Mapping Eelgrass (*Zostera marina*) With A Novel Towfish: Richibucto And Shippagan, New Brunswick

H. Vandermeulen

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

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MAPPING EELGRASS (*ZOSTERA MARINA*) WITH A NOVEL TOWFISH: RICHIBUCTO AND SHIPPAGAN, NEW BRUNSWICK

by

H. Vandermeulen

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

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

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LIST OF FIGURES

ABSTRACT

Vandermeulen, H. 2013. Mapping eelgrass (*Zostera marina*) with a novel towfish: Richibucto and Shippagan, New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 3064: v + 19 p.

A towfish containing sidescan and video hardware was used to map eelgrass in two shallow northern New Brunswick estuaries. The sidescan and video data were useful in documenting suspected impacts of oyster aquaculture gear and eutrophication on eelgrass. With one boat and a crew of three, the mapping was accomplished at a rate of almost 10 km^2 per day. That rate far exceeds what could be accomplished by a SCUBA based survey with the same crew. Moreover, the towfish survey applied with a complementary echosounder survey is potentially a more cost effective mapping method than satellite based remote sensing.

RÉSUMÉ

Vandermeulen, H. 2013. Vandermeulen, H. 2013. Cartographie des zostères (Zostera marina) à l'aide d'un nouveau poisson : Richibucto et Shippagan, Nouveau-Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 3064: v + 19 p.

On utilise un poisson muni d'équipement vidéo et de balayage latéral afin de cartographier les zostères dans deux estuaires peu profonds au nord du Nouveau-Brunswick. Les données recueillies par l'équipement vidéo et de balayage latéral ont servi à documenter l'effet soupçonné des engins d'ostréiculture et de l'eutrophisation sur les zostères. La cartographie a été effectuée à un rythme de près de 10 km^2 par jour à bord d'une embarcation comptant trois équipiers. Ce rythme est fort supérieur à celui que l'on obtiendrait en réalisant un relevé en plongée avec le même équipage. De plus, une méthode de cartographie qui combine le relevé par poisson avec le relevé par échosondeur pourrait s'avérer moins coûteuse que la télémesure par satellite.

INTRODUCTION

The Gulf Region of the Department of Fisheries and Ocean (DFO) has a long history of involvement in oyster aquaculture impact assessment in the large estuaries along the north shore of New Brunswick. These estuaries contain an abundance of eelgrass (*Zostera marina* L.). In the early 2000s, Gulf Region began to develop a 'Replacement Class Screening' report under the Canadian Environmental Assessment Act for oyster aquaculture projects in the area. The goal was to streamline the aquaculture assessment process.

In 2006, DFO's Canadian Science Advisory Secretariat organized a national workshop on "Aquaculture – Environment Interactions: Shellfish Aquaculture in the Marine Environment". The author contributed a working paper to that workshop which included an evaluation of eelgrass as sensitive habitat (Vandermeulen et al. 2006). One recommendation from the workshop was to "develop robust sampling designs for monitoring shellfish aquaculture effects in coastal regions" – including potential bay-wide effects (DFO 2006).

Following this recommendation, in 2007 the author mapped eelgrass in two of the northern New Brunswick estuaries, Richibucto Bay and a portion of the Shippagan area bays, using a newly developed towfish system with video and sidescan capability. The intent was two-fold, to test the towfish system for mapping eelgrass on bay-wide scales, and to use that data to ground-truth benthic classifications from satellite and aerial images of the bays[1].

2.0 MATERIALS AND METHODS

2.1 Standard Equipment and Methods

The survey boat, equipment, methods and data analysis are described in Vandermeulen (2007; 2011a). A 22' Cape Sable style Rosborough custom wheelhouse research vessel was chosen as the platform for the electronics because of its very shallow draft (46 cm), good working deck space, and trailer-ability. The towfish was towed at depth behind the boat along predetermined transects that were spaced to uniformly cover the areas of interest in each bay. Towing speeds were approximately 1.5 knots.

The towfish included a 330 kHz sidescan (30 m swath width); video camera with 10 cm scale lasers; and transponder for accurate latitude / longitude positioning of the towfish (approximately 2 m accuracy). As the towfish was pulled along the bottom (about 20 cm above the substrate), the video record 'ground-truthed' the sidescan imagery in real time. The operator in the wheelhouse had a continuous display of both video and sidescan data (a waterfall display). The video record can also provide some additional qualitative data like the relative density of the eelgrass bed, fouling of the blades, or the presence of invertebrates or fish. All field data (video clips, sidescan

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[1] The results of the remote sensing analysis will be published elsewhere.

GeoTIFF images, towfish tracks) were embedded in ArcGIS projects on large external hard drives.

2.2 Special Methods to Generate Ground-truth Data

For this particular survey, additional data analysis was performed to create data sets of use to ground-truth aerial or satellite imagery. The video from each transect was examined to discern patches of homogenous bottom type large enough to be of use in image analysis. It was determined that approximately one minute of video of homogenous bottom type would represent a patch approximately 45 m in diameter (1.5 knot tow speed for 1 min = 45 m). That scale (45 m) was also comparable to the sidescan swath width (30 m), so the sidescan imagery could support the video analysis at this scale. The 45 m scale was also large enough to cover an adequate number of pixels in both aerial or satellite images for that level of image analysis.

By following the above methods, each towfish transect was found to have a number of uniform bottom type patches of 45 m diameter. Each of these represented a data point of uniform cover class (bare substrate, thin / patchy eelgrass, or dense eelgrass) to ground-truth aerial or satellite imagery. The cover class data points were plotted with MapInfo software.

3.0 RESULTS

3.1 Richibucto Bay

Richibucto Bay was mapped in four days, July 2 through 5, 2007. A screen shot of the original ArcGIS project is provided in Figure 1. A total of 27 towfish transects were performed over the four day period.

The sidescan imagery was very helpful for interpreting eelgrass features in Richibucto Bay. Figure 2 shows a classic pattern of patchy eelgrass on a soft bottom picked up by the sidescan system. Individual patches of eelgrass can be counted, measured or otherwise assessed against landscape metrics as desired. The swath width is 30 m, so many of the individual patches in Figure 2 are about 1 to 2 m in diameter. For our eelgrass classification of the bay this is what we mean by ‘patchy’. Note that the video clip associated with this towfish track confirms that the eelgrass was patchy. In current swept areas patchy eelgrass beds can be a healthy and normal condition – usually occurring in the shallows. Patchy eelgrass at depth may mean light limitation stress (see discussion below for ‘thin’ eelgrass cover).

Figure 3 shows the sidescan imagery associated with ‘dense’ eelgrass cover and ‘bare’ substrate, also confirmed by the associated video clip. Note the very abrupt transition from bare substrate in the deeper channel to dense eelgrass cover on either side of the channel. That pattern is common in many estuaries and occurs as the deeper edge of an eelgrass bed reaches its light limitation point for growth.

Figure 4 indicates a transition from a dense eelgrass bed to thinly spread eelgrass at depth. In our classification, this is what we mean by ‘thin’. It is not possible to quantify shoot density with our video; the resolution is not high enough[2]. In the author’s opinion thinly spread eelgrass at depth probably results from a historically dense eelgrass bed undergoing stress due to light limitation increasing as the years go by (water column turbidity due to human activity - eutrophication or particles in the water). The original dense bed at depth loses leaves and rhizomes over time as the low light stress continues, leaving behind the surviving clumps of leaves widely spaced over the bottom. Eventually, the eelgrass cover at depth is likely to be lost altogether.

A description of oyster aquaculture methods in New Brunswick can be found in the “Reference Manual for Oyster Aquaculturists” (New Brunswick 2008). One of the more common units of production is the ‘longline’, which is a string of floating rectangular bags containing oysters. The bags are strung broad side up in pairs, and the longlines are routinely 60 m long and about 2.4 m wide (New Brunswick 2008). Figure 5 is a satellite image from Google Maps indicating longlines of oyster bags in Richibucto Bay. Note how these longlines are arranged very close to shore.

Oyster bag longlines are placed below the water surface during the winter months to avoid ice. In shallow water, this sometimes means placing the gear directly on the bottom, or on low racks – on top of eelgrass. Figure 6 provides indirect evidence that oyster gear placed on the bottom may be destroying eelgrass. The sidescan indicates a rectangular hole in an otherwise dense eelgrass bed. The width of the bare patch is consistent with two longlines placed side by side. Nature rarely produces such perfectly rectangular geometry. Also, if this was ice damage it was very local. Figure 7 provides two more examples of very angular damage in dense eelgrass beds in Richibucto which may represent impacts from longlines.

180 ground-truth data points were created for the Richibucto series of transects (Figure 8). 30% of the survey area was bare substrate (usually in the deeper channels, note position of the red dots); 26% was thin or patchy eelgrass cover; and 44% was dense eelgrass cover (e.g. eelgrass so dense you cannot see the substrate in most of the video). Note the preponderance of bare substrate or patchy eelgrass in the Northwest Branch of the bay.

Figure 9 is a close up view of the Northwest Branch of Richibucto Bay. Note how bare substrate is found in the deepest parts of the channel on the right side of the image. Bare channel bottoms are normal due to strong currents and scouring. However, as you move to the west (left) more bare patches can be found outside of channel areas, at sites where eelgrass should be growing well. The video record indicated that eelgrass in the western end was heavily epiphytized and did not seem ‘healthy’. Eutrophication is suspected.

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[2] Our lab is presently developing a high resolution HD camera system for the towfish. That upgrade should allow for the quantification of eelgrass metrics like shoot density, or the presence of invertebrates and fish.

3.2 Shippagan

The Shippagan area was mapped over five days, June 18 through 22, 2007. A screen shot of the original ArcGIS project is provided in Figure 10. A total of 20 transects were run over this five day period. In general, these transects were much longer than those run at Richibucto.

As for Richibucto, some indirect evidence of oyster gear impacts on eelgrass was found. Figure 11 indicates a rectangular patch of destruction in transect 10 in Shippagan. The video footage confirms the destruction of eelgrass at the site.

The Lameque Harbour portion of the Shippagan area provided some interesting data. Transect 18 was run almost due south of the Lameque Harbour jetties, which have an outfall associated with fish processing effluent. Evidence of localized eutrophication impacts were very strong (Figure 12). Eelgrass was absent near the jetties, having been replaced by a dense *Ulva* mat[3]. 'Healthy' dense eelgrass cover did not reoccur until close to the opposite shore, far to the south (Figure 12)[4].

123 ground-truth data points were created for the Shippagan series of transects (Figure 13). 46% of the survey area was bare substrate (no eelgrass but sometimes with drift algal cover as at Lameque). This is a larger percentage of 'bare' substrate than Richibucto and may reflect differences in environmental conditions. However, Shippagan waters are much more commercially active, and more likely to have human impacts. 15% was thin or patchy eelgrass cover and 39% was dense eelgrass cover (similar to Richibucto).

DISCUSSION

The towfish survey methods proved to be quite efficient. The total field time spent at Richibucto and Shippagan was nine days, covering a total area of approximately 85 km^2 with 47 transects (60 km total transect length). In other words, a crew of three for the cost of fuel and some minor expendables like video tapes were able to map eelgrass at a rate of almost 10 km^2 per day. A SCUBA based survey would not have been able to cover the area to the same level of detail nearly as quickly, and at far greater cost.

Approximately 82% of points selected in the QuickBird satellite image of Richibucto classified correctly against the ground-truth data points presented here (Matt Mahoney, pers. comm.). This relatively high level of success is most likely due to the clear, shallow waters of Richibucto Bay. Shippagan, which has much more turbid waters, had only approximately 60% of satellite image points classified correctly against the ground-truth data points presented here (Matt Mahoney, pers. comm.). In general, although the aerial methods covered 'all' areas of the bays, sun glint, lack of

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[3] Dense mats of the green alga *Ulva* are a common response to nearshore eutrophication in marine environments, and these mats can replace eelgrass (Vandermeulen et al. 2011). The author has mapped similar *Ulva* mats in hyper-eutrophic estuaries in Prince Edward Island.

[4] Although the video record accounts for most of this analysis, there were subtle differences in the sidescan imagery for eelgrass areas versus areas dominated by *Ulva*.

contrast and water turbidity can limit their benthic classification results (Matt Mahoney, pers. comm.).

The survey design was created to produce data points to ground-truth satellite and aerial imagery. The resulting towfish transects were quite widely spaced. However, even with this fairly coarse resolution it was possible to map eelgrass and assess some impacts on bay-wide scales. Both Richibucto and Shippagan had areas with suspected eutrophication impacts on eelgrass, and evidence was found for oyster aquaculture gear impacts at both sites as well. Adding more transects to both sites would have defined these impacts more clearly, and provided more detailed eelgrass cover maps. Additionally, for very little extra time and effort, an echo sounder survey could have provided even more detailed information on bottom type and eelgrass cover for both bays (Vandermeulen 2011b) – supplanting the need for any aerial or satellite imagery capture and analysis, which is far more costly[5].

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Sylvio Doiron, Remi Gionet, Carole Godin, Marc Godin, Matthew Hardy, Guy Robichaud, Fernand Savoie, Sean Steller and Anne Turcotte assisted on deck and at the helm. Cam Lirette put together the original ArcGIS projects. Venetia Joseph performed the first round of video analysis to generate data points for aerial ground truthing.

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[5] The satellite photos alone for Richibucto and Shippagan cost approximately $7000 (Guy Robichaud, pers. comm.).

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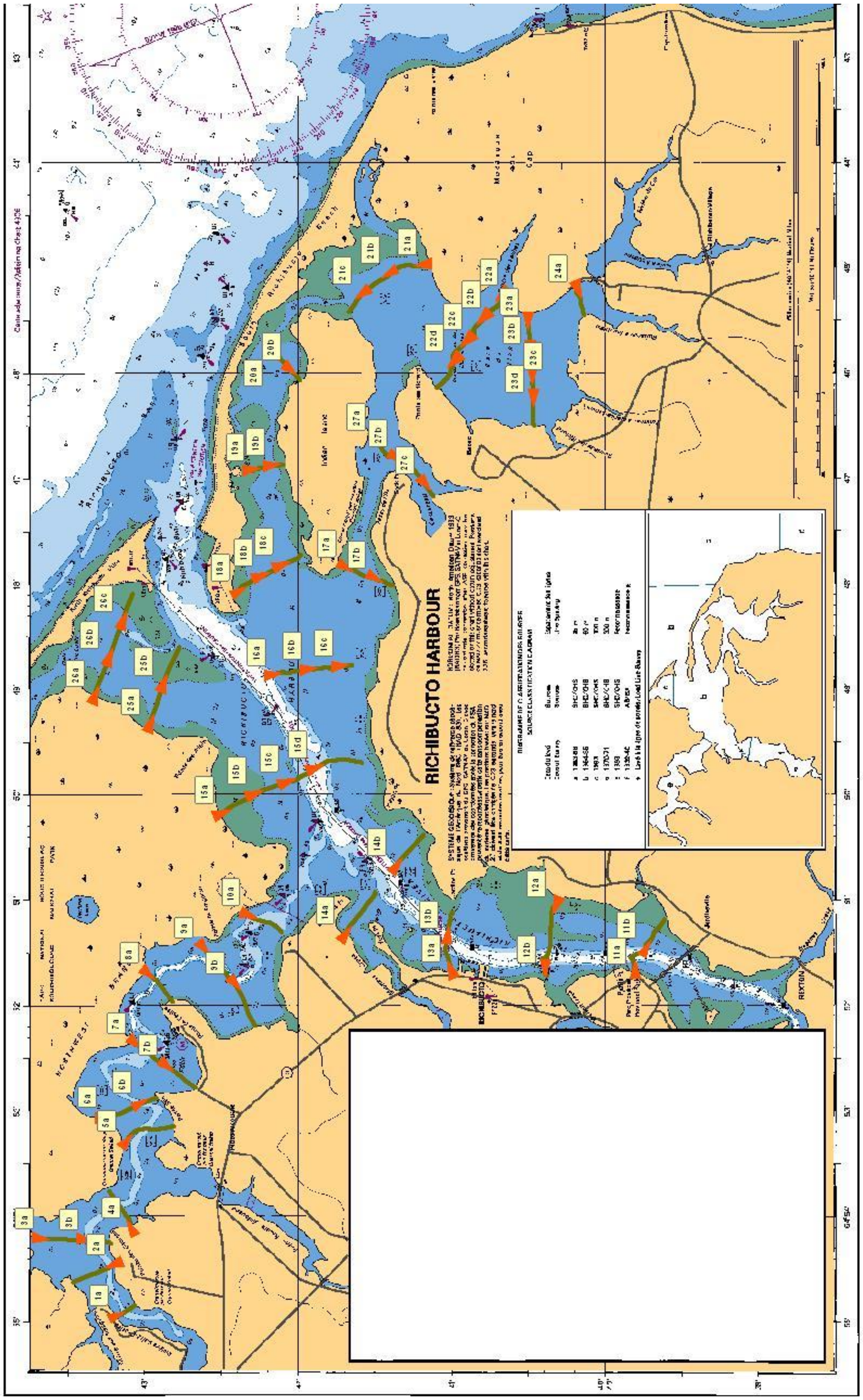

Figure 1: Chart of Richibucto Bay. At this scale the details of the embedded sidescan images are not visible. The green lines indicate the towfish transects. Each transect is numbered, and the letters represent video clip names (e.g. transect 7 has two video clips associated with it, 7a and 7b). The red arrows indicate the starting point and direction of tow for each video clip.

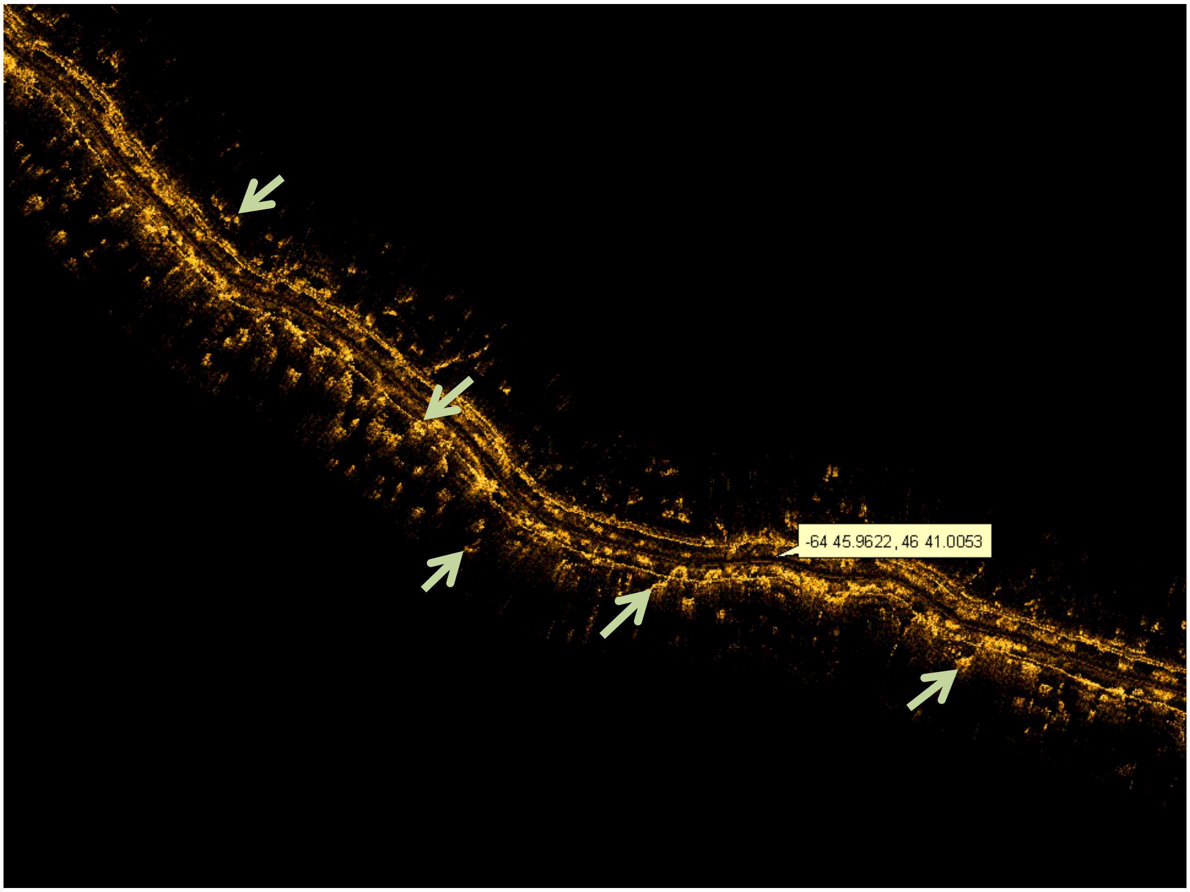

Figure 2: Sidescan image near western end of Richibucto transect Rb22. The text balloon indicates the location of an area of patchy eelgrass which extends over most of the image (as verified by the video clip). The arrows indicate various eelgrass patches which show up bright yellow because of their acoustic reflectivity. The surrounding sediment is soft and acoustically ‘dark’.

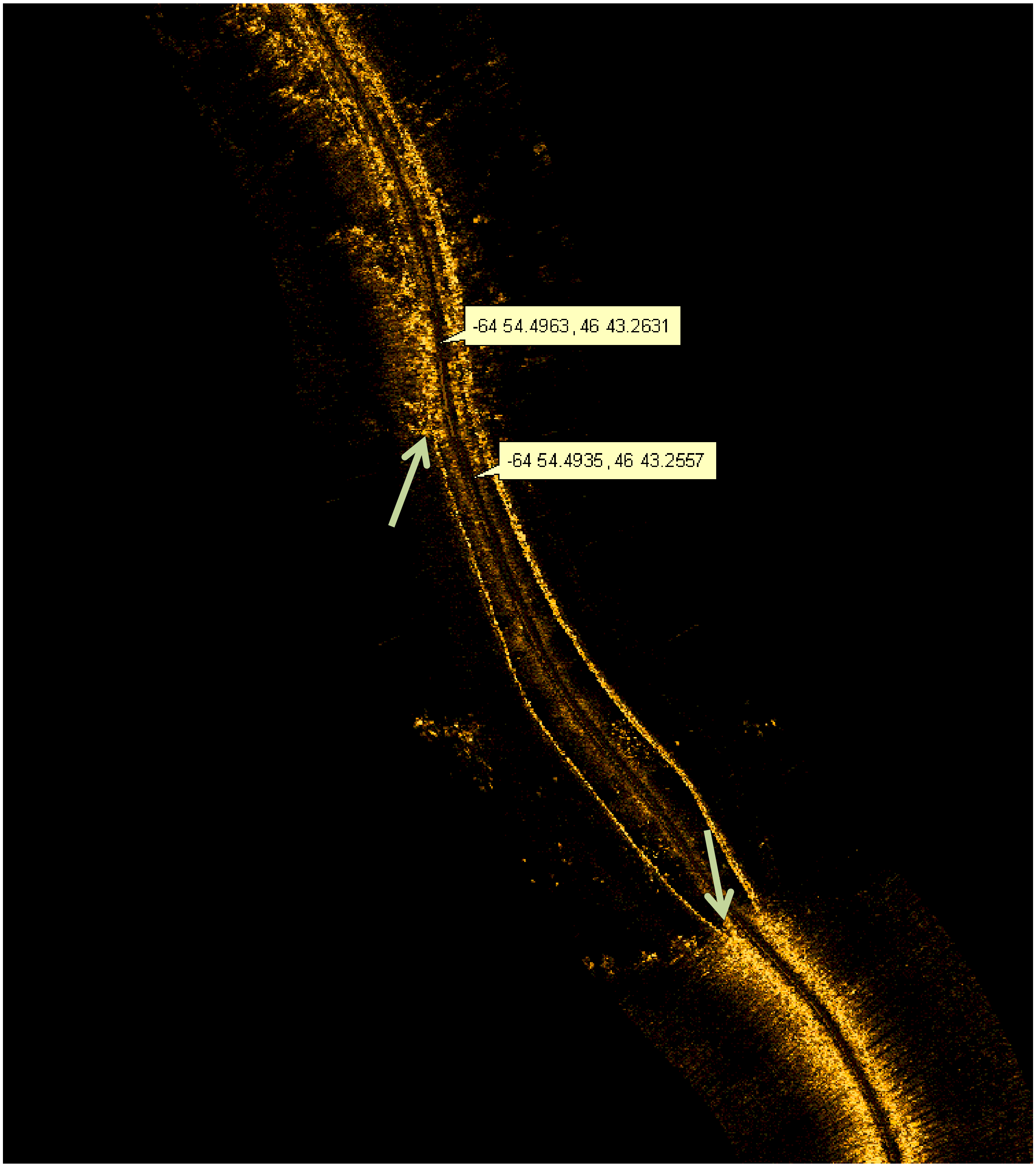

Figure 3: Sidescan image from southern half of transect Rb2. The middle portion of the figure is a soft bottom channel with no eelgrass (low acoustic reflectivity, dark brown – the two yellow stripes on either side of the towfish path are artifacts). The arrows indicate the edge of the eelgrass beds on either side of the channel. The beds are a dense cover of eelgrass showing up as continuous bright yellow areas on the top and bottom of the image. Top text balloon indicates a location of dense eelgrass cover; bottom text balloon is a position with no eelgrass (confirmed by the video clip at those points).

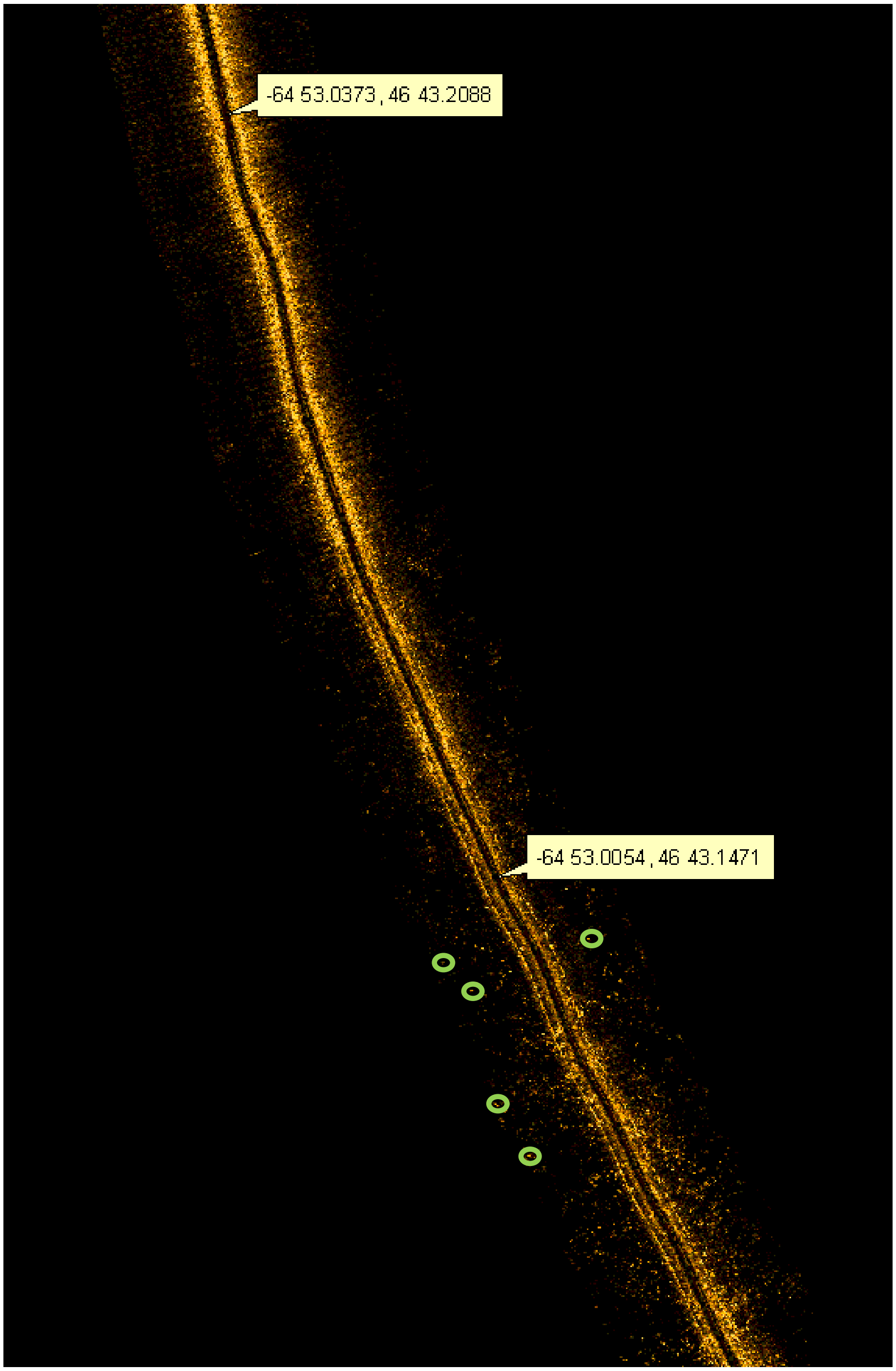

Figure 4: North end of Rb6 – from shallows to the north (top of image) until just before the deeper channel (bottom of image). Text balloon at top indicates position of dense eelgrass, note high intensity return on either side of the towfish path (dark region in middle) which does not travel very far to port or starboard as the dense eelgrass reflects most of the ping energy back to the towfish. Text balloon at bottom is position of thinly spread eelgrass, individual clumps of leaves show up as bright specs (some examples circled in green) and the sidescan swath covers a wider area as more acoustic energy is left to reach the limits of the instrument (15m on either side of the towfish).

Figure 5: The white lines on the water represent ‘longlines’ of oyster bags (Richibucto Bay; image from Google Maps, ©2012 Google).

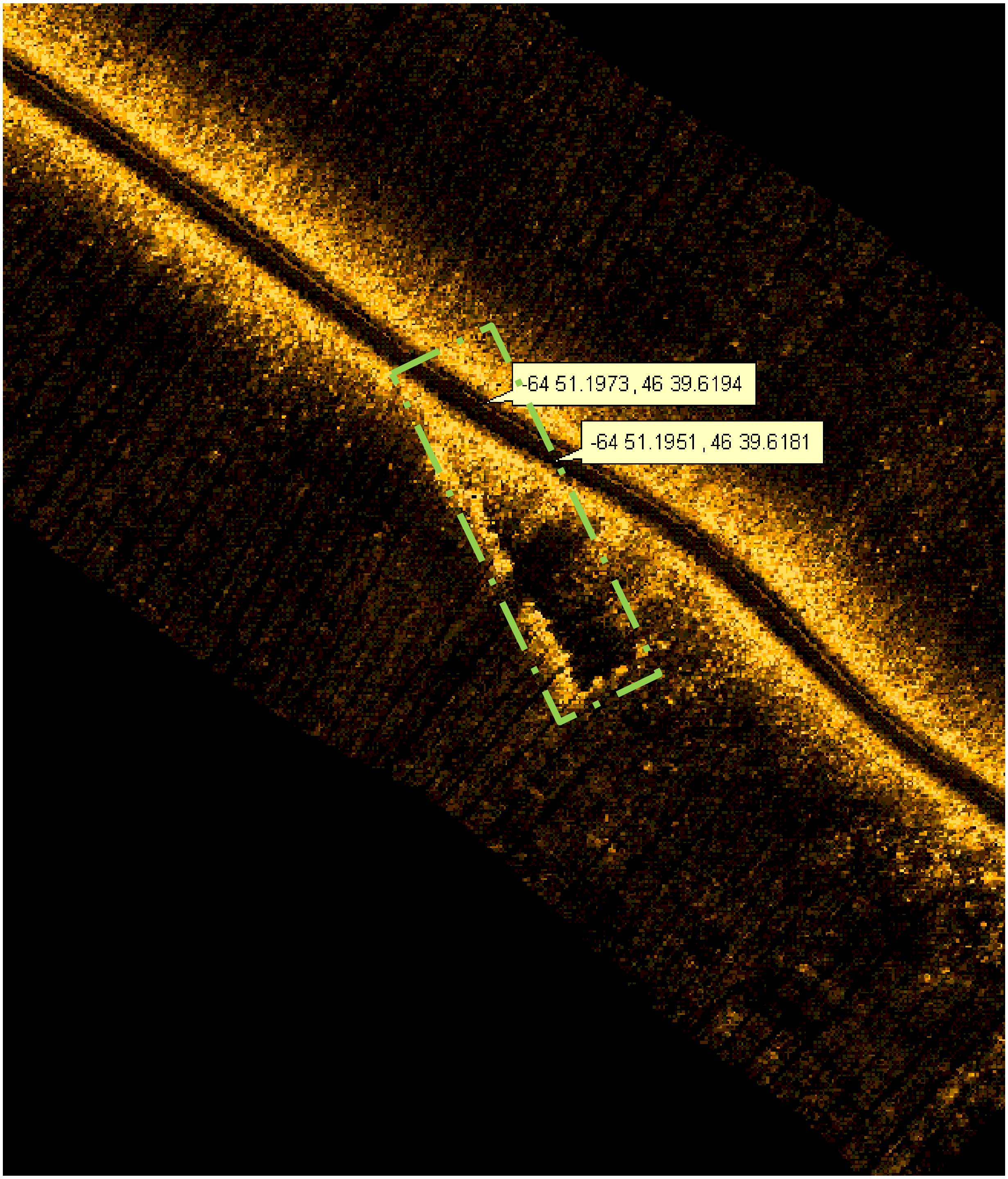

Figure 6: South end of Rb11b - possible damage to eelgrass due to oyster longlines resting on the bottom over winter. Note the very angular aspect of the bare patch (highlighted by green rectangle). The bare patch is about 5 m wide and was not resolved by the sidescan swath on the upper side of the image (i.e. the length of the bare patch cannot be determined). The upper text balloon indicates a location where the towfish video shows a wide bare patch with a few shoots of eelgrass, all video prior to this point (i.e. on the left in this image) shows dense eelgrass cover. The lower location balloon indicates the point where the video records a 'wall' of eelgrass again.

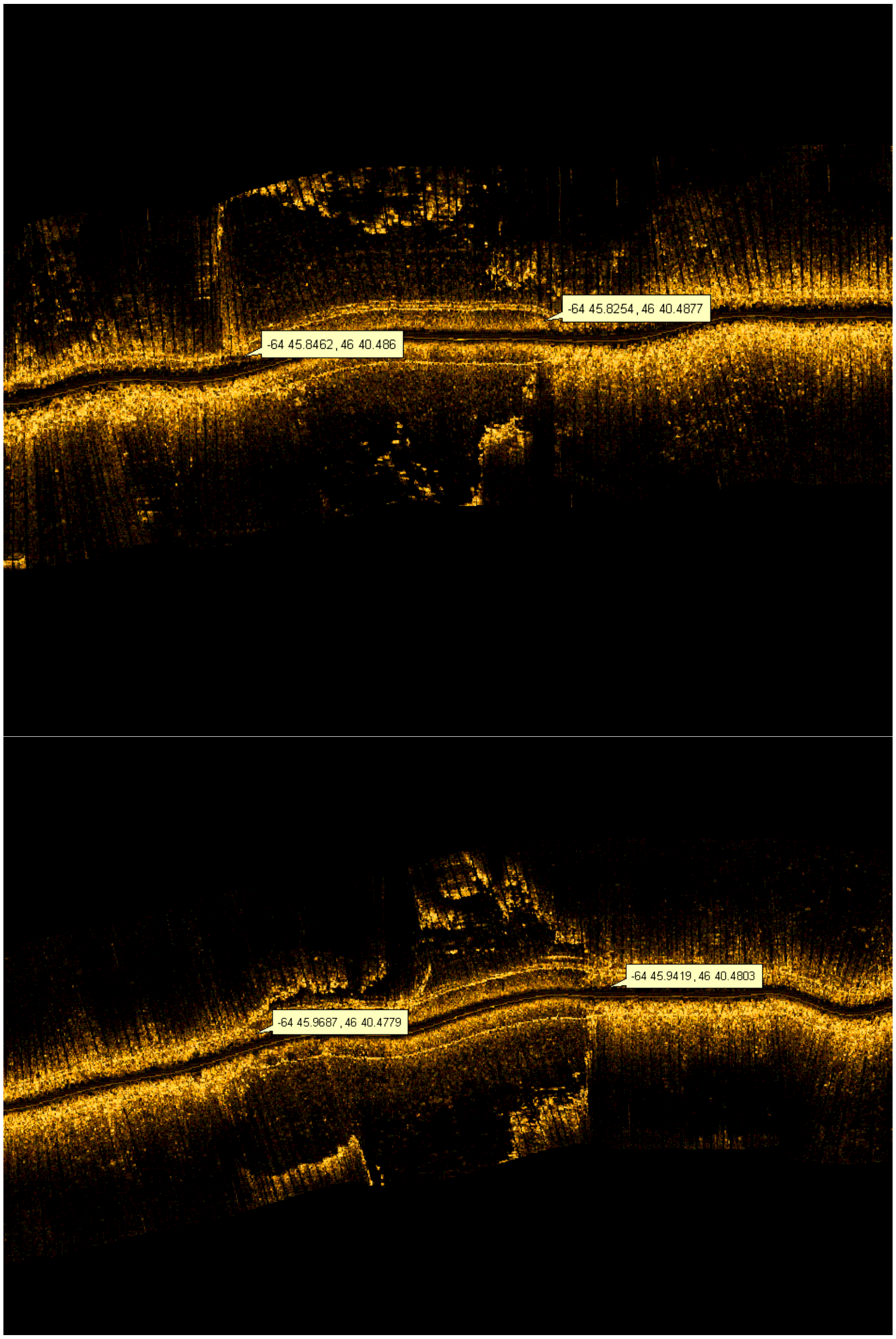

Figure 7: Middle of Rb23 – more evidence of human disturbance, very angular bare patches. Long dense eelgrass to the right and left on each image, text balloons indicate locations of abrupt transition from dense eelgrass to bare substrate in the video record. The area in between each set of text balloons is bare substrate with some shoots of eelgrass and an extensive cover of algae (most likely drift material).

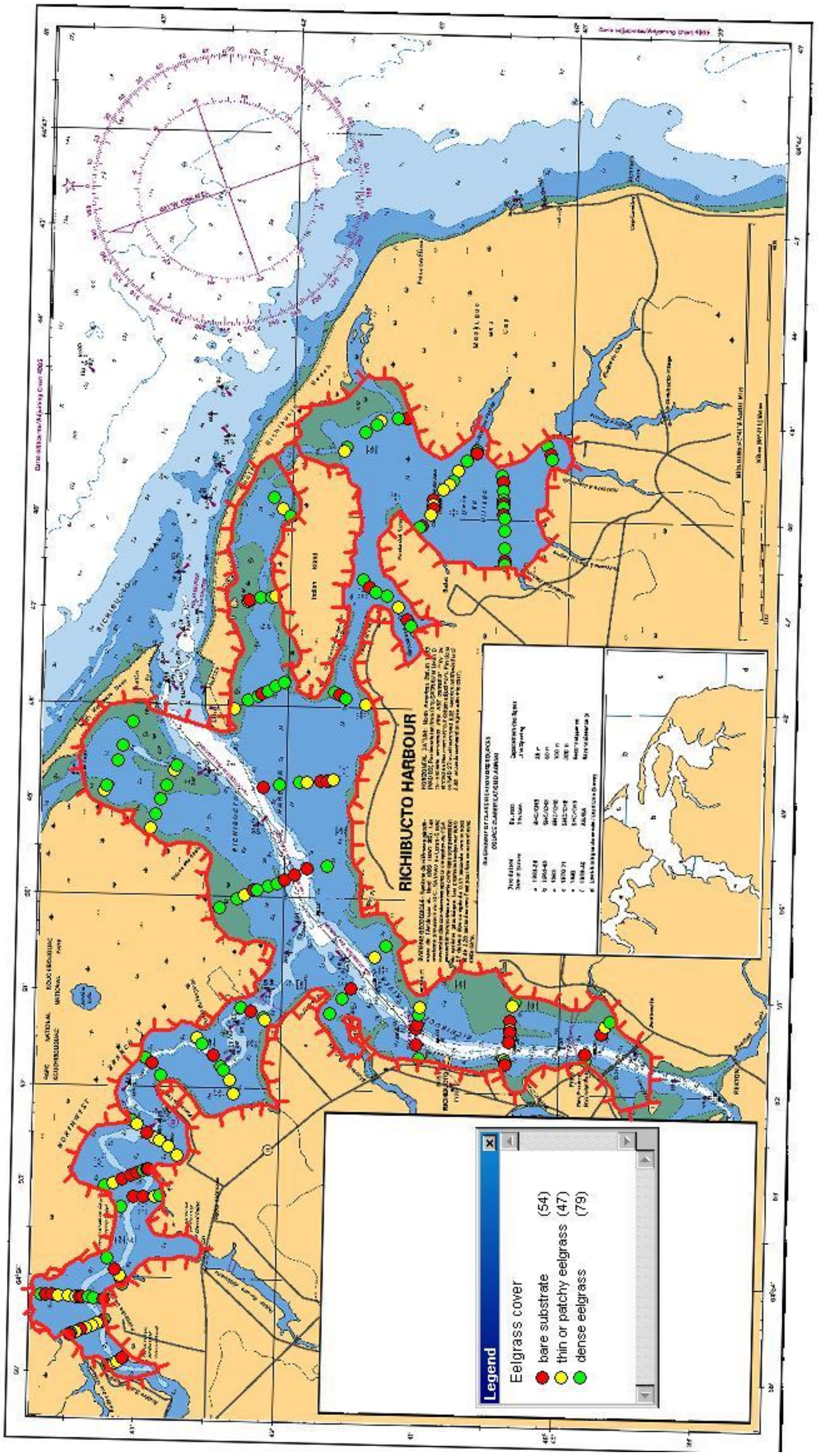

Figure 8: The ground-truth data points for Richibucto Bay. The survey area is defined by the red textured line, it is 28.12 km^2.

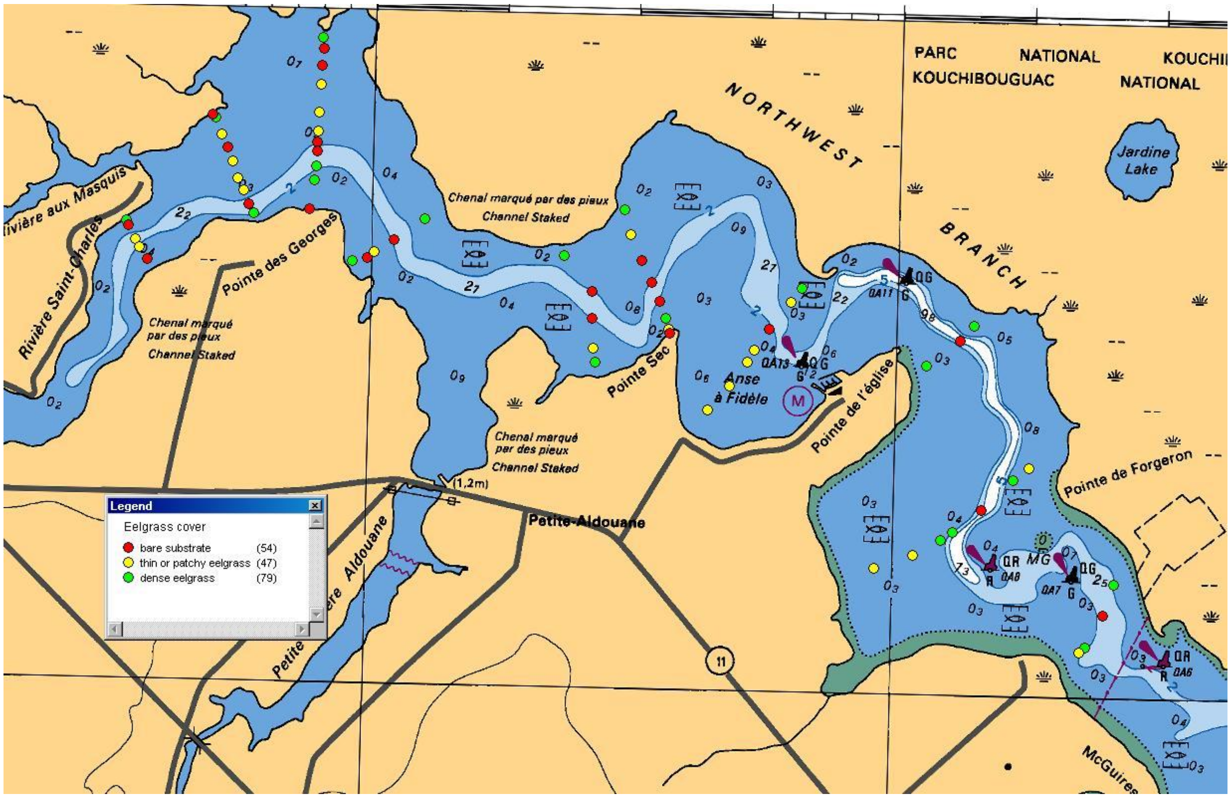

Figure 9: Ground-truth data points in the Northwest Branch of Richibucto Bay.

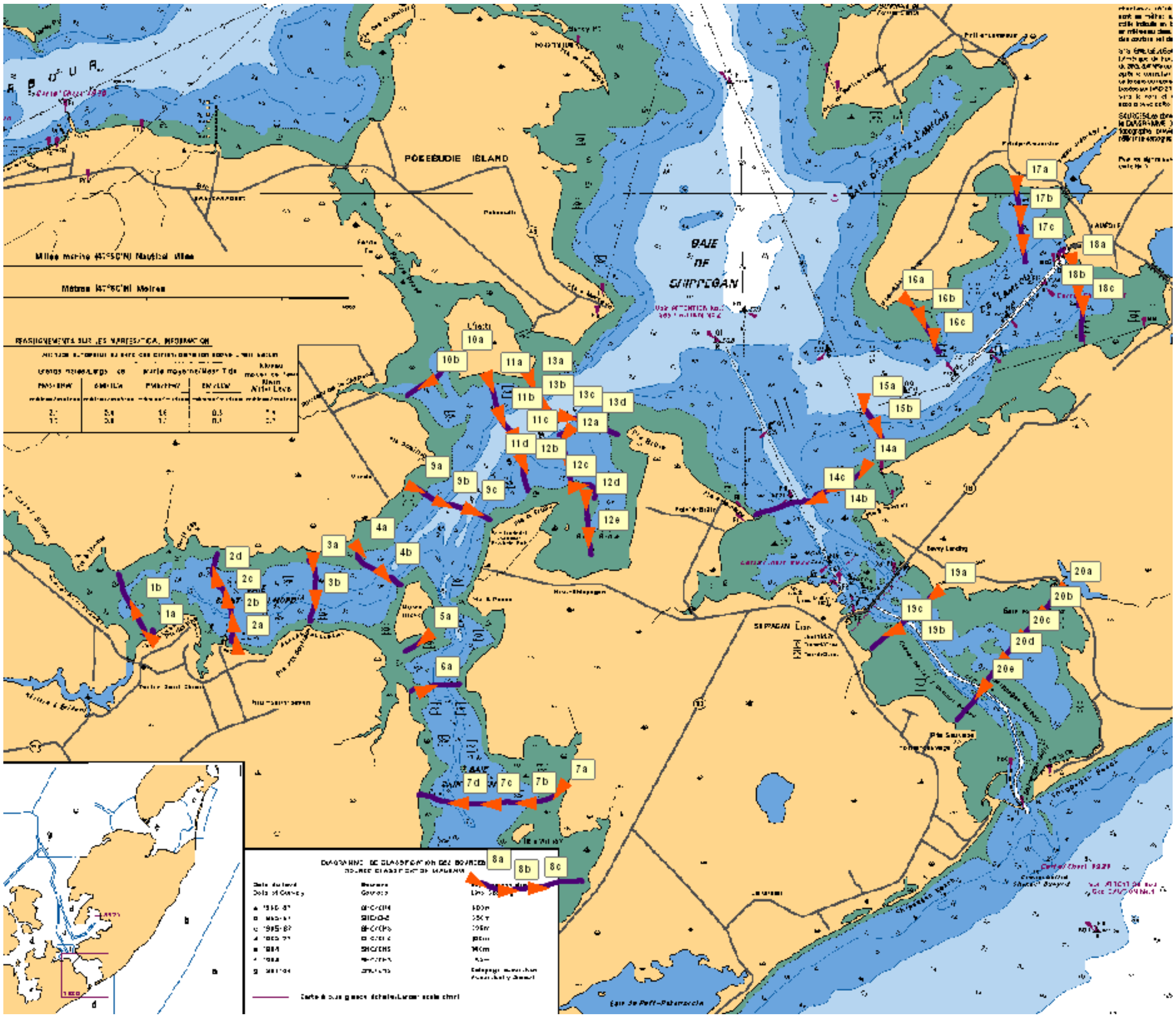

Figure 10: Chart of the Shippagan area. Transects visible with numbered video clip sequences.

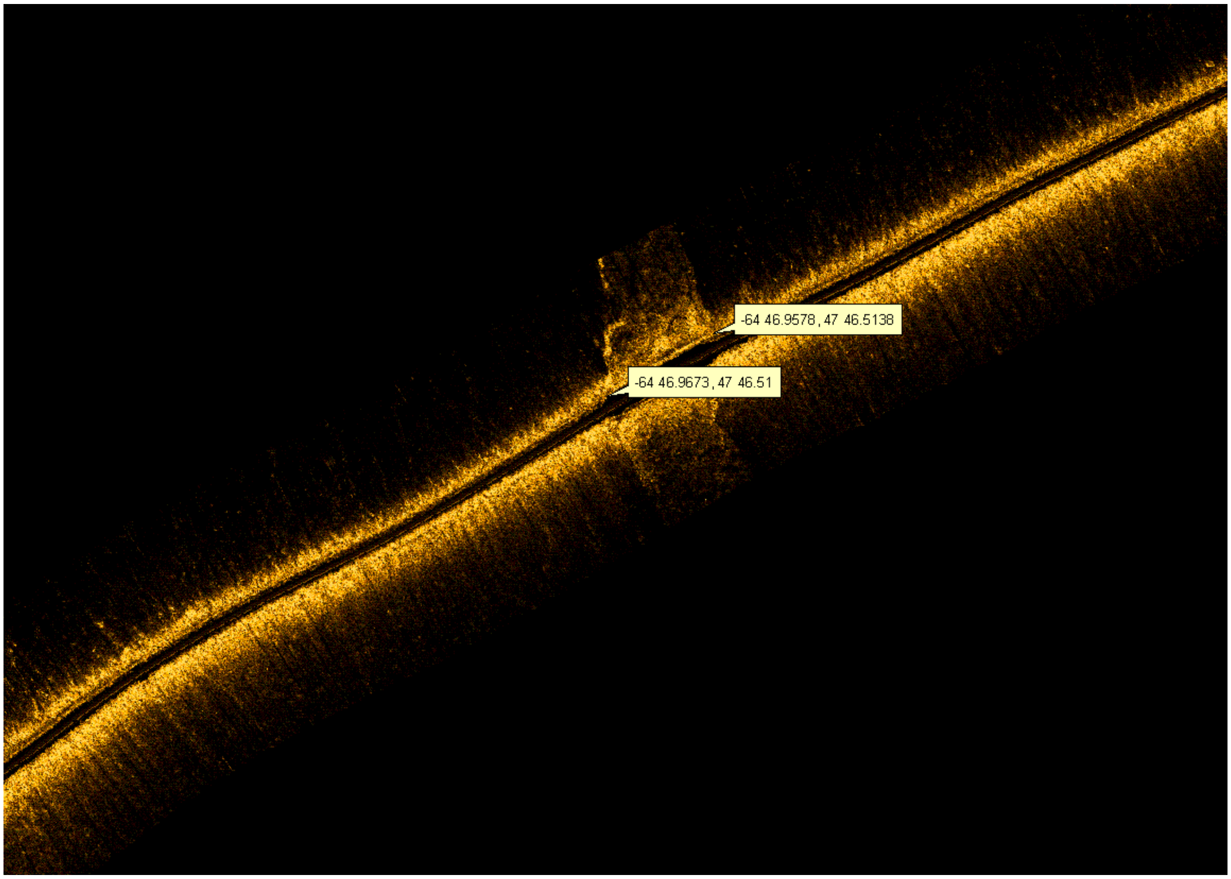

Figure 11: Middle of transect 10 in Shippagan. Very dense healthy eelgrass to right and left on image. Top text balloon indicates position in video record where eelgrass abruptly ends and a bare patch begins. The bare patch is a relatively firm bottom with a cover (drift material?) of turf algae. The bare patch is very rectangular in aspect with a width of about 15 m. The bottom text balloon indicates position where dense eelgrass begins again.

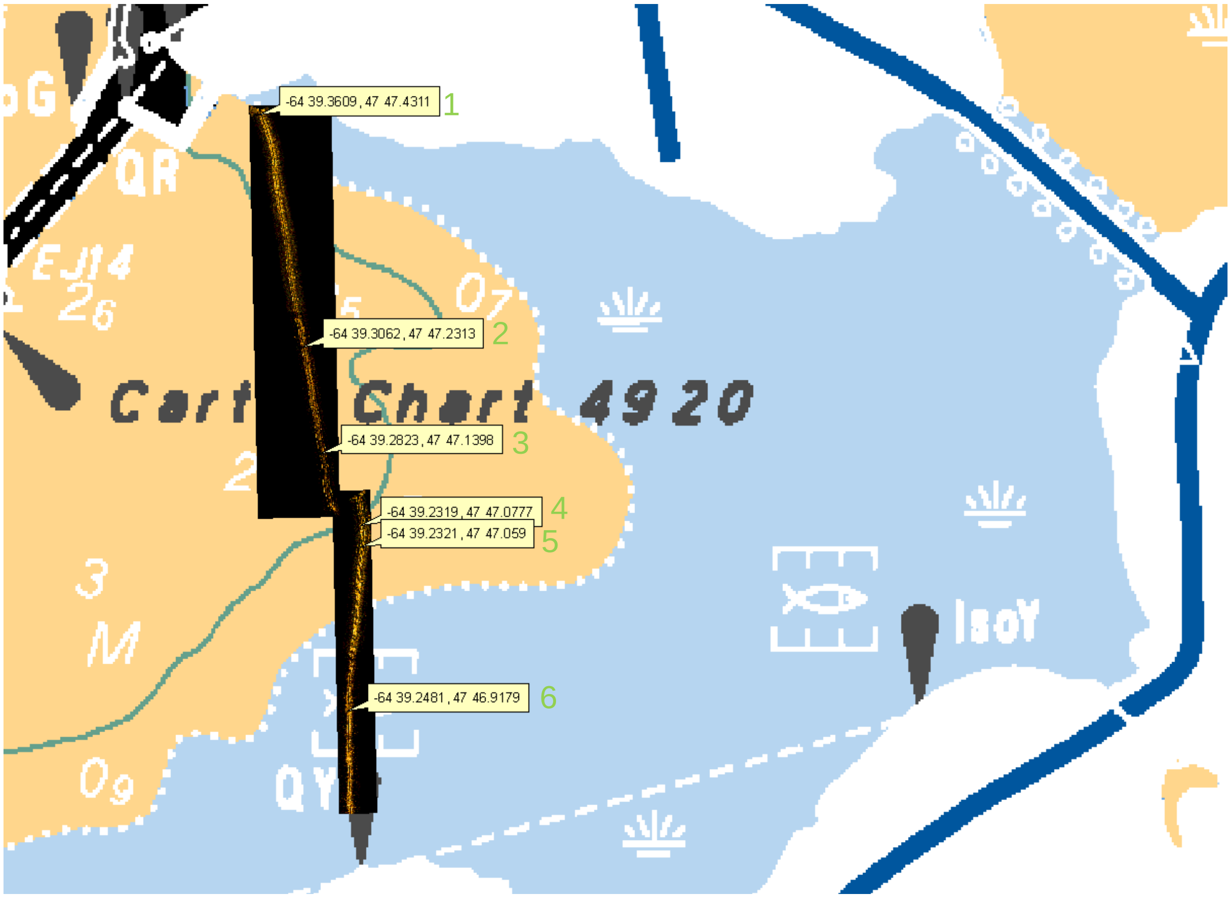

Figure 12: Transect 18 in Shippagan. Land is white in this false color image, roads are dark blue. Note jetties of Lameque Harbor in upper left. Position 1 – dense *Ulva* mat completely covers the bottom, nothing else seen; Position 2 – dense *Ulva* mat continues to this point; Position 3 – *Ulva* mat starts to thin out, bare patches of sediment can be seen; Position 4 – *Ulva* mat mixed with bare sediment continues, some clumps of eelgrass start to appear; Position 5 – eelgrass gets denser but covered in epiphytes and 'silt', some *Ulva* blades and bare sediment; Position 6 – eelgrass dense with less epiphyte and silt load, almost no *Ulva* blades or bare sediment. The Position 6 pattern continues until the southern end of the transect.

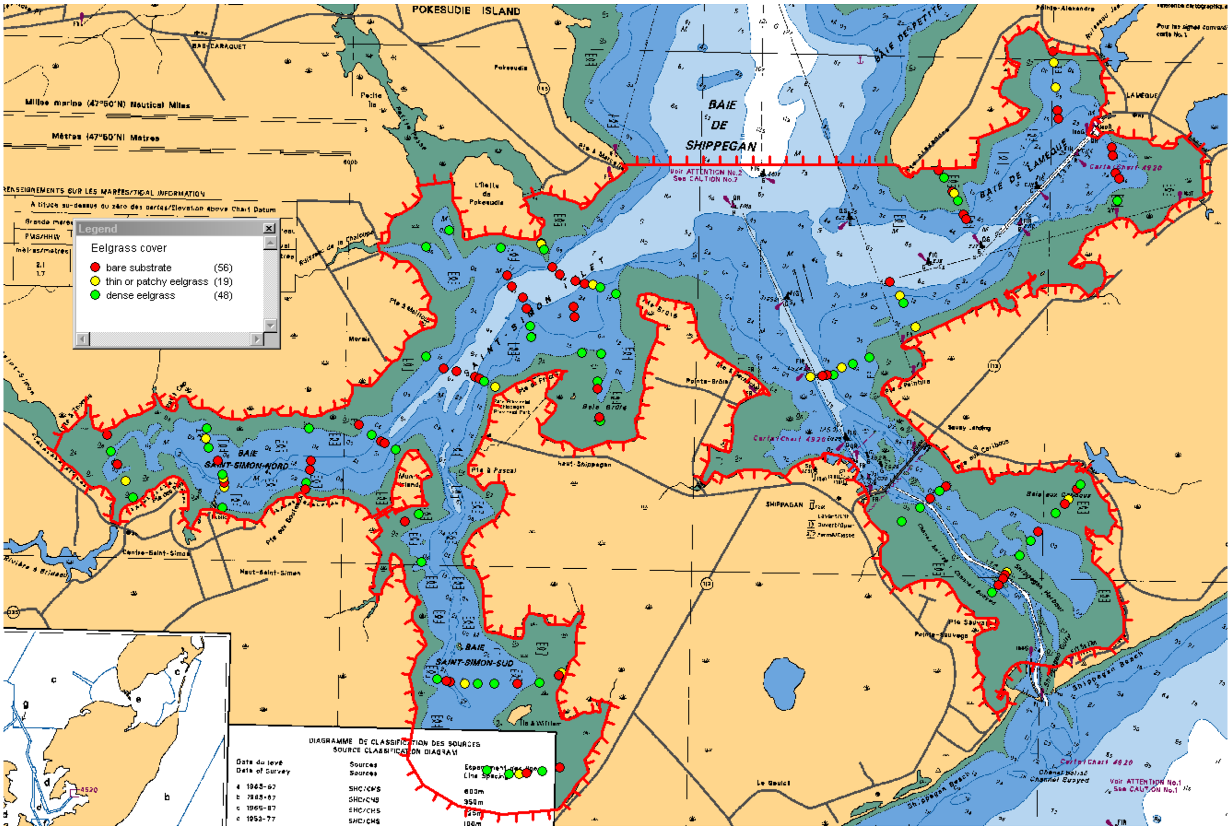

Figure 13: The ground-truth data points for Shippagan. The survey area is defined by the red textured line, it is 56.52 km^2.