Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2



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Executive Summary

A DGPS-positioned, towed video camera system was used to collect imagery of the seabed. Nominal shore-normal and shore-parallel transect line spacing was 160 m. Cross-over points between the shore-normal and shore-parallel transect lines were used to determine the confidence levels in the interpretation of the image data. Surveys were carried out in waters up to 60 m depth.

A data record of substrate and biota classes was produced for each second of video imagery using a substrate and biotic classification similar to that used by the British Columbia Land Use Coordination Office (LUCO).

All classification data was entered into a relational database. Maps of observed species distribution and estimated species ranges were produced using ArcGIS. A library of linked and searchable video annotations was produced.

The overall confidence level of the survey was 92%. Poor visibility was the main reason for decreased confidence levels.

The following substrate and biota features were observed:

1. The site is located directly in the plume of the Skeena River, resulting in normally high turbidity. As a result, the visibility at the site seldom exceeded 1 m.
2. Based on video observations, the site substrate consisted largely of silt-mud, with some shell, wood, and organic debris. Bedrock occurred around Coast Island, the reef to the NE of Coast Island, and Bacon Rock. Sand was present along the shore or Ridley Island, and to a lesser extent, around Coast Island and the reef to the NE of Coast Island.
3. Commercial crab harvesting operations took place at the site throughout the duration of the survey. The presence of crab gear on the seafloor was observed frequently in the video footage.
4. In many of the shallow areas around Coast Island and the reef to the NE of Coast Island, vegetation dominated the benthic environment. Vegetation was less dominant along the Ridley Island shoreline; however, significant amounts of eelgrass were present.
5. The most dominant alga in terms of both number of observations and area was sugar wrack kelp.
6. Based on a statistical analysis of the data, the highest concentrations of bull kelp (*Nereocystis*) were found around the rocky reef to the NE of Coast Island, at the northern tip of Coast Island, and along the SW shore of Coast Island.
7. Six other species of kelp were observed at the site: *Laminaria setchellii* (split kelp), *Laminaria saccharina* (sugar wrack kelp), *Laminaria yezoensis* (suction-cup kelp), *Costaria costata* (seersucker kelp), *Agarum fimbriatum* (fringed sea colander kelp), and *Alaria* sp.
8. Eelgrass was found along the SE shore of Coast Island, and in a strip along the section of Ridley Island shore that was surveyed. While present, the eelgrass beds were relatively sparse in nature, seldom exceeding 75% cover. Based on a statistical analysis of the data, the highest concentrations of eelgrass were found in a small area along the SE shore of Coast Island and in a patch along the northern section of the Ridley Island shoreline.
9. The most dominant fauna in terms of both number of observations and area were unmounded holes. Unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp.
10. As a group, echinoderms were the most diverse organisms at the site.
11. Orange sea pens were widely distributed throughout the site. Based on a statistical analysis of the data, the highest concentrations of sea pens were found in an area to the SW of Coast Island and another area off the north tip of Coast Island.

12. Dungeness crabs were observed throughout the site. Based on a statistical analysis of the data, the highest concentrations of Dungeness crabs were found off the SE shore of Coast Island, off the north tip of Coast Island, and between the rocky reef and Ridley Island. Two of these areas are closely associated with the regions of highest eelgrass density.
13. Spiny pink shrimp, which were very common at the site, were found in waters of depths greater than 10 m.
14. Fish were found in moderate abundance at this site, mostly at depths greater than 10 m.
15. The following commercial species were observed at the site:
    a. spiny pink shrimp in very high abundance
    b. geoduck clams in high abundance
    c. Dungeness crab in high abundance
    d. spot prawns in moderate abundance
    e. California sea cucumbers in moderate abundance
    f. flatfish in moderate abundance
    g. longnose skates in low abundance
16. The overall Shannon's diversity index for the site was 3.734 and the species richness was 57. By comparison with other local sites, the diversity for this site is quite high.
17. Maximum species richness for the site occurs in three regions: (1) an area along the SW shore of Coast Island; (2) the northern tip of Coast Island; and (3) the area between the rocky reef and Ridley Island. Maximum species diversity is correlated with:
    a. water depth. Shallow, well-lit regions support good algal growth. This, in turn, supports high faunal diversity.
    b. rocky, rugged terrain. Rocky terrain provides many crevices and cracks where organisms can become established, thus increasing faunal diversity.

1 Ridley Island Subtidal Survey Methodology

1.1 Towed Benthic Video Survey Design

1.1.1 Towed Video System

A DGPS-positioned, towed video system was used to collect imagery of the seabed (similar to the Seabed Imaging and Mapping System [SIMS] used by CORI). This system was a custom-built model designed for use in the steep, rugged terrain characteristic of British Columbia fjords. Typical tow speed was 0.8 knots. The towed video system had two video cameras - one in a forward-looking orientation and one in a downward-looking orientation. Both cameras have a Sony 1/3" super HAD color CCD with 480 lines horizontal resolution (768 x 494 pixels) and 0.5 lux @ F 2.0. These cameras provided composite video signals to an overlay unit that stamped the DGPS position data (latitude/longitude), together with date and time, on each video frame. The video signal was also displayed in real-time on the vessel, where it was used to adapt the survey to particular features that were seen while underway. High intensity white LEDs were mounted on the camera to provide additional illumination when it was required.

The altitude of the underwater camera was controlled using a hydraulic winch which was operated from the bridge while monitoring the real-time video feed from the camera. Typically, the camera was towed approximately 1 m above the seabed.

1.1.2 Video Recording System

The dual analog camera signals were recorded using a digital video recorder directly onto a hard drive. After the survey was completed, the raw video data was copied onto DVDs. As the digital video recorder creates video files in a proprietary format, software to view and convert the video data into other formats was also provided on each raw video DVD.

1.1.3 Survey Design

The data for this report comes from two benthic video surveys of the Canpotex site - the first completed during the period January 20th to January 21st, 2009, and the second completed during the period May 18th to May 20th, 2009. For both surveys, the nominal shore-normal and shore-parallel transect line spacing was 160 m (Figure 1). All shore-normal survey track-lines were continued inshore to about 2 m water depth or to the limit of safe navigation. Surveys were carried out in waters up to 60 m depth.

1.2 Classification and Mapping

1.2.1 Database of Species and Substrate Classifications

Raw video of the transects was reviewed and classified using a substrate and biotic classification similar to that used by the British Columbia Land Use Coordination Office (LUCO). A data record of substrate and biota classes was produced for each second of video imagery.

The geology database contains information on substrate type (Table A1 in the Appendix) and percentage substrate cover (Table A2 in the Appendix). Anthropogenic features were mapped as part of the geological inventory.

The biological database captured detail on seabed biota within two general categories, vegetation (Table A3 in the Appendix) and fauna (Table A5 in the Appendix). Up to three faunal and floral types were evaluated for each second of video and given distribution codes. Vegetation coverage classes (Table A4 in the Appendix) and faunal distribution classes (Table A6 in the Appendix) were also recorded. Note that very small species (e.g., barnacles, small tube worms, small algal species), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) were often not identified in the video footage, and were therefore not included in the database.

Video annotation created a linked, random-access database of all the video data which can be readily searched using keywords from the classification scheme. Additionally, the provided "Transect Player" software links video and GPS data, allowing simultaneous viewing of the camera's geographical position on a map and the video images captured by the camera at that location.

All classification data was also entered into a relational Access database, which was then used to generate the data for mapping. This database contains a "Filter by Video" function which allows the user to browse through the data for each transect as a series of data recording forms.

1.2.2 ArcGIS Mapping

Maps of observed species distribution and estimated species ranges were produced using ArcGIS. These maps have been provided as an ArcGIS project which can be viewed using the supplied ArcReader.

1.2.3 Survey Confidence Levels

All transect cross-over points were used to determine the confidence levels in the interpretation of the image data. All the data records within a 5.0 m radius (the maximum positional error of a DGPS signal) of the location where two transect lines crossed were analyzed for similarities. The number of times that data records from both transect lines had the same values for each classification category (e.g., substrate, vegetation, fauna) was recorded and used to generate percentage confidence.

1.2.4 Substrate Maps

Substrate observations were mapped as a series of points in ArcMap. A hexagonal grid (composed of hexagonal polygons with widths of 40 m) was overlaid on the observation points. Each polygon was assigned a substrate code based on the code of the majority of the data points, weighted by percentage cover, within that polygon. Polygons which contained no data points were assigned the code of the nearest neighbouring polygon.

1.2.5 Range Maps

Range maps for flora and fauna were generated using the fixed kernel density estimation procedure. Flora observations were weighted by abundance (see Table A4 in the Appendix) and fauna observations were weighted by distribution (see Table A6 in the Appendix). In order to allow overlap of polygons between transects, the search radius (a.k.a. the smoothing factor) was set to the distance between transects (e.g., 160 m). For each organism, a 95% volume contour was generated. This consisted of a polygon covering a geographical area in which 95% of the estimated population was expected to be found.

1.2.6 Dominant Species Maps

Species observations for both flora and fauna were mapped as a series of points in ArcMap. A hexagonal grid (composed of hexagonal polygons with widths of 40 m) was overlaid on the observation points. Each polygon was assigned a species code based on the most abundant species within that polygon, weighted by abundance (for flora) or distribution (for fauna). Polygons which contained no data points were assigned the code of the nearest neighbouring polygon.

1.2.7 Minor Species Maps

Species observations for both flora and fauna were mapped as a series of points in ArcMap. A hexagonal grid (composed of hexagonal polygons with widths of 40 m) was overlaid on the observation points. Each polygon was assigned a species code based on the code of least abundant species within that polygon, weighted by abundance (for flora) or distribution (for fauna). Polygons which contained no data points were assigned the code of the nearest neighbouring polygon.

1.2.8 Diversity Analysis Using Range Maps

Calculations of Shannon's diversity index, Shannon's evenness, and Simpson's dominance index were carried out in ArcMap using the range map polygons. Note that the diversity values generated from the range map data should be considered minimum values for the site, as very small species (e.g., barnacles, small tube worms), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) are often not identified in the video footage, and are therefore may not included in the diversity calculations.

1.2.9 Species Richness Maps

A hexagonal grid (composed of hexagonal polygons with widths of 40 m) was overlaid on a shape file containing all the range map polygons for a particular category (e.g., flora, fauna, total species). Using polygon in polygon analysis, each hexagonal polygon was assigned a number equal to the number of range map polygons with which it overlapped. This assigned number was equal to the species richness in a given hexagonal polygon, since each range map polygon represented a different species. The coded hexagonal polygons were used to generate a species richness map.

2 Ridley Island Subtidal Survey Results

2.1 Benthic Video Survey

The transect lines for the survey as carried out are shown in Figure 2. Coverage for the site was excellent, with good extension of the transects to the edges of the proposed survey boundary. Other factors which had an effect on the survey quality and resolution were:

1. ***kelp*** - kelp beds limited access to shallow regions of the site. Fringing kelp beds along the islands and submerged rock reefs at the site (see Figure 10) made access to these areas impossible due to restrictions associated with operating the boat and gear safely within the kelp beds.
2. ***turbid water*** – the site is located directly in the plume of the Skeena River (see Figure 3), resulting in normally high turbidity. As a result, the visibility at the site seldom exceeded 1 m. High intensity LEDs were used to provide light during the video runs; however back-scattering of light from the silt particles often created a "halo effect", causing additional visibility issues. This reduced the resolution of the video camera, producing a grainy image quality. In spite of these problems, the image quality was deemed sufficient for organism identification. Due to the limited visibility, the camera was often towed less than 1 m above the bottom, resulting in a relatively small field of view and a low towing speed (0.5 knots).
3. ***strong currents*** – strong currents occasionally made course-holding difficult on a few of the transects.
4. ***seasonal differences*** – some of the transect data was collected during the winter, while other data was collected during the spring. There may have been seasonal differences in the abundances of motile organisms, such as fish, crabs, prawns, and shrimp.

Five DVDs of raw video data were generated from the survey. Processing and annotation of the video data produced three DVDs containing the clipped and converted videos and viewers to visualize the data.

2.2 Survey Confidence Levels

A total of 84 cross-over points were used to determine the survey confidence levels (refer to the "Cross over points" layer in the attached ArcGIS project). Each pair of records was compared for:

1. substrate
2. fauna
3. flora

The results of this analysis are given in Table 1.

Table 1. Confidence levels in data interpretation.

Category	# Points Compared	# Points in Agreement	% Confidence
Substrate	84	81	96
Flora	84	77	92
Fauna	84	75	89
Overall	**252**	**233**	**92**

The overall confidence level of 92% is very good. In regions where the substrate was changing (e.g., from sand to silt-mud), poor visibility made substrate interpretation more subjective, resulting in lower confidence levels in assignment of substrate type in these regions.

There was some difficulty in differentiating between the various species of soft brown kelps present at the site, particularly when visibility was poor, and this may have led to a slight decrease in the confidence levels for assignment of flora.

Lower confidence levels in assignment of fauna are expected, as fauna are mobile and may have moved out of the cross-over area between transects.

2.3 Substrate

Based on video observations, the site substrate consisted largely of silt-mud, with some shell, wood, and organic debris (see Figure 4). Bedrock occurred around Coast Island, the reef to the NE of Coast Island, and Bacon Rock. Sand was present along the shore or Ridley Island, and to a lesser extent, around Coast Island and the reef to the NE of Coast Island.

A significant wave and current shadow (e.g., tombolo effect) occurred behind Coast Island. This resulted in the deposition of large amounts of organic debris (seaweed wrack) between Coast Island and Ridley Island (see Figure 5).

Commercial crab harvesting operations took place at the site throughout the duration of the survey. The presence of crab gear on the seafloor was observed frequently in the video footage (see Figure 6). Crabs were also observed in and around commercial crab traps (see Figure 7).

Anthropogenically-produced garbage was observed in moderate amounts at the site (see Figure 8). As with the organic debris, much of this garbage was trapped in the current shadow region behind Coast Island.

2.4 Flora

In many of the shallow areas around Coast Island and the reef to the NE of Coast Island, vegetation dominated the benthic environment. Vegetation was less dominant along the Ridley Island shoreline; however, significant amounts of eelgrass were present.

Algal abundance declined as one moved away from the shallow water regions as a result of the rapid decrease in light in the offshore direction. Due to the extreme turbidity, which reduced light for photosynthesis, and the heavy siltation, which rapidly covered nonmotile organisms, the algal abundance in the offshore regions of the site was low.

Table 2 lists the various groups of flora identified at the site, and their abundances in terms of both total number of observations and percentage of total flora abundance by area based on the range maps for each group.

Table 2. Abundances of various flora groups.

Flora identification	Number of Observations	% of Total Flora Abundance by Area
Sugar wrack kelp	2863	9.72
Filamentous reds	2169	8.21
Fringed sea colander kelp	914	7.56
Foliose reds	868	9.35
Eelgrass	774	4.61
Suction-cup kelp	707	6.01
Nereocystis	453	9.62
Coralline reds	322	6.85
Stringy acid weed	98	6.55
Alaria	96	7.00
Foliose greens	81	7.78
Split kelp	40	3.24
Broad acid weed	38	6.88
Filamentous greens	19	5.38
Seersucker kelp	10	1.23

Some observations regarding flora at the Canpotex site are:

1. The greatest algal abundance at the site occurred along the small stretch of Ridley Island shoreline that was mapped, and around Coast Island and the rocky reef to the NE of Coast Island. These regions were shallow, and had some amount of either rock or cobble substrate present. The combination of greater light penetration and harder substrate for algal holdfasts made these areas better sites for algal growth.
2. The most dominant alga in terms of both number of observations and area was sugar wrack kelp.
3. Green seaweeds occurred mainly in the region between Coast Island and Ridley Island. Foliose greens were more abundant and widely dispersed than filamentous greens (see Figure 9).
4. Surface beds of bull kelp (*Nereocystis*) were observed on the west side of Coast Island, and associated with the rocky reef to the NE of Coast Island (see Figure 10). Benthic videography was not carried out in these beds due to potential entanglement of gear and shallow water. Some subsurface *Nereocystis* was observed in the video footage from the east side of Coast Island and the shoreline of Ridley Island. The surface and subsurface observations of *Nereocystis* were combined to generate a range map for *Nereocystis* (see Figure 11). Based on a statistical analysis of the data, the highest concentrations of *Nereocystis* were found around the rocky reef to the NE of Coast Island, at the northern tip of Coast Island, and along the SW shore of Coast Island (see Figure 12).
5. Three species of *Laminaria* were observed at the site: *Laminaria setchellii* (split kelp), *Laminaria saccharina* (sugar wrack kelp), and *Laminaria yezoensis* (suction-cup kelp) (see Figure 13). Sugar wrack kelp was the most abundant of the three species, and was widely dispersed around Coast Island and the reef to the NE of Coast Island. Suction-cup kelp was locally abundant at specific regions within the site (north and south tips of Coast Island, the rocky reef to the NE of Coast Island, and at one location along the Ridley Island shoreline). Split kelp only occurred at the north end of Coast Island and around the rocky reef to the NE of Coast Island.
6. Three other kelp species also occurred at the Canpotex site: *Costaria costata* (seersucker kelp), *Agarum fimbriatum* (fringed sea colander kelp), and *Alaria* sp. (see Figure 14). Fringed sea colander kelp was the most widely dispersed of these three, and occurred around Coast Island and the reef to the NE of Coast Island. *Alaria* only occurred in the region between Coast Island and Ridley Island, and seersucker kelp was only observed on the reef to the NE of Coast Island.
7. Two species of *Desmarestia* were observed at the site: *Desmarestia viridis* (stringy acid weed) and *Desmarestia lingulata* (broad acid weed) (see Figure 15). Both species occurred along the eastern shore of Coast Island, around the rocky reef to the NE of Coast Island, and along the shoreline of Ridley Island.
8. Foliose, filamentous, and coralline red algae were all observed at the Canpotex site (see Figure 16). Foliose reds were the most areally dispersed of the three groups; however, filamentous reds were the most abundant in terms of numbers of observations. Coralline reds occurred at specific locations in the sites where exposed bedrock was present (north tip of Coast Island, SW shore of Coast Island, and the rocky reef to the NE of Coast Island).
9. Eelgrass was found along the SE shore of Coast Island, and in a strip along the section of Ridley Island shore that was surveyed (see Figure 17). While present, the eelgrass beds were relatively sparse in nature, seldom exceeding 75% cover. Based on a statistical analysis of the data, the highest concentrations of eelgrass were found in a small area along the SE shore of Coast Island and in a patch along the northern section of the Ridley Island shoreline (see Figure 18).

2.5 Fauna

Table 3 lists the various groups of fauna identified at the site, and their abundances in terms of both total number of observations and percentage of total fauna abundance by area based on the range maps for each group.

Table 3. Abundances of various fauna groups.

Fauna identification	Number of Observations	% of Total Fauna Abundance by Area
Unmounded hole	47084	12.40
Spiny pink shrimp	4717	2.51
Orange sea pen	1967	6.74
Bryozoan complex	914	2.63
Geoduck clam	550	7.92
Sunflower seastar	178	6.38
Dungeness crab	106	7.73
Red sea cucumber	85	2.23
Northern ronquil	44	2.17
Plumose anemone	44	4.36
Spot prawn	38	2.89
Unidentified eelpout	33	1.40
False ochre seastar	31	2.40
California sea cucumber	29	2.45
Short-spined seastar	27	1.94
Unidentified flatfish	27	2.63
Bacterial mat	23	1.83
Unidentified sculpin	21	2.14
Parchment tube worm	18	2.42
Stalked vase sponge	17	1.33
Painted star	16	2.48
Calcareous tube worm	13	1.10
Ochre seastar	12	2.28
Decorator crab	11	1.85
Vermilion star	11	1.57
Longnose skate	10	1.61
Snake lock anemone	10	1.33
Unidentified fish	10	2.00
Long ray star	9	1.53
Spiny mudstar	8	1.26
California lamp shell	6	0.41
Dogwinkle	6	1.22
Mounded hole	4	0.76
Solaster sp.	4	0.81
Pacific lugworm	3	0.41
Henricia sp.	2	0.41
Unidentified pandalid	2	0.41
Unidentified tunicate	2	0.41
Black-eyed goby	1	0.41
Gray brittle star	1	0.41
Moon jellyfish	1	0.41
Unidentified crab	1	0.41

Some observations regarding fauna at the Canpotex site are:

1. The most dominant fauna in terms of both number of observations and area were unmounded holes. Unmounded holes represent the observed surface disturbances caused by a number of unidentified infauna, including burrowing polychaetes, some bivalve species, and mud shrimp.
2. As a group, echinoderms were the most diverse organisms at the site.
3. The following distribution patterns were observed for organisms for which there were more than 4 sitings:

a. In several areas around the southern region of the site, yellow to orange colored bacterial mats were observed on the silt-mud sediment surface (see Figure 19). These were probably regions where sulphuretums (ecosystems in which bacteria convert sulfur into different chemical forms, such as sulfate) were active. Rapid breakdown of woody debris in a low oxygen environment can result in the production of hydrogen sulfide, a condition which can favor the formation of sulphuretums.
b. Stalked vase sponges occurred in shallow water on the western side of Coast Island (see Figure 20).
c. Plumose anemones were found throughout the site wherever suitable substrate occurred (see Figure 21). They were typically associated with bedrock, or with cobble and pieces of woody debris on an otherwise silt-mud substrate. Snake lock anemones tended to occur in and around Coast Island and the rocky reef to the NE of Coast Island (see Figure 21).
d. Orange sea pens were widely distributed throughout the site (see Figure 22). The majority of the population consisted of small (probably less than 10 cm tall) individuals which were found to the west of Coast Island. These individual most likely resulted from a recent spawn of sea pens. Larger individuals were located between Coast Island and Ridley Island. Based on a statistical analysis of the data, the highest concentrations of sea pens were found in an area to the SW of Coast Island and another area off the north tip of Coast Island (see Figure 23).
e. A few dogwinkles were observed (see Figure 24). They were mainly found on a silt-mud to sand substrate.
f. Unmounded holes were found in high abundance throughout the site (see Figure 25). These holes probably represented a variety of infaunal organisms; however most cannot be accurately identified from video images. In some cases, the larger clams, such as geoducks, can be identified by their characteristic siphon hole pattern and occasional sitings of the actual siphons. Where identification was possible, geoducks were generally observed in waters of depths less than 20 m (see Figure 25). Many other clam species were probably also present throughout the site, as indicated by the presence of empty shells on the surface of the substrate.
g. Parchment tube worms were mainly found on the west side of Coast Island and around the rocky reef to the NE of Coast Island (see Figure 26). This grouping probably represented more than one species, as the tube worms were observed both in mud-silt substrate and on bedrock. Calcareous tube worms were observed on exposed bedrock in several regions of the site (SW shore of Coast Island, north tip of Coast Island, and around the reef to the NE of Coast Island) (see Figure 26).
h. A “bryozoan complex”, consisting of byrozoans, hydroids, sponges, and other encrusting fauna, was present on exposed rocks in shallow water on the west side of Coast Island, around the reef to the NE of Coast Island, and in the Bacon Rock area (see Figure 27).
i. A few California lamp shells were observed in the rocky reef area to the NE of Coast Island (see Figure 28).
j. Decorator crabs were observed in association with seaweed, either in living and attached seaweed around Coast Island and the reef to the NE of Coast Island, or in patches of seaweed drift between Coast Island and Ridley Island (see Figure 29). Dungeness crabs were observed throughout the site (see Figure 29). Based on a statistical analysis of the data, the highest concentrations of Dungeness crabs were found off the SE shore of Coast Island, off the north tip of Coast Island, and between the rocky reef and Ridley Island (see Figure 30). Interestingly, two of these areas (off the SE shore of Coast Island and between the rocky reef and Ridley Island) are closely associated with the regions of highest eelgrass density.

k. Second only to unmounded holes in abundance, spiny pink shrimp were very common at the site. They were found only in waters of depths greater than 10 m. Also found in the same regions, but at a much lower abundance, were spot prawns (see Figure 31). While overlapping in range with spiny pink shrimp, spot prawns also occurred in somewhat deeper waters as well. The majority of shrimp and prawn sitings came from transects which were carried out during the January video survey. This may be the result of seasonal variations in shrimp and prawn abundance.
l. Seastars were abundant and widely dispersed throughout the site, without any particular patterns of distribution (see Figure 32 and Figure 33). Sunflower seastars were the most abundant seastars at the site. Most of the seastars were observed in waters of less than 10 m depth.
m. Both California sea cucumbers and red sea cucumbers were seen in areas around Coast Island and the rocky reef to the NE of Coast Island. Additionally, California sea cucumbers were observed in the area around Bacon Rock (see Figure 34). Red sea cucumbers were more abundant at the site than California sea cucumbers.
n. In general, fish were found in moderate abundance at this site (see Figure 35). The most common fish were Northern ronquils, eelpouts, and flatfish. The majority of fish were found in waters of depths greater than 10 m. The longnose skate distribution was somewhat reflective of the Dungeness crab distribution, and it was probable that the skates were in the area feeding on the crab population.

4. The following commercial species were observed at the site:
   a. spiny pink shrimp in very high abundance
   b. geoduck clams in high abundance
   c. Dungeness crab in high abundance
   d. spot prawns in moderate abundance
   e. California sea cucumbers in moderate abundance
   f. flatfish in moderate abundance
   g. longnose skates in low abundance

2.6 Diversity Analyses

2.6.1 Dominant and Minor Vegetation Analyses

Analysis of vegetation species dominance shows that the most dominant specie at the site was sugar wrack kelp (see Figure 36). However, foliose red algae and eelgrass were also very abundant. In considering the entire site, flora diversity in shallow water is very high, whereas flora diversity in deeper water is very low due to high turbidity and low light conditions. The map of minor vegetation species also shows very high diversity in shallow water, with 13 species more or less equally distributed throughout this region (see Figure 37). It should be noted that many of the smaller seaweed species cannot be identified using a video camera (they often require the use of a microscope for accurate identification), and thus the actual flora diversity of the site is probably somewhat higher. The diversity in each individual polygon is quite high. In the areas where algae occurred, only 20% of the individual polygons showed no diversity (e.g., contained only one species).

2.6.2 Dominant and Minor Fauna Analyses

Analysis of fauna species dominance shows that unmounded holes are clearly the most dominant fauna overall (see Figure 38). However, spiny pink shrimp are more dominant in deeper waters, and the "bryozoans complex" is more dominant in rocky habitats. In considering the entire site, fauna diversity is moderately high, as shown in the map of minor species (see Figure 39). Note, however, that unmounded holes and spiny pink shrimp are still present as the least abundant species in a number of polygons. Again, very small species (e.g., barnacles, small tube worms), infauna (e.g., clams), cryptic fauna (e.g., flatfish, decorator crabs), or hidden fauna (e.g., under kelp fronds) often cannot be identified in the video footage, and thus the actual fauna diversity of the site is probably higher than observed. The diversity in each individual polygon is moderately high. For fauna, only 26% of the individual polygons showed no diversity.

2.6.3 Diversity Indices

The overall Shannon's diversity index for the site was 3.734, and the species richness was 57. By comparison, if all organisms in the site were completely evenly distributed (which would generate a maximum value for Shannon's diversity index), the maximum possible diversity for the site with a species richness of 57 would be 4.043. This suggests that the particular complement of species at this site are moderately close to reaching their maximum diversity. The Shannon's evenness value of 0.924 also indicates that the species are relatively evenly distributed throughout the site (a value of 1.0 would indicate a completely even distribution).

To determine how the diversity of this site ranks with other sites in the area, we need to have some comparative values for species richness. Dr. Shannon Bard has provided information on species richness for a number of sites in the Prince Rupert area on her website (http://www.ecotoxicology.ca/csi/Prince%20Rupert.html). Her data indicates that recent values for species richness (2003) range from approximately 38 to approximately 60. Using these two values of species richness, we can calculate a range for the maximum value of Shannon's diversity index for the area from 3.638 to 4.094. By comparison, the value of 4.043 for this site is quite high (i.e., it has a relative richness of 95% using a maximum potential species richness of 60).

The site has a Simpson's dominance index of 0.309. The Simpson's dominance index approaches 1.0 as one particular species dominates the site. A value of 0.309 suggests that there is some dominance by organisms (particularly unmounded holes and spiny pink shrimp) at the site, but no extreme dominance (e.g., there are very few locations at the site where only one species is found).

Figure 40 shows the species richness map for the site. Species richness in each hexagonal polygon ranges from 0 to 35. Maximum species richness for the site occurs in three regions: (1) an area along the SW shore of Coast Island; (2) the northern tip of Coast Island; and (3) the area between the rocky reef and Ridley Island. Maximum species diversity is correlated with

1. ***water depth*** - shallow, well-lit regions support good algal growth. This, in turn, supports high faunal diversity.
2. ***rocky, rugged terrain*** - rocky terrain provides many crevices and cracks where organisms can become established, thus increasing faunal diversity.

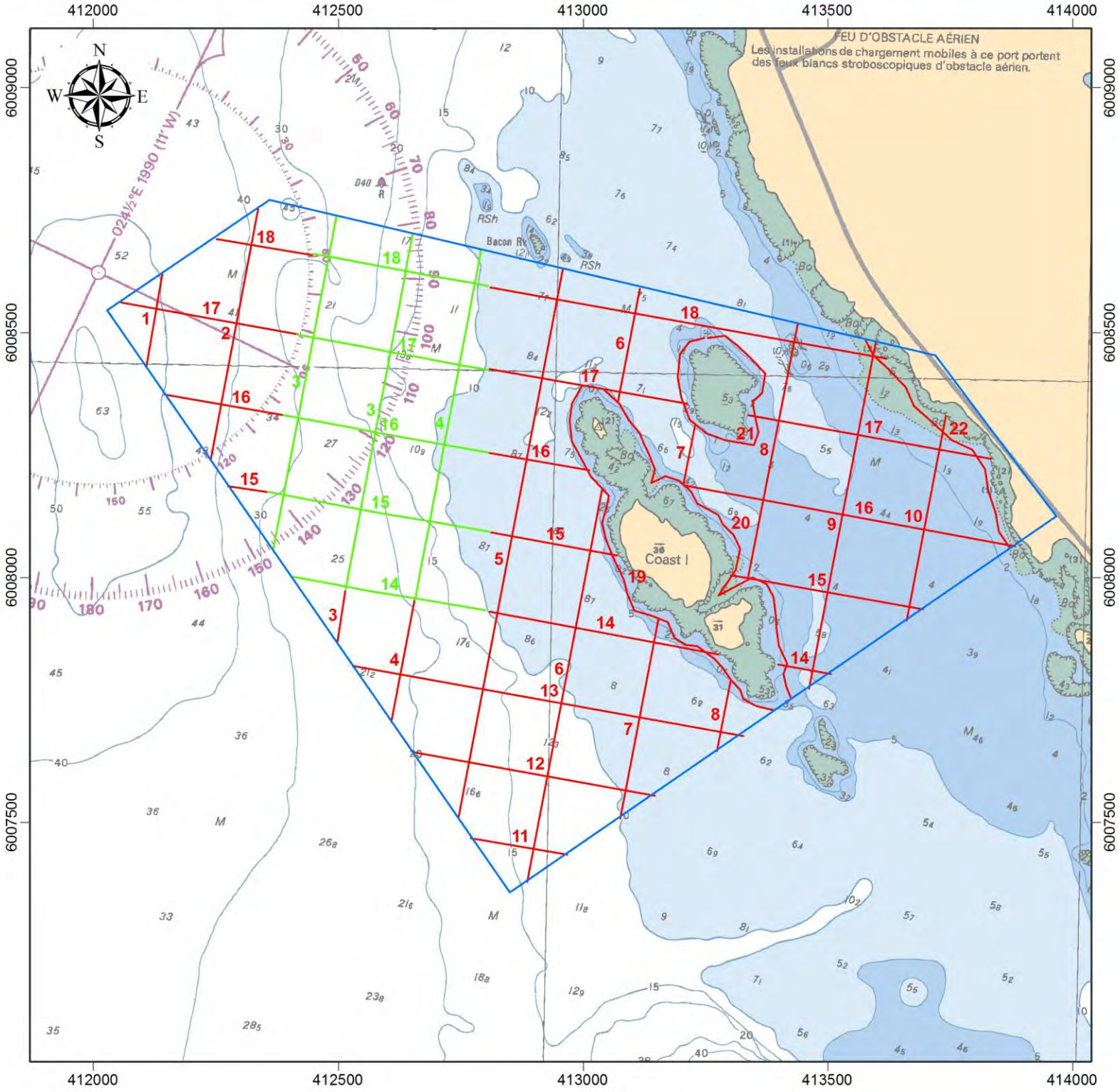
2.7 Project Deliverables

In addition to this report, the following materials have also been provided from the subtidal survey:

1. Five DVDs containing raw georeferenced seabed video imagery* (overlaid with time, latitude, and longitude) of the survey site.
2. One CD containing:
    a. a georeferenced, classified Access database* for biological and physical features of the seabed.
    b. an electronic ArcGIS project* containing maps of analyzed video data.
    c. a report describing and explaining the results of the video survey.
3. Three DVDs containing:
    a. java-based software which links video* and GPS data, allowing simultaneous viewing of the camera's geographical position on a map and the video images captured by the camera at that location.
    b. a library of video* annotations

*Note: time on the video imagery, in the database, and in the ArcGIS project is given in PST (Pacific Standard Time).

3 Figures



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 1.
Survey design showing transects.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

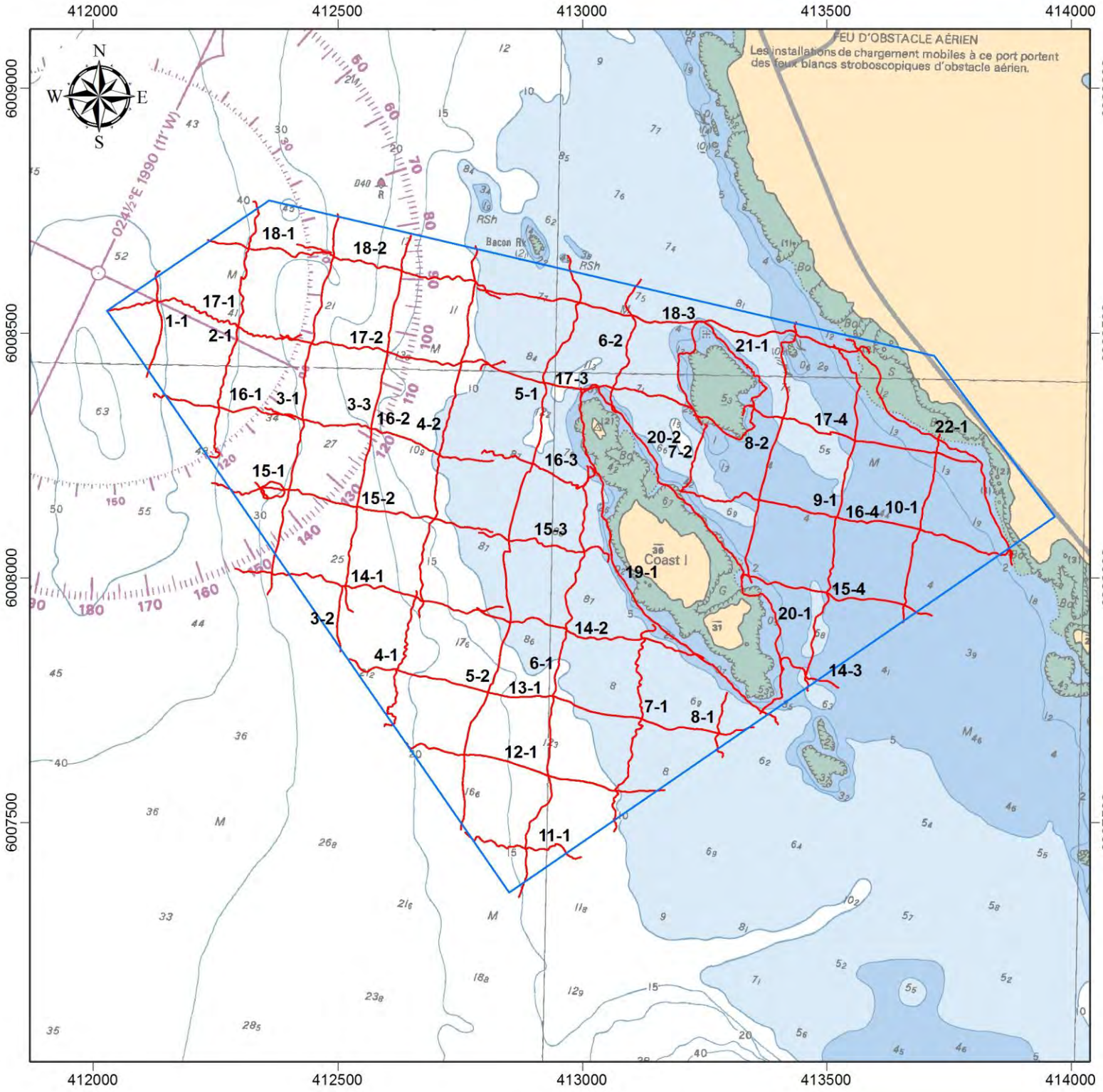
Scale: 1:11,000

Legend

- Survey transects - May
- Survey transects - January
- Survey boundary

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal
Subtidal Video Survey 2

Figure 2.
Completed survey showing transects.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

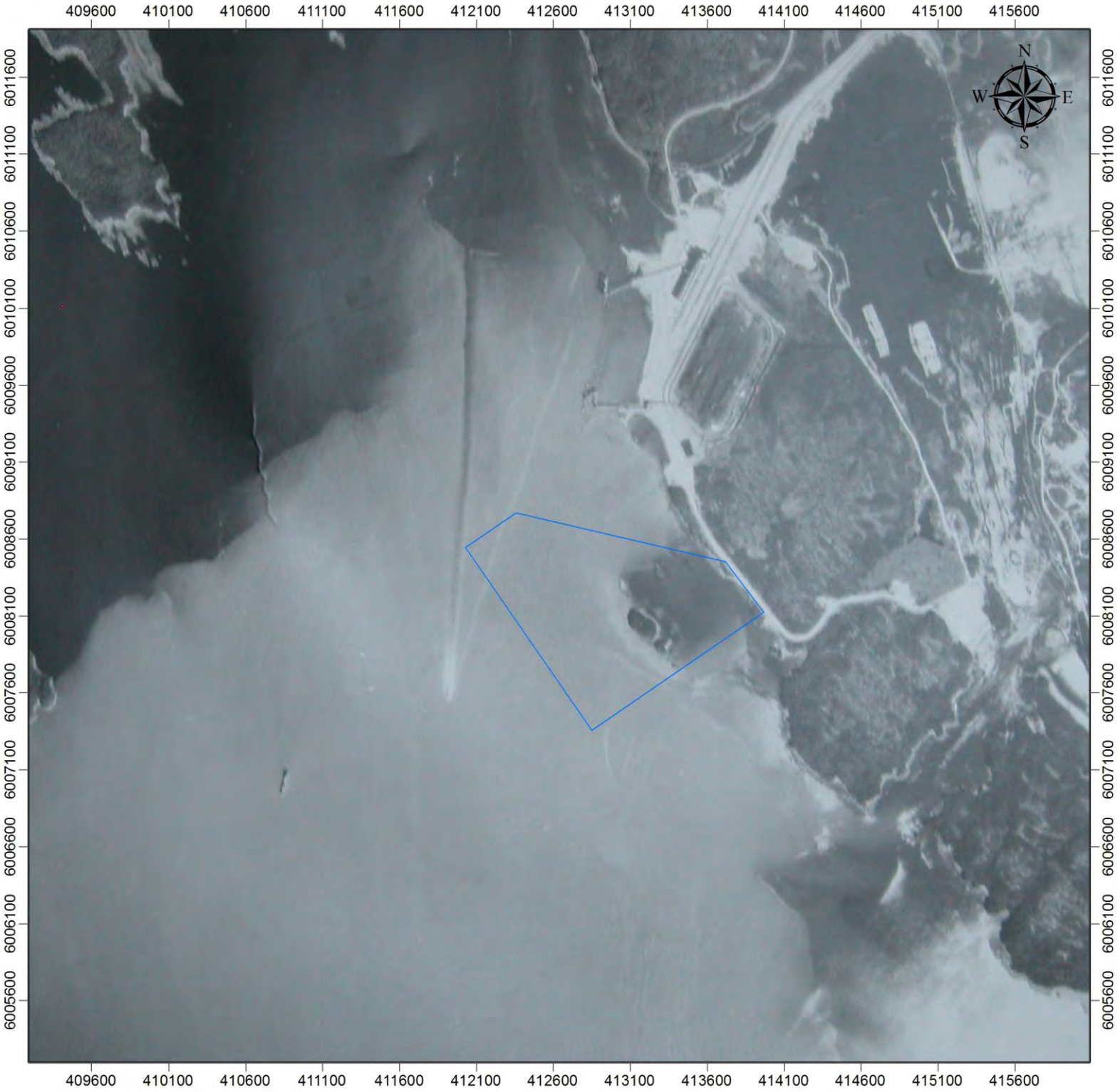
Scale: 1:11,000

Legend

- Survey boundary
- Transect lines

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal Subtidal Video Survey

Figure 3.
Aerial photograph of the Skeena River plume in relation to the site boundaries.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid
(shore-normal and shore-parallel).

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

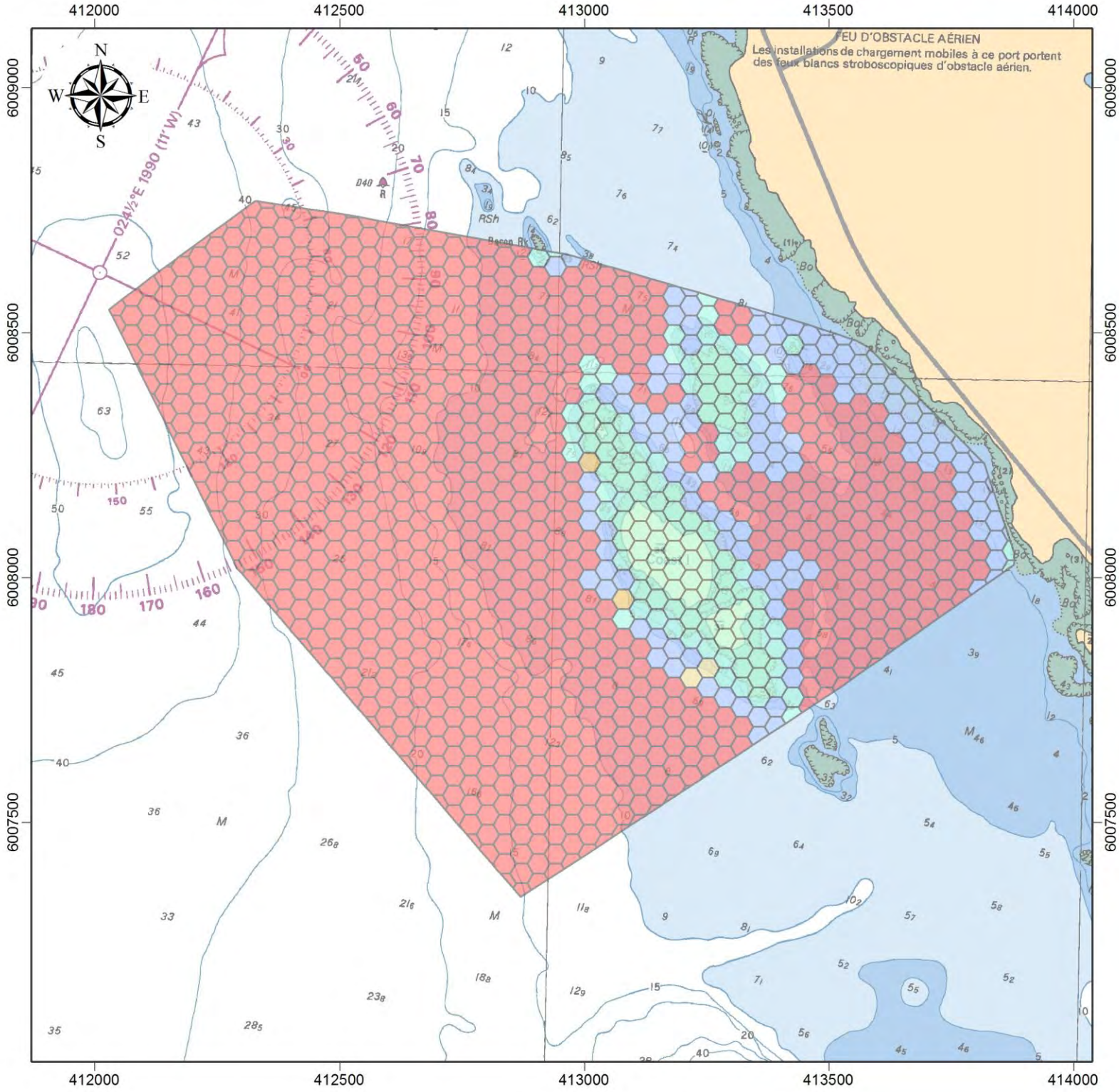
Scale: 1:35,000

Legend

Survey boundary

0 250 500 1,000 Meters

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Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 4.
Substrate map.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

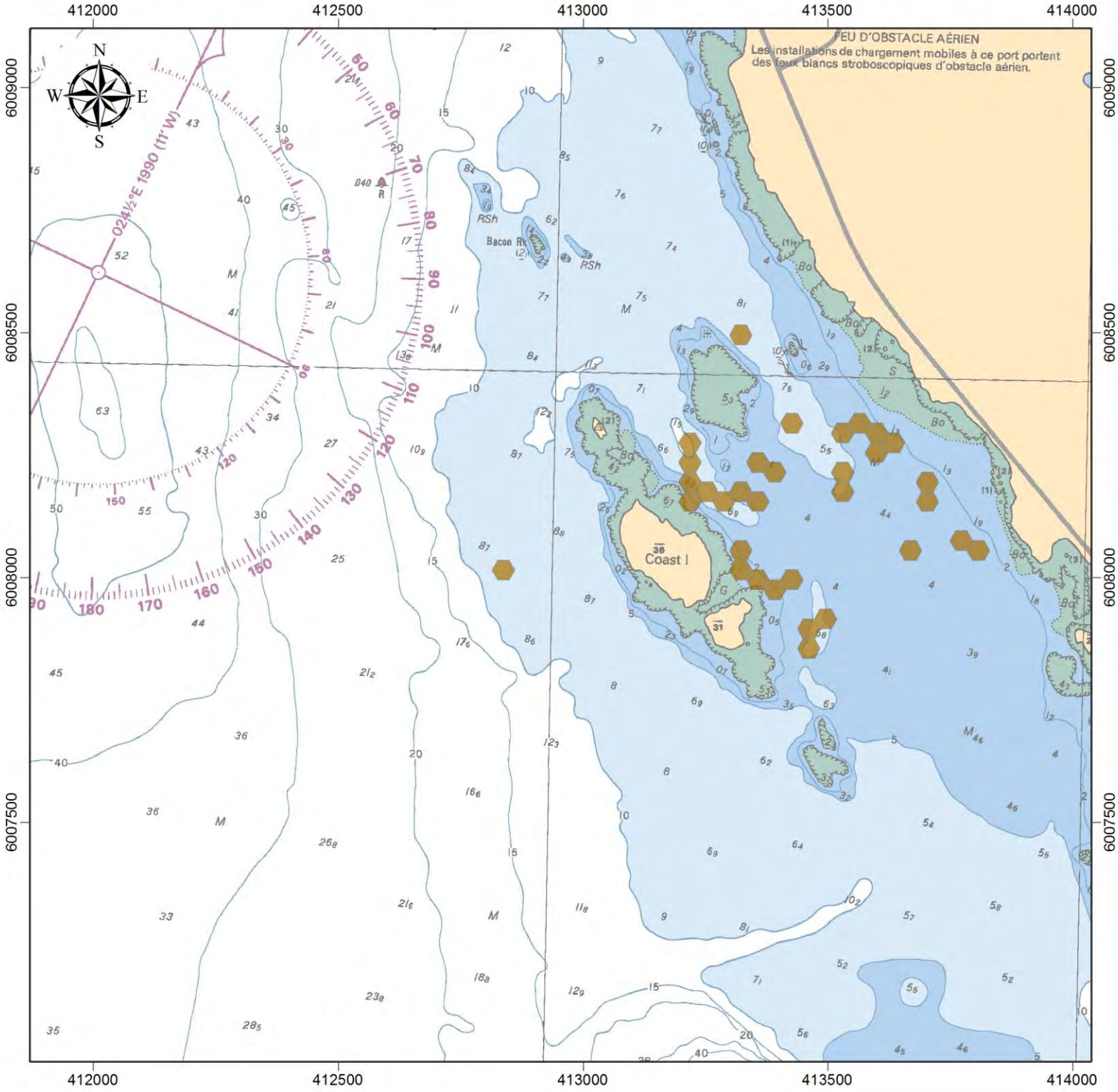
Legend

Dominant substrate map

- Cobble
- Rock
- Sand
- Silt-mud
- Veneer over bedrock

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 5.
Map of deposition of organic seaweed wrack.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

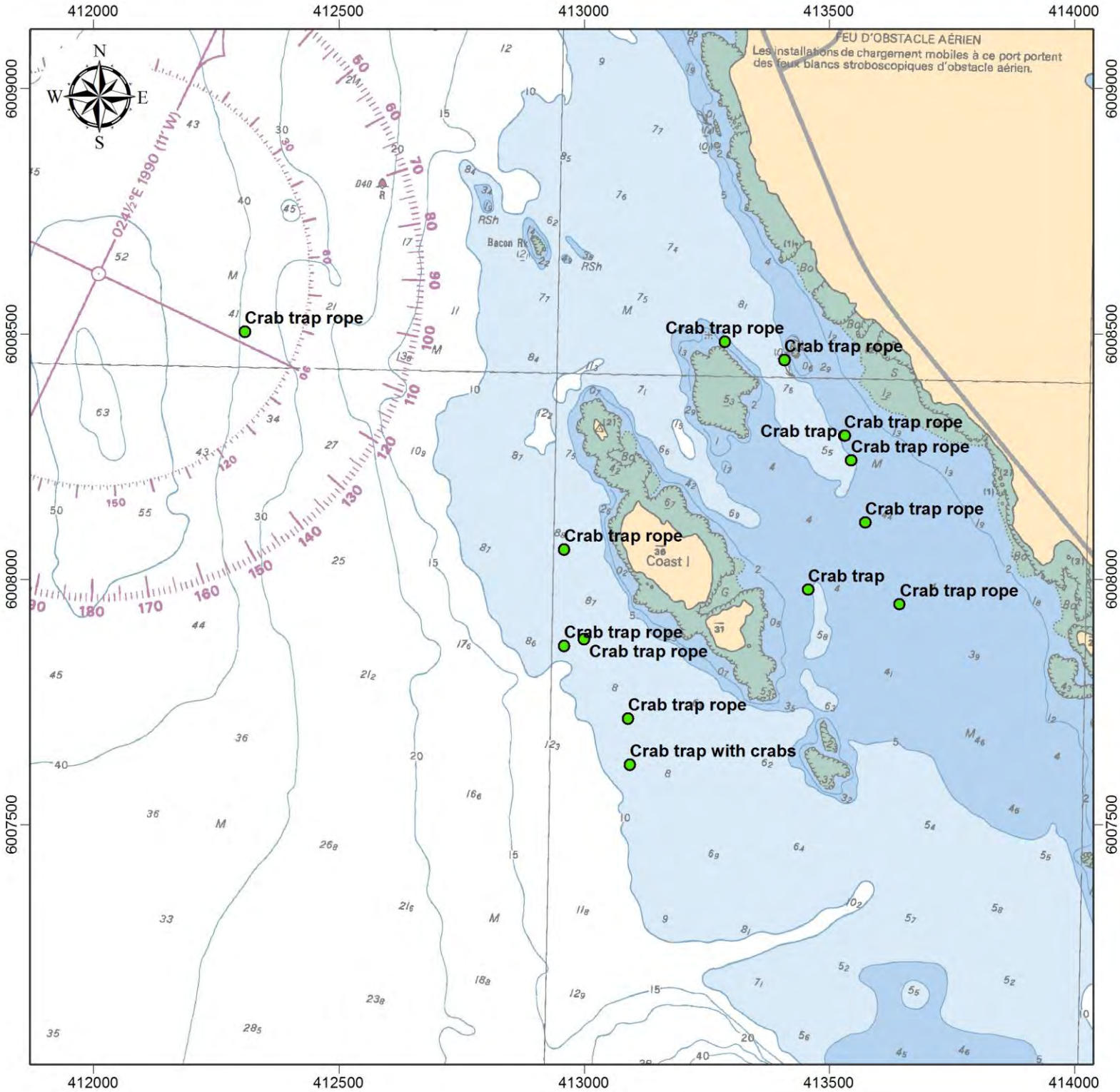
Scale: 1:11,000

Legend

Seaweed wrack

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal
Subtidal Video Survey 2

Figure 6.
Map of observations of commercial crab gear.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

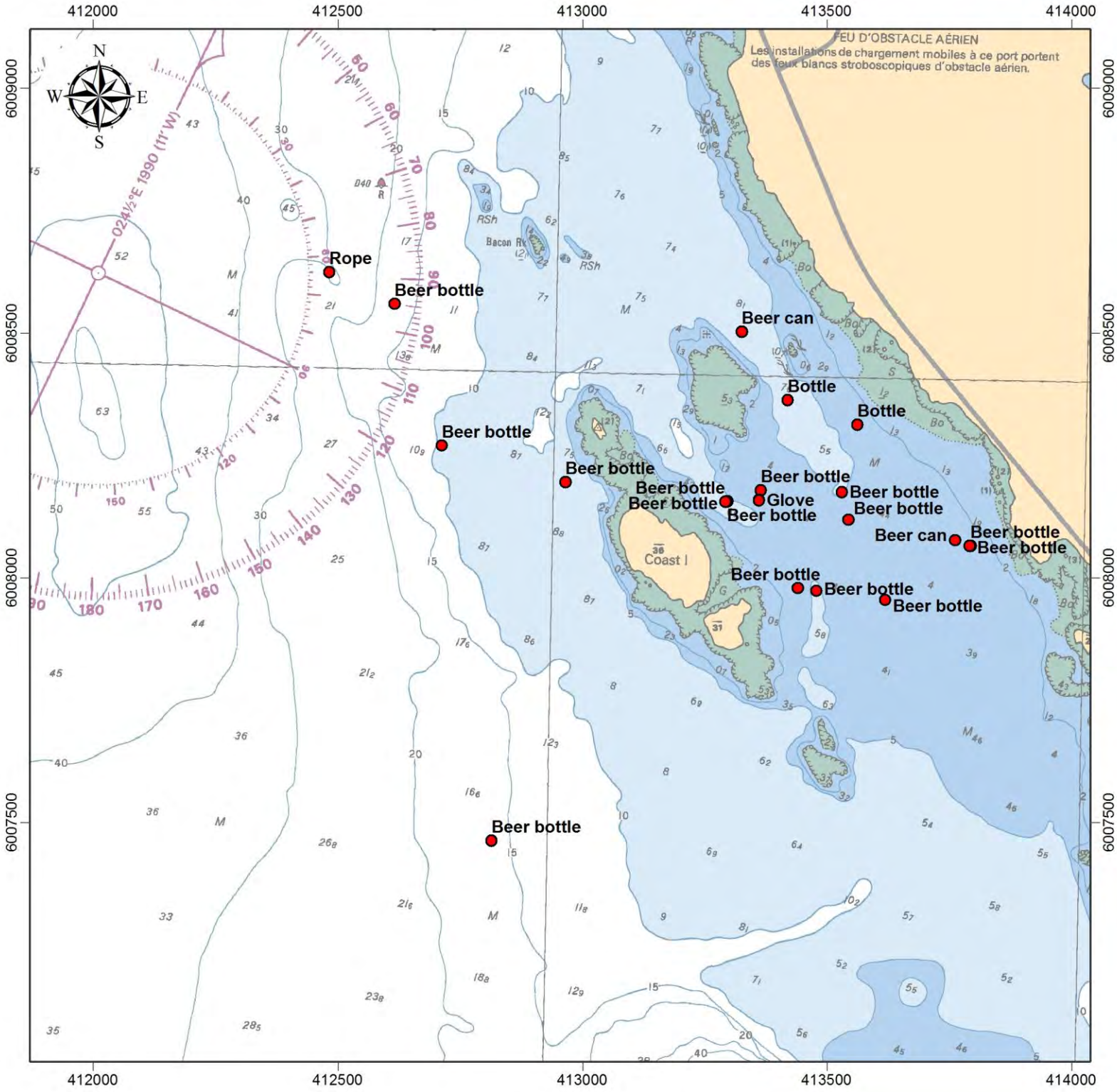
- Anthropogenic - crabbing

0 62.5 125 250 Meters

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Figure 7. Video image of crabs caught in a commercial crab trap at the Canpotex site.



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 8.
Map of observations of anthropogenic garbage.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

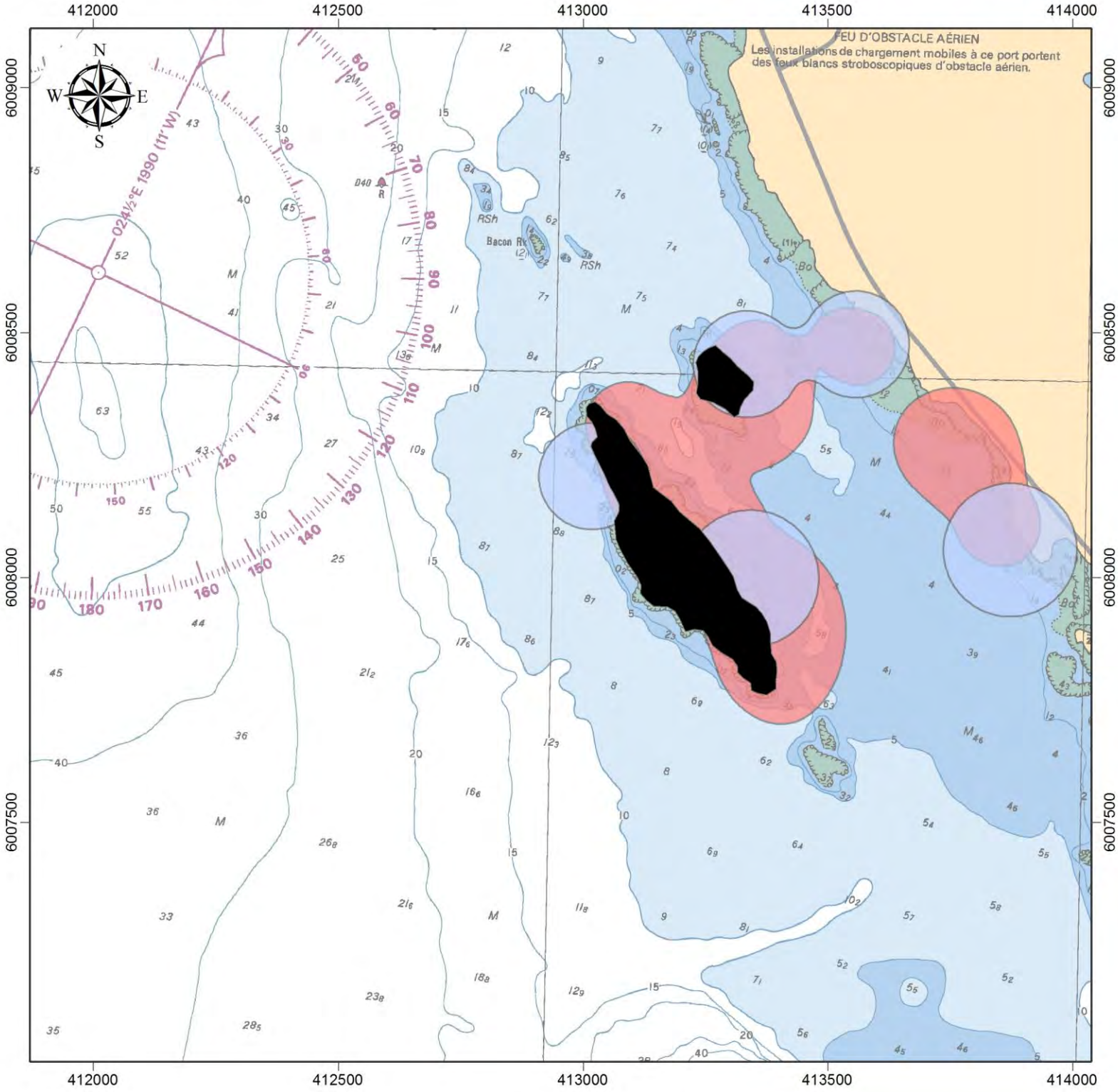
Scale: 1:11,000

Legend

- Anthropogenic - garbage

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 9.
Range map for green seaweeds.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

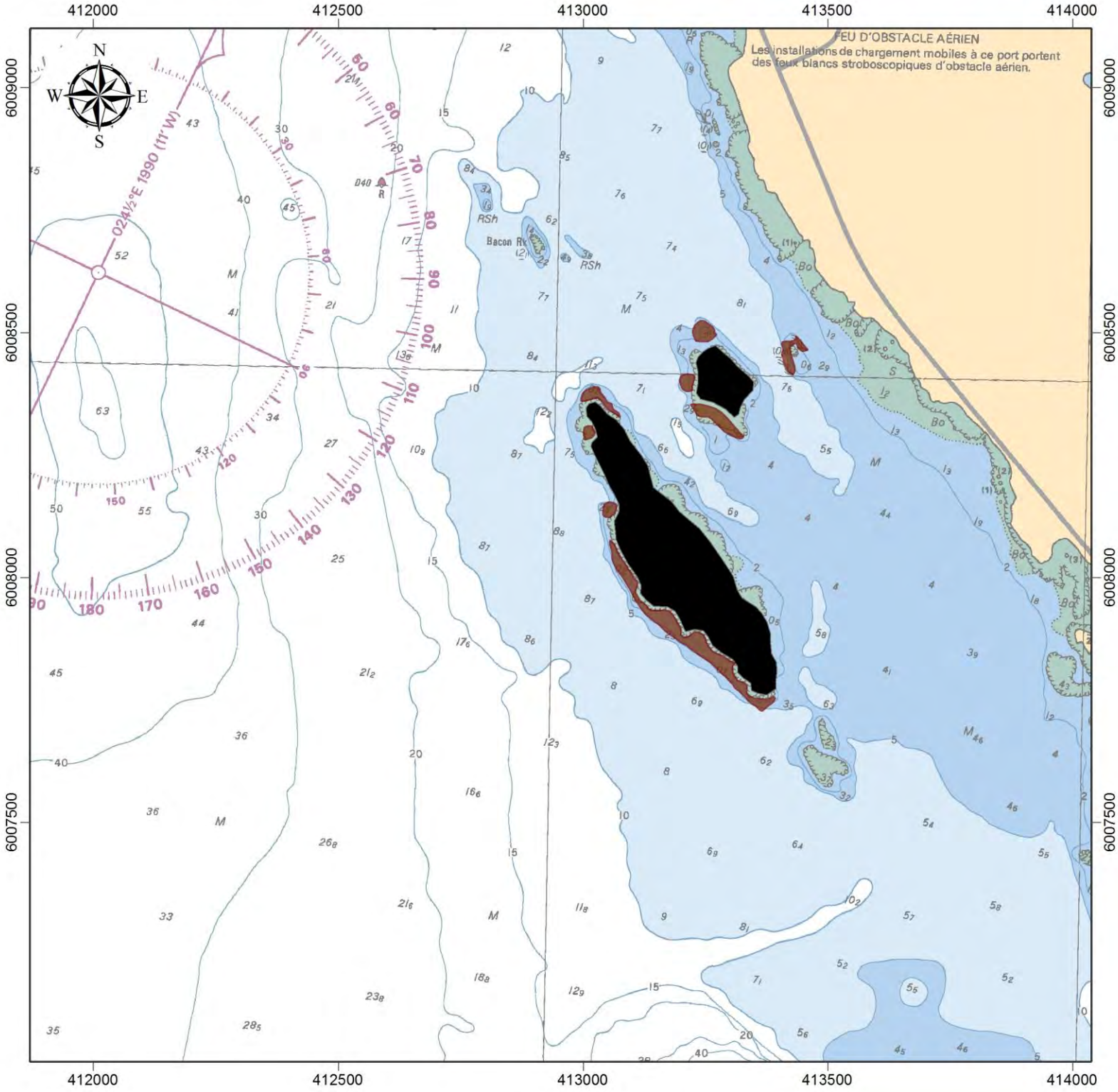
Scale: 1:11,000

Legend

- Rock mask
- Foliose greens
- Filamentous greens

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 10.
Map of surface observations of Nereocystis.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

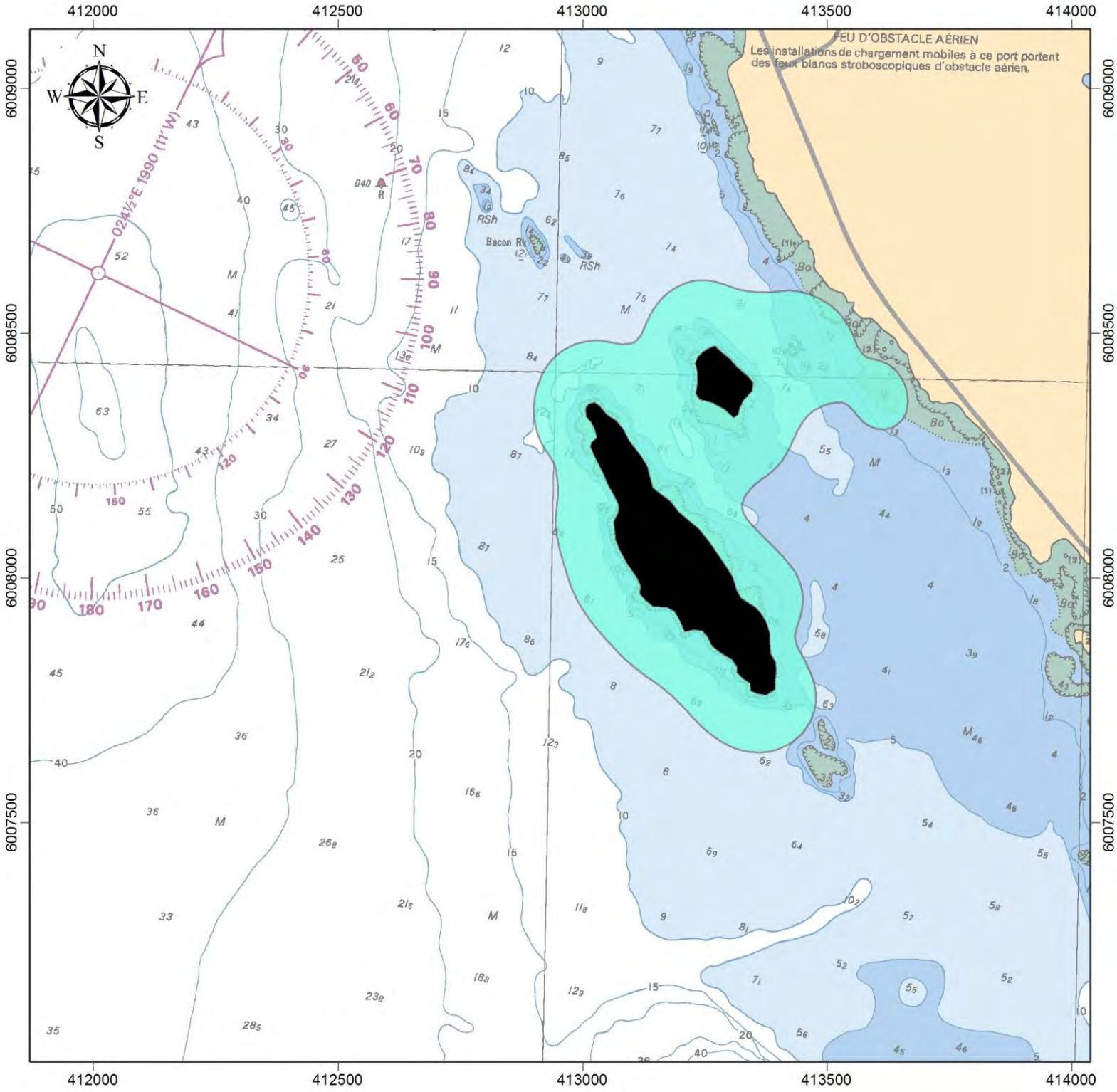
Scale: 1:11,000

Legend

- Rock mask
- Nereocystis observations

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 11.
Range map for Nereocystis.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

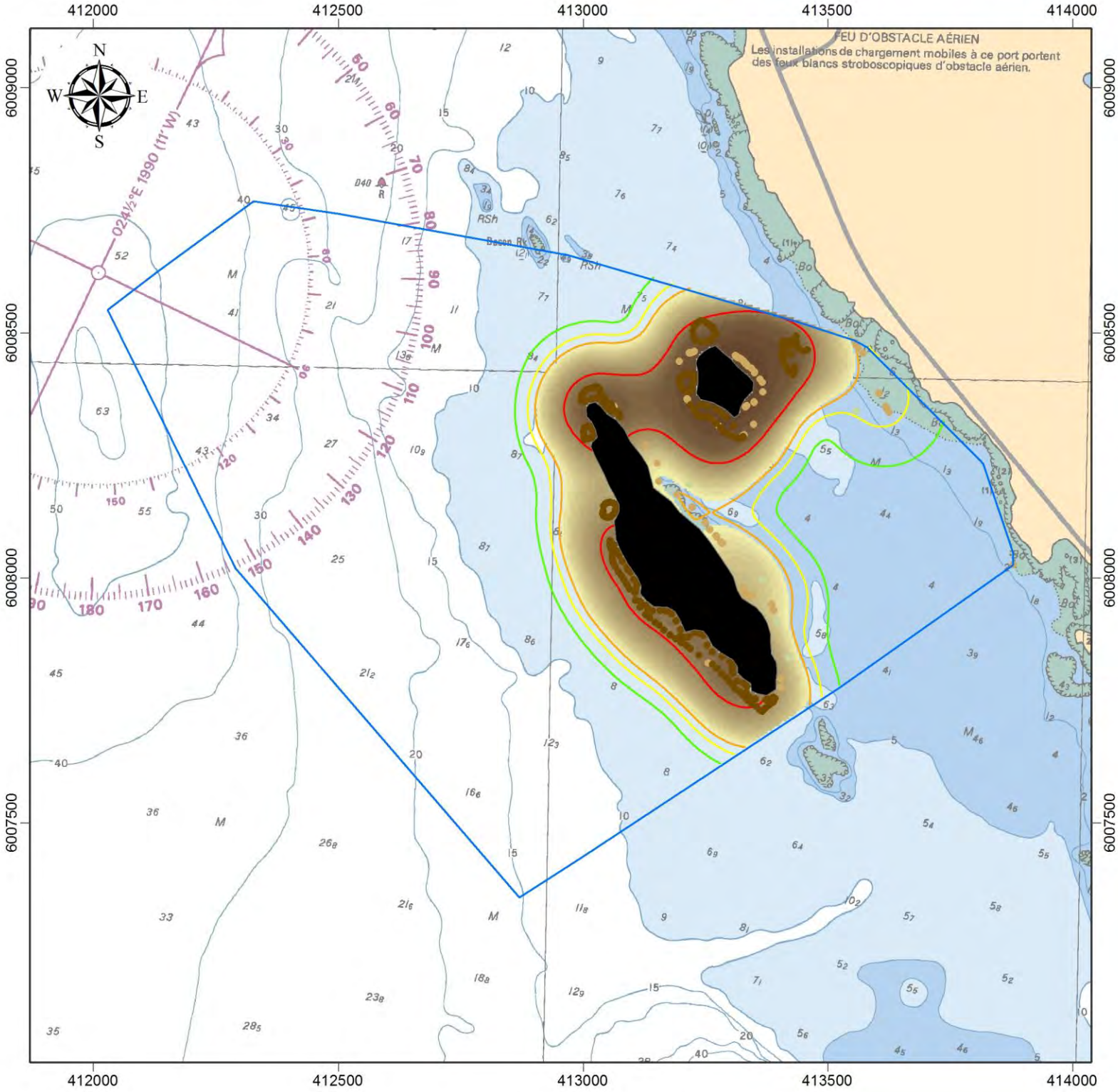
Scale: 1:11,000

Legend

- Rock mask
- Nereocystis

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 12.
Density map for Nereocystis.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

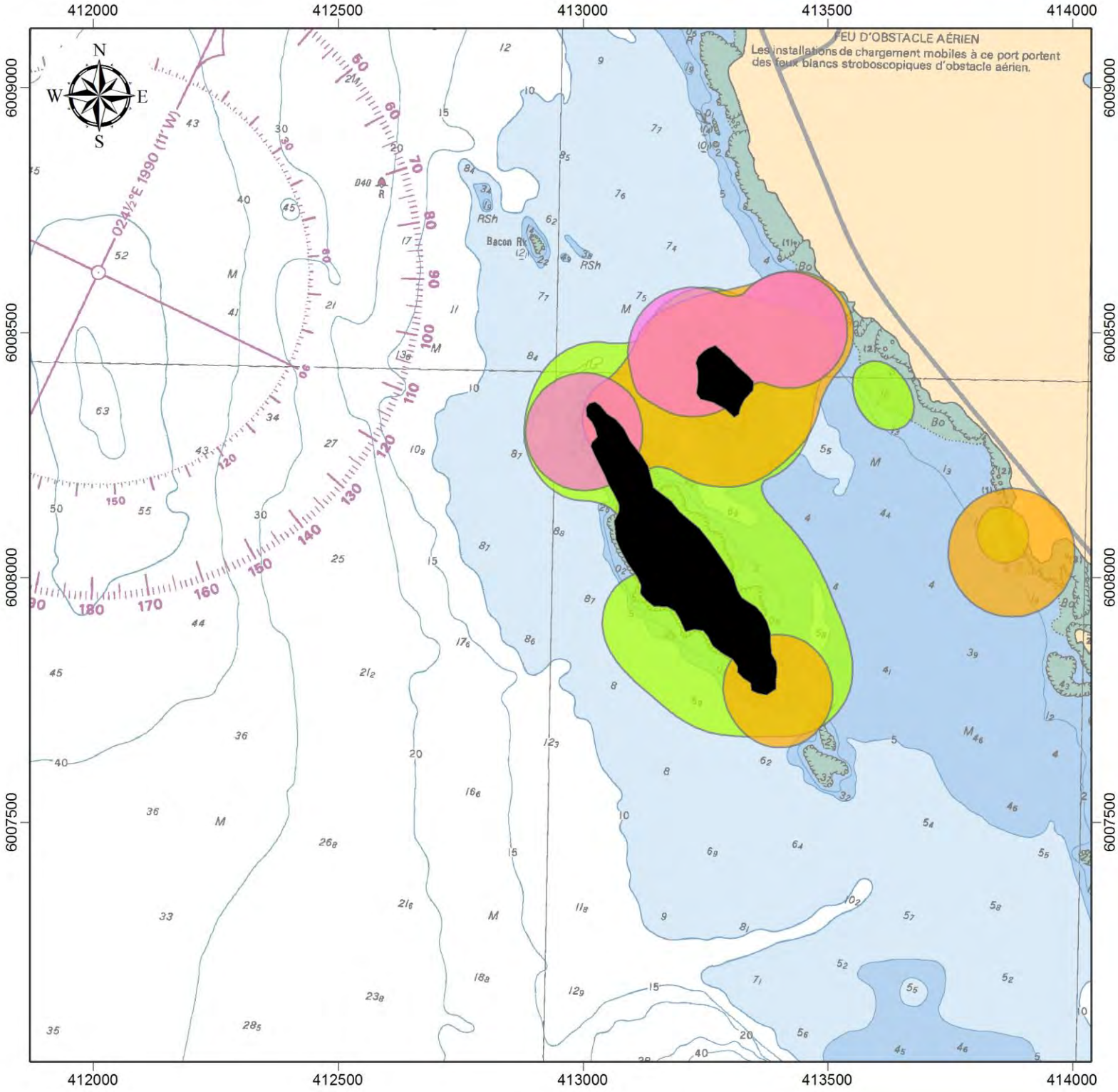
- Video boundary
- Rock mask
- Nereocystis 50% population contour
- Nereocystis 90% population contour
- Nereocystis 95% population contour
- Nereocystis 99% population contour

Nereocystis observations

- Sparse
- Low
- Moderate
- Dense

0 62.5 125 250 Meters

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Canpotex - Ridley Island Potash Terminal
Subtidal Video Survey 2

Figure 13.
Range map for Laminaria species.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

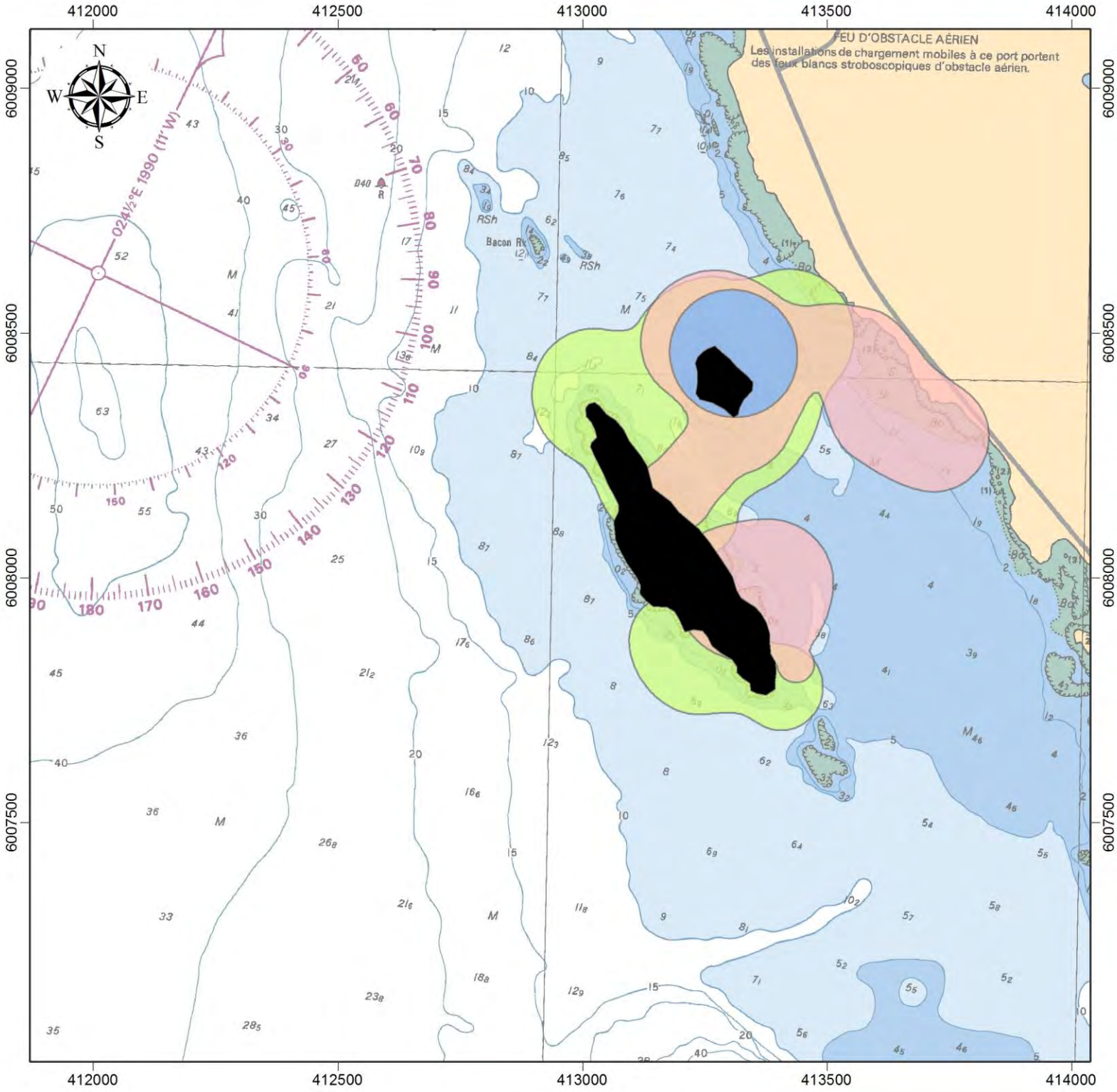
Scale: 1:11,000

Legend

- Rock mask
- Sugar wrack kelp
- Suction-cup kelp
- Split kelp

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 14.
Range map for other kelps.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

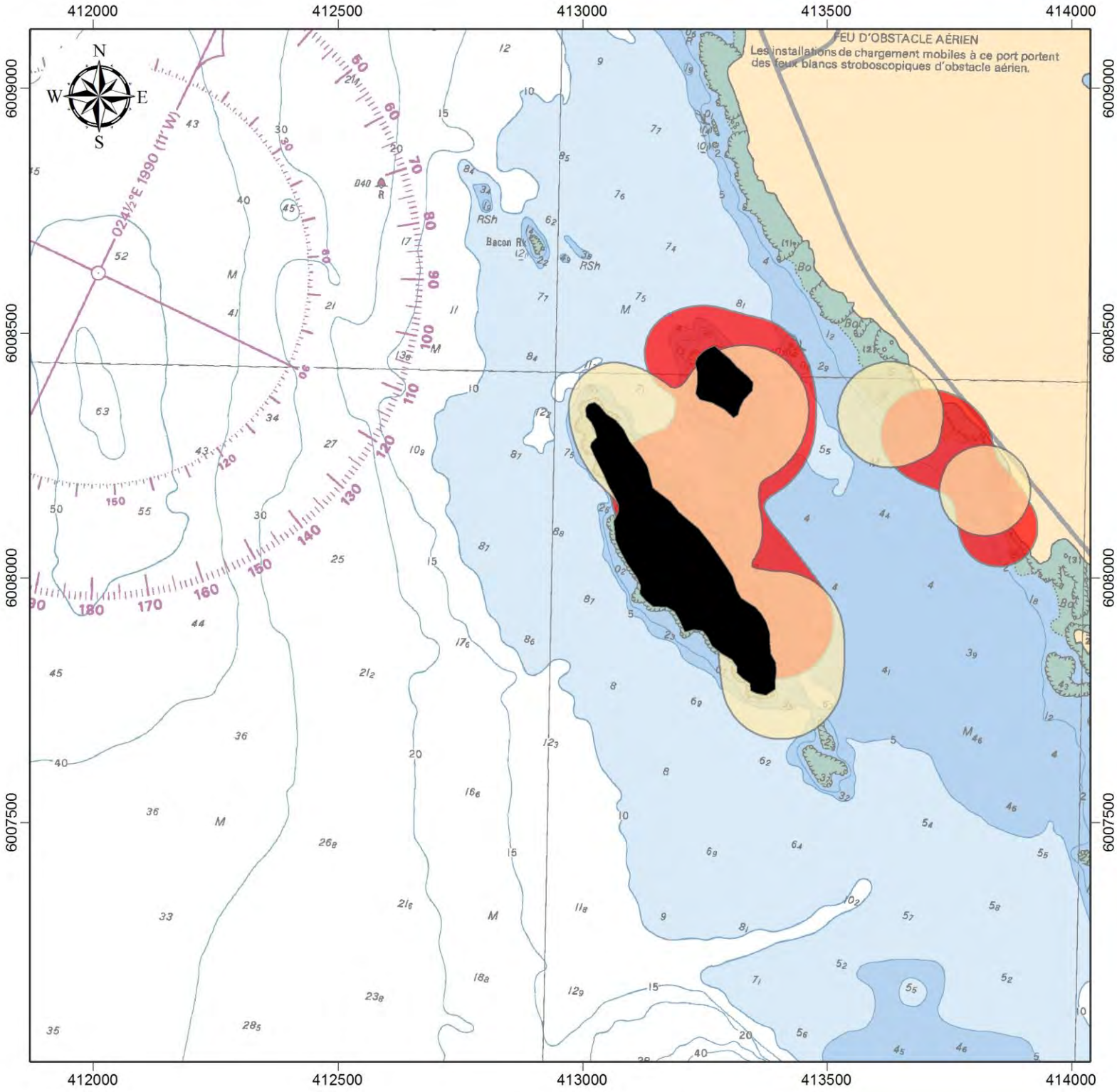
Scale: 1:11,000

Legend

- Rock mask
- Seersucker kelp
- Alaria
- Fringed sea colander kelp

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 15.
Range map for Desmarestia species.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

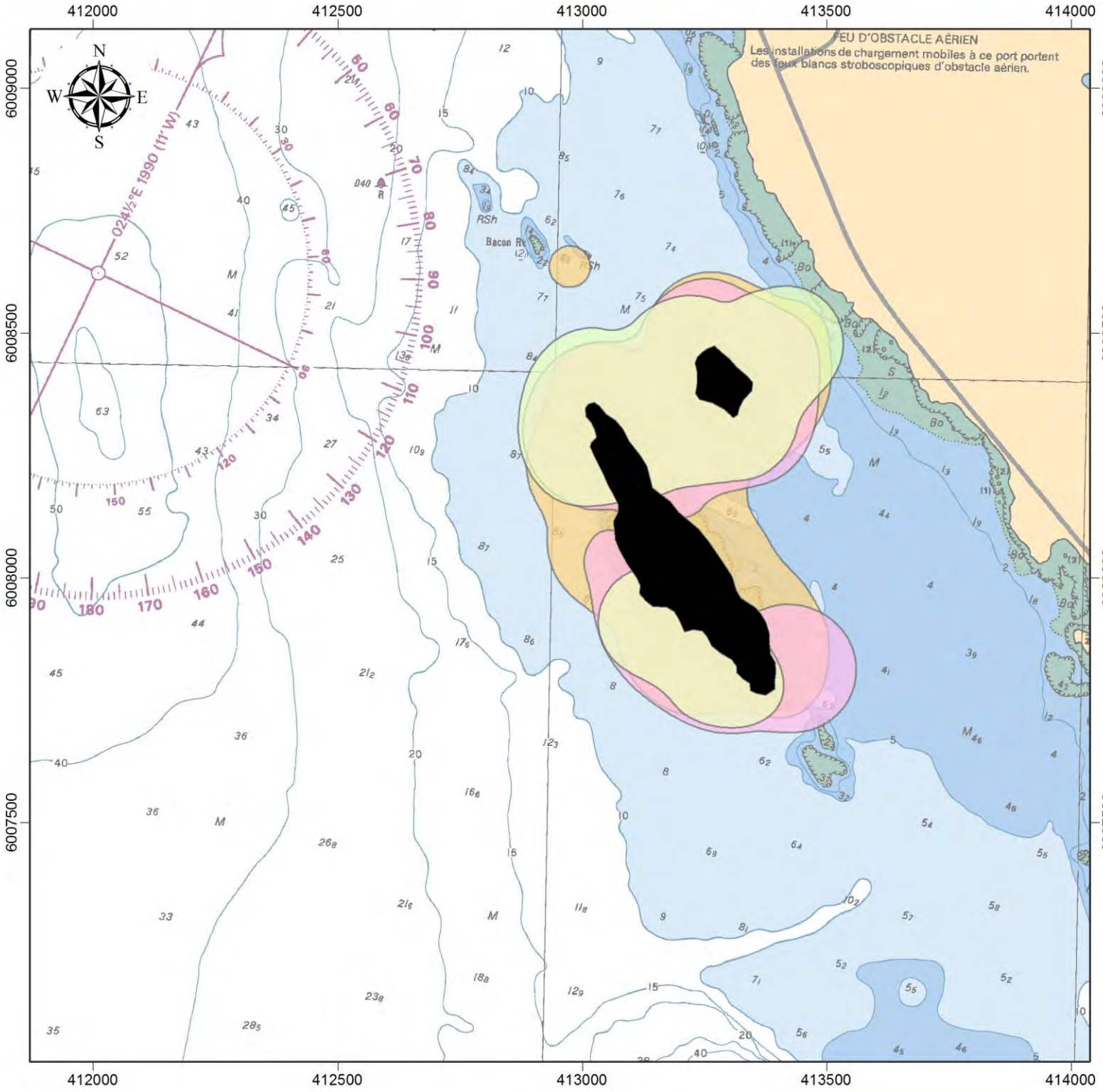
Scale: 1:11,000

Legend

- Rock mask
- Stringy acid weed
- Broad acid weed

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 16.
Range map for red seaweeds.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

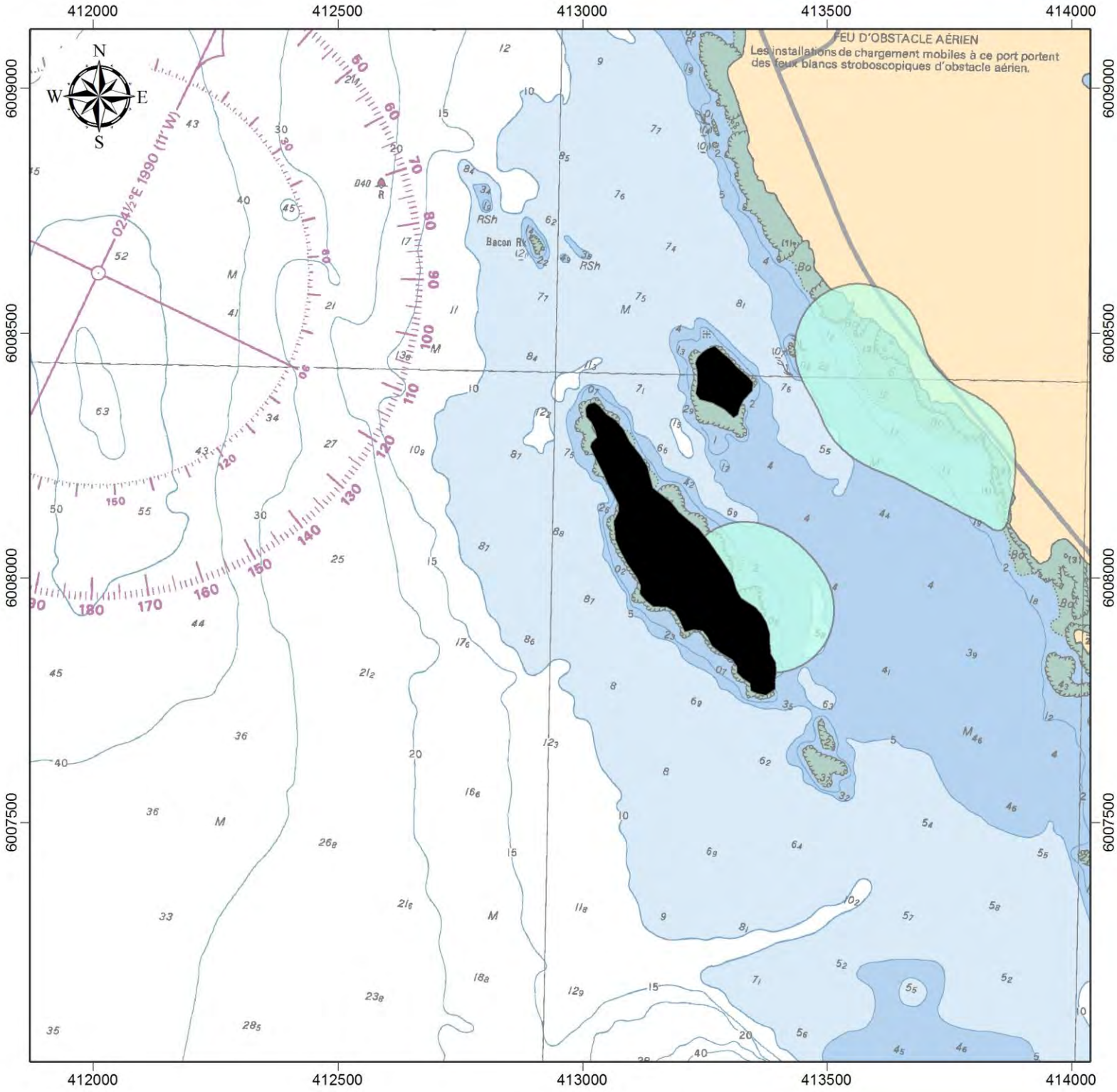
Scale: 1:11,000

Legend

- Rock mask
- Coralline reds
- Filamentous reds
- Foliose reds

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 17.
Range map for eelgrass

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

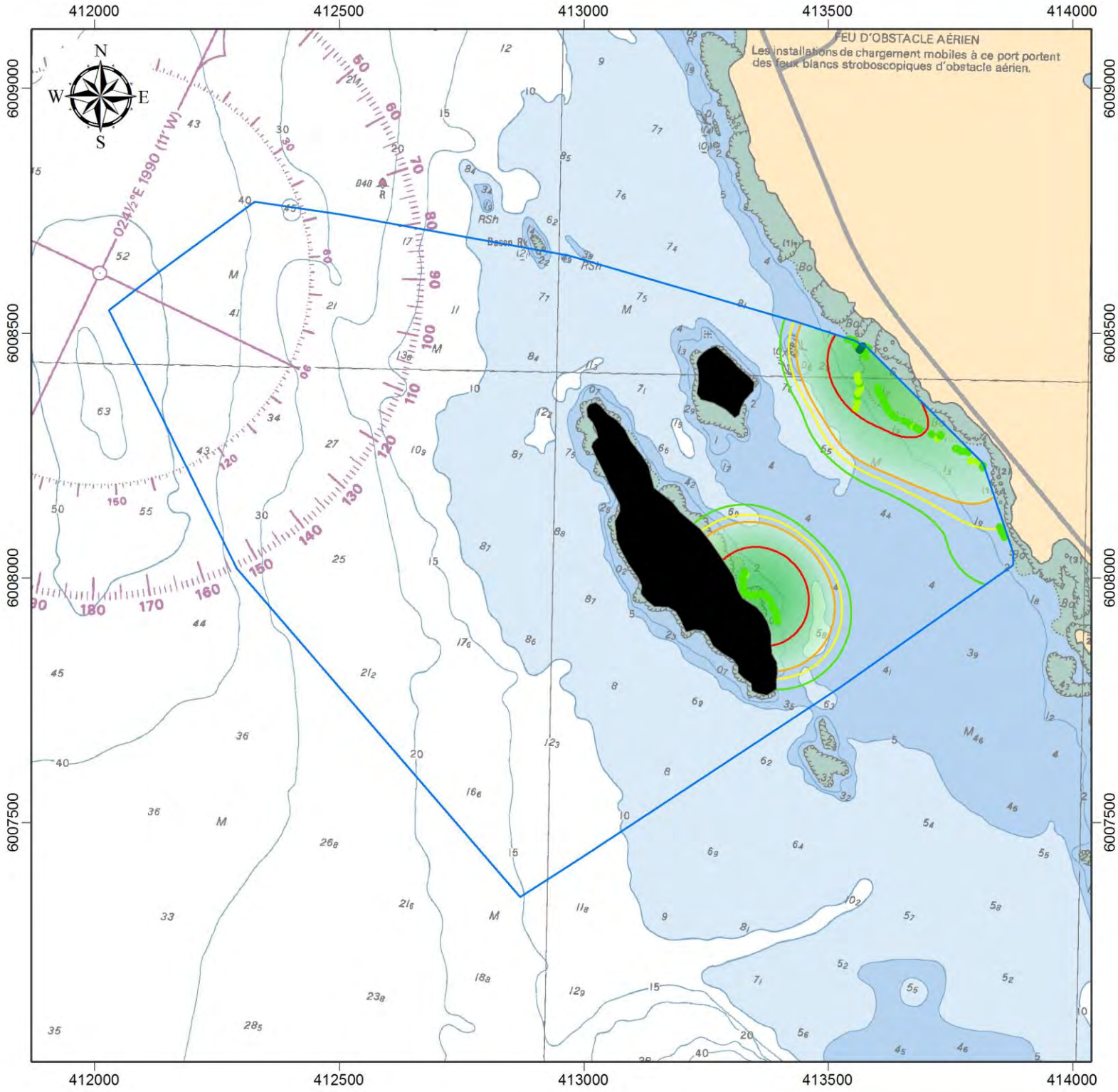
Scale: 1:11,000

Legend

- Rock mask
- Eelgrass

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal
Subtidal Video Survey 2

Figure 18.
Density map for eelgrass

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

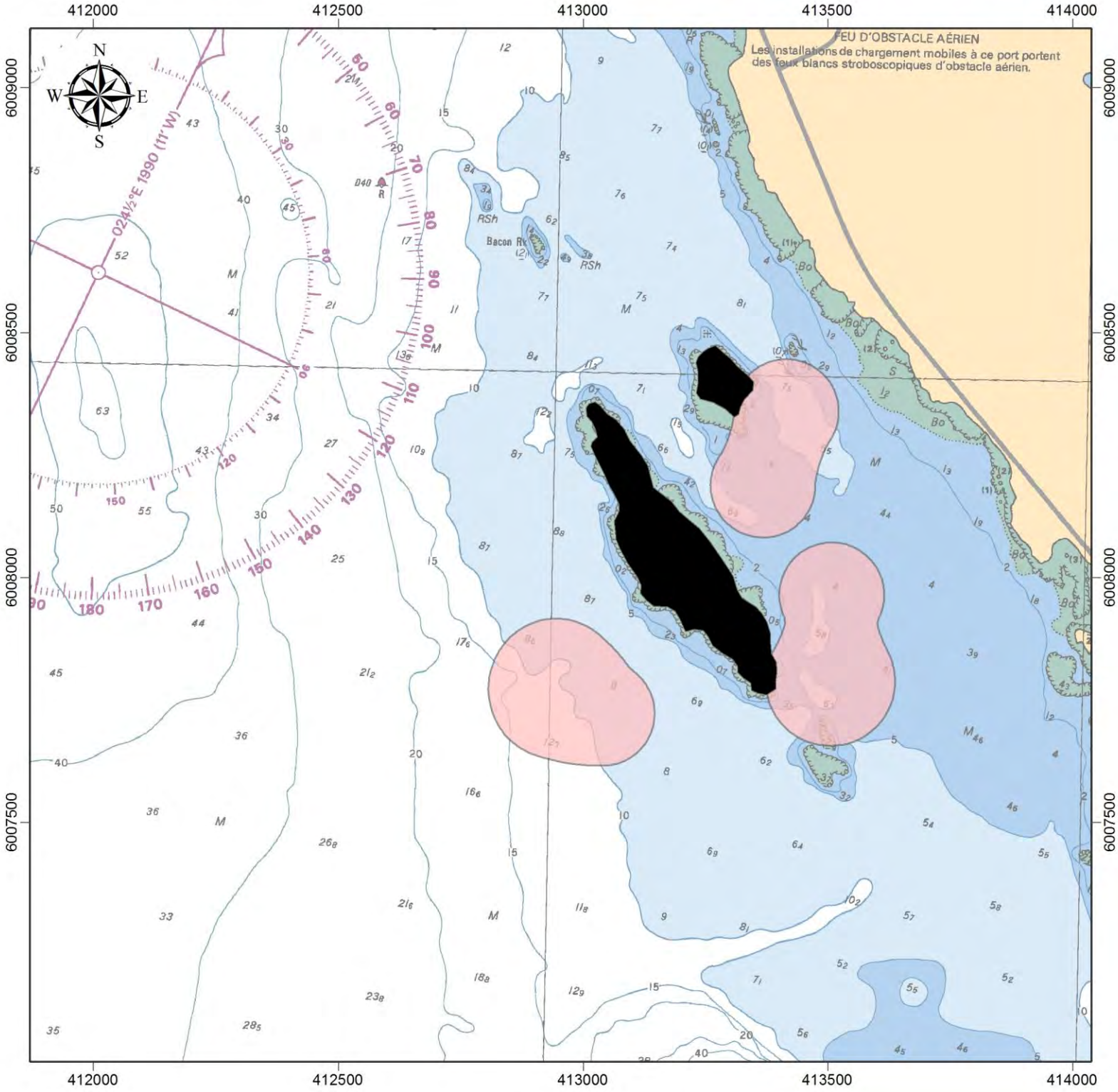
- Video boundary
- Rock mask
- Eelgrass 50% population contour
- Eelgrass 90% population contour
- Eelgrass 95% population contour
- Eelgrass 99% population contour

Eelgrass observations

- Sparse
- Low
- Moderate

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 19.
Range map for bacterial mats.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

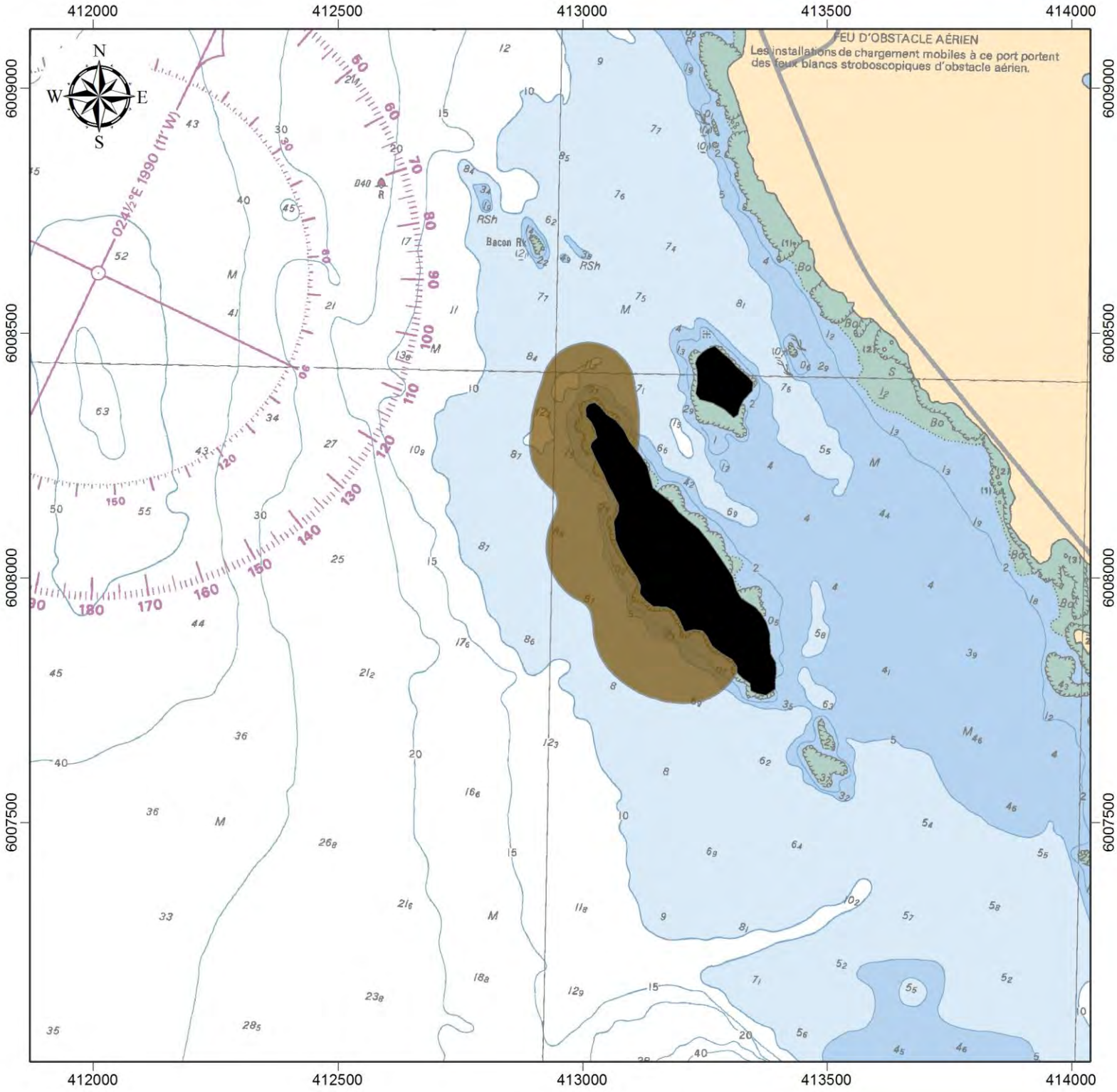
Scale: 1:11,000

Legend

- Rock mask
- Bacterial mat

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 20.
Range map for sponges.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

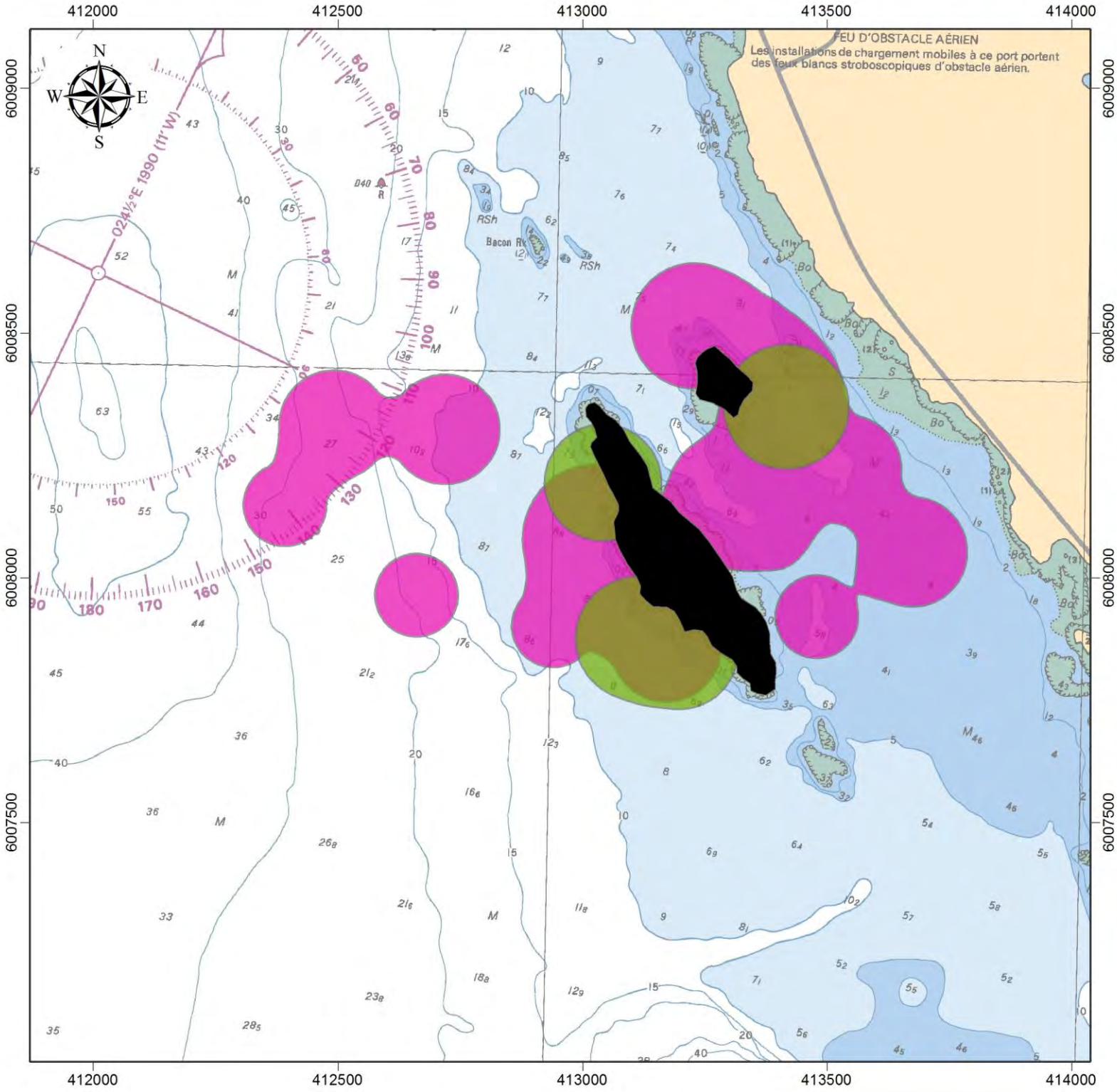
Scale: 1:11,000

Legend

- Rock mask
- Stalked vase sponge

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 21.
Range map for anemones.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

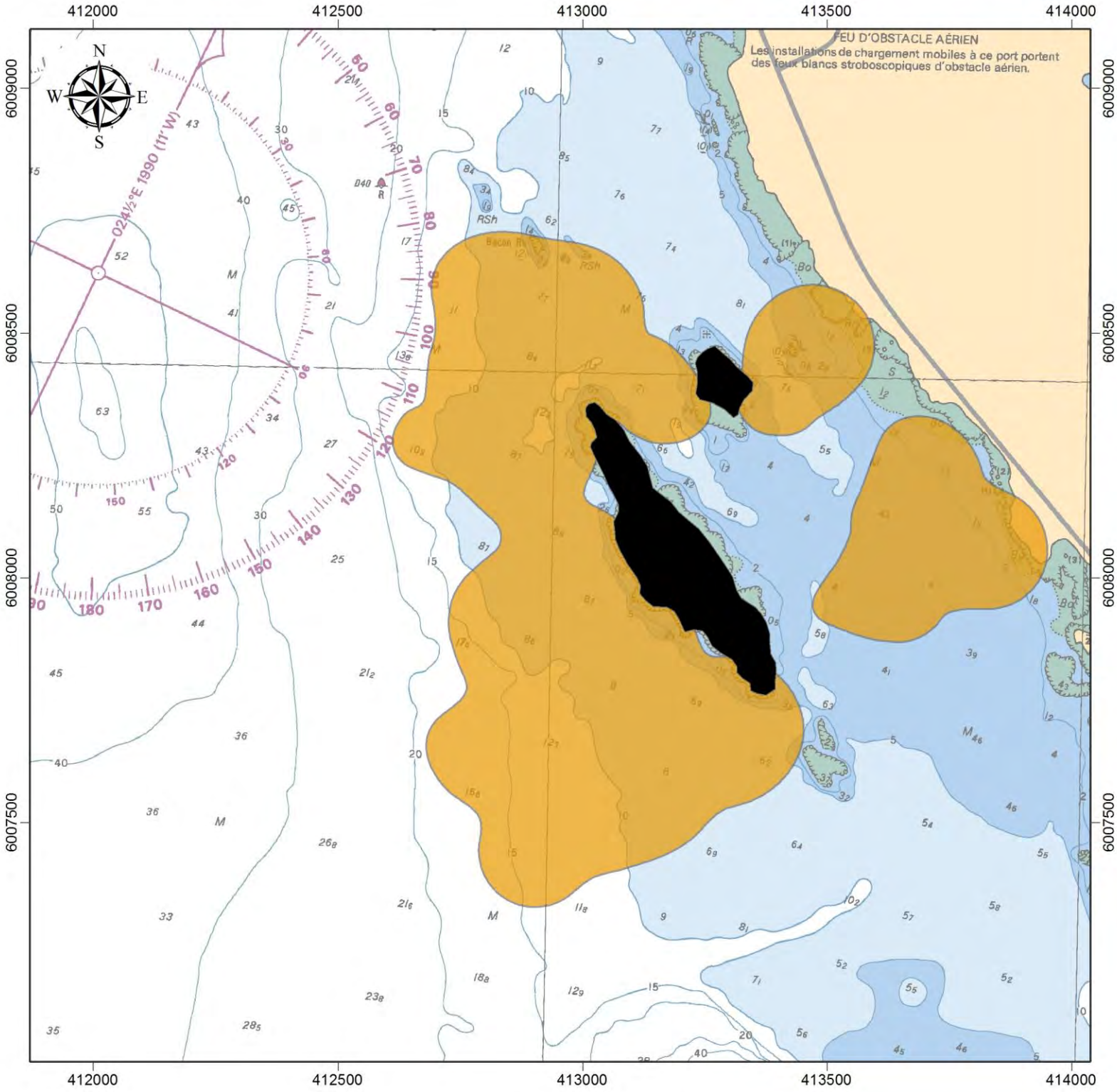
Scale: 1:11,000

Legend

- Rock mask
- Snake lock anemone
- Plumose anemone

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 22.
Range map for orange sea pens.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

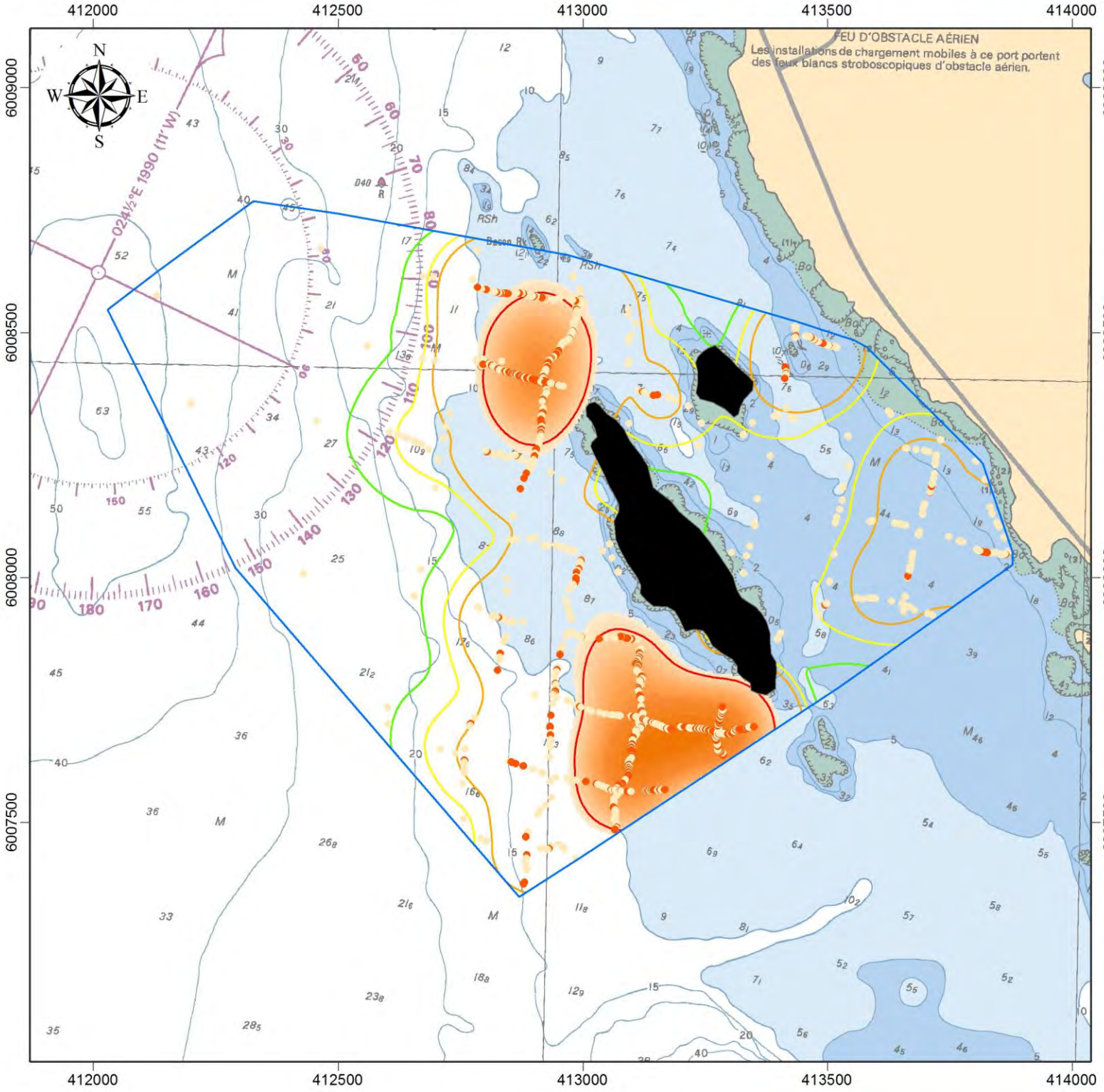
Scale: 1:11,000

Legend

- Rock mask
- Orange sea pen

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 23.
Density map for orange sea pens.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

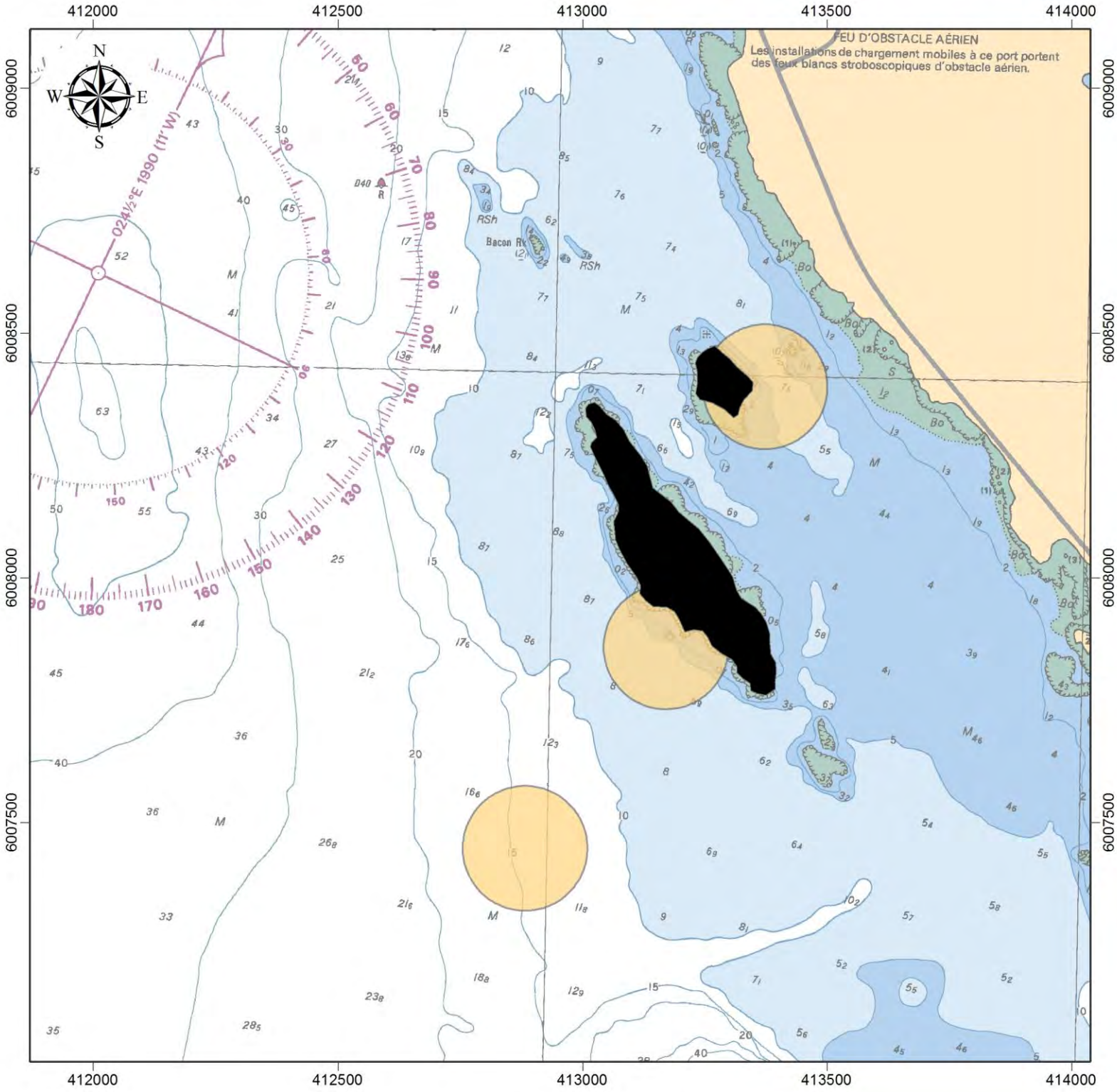
- Video boundary
- Rock mask
- Orange sea pens 50% population contour
- Orange sea pens 90% population contour
- Orange sea pens 95% population contour
- Orange sea pens 99% population contour

Orange sea pens observations

- Few
- Patchy

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 24.
Range map for gastropods.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

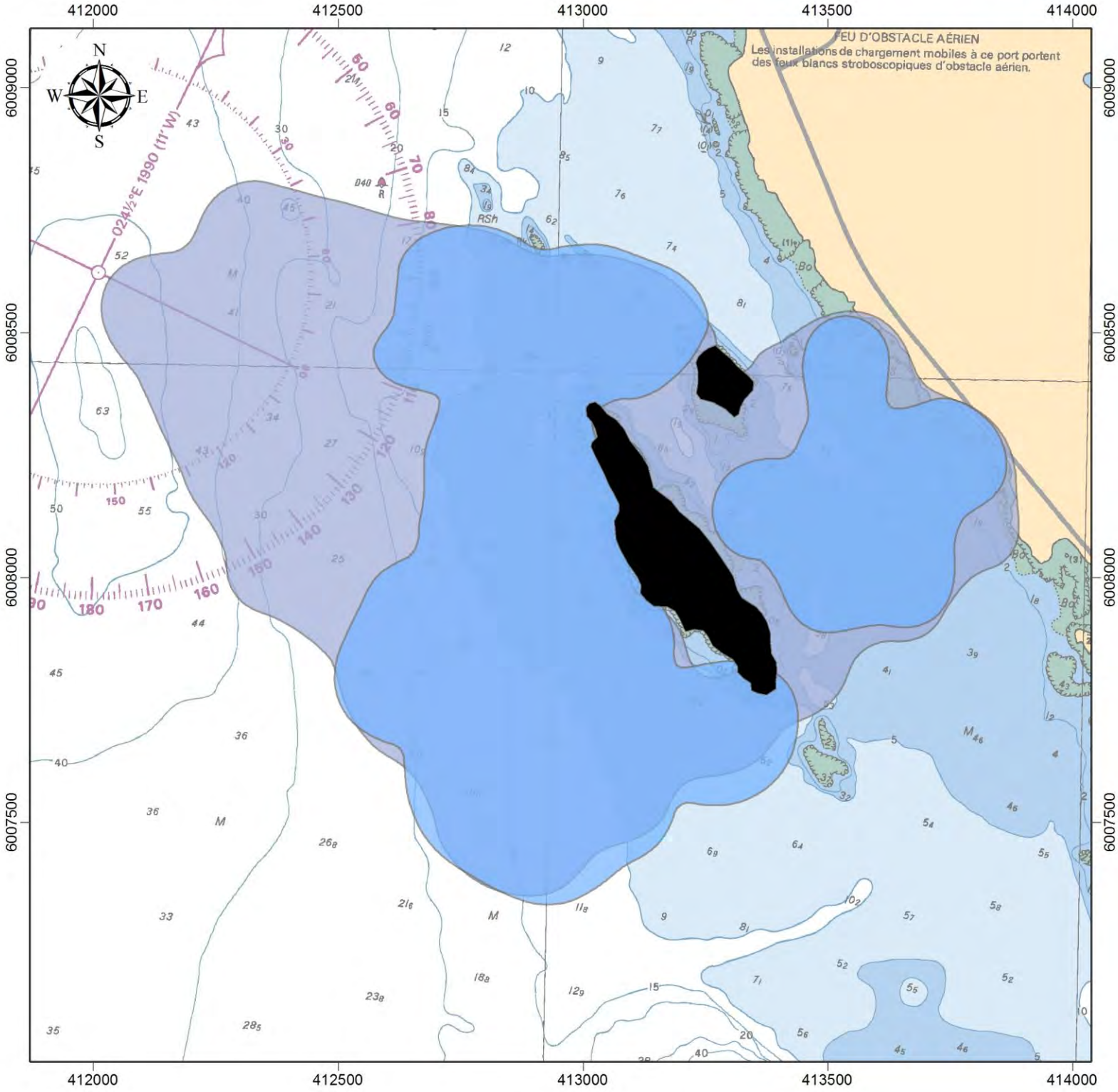
Scale: 1:11,000

Legend

- Rock mask
- Dogwinkle

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal
Subtidal Video Survey 2

Figure 25.
Range map for clams and unmounded holes.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

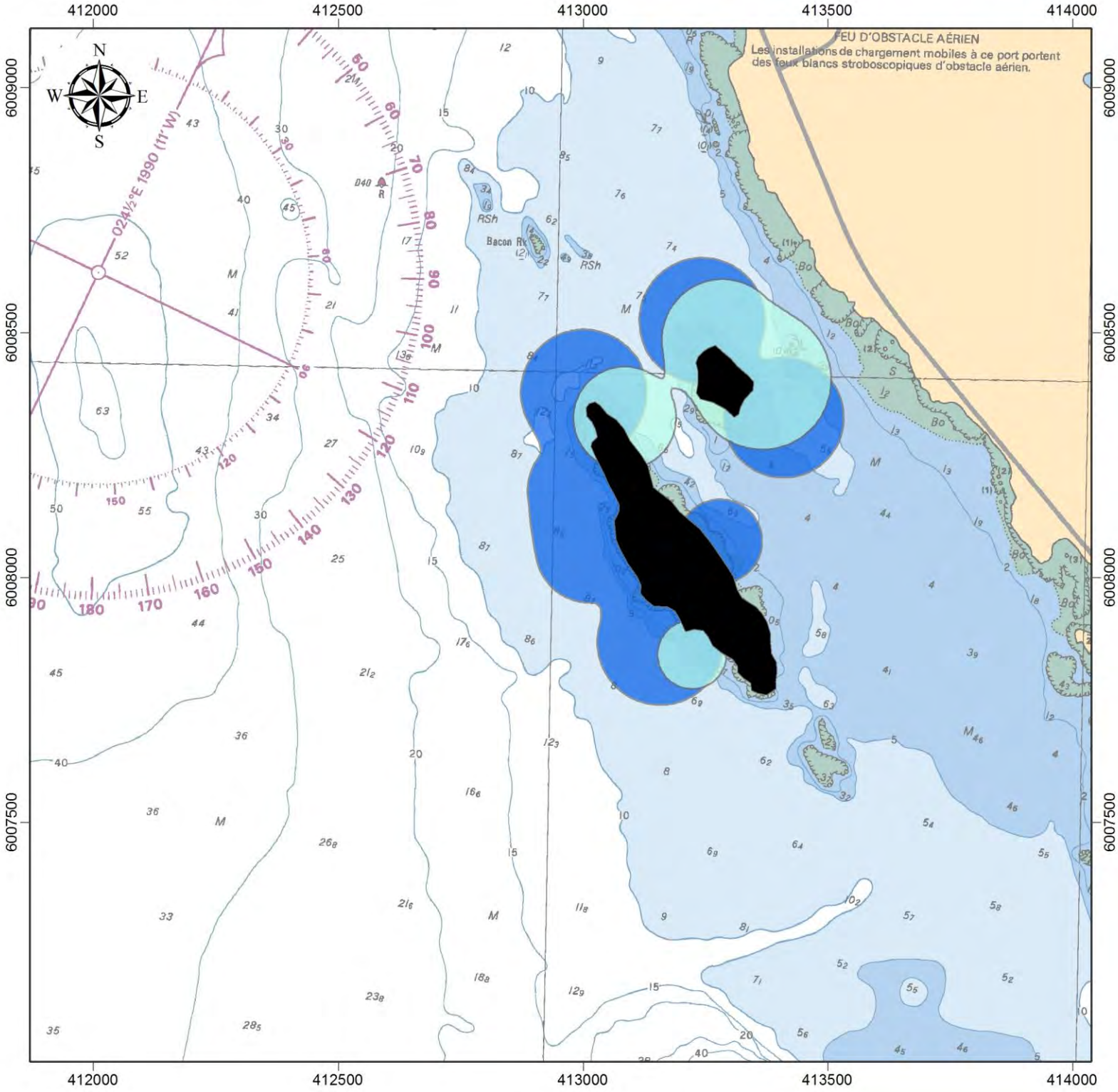
Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

- Rock mask
- Geoduck clam
- Unmounded hole

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 26.
Range map for polychaetes.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

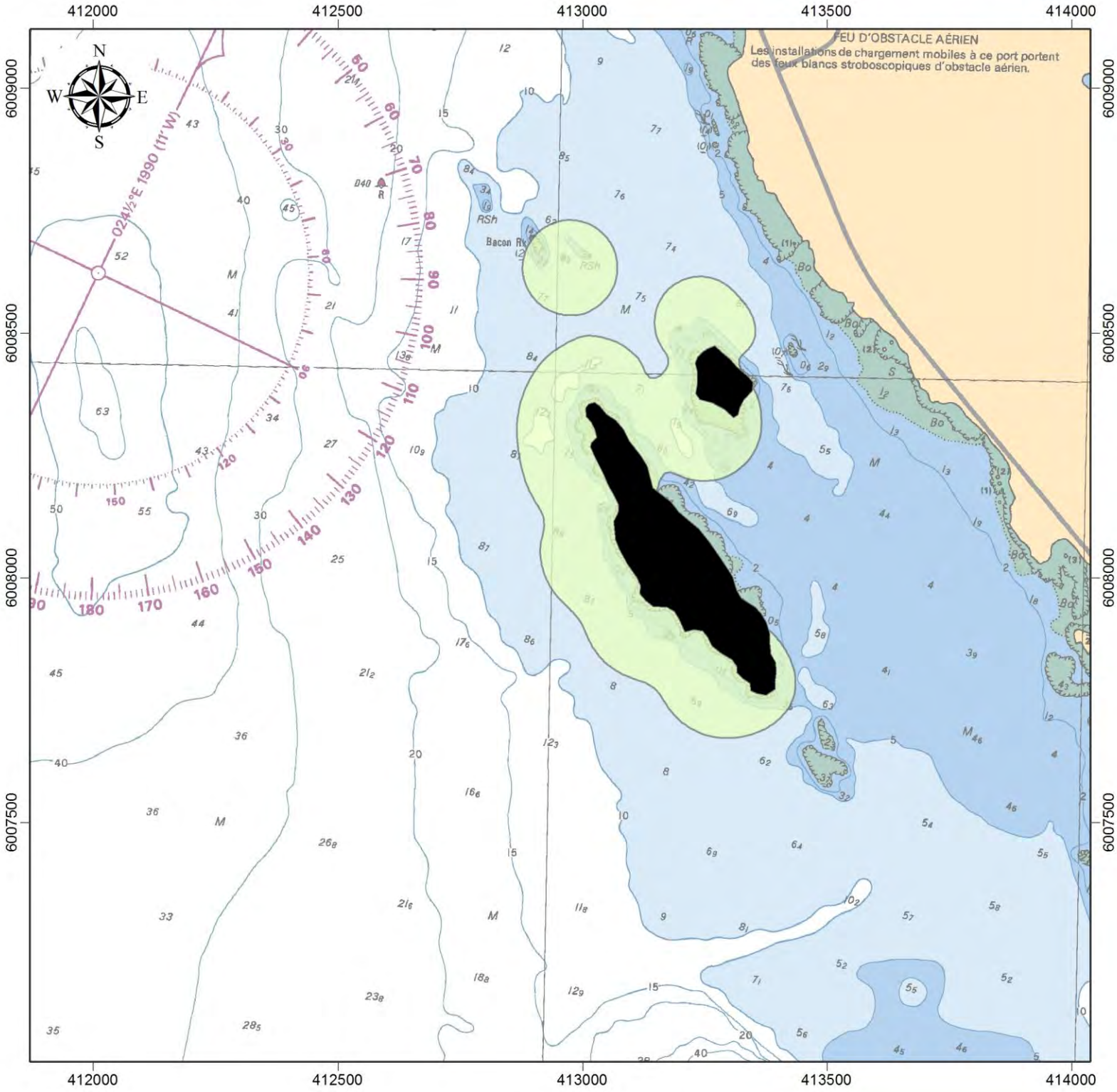
Scale: 1:11,000

Legend

- Rock mask
- Calcareous tube worm
- Parchment tube worm

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 27.
Range map for the "bryozoan complex".

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

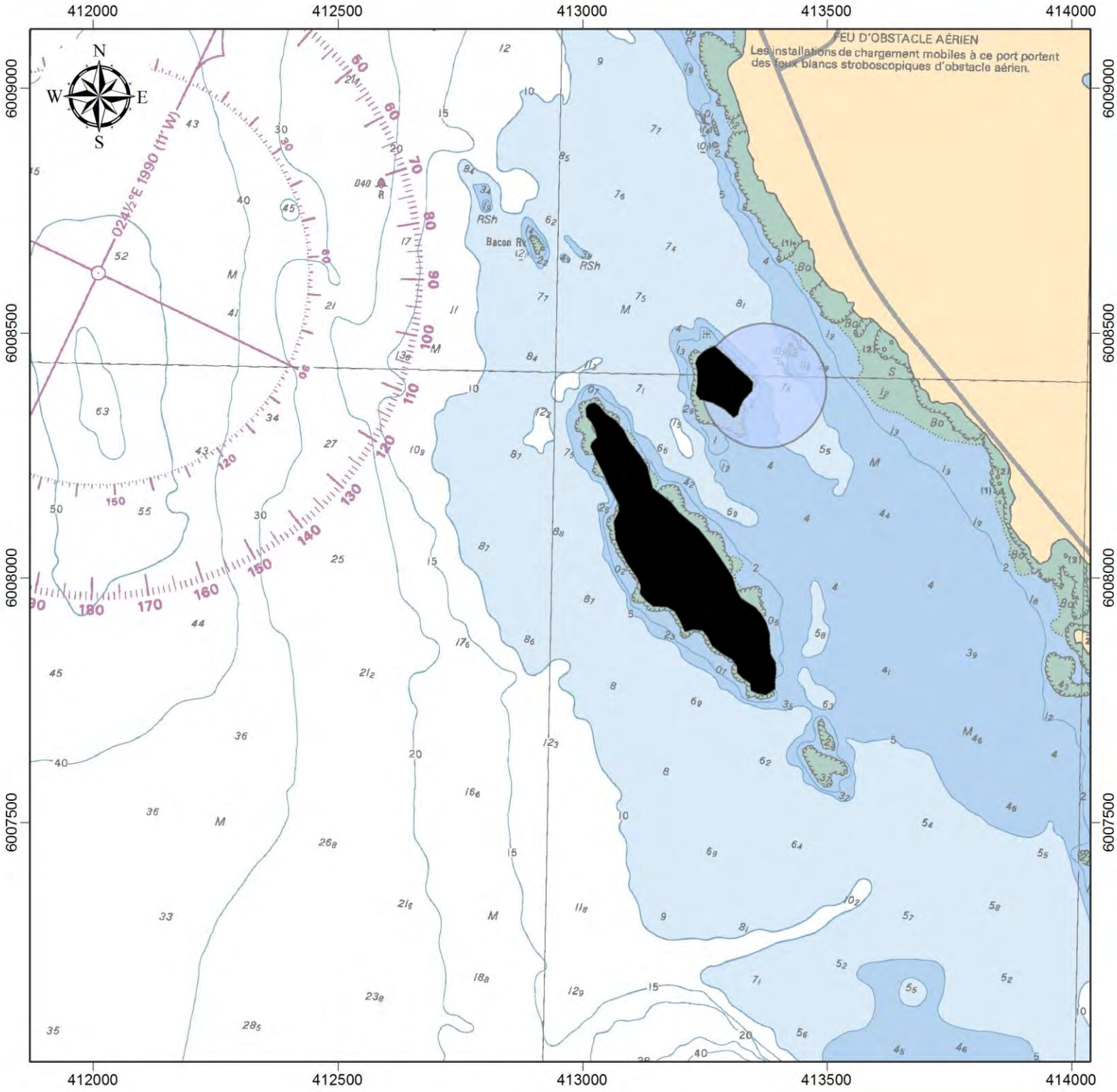
Scale: 1:11,000

Legend

- Rock mask
- Bryozoan complex

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 28.
Range map for brachiopods.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

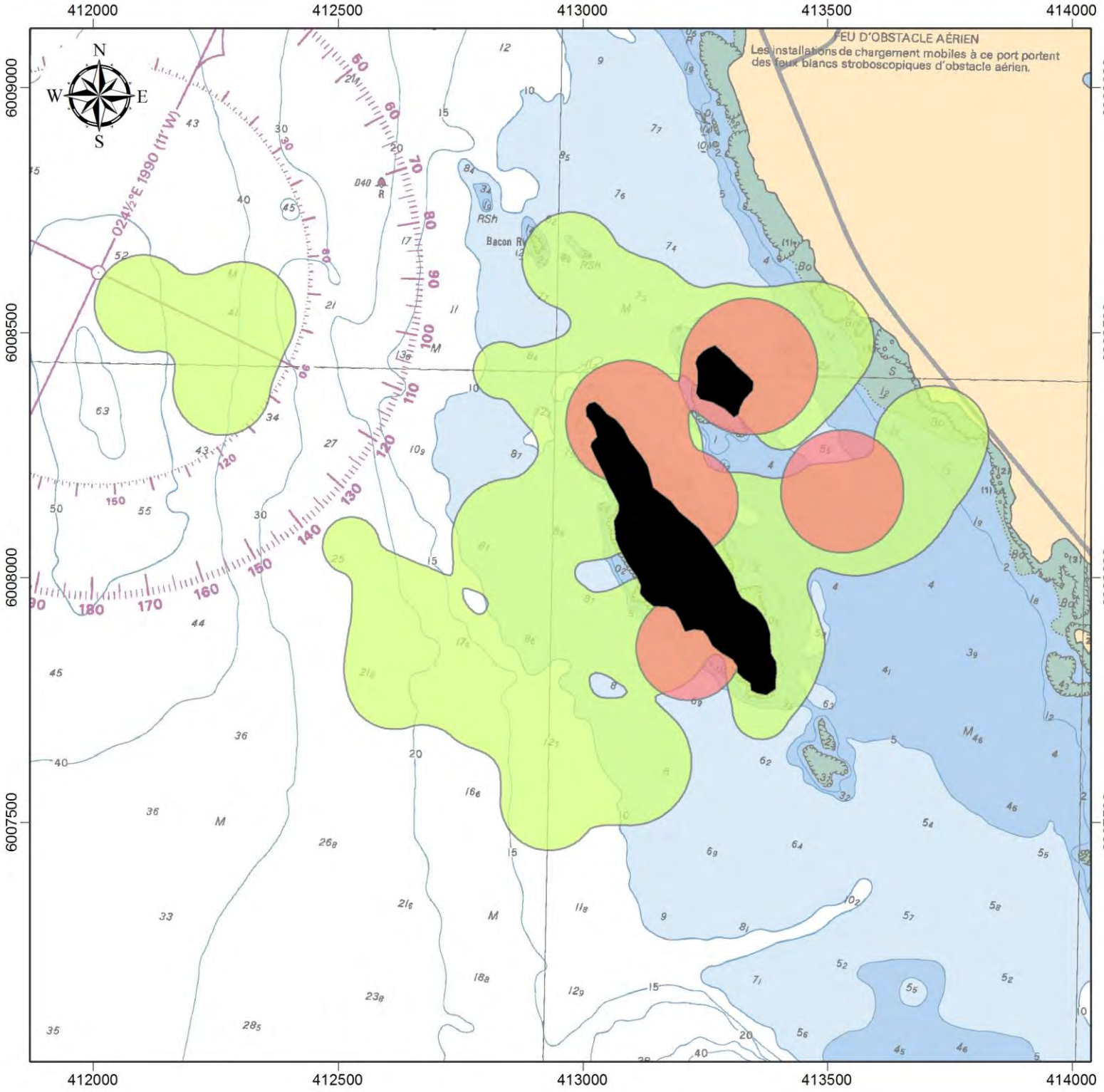
Scale: 1:11,000

Legend

- Rock mask
- California lamp shell

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 29.
Range map for crabs.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

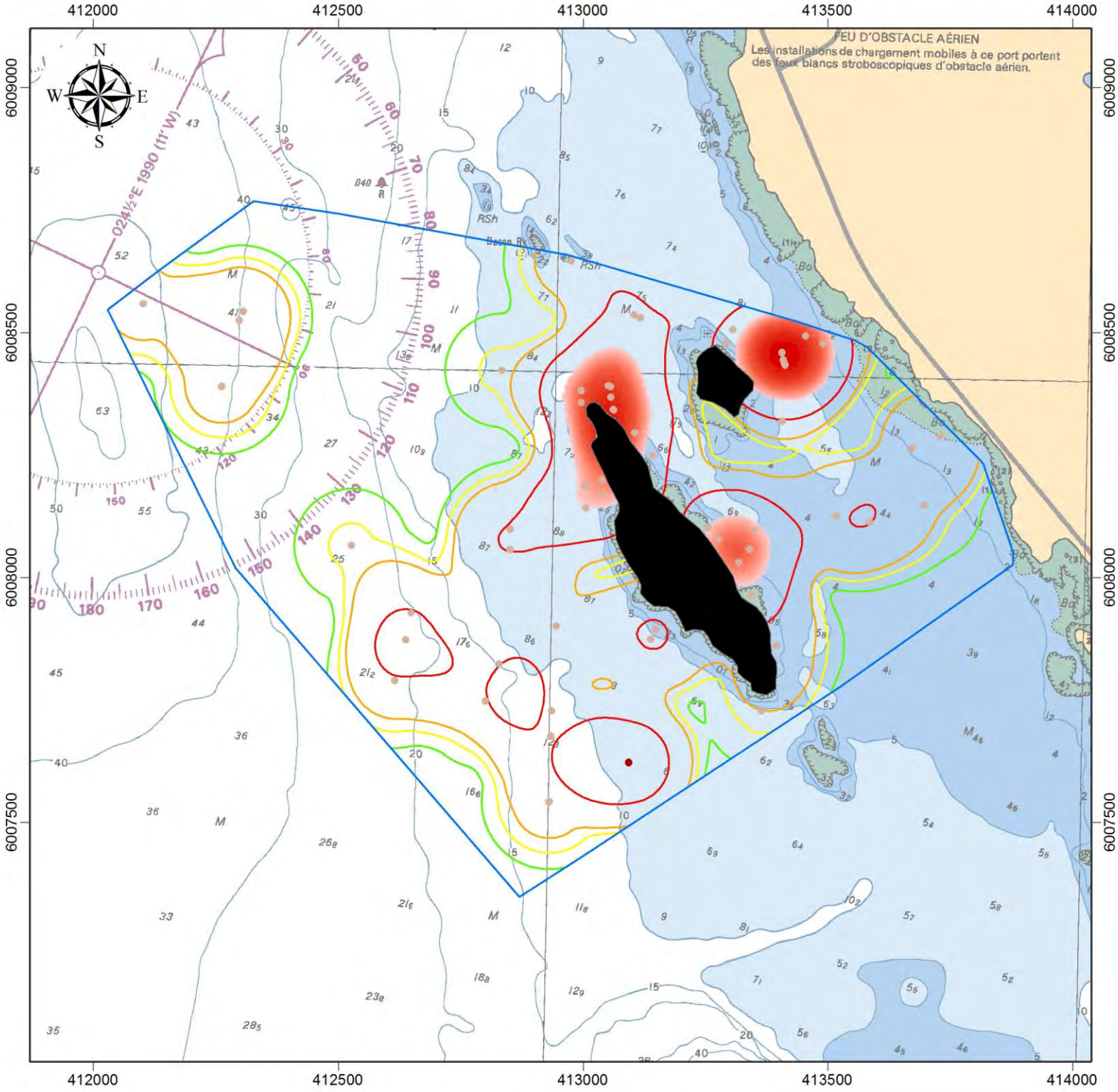
Scale: 1:11,000

Legend

- Rock mask
- Decorator crab
- Dungeness crab

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal
Subtidal Video Survey 2

Figure 30.
Density map for Dungeness crabs.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

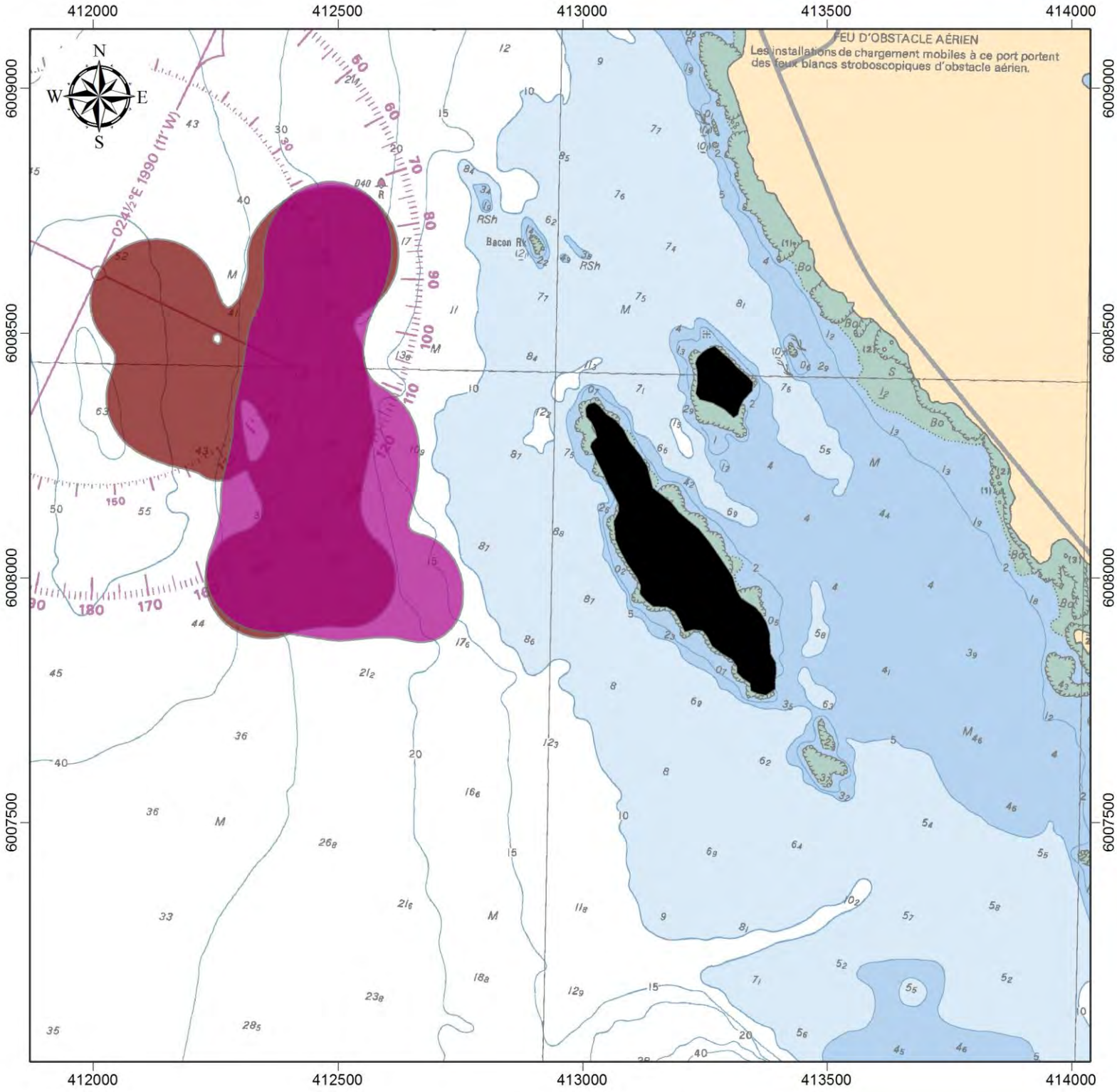
- Video boundary
- Rock mask
- Dungeness crabs 50% population contour
- Dungeness crabs 90% population contour
- Dungeness crabs 95% population contour
- Dungeness crabs 99% population contour

Dungeness crabs observations

- Few
- Patchy

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 31.
Range map for pandalids.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

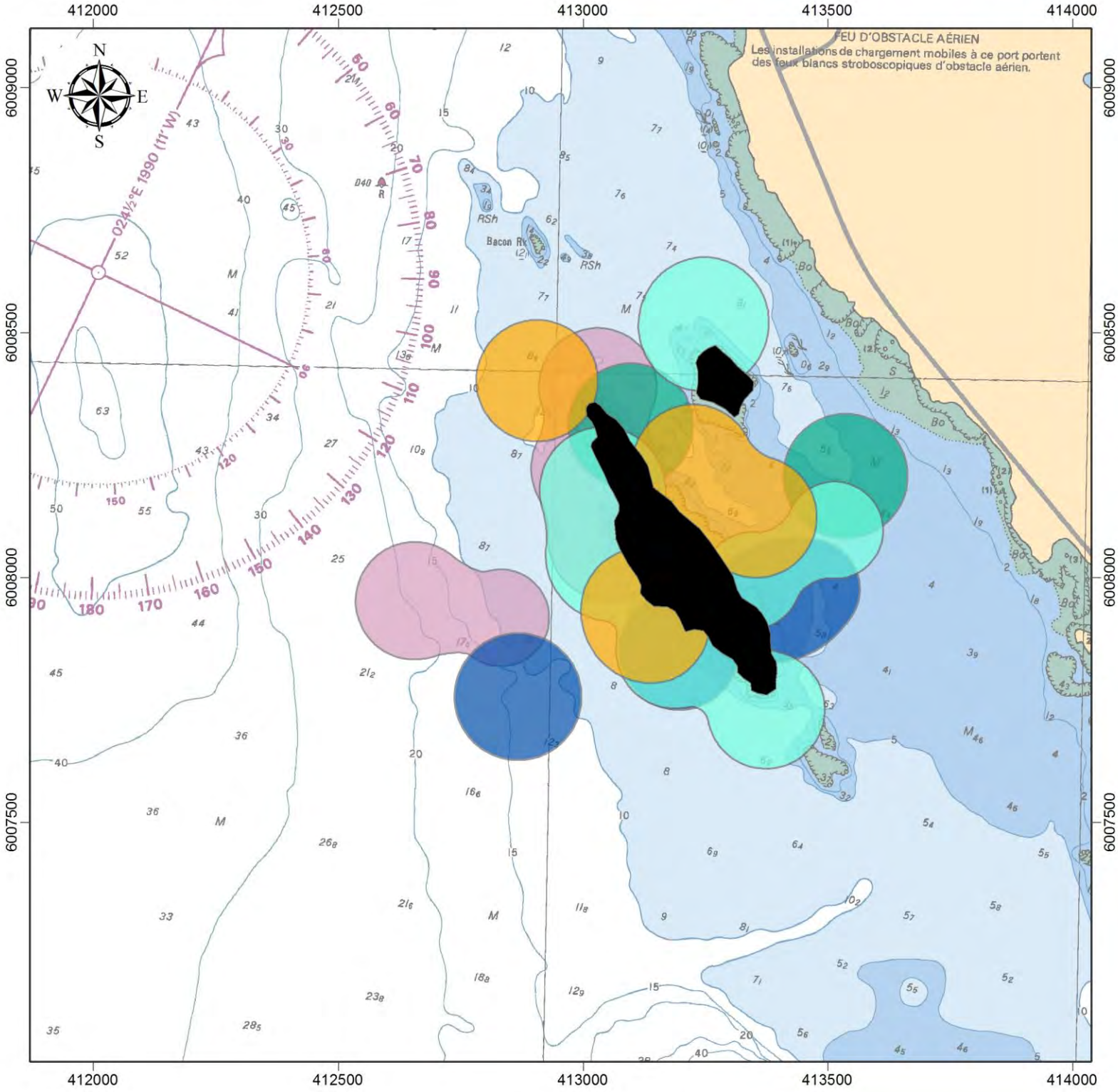
Scale: 1:11,000

Legend

- Rock mask
- Spiny pink shrimp
- Spot prawn

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 32.
Range map 1 for seastars.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

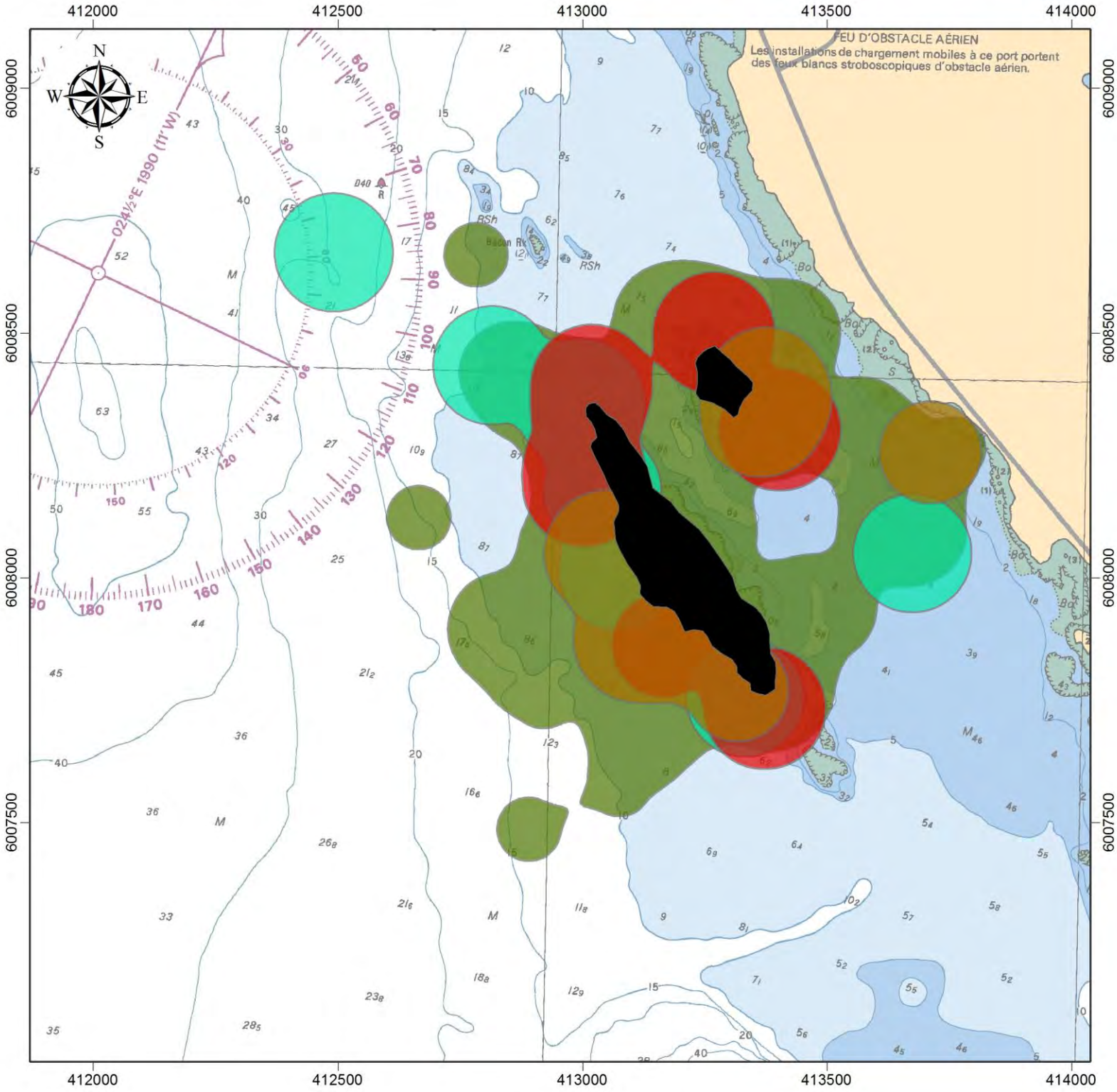
Scale: 1:11,000

Legend

- Rock mask
- Long ray star
- False ochre seastar
- Solaster sp.
- Spiny mudstar
- Vermilion star

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 33.
Range map 2 for seastars.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

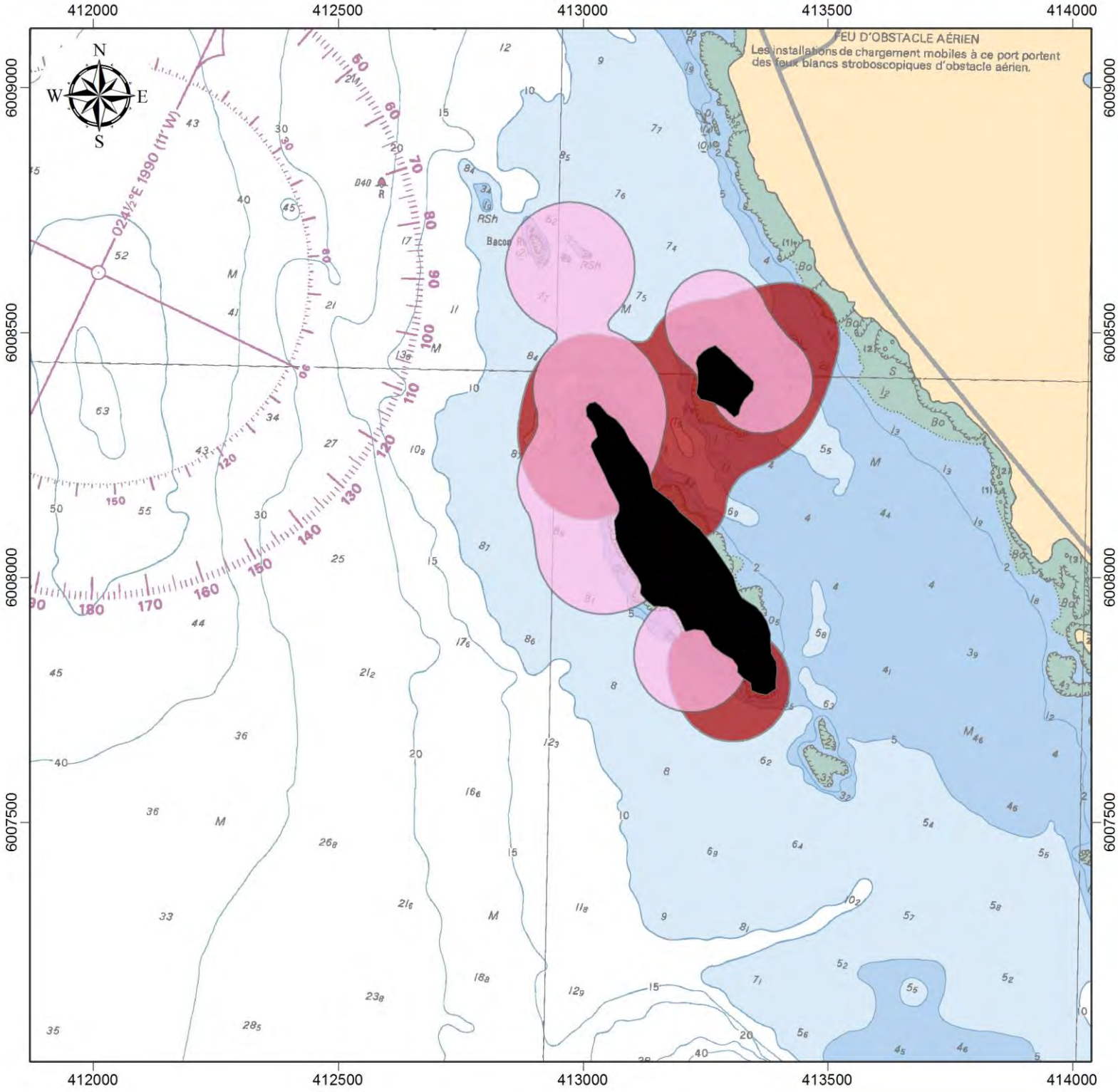
Scale: 1:11,000

Legend

- Rock mask
- Short-spined seastar
- Ochre seastar
- Painted star
- Sunflower seastar

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 34.
Range map for sea cucumbers.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

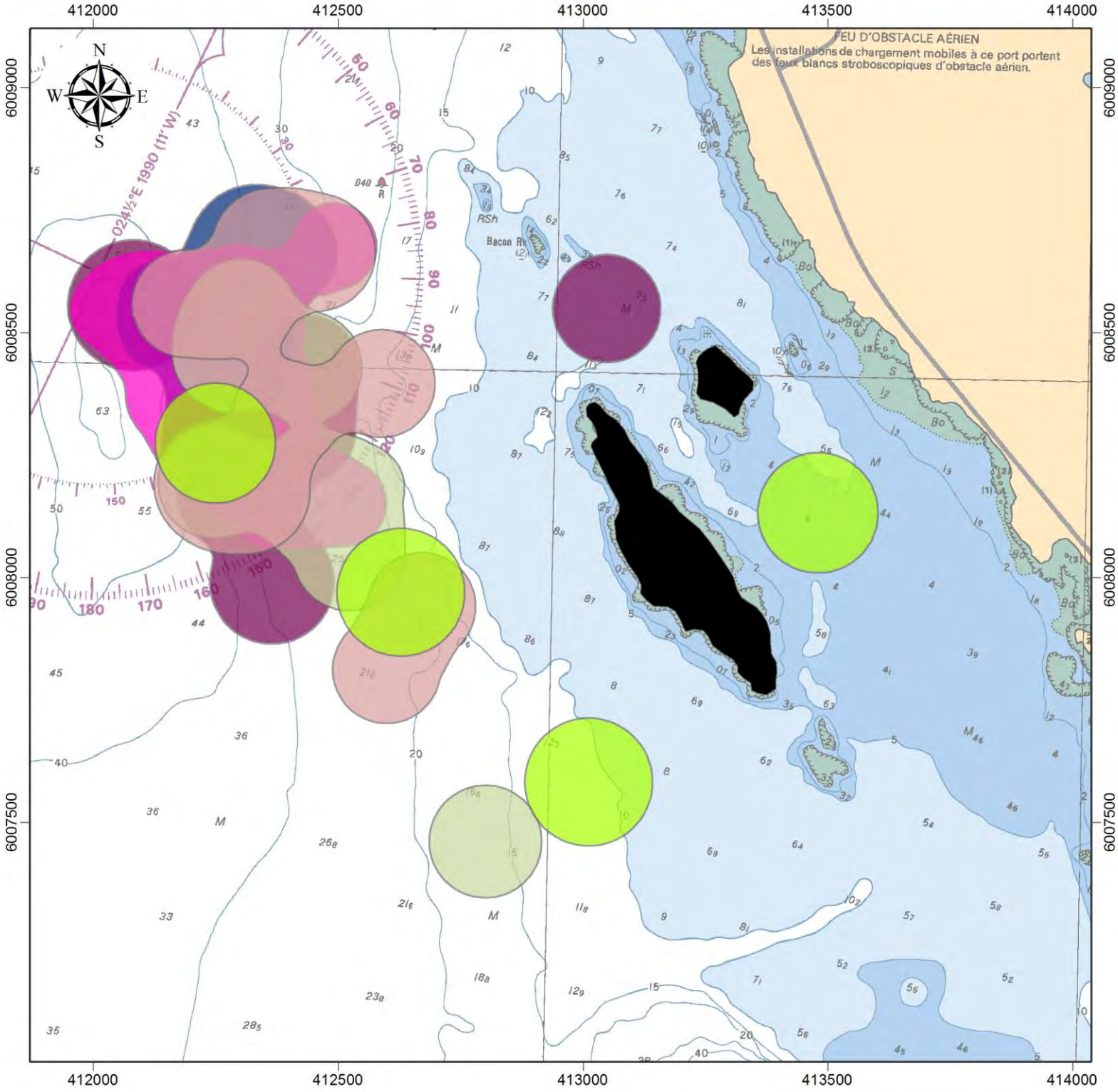
Scale: 1:11,000

Legend

- Rock mask
- California sea cucumber
- Red sea cucumber

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 35.
Range map for fish.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

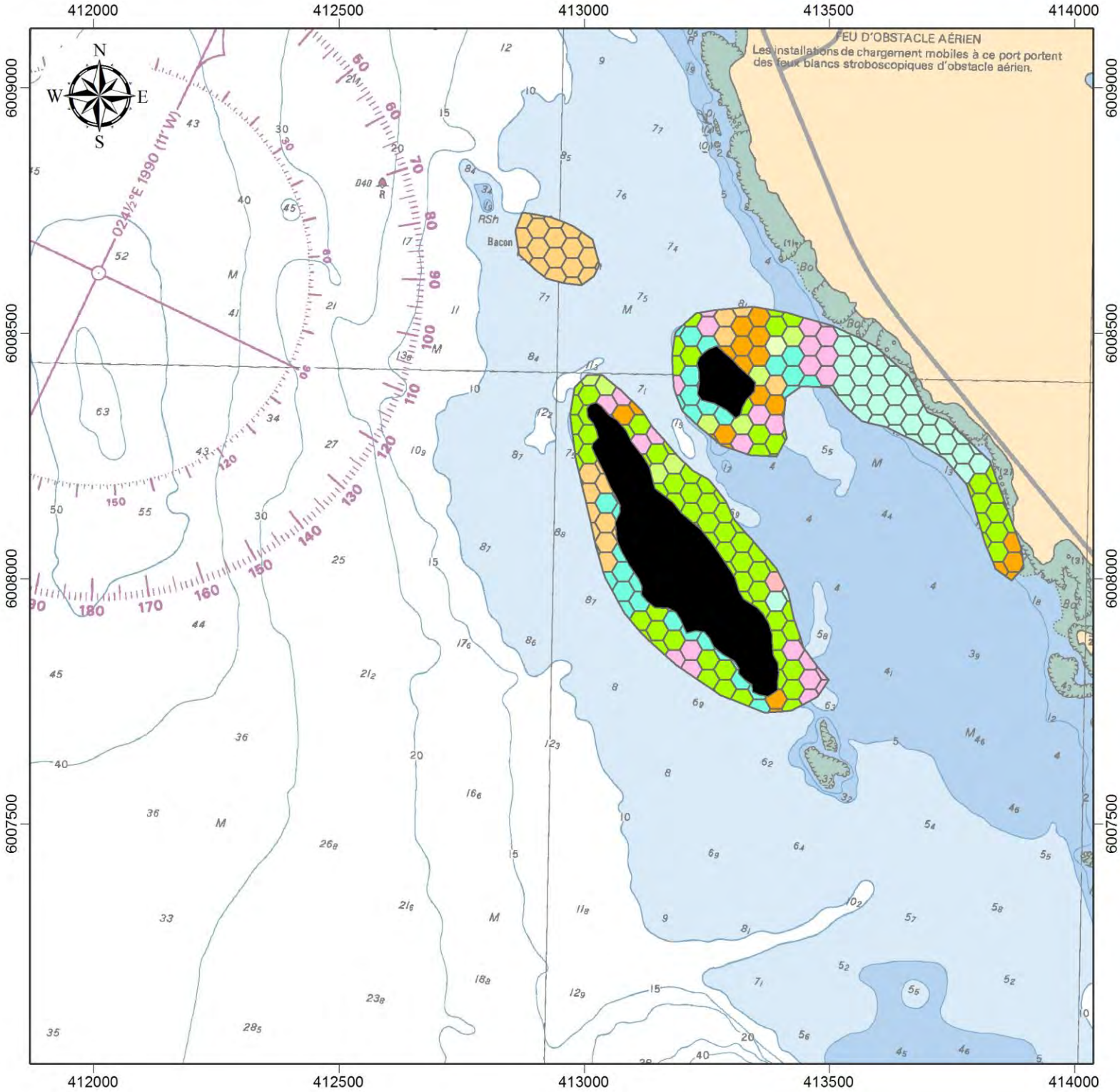
Scale: 1:11,000

Legend

- Rock mask
- Longnose skate
- Unidentified flatfish
- Unidentified sculpin
- Northern ronquil
- Unidentified eelpout
- Unidentified fish

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 36.
Map of dominant vegetation species.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

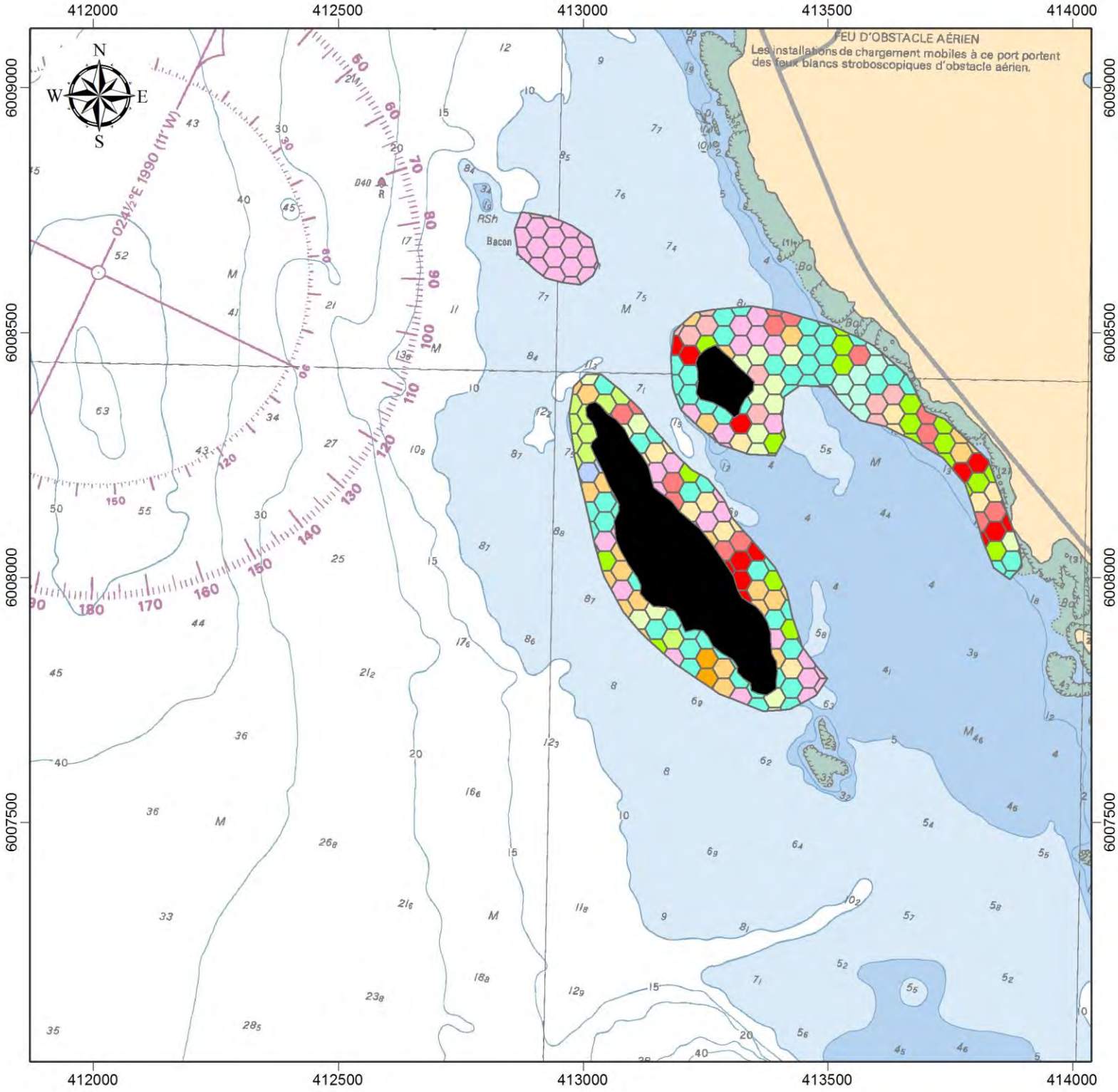
- Rock mask

Dominant vegetation map

- Alaria
- Coralline reds
- Eelgrass
- Filamentous reds
- Foliose reds
- Fringed sea colander kelp
- Nereocystis
- Suction-cup kelp
- Sugar wrack kelp

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 37.
Map of minor vegetation species.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

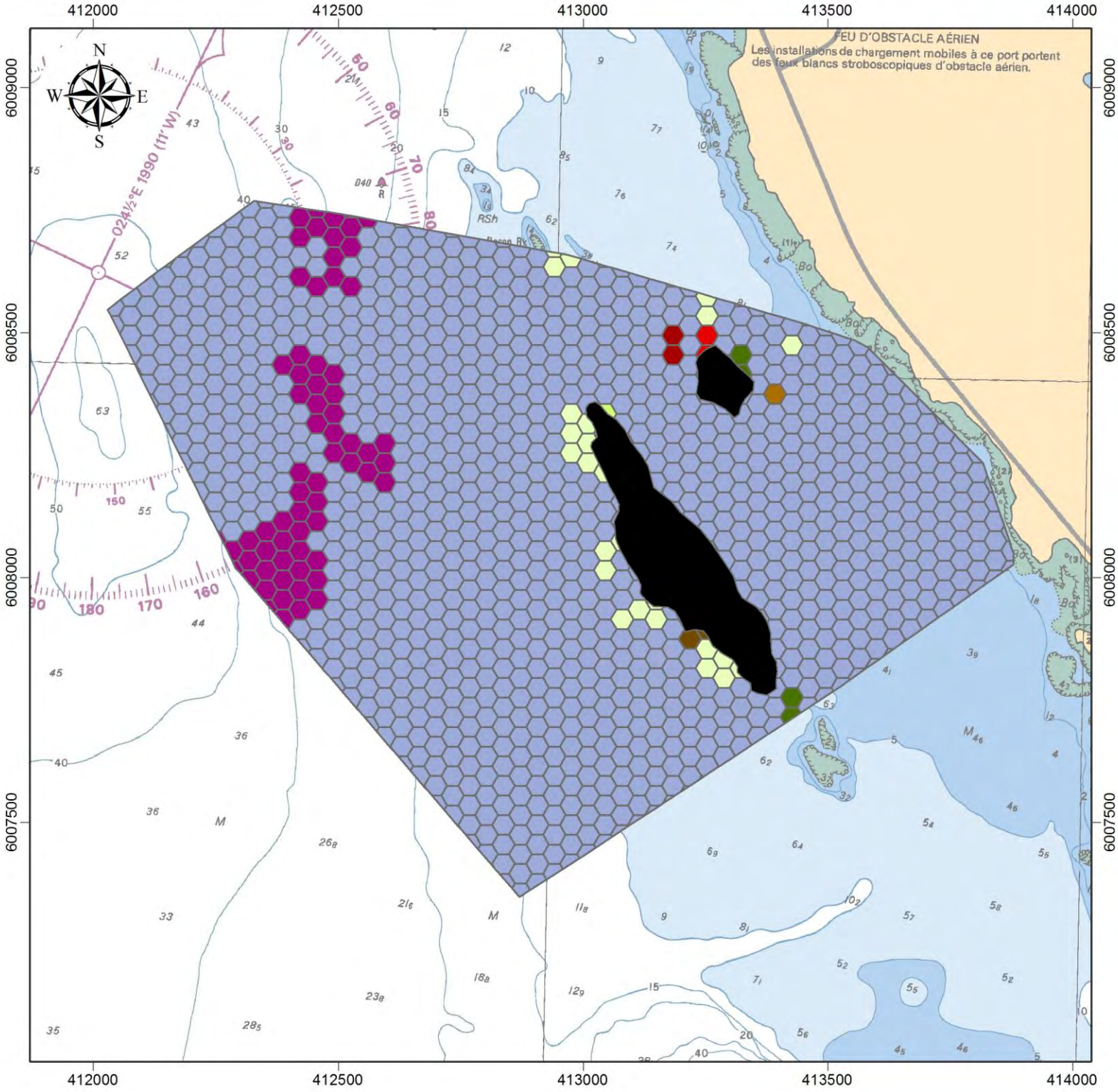
- Rock mask

Minor vegetation map

- Alaria
- Broad acid weed
- Coralline reds
- Eelgrass
- Filamentous greens
- Filamentous reds
- Foliose greens
- Foliose reds
- Fringed sea colander kelp
- Nereocystis
- Stringy acid weed
- Suction-cup kelp
- Sugar wrack kelp

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal
Subtidal Video Survey 2

Figure 38.
Map of dominant fauna species.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

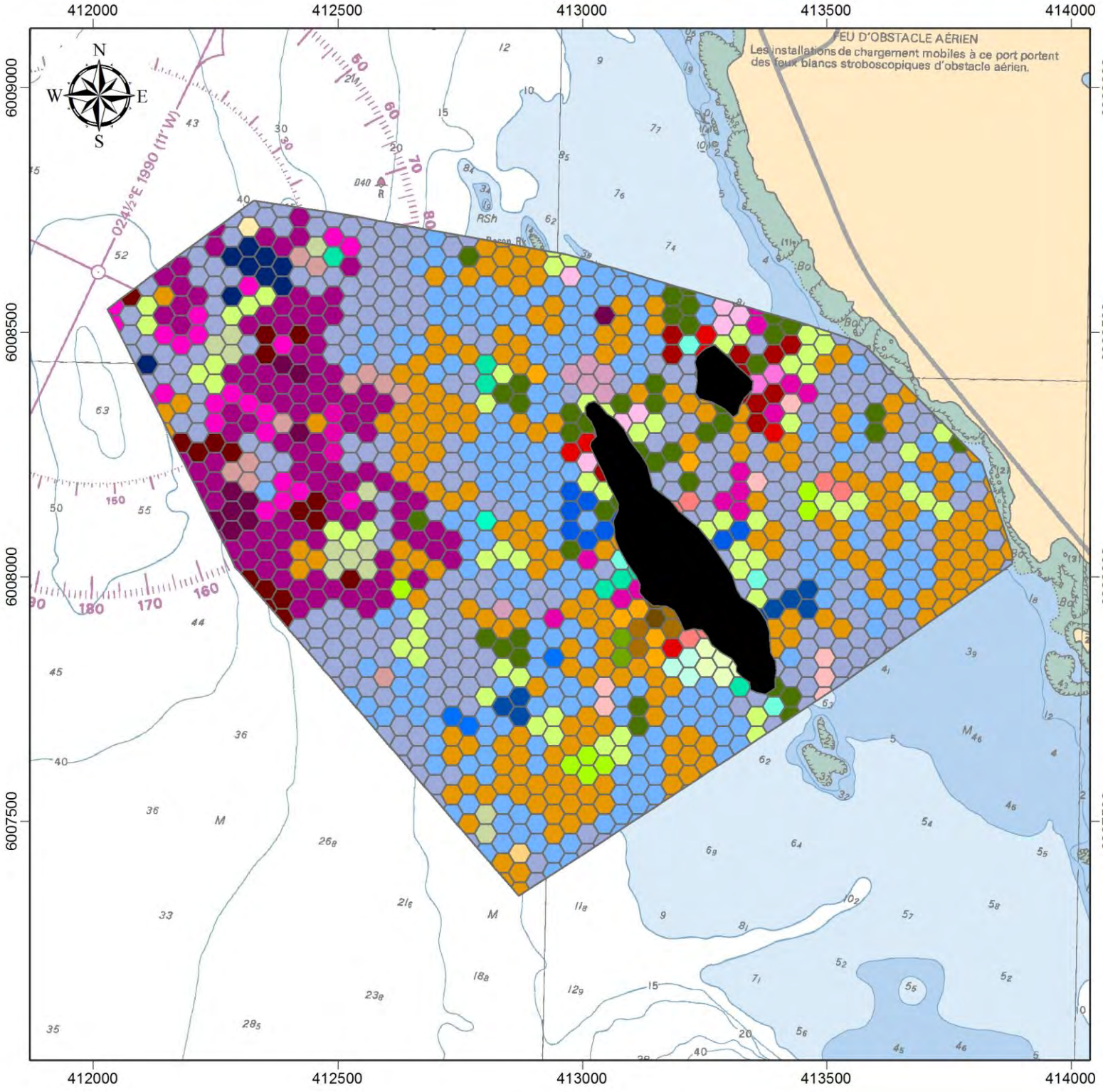
- Rock mask

Dominant fauna map

- Bryozoan complex
- Dungeness crab
- Ochre seastar
- Red sea cucumber
- Short-spined seastar
- Spiny pink shrimp
- Stalked vase sponge
- Sunflower seastar
- Unmounded hole

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 39.
Map of minor fauna species.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

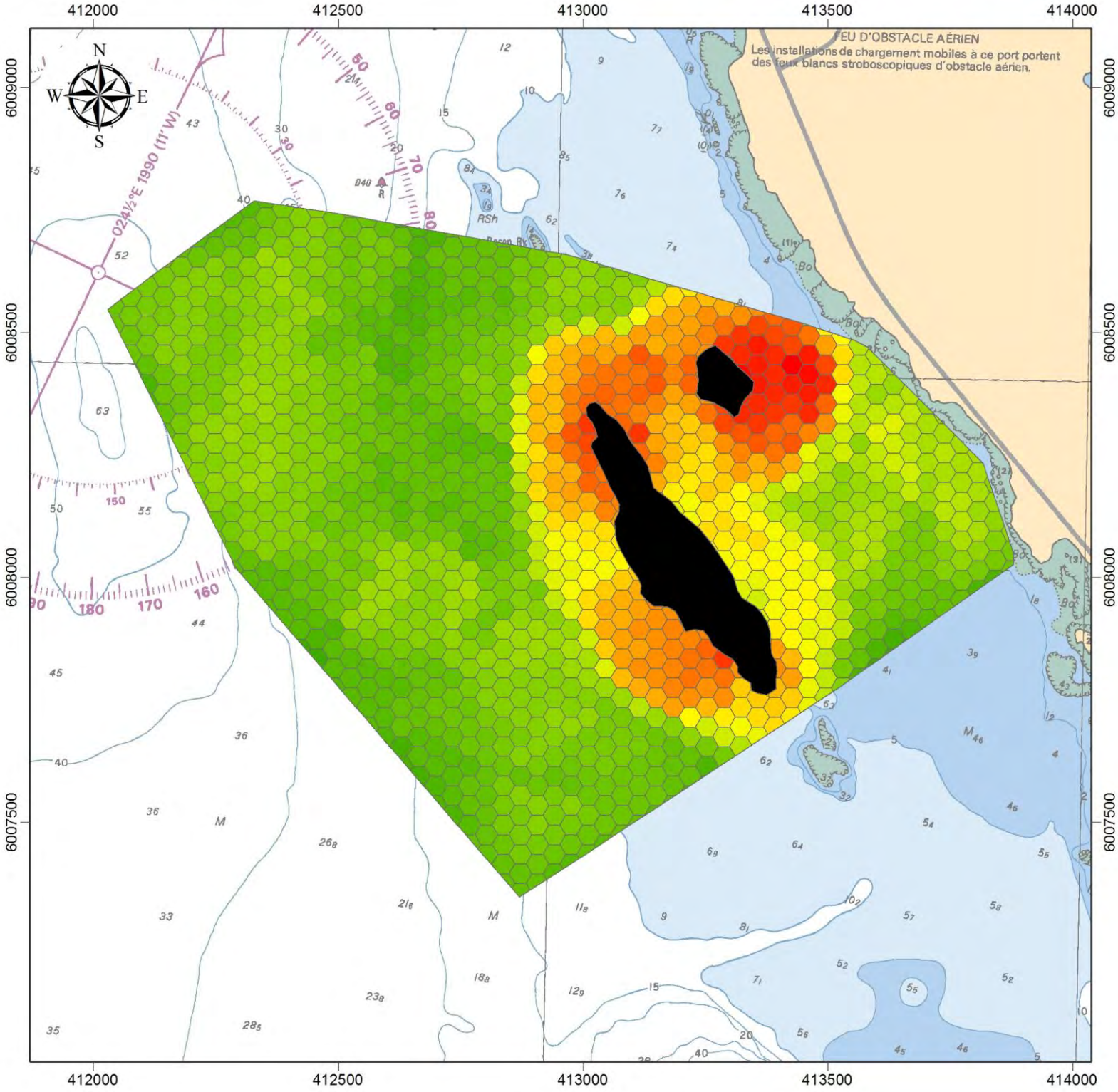
- Rock mask

Minor fauna map

- Bacterial mat
- Black-eyed goby
- Bryozoan complex
- Calcareous tube worm
- California sea cucumber
- Decorator crab
- Dogwinkle
- Dungeness crab
- False ochre seastar
- Geoduck clam
- Gray brittle star
- Long ray star
- Longnose skate
- Moon jellyfish
- Mounded hole
- Northern ronquil
- Ochre seastar
- Orange sea pen
- Painted star
- Parchment tube worm
- Plumose anemone
- Red sea cucumber
- Short-spined seastar
- Snake lock anemone
- Spiny mudstar
- Spiny pink shrimp
- Spot prawn
- Stalked vase sponge
- Sunflower seastar
- Unidentified eelpout
- Unidentified fish
- Unidentified flatfish
- Unidentified sculpin
- Unmounded hole
- Vermilion star

0 62.5 125 250 Meters

OCEAN ECOLOGY



Canpotex - Ridley Island Potash Terminal Subtidal Video Survey 2

Figure 40.
Species richness map.

Positioning system:
Electronic charting software using DGPS

Survey resolution:
160 m grid.

Chart used for navigation:
CHS 395502
(Porpoise Harbour)

Chart datum: LNT

Projection:WGS 1984 UTM Zone 9N

Scale: 1:11,000

Legend

- Rock mask
- **Species**
  - 0
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
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  - 32
  - 33
  - 34
  - 35

0 62.5 125 250 Meters

OCEAN ECOLOGY

4 Disclaimer

The findings presented in this report are based upon data collected during the period January 20th to January 21st, 2009 and May 18th to May 20th, 2009 using the methodology described in the Survey Methodology section of this report. Ocean Ecology has exercised reasonable skill, care, and diligence to collect and interpret the data, but makes no guarantees or warranties as to the accuracy or completeness of this data.

This report has been prepared solely for the use of the Canpotex - Ridley Island Potash Terminal Project of Jacques Whitford Stantec AXYS Ltd., pursuant to the agreement between Ocean Ecology and Jacques Whitford Stantec AXYS Ltd. Any use which other parties make of this report, or any reliance on or decisions made based on it, are the responsibility of such parties. Ocean Ecology accepts no responsibility for damages, if any, suffered by other parties as a result of decisions made or actions based on this report.

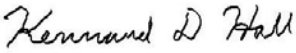
Any questions concerning the information or its interpretation should be directed to the undersigned.

Prepared By:



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Oceanographer, R.P.Biol.

Reviewed By:



Kennard Hall, Captain
Partner, Ocean Ecology

5 Appendix

Table A1. Substrate type codes.

Substrate Composition	Class	Subclass	Description
Rock (R)			Bedrock outcrop; may be partially covered with a veneer of sediment.
Veneer over bedrock (vR)			Intermittently visible bedrock covered with a thin veneer of clastic sediments.
Clastic (C)			Seabed comprised of mineral grains of gravel-, sand- or mud-sized material.
	Gravel (G)	Boulder (B)	Percentage boulder (>25.6 cm in size) on seabed.
		Cobble (CO)	Percentage cobble (6.4 to 25.6 cm in size) on seabed.
		Pebble (P)	Percentage pebble (4 mm to 6.4 cm in size) on seabed.
		Granules (GR)	Percentage granules (2-4 mm in size) on seabed.
	Sand (S)	Sand (S)	Percentage sand (0.062 to 2 mm in size) on seabed.
	Silt-mud (M)	Silt-mud (M)	Percentage silt-mud (<0.62 mm in size) on seabed.
Biogenic (B)			Surface of seabed comprised of material of biogenic origin, such as vegetation.
	Organics (O)	Shell (SH)	Percentage coarse (> 2 mm in size) shell debris on seabed.
		Organic debris (OD)	Percentage organic debris on seabed.
		Wood debris (WD)	Percentage wood debris on seabed.
Anthropogenic (A)			Features of man-made origin, such as trawl marks, anchor drag marks, or cable drag marks.

Table A2. Percentage substrate cover codes.

Class Code	Percentage Cover
1	T-5%
2	5-30%
3	30-50%
4	50-80%
5	>80%

Table A3. Vegetation codes.

Algal Class	Subclass	Code	Description
Green Algae (GRA)	Foliose greens	FOG	Primarily *Ulva*, but also including *Enteromorpha* and *Monostroma.*
	Filamentous greens	FIG	The various filamentous green/red assemblages (*Spongomorpha/Cladophora* types).
Brown Algae (BA)	Fucus	FUC	*Fucus* and *Pelvetiopsis* species groups.
	Sargassum	SAR	*Sargassum* is the dominant and primary algal species.
	Nemalion	NEM	Filamentous *Nemalion* sp. is the dominant species.
	Soft brown kelps	BKS	Large laminarian bladed kelps, including *L. saccharina* and *groenlandica*, *Costaria costata, Cymathere triplicata.*
	Seersucker kelp	SEE	*Costaria costata.*
	Split kelp	SPL	*Laminaria setchellii.*
	Sugar wrack kelp	SWK	*Laminaria saccharina.*
	Suction-cup kelp	SUC	*Laminaria yezoensis*.
	Dark brown kelps	BKD	The LUCO chocolate brown group,. *L. setchelli, Pterygophora, Lessoniopis. Alaria* and *Egregia* may also be present. Generally more exposed than soft browns.
	Alaria	ALA	*Alaria* sp.
	Agarum	AGR	*Agarum* is the dominant species, but other laminarians may also occur. Generally found deeper than Laminarian subgroup.
	Fringed sea colander kelp	FSC	*Agarum fimbriatum*.
	Stringy acid weed	STW	*Desmarestia viridis.*
	Broad acid weed	BRW	*Desmarestia lingulata.*
	Macrocystis	MAC	Beds of canopy forming giant kelp.
	Nereocystis	NER	Beds of canopy forming bull kelp.

Table A3. Continued.

Algal Class	Subclass	Code	Description
Red Algae (RED)	Foliose reds	FOR	A diverse species mix of foliose red algae (*Gigartina*, *Iridea, Rhodymenia, Constantinia*) which may be found from the lower intertidal to depths of 10 m primarily on rocky substrate.
	Filamentous reds	FIR1	A diverse species mix of filamentous red algae (including *Gastroclonium, Odonthalia, Prionitis*) which may be found from the lower intertidal to depths of 10 m, often co-occurring with the foliose red group described above.
	Filamentous reds	FIR2	A mix of red algae (primarily *Neoagardhiella*and *Gracilaria*) which grow on "submerged" cobble and pebble in fine sand and silt bottoms.
	Coralline reds	COR	Rocky areas with growths of encrusting and foliose forms of coralline algae.
	Halosaccion	HAL	*Halosaccion glandiforme.*
Seagrasses (SGR)	Eelgrass	ZOS	Eelgrass beds.
	Surfgrass	PHY	Areas of surfgrasses (*Phyllospadix*), which may co-occur with subgroup BKS or BKD above.
No Vegetation		NOV	No vegetation observed.
Cannot Classify		X	Vegetation present by cannot be identified. Imagery is not clear, classification not possible.

Table A4. Vegetation coverage codes.

Code	Class	Abundance
1	Sparse	Less than 5% cover.
2	Low	5 to 25% cover.
3	Moderate	26 to 75% cover.
4	Dense	>75% cover.

Table A5. Fauna codes.

Species or Species Complex	Code	Description
Bacterial mat	BCM	Unidentified bacterial mat; sulfuretum.
Sponges	USP	Unidentified sponge.
	CLD	Cloud sponge (*Aphrocallistes vastus*).
	SBS	Sharp lipped boot sponge (*Rhabdocalyptus dawsoni*).
	RSB	Round lipped boot sponge (*Staurocalyptus dowlingi*).
	SVS	Stalked vase sponge (*Leucilla nuttingi*).
	BRS	Breast sponge (*Eumastia sitiens*).
Jellyfish	MJF	Moon jellyfish (*Aurelia labiata*).
	CYC	Lion's mane jellyfish (*Cyanea capillata*).
Hydroids	HYD	Unidentified hydroids.
	HYM	Hydromedusa sp.
Anemones	PAF	Tube-dwelling anemone (*Pachycerianthes fimbriatus)*.
	MET	Plumose anemone (*Metridium* sp.).
	URT	Sea anemone (*Urticina* sp.).
	XAN	Giant green anemone (*Anthopleura xanthogrammica*).
	CRI	Snake lock anemone (*Cribrinopsis* sp.).
	ANT	Sea anemone (*Anthopleura* sp.).
	STR	Strawberry anemone (*Corynactis californica*).
Corals/Hydrocorals	SPO	Orange sea pen (*Ptilosarcus gurneyi*).
	SPW	White sea pen (*Virgularia* sp.).
	CUP	Orange cup coral (*Balanophyllia elegans*).
	SWP	Sea whip (*Balticina septentrionalis*).
	STY	Pink hydrocoral (*Stylaster* sp.).
Worms	TUB	Parchment tube dwelling polychaete worms.
	TUC	Calcareous tube dwelling polychaete worms.
	LUG	Pacific lugworm (*Abarenicola pacifica*).

Table A5. Continued.

Species or Species Complex	Code	Description
Crabs	CRB	Unidentified crab.
	CAN	*Cancer* sp.
	DUN	Dungeness crab (*Cancer magister*).
	TAN	Tanner crab (*Chionoecetes* sp.).
	KCR	Kelp crab (*Pugettia* sp.).
	BXC	Box crab (*Lopholithodes foraminatus*).
	ORE	Decorator crab (*Oregonia gracilis*).
	SQT	Squat lobster (*Munida quadraspina*).
Shrimps (Pandalid)	PAN	Unidentified pandalid.
	PRN	Spot prawn (*Pandalus platyceros*).
	PNB	Spiny pink shrimp (*Pandalus borealis*).
	PNH	Humpback shrimp (*Pandulus hypsinotus*).
Ghost and mud shrimps	GHS	Ghost shrimp (*Callianassa californiensis*).
	MDS	Mud shrimp (*Upogebia pugettensis*).
Gastropods	WHK	Unidentified whelk.
	NUC	Dogwinkle (*Nucella* sp.).
	WLN	White-lined nudibranch (*Dirona albolineata*).
	TOT	Orange-peel nudibranch (*Tochuina tetraquetra*).
Bivalves	MUS	Mussel bed (*Mytilus trossulus*).
	GCL	Geoduck clam (*Panopea abrupta*).
	HCL	Horseclam (*Tresus* sp.).
	PCL	Piddock clam.
	BCL	Butter clam (*Saxidomas gigantea*).
	COC	Nuttall's cockle (*Clinocardium nuttallii*).
	SFC	Softshell clam (*Mya* sp.).
	OYS	Oyster.
	OCL	Other clam species.
	SCA	Scallop (*Chlamys* sp.)
	TER	Teredo worm (*Bankia setacea*).
Octopus	OCT	Pacific octopus (*Octopus*).
Bryozoan Complex	BRY	Bryozoans, ascidians, sponges - generally on rock substrate.
Brachiopods	BRA	Unidentified brachiopod.
	LAM	California lamp shell (*Laqueus californicus*).

Table A5. Continued.

Species or Species Complex	Code	Description
Seastars	BRE	Short-spined seastar (*Pisaster brevispinus*).
	EVA	False ochre seastar (*Evasterias troschelli*).
	PYC	Sunflower seastar (*Pycnopodia helianthoides*).
	POR	Ochre seastar (*Pisaster ochraceus*).
	DER	Leather star (*Dermasterias imbricata*).
	GEP	Gunpowder star (*Gephyreaster swifti*).
	WRS	Wrinkled star (*Pteraster militaris*).
	PTT	Slime star (*Pteraster tesselatus*).
	VER	Vermilion star (*Mediaster aequalis*).
	HEN	Seastar (*Henricia* sp.).
	SOL	Seastar (*Solaster* sp.).
	COO	Cookie star (*Ceremaster patagonius*).
	PLS	Pale star (*Leptychaster pacificus*).
	SMS	Spiny mudstar (*Luidia foliolata*).
	ORT	Painted star (*Orthasterias koehleri*).
	STF	Long ray star (*Stylasteria forreri*).
	SIX	Six-armed star (*Leptasterias* sp.).
	ROS	Rose star (*Crossaster papposus*).
	STR	Unidentified seastar.
Brittle Stars	BRT	Unidentified brittle star.
	GYB	Gray brittle star (*Ophiura lütkeni*).
Basket Stars	BSK	Basket star (*Gorgonocephalus* sp.).
Feather Stars	FST	Feather star (*Florometra serratissima*).
Sand Dollars	SDD	Sand dollar (*Dendraster excentricus*).
Sea Urchins	RSU	Red sea urchin (*Strongylocentrotus franciscanus*).
	GSU	Green sea urchin (*Strongylocentrotus droebachiensis*).
	WSU	White sea urchin (*Strongylocentrotus pallidus*).
	PSU	Purple sea urchin (*Strongylocentrotus purpuratus*).
Sea Cucumbers	RCU	Rea sea cucumber (*Cucumaria miniata*).
	WCU	White sea cucumber (*Psolus squamatus*).
	PAR	California sea cucumber (*Parastichopus californicus*).
	ASC	Aggregating sea cucumber (*Pseudocnus* sp.).
Tunicates	TUN	Unidentified tunicate.
	CIO	Tunicate (*Ciona* sp.).
	PEA	Pacific sea peach (*Halocynthia aurantium*)
In fauna "holes"	HLM	Mounded worm, clam or crustacean hole, but species or species group cannot be distinguished.
	HLF	Unmounded (flat) worm or clam hole, but species or species group cannot be distinguished.

Table A5. Continued.

Species or Species Complex	Code	Description
Fish	FSH	Unidentified fish.
	SAL	Unidentified salmonid.
	ELP	Unidentified eelpout (Zoarcidae).
	POA	Unidentified poacher.
	GBE	Black-eyed goby (*Coryphoterus nicholsi*).
	PLP	Pile perch (*Rhacochilus vacca*).
	PST	Striped perch (*Embiotica lateralis*).
	FTF	Unidentified flatfish.
	RFS	Unidentified rockfish.
	BRF	Black rockfish (*Sebastes melanops*).
	NRK	China rockfish (*Sebastes nebulosus*).
	CRK	Copper rockfish (*Sebastes caurinus*).
	QRF	Quillback rockfish (*Sebastes maliger*).
	TRF	Tiger rockfish (*Sebastes nigrocinctus*).
	YRF	Yelloweye rockfish (*Sebastes ruberrimus*).
	GLG	Unidentified greenling (Hexagrammid).
	KGR	Kelp greenling (*Hexagrammos decagrammus*).
	LNG	Lingcod (*Ophiodon elongatus*).
	SCU	Unidentified sculpin (Cottidae).
	NRN	Northern ronquil (*Ronquilus jordani*).
	RAT	Ratfish (*Hydrolagus colliei*).
	LSK	Longnose skate (*Raja rhina*)
Unknown	UNK	Macro fauna visible but cannot be identified.
No Fauna	**NOF**	No fauna observed.

Table A6. Faunal distribution classes.

Code	Descriptor	Distribution
1	Few	Rare (single) or a few sporadic individuals.
2	Patchy	A single patch, several individuals or a few patches.
3	Uniform	Continuous uniform occurrence.
4	Continuous	Continuous occurrence with a few gaps.
5	Dense	Continuous dense occurrence.
6		Code specific for school of fish.

