# Towed Benthic Video Survey of Site 1 for the Canpotex Potash Terminal Project Disposal at Sea Application

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**Barb Faggetter, Ph.D., R.P.Bio**
**Ocean Ecology**
1662 Parmenter Ave.
Prince Rupert, BC V8J 4R3
Telephone: (250) 622-2501
Email: blueseas@oceanecology.ca

# Towed Benthic Video Survey of Site 1 for the Canpotex Potash Terminal Project Disposal at Sea Application

Prepared for: Sandra Webster, PhD, R.P.Bio.
Senior Biologist, Environmental Management
Stantec
4370 Dominion Street 5th Floor
Burnaby BC V5G 4L7

Prepared by: Ocean Ecology

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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 120 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 63 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 100%. This was not surprising given the homogeneity of the site substrate and the ubiquitous nature of “unmounded hole” fauna.

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 was homogenously silt-mud, except for a small amount of rock seen in northwest corner of the site.
3. Anthropogenically-produced garbage was observed in small amounts at the site. This garbage appeared to provide habitat complexity for organisms such as spot prawns, which aggregated in large numbers around the garbage.
4. Due to the depth of the site, no flora was observed.
5. The most dominant fauna at the site 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. Unmounded holes were distributed more or less uniformly throughout the site. While not clearly identifiable, many clam species were probably present throughout the site, as indicated by the presence of empty shells on the surface of the substrate.
6. As a group, fish were the most diverse organisms at the site.
7. Plumose anemones were found in association with the small amount of rock observed at the site, whereas sea whips were found associated with silt-mud substrate. Both species occurred largely at depths shallower than 50 m, and thus were located in a “rim” around the site boundary.
8. Both Dungeness and tanner crabs were found in moderate abundance at the site. While their ranges overlap somewhat, Dungeness crabs tended to be found in shallower water than tanner crabs. As a result, the Dungeness crabs were located mainly around the “rim” of Site 1, whereas the tanner crabs were found in the “depression” of Site 1.
9. Spot prawns were very abundant at the site, and were found mainly at depths below 50 m. Based on life stage depth and substrate preferences, the spot prawns observed at Site 1 were most likely adult males. They are probably a localized population, with limited migration out of the site into shallower areas with rockier substrate for feeding and during breeding.
10. Northern ronquils were very abundant at the site, as well as a variety of flatfish. Starry flounders and rock soles were found mainly in the northern regions of the site. Northern ronquils and unidentified eelpout and sculpin species were observed throughout the site.

11. The following commercial species were observed at the site:
    a. spot prawns in high abundance
    b. Dungeness crabs in moderate abundance
    c. tanner crabs in moderate abundance
    d. flatfish in moderate abundance
    e. longnose skates in low abundance
12. The overall Shannon's diversity index for the site was 2.629, and the species richness was 22. By comparison with other local sites, the diversity for this site is quite low.
13. Maximum species richness for the site occurred in the deeper regions of the site and towards the northern end of the site. In general, maximum diversity appears to be correlated with anything that increases habitat complexity, such as (1) rocks in the northwest corner of the site; and (2) anthropogenically-derived garbage in the deeper northern parts of the site

# 1 Introduction

Canpotex and the Prince Rupert Port Authority (PRPA) are proposing to dispose of ~724,000 $m^3$ of dredgate at one or two new disposal sites within the PRPA harbour boundaries. Baseline information is required for the environmental assessment (EA) of this project, and by Environment Canada as part of the permit application process for disposal at a new site.

As a part of the baseline study for the project, a towed benthic video survey was carried out at the smaller and shallower of the two proposed disposal sites, referred to as Site 1 (see Figure 1).

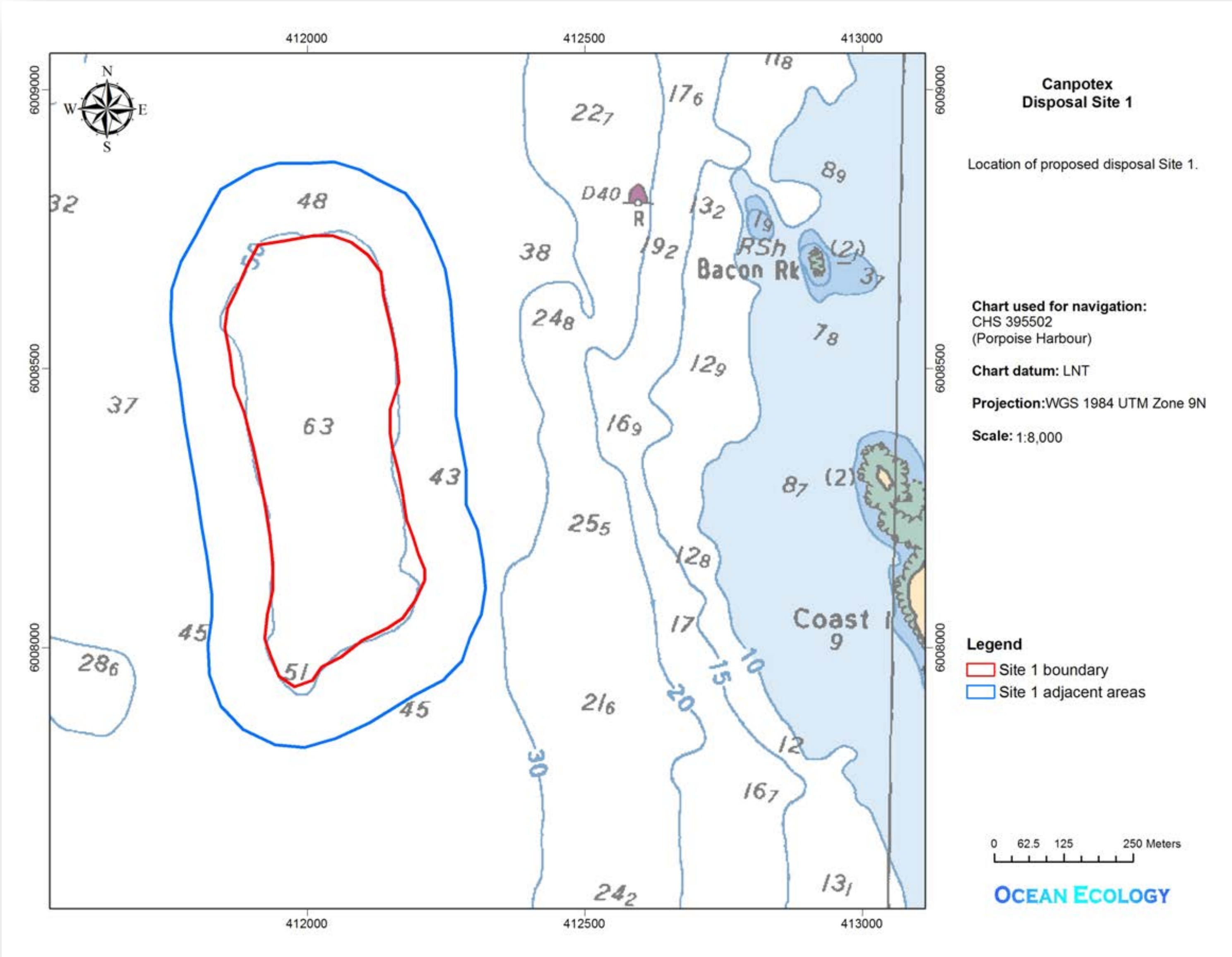


Figure 1. Location of proposed disposal Site 1.

# 2 Canpotex Disposal Site 1 Survey Methodology

## 2.1 Towed Benthic Video Survey

### *2.1.1 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 (e.g., not commercially available) designed for use in the steep, rugged terrain characteristic of British Columbia fjords (see Figure 2). Typical tow speed for the system was 0.7 knots. The towed video system has 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 downward-looking camera was also equipped with a pair of scaling lasers with a center-to-center distance of 4 cm.

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.

Figure 2. Towed video camera system about to be deployed.

### *2.1.2 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.

### *2.1.3 Survey Design*

The benthic video survey of Site 1 was carried out on April 16$^{th}$ and 17$^{th}$, 2011. The survey design consisted of a grid survey pattern with a nominal shore-normal and shore-parallel transect line spacing of 120 m (see Figure 3). Surveys were carried out in waters up to approximately 63 m depth.

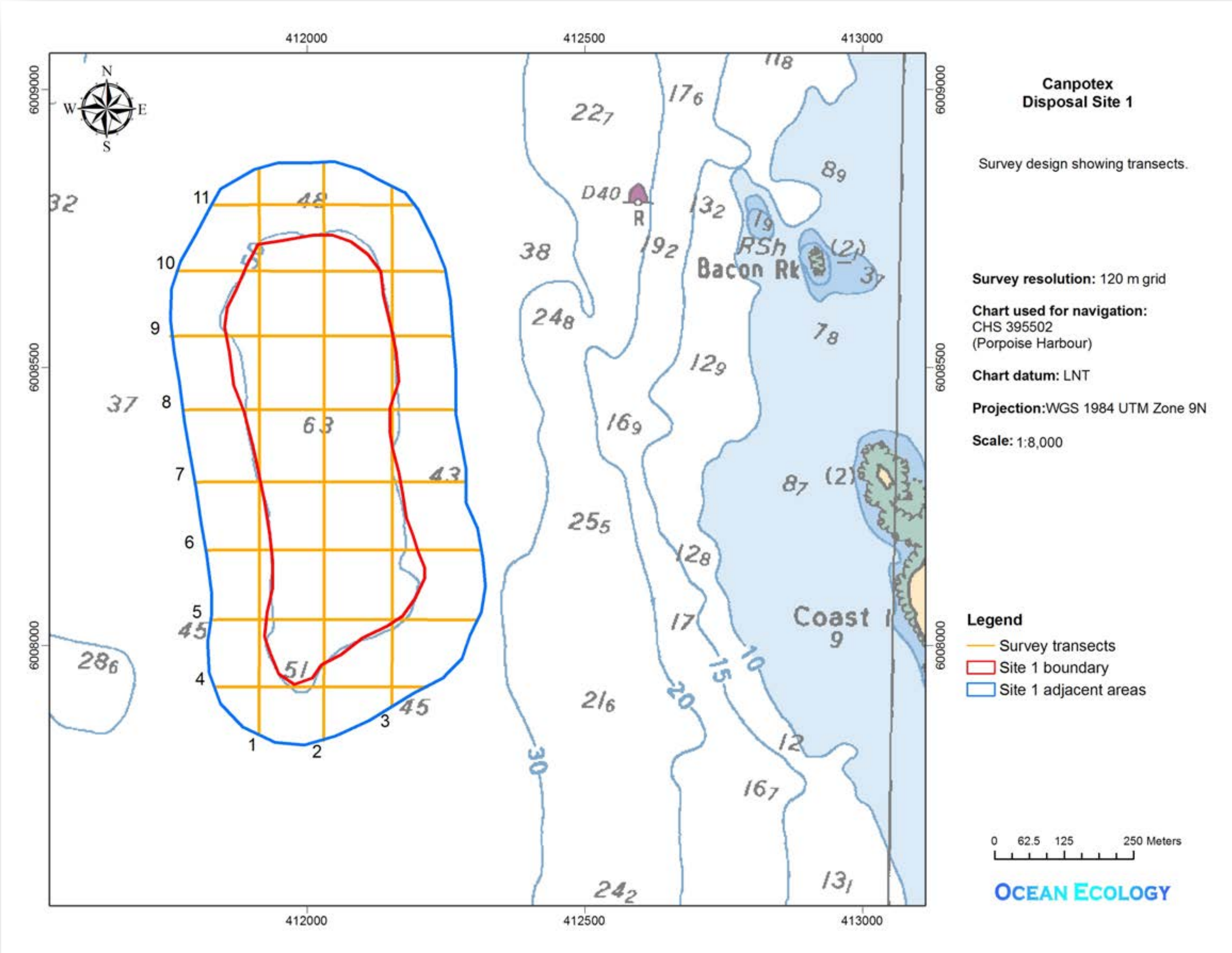


Figure 3. Survey design showing transects.

## 2.2 Classification and Mapping

### *2.2.1 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 3 in the Appendix) and percentage substrate cover (Table 5 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 6 in the Appendix) and fauna (Table 8 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 7 in the Appendix) and faunal distribution classes (Table 9 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.

### *2.2.2 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.

### *2.2.3 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, fauna) was recorded and used to generate percentage confidence.

### *2.2.4 Range Maps*

Range maps for fauna were generated using the fixed kernel density estimation procedure. Fauna observations were weighted by distribution (see Table 9 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., 120 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.

### *2.2.5 Dominant Species Maps*

Species observations for fauna were mapped as a series of points in ArcMap. A hexagonal grid (composed of hexagonal polygons with widths of 30 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 distribution. Polygons which contained no data points were assigned the code of the nearest neighbouring polygon.

### *2.2.6 Minor Species Maps*

Species observations for fauna were mapped as a series of points in ArcMap. A hexagonal grid (composed of hexagonal polygons with widths of 30 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 distribution. Polygons which contained no data points were assigned the code of the nearest neighbouring polygon.

### *2.2.7 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.

### *2.2.8 Species Richness Maps*

A hexagonal grid (composed of hexagonal polygons with widths of 30 m) was overlaid on a shape file containing the fauna range map polygons. 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.

# 3 Canpotex Disposal Site 1 Survey Results

## 3.1 Benthic Video Survey

The transect lines for the survey as carried out are shown in Figure 4. Coverage for the site was excellent, with good extension of the transects to the edges of the proposed disposal site boundary. Other factors which had an effect on the survey quality and resolution were:

1. ***Turbid water*** – the site is located directly in the plume of the Skeena River (see Figure 5), 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 (less than 0.5 knots).
2. ***Strong currents*** – strong currents occasionally made course-holding difficult on a few of the transects.
3. ***Loss of DGPS signal*** – occasionally during the survey, the high accuracy DGPS signal was lost, and a lower accuracy GPS signal had to be used, thus increasing positional error. Overall, a DGPS quality signal was received for 91% of the video survey.
4. ***Video interference*** - on April 16$^{th}$, 2011, significant electromagnetic interference occurred in the video signal during the survey at Site 1. This interference did not occur during equipment set-up at Rushbrook dock, was not observed at the site on April 17$^{th}$, 2011, and did not occur again during video surveys at other sites the following week. It appears that some equipment at Ridley Island, or on the ships loading at the terminals, was generating an electromagnetic signal with sufficient power at a frequency which resulted in video interference.

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

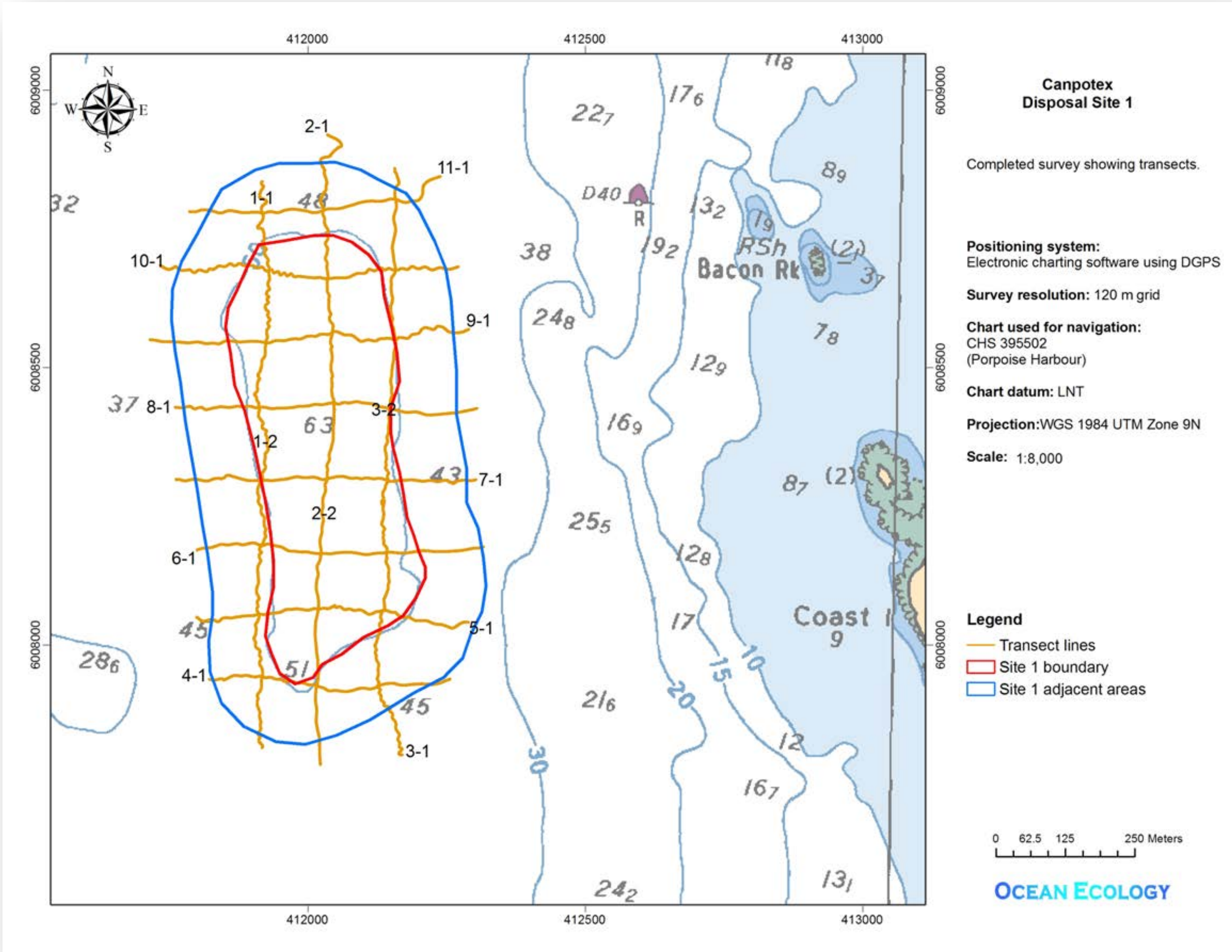


Figure 4. Completed survey showing transects.

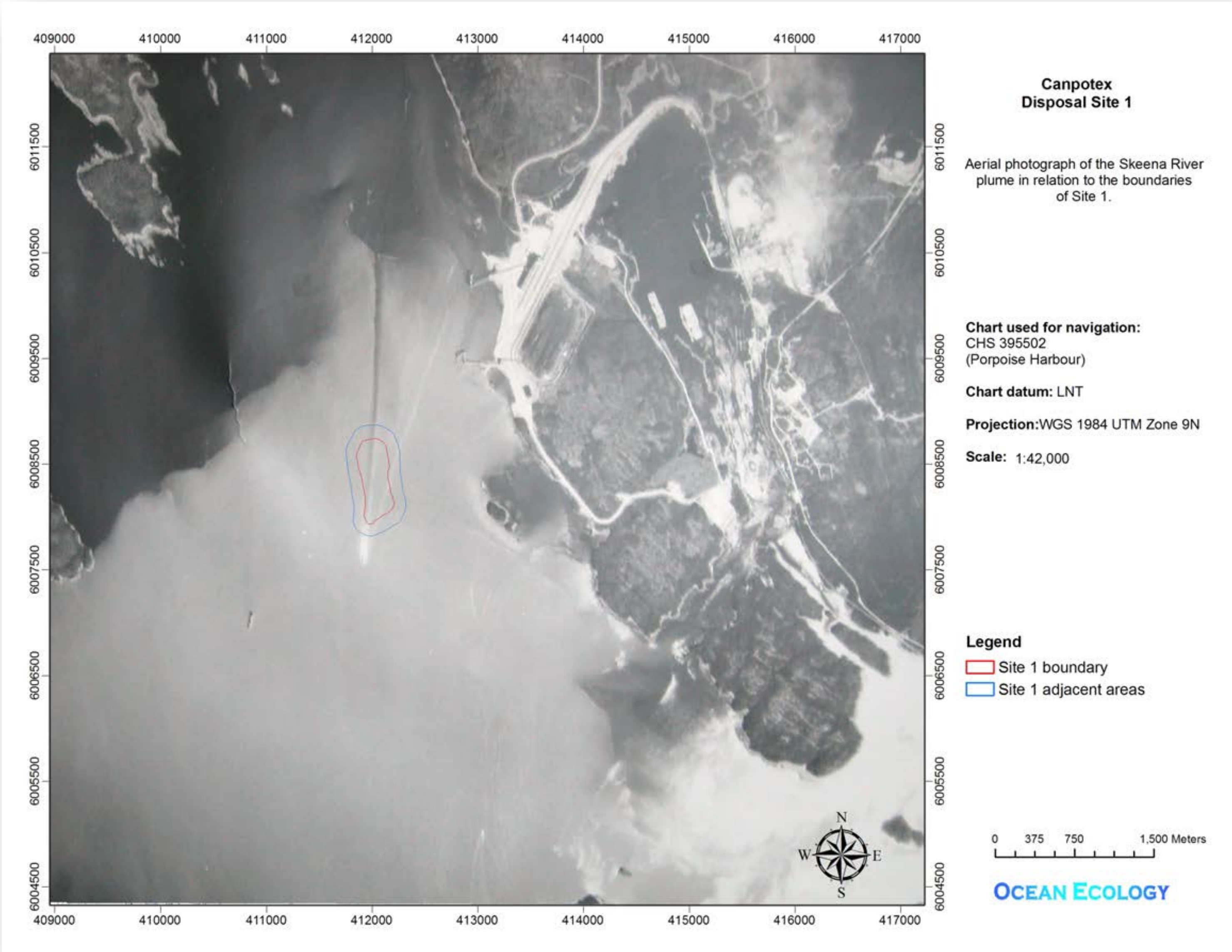


Figure 5. Aerial photograph of the Skeena River plume in relation to the boundaries of Site 1.

### 3.2 Survey Confidence Levels

A total of 24 cross-over points were used to determine the survey confidence levels (refer to the “Cross over analysis” layer in the attached ArcGIS project). Each pair of records was compared for:

1. substrate
2. fauna

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 | 24 | 24 | 100 |
| Fauna | 24 | 24 | 100 |
| **Overall** | **48** | **48** | **100** |

The overall confidence level of 100% is not surprising given the homogeneity of the site substrate and the ubiquitous nature of “unmounded hole” fauna.

### 3.3 Substrate

Based on video observations, the site substrate was homogenously silt-mud, except for a small amount of rock seen in northwest corner of the site. Figure 6 shows the locations of the 30 m diameter polygons in which rock was observed from the video survey.

Anthropogenically-produced garbage was observed in small amounts at the site. Figure 7 shows the locations of the 30 m diameter polygons in which garbage was observed from the video survey. Interestingly, in the flat and featureless benthic environment of Site 1, these “garbage dumps” formed regions where certain organisms, such as spot prawns, aggregated in large numbers. Detailed analysis of video transects reported by Schlining (1999) showed that prawns were not usually associated with barren sediments, but appeared to actively seek out habitats that were more complex, including drift algae (loose kelp on the sea floor). Anthropogenically-produced garbage may also provide habitat complexity for these organisms.

### 3.4 Flora

Due to the depth of the site, no flora was observed.

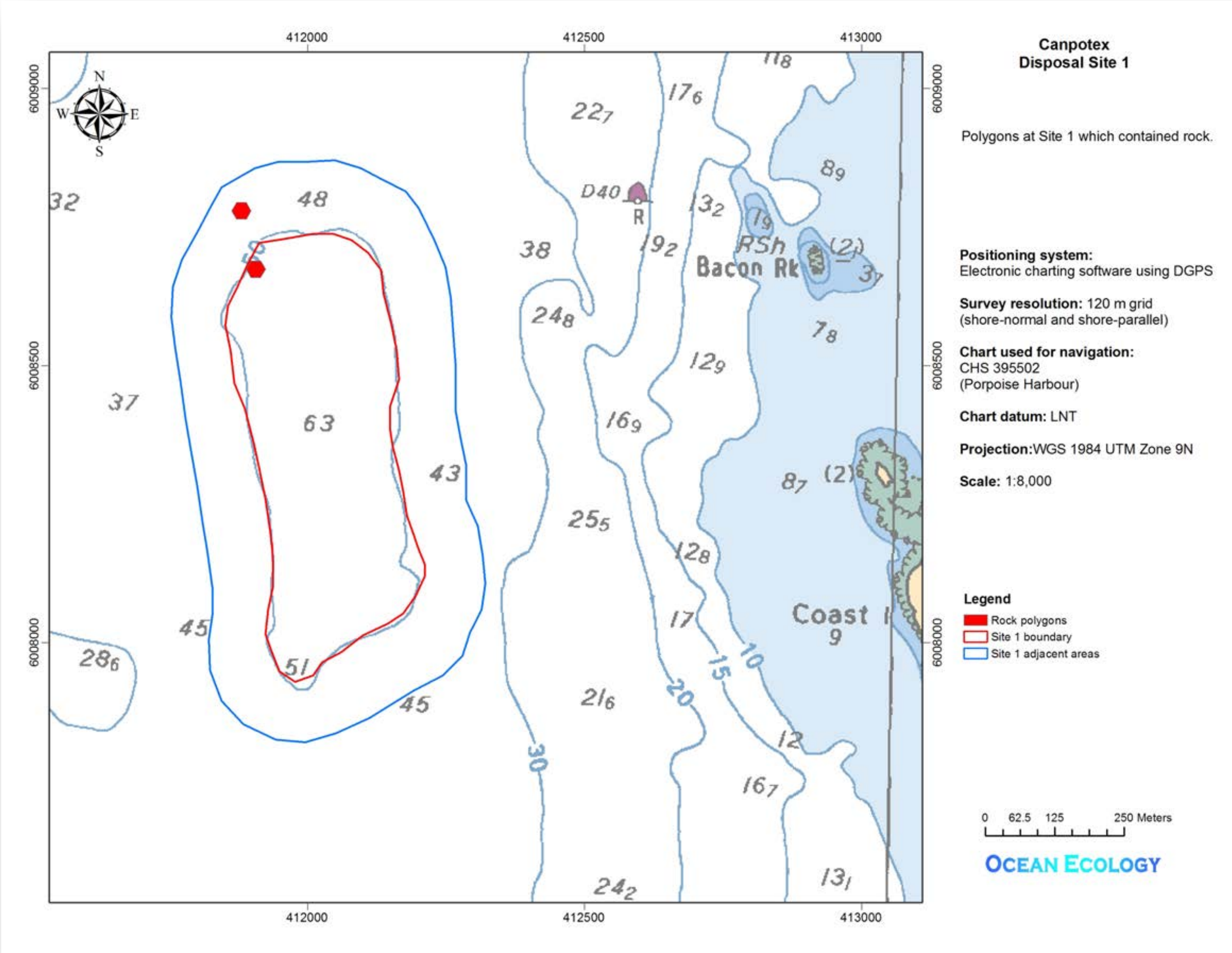


Figure 6. Polygons at Site 1 which contained rock.

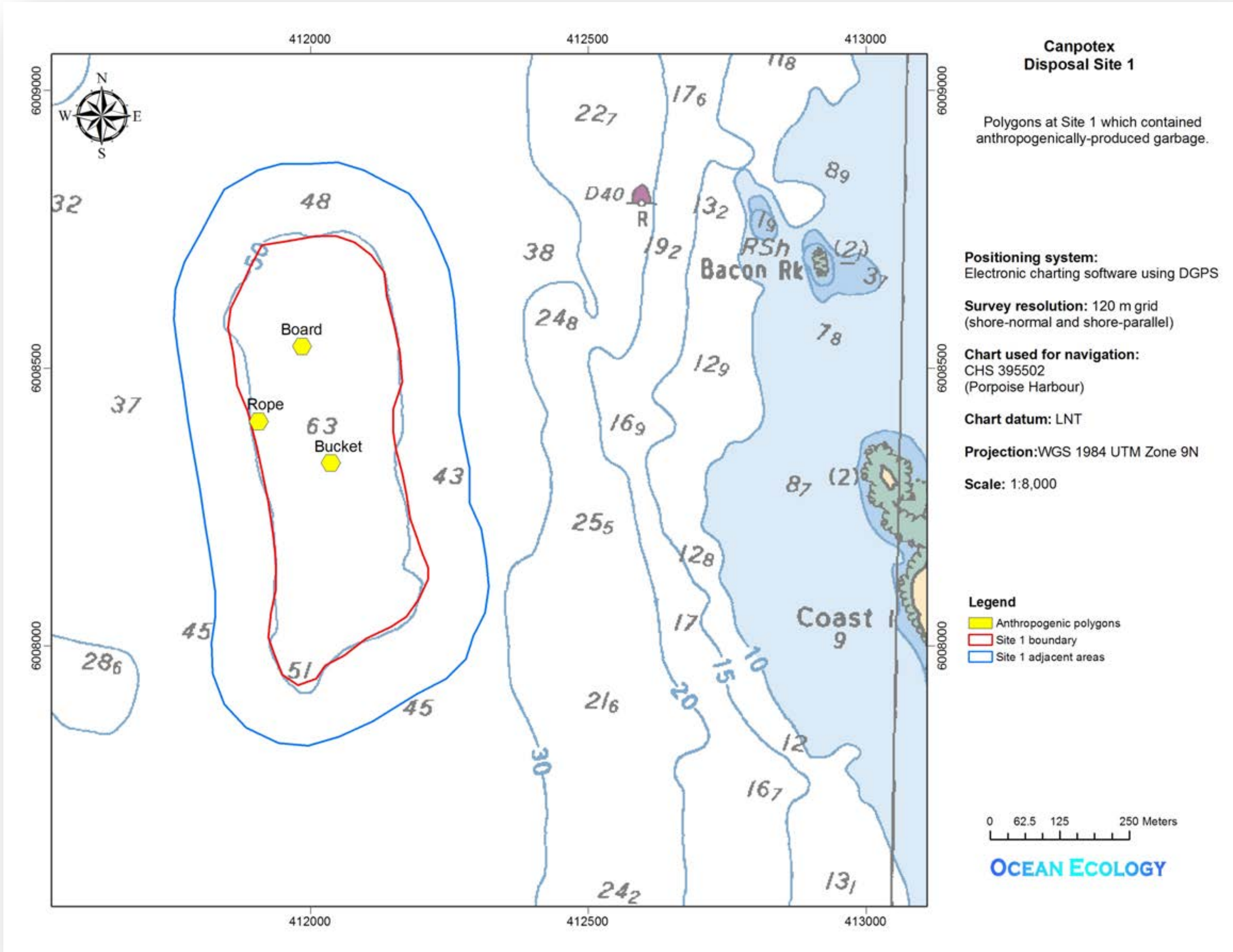


Figure 7. Polygons at Site 1 which contained anthropogenically-produced garbage.

### 3.5 Fauna

Table 2 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 2. Abundances of various fauna groups.

| Fauna identification | Number of Observations | % of Total Fauna Abundance by Area |
|---|---|---|
| Unmounded hole | 20178 | 15.57 |
| Northern ronquil | 506 | 14.67 |
| Spot prawn | 393 | 6.65 |
| Unidentified flatfish | 57 | 12.16 |
| Unidentified eelpout | 46 | 10.70 |
| Dungeness crab | 25 | 7.69 |
| Tanner crab | 23 | 6.18 |
| Plumose anemone | 19 | 1.61 |
| Rock sole | 15 | 4.50 |
| Starry flounder | 9 | 2.88 |
| Unidentified sculpin | 9 | 3.34 |
| Sea whip | 8 | 3.24 |
| Unidentified fish | 8 | 2.41 |
| Big skate | 2 | 0.84 |
| Moon jellyfish | 2 | 0.84 |
| Mounded hole | 2 | 0.84 |
| Orange sea pen | 2 | 1.66 |
| Ratfish | 2 | 0.84 |
| Sunflower seastar | 2 | 0.84 |
| Pacific snake prickleback | 1 | 0.84 |
| Snake lock anemone | 1 | 0.84 |
| Striped nudibranch | 1 | 0.84 |

Some observations regarding fauna at Site 1 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. Unmounded holes were distributed more or less uniformly throughout the site.
2. As a group, fish 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. Plumose anemones were found at the northwest corner of the site in association with the small amount of rock observed in this region (see Figure 8). Sea whips were found at both the north and south ends of the site associated with silt-mud substrate (see Figure 8). Both species occurred largely at depths shallower than 50 m, and thus were located in a “rim” around the site boundary.

    b. Spot prawns were the third most abundant organism at the site, and were found mainly at depths below 50 m. Mature adult spot prawns are found on bottom types ranging from soft to rocky. In the northern part of their range (Alaska and northern British Columbia), they are most abundant between 45 - 140 m. Males are typically caught in bottom trawls on sandy or muddy bottoms, while females are rarely caught outside rocky habitat (Lowry, 2007; Berkeley, 1930). Thus, the spot prawns observed at Site 1 were most likely adult males. Once they have settled and migrated to adult grounds, spot prawns appear to remain in a very restricted area throughout the rest of their life; probably limited by the size of the habitat patch they inhabit (Lowry, 2007). Tagging studies have shown that prawns were captured within 1.7 km of their release location over a period of several years (Kimker *et al*., 1996). The spot prawns at Site 1 are probably a localized population, with limited migration out of the site into shallower areas with rockier substrate for feeding and during breeding.

    c. Both Dungeness and tanner crabs were found in moderate abundance at Site 1 (see Figure 10). While their ranges overlap somewhat, Dungeness crabs tended to be found in shallower water than tanner crabs. As a result, the Dungeness crabs were located mainly around the “rim” of Site 1, whereas the tanner crabs were found in the “depression” of Site 1.

    d. Northern ronquils were the second most abundant organism at the site, and were distributed fairly evenly throughout the site. Also abundant were a variety of flatfish, mostly unidentifiable in the video footage (see Figure 11). The larger, and thus more easily identifiable, starry flounders and rock soles were found mainly in the northern regions of the site. Unidentified eelpout and sculpin species were observed throughout the site (see Figure 12).

    e. Unmounded holes were the most abundant group of organisms at the site, and were distributed uniformly throughout the site. These holes probably represented a variety of infaunal organisms; however most cannot be accurately identified from video images. While not clearly identifiable, many clam species were probably present throughout the site, as indicated by the presence of empty shells on the surface of the substrate.

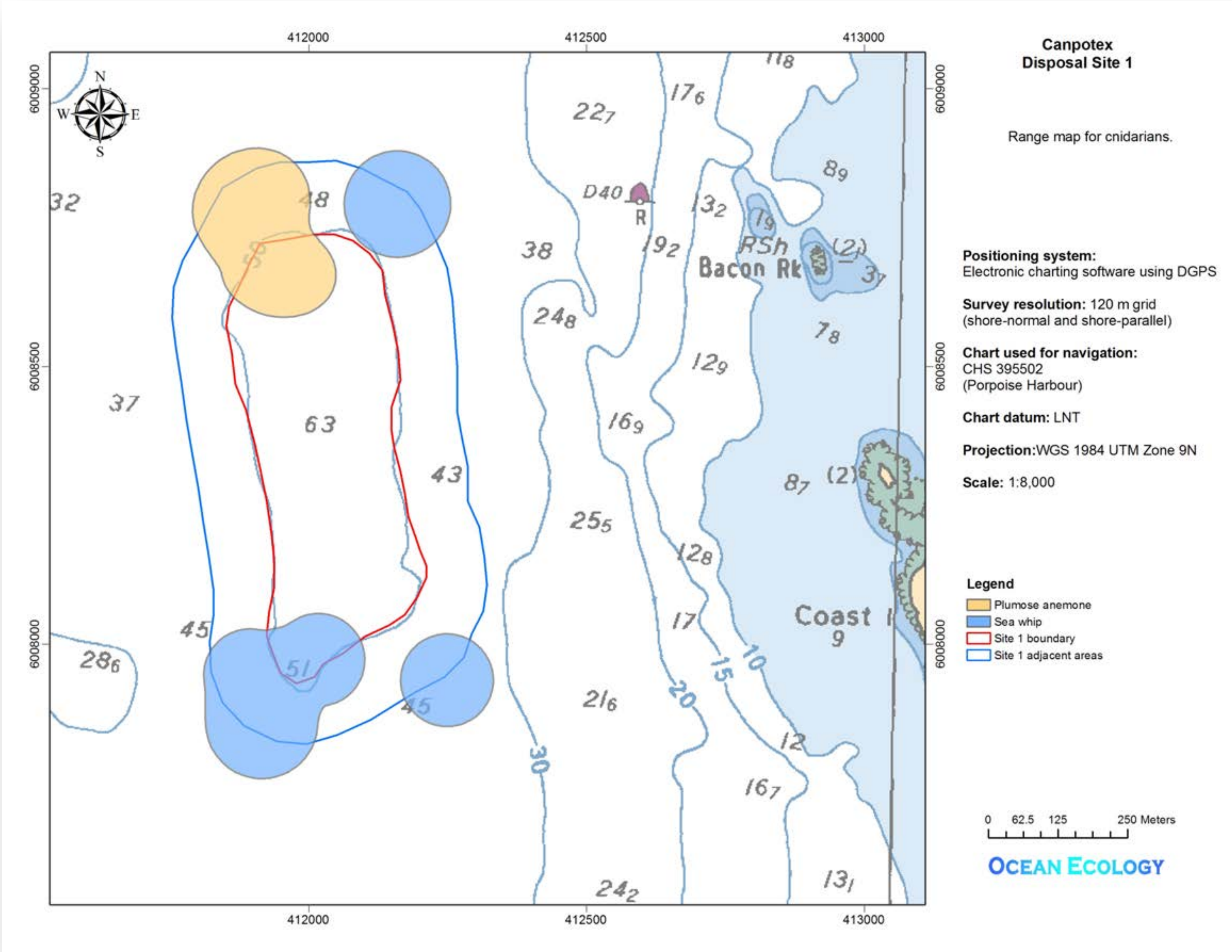


Figure 8. Range map for cnidarians.

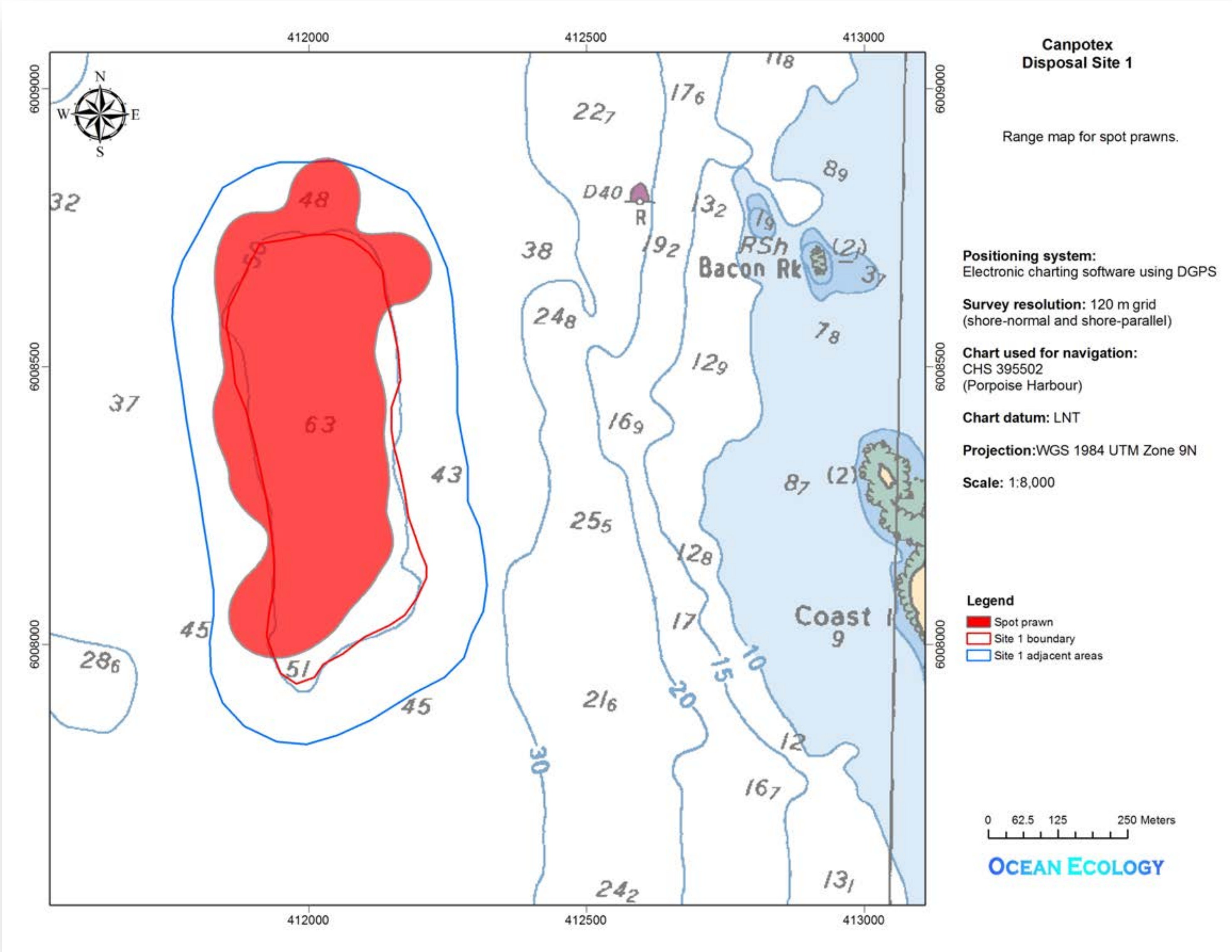


Figure 9. Range map for spot prawns.

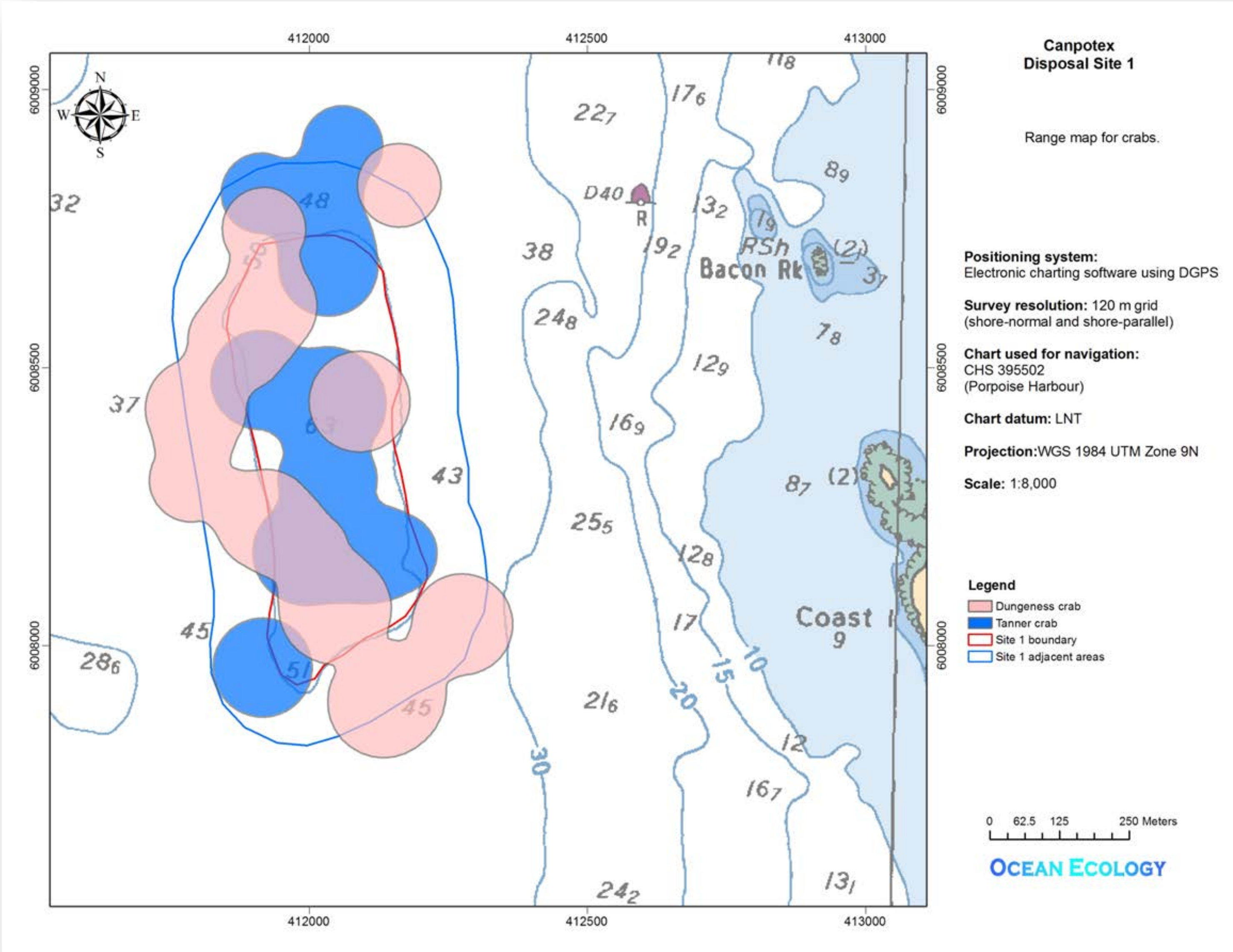


Figure 10. Range map for crabs.

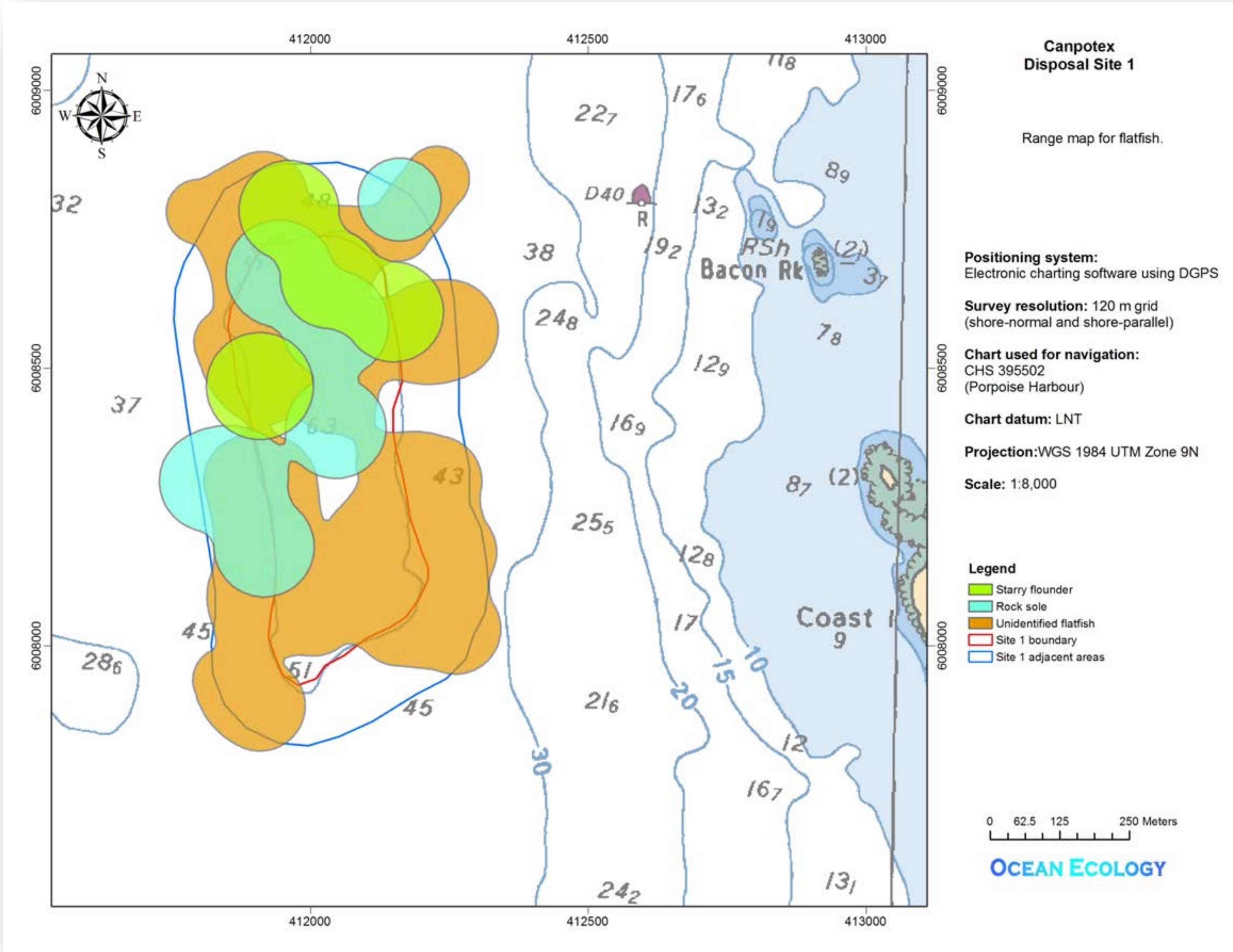


Figure 11. Range map for flatfish.

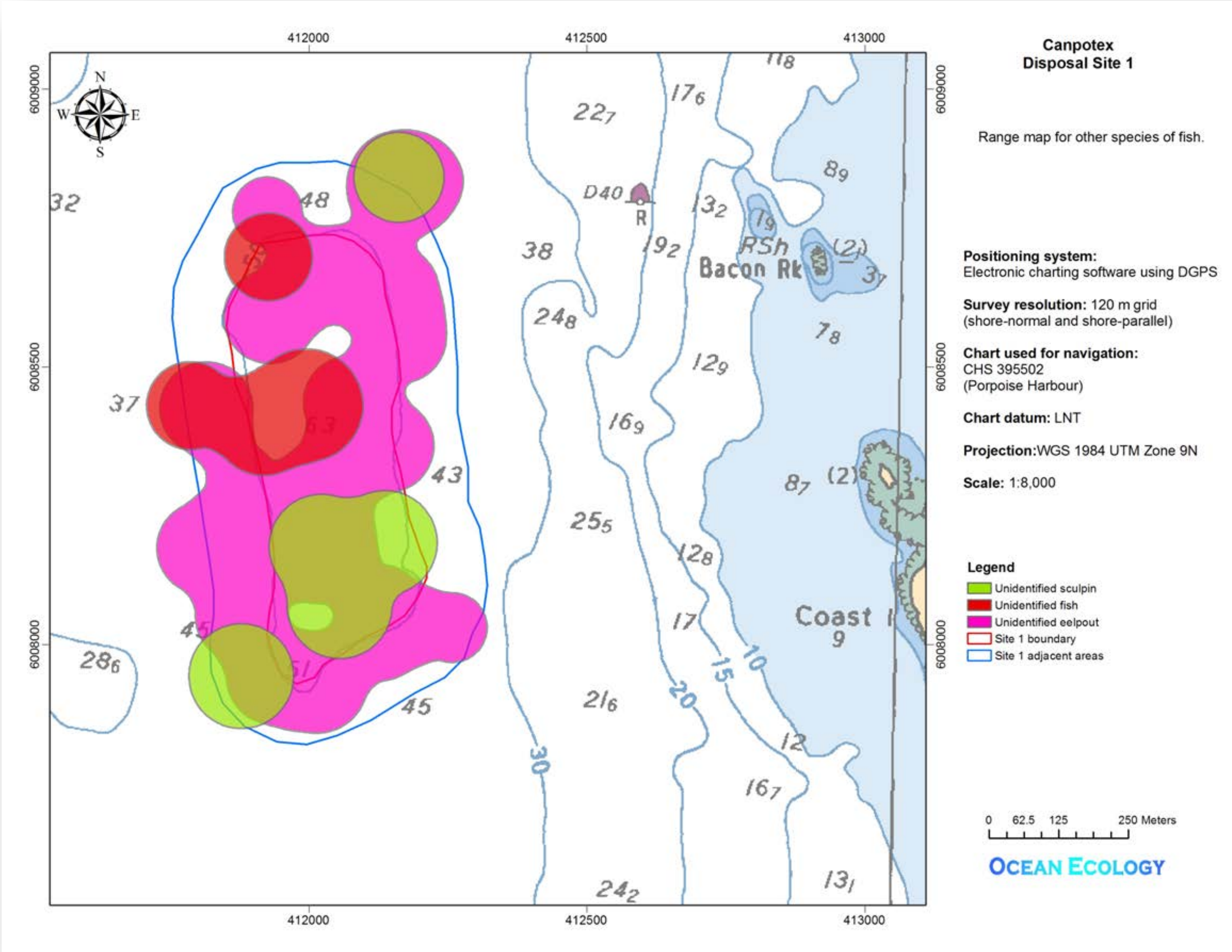


Figure 12. Range map for other species of fish.

4. The following commercial species were observed at the site:
    a. spot prawns in high abundance
    b. Dungeness crabs in moderate abundance
    c. tanner crabs in moderate abundance
    d. flatfish in moderate abundance
    e. longnose skates in low abundance

## 3.6 Diversity Analyses

### *3.6.1 Dominant and Minor Fauna Analyses*

Analysis of fauna species dominance shows that unmounded holes are clearly the most dominant fauna overall (see Figure 13). Only in two small locations are other organisms more dominant: (1) in the northwest corner of the site where a small amount of rock is present and plumose anemones become dominant, and (2) at one small spot in the middle of the site where an anthropogenically-derived “board” increases habitat complexity for spot prawns, thus increasing their abundance and dominance.

In considering the entire site, fauna diversity is relatively low, as shown in the map of minor species (see Figure 14). Three species groups - unmounded holes, northern ronquils, and spot prawns - dominated the majority of the polygons. On a smaller scale perspective, 25% of the individual polygons showed no diversity (e.g., only one type of organism was observed within the polygon). 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.

### *3.6.2 Diversity Indices*

The overall Shannon’s diversity index for the site was 2.629, and the species richness was 22. This is much lower than that at the nearby Canpotex site, which had an overall Shannon’s diversity index of 3.734 and a species richness of 57. If all organisms at Site 1 were completely evenly distributed (which would generate a maximum value for Shannon’s diversity index), the maximum possible diversity for the site would be 3.091. This suggests that the particular complement of species at this site is fairly close to reaching their maximum diversity. The Shannon’s evenness value of 0.850 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 2.629 for Site 1 is very low (i.e., it has a relative richness of 37% using a maximum potential species richness of 60).

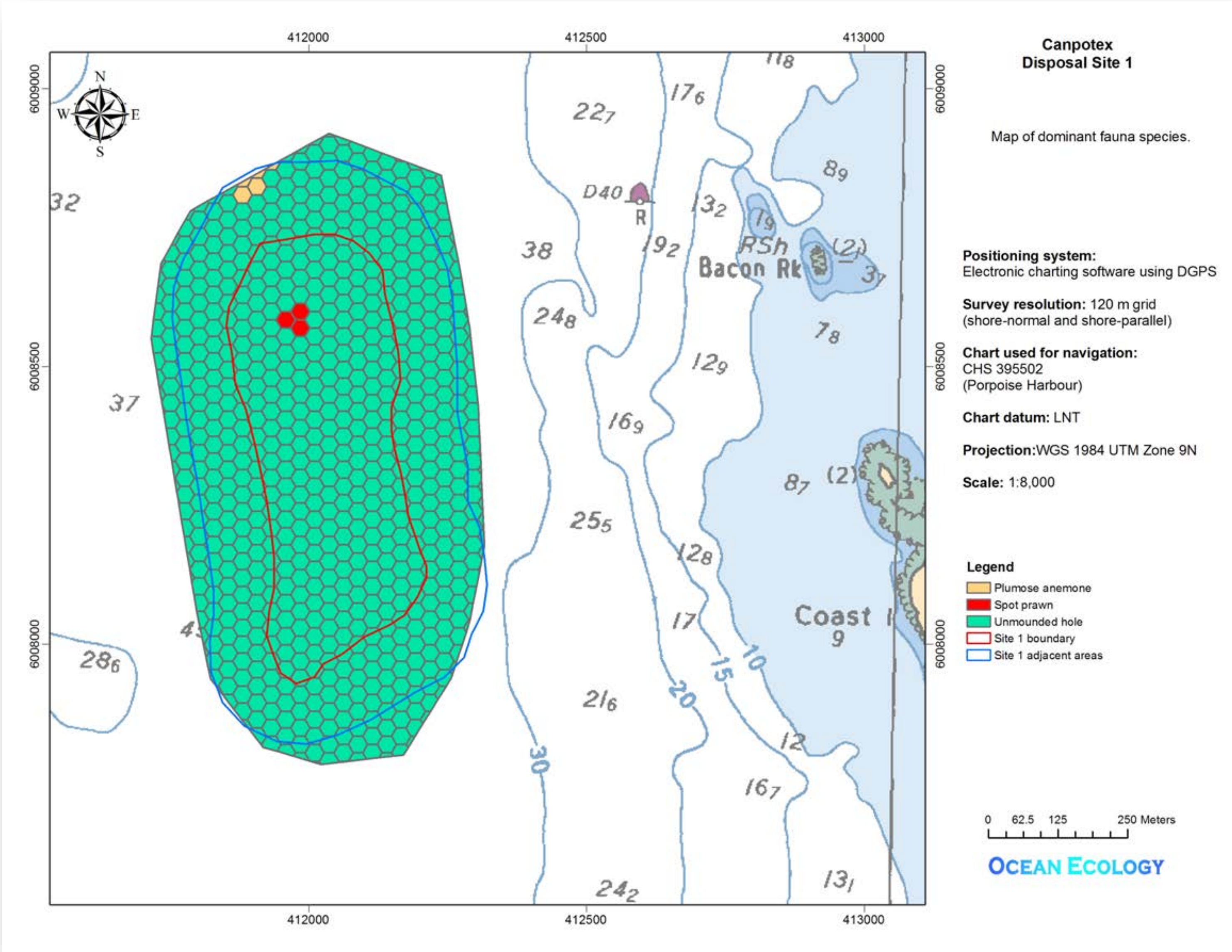


Figure 13. Map of dominant fauna species.

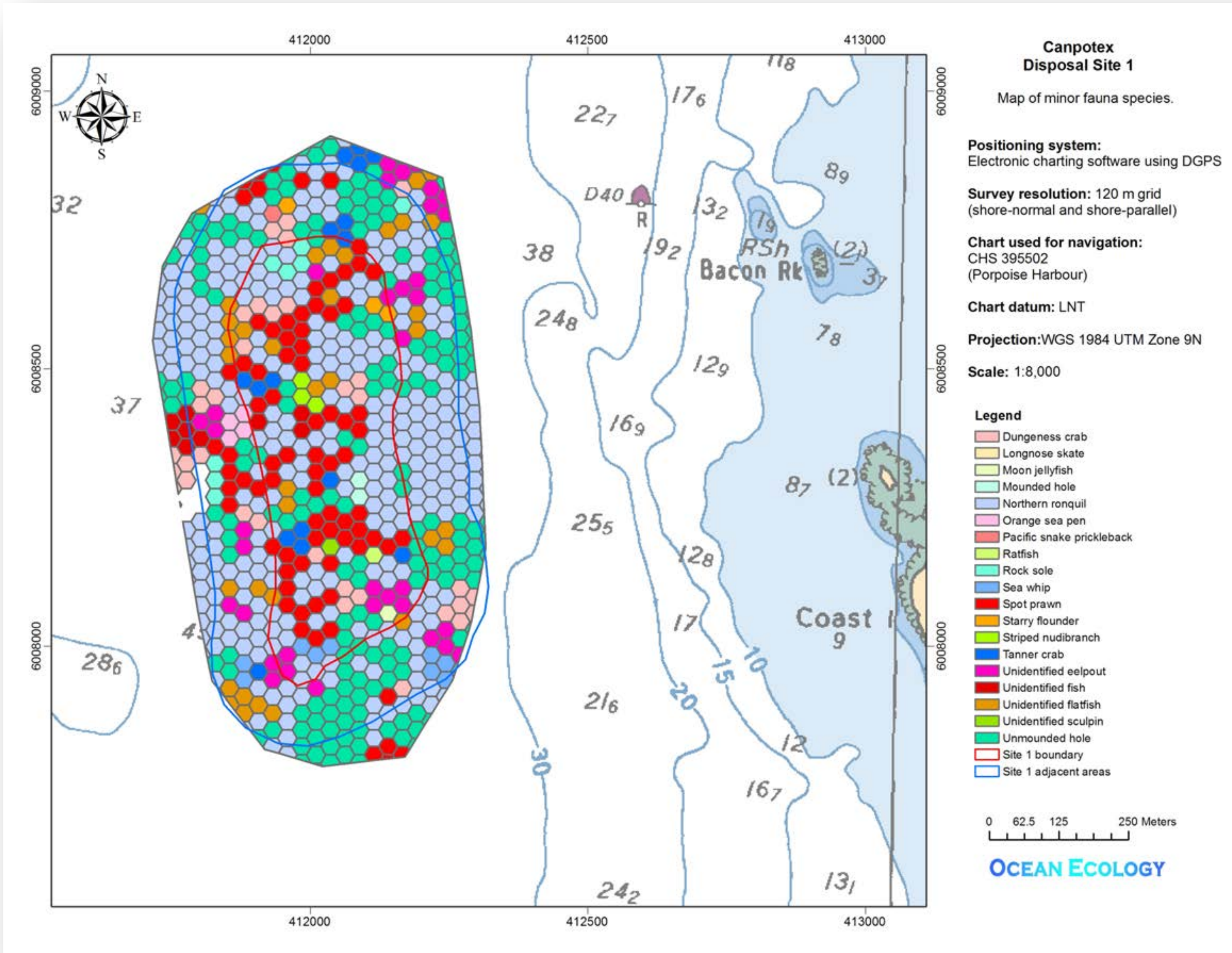


Figure 14. Map of minor fauna species.

The site has a Simpson's dominance index of 0.462. The Simpson's dominance index approaches 1.0 as one particular species dominates the site. A value of 0.462 suggests that there is some dominance by organisms (particularly unmounded holes, northern ronquils, and spot prawns) at the site, but only limited areas of extreme dominance (e.g., 25% of the site where only one species is found).

Figure 15 shows the species richness map for the site. Species richness in each hexagonal polygon ranges from 0 to 13 (as compared to a species richness range of 0 to 35 for the Canpotex site). Maximum species richness for the site occurs in the deeper regions of the site and towards the northern end of the site. In general, maximum diversity appears to be correlated with anything that increases habitat complexity, such as (1) rocks in the northwest corner of the site; and (2) anthropogenically-derived garbage in the deeper northern parts of the site.

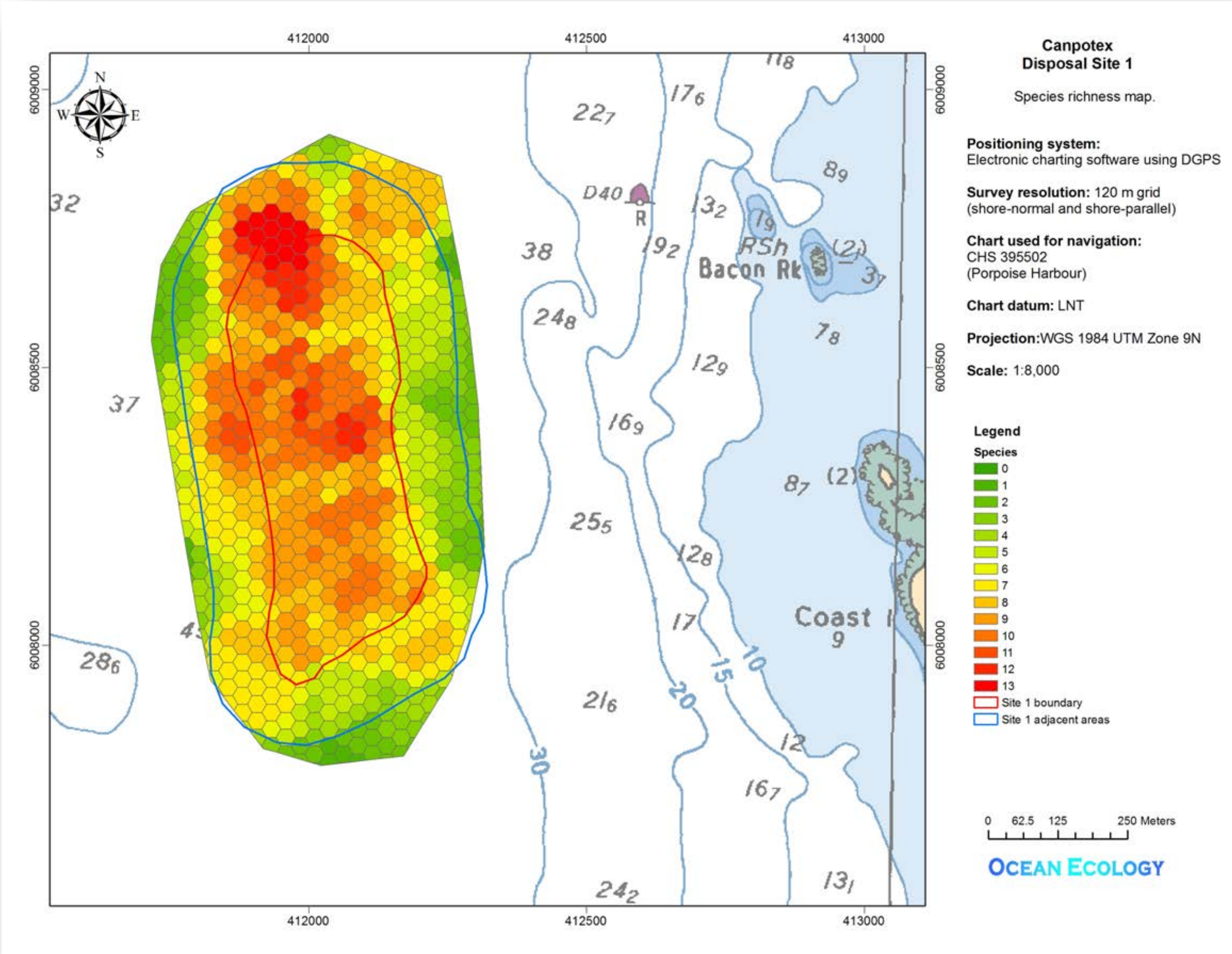


Figure 15. Species richness map.

# 4 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. Five 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
3. One DVD 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.

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

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# 6 Appendix

Table 3. 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 4. Average particle size values.

| Substrate Class/Subclass | Average Size (mm) |
|---|---|
| Rock | 10000 |
| Veneer over bedrock | 10000 |
| Boulder | 512 |
| Cobble | 256 |
| Pebble | 64 |
| Granules | 4 |
| Sand | 2 |
| Silt-mud | 0.62 |
| Shell | -- |
| Organic debris | -- |
| Wood debris | -- |
| Anthropogenic | -- |

Table 5. Percentage substrate cover codes.

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

Table 6. 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*. |
| | Three-ribbed kelp | TRK | *Cymathere triplicata*. |
| | 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. |

| 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.* |
| | Red fringe | RFR | *Smithora.naiadum* |
| 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 7. 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 8. 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*). |

| 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*). |
| | BXC | Box crab (*Lopholithodes foraminatus*). |
| | HEC | Helmet crab (*Telmessus cheiragonus*). |
| | 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. |
| | ELI | Eelgrass limpet (*Lottia alveus paralella*). |
| | NUC | Dogwinkle (*Nucella* sp.). |
| | CDV | Carinate dovesnail (*Alia carinata*) |
| | TBI | Threaded bittium (*Bittium eschrichtii*) |
| | MOO | Moon snail (*Euspira lewisii*). |
| | WLN | White-lined nudibranch (*Dirona albolineata*). |
| | TOT | Orange-peel nudibranch (*Tochuina tetraquetra*). |
| | SNU | Striped nudibranch (*Armina californica*) |
| 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*). |

| 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. |

| Species or Species Complex | Code | Description |
|---|---|---|
| Fish | FSH | Unidentified fish. |
| | SAL | Unidentified salmonid. |
| | ELP | Unidentified eelpout (Zoarcidae). |
| | POA | Unidentified poacher. |
| | PSP | Pacific snake prickleback (*Lumpenus sagitta*) |
| | TUS | Tubesnout (*Aulorhynchus flavidus*). |
| | GBE | Black-eyed goby (*Coryphoterus nicholsi*). |
| | PLP | Pile perch (*Rhacochilus vacca*). |
| | PST | Striped perch (*Embiotica lateralis*). |
| | SHP | Shiner perch (*Cymatogaster aggregata*). |
| | FTF | Unidentified flatfish. |
| | STF | Starry flounder (*Platichthys stellatus*). |
| | RKS | Rock sole (*Lepidopsetta bilineata*) |
| | 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*). |
| | BSK | Big skate (*Raja binoculata*) |
| | LSK | Longnose skate (*Raja rhina*) |
| Unknown | UNK | Macro fauna visible but cannot be identified. |
| **No Fauna** | **NOF** | No fauna observed. |

Table 9. 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. |

# 7 Disclaimer

The findings presented in this report are based upon data collected during the days April16th and April 17th, 2011 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.

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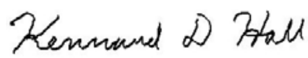
Any questions concerning the information or its interpretation should be directed to the undersigned.

Prepared By:

Barb Faggetter, Ph.D
Oceanographer, R.P.Bio.

Reviewed By:



Kennard Hall, Captain
Partner, Ocean Ecology