Video-Sidescan and Echosounder Surveys of Nearshore Bras d'Or Lake

H. Vandermeulen

Fisheries and Oceans Canada
Science Branch, Maritimes Region
St. Andrews Biological Station
531 Brandy Cove Road
St. Andrews, N.B.
E5B 2L9

2016

Canadian Technical Report of Fisheries and Aquatic Sciences 3183

Canadian Technical Report of Fisheries and Aquatic Sciences

Technical reports contain scientific and technical information that contributes to existing knowledge but which is not normally appropriate for primary literature. Technical reports are directed primarily toward a worldwide audience and have an international distribution. No restriction is placed on subject matter and the series reflects the broad interests and policies of the Department of Fisheries and Oceans, namely, fisheries and aquatic sciences.

Technical reports may be cited as full publications. The correct citation appears above the abstract of each report. Each report is abstracted in *Aquatic Sciences and Fisheries Abstracts* and indexed in the Department's annual index to scientific and technical publications.

Numbers 1 - 456 in this series were issued as Technical Reports of the Fisheries Research Board of Canada. Numbers 457 - 714 were issued as Department of the Environment, Fisheries and Marine Service Technical Reports. The current series name was changed with report number 925.

Technical reports are produced regionally but are numbered nationally. Requests for individual reports will be filled by the issuing establishment listed on the front cover and title page. Out-of-stock reports will be supplied for a fee by commercial agents.

Rapport technique canadien des sciences halieutiques et aquatiques

Les rapports techniques contiennent des renseignements scientifiques et techniques qui constituent une contribution aux connaissances actuelles, mais que ne sont pas normalement appropriés pour la publication dans un journal scientifique. Les rapports techniques sont destinés essentiellement à un public international et ils sont distribués à cet échelon. Il n'y a aucune restriction quant au sujet; de fait, la série reflète la vaste gamme des intérêts et des politiques du ministère des Pêches et des Océans, c'est-à-dire les scences halieutiques et aquatiques.

Les rapports techniques peuvent être cités comme des publications complètes. Le titre exact paraît au-dessus du résumé de chaque rapport. Les rapports techniques sont résumés dans la revue *Résumés des sciences aquatiques et halieutiques*, et ils sont classés dans l'index annual des publications scientifiques et techniques du Ministère.

Les numéros 1 à 456 de cette série ont été publiés à titre de rapports techniques de l'Office des recherches sur les pêcheries du Canada. Les numéros 457 à 714 sont parus à titre de rapports techniques de la Direction générale de la recherche et du développement, Service des pêches et de la mer, ministère de l'Environnement. Les numéros 715 à 924 ont été publiés à titre de rapports techniques du Service des pêches et de la mer, ministère des Pêches et de l'Environnement. Le nom actuel de la série a été établi lors de la parution du numéro 925.

Les rapports techniques sont produits à l'échelon regional, mais numérotés à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page du titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Canadian Technical Report of
Fisheries and Aquatic Sciences 3183

2016

VIDEO-SIDESCAN AND ECHOSOUNDER SURVEYS OF NEARSHORE BRAS D'OR LAKE

by

H. Vandermeulen

Fisheries and Oceans Canada
Science Branch, Maritimes Region
St. Andrews Biological Station
531 Brandy Cove Road
St. Andrews, N.B.
E5B 2L9

E-mail: herb.vandermeulen@dfo-mpo.gc.ca

This is the three hundred and twenty first Technical Report
of the St. Andrews Biological Station.

Cat. No. Fs 97-6/3183E-PDF ISBN 978-0-660-06607-3 ISSN 1488-5379

Correct citation for this publication:

Vandermeulen, H. 2016. Video-sidescan and echosounder surveys of nearshore Bras d'Or Lake. Can. Tech. Rep. Fish. Aquat. Sci. 3183: viii + 39 p.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Vandermeulen, H. 2016. Video-sidescan and echosounder surveys of nearshore Bras d'Or Lake. Can. Tech. Rep. Fish. Aquat. Sci. 3183: viii + 39 p.

A history of nearshore benthic surveys of Bras d'Or Lake from 2005 – 2011 is presented. Early work utilized drop camera and fixed mount sidescan. The next phase was one of towfish development, where camera and sidescan were placed on one platform with transponder-based positioning. From 2009 to 2011 the new towfish was used to ground truth an echosounder. The surveys were performed primarily in the northern half of the lake; from 10 m depth right into the shallows at less than 1 m. Different shorelines could be distinguished from others based upon the relative proportions of substrate types and macrophyte canopy. The vast majority of macrophytes occurred within the first 3 m of depth. This zone was dominated by a thin but consistent cover of eelgrass (*Zostera marina* L.) on almost all shores with a current or wave regime conducive to the growth of this plant. However, the eelgrass beds were frequently in poor shape and the negative impacts of commonly occurring water column turbidity, siltation, or possible localized eutrophication, are suspected. All survey data were placed into a Geographic Information System, and this document is a guide to that package. The Geographic Information System could be used to answer management questions such as the placement and character of habitat compensation projects, the selection of nearshore protected areas or as a baseline to determine long term changes.

RÉSUMÉ

Vandermeulen, H. 2016. Relevés des zones littorales du lac Bras d'Or par vidéo à balayage latéral et par échosondeur. Can. Tech. Rep. Fish. Aquat. Sci. 3183: viii + 39 p.

Un historique des relevés benthiques des zones littorales du lac Bras d'Or (de 2005 à 2011) est présenté. Pour les premiers travaux, on a utilisé une caméra sous-marine et un sonar latéral à support fixe. La prochaine étape était le développement d'un poisson; dans cet appareil, la caméra et le sonar latéral ont été placés sur une plateforme avec positionnement par transpondeur. De 2009 à 2011, ce nouveau poisson a été utilisé pour obtenir une référence-terrain d'un échosondeur. Les relevés ont été principalement réalisés dans la moitié nord du lac, à savoir d'une profondeur de dix mètres jusqu'aux eaux peu profondes à moins d'un mètre. On pouvait faire la distinction entre les différents rivages à partir des proportions relatives des types de substrat et de la couverture de macrophytes. La grande majorité des macrophytes étaient présents dans les trois premiers mètres de profondeur. Cette zone était dominée par une couverture mince, mais uniforme, de zostère (*Zostera marina* L.) sur presque tous les rivages avec un régime de courants ou de vagues propices à la croissance de cette plante. Cependant, les herbiers de zostère étaient souvent en mauvais état, et on présume qu'ils subissent des répercussions négatives en raison de la fréquente turbidité de la colonne d'eau, de l'envasement et de la possible eutrophisation localisée. Toutes les données d'enquête ont été intégrées à un système d'information géographique, et le présent document est un guide pour cette trousse. Le système d'information géographique pourrait être utilisé pour répondre aux questions de gestion, y compris le placement et la nature des projets de compensation de l'habitat ainsi que la sélection des zones de protection sur le littoral. Il pourrait aussi servir de base de référence pour déterminer les changements à long terme.

INTRODUCTION

The author spent the period of 2005 to 2011 investigating nearshore habitats in Bras d'Or Lake (Cape Breton, Nova Scotia). The earliest attempts were at River Denys Basin with a hull mounted sidescan ground-truthed via drop camera or direct observations (Vandermeulen 2007, 2014a). Video and sidescan hardware were then fused into one towfish for the next series of surveys (Vandermeulen 2011a). The final step was to use the towfish to ground-truth a newly acquired echosounder system, a BioSonics Inc. DT-X with dual transducers (Vandermeulen 2011b). The towfish/echosounder combination made it possible to cover much longer distances of shoreline per survey compared to the towfish alone. For this publication, the author reprocessed all echosounder data utilizing the new 'Visual Habitat' software from BioSonics. Visual Habitat is far superior to previous BioSonics software for determining bottom classifications and macrophyte cover.

The focus of the early surveys was primarily to locate eelgrass beds in the shallows. However, with the addition of the BioSonics package it became clear that information could also be gathered on bottom type and general macrophyte cover over large areas. In addition, the video could be used to investigate macro-invertebrate and fish populations within different bottom types and macrophyte beds.

A new Geographic Information System (GIS) package has been created which includes all of the Bras d'Or Lake survey data from 2005 to 2011. This new package provides baseline information for managers to ask much broader questions than simply "Where is the eelgrass?". The GIS can be used to create new layers concerning potential protected areas, habitat compensation projects, habitats requiring restoration, productive habitats, or baselines to track change over time. The new GIS package is described here.

2.0 MATERIALS AND METHODS

2.1 Survey Sites and Methods

The overview map showing all surveyed areas is shown in Figure 1. The surveys were divided up as follows:

1. River Denys Basin (2005) – This was an early attempt to test field equipment on a 15 foot Boston Whaler (Fig. 2). The methods are described in Vandermeulen (2007, 2014a).
2. The five First Nations shorelines (2007 & 2008) – Including Eskasoni, Malagawatch (and a portion of River Denys Basin), Wagmatcook, Whycocomagh and Chapel Island. The subjects of these surveys were eelgrass beds. A new 22 foot wheelhouse vessel was used as a survey platform with a new towfish (Fig. 3). The methods are described in Vandermeulen (2011a).
3. Whycocomagh to Baddeck (2009) – This included a revisit of River Denys Basin. The purpose of this and all subsequent surveys was to cover longer distances of

shoreline looking for a variety of nearshore habitats using the towfish and a new echosounder (Fig. 4). The methods are described in Vandermeulen (2011b).

4. Whycocomagh to Iona (2010) – Continued long-distance survey, methods as in Vandermeulen (2011b).
5. The south side of St. Andrews Channel (2011) - Continued long-distance survey, methods as in Vandermeulen (2011b).

3.0 RESULTS

3.1 Data collected in the field

3.1.1 2005

Sidescan transects were run in River Denys Basin on September 27 & 28th, 2005. Drop camera video clips were collected along these transects on September 30[1]. The transects were coded as RDb1-4, RDb5a & b, and RDb6-9 (ten transects in all).

3.1.2 2007 & 2008

Towfish survey runs were performed in Whycocomagh Bay and Wagmatcook from August 29-31, 2007. The Eskasoni survey took place October 9-12, 2007. Malagawatch was surveyed October 22-24, 2007 and this included the eastern portion of River Denys Basin. There was a transceiver equipment failure during the Malagawatch survey, so some towfish transects were not run. The Chapel Island survey occurred from July 8-9, 2008. The remaining Malagawatch transects were covered on July 10, 2008.

The towfish transects were coded as follows[2]:

- Whycocomagh; WH01-30 (30 transects)
- Wagmatcook; WK01-12 (12 transects)
- Eskasoni; ES01a&b, ES02-08, ES09&b, ES10-12, ES13b, ES14-26, ES27b, ES28-68, ES69b, ES70-72, ES75 (73 transects)
- Malagawatch; MA01-12, MA13b, MA14-67, MA68b, MA70-76 (76 transects)
- Chapel Island; CI01-15, CI16&b, CI17-91 (92 transects)
- Malagawatch (2008); MA77-82 (6 transects)

[1] The drop camera video clips were of poor quality due to water turbidity. The clips were included in file folders for the GIS project but not embedded into a layer in the GIS.
[2] Some transect numbers were skipped as that planned transect could not be run in the field. Transects with a or b designations came about if the original planned transect could not be run in one section in the field.

3.1.3 2009

Towfish transects were run from Whycocomagh Bay to Baddeck October 27-29, 2009. Separate towfish cross transects were run where possible at all transects at 5 and 10m, anticipating these as cross points for the echosounder survey later on. This pattern of towfish use was only done in 2009, as the extra effort did not improve overall results significantly. Echosounder runs at 5 and 10m depth contour lines were performed along this same stretch of shoreline on October 30.

Several transects were run in the western end of River Denys Basin on October 31, with an echosounder run at the 5m contour line on November 1, 2009.

The towfish transects were coded as follows:

- BL01-40 (40 transects); with sub-codes for the 5 or 10m cross runs (e.g. BL20-10)
- River Denys; RD01-05 (5 transects); with sub-codes for the 5m cross runs with orientation (e.g. RD05-5w)

3.1.4 2010

It was determined that the 2009 surveys produced a sampling grid which was too coarse. The towfish transects were spaced too far apart (approximately 2 km separation) and echosounder runs at 5 and 10 m depth missed a relatively lush macrophyte canopy in the shallows. For 2010, the towfish transects were spaced more closely (approximately 1 km apart) and the 3 m contour was added to the echosounder runs.

Towfish transects were run from Whycocomagh Bay to Iona October 19-24, 2010. Echosounder runs at 3, 5 and 10m depth contour lines were performed along this same stretch of shoreline October 25-29.

The towfish transects were coded as follows:

- BD01-04, BD05&b, BD07-18, BD19&b, BD20-24, BD24real, BD25-61 (63 transects)

3.1.5 2011

2010 survey protocols were followed again this year. Towfish transects were run along the south shore of St. Andrews Channel October 14-18, 2011. Echosounder runs at 3, 5 and 10m depth contour lines were performed along this same stretch of shoreline October 21-23.

The towfish transects were coded as follows:

- SA01-62 (62 transects)

3.2 The GIS Project and its Layers

3.2.1 GIS project workspace

The GIS was developed using MapInfo Professional ver. 10.5. The workspace file was placed on the root directory of an external 2TB drive and was called ‘bdormax.wor’. All data were placed on the drive into a root file folder called ‘bras dor’ with sub-folders labelled ‘charts’, ‘excel files’, ‘sidescan images’, and ‘videos’. The total amount of data on the drive was 770 GB, representing over 3800 files.

The external drive was seen as G:\ during the building of the GIS workspace, and the GIS will be most stable if the drive is picked up as G:\ by other computers. However, relative file paths were used in all cases (e.g. the GIS *.TAB files for video clip positions were placed in the same folders as the associated *.AVI video clips), so the GIS should work smoothly on any computer with MapInfo Professional ver. 10.5 or higher.

The workspace is best viewed with both ‘Layer Control’ and ‘Legend’ boxes open to provide clarity (Fig. 5). The ‘Layer Control’ box is the key to utilizing and exploring the workspace. It is organized as described in Table 1. Details of the layer groupings are described below.

3.2.2 Base charts

4277 is the St. Andrews Channel area; 4279_1 is the southern portion of the Lake; 4279_3 is an extension for the Eskasoni area; 427801 covers the area from Whycocomagh to Baddeck and Iona.

3.2.3 Sidescan imagery

The sidescan proved to be very useful for discerning soft versus hard bottoms, and three dimensional bottom features (texture). The GeoTIFF images were produced so that soft bottoms with low acoustic reflectivity were indicated as dark brown, while acoustically reflective hard surfaces (e.g. rocks, pilings, debris) were light brown to yellow. The hardness contrast is illustrated in Fig. 6 for ES06. In this figure, the transect begins at the north end of the image at the red arrow where the video clip has been embedded, the depth of the water here is approximately 1 m and the bottom is quite hard as indicated by the brassy tinge of the sidescan. As the towfish was dropped deeper into the channel, the bottom became quite soft and the brassy tinge is replaced by dark brown or black, indicating a soft or acoustically non-reflective bottom. At the far south end of the transect the towfish is now in shallow waters once again and the brassy tinge returns. The width of this and all sidescan images is 30 m.

Each sidescan GeoTIFF was imported into the GIS, its background made transparent and then a black polygon was masked directly underneath the image to provide proper contrast. In the Layer Control area each black polygon was given a BG filename matching the original GeoTIFF filename (e.g. ES06BG masks ES06). If the masking BG layer is turned off, the related GeoTIFF image will appear washed out or almost completely indecipherable if the bottom is very soft.

Figure 7 is a portion of transect BD47. A dense cobble field is seen at the north end of this image and bottom here was very hard and textured. The arrows indicate three large boulders with long acoustic shadows on a relatively hard packed and smooth sand/gravel bottom to the south.

3.2.4 Video clips

While there was an extraordinary amount of detail provided by the GeoTIFF sidescan imagery, it was imperative to ground truth these images. The video camera on the towfish provided this service. Since video was collected at the same time that the sidescan was running, the ground truthing occurred in real time. The midline of each GeoTIFF image indicates the towfish path, and red arrows embedded along that path in the GIS indicate relevant video clip positions.

As mentioned above, the GeoTIFF imagery was very good for indicating bottom type. However, the video footage became invaluable for ground truthing on certain bottom types. For example, a dense eelgrass bed frequently had the same acoustic signature and texture as a hard packed sand bottom (Fig. 8). The video was used to discern the difference. Note that each frame of video includes an overlay with true towfish position and GMT date and time stamps. In Figure 8, the video frame position is 45° 42.8739" north latitude by 60° 46.4740" west longitude.

3.2.5 Towfish classifications

With the sidescan and video layers in place it became possible to create bottom type and macrophyte "towfish classifications". The first example of this occurred with the 2007 and 2008 data sets. Maps were created indicating the presence of eelgrass beds by interpolating between transects. The results are shown in Figures 9-13.

Starting in 2009, towfish classifications were created that examined the entire macrophyte canopy, not just eelgrass. Sidescan imagery was actually quite useful for discerning canopy types, especially for eelgrass – but the bulk of identifications were obtained from the video footage. Bottom type classifications were created by examining sidescan GeoTIFFs and corresponding video.

The spreadsheet used for the 2009 towfish bottom classification was called "Bras d'Or Bottom Type.xls" and it was used to create a layer in the GIS for bottom types located just above that filename. The legend title for that layer is "Bras d'Or Bottom Type Towfish 2009". Figure 14 shows this classification at the 5 and 10 m cross points of transect BL04. The uniform bottom type at the 5 m cross point is classed as cobble on sand/mud. At 10 m, the bottom grades from cobble to cobble on sand/mud through to sand at the western end of the cross point where it runs over the main transect which trends perpendicular to shore.

The spreadsheet used for the 2009 towfish macrophyte classification was called "Bras d'Or Macrophyte.xls". The legend title for the macrophyte layer created just above it in the Layer Control is “Bras d’Or Macrophytes Towfish 2009”. There were no macrophytes at the cross points for BL04, so no colored dots are present there when the layer is turned on (Fig. 15). The names used in the macrophyte legend box are explained in Table 2.

The spreadsheet used for the 2009 towfish bottom classification in River Denys Basin was called “River Denys Bottom Type.xls”. The legend title for the bottom type layer created just above it in the Layer Control is “River Denys Bottom Type Towfish 2009”.

In 2010, the spreadsheet used to hold both macrophyte and bottom type towfish classifications was called “BD 2010 video GT hardness.xls” the corresponding layer legends were “BD 2010 video macrophyte” and “BD 2010 video bottom type”. Similarly, in 2011 the spreadsheet was called “SA spreadsheetA.xls” and the legends were “SA towfish 2011 bottom type” and “SA towfish 2011 macrophyte”.

The texture seen in the sidescan imagery would frequently match the macrophyte cover noted in the video. Figure 16 is an example of this, where the deeper portions of the sidescan GeoTIFF in transect BD20 indicate a soft bottom where one would not expect to find macrophyte cover and none are seen in the classification (red dots). In the same figure, you can see a change in the sidescan GeoTIFF in the shallows where it brightens up due to the presence of an eelgrass bed (yellow stars).

Although the video information was primarily used to create macrophyte and bottom type towfish classifications, other classifications were possible as well. The video was clear enough to see fish (Fig. 17), invertebrates (Fig. 18), fish assemblages (Fig. 19), and eelgrass “health” (Fig. 20). With true towfish position data available in each frame of video, any one of these features could have been quantified and placed as a new towfish classification layer in the GIS.

An example of one of these classifiable features is provided in Figure 21. These odd golf ball sized objects were seen on the bottom at several locations in Wagmatcook. They had the consistency of fluffy balls of cotton and are reminiscent of the oomycete *Leptomitus*. They are an indicator of potential organic contamination in the water column and the author has mapped them previously on bay-wide scales in a GIS using the same towfish in several northern New Brunswick estuaries (Vandermeulen 2014b).

3.2.6 Echosounder classifications

The 430 kHz transducer on the BioSonics DT-X echosounder was designed to discern macrophyte cover and canopy height above true bottom position. Older BioSonics software packages ran batch job algorithms on raw echogram files to define bottom position and canopy height. However, the results were not overlaid against the original echograms to allow a visual confirmation of accuracy. One of the problems with the older software packages was the tendency for false positive macrophyte canopy identification on softer bottoms.

These issues were resolved with the publication of the new Visual Habitat software package from BioSonics in 2012. Visual Habitat (VH) ran bottom and canopy detection batch jobs as before, but did place the results back in the original echograms and allowed for hand editing if conspicuous errors were seen (Fig. 22). The editing capability vastly reduced false positives and other errors[3] when average canopy height and bottom type calculations were performed on clusters of pings in the later stages of VH analyses.

The topmost layers in the GIS were those associated with the final echosounder classifications created using VH. The resulting spreadsheets had titles similar to those used for the towfish classifications. “Baddeck” refers to files from 2009, “Denys” is for Denys Basin in 2009, BD is for the 2010 survey and SA is from 2011 data. In the same spreadsheet titles the depth contours are identified in meters, “plants” refers to canopy height data in meters and “six cluster” refers to a six cluster bottom type classification from VH. The layers produced from each of these spreadsheets used similar coding in their legends.

For the purposes of ground truthing, each VH echosounder classification was checked against towfish classifications at cross points for each relevant towfish transect. This is illustrated at the BL01 transect cross point at 5 m (Fig. 23). In this image, the VH bottom type classification is seen as a string of colored dots running along the 5 m depth contour and crossing the sidescan imagery at the 5 m cross point towfish transect. In this six cluster VH classification we have one cluster representing a soft bottom acoustic signature (red dots), two acoustic signature clusters indicating intermediate bottom hardness (light blue dots), two indicating a harder bottom signature (dark blue dots) and a smaller cluster of unclassified signatures (white dots)[4]. Compare this string of dots to those in the towfish classification. Note how the towfish classification indicates a mud bottom (yellow dots) over most of the transect, and the VH classification close to those towfish dots tend to be strings of red and light blue dots which confirm the relatively soft nature of the bottom in this area. Conversely, the harder “sand” (light blue) dots in the towfish classification are associated with a bright area in the sidescan image to the east and light blue and dark blue VH dots (the VH ‘soft’ red dots to not appear in this area at all). Both towfish and VH classifications confirm a harder bottom in this area. In this manner, the towfish classifications ground truthed the VH classifications.

Similarly, the towfish data were used to ground truth VH canopy height classifications. This is illustrated at the same location in the BL01 transect cross (Fig. 24). Here we see a string of red dots from the VH canopy height classification referring to a canopy height of 0.15 m or less, which was essentially the detection limit of the analysis. Hence, VH could not detect a canopy anywhere along this cross transect. This is confirmed by the towfish macrophyte classification which also did not see any macrophytes in the area (no colored dots anywhere along the midline of the sidescan imagery).

Eelgrass formed the tallest macrophyte canopy in all cases. This is illustrated at the 3m contour cross at towfish transect BD15 (Fig. 25). The VH canopy height classification detects a canopy in this area with a height of 0.15 - 0.4 m (light green dots) and occasionally over 0.4 m (dark green dots). This matches the towfish classification of continuous or patchy eelgrass at this depth. The eelgrass bed is not a particularly large

[3] Mainly bottom detection errors.
[4] ‘Unclassified’ acoustic signatures refer to those generated by Visual Habitat but not seen at any towfish cross point. Hence, they were not ground-truthed and remained unclassified.

one, however, as the VH classification indicates no canopy to the east and west (dominance of red dots).

Here is a summary of the quality of the VH classifications in the GIS:

- 2009 Baddeck survey at 5 m contour – the bottom classification correlated quite well with the related towfish classification. Soft, intermediate and hard acoustic signatures were noted by VH. The tallest canopy seen in the canopy height classification was 0.812 m. The 0.4 – 0.82 m bin did a good job of “seeing” taller dense eelgrass. The canopy height detection limit was set at 0.15 m – no false positive canopies were seen at towfish cross points with this setting.
- 2009 Baddeck survey at 10 m contour – the bottom classification correlated quite well with the related towfish classification. Soft, intermediate and hard acoustic signatures were noted, with soft bottoms dominating. The tallest canopy seen in the canopy height classification was 0.496 m. The canopy height detection limit was set at 0.2 m – no false positive canopies were seen at towfish cross points with this setting. However, with that detection limit only 1% of VH points indicated a canopy. A limited canopy is expected at 10 m. However, the 0.2 m setting may be conservative as low sparse eelgrass noted in the towfish classification was missed by the VH classification in at least one transect cross point. Other macrophyte canopies were detected by VH at towfish cross points.
- 2009 River Denys survey at 5 m contour – the bottom classification was of moderate quality. Two acoustic categories were unclassified and it was difficult to discern between intermediate and harder bottoms. Much of the bottom was soft. Although no formal towfish macrophyte classifications were created, it was possible to run a VH canopy height analysis. The canopy height detection limit was set at 0.2 m and no false positives were seen in the video at cross points. The bottom was quite bare of macrophytes in general and less than 1% of the VH classification points indicated a canopy. However, the VH analyses did “see” a canopy where one existed at towfish cross points and at locations where one would intuitively expect the canopy (such as in the shallows).
- 2010 BD survey at 3 m contour – the bottom was very heterogeneous at this depth. Soft, intermediate and hard acoustic signatures were noted and the classification held up well at most transect cross points. The tallest canopy seen in the canopy height classification was 0.724 m. The canopy height detection limit was set at 0.15 m – no false positive canopies were seen at towfish cross points with this setting. Visual Habitat canopy heights of <0.4 m were frequently associated with *Ascophyllum* in the towfish classification. Canopy heights of between 0.4 and 0.73 m were exclusively associated with the eelgrass beds at towfish cross points.
- 2010 BD survey at 5 m contour – the bottom was still quite heterogeneous at this depth and difficult to classify in the VH analysis. Composite acoustic signatures such as intermediate / hard were seen and intermediate signatures were sometimes associated with soft bottoms in the towfish analysis. The tallest

canopy seen in the canopy height classification was 0.816 m. The canopy height detection limit was set at 0.2 m – and some false positive canopies were seen at towfish cross points with this setting. Canopy heights of <0.4 m were frequently associated with 'red turf' in the towfish classification and the VH classification missed this canopy about half of the time. Taller canopy heights were associated with eelgrass, *Laminaria* / *Saccharina* and *Ascophyllum*. The VH analysis saw this taller canopy in each instance except at the cross point with BD61, where the towfish video indicated relatively long *Saccharina* thalli which happened to be lying flat against the bottom (i.e. no substantial canopy to detect).

- 2010 BD survey at 10 m contour – hard bottoms were quite rare at this depth and approximately 50% of the bottom was classified as soft in the VH analysis. The bottom classification held up quite well and almost all cross points matched the towfish analysis for hardness. The tallest canopy seen in the canopy height classification was 1.58 m, although this may be an artifact as no tall canopies occurred at cross points and these taller canopy points appeared to be randomly scattered. The canopy height detection limit was set at 0.2 m – and almost no false positive canopies were seen at towfish cross points with this setting. Approximately 95% of the bottom was classified as bare with this detection limit.
- 2011 SA survey at 3 m contour – at this depth almost all bottoms were "hard" in the towfish classification and no soft bottoms were seen in the VH classification. Indeed, only slight differences were seen between the intermediate and hard acoustic signature groups. The tallest canopy seen in the canopy height classification was 1.14 m. The canopy height detection limit was set at 0.15 m – and some false positive canopies were seen at towfish cross points with this setting. Overall, this VH analysis was quite good at discerning *Ascophyllum*, *Laminaria* / *Saccharina* and eelgrass canopies and relatively good at discerning red turf canopies.
- 2011 SA survey at 5 m contour – most of the bottom at this depth was quite uniform comprising different combinations of sand/cobble. There was a great deal of overlap in the VH classification due to very similar bottom signatures overall at this depth. The tallest canopy seen in the canopy height classification was 1.23 m. The canopy height detection limit was set at 0.2 m. This was a relatively poor VH canopy height classification with numerous false positives and also frequent missed canopies (i.e. the towfish classification indicated macrophytes while the VH classification was not able to at the same cross point).
- 2011 SA survey at 10 m contour – the VH classification saw a gradation of acoustic signatures at this depth with soft/intermediate and intermediate/hard mixed bottom types. The classification worked well for softer areas, often matching the towfish classification at cross points. The tallest canopy seen in the canopy height classification was 0.675 m. The canopy height detection limit was set at 0.2 m, indicating that 96% of the bottom was bare. There were no false positives at any cross point. According to the video, macrophytes were quite rare and dispersed at this depth and the VH analysis was unable to pick up a canopy reliably.

DISCUSSION

The results presented here were driven by an evolution of survey equipment and methods over time. The early work, particularly in the time period of 2007/2008, focused on towfish based sidescan and video data to detect eelgrass beds along relatively small or bay-scale sections of shoreline. Later on, much longer sections of shoreline were surveyed (multiple bay scale) utilizing sidescan-video data to ground truth echosounder survey results. These larger scale surveys used echosounder data to determine general characteristics of bottom type and macrophyte canopy between towfish transects – the focus was no longer eelgrass beds alone.

While the highest quality of spatial data were obtained from the towfish transects, the echosounder data did prove useful. This was largely driven by the use of Visual Habitat software, which created bottom type and canopy height classifications which were often consistent with the towfish based ground-truth classifications at transect cross points.

There was a logical consistency in the VH results; hard and soft bottoms or macrophyte cover were indicated at locations where one would expect them. For example, macrophyte canopies were indicated most often in shallow waters and the tallest canopies were associated with eelgrass beds. Also, softer bottoms were indicated by VH in depositional areas such as deeper waters or quieter back bays.

The vast majority of macrophytes occurred within the first 3 m of depth. This zone was dominated by a thin but consistent cover of eelgrass (*Zostera marina* L.) on almost all shores with a current or wave regime conducive to the growth of this plant. However, the eelgrass beds were frequently in poor shape and the negative impacts of commonly occurring water column turbidity, siltation, or possible localized eutrophication, are suspected.

Approximately one third of the estimated 1000 km length of Bras d’Or Lake shoreline was covered in our surveys (Fig. 1). Two main types of bottom were observed, mud at depth and sand or cobble in the shallows. Cobble is definitely the most productive habitat as far as fish are concerned, especially when it trends deeper.

The data embedded into the GIS (bottom type and macrophyte cover) can be used to answer a variety of management based questions at different scales. The GIS should be particularly useful for determining the nature and location of compensation projects due to habitat loss from construction activities, areas to protect or high productivity areas. Future surveys of similar design could be used to detect long-term changes in Bras d’Or Lake over long stretches of the nearshore.

As noted in the results section, the video data from the towfish can be used to classify and map a wide variety of bottom features of interest to management. Vandermeulen (2014b) provides bay-scale maps of bottom features such as eelgrass cover and health; benthic algal growth; bacterial mats and oysters utilizing the same towfish deployed in Bras d’Or Lake. The success of these maps stems from the fact that the towfish transects were spaced at less than 500 m apart. Future surveys in Bras d’Or Lake should use similar transect spacing in order to maximize the information gathered by the towfish. The author is presently developing a fiber-optic-based HD camera system on an upgraded towfish platform to maximize the information gathered by the video stream (e.g. clear screenshots for quantification).

Tighter spacing on future towfish transects in Bras d'Or Lake will provide the additional benefit of a greater number of cross points per kilometer of shoreline to ground truth echosounder classifications. The echosounder runs should continue at 3, 5 and 10 m contours in order to maximize the ability of the echosounder to pick up a macrophyte signal.

ACKNOWLEDGMENTS

Paul Keizer and Dave Duggan provided the seed funds to purchase the original survey equipment and software to begin the work at River Denys Basin in 2005. Gary Bugden coordinated the author's efforts with other researchers working in the basin from 2005 onwards and provided some additional funding.

Shelly Denny set up the funding for the surveys in 2007/08 and Dave Duggan provided the BioSonics echosounder. David Duggan continued to provide survey funding from this time period through 2011, along with coordination from Jason Naug.

The field assistance of Sean Steller, Patrick Faye, Shawn Roach, Dean Denny, Allison McIsaac, Vivian Bouchard, Brian Jones, Sarah Claridge, Jason McLean and Megan Wilson is appreciated. Sean Steller prepped the video clips in 2005. Cam Lirette examined the towfish data from 2007/08 and created those eelgrass maps. Megan Wilson assisted with the development of the 2009 towfish classifications and Brian Jones processed them. The 2010 and 2011 towfish classifications were developed by Megan Wilson and Sarah Claridge.

The surveys could not have occurred without the efforts of Shelly Denny and the people of the Mi'kmaq First Nation. During calm weather and storms, through night and day, Shelly and her crew were there for us - Wela'lin to all.

REFERENCES

Vandermeulen, H. 2007. Drop and towed camera systems for ground-truthing high frequency sidescan in shallow waters. Can. Tech. Rep. Fish. Aquat. Sci. 2687: v + 17 p.

Vandermeulen, H. 2011a. Mapping the nearshore using a unique towfish. Can. Tech. Rep. Fish. Aquat. Sci. 2959: v+ 18p.

Vandermeulen, H. 2011b. An echosounder system ground-truthed by towfish data: A method to map larger nearshore areas. Can. Tech. Rep. Fish. Aquat. Sci. 2958: v+ 21p.

Vandermeulen, H. 2014a. Nearshore habitat mapping in Atlantic Canada: Early results with high frequency side-scan sonar, drop and towed cameras. Can. Tech. Rep. Fish. Aquat. Sci. 3092: vi + 16 p.

Vandermeulen, H. 2014b. Bay-scale assessment of eelgrass beds using sidescan and video. Helgol. Mar. Res. 68: 559-569.

Table 1: The GIS workspace layers as indicated in the Layer Control box.

Visual Habitat estimations of canopy height and bottom type along St. Andrew's Channel at 3, 5, and 10 m contour lines (2011)
Visual Habitat estimations of canopy height and bottom type from Whycocomagh to Iona at 3, 5, and 10 m contour lines (2010)
Visual Habitat estimations of canopy height and bottom type in River Denys Basin at the 5m contour line (2009)
Visual Habitat estimations of canopy height and bottom type from Whycocomagh to Baddeck at 5 and 10 m contour lines (2009)
Towfish transect macrophyte and bottom type classifications along St. Andrew's Channel (2011)
Towfish transect macrophyte and bottom type classifications from Whycocomagh to Iona (2010)
Towfish transect bottom type classification for River Denys Basin (2009)
Towfish transect macrophyte and bottom type classifications from Whycocomagh to Baddeck (2009)
Video clip locations by site and year
Sidescan imagery for St. Andrew's Channel (2011)
Sidescan imagery from Whycocomagh to Iona (2010)
Sidescan imagery for River Denys Basin (2009)
Sidescan imagery from Whycocomagh to Baddeck (2009)
Sidescan imagery for Malagawatch (2008)
Sidescan imagery for Chapel Island (2008)
Sidescan imagery for Wagmatcook (2007)
Sidescan imagery for Whycocomagh (2007)
Sidescan imagery for Malagawatch (2007)
Sidescan imagery for Eskasoni (2007)
Sidescan imagery for River Denys Basin (2005)
The base charts

Table 2: Names used in the towfish macrophyte classification legends and corresponding taxon names.

Legend name	Taxon
Agarum	*Agarum clathratum* Dumortier
Asco. / Asc.	*Ascophyllum nodosum* (L.) Le Jolis
Chorda / Chor.	*Chorda* Stackhouse
Eelgrass	*Zostera marina* L.
Filamentous algae	a mixture of species of *Ceramium*, *Ectocarpus*, *Pilayella*, etc.
Fucus	*Fucus* L. species
Fucus serr.	*Fucus serratus* L.
Laminaria / L. long / Lam.	a mixture of *Saccharina latissima* (Linnaeus) C.E.Lane, C.Mayes, Druehl & G.W.Saunders and *Laminaria digitata* (Hudson) J.V.Lamouroux
Red algae / Red Turf / RT	a mixture of filamentous forms and more folious thalli like *Phyllophora* Greville
RW	a mixture of 'rockweed' species from *Ascophyllum* and *Fucus*

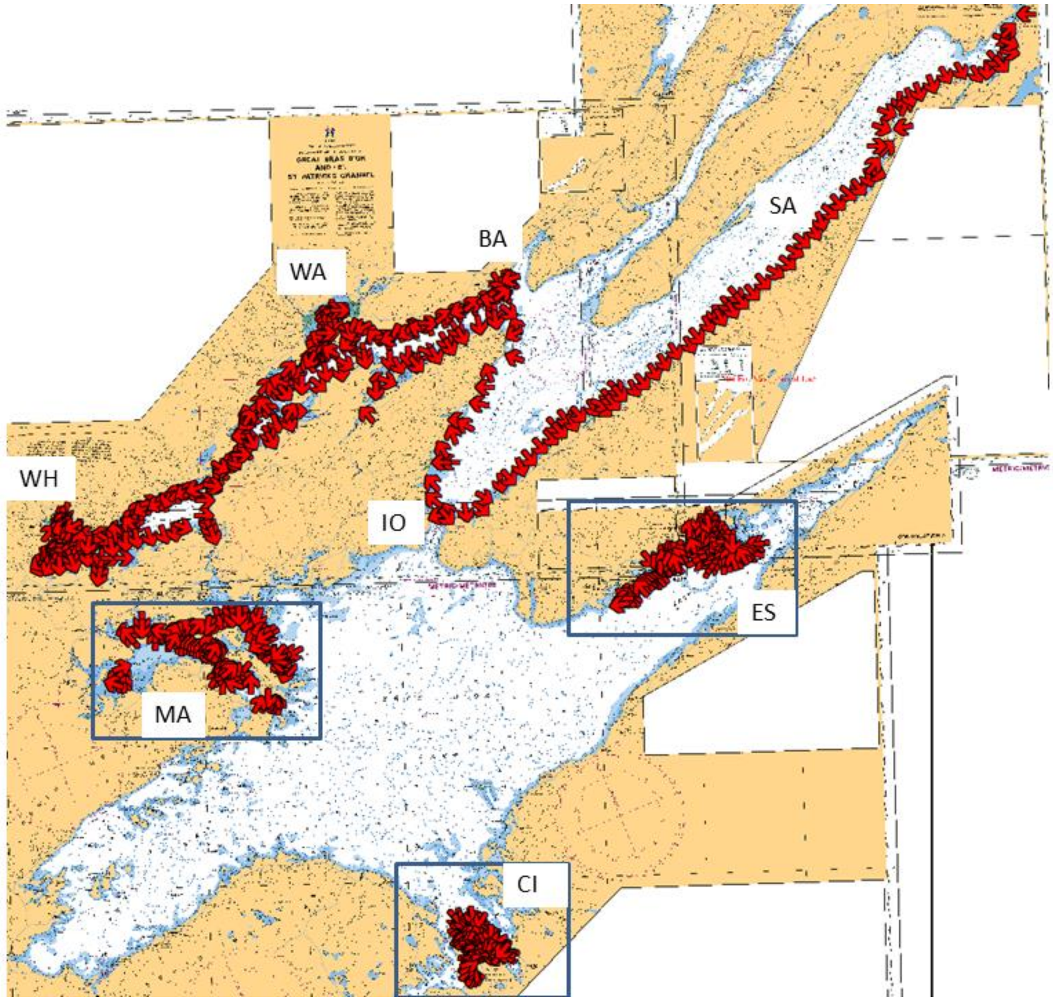

Figure 1: Bras d'Or Lake survey areas. **BA** – Baddeck, **CI** – Chapel Island, **ES** – Eskasoni, **IO** – Iona, **MA** – Malagawatch (including River Denys Basin), **WA** – Wagmatcook, **WH** – Whycocomagh, **SA** – St. Andrew's Channel. The red arrows indicate video clips from the towfish transects.

Figure 2: 2005 drop camera and sidescan arrangement on 15 foot Boston Whaler. Wooden boxes contain electronics, white tubing for ventilation. Top – arrow indicates sidescan hauled up for transport (note red tail); Bottom – arrow indicates drop camera frame on deck for transport.

Figure 3: 2007/08 new towfish on 22 foot Rosborough. Top – boat, trailer and truck; Bottom – towfish with red sidescan on top, then camera and lasers, and dark green transponder tube on bottom.

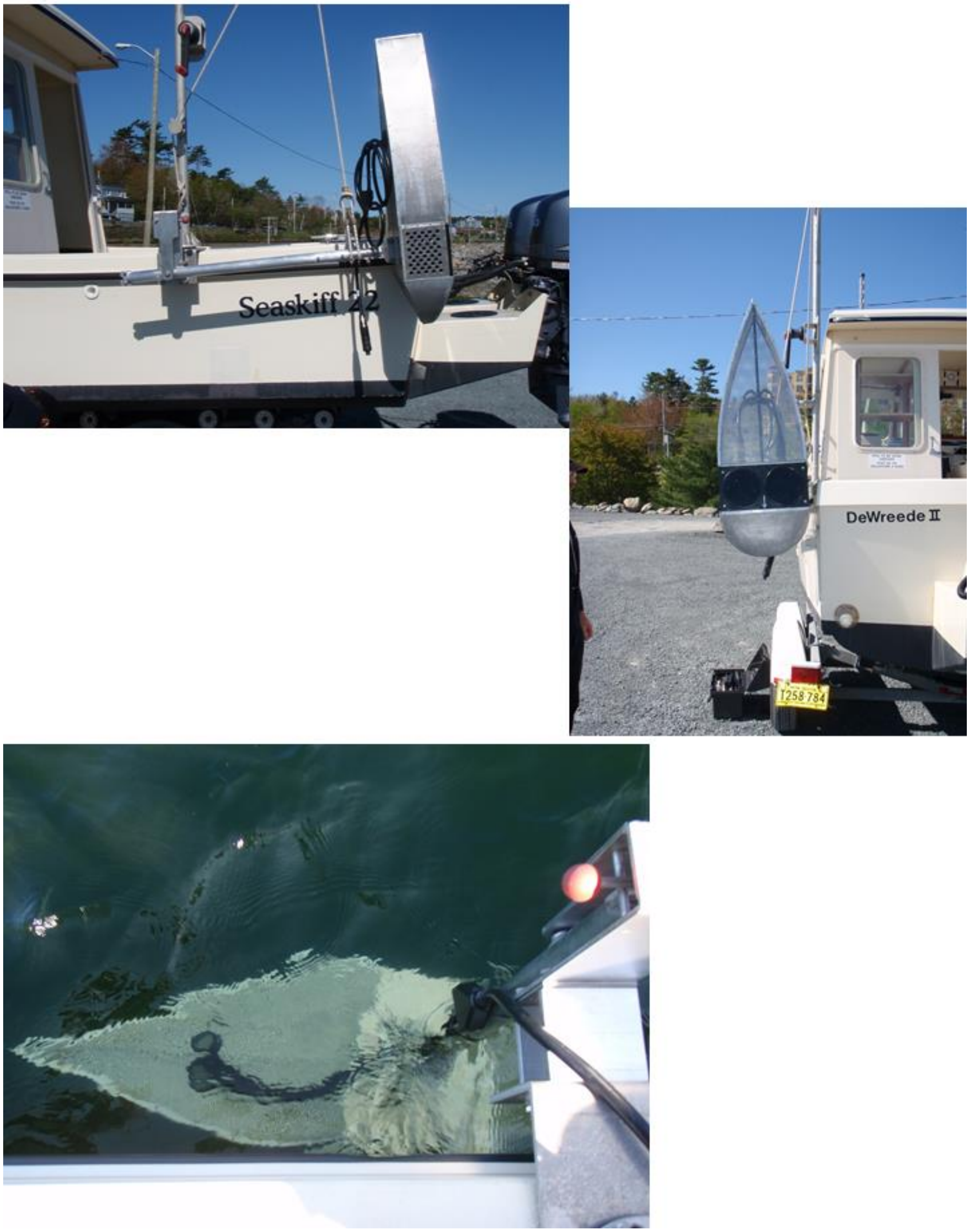

Figure 4: 2009-2011 new echosounder. Top – side view of transponder cage raised for transport; Middle – end view of raised cage; Bottom – cage immersed while on survey.

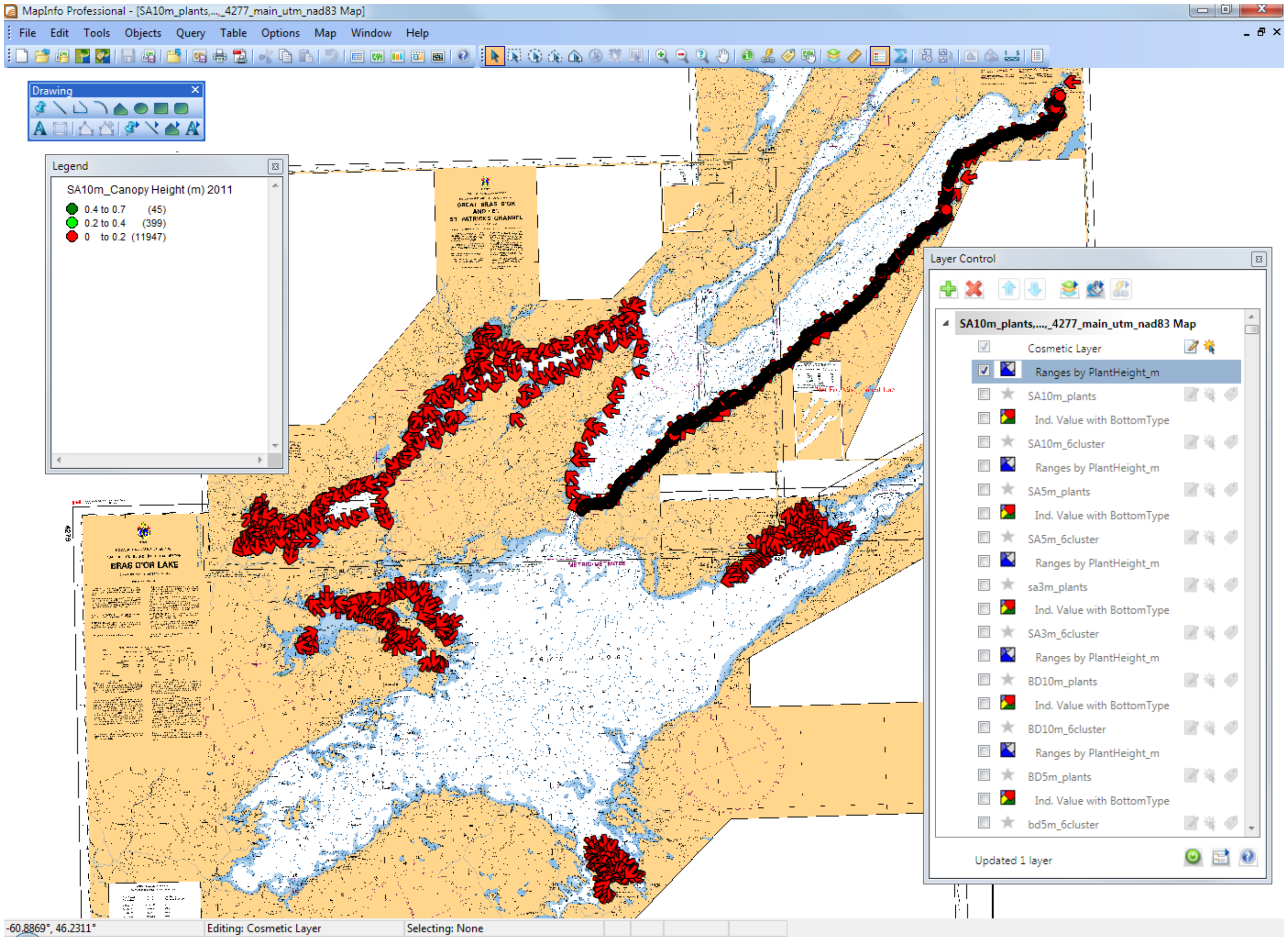

Figure 5: GIS workspace with Layer Control and Legend boxes open for clarity. The screen shows Visual Habitat macrophyte canopy height estimations at the 10m contour along the St. Andrews Channel south shore. The tallest macrophytes were just under 0.7m height.

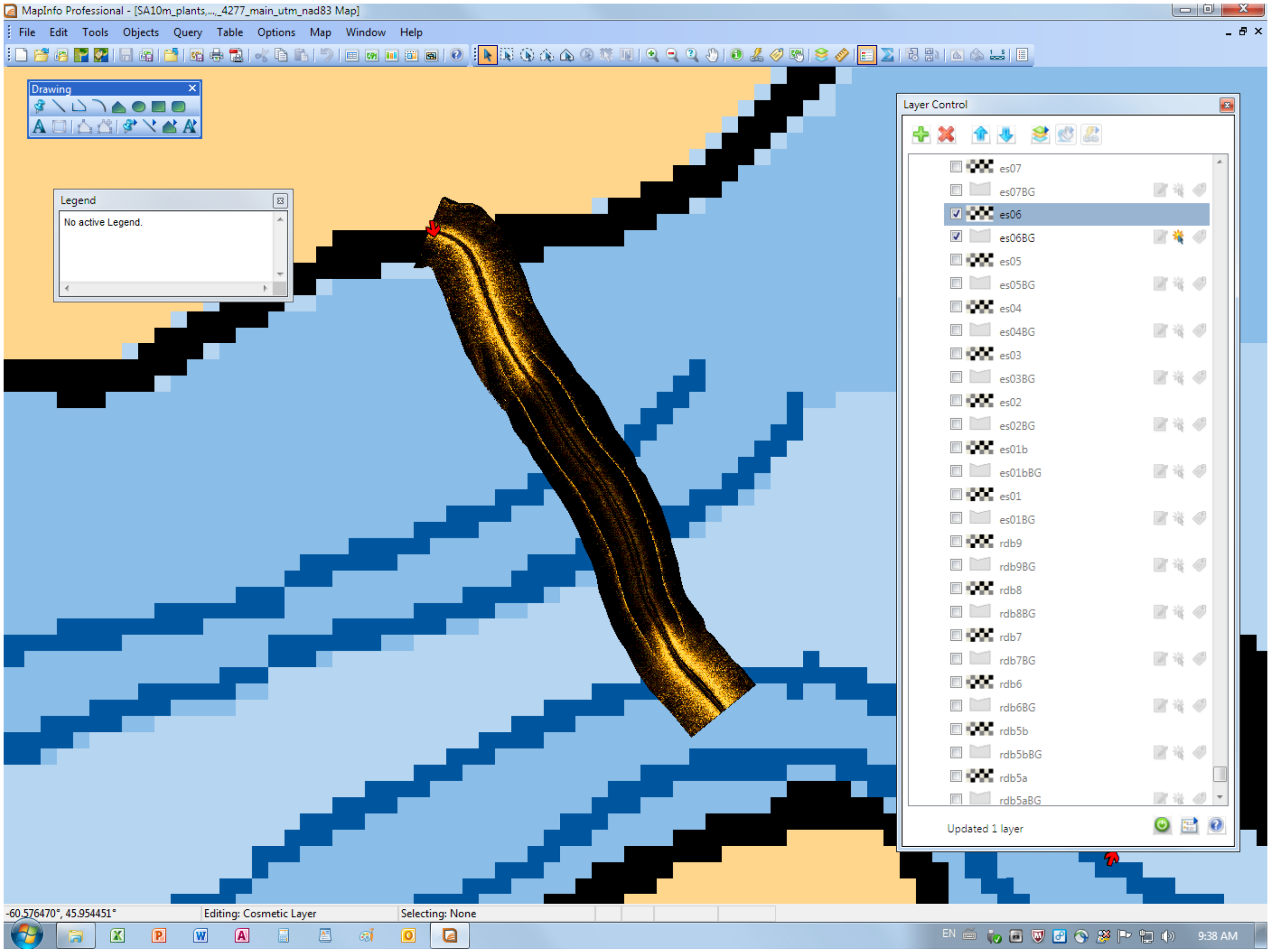

Figure 6: Sidescan image (GeoTIFF) for Eskasoni towfish transect ES06. The red arrow indicates the beginning of the transect and the location of the embedded video clip from the tow.

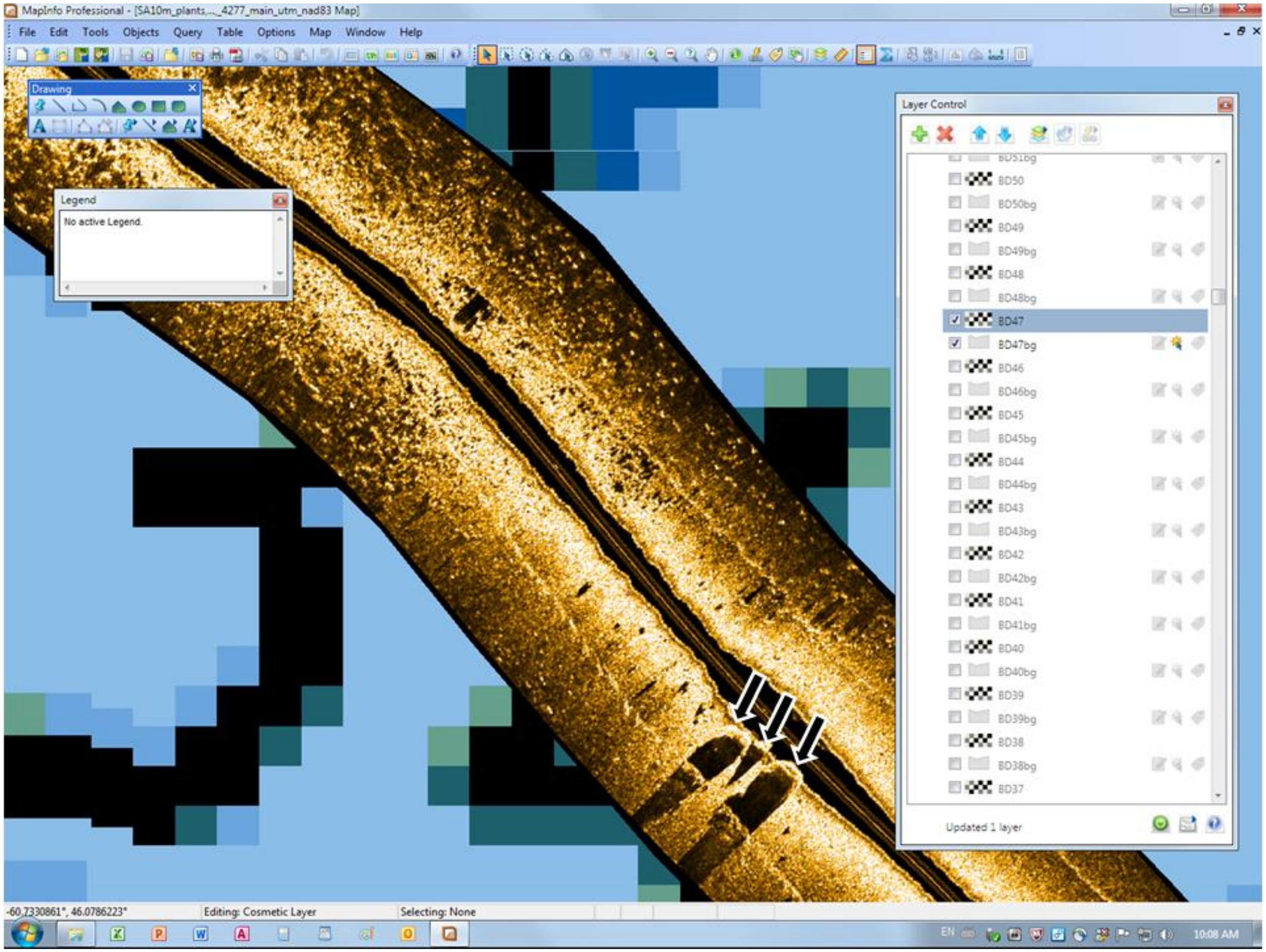

Figure 7: Sidescan image (GeoTIFF) for towfish transect BD47 off of the east end of Spectacle Island. The arrows indicate three large boulders.

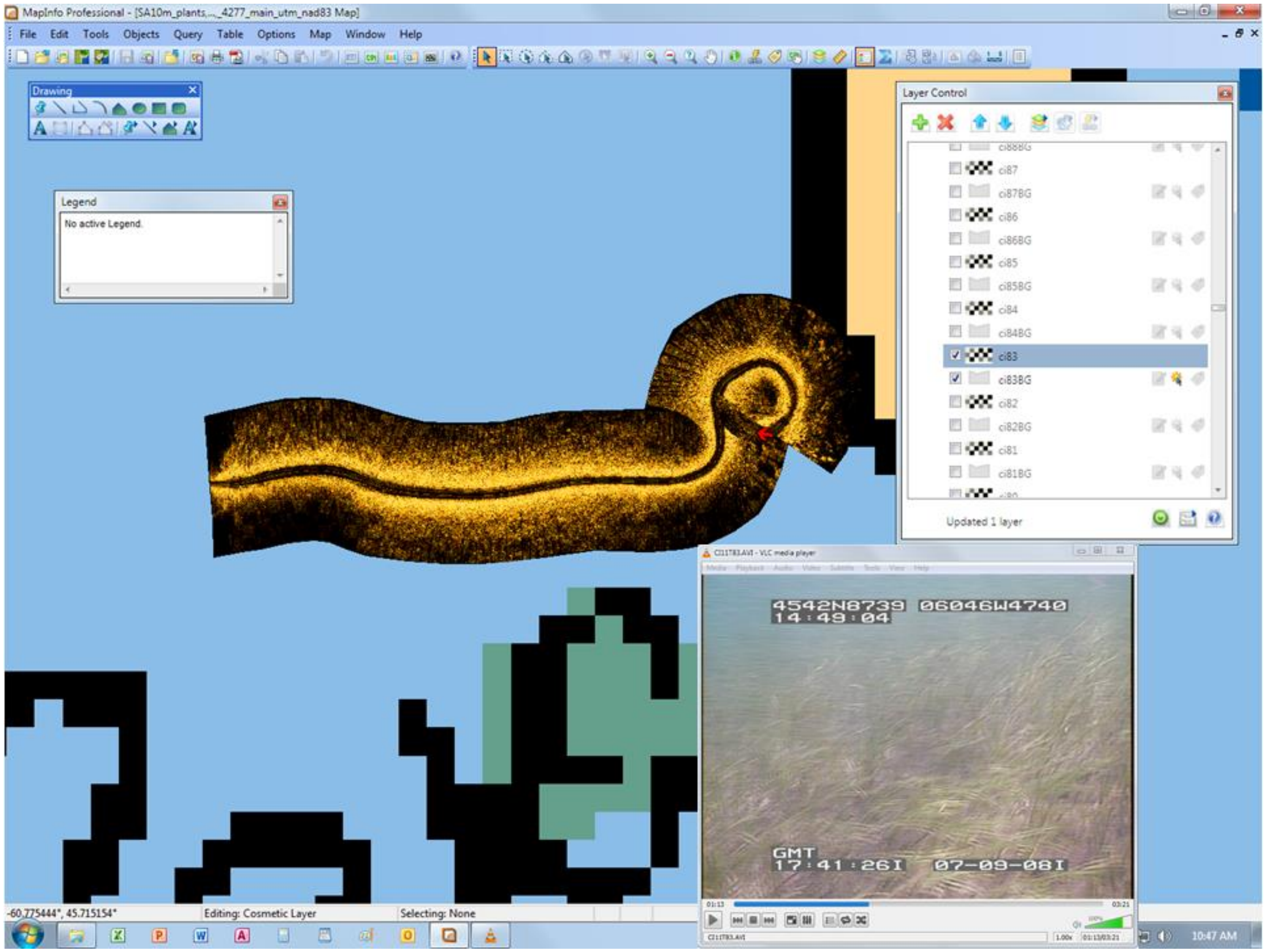

Figure 8: Transect CI83. In the sidescan image, the bottom appears to be fairly uniform and flat, with quite high reflectivity indicating sand. However, the video indicates that the bottom is actually covered in a dense continuous eelgrass bed (video screenshot insert). The circular distortion at the beginning of the sidescan image on the right is an artifact due to the towfish spinning.

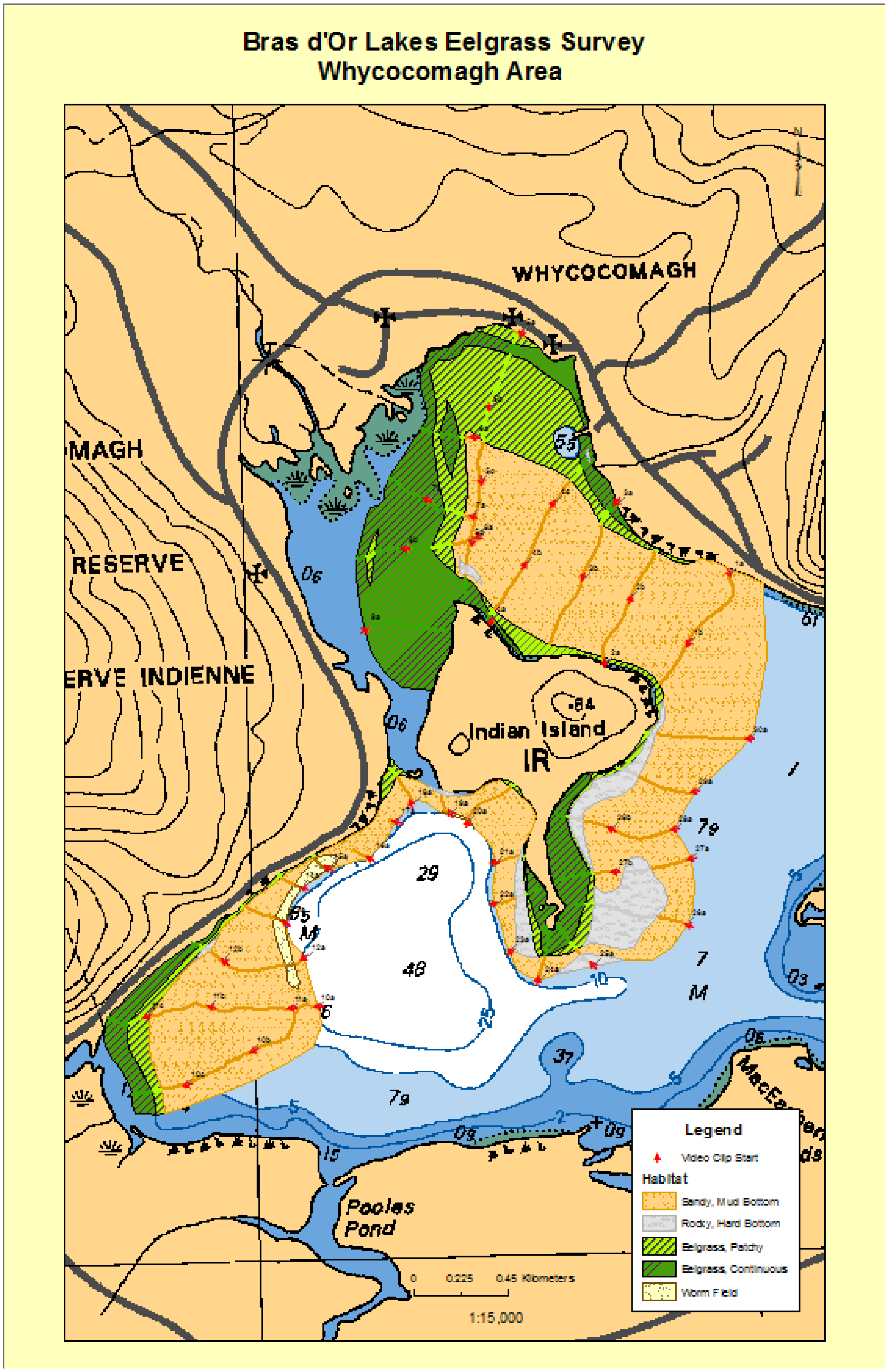

Figure 9: Eelgrass map for Whycocomagh.

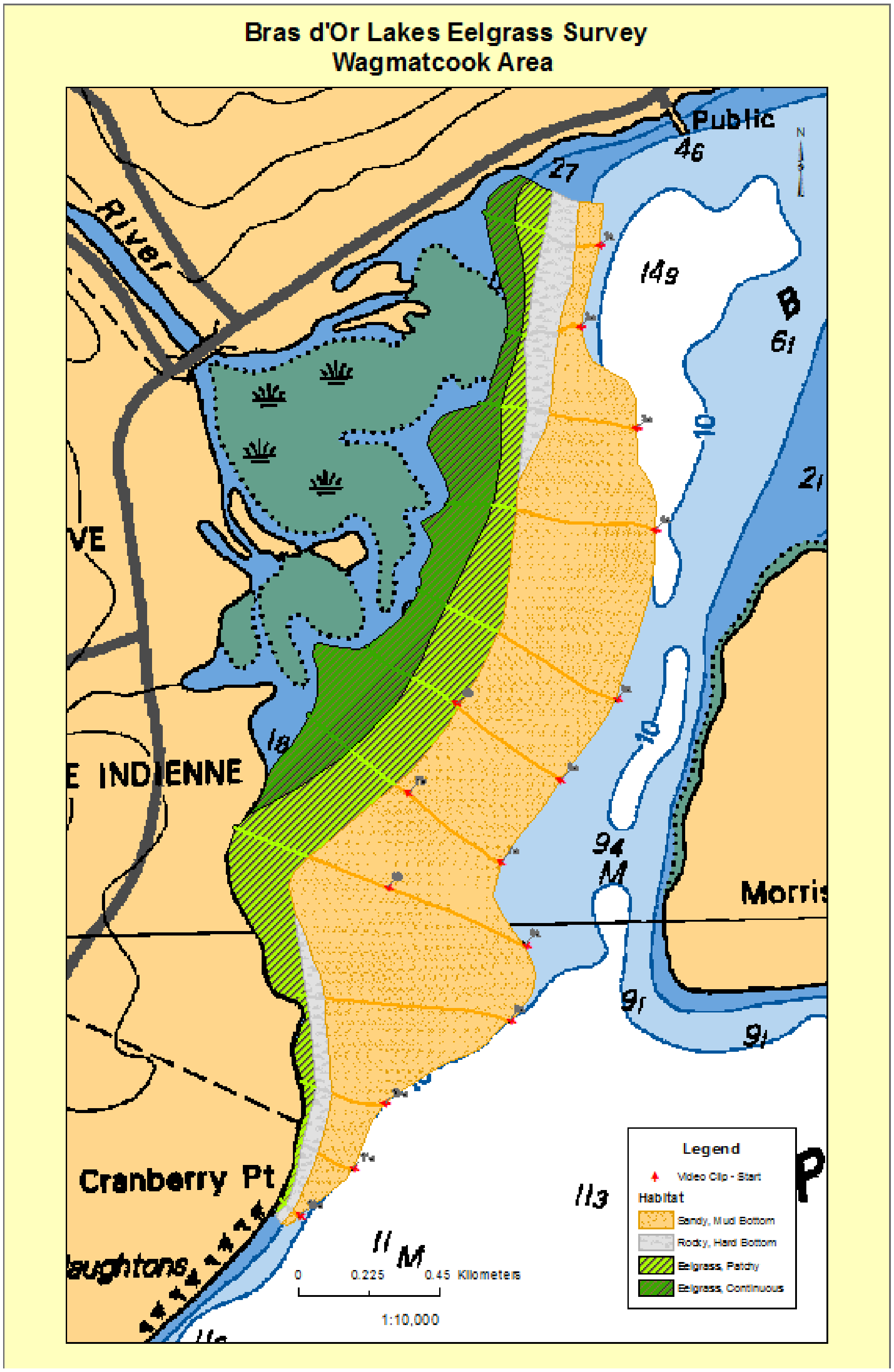

Figure 10: Eelgrass map for Wagmatcook.

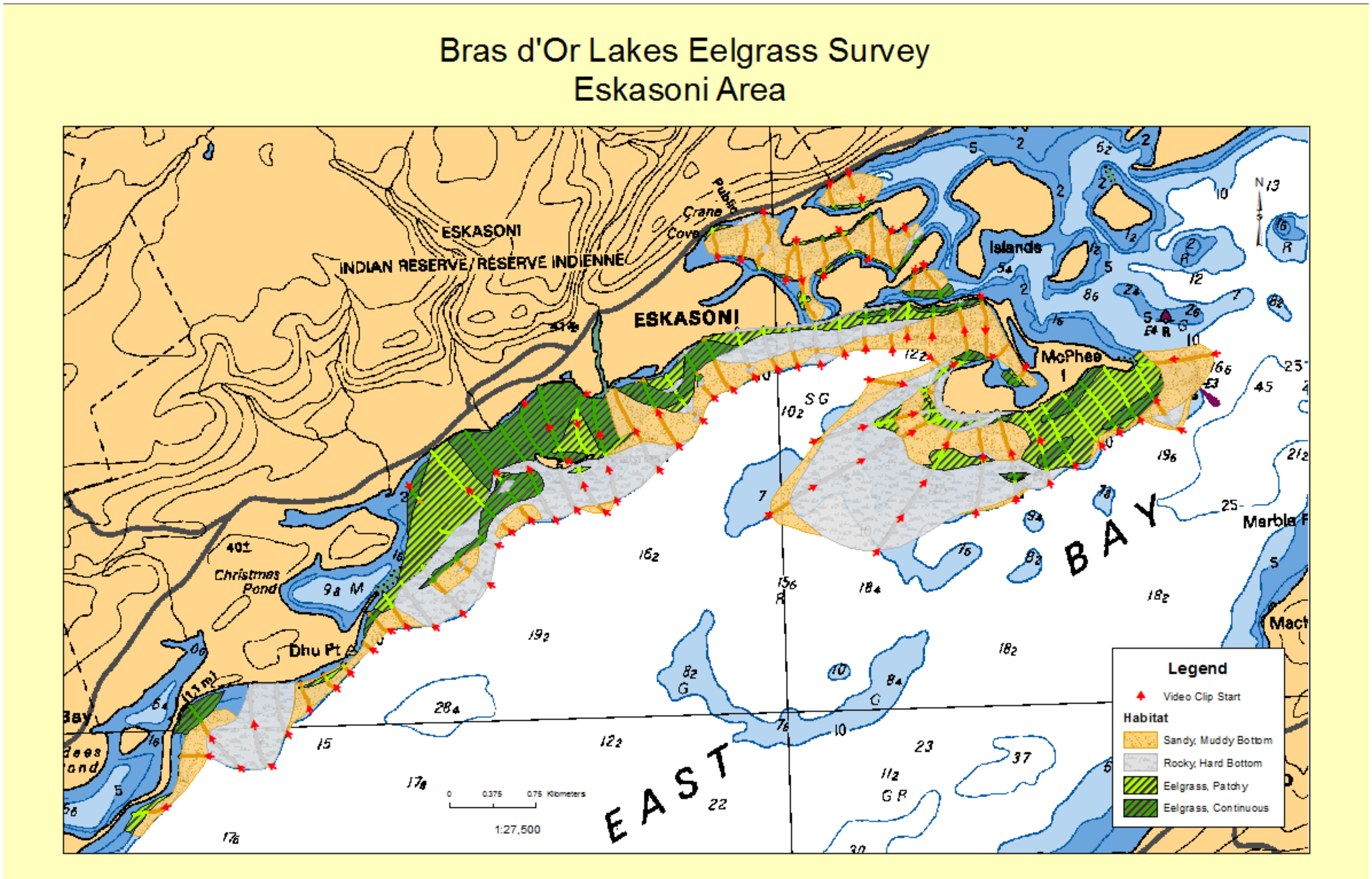

Figure 11: Eelgrass map for Eskasoni.

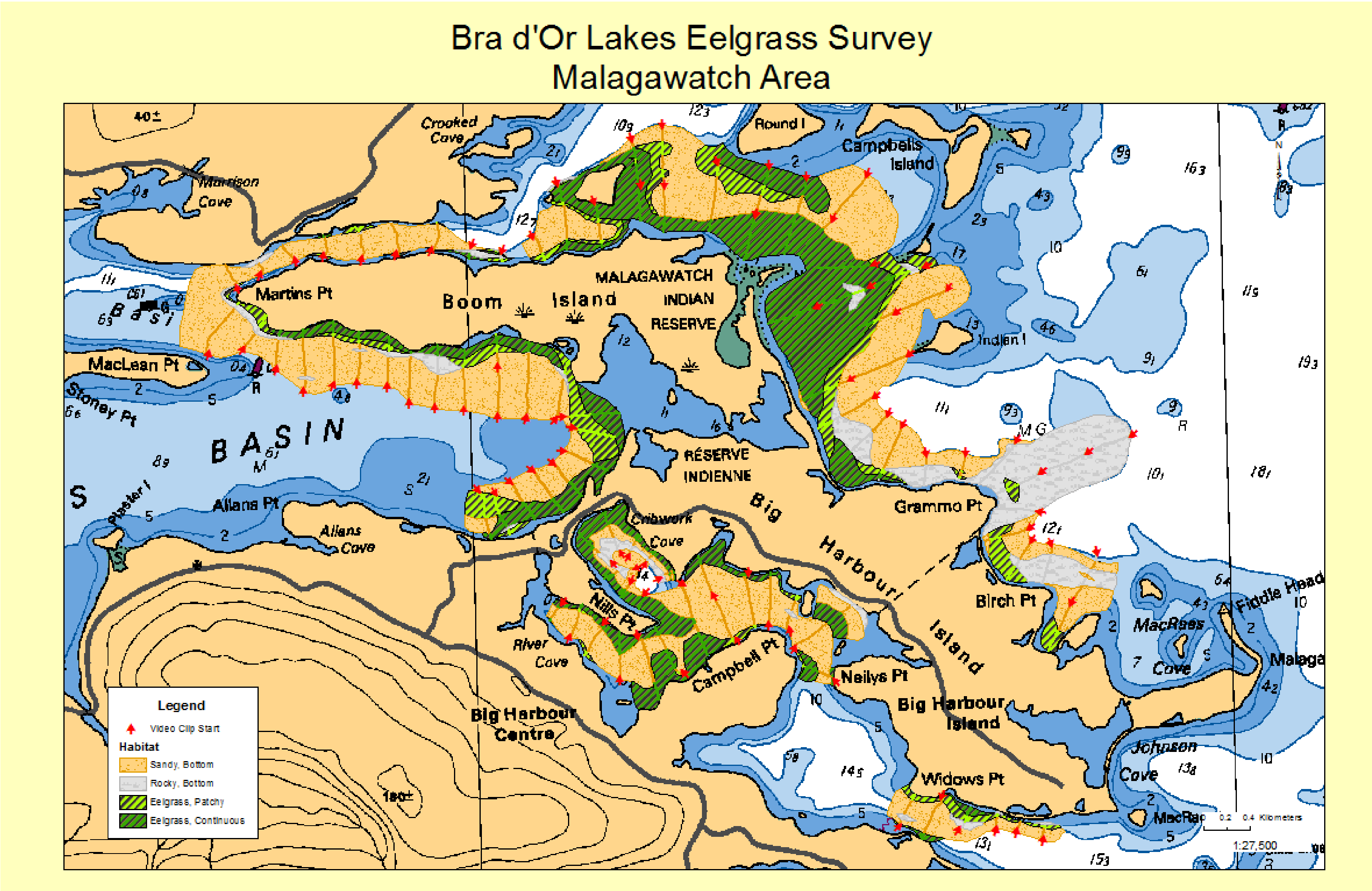

Figure 12: Eelgrass map for Malagawatch.

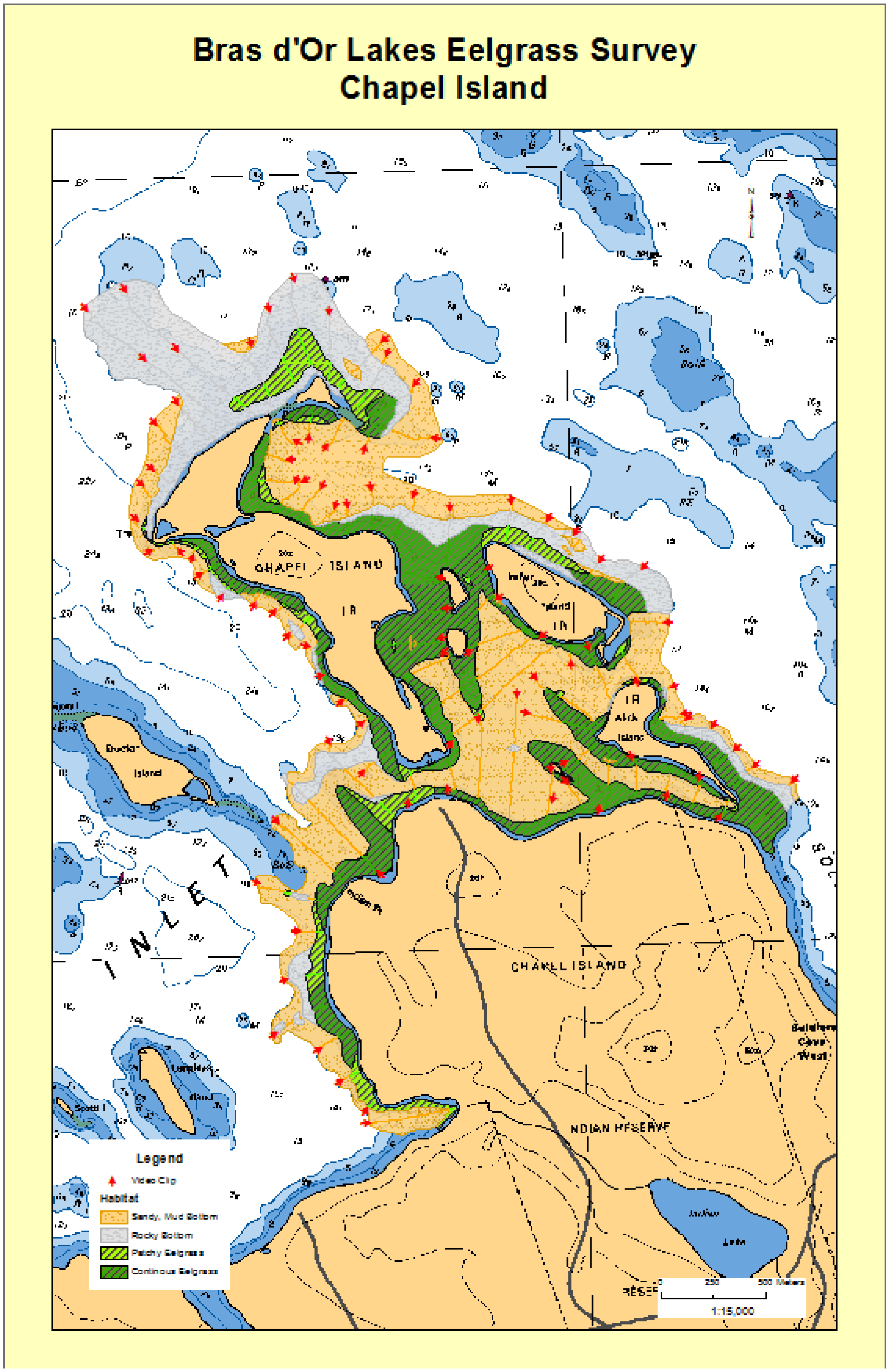

Figure 13: Eelgrass map for Chapel Island.

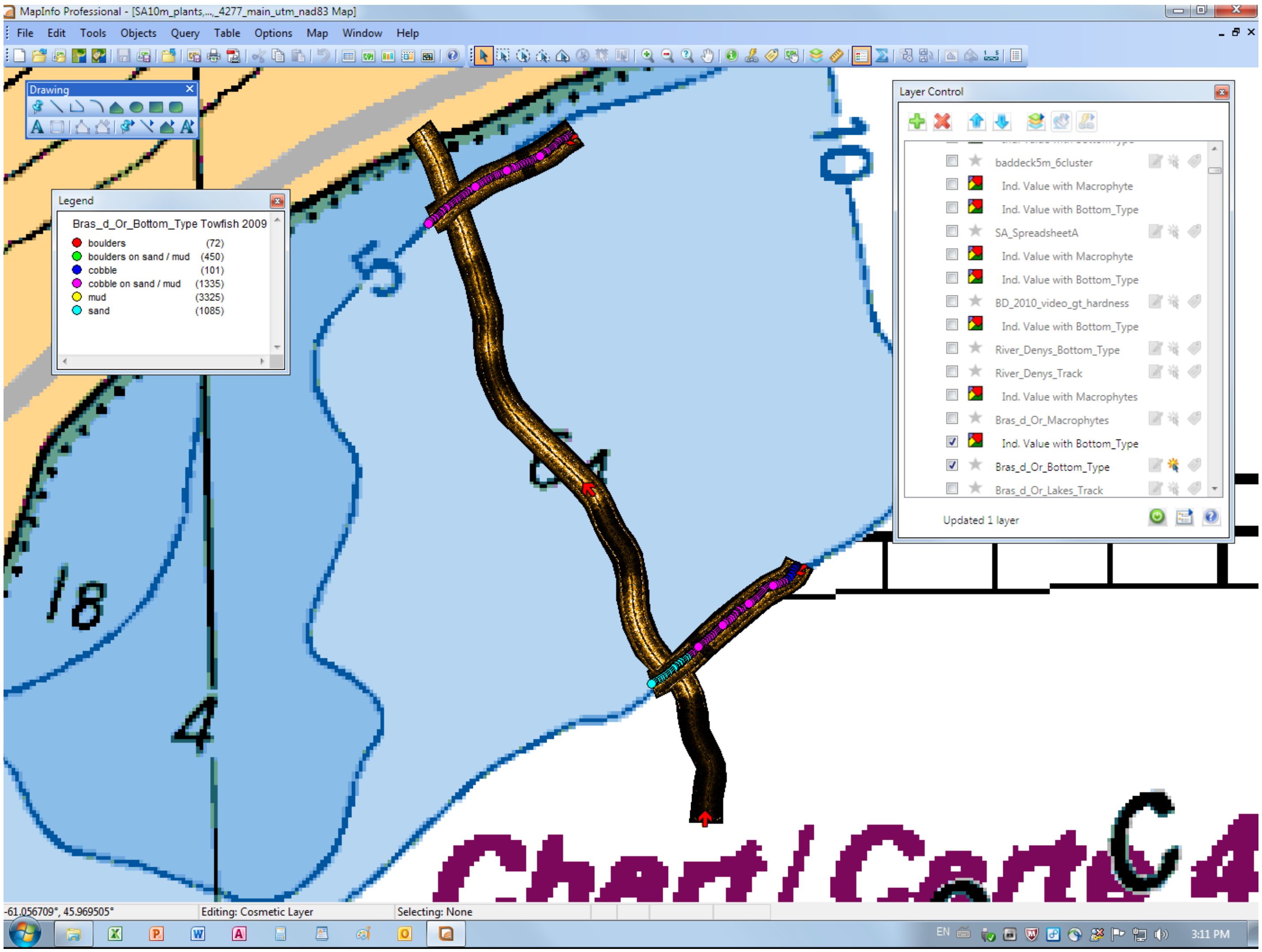

Figure 14: 2009 towfish bottom classification at 5 and 10m crosses of transect BL04.

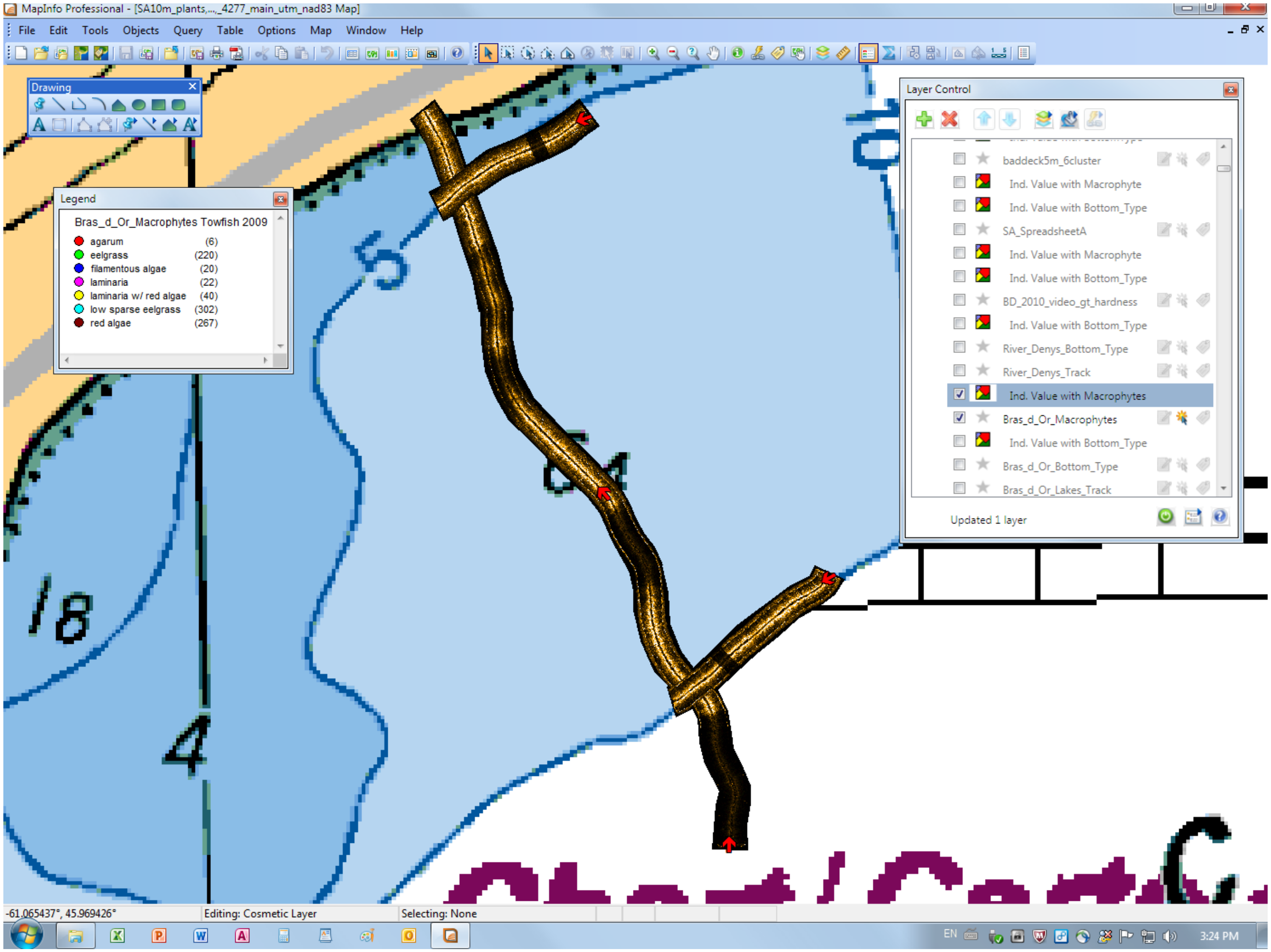

Figure 15: 2009 towfish macrophyte classification at BL04. No macrophytes are present at 5 or 10 m cross points.

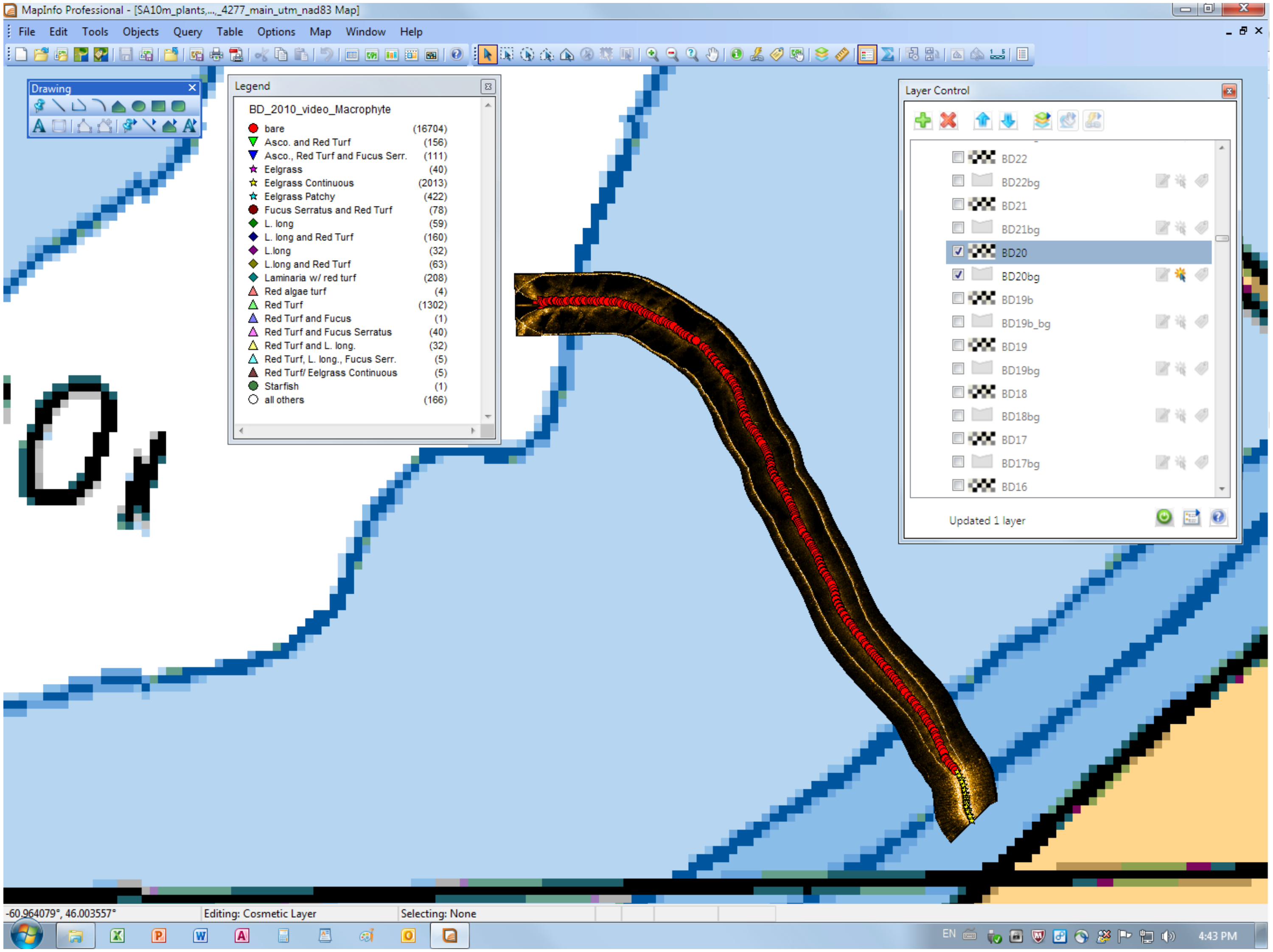

Figure 16: 2010 towfish macrophyte classification at BD20.

Figure 17: A large mature eel in the shallows at ES31. The image is at an angle due to the towfish slewing during a tight turn.

Figure 18: A crab at ES44.

Figure 19: A dense group of forage fish at ES25.

Figure 20: Clean “healthy” eelgrass at ES49.

Figure 21: ‘Leptomitis like’ objects (arrows) at WK01.

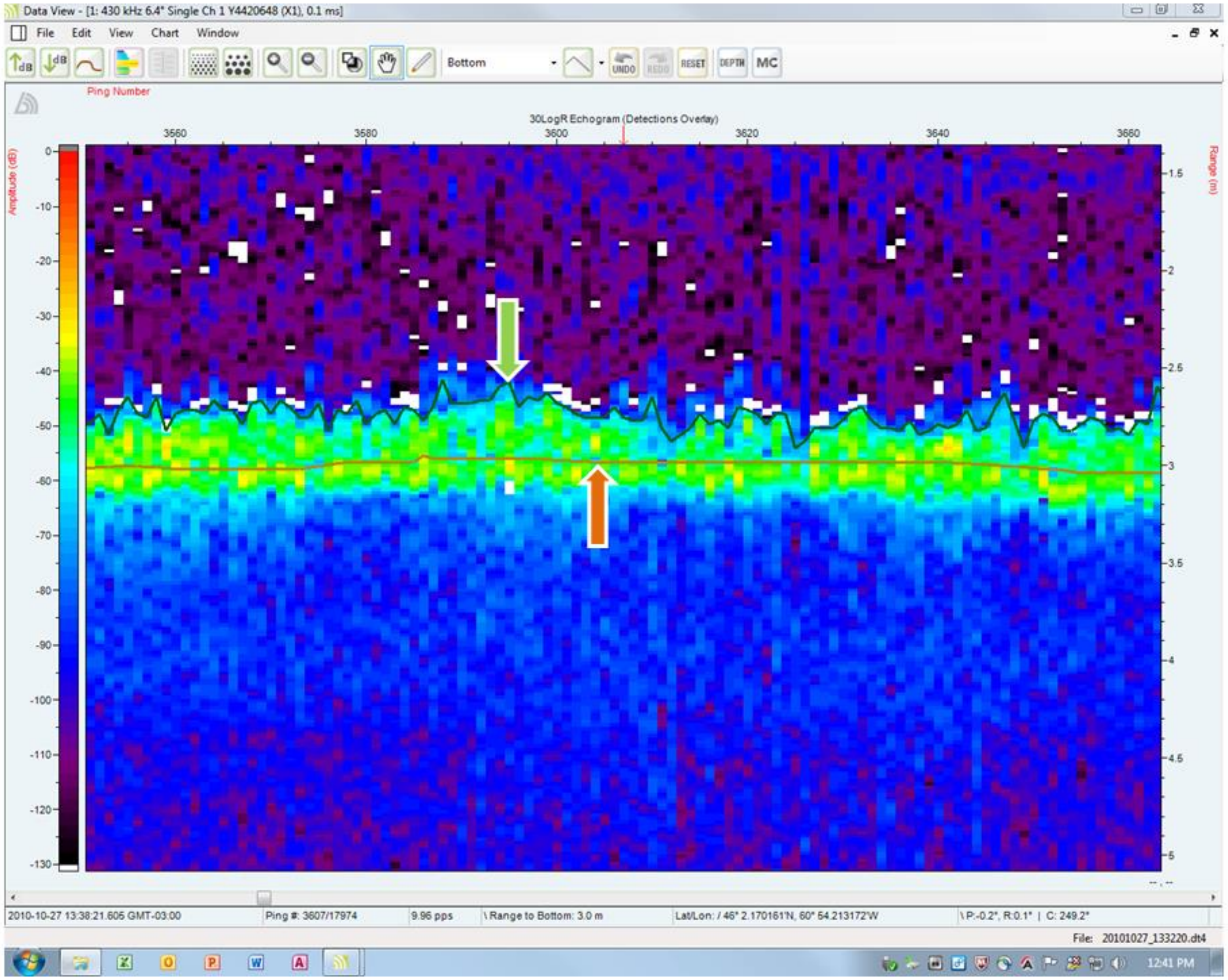

Figure 22: Echogram in the Visual Habitat edit screen. The green arrow points to a dark green line which defines the top of the macrophyte canopy. The brown arrow points to the dark brown line defining true bottom position. Both canopy and bottom lines were first calculated by the Visual Habitat software and later edited by hand to remove errors. The complete echogram file contains over 17,000 pings. This screen shot centers upon the area around ping 3600, from an echosounder run at the 3m contour line.

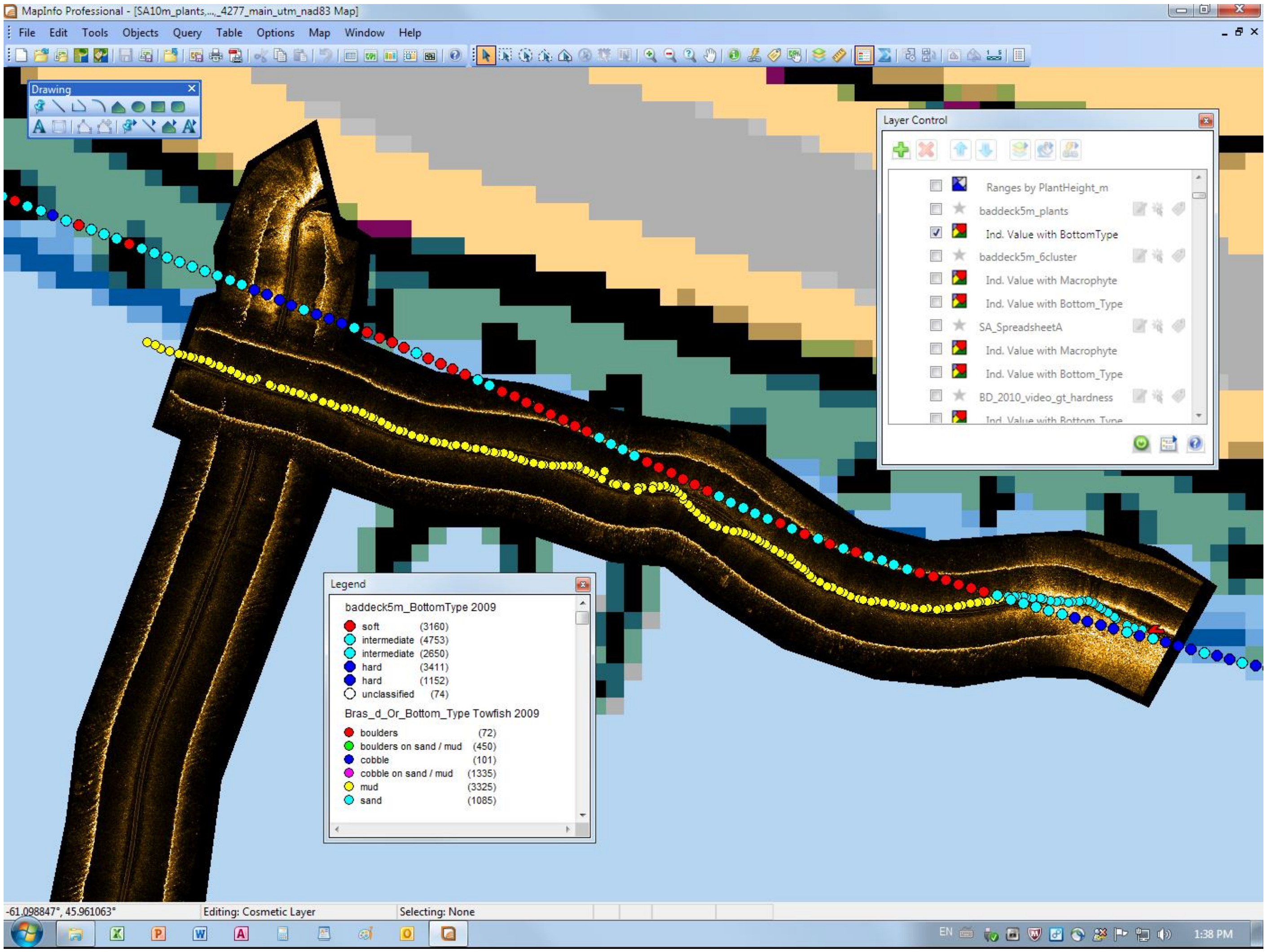

Figure 23: 2009 towfish bottom classification at BL01 (5m) versus the Visual Habitat bottom classification at the same location.

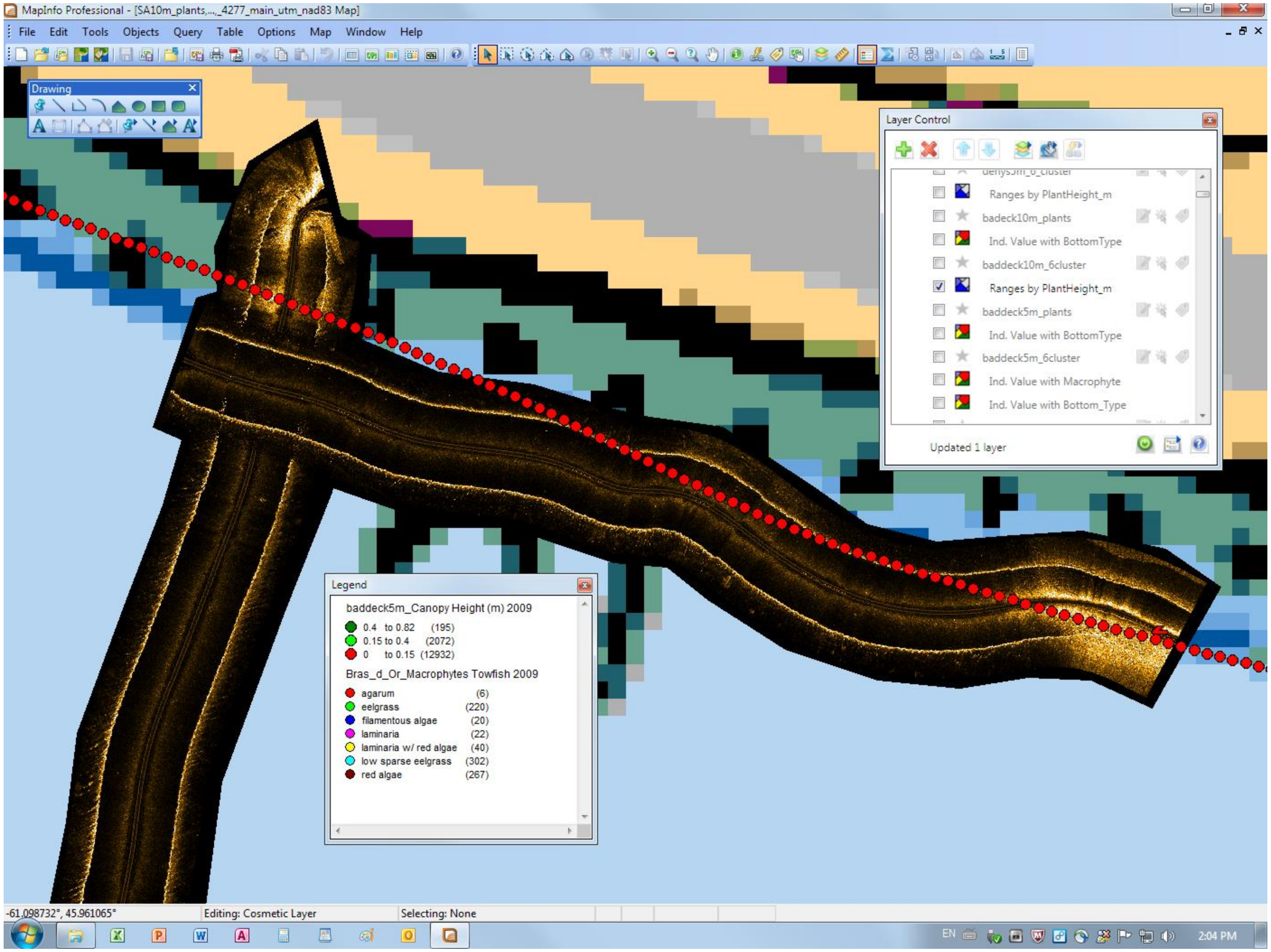

Figure 24: 2009 towfish macrophyte classification at BL01 (5m) versus the Visual Habitat canopy height classification at the same location.

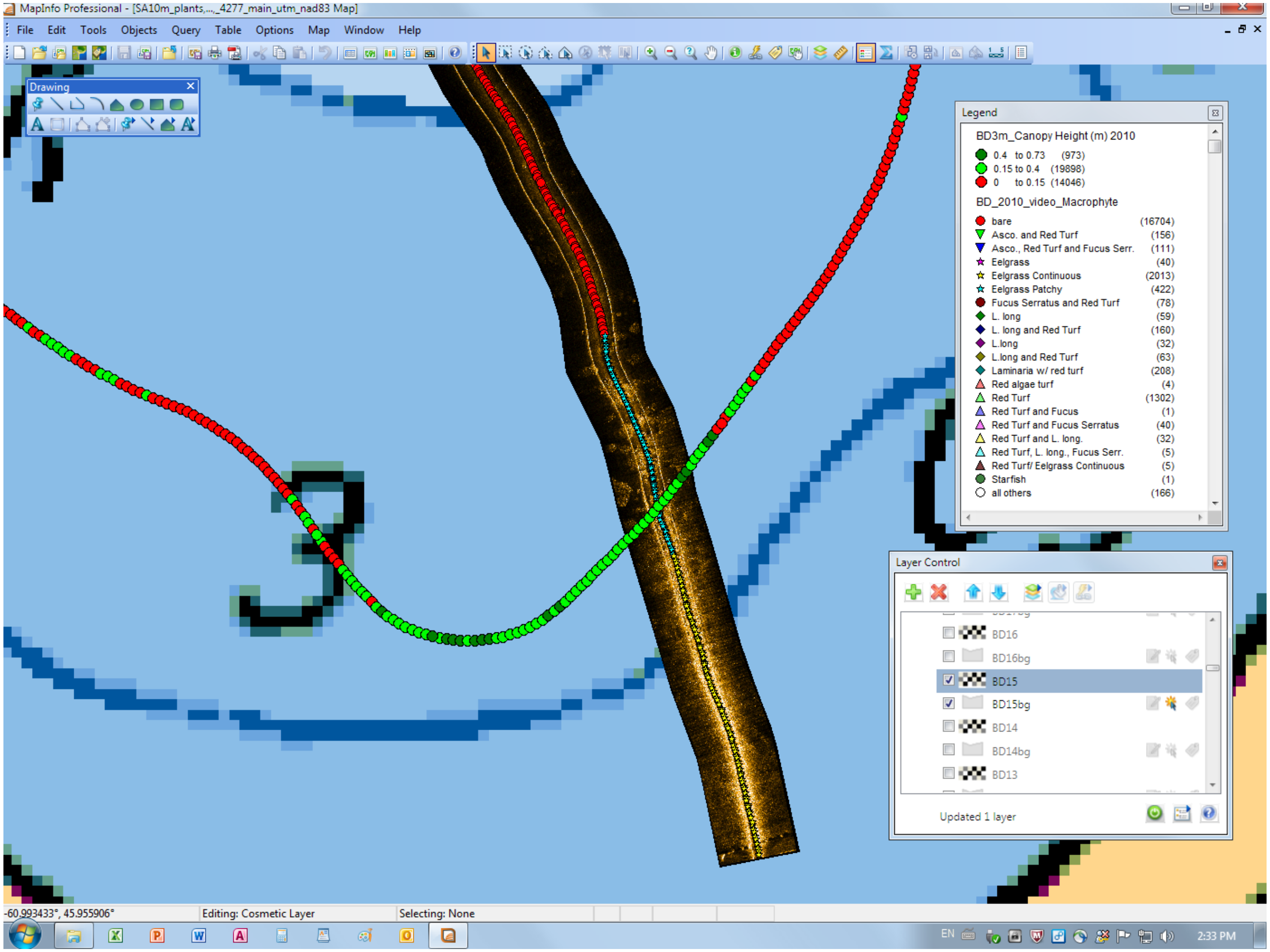

Figure 25: Eelgrass detected in the towfish classification and in the Visual Habitat analysis at 3m (BD15).