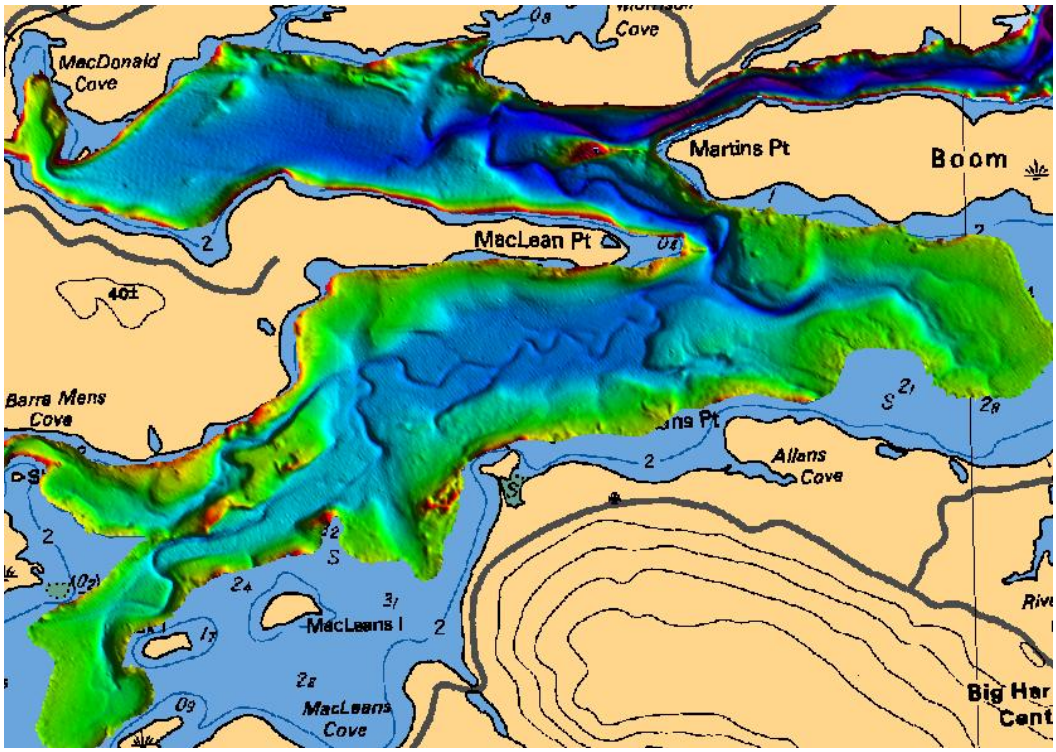
Interferometric Sidescan Surveys in Denys Basin, Bras d' Or Lakes, Nova Scotia, 2004



J. Shaw, P. J. Potter, D. Beaver and D.R. Parrott

Geological Survey of Canada (Atlantic)
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CONTENTS

FIGURES

BACKGROUND TO THE REPORT

This report was commissioned by the Department of Fisheries and Oceans under an interdepartmental letter of agreement (F5955-040411). The goal was to conduct an interferometric sidescan survey, create bathymetry and backscatter images, and provide advice on interpretation of the data.

CRUISE INFORMATION

Cruise	2004-5000
Vessel	Survey launch Penguin
Dates	27 July - 9 August
Areas of operation	Denys Basin, Bras d' Or lakes, Cape Breton, Nova Scotia
Personnel	D. Beaver (GSC)
	C. Reid (CHS)

SUMMARY OF OPERATIONS

The launch was taken from Dartmouth to the Bras d' Or Lakes on 27th July 2004 (JD 209). The tide gauge at Grand Narrows (the Iona Marina) was already installed, but batteries were installed on 27th July. Surveys commenced on 28th July (JD 210) and ran until 8th August (day 221). Tides were downloaded daily. The launch was removed from the water on 9th August and taken to Dartmouth.

THE SURVEY

The vessel and survey methods

The Penguin (Fig. 1) is a standard hydrographic launch. Two staff were aboard during the survey: a coxswain (Reid) and the operator (Beaver). Generally speaking survey lines were 25 metres apart. Sound velocity profiles were collected every day before the start of surveys using a Smart SVP system; data were entered into the system. The area surveyed is shown on Figure 2. While a large part of the basin was surveyed in the time allotted, a few days more time would have resulted in a more complete coverage.

Figure 1: The hydrographic survey launch *Penguin*.

Figure 2: The stern of the *Penguin* showing the mount for the sound velocity profiler.

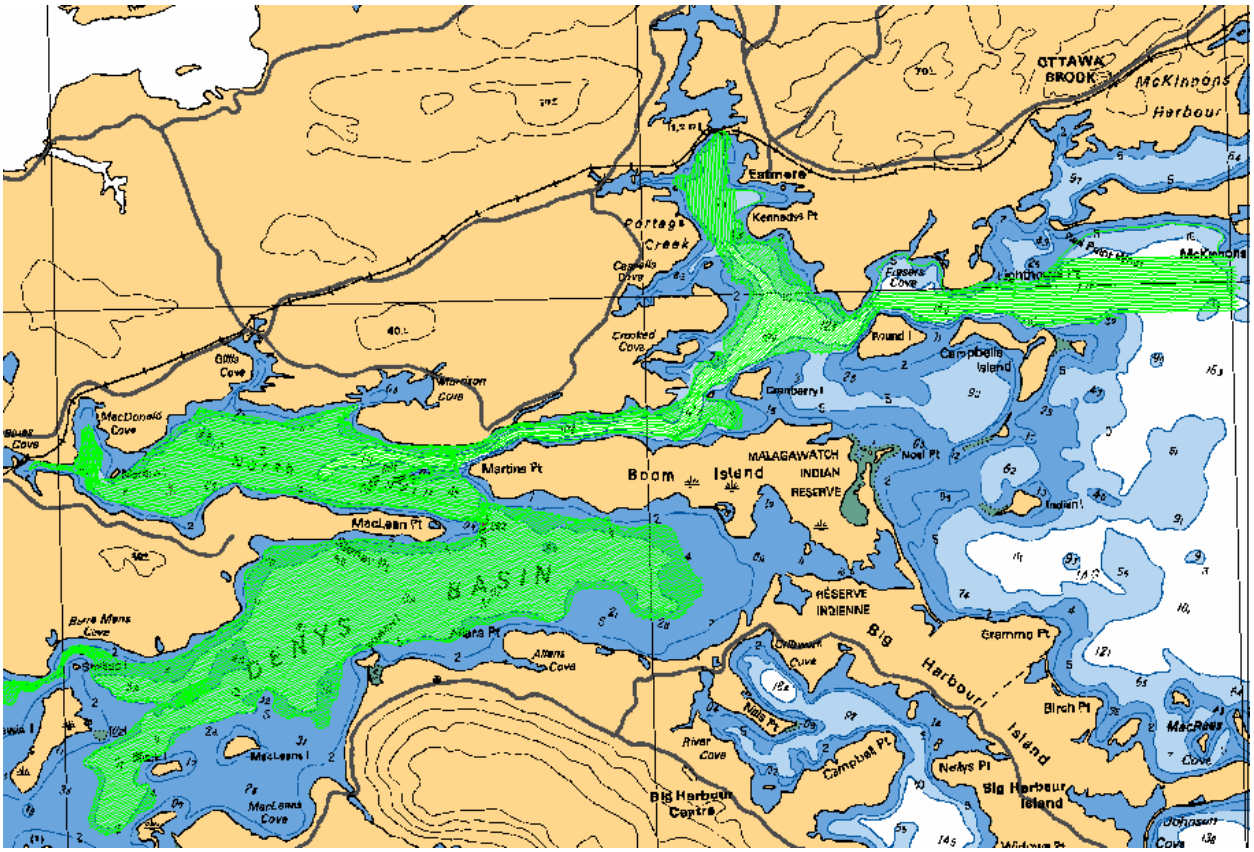

Figure 3: Survey tracks in Denys Basin, Cruise *Penguin* 2004-500.

Interferometric Sidescan Sonar

A SEA Submetrix 2000 system interferometric sidescan sonar system was used to collect both sidescan sonar and bathymetry data. The system was mounted on an over-the-side mount in the hydrographic survey launch *Penguin* (Figure 2). The system uses 237 kHz transducer to provide a depth resolution of about 1 % of water depth or 10 cm. A TSS DMS205 attitude sensing system was used to determine the vessel attitude. The system integrates data from an inertial measurement unit and accelerometers to provide a heave accuracy of 5 cm, with a resolution of 1 cm and a roll and pitch accuracy of +/1 0.05 degrees with an accuracy of 0.01 degrees. A Brown Meridian Surveyor digital gyrocompass provided heading information. Information on these instruments can be found on the VT Group PLC website at http://www.vttss.com/index.shtml.

Knudsen sounder

The vessel was also configured with a Knudsen 3.5 kHz and 28 kHz sounder that was used to collect sub-bottom information. The digital sub-bottom profiles are available for every line that was surveyed (see Figure 14 for some examples).

DATA PROCESSING

Bathymetry data were cleaned using SWATHplus acquisition software. They were imported into Caris HIPS (Hydrographic Information Processing System) for quality assurance; no further cleaning was done. A sidescan mosaic was made using SIPS (Sidescan Information Processing System) in HIPS. Various grid sizes were chosen. The images shown in this report are from a 2-metre grid that was produced using the 'shinethrough' option in HIPS. This process uses the highest value in areas of overlap.

RESULTS

Bathymetry

Figure 4 shows the bathymetry of the area that was surveyed. The data have been given a 'rainbow' colour scheme and shaded from the northeast. The imagery is dominated by a drowned fluvial system that drains to the east. Denys Basin is a relatively shallow part of the Bras d' Or Lakes. In the early Holocene the basin was completely emergent: the shores of the ancient lake were at -25 m. After ca. 6000 BP sea level flooded into the lakes, making them brackish. Sea level has been rising since then. Ancient river channels are well preserved because wave energy levels are low in the very sheltered basin. They lie under a carpet of mud.

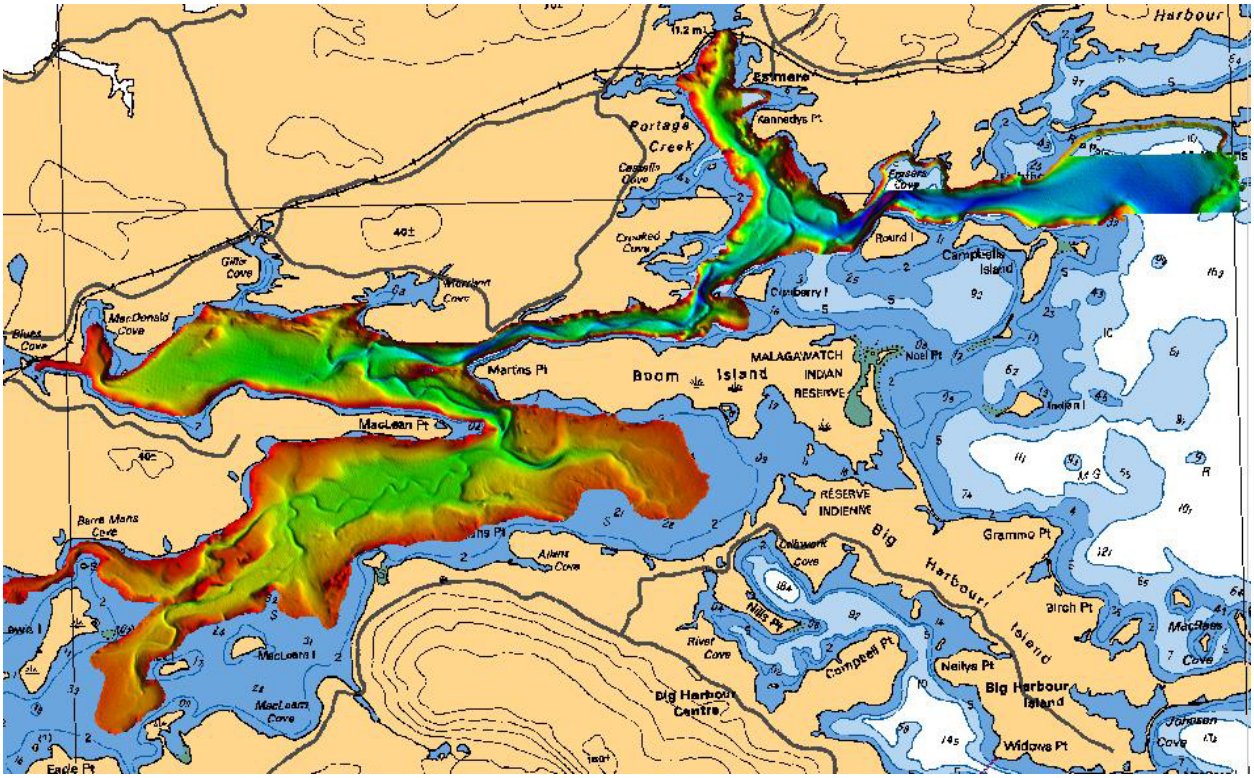

Figure 4: Bathymetry of Deny Basin.

Sidescan

The sidescan imagery from Denys Basin (Fig. 5) has an overall gray appearance. In a following section a series of examples will be used to show that it differs completely from Simrad EM-3000 backscatter data previously collected the Canadian Hydrographic Service and processed at the Geological Survey of Canada (Atlantic). Figure 6 shows EM-3000 backscatter. The sidewalls of the basin have high backscatter (dark indigo colour) while everywhere else has a pale gray. The interpretation would normally be that the dark areas are areas in which glacial diamict (till) or glaciomarine/lacustrine sediments are exposed, giving a 'hard' seabed, probably muddy gravel. The pale gray areas would be interpreted as mud.

However, when gridded at 2 metres and viewed at high resolution, the *Penguin* sidescan imagery reveals very clearly the distribution of oval to circular shell beds in the survey area, and anthropogenic objects (see discussion section for examples).

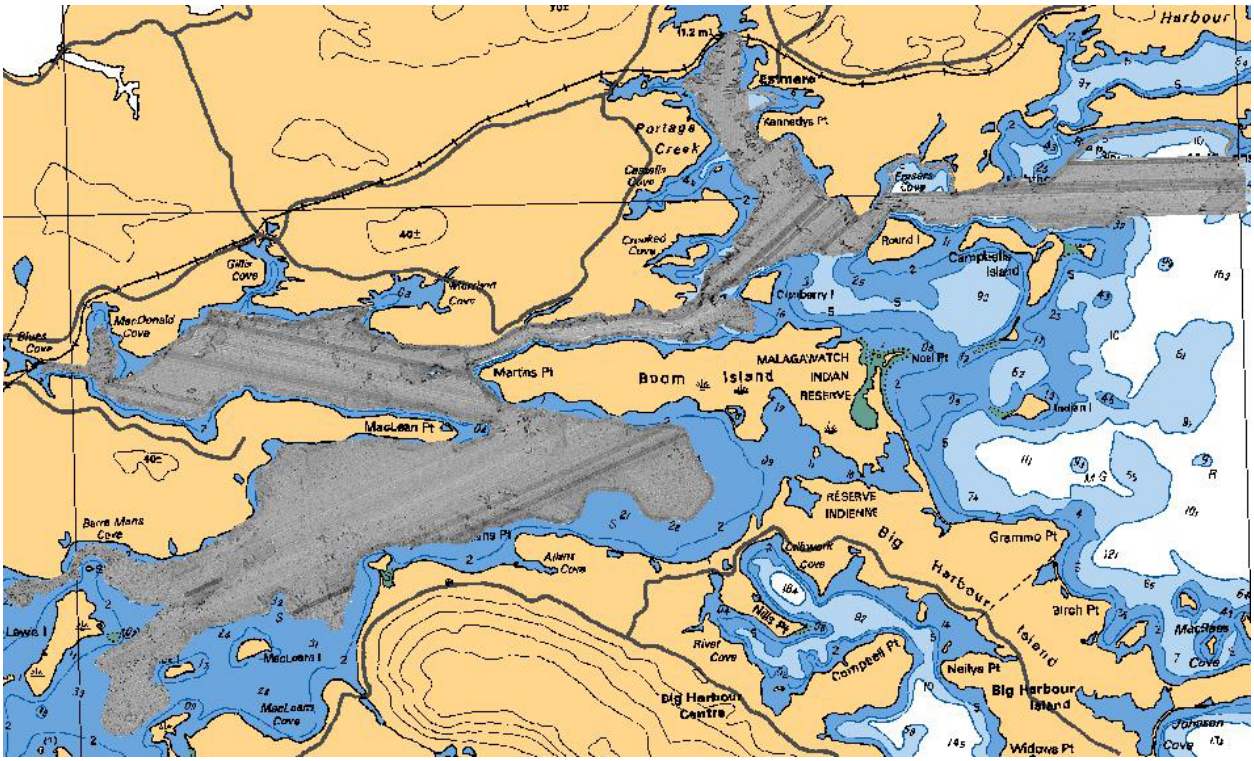

Figure 5: Sidescan in Denys Basin.

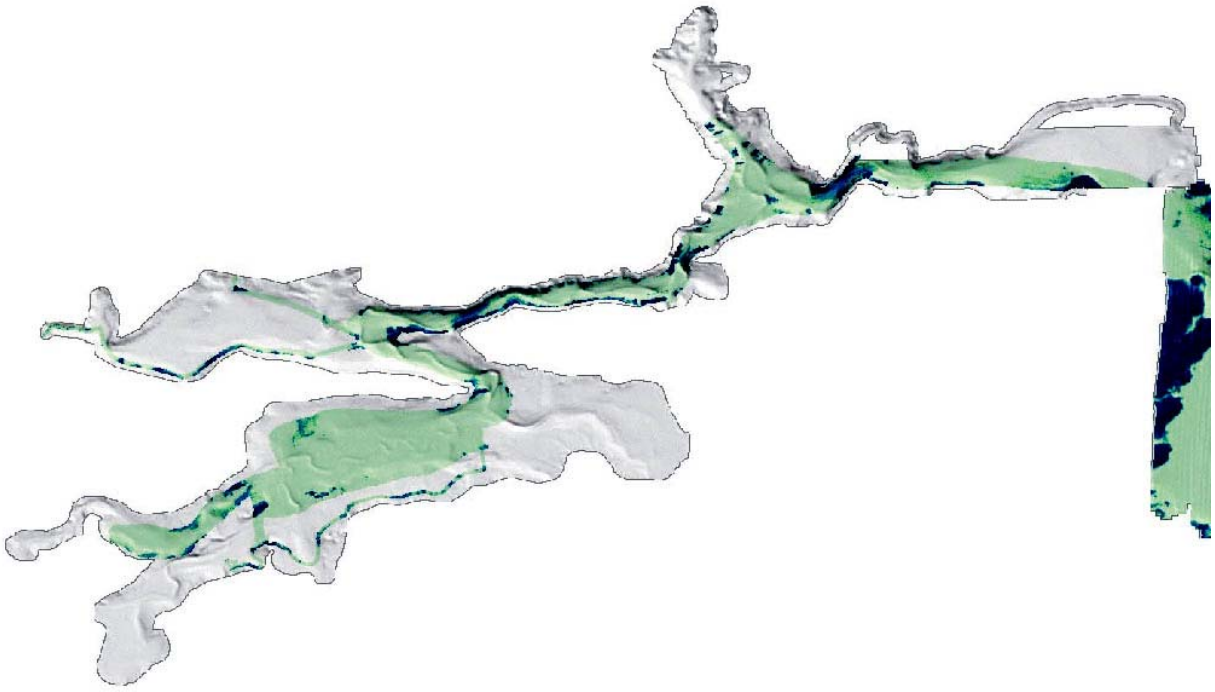

Figure 6: EM-3000 backscatter superimposed on the bathymetry of Denys Basin.

PRELIMINARY SCIENTIFIC INTERPRETATION

An ancient fluvial system is located in the basin. It operated in its entirety until ca. 6000 ka BP when the ocean entered the Bras d' Or Lakes, salinity increased, and sea-level started to rise. The valleys are seen in the bathymetry (e.g., Figures 8 and 9) but not in the backscatter and sidescan, showing that they are buried in mud.

Circular to oval areas of very high reflectivity (dark tone on the sidescan imagery) occur in two principal areas: the western part of North Basin (Figure 11) and the western part of Denys Basin Proper (Figures 12, 13). These are interpreted as oyster beds. A DFO survey in the fall of 2005 confirmed this. They are commonly 5 m in diameter, but some are smaller and others about 10 m across. One oval patch is 20 m long. The Knudsen 3.5 kHz sub-bottom profiler records (Figure 14, upper two images) show that the supposed oyster beds are the exposed tops of bioherms. They extend downwards to a hard substrate that is as deep as -10 m below sea level on some lines, and average 4 m in height. A 'back of the envelope' calculation, using a sea-level curve for the lakes that is under development, suggests that the bioherms may be as much as 3500 years old. In some areas, it is evident that the bioherms could not keep pace with sedimentation, and are now buried below mud (Figure 14, bottom image).

Anthropogenic objects (Figure 15) are clearly seen in several areas, particularly the western part of North Basin. These long linear features with high reflectivity are associated with oyster culture activities.

SUMMARY

- This was the first operational survey for the GSCA interferometric system. Overall the results are exciting, and show the potential of this equipment. The multibeam bathymetry imagery is of high quality.

- The sidescan imagery differs greatly from the Simrad EM-3000 backscatter. A comparison between the two types of data and an assessment of the reasons for the differences should be made. The imagery of supposed shell beds and anthropogenic objects shows that interferometric systems have great potential in areas such as Denys Basin.

- From a scientific point of view the results of the survey are extremely exciting. This may be the first imaging of oyster beds in the Bras d' Or lakes. Some interesting questions arise, in particular why the beds are restricted to certain areas in the western parts of Denys Basin. Is it because of salinity?

- The use of a dual frequency sub-bottom profiler greatly enhances the capability of the interferometric system. It is recommended that this become standard practice.

- The sounder data show that the shell beds are the exposed tops of bioherms. The bioherms are up to 4 m in height and may be up to 3500 years old.

- Some bioherms have been buried in mud. The questions that arise are when this happened and why. Was the burial very recent, and related to human activity that created a higher sediment input to the basin?

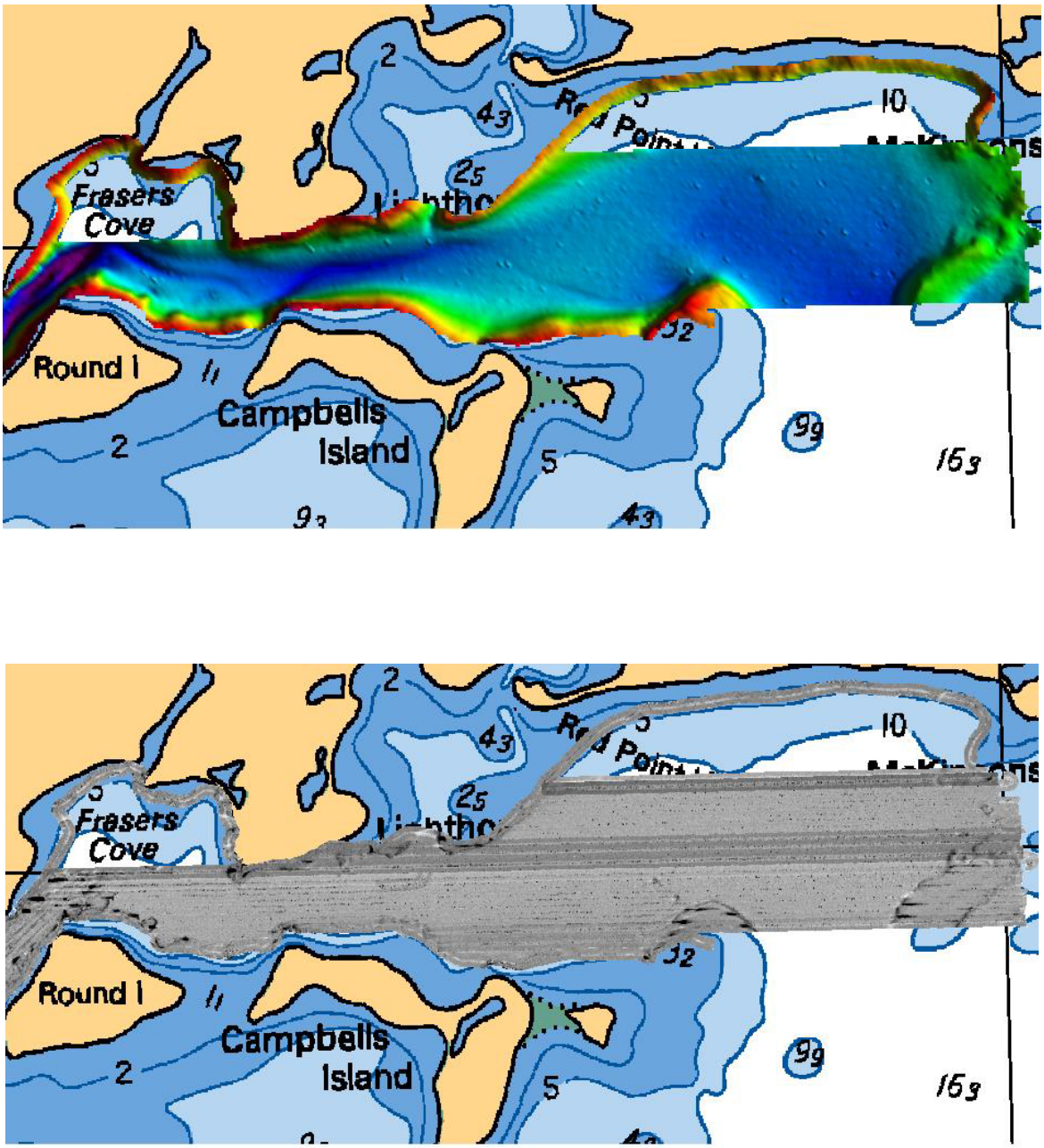

Fig. 7 Bathymetry (top) and sidescan (bottom). The dark tones in the sidescan record correspond with the edges of high-relief areas that have high backscatter in the Simrad EM-3000 data.

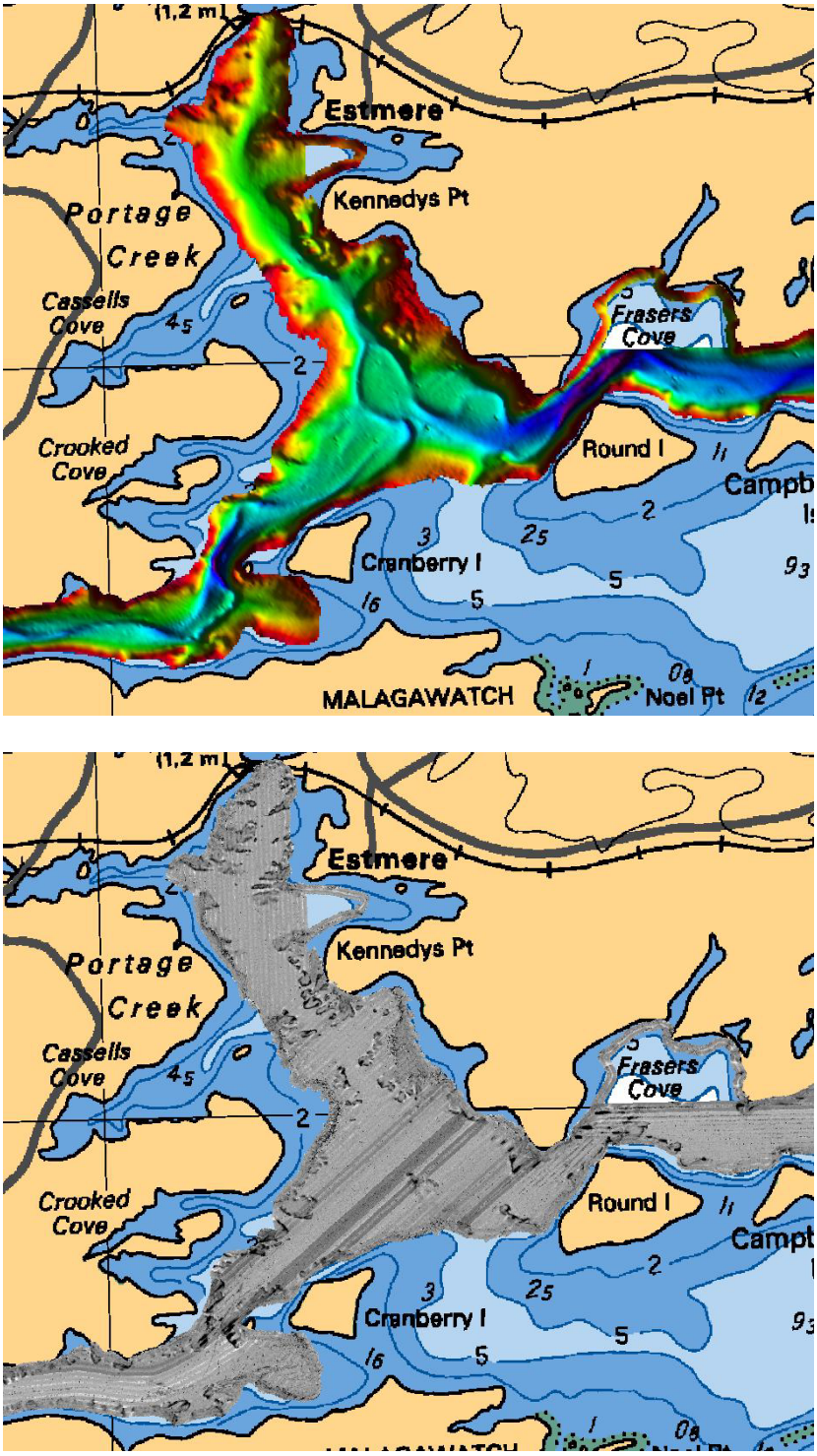

Figure 8: Bathymetry (top) and sidescan (bottom). Again, dark areas in the sidescan record delineate the edges of areas of high relief.

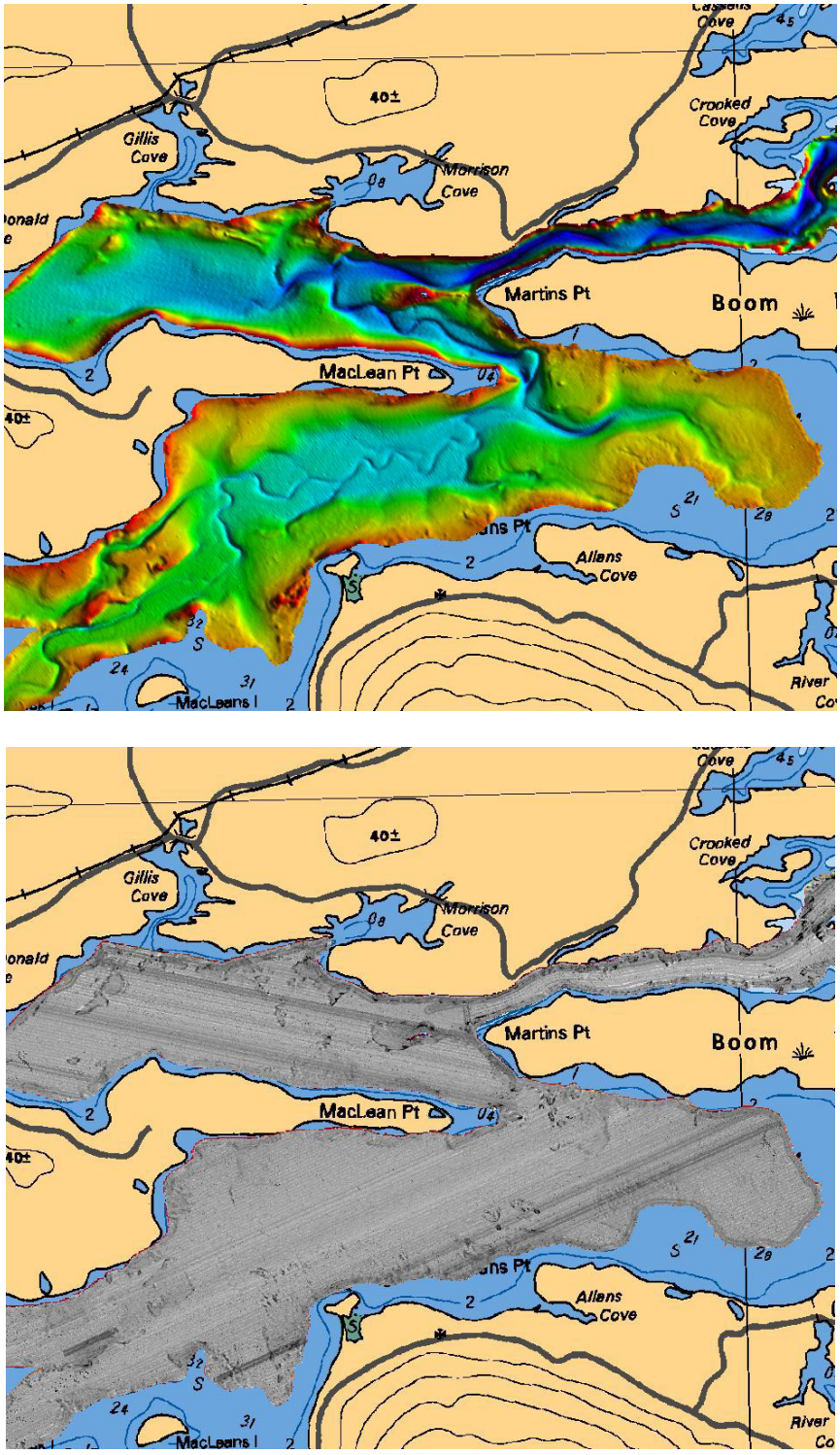

Figure 9: Bathymetry (top) and sidescan (bottom).

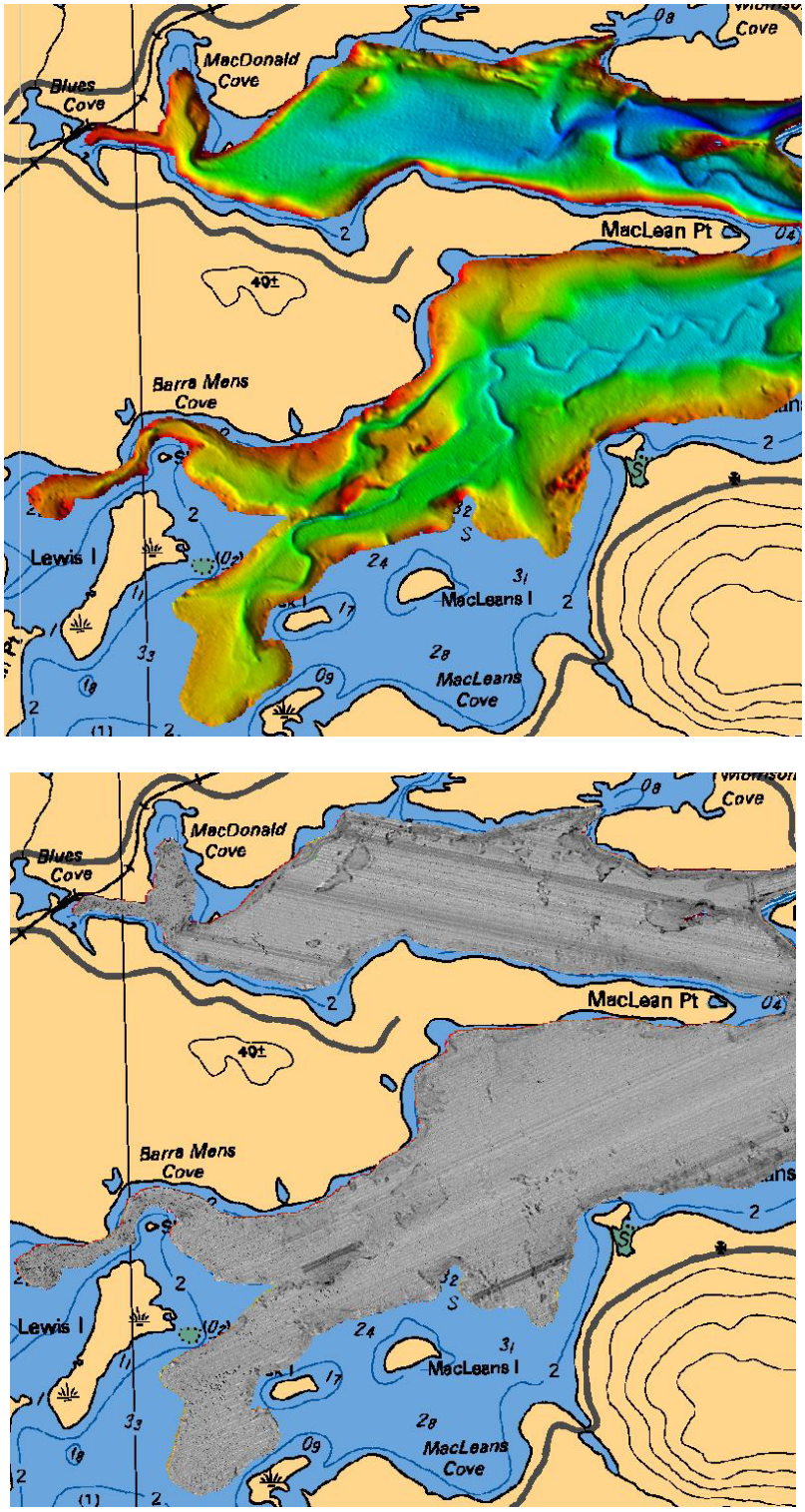

Figure 10: Bathymetry (top) and sidescan (bottom). Areas of oyster (?) bioherms occur in the northwest and southwest arms of the basin. They are clearly seen on the sidescan imagery, but not at this resolution.

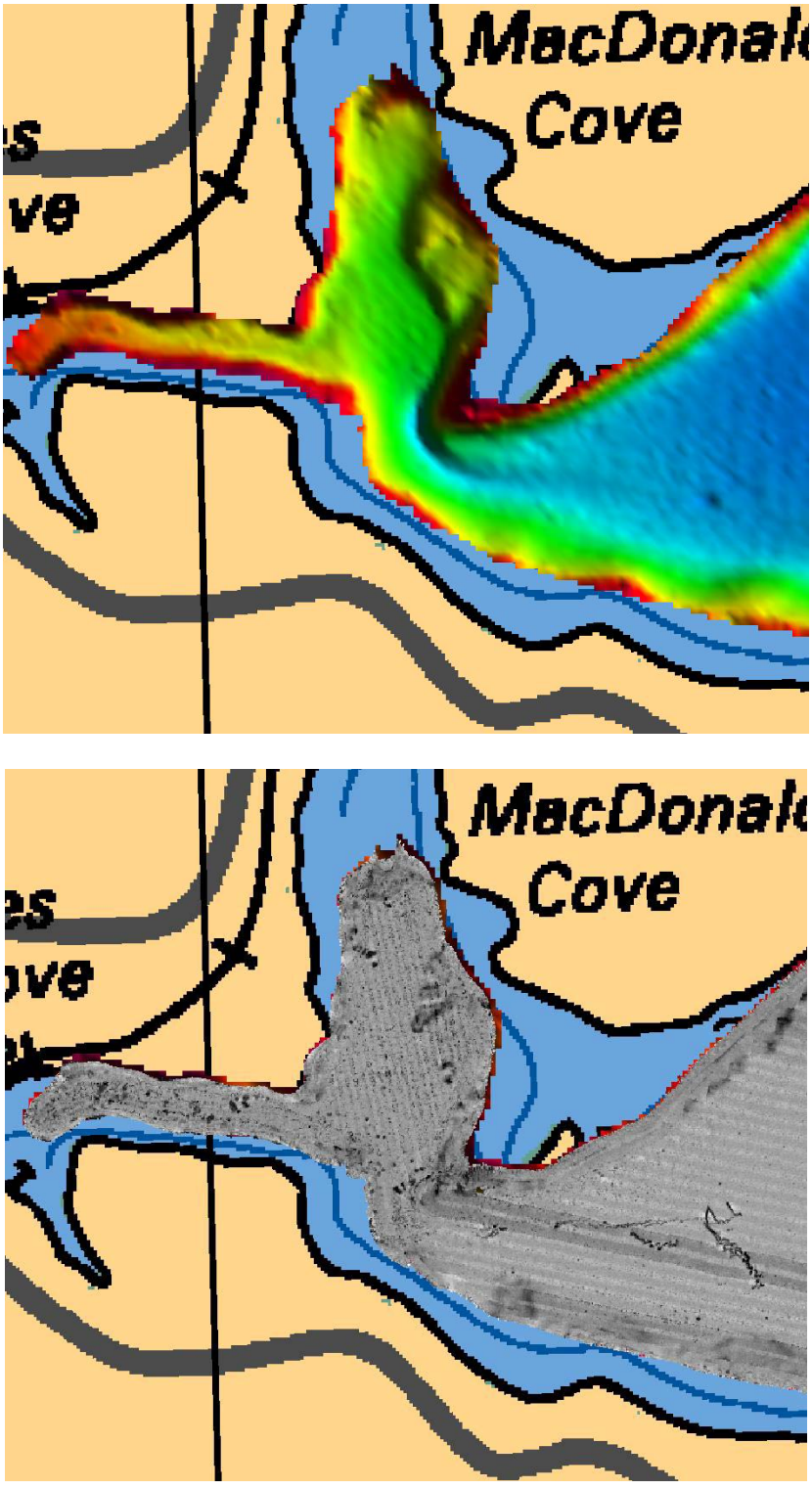

Figure 11: Bathymetry (top) and sidescan (bottom). The darker spots at the west side of the image are interpreted as oyster (?) bioherms. The irregular, dark structure at the right is believed to be related to aquaculture activities.

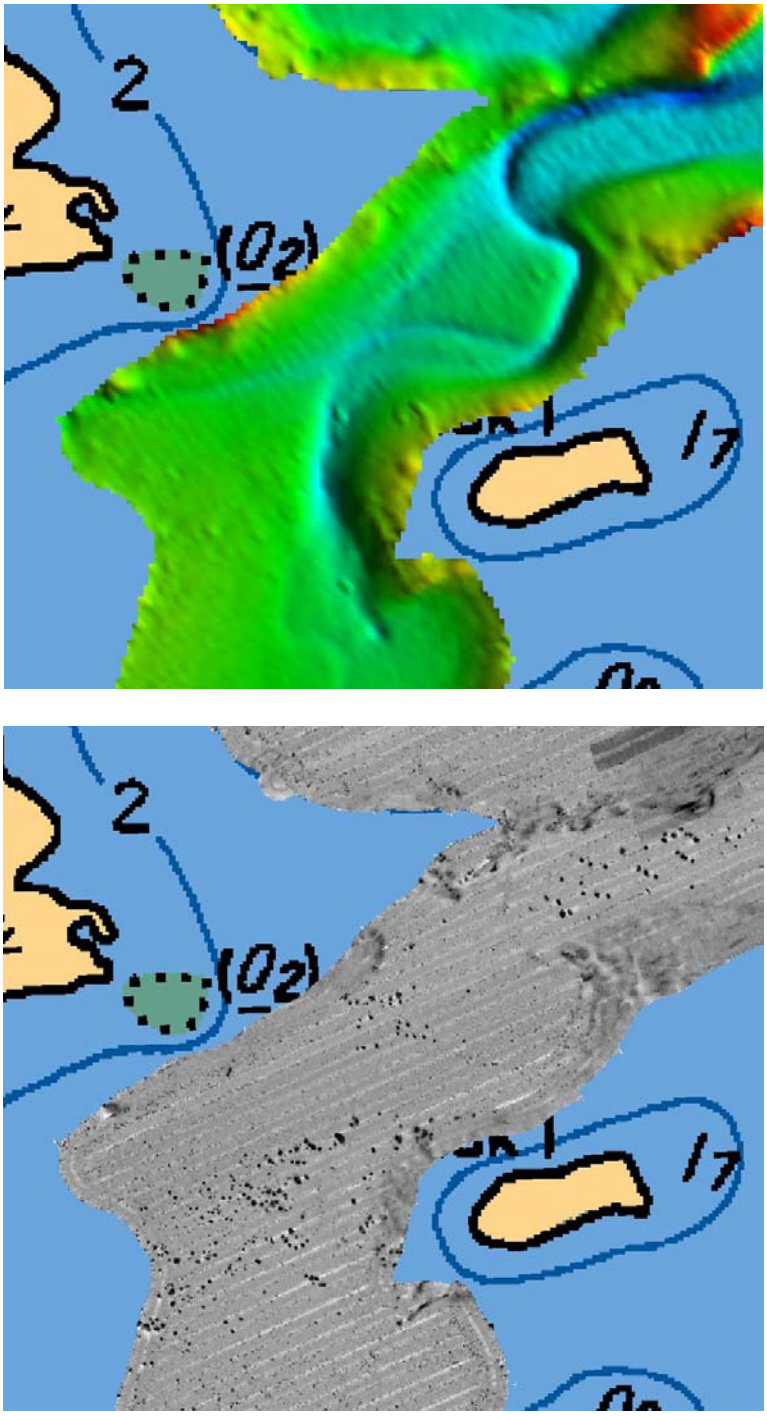

Figure 12: Bathymetry (top) and sidescan (bottom). There is a high concentration of oyster (?) bioherms in this area (dark spots in the sidescan image).

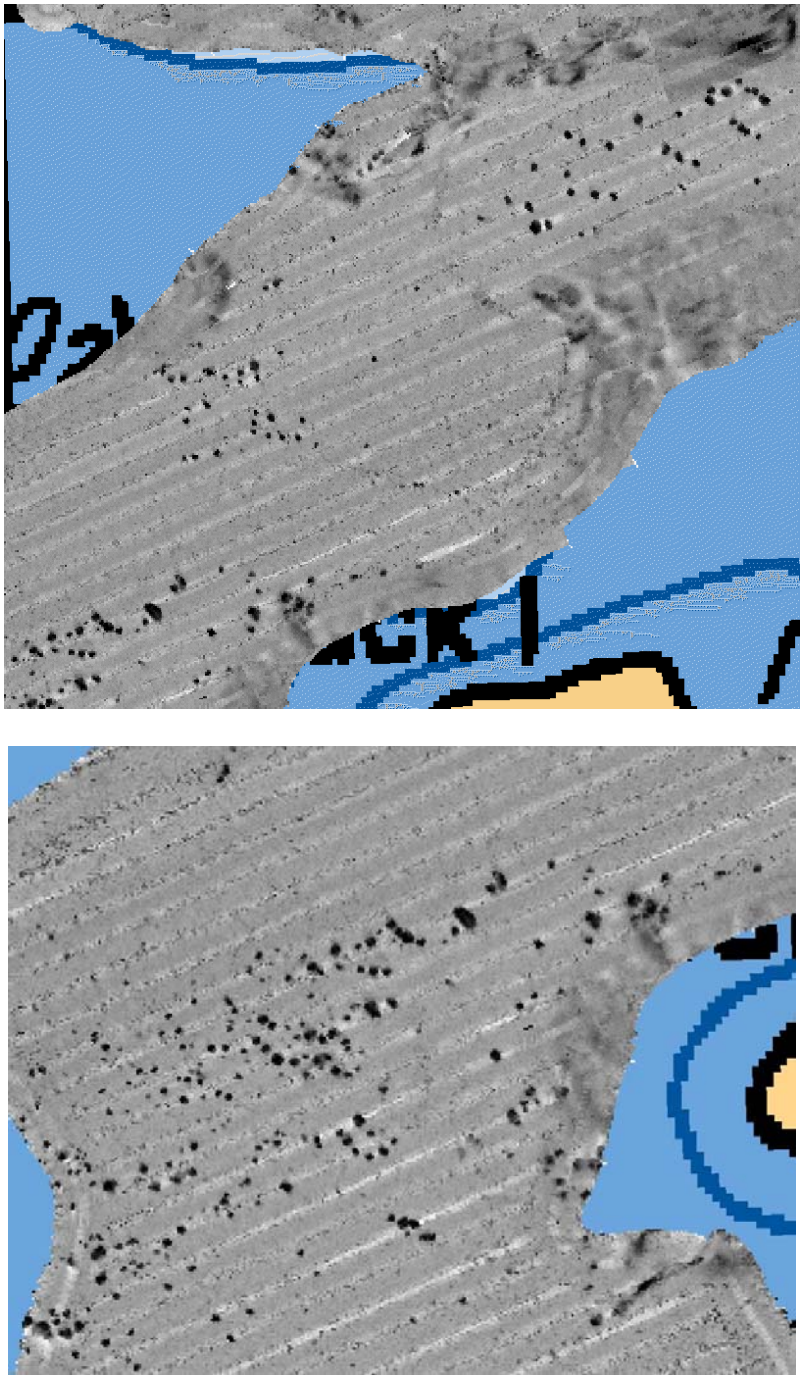

Figure 13: Enlarged view of oyster (?) beds in the southwest part of the basin.

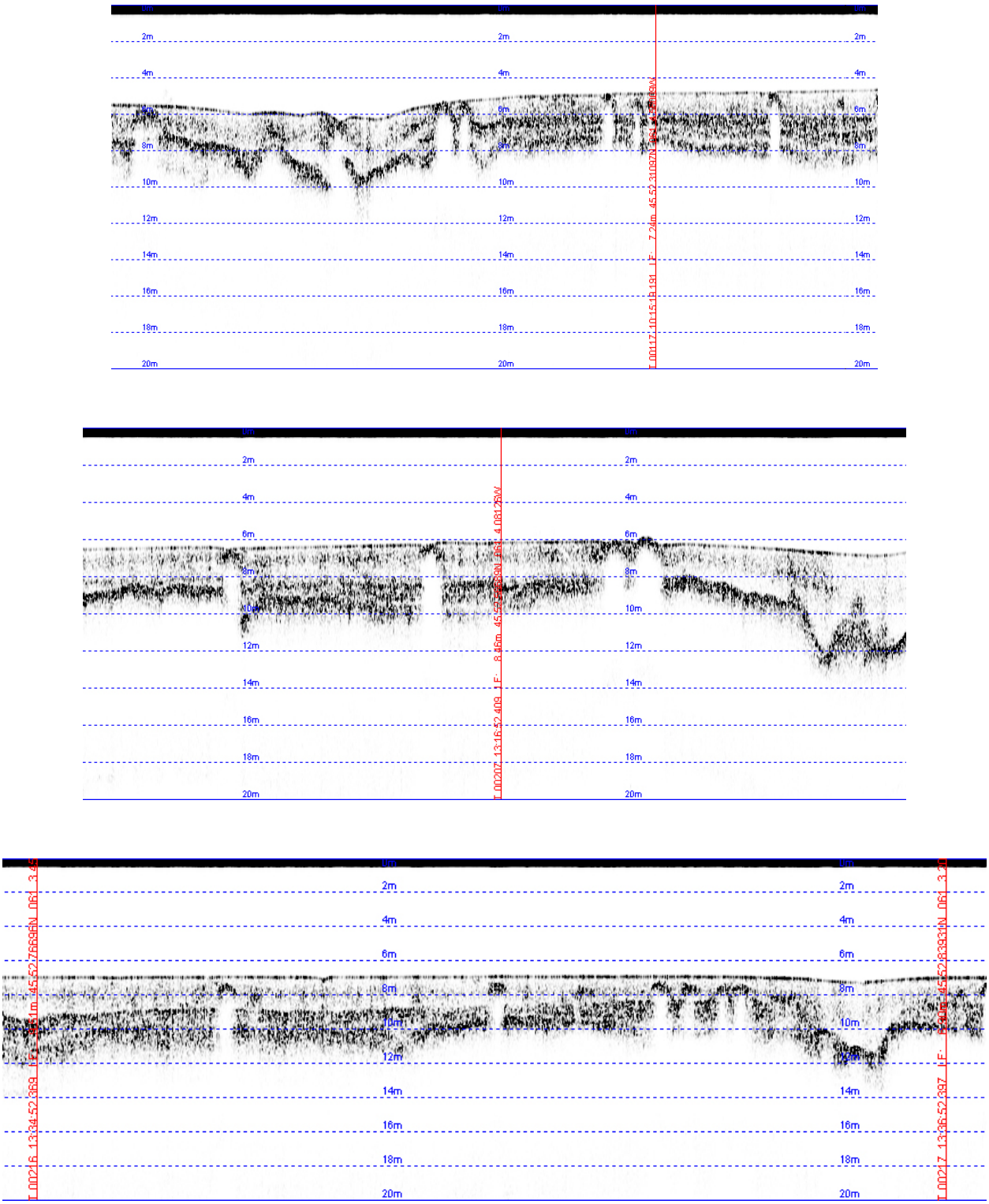

Figure 14: Knudsen 28 kHz sub-bottom profiles showing oyster (?) bioherms (top two images) and buried bioherms (bottom image).

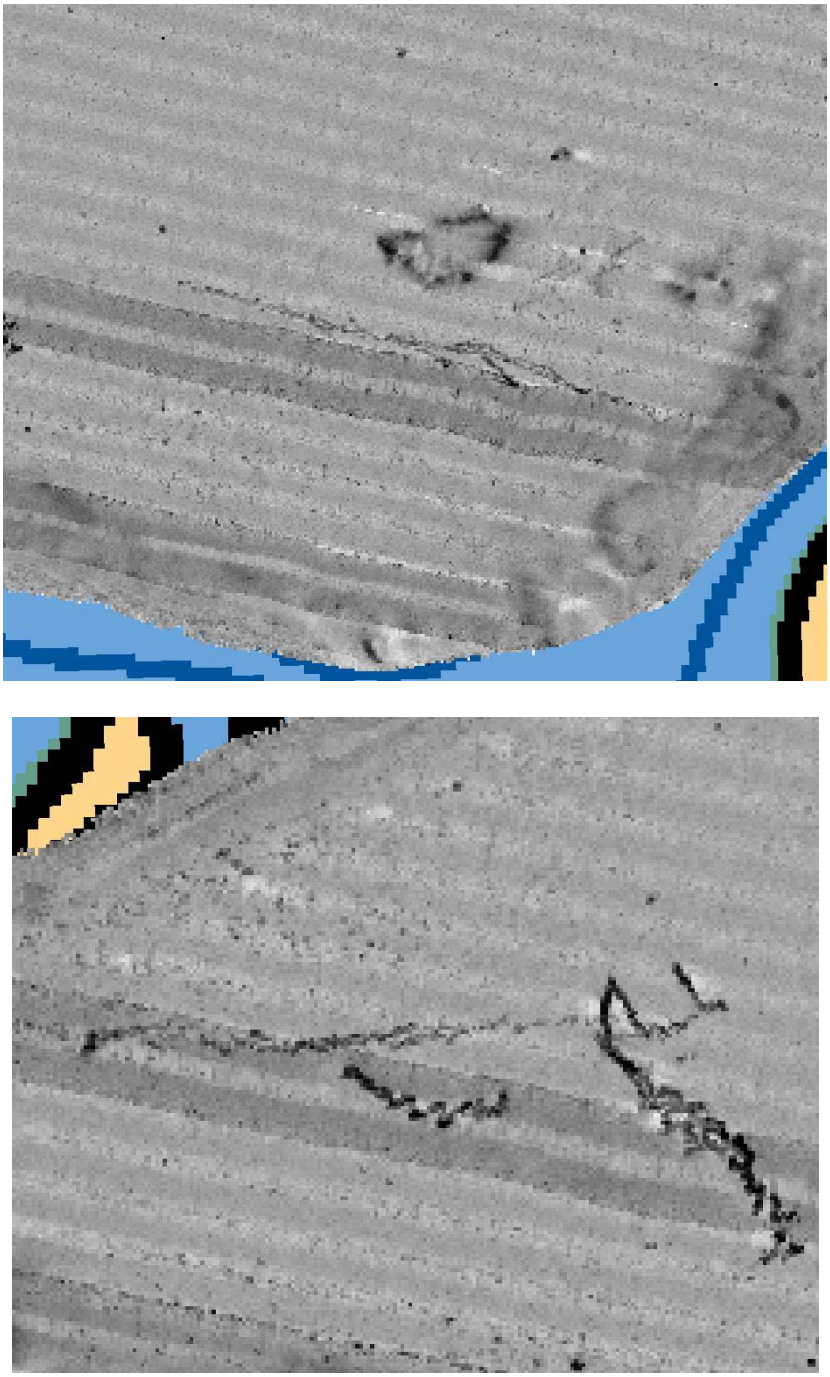

Figure 15: Sidescan imagery showing anthropogenic features on the sea floor in North Basin. In the upper image, the long linear feature running diagonally is 380 m long; in the bottom image, the features extend over a distance of 400 m. These may be strings of oyster breeding devices.