242.5	0.0000056	-52.498
"T1_5"	20120531	-64.4294	45.3684	20.19	20.41	12.93	42.95	1032.6	767	Day	502	-78.1216	23.2	0.0000005	-62.684
"T2_1"	20120531	-64.4279	45.3672	12.34	12.42	4.58	48.59	1003.0	272	Day	1032	-86.3574	4.0	0.0000001	-70.271
"T2_2"	20120531	-64.4286	45.3673	14.35	14.54	11.53	46.12	1024.2	684	Day	726	-73.8753	67.4	0.0000016	-58.061
"T2_3"	20120531	-64.4289	45.3675	16.65	16.76	6.13	40.77	1023.0	364	Day	304	-69.8374	146.7	0.0000034	-54.680
"T2_4"	20120531	-64.4284	45.3674	18.36	18.42	3.90	39.43	1008.6	232	Day	222	-83.8389	5.6	0.0000001	-68.862
"T2_5"	20120531	-64.4284	45.3674	20.45	20.52	3.67	42.15	1018.6	218	Day	545	-82.0211	9.2	0.0000002	-66.684
"T3_1"	20120531	-64.4302	45.3671	12.44	12.52	4.55	48.71	999.7	270	Day	1023	-76.2787	41.4	0.0000010	-60.180
"T3_2"	20120531	-64.4294	45.3669	14.57	14.63	3.53	46.09	1016.6	209	Day	697	-77.9988	26.0	0.0000006	-62.188
"T3_3"	20120531	-64.4295	45.3670	16.93	16.99	3.72	40.40	995.2	220	Day	272	-58.4926	1977.0	0.0000459	-43.385
"T3_4"	20120531	-64.4295	45.3670	18.44	18.51	4.45	38.76	996.0	264	Day	227	-72.0852	82.1	0.0000019	-57.203
"T3_5"	20120531	-64.4303	45.3671	20.56	21.01	26.78	43.09	1175.5	1588	Day	612	-73.5393	67.0	0.0000016	-58.084
"T4_1"	20120531	-64.4288	45.3654	12.56	12.63	4.78	41.68	958.9	282	Day	1012	-75.6227	39.8	0.0000009	-60.347
"T4_2"	20120531	-64.4289	45.3656	14.67	14.88	12.92	38.27	1015.4	766	Day	661	-74.2523	49.0	0.0000011	-59.439
"T4_3"	20120531	-64.4301	45.3658	17.00	17.11	6.70	34.66	1147.9	397	Day	261	-76.5454	25.5	0.0000006	-62.283
"T4_4"	20120531	-64.4294	45.3656	18.53	18.59	3.72	32.45	994.6	221	Day	233	-79.699	11.3	0.0000003	-65.813
"T4_5"	20120531	-64.4294	45.3655	21.07	21.13	3.60	36.60	1003.6	213	Day	679	-56.4685	2782.1	0.0000645	-41.901
"T5_1"	20120531	-64.4307	45.3650	12.66	12.73	4.05	41.64	977.9	240	Day	1001	-83.493	6.5	0.0000002	-68.221
"T5_2"	20120531	-64.4312	45.3651	14.95	15.01	3.47	37.70	953.5	206	Day	622	-70.6685	109.8	0.0000025	-55.938
"T5_3"	20120531	-64.4310	45.3650	17.13	17.20	3.82	32.48	1064.2	227	Day	251	-84.1657	4.0	0.0000001	-70.273
"T5_4"	20120531	-64.4307	45.3649	18.61	18.69	4.60	32.24	1032.6	273	Day	240	-81.242	7.9	0.0000002	-67.392
"T5_5"	20120531	-64.4290	45.3646	21.28	22.19	54.73	35.37	1703.9	3246	Day	821	-76.3804	27.2	0.0000006	-62.004
"T6_1"	20120531	-64.4296	45.3638	12.75	12.85	6.05	40.01	1004.2	359	Day	988	-70.7584	116.0	0.0000027	-55.702
"T6_2"	20120531	-64.4301	45.3639	15.04	15.32	16.52	35.89	1029.6	980	Day	582	-77.8935	19.5	0.0000005	-63.436
"T6_3"	20120531	-64.4303	45.3639	17.22	17.32	6.05	31.33	1006.9	359	Day	241	-71.9053	64.9	0.0000015	-58.221
"T6_4"	20120531	-64.4301	45.3638	18.70	18.76	3.80	30.75	1015.1	225	Day	247	-77.2967	18.3	0.0000004	-63.723
"T6_5"	20120531	-64.4297	45.3637	22.22	22.28	3.60	36.60	992.5	213	Day	927	-68.006	195.2	0.0000045	-53.439
"T7_1"	20120531	-64.4314	45.3632	12.88	12.94	3.48	40.99	997.7	207	Day	976	-85.0718	4.4	0.0000001	-69.885

Table A5-9-7.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T7_2"	20120531	-64.4317	45.3633	15.36	15.42	3.97	34.81	1012.2	235	Day	539	-79.3587	13.4	0.0000003	-65.072
"T7_3"	20120531	-64.4314	45.3632	17.34	17.40	3.78	32.09	991.7	224	Day	233	-86.3475	2.4	0.0000001	-72.524
"T7_5"	20120531	-64.4310	45.3630	18.78	18.86	4.87	31.84	1054.0	289	Day	257	-75.7758	27.2	0.0000006	-61.999
"T7_5"	20120531	-64.4298	45.3629	22.34	22.91	34.08	38.94	1382.0	2021	Day	996	-77.1502	25.7	0.0000006	-62.242
"T8_1"	20120531	-64.4298	45.3619	12.97	13.13	9.32	42.33	999.8	553	Day	959	-81.7282	9.9	0.0000002	-66.369
"T8_2"	20120531	-64.4314	45.3622	15.45	15.71	15.15	36.40	1037.4	899	Day	503	-80.0049	12.2	0.0000003	-65.468
"T8_3"	20120531	-64.4312	45.3621	17.42	17.52	5.98	33.32	1008.7	355	Day	226	-69.0081	137.2	0.0000032	-54.971
"T8_4"	20120531	-64.4309	45.3619	18.87	18.94	3.75	33.68	1030.1	222	Day	266	-74.3272	40.9	0.0000009	-60.227
"T8_5"	20120531	-64.4303	45.3619	23.14	23.20	3.87	41.44	1000.4	229	Tran2	1073	-64.2287	544.7	0.0000126	-48.983
"X1_1"	20120531	-64.4299	45.3475	13.17	13.46	17.35	76.70	3264.2	1029	Day	921	-79.2858	34.9	0.0000008	-60.915
"X1_2"	20120531	-64.4303	45.3472	15.72	15.99	15.98	70.81	3290.7	948	Day	448	-82.9117	13.9	0.0000003	-64.930
"X1_3"	20120531	-64.4304	45.3468	17.53	17.75	13.13	69.03	3208.9	779	Day	217	-86.7619	5.5	0.0000001	-68.905
"X1_4"	20120531	-64.4312	45.3453	18.98	19.36	22.53	67.97	3262.4	1337	Day	300	-84.2088	9.8	0.0000002	-66.428
"Y1_1"	20120531	-64.4393	45.3326	13.52	13.54	1.45	45.92	462.8	86	Day	888	-87.6882	2.8	0.0000001	-71.897
"Y1_2"	20120531	-64.4434	45.3327	16.00	16.07	3.85	35.00	1124.9	229	Day	414	-83.7541	4.9	0.0000001	-69.437
"Y1_3"	20120531	-64.4434	45.3326	17.77	17.84	4.13	32.72	1086.0	245	Day	212	-86.2831	2.5	0.0000001	-72.349
"Y1_4"	20120531	-64.4432	45.3327	19.43	19.56	7.62	33.79	1107.5	451	Day	349	-83.3068	5.2	0.0000001	-69.189
"X2_1"	20120531	-64.4419	45.3516	13.60	14.06	27.62	67.98	4356.3	1638	Day	838	-80.2295	24.5	0.0000006	-62.448
"X2_2"	20120531	-64.4422	45.3515	16.09	16.44	20.77	61.69	4361.0	1231	Day	375	-82.0903	14.3	0.0000003	-64.790
"X2_3"	20120531	-64.4423	45.3520	17.86	18.17	18.98	58.80	4373.2	1126	Day	211	-87.0237	4.3	0.0000001	-69.963
"X2_4"	20120531	-64.4414	45.3536	19.59	20.06	28.63	59.98	4325.1	1698	Day	408	-83.2428	10.6	0.0000002	-66.082

Table A5-9-7.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the May 31, 2012 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120531	-64.4253	45.3686	12.16	12.22	3.47	43.64	758.6	205	Day	1045	-72.8839	94.2	0.0000022	-56.605
"T0_2"	20120531	-64.4279	45.3690	14.08	14.23	9.38	42.40	1024.7	557	Day	779	-76.4874	25.0	0.0000006	-62.364
"T0_3"	20120531	-64.4279	45.3690	16.46	16.55	5.27	37.10	1014.0	313	Day	334	-80.5878	11.7	0.0000003	-65.669
"T0_4"	20120531	-64.4278	45.3691	18.19	18.25	4.10	35.23	987.3	244	Day	215	-68.1521	225.6	0.0000052	-52.811
"T0_5"	20120531	-64.4270	45.3688	20.08	20.16	4.70	37.33	1004.9	279	Day	468	-82.9377	6.5	0.0000002	-68.192
"T1_1"	20120531	-64.4294	45.3684	12.23	12.31	4.80	50.59	969.6	285	Day	1039	-78.0008	30.7	0.0000007	-61.470
"T1_2"	20120531	-64.4292	45.3684	14.27	14.32	2.88	47.20	990.1	171	Day	754	-77.3415	21.7	0.0000005	-62.989
"T1_3"	20120531	-64.4289	45.3684	16.57	16.63	3.90	41.69	986.6	231	Day	319	-80.1065	13.0	0.0000003	-65.194
"T1_4"	20120531	-64.4292	45.3684	18.27	18.34	4.47	40.22	1027.6	265	Day	218	-68.1101	247.8	0.0000057	-52.404
"T1_5"	20120531	-64.4294	45.3684	20.19	20.41	12.93	42.95	1032.6	767	Day	502	-81.2231	10.4	0.0000002	-66.158
"T2_1"	20120531	-64.4279	45.3672	12.34	12.42	4.58	48.59	1003.0	272	Day	1032	-86.4639	4.4	0.0000001	-69.954
"T2_2"	20120531	-64.4286	45.3673	14.35	14.54	11.53	46.12	1024.2	684	Day	726	-74.8541	50.9	0.0000012	-59.276
"T2_3"	20120531	-64.4289	45.3675	16.65	16.76	6.13	40.77	1023.0	364	Day	304	-80.0368	12.2	0.0000003	-65.472
"T2_4"	20120531	-64.4284	45.3674	18.36	18.42	3.90	39.43	1008.6	232	Day	222	-81.9123	10.3	0.0000002	-66.207
"T2_5"	20120531	-64.4284	45.3674	20.45	20.52	3.67	42.15	1018.6	218	Day	545	-82.3464	9.1	0.0000002	-66.759
"T3_1"	20120531	-64.4302	45.3671	12.44	12.52	4.55	48.71	999.7	270	Day	1023	-85.9978	4.5	0.0000001	-69.786
"T3_2"	20120531	-64.4294	45.3669	14.57	14.63	3.53	46.09	1016.6	209	Day	697	-77.4308	33.1	0.0000008	-61.142
"T3_3"	20120531	-64.4295	45.3670	16.93	16.99	3.72	40.40	995.2	220	Day	272	-81.7484	7.4	0.0000002	-67.630
"T3_4"	20120531	-64.4295	45.3670	18.44	18.51	4.45	38.76	996.0	264	Day	227	-71.9187	99.9	0.0000023	-56.348
"T3_5"	20120531	-64.4303	45.3671	20.56	21.01	26.78	43.09	1175.5	1588	Day	612	-78.0851	18.4	0.0000004	-63.701
"T4_1"	20120531	-64.4288	45.3654	12.56	12.63	4.78	41.68	958.9	282	Day	1012	-76.0421	39.2	0.0000009	-60.414
"T4_2"	20120531	-64.4289	45.3656	14.67	14.88	12.92	38.27	1015.4	766	Day	661	-73.2466	62.3	0.0000014	-58.397
"T4_3"	20120531	-64.4301	45.3658	17.00	17.11	6.70	34.66	1147.9	397	Day	261	-77.1683	26.6	0.0000006	-62.102
"T4_4"	20120531	-64.4294	45.3656	18.53	18.59	3.72	32.45	994.6	221	Day	233	-80.2210	11.9	0.0000003	-65.591
"T4_5"	20120531	-64.4294	45.3655	21.07	21.13	3.60	36.60	1003.6	213	Day	679	-73.1608	64.2	0.0000015	-58.272
"T5_1"	20120531	-64.4307	45.3650	12.66	12.73	4.05	41.64	977.9	240	Day	1001	-85.2868	4.5	0.0000001	-69.783
"T5_2"	20120531	-64.4312	45.3651	14.95	15.01	3.47	37.70	953.5	206	Day	622	-70.7425	116.3	0.0000027	-55.688
"T5_3"	20120531	-64.4310	45.3650	17.13	17.20	3.82	32.48	1064.2	227	Day	251	-83.4931	5.9	0.0000001	-68.642
"T5_4"	20120531	-64.4307	45.3649	18.61	18.69	4.60	32.24	1032.6	273	Day	240	-81.7422	8.9	0.0000002	-66.863
"T5_5"	20120531	-64.4290	45.3646	21.28	22.19	54.73	35.37	1703.9	3246	Day	821	-75.5169	27.4	0.0000006	-61.974
"T6_1"	20120531	-64.4296	45.3638	12.75	12.85	6.05	40.01	1004.2	359	Day	988	-70.2547	154.1	0.0000036	-54.466
"T6_2"	20120531	-64.4301	45.3639	15.04	15.32	16.52	35.89	1029.6	980	Day	582	-76.9427	28.4	0.0000007	-61.813
"T6_3"	20120531	-64.4303	45.3639	17.22	17.32	6.05	31.33	1006.9	359	Day	241	-72.2838	75.8	0.0000018	-57.546
"T6_5"	20120531	-64.4301	45.3638	18.70	18.76	3.80	30.75	1015.1	225	Day	247	-78.0282	17.5	0.0000004	-63.906
"T6_4"	20120531	-64.4297	45.3637	22.22	22.28	3.60	36.60	992.5	213	Day	927	-77.8066	13.2	0.0000003	-65.136
"T7_1"	20120531	-64.4314	45.3632	12.88	12.94	3.48	40.99	997.7	207	Day	976	-83.8882	7.1	0.0000002	-67.822

Table A5-9-7.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T7_2"	20120531	-64.4317	45.3633	15.36	15.42	3.97	34.81	1012.2	235	Day	539	-64.213	546.7	0.0000127	-48.968
"T7_3"	20120531	-64.4314	45.3632	17.34	17.40	3.78	32.09	991.7	224	Day	233	-83.1208	6.6	0.0000002	-68.178
"T7_4"	20120531	-64.4310	45.3630	18.78	18.86	4.87	31.84	1054.0	289	Day	257	-76.7757	28.1	0.0000007	-61.865
"T7_5"	20120531	-64.4298	45.3629	22.34	22.91	34.08	38.94	1382.0	2021	Day	996	-78.0839	17.3	0.0000004	-63.961
"T8_1"	20120531	-64.4298	45.3619	12.97	13.13	9.32	42.33	999.8	553	Day	959	-78.2072	27.1	0.0000006	-62.021
"T8_2"	20120531	-64.4314	45.3622	15.45	15.71	15.15	36.40	1037.4	899	Day	503	-77.6185	24.7	0.0000006	-62.426
"T8_3"	20120531	-64.4312	45.3621	17.42	17.52	5.98	33.32	1008.7	355	Day	226	-69.92	138.3	0.0000032	-54.936
"T8_4"	20120531	-64.4309	45.3619	18.87	18.94	3.75	33.68	1030.1	222	Day	266	-74.6015	48.6	0.0000011	-59.476
"T8_5"	20120531	-64.4303	45.3619	23.14	23.20	3.87	41.44	1000.4	229	Tran2	1073	-79.9195	14.6	0.0000003	-64.700
"X1_1"	20120531	-64.4299	45.3475	13.17	13.46	17.35	76.70	3264.2	1029	Day	921	-77.9566	52.9	0.0000012	-59.112
"X1_2"	20120531	-64.4303	45.3472	15.72	15.99	15.98	70.81	3290.7	948	Day	448	-83.0817	14.1	0.0000003	-64.845
"X1_3"	20120531	-64.4304	45.3468	17.53	17.75	13.13	69.03	3208.9	779	Day	217	-81.162	22.7	0.0000005	-62.793
"X1_4"	20120531	-64.4312	45.3453	18.98	19.36	22.53	67.97	3262.4	1337	Day	300	-76.1268	71.2	0.0000017	-57.822
"Y1_1"	20120531	-64.4393	45.3326	13.52	13.54	1.45	45.92	462.8	86	Day	888	-87.2506	3.7	0.0000001	-70.668
"Y1_2"	20120531	-64.4434	45.3327	16.00	16.07	3.85	35.00	1124.9	229	Day	414	-84.3926	5.3	0.0000001	-69.142
"Y1_3"	20120531	-64.4434	45.3326	17.77	17.84	4.13	32.72	1086.0	245	Day	212	-86.3897	3.2	0.0000001	-71.242
"Y1_4"	20120531	-64.4432	45.3327	19.43	19.56	7.62	33.79	1107.5	451	Day	349	-83.2582	6.3	0.0000001	-68.355
"X2_1"	20120531	-64.4419	45.3516	13.60	14.06	27.62	67.98	4356.3	1638	Day	838	-78.6967	38.2	0.0000009	-60.524
"X2_2"	20120531	-64.4422	45.3515	16.09	16.44	20.77	61.69	4361.0	1231	Day	375	-75.8501	64.5	0.0000015	-58.252
"X2_3"	20120531	-64.4423	45.3520	17.86	18.17	18.98	58.80	4373.2	1126	Day	211	-86.2142	5.9	0.0000001	-68.602
"X2_4"	20120531	-64.4414	45.3536	19.59	20.06	28.63	59.98	4325.1	1698	Day	408	-79.0151	30.3	0.0000007	-61.524

Table A5-9-8.1. Summary of acoustic backscatter from **2 m** below the transducer to bottom by individual transect for the June 25, 2012 survey in Minas Passage. Note time is expressed in hour decimal minutes**.**

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120625	-64.4266	45.3688	9.14	9.19	3.08	43.49	488.4	92	Tran1	962	-81.3778	13.6	0.0000003	-64.994
"T0_2"	20120625	-64.4303	45.3697	12.43	12.50	4.07	37.87	676.7	241	Day	291	-74.3376	60.1	0.0000014	-58.554
"T0_3"	20120625	-64.4279	45.3690	14.54	14.64	5.53	35.31	990.8	328	Day	208	-64.2986	565.7	0.0000131	-48.819
"T0_4"	20120625	-64.4288	45.3693	17.01	17.11	5.92	39.92	1170.6	351	Day	684	-63.6358	745.0	0.0000173	-47.624
"T0_5"	20120625	-64.4275	45.3688	20.41	20.49	4.67	45.72	972.1	277	Day	1090	-66.9683	396.1	0.0000092	-50.367
"T0_6"	20120625	-64.4287	45.3693	21.47	21.59	7.43	44.81	1020.2	441	Day	968	-67.7329	325.6	0.0000076	-51.219
"T0_7"	20120625	-64.4279	45.3692	23.27	23.40	7.75	40.71	1017.1	460	Day	624	-49.0753	21711.9	0.0005037	-32.978
"T0_8"	20120626	-64.4277	45.3689	1.99	2.09	5.87	35.84	934.0	348	Night	217	-59.5983	1694.4	0.0000393	-44.055
"T0_9"	20120626	-64.4279	45.3688	4.15	4.23	4.42	38.21	1005.1	262	Night	438	-57.93	2652.8	0.0000615	-42.108
"T0_10"	20120626	-64.4276	45.3691	8.13	8.23	5.67	45.73	1009.7	335	Night	1103	-53.079	9699.6	0.0002250	-36.477
"T1_1"	20120625	-64.4334	45.3693	9.28	9.29	0.80	50.01	204.7	24	Tran1	940	-75.7763	57.0	0.0000013	-58.786
"T1_2"	20120625	-64.4287	45.3684	12.56	12.64	4.78	42.23	988.8	284	Day	270	-52.5567	10102.9	0.0002344	-36.300
"T1_3"	20120625	-64.4254	45.3676	14.65	14.71	3.17	39.96	455.8	186	Day	217	-73.0241	85.8	0.0000020	-57.008
"T1_4"	20120625	-64.4293	45.3684	17.16	17.48	19.22	45.71	1089.1	1120	Day	746	-62.0648	1224.8	0.0000284	-45.464
"T1_5"	20120625	-64.4288	45.3683	20.50	20.60	5.60	50.48	995.8	332	Day	1082	-62.7476	1155.6	0.0000268	-45.717
"T1_6"	20120625	-64.4289	45.3683	21.61	21.67	3.68	49.82	981.9	218	Day	950	-62.8737	1108.1	0.0000257	-45.899
"T1_7"	20120625	-64.4290	45.3683	23.42	23.50	5.08	45.69	996.6	302	Day	600	-49.5985	21599.5	0.0005011	-33.000
"T1_8"	20120626	-64.4288	45.3683	2.13	2.22	5.30	41.25	999.3	315	Night	215	-59.5348	1978.9	0.0000459	-43.381
"T1_9"	20120626	-64.4290	45.3683	4.26	4.47	12.35	43.17	1000.5	732	Night	475	-58.1697	2835.8	0.0000658	-41.818
"T2_1"	20120625	-64.4281	45.3674	9.32	9.46	8.23	47.99	1007.6	247	Tran1	922	-70.466	185.8	0.0000043	-53.654
"T2_2"	20120625	-64.4287	45.3676	12.67	12.81	8.77	41.21	1004.9	520	Day	248	-69.701	190.3	0.0000044	-53.551
"T2_3"	20120625	-64.4290	45.3675	14.78	14.88	5.85	40.66	1102.0	347	Day	235	-75.9958	44.1	0.0000010	-59.904
"T2_4"	20120625	-64.4282	45.3673	17.52	17.58	3.78	44.69	1001.4	224	Day	800	-53.3355	8936.0	0.0002073	-36.833
"T2_5"	20120625	-64.4285	45.3674	20.61	20.69	4.53	49.81	1001.6	269	Day	1074	-58.2197	3234.5	0.0000750	-41.247
"T2_6"	20120625	-64.4273	45.3671	21.69	21.88	11.48	48.66	1026.8	681	Day	926	-58.0851	3259.6	0.0000756	-41.213
"T2_7"	20120625	-64.4288	45.3674	23.53	23.73	12.37	45.02	1034.1	732	Day	565	-54.9323	6232.3	0.0001446	-38.398
"T2_8"	20120626	-64.4289	45.3676	2.25	2.37	7.05	40.78	1016.8	418	Night	215	-70.8447	144.7	0.0000034	-54.740
"T2_9"	20120626	-64.4290	45.3677	4.50	4.57	4.13	42.50	1006.8	242	Night	506	-58.6058	2525.4	0.0000586	-42.322
"T3_1"	20120625	-64.4294	45.3670	9.54	9.60	3.68	46.63	998.6	110	Tran1	889	-70.5554	176.9	0.0000041	-53.868
"T3_2"	20120625	-64.4293	45.3670	12.84	12.91	4.30	40.27	1000.2	255	Day	321	-72.6664	93.9	0.0000022	-56.617
"T3_3"	20120625	-64.4286	45.3669	14.90	15.01	6.40	40.28	859.2	379	Day	253	-76.0339	43.3	0.0000010	-59.983
"T3_4"	20120625	-64.4283	45.3667	17.69	18.15	27.83	45.33	1270.6	1601	Day	879	-64.3696	714.3	0.0000166	-47.806
"T3_5"	20120625	-64.4292	45.3670	20.70	20.80	5.93	48.98	998.5	352	Day	1065	-57.6815	3600.6	0.0000835	-40.781
"T3_6"	20120625	-64.4294	45.3669	21.90	21.96	3.55	48.77	1000.1	210	Day	903	-65.4863	594.4	0.0000138	-48.604
"T3_7"	20120625	-64.4295	45.3669	23.75	23.81	3.50	44.46	987.4	207	Day	533	-57.3247	3547.8	0.0000823	-40.845
"T3_8"	20120626	-64.4292	45.3669	2.39	2.50	6.63	39.75	995.8	393	Night	218	-66.5426	379.8	0.0000088	-50.550
"T3_9"	20120626	-64.4297	45.3670	4.61	5.02	24.77	42.68	1115.0	1468	Night	567	-55.0978	5687.8	0.0001320	-38.796

Table A5-9-8.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T4_1"	20120625	-64.4288	45.3655	9.63	9.85	13.03	39.72	1016.8	391	Tran1	857	-74.1318	66.1	0.0000015	-58.141
"T4_2"	20120625	-64.4297	45.3658	12.94	13.09	8.53	35.02	998.5	503	Day	215	-78.9318	19.3	0.0000004	-63.488
"T4_3"	20120625	-64.4332	45.3664	15.04	15.07	1.55	42.56	326.3	89	Day	267	-76.3824	42.2	0.0000010	-60.092
"T4_4"	20120625	-64.4298	45.3656	18.19	18.25	3.32	40.51	994.8	196	Day	938	-54.8522	5713.2	0.0001326	-38.776
"T4_5"	20120625	-64.4292	45.3656	20.83	20.90	4.38	43.05	997.8	258	Day	1055	-61.5036	1312.5	0.0000305	-45.164
"T4_6"	20120625	-64.4296	45.3657	21.99	22.22	13.82	42.46	1021.3	807	Day	870	-61.6967	1238.3	0.0000287	-45.417
"T4_7"	20120625	-64.4295	45.3658	23.83	0.05	-1426.82	38.19	1044.7	782	Night	499	-61.0024	1306.8	0.0000303	-45.183
"T4_8"	20120626	-64.4296	45.3656	2.53	2.63	6.53	34.07	1008.9	384	Night	223	-73.7914	61.3	0.0000014	-58.468
"T4_9"	20120626	-64.4300	45.3654	5.07	5.13	3.53	37.54	994.8	203	Night	634	-55.3986	4668.4	0.0001083	-39.653
"T5_2"	20120625	-64.4302	45.3649	13.12	13.18	4.15	32.21	983.1	246	Day	200	-79.7606	14.7	0.0000003	-64.680
"T5_3"	20120625	-64.4275	45.3643	15.09	15.27	10.65	30.84	1605.5	624	Day	285	-69.9869	133.3	0.0000031	-55.096
"T5_4"	20120625	-64.4286	45.3647	18.30	18.77	27.70	38.23	1240.5	1605	Day	994	-65.0769	511.9	0.0000119	-49.253
"T5_5"	20120625	-64.4303	45.3648	20.92	20.99	4.62	41.65	994.4	274	Day	1044	-59.048	2234.9	0.0000519	-42.852
"T5_6"	20120625	-64.4306	45.3650	22.24	22.30	3.57	39.79	996.5	212	Day	839	-61.1056	1329.5	0.0000308	-45.108
"T5_7"	20120626	-64.4302	45.3648	0.07	0.13	3.48	35.42	994.9	207	Night	468	-64.6922	518.2	0.0000120	-49.200
"T5_8"	20120626	-64.4304	45.3649	2.65	2.75	5.97	32.12	1002.0	354	Night	231	-65.1749	420.5	0.0000098	-50.107
"T5_9"	20120626	-64.4279	45.3644	5.21	6.15	56.53	33.79	1638.9	2670	Night	741	-57.8554	2386.0	0.0000554	-42.568
"T6_2"	20120625	-64.4303	45.3639	13.22	13.36	8.73	32.20	997.8	511	Day	189	-81.079	10.8	0.0000003	-66.001
"T6_3"	20120625	-64.4294	45.3638	15.40	15.47	4.45	30.89	1041.8	256	Day	328	-76.7358	28.2	0.0000007	-61.838
"T6_4"	20120625	-64.4294	45.3636	18.80	18.86	3.63	38.48	1036.8	209	Day	1037	-49.3745	19155.7	0.0004444	-33.522
"T6_5"	20120625	-64.4299	45.3639	21.01	21.10	5.25	40.28	1008.3	309	Day	1033	-59.9038	1774.9	0.0000412	-43.853
"T6_6"	20120625	-64.4292	45.3636	22.33	22.65	19.42	38.11	1039.7	1144	Day	798	-57.3607	3016.4	0.0000700	-41.550
"T6_7"	20120626	-64.4301	45.3639	0.15	0.39	14.43	34.30	1012.6	846	Night	432	-65.5959	407.6	0.0000095	-50.243
"T6_8"	20120626	-64.4304	45.3640	2.78	2.87	5.92	31.79	1007.5	346	Night	239	-64.1428	527.8	0.0000122	-49.120
"T6_9"	20120626	-64.4298	45.3637	6.20	6.26	3.60	36.71	983.1	192	Night	876	-45.9106	40574.2	0.0009414	-30.262
"T7_2"	20120625	-64.4314	45.3632	13.39	13.46	4.25	32.61	1010.0	252	Day	181	-81.5145	9.9	0.0000002	-66.381
"T7_3"	20120625	-64.4313	45.3632	15.49	15.64	9.02	33.39	1000.1	532	Day	352	-63.8898	587.7	0.0000136	-48.654
"T7_5"	20120625	-64.4314	45.3631	21.15	21.22	4.12	41.57	1021.5	242	Day	1018	-61.1768	1366.5	0.0000317	-44.989
"T7_6"	20120625	-64.4316	45.3634	22.67	22.74	4.10	38.23	998.6	240	Day	755	-56.5587	3639.5	0.0000844	-40.735
"T7_7"	20120626	-64.4316	45.3632	0.41	0.48	4.37	34.60	995.3	254	Night	401	-59.3322	1739.4	0.0000404	-43.941
"T7_8"	20120626	-64.4304	45.3629	2.90	3.00	6.10	32.46	912.9	361	Night	249	-65.2974	413.2	0.0000096	-50.183
"T7_9"	20120626	-64.4311	45.3631	6.31	6.90	35.43	38.82	1439.6	2060	Night	949	-54.8995	5415.5	0.0001256	-39.009
"T8_2"	20120625	-64.4315	45.3621	13.49	13.62	8.00	33.13	998.8	474	Day	175	-81.357	10.4	0.0000002	-66.155
"T8_3"	20120625	-64.4309	45.3620	15.66	15.72	3.98	34.62	1003.1	237	Day	378	-60.5135	1325.9	0.0000308	-45.120

Table A5-9-8.1. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_5"	20120625	-64.4305	45.3620	21.23	21.36	7.45	42.67	1016.3	440	Day	1002	-58.5119	2590.5	0.0000601	-42.211
"T8_6"	20120625	-64.4311	45.3621	22.78	23.17	23.65	39.18	1064.5	1401	Day	701	-59.9714	1700.0	0.0000394	-44.041
"T8_7"	20120626	-64.4315	45.3622	0.51	0.74	14.02	35.25	1008.9	831	Night	368	-64.1242	587.7	0.0000136	-48.653
"T8_8"	20120626	-64.4318	45.3622	3.02	3.11	5.23	33.03	1017.1	310	Night	260	-63.7513	600.1	0.0000139	-48.562
"T8_9"	20120626	-64.4310	45.3618	6.94	7.00	3.80	44.77	997.6	225	Night	1008	-52.2963	11371.7	0.0002638	-35.787
"X1_2"	20120625	-64.4306	45.3464	13.64	13.91	16.45	70.20	3157.2	958	Day	170	-77.6161	52.4	0.0000012	-59.153
"X1_3"	20120625	-64.4306	45.3465	15.74	16.09	21.03	71.35	3394.9	1237	Day	426	-61.7696	2046.1	0.0000475	-43.236
"X1_7"	20120626	-64.4304	45.3468	0.90	1.26	21.88	71.17	3230.3	1293	Night	297	-64.4749	1094.6	0.0000254	-45.952
"X1_8"	20120626	-64.4308	45.3455	3.12	3.42	18.28	69.63	3233.3	1080	Night	286	-71.6764	204.0	0.0000047	-53.248
"X1_9"	20120626	-64.4306	45.3457	7.06	7.36	17.90	80.24	3333.0	1040	Night	1039	-54.7881	11483.4	0.0002664	-35.744
"Y1_2"	20120625	-64.4426	45.3327	13.92	14.00	5.13	33.23	1068.4	305	Day	171	-77.2231	27.1	0.0000006	-62.008
"Y1_3"	20120625	-64.4424	45.3326	16.11	16.22	6.35	35.78	1097.1	376	Day	476	-76.2799	36.3	0.0000008	-60.744
"Y1_7"	20120626	-64.4422	45.3327	1.27	1.33	3.80	34.84	853.7	226	Night	268	-74.8145	49.6	0.0000011	-59.393
"Y1_8"	20120626	-64.4428	45.3326	3.43	3.57	8.63	33.82	1122.3	512	Night	318	-75.423	41.8	0.0000010	-60.132
"Y1_9"	20120626	-64.4425	45.3326	7.41	7.50	5.32	41.68	1123.1	314	Night	1066	-58.8316	2350.8	0.0000545	-42.633
"X2_1"	20120625	-64.4424	45.3509	11.52	12.01	29.58	68.37	3859.8	1754	Day	424	-75.7492	78.4	0.0000018	-57.401
"X2_2"	20120625	-64.4422	45.3517	14.01	14.41	24.22	57.69	4406.1	1418	Day	179	-77.1826	47.6	0.0000011	-59.571
"X2_3"	20120625	-64.4396	45.3550	16.23	16.96	43.45	60.51	4480.0	2569	Day	575	-59.5318	2904.8	0.0000674	-41.714
"X2_7"	20120626	-64.4422	45.3515	1.36	1.86	29.95	59.86	4376.2	1770	Night	239	-67.131	499.5	0.0000116	-49.360
"X2_8"	20120626	-64.4420	45.3526	3.58	4.04	27.75	60.32	4351.0	1630	Night	367	-68.9516	330.9	0.0000077	-51.147
"X2_9"	20120626	-64.4424	45.3511	7.55	7.99	26.57	69.17	4451.9	1555	Night	1090	-58.8214	3910.6	0.0000907	-40.422

Table A5-9-8.2. Summary of acoustic backscatter from **10 m** below the transducer to bottom by individual transect for the June 25, 2012 survey in Minas Passage. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120625	-64.4266	45.3688	9.14	9.19	3.08	43.49	488.4	92	Tran1	962	-80.9924	12.2	0.0000003	-65.494
"T0_2"	20120625	-64.4303	45.3697	12.43	12.50	4.07	37.87	676.7	241	Day	291	-75.1111	55.8	0.0000013	-58.879
"T0_3"	20120625	-64.4279	45.3690	14.54	14.64	5.53	35.31	990.8	328	Day	208	-77.9339	18.9	0.0000004	-63.573
"T0_4"	20120625	-64.4288	45.3693	17.01	17.11	5.92	39.92	1170.6	351	Day	684	-69.6196	150.1	0.0000035	-54.581
"T0_5"	20120625	-64.4275	45.3688	20.41	20.49	4.67	45.72	972.1	277	Day	1090	-68.9026	209.2	0.0000049	-53.139
"T0_6"	20120625	-64.4287	45.3693	21.47	21.59	7.43	44.81	1020.2	441	Day	968	-69.6311	172.7	0.0000040	-53.973
"T0_7"	20120625	-64.4279	45.3692	23.27	23.40	7.75	40.71	1017.1	460	Day	624	-53.0506	6981.0	0.0001620	-37.906
"T0_8"	20120626	-64.4277	45.3689	1.99	2.09	5.87	35.84	934.0	348	Night	217	-67.7836	199.8	0.0000046	-53.340
"T0_9"	20120626	-64.4279	45.3688	4.15	4.23	4.42	38.21	1005.1	262	Night	438	-70.8227	107.7	0.0000025	-56.023
"T0_10"	20120626	-64.4276	45.3691	8.13	8.23	5.67	45.73	1009.7	335	Night	1103	-68.6295	222.8	0.0000052	-52.865
"T1_1"	20120625	-64.4334	45.3693	9.28	9.29	0.80	50.01	204.7	24	Tran1	940	-78.7914	17.0	0.0000004	-64.041
"T1_2"	20120625	-64.4287	45.3684	12.56	12.64	4.78	42.23	988.8	284	Day	270	-58.4422	2110.9	0.0000490	-43.100
"T1_3"	20120625	-64.4254	45.3676	14.65	14.71	3.17	39.96	455.8	186	Day	217	-77.5068	24.4	0.0000006	-62.463
"T1_4"	20120625	-64.4293	45.3684	17.16	17.48	19.22	45.71	1089.1	1120	Day	746	-71.3429	119.3	0.0000028	-55.580
"T1_5"	20120625	-64.4288	45.3683	20.50	20.60	5.60	50.48	995.8	332	Day	1082	-64.8773	595.3	0.0000138	-48.598
"T1_6"	20120625	-64.4289	45.3683	21.61	21.67	3.68	49.82	981.9	218	Day	950	-67.6466	309.8	0.0000072	-51.434
"T1_7"	20120625	-64.4290	45.3683	23.42	23.50	5.08	45.69	996.6	302	Day	600	-51.6059	11217.6	0.0002603	-35.846
"T1_8"	20120626	-64.4288	45.3683	2.13	2.22	5.30	41.25	999.3	315	Night	215	-67.9613	229.0	0.0000053	-52.746
"T1_9"	20120626	-64.4290	45.3683	4.26	4.47	12.35	43.17	1000.5	732	Night	475	-72.783	79.8	0.0000019	-57.324
"T2_1"	20120625	-64.4281	45.3674	9.32	9.46	8.23	47.99	1007.6	247	Tran1	922	-75.7395	46.0	0.0000011	-59.722
"T2_2"	20120625	-64.4287	45.3676	12.67	12.81	8.77	41.21	1004.9	520	Day	248	-74.4932	50.8	0.0000012	-59.283
"T2_3"	20120625	-64.4290	45.3675	14.78	14.88	5.85	40.66	1102.0	347	Day	235	-77.2925	26.2	0.0000006	-62.155
"T2_4"	20120625	-64.4282	45.3673	17.52	17.58	3.78	44.69	1001.4	224	Day	800	-64.4135	572.1	0.0000133	-48.770
"T2_5"	20120625	-64.4285	45.3674	20.61	20.69	4.53	49.81	1001.6	269	Day	1074	-67.5162	319.1	0.0000074	-51.306
"T2_6"	20120625	-64.4273	45.3671	21.69	21.88	11.48	48.66	1026.8	681	Day	926	-67.0917	342.2	0.0000079	-51.002
"T2_7"	20120625	-64.4288	45.3674	23.53	23.73	12.37	45.02	1034.1	732	Day	565	-61.7305	1070.6	0.0000248	-46.048
"T2_8"	20120626	-64.4289	45.3676	2.25	2.37	7.05	40.78	1016.8	418	Night	215	-75.0035	44.6	0.0000010	-59.849
"T2_9"	20120626	-64.4290	45.3677	4.50	4.57	4.13	42.50	1006.8	242	Night	506	-73.7911	62.1	0.0000014	-58.415
"T3_1"	20120625	-64.4294	45.3670	9.54	9.60	3.68	46.63	998.6	110	Tran1	889	-76.7451	35.2	0.0000008	-60.877
"T3_2"	20120625	-64.4293	45.3670	12.84	12.91	4.30	40.27	1000.2	255	Day	321	-73.4231	63.2	0.0000015	-58.337
"T3_3"	20120625	-64.4286	45.3669	14.90	15.01	6.40	40.28	859.2	379	Day	253	-76.4545	31.5	0.0000007	-61.367
"T3_4"	20120625	-64.4283	45.3667	17.69	18.15	27.83	45.33	1270.6	1601	Day	879	-72.3377	93.9	0.0000022	-56.619
"T3_5"	20120625	-64.4292	45.3670	20.70	20.80	5.93	48.98	998.5	352	Day	1065	-62.9299	899.3	0.0000209	-46.806
"T3_6"	20120625	-64.4294	45.3669	21.90	21.96	3.55	48.77	1000.1	210	Day	903	-67.892	285.4	0.0000066	-51.790
"T3_7"	20120625	-64.4295	45.3669	23.75	23.81	3.50	44.46	987.4	207	Day	533	-66.3991	359.9	0.0000083	-50.783
"T3_8"	20120626	-64.4292	45.3669	2.39	2.50	6.63	39.75	995.8	393	Night	218	-76.5388	30.3	0.0000007	-61.524
"T3_9"	20120626	-64.4297	45.3670	4.61	5.02	24.77	42.68	1115.0	1468	Night	567	-68.0496	234.1	0.0000054	-52.651

Table A5-9-8.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T4_1"	20120625	-64.4288	45.3655	9.63	9.85	13.03	39.72	1016.8	391	Tran1	857	-74.7421	45.9	0.0000011	-59.731
"T4_2"	20120625	-64.4297	45.3658	12.94	13.09	8.53	35.02	998.5	503	Day	215	-79.3629	13.5	0.0000003	-65.048
"T4_3"	20120625	-64.4332	45.3664	15.04	15.07	1.55	42.56	326.3	89	Day	267	-77.3817	27.2	0.0000006	-61.998
"T4_4"	20120625	-64.4298	45.3656	18.19	18.25	3.32	40.51	994.8	196	Day	938	-60.7402	1181.2	0.0000274	-45.622
"T4_5"	20120625	-64.4292	45.3656	20.83	20.90	4.38	43.05	997.8	258	Day	1055	-69.0783	186.7	0.0000043	-53.634
"T4_6"	20120625	-64.4296	45.3657	21.99	22.22	13.82	42.46	1021.3	807	Day	870	-68.6088	204.5	0.0000047	-53.238
"T4_7"	20120625	-64.4295	45.3658	23.83	0.05	-1426.82	38.19	1044.7	782	Night	499	-67.5547	228.4	0.0000053	-52.758
"T4_8"	20120626	-64.4296	45.3656	2.53	2.63	6.53	34.07	1008.9	384	Night	223	-78.3191	16.5	0.0000004	-64.161
"T4_9"	20120626	-64.4300	45.3654	5.07	5.13	3.53	37.54	994.8	203	Night	634	-63.3031	594.8	0.0000138	-48.601
"T5_2"	20120625	-64.4302	45.3649	13.12	13.18	4.15	32.21	983.1	246	Day	200	-81.3805	7.6	0.0000002	-67.543
"T5_3"	20120625	-64.4275	45.3643	15.09	15.27	10.65	30.84	1605.5	624	Day	285	-77.2672	18.5	0.0000004	-63.684
"T5_4"	20120625	-64.4286	45.3647	18.30	18.77	27.70	38.23	1240.5	1605	Day	994	-72.5291	72.7	0.0000017	-57.727
"T5_5"	20120625	-64.4303	45.3648	20.92	20.99	4.62	41.65	994.4	274	Day	1044	-67.2459	273.3	0.0000063	-51.979
"T5_6"	20120625	-64.4306	45.3650	22.24	22.30	3.57	39.79	996.5	212	Day	839	-67.7979	227.4	0.0000053	-52.778
"T5_7"	20120626	-64.4302	45.3648	0.07	0.13	3.48	35.42	994.9	207	Night	468	-68.7511	157.5	0.0000037	-54.373
"T5_8"	20120626	-64.4304	45.3649	2.65	2.75	5.97	32.12	1002.0	354	Night	231	-71.7687	69.1	0.0000016	-57.948
"T5_9"	20120626	-64.4279	45.3644	5.21	6.15	56.53	33.79	1638.9	2670	Night	741	-66.1691	268.3	0.0000062	-52.058
"T6_2"	20120625	-64.4303	45.3639	13.22	13.36	8.73	32.20	997.8	511	Day	189	-81.2115	7.9	0.0000002	-67.377
"T6_3"	20120625	-64.4294	45.3638	15.40	15.47	4.45	30.89	1041.8	256	Day	328	-77.3427	18.2	0.0000004	-63.750
"T6_4"	20120625	-64.4294	45.3636	18.80	18.86	3.63	38.48	1036.8	209	Day	1037	-57.2806	2456.0	0.0000570	-42.443
"T6_5"	20120625	-64.4299	45.3639	21.01	21.10	5.25	40.28	1008.3	309	Day	1033	-70.8535	114.2	0.0000027	-55.767
"T6_6"	20120625	-64.4292	45.3636	22.33	22.65	19.42	38.11	1039.7	1144	Day	798	-67.1012	252.9	0.0000059	-52.316
"T6_7"	20120626	-64.4301	45.3639	0.15	0.39	14.43	34.30	1012.6	846	Night	432	-72.0288	71.0	0.0000016	-57.832
"T6_8"	20120626	-64.4304	45.3640	2.78	2.87	5.92	31.79	1007.5	346	Night	239	-78.9443	13.1	0.0000003	-65.184
"T6_9"	20120626	-64.4298	45.3637	6.20	6.26	3.60	36.71	983.1	192	Night	876	-52.0644	7688.9	0.0001784	-37.486
"T7_2"	20120625	-64.4314	45.3632	13.39	13.46	4.25	32.61	1010.0	252	Day	181	-81.6427	7.3	0.0000002	-67.735
"T7_3"	20120625	-64.4313	45.3632	15.49	15.64	9.02	33.39	1000.1	532	Day	352	-71.0801	85.3	0.0000020	-57.036
"T7_5"	20120625	-64.4314	45.3631	21.15	21.22	4.12	41.57	1021.5	242	Day	1018	-67.6076	250.9	0.0000058	-52.350
"T7_6"	20120625	-64.4316	45.3634	22.67	22.74	4.10	38.23	998.6	240	Day	755	-68.876	168.7	0.0000039	-54.074
"T7_7"	20120626	-64.4316	45.3632	0.41	0.48	4.37	34.60	995.3	254	Night	401	-79.1925	13.8	0.0000003	-64.946
"T7_8"	20120626	-64.4304	45.3629	2.90	3.00	6.10	32.46	912.9	361	Night	249	-78.0952	16.3	0.0000004	-64.213
"T7_9"	20120626	-64.4311	45.3631	6.31	6.90	35.43	38.82	1439.6	2060	Night	949	-65.0965	410.7	0.0000095	-50.210
"T8_2"	20120625	-64.4315	45.3621	13.49	13.62	8.00	33.13	998.8	474	Day	175	-81.4048	7.8	0.0000002	-67.406
"T8_3"	20120625	-64.4309	45.3620	15.66	15.72	3.98	34.62	1003.1	237	Day	378	-80.0615	11.3	0.0000003	-65.812

Table A5-9-8.2. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_5"	20120625	-64.4305	45.3620	21.23	21.36	7.45	42.67	1016.3	440	Day	1002	-67.5436	262.9	0.0000061	-52.147
"T8_6"	20120625	-64.4311	45.3621	22.78	23.17	23.65	39.18	1064.5	1401	Day	701	-69.7818	141.2	0.0000033	-54.845
"T8_7"	20120626	-64.4315	45.3622	0.51	0.74	14.02	35.25	1008.9	831	Night	368	-75.2633	34.9	0.0000008	-60.913
"T8_8"	20120626	-64.4318	45.3622	3.02	3.11	5.23	33.03	1017.1	310	Night	260	-76.3457	25.0	0.0000006	-62.364
"T8_9"	20120626	-64.4310	45.3618	6.94	7.00	3.80	44.77	997.6	225	Night	1008	-64.1937	603.1	0.0000140	-48.541
"X1_2"	20120625	-64.4306	45.3464	13.64	13.91	16.45	70.20	3157.2	958	Day	170	-77.3489	49.4	0.0000011	-59.412
"X1_3"	20120625	-64.4306	45.3465	15.74	16.09	21.03	71.35	3394.9	1237	Day	426	-70.7301	230.7	0.0000054	-52.714
"X1_7"	20120626	-64.4304	45.3468	0.90	1.26	21.88	71.17	3230.3	1293	Night	297	-73.4516	122.9	0.0000029	-55.448
"X1_8"	20120626	-64.4308	45.3455	3.12	3.42	18.28	69.63	3233.3	1080	Night	286	-72.2143	159.5	0.0000037	-54.318
"X1_9"	20120626	-64.4306	45.3457	7.06	7.36	17.90	80.24	3333.0	1040	Night	1039	-60.21	2965.9	0.0000688	-41.623
"Y1_2"	20120625	-64.4426	45.3327	13.92	14.00	5.13	33.23	1068.4	305	Day	171	-76.5722	23.9	0.0000006	-62.556
"Y1_3"	20120625	-64.4424	45.3326	16.11	16.22	6.35	35.78	1097.1	376	Day	476	-78.546	16.7	0.0000004	-64.112
"Y1_7"	20120626	-64.4422	45.3327	1.27	1.33	3.80	34.84	853.7	226	Night	268	-73.9686	46.4	0.0000011	-59.683
"Y1_8"	20120626	-64.4428	45.3326	3.43	3.57	8.63	33.82	1122.3	512	Night	318	-78.3815	16.1	0.0000004	-64.266
"Y1_9"	20120626	-64.4425	45.3326	7.41	7.50	5.32	41.68	1123.1	314	Night	1066	-74.2805	54.1	0.0000013	-59.009
"X2_1"	20120625	-64.4424	45.3509	11.52	12.01	29.58	68.37	3859.8	1754	Day	424	-78.3956	37.6	0.0000009	-60.589
"X2_2"	20120625	-64.4422	45.3517	14.01	14.41	24.22	57.69	4406.1	1418	Day	179	-77.4058	38.9	0.0000009	-60.444
"X2_3"	20120625	-64.4396	45.3550	16.23	16.96	43.45	60.51	4480.0	2569	Day	575	-64.9363	726.0	0.0000168	-47.736
"X2_7"	20120626	-64.4422	45.3515	1.36	1.86	29.95	59.86	4376.2	1770	Night	239	-68.7531	297.8	0.0000069	-51.606
"X2_8"	20120626	-64.4420	45.3526	3.58	4.04	27.75	60.32	4351.0	1630	Night	367	-74.3253	83.3	0.0000019	-57.140
"X2_9"	20120626	-64.4424	45.3511	7.55	7.99	26.57	69.17	4451.9	1555	Night	1090	-69.2104	316.1	0.0000073	-51.347

Table A5-9-8.3. Summary of acoustic backscatter from **edited surface** (turbulence/bubble noise removed) to bottom by individual transect for the June 25, 2012 survey in Minas Passage. This estimate contains only fish-like targets in the estimate of backscatter. Several transects were not completed due to technical problems. Note time is expressed in hour decimal minutes.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T0_1"	20120625	-64.4266	45.3688	9.14	9.19	3.08	43.49	488.4	92	Tran1	962	-81.3809	13.7	0.0000003	-64.991
"T0_2"	20120625	-64.4303	45.3697	12.43	12.50	4.07	37.87	676.7	241	Day	291	-75.7915	57.0	0.0000013	-58.784
"T0_3"	20120625	-64.4279	45.3690	14.54	14.64	5.53	35.31	990.8	328	Day	208	-77.5213	26.5	0.0000006	-62.109
"T0_4"	20120625	-64.4288	45.3693	17.01	17.11	5.92	39.92	1170.6	351	Day	684	-77.1946	23.5	0.0000005	-62.637
"T0_5"	20120625	-64.4275	45.3688	20.41	20.49	4.67	45.72	972.1	277	Day	1090	-69.1058	207.4	0.0000048	-53.176
"T0_6"	20120625	-64.4287	45.3693	21.47	21.59	7.43	44.81	1020.2	441	Day	968	-69.7965	172.0	0.0000040	-53.990
"T0_7"	20120625	-64.4279	45.3692	23.27	23.40	7.75	40.71	1017.1	460	Day	624	-76.0299	0.2	0.0000000	-83.222
"T0_8"	20120626	-64.4277	45.3689	1.99	2.09	5.87	35.84	934.0	348	Night	217	-78.5286	12.5	0.0000003	-65.391
"T0_9"	20120626	-64.4279	45.3688	4.15	4.23	4.42	38.21	1005.1	262	Night	438	-77.9147	14.8	0.0000003	-64.652
"T0_10"	20120626	-64.4276	45.3691	8.13	8.23	5.67	45.73	1009.7	335	Night	1103	-69.5355	130.2	0.0000030	-55.198
"T1_1"	20120625	-64.4334	45.3693	9.28	9.29	0.80	50.01	204.7	24	Tran1	940	-77.793	23.4	0.0000005	-62.656
"T1_2"	20120625	-64.4287	45.3684	12.56	12.64	4.78	42.23	988.8	284	Day	270	-71.5682	89.3	0.0000021	-56.835
"T1_3"	20120625	-64.4254	45.3676	14.65	14.71	3.17	39.96	455.8	186	Day	217	-77.7835	26.7	0.0000006	-62.072
"T1_4"	20120625	-64.4293	45.3684	17.16	17.48	19.22	45.71	1089.1	1120	Day	746	-77.3448	26.7	0.0000006	-62.086
"T1_5"	20120625	-64.4288	45.3683	20.50	20.60	5.60	50.48	995.8	332	Day	1082	-64.9752	590.9	0.0000137	-48.630
"T1_6"	20120625	-64.4289	45.3683	21.61	21.67	3.68	49.82	981.9	218	Day	950	-68.4648	252.5	0.0000059	-52.322
"T1_7"	20120625	-64.4290	45.3683	23.42	23.50	5.08	45.69	996.6	302	Day	600	-71.7449	71.7	0.0000017	-57.788
"T1_8"	20120626	-64.4288	45.3683	2.13	2.22	5.30	41.25	999.3	315	Night	215	-70.9856	79.6	0.0000018	-57.333
"T1_9"	20120626	-64.4290	45.3683	4.26	4.47	12.35	43.17	1000.5	732	Night	475	-77.305	20.7	0.0000005	-63.179
"T2_1"	20120625	-64.4281	45.3674	9.32	9.46	8.23	47.99	1007.6	247	Tran1	922	-76.9743	33.0	0.0000008	-61.166
"T2_2"	20120625	-64.4287	45.3676	12.67	12.81	8.77	41.21	1004.9	520	Day	248	-78.346	21.2	0.0000005	-63.073
"T2_3"	20120625	-64.4290	45.3675	14.78	14.88	5.85	40.66	1102.0	347	Day	235	-77.4352	30.8	0.0000007	-61.457
"T2_4"	20120625	-64.4282	45.3673	17.52	17.58	3.78	44.69	1001.4	224	Day	800	-77.1048	27.0	0.0000006	-62.027
"T2_5"	20120625	-64.4285	45.3674	20.61	20.69	4.53	49.81	1001.6	269	Day	1074	-67.8888	284.5	0.0000066	-51.804
"T2_6"	20120625	-64.4273	45.3671	21.69	21.88	11.48	48.66	1026.8	681	Day	926	-69.4815	171.5	0.0000040	-54.004
"T2_7"	20120625	-64.4288	45.3674	23.53	23.73	12.37	45.02	1034.1	732	Day	565	-69.8359	94.7	0.0000022	-56.584
"T2_8"	20120626	-64.4289	45.3676	2.25	2.37	7.05	40.78	1016.8	418	Night	215	-75.14	44.4	0.0000010	-59.867
"T2_9"	20120626	-64.4290	45.3677	4.50	4.57	4.13	42.50	1006.8	242	Night	506	-78.9683	14.9	0.0000003	-64.615
"T3_1"	20120625	-64.4294	45.3670	9.54	9.60	3.68	46.63	998.6	110	Tran1	889	-76.9002	36.7	0.0000009	-60.704
"T3_2"	20120625	-64.4293	45.3670	12.84	12.91	4.30	40.27	1000.2	255	Day	321	-79.0464	17.5	0.0000004	-63.920
"T3_3"	20120625	-64.4286	45.3669	14.90	15.01	6.40	40.28	859.2	379	Day	253	-76.3679	39.6	0.0000009	-60.369
"T3_4"	20120625	-64.4283	45.3667	17.69	18.15	27.83	45.33	1270.6	1601	Day	879	-77.4435	26.0	0.0000006	-62.201
"T3_5"	20120625	-64.4292	45.3670	20.70	20.80	5.93	48.98	998.5	352	Day	1065	-63.0581	842.3	0.0000195	-47.090
"T3_6"	20120625	-64.4294	45.3669	21.90	21.96	3.55	48.77	1000.1	210	Day	903	-68.2123	266.3	0.0000062	-52.091
"T3_7"	20120625	-64.4295	45.3669	23.75	23.81	3.50	44.46	987.4	207	Day	533	-66.7466	320.4	0.0000074	-51.288
"T3_8"	20120626	-64.4292	45.3669	2.39	2.50	6.63	39.75	995.8	393	Night	218	-77.77	22.2	0.0000005	-62.888
"T3_9"	20120626	-64.4297	45.3670	4.61	5.02	24.77	42.68	1115.0	1468	Night	567	-78.7757	13.9	0.0000003	-64.901

Table A5-9-8.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T4_1"	20120625	-64.4288	45.3655	9.63	9.85	13.03	39.72	1016.8	391	Tran1	857	-75.0368	47.3	0.0000011	-59.598
"T4_2"	20120625	-64.4297	45.3658	12.94	13.09	8.53	35.02	998.5	503	Day	215	-78.2094	23.1	0.0000005	-62.707
"T4_3"	20120625	-64.4332	45.3664	15.04	15.07	1.55	42.56	326.3	89	Day	267	-77.251	34.0	0.0000008	-61.032
"T4_4"	20120625	-64.4298	45.3656	18.19	18.25	3.32	40.51	994.8	196	Day	938	-77.626	23.2	0.0000005	-62.689
"T4_5"	20120625	-64.4292	45.3656	20.83	20.90	4.38	43.05	997.8	258	Day	1055	-69.2569	178.7	0.0000041	-53.824
"T4_6"	20120625	-64.4296	45.3657	21.99	22.22	13.82	42.46	1021.3	807	Day	870	-68.9309	184.4	0.0000043	-53.687
"T4_7"	20120625	-64.4295	45.3658	23.83	0.05	-1426.82	38.19	1044.7	782	Night	499	-70.8559	75.1	0.0000017	-57.589
"T4_8"	20120626	-64.4296	45.3656	2.53	2.63	6.53	34.07	1008.9	384	Night	223	-78.3513	17.8	0.0000004	-63.849
"T4_9"	20120626	-64.4300	45.3654	5.07	5.13	3.53	37.54	994.8	203	Night	634	-70.3185	69.2	0.0000016	-57.944
"T5_2"	20120625	-64.4302	45.3649	13.12	13.18	4.15	32.21	983.1	246	Day	200	-79.4926	15.8	0.0000004	-64.359
"T5_3"	20120625	-64.4275	45.3643	15.09	15.27	10.65	30.84	1605.5	624	Day	285	-77.2195	24.7	0.0000006	-62.420
"T5_4"	20120625	-64.4286	45.3647	18.30	18.77	27.70	38.23	1240.5	1605	Day	994	-77.9797	19.3	0.0000004	-63.490
"T5_5"	20120625	-64.4303	45.3648	20.92	20.99	4.62	41.65	994.4	274	Day	1044	-67.4399	274.1	0.0000064	-51.966
"T5_6"	20120625	-64.4306	45.3650	22.24	22.30	3.57	39.79	996.5	212	Day	839	-67.9182	196.0	0.0000045	-53.421
"T5_7"	20120626	-64.4302	45.3648	0.07	0.13	3.48	35.42	994.9	207	Night	468	-67.8326	183.1	0.0000042	-53.717
"T5_8"	20120626	-64.4304	45.3649	2.65	2.75	5.97	32.12	1002.0	354	Night	231	-72.3002	60.6	0.0000014	-58.523
"T5_9"	20120626	-64.4279	45.3644	5.21	6.15	56.53	33.79	1638.9	2670	Night	741	-77.0657	11.3	0.0000003	-65.798
"T6_2"	20120625	-64.4303	45.3639	13.22	13.36	8.73	32.20	997.8	511	Day	189	-77.9562	22.7	0.0000005	-62.781
"T6_3"	20120625	-64.4294	45.3638	15.40	15.47	4.45	30.89	1041.8	256	Day	328	-76.918	27.5	0.0000006	-61.946
"T6_4"	20120625	-64.4294	45.3636	18.80	18.86	3.63	38.48	1036.8	209	Day	1037	-81.1046	8.5	0.0000002	-67.053
"T6_5"	20120625	-64.4299	45.3639	21.01	21.10	5.25	40.28	1008.3	309	Day	1033	-71.5156	101.2	0.0000023	-56.294
"T6_6"	20120625	-64.4292	45.3636	22.33	22.65	19.42	38.11	1039.7	1144	Day	798	-69.1841	120.3	0.0000028	-55.544
"T6_7"	20120626	-64.4301	45.3639	0.15	0.39	14.43	34.30	1012.6	846	Night	432	-74.2885	36.6	0.0000008	-60.706
"T6_8"	20120626	-64.4304	45.3640	2.78	2.87	5.92	31.79	1007.5	346	Night	239	-79.0417	14.0	0.0000003	-64.893
"T6_9"	20120626	-64.4298	45.3637	6.20	6.26	3.60	36.71	983.1	192	Night	876	-77.5472	11.0	0.0000003	-65.944
"T7_2"	20120625	-64.4314	45.3632	13.39	13.46	4.25	32.61	1010.0	252	Day	181	-81.5288	10.1	0.0000002	-66.320
"T7_3"	20120625	-64.4313	45.3632	15.49	15.64	9.02	33.39	1000.1	532	Day	352	-77.8203	19.9	0.0000005	-63.350
"T7_5"	20120625	-64.4314	45.3631	21.15	21.22	4.12	41.57	1021.5	242	Day	1018	-68.2665	226.7	0.0000053	-52.791
"T7_6"	20120625	-64.4316	45.3634	22.67	22.74	4.10	38.23	998.6	240	Day	755	-70.8348	89.6	0.0000021	-56.824
"T7_7"	20120626	-64.4316	45.3632	0.41	0.48	4.37	34.60	995.3	254	Night	401	-79.4965	12.7	0.0000003	-65.322
"T7_8"	20120626	-64.4304	45.3629	2.90	3.00	6.10	32.46	912.9	361	Night	249	-78.1615	16.5	0.0000004	-64.159
"T7_9"	20120626	-64.4311	45.3631	6.31	6.90	35.43	38.82	1439.6	2060	Night	949	-75.9475	18.3	0.0000004	-63.724
"T8_2"	20120625	-64.4315	45.3621	13.49	13.62	8.00	33.13	998.8	474	Day	175	-81.375	10.6	0.0000002	-66.098
"T8_3"	20120625	-64.4309	45.3620	15.66	15.72	3.98	34.62	1003.1	237	Day	378	-79.5763	15.1	0.0000004	-64.552

Table A5-9-8.3. Continued.

Transect Number	Date	Mid Longitude	Mid Latitute	Start Time GMT	End Time GMT	Duration (min)	Mean Height (m)	Transect Length (m)	Transect Pings	Day/night	Tide Height (cm)	Sv mean	NASC	Area Backscattering Coefficent	Area Backscattering Strength
"T8_5"	20120625	-64.4305	45.3620	21.23	21.36	7.45	42.67	1016.3	440	Day	1002	-68.5921	207.5	0.0000048	-53.175
"T8_6"	20120625	-64.4311	45.3621	22.78	23.17	23.65	39.18	1064.5	1401	Day	701	-70.5979	95.0	0.0000022	-56.566
"T8_7"	20120626	-64.4315	45.3622	0.51	0.74	14.02	35.25	1008.9	831	Night	368	-80.7904	9.4	0.0000002	-66.614
"T8_8"	20120626	-64.4318	45.3622	3.02	3.11	5.23	33.03	1017.1	310	Night	260	-76.4556	25.2	0.0000006	-62.327
"T8_9"	20120626	-64.4310	45.3618	6.94	7.00	3.80	44.77	997.6	225	Night	1008	-73.369	50.5	0.0000012	-59.315
"X1_2"	20120625	-64.4306	45.3464	13.64	13.91	16.45	70.20	3157.2	958	Day	170	-77.6235	52.7	0.0000012	-59.125
"X1_3"	20120625	-64.4306	45.3465	15.74	16.09	21.03	71.35	3394.9	1237	Day	426	-78.2986	37.8	0.0000009	-60.568
"X1_7"	20120626	-64.4304	45.3468	0.90	1.26	21.88	71.17	3230.3	1293	Night	297	-77.0132	52.7	0.0000012	-59.131
"X1_8"	20120626	-64.4308	45.3455	3.12	3.42	18.28	69.63	3233.3	1080	Night	286	-72.4306	163.0	0.0000038	-54.223
"X1_9"	20120626	-64.4306	45.3457	7.06	7.36	17.90	80.24	3333.0	1040	Night	1039	-75.2705	62.5	0.0000014	-58.387
"Y1_2"	20120625	-64.4426	45.3327	13.92	14.00	5.13	33.23	1068.4	305	Day	171	-77.2466	27.3	0.0000006	-61.982
"Y1_3"	20120625	-64.4424	45.3326	16.11	16.22	6.35	35.78	1097.1	376	Day	476	-78.1039	24.0	0.0000006	-62.545
"Y1_7"	20120626	-64.4422	45.3327	1.27	1.33	3.80	34.84	853.7	226	Night	268	-74.8052	49.4	0.0000011	-59.409
"Y1_8"	20120626	-64.4428	45.3326	3.43	3.57	8.63	33.82	1122.3	512	Night	318	-78.7002	18.5	0.0000004	-63.679
"Y1_9"	20120626	-64.4425	45.3326	7.41	7.50	5.32	41.68	1123.1	314	Night	1066	-81.3525	9.7	0.0000002	-66.495
"X2_1"	20120625	-64.4424	45.3509	11.52	12.01	29.58	68.37	3859.8	1754	Day	424	-78.7121	36.2	0.0000008	-60.760
"X2_2"	20120625	-64.4422	45.3517	14.01	14.41	24.22	57.69	4406.1	1418	Day	179	-77.8084	41.0	0.0000010	-60.214
"X2_3"	20120625	-64.4396	45.3550	16.23	16.96	43.45	60.51	4480.0	2569	Day	575	-75.792	43.5	0.0000010	-59.961
"X2_7"	20120626	-64.4422	45.3515	1.36	1.86	29.95	59.86	4376.2	1770	Night	239	-68.9208	291.2	0.0000068	-51.703
"X2_8"	20120626	-64.4420	45.3526	3.58	4.04	27.75	60.32	4351.0	1630	Night	367	-74.5938	83.2	0.0000019	-57.144
"X2_9"	20120626	-64.4424	45.3511	7.55	7.99	26.57	69.17	4451.9	1555	Night	1090	-74.601	74.0	0.0000017	-57.651

APPENDIX 6: COMPUTATION OF OBSERVED WATER VOLUMES IN MULTI-BEAM FAN SECTIONS

1. THEORY

It is required to calculate the total volume of water observed in a standard port-starboard 2-D multi-beam (MS 2000) fan section between defined depths limits in the vertical measured from the transducer.

Assume an (X, Y, Z) coordinate system X +ve to the right, Y +ve out of the page, and Z +ve downward. Let the origin (0, 0, 0) be the position of the sonar transducer with the fan in the plane of the page, and symmetrical about the Z axis (Fig. A6-1(A)).

Let R_{Max} be the maximum effective sonar profiling range (e.g. 50 m). In deep unobstructed water this distance will normally correspond to the sonar maximum range setting. If an intense scatterer, such as the ocean bottom or the turbine superstructure lies within the nominal sonar range, the radial distance from the transducer to the intense scatterer usually defines the maximum effective observations range for water column fish targets. The reason is that high amplitude reflected energy from the intense will both enter the side lobes of all synthesized fan beams but, more importantly, introduce elemental voltage overloads and consequent non-linearities into the beamforming process. The usual effect is obscuration of all fan beams at and also beyond the intense scatterer range. Therefore the maximum effective profiling range for fish is the minimum range from the transducer to the intense scatterer.

For the purpose of computing fish density from visual, fan-section echogram fish counts over a defined water column depth interval, for instance between depth z_1 and z_2, measured below and relative to the sonar transducer, it is necessary to compute the water volume, V, observed between the upper and lower bounding depths of this depth interval out to the maximum effective profiling range R_{Max} on the specific fan section or multiple sections.

To proceed: With reference to Fig. A6-1(B), at vertical range z from the transducer let a horizontal strip be extracted from the observed fan water volume ensonified by a single sonar transmission or "ping", the strip running horizontally through the receiving fan. The out-of-fan, i.e. (X, Y) plane, half-width of this strip as a function of $y(x)$, when θ is small, is given to an excellent approximation by: $y = R\sin\theta$ where θ is the "effective" half-beamwidth of the semi-cylindrical Mills Cross radiating element measured from the (X, Z) plane. The receiving array beamwidth is much larger than the transmit beamwidth in the same plane and, therefore, has little influence on the out-of (X Y) plane response. This approximation ignores the very slight out-of-fan-plane curvature of the strip defined by individual fan beams ensonifying the given strip at multiple instantaneous points in time.

Let *A* be the total area of the ensonified horizontal strip:

$$V = \int_{z_1}^{z_2} A(z).dz \tag{1}$$

where

$$\begin{aligned} A(z) &= 4\int_0^{x_{Max}} y(x).dx \\ &= 4\int_0^{X_{Max}} \sqrt{x^2+z^2}.\sin\theta.dx \\ &= 2\sin\theta \left| x\sqrt{x^2+z^2} + z^2\log\left(x+\sqrt{x^2+z^2}\right)\right|_0^{X_{Max}} \\ &= 2\sin\theta\left[X_{Max}\sqrt{X_{Max}^2+z^2} + z^2\log\left(X_{Max}+\sqrt{X_{Max}^2+z^2}\right) - z^2\log \mathrm{z}\right] \end{aligned} \tag{2}$$

For a given R_{Max}, X_{Max} is a function of *z*:

$$A(z) = 2\sin\theta\left\lfloor\sqrt{R_{Max}^2 - z^2}\ R_{Max} + z^2\log\left((\sqrt{R_{Max}^2-z^2}+R_{Max}\right) - z^2\log \mathrm{z}\right\rfloor \tag{3}$$

The observed volume can be found by substituting *A*(*z*) from equation (3) into equation (1). This yields an integral that cannot be evaluated in closed form but which can be readily approximated numerically as a finite summation using a reasonably small incremental Δz between the limits z_1 and z_2.

2. IMPLEMENTATION

In regard to implementation for the 16 Sept. 2010 Minas Passage data set: Fish density was estimated in contiguous 2 m vertical bins and a Δz of 0.2 m was employed to compute the finite sum approximating the integral of Equation (1).

The most critical question is the selection of the "effective" half-beamwidth θ. For the initial reduction of the Minas Passage data to fish density a unit "effective" beamwidth of 1°, or equivalently a half-beamwidth of 0.5° was assumed. Assigning a realistic half-beamwidth reduces to determining the maximum angular displacement from the central fan plane that a fish can be located and still be identified as a valid fish target on manual inspection of the fan section echogram. Clearly, this depends on the signal-to-noise ratio of the fish target echo if it were fan-centered which, in turn, is dependent on its target strength, orientation, range and a number of instrumentation and environmental parameters. Therefore, the "effective" beamwidth might be expected to vary with the nature of the target and with the target observation range (The manufacturer's stated "nominal" -3 dB to -3 dB beamwidth of the MS 2000 linear transmit array used in Mills Cross configuration with the receive array was 1.5°, or seemingly closer to 1.6° for the actual element used, is not a particularly relevant measure in this regard).

An approximate estimate of the dynamic range between the strongest observed echoes to the minimum detectable during the manual counting process is about 20 dB – perhaps slightly more (actually depth dependent for targets of same target strength). The -20 dB point for a shaded line array transmit element should occur at an off-axis angle about 2.5 times the -3 dB off-axis angle (see measurements for 90 kHz SM 2000 with similar nominal 1.5° transmit beam in Foote et al. (2005), and for typical shaded line array responses shown in Clay & Medwin (1977)). Therefore, for counting stronger fish targets the effective detection beamwidth of the transducer actually utilized should be in the neighbourhood of 2.5 x 1.5° ~ 3.75° yielding an effective half-beamwidth of just under 2°. Consequently, the fish densities computed with a reference 1° beam should be decreased by a factor of about 3.75 to give the best estimate of the actual physical fish density.

3. DISCUSSION

Clearly fish density estimates based on manual counting as outlined should normally be considered less definitive than those furnished by well calibrated split-beam sounders. Nevertheless, one potential advantage of multi-beam derived fish densities is the comparatively larger water volume **non-redundantly** ensonified by the multi-beam fan compared to that ensonified by a typical split-beam system. This can be an important consideration when fish targets are sparse and one wishes to localize fish distributions spatially. As pointed out in the main text, the manual selection of multi-beam targets does afford a high degree of spurious bubble cloud echo rejection, a weakness of our alternative and in principle better quantifiable multi-beam Volume Backscattering Strength technique applied in the Minas Passage survey environment.

Clearly, multi-beam direct counting techniques could be made more objective if echo selection were automated – perhaps using matched filter techniques with a reference pulse waveform to enhance individual echoes and to reject noise. Echo variation between adjacent partially overlapping fan sections could also be used in an automated manner for the selection of valid echoes. The employment of beam stabilization - unfortunately not implemented in the current MS 2000 but routinely employed in not dissimilar bathymetric multi-beams - combined with proper adjustment of vessel speed and ping rate could well make possible reliable tracking of fish echoes between successive fan ensonifications, counting echoes from discrete fish targets only once as they transit the central fan plane. This would permit absolute fish number enumeration within the well-defined total contiguous volumetric space scanned along track over an extended transect. Such an enumeration process could potentially be quite accurate since it would eliminate the present necessity of defining an "effective" single ping sampling volume whereby each ping is considered a separate sampling entity and the information contained in spatial target correlations between fan sections is not utilized. Beam stabilization might well allow very accurate fish counting, and perhaps even target strength estimation, making multi-beam information extraction more competitive with that furnished by current split-beam sounders.

REFERENCES (APPENDIX 6)

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FIGURE (APPENDIX 6)

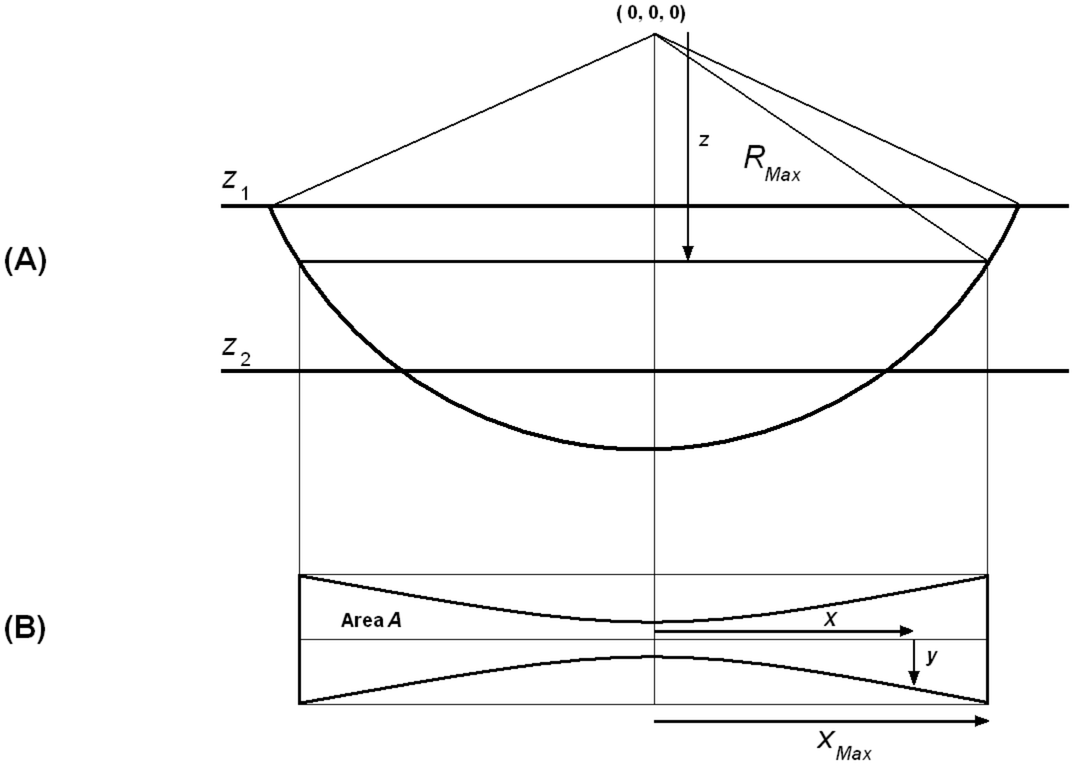

Figure A6-1. 2-D multi-beam sonar observation geometry. (A) – Observed volume in (*X*, *Z*) plane between depths z_1 and z_2 and extending radially from the transducer origin (0, 0, 0) to maximum viewed radial range R_{Max} from the transducer.(B) – Observed strip in (*X*, *Y*) plane at depth *z*.

APPENDIX 7: COMPUTATION OF VOLUME BACSCATTERING STRENGTH USING THE MS 2000 MULTI-BEAM SONAR

1. THEORY

A convenient expression for computing volume backscattering strength for the MS 2000 (previously designated "SM 2000") sonar is given by equation (32) of Cochrane et al. (2003). If the complex bracketed term in the same equation, which represents the computed beamformer output voltage with a 20 log R + absorption time variable gain (TVG), is designated $V_{BF}(\theta_b, t)$ the resultant expression may be written (also compare Melvin et al. (2003) p. 671):

$$S_v(\theta_b,t) = 20\log V_{BF}(\theta_b,t) + C_{Cal}(90^{\circ}) - 10\log\left(\Psi_{DC}(\theta_b)\frac{c\Delta t}{2}\right) \qquad (1)$$

where

S_v is the volume backscattering strength in logarithmic (i.e. decibel) units.

θ_b is the orientation angle of a given synthesized beam

t is the instantaneous observation range expressed as 2-way acoustic travel time (s)

c is the acoustic sound speed in water (m/s)

Δt is the sonar transmitted pulse length (s)

$V_{BF}(\theta_b, t)$ is the appropriately normalized beamformer output voltage for a beam synthesized at angle θ_b and for travel time t (i.e. at observation range $R = ct/2$)

C_{Cal} (90^{o}) is an absolute sonar calibration constant. In practice it is determined by observing the beamformer output voltage for an echo from an artificial acoustic calibration standard target (usually a precisely machined tungsten carbide sphere) centered in the central sonar fan beam i.e. the "90^{o} fan beam" which for our present sonar configuration points vertically downwards.

Ψ_{DC} (θ_b) is the θ_b beam-specific Integrated Beam Width Factor (IBWF) (Clay & Medwin 1977). It is the "effective" sonar beam width or opening expressed as solid angle on an enclosing sphere and includes the combined effects of actual sonar transmit and receive beam directivities. For the special case of totally omni-directional beams $\Psi_{DC} = 4\pi$. As explained in Cochrane et al. (2003) – also see below - Ψ_{DC} (θ_b) is normalized to the on-axis transmit and receive responses of a fan beam synthesized at 90^{o} (the angular center of a regular beam fan) rather than being normalized to the on-axis responses of the fan beam synthesized at θ_b .

In expression (1) if the bracketed portion of the last term is multiplied by the square of the instantaneous range R then $\left(\Psi_{DC}(\theta_b)\frac{c\Delta t}{2}\right)R^2$ is the "effective" instantaneously ensonified sonar volume i.e. the volume of the outward expanding ensonified shell from which backscatter is being received at a given instant.

In Clay & Medwin (1977) Ψ_D is defined in the general form:

$$\Psi_D = \int_{4\pi} D_r^2 D_s^2 d\Omega \qquad (2)$$

where D_r is the directional response of the source and D_s the directional response of the receiver.

The MS 2000 multi-beam configuration employed in Minas Passage utilized independent transmitting and receiving transducers arranged in "Mills Cross" geometric configuration. Either 128 or 256 equally spaced and partially overlapping synthesized fan beam amplitudes were computed spanning 180° of equatorial azimuth centered on the mid-point of the 80 element MS 2000 receiving array. Individual receive beams were narrow, approximately 3° (- 3 dB to -3 dB beamwidth), in the along fan (θ) direction, but much wider, approximately 20°, in the out-of-fan (ϕ) direction. The orthogonally placed transmit transducer, probably a linearly tapered line array, was of wide beamwidth, approaching 180°, in the fan direction but of narrow beamwidth, about 1.6°, in the out-of-fan direction. The transmit element was oriented with its major dimension orthogonal to the equatorial plane of the circular arc receive array. In theory, the linear array should pass through the origin of the circular arc, but in practice it is sufficient that it be placed only proximate to but still orthogonal to the arc plane. Combining transmit and receive responses, each resultant synthesized beam is characterized by a roughly 3 x 1.6° footprint in 3-D space. Complexity arises from the fact that the fan plane receive beamwidths increase significantly for the outer beams – i.e. for beams near the outer edges of the array - due to the fact that increasingly shorter angular arcs of the equatorial array are effectively available for receive beamforming. Also, the measured broad equatorial plane transmit response pattern from the physically separate line array tapers-off significantly near the ends of the 180 degree fan-beam spread due to the manner in which the transmit line array elements are mounted and baffled. These effects must be accurately accounted for in any multi-beam quantification.

Expression

$\Psi_D = \int_{4\pi} D_R^2 D_S^2 d\Omega$ when applied to the MS 2000 can be rewritten in the form

$$\Psi_D(\theta_b) = \int_{4\pi} D_R^2(\theta_b, \theta, \phi) D_S^2(\theta_b, \theta, \phi) d\Omega \qquad (3)$$

If the approximations from relations (19) and (20) of Cochrane et al. (2003) are introduced:

$$D_R(\theta_b, \theta, \phi) \cong D_{R\phi}(\theta_b, \phi)\, D_{R\theta}(\theta_b, \theta) \qquad (4)$$

$$D_S(\theta_b, \theta, \phi) \cong D_{S\phi}(\theta_b, \phi)\, D_{S\theta}(\theta_b, \theta) \qquad (5)$$

and if the integration range limits for any specific beam are confined to reasonably small values of θ and ϕ on the unit sphere, expression (3) may be written:

$$\Psi_{DC}(\theta_b) = \iint (D_{R\phi}(\theta_b, \phi) D_{R\theta}(\theta_b, \theta) D_{S\phi}(\theta_b, \phi) D_{S\theta}(\theta_b, \theta))^2 .d\phi.d\theta \qquad (6)$$

In the above expression (6), Ψ_D has been renamed Ψ_{DC} to signify that all directivity functions in the integral are defined relative to the maximum transmit and receive responses of a beam synthesized at the fan center - not the maximum responses of each individual beam synthesized in the θ_b direction. This has the effect of allowing all synthesized beams to be calibrated in principle by relation (1) requiring only a single measurement of a calibration target in the central fan beam – as opposed to calibration measurements in each individual beam – nevertheless, Ψ_{DC} (θ_b) must still be evaluated. Evaluation of Ψ_{DC} (θ_b) can proceed either fully empirically by (further) extensive detailed beam pattern measurements, by theoretical computation, or a labour-saving combination of the two – the latter approach was adopted in Cochrane et al. (2003) the important difference being that the 2003 work used the MS 2000 circular arc array also in transmit mode i.e. no physically separate transmit transducer was utilized.

2. IMPLEMENTATION

2.1 Computation of Ψ_{DC}

As in the 2003 work we proceed by computing Ψ_{DC} (θ_b) by a combination of theoretical and empirical measurements. However, the current calculation will rely entirely on a theoretical description of the receive response, a procedure having distinct limitations but probably sufficiently adequate for the present purposes since we are mainly relying on MS 2000 observations to supplement the EK60, the latter split-beam system constituting the primary quantitative tool. The MS 2000 remains uncalibrated in an absolute sense since the single calibration constant C_{Cal} (90°) remains undetermined. **Therefore, at the present time the MS 2000 can provide only relative measures of S_v, for instance relative profiles of S_v vs. depth, but not absolute measures of the same quantity for which one must solely rely on the EK60.**

Central beam normalized Ψ_{DC} values appropriate to each synthesized beam can be obtained by numerical evaluation of expression (6) considering each directivity function in turn:

$D_{R\phi}$ (θ_b, ϕ) is fairly well described by the sync function response of a theoretical line element of width equal to the physical cross-fan width of all elements in the circular transducer head and should be essentially independent of θ_b. It is readily computed and is displayed in Fig. 4 of Cochrane et al. (2003).

$D_{R\theta}$(θ_b, θ) is a more involved quantity to compute, its form varying with chosen θ_b particularly, as noted, for beams near the ends of the fan. For any chosen θ_b $D_{R\theta}$ falls off rapidly as θ departs from the beam direction θ_b (i.e. defining a narrow beamwidth in the fan direction). The rapidity and nature of this fall-off will depend on the weighting (window) functions chosen for beam synthesis. A "low side lobes" Hamming window with an "*a*" parameter of 0.54 has been used for both our off-line beamforming and our theoretical modelling of the receive response. Computed examples are shown in Fig. 2 of Cochrane et al. 2003.

$D_{S\phi}$ (θ_b, ϕ) is modeled by the response of a cosine-shaded line array of a length chosen to match the empirically measured directivity (a Simrad-Mesotech provided calibration) of the MS 2000 transmit element. Its response is assumed independent of θ_b. Suitable mathematical expressions are given in Clay & Medwin (1977). Our length parameter has been chosen to reasonably match both the -3 dB and -6 dB empirical beamwidths and pattern measured by the manufacturer. The precise nature of the shading function employed by the manufacturer is unknown but cosine shading is probably adequate for most purposes. We use the expression:

$$D_{S\phi}(\phi) = \frac{\cos\left(\frac{kW_c}{2}\sin(\phi)\right)}{1 - \left(\frac{kW_c}{\pi}\sin(\phi)\right)^2} \qquad (7)$$

where

$k = 2\,\pi\,f\,/\,c$

and

W_c the active array length is experimentally chosen as 0.276 m.

For the assigned physical array length the -3 dB to -3 dB beamwidth computes to 1.8°, slightly wider than the nominal manufacturer supplied value of 1.6° but with good roll-off characteristics. In reality, for present purposes extremely accurate evaluation of $D_{S\phi}$ (θ_b, ϕ) is unnecessary since it appears as a common factor in the response of all beams and one is concerned about relative VBS only. However, if absolute VBS were eventually to be computed by experimental evaluation of C_{Cal} (90°) etc. precise evaluation of $D_{S\phi}$ (θ_b, ϕ) would become crucial.

$D_{S\theta}(\theta_b, \theta)$ varies with θ and θ_b is superfluous since the same transmit response is common to all fan receive beams - although for a beam synthesized at θ_b the transmit response for θ values close to θ_b will be the most critical for evaluation of expression (6). While the transmit pattern of a pure shaded line array oriented perpendicular to the receive fan should have no θ dependence, the MS 2000 line array is mounted on a baffle oriented perpendicular to the equatorial plane of the receive array and the baffling strongly diminishes the transmit response amplitude for θ values deviating $\pm 90^{\circ}$ from the central fan beam orientation. Lesser, but still significant, systematic variations in θ occur nearer the center of ifs pattern i.e. closer to the central synthesized receive beam orientation. This quantity has been scaled from empirical measurements performed and supplied by Simrad-Mesotech.

Expression (6) has been evaluated for the current MS 2000 configuration using a $30 \times 30^{\circ}$ numerical integration grid about each fan beam center and use of a 0.05° numerical integration increment (Fig. A7-1). If still larger grids are employed one must be careful to employ proper area weighting on the spherical surface to avoid biasing integration estimates toward the polar regions.

It should be emphasized that the above quantification methodology has the fundamental limitation of being totally reliant on a theoretical description of the **receive** directivities – i.e. the non-ideal characteristics of any real circular arc array are **not** accounted for. The experimental calibration procedure of Cochrane & Melvin (2003) is one step better but still only partially captures these non-ideal behaviours. However, its implementation would require measurements of the combined transmit – receive response in the entire sonar equatorial plane necessarily requiring a calibration facility allowing beam measurements at ranges of 10 m or so combined with extreme geometrical (mechanical) stability to accommodate the very narrow out-of-fan plane response of the external transmit transducer of the current sonar. The local DRDC Atlantic barge calibration facility would not satisfy the stability requirement. Finally, it should be noted that the calibration constant C_{Cal} (90°) remains unevaluated so S_v profiles obtained by employing expression (1) are not absolute but can, nevertheless, be legitimately compared beam-to-beam in a relative sense.

An alternative approach to absolute multi-beam absolute calibration might lie in evaluating C_{Cal} (90°) by way of statistically valid field data inter-comparisons between central beam derived backscatter levels and those determined using a well calibrated, conventional 200 kHz echosounder. This would still require Ψ_{DC} to be evaluated by other techniques as outlined above in order to extend absolute quantification to all beams.

2.2 Calculation of VBS

It will be assumed that calculation of S_v proceeds by way of Eq. (1) where in the absence of absolute calibration the calibration constant is initially assigned an arbitrary value which must continue to be assigned in a consistent manner. In this report S_v is most often plotted in linear rather than decibel form, the linear form more properly denoted s_v if one follows the notation convention of Clay & Medwin (1977) although we will not make the notational distinction provided linear form S_v is clearly indicated in context. In linear form, Eq. (1) reduces to

$$s_v(\theta_b, t) = Const. \text{ x } \frac{V_{BF}{}^2}{\Psi_{DC}(\theta_b)\ \Delta t} \qquad (8)$$

where V_{BF} is corrected by the proper 20 log R + absorption TVG function to 1 m observation range. It appears that for our data collections the MS 2000 internally applied a 20 log R spreading constant plus a fixed 50 dB/km one-way absorption correction. We further correct the absorptions in post-processing to those computed from the site-specific measured temperature and salinities using the formulations of Francois & Garrison (1982a,b).

In principle the computed s_v, pulse length, Δt, dependency should also allow one to compute correct relative s_v's for differing sonar maximum profiling ranges, as changing the sonar maximum profiling range automatically changes the emitted sonar pulse length. Nevertheless, there remains some uncertainty in exactly how MS 2000 system gains change under these circumstances – so we cannot be absolutely certain at present that this is accomplished exactly as assumed – absolute calibration at variable range settings at a suitable facility would address these questions with greater certainty. System bandwidth also changes with pulse length, a fairly small effect on legitimate signals if bandwidth is properly matched to pulse length, but of more importance in regard to system noise levels and the performance of any algorithms applied late in the data processing to consistently correct for or eliminate noise as treated below. Bandwidth changes could be important when comparing noisy data collected at differing maximum range settings.

2.3 Noise Reduction Algorithms

Algorithms were applied in an attempt to reduce undesired noise from each individual sonar fan section on a ping-by-ping basis. Specific types of noise identified and subsequent actions implemented to eliminate each are listed below:

Thresholding - Beamformer amplitudes on a beam-by-beam, range (time) sample-by-sample basis, after application of 20 log R + absorption TVG, are subjected to a fixed amplitude threshold. Amplitudes above the threshold are passed without alteration for further processing, while amplitudes falling below the threshold are set to zero. Thresholding is commonly applied in quantifying the outputs of standard single beam echosounders, particularly, if sparse well resolved fish echoes of reasonable signal-to-noise amplitude are being observed. The idea is that reasonably continuous low amplitude signals may arise from zooplankton scattering or other undesired noise sources, providing an often comparatively constant level diffuse signal background between discrete fish echoes or isolated regions (patches) of fish backscattering. A carefully chosen thresholding level can reduce the unwanted low-level but continuous signal contributions leaving the sparser higher-level signals of fish origin relatively unchanged. This can be particularly important if vertical integration of linear S_v (thereby yielding columnar or area backscatter "S_a") is to be applied where the contribution from the unwanted background signals can otherwise prove to be non-negligible. For the Minas Passage data, diffuse low level backscatter arising from air bubbles can provide such a low level diffuse background signal. Low level noise from ship machinery, propellers, and the sonar electronics, including small unwanted DC offsets can also, to a degree be suppressed, although thresholding after 20 log R TVG may not be the optimal procedure these all these noise sources. Thresholding cannot eliminate higher level unwanted signals (often the case for more intense bubble clouds and many noise pulses). Thresholding can also remove some legitimate fish-origin signals especially those arising from fish echoes at longer ranges since these signals fall-off with range at a 40 log R rate and will therefore will decrease in amplitude with range after application of standard 20 log R TVG and will therefore be thresholded-out beyond a certain range – the range decreasing if progressively higher thresholds are set to eliminate higher level background noise. We apply a constant threshold level for all Minas Passage profiles, the chosen value arrived at by experiment using a number of different data sets.

A demonstration of both the virtues and limitations of thresholding is shown in Fig. A7-2. Multiple S_v (linear form) vs. depth profiles for an identical 800 ping sequence from the 16 Sept. 2010 multi-beam survey are overlain, each profile using a different threshold level. The chosen dataset is characterized by high S_v levels near-surface falling off with depth in a crudely exponential-like manner. The high near-surface S_v values appear typical of bubble clouds. A prominent layer is present between about 10 and 20 m depth, peaking at about 15 m. This layer arises from fish, whose echoes are clearly discernable on fan sections. Another fish-like layer appears at about 25 m depth. The applied thresholding levels decrease from left to right namely 2.0, 1.5, 1.0, 0.75, 0.5, and 0.0% of "full scale".

With the application of progressively higher thresholding levels the level of bubble cloud origin backscatter is observed to decrease, especially evidenced by progressively lower S_v minimums in the backscatter "valley" at about 10 m depth. For thresholds of 1% and lower the peak amplitude of the "fish" layer near 15 m depth (the peak amplitude of fish layer is proportional to the signal power due to fish + the signal power due to bubble background at same depth) compared to the minimum residual value at about 10 m depth does not vary enormously. Therefore, the effect of thresholds up to about the 1% level is mainly the removal of the background bubble noise contribution to S_v. However, on proceeding to 1.5 and 2% threshold levels a strong effect on the amplitude of the fish peak in relation to the 10 m depth minimum level is observed. This observation would suggest that the higher level thresholding is beginning to eliminate a significant fraction of legitimate fish echoes. In other words, the third profile (1% thresholding) appears to largely capture the true amplitude of the ~15 m depth fish layer above the exponentially tapering bubble backscatter level while at the same time eliminating a major portion of the bubble backscatter background itself.

In the case of the deeper fish layer at 25 m the 1% S_v (amplitude) thresholding would appear to be slightly too high as the amplitude of this layer is significantly impacted. The reason could simply be the existence of comparatively smaller fish at ~25 m depth – and therefore weaker echoes. However, it seems more likely a result stemming from application of the 20 log R sounder TVG. In the absence of TVG isolated fish echoes of fixed target strength will decrease in amplitude with range at a theoretical 40 log R decibel rate and hence will be undercompensated by the "standard" sonar-applied 20 log R TVG. Therefore, at increasing ranges such echoes will become progressively more vulnerable to elimination by a fixed threshold. To minimize such effects the amplitude threshold was reduced to 0.5% in the standard processing applied to our multi-beam surveys - the decision being that improved amplitude delineation of deeper fish layers could be profitably traded off for a modest increase in surface bubble layer amplitude. More extreme levels of scattering from very intense shallower bubble layers, little affected by any applied low level thresholding, are often alternatively suppressed by the "spoke" and "ring" noise suppression measures described below.

Ring noise – "Ring Noise" is characterized by highly elevated noise signal components affecting all fan beams simultaneously, i.e. at the same range, therefore visually manifesting on fan section echograms as a fairly uniform ring portion or arc, centered on the sonar transducer and extending over the full angular extent of the synthesized fan (180° for the MS 2000). One common type appears to arise from direct reception of transmitted, out-of-band EK60 pulses (split-beam running asynchronously with multi-beam) which overload the MS 2000 receive array elemental preamps. Subsequent beamforming is corrupted for a short period resulting in generation of a short duration, high amplitude geometric "ring" on fan sections. Longer duration "rings" occur from the regular MS 2000 bottom return which similarly overloads the elemental preamps causing all fan beam data beyond the minimum bottom return range to be corrupted and driven to saturation or near saturation - even in the case of beams oriented far from the vertical. Such noise can be largely eliminated by the following procedure applied to every successive fan section: For each individual range bin or discrete range value, sum and average the bin amplitudes over all fan beams lying within a 140° fan arc centered on the fan center (the center generally defined by the vertical beam direction). If the average value exceeds a preset amplitude criterion, all bin amplitudes at this specific range for all beams of the fan are both blanked to zero for display purposes, and, more importantly, also eliminated from further S_v quantitative processing. Note that application of this procedure will usually eliminate all or virtually all of the sonar bottom and sub-bottom return as well as any interference generated by received EK60 pulses affecting mid-water range bins.

Arc noise – EK60 pulses reflected from the bottom (perhaps the 1st harmonic of 120 kHz leaking through the skirts of the MS 2000 bandpass filters since the effects seem strongest for short MS 2000 range settings where sonar receiver bandwidths are widest) produce relative long duration, 5 ms or so, limited angular extent, about 10°, high amplitude arcs on affected fan sections. The arcs like "Ring Noise" above being centered on the fan center but are of more limited angular extent. "Arc noise" noise can be largely eliminated by the following process applied to each successive fan section: For each range bin up to the initial bottom return range, and for all beams lying within a 12° arc centered on the fan center, sum the range bin-specific beam amplitudes. If the range-specific sum exceeds a preset value all relevant bin data at this range and for all range values starting 3 ms before and ending 3 ms after the offending bin sum for **all** fan beams of the specific fan section, regardless of direction, are blanked to zero for display purposes and, like "Ring Noise", also eliminated from further S_v quantitative processing.

Spoke noise – Virtually continuous to semi-continuous noise bursts from sources such as cavitating ship propellers affect multi-beams differently than noise from intermittent pulsed echosounders.. "Spoke noise" is characterized by a narrow angular range of fan beams displaying enhanced levels over a broad continuous span of ranges or over essentially all ranges simultaneously (visually manifesting as radial "spokes" on fan section echograms. The noise levels, which generally increase in amplitude with range after application of sounder TVG, may arise from virtually continuous ship-origin noise within the frequency pass-band of the sonar being strongly reflected from small isolated portions of a hard, rough, and faceted sea-bottom. It may also originate from noise directly radiated from the propeller being communicated more directly to the sonar array in some obscure fashion in which case the "spokes" tend to recur at the same characteristic angles (in the case of noise arriving at the receive array from well off the equatorial plane, the normal phase delay beam forming is to some degree, impaired resulting in a wider angular response than normal from the beamformer). The effect of spoke noise can minimized by the following procedure applied to each successive fan section: For each individual fan beam, sum and average signal levels bin-by-bin from the transducer to either total range or the range of the initial bottom reflection - whichever comes first. If the average signal level exceeds a pre-set criteria, the specific beam signal amplitudes for **all** ranges are blanked to zero and eliminated from graphic display and from further S_v quantitative processing. An added benefit of the spoke noise suppression algorithm is some effectiveness in eliminating bubble cloud backscatter especially in fan beams inclined close to the horizontal. A single spatially extended bubble cloud can affect backscatter over a large fraction of the total profiling range of (especially) shallow trajectory beams triggering their blanking – although such bubble backscatter does not constitute true "spoke noise" by our strict definition above.

It will be noted that for every fan section a record is maintained of all (circular, arc, or spoke noise) blanked beam amplitudes and these are eliminated – as opposed to being assigned zero values - in the computation of S_v vs. depth profiles. This procedure is designed to eliminate a false bias toward lower S_v values which would occur if blanked beam amplitudes within significantly large areas of fan sections were simply averaged-in as zero values. The blanking procedures rely upon analysis of the original signals. For example, "Arc Noise" removal is not applied to a section and the modified section then subjected to "Spoke Noise" removal.

An example of noise blanking is shown in Fig. A7-3. Section A (top) displays an unprocessed section with some near-transducer reverberation, a mid-water ring arising from an interfering direct EK60 transmission, another "ring" due to multi-beam bottom echo overload, as well as some near-surface bubble reverberation backscatter. Section B (bottom) shows the high suppression of near-transducer, mid-water, and bottom echo noise using “ring noise” blanking and partial suppression of near surface bubble cloud noise by “spoke noise” blanking. Signal thresholding, not utilized in these examples, is applied at a later stage of the processing.

Near-field transducer effects – Real sonar transducers are not “point” acoustic sources or receivers. Transmit transducers of finite size are characterized by a close-in physical region in which the emitted sound pressure field measured at an on-axis point deviates considerably from the simple 20 log R spherical spreading loss relationship assumed for a “point” source emitter. An analogous situation applies to a spatially extended transducer in receive mode from a proximate on-axis source. In the transmit case this is mainly due to the phase mismatches of pressure signals emitted from differing parts of an extended transducer and as received at a point. Regions of space in which these effects are large are best eliminated from analysis.

For the MS 2000, near-field effects are most significant in connection with the narrow-beam transmit transducer which possess an extended physical length dimension of about 0.276 m. To evaluate the relevant near-field distance, computer codes were developed to model the transmit element for the simplest case of a (to a first approximation) 1-dimensional non-shaded line array. The line array was simulated by 100 equi-spaced radiating point centers, transmitting to a measurement point at a variable radial distance from the radiator located on the array plane of symmetry. Both anomalous elemental phase (primary) and amplitude (secondary) effects were considered. Figure A7-4 shows the computed propagation loss deviations from simple 2-point spherical spreading. If the actual array is shaded (likely) the effects would be slightly smaller. It is seen that in order to ensure that near-field effects are restricted to < 0.5 dB all fan beam ranges less than 7.5 m should be excluded. This was implemented in the current MS 2000 signal processing. Note that sampled water depths are not thereby limited to depths > (7.5 m + transducer depth) since the outermost inclined sonar beams can sample close to the surface at ranges > 7.5 m.

VBS vs. Depth Profiles – In the present analysis VBS vs. depth profiles are computed for successive 1 m vertical depth intervals using as input a series of successive (most commonly) 128 beams fans. To generate profiles of VBS vs. Depth from fans of VBS vs. range beam profiles with individual beams occupying differing of orientations from the vertical requires the application of an appropriate mapping function. A number of mapping considerations exist: A given vertical depth interval at shallow depths (relative to the maximum profiling range) will be more efficiently sampled by a fan beam oriented at a shallow angle to the horizontal in contrast to a beam passing through the same defined vertical depth interval at a steep angle from the horizontal - more beam range samples will lie within the specified depth range in the former case than in the latter. It can also be argued that for a defined vertical depth interval, beam samples intersecting the depth interval at longer profiling ranges should receive more weight than beam samples intersecting the same interval at shorter profiling ranges since a larger volume of water is sampled in the former case than in the latter (successive beam overlaps and the vertical extent of a specific beam sample can also influence this argument to varying degrees). These considerations have informed the choice of mapping function and the resultant processing algorithm.

The adopted procedure for VBS estimation is as follows: Consider each vertical depth interval in succession: Each fan beam is examined. If a portion of a specific fan beam, as defined by its central axis and lying beyond the near-field exclusion range but at a lesser range than the transducer to bottom range, intersects the relevant vertical depth interval all beam points (i.e. beam-specific VBS vs. range estimates) lying within the depth interval are entered into an weighted arithmetic average. The chosen weighting function is directly proportional to profiling range (alternatively, one might argue for a "range squared" weighting, to weight directly proportional to ensonified volume but counter arguments based on the increasing loss of vertical resolution with range argue against such extreme weighting – the adopted "linear with range" weighting representing an operational compromise). If the specific beam points have been blanked prior due to the action of one or more of the above outlined noise removal algorithms (matrices are maintained to determine this fact) the relevant beam points are excluded. The final result is a profile of average S_v vs. Depth excluding all flagged "bad", i.e. noisy or otherwise excluded, data points computed over either a specified number of successive fan sections or over all fan sections comprising a spatial survey transect or profile.

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FIGURES (APPENDIX 7)

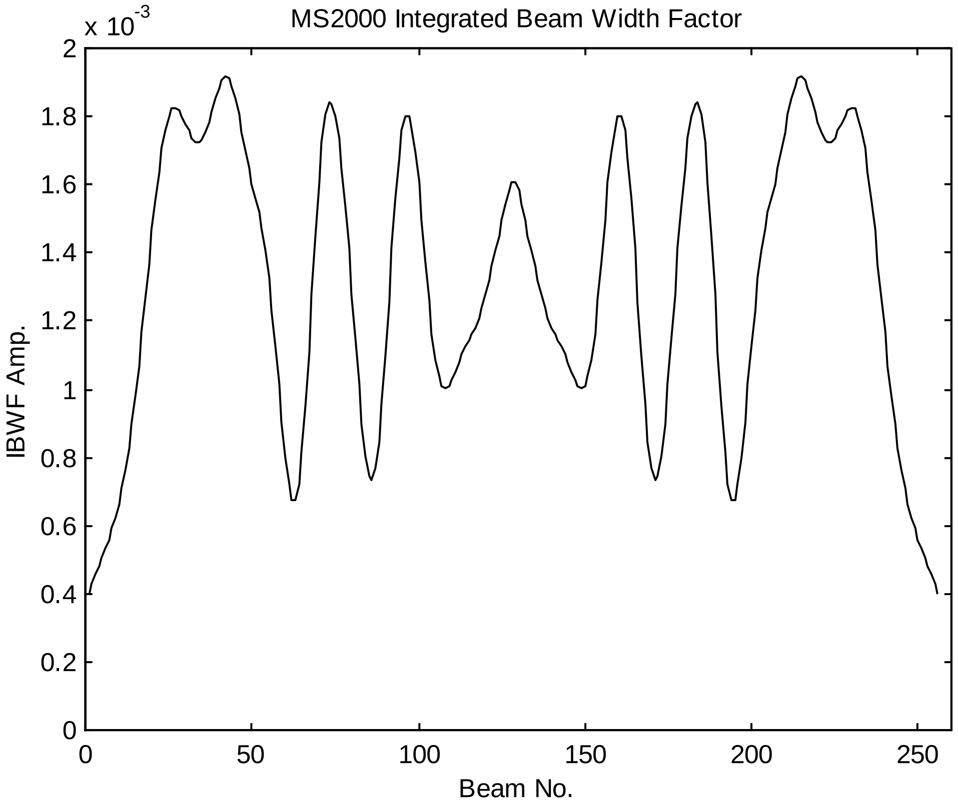


Figure A7-1. Computed Integrated Beam Width Factor for the MS 2000 sonar is shown as a function of fan beam number when synthesizing a fan of 256 beams. The sonar is configured using a narrow beam external transmit transducer in Mills Cross configuration with the circular arc receive transducer. The center of the beam fan as well as the physical center of the 80 element receive array arc lies between beams 127 and 128, while beams 1 and 256 lie at -90° and +90° relative to the array center.

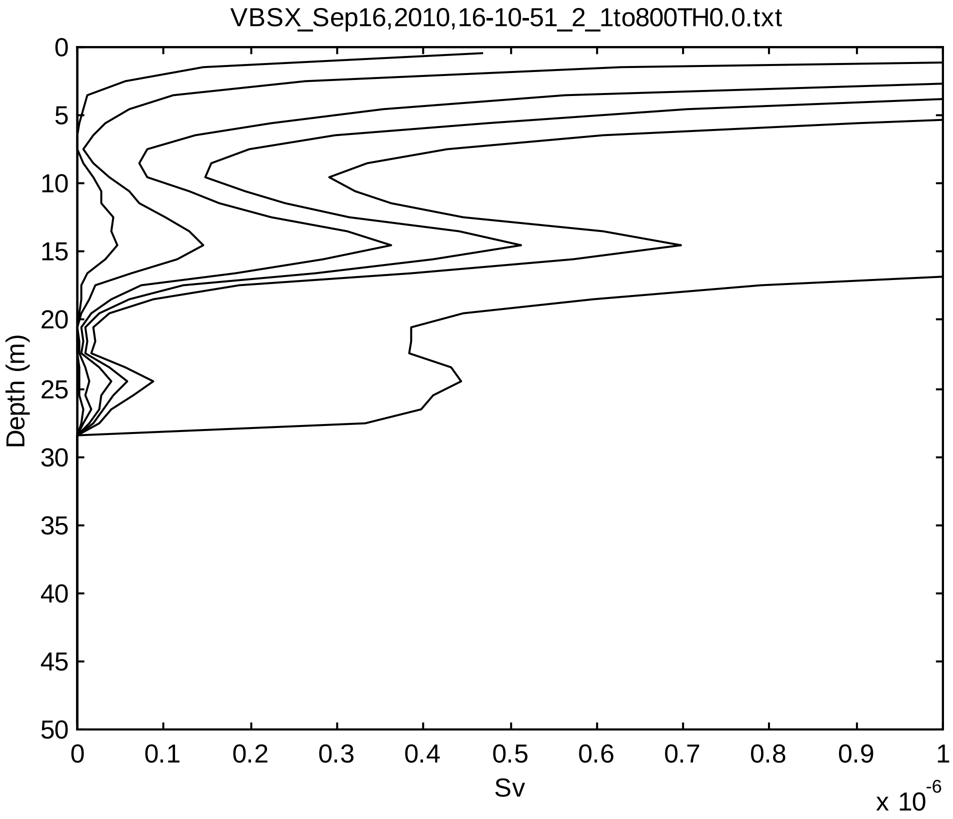


Figure A7-2. Volume Backscattering Strength (linear form) vs. depth plotted for six differing levels of signal amplitude thresholding. Normal linear backscatter units are m^{-1} but multi-beam sonar absolute calibration has not been determined.

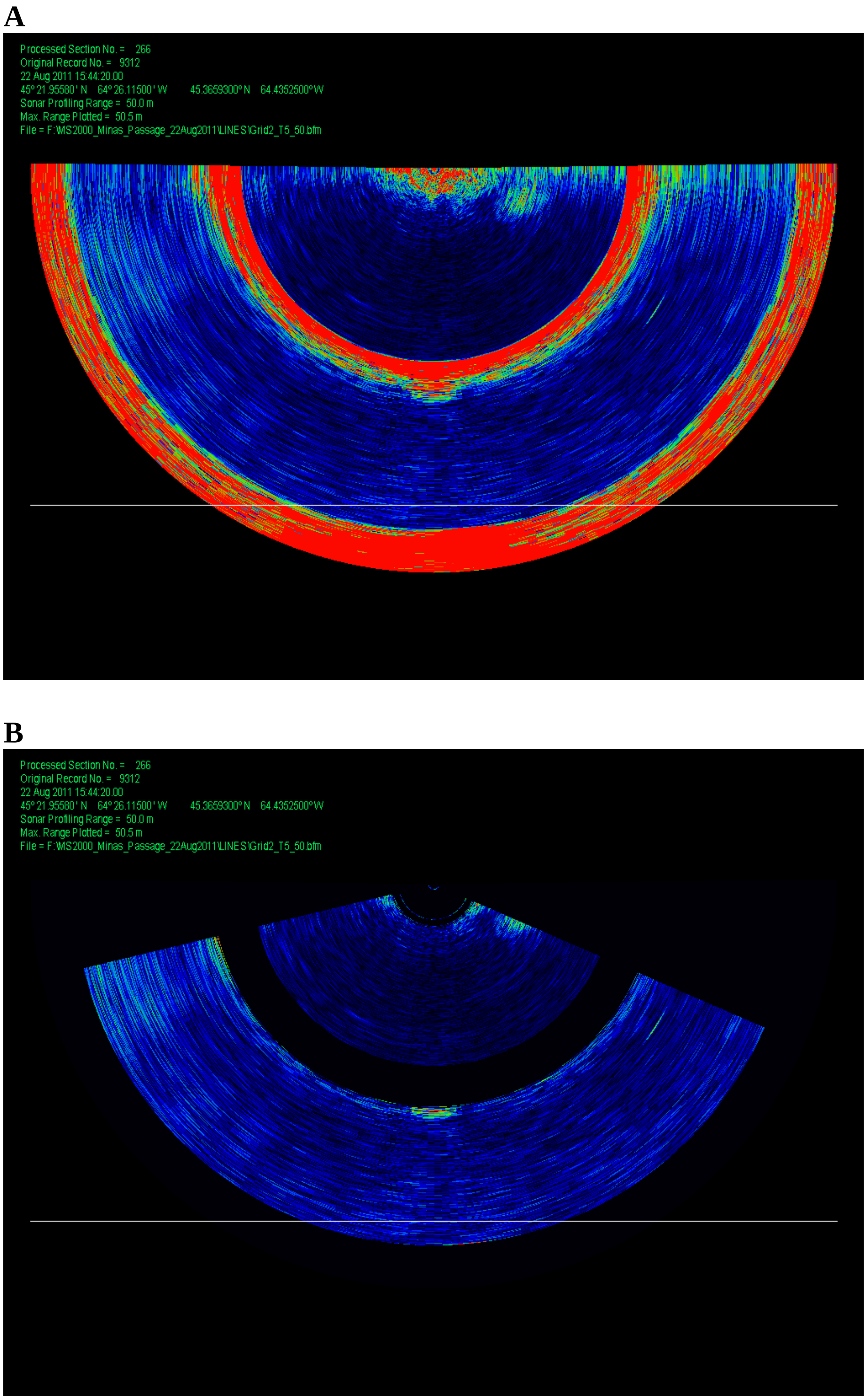


Figure A7-3. MS 2000 multi-beam fan sections without and with noise reduction:
A. No noise reduction
B. Application of multiple noise reduction algorithms
White line represents acoustic bottom detection depth minus a pre-set vertical safety margin on considering rapid changes in bottom bathymetry in survey area.

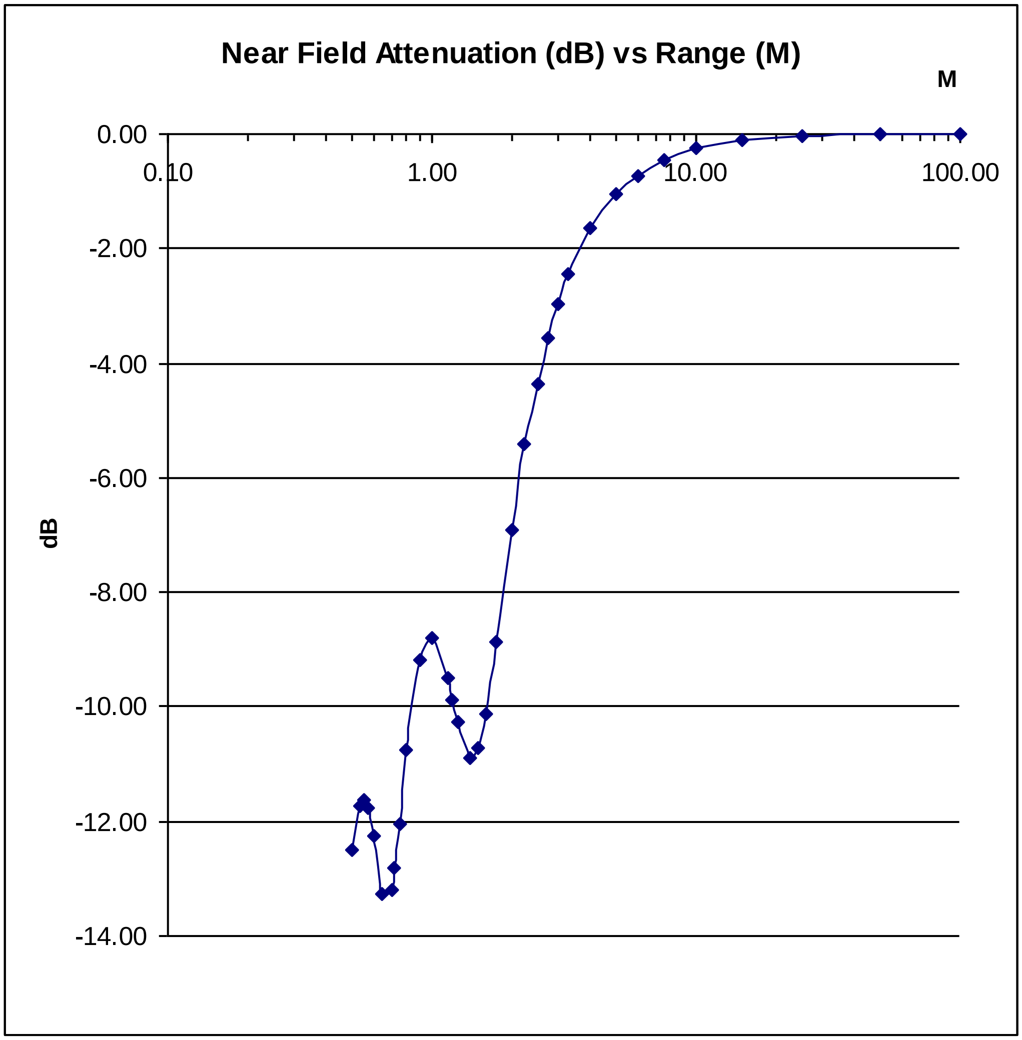


Figure A7-4. Near field propagation loss in excess of simple spherical spreading computed for points on the plane of symmetry perpendicular to a 0.276 m non-shaded line array.

APPENDIX 8: PROFILES OF MULTI-BEAM DERIVED VOLUME BACKSCATTERING STRENGTH VS. DEPTH FOR MINAS PASSAGE STUDY AREA

1. GENERAL

The profiles of linear form Volume Backscattering Strength ($\boldsymbol{S}_v$) vs. Depth to follow have been subjected to several differing noise reduction algorithms, including signal thresholding, which remove some – but by no means all – apparent backscatter arising from bubble clouds, sonar mutual interference, and vessel/flow noise. The levels of undesired backscatter vary greatly with tidal flow (i.e. bubble cloud effects) and vessel survey speed relative to the water column (i.e. propeller cavitation and flow noise). The rather high levels of noise reduction necessarily employed undoubtedly have some difficult to quantify effects on legitimate fish-origin backscatter levels.

While VBS levels are uncalibrated we have attempted, at least to the best of our knowledge, to keep relative VBS levels consistent across variations in multi-beam operating parameters associated with changes in system maximum profiling range. Compensation has also been applied to remove the effect of seasonal changes in water column acoustic absorption.

Depths are plotted relative to the water surface. The MS 2000 system does not employ beam stabilization to compensate for vessel pitch and roll.

Due to the multiplicity of plots in this Appendix the plots are not numbered in the normal manner but can be referenced by specific survey, grid, and transect number(s).

2. DATASET: 16 SEPT. 2010

2.1 Analysis Parameters: 16 Sept. 2010

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

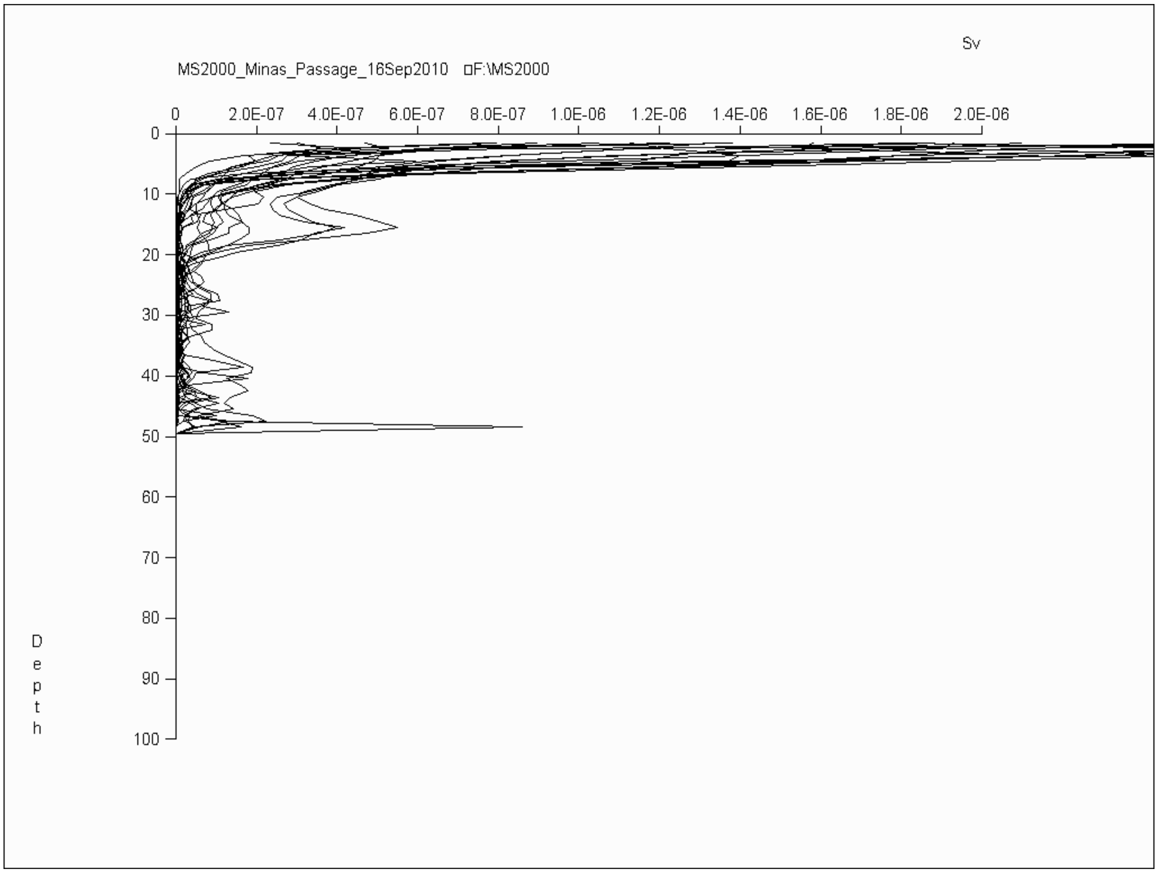
Alpha Correction = 61.2 dB/km

2.2 Lines: 16 Sept. 2010

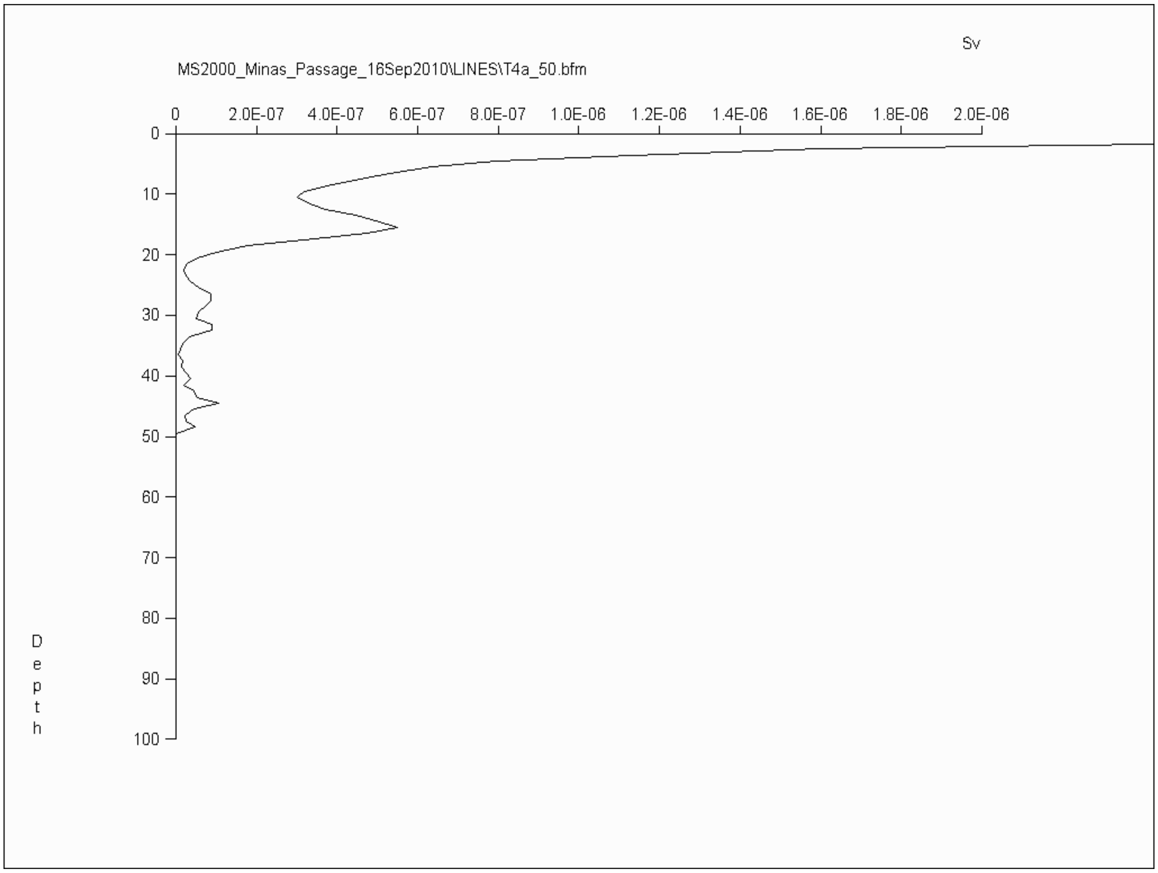
Format:

Line_Range	"Field Data File"	Start	End (Ping)
T4a_50	"Sep16,2010,16-10-51.smb"	1	2750
T4b_50	"Sep16,2010,16-10-51.smb"	2751	3120
T4c_50	"Sep16,2010,16-10-51.smb"	3121	4643
T5a_50	"Sep16,2010,16-10-51.smb"	4721	4990
T6a_50	"Sep16,2010,16-10-51.smb"	5068	7000
T7a_50	"Sep16,2010,16-10-51.smb"	7070	7352
T4d_50	"Sep16,2010,16-10-51.smb"	7584	9079
T3a_50	"Sep16,2010,16-10-51.smb"	9150	9486
T2a_50	"Sep16,2010,16-10-51.smb"	9532	10338
T1a_50	"Sep16,2010,16-10-51.smb"	10371	10766
T4e_50	"Sep16,2010,16-10-51.smb"	10910	11900
T5b_75	"Sep16,2010,19-30-26.smb"	15	366
T6b_75	"Sep16,2010,19-30-26.smb"	443	1284
T7b_75	"Sep16,2010,19-30-26.smb"	1333	1695
T4f_75	"Sep16,2010,19-30-26.smb"	1890	2500
T5c_50	"Sep16,2010,20-12-34.smb"	10	523
T6c_50	"Sep16,2010,20-12-34.smb"	574	1108
T7c_50	"Sep16,2010,20-12-34.smb"	1157	1890
T4g_50	"Sep16,2010,20-12-34.smb"	2032	2473
T4h_50	"Sep16,2010,20-12-34.smb"	2500	3985
T3b_50	"Sep16,2010,20-12-34.smb"	4040	4370
T2b_50	"Sep16,2010,20-12-34.smb"	4470	6151
T1b_50	"Sep16,2010,20-12-34.smb"	6250	6512
T4i_50	"Sep16,2010,20-12-34.smb"	7052	8000
T4j_50	"Sep16,2010,20-12-34.smb"	8001	8114

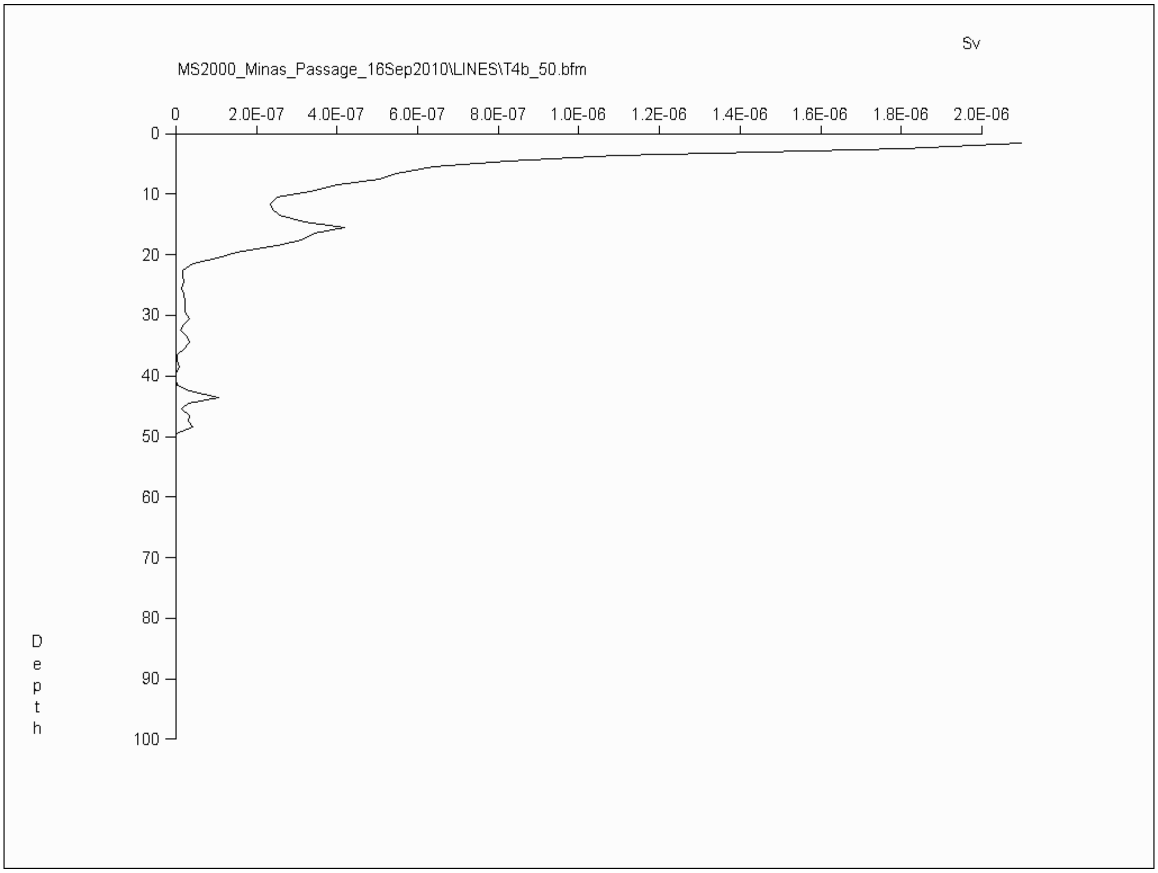
2.3 S_v Profiles: 16 Sept. 2010



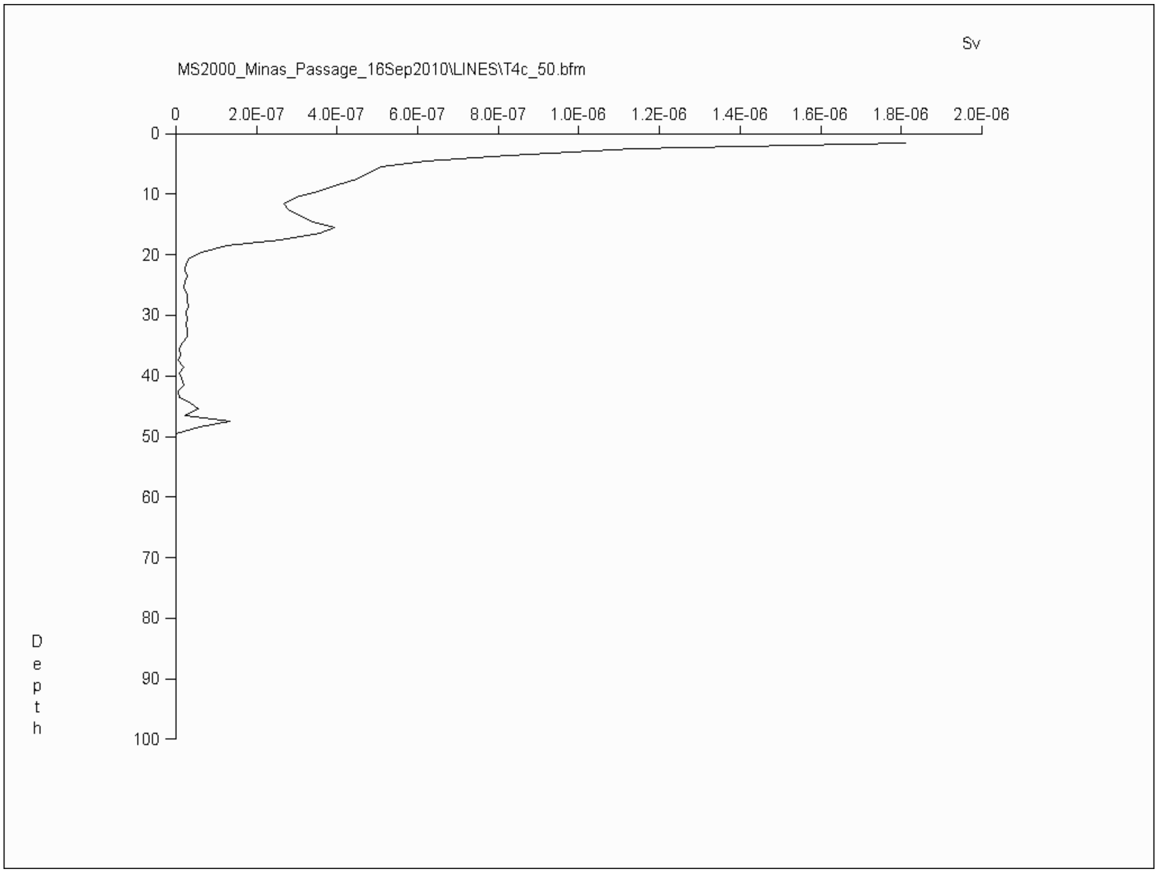
S_v vs. depth profiles for all profiles collected on the initial 16 Sept. 2010 survey. Data were collected from 09:17 to 15:32 ADT. Precise absorption corrections of 61.2 dB/km were applied.



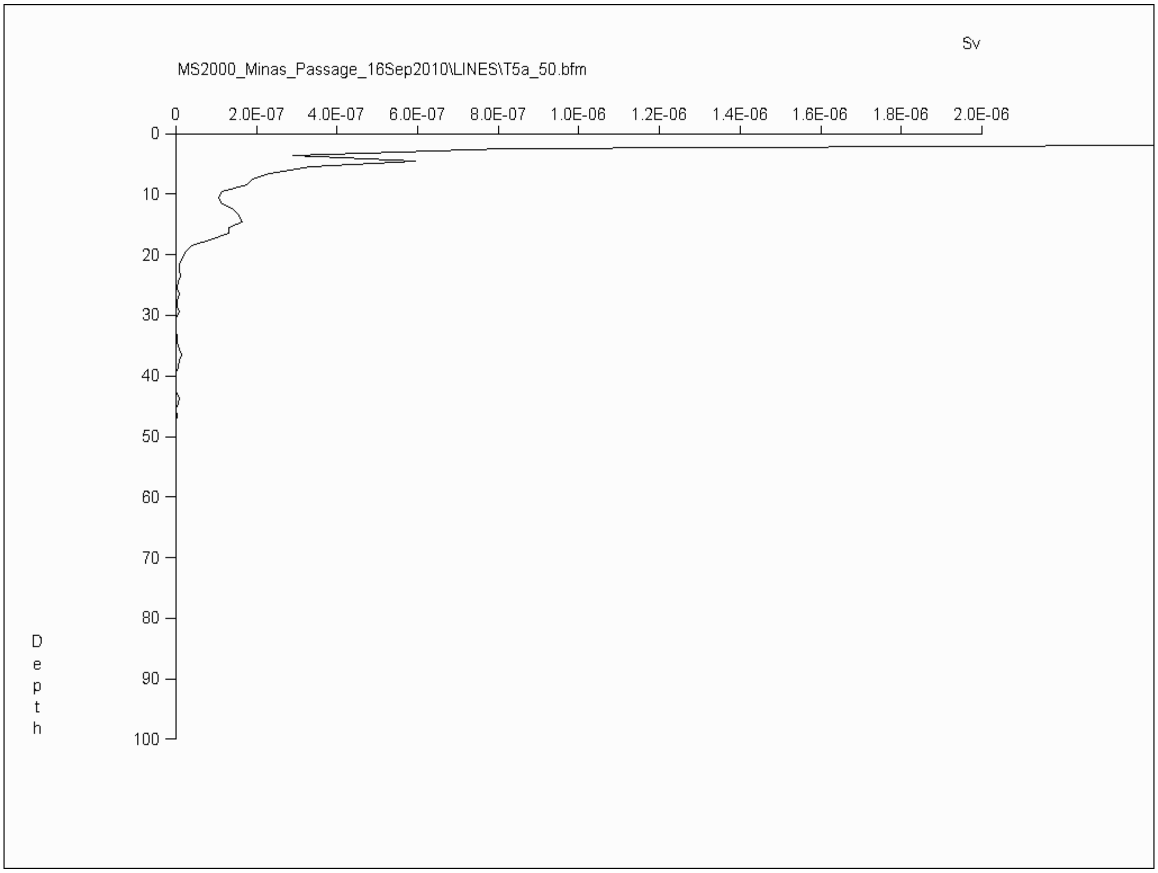
16 Sept. 2010. From 09:16:43 – 10:01:59 ADT. Line T4a. Recorded on rising ebb tide flow, nominal max ebb flow (10:30 ADT). Layer centered near 15 m depth has been verified as fish by visual examination of MS 2000 fan beam sections.



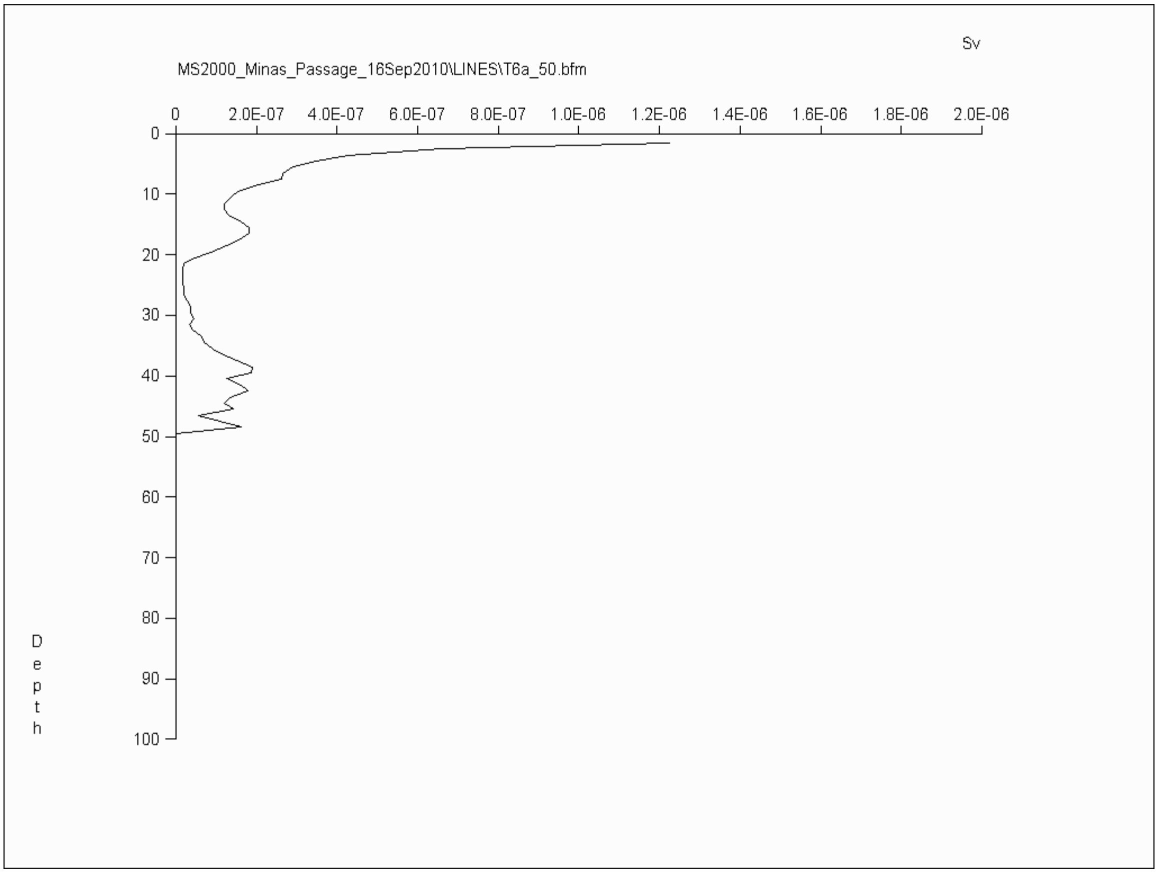
16 Sept. 2010. From 10:02:00 – 10:08:06 ADT. Line T4b. Recorded on rising ebb tide flow, nominal max ebb flow (10:30 ADT). Layer centered near 15 m depth has been verified as fish by examination of fan beam sections.



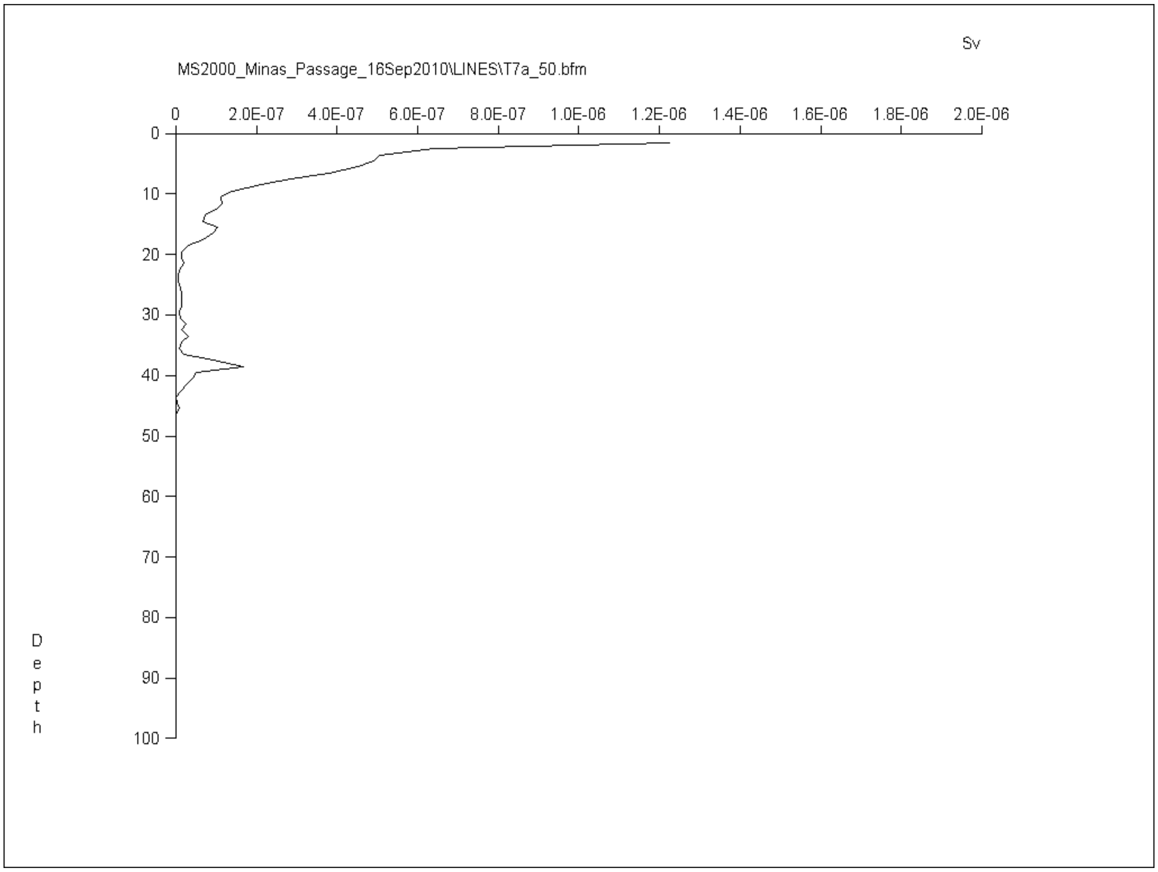
16 Sept. 2010. From 10:08:07 – 10:33:14 ADT. Line T4c. Recorded around nominal max ebb flow (10:30 ADT). Layer centered near 15 m depth has been verified as fish by examination of fan beam sections.



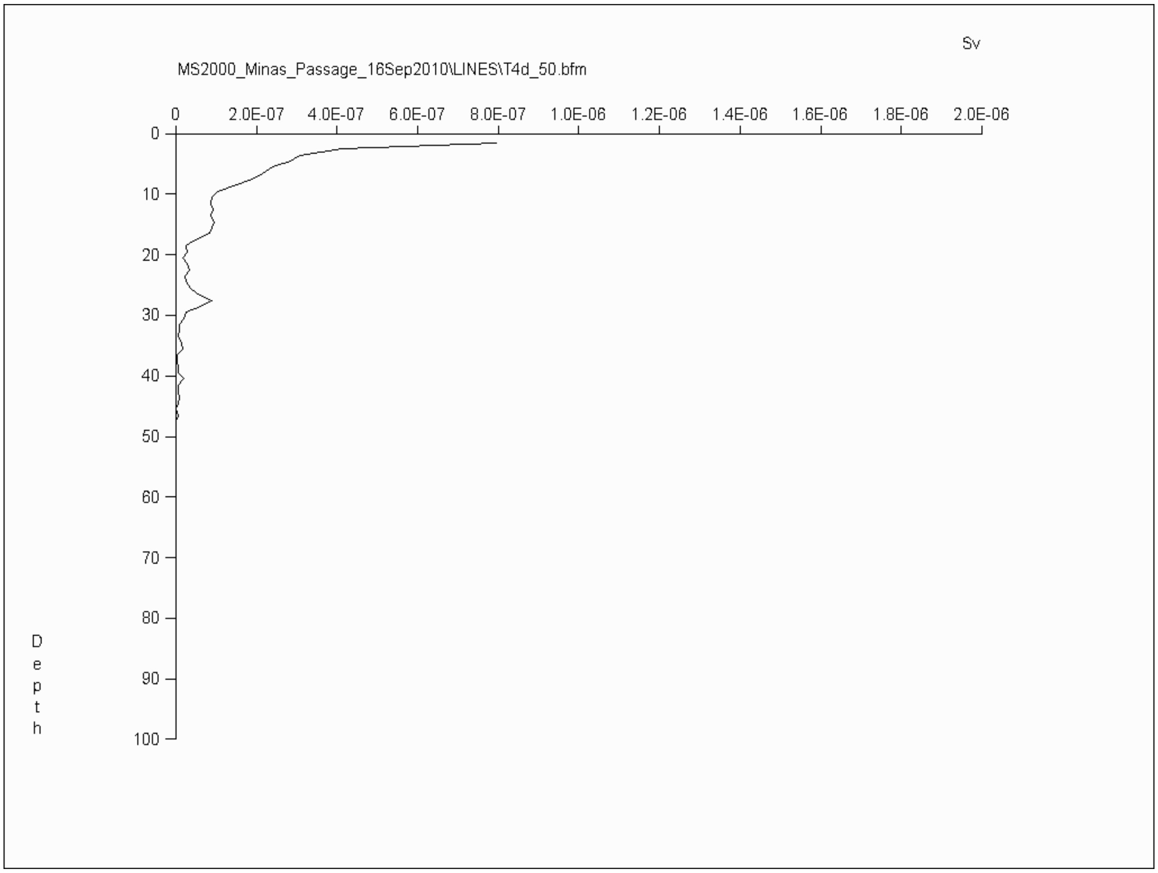
16 Sept. 2010. From 10:34:31 – 10:38:57 ADT. Line T5a. Recorded near nominal max ebb flow (10:30 ADT).



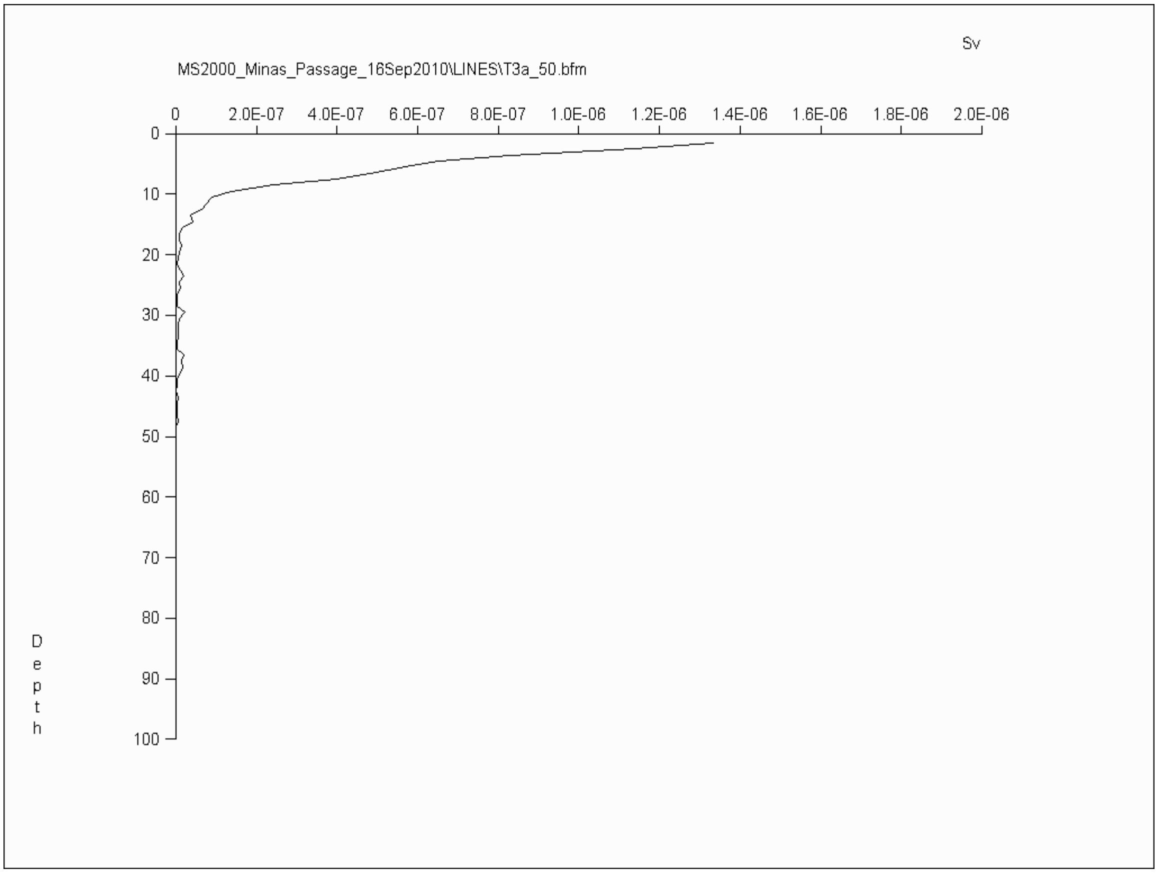
16 Sept. 2010. From 10:40:14 – 11:12:07 ADT. Line T6a. Recorded after nominal max ebb flow (10:30 ADT). Fish may be present in 15 – 20 m depth range but this fact could not be unambiguously verified from visual examination of fan sections.



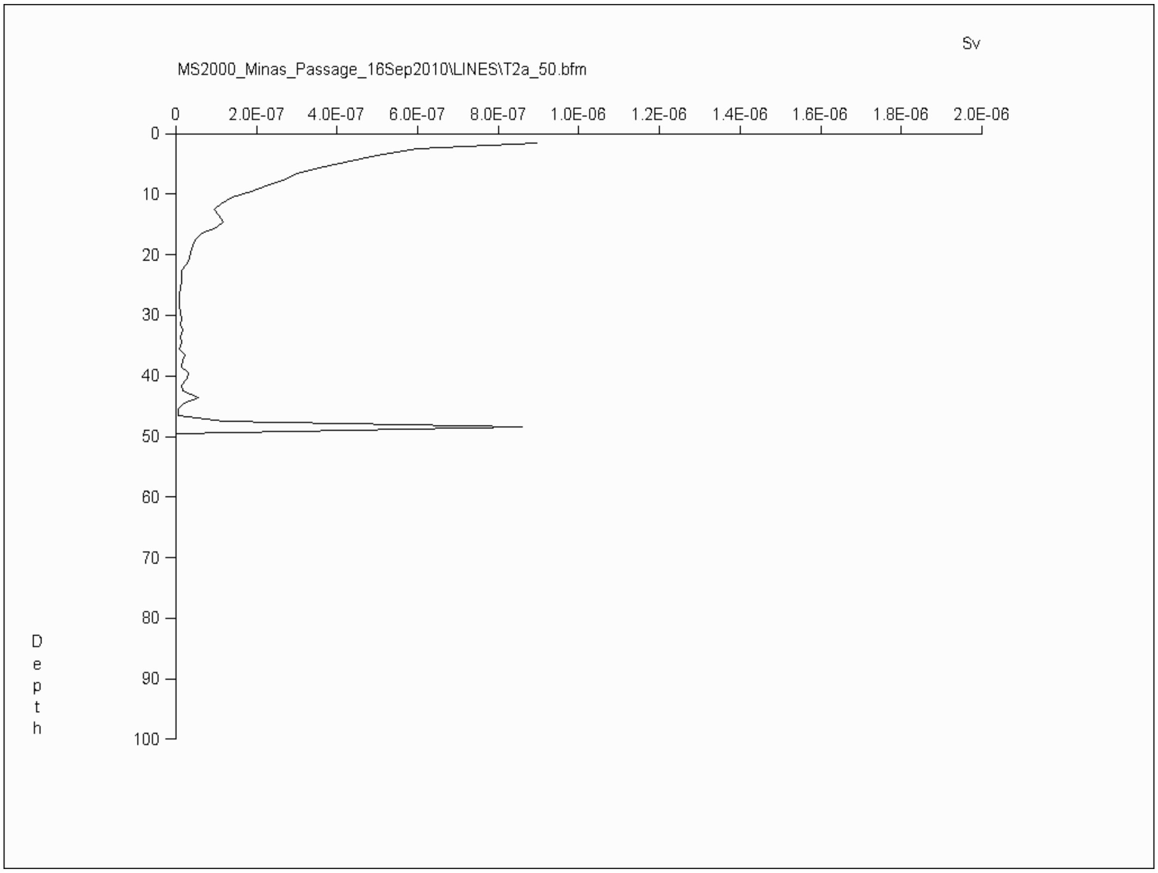
16 Sept. 2010. From 11:13:16 – 11:17:54 ADT. Line T7a. Recorded on declining ebb tidal flow.



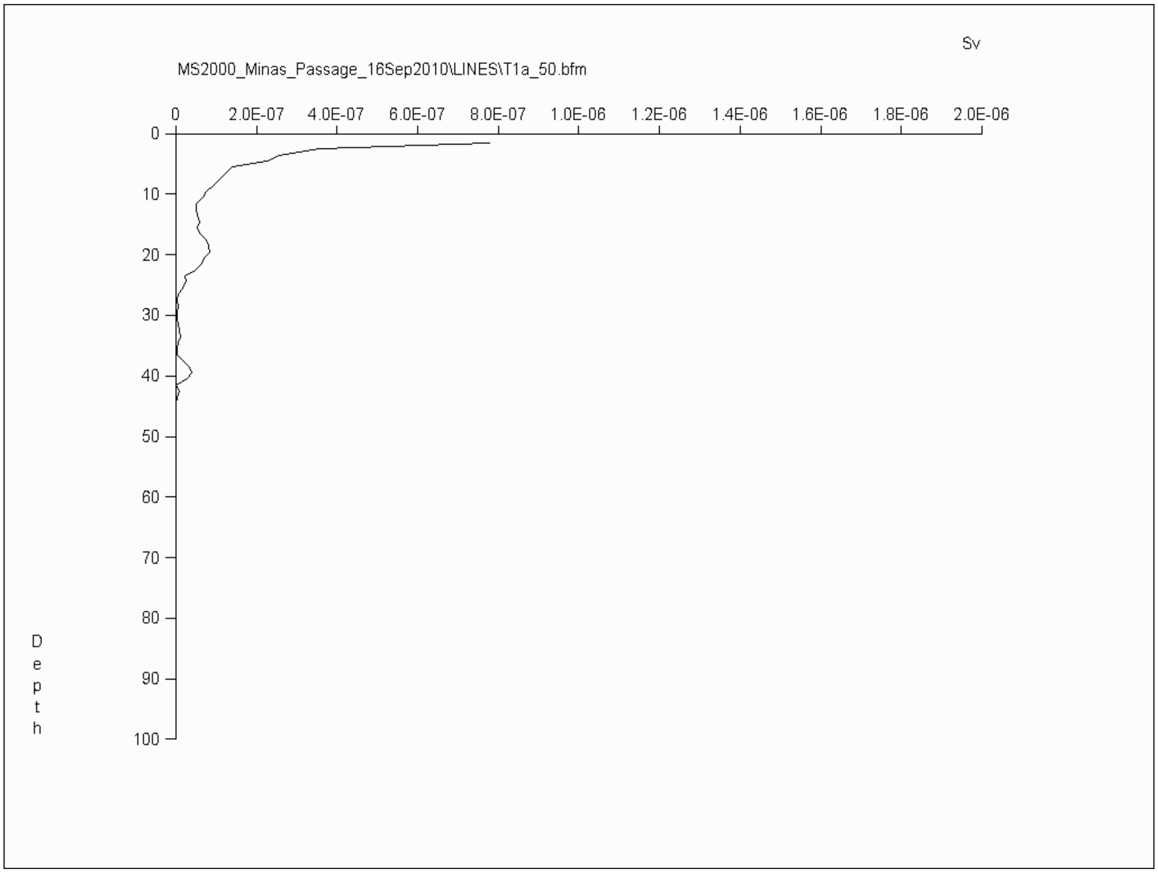
16 Sept. 2010. From 11:21:44 – 11:46:22 ADT. Line T4d. Recorded on declining ebb tidal flow.



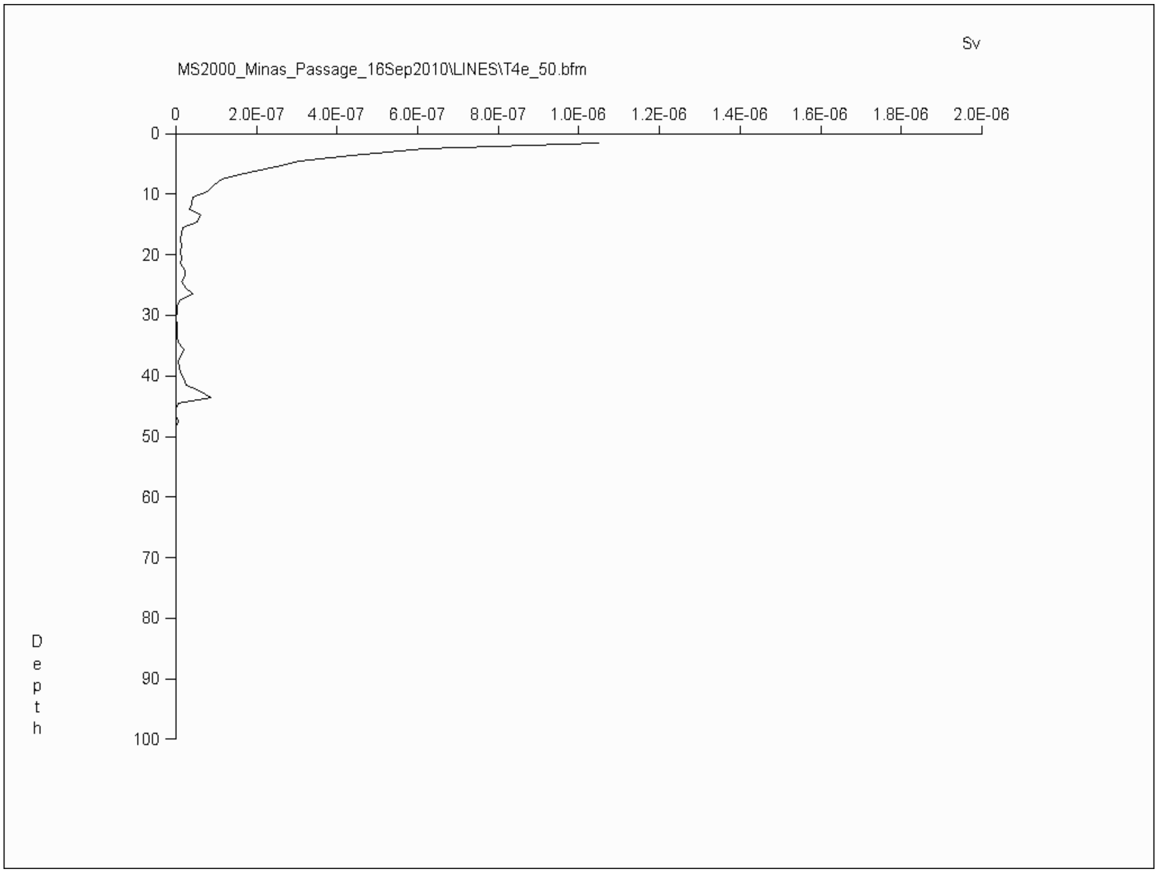
16 Sept. 2010. From 11:41:32 – 11:53:04 ADT. Line T3a. Recorded on declining ebb tidal flow.



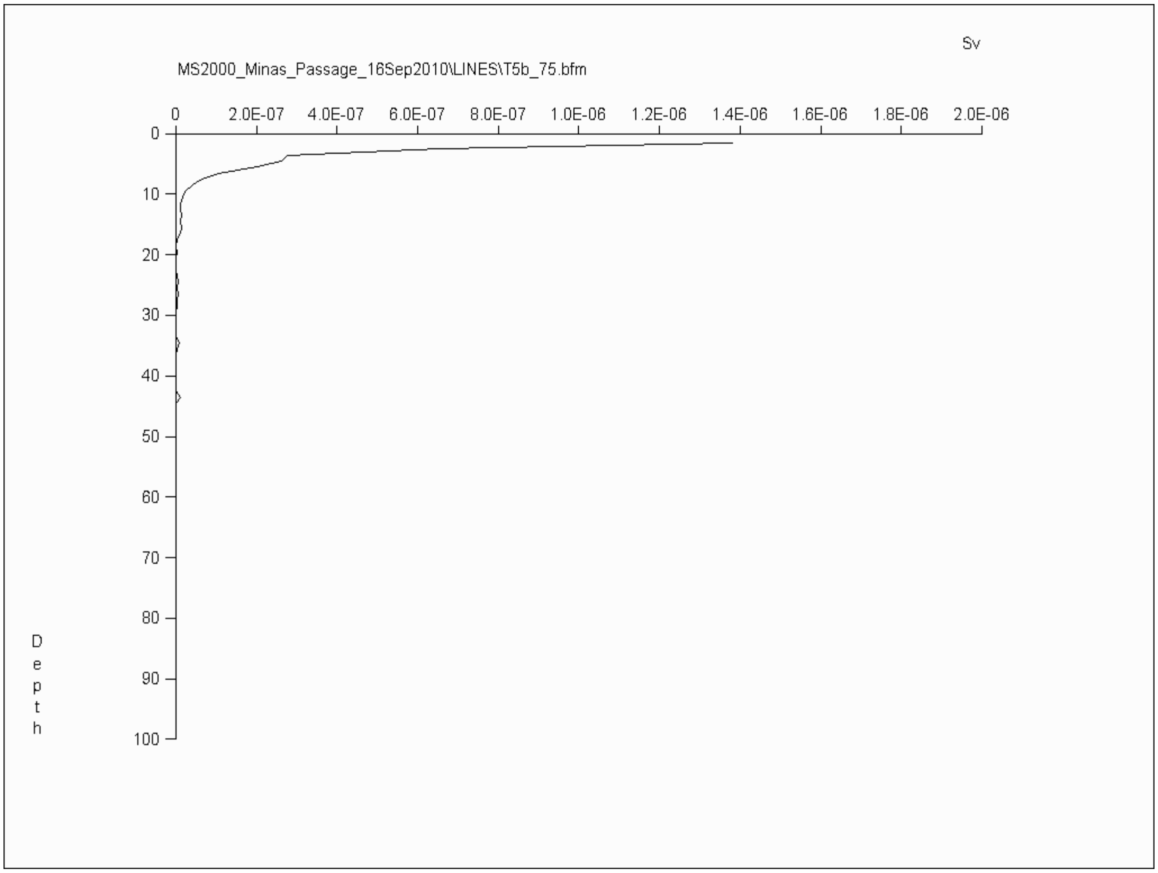
16 Sept. 2010. From 11:53:49 – 12:07:06 ADT. Line T2a. Recorded on declining ebb tidal flow.



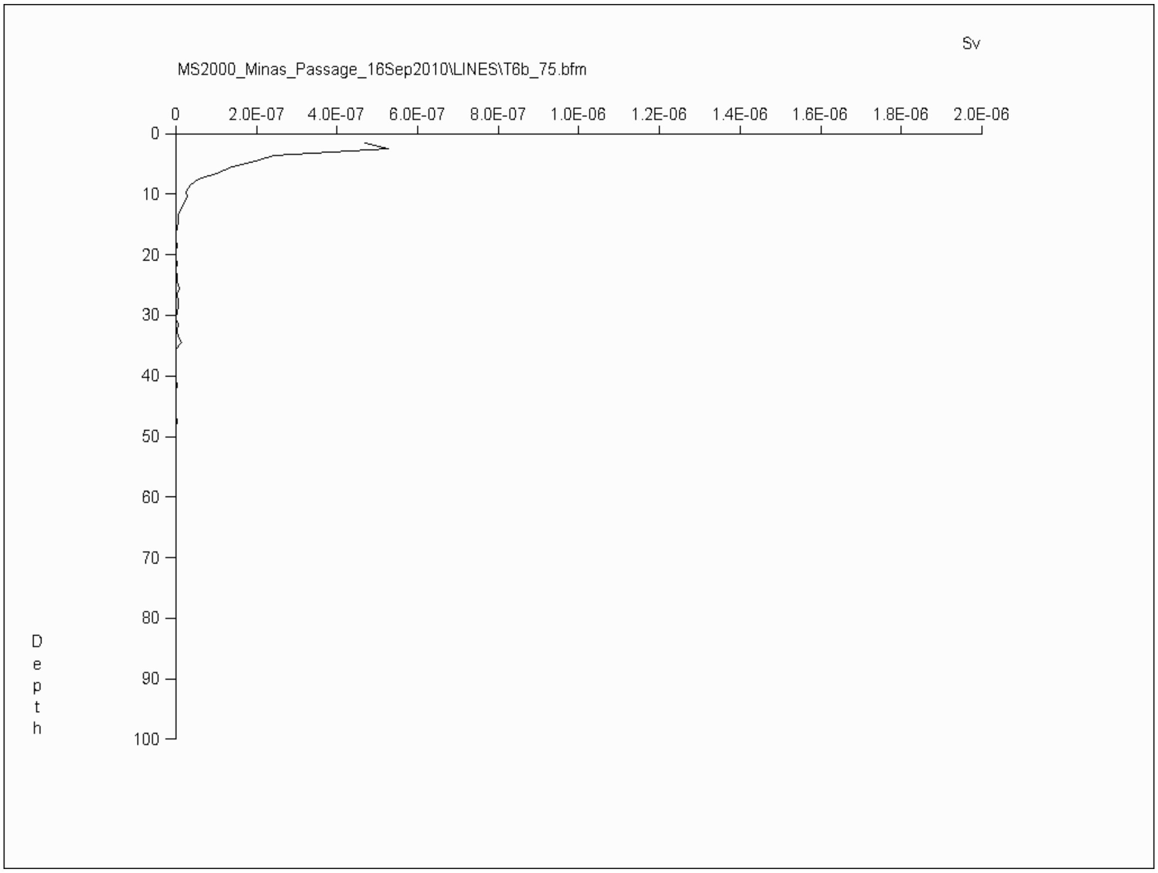
16 Sept. 2010. From 12:07:39 – 12:14:12 ADT. Line T1a. Recorded on declining ebb tidal flow.



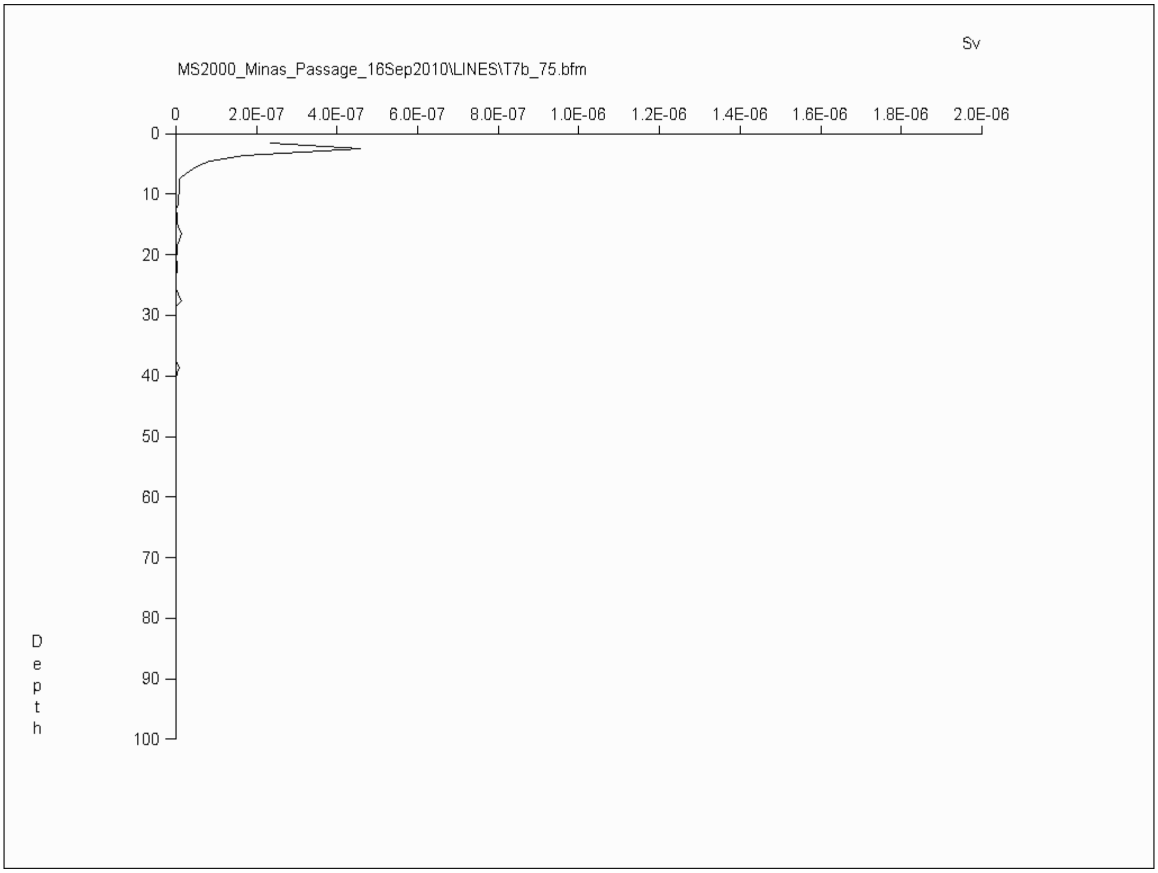
16 Sept. 2010. From 12:16:34 – 12:32:53 ADT. Line T4e. Recorded on declining ebb tidal flow ending about 1hr before low tide (13:38 ADT).



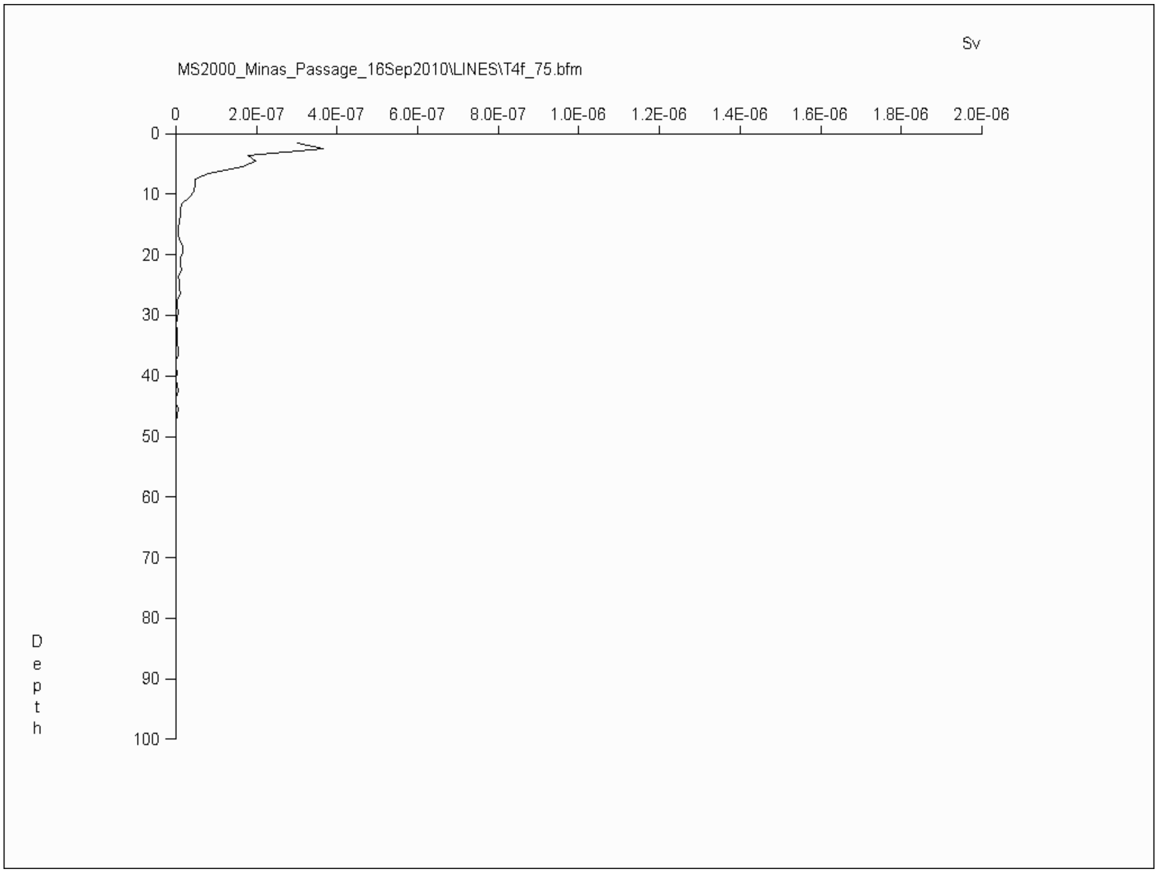
16 Sept. 2010. From 12:36:10 – 12:41:56 ADT. Line T5b. Recorded on declining ebb tidal flow approaching LT (13:38 ADT).



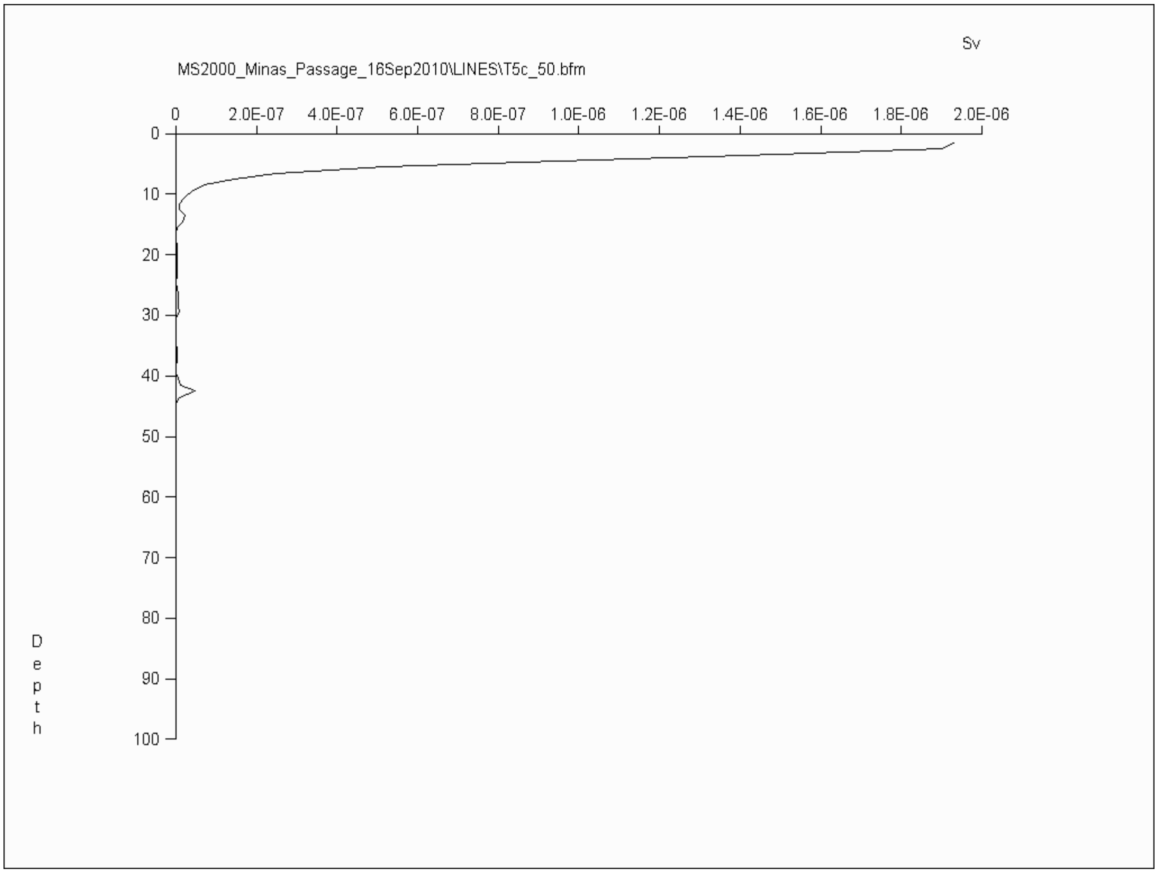
16 Sept. 2010. From 12:43:12 – 12:57:04 ADT. Line T6b. Recorded on declining ebb tidal flow approaching LT (13:38 ADT).



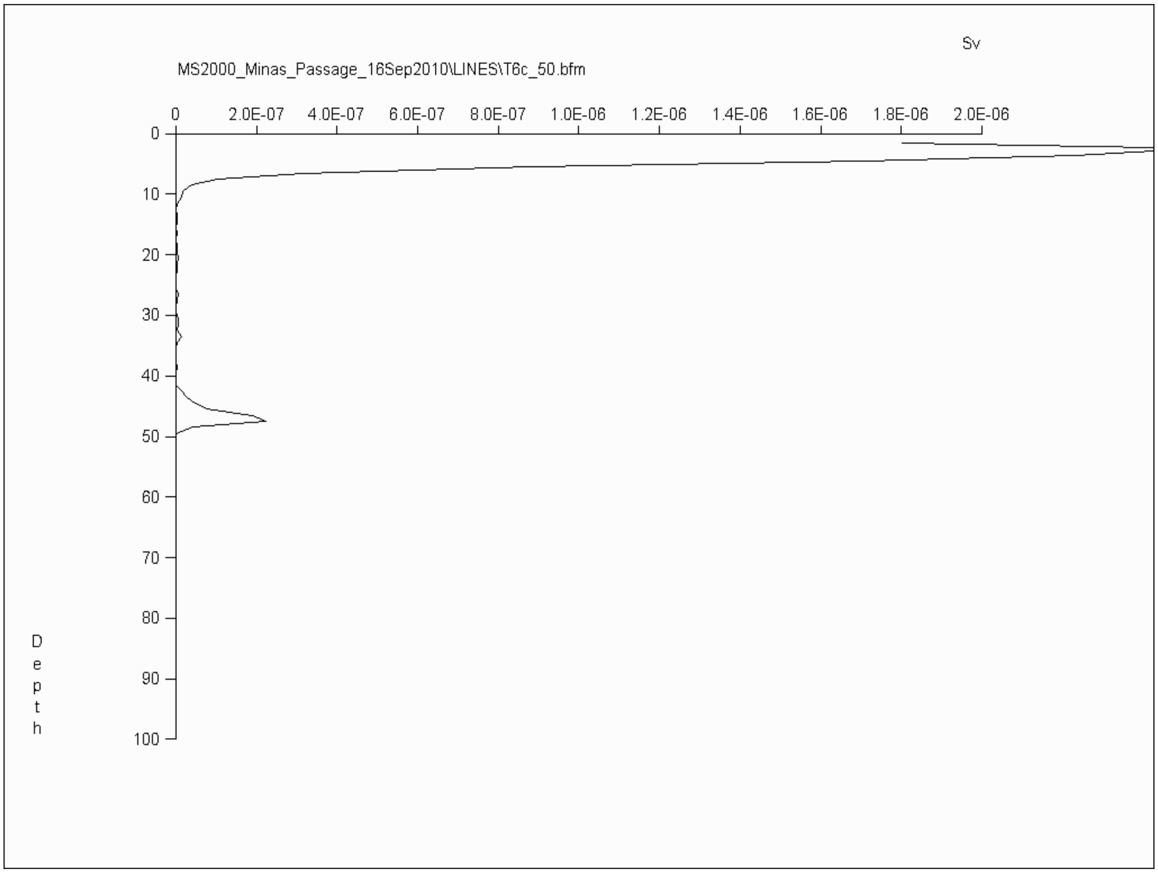
16 Sept. 2010. From 12:57:52 – 13:03:50 ADT. Line T7b. Recorded on declining ebb tidal flow approaching LT (13:38 ADT).



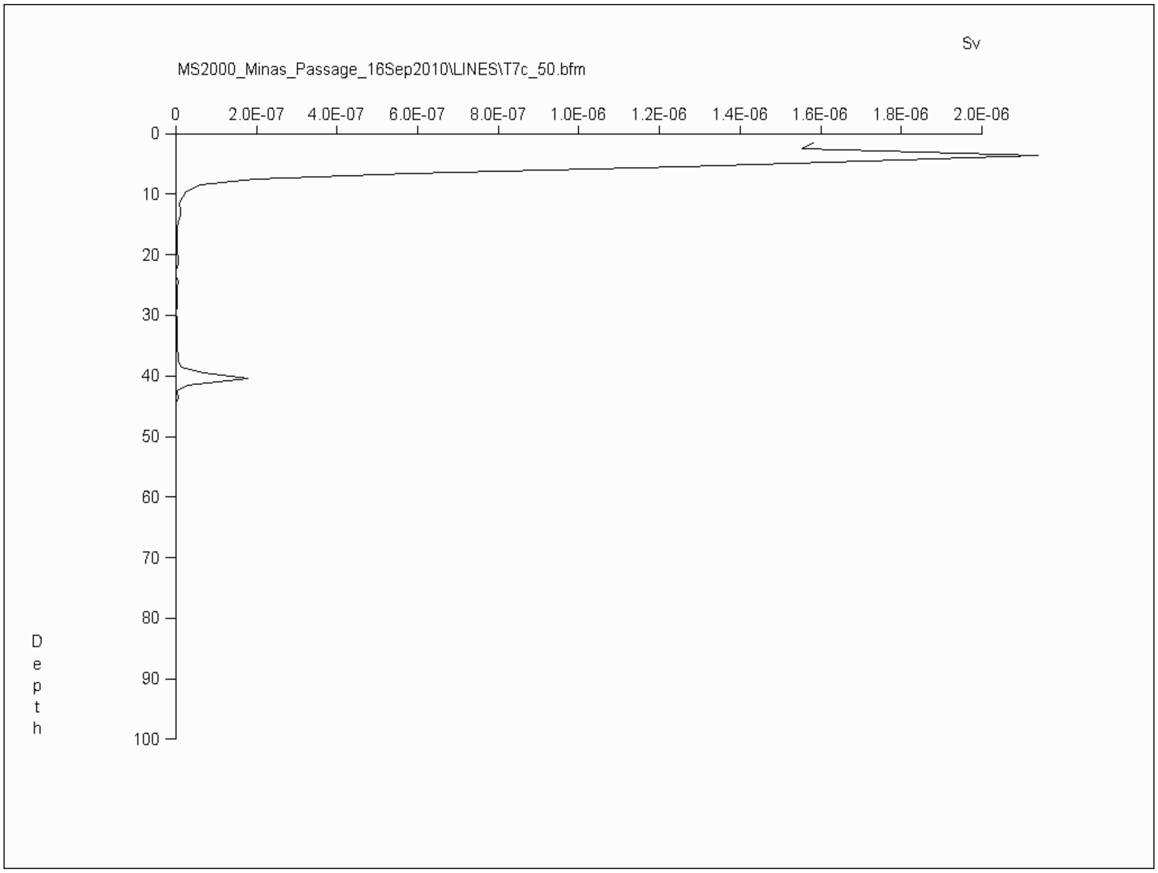
16 Sept. 2010. From 13:07:03 – 13:17:09 ADT. Line T4f. Recorded on declining ebb tidal flow as LT slack water approached (13:38 ADT).



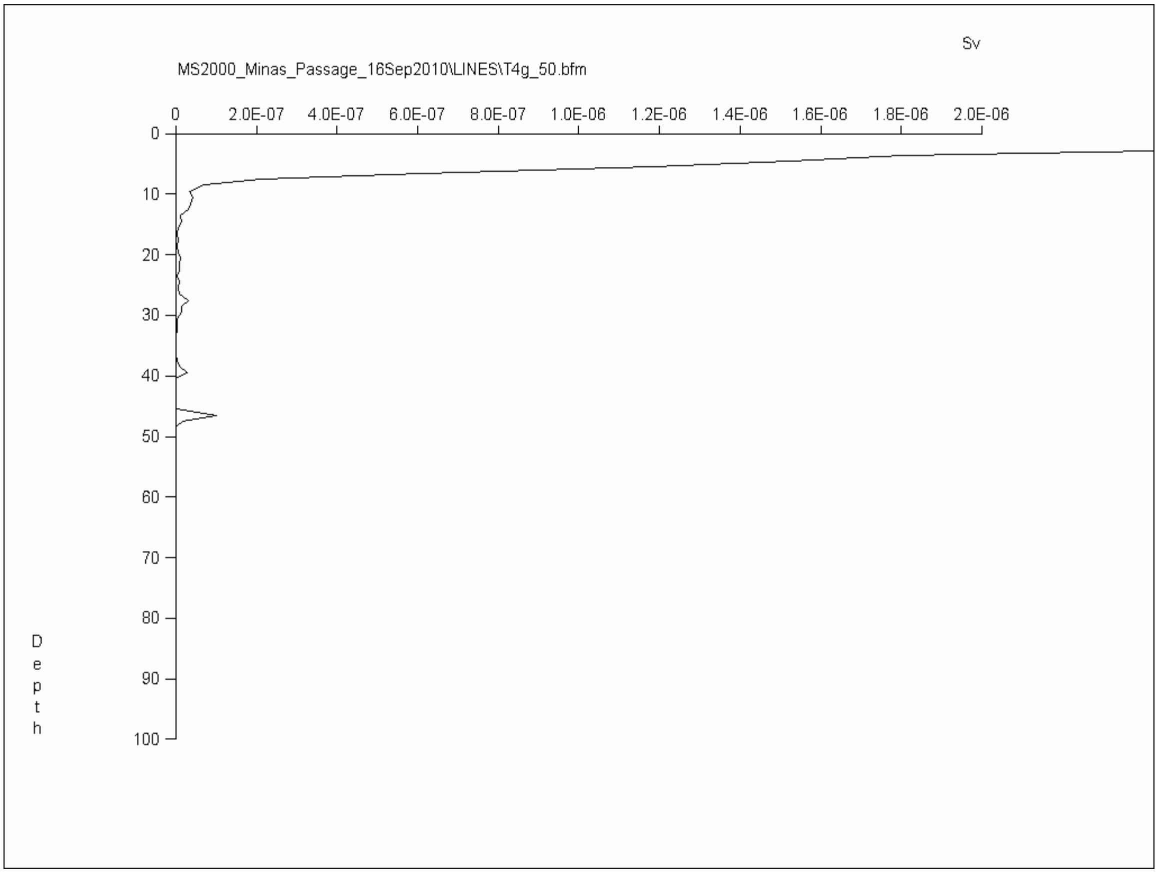
16 Sept. 2010. From 13:18:09 – 13:26:36 ADT. Line T5c. Recorded on declining ebb tidal flow just before predicted LT slack water (13:38 ADT).



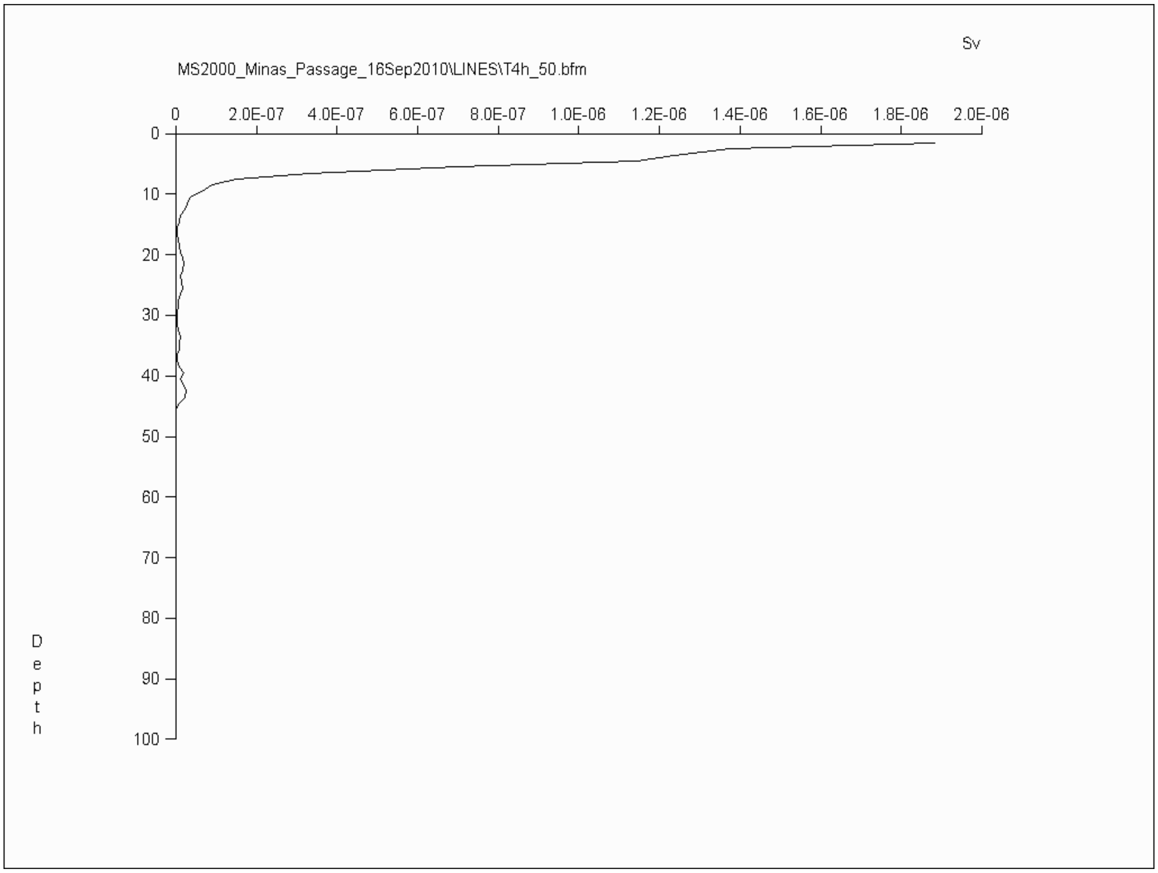
16 Sept. 2010. From 13:27:26 – 13:36:14 ADT. Line T6c. Recorded very close to LT slack water (13:38 ADT).



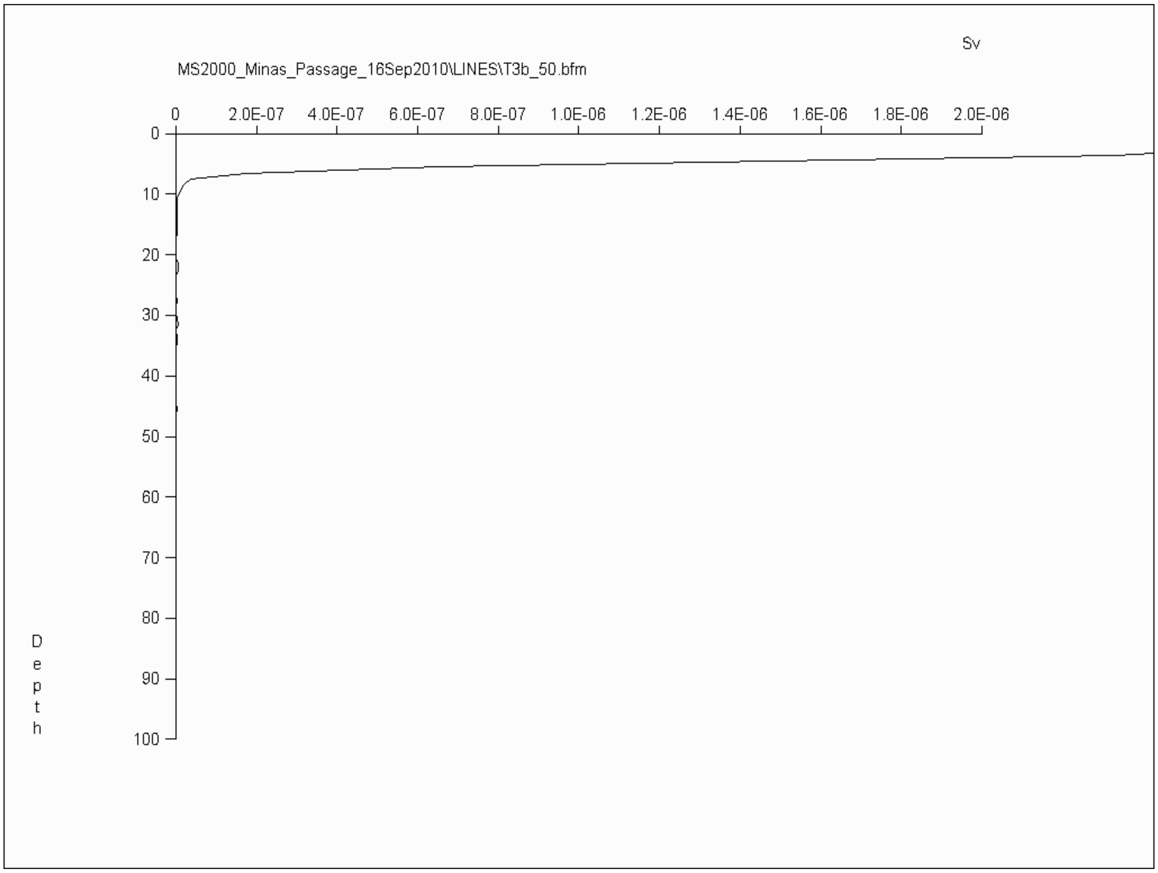
16 Sept. 2010. From 13:37:03 – 13:49:07 ADT. Line T7c. Recorded around LT slack water (13:38 ADT).



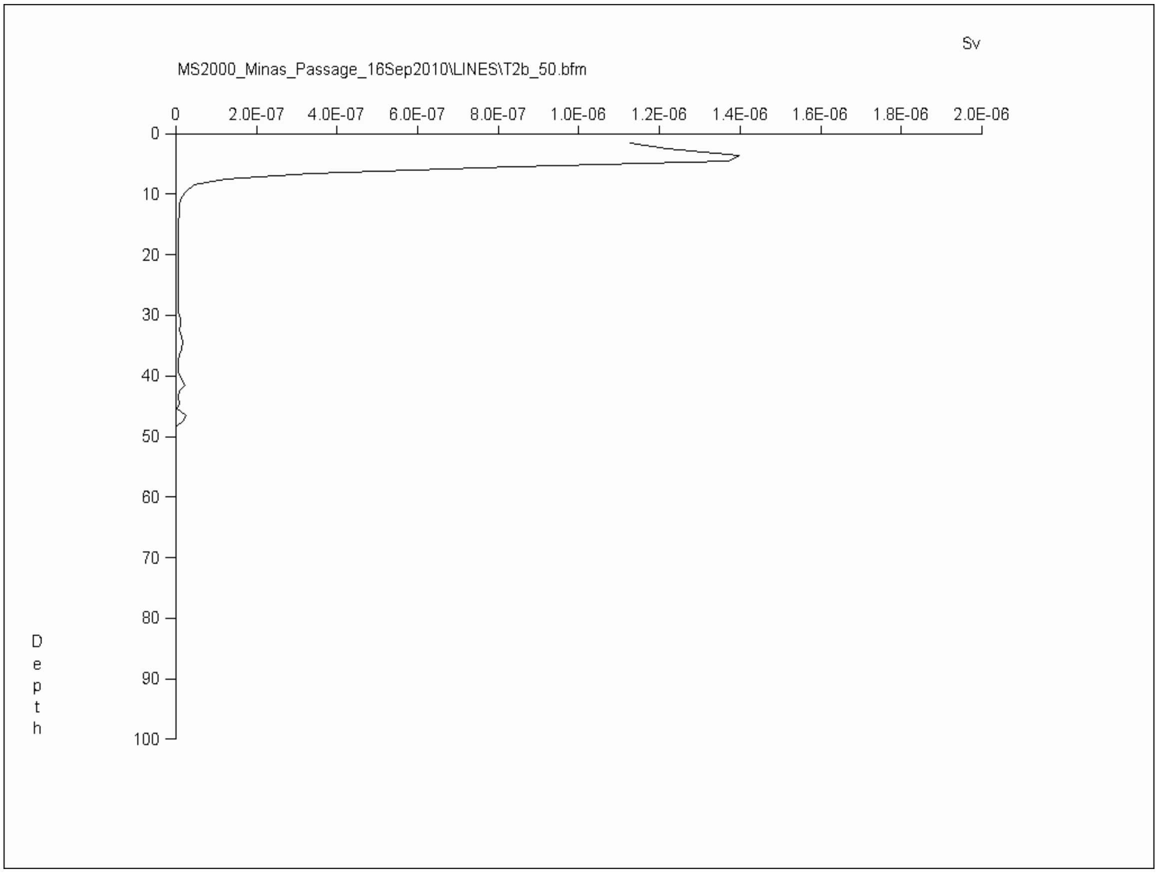
16 Sept. 2010. From 13:51:28 – 13:58:43 ADT. Line T4g. Recorded just after LT slack water (13:38 ADT).



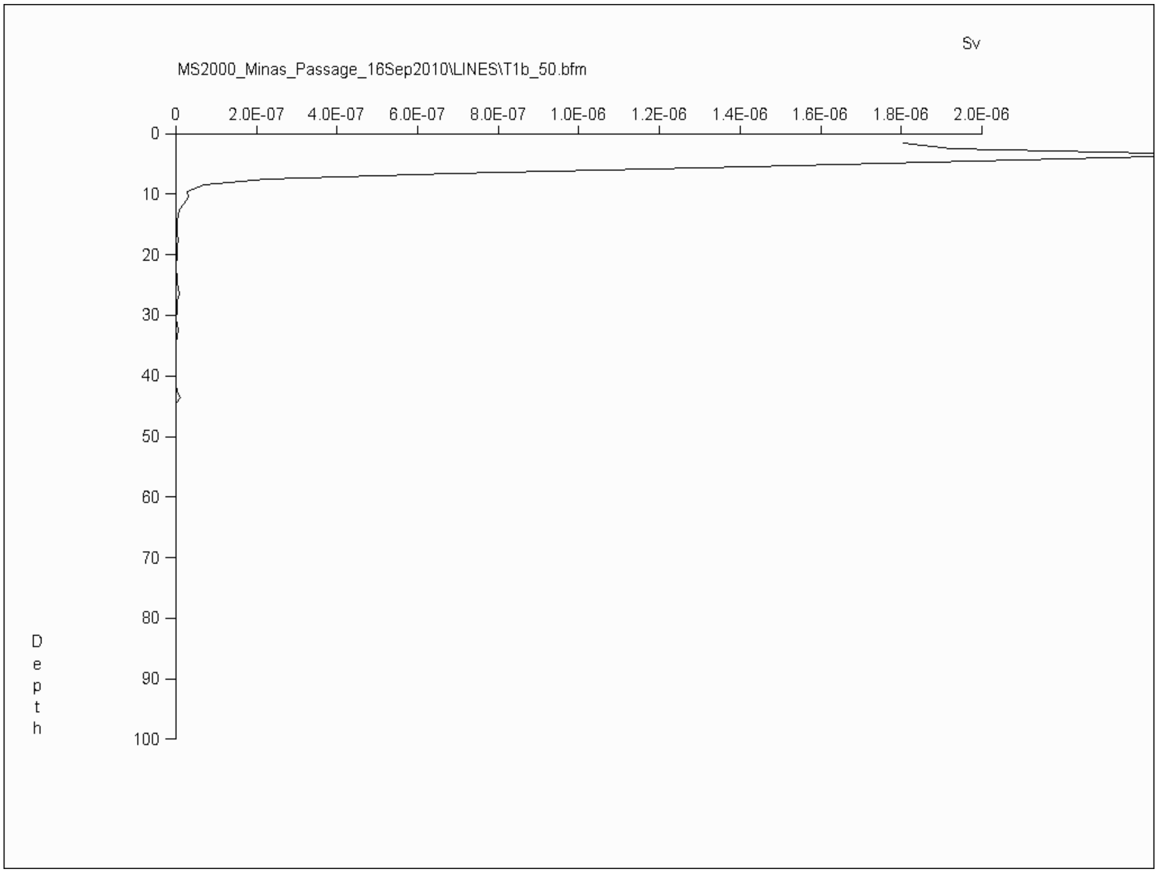
16 Sept. 2010. From 13:59:10 – 14:23:41 ADT. Line T4h. Recorded on rising portion of flood tide cycle following LT (13:38 ADT).



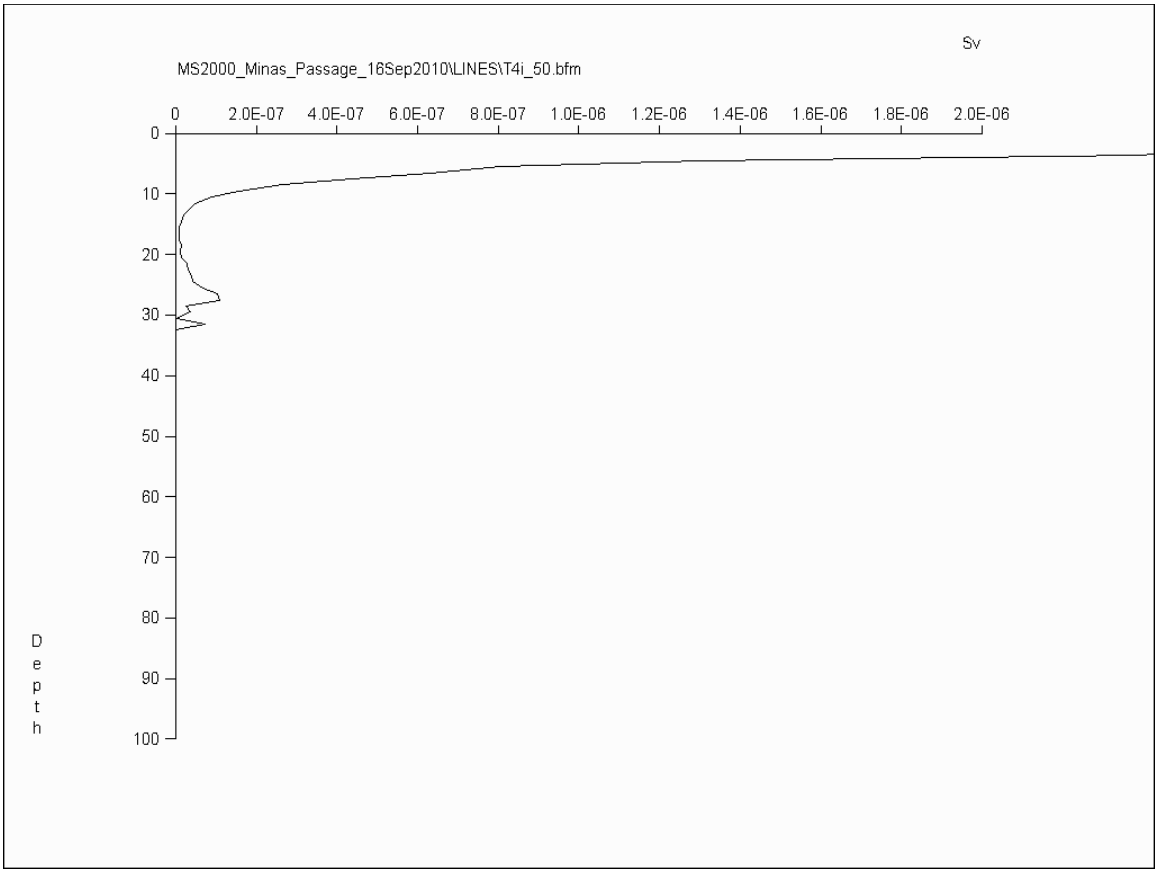
16 Sept. 2010. From 14:24:36 – 14:30:01 ADT. Line T3b. Recorded on rising portion of flood tide cycle.



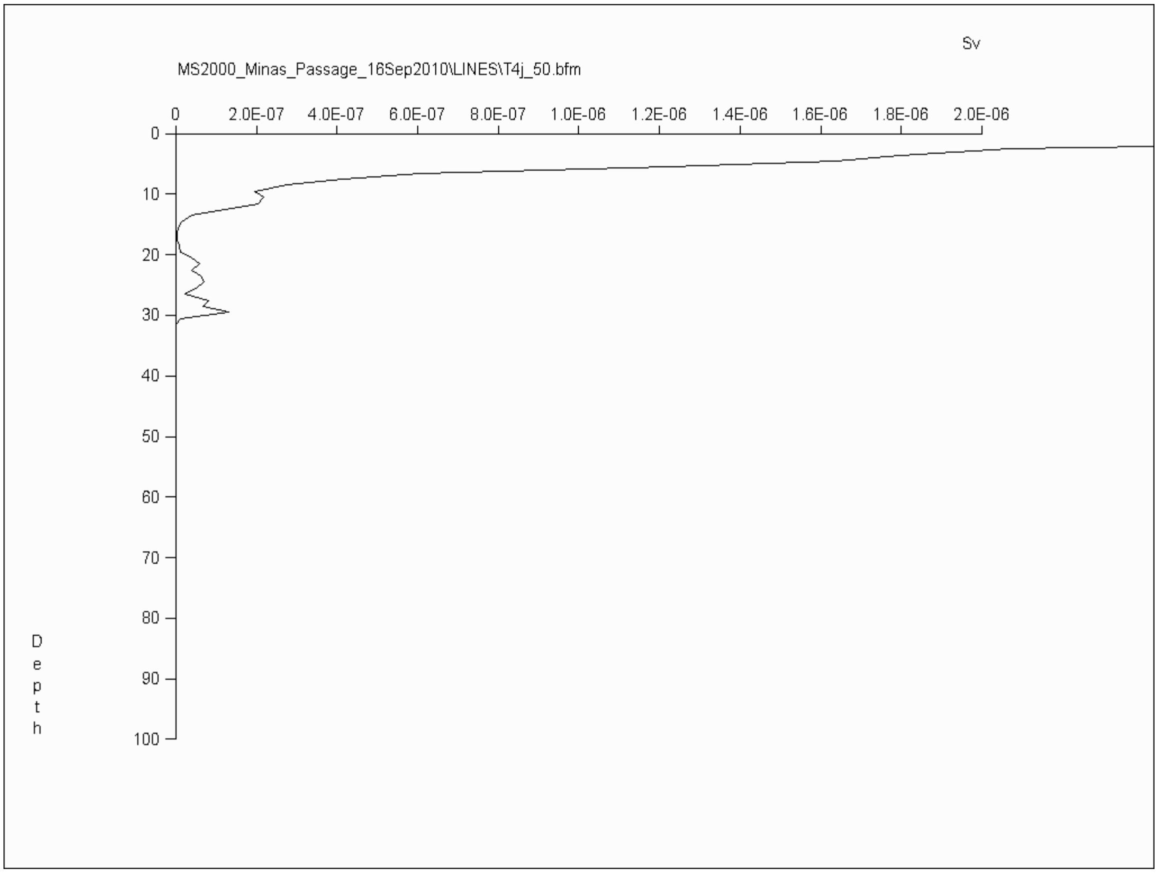
16 Sept. 2010. From 14:31:40 – 14:59:22 ADT. Line T2b. Recorded on rising portion of flood tide cycle approx. 1 hour past LT (13:38 ADT).



16 Sept. 2010. From 15:01:00 – 15:05:19 ADT. Line T1b. Recorded on mid rising portion of flood tide cycle.



16 Sept. 2010. From 15:14:15 – 15:29:53 ADT. Line T4i. Recorded on rising portion of flood tide cycle, with maximum nominal flood predicted for 16:43 ADT. A fish origin for the $\boldsymbol{S_v}$ peak between 20 to 30 m depth could not established from visual examination of fan sections.



16 Sept. 2010. From 15:29:54 – 15:31:45 ADT. Line T4j. Recorded on rising portion of flood tide cycle, maximum nominal flood predicted for 16:43 ADT. This was the last grid profile recorded. A fish origin for the echo peak between 20 to 30 m depth could not be established from visual examination of fan sections.

3. DATASET: 22 AUG. 2011

3.1 Analysis Parameters: 22 Aug. 2011

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

Alpha Correction = 59.6 dB/km

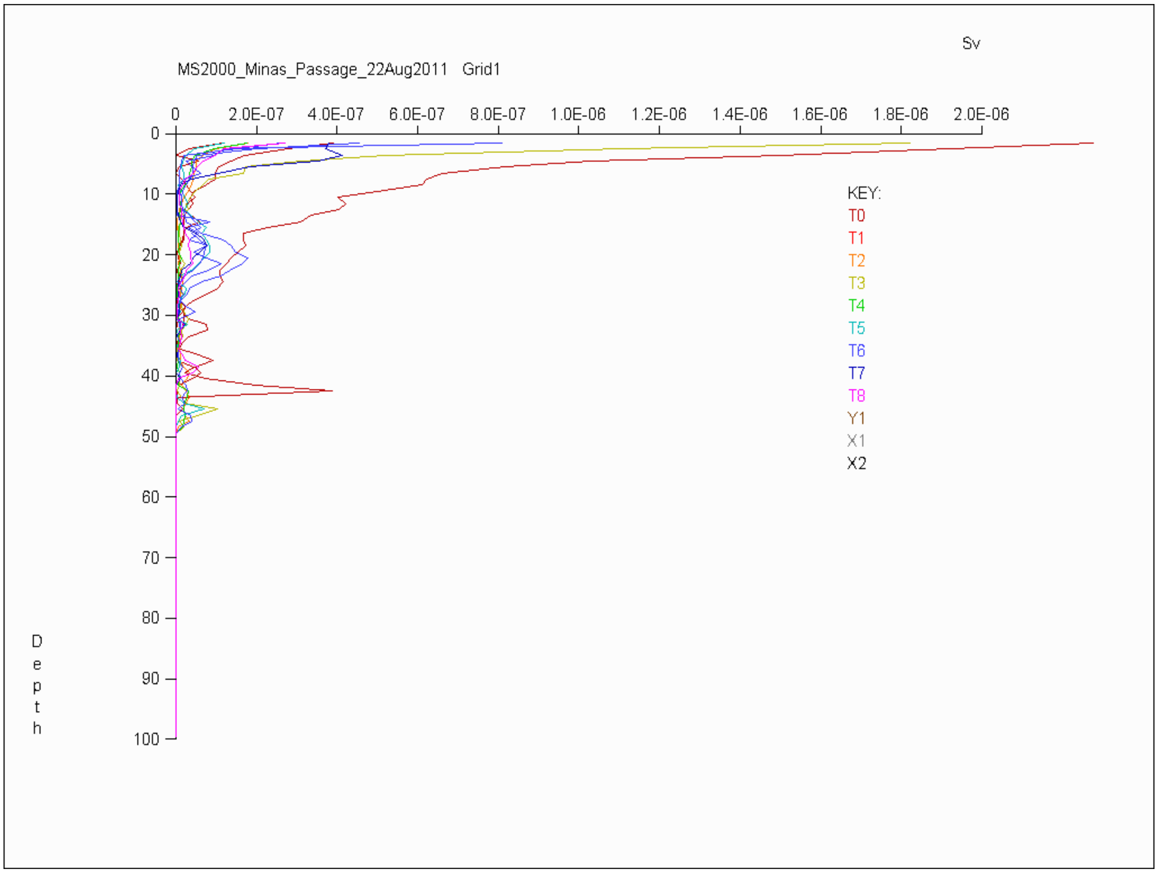
3.2 Lines: 22 Aug. 2011

Format:

Grid_Line_Range_Sub-line	"Field Data File"	Start	End (Ping)
Grid1_T0_50	"Aug22,2011,15-44-55.smb"	1	291
Grid1_T0_75_1	"Aug22,2011,15-44-55.smb"	292	310
Grid1_T0_50_2	"Aug22,2011,15-44-55.smb"	310	500
Grid1_T1_50	"Aug22,2011,15-44-55.smb"	580	820
Grid1_T2_50	"Aug22,2011,15-44-55.smb"	940	1780
Grid1_T3_50	"Aug22,2011,15-44-55.smb"	1965	2210
Grid1_T4_50	"Aug22,2011,15-44-55.smb"	2330	2935
Grid1_T5_50	"Aug22,2011,17-13-12.smb"	1	337
Grid1_T6_50	"Aug22,2011,17-13-12.smb"	484	1122
Grid1_T6_30_1	"Aug22,2011,17-13-12.smb"	1123	1185
Grid1_T6_50_2	"Aug22,2011,17-13-12.smb"	1186	1443
Grid1_T7_50	"Aug22,2011,17-13-12.smb"	1564	1891
Grid1_T8_50	"Aug22,2011,17-13-12.smb"	2051	2829
Grid1_X1_50	"Aug22,2011,17-13-12.smb"	3410	3676
Grid1_X1_100_1	"Aug22,2011,17-13-12.smb"	3677	4688
Grid1_Y1_100	"Aug22,2011,17-13-12.smb"	4689	4860
Grid1_X2_100	"Aug22,2011,17-13-12.smb"	4861	6205
Grid2_T0_50	"Aug22,2011,17-13-12.smb"	6701	7109
Grid2_T1_50	"Aug22,2011,17-13-12.smb"	7185	7467
Grid2_T2_50	"Aug22,2011,17-13-12.smb"	7554	7946
Grid2_T3_50	"Aug22,2011,17-13-12.smb"	8007	8298
Grid2_T4_50	"Aug22,2011,17-13-12.smb"	8385	8780
Grid2_T5_50	"Aug22,2011,17-13-12.smb"	8862	9150
Grid2_T6_50	"Aug22,2011,17-13-12.smb"	9230	9587
Grid2_T7_50	"Aug22,2011,17-13-12.smb"	9656	9955
Grid2_T8_50	"Aug22,2011,17-13-12.smb"	10048	10388
Grid2_X1_100	"Aug22,2011,17-13-12.smb"	10418	11460
Grid2_Y1_100	"Aug22,2011,17-13-12.smb"	11461	11865
Grid2_X2_100	"Aug22,2011,17-13-12.smb"	11866	13144
Grid3_T0_100	"Aug22,2011,17-13-12.smb"	13154	13182
Grid3_T0_50_1	"Aug22,2011,17-13-12.smb"	13183	13435
Grid3_T1_50	"Aug22,2011,17-13-12.smb"	13533	14097
Grid3_T2_50	"Aug22,2011,17-13-12.smb"	14161	14425
Grid3_T3_50	"Aug22,2011,17-13-12.smb"	14496	14980
Grid3_T4_50	"Aug22,2011,17-13-12.smb"	15059	15308
Grid3_T5_50	"Aug22,2011,17-13-12.smb"	15401	16022
Grid3_T6_50	"Aug22,2011,17-13-12.smb"	16104	16347
Grid3_T7_50	"Aug22,2011,17-13-12.smb"	16459	17454
Grid3_T8_50	"Aug22,2011,17-13-12.smb"	17530	17780
Grid3_X1_50	"Aug22,2011,17-13-12.smb"	17829	17966

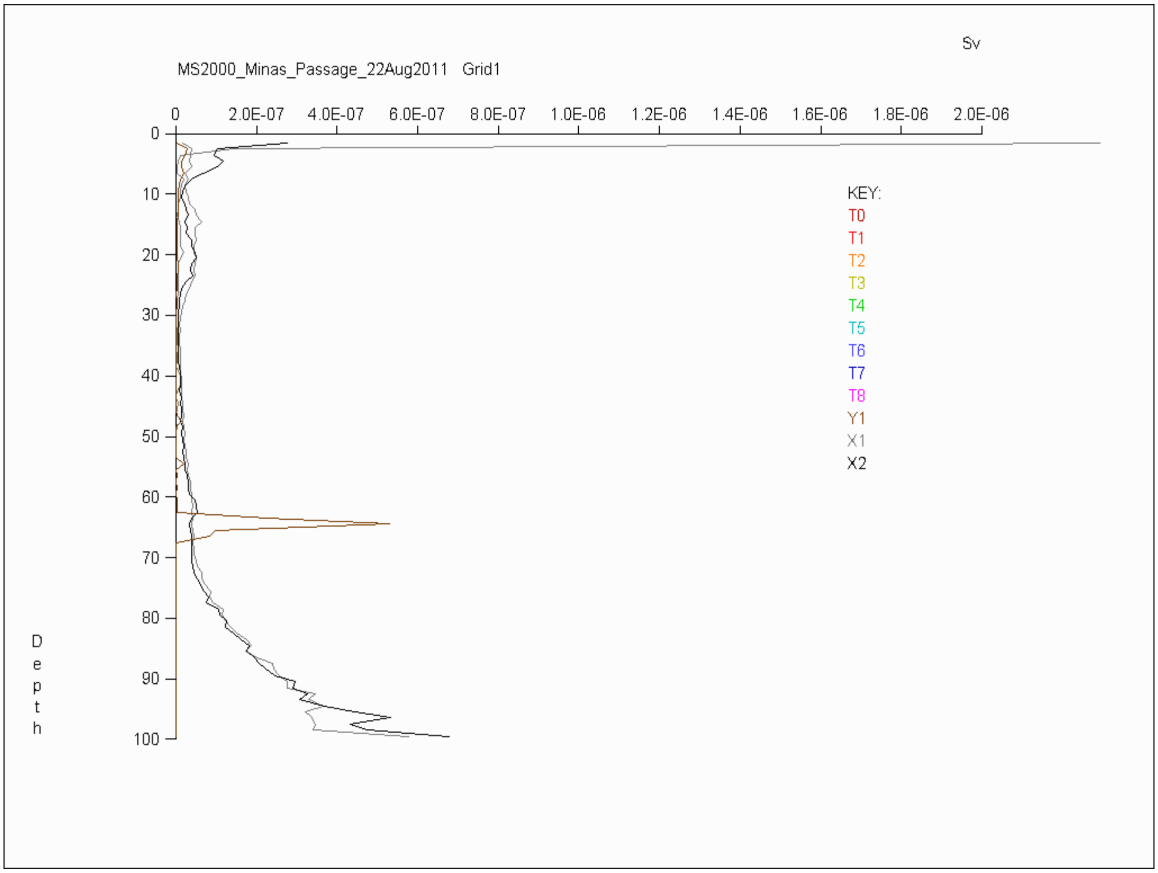
Grid3_X1_100_1	"Aug22,2011,17-13-12.smb"	17967	19345
Grid3_Y1_100	"Aug22,2011,17-13-12.smb"	19346	19691
Grid3_X2_100	"Aug22,2011,17-13-12.smb"	19692	22898
Grid4_T0_50	"Aug22,2011,17-13-12.smb"	23007	23451
Grid4_T1_50	"Aug22,2011,17-13-12.smb"	23640	24779
Grid4_T2_50	"Aug22,2011,17-13-12.smb"	24918	25259
Grid4_T3_50	"Aug22,2011,17-13-12.smb"	25576	26680
Grid4_T4_50	"Aug22,2011,17-13-12.smb"	26817	27147
Grid4_T5_50	"Aug22,2011,17-13-12.smb"	27296	28182
Grid4_T6_50	"Aug22,2011,17-13-12.smb"	28290	28654
Grid4_T7_50	"Aug22,2011,17-13-12.smb"	28788	29484
Grid4_T8_50	"Aug22,2011,17-13-12.smb"	29564	29963

3.3 S_v Profiles: 22 Aug. 2011

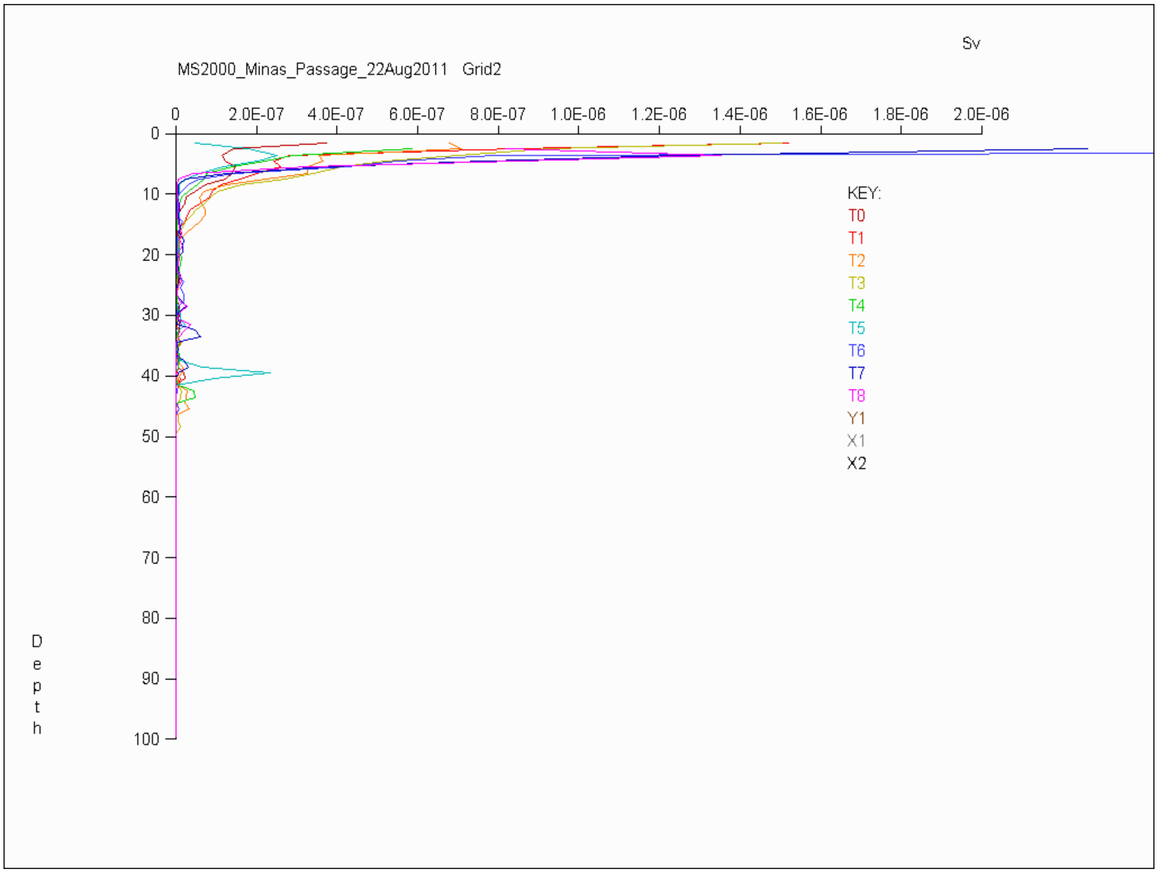


Relative S_v (linear) vs. depth (m) Grid 1, 22 Aug. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 1 T0 – T8 was steamed from 08:46 to 11:00 ADT 22 Aug. 2011. HT at Cape Sharp occurred at 07:00 ADT and nominal maximum ebb flow at 10:05 ADT. Therefore, these profiles would be characterized as occurring during high ebb flow. The layer centered near 20 m depth on T6 has been verified as fish by manual examination of fan sections.

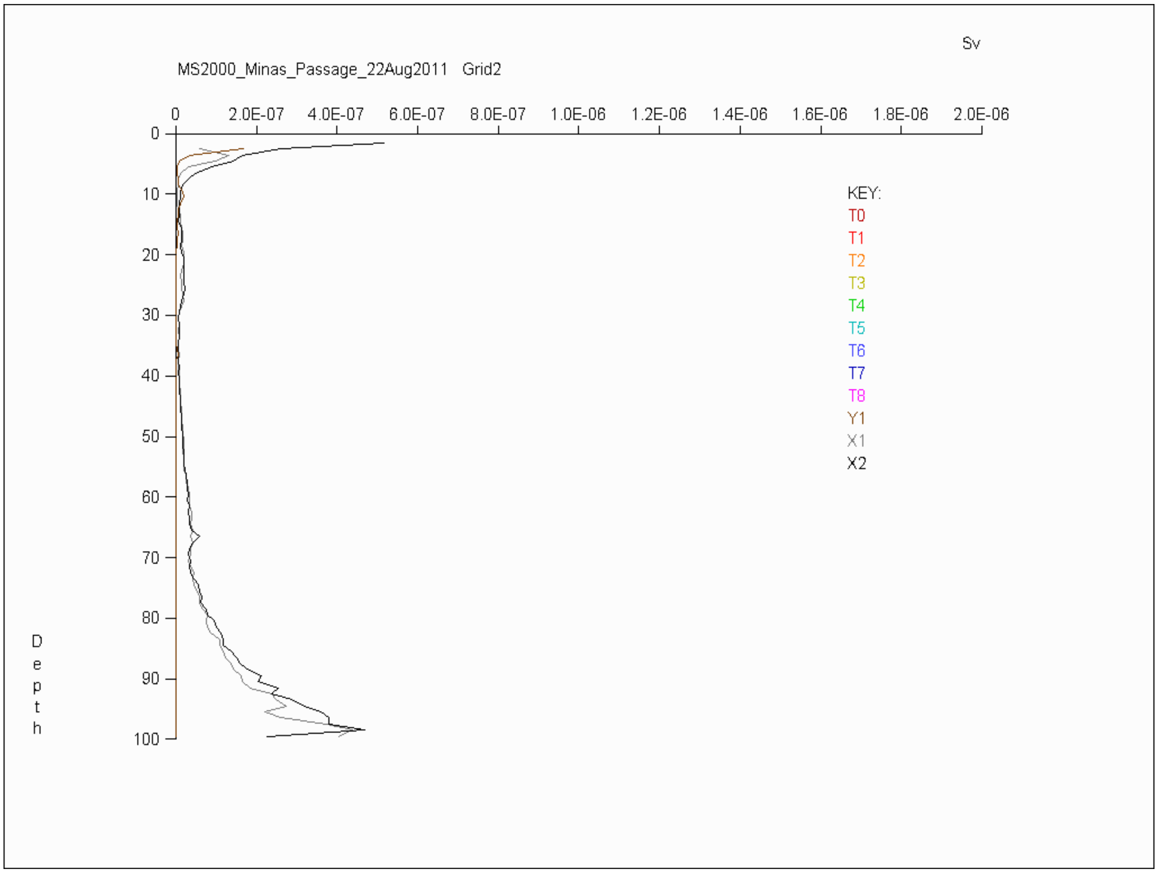


Grid 1 X1, Y1 & X2 were steamed between 11:10 and 11:56 ADT. LT occurred at 13:09 ADT. These transects were steamed during the declining ebb flow. Visual inspection of X1 fan sections showed numerous compact schools between the intensive grid and the deep channel in the depth range 10 – 30 m. Much lower fish densities occurred south of the deep channel. SNR was excellent with no plumes and low vessel noise. A similar pattern was observed on X2.

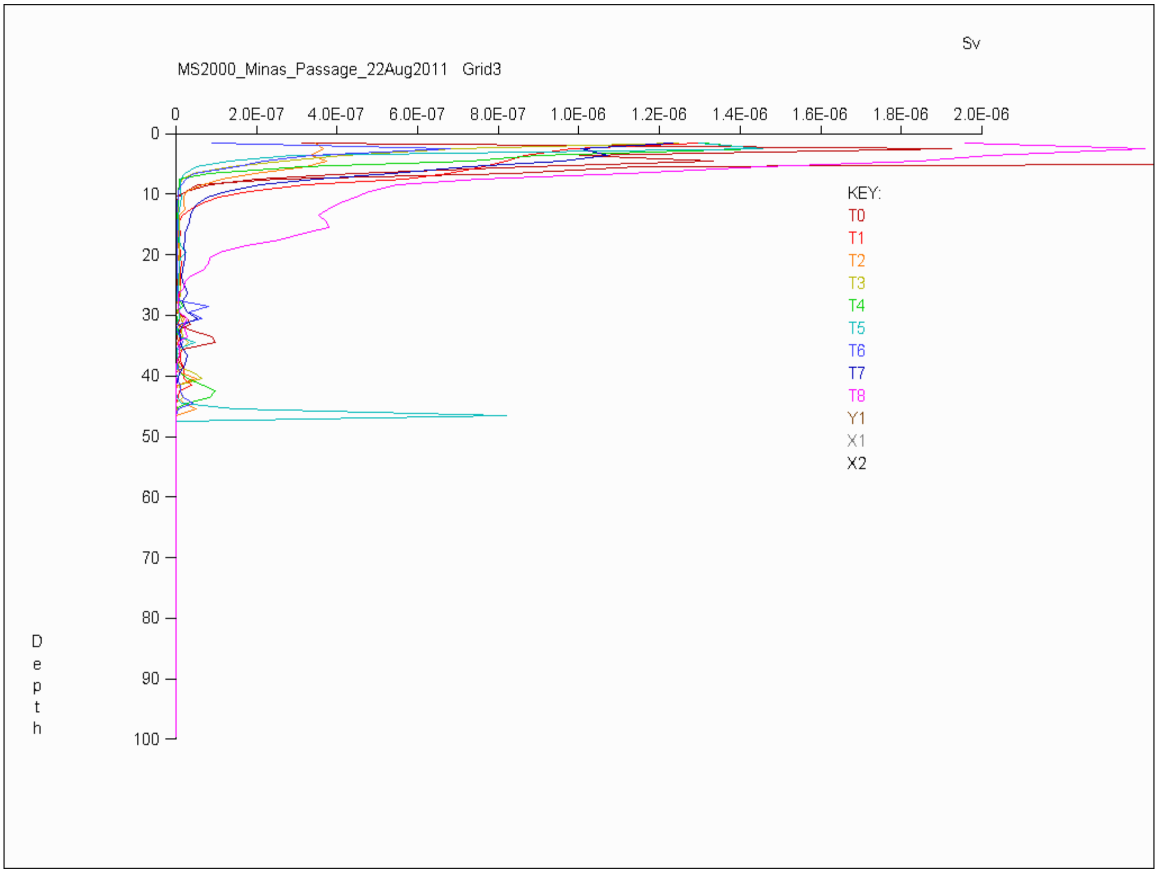


Relative S_v (linear) vs. depth (m) Grid 2, 22 Aug. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 2 T0 – T8 were steamed between 12:04 and 13:05 ADT. LT occurred at 13:09. Therefore, these profiles were steamed near the end of the declining ebb flow.

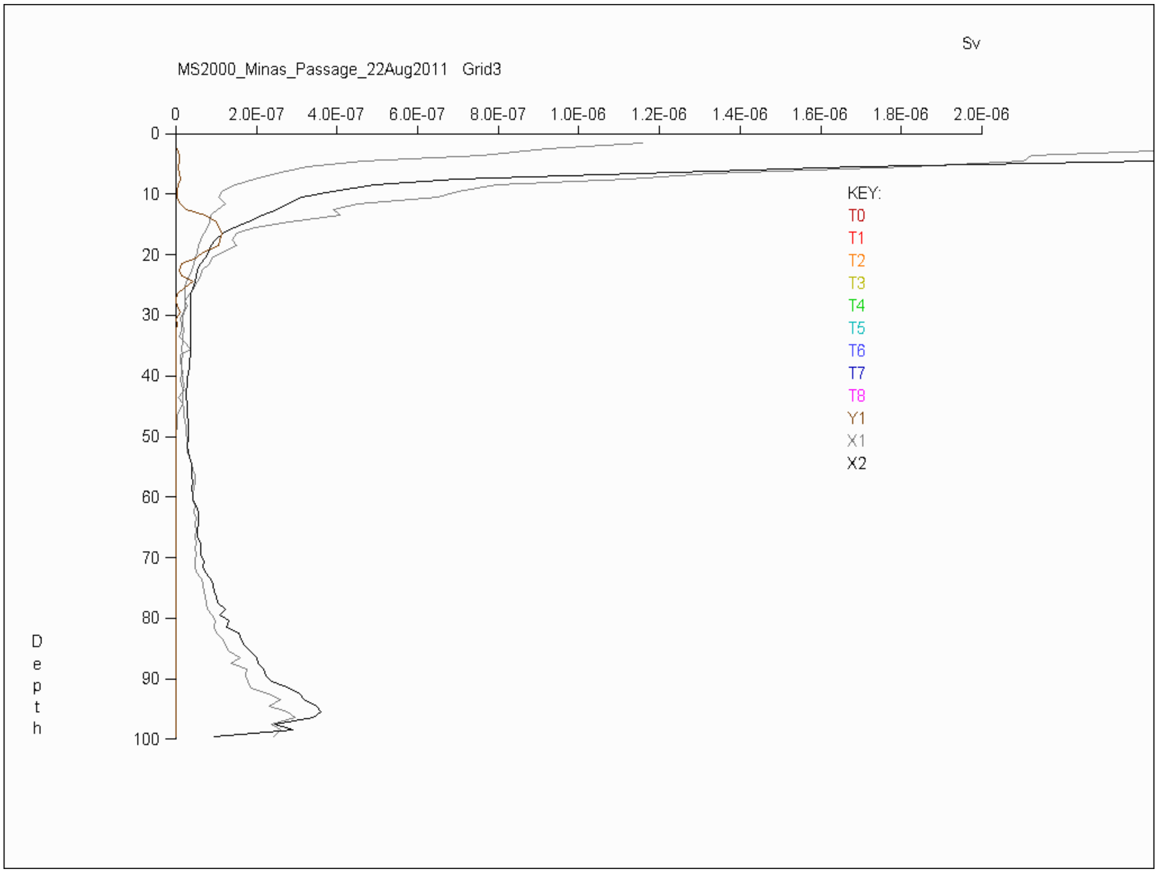


Grid 2 X1, Y1 & X2 were steamed between 13:06 and 13:51 ADT. LT was at 13:09. Therefore, these profiles were steamed from slack water into the first hour of the flood tide cycle. There exists a suggestion of a weak fish layer between 10 and 30 m on X1 and X2. Visual inspection of fan sections revealed some fish schools in this depth range but persistent sources of noise largely confined to the same depth interval were also present, so the origin of the layer remains uncertain.

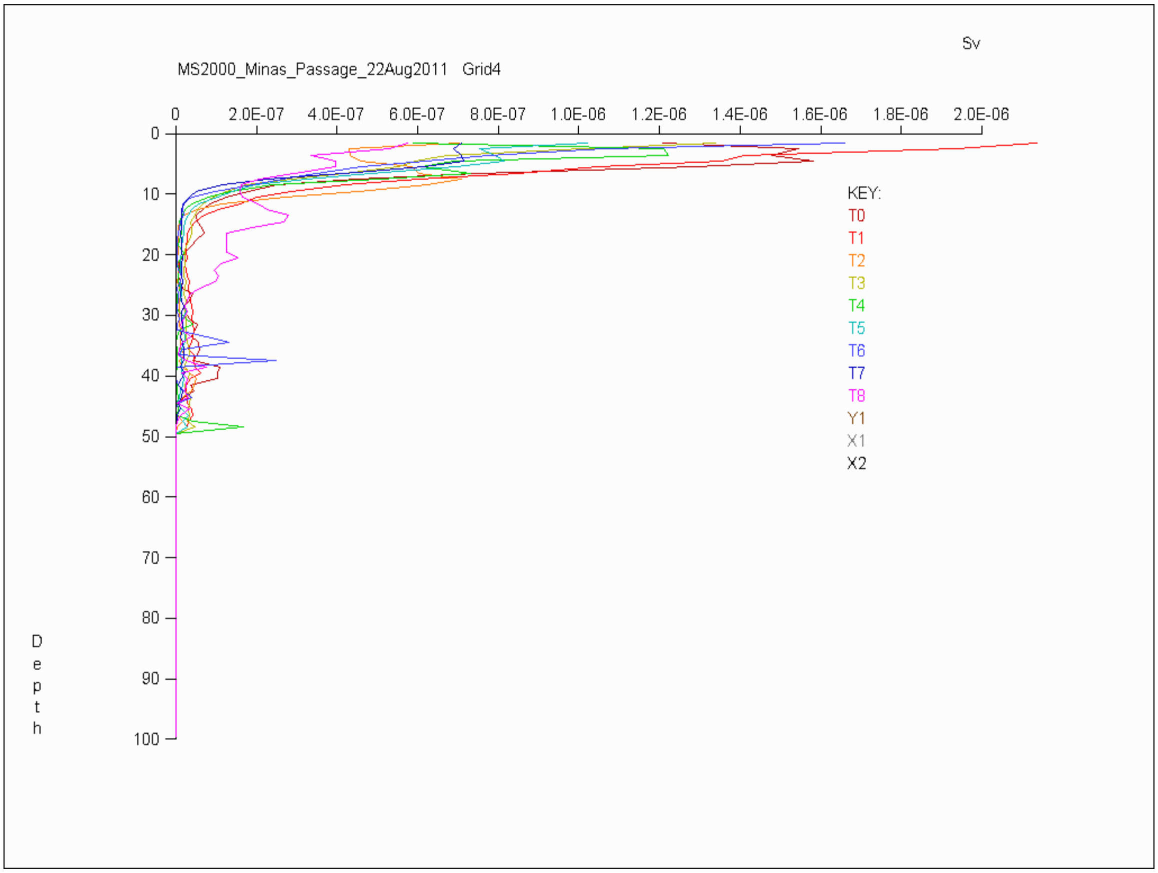


Relative S_v (linear) vs. depth (m) Grid 3, 22 Aug. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 3 T0 – T8 were steamed between 13:51 and 15:07 ADT. Nominal maximum flood was predicted for 16:17 ADT. Therefore these profiles were steamed during the rising flood tide.



Grid 3 X1, Y1 & X2 were steamed between 15:08 and 16:32 ADT. Nominal maximum food current was predicted for 16:17 ADT. Therefore, these profiles were steamed near maximum flood current. There is strong evidence of bubble scattering in the upper 10 – 15 m which is less commonly observed in the central and southern portion of Minas Passage. Visual examination of Y1 fan sections revealed intense schools of fish in the 15 – 20 m depth range attesting to the reality of the layer revealed in the ***S_v*** profiles above.



Relative S_v (linear) vs. depth (m) Grid 4, 22 Aug. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 4 T0 – T8 were steamed between 16:34 and 18:29 ADT. Maximum flood current was predicted for 16:17 ADT with HT (Cape Sharp) at 19:26 ADT. Therefore, these profiles were streamed from near maximum flood current into the declining portion of the flood cycle.

No cross-channel lines were run on Grid 4.

4. DATASET: 19 SEPT. 2011

4.1 Analysis Parameters: 19 Sept. 2011

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

Alpha Correction = 61.2 dB/km

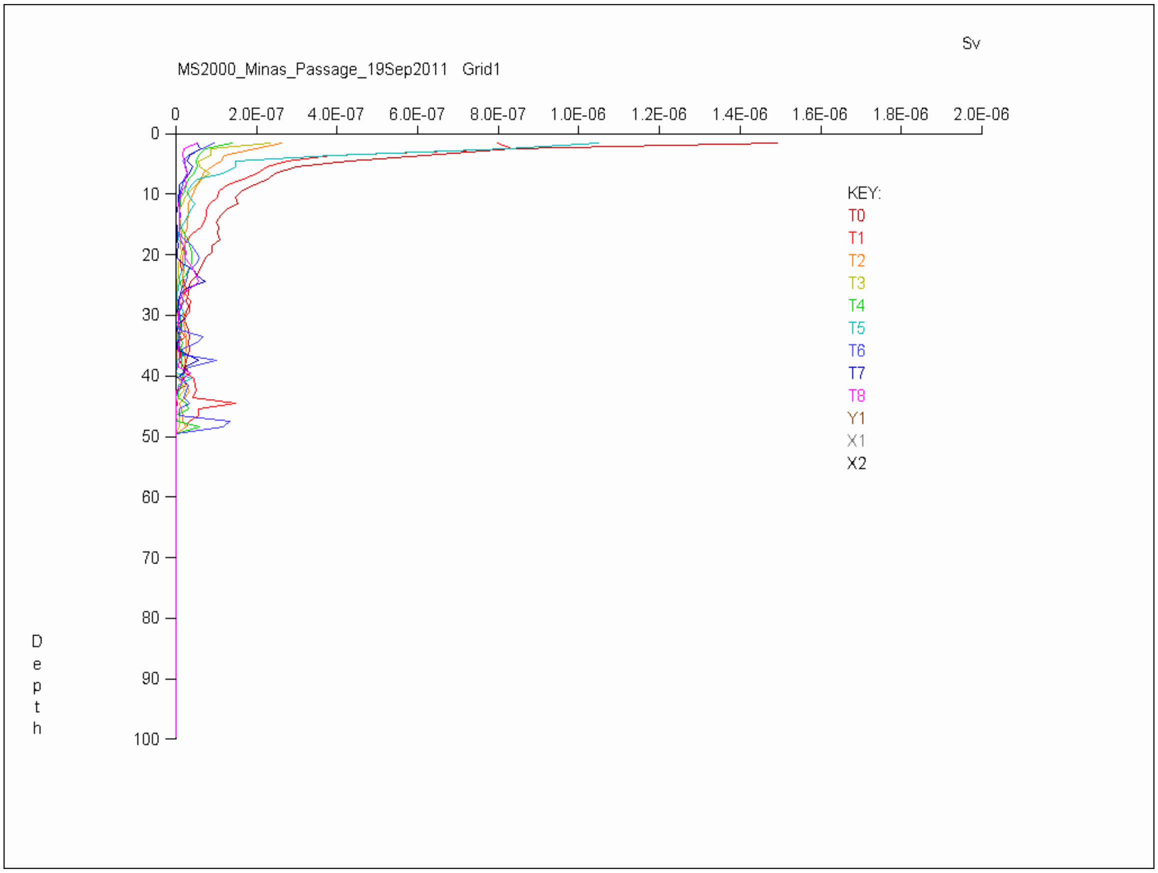
4.2 Lines: 19 Sept. 2011

Format:

Grid_Line_Range_Sub-line	**“Field Data File”**	**Start**	**End (Ping)**
Grid1_T0_50	"Sep19,2011,14-50-44.smb"	290	885
Grid1_T1_50	"Sep19,2011,14-50-44.smb"	958	1321
Grid1_T2_50	"Sep19,2011,14-50-44.smb"	1462	2145
Grid1_T3_50	"Sep19,2011,14-50-44.smb"	2211	2526
Grid1_T4_50	"Sep19,2011,14-50-44.smb"	2698	3511
Grid1_T5_50	"Sep19,2011,14-50-44.smb"	3888	4215
Grid1_T6_50	"Sep19,2011,14-50-44.smb"	4332	5135
Grid1_T7_50	"Sep19,2011,14-50-44.smb"	5178	5509
Grid1_T8_50	"Sep19,2011,14-50-44.smb"	5653	6343
Grid1_X1_100	"Sep19,2011,14-50-44.smb"	6491	7946
Grid1_Y1_100	"Sep19,2011,14-50-44.smb"	7947	8208
Grid1_X2_100	"Sep19,2011,14-50-44.smb"	8228	9854
Grid2_T0_50	"Sep19,2011,14-50-44.smb"	9978	10364
Grid2_T1_50	"Sep19,2011,14-50-44.smb"	10436	10785
Grid2_T2_50	"Sep19,2011,14-50-44.smb"	10901	11263
Grid2_T3_50	"Sep19,2011,14-50-44.smb"	11340	11696
Grid2_T4_50	"Sep19,2011,14-50-44.smb"	11837	12179
Grid2_T5_50	"Sep19,2011,14-50-44.smb"	12250	12602
Grid2_T6_50	"Sep19,2011,14-50-44.smb"	12703	13040
Grid2_T7_50	"Sep19,2011,14-50-44.smb"	13121	13468
Grid2_T8_50	"Sep19,2011,14-50-44.smb"	13584	13909
Grid2_X1_100	"Sep19,2011,14-50-44.smb"	13980	15000
Grid2_Y1_100	"Sep19,2011,14-50-44.smb"	15001	15643
Grid2_X2_100	"Sep19,2011,14-50-44.smb"	15664	16947
Grid3_T0_100	"Sep19,2011,14-50-44.smb"	17001	17037
Grid3_T0_50_1	"Sep19,2011,14-50-44.smb"	17038	17276
Grid3_T1_50	"Sep19,2011,14-50-44.smb"	17495	18080
Grid3_T2_50	"Sep19,2011,14-50-44.smb"	18168	18497
Grid3_T3_50	"Sep19,2011,14-50-44.smb"	18643	19565
Grid3_T4_50	"Sep19,2011,14-50-44.smb"	19770	20070
Grid3_T5_50	"Sep19,2011,14-50-44.smb"	20261	21156
Grid3_T6_50	"Sep19,2011,14-50-44.smb"	21279	21536
Grid3_T7_50	"Sep19,2011,14-50-44.smb"	21830	23014
Grid3_T8_50	"Sep19,2011,14-50-44.smb"	23270	23520
Grid3_X1_100	"Sep19,2011,14-50-44.smb"	23763	25129
Grid3_Y1_100	"Sep19,2011,14-50-44.smb"	25130	25599
Grid3_X2_100	"Sep19,2011,14-50-44.smb"	25600	28705
Grid4_T0_100	"Sep19,2011,14-50-44.smb"	28735	28982
Grid4_T1_50	"Sep19,2011,14-50-44.smb"	29170	30251
Grid4_T2_50	"Sep19,2011,14-50-44.smb"	30332	30568

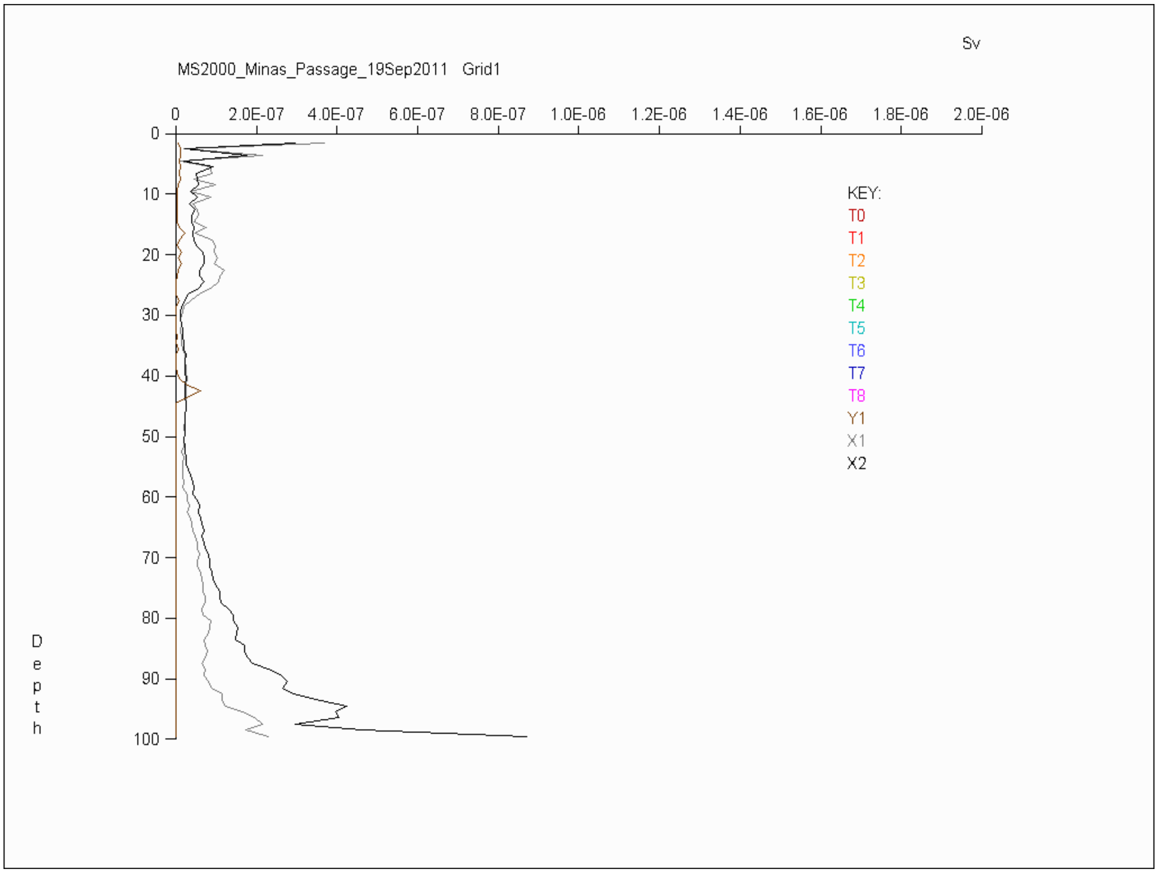
Grid4_T3_50	"Sep19,2011,14-50-44.smb"	30868	31779
Grid4_T4_50	"Sep19,2011,14-50-44.smb"	31860	32120
Grid4_T5_50	"Sep19,2011,14-50-44.smb"	32398	33177
Grid4_T6_50	"Sep19,2011,14-50-44.smb"	33230	33493
Grid4_T7_50	"Sep19,2011,14-50-44.smb"	33687	34270
Grid4_T8_50	"Sep19,2011,14-50-44.smb"	34340	34608

4.3 S_v Profiles: 19 Sept. 2011

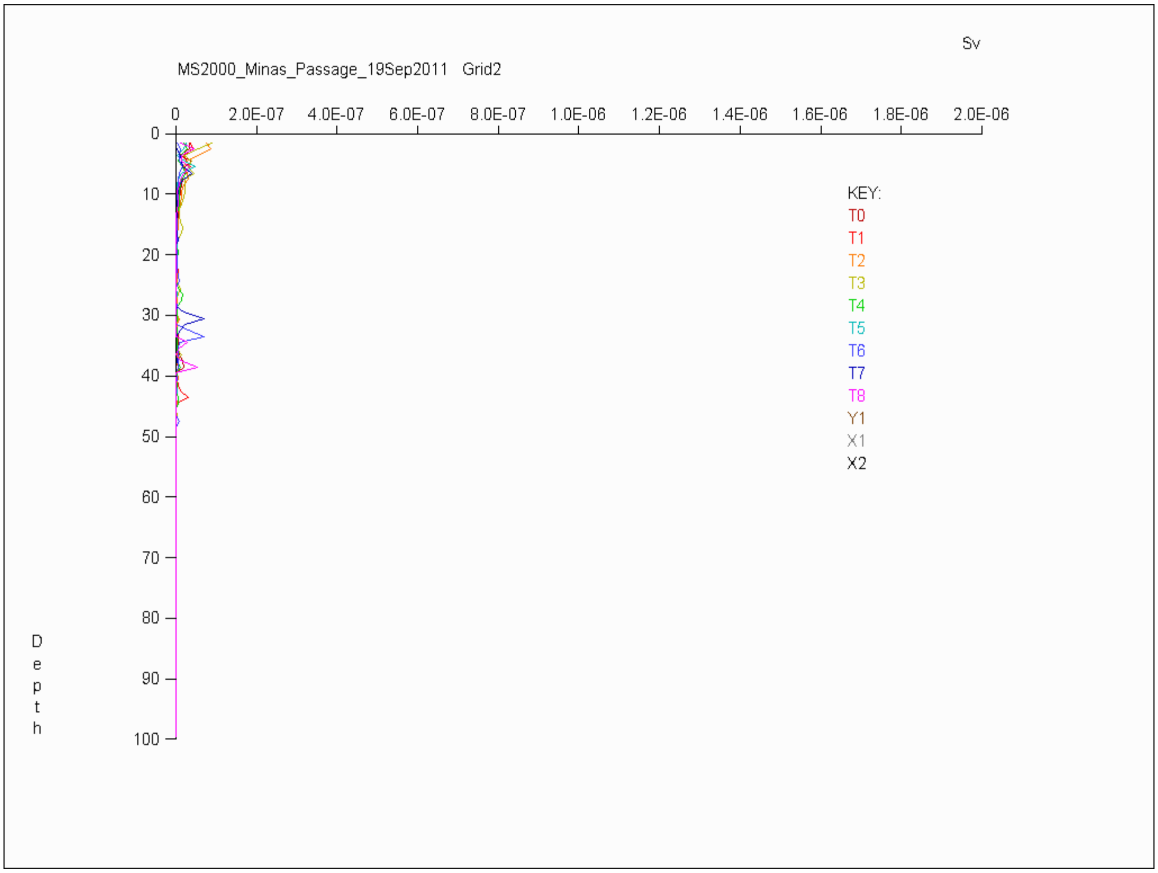


Relative S_v (linear) vs. depth (m) Grid 1, 19 Sept. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 1 Profiles T0 to T8 were surveyed from 07:56 to 09:36 ADT 19 on Sept. 2011. Nominal maximum ebb current (Cape Sharp) was predicted for 08:43 ADT. Therefore, these profiles extend through the maximum of the ebb current flow.

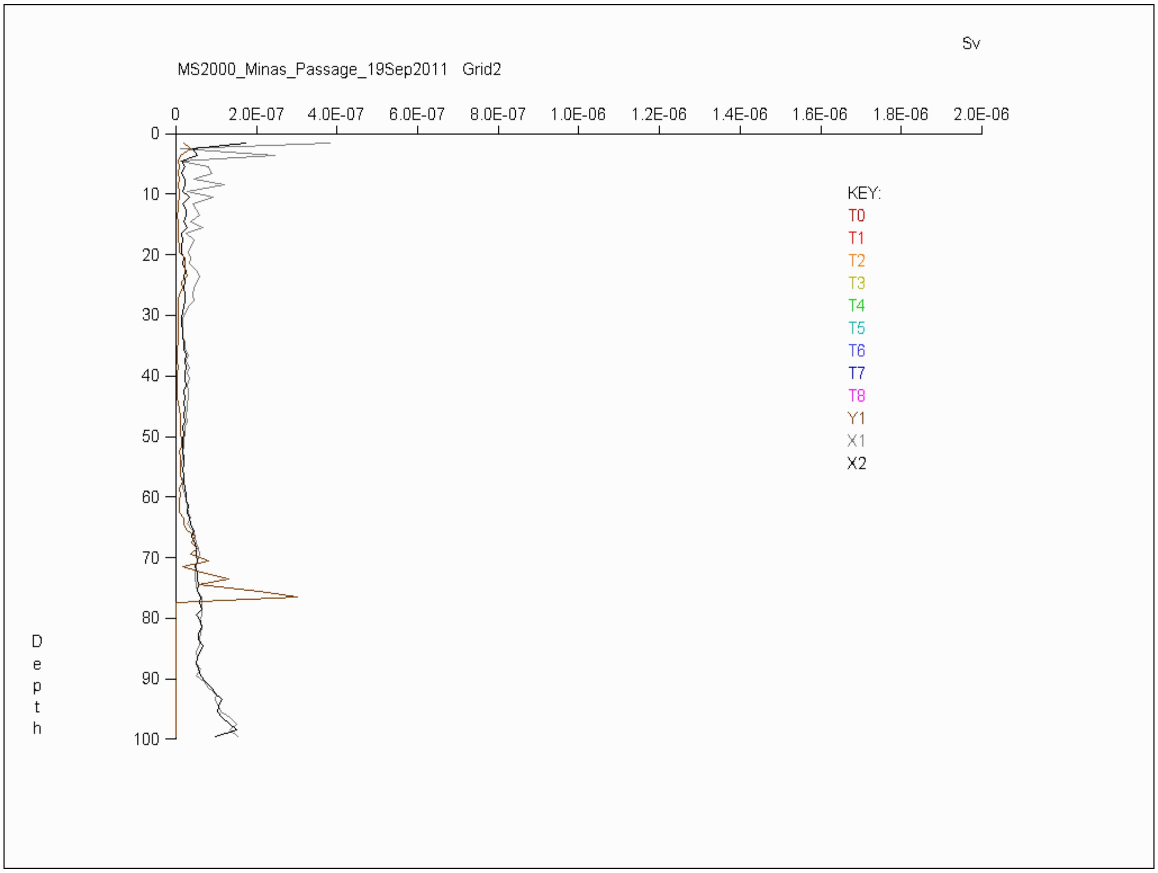


Grid 1 Profiles X1, Y1 & X2 were steamed from 09:38 to 10:34 ADT. Nominal max ebb flow was at 08:43 with LT occurring at 11:47 ADT. Therefore, these profiles are representative of the declining portion of the ebb flow. Visual inspection of X1 fan sections appears to verify the fish layer 15 – 28 m extending across the entire channel at good observation SNR. Inspection of X2 reveals fewer fish in same general depth range but also higher noise levels. The layer on X2 in the same depth range is probably also fish but with a higher proportion of noise.

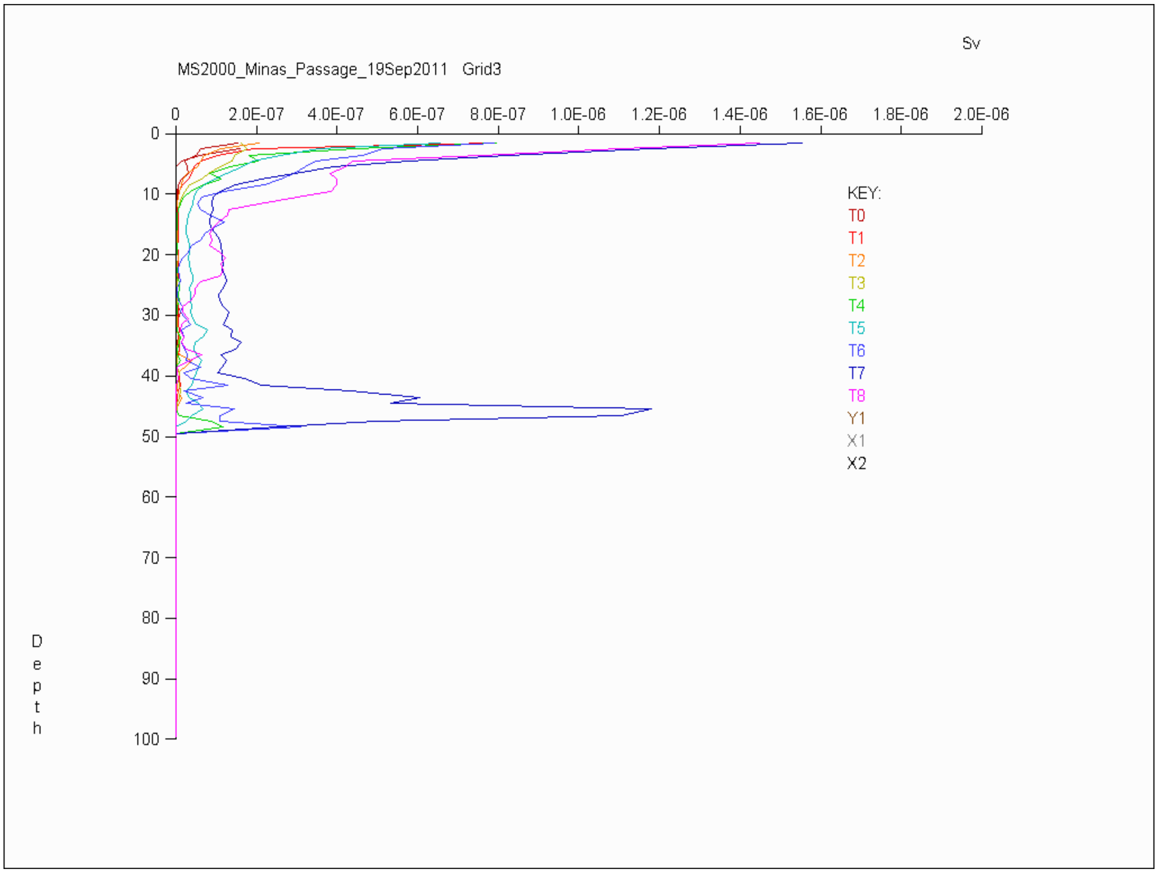


Relative S_v (linear) vs. depth (m) Grid 2, 19 Sept. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 2 Profiles T0 to T8 were surveyed from10:36 to 11:41 ADT. LT was at 11:47 ADT. Therefore, these profiles are representation of the late ebb tide cycle ending near LT.

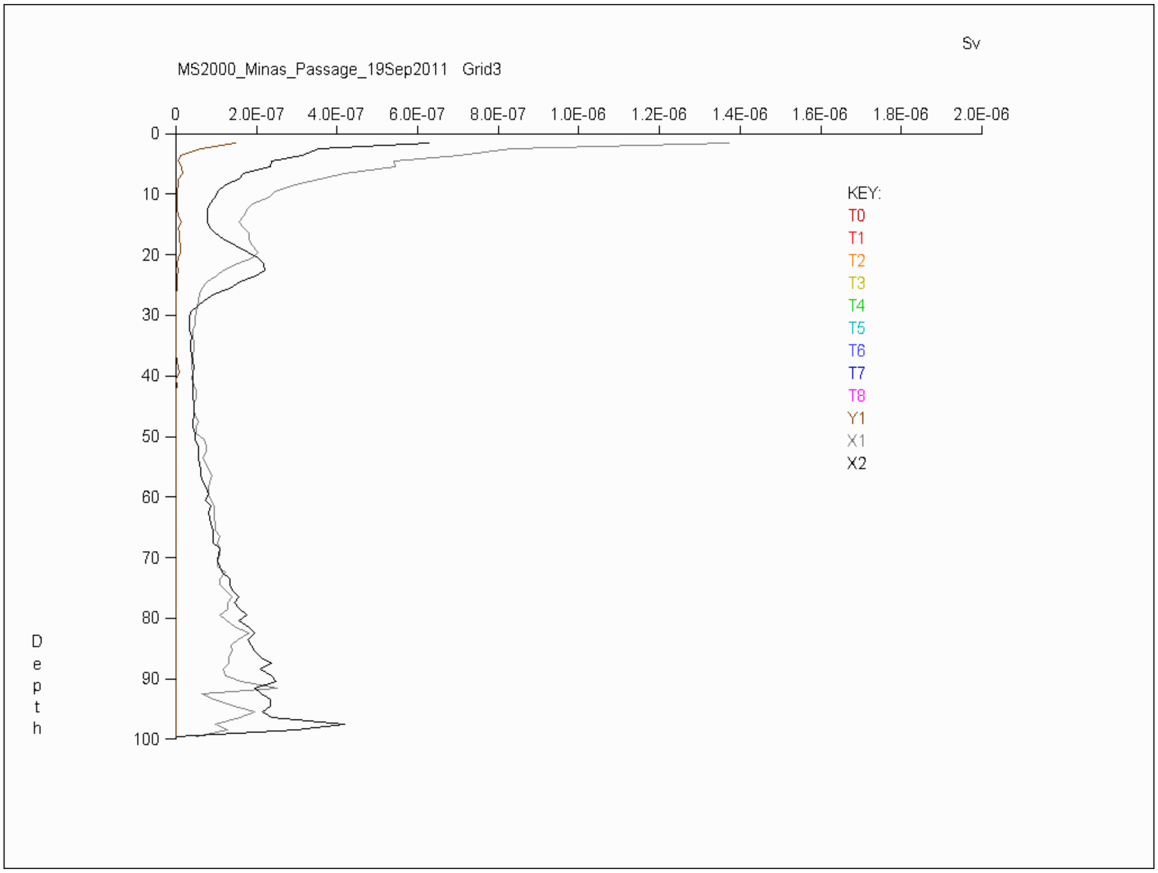


Grid 2 Profiles X1, Y1 & X2 were steamed from 11:42 to 12:31 ADT. LT occurred at 11:47 ADT. Therefore, steaming of these profiles started near LT slack water and continued nearly one hour into the flood tide cycle. Visual inspection of fan sections showed the layer on X1 from 20 – 30 m may be real (some schools seen esp. mid-channel) but is not certain considering observed noise levels. A possible deeper layer from 30 – 50 m on both X1 and X2 could not be verified as arising from fish.

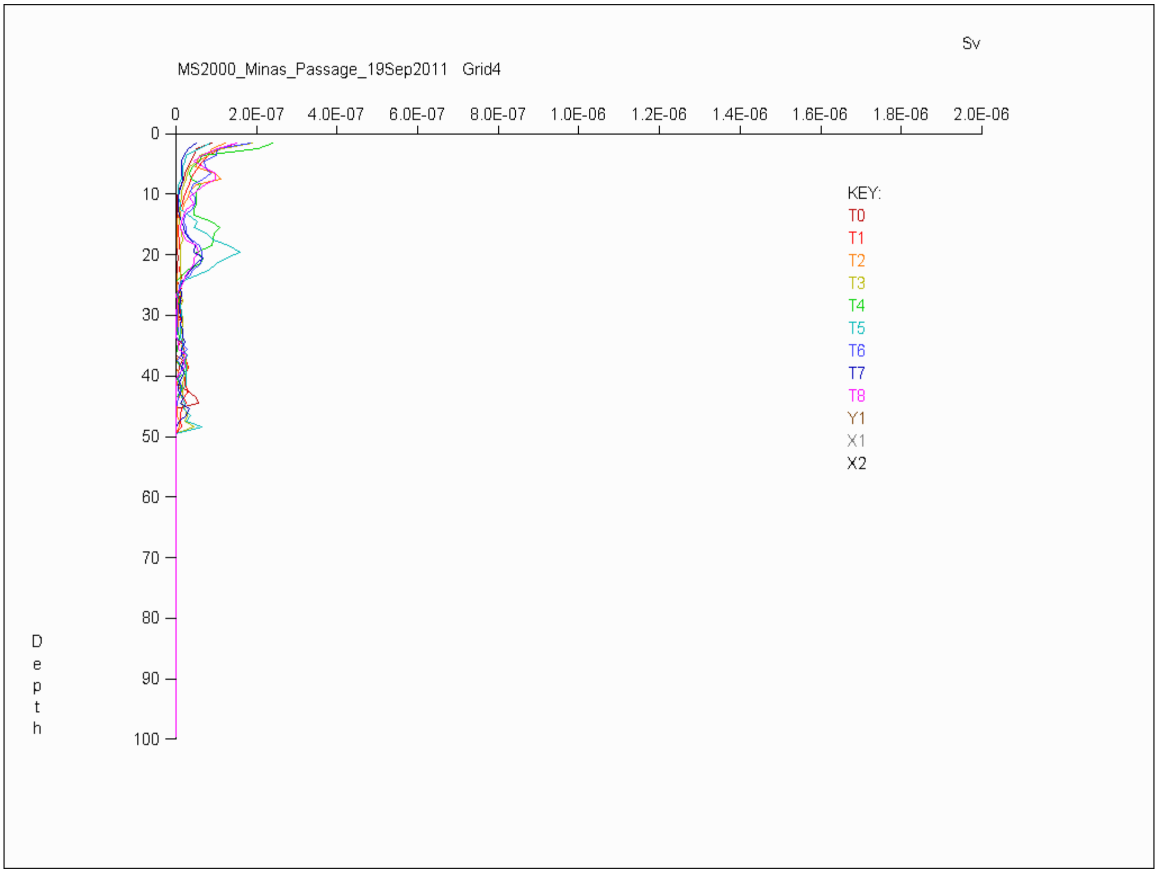


Relative S_v (linear) vs. depth (m) Grid 3, 19 Sept. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 3 Profiles T0 to T8 were steamed from 12:33 to 14:20 ADT. Nominal maximum flood current was at 14:53 ADT. Therefore these profiles were steamed on the increasing flood current. Visual examination of T7 fan sections indicated that the high backscatter levels below 10 m depth were the result of high noise levels rather than increased fish density.



Grid 3 Profiles X1, Y1 & X2 were steamed from 14:24 to 15:45 ADT. Nominal maximum flood current was predicted for 14:53 ADT. Therefore, these profiles were steamed around maximum flood current. Examination of relevant fan sections indicated that the peak in X2 backscatter levels between 16 & 26 m was real and arose from enhanced fish densities.



Relative S_v (linear) vs. depth (m) Grid 4, 19 Sept. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 4 Profiles T0 to T8 were steamed from 15:46 to 17:23 ADT. This time period corresponded to the waning portion of the flood tide with approaching HT slack water (17:59 ADT). The completion of T8 marked the end of the survey.

A fish layer appeared at about 20 m depth on the more southern intensive grid profiles, T4 to T8, peaking on T4 & T5. This fact was verified by visual inspection of fan sections. Survey of T4 began at 16:38 ADT. Sunset occurred at 19:19 ADT.

Note that a fish layer around 20 m depth was also noted on the immediately preceding (Grid #3) cross-channel transects.

5. DATASET: 03 OCT. 2011

5.1 Analysis Parameters: 03 Oct. 2011

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

Alpha Correction = 61.2 dB/km

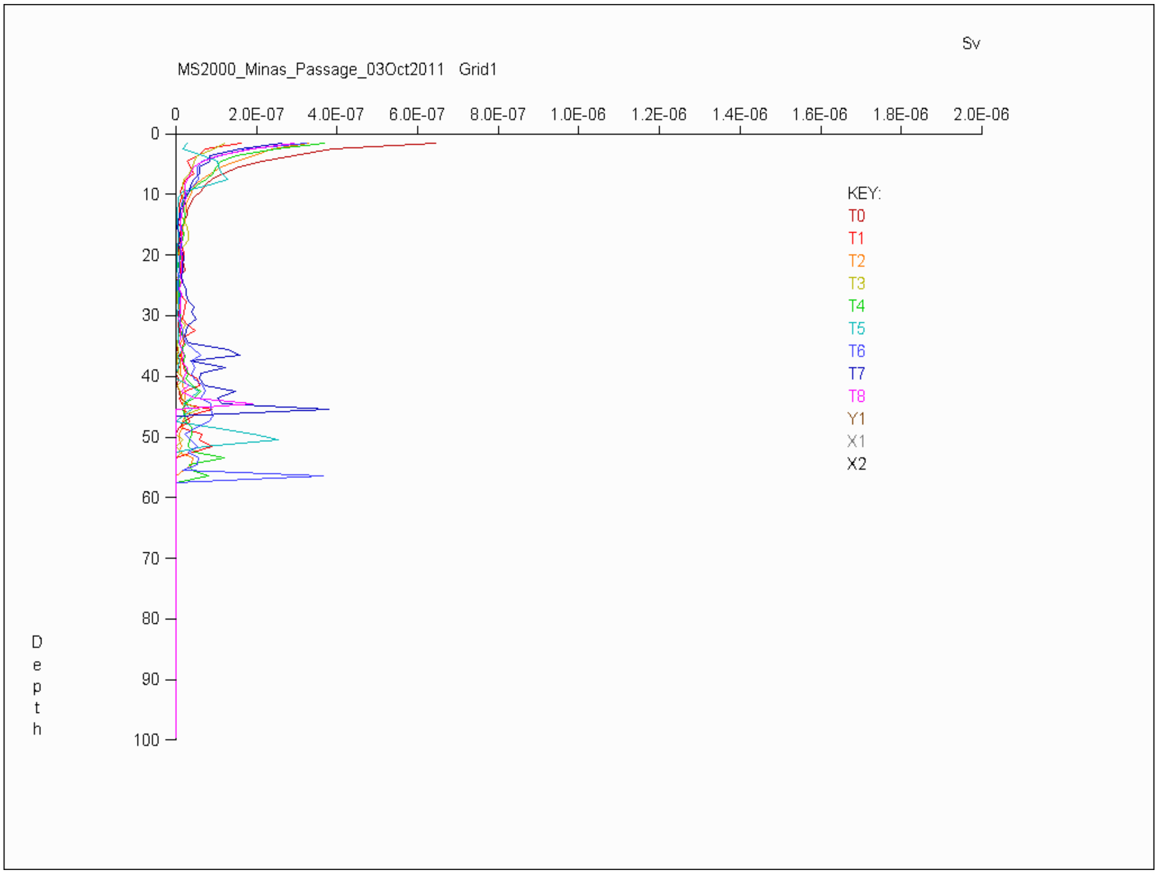
5.2 Lines: 03 Oct. 2011

Format:

Grid_Line_Range_Sub-line	“Field Data File”	Start	End (Ping)
Grid1_T0_100	"Oct03,2011,13-55-18.smb"	1	498
Grid1_T1_100	"Oct03,2011,14-08-40.smb"	1	227
Grid1_T2_100	"Oct03,2011,14-13-27.smb"	1	880
Grid1_T3_100	"Oct03,2011,14-31-47.smb"	1	297
Grid1_T4_100	"Oct03,2011,14-37-10.smb"	1	968
Grid1_T5_100	"Oct03,2011,14-55-52.smb"	1	294
Grid1_T6_100	"Oct03,2011,15-02-19.smb"	1	1319
Grid1_T7_100	"Oct03,2011,15-27-32.smb"	1	281
Grid1_T8_100	"Oct03,2011,15-34-08.smb"	1	1443
Grid1_X1_150	"Oct03,2011,16-02-50.smb"	1	1330
Grid1_Y1_150	"Oct03,2011,16-31-56.smb"	1	329
Grid1_X2_150	"Oct03,2011,16-37-38.smb"	1	1683
Grid2_T0_150	"Oct03,2011,17-05-40.smb"	1	525
Grid2_T1_50	"Oct03,2011,17-15-08.smb"	1	266
Grid2_T2_75	"Oct03,2011,17-21-41.smb"	1	656
Grid2_T3_75	"Oct03,2011,17-34-14.smb"	1	247
Grid2_T4_75	"Oct03,2011,17-41-41.smb"	1	602
Grid2_T5_75	"Oct03,2011,17-52-04.smb"	1	263
Grid2_T6_75	"Oct03,2011,17-57-44.smb"	1	646
Grid2_T7_75	"Oct03,2011,18-11-07.smb"	1	269
Grid2_T8_75	"Oct03,2011,18-17-35.smb"	1	513
Grid2_X1_150	"Oct03,2011,18-27-46.smb"	1	1051
Grid2_Y1_150	"Oct03,2011,18-47-08.smb"	1	324
Grid2_X2_150	"Oct03,2011,18-53-14.smb"	1	1284
Grid3_T0_75	"Oct03,2011,19-15-45.smb"	1	248
Grid3_T1_75	"Oct03,2011,19-21-36.smb"	1	338
Grid3_T2_75	"Oct03,2011,19-28-04.smb"	1	231
Grid3_T3_100	"Oct03,2011,19-35-32.smb"	1	182
Grid3_T4_100	"Oct03,2011,19-39-00.smb"	1	230
Grid3_T5_100	"Oct03,2011,19-44-08.smb"	1	359
Grid3_T6_100	"Oct03,2011,19-51-08.smb"	1	237
Grid3_T7_100	"Oct03,2011,19-56-11.smb"	1	414
Grid3_T8_100	"Oct03,2011,20-04-16.smb"	1	227
Grid3_X1_150	"Oct03,2011,20-09-23.smb"	1	949
Grid3_y1_150	"Oct03,2011,20-26-28.smb"	1	429
Grid3_X2_150	"Oct03,2011,20-33-40.smb"	1	1786
Grid4_T0_75	"Oct03,2011,21-06-02.smb"	1	241
Grid4_T1_75	"Oct03,2011,21-10-49.smb"	1	1410
Grid4_T2_75	"Oct03,2011,21-38-51.smb"	1	221

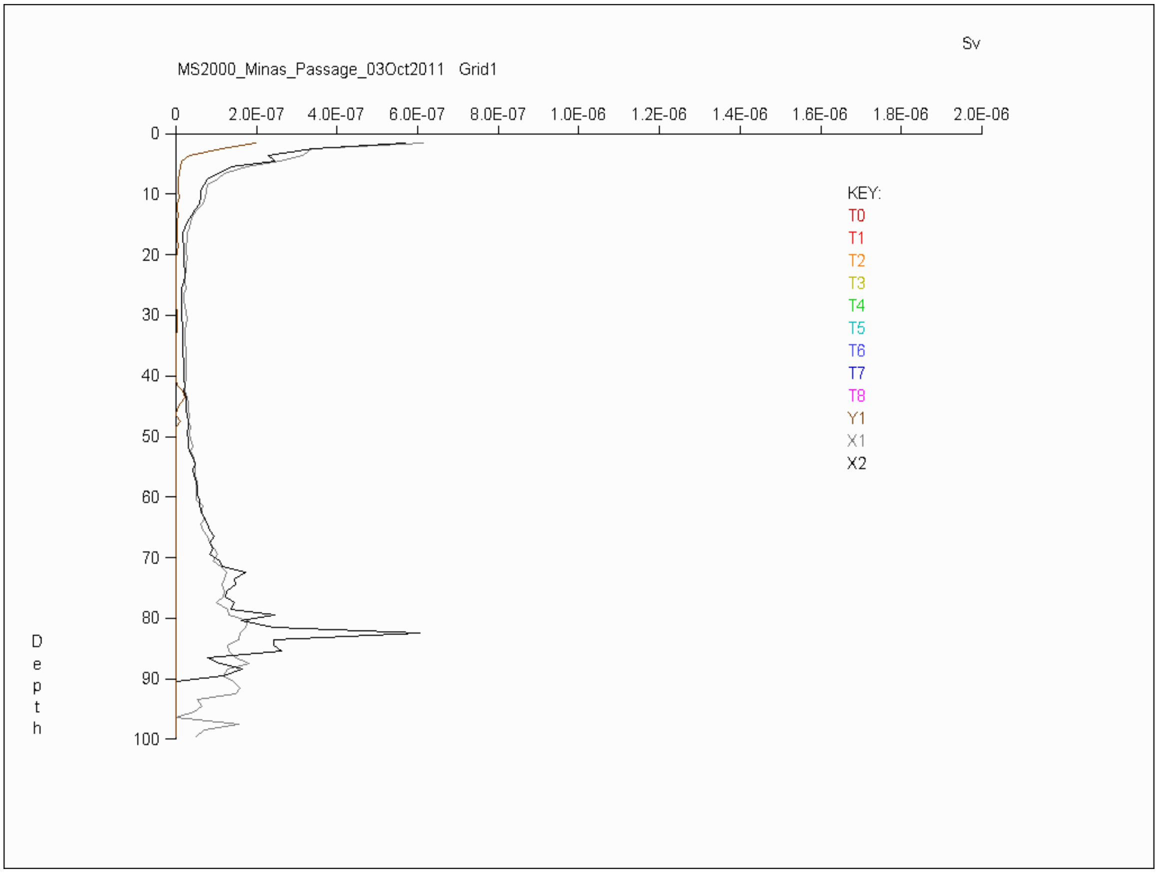
Grid4_T3_75	"Oct03,2011,21-50-56.smb"	1	2550
Grid4_T4_75	"Oct03,2011,22-33-40.smb"	1	225
Grid4_T5_75	"Oct03,2011,22-39-32.smb"	1	2249
Grid4_T6_75	"Oct03,2011,23-21-39.smb"	1	174
Grid4_T7_75	"Oct03,2011,23-27-02.smb"	1	1288
Grid4_T8_75	"Oct03,2011,23-52-49.smb"	1	185
Grid4_X1_150	"Oct03,2011,23-57-40.smb"	1	1033
Grid4_X1_150_1	"Oct04,2011,00-14-48.smb"	1	186

5.3 S_v Profiles: 03 Oct. 2011



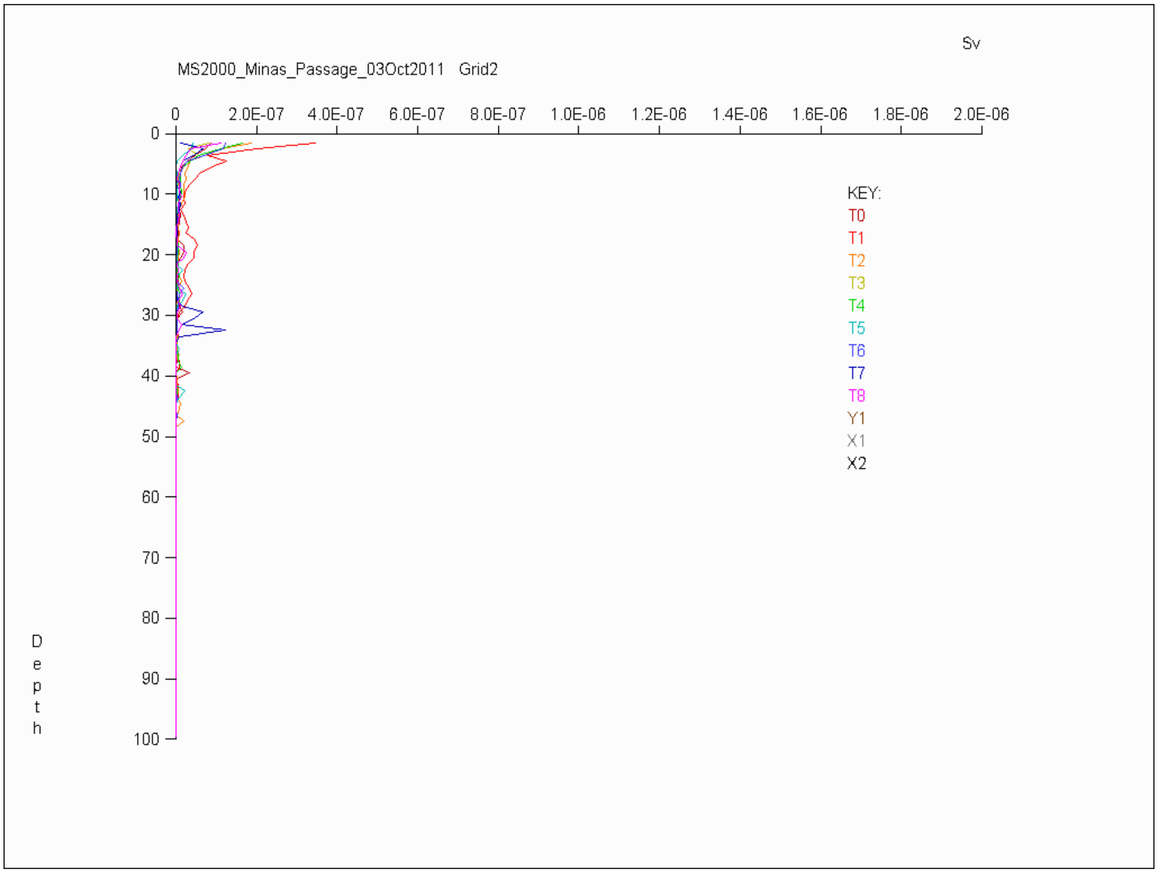
Relative S_v (linear) vs. depth (m) Grid 1, 03 Oct. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 1 Profiles T0 – T8 were steamed from 06:56 to 09:01 ADT on 03 Oct 2011. HT at Cape Sharp was at 05:32 ADT with nominal maximum ebb flow predicted for 08:41 ADT. Therefore, these profiles were steamed mainly on the rising portion of the ebb tide ending just after maximum ebb flow.



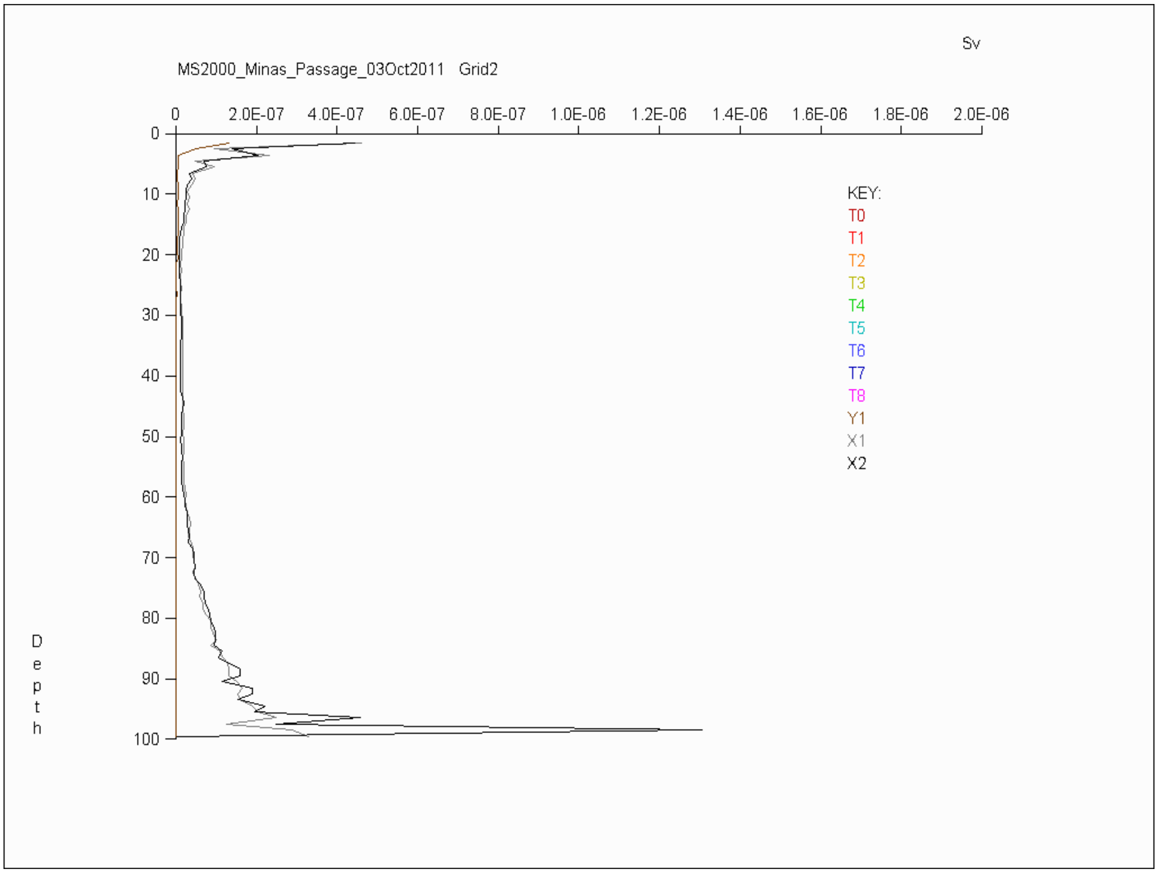
Profiles X1, Y1 & X2 were steamed from 09:10 to 10:06 ADT. Maximum nominal ebb flow was at 08:41 with LT at 11:50 ADT. Therefore these profiles were steamed on the declining portion of the ebb current flow.

Fish were noted in the deep channel on X2 at > 75 m depth. Some deep targets were also observed on X1, however visual examination of fan sections showed little evidence that the observed apparent backscattering enhancement below 70 m depth arose from anything other than increased noise.

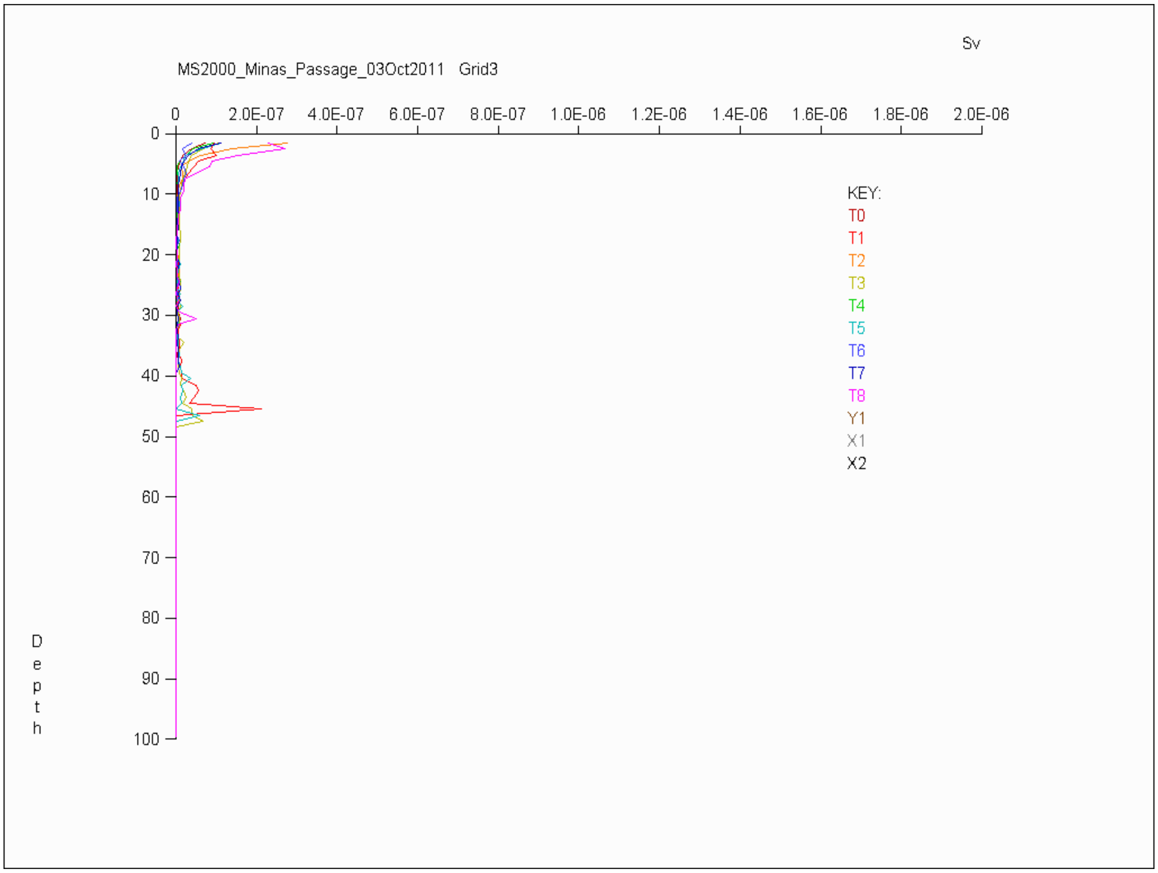


Relative S_v (linear) vs. depth (m) Grid 2, 03 Oct. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 2 Profiles T0 to T8 were steamed from 10:06 to 11:28 ADT. LT was at 11:50 ADT. Therefore, these profiles were steamed during the declining portion of the ebb current extending to almost slack water.

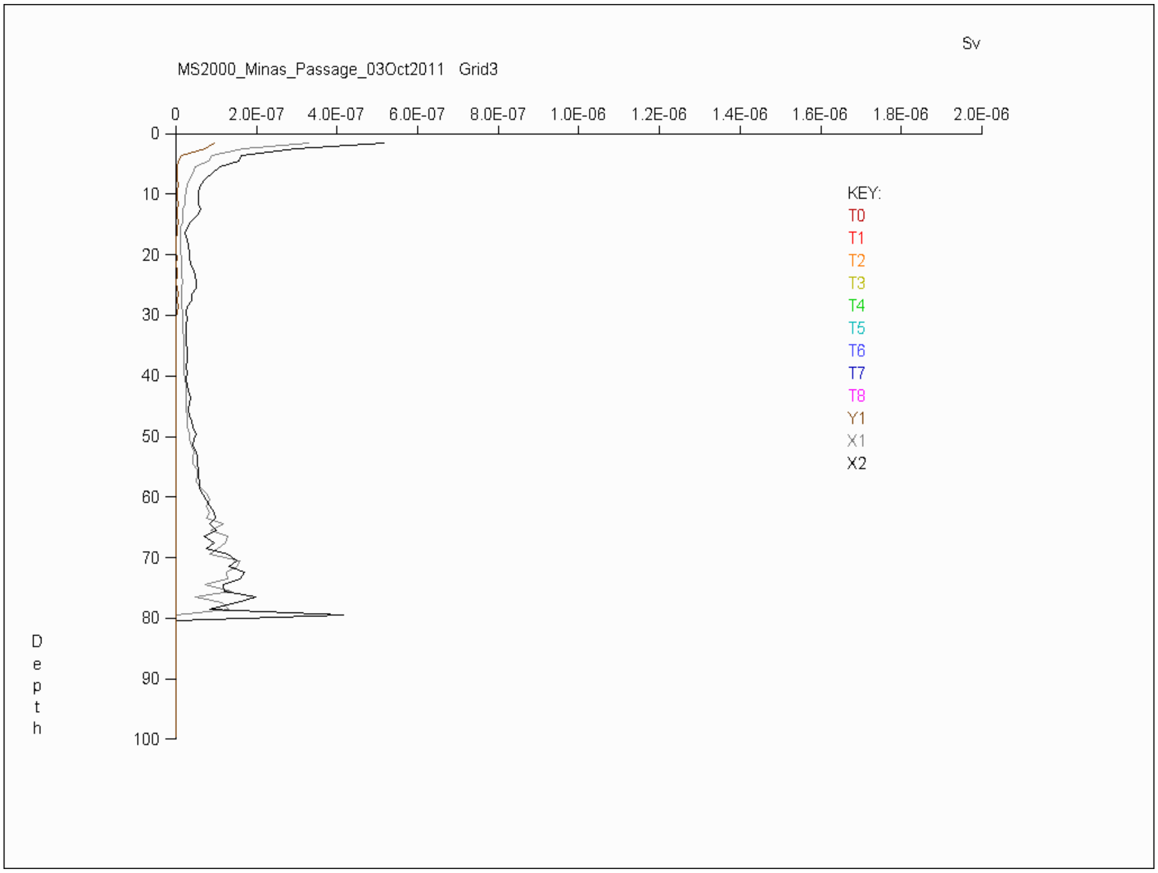


Grid 2 Profiles X1, Y1 & X2 were steamed from 11:30 to 12:15 ADT. LT occurred at 11:50 ADT, so these profiles were steamed near LT slack water.

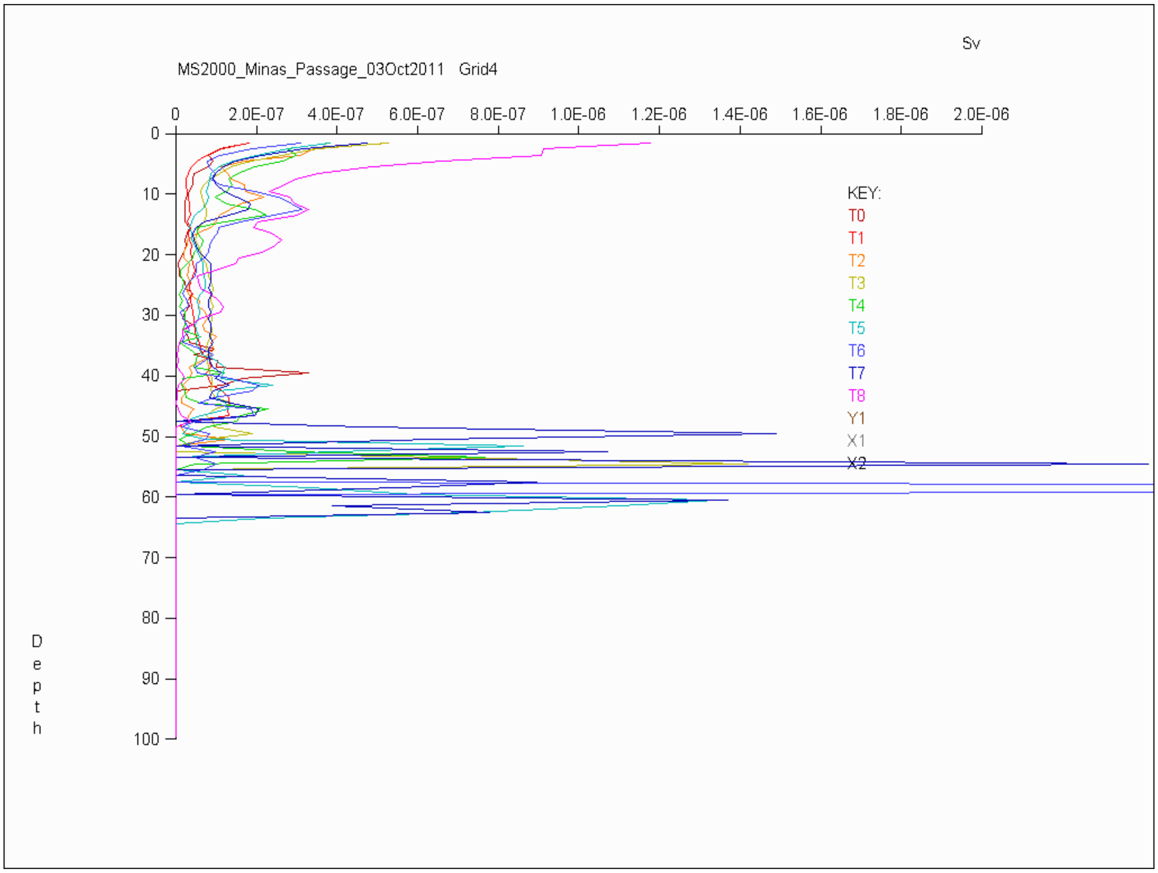


Relative S_v (linear) vs. depth (m) Grid 3, 03 Oct. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 3 Profiles T0 to T8 were steamed from 12:16 to 13:09 ADT. LT was at 11:50 ADT with maximum nominal flood current predicted for 14:53 ADT. Therefore, these profiles were steamed on the rising portion of the flood current cycle.



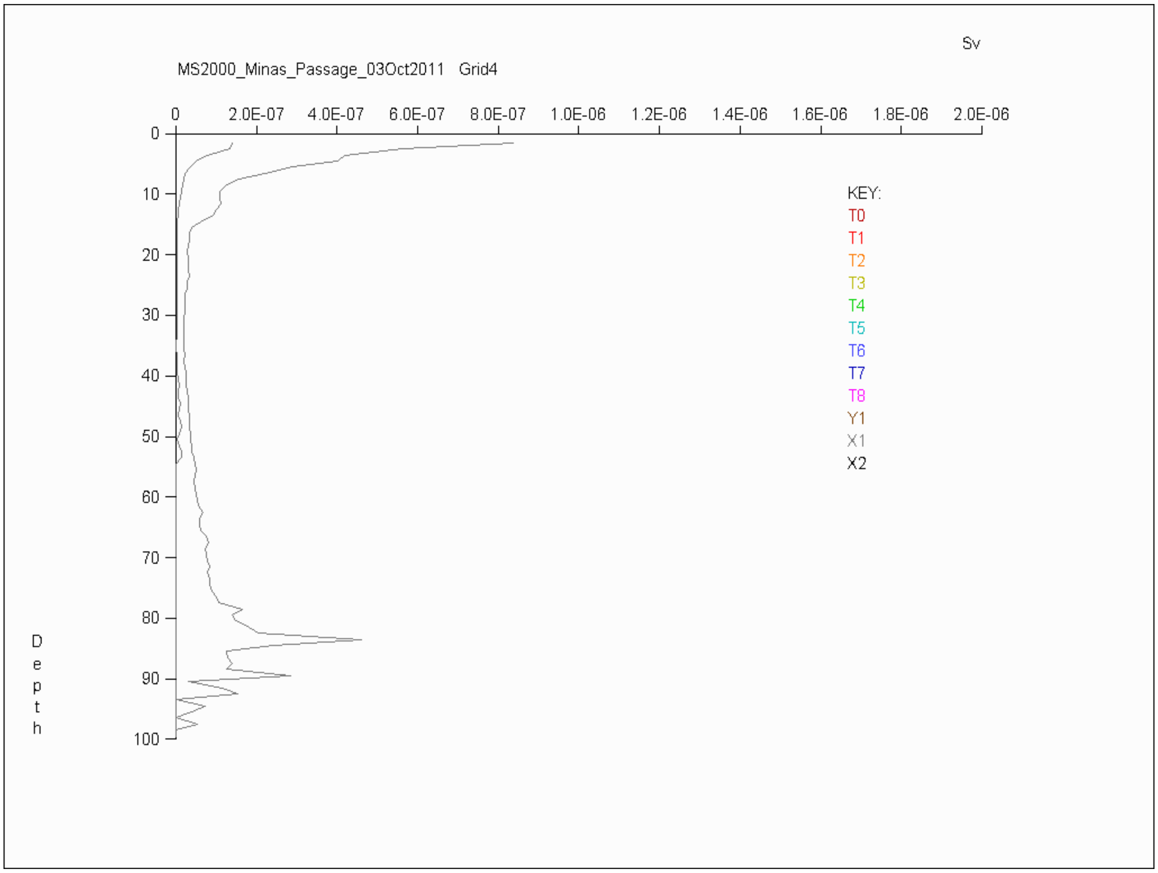
Grid 3 Profiles X1, Y1 & X2 were steamed from 13:10 to 14:05 ADT. Maximum nominal flood current was predicted for 14:53 ADT. Therefore, these profiles were steamed approaching maximum flood. Careful examination of fan sections pointed to the reality of the apparent fish layer on X1 between about 17 and 30 m depths, although noise levels are high. The rise in X1 and X2 levels beyond 60 m depth is definitely due to noise.



Relative S_v (linear) vs. depth (m) Grid 4, 03 Oct. 2011 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 4 Profiles T0 to T8 were steamed from 14:07 to 16:56 ADT. Maximum nominal flood was at 14:53 ADT and HT at 17:56 ADT. Therefore, these profiles extended through maximum flood to within about 1 hr of HT.

Plots might suggest fish near 10 m depth and also in the depth range 35 – 45 m. Field notes for T6 mention schools of fish on T6 near 15 and 30 m. Examination of fan sections suggests that enhanced backscatter levels between 7 and 22 m depth on profiles T6 to T8 do indeed arise from fish while the deeper and more irregular enhanced levels between 35 and 45 m observed on all transects arise from noise.
T3 was steamed at about maximum flood current (14:53 ADT) with HT slack water occurring near the southern end of X1 at 17:56 ADT. T8 ended at 16:56 ADT, about 1 hr before high tide and about 2 hours before sunset.



Grid 4 Profile X1 was steamed in two sections in the period 16:58 to 17:18 ADT. HT was at 17:56 ADT so this profile was steamed in the latter part of the flood cycle approaching HT. The survey terminated at the south end of X1. Local sunset occurred at 18:53 ADT well after the end of survey.

The shallower X1 segment was of short duration and was steamed approaching the southern coastline. The deeper (inc. mid-channel), longer duration segment shows rising backscatter at depth which might suggest fish at around 80 m in the deep channel, however, visual inspection of MS 2000 fan section echograms strongly suggested noise levels to be sufficiently high as to mask any real fish echoes present.

6. DATASET: 22 NOV. 2011

6.1 Analysis Parameters: 22 Nov. 2011

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

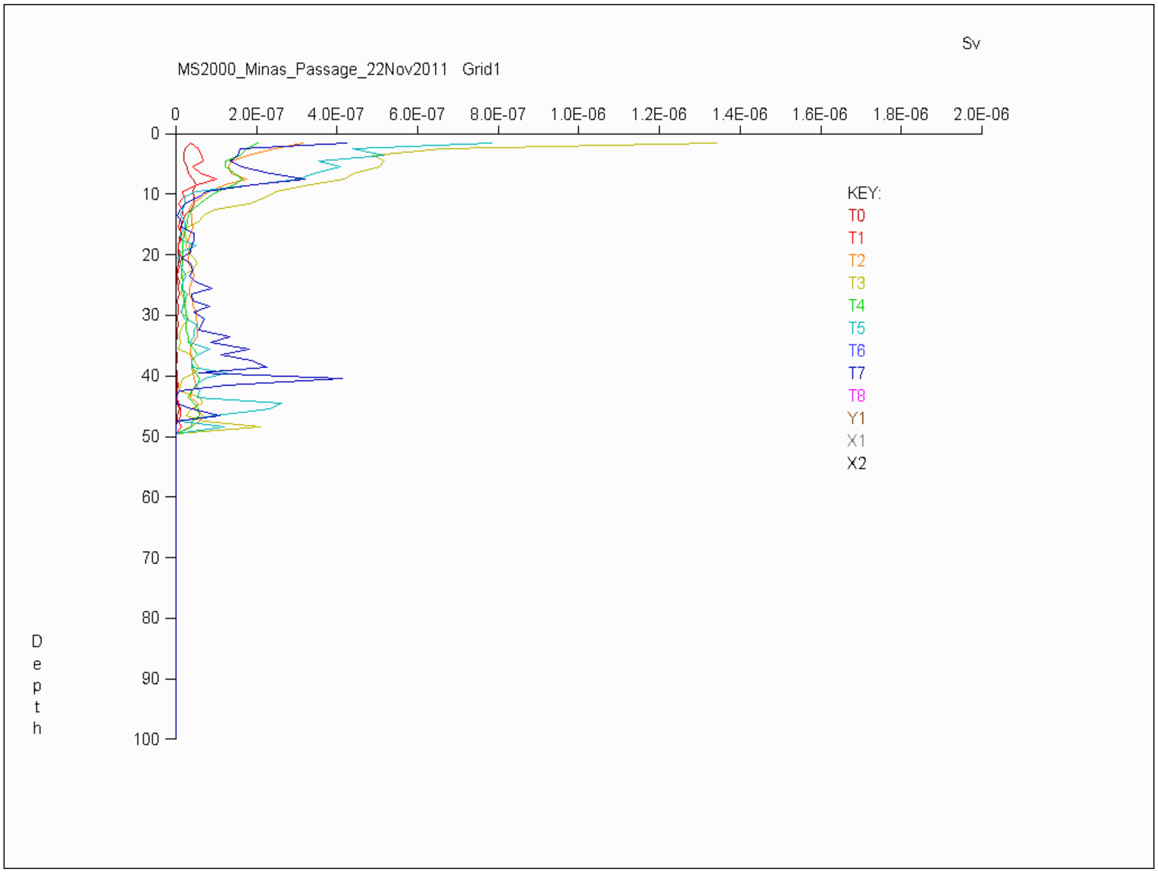
Alpha Correction = 50.1 dB/km

6.2 Lines: 22 Nov. 2011

Format:

Grid_Line_Range_Sub-line	"Field Data File"	Start	End (Ping)
Grid1_T0_75	"Nov22,2011,18-22-25.smb"	1	549
Grid1_T1_50	"Nov22,2011,18-32-28.smb"	1	218
Grid1_T2_50	"Nov22,2011,18-38-04.smb"	1	1180
Grid1_T3_50	"Nov22,2011,18-59-36.smb"	1	197
Grid1_T4_50	"Nov22,2011,19-07-14.smb"	1	2299
Grid1_T5_50	"Nov22,2011,19-48-57.smb"	1	209
Grid1_T7_50	"Nov22,2011,20-26-37.smb"	1	37

6.3 S_v Profiles: 22 Nov. 2011



Relative S_v (linear) vs. depth (m) Grid 1, 22 Nov. 2011 Minas Passage survey. Intensive grid lines T0 – T6 only.

Grid 1 T0 – T7 were steamed from 10:22 to 12:28 AST on 22 Nov. 2011. Cape Sharp HT occurred at 09:32 AST with nominal peak ebb flow predicted for 12:41 AST. Therefore, these profiles are steamed on the rising portion of the ebb flow.

The MS 2000 failed (for the duration of the survey) at the beginning of Grid 1 T8. T6 is also missing due to equipment problems. Real-time EK60 echograms showed some fish in the 20 – 40 m depth range so the $\boldsymbol{S_v}$ increases near-bottom could be real. However, inspection of T7 fan sections revealed that the enhanced levels between 33 and 42 m depth were due to high levels of "spoke" noise. Bubble plumes extended from the surface to about 20 m depth.

7. DATASET: 25 – 26 JAN. 2012

7.1 Analysis Parameters: 25 - 26 Jan. 2012

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

Alpha Correction = 40.1 dB/km

7.2 Lines: 25 - 26 Jan. 2012

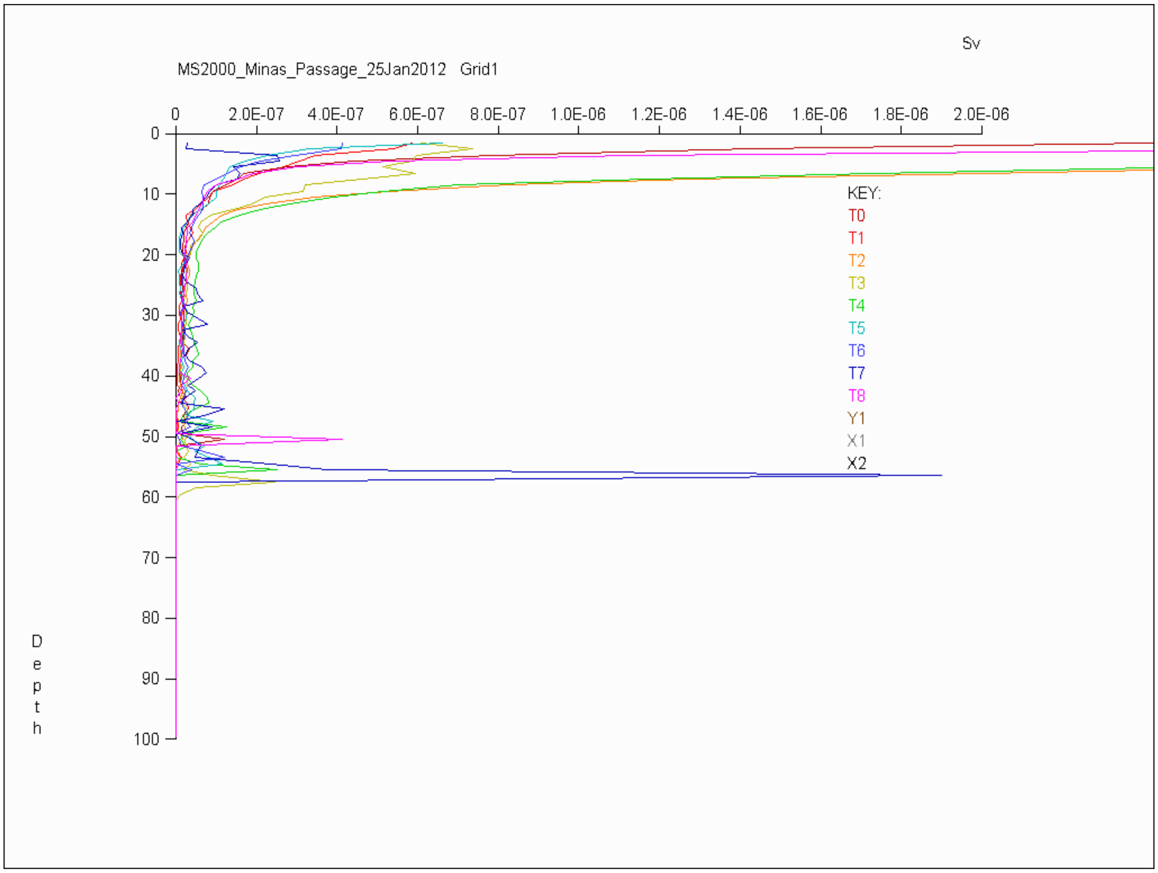
Format:

Grid_Line_Range_Sub-line	"Field Data File"	Start	End (Ping)
Grid1_T0_75	"Jan25,2012,22-32-54.smb"	1	354
Grid1_T1_75	"Jan25,2012,22-41-00.smb"	1	238
Grid1_T2_75	"Jan25,2012,22-46-37.smb"	1	219
Grid1_T4_75	"Jan25,2012,23-03-54.smb"	1	613
Grid1_T5_75	"Jan25,2012,23-15-39.smb"	1	233
Grid1_T6_75	"Jan25,2012,23-22-08.smb"	1	721
Grid1_T7_75	"Jan25,2012,23-35-25.smb"	1	244
Grid1_T8_75	"Jan25,2012,23-42-06.smb"	1	943
Grid1_X1_150	"Jan25,2012,23-57-54.smb"	1	1073
Grid1_Y1_75	"Jan26,2012,00-16-23.smb"	1	361
Grid1_X2_150	"Jan26,2012,00-22-32.smb"	50	2001
Grid2_T0_75	"Jan26,2012,00-55-46.smb"	1	333
Grid2_T1_75	"Jan26,2012,01-02-31.smb"	1	253
Grid2_T2_75	"Jan26,2012,01-08-16.smb"	1	564
Grid2_T3_75	"Jan26,2012,01-18-10.smb"	1	230
Grid2_T4_75	"Jan26,2012,01-23-36.smb"	1	590
Grid2_T5_75	"Jan26,2012,01-34-19.smb"	1	240
Grid2_T6_75	"Jan26,2012,01-44-23.smb"	1	709
Grid2_T7_75	"Jan26,2012,01-58-03.smb"	1	223
Grid2_T8_75	"Jan26,2012,02-04-21.smb"	1	752
Grid2_X1_75	"Jan26,2012,02-18-49.smb"	1	234
Grid2_X1_150_1	"Jan26,2012,02-22-54.smb"	1	831
Grid2_Y1_75	"Jan26,2012,02-36-52.smb"	1	53
Grid2_Y1_75_1	"Jan26,2012,02-37-46.smb"	1	143
Grid2_X2_150	"Jan26,2012,02-40-18.smb"	1	1282
Grid3_T0_75	"Jan26,2012,03-02-46.smb"	1	298
Grid3_T1_75	"Jan26,2012,03-08-38.smb"	1	223
Grid3_T2_75	"Jan26,2012,03-13-19.smb"	1	309
Grid3_T3_75	"Jan26,2012,03-19-01.smb"	1	216
Grid3_T4_75	"Jan26,2012,03-23-52.smb"	1	352
Grid3_T5_75	"Jan26,2012,03-30-29.smb"	1	218
Grid3_T6_75	"Jan26,2012,03-35-30.smb"	1	340
Grid3_T7_75	"Jan26,2012,03-41-53.smb"	1	234
Grid3_T8_75	"Jan26,2012,03-47-01.smb"	1	326
Grid3_X1_150	"Jan26,2012,03-53-46.smb"	1	804
Grid3_Y1_75	"Jan26,2012,04-08-37.smb"	1	271
Grid3_X2_150	"Jan26,2012,04-13-31.smb"	1	956
Grid3_X2_75_1	"Jan26,2012,04-30-05.smb"	1	184
Grid4_T0_75	"Jan26,2012,04-33-31.smb"	1	211

Grid4_T1_75	"Jan26,2012,04-38-24.smb"	1	404
Grid4_T2_75	"Jan26,2012,04-47-02.smb"	1	276
Grid4_T3_75	"Jan26,2012,04-52-53.smb"	1	427
Grid4_T4_75	"Jan26,2012,05-02-59.smb"	1	250
Grid4_T5_75	"Jan26,2012,05-09-54.smb"	1	443
Grid4_T6_75	"Jan26,2012,05-33-37.smb"	1	214
Grid4_T7_75	"Jan26,2012,05-40-39.smb"	1	859
Grid4_T8_75	"Jan26,2012,05-58-26.smb"	1	192
Grid4_X1_150	"Jan26,2012,06-11-39.smb"	1	1171
Grid4_Y1_75	"Jan26,2012,06-32-23.smb"	1	341
Grid4_X2_150	"Jan26,2012,06-40-12.smb"	1	2326
Grid5_T0_75	"Jan26,2012,09-44-22.smb"	1	243
Grid5_T1_75	"Jan26,2012,09-52-04.smb"	1	386
Grid5_T2_75	"Jan26,2012,09-59-31.smb"	1	251
Grid5_T3_75	"Jan26,2012,10-06-55.smb"	1	352
Grid5_T4_75	"Jan26,2012,10-13-38.smb"	1	257
Grid5_T5_75	"Jan26,2012,10-21-08.smb"	1	362
Grid5_T6_75	"Jan26,2012,10-27-54.smb"	1	258
Grid5_T7_75	"Jan26,2012,10-34-19.smb"	1	334
Grid5_T8_75	"Jan26,2012,10-40-37.smb"	1	268
Grid5_X1_150	"Jan26,2012,10-45-12.smb"	75	1008
Grid5_Y1_75	"Jan26,2012,11-02-24.smb"	1	237
Grid5_X2_150	"Jan26,2012,11-10-29.smb"	1	1142
Grid6_T0_75	"Jan26,2012,11-30-40.smb"	1	307
Grid6_T1_75	"Jan26,2012,11-36-26.smb"	1	256
Grid6_T2_75	"Jan26,2012,11-45-55.smb"	1	540
Grid6_T3_75	"Jan26,2012,11-56-24.smb"	1	210
Grid6_T4_75	"Jan26,2012,12-02-45.smb"	1	785
Grid6_T5_75	"Jan26,2012,12-18-43.smb"	1	217
Grid6_T6_75	"Jan26,2012,12-25-06.smb"	1	926
Grid6_T7_75	"Jan26,2012,12-43-25.smb"	1	263
Grid6_T8_75	"Jan26,2012,12-51-17.smb"	1	988
Grid6_X1_150	"Jan26,2012,13-08-20.smb"	1	1102
Grid6_Y1_75	"Jan26,2012,13-27-21.smb"	1	141
Grid6_X2_150	"Jan26,2012,13-30-20.smb"	1	1514
Grid7_T0_75	"Jan26,2012,13-56-45.smb"	1	313
Grid7_T2_75	"Jan26,2012,14-11-22.smb"	1	406
Grid7_T3_75	"Jan26,2012,14-18-37.smb"	1	247
Grid7_T4_75	"Jan26,2012,14-24-30.smb"	1	431
Grid7_T5_75	"Jan26,2012,14-32-21.smb"	1	225
Grid7_T6_75	"Jan26,2012,14-37-33.smb"	1	489
Grid7_T7_75	"Jan26,2012,14-46-40.smb"	1	231
Grid7_T8_75	"Jan26,2012,14-54-21.smb"	1	463
Grid7_X1_150	"Jan26,2012,15-02-44.smb"	1	844
Grid7_Y1_75	"Jan26,2012,15-17-10.smb"	1	192
Grid7_X2_150	"Jan26,2012,15-20-38.smb"	1	1122

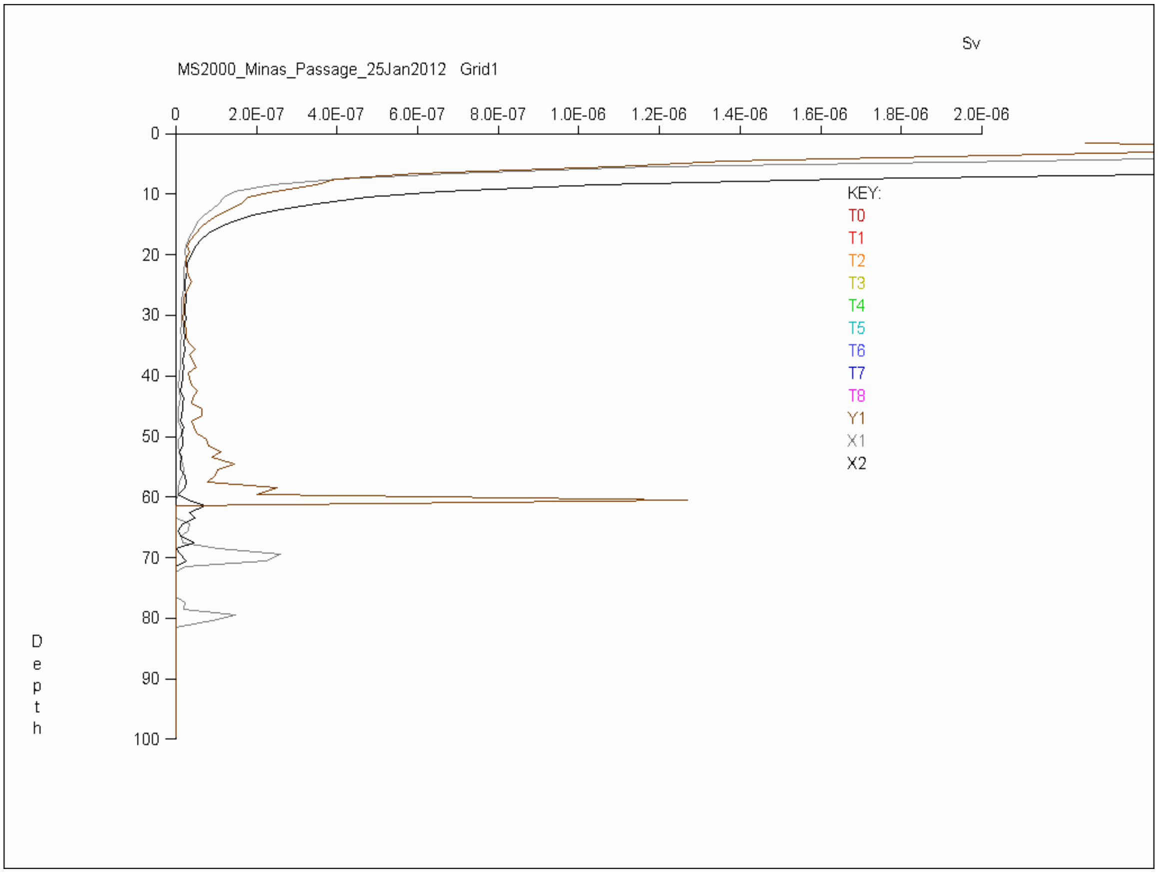
Grid8_T0_75	"Jan26,2012,15-40-32.smb"	1	239
Grid8_T1_75	"Jan26,2012,15-45-24.smb"	1	241
Grid8_T2_75	"Jan26,2012,15-50-22.smb"	1	250
Grid8_T3_75	"Jan26,2012,15-55-13.smb"	1	244
Grid8_T4_75	"Jan26,2012,16-00-26.smb"	1	268
Grid8_T5_75	"Jan26,2012,16-05-46.smb"	1	241
Grid8_T6_75	"Jan26,2012,16-10-44.smb"	1	269
Grid8_T7_75	"Jan26,2012,16-16-15.smb"	1	242
Grid8_T8_75	"Jan26,2012,16-21-26.smb"	1	274
Grid8_X1_150	"Jan26,2012,16-26-36.smb"	1	767
Grid8_Y1_75	"Jan26,2012,16-39-45.smb"	1	285
Grid8_X2_150	"Jan26,2012,16-44-54.smb"	1	1053
Grid9_T0_150	"Jan26,2012,17-04-24.smb"	1	110
Grid9_T0_75_1	"Jan26,2012,17-06-34.smb"	1	107
Grid9_T1_75	"Jan26,2012,17-09-04.smb"	1	424
Grid9_T2_75	"Jan26,2012,17-17-30.smb"	1	232
Grid9_T3_75	"Jan26,2012,17-22-27.smb"	1	349
Grid9_T4_75	"Jan26,2012,17-29-32.smb"	1	205
Grid9_T5_75	"Jan26,2012,17-35-33.smb"	1	465
Grid9_T6_75	"Jan26,2012,17-44-34.smb"	1	231
Grid9_T7_75	"Jan26,2012,17-55-16.smb"	1	632
Grid9_T8_75	"Jan26,2012,18-07-00.smb"	1	200
Grid9_X1_150	"Jan26,2012,18-12-04.smb"	1	877
Grid9_Y1_75	"Jan26,2012,18-28-29.smb"	1	263
Grid9_X2_150	"Jan26,2012,18-33-38.smb"	1	1439
Grid10_T0_75	"Jan26,2012,19-28-31.smb"	1	224
Grid10_T1_75	"Jan26,2012,19-38-09.smb"	1	1845
Grid10_T2_75	"Jan26,2012,20-12-00.smb"	1	188

7.3 S_v Profiles: 25 - 26 Jan. 2012

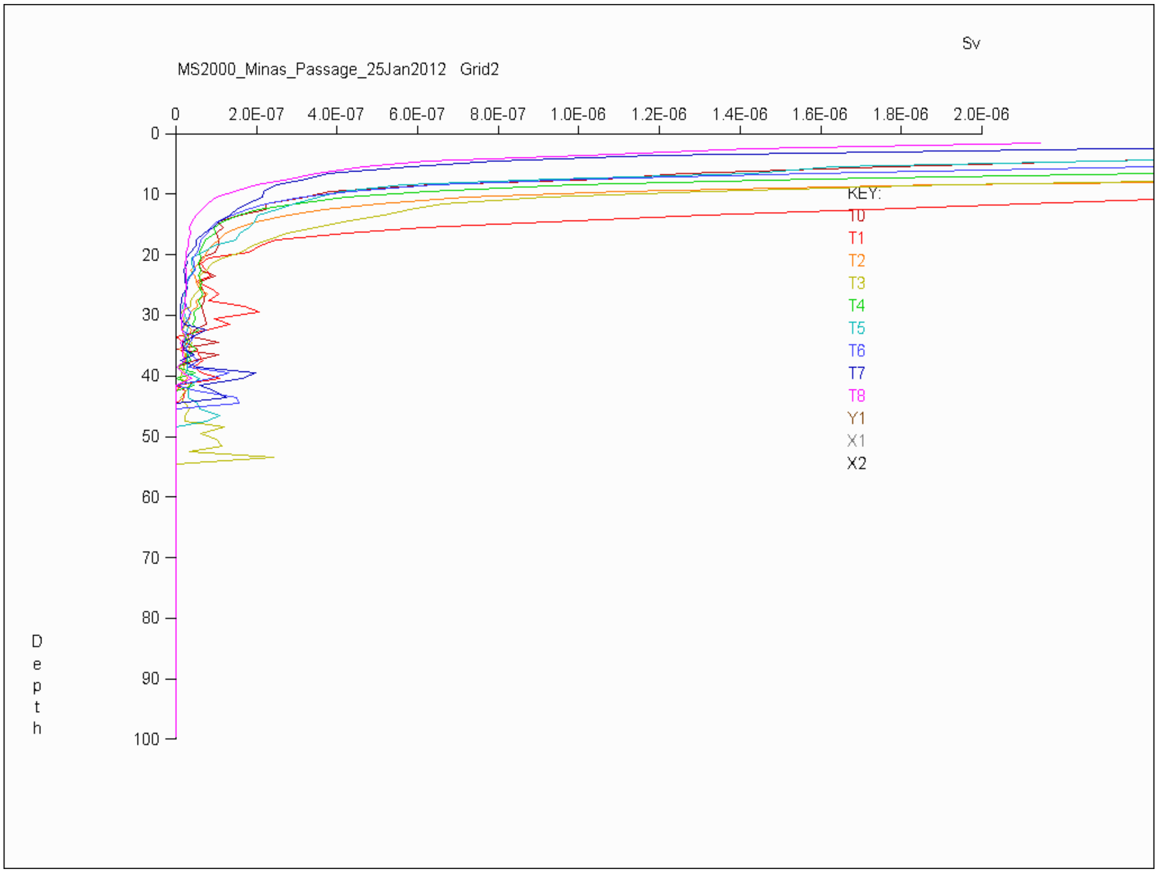


Relative S_v (linear) vs. depth (m) Grid 1, 25 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 1 Profiles T0 to T8 were surveyed from 14:33 to 15:58 AST. HT was at 13:57 AST so these observations were made on the increasing ebb tide flow.



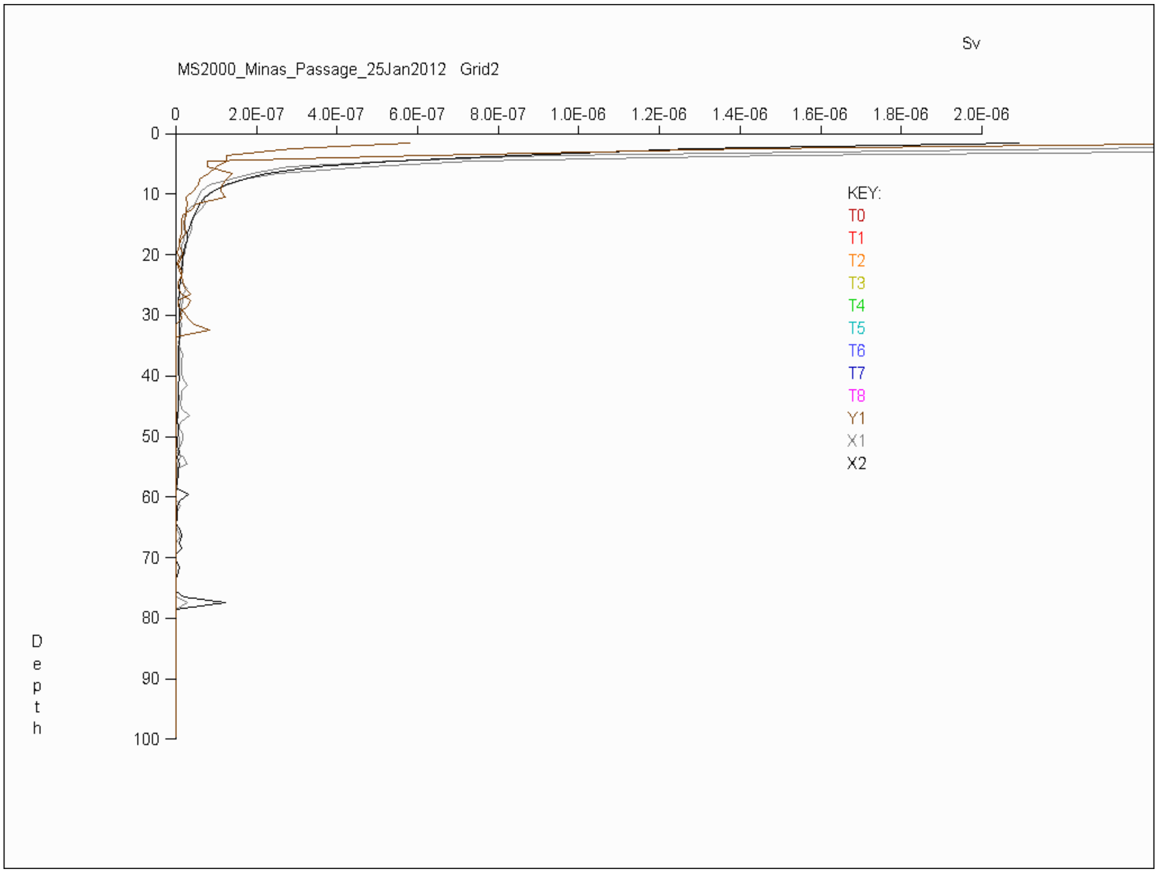
Grid 1 Profiles X1, Y1 & X2 were steamed from 15:58 to 16:56 AST. Nominal max ebb flow was as 17:09 AST. Therefore these profiles were steamed on the increasing ebb current terminating close to nominal max ebb. Visual examination of Y1 fan sections revealed that the enhanced levels from about 45 to 55 m arose from "spoke" noise.



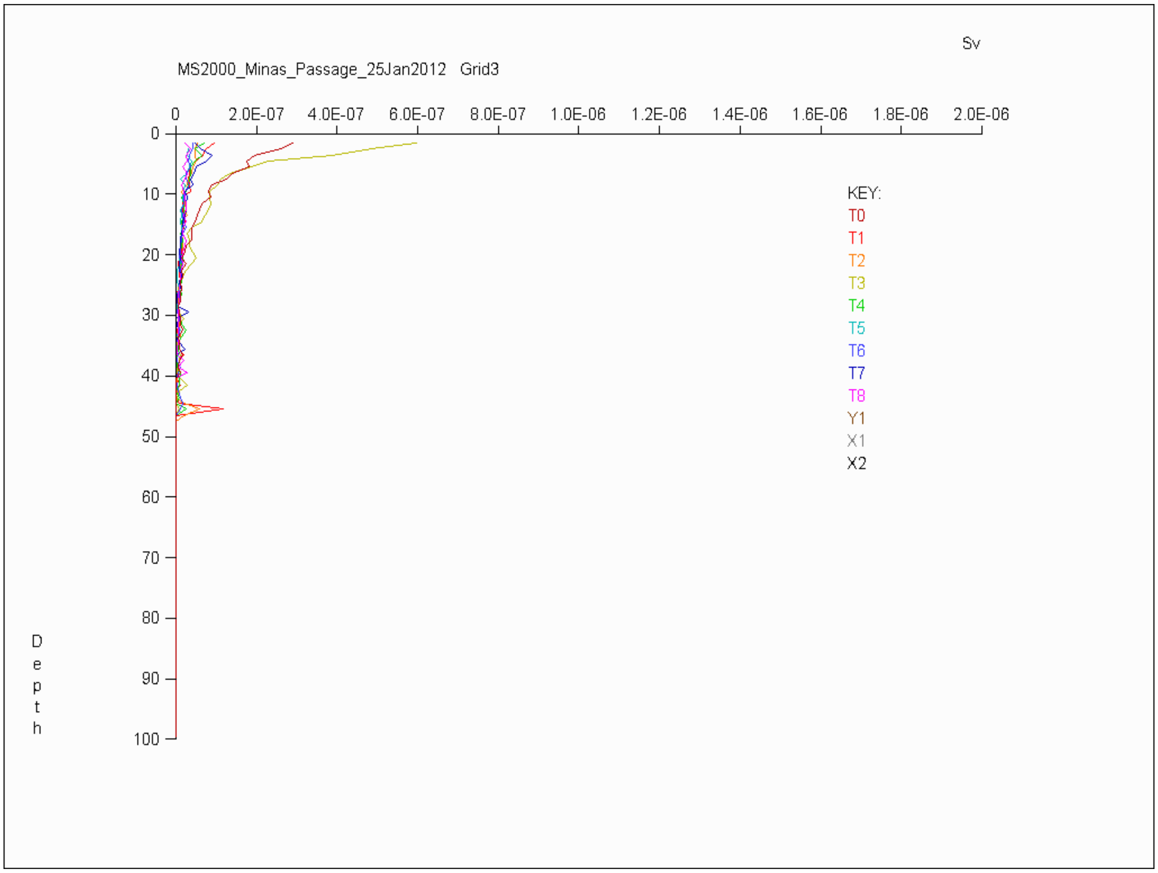
Relative S_v (linear) vs. depth (m) Grid 2, 25 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 2 Profiles T0 to T8 were surveyed from 16:56 to 18:17 AST.

Real-time field notes reported a difficulty in separating fish from bubble plumes. Sunset occurred at 17:12 AST on transect T2 near maximum ebb flow. Since nominal max ebb flow was at 17:09 AST these profiles were, for the most part, run on the decreasing ebb cycle stating near max ebb. Plume backscattering levels were very high and noise often completely dominated echograms leading to total or near total rejection of the sections in processing. Visual inspection of the fan sections in post-processing noted some fish in the 15 to 20 m depth range on the odd numbered profiles (steamed with the current and therefore of lower noise levels). While some fish were undoubtedly present, noise levels were sufficiently high to make any fish contributions to the observed backscatter profiles uncertain.

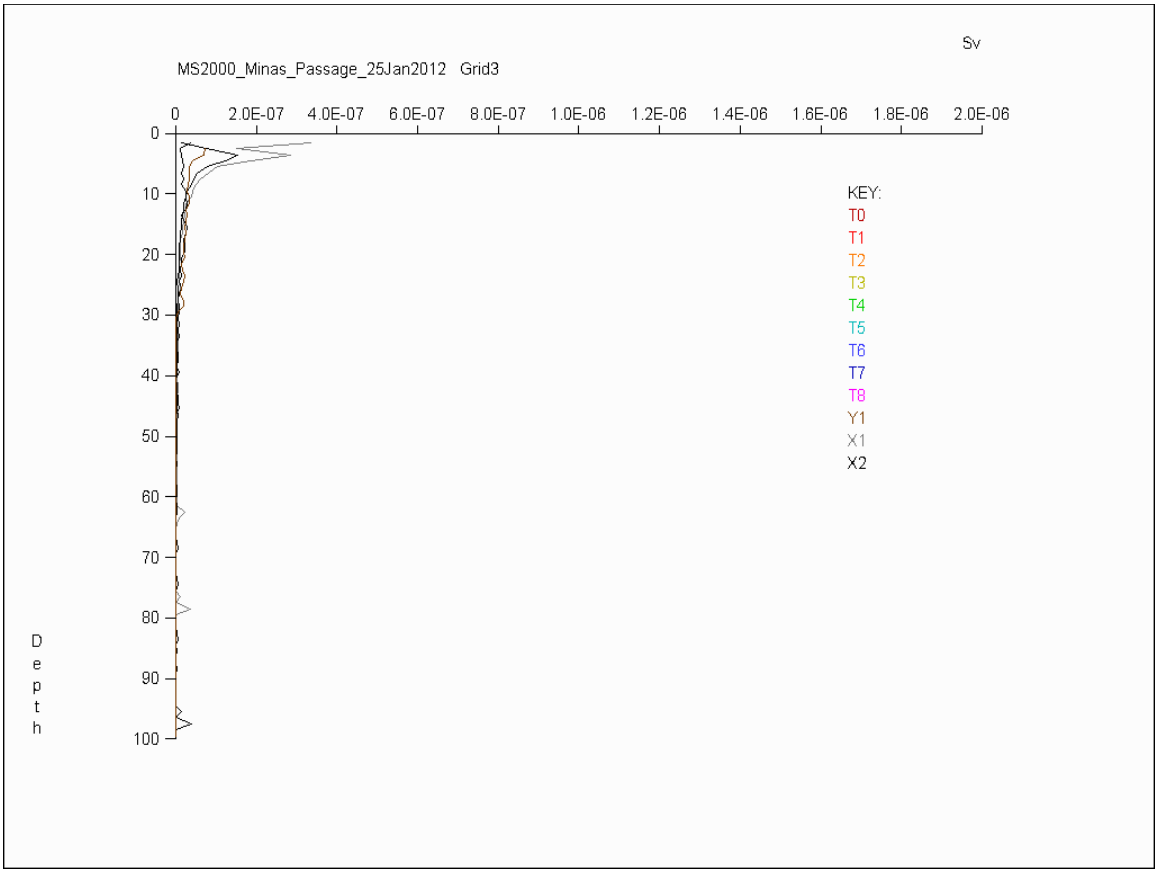


Grid 2 Profiles X1, Y1 & X2 were steamed from 18:18 to 19:02 AST. Cape Sharp LT was at 20:21 AST. Therefore, these profiles were steamed on the declining portion of the ebb tide cycle. Profiles X1 and Y1 were both performed in two segments.

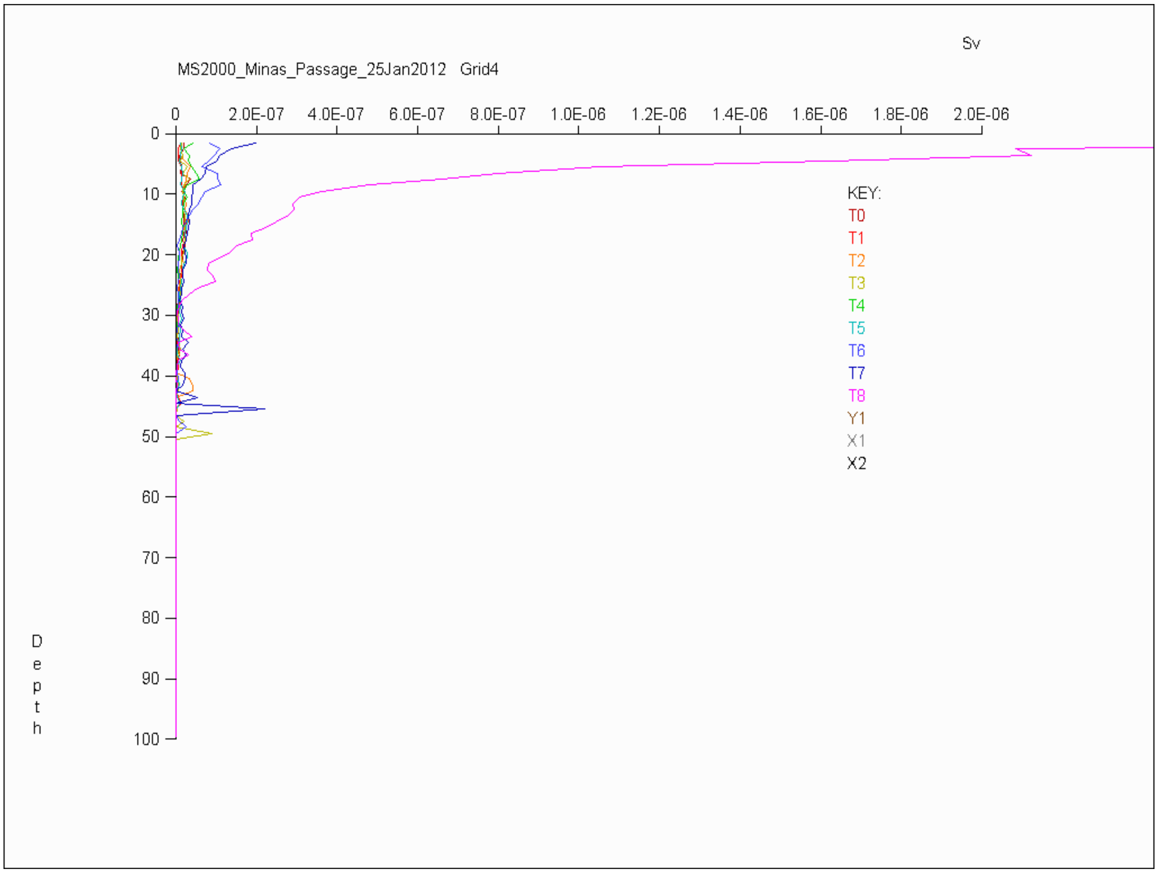


Relative S_v (linear) vs. depth (m) Grid 3, 25 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 3 Profiles T0 to T8 were surveyed from 19:03 to 19:52 AST. These profiles were steamed at the tail end of the ebb tide cycle, LT occurring at 20:21 AST about 30 min. after the final profile. Plumes appeared to die away 70 min. or so before LT slack water.

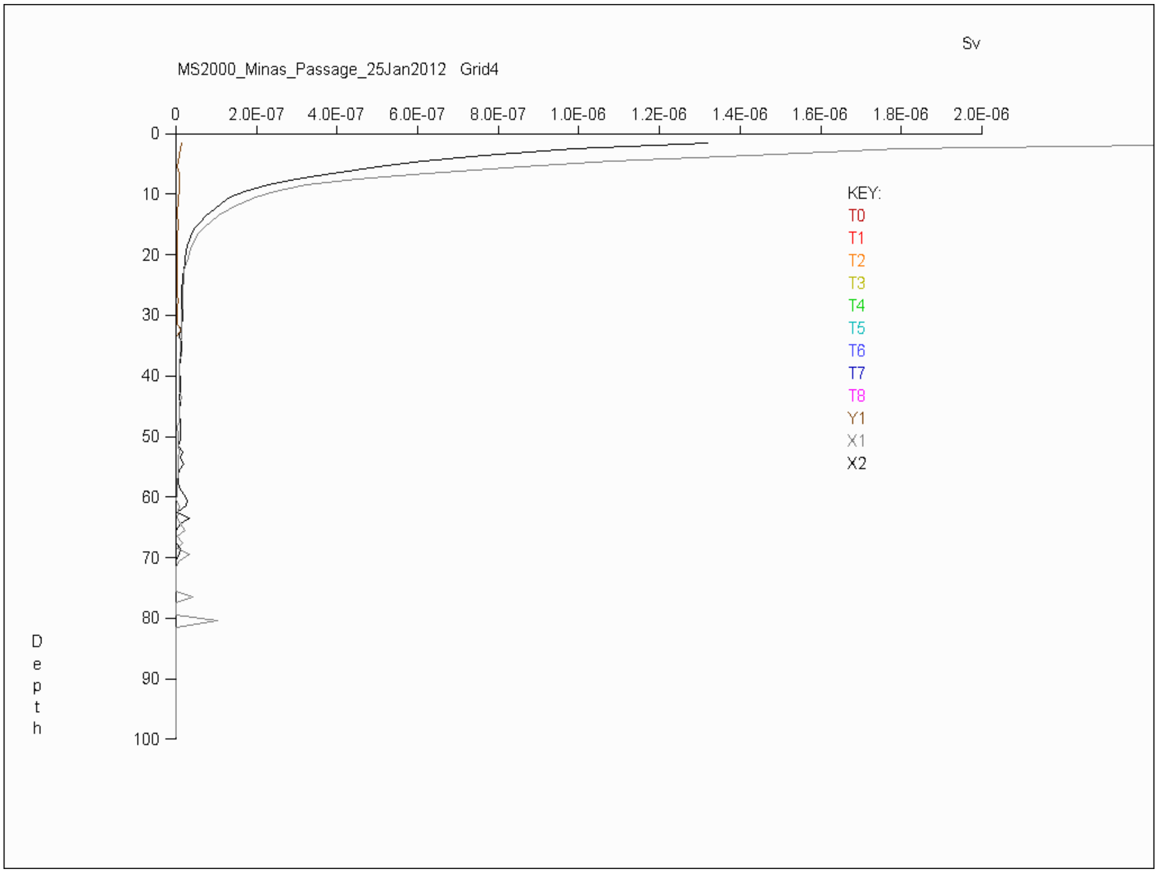


Grid 3 Profiles X1, Y1 & X2 were steamed from 19:54 to 20:33 AST. LT occurred at 20:21 AST so these profiles were steamed around low tide. Line X2 was performed in 2 segments.

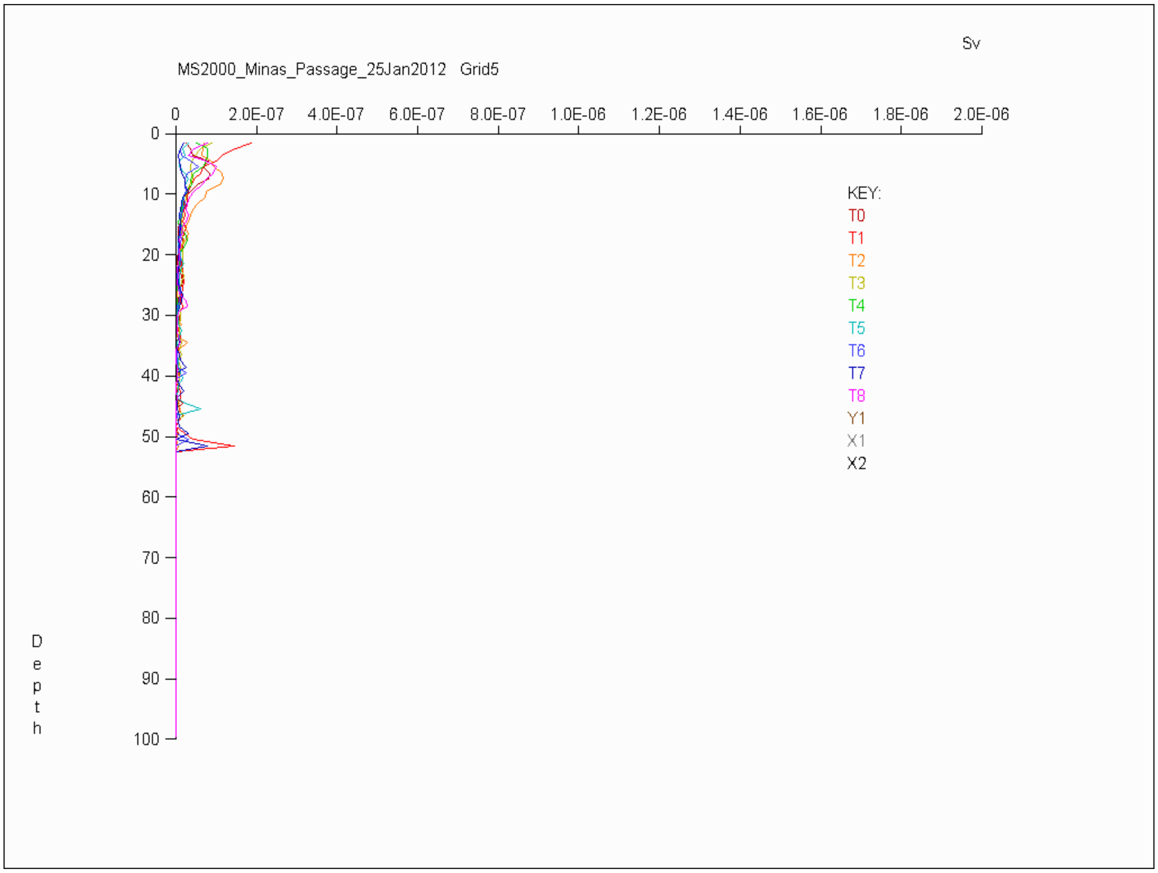


Relative S_v (linear) vs. depth (m) Grid 4, 25 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 4 Profiles T0 to T8 were surveyed from 20:34 to 22:02 AST. Cape Sharp LT was at 20:21 AST, therefore these profiles were survey early in the flood cycle. Plume activity started about 90 min. or so into the flood cycle.

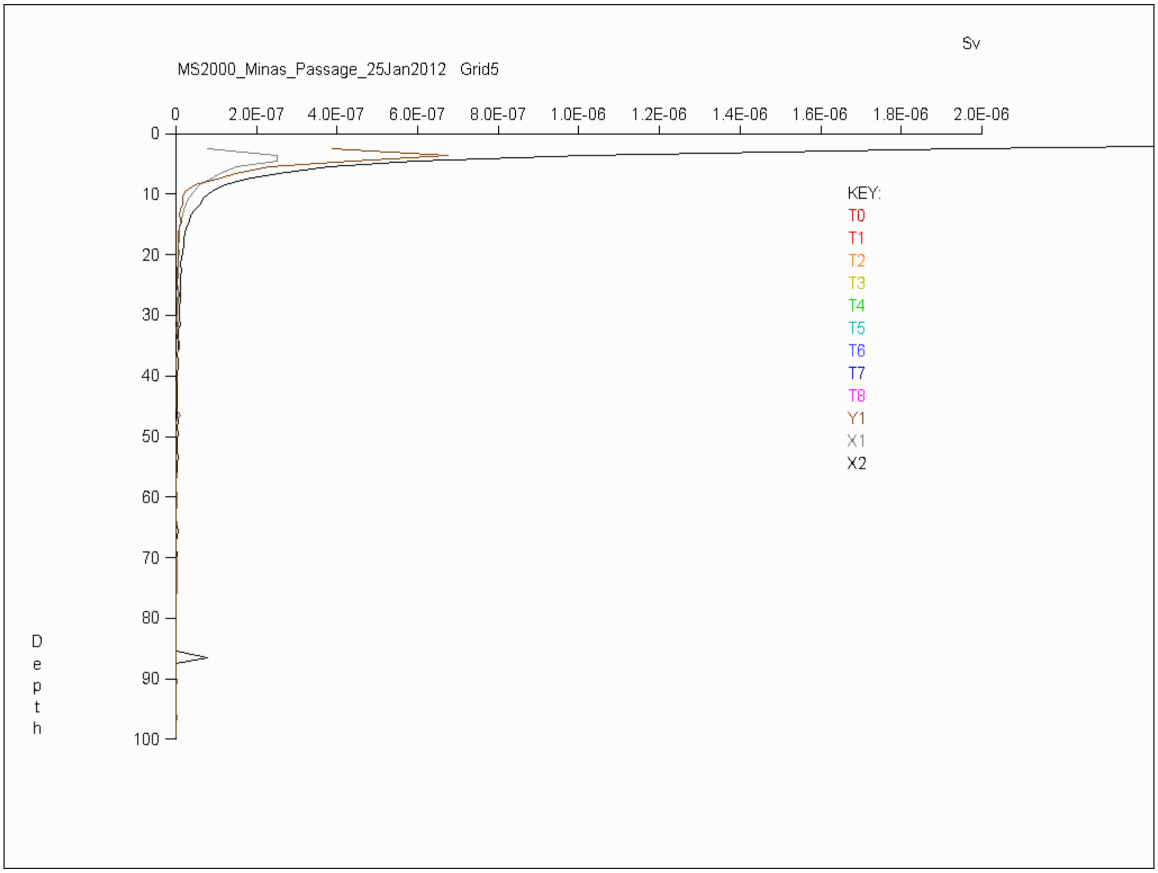


Grid 4 Profiles X1, Y1 & X2 were steamed from 22:12 to 23:19 AST. These profiles were steamed on the rising portion of the flood cycle with nominal maximum flood current occurring at 23:21 AST.

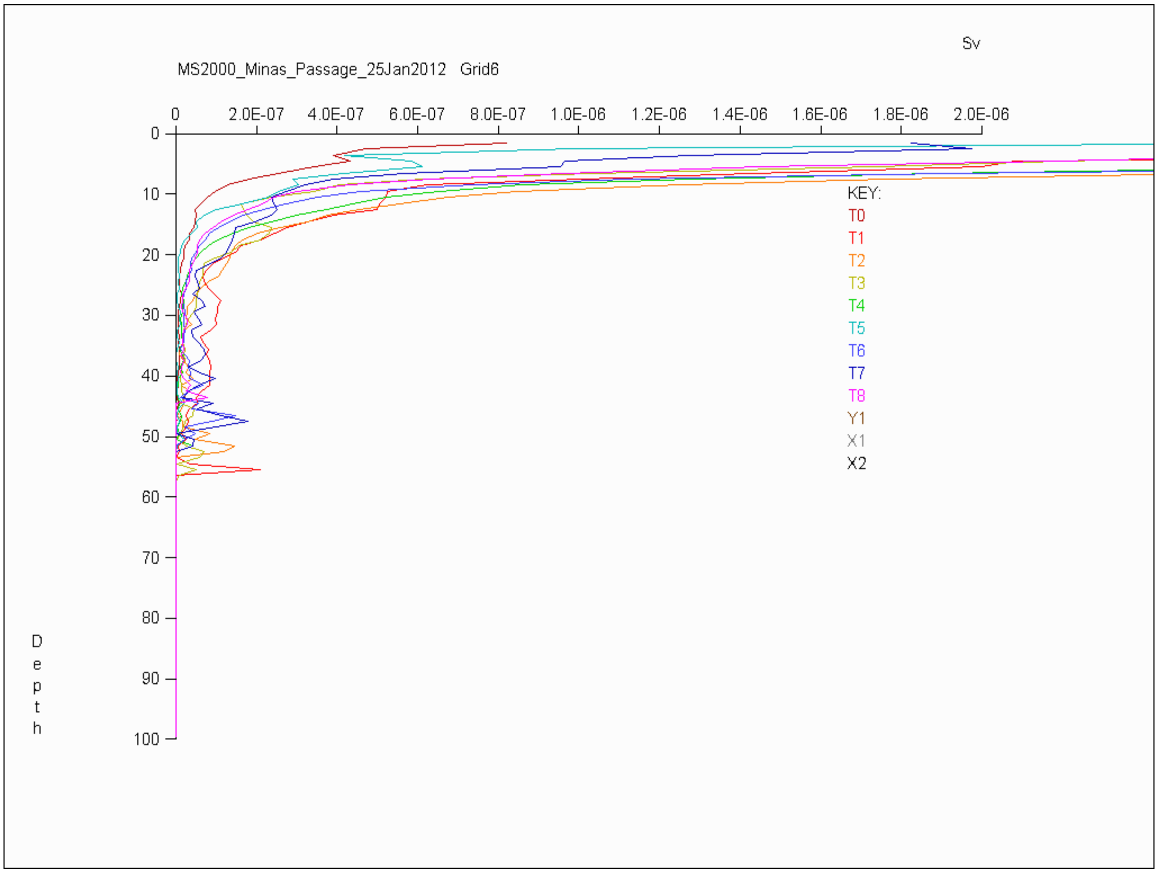


Relative S_v (linear) vs. depth (m) Grid 5, 26 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 5 Profiles T0 to T8 were surveyed from 01:44 to 02:45 AST. These profiles were steamed around high tide slack water (Cape Sharp HT at 02:21 AST).

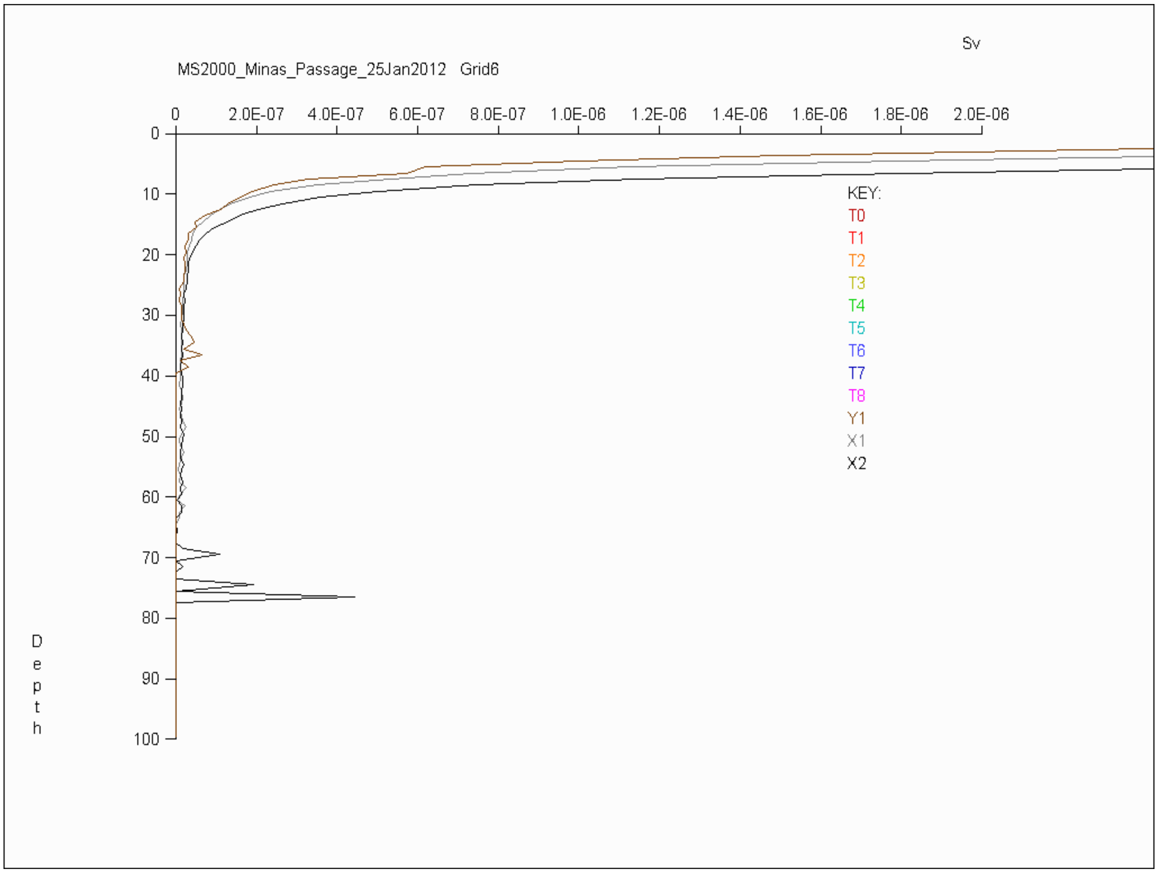


Grid 5 Profiles X1, Y1 & X2 were steamed from 02:46 to 03:29 AST just after HT (02:21 AST at Cape Sharp) on the early rising portion of the ebb flow. Does Y1 display a near surface fish layer? Visual inspections of fan sections seem to show mainly plume backscatter but numerous weak fish-like targets appeared present above 25 – 30 m depth. One would hardly expect to see plumes only 45 min. into ebb flow on the south coast transect.

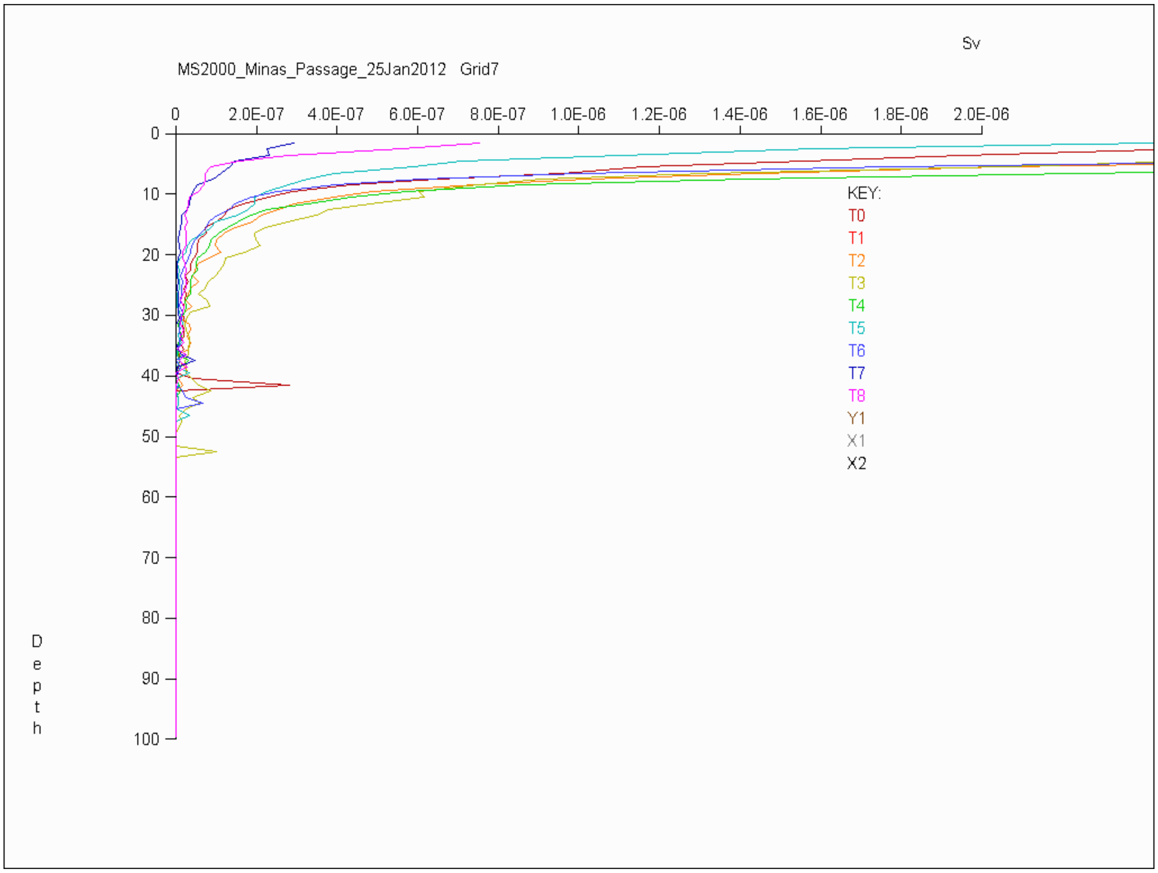


Relative S_v (linear) vs. depth (m) Grid 6, 26 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 6 Profiles T0 to T8 were surveyed from 03:31 to 05:08 AST. These profiles were steamed on the rising portion of the night ebb tide. HT was at 02:21 AST. Nominal max ebb flow was at 05:32 AST about 24 min. after the end of T8. Visual examination of fan sections indicated that any apparent enhancements in backscatter levels below 25 m depth probably arose from "spoke" noise.

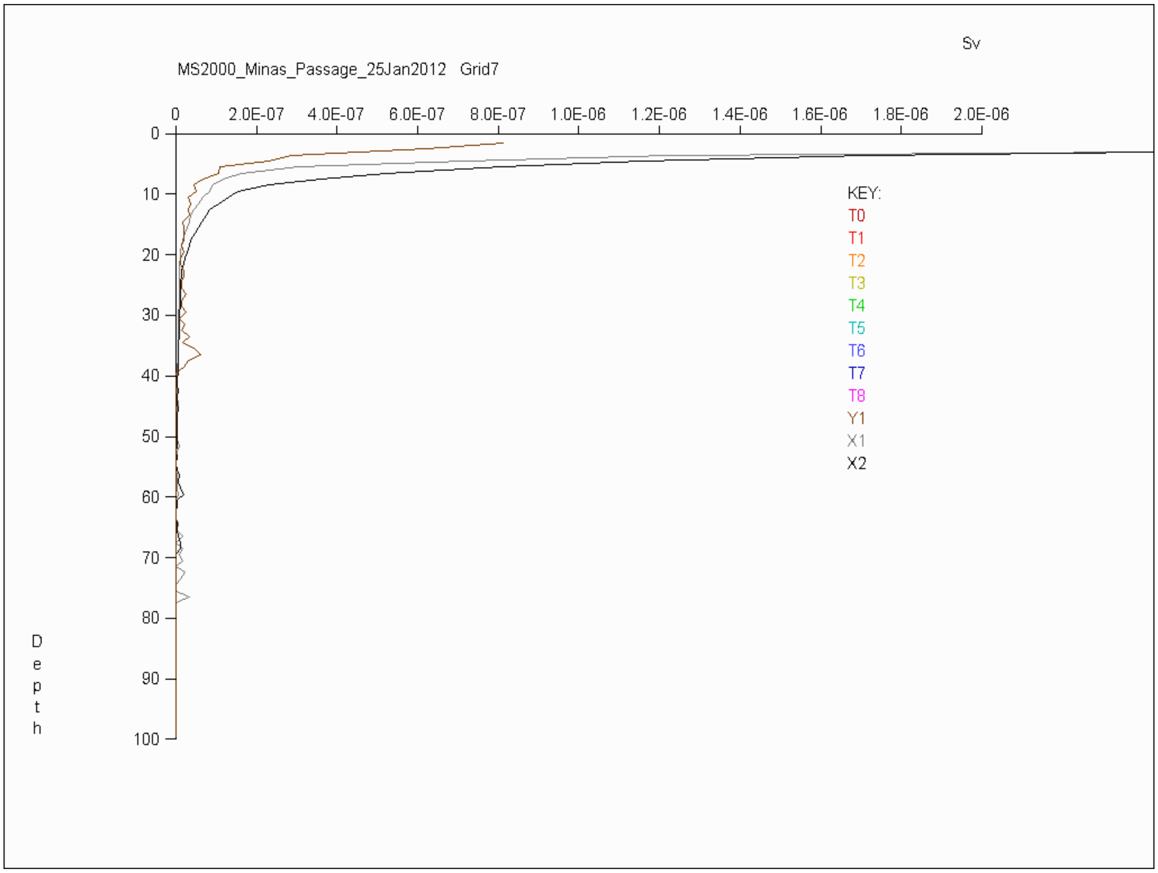


Grid 6 Profiles X1, Y1 & X2 were steamed from 05:08 to 05:55 AST around nominal maximum ebb flow (05:32 AST). Bubbles plumes were observed in the top 10 m. Visual examination of fan sections suggested that the apparent enhancement in Y1 backscatter around 35 m depth was spurious and arose from noise.

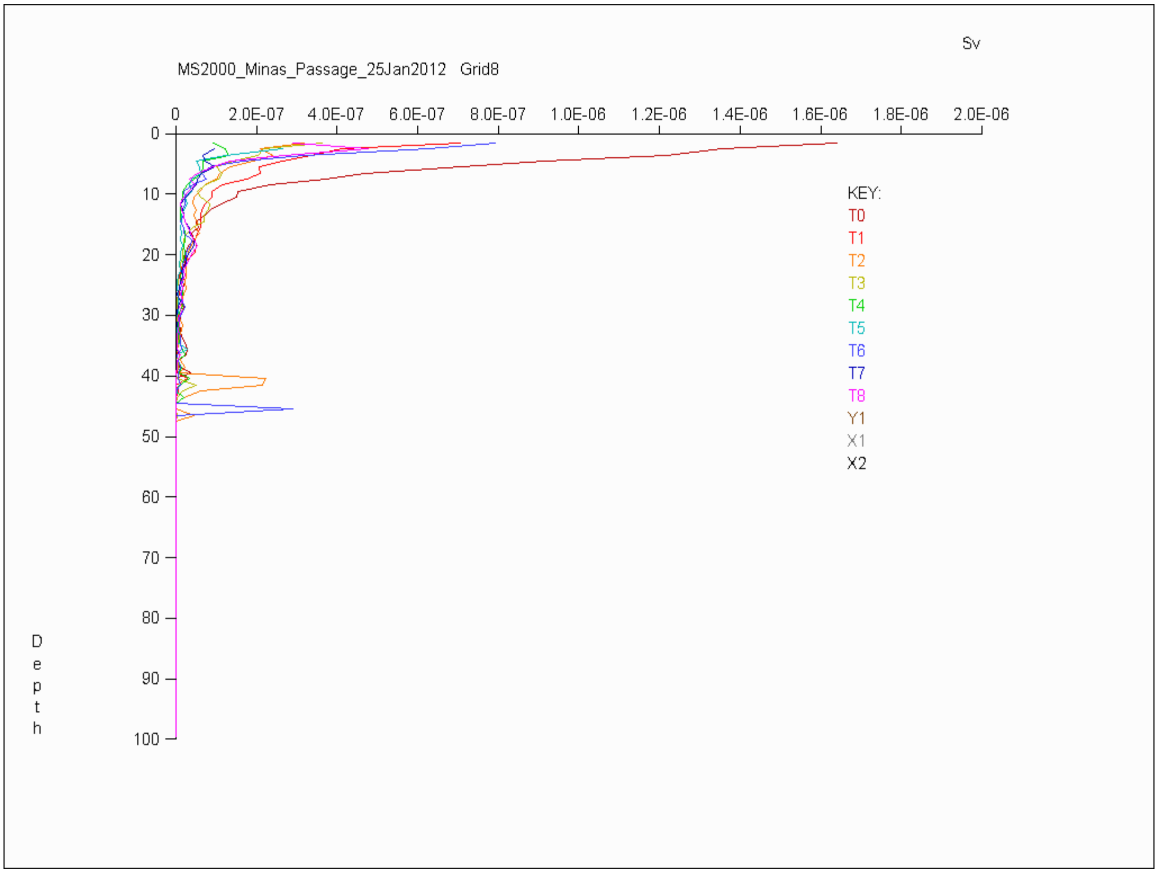


Relative S_v (linear) vs. depth (m) Grid 7, 26 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 7 Profiles T0 to T8 were surveyed from 05:57 to 07:02 AST over the declining portion of the early morning ebb cycle (max. ebb at 05:32 AST, LT at 08:42 AST) while still in darkness (local sunrise 07:43 AST). Line T1 did not record due to an equipment glitch.

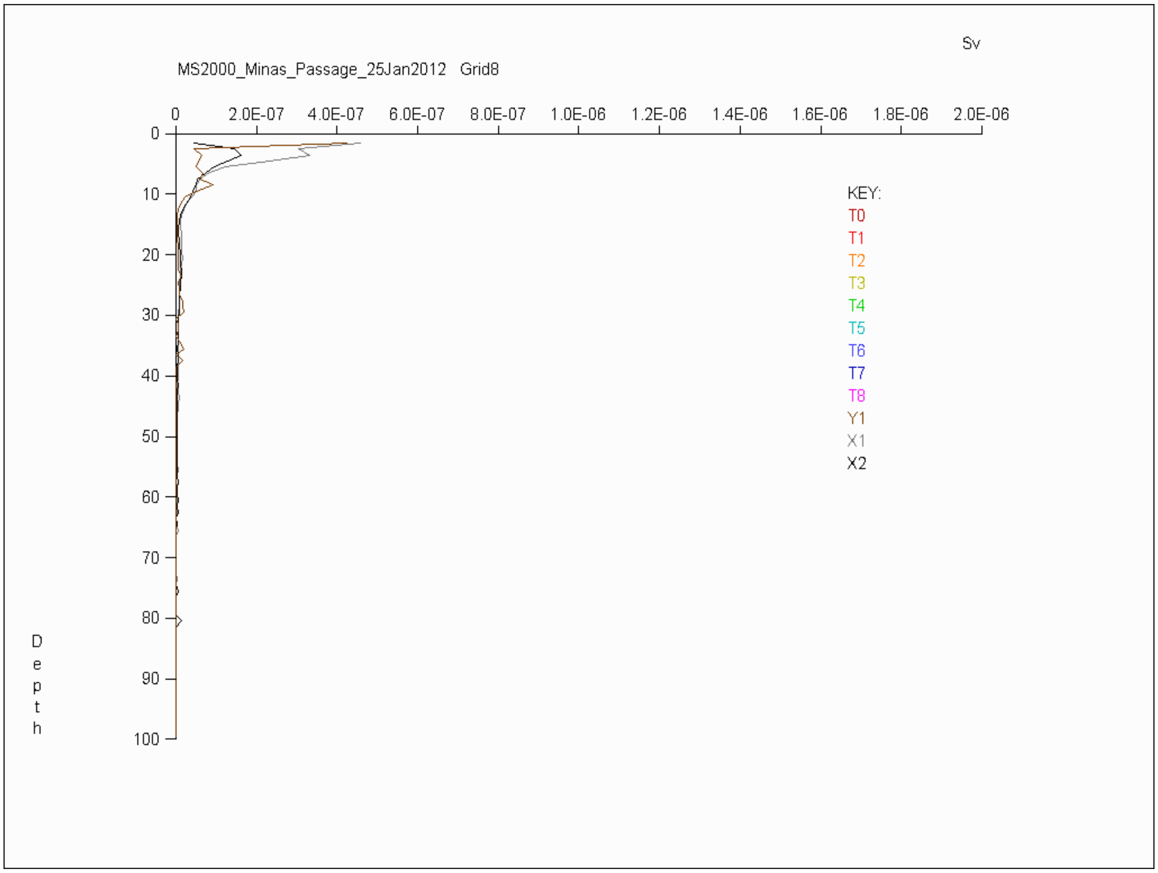


Grid 7 Profiles X1, Y1 & X2 were steamed from 07:03 to 07:39 AST on the declining portion of the ebb tide (nominal max. ebb at 05:32 AST, LT at 08:42 AST). Visual examination of fan sections indicated that the apparent rise in Y1 backscatter near maximum range was due to noise.

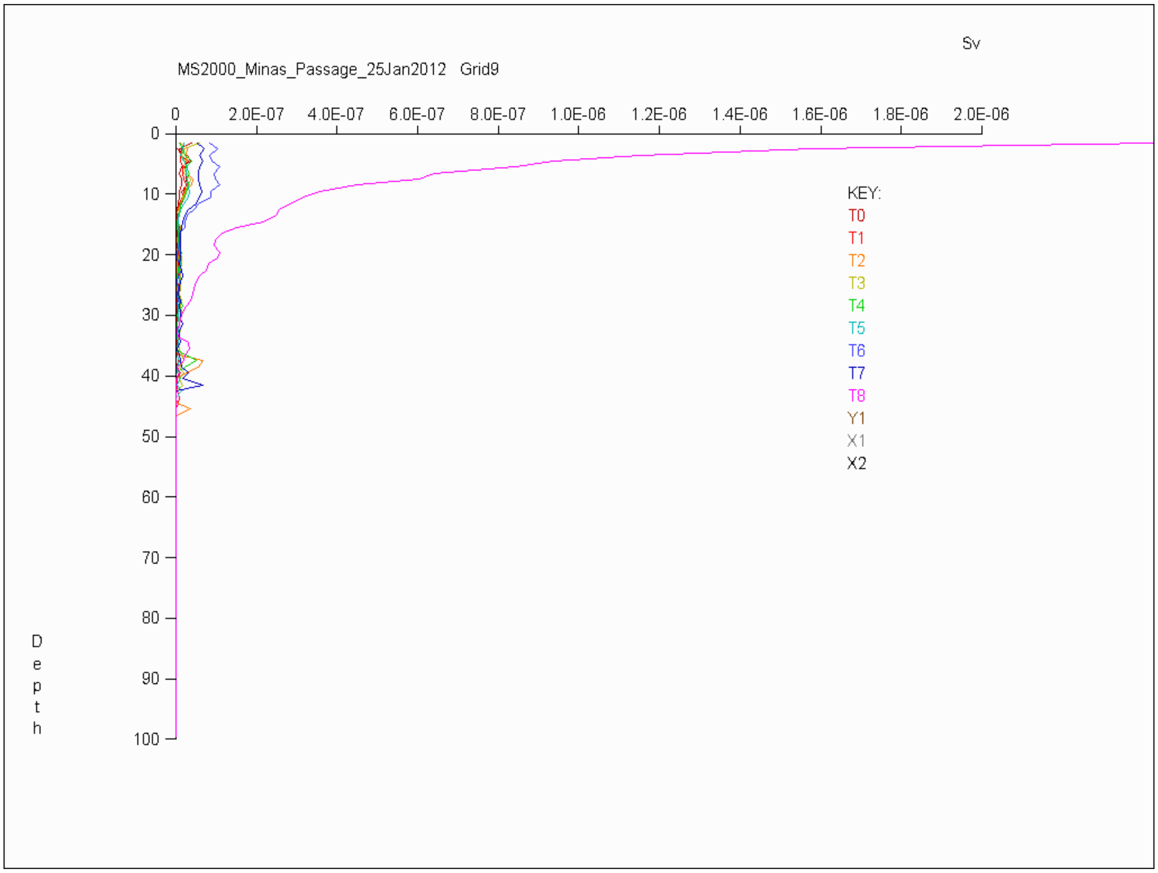


Relative S_v (linear) vs. depth (m) Grid 8, 26 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 8 Profiles T0 to T8 were surveyed from 07:41 to 08:26 AST on the declining portion of the ebb tide extending almost to LT (08:42 AST). Local sunrise occurred at 07:43 AST, essentially at the start of T0.

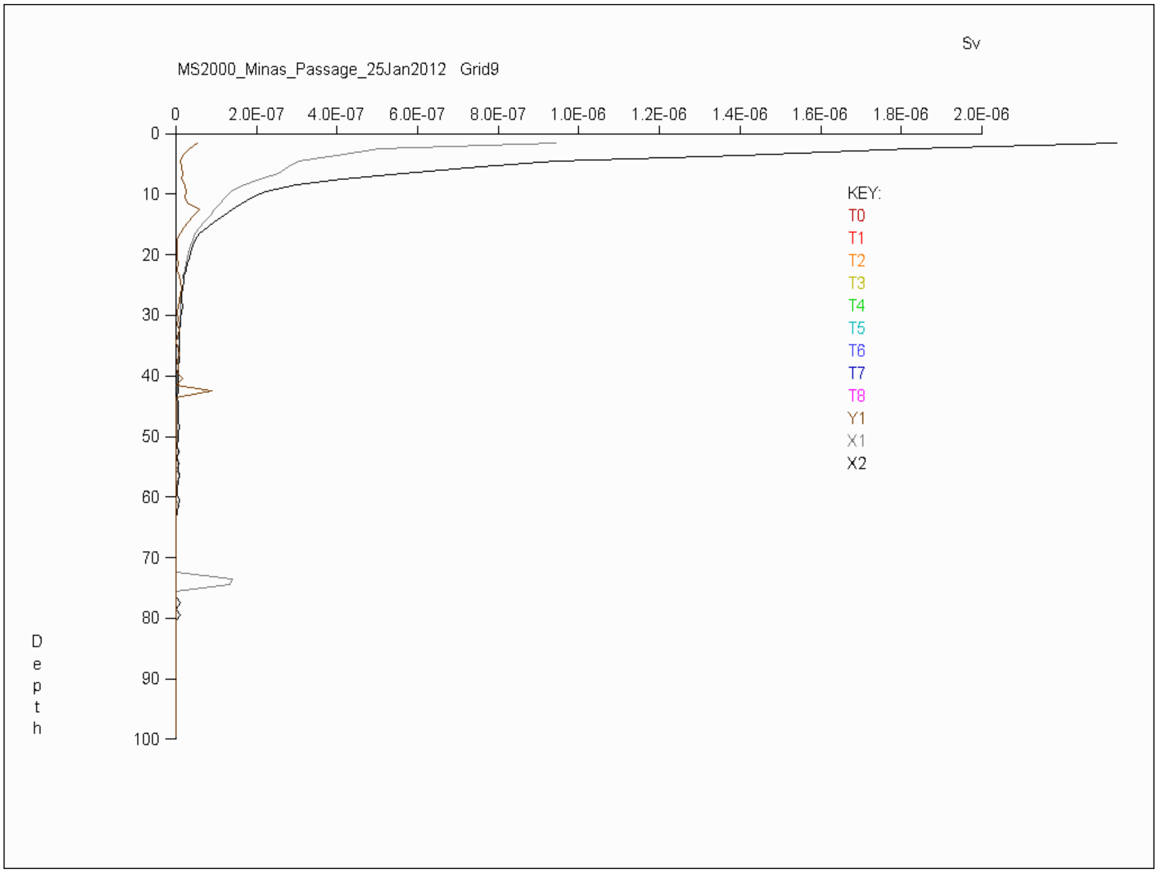


Grid 8 Profiles X1, Y1 & X2 were steamed from 08:27 to 09:02 AST around low tide slack water (08:42 AST at Cape Sharp).

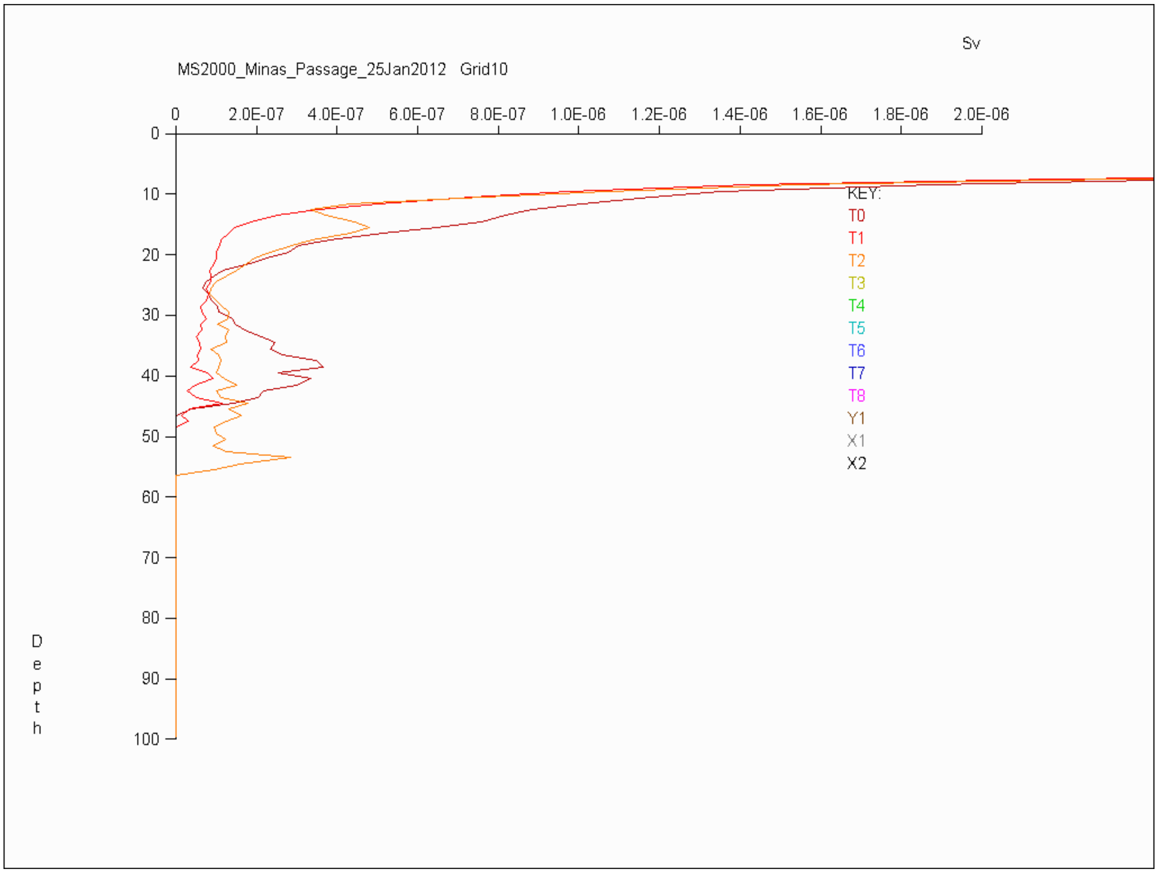


Relative *S_v* (linear) vs. depth (m) Grid 9, 26 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 9 Profiles T0 to T8 were surveyed from 09:05 to 10:10 AST on the rising portion of the flood tide in daylight. LT was at 08:42 AST, maximum flood at 11:41 AST (Cape Sharp). Bubble plumes suddenly started up about 90 min. into the flood cycle producing high backscatter on T8.



Grid 9 Profiles X1, Y1 & X2 were steamed from 10:18 to 10:57 AST. These profiles were steamed on the increasing flood tide. LT at Cape Sharp was at 08:42 AST and nominal maximum flood current at 11:41 AST. The course of profile X2 deviated considerably to the east, north of mid-channel due to excessive currents and was curtailed early near the center of the intensive grid.



Relative S_v (linear) vs. depth (m) Grid 10, 26 Jan. 2012 Minas Passage survey. Intensive grid lines T0 – T2 only.

Grid 10 Profiles T0, T1 & T2 were steamed from 11:29 to 12:15 AST around maximum nominal flood tide (11:41 AST). Visual inspection of the T0 profile revealed high levels of plume backscatter as well as "spoke" noise (unexpected while essentially drifting with current). Some fish-like appearing targets were visible on fan sections but it was quite uncertain whether they were actually fish and their overall contribution to the profile should be less than residual (i.e. un-removed portion of) "spoke noise".

8. DATASET: 19 - 20 MAR. 2012

8.1 Analysis Parameters: 19 – 20 Mar. 2012

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

Alpha Correction = 39.7 dB/km

8.2 Lines: 19 - 20 Mar. 2012

Format:

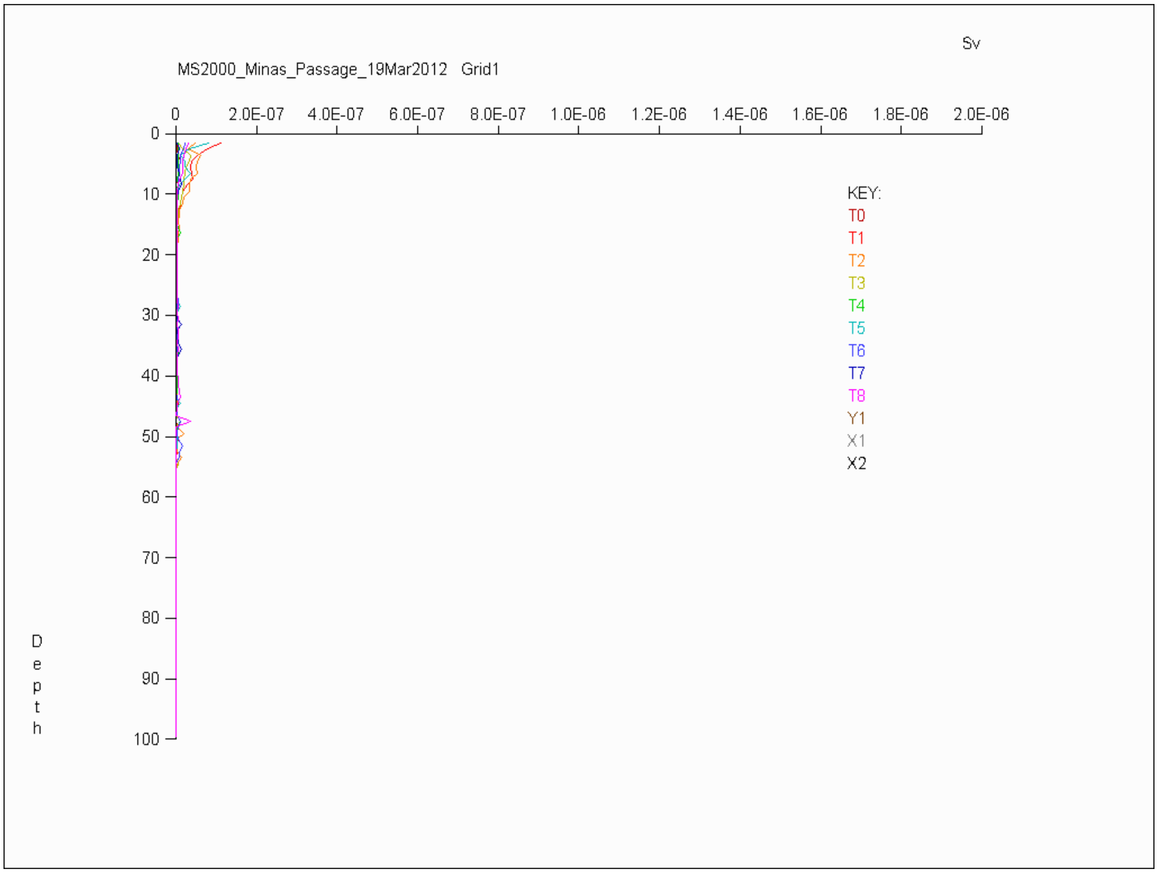
Grid_Line_Range_Sub-line	**“Field Data File”**	**Start**	**End (Ping)**
Grid1_T0_150	"Mar19,2012,18-23-04.smb"	1	248
Grid1_T1_150	"Mar19,2012,18-28-11.smb"	1	242
Grid1_T2_150	"Mar19,2012,18-33-08.smb"	1	246
Grid1_T3_150	"Mar19,2012,18-38-10.smb"	1	229
Grid1_T4_150	"Mar19,2012,18-43-13.smb"	1	279
Grid1_T5_150	"Mar19,2012,18-48-52.smb"	1	219
Grid1_T6_150	"Mar19,2012,18-53-31.smb"	1	286
Grid1_T7_150	"Mar19,2012,18-59-19.smb"	1	218
Grid1_T8_150	"Mar19,2012,19-03-40.smb"	1	347
Grid1_X1_150	"Mar19,2012,19-10-50.smb"	1	781
Grid1_Y1_75	"Mar19,2012,19-25-31.smb"	1	123
Grid1_X2_150	"Mar19,2012,19-28-01.smb"	1	1171
Grid2_T0_75	"Mar19,2012,19-48-01.smb"	1	352
Grid2_T1_75	"Mar19,2012,19-54-50.smb"	1	223
Grid2_T2_75	"Mar19,2012,19-59-23.smb"	1	557
Grid2_T3_75	"Mar19,2012,20-10-26.smb"	1	202
Grid2_T4_75	"Mar19,2012,20-14-53.smb"	1	611
Grid2_T5_75	"Mar19,2012,20-31-54.smb"	1	701
Grid2_T7_75	"Mar19,2012,20-45-23.smb"	1	189
Grid2_T8_75	"Mar19,2012,20-49-44.smb"	1	771
Grid2_X1_150	"Mar19,2012,21-05-00.smb"	1	1065
Grid2_Y1_75	"Mar19,2012,21-30-12.smb"	1	225
Grid2_X2_150	"Mar19,2012,21-35-34.smb"	1	1358
Grid3_T0_150	"Mar19,2012,21-59-16.smb"	1	336
Grid3_T1_75	"Mar19,2012,22-05-51.smb"	1	254
Grid3_T2_75	"Mar19,2012,22-10-41.smb"	1	466
Grid3_T3_75	"Mar19,2012,22-20-17.smb"	1	236
Grid3_T4_75	"Mar19,2012,22-25-02.smb"	1	458
Grid3_T6_75	"Mar19,2012,22-42-04.smb"	1	557
Grid3_T7_75	"Mar19,2012,22-52-41.smb"	1	215
Grid3_T8_75	"Mar19,2012,22-58-26.smb"	1	507
Grid3_X1_150	"Mar19,2012,23-11-28.smb"	1	886
Grid3_Y1_75	"Mar19,2012,23-27-30.smb"	1	262
Grid3_X2_150	"Mar19,2012,23-33-30.smb"	1	1162
Grid4_T0_75	"Mar19,2012,23-54-12.smb"	1	311
Grid4_T1_75	"Mar20,2012,00-00-37.smb"	1	260
Grid4_T2_75	"Mar20,2012,00-06-32.smb"	1	281
Grid4_T3_75	"Mar20,2012,00-11-30.smb"	1	264
Grid4_T4_75	"Mar20,2012,00-18-15.smb"	1	314

Grid4_T5_75	"Mar20,2012,00-24-49.smb"	1	243
Grid4_T6_75	"Mar20,2012,00-31-08.smb"	1	289
Grid4_T7_75	"Mar20,2012,00-37-53.smb"	1	274
Grid4_T8_75	"Mar20,2012,00-42-55.smb"	1	290
Grid4_X1_150	"Mar20,2012,00-50-38.smb"	1	863
Grid4_Y1_75	"Mar20,2012,01-05-48.smb"	1	354
Grid4_X2_150	"Mar20,2012,01-12-07.smb"	1	1125
Grid5_T0_75	"Mar20,2012,01-31-57.smb"	1	239
Grid5_T1_75	"Mar20,2012,01-36-44.smb"	1	382
Grid5_T2_75	"Mar20,2012,01-43-59.smb"	1	242
Grid5_T3_75	"Mar20,2012,01-49-25.smb"	1	482
Grid5_T4_75	"Mar20,2012,01-58-55.smb"	1	218
Grid5_T5_75	"Mar20,2012,02-04-45.smb"	1	552
Grid5_T6_75	"Mar20,2012,02-15-28.smb"	1	303
Grid5_T7_75	"Mar20,2012,02-21-54.smb"	1	986
Grid5_T8_75	"Mar20,2012,02-41-13.smb"	1	190
Grid5_X1_150	"Mar20,2012,02-45-06.smb"	1	1041
Grid5_Y1_75	"Mar20,2012,03-04-52.smb"	1	302
Grid5_X2_150	"Mar20,2012,03-16-38.smb"	1	2000
Grid5_X2_150_1	"Mar20,2012,03-16-38.smb"	2001	3233
Grid6_T0_75	"Mar20,2012,04-13-14.smb"	1	192
Grid6_T1_75	"Mar20,2012,04-17-30.smb"	1	992
Grid6_T2_75	"Mar20,2012,04-37-32.smb"	1	194
Grid6_T3_75	"Mar20,2012,04-42-39.smb"	1	1114
Grid6_T4_75	"Mar20,2012,05-07-55.smb"	1	225
Grid6_T5_75	"Mar20,2012,05-14-38.smb"	1	910
Grid6_T6_75	"Mar20,2012,05-31-34.smb"	1	239
Grid6_T7_75	"Mar20,2012,05-39-28.smb"	1	563
Grid6_T8_75	"Mar20,2012,05-55-50.smb"	1	250
Grid6_X1_150	"Mar20,2012,06-03-14.smb"	1	761
Grid6_Y1_75	"Mar20,2012,06-17-14.smb"	1	260
Grid6_X2_150	"Mar20,2012,06-24-48.smb"	1	1137
Grid7_T0_75	"Mar20,2012,06-44-41.smb"	1	216
Grid7_T1_75	"Mar20,2012,06-49-04.smb"	1	233
Grid7_T2_75	"Mar20,2012,06-53-48.smb"	1	218
Grid7_T3_75	"Mar20,2012,06-58-17.smb"	1	226
Grid7_T4_75	"Mar20,2012,07-03-04.smb"	1	231
Grid7_T5_75	"Mar20,2012,07-07-43.smb"	1	221
Grid7_T6_75	"Mar20,2012,07-12-26.smb"	1	253
Grid7_T7_75	"Mar20,2012,07-17-26.smb"	1	202
Grid7_T8_75	"Mar20,2012,07-22-05.smb"	1	275
Grid7_X1_150	"Mar20,2012,07-28-19.smb"	1	747
Grid7_Y1_75	"Mar20,2012,07-41-56.smb"	1	218
Grid7_X2_150	"Mar20,2012,07-46-56.smb"	1	1157
Grid8_T0_75	"Mar20,2012,08-07-38.smb"	1	358
Grid8_T1_75	"Mar20,2012,08-14-29.smb"	1	222

Grid8_T2_75	"Mar20,2012,08-19-38.smb"	1	514
Grid8_T3_75	"Mar20,2012,08-29-18.smb"	1	224
Grid8_T4_75	"Mar20,2012,08-34-49.smb"	1	592
Grid8_T5_75	"Mar20,2012,08-45-26.smb"	1	210
Grid8_T6_75	"Mar20,2012,08-50-41.smb"	1	725
Grid8_T7_75	"Mar20,2012,09-03-43.smb"	1	212
Grid8_T8_75	"Mar20,2012,09-09-11.smb"	1	799
Grid8_X1_150	"Mar20,2012,09-22-51.smb"	1	1041
Grid8_Y1_75	"Mar20,2012,09-41-39.smb"	1	231
Grid8_X2_150	"Mar20,2012,09-47-07.smb"	1	1431
Grid9_T0_75	"Mar20,2012,10-12-23.smb"	1	326
Grid9_T2_75	"Mar20,2012,10-23-14.smb"	1	425
Grid9_T3_75	"Mar20,2012,10-31-04.smb"	1	201
Grid9_T4_75	"Mar20,2012,10-35-58.smb"	1	446
Grid9_T5_75	"Mar20,2012,10-43-38.smb"	1	205
Grid9_T6_75	"Mar20,2012,10-48-34.smb"	1	500
Grid9_T7_75	"Mar20,2012,10-58-57.smb"	1	209
Grid9_T8_75	"Mar20,2012,11-02-43.smb"	1	503
Grid9_X1_150	"Mar20,2012,11-13-13.smb"	1	850
Grid9_Y1_75	"Mar20,2012,11-28-49.smb"	1	236
Grid9_X2_150	"Mar20,2012,11-33-07.smb"	1	1100
Grid10_T0_75	"Mar20,2012,11-53-15.smb"	1	275
Grid10_T1_75	"Mar20,2012,11-58-19.smb"	1	198
Grid10_T2_75	"Mar20,2012,12-02-32.smb"	1	270
Grid10_T3_75	"Mar20,2012,12-07-55.smb"	1	221
Grid10_T4_75	"Mar20,2012,12-12-24.smb"	1	291
Grid10_T5_75	"Mar20,2012,12-18-19.smb"	1	197
Grid10_T6_75	"Mar20,2012,12-22-34.smb"	1	293
Grid10_T7_75	"Mar20,2012,12-28-27.smb"	1	204
Grid10_T8_75	"Mar20,2012,12-33-13.smb"	1	283
Grid10_X1_150	"Mar20,2012,12-38-50.smb"	1	758
Grid10_Y1_75	"Mar20,2012,12-53-21.smb"	1	281
Grid10_X2_150	"Mar20,2012,12-58-31.smb"	1	1095
Grid11_T0_75	"Mar20,2012,13-17-12.smb"	1	268
Grid11_T1_75	"Mar20,2012,13-22-27.smb"	1	341
Grid11_T2_75	"Mar20,2012,13-30-14.smb"	1	256
Grid11_T3_75	"Mar20,2012,13-35-42.smb"	1	333
Grid11_T4_75	"Mar20,2012,13-43-04.smb"	1	260
Grid11_T5_75	"Mar20,2012,13-49-13.smb"	1	370
Grid11_T6_75	"Mar20,2012,14-00-36.smb"	1	39
Grid11_T7_75	"Mar20,2012,14-02-35.smb"	1	399
Grid11_T8_75	"Mar20,2012,14-10-03.smb"	1	239
Grid11_X1_150	"Mar20,2012,14-16-03.smb"	1	869
Grid11_Y1_75	"Mar20,2012,14-31-59.smb"	1	434
Grid11_X2_150	"Mar20,2012,14-40-07.smb"	1	1554
Grid12_T0_75	"Mar20,2012,15-07-43.smb"	1	195

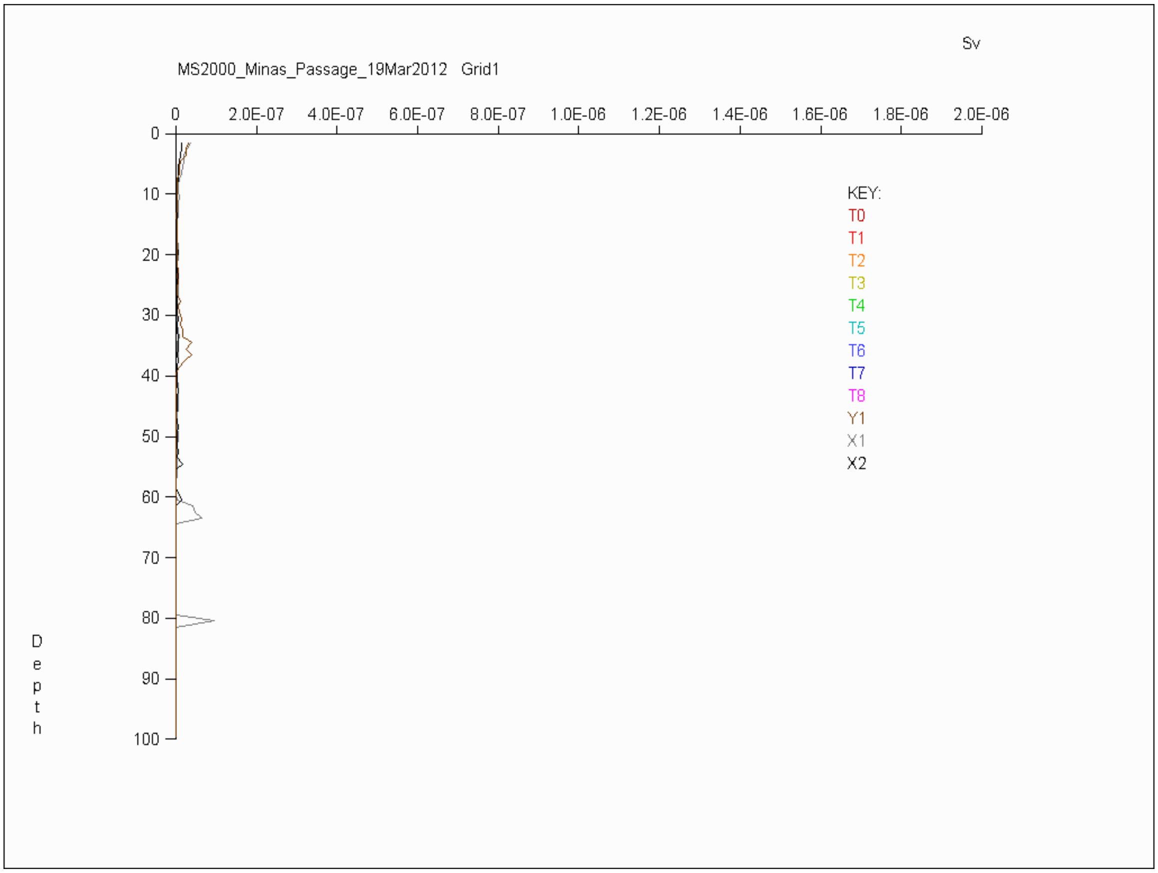
Grid12_T1_75	"Mar20,2012,15-14-11.smb"	1	1145
Grid12_T2_75	"Mar20,2012,15-34-41.smb"	1	190
Grid12_T3_75	"Mar20,2012,15-45-53.smb"	1	2858
Grid12_T4_75	"Mar20,2012,16-36-06.smb"	1	190
Grid12_T5_75	"Mar20,2012,16-44-42.smb"	1	2521
Grid12_T6_75	"Mar20,2012,17-28-09.smb"	1	173

8.3 *S_v* Profiles: 19 – 20 Mar. 2011

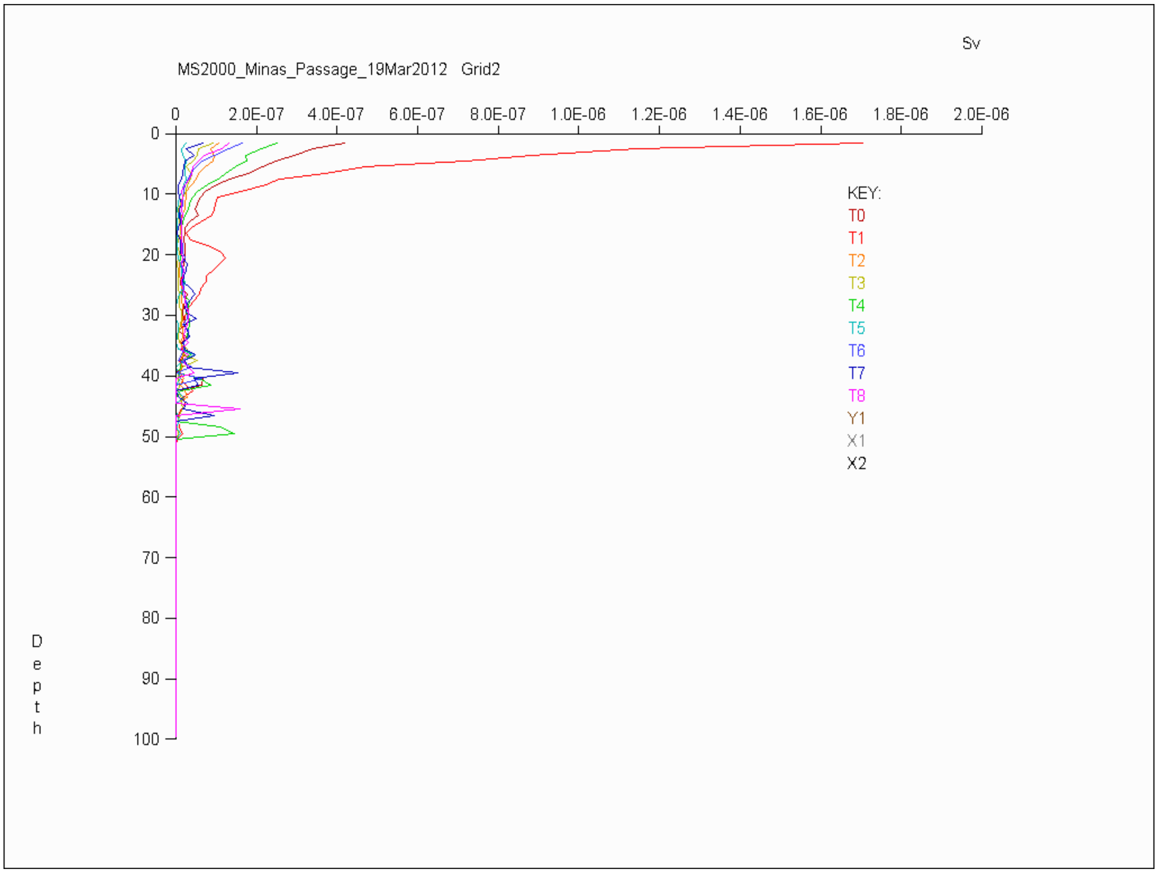


Relative *S_v* (linear) vs. depth (m) Grid 1, 19 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 1 Lines T0 to T8 were steamed from 11:23 to 12:10 ADT near the start of ebb flow cycle following HT (Cape Sharp) at 11:00 ADT.

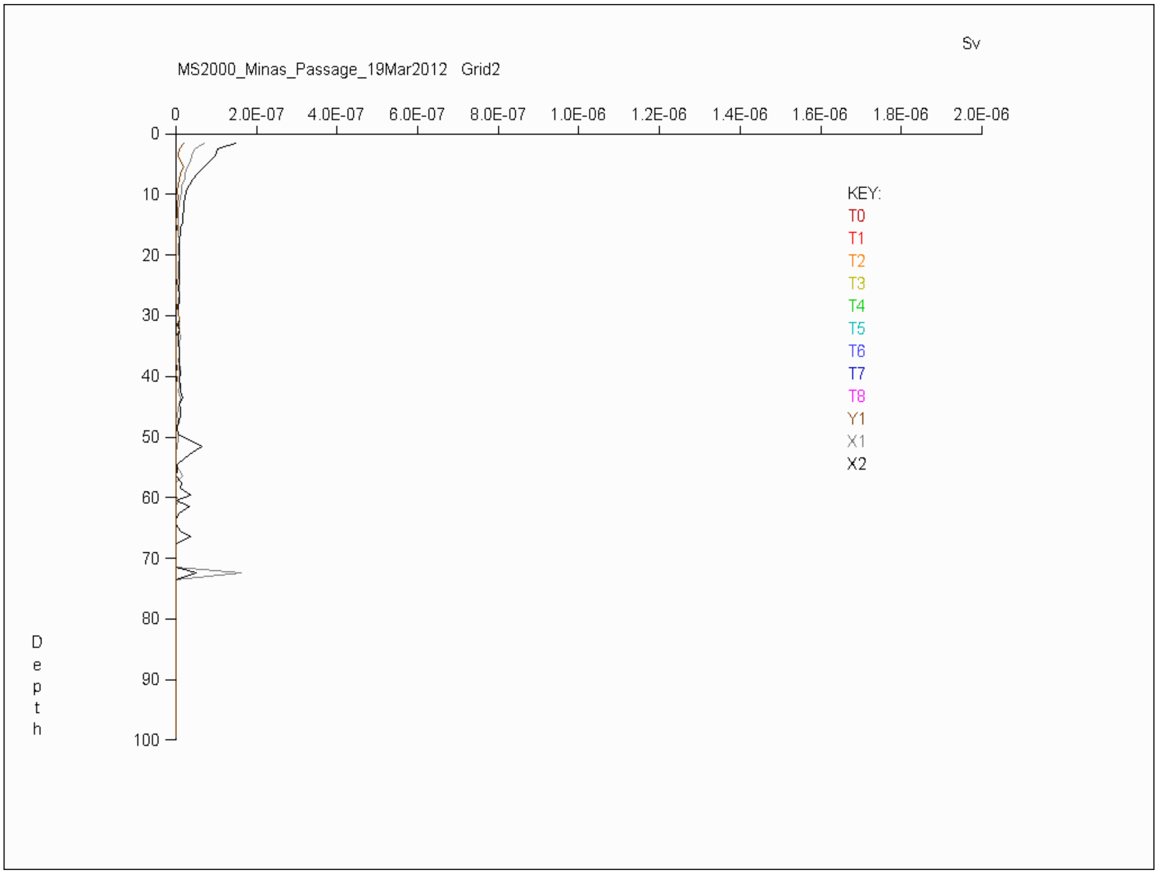


Lines X1, Y1 & X2 were steamed from 12:11 to 12:47 ADT on the rising portion of the ebb current with maximum nominal ebb flow (Cape Sharp) not occurring until 14:11 ADT. Visual inspection of fan sections indicated that the apparent increase in backscatter levels on Y1 at around 35 m depth probably arose from noise.

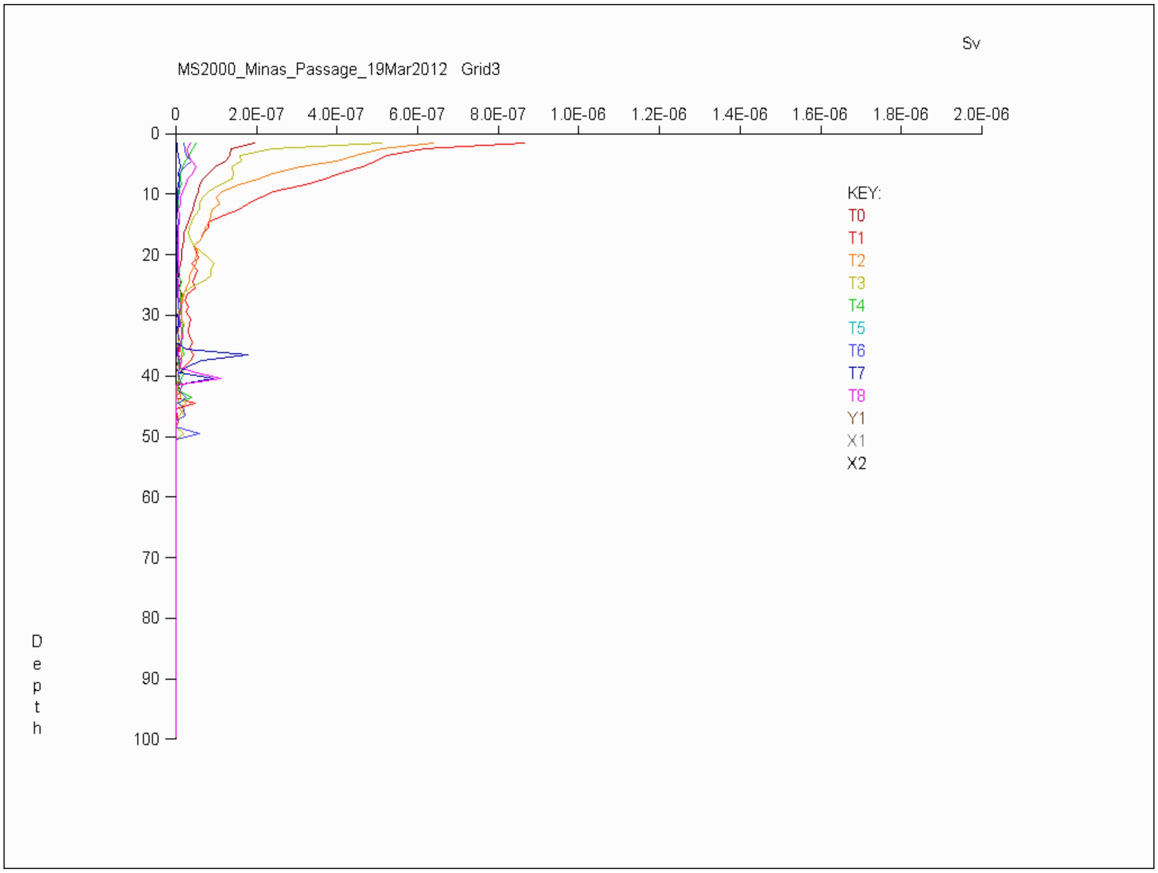


Relative S_v (linear) vs. depth (m) Grid 2, 19 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 2 Lines T0 to T8 were steamed from 12:48 to 14:04 ADT approaching maximum nominal ebb flow at 14:11 ADT. Did a fish burst occur on T1(?) – visual inspection of fan sections suggested that the enhanced backscatter from about 17 to 27 m depth arose from a convoluted extension to a surface bubble plume. Also note the absence of similar peaks in this depth range on adjacent profiles.

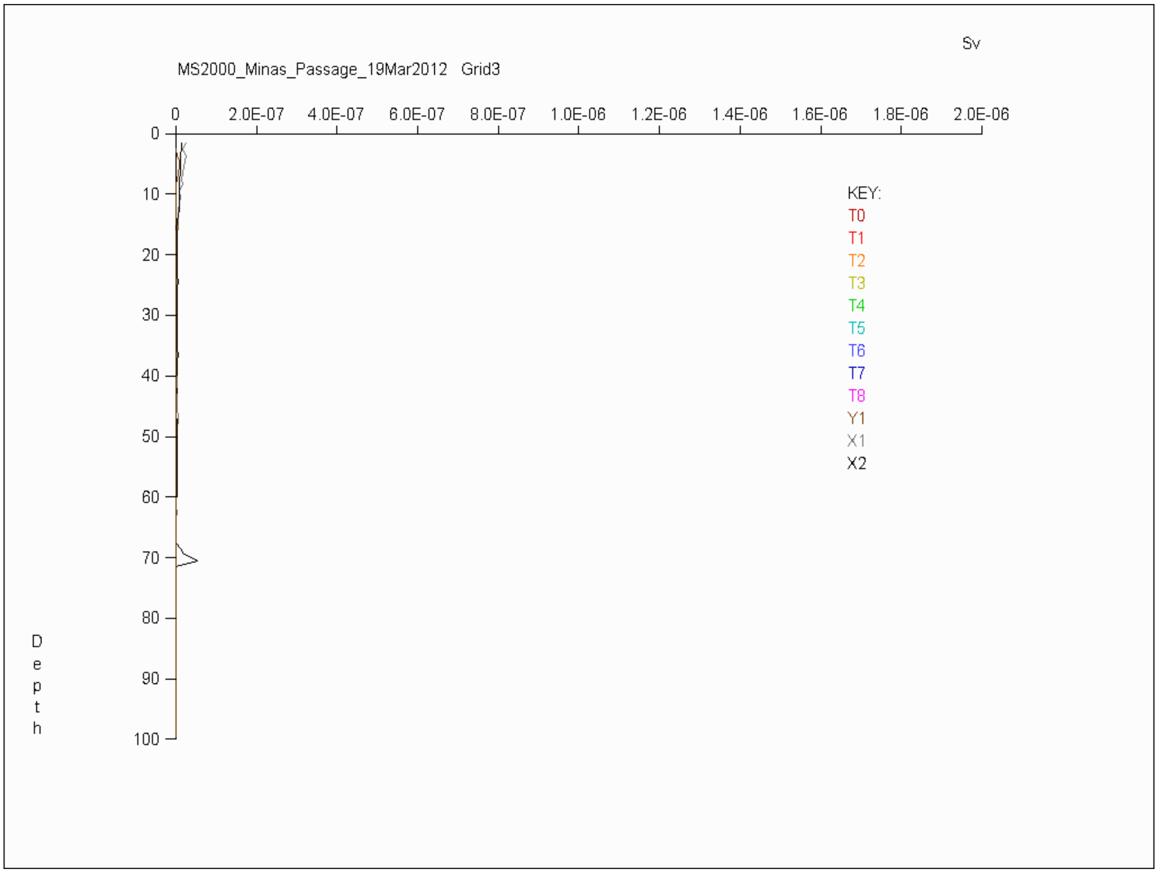


Lines X1, Y1 & X2 were steamed from 14:07 to 14:58 ADT around max nominal ebb flow (14:11 ADT). Note relative lack of indicators of plumes.

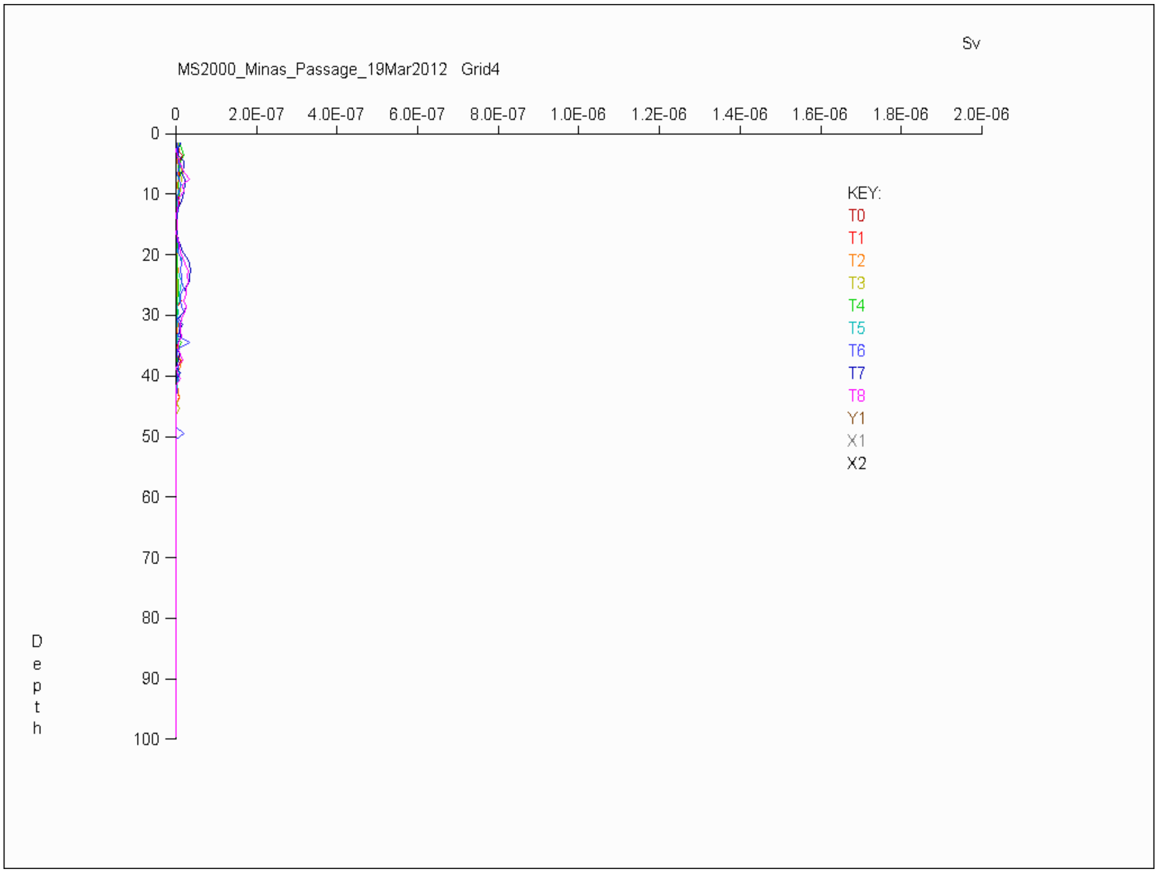


Relative S_v (linear) vs. depth (m) Grid 3, 19 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 3 Lines T0 to T8 were steamed from 14:59 to 16:07 ADT on the declining ebb flow. Nominal maximum ebb flow occurred at 14:11 ADT. No transect T5 was recorded due to a MS 2000 glitch.

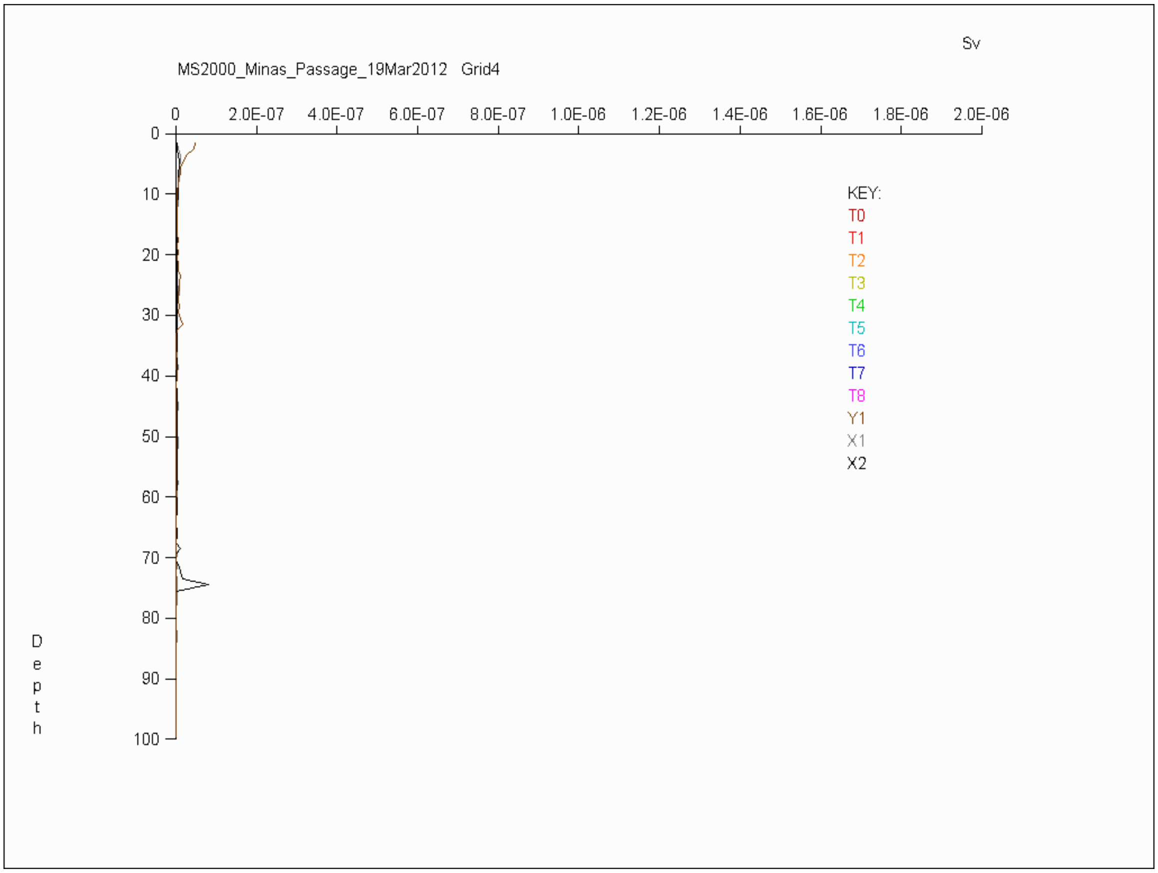


Lines X1, Y1 & X2 were steamed from 16:12 to 16:53 ADT. Lines were steamed on the declining portion of the ebb current approaching LT slack water at 17:22 ADT.

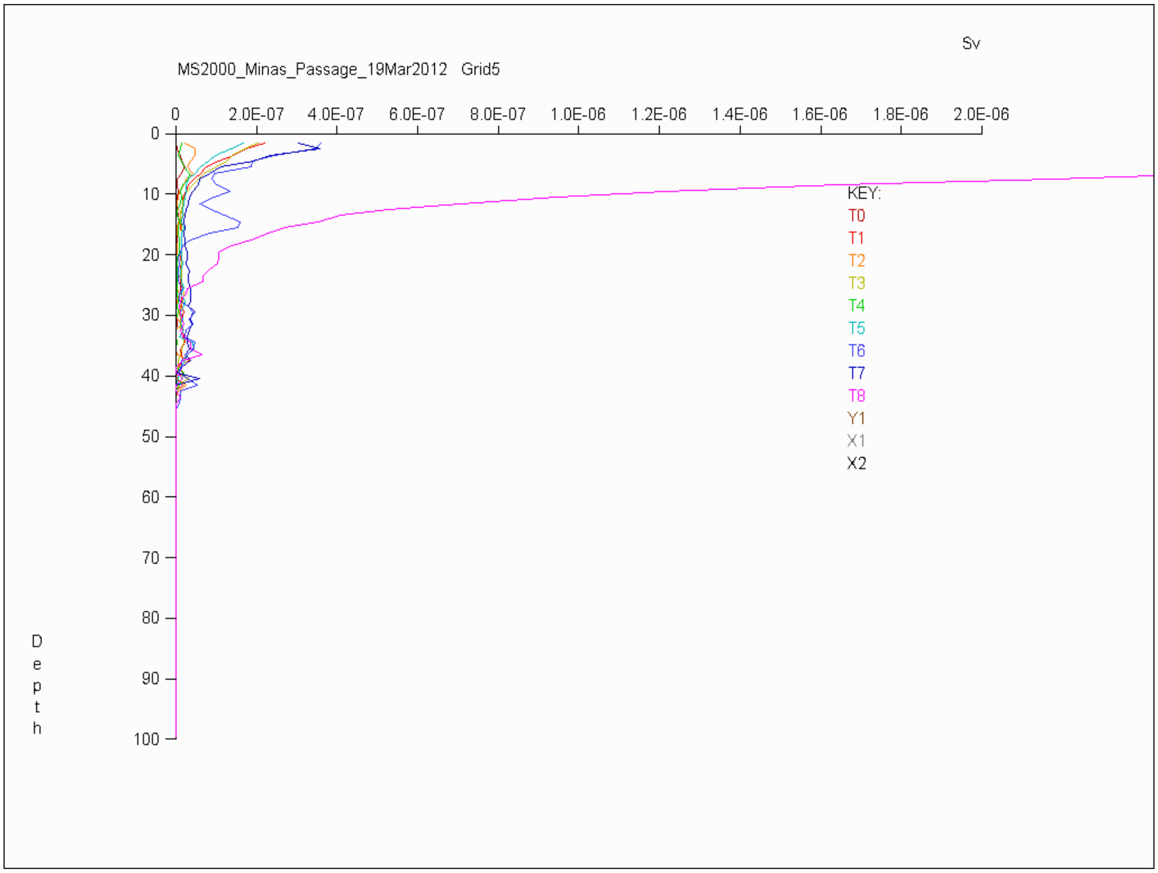


Relative S_v (linear) vs. depth (m) Grid 4, 19 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 4 Lines T0 to T8 were steamed from 16:54 to 17:49 ADT. LT (Cape sharp) occurred at 17:22 ADT so these lines were surveyed around low tide slack water. Visual inspection of fan sections T7 and T8 revealed a large number of weak fish echoes at good SNR between 17 and 30 m depth – these layers are real. It is also suggestive that a shallower layer from 4 to 12 m depth is also real but again quite weak.

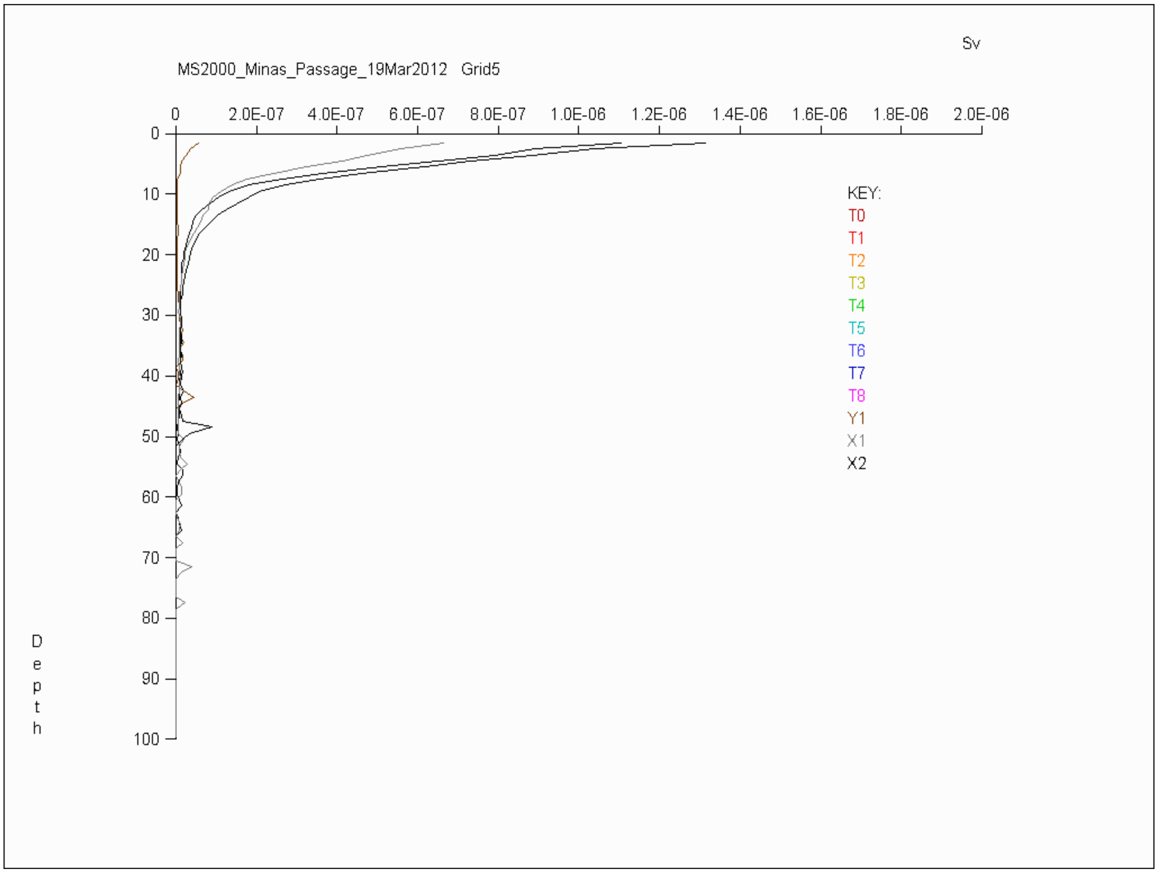


Lines X1, Y1 & X2 were steamed from 17:51 to 18:31 ADT. LT was at 17:22 ADT so these lines were surveyed on the early rising portion of the flood tide.



Relative S_v (linear) vs. depth (m) Grid 5, 19 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

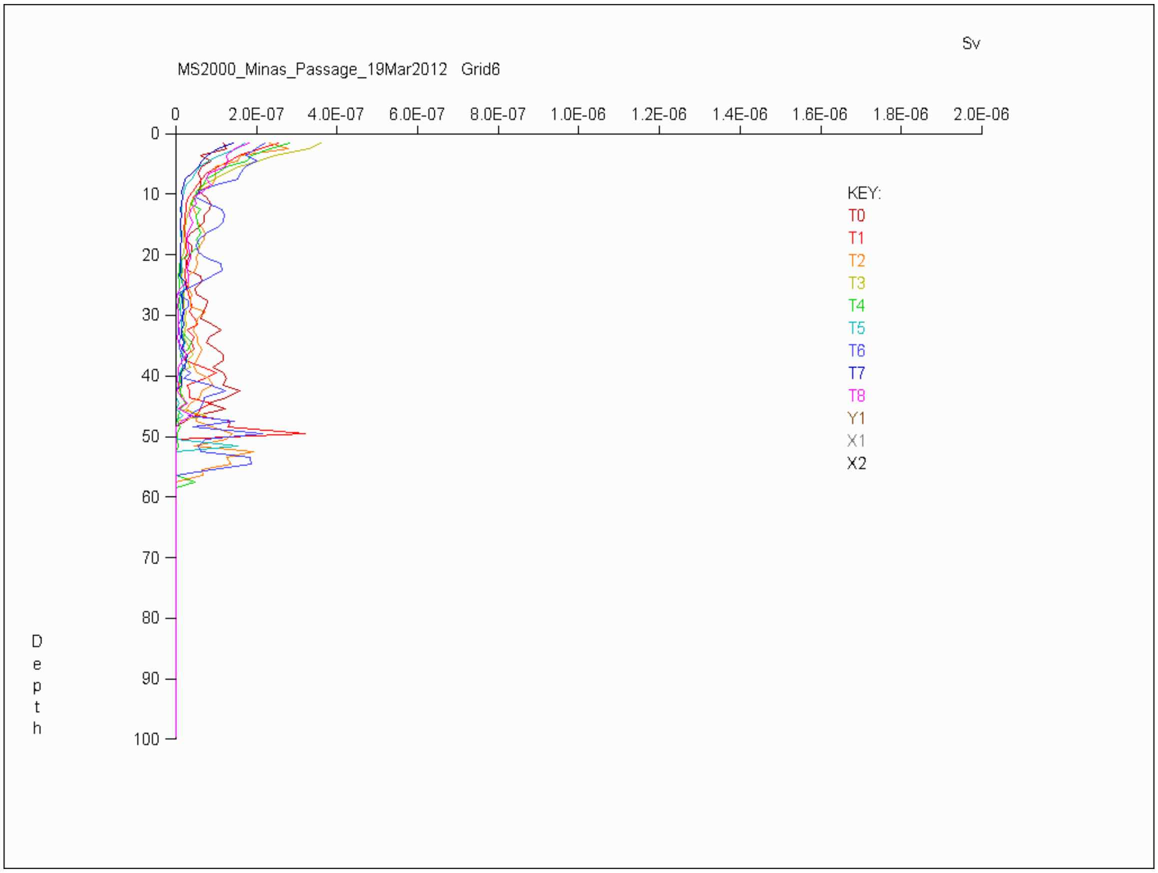
Grid 5 Lines T0 to T8 were steamed from 18:32 to 19:44 ADT approaching max flood current at 20:26 ADT. Plumes started-up about 2 hrs (or more) into flood cycle. Sunset occurred at 19:27 ADT on transect T7.



Lines X1, Y1 & X2 were steamed from 19:47 to 21:10 ADT. These profiles were steamed around nominal maximum flood current which was predicted for 20:26 ADT (Cape Sharp).

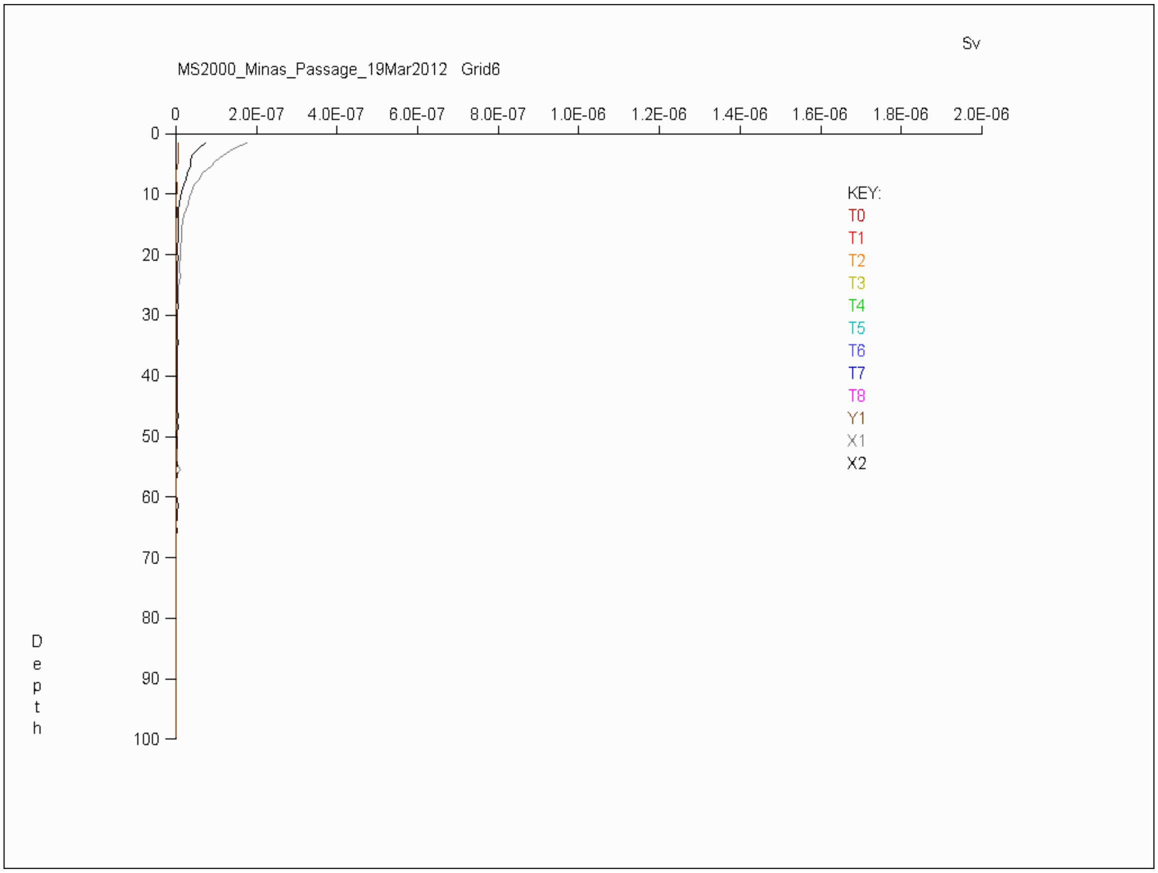
Line X2 was completed in 2 sections with considerable deviation from the nominal line due to high currents.

There is strong evidence of plume action into the deeper portions of the channel but Y1 along the southern coast appeared unaffected.

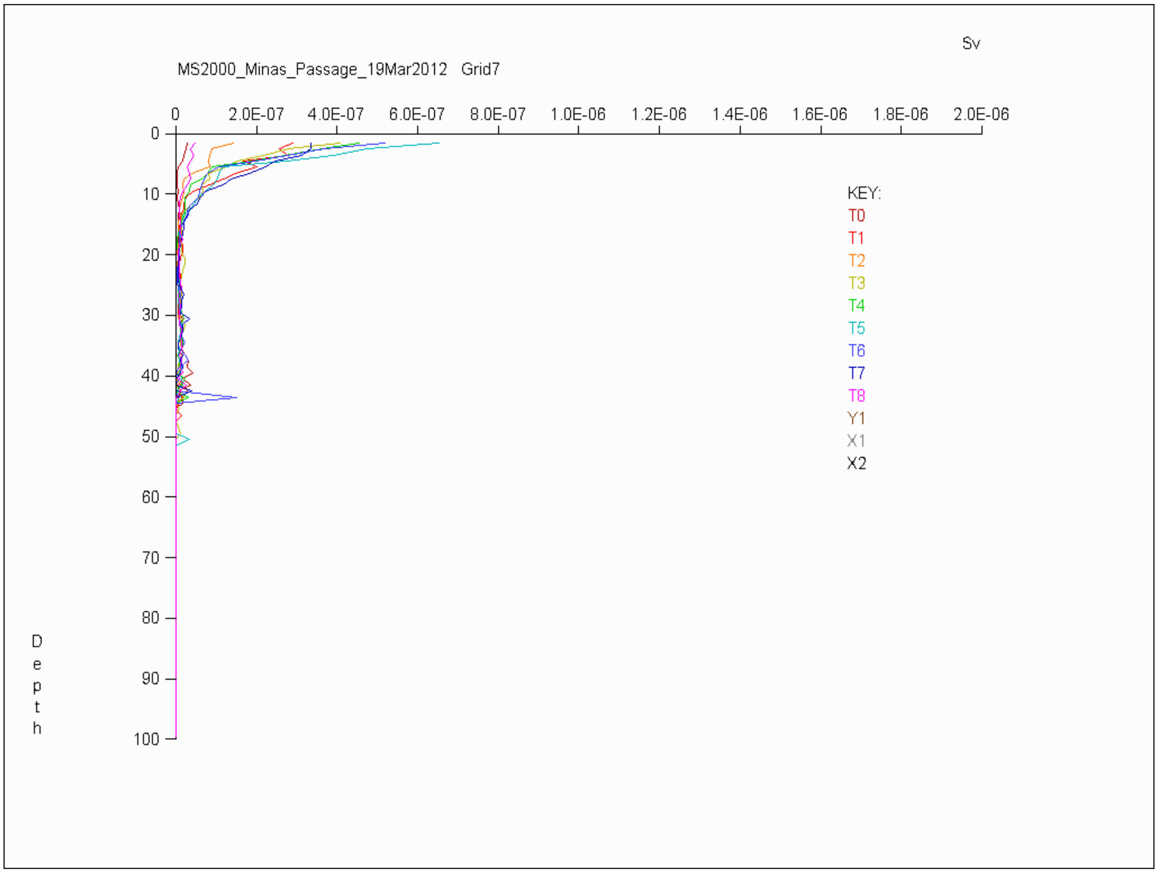


Relative S_v (linear) vs. depth (m) Grid 6, 19 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 6 Lines T0 to T8 were steamed from 21:14 to 23:00 ADT on the declining night flood tide (HT at 23:29 ADT). On the visual inspection of fan sections some fish were clearly present but it was not absolutely obvious that fish backscatter dominated over also present "spoke" noise in generating the "bumpy" character of the backscatter profiles in the 10 to 45 m depth range.

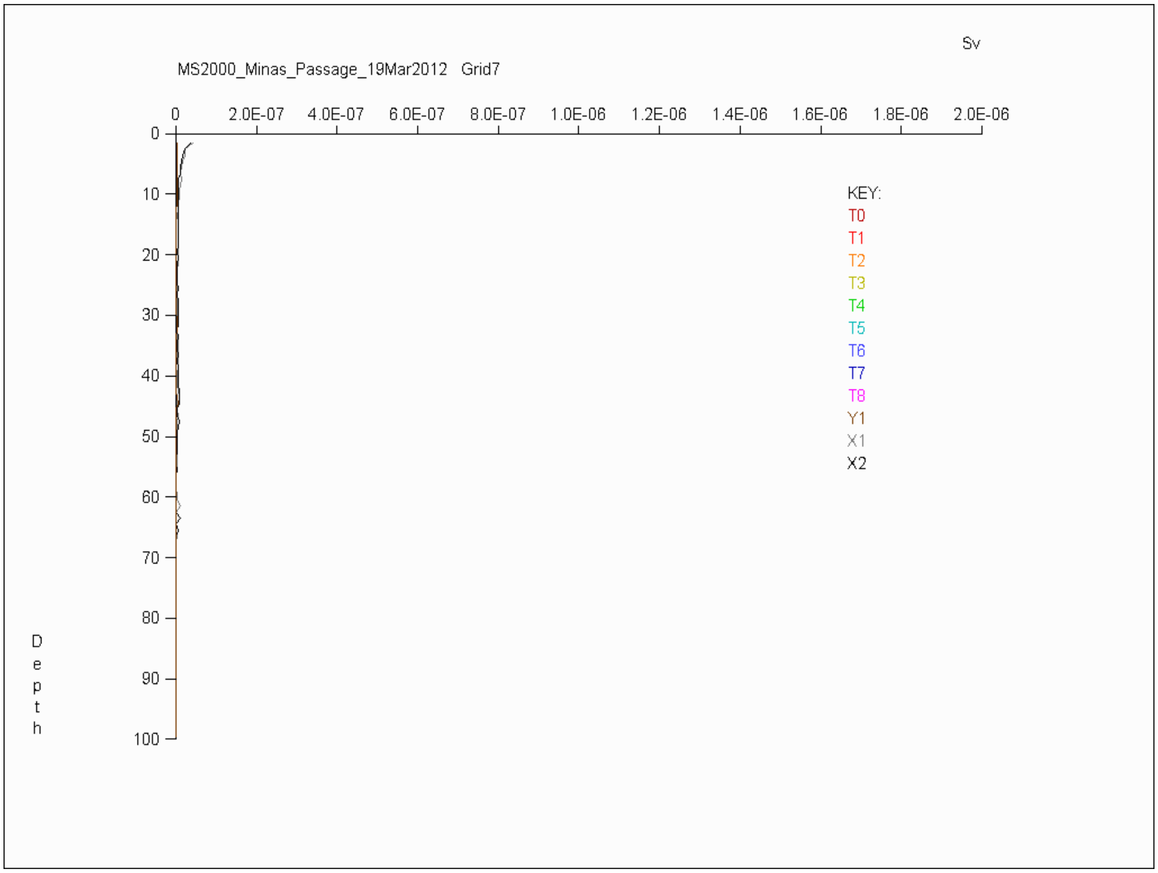


Lines X1, Y1 & X2 were steamed from 23:03 to 23:44 ADT around high tide slack water (HT at 23:29 ADT).

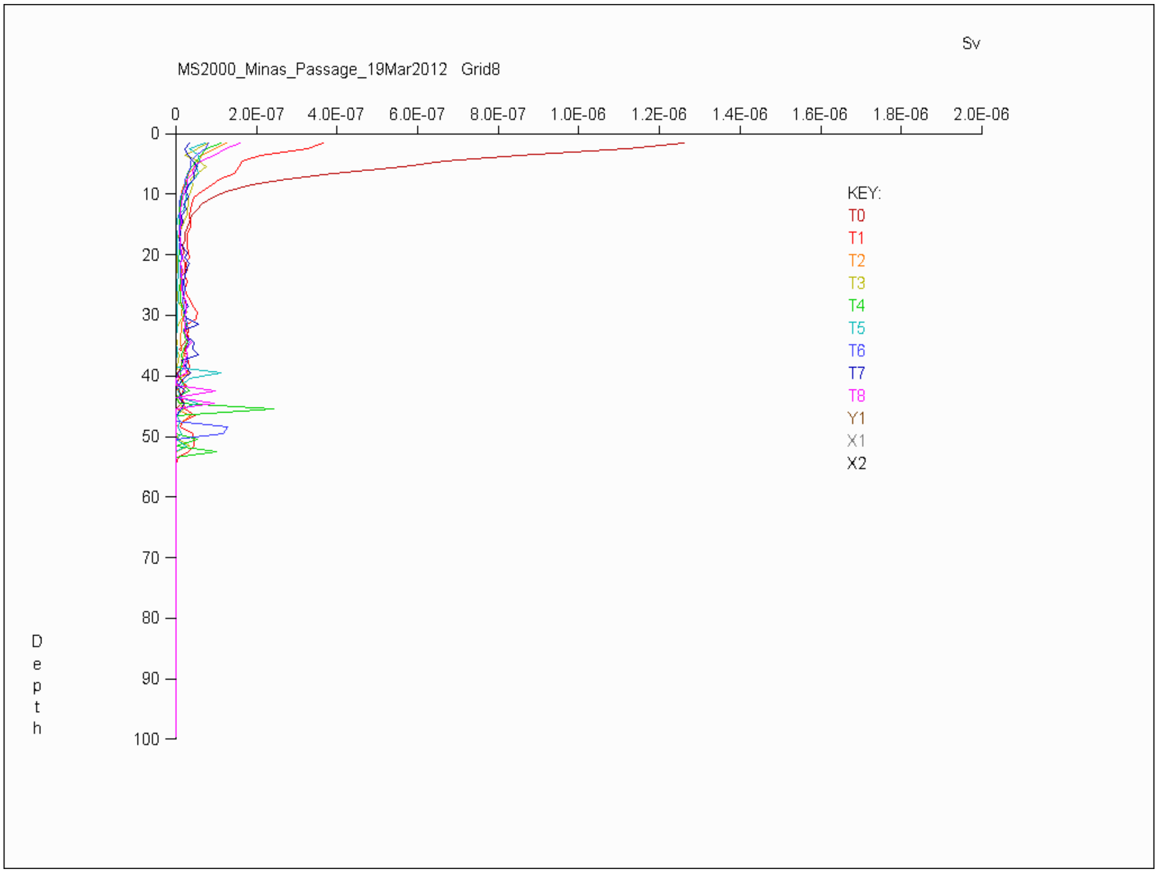


Relative S_v (linear) vs. depth (m) Grid 7, 19 - 20 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 7 Lines T0 to T8 were steamed from 23:45 to 00:27 ADT beginning just after the start of the ebb tide (HT at 23:29 ADT March 19th).

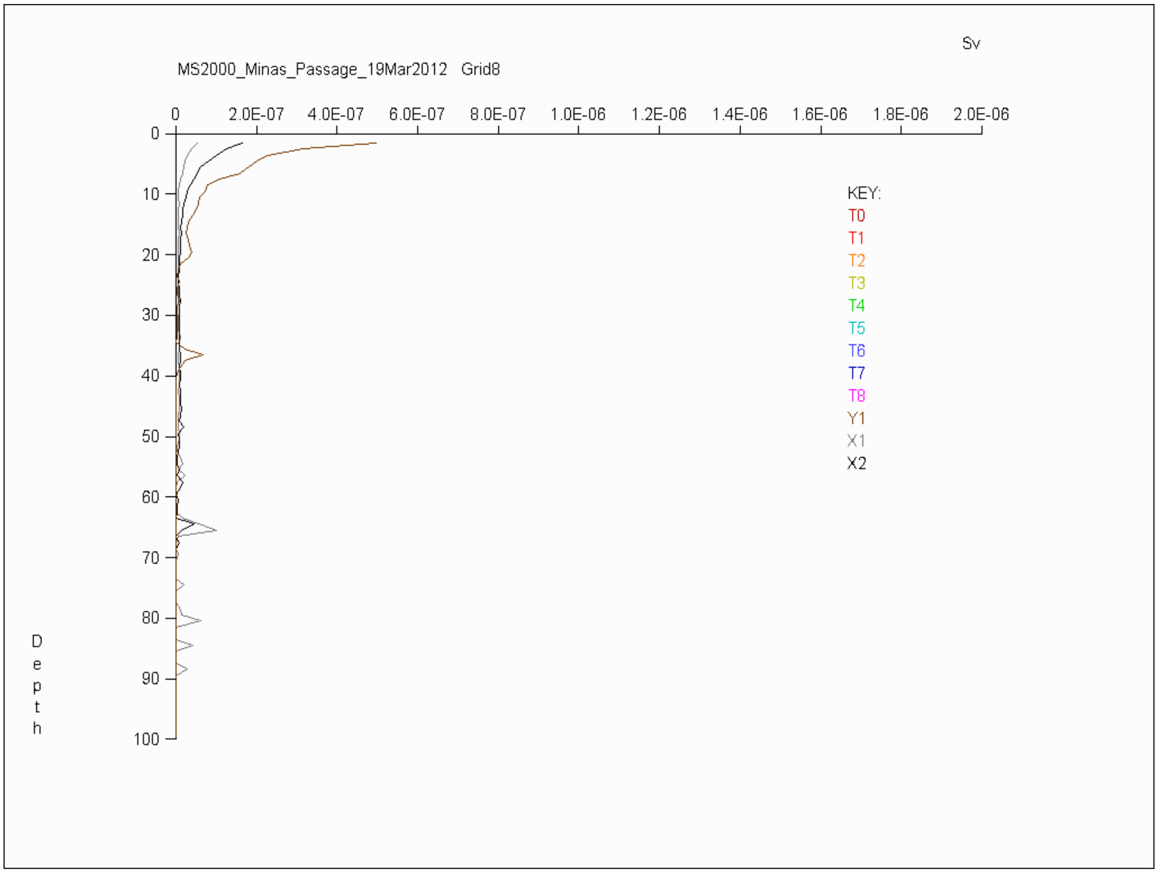


Lines X1, Y1 & X2 were steamed from 00:28 to 01:06 ADT on the rising portion of the ebb tide with maximum nominal ebb not occurring until 02:39 ADT.

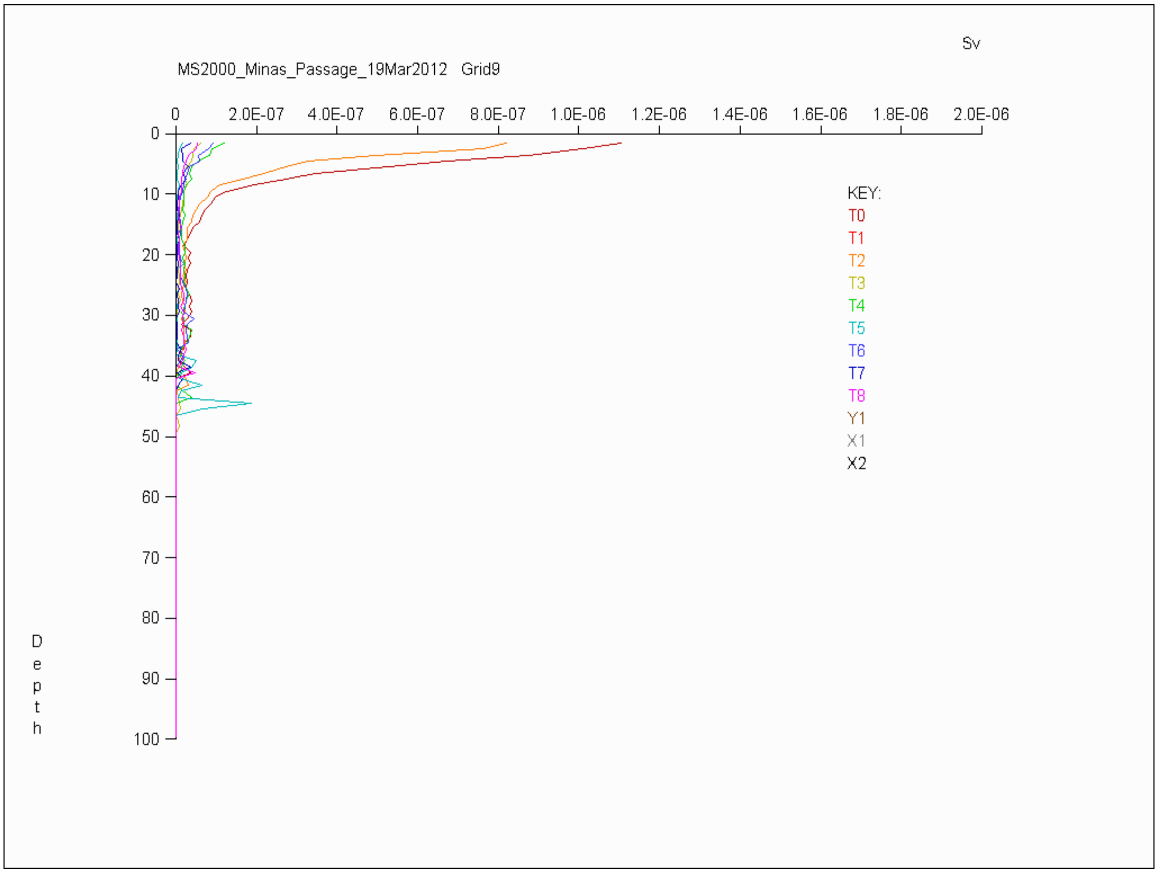


Relative S_v (linear) vs. depth (m) Grid 8, 20 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 8 Lines T0 to T8 were steamed from 01:08 to 02:22 ADT mainly on the rising portion of the ebb tide approaching maximum nominal ebb flow (02:39 ADT). Below 38 m depth, spikes appeared on the backscatter profiles, visual fan sections suggested a "spoke" noise origin.

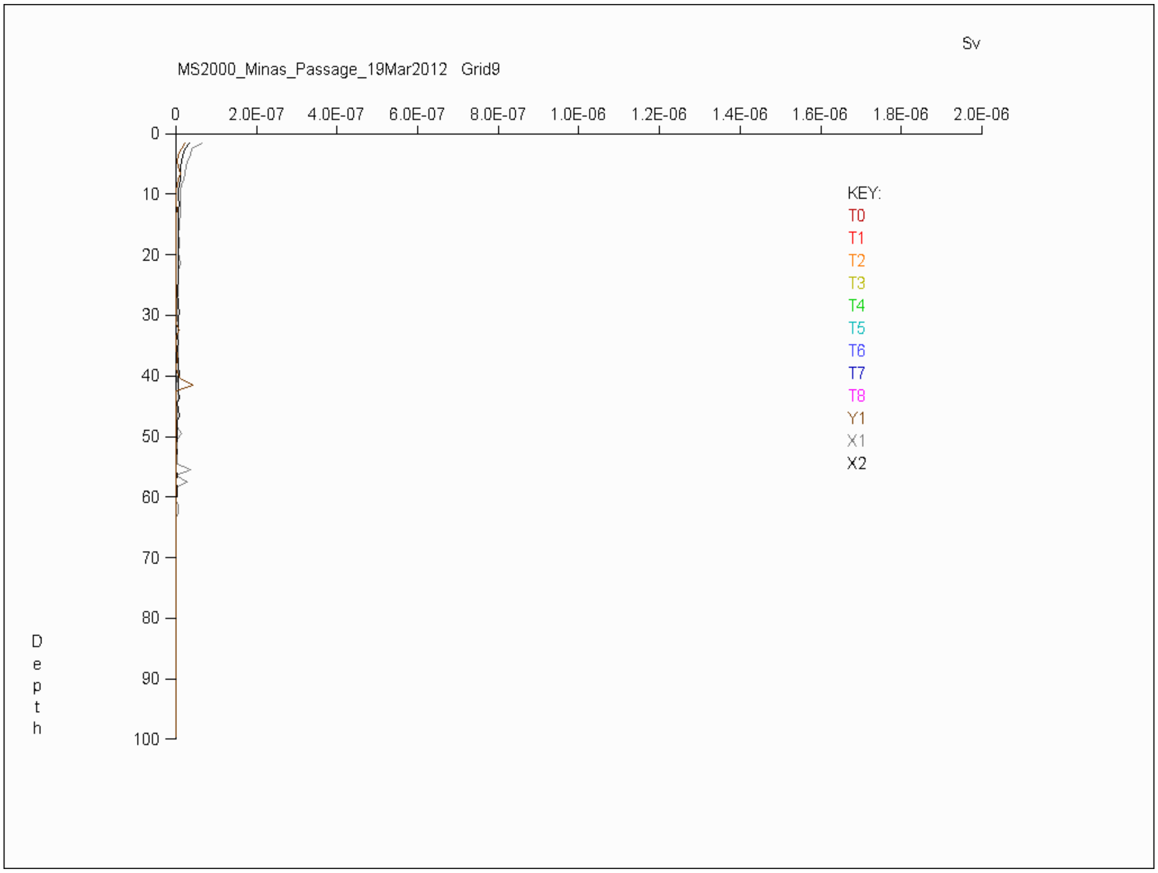


Lines X1, Y1 & X2 were steamed from 02:23 to 03:11 ADT through maximum nominal ebb flow at 02:39 ADT. Evidence for unusually strong plume action on south coast transect Y1.

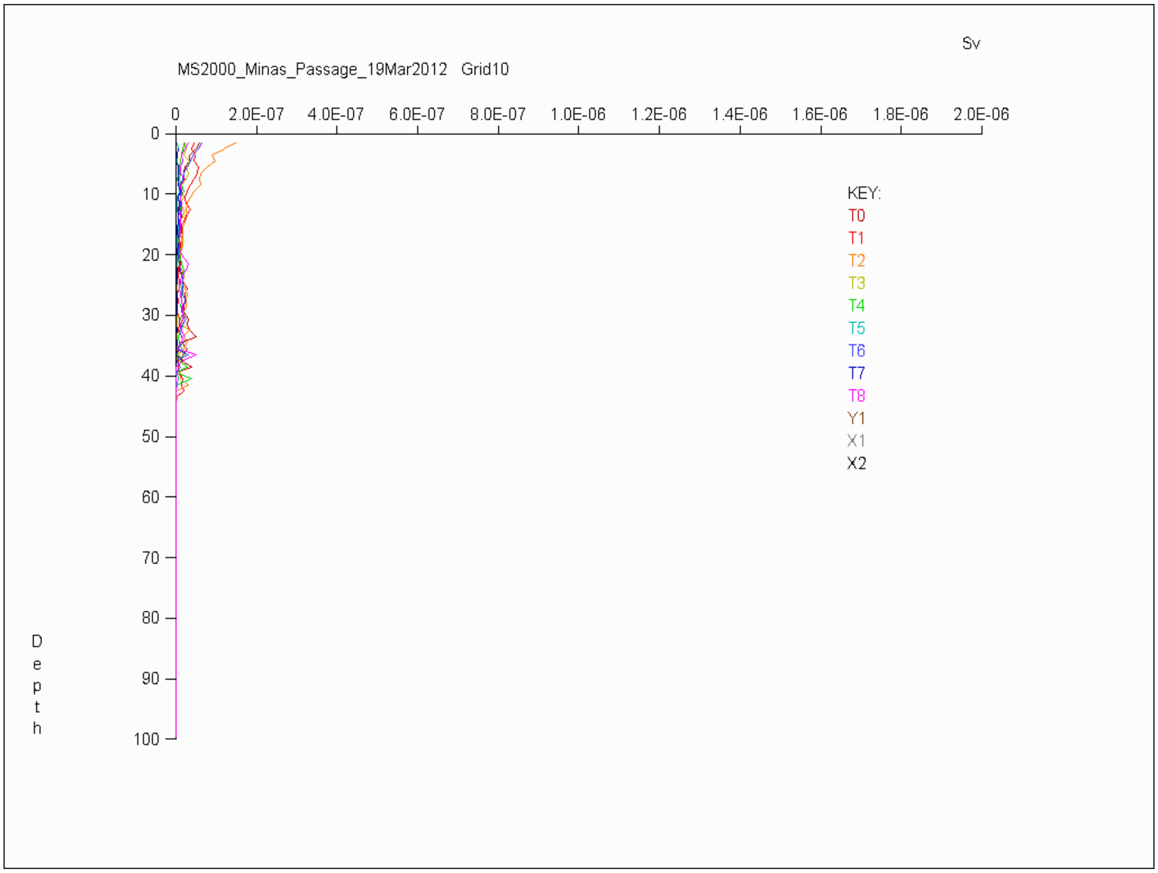


Relative S_v (linear) vs. depth (m) Grid 9, 20 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 9 Lines T0 to T8 were steamed from 03:12 to 04:13 ADT (20th March) on the declining portion of the ebb tide (HT at 23:29 ADT, LT at 05:48 ADT, and nominal maximum ebb flow at 02:39 ADT). Profile T1 is missing due to a MS 2000 glitch. Did plumes suddenly disappear or were they confined only to the innermost transects immediately downstream of Black Rock?

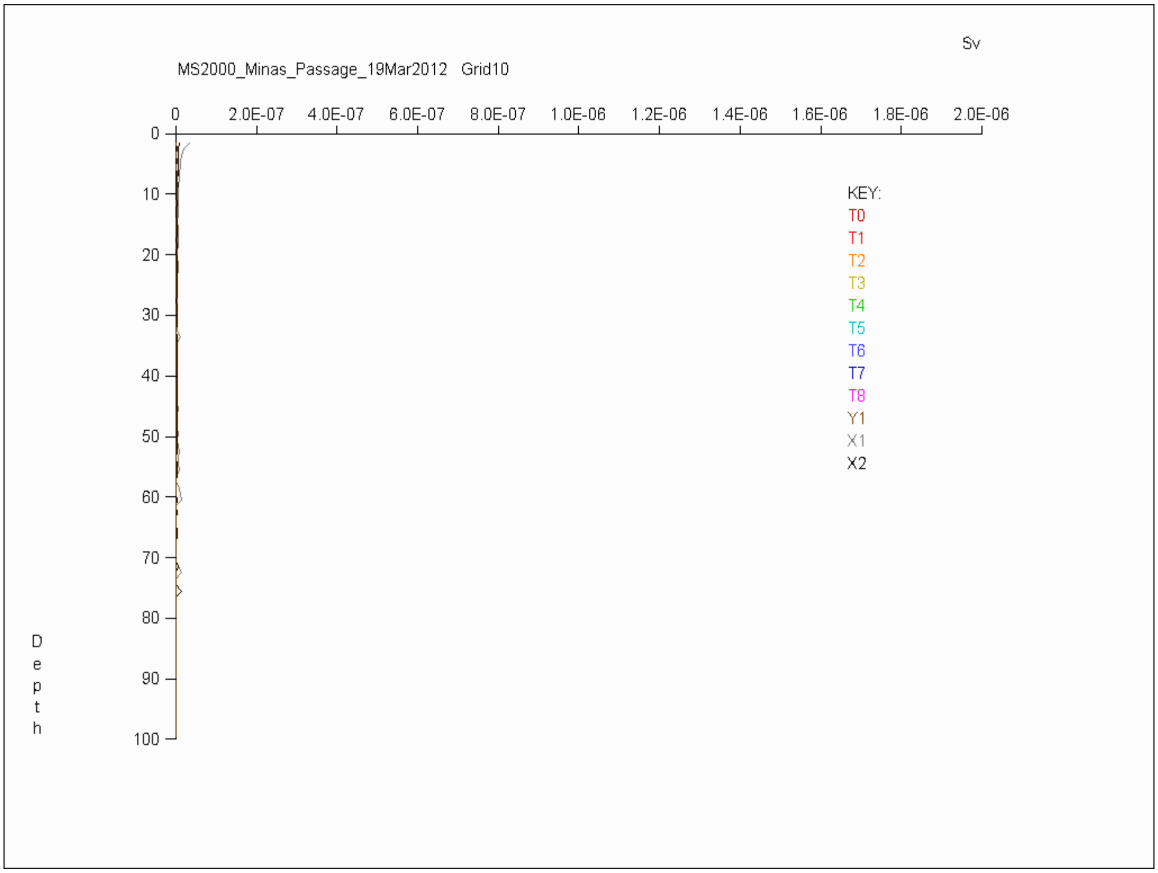


Lines X1, Y1 & X2 were steamed from 04:13 to 04:52 ADT on the declining portion of the ebb tide with LT (Cape Sharp) at 05:48 ADT.

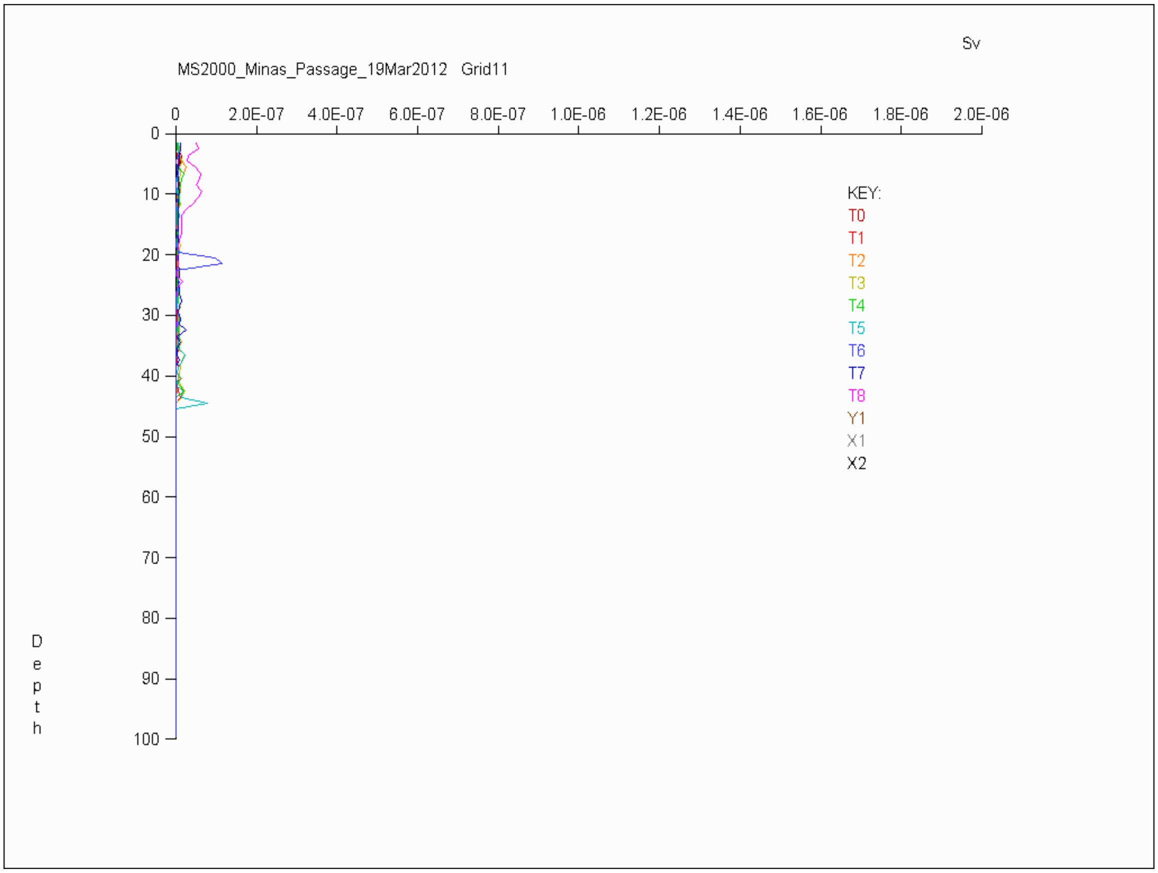


Relative S_v (linear) vs. depth (m) Grid 10, 20 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 10 Lines T0 to T8 were steamed from 04:53 to 05:38 ADT on the declining portion of the ebb flow extending almost to LT at 05:48 ADT.

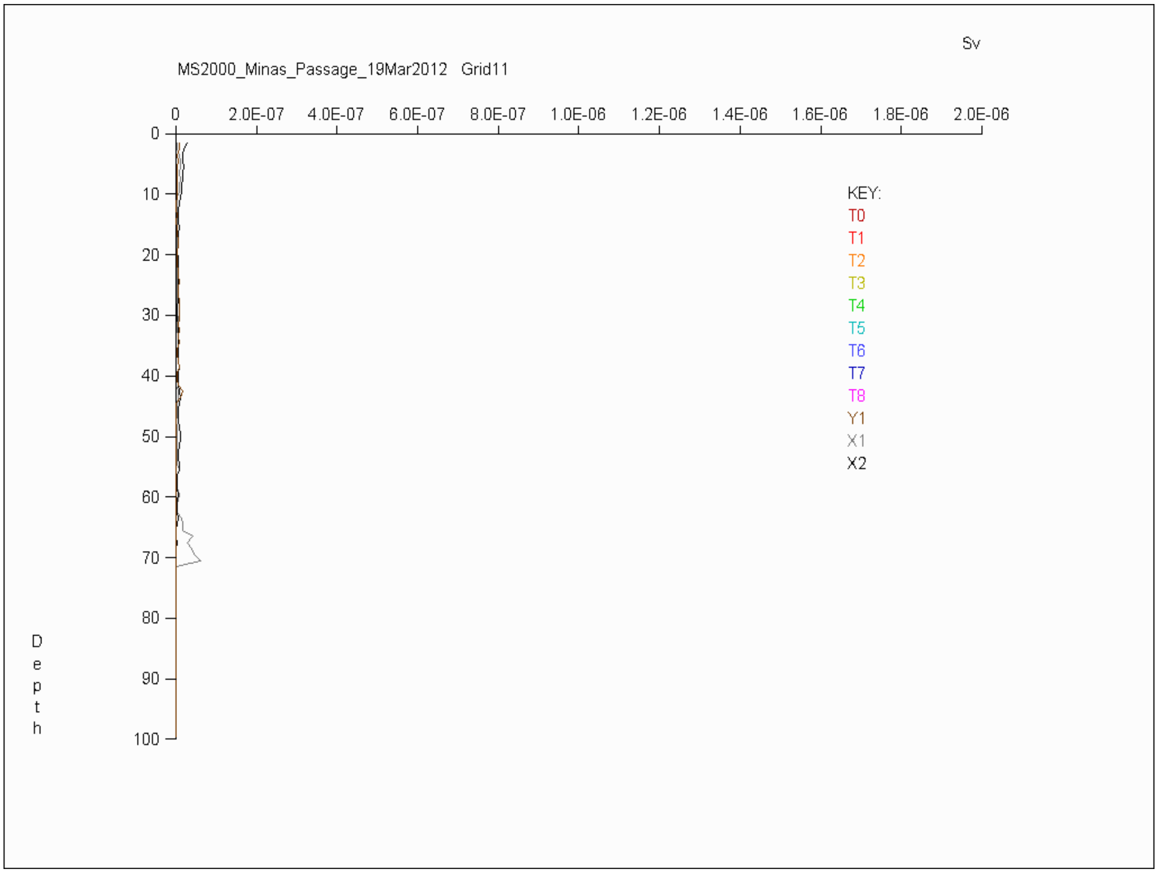


Lines X1, Y1 & X2 were steamed from 05:39 to 06:17 ADT around LT slack water at 05:48 ADT.

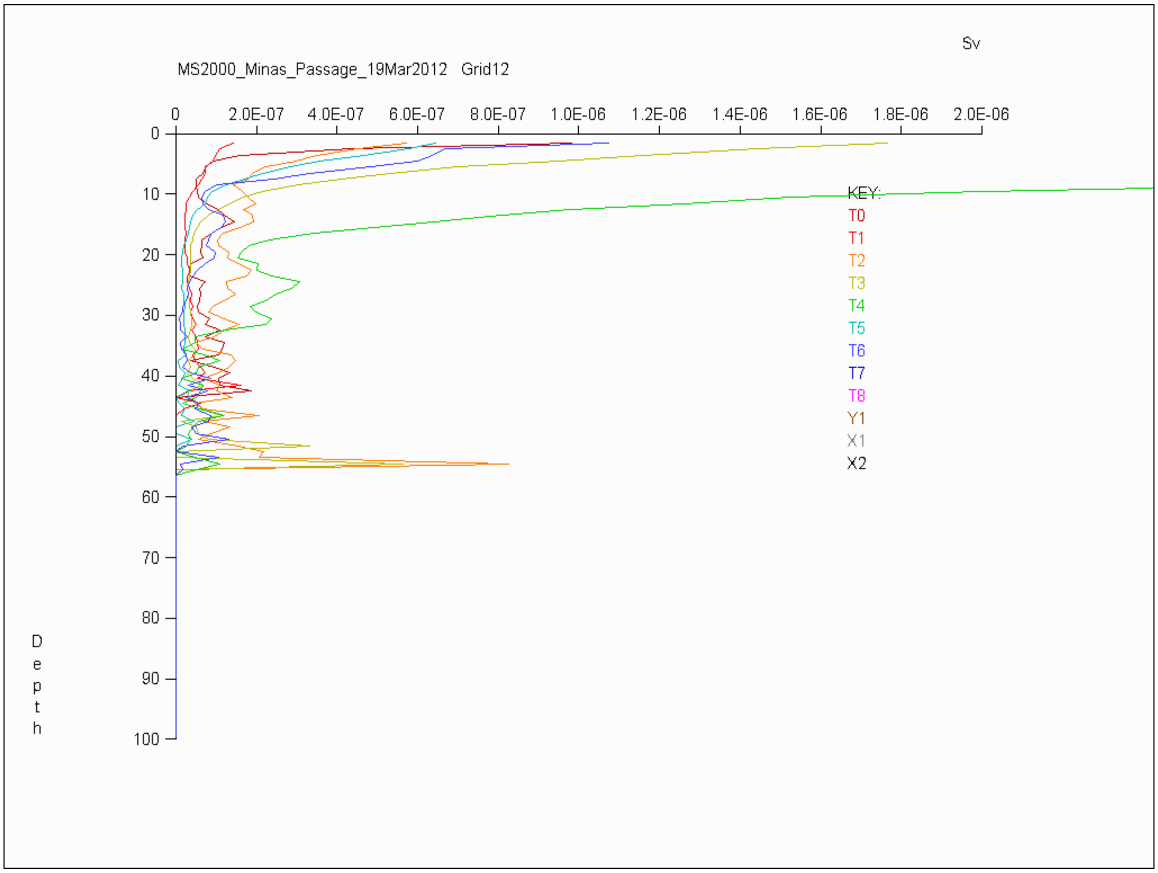


Relative S_v (linear) vs. depth (m) Grid 11, 20 March 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 11 Lines T0 to T8 were steamed from 06:18 to 07:14 ADT on the rising portion of the flood tide (LT at 05:48 ADT). Local sunrise occurred at 07:18 ADT (20th March). Line T6 was shortened due to MS 2000 glitch.



Lines X1, Y1 & X2 were steamed from 07:16 to 08:06 ADT on the rising portion of the flood cycle, approaching maximum nominal flood current at 08:51 ADT.



Relative S_v (linear) vs. depth (m) Grid 12, 20 March 2012 Minas Passage survey. Intensive grid lines T0 – T6 only.

Grid 12 Lines T0 to T6 were steamed from 08:08 to 10:33 ADT near maximum nominal flood current (08:51 ADT). LT was at 05:48 ADT and HT 11:54 at ADT. Lines T2 & T4 showed enhanced backscatter in the 20 – 35 m depth range. Visual inspection of fan sections revealed some fish but the enhanced backscatter probably arose from extended depth bubble plumes. On the odd numbered profiles the vessel essentially drifted with the high currents so backscatter from a single appropriately placed bubble plume could dominate the entire line recording. The survey finished at the end of transect T6.

9. DATASET: 31 MAY 2012

9.1 Analysis Parameters: 31 May 2012

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

Alpha Correction = 49.4 dB/km

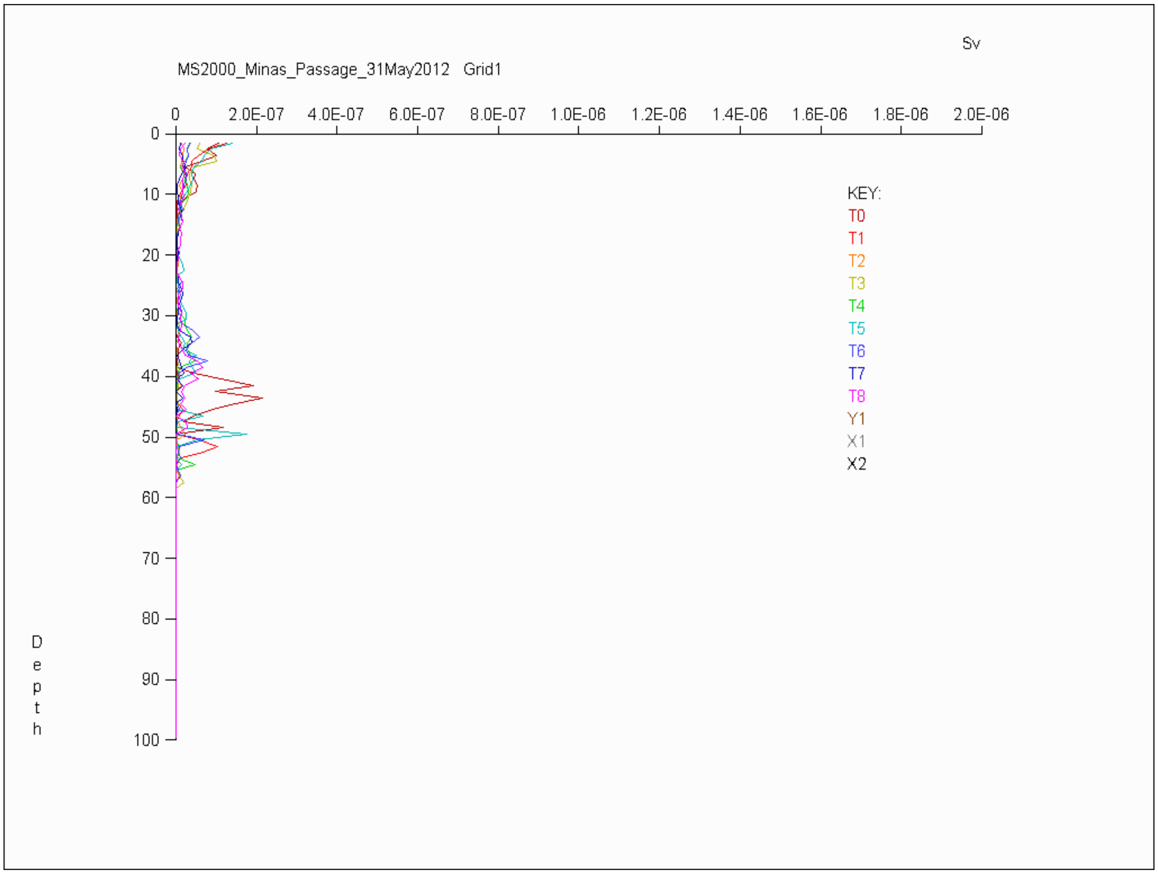
9.2 Lines: 31 May 2012

Format:

Grid_Line_Range_Sub-line	“Field Data File”	Start	End (Ping)
Grid1_T0_75	"May31,2012,16-08-13.smb"	1	268
Grid1_T1_75	"May31,2012,16-13-46.smb"	1	292
Grid1_T2_75	"May31,2012,16-19-49.smb"	1	277
Grid1_T3_75	"May31,2012,16-26-12.smb"	1	276
Grid1_T4_75	"May31,2012,16-33-05.smb"	1	296
Grid1_T5_75	"May31,2012,16-39-21.smb"	1	245
Grid1_T6_75	"May31,2012,16-44-47.smb"	1	366
Grid1_T7_75	"May31,2012,16-52-32.smb"	1	210
Grid1_T8_75	"May31,2012,16-57-53.smb"	1	564
Grid1_X1_150	"May31,2012,17-09-50.smb"	1	1057
Grid1_Y1_75	"May31,2012,17-30-31.smb"	1	205
Grid1_X2_150	"May31,2012,17-35-28.smb"	1	1690
Grid2_T0_75	"May31,2012,18-04-34.smb"	1	567
Grid2_T1_75	"May31,2012,18-15-49.smb"	1	175
Grid2_T2_75	"May31,2012,18-20-50.smb"	1	703
Grid2_T3_75	"May31,2012,18-33-41.smb"	1	211
Grid2_T4_75	"May31,2012,18-40-00.smb"	1	787
Grid2_T5_75	"May31,2012,18-56-52.smb"	1	209
Grid2_T6_75	"May31,2012,19-02-21.smb"	1	998
Grid2_T7_75	"May31,2012,19-20-58.smb"	1	236
Grid2_T8_75	"May31,2012,19-27-12.smb"	1	914
Grid2_X1_150	"May31,2012,19-43-44.smb"	1	931
Grid2_Y1_75	"May31,2012,20-00-05.smb"	1	234
Grid2_X2_150	"May31,2012,20-05-22.smb"	1	1257
Grid3_T0_75	"May31,2012,20-27-21.smb"	1	319
Grid3_T1_75	"May31,2012,20-33-24.smb"	1	236
Grid3_T2_75	"May31,2012,20-38-55.smb"	1	374
Grid3_T3_75	"May31,2012,20-54-53.smb"	1	226
Grid3_T4_75	"May31,2012,21-00-46.smb"	1	356
Grid3_T5_75	"May31,2012,21-07-53.smb"	1	218
Grid3_T6_75	"May31,2012,21-12-49.smb"	1	365
Grid3_T7_75	"May31,2012,21-19-58.smb"	1	228
Grid3_T8_75	"May31,2012,21-24-59.smb"	1	362
Grid3_X1_150	"May31,2012,21-31-53.smb"	1	814
Grid3_Y1_75	"May31,2012,21-46-11.smb"	1	252
Grid3_X2_75	"May31,2012,21-51-11.smb"	1	1142
Grid4_T0_75	"May31,2012,22-11-02.smb"	1	247
Grid4_T1_75	"May31,2012,22-16-05.smb"	1	271
Grid4_T2_75	"May31,2012,22-21-28.smb"	1	234

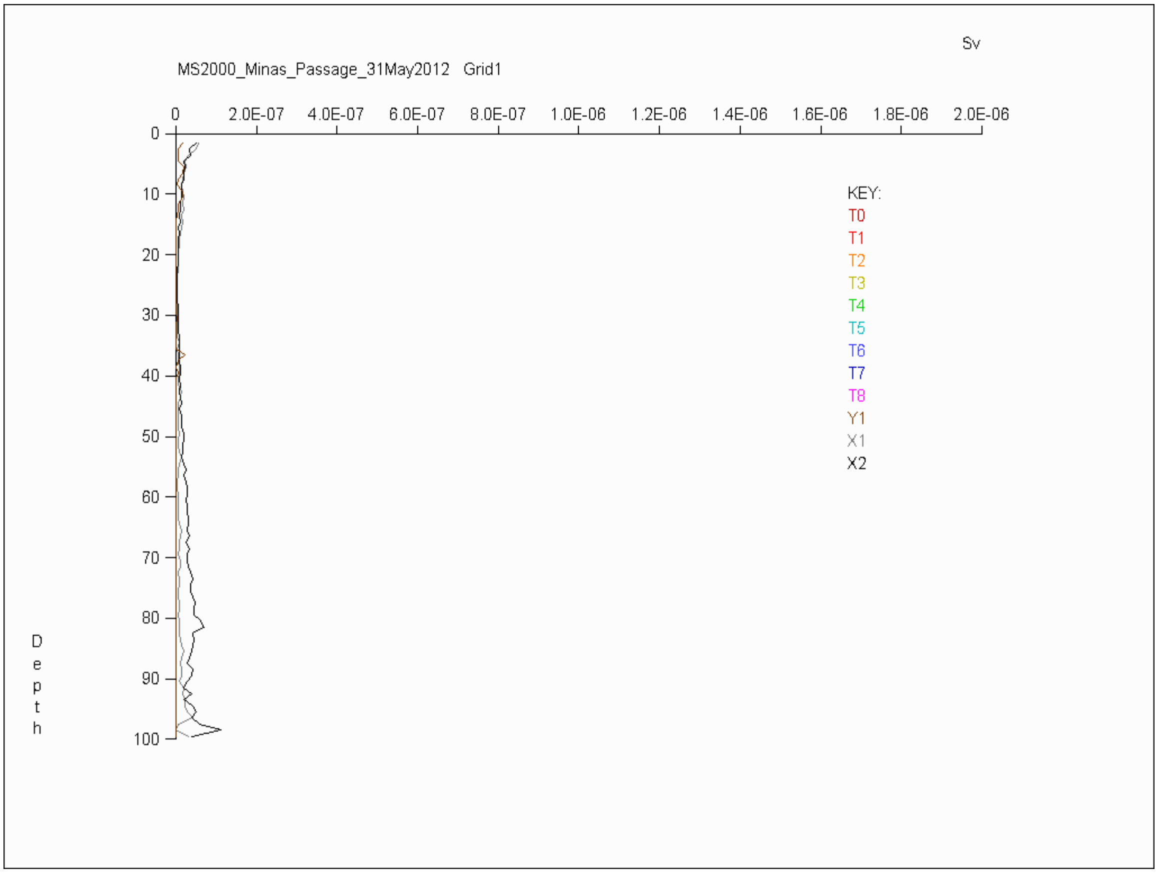
Grid4_T3_75	"May31,2012,22-26-04.smb"	1	268
Grid4_T4_75	"May31,2012,22-31-43.smb"	1	221
Grid4_T5_75	"May31,2012,22-36-23.smb"	1	280
Grid4_T6_75	"May31,2012,22-41-55.smb"	1	228
Grid4_T7_75	"May31,2012,22-46-39.smb"	1	281
Grid4_T8_75	"May31,2012,22-52-17.smb"	1	221
Grid4_X1_150	"May31,2012,22-58-53.smb"	1	1364
Grid4_Y1_75	"May31,2012,23-25-56.smb"	1	458
Grid4_X2_150	"May31,2012,23-35-01.smb"	1	1731
Grid5_T0_75	"Jun01,2012,00-04-37.smb"	1	285
Grid5_T1_75	"Jun01,2012,00-11-24.smb"	1	781
Grid5_T2_75	"Jun01,2012,00-27-07.smb"	1	221
Grid5_T3_75	"Jun01,2012,00-33-30.smb"	1	1619
Grid5_T4_75	"Jun01,2012,01-03-53.smb"	1	213
Grid5_T5_75	"Jun01,2012,01-16-26.smb"	1	3314
Grid5_T6_75	"Jun01,2012,02-12-59.smb"	1	216
Grid5_T7_75	"Jun01,2012,02-20-12.smb"	1	2059
Grid5_T8_75	"Jun01,2012,03-08-17.smb"	1	232

9.3 S_v Profiles: 31 May 2012

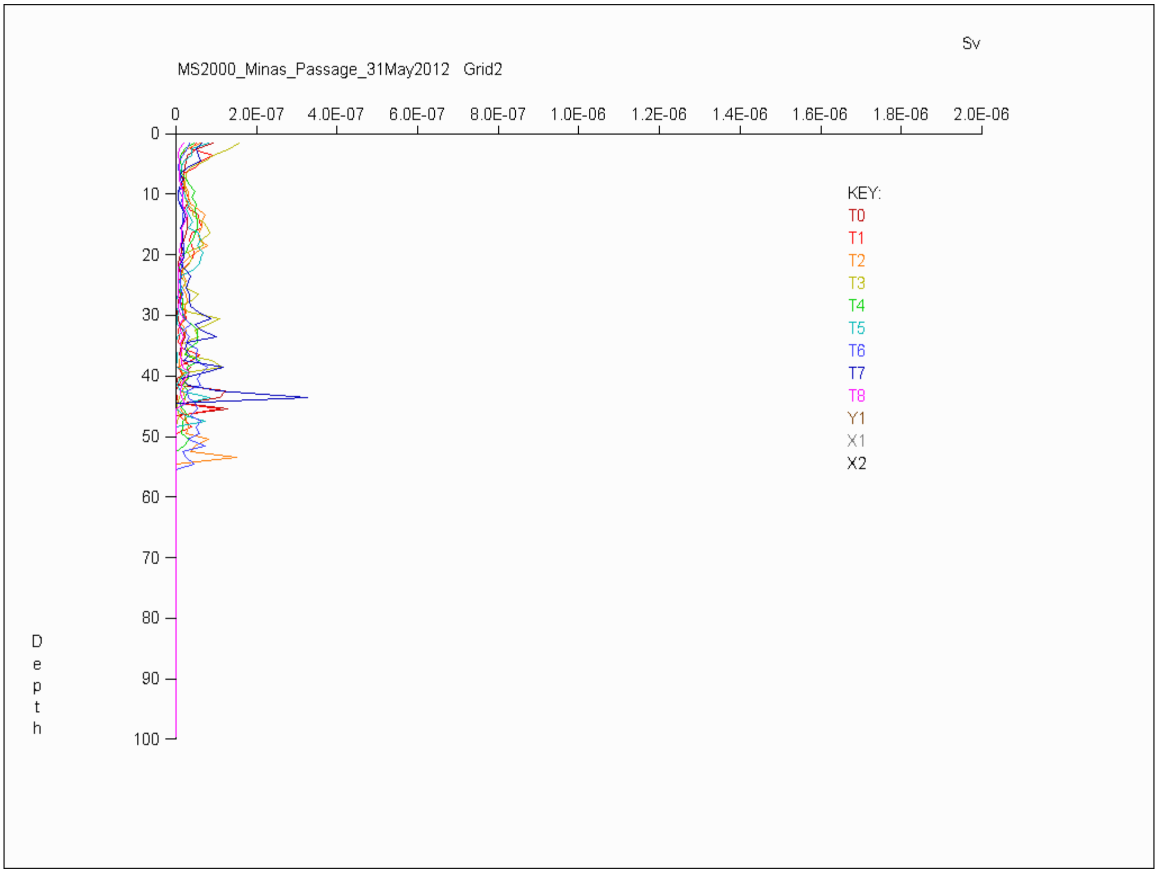


Relative S_v (linear) vs. depth (m) Grid 1, 31 May 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 1 Profiles T0 to T8 were steamed from 09:07 to 10:08 ADT through HT slack water (occurring on line T4 at 09:34 ADT). Fish were noted in the lower 10 – 20 m of the water column. Visual inspection of fan sections show compact, intensely scattering fish schools near bottom which may well explain the peak in T0 backscatter in the 40 – 48 m depth range and perhaps the peaks observed on profiles T1 and T5 around 50 m depth.

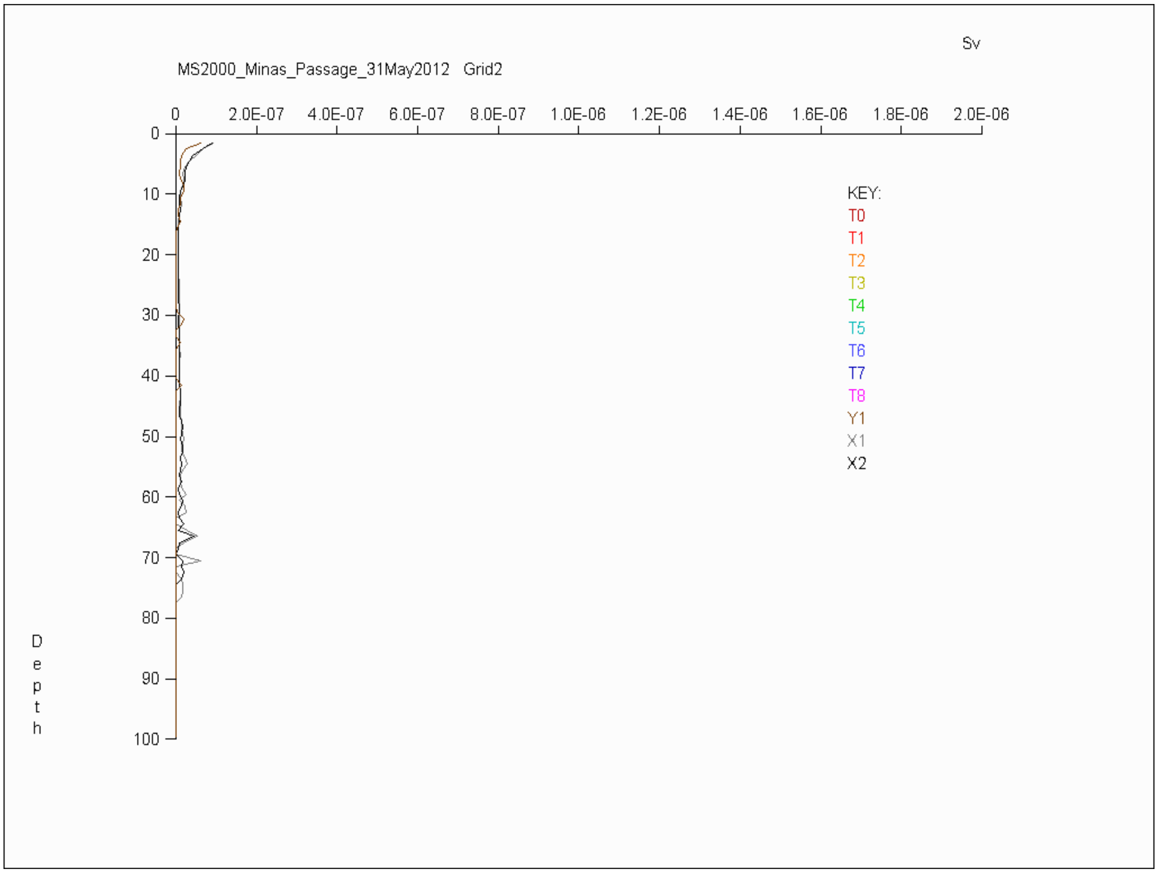


Profiles X1, Y1 & X2 were steamed from 10:10 to 11:03 ADT on the increasing ebb flow (Cape Sharp HT occurred at 09:34 ADT). Visual inspection of fan sections revealed that the apparent increased backscatter on X2 from about 50 to 90 m depth arose from especially intense "spoke" noise producing fish-like echoes in preferred angular directions but without any degree of ping-to-ping continuity which should characterize legitimate fish echoes at long ranges.

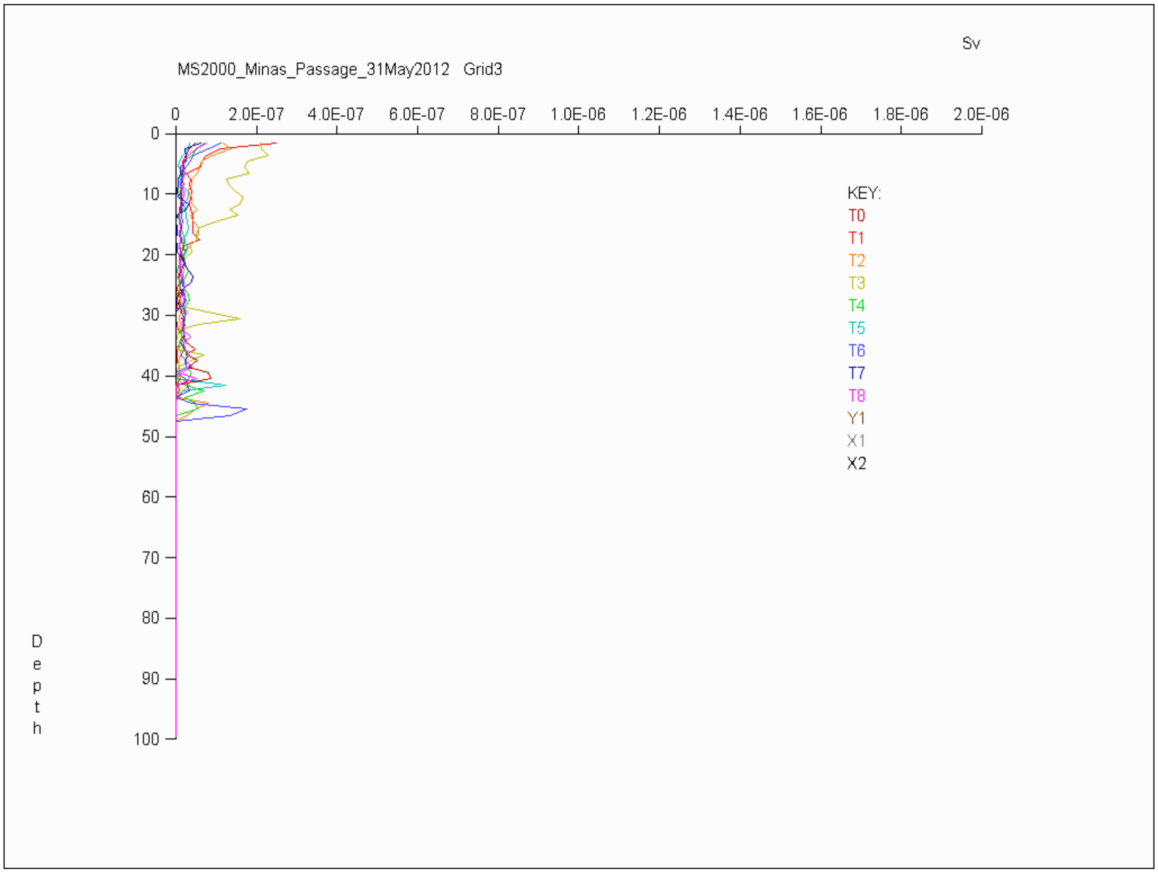


Relative S_v (linear) vs. depth (m) Grid 2, 31 May 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 2 Profiles T0 to T8 were steamed from 11:05 to 12:42 ADT on the rising ebb flow. Maximum nominal ebb flow occurred at 12:39 ADT near the end of transect T8.

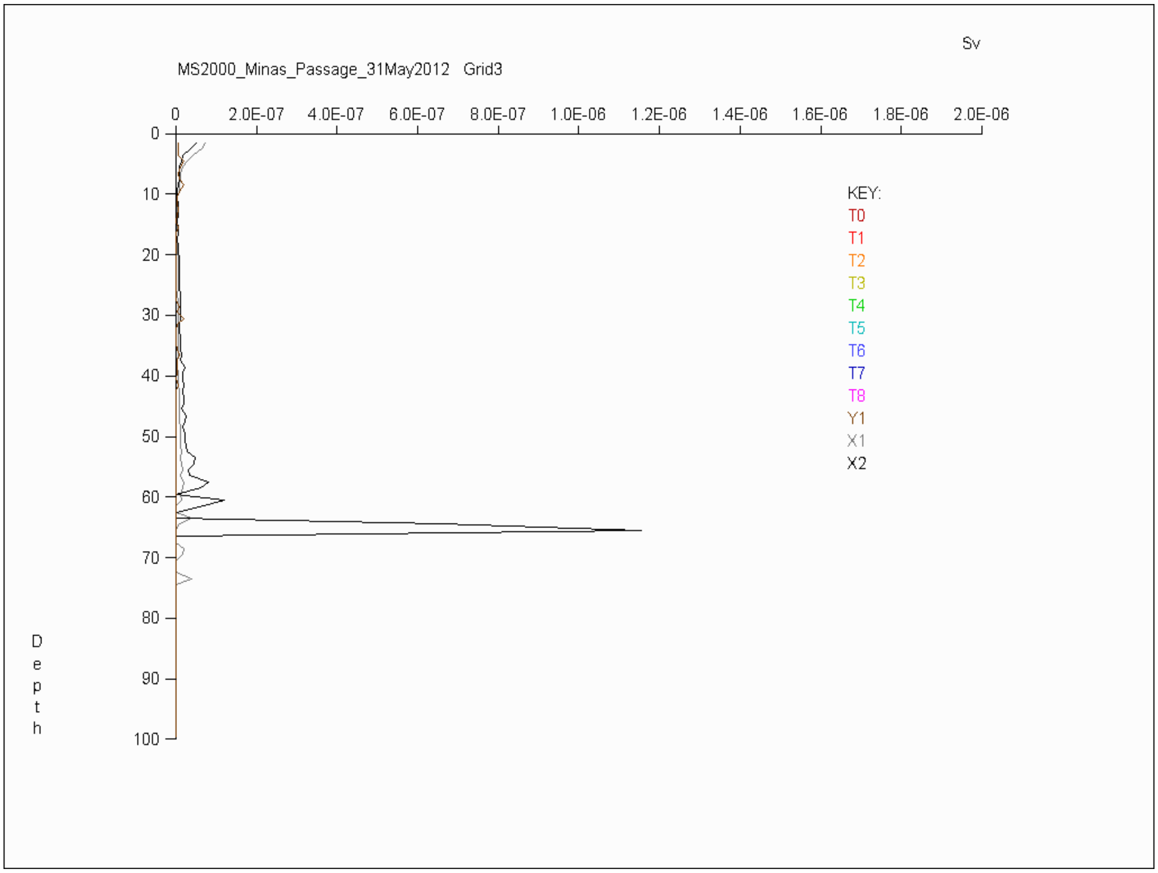


Profiles X1, Y1 & X2 were steamed from 12:44 to 13:26 ADT on the declining ebb current flow, X1 starting at about nominal maximum ebb (12:39 ADT).

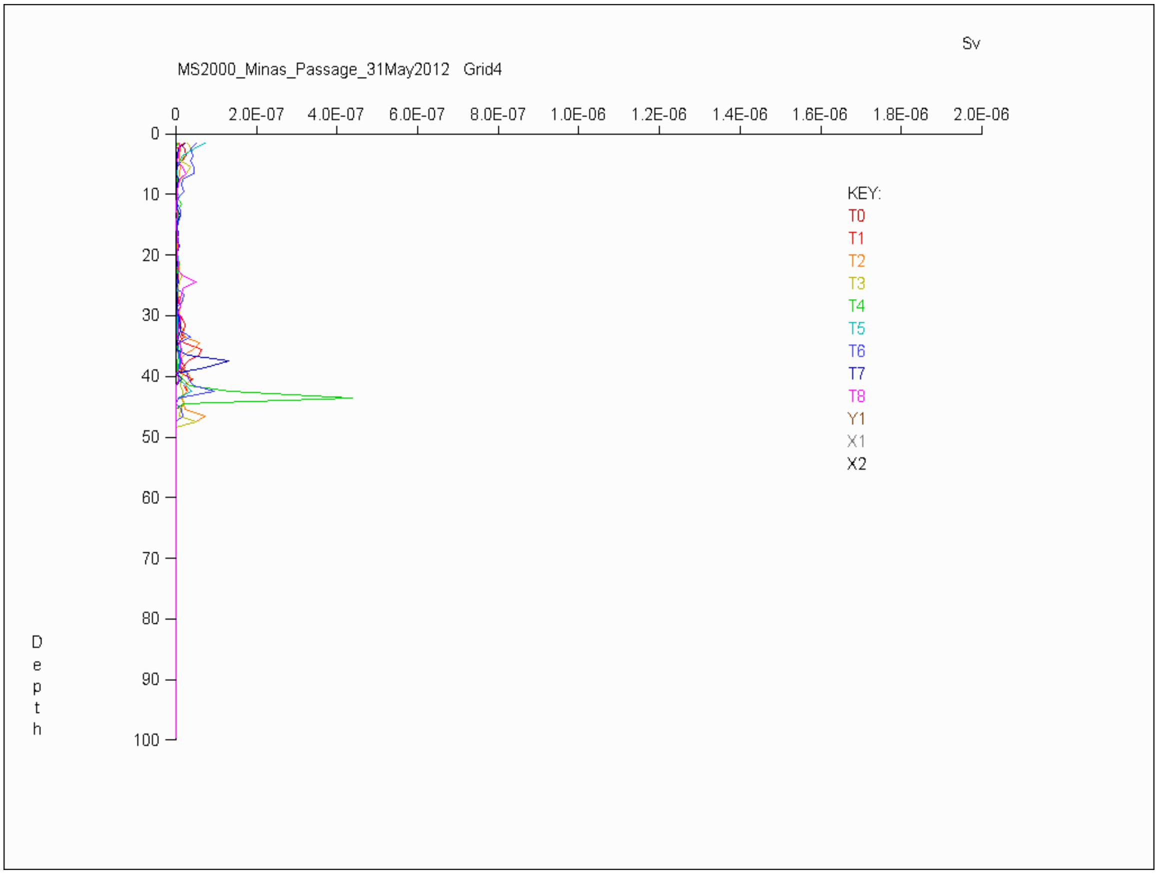


Relative S_v (linear) vs. depth (m) Grid 3, 31 May 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 3 Profiles T0 to T8 were steamed from 13:27 to 14:31 ADT on the declining ebb flow with LT at 15:44 ADT. Few fish echoes were noted on the real-time echograms.

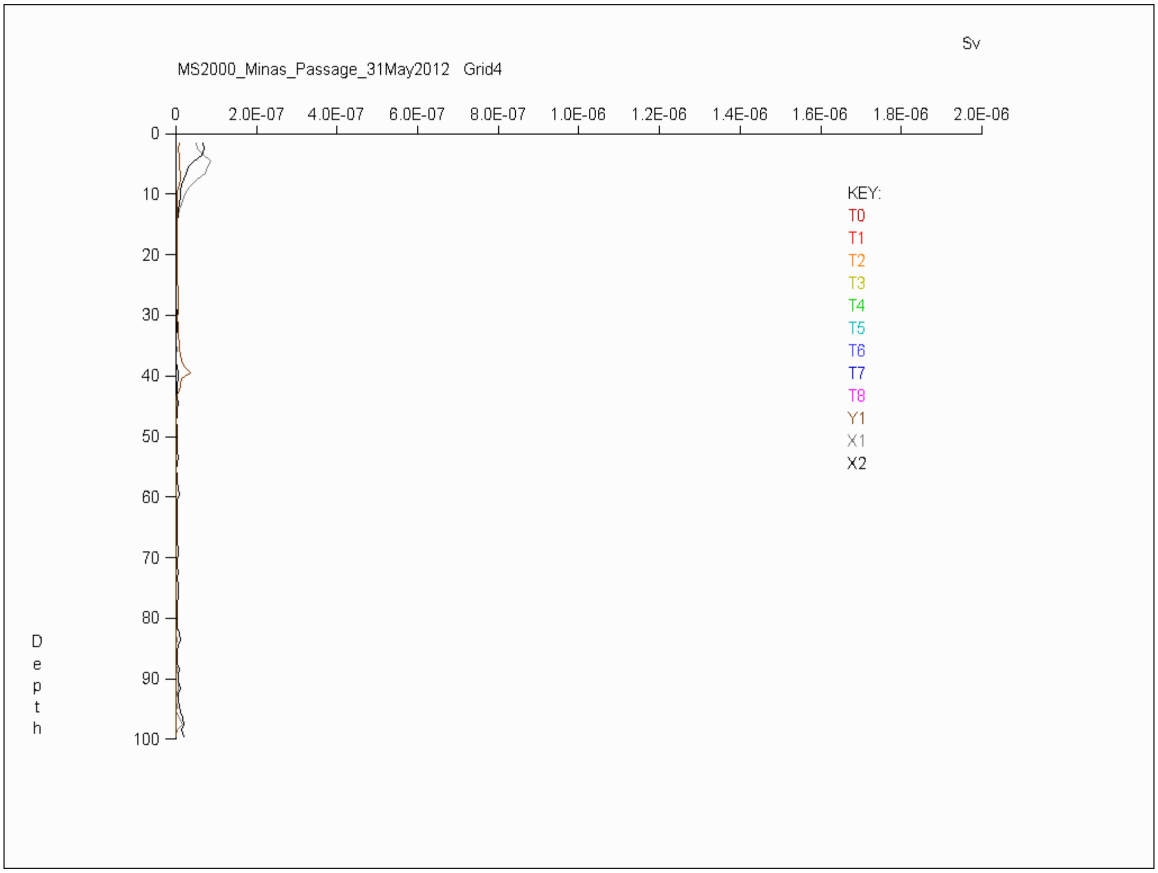


Profiles X1, Y1 & X2 were steamed from 14:32 to 15:10 ADT on the declining ebb tide approaching LT at 15:44 ADT. Few fish echoes were observed on real-time echograms. On visual inspection of fan sections the rise in X2 backscatter between 45 and 63 m depth appeared due to noise.

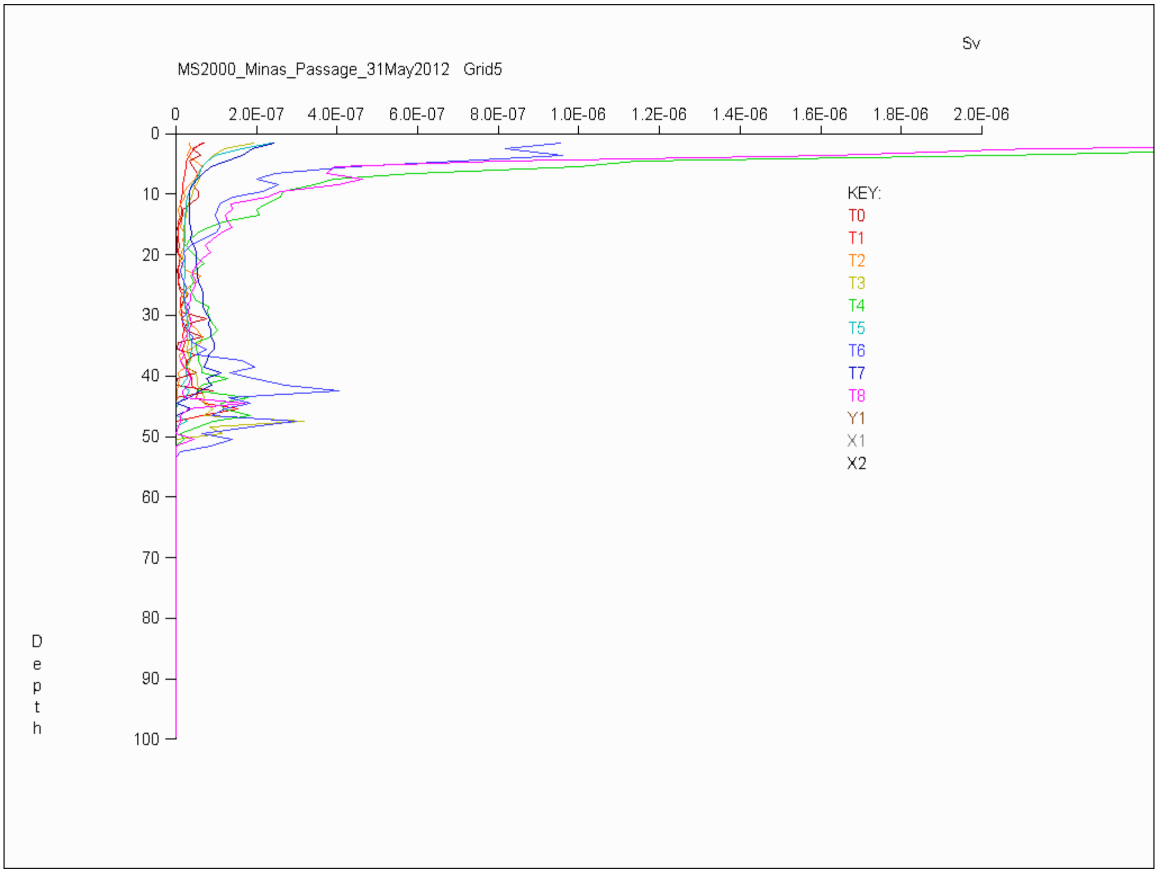


Relative S_v (linear) vs. depth (m) Grid 4, 31 May 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 4 Profiles T0 to T8 were steamed from 15:11 to 15:56 ADT around low tide (15:44 ADT) slack water.



Profiles X1, Y1 & X2 were steamed from 15:59 to 17:04 ADT on the rising portion of the flood cycle (Cape Sharp LT at 15:55 ADT).



Relative S_v (linear) vs. depth (m) Grid 5, 31 May 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 5 Profiles T0 to T8 were steamed from 17:05 to 20:12 ADT extending through nominal maximum flood flow (18:53 ADT). HT was at 22:02 ADT. Echograms (esp. split-beam) revealed considerable fish on bottom or close to bottom. These fish may have been rising off bottom during the last several transects in response to declining light levels (sunset occurred at 20:56 ADT).

Noise levels were extremely high on the odd numbered profiles above, the survey vessel having to head into the flood current at a relative speed of the order of 10 knots to make headway. The even numbered profiles displayed lower noise levels but the volume of water independently sampled was necessarily much lower. Fish echoes were visually observed on fan beam echograms at depth (as on the split-beam) but it is uncertain these alone, excluding "spoke" noise on lines steamed against the current and backscatter from deeply convected detached portions of bubble plumes, were sufficient to account of the observed enhanced backscatter below 30 m depth.

10. DATASET: 25 – 26 JUN. 2012

10.1 Analysis Parameters: 25 – 26 Jun. 2012

Beam Fan Quant. Processing Sector = 180°
Vertical Bin width = 1 m

Range Eliminate Start = 0.0
Range Eliminate End = 7.5 m

Transducer Depth = 1.5 m

Lower Amplitude Threshold = 0.005
Upper Amplitude Threshold = 1.0

Circular Noise Removal Limit = 0.002
Circular Noise Summation Angle = 140°
Arc Noise Removal Limit = 0.007
Spoke Noise Removal Limit = 0.001

Bottom Track Back-off = 3.0 m

Alpha Correction = 53.9 dB/km

10.2 Lines: 25 - 26 Jun. 2012

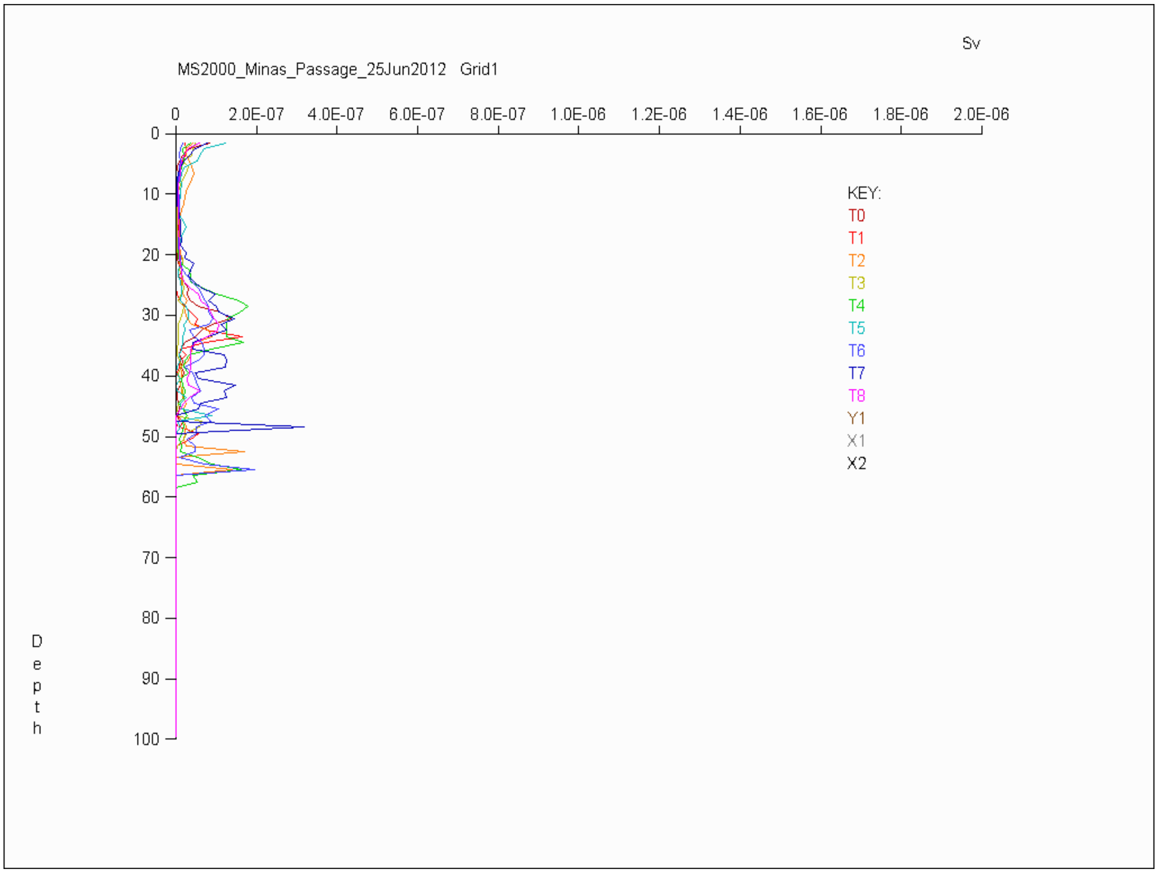
Format:

Grid_Line_Range_Sub-line	"Field Data File"	Start	End (Ping)
Grid1_T0_75	"Jun25,2012,13-06-09.smb"	1	361
Grid1_T1_75	"Jun25,2012,13-13-42.smb"	1	240
Grid1_T2_75	"Jun25,2012,13-19-11.smb"	1	490
Grid1_T3_75	"Jun25,2012,13-32-22.smb"	1	222
Grid1_T4_75	"Jun25,2012,13-38-03.smb"	1	788
Grid1_T5_75	"Jun25,2012,14-00-04.smb"	1	287
Grid1_T6_75	"Jun25,2012,14-06-42.smb"	1	1005
Grid1_T7_75	"Jun25,2012,14-24-18.smb"	1	242
Grid1_T8_75	"Jun25,2012,14-30-50.smb"	1	1295
Grid1_X1_150	"Jun25,2012,14-54-09.smb"	1	1544
Grid1_Y1_75	"Jun25,2012,15-21-12.smb"	1	241
Grid1_X2_150	"Jun25,2012,15-26-47.smb"	1	2042
Grid2_T0_75	"Jun25,2012,16-25-59.smb"	1	369
Grid2_T1_75	"Jun25,2012,16-33-32.smb"	1	290
Grid2_T2_75	"Jun25,2012,16-40-05.smb"	1	530
Grid2_T3_75	"Jun25,2012,16-50-18.smb"	1	258
Grid2_T4_75	"Jun25,2012,16-56-39.smb"	1	517
Grid2_T5_75	"Jun25,2012,17-06-55.smb"	1	251
Grid2_T6_75	"Jun25,2012,17-12-58.smb"	1	527
Grid2_T7_75	"Jun25,2012,17-23-14.smb"	1	263
Grid2_T8_75	"Jun25,2012,17-29-23.smb"	1	485
Grid2_X1_150	"Jun25,2012,17-38-18.smb"	1	996
Grid2_Y1_75	"Jun25,2012,17-55-09.smb"	1	313
Grid2_X2_150	"Jun25,2012,18-00-35.smb"	1	1464
Grid3_T0_75	"Jun25,2012,18-32-27.smb"	1	335
Grid3_T1_75	"Jun25,2012,18-39-05.smb"	1	434
Grid3_T2_75	"Jun25,2012,18-47-19.smb"	1	283
Grid3_T3_75	"Jun25,2012,18-53-59.smb"	1	449
Grid3_T4_75	"Jun25,2012,19-02-33.smb"	1	277
Grid3_T5_75	"Jun25,2012,19-08-26.smb"	1	456
Grid3_T6_75	"Jun25,2012,19-23-49.smb"	1	265
Grid3_T7_75	"Jun25,2012,19-29-17.smb"	1	544
Grid3_T8_75	"Jun25,2012,19-39-11.smb"	1	242
Grid3_X1_150	"Jun25,2012,19-45-23.smb"	1	1216
Grid3_Y1_75	"Jun25,2012,20-06-34.smb"	1	377
Grid3_X2_150	"Jun25,2012,20-13-55.smb"	1	2638
Grid4_T0_75	"Jun25,2012,21-01-47.smb"	1	298
Grid4_T1_75	"Jun25,2012,21-09-38.smb"	1	1160
Grid4_T2_75	"Jun25,2012,21-31-05.smb"	1	223
Grid4_T3_75	"Jun25,2012,21-40-10.smb"	65	1742

Grid4_T4_75	"Jun25,2012,22-11-34.smb"	1	202
Grid4_T5_75	"Jun25,2012,22-18-53.smb"	1	1644
Grid4_T6_75	"Jun25,2012,22-48-05.smb"	1	205
Grid5_T0_75	"Jun26,2012,00-24-36.smb"	1	282
Grid5_T1_75	"Jun26,2012,00-30-16.smb"	1	338
Grid5_T2_75	"Jun26,2012,00-36-45.smb"	1	274
Grid5_T3_75	"Jun26,2012,00-42-11.smb"	1	360
Grid5_T4_75	"Jun26,2012,00-49-33.smb"	1	263
Grid5_T5_75	"Jun26,2012,00-54-55.smb"	1	278
Grid5_T6_75	"Jun26,2012,01-00-47.smb"	1	316
Grid5_T7_75	"Jun26,2012,01-08-51.smb"	1	243
Grid5_T8_75	"Jun26,2012,01-14-01.smb"	1	446
Grid5_Z1_75	"Jun26,2012,01-21-41.smb"	1	279
Grid6_T0_75	"Jun26,2012,01-27-59.smb"	1	447
Grid6_T1_75	"Jun26,2012,01-36-19.smb"	1	221
Grid6_T2_75	"Jun26,2012,01-41-15.smb"	1	694
Grid6_T3_75	"Jun26,2012,01-53-47.smb"	1	215
Grid6_T4_75	"Jun26,2012,01-59-34.smb"	1	837
Grid6_T5_75	"Jun26,2012,02-14-30.smb"	1	217
Grid6_T6_75	"Jun26,2012,02-19-31.smb"	1	1172
Grid6_T7_75	"Jun26,2012,02-40-18.smb"	1	248
Grid6_T8_75	"Jun26,2012,02-46-35.smb"	1	1431
Grid6_Z1_75	"Jun26,2012,03-10-29.smb"	1	279
Grid7_T0_75	"Jun26,2012,03-16-17.smb"	1	464
Grid7_T1_75	"Jun26,2012,03-25-03.smb"	1	308
Grid7_T2_75	"Jun26,2012,03-31-38.smb"	1	750
Grid7_T3_75	"Jun26,2012,03-44-56.smb"	1	210
Grid7_T4_75	"Jun26,2012,03-49-58.smb"	1	799
Grid7_T5_75	"Jun26,2012,04-04-06.smb"	1	211
Grid7_T6_75	"Jun26,2012,04-09-03.smb"	1	876
Grid7_T7_75	"Jun26,2012,04-24-30.smb"	1	262
Grid7_T8_75	"Jun26,2012,04-30-22.smb"	1	848
Grid7_X1_150	"Jun26,2012,04-53-52.smb"	1	1327
Grid7_Y1_150	"Jun26,2012,05-16-12.smb"	1	288
Grid7_X2_150	"Jun26,2012,05-21-35.smb"	1	1811
Grid8_T0_75	"Jun26,2012,05-59-13.smb"	1	353
Grid8_T1_75	"Jun26,2012,06-08-03.smb"	1	320
Grid8_T2_75	"Jun26,2012,06-14-49.smb"	1	427
Grid8_T3_75	"Jun26,2012,06-23-09.smb"	1	401
Grid8_T4_75	"Jun26,2012,06-31-30.smb"	1	396
Grid8_T5_75	"Jun26,2012,06-39-13.smb"	1	361
Grid8_T6_75	"Jun26,2012,06-46-31.smb"	1	356
Grid8_T7_75	"Jun26,2012,06-53-52.smb"	1	398
Grid8_T8_75	"Jun26,2012,07-01-28.smb"	1	308
Grid8_X1_150	"Jun26,2012,07-07-03.smb"	1	1105
Grid8_Y1_75	"Jun26,2012,07-25-43.smb"	1	522

Grid8_X2_75	"Jun26,2012,07-34-48.smb"	1	116
Grid8_X2_150_1	"Jun26,2012,07-36-59.smb"	1	1547
Grid9_T0_75	"Jun26,2012,08-09-12.smb"	1	269
Grid9_T1_75	"Jun26,2012,08-15-52.smb"	1	747
Grid9_T2_75	"Jun26,2012,08-29-54.smb"	1	250
Grid9_T3_75	"Jun26,2012,08-36-22.smb"	1	1496
Grid9_T4_75	"Jun26,2012,09-04-27.smb"	1	216
Grid9_T5_75	"Jun26,2012,09-12-27.smb"	1	3427
Grid9_T6_75	"Jun26,2012,10-11-38.smb"	1	220
Grid9_T7_75	"Jun26,2012,10-18-20.smb"	1	2134
Grid9_T8_75	"Jun26,2012,10-56-25.smb"	1	231
Grid9_X1_150	"Jun26,2012,11-03-44.smb"	1	1074
Grid9_Y1_75	"Jun26,2012,11-24-37.smb"	1	321
Grid9_X2_150	"Jun26,2012,11-32-53.smb"	1	1606
Grid10_T0_75	"Jun26,2012,12-07-50.smb"	1	346

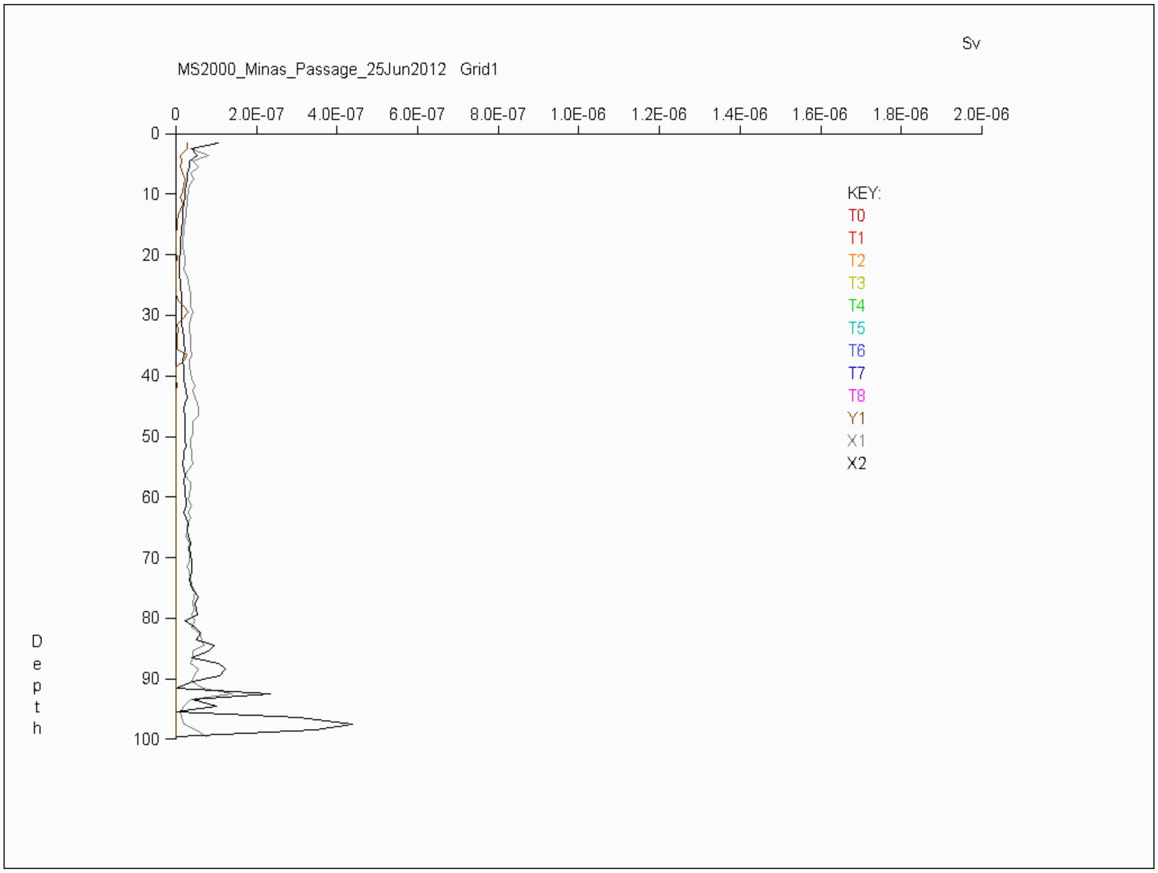
10.3 S_v Profiles: 25 - 26 Jun. 2012



Relative S_v (linear) vs. depth (m) Grid 1, 25 June 2012 Minas Passage survey Intensive grid lines T0 – T8 only.

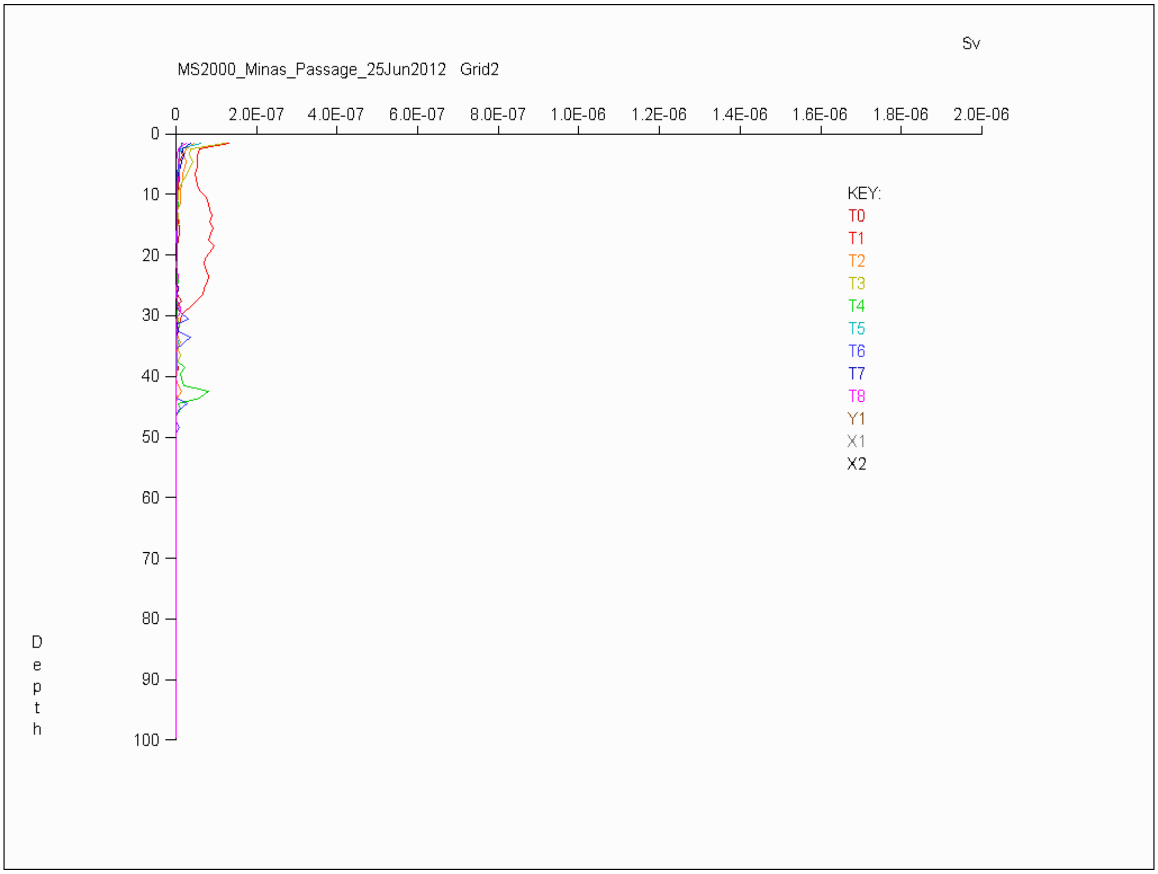
Grid 1 lines T0 to T8 were steamed between 06:06 ADT (on ebb flow < 1 hr past Cape Sharp HT at 0516 ADT, local sunrise at 05:29 ADT) and 07:52 ADT (about 1/2 hour before nominal maximum ebb predicted for 08:25 ADT). From the real-time cruise notes: On line T0 good abundances of fish were sighted on both acoustic systems (i.e. EK60 & MS 2000), fish distributions broadly peaking at about 40 m depth. Plumes began to appear about 06:22 ADT (on line T2). The EK60 showed fish peaking from 30 – 35 m depth. On T4 the fish layer seemed to lie at 25 – 30 m. The relatively high fish densities appeared to decline rapidly near the east end of T4 (06:51 ADT), about 90 min. into the ebb cycle, and about half way between HT slack water and nominal maximum ebb flow. A layer of fish persisted at 25 - 30 m on T6 although strong “spoke noise” was present on the MS. On T8 a fish layer was noted at ~30 m depth on both systems as well as abundant MS “spoke noise”.

On the whole, visual inspection of fan sections tended to support a fish origin for most of the observed increased backscatter below 25 m depth. It will be noted that in the above plot, even numbered profiles were steamed against the increasing ebb flow and in the absence of the noise reduction algorithms applied would be expected to display exponentially increasing ship-origin noise from 20 m depth to bottom (ship rpm’s were lowered on T4). The odd numbered profiles, steamed with the current, might be expected to portray more realistic fish densities although the independently sampled water volumes would be comparatively lower because of the shorter temporal profiles and the vessel tending to “travel with” the surrounding water parcel leading to a lower degree of independence between successive samples. T7 appeared to show fish scattering layers below 25 m, and T4, layers between 25 and 35 m which seemed to dominate over strong ship noise (especially “spoke” noise) which, if unsuppressed in processing, would monotonically increase with depth.



Lines X1, Y1 & X2 were steamed between 07:54 and 09:01 ADT, centered around max nominal ebb flow predicted for 08:25 ADT. On starting cross-channel line X1, a fish layer near 35 m was observed to initially deepen remaining about 20 m above bottom. It will be noted that X1 backscatter levels appear to be slightly elevated with respect to X2 in the 20 – 55 m depth interval which could be a result of this fish concentration. On visual inspection of the multi-beam fan sections for X1 the above layer consisting of numerous individual echoes as well as small dense schools could be clearly followed south from the intensive grid to the middle of the deep channel. South of the deep channel it diminished in intensity markedly and blended into the ambient noise. On the northward return transect X2, fish echoes in the same depth range were encountered from the north side of the deep channel to about the intersection with T8. Few echoes were encountered on X2 when skirting the west side of the intensive grid from T8 to T0.

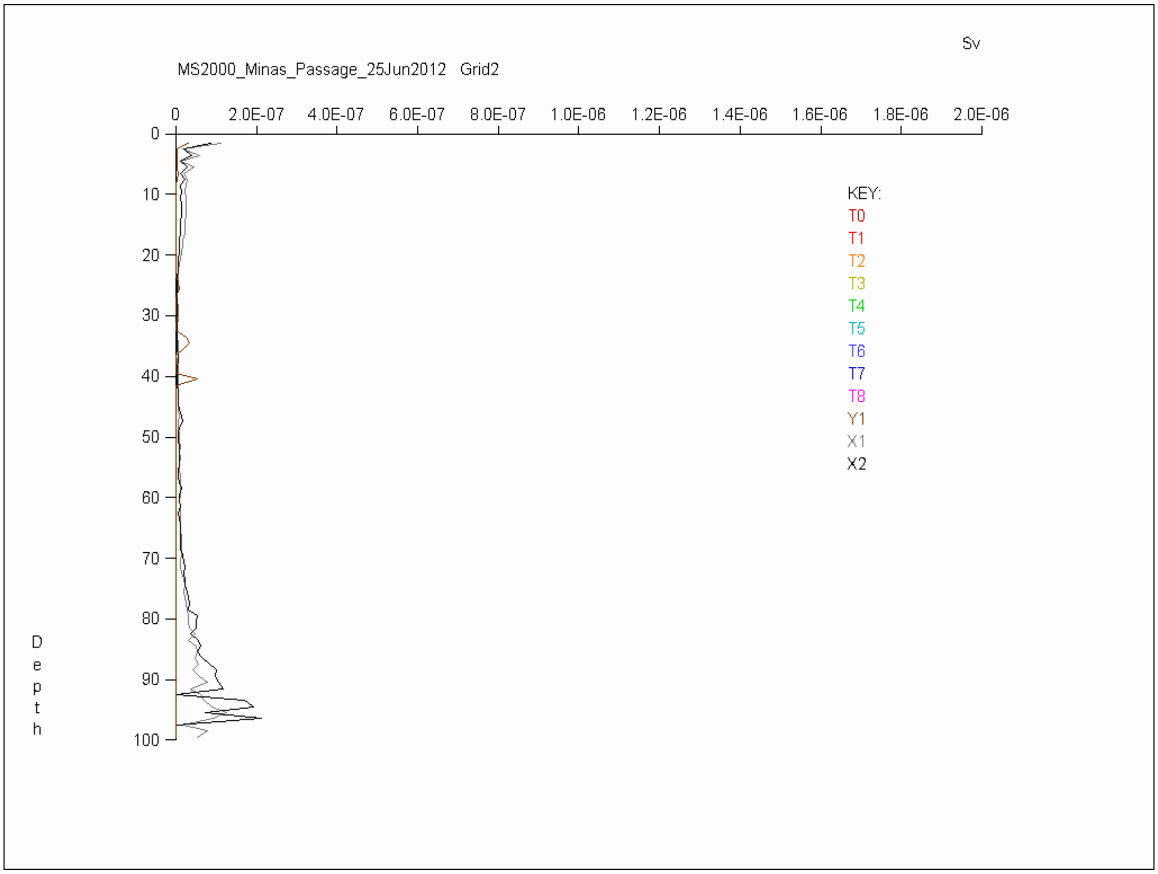
Visually, noise levels, especially “spoke” noise, generally appeared higher on X2 than on X1. The increasing backscatter levels below 60 - 70 m on both X1 and X2, and especially below 85 m on X2, appear a product of noise rather than obvious visible increases in fish target abundances.



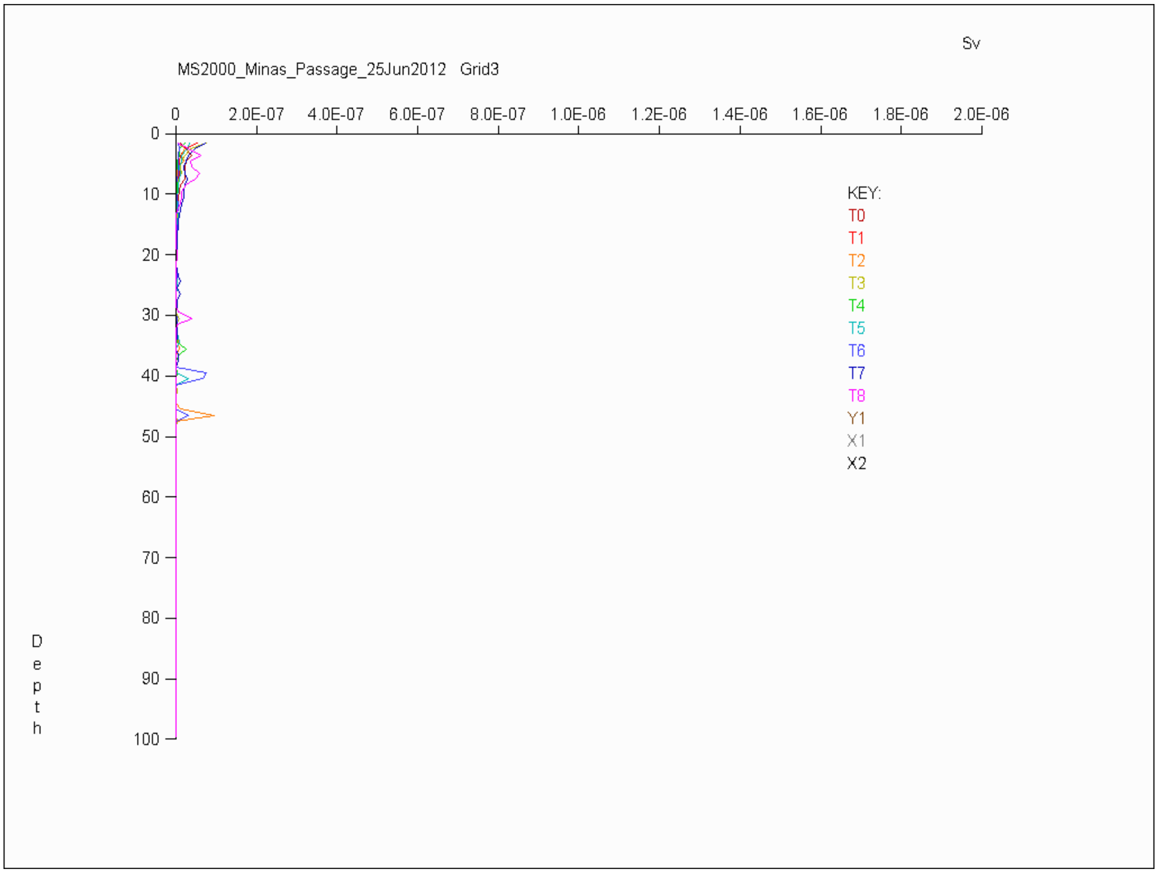
Relative S_v (linear) vs. depth (m) Grid 2, 25 June 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 2 lines T0 to T8 were steamed between 09:26 ADT (about 1 hour past nominal maximum ebb flow at 08:25 ADT) and 10:38 ADT (about 1 hour before low tide slack water predicted for 11:33 ADT at Cape Sharp).

Lines T0 to T8 revealed few fish on either system. Visual inspection of fan sections showed the increased backscattered on T1 between 10 and 30 m depth arose from a deep-penetrating bubble plume event. An attempt was made to keep rpm's down to eliminate noise on the MS. Some fish-like targets appeared in the upper 10 m on the EK60 split-beam. These targets were likely fish but bubbles cannot be definitively ruled out. A few EK60 targets were detected with TS's in the -41 to -42 dB range.



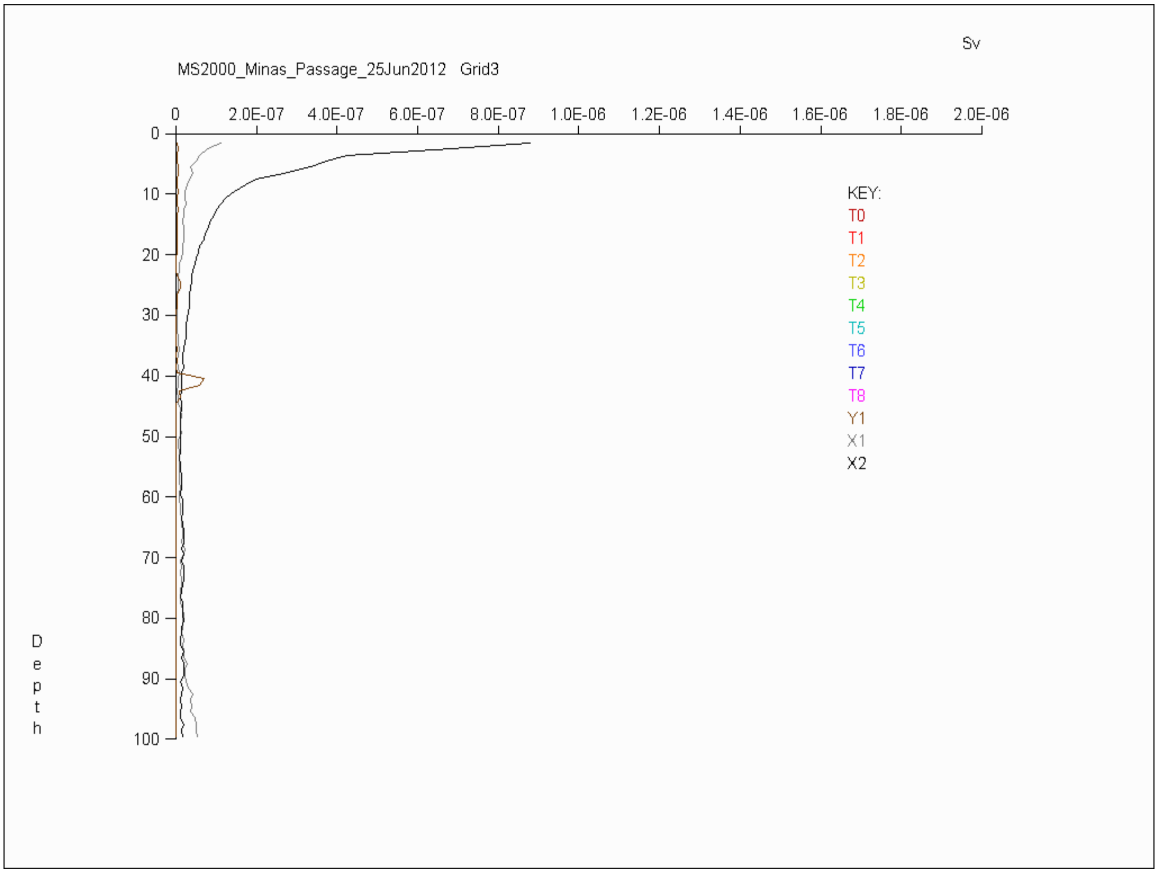
Lines X1, Y1 and X2 were steamed between 10:38 and 11:25 ADT finishing near LT slack water predicted for 11:33 ADT. Y1 echograms revealed some fish within 10 m of the bottom and similarly for X2. Were herring gathering near bottom as slack water approached?



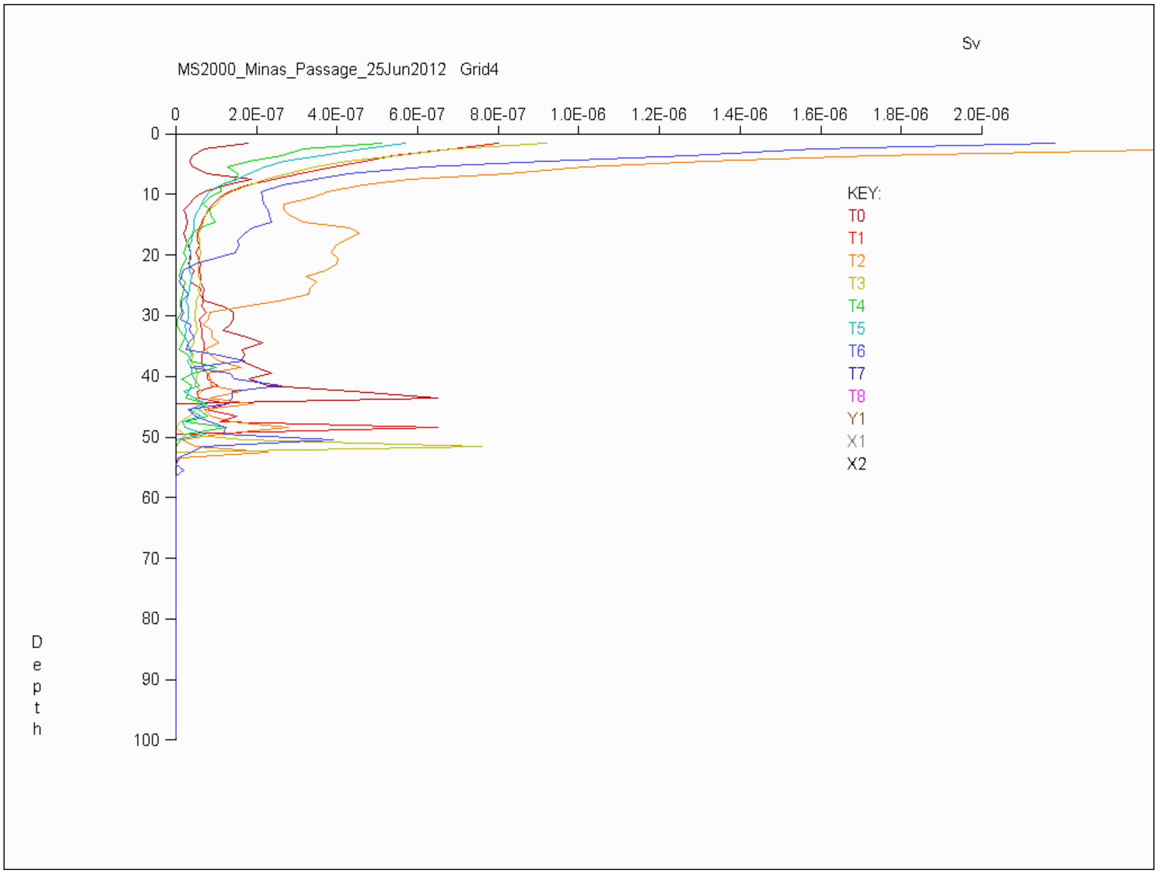
Relative S_v (linear) vs. depth (m) Grid 3, 25 June 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 3 lines T0 to T8 were steamed between 11:33 ADT (corresponding with low tide slack water) and 12:43 ADT (about two hours before nominal maximum flood current).

Only a few fish targets were observed on line T0 to line T8 real-time echograms. Some fish targets appeared near-surface and a few near-bottom, with virtually no targets observed in mid-water. Plume action initiated near the east end of T7 about 1 hour into the flood tide. There was an impression that near-surface fish might be pulled down in the downwelling bubble plumes and that this process, rather than fish attraction to the plumes, might explain why some deep-going plumes appear to be closely surrounded by fish-like echoes.



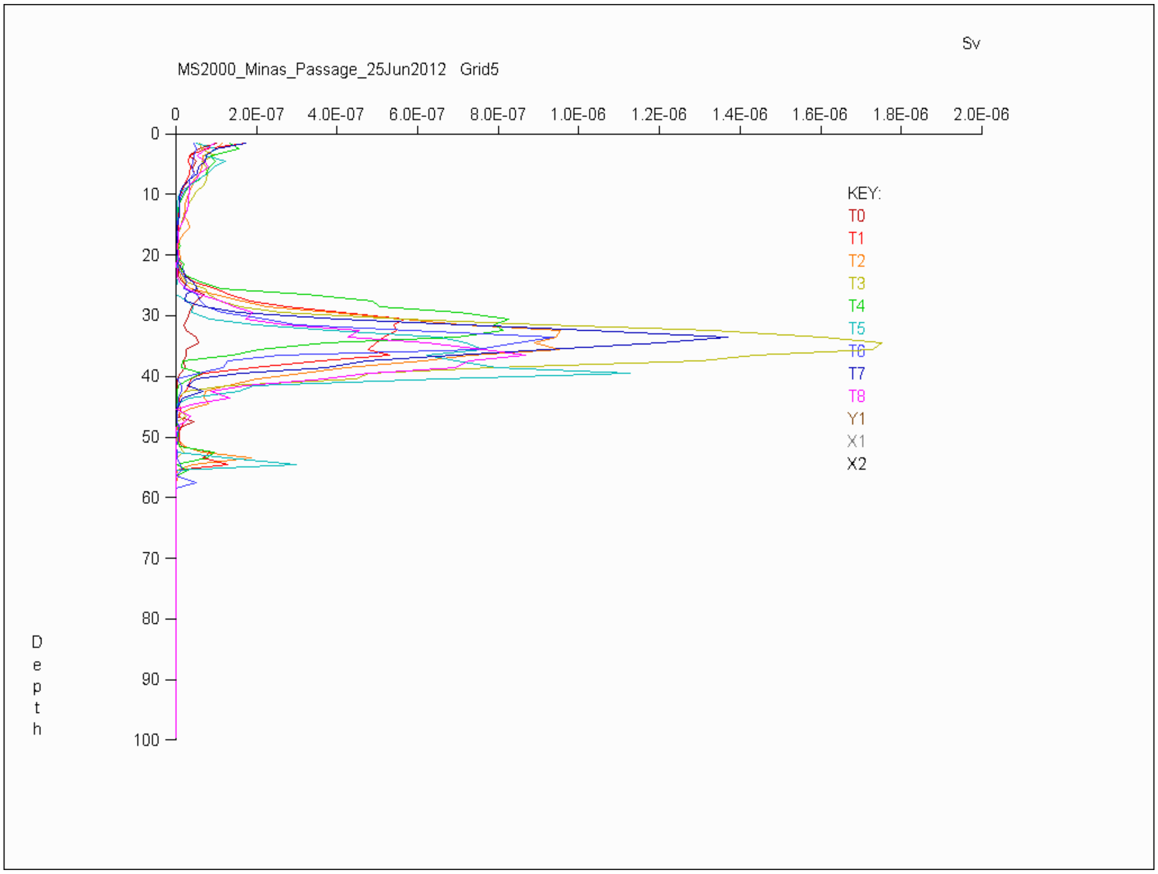
Lines X1, Y1 and X2 were steamed between 12:46 and 13:57 ADT on the increasing flood current, with max nominal flood predicted for 14:39 ADT. Visual inspection of fan sections could not confirm a fish origin for the increase in backscatter levels on Y1 near 40 m depth. Plume backscatter becomes intense during X2 and remains prominent on intensive Grid 4 immediately following. The roughly exponential taper with depth gives little indication of a backscattering component arising from fish.



Relative S_v (linear) vs. depth (m) Grid 4, 25 June 2012 Minas Passage survey. Intensive grid lines T0 – T6 (note!) only.

Grid 4 lines T0 to T6 were steamed between 14:02 ADT (about 40 min. before nominal maximum flood current predicted for 14:39 ADT) and 15:52 ADT (about 70 min. past maximum flood). On the close-spaced grid, numerous fish echoes were noted in the lower water column in the 30 – 45 m depth range. Were these being re-suspended off the bottom? Real-time TS frequencies from the EK60 rose continuously from the upper limit of -39.5 dB to the lower limit of -50 dB (were the lower target strengths perhaps dominated by bubbles?). T3 was steamed near nominal maximum flood current. Fish were observed between the base of the bubble plumes and the bottom. At times an EK60 observed TS mode at -42 or -43 dB appeared present while at other times the TS distribution rose in a continuous fashion with decreasing target strength. Were fish in the lower half of the water column perhaps settling onto the bottom - becoming sparser in mid-water in the process? By T4, fish had virtually disappeared, the few detections encountered suggesting modes around -35.5 to -35.8 dB and -42.5 to -42.8 dB.

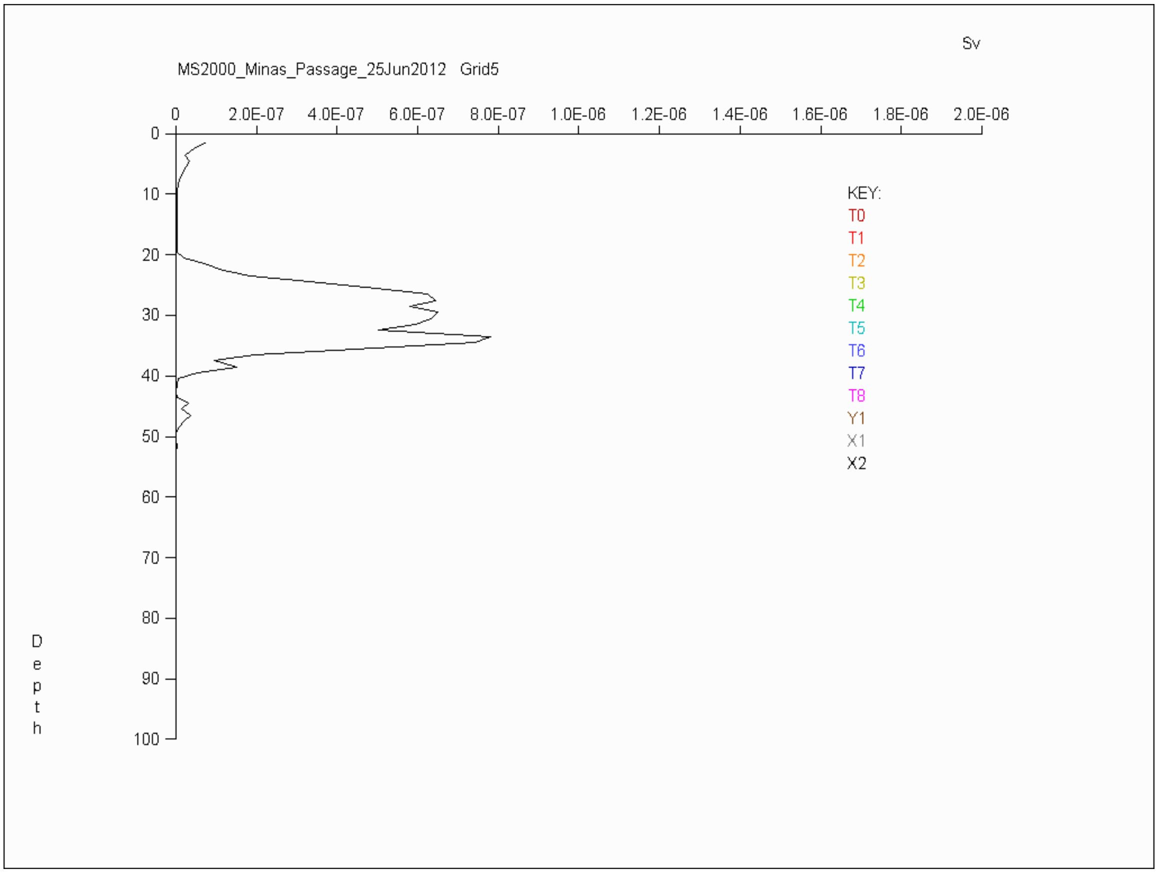
The odd number transects steamed into the flood current are more likely to be influenced by ship noise. While inspection of multi-beam fan sections did disclose fish echoes, high levels of residual “spoke” noise were also present and were probably dominant in shaping the multi-beam backscattering profiles below 30 m depth displayed above. The best case for fish significantly influencing the multi-beam sections above would be on profiles T0 to T4 before their disappearance on the EK60 – but this remains uncertain. The “bump” in backscattering levels on profile T2 in the 15 – 30 m depth range appeared to have a bubble plume origin. Grid 4 survey was suspended at the end of T6, the vessel returning to Parrsboro



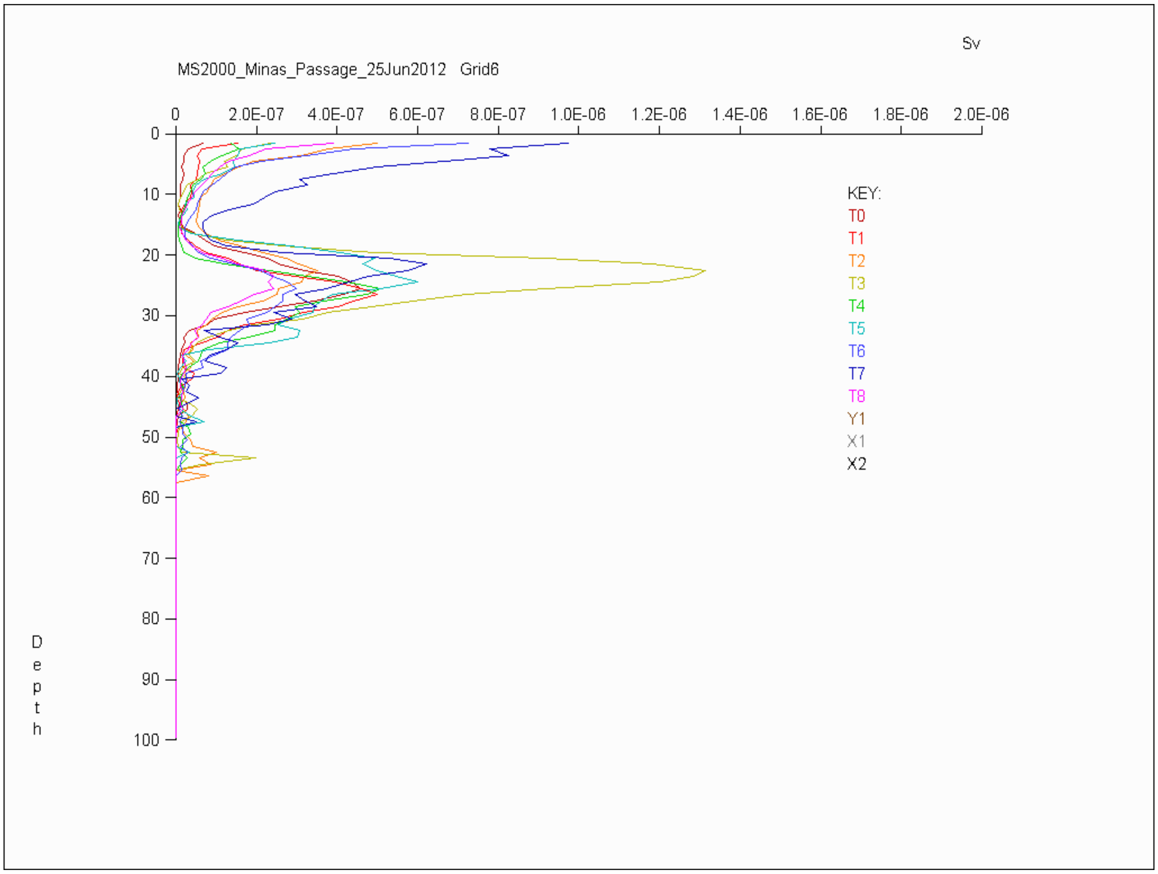
Relative S_v (linear) vs. depth (m) Grid 5, 25 June 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 5 lines T0 to T8 were steamed between 17:25 ADT (about 20 min. before high tide slack water at 17:44 ADT) and extended to 18:21 ADT (about 40 min. into the ebb tide cycle).

Immediately after completion of T0, which showed only very modest quantities of fish, backscatter levels of apparent fish origin increased sharply in the depth range 25 - 49 m. Peak backscattering levels rose continuously over profiles T1 to T3, maximizing on T3, this specific profile ending at almost HT slack water. Levels were slightly lower on profiles T4 to T8. On real-time EK60 echograms, fish occurred in dense clusters. There was evidence of a second fish layer within 15 m of the bottom. Visual inspection of the fan sections also revealed dense fish clusters or small schools strongly supporting a fish origin for these backscatter layers.



From 18:22 to 18:26 ADT. Grid 5 Z1 during the rising ebb tide constituted a special transect from the end of Grid 5 T8 to the beginning of Grid 6 T0. The cross-channel transects were not run in order to facilitate a higher time resolution analysis of fish presence on the 8-line intensive grid.

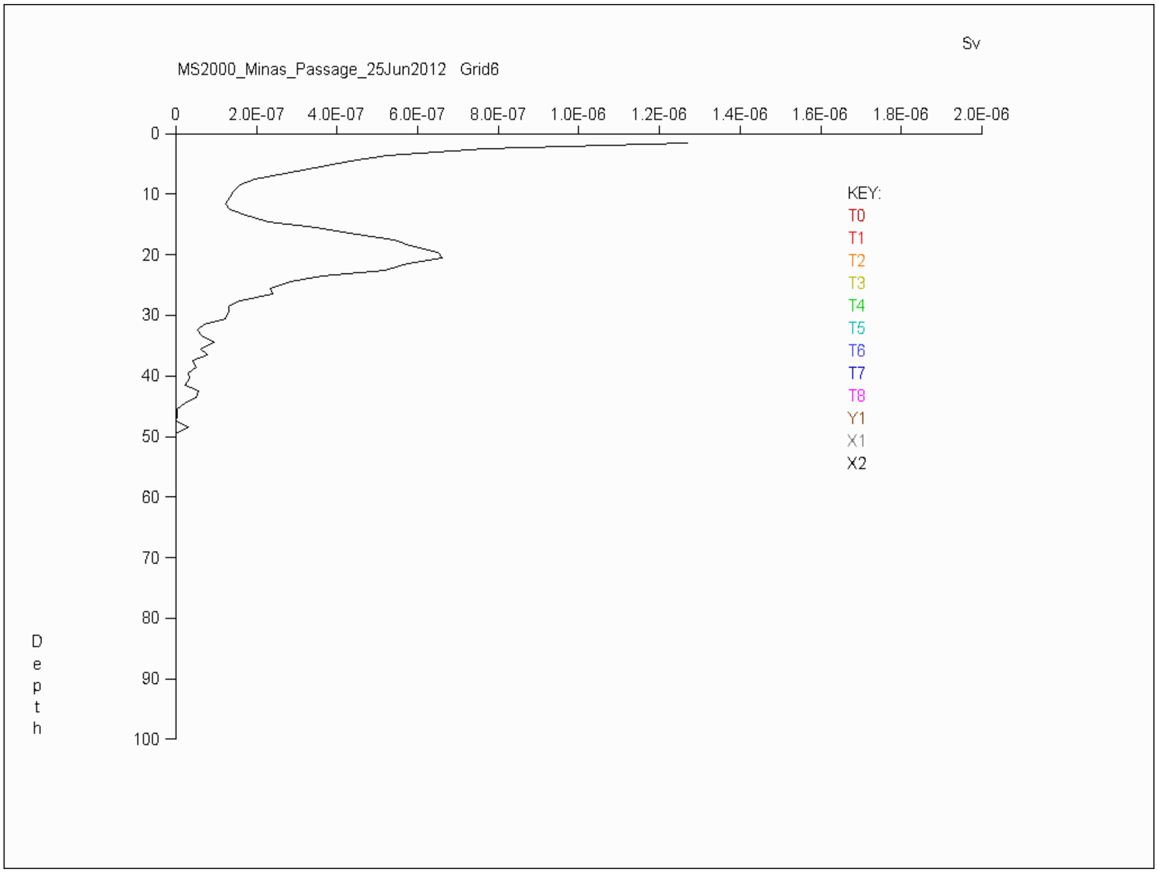


Relative *S*$_v$ (linear) vs. depth (m) Grid 6, 25 June 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

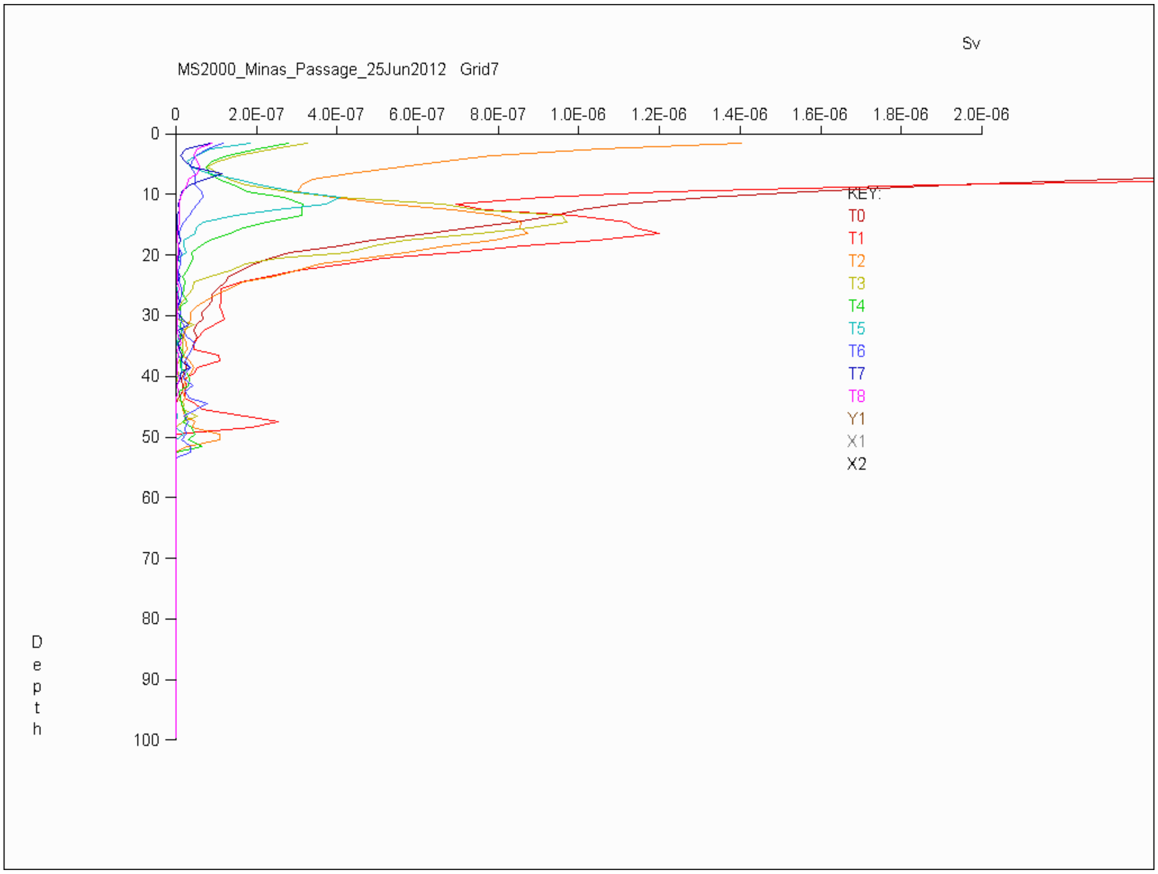
Grid 6 lines T0 to T8 were steamed between 18:28 ADT (on the increasing ebb current about 45 min. past Cape Sharp HT at 17:44 ADT) and 20:10 ADT (about 40 min. before maximum nominal ebb flow at 20:52 ADT and about 1 hr. before local sunset at 21:08 ADT).

Very high backscatter levels, confirmed by visual examination of fan sections, were observed especially in the 20 – 35 m range. Fish densities maximized on T3 (as on immediately preceding Grid 5) about 2 hours prior to max. ebb flow, with abundant fish persisting to at least transects T8, the immediately following diagonal transect Z1, and quite possibly to line T1 of Grid 7 (see Grid 7 comments below). Fish appeared in close-packed dense clusters extending all the way to bottom.

These evening ebb tide fish densities appeared much higher than those observed on Grid 1 during the corresponding portion of the morning ebb tide.



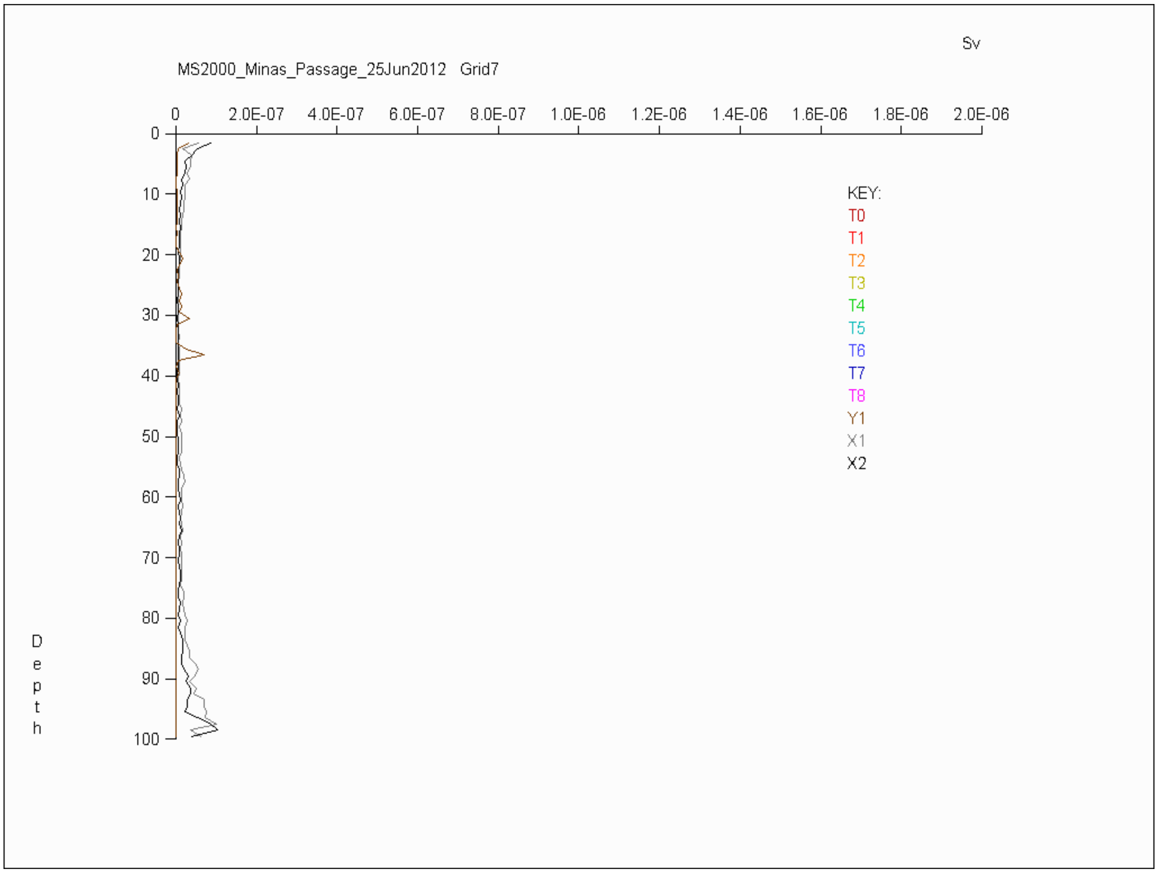
Diagonal intensive grid transect Z1 ran from 20:12 to 20:15 ADT with max nominal ebb predicted for 20:52 ADT.



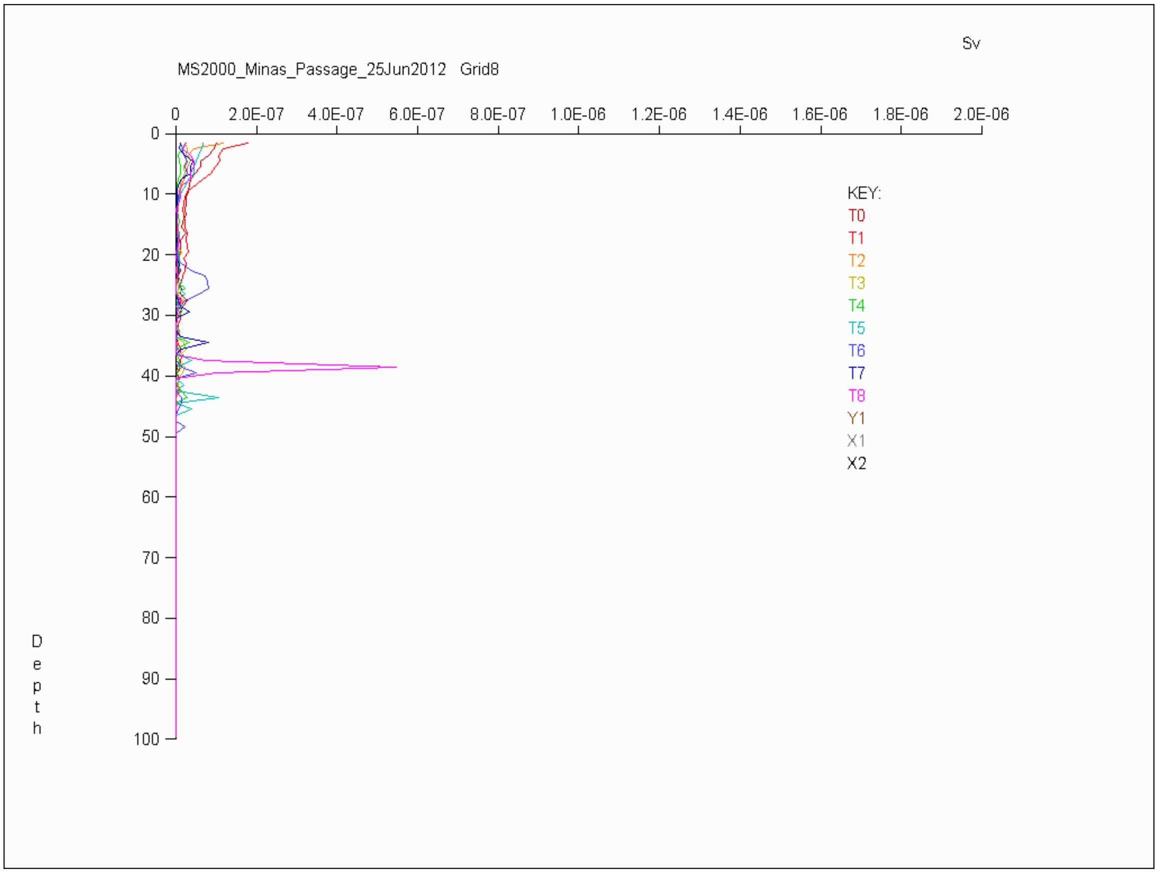
Relative S_v (linear) vs. depth (m) Grid 7, 25 June 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 7 lines T0 to T8 were steamed between 20:16 ADT (about 40 min. before nominal maximum ebb flow at 20:52 ADT) and 21:44 ADT (about 50 min. after maximum ebb). Local sunset occurred at 21:08 ADT.

Natural light levels decreased very rapidly during Grid 7. Sunset occurred at the end of transect T5 only a few minutes past nominal maximum ebb flow which occurred on transect T4. A backscatter layer at 15 – 20 m first distinctly observed on T1 appeared to move systematically upwards to the near-surface during later transects T7 and T8 which were profiled shortly after sunset. The backscatter layer appeared to sharply decrease in intensity during its ascent. It is possible fish were accumulating on the surface becoming not easily observable by the MS, or fish echoes were otherwise masked by strong near-surface bubble backscatter present near maximum ebb flow. Such embedded fish echoes would be largely eliminated as noise in subsequent processing which tended to blank strong extended areas of backscatter. Visual examination of fan sections supported this general upward migration pattern. As a point of interest, the non noise-reduced even numbered profiles (not shown) are dominated by sharply increasing ship noise levels below 30 – 35 m depth, an effect not readily discerned on the noise-reduced profiles as displayed above.



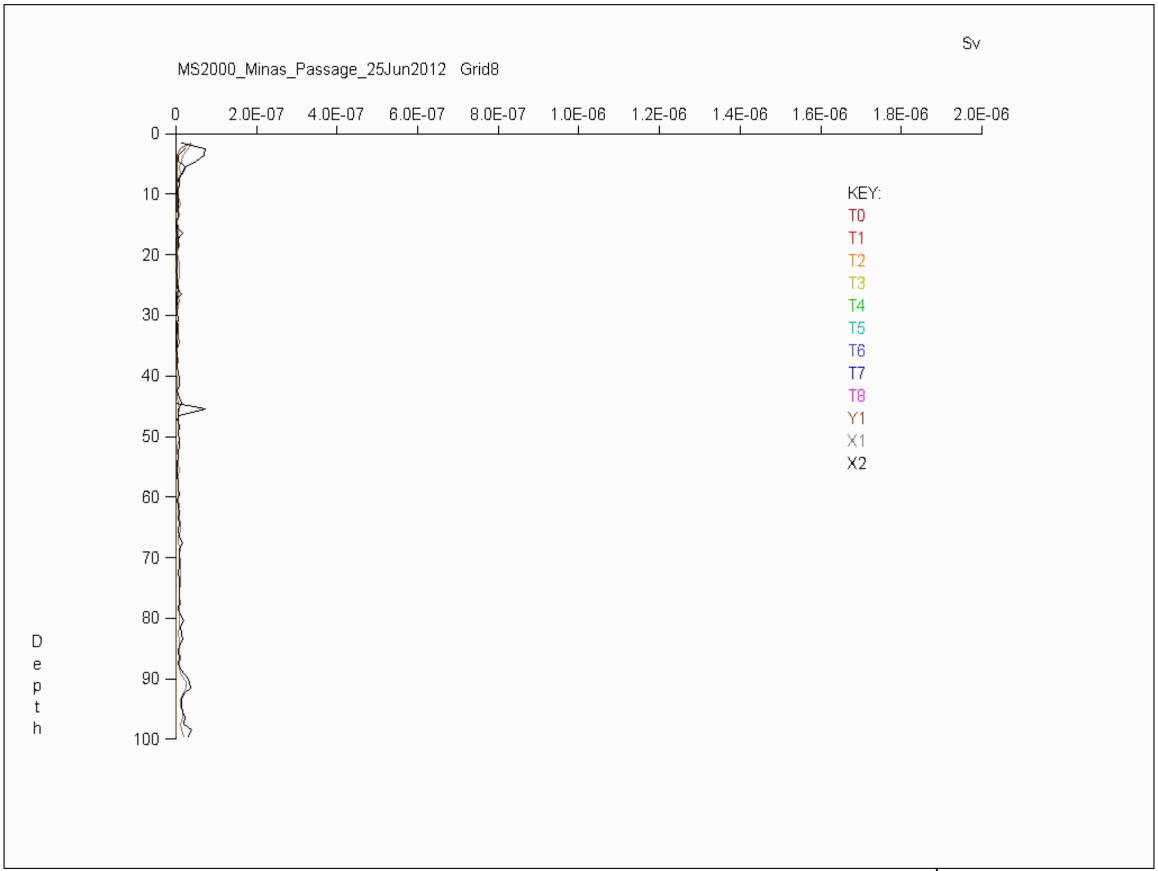
Lines X1, Y1 and X2 were steamed between 21:54 and 22:52 ADT on the declining ebb tide cycle.



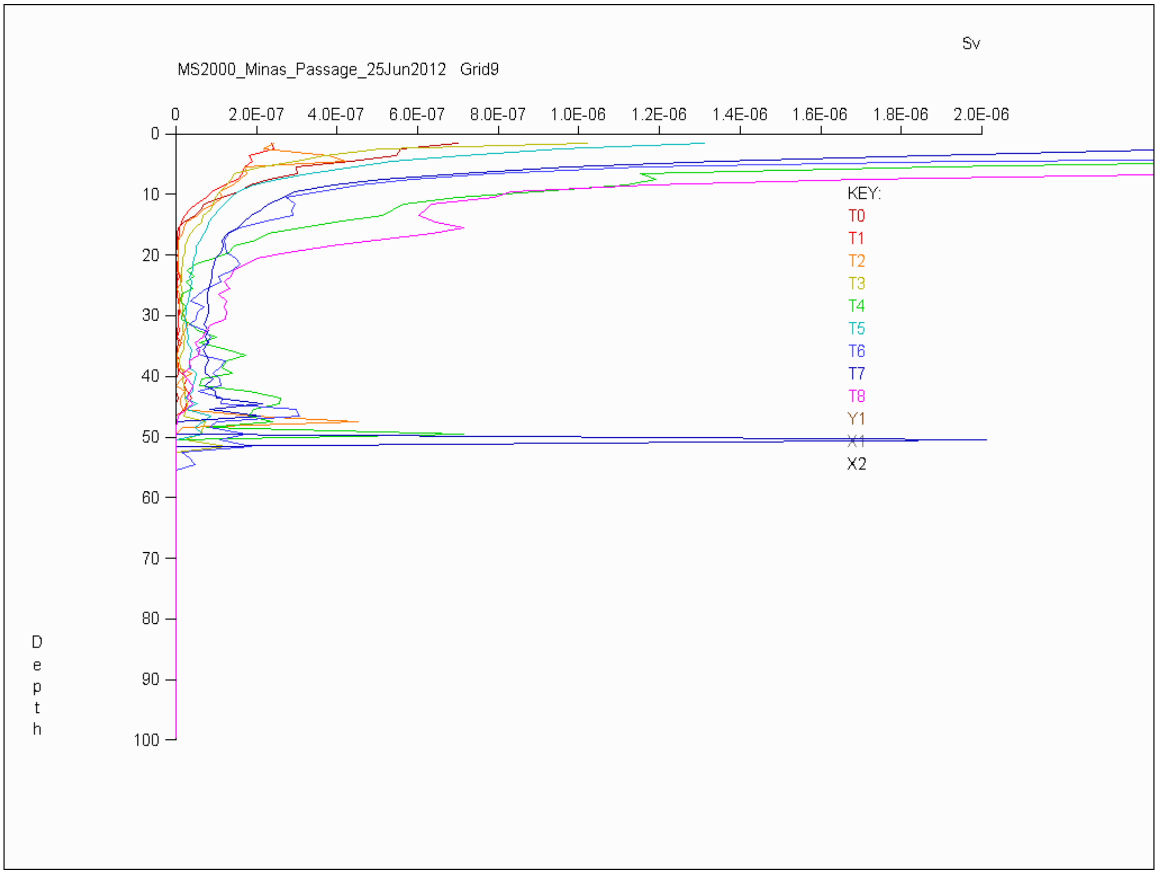
Relative S_v (linear) vs. depth (m) Grid 8, 25 - 26 June 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 8 lines T0 to T8 were steamed between 22:59 ADT June 25th (about 1 hour before low tide at 23:59 ADT) and 00:06 ADT June 26th (a few minutes past low tide slack water at 23:59 ADT).

Plumes were absent. Backscatter rises on T1 & T2 in the upper 5 m, perhaps a bit more sharply than on daytime Grids 1, 2 & 3. This could indicate fish in the very near-surface – but this fact remains uncertain. Otherwise there are few indications of fish elsewhere in the water column.



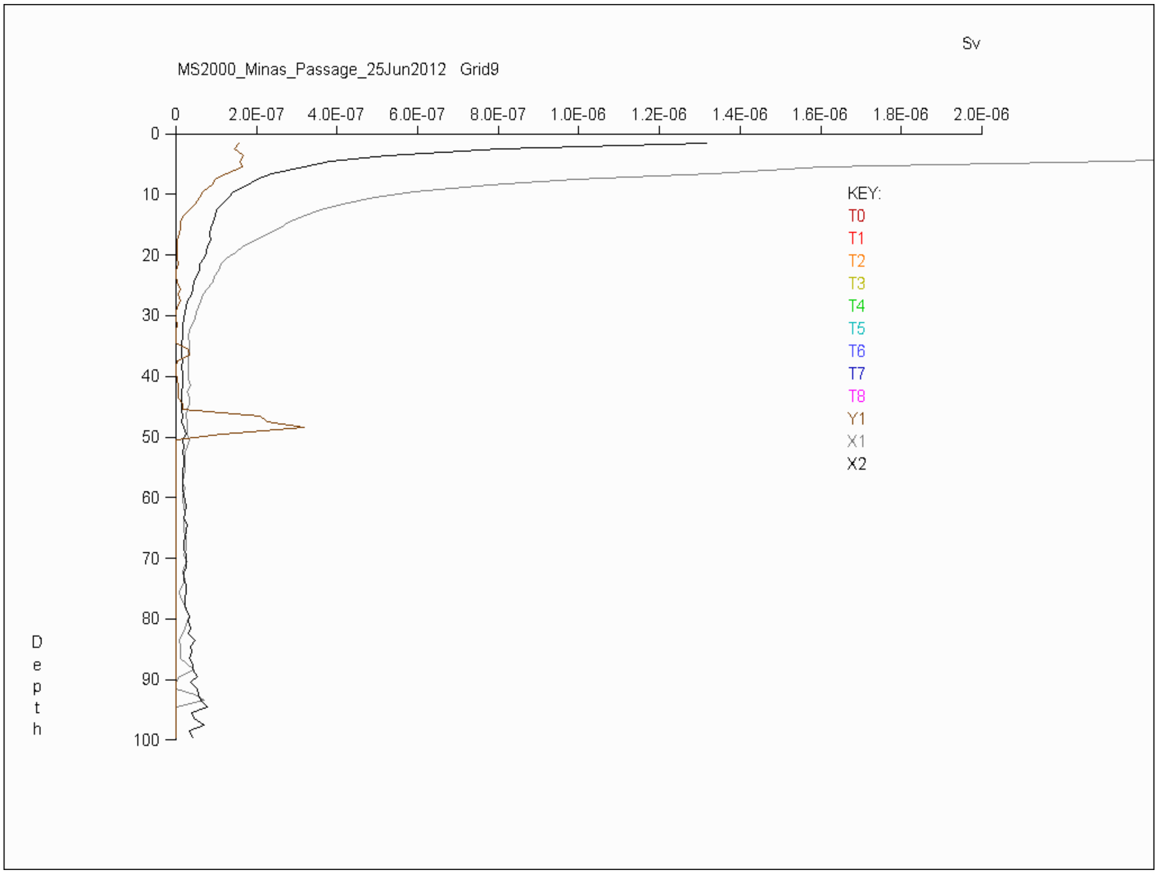
Lines X1, Y1 and X2 were steamed from 00:07 to 01:03 ADT (June 26th) beginning near LT slack water.



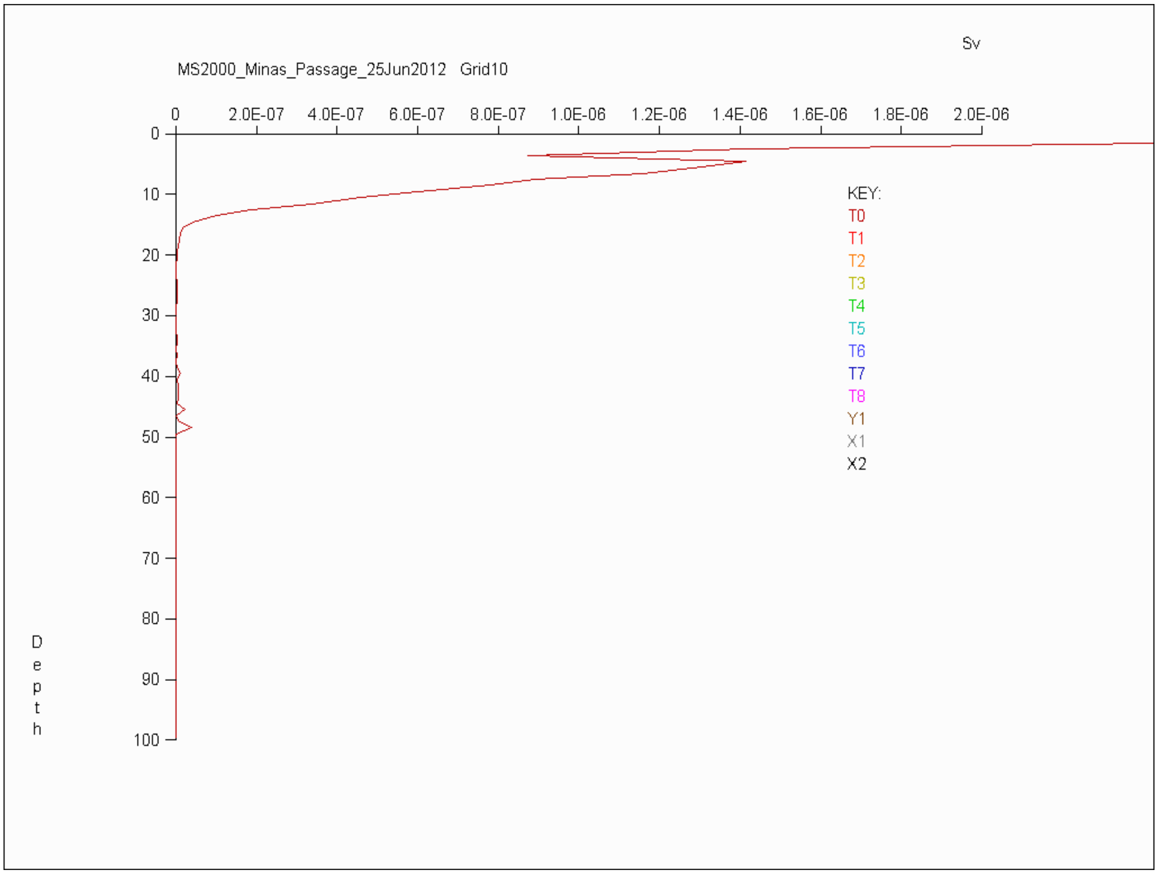
Relative S_v (linear) vs. depth (m) Grid 9, 26 June 2012 Minas Passage survey. Intensive grid lines T0 – T8 only.

Grid 9 lines T0 to T8 were steamed between 01:09 ADT (starting on the increasing flood current just over 1 hour past low tide at 23:59 ADT) and 04:00 ADT (about 1 hour past the nominal maximum flood current predicted for 03:04 ADT). It was still dark, local sunrise not occurring until 05:29 ADT.

The nominal maximum flood occurred at 03:04 ADT near the end of T5, a profile which required nearly one hour steaming against the strong flood current.
A few fish were noted near bottom on line T3 on real-time EK60 split-beam echograms. Near the end of T8 some fish were noted (on EK60) near-bottom in the depth range 30 – 50 m. There existed some indications of fish in these depth ranges on the even numbered multi-beam backscatter profiles. However, the deeper portions of the odd numbered profiles (possibly excepting T1) were dominated by ship noise as the vessel bucked strong flood currents, an effect not as clearly apparent on the noise reduced data displayed above. Bubble scattering from plumes probably accounts for the high and varying scattering levels above 20 m depth although visual inspection of multi-beam fan sections showed some fish echoes in the 10 – 13 m depth range (near base of plumes – could these first be pulled down from the surface by strong convective vortices?) but few clearly discernable fish targets near-bottom.



Lines X1, Y1 and X2 were steamed from 04:04 to 04:59 ADT. On the declining flood current with HT scheduled for 06:08 ADT just over 1hour after completion of these transects. Plume action seemed to be declining by the time X2 was steamed. The peak in Y1 backscatter between 45 and 50 m depth is spurious, not arising from fish as discerned from visual inspection of fan sections.



Relative S_v (linear) vs. depth (m) Grid 10, 26 June 2012 Minas Passage survey. Intensive grid line T0 only.

Grid 10 consisted of only line T0 steamed between 05:08 and 05:14 ADT on the decreasing flood flow, about 1 hour before high tide slack water (06:08 ADT). Local sunrise occurred at 05:29 ADT.

Judging by the earlier analogous Grid 7 sunset observations, any near or on-surface fish layer might well display some light-induced migrational sensitivity during this transect. Plume activity might be expected to be only modest or non-existent. A scattering layer above 15 m appeared present, with little else below. On visually examining corresponding MS fan sections it was not immediately obvious that the near-surface scattering arose from fish - as opposed to a bubble cloud origin. Well defined, discrete fish echoes in the lower water column seemed considerably less numerous than on Grid 9. Winds were observed to rise near dawn so wind-induced Langmuir circulations could be augmenting bubble plume effects which would otherwise be expected to be in decline at this phase of the tidal cycle.