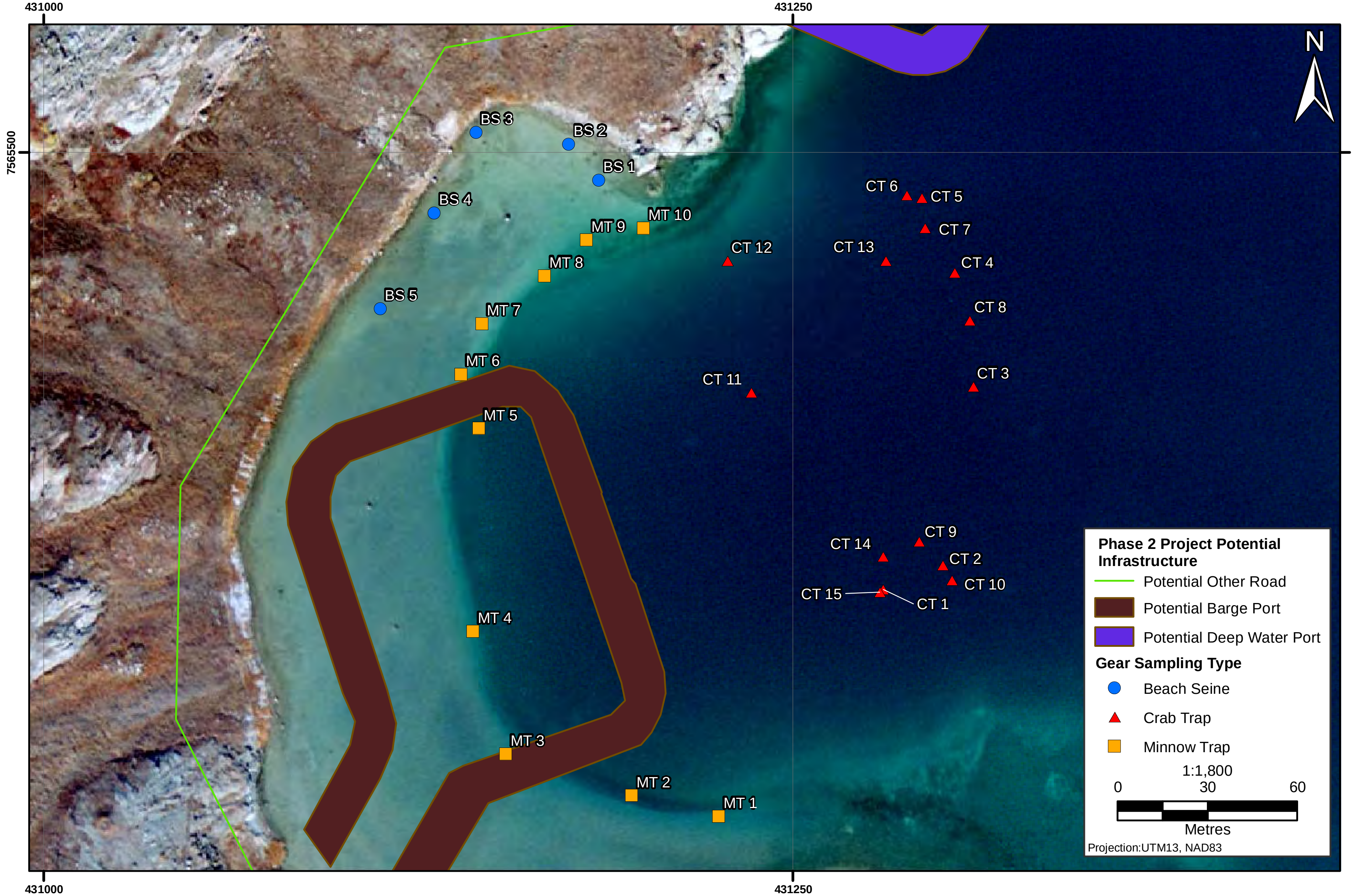


Figure 2.3-19

NEWMONT NORTH AMERICA

Beach Seine, Minnow Trap and Crab Trap Locations During the Early Sampling Survey of the Fish Community at Site P4 in Roberts Bay, Hope Bay Belt Project, 2010

Figure 2.3-19

Rescan Engineers & Scientists

PROJECT # 1009-002-08 GIS # HB-06-098d November 8, 2010

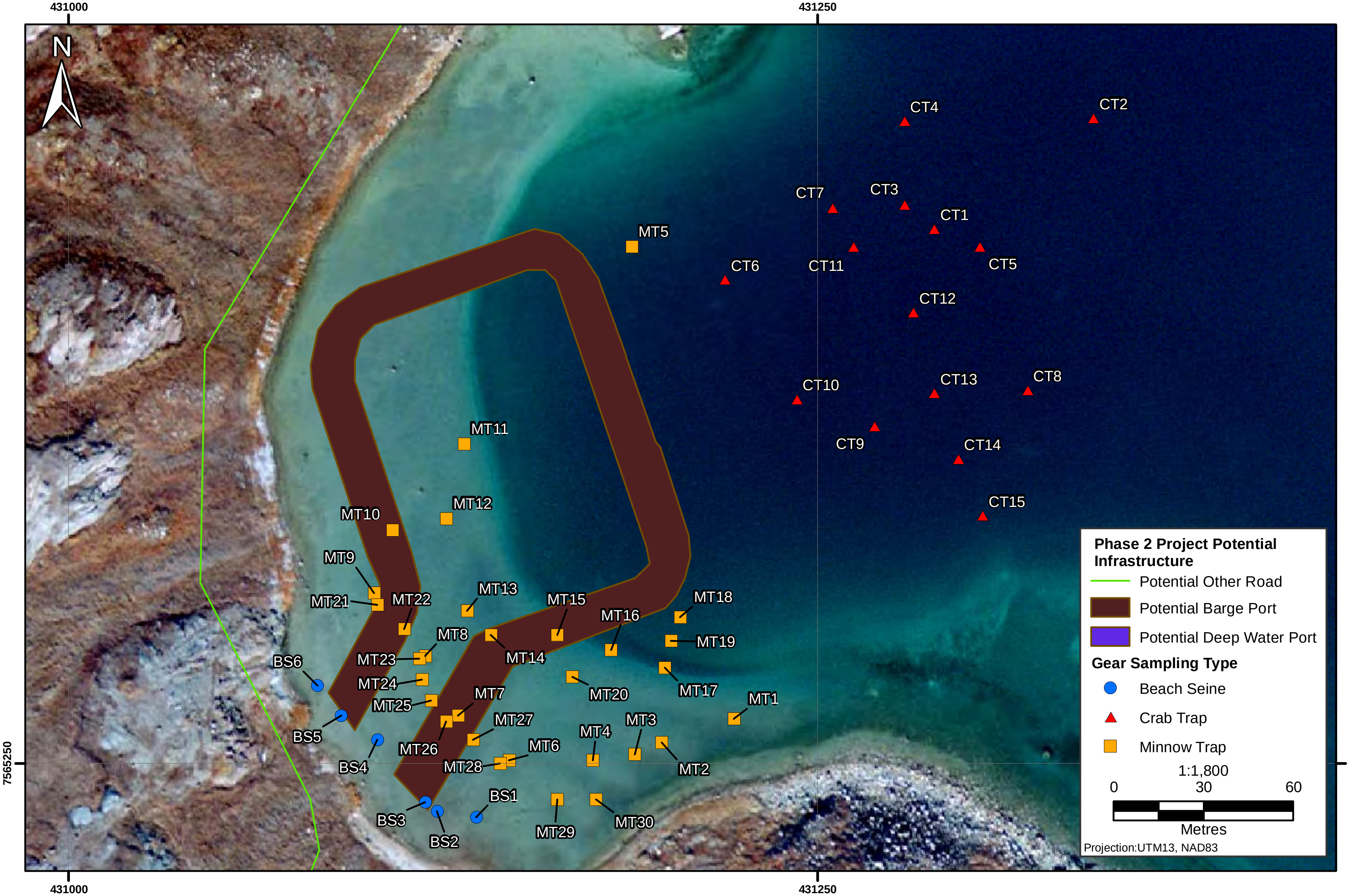


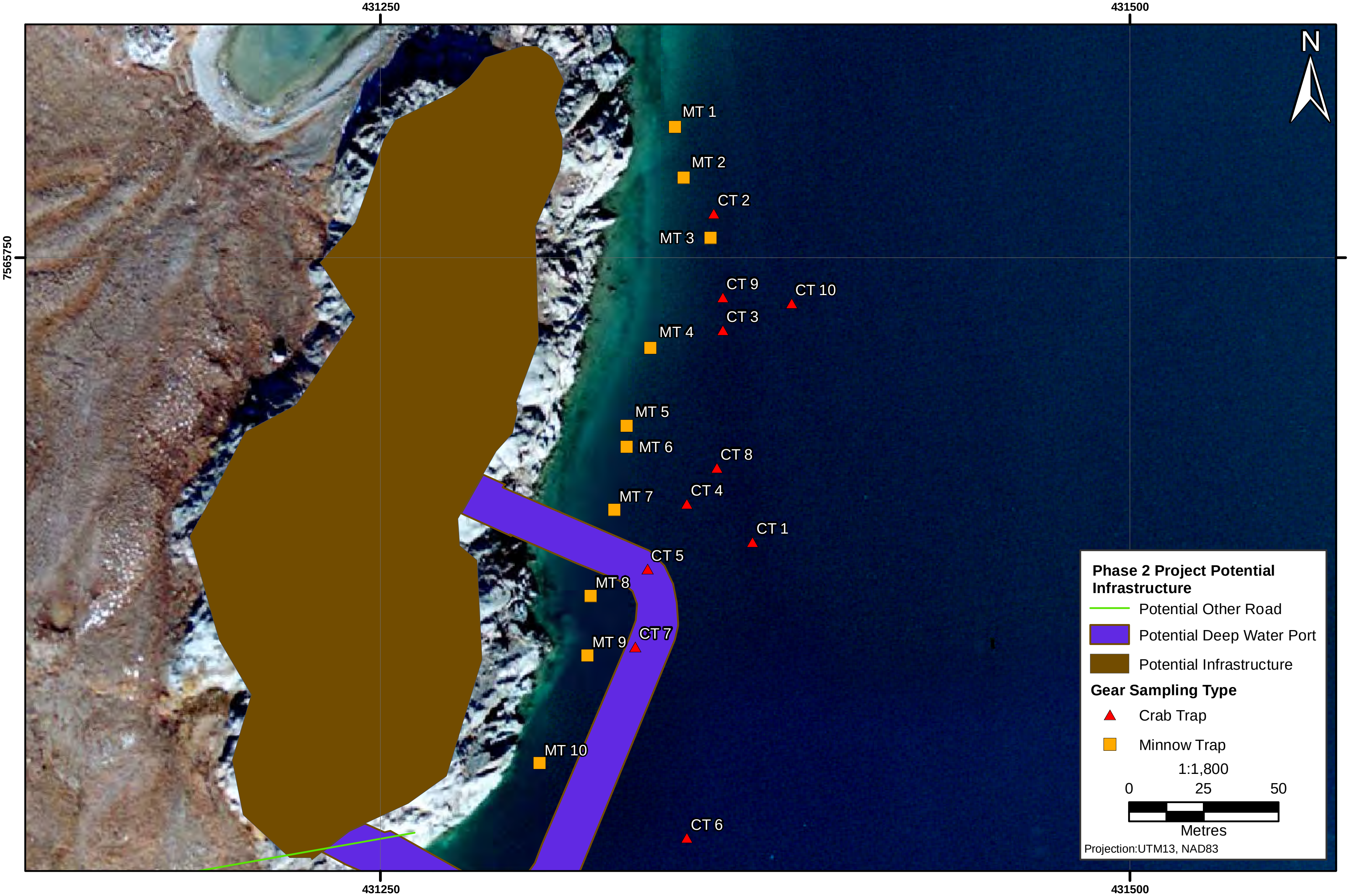
Figure 2.3-20

NEWMONT NORTH AMERICA

Beach Seine, Minnow Trap and Crab Trap Locations During the Late Sampling Survey of the Fish Community at Site P4 in Roberts Bay, Hope Bay Belt Project, 2010

Figure 2.3-20

Rescan Engineers & Scientists



NEWMONT NORTH AMERICA

Minnow Trap and Crab Trap Locations During the Early Sampling Survey of the Fish Community at Site P5 in Roberts Bay, Hope Bay Belt Project, 2010

Figure 2.3-21

Rescan Engineers & Scientists

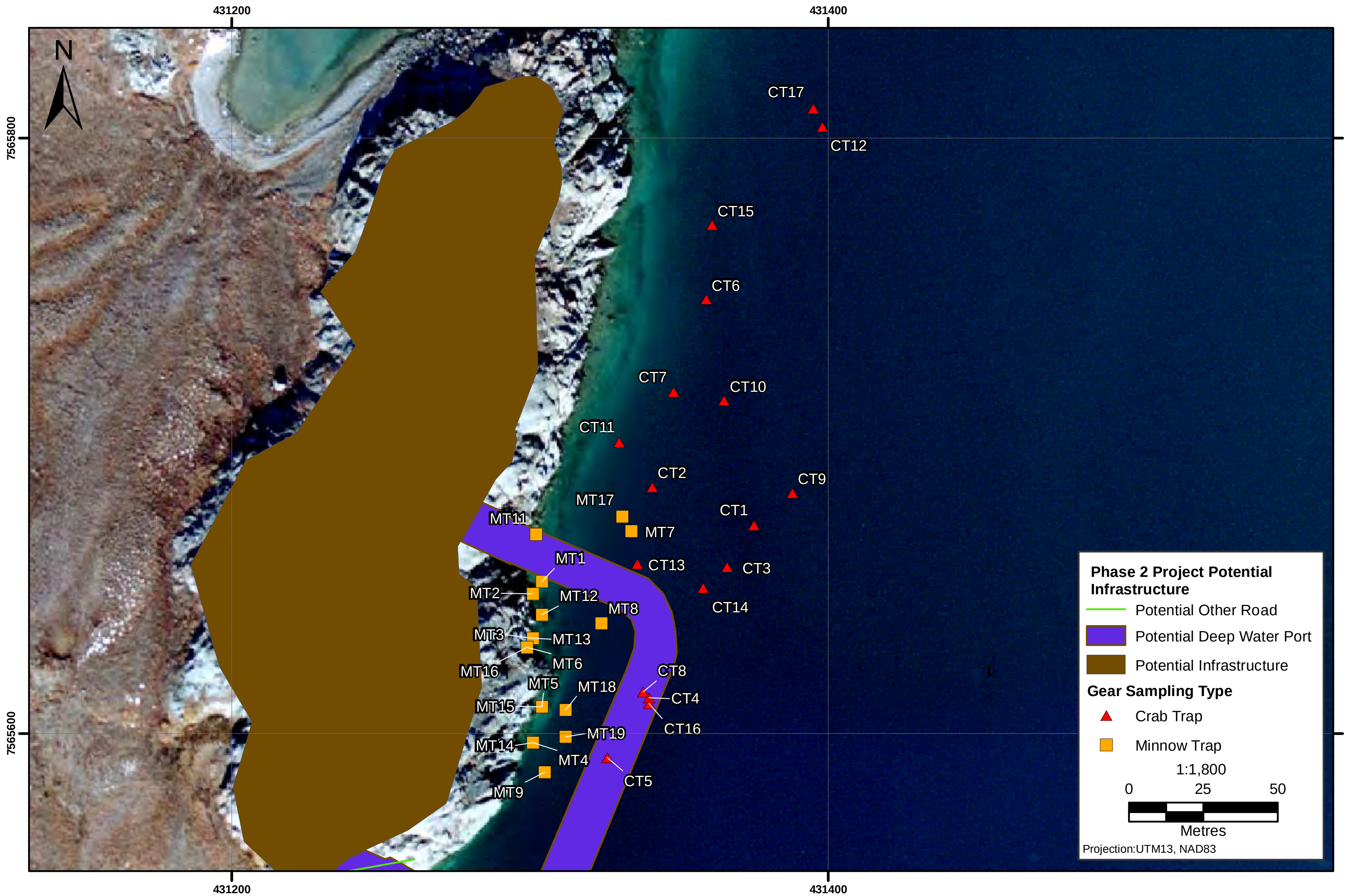
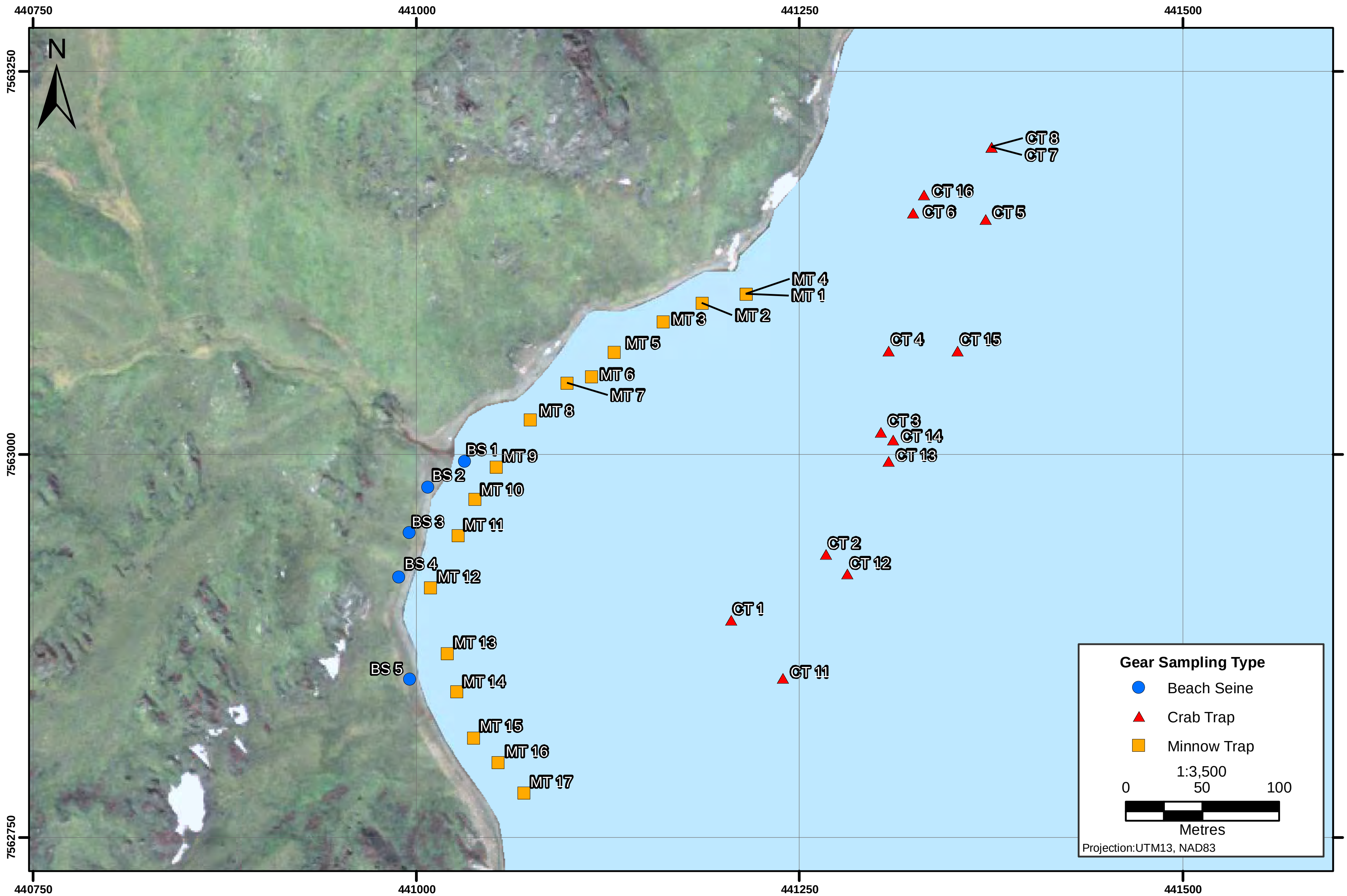


Figure 2.3-22

NEWMONT NORTH AMERICA

Minnow Trap and Crab Trap Locations During the Late Sampling Survey of the Fish Community at Site P5 in Roberts Bay, Hope Bay Belt Project, 2010

Rescan Engineers & Scientists



NEWMONT NORTH AMERICA

Beach Seine, Minnow Trap and Crab Trap Locations During the Early Sampling Survey of the Fish Community at Site REF in Reference Bay, Hope Bay Belt Project, 2010

Figure 2.3-23

Rescan Engineers & Scientists

PROJECT # 1009-002-08 GIS # HB-06-098f November 8, 2010

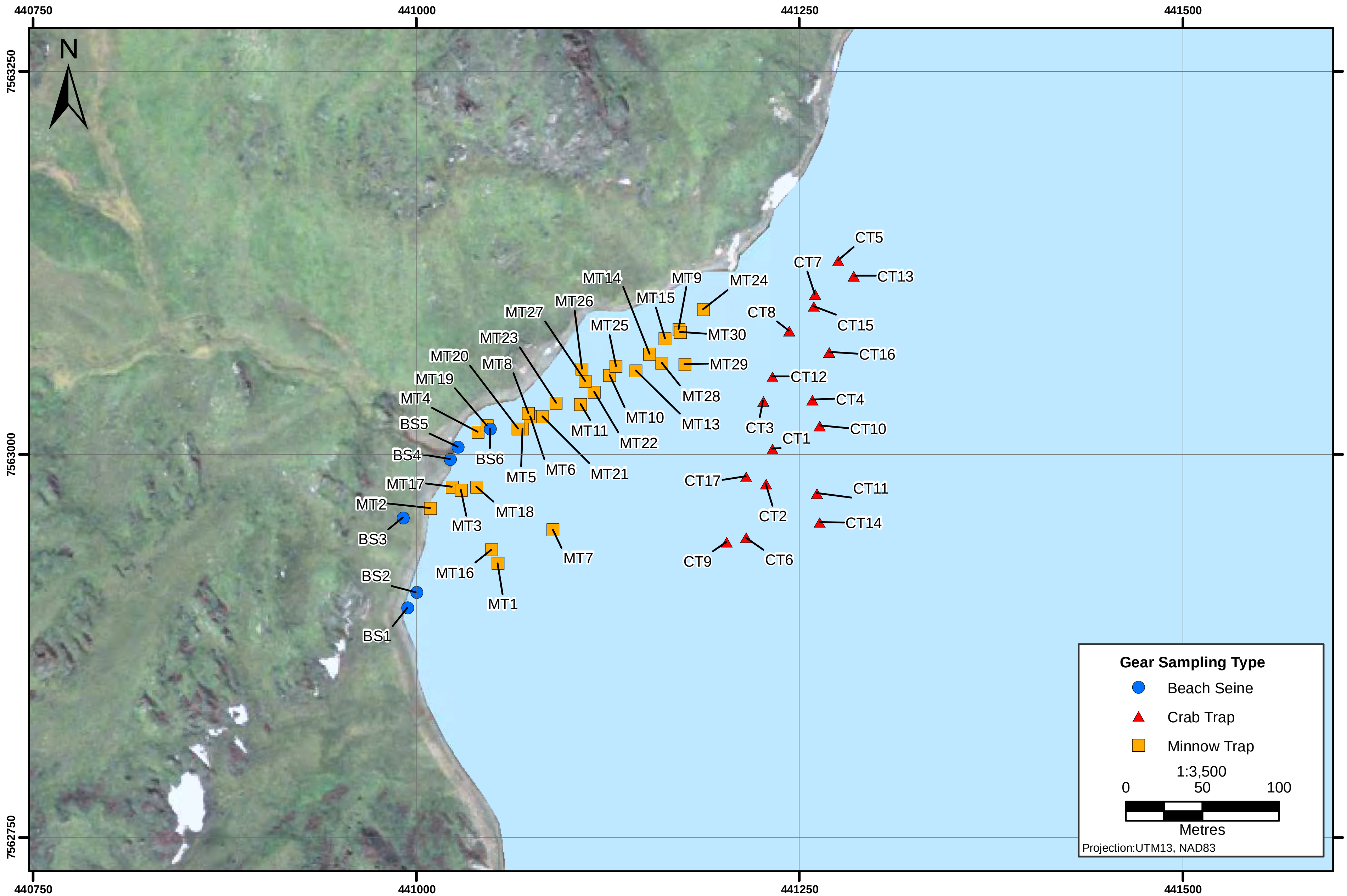


Figure 2.3-24

NEWMONT NORTH AMERICA

Beach Seine, Minnow Trap and Crab Trap Locations During the Late Sampling Survey of the Fish Community at Site REF in Reference Bay, Hope Bay Belt Project, 2010

Rescan Engineers & Scientists

Figure 2.3-24

Plate 2.3-1. A beach seine set at a potential infrastructure site (P3) in Roberts Bay, Hope Bay Belt Project, 2010.

2.3.2.6 Crab Traps

Crab traps were used to sample fish and large invertebrates (also called macrobenthos) such as crabs and isopods. The traps consisted of a collapsible, spring-loaded rectangular stainless steel frame with 38 mm mesh netting and two gate style entrances. When open, the trap measured 30 cm by 42 cm by 80 cm and had a 22 cm by 8 cm opening. A bait box was filled with a combination of dry commercial crab bait and raw fish before being attached to the interior of the trap. As with minnow traps, crab traps were set overnight and retrieved the next possible day. Figures 2.3-13 to 2.3-24 show the locations of each crab trap set.

2.3.2.7 Trap Nets

Trap nets are a passive sampling method with three components: the lead net, two wings (one for each side), and the box trap (Plate 2.3-2). The lead net was a single 50 m x 1.8 m seine net with a mesh size of 25 mm which was anchored to shore and stretched perpendicularly to a maximum depth of 1.8 m at high tide (the height of the nets used). The lead net interrupted the movement of any fish swimming parallel to the shoreline. The natural reaction of fish is to follow the lead net, either to shore (where they would turn around) or out to the box trap. The box trap was attached to the lead net and made of 12 mm mesh measuring 1.8 m deep x 3.7 m long x 1.8 m wide. It has a small opening next to the lead net. To funnel fish into the box trap, two wings were attached to the box that extended 15 m from either side at a 45º angle towards shore. Once inside the trap, fish tended to stay inside because they find the small opening difficult to locate.

Large yellow buoys (for easy location by boat traffic) were attached to the surfaces of the lead net, box trap and wings. A weighted lead line kept the lead net and wings on the seafloor. The trap nets remained vertical in the water, preventing fish from escaping either along the seafloor or the surface. To secure the net against swells and wind-driven waves, the ends of the box trap and wings were each anchored with gravel-filled sandbags weighing approximately 35 kg and the lead net was firmly tied or anchored onshore.

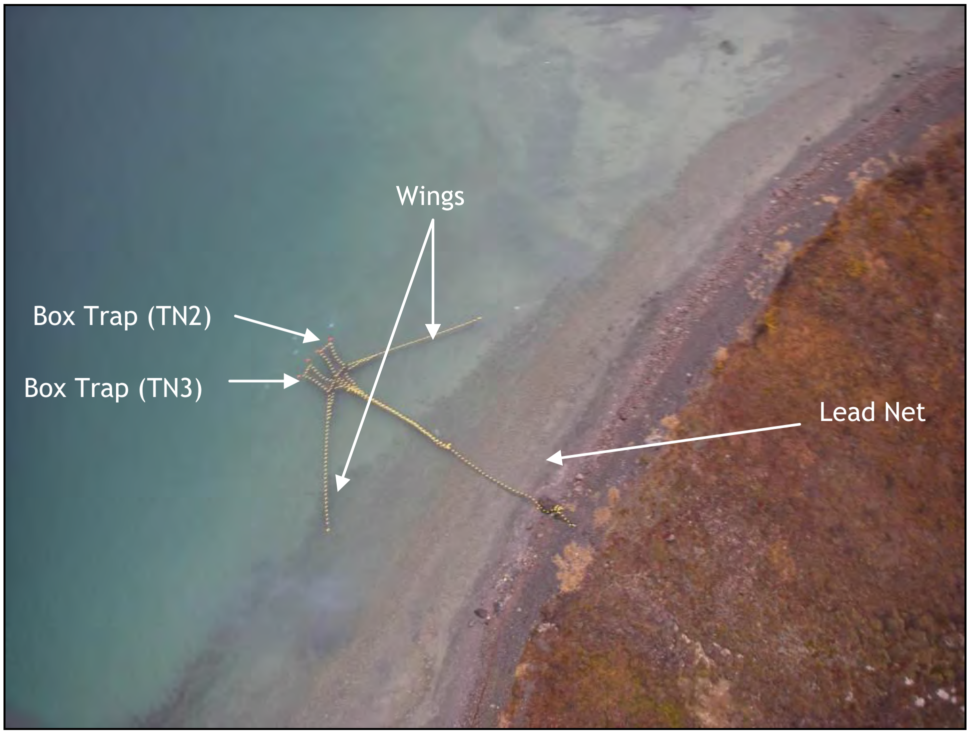


Plate 2.3-2. Aerial view of trap nets TN2 and TN3 fully deployed in Roberts Bay.

Trap nets were installed at three sites to assess fish movements along the western shore of Roberts Bay (see Figure 2.1-2). TN1, which was installed at site P1, was multi-directional (i.e., fish could enter from either direction). TN2 and TN3 were directional between sites P3 and P4 (i.e., TN2 captured northward-moving fish while TN3 captured southward-moving fish). TN4 was multi-directional past the northern boundary of P5.

2.3.3 Sample Processing

Upon gear retrieval, all fish and macrobenthos were immediately removed and placed in a water-filled plastic tub until they could be processed onshore. During processing, each specimen was assigned a unique sample number, identified to species, measured for fork length (mm) and weighed to the nearest 0.1 or 1 g, depending on total weight. For fish captured in the trap nets, all Arctic char, lake trout, and saffron cod greater than 300 mm in length were tagged with an individually numbered Floy tag inserted through the fin rays at the bottom of the dorsal fin (Plate 2.3-3). All tagged fish, as well as selected fish captured at sites P1 to P5 and REF, were sampled for aging structures. Scales were collected with forceps or a scalpel blade below the posterior margin of the dorsal fin on the left side of the fish and two to three pelvic fin rays were also collected with clippers. Otoliths were collected from those fish that died as a result of capture and handling. Processed fish were placed into a water-filled bin for recovery, and were then released live at the site of capture.

A minimum of two aging structures from each fish were placed on wax paper and kept in a labelled envelop with the site, date, species and unique sample number and sent to North Shore Environmental Services (Thunder Bay, ON) for analysis. Age was estimated by counting the number of annuli (yearly rings) from each structure. Scales were attached to plastic fiches and annuli were counted with a microfiche reader. Fin rays were air-dried and then mounted in a 50:50 epoxy medium. Microsections were cut from the fin rays using a Beuler Isomet diamond saw and mounted on slides for inspection using a compound microscope. Otoliths were air-dried, cracked and passed over a flame to increase the visibility of annuli. Otoliths were then mounted in Plasticine and immersed in oil for better inspection using a compound microscope. When more than one structure was used for aging, the structure with the highest confidence, based on professional opinion, was used.

Plate 2.3-3. A saffron cod tagged with a dorsal Floy tag.

Following the methodology of the 2009 study (Rescan 2010), Pacific herring stomachs were collected for diet analysis. A subset of Pacific herring was sacrificed for stomach samples in both Roberts Bay and Reference Bay. Stomachs were preserved in 10% formalin and sent to Applied Technical Services (Victoria, BC) for taxonomic analysis of their contents, including number and weight of prey organisms. Percent digestion of the stomach contents and percent fullness were visually estimated by laboratory personnel.

2.4 MACROBENTHOS COMMUNITY

Macrobenthos were identified to the lowest taxonomic level, measured in length to the nearest mm and weighed to the nearest 0.1 g. Due to differences in body morphology, length data were measured by different methods depending upon taxonomic groups (Table 2.4-1).

Table 2.4-1. Measurements Taken of Macrobenthos Collected in Roberts Bay and Reference Bay, Hope Bay Belt Project, 2010

Macrobenthos	Measurements
Crabs	carapace width
Isopods	total length
sea stars	maximum length -from one arm tip to another
sea urchins	diameter of test

2.5 DATA ANALYSIS

2.5.1 Community Composition

For each gear type, catch was standardized for fishing effort using catch-per-unit-effort (CPUE). For gillnets, CPUE was calculated as the number of fish caught per 100 m^2 of net surface area per hour:

$$CPUE = \text{number of fish caught per net} \times (100\ m^2 / \text{total net area}) / \text{set time (h)}$$

For long lines, CPUE was calculated as the number of fish caught per hook per hour:

$$CPUE = \text{number of fish caught per long line} / \text{number of hooks} / \text{set time (h)}$$

For beach seines, CPUE was calculated as the number of fish caught per area seined:

$$CPUE = \text{number of fish caught} / \text{total area seined} (m^2)$$

For minnow traps, crab traps and trap nets, CPUE was calculated as the number of fish caught per trap per 24 hours:

$$CPUE = \text{number of fish} \times [24\ (\text{hrs}) / \text{set time (h)}]$$

Non-parametric Multidimensional Scaling Analysis (nMDS) was used to compare community composition among sites P1 to P5 and REF using CPUE data. All CPUE values, separated by site, sampling period and gear, were log(CPUE + 1) transformed to normalize their frequency distribution, and compared using the Bray-Curtis Similarity Index. Those indices were used as a relative distance among sample points. nMDS produced scatter plots where sites in close proximity represent similar communities and sites far away from each other are dissimilar. Next, a Two Way Analysis of Similarity (ANOSIM) was performed on the results of the nMDS to test for significant differences in species composition among sites, with sampling periods as a nested factor. A Similar Percentages (SIMPER) Analysis was also conducted to identify the main species differences among sites and sampling periods.

2.5.2 Biological Characteristics

Biological characteristics were analyzed separately for fish caught in Roberts Bay and Reference Bay because future mine activities will occur in Roberts Bay but not Reference Bay, and because the two bays are separated by 20 km of swimming distance, and hence are likely to support different breeding populations. Fish caught in Roberts Bay were pooled by species because they were assumed to belong to a single breeding population for each species (but see weight-length analyses below).

Length-frequency distributions were used to show the dominant size classes for those species with a sample size of more than eight (Johnson et al. 2007). Condition and weight-length regressions were used as indicators of the relative health of fish. Condition was based on the ratio of weight to length (Ricker 1975):

$$\text{Condition} = \text{weight (g)} \times 10^5 / \text{length}^3\ (\text{mm})$$

Weight was multiplied by a factor of 10^5 to avoid fractional values, and a weight-length exponent of 3 was assumed to apply to all species of fish.

Weight was regressed on length for each species. Weight and length were transformed with natural logarithms to normalize the data and homogenize the variances – the two prerequisites of parametric statistics:

$$ln(weight) = ln(a) + b[ln(length)]$$

where *a* is a coefficient and *b* is the slope of the regression. Weight-length relationships were only calculated for fish species captured in large enough numbers (≥8) to make the regression statistically significant and meaningful.

Analysis of Covariance (ANCOVA) was performed on all Roberts Bay weight-length relationships to test for differences in intercepts among sites and trap nets. For each species, a General Linear Model (GLM) was first used to test for uniformity of slope (i.e., by testing for a significant interaction of slope and site). If there was no significant interaction, then a uniform slope was assumed and ANCOVA was used to test for site-specific differences in intercepts. If the GLM had a significant interaction, then slopes were assumed to vary significantly among sites and separate weight-length regressions were calculated for each site and trap net.

Length-age relationships were described with the von Bertalanffy growth model (Ricker 1975):

$$L_t = L_\infty(1 - exp(-K(t - t_0)))$$

where L_t = length (mm) at age t (years), L_∞ = asymptotic length (mm) (i.e., length at infinite age), K = growth rate ($year^{-1}$) and t_0 = age (years) at L = 0 mm. For some species, the age ranges were too narrow to allow estimation of a realistic value of t_0. In those cases t_0 was fixed at 0 years and only L_∞ and K were estimated.

All linear regressions were reported with the appropriate sample size (n), coefficient of determination (r^2, the fraction of variation in the independent parameter that was explained by the dependent parameter) and probability (p) of Type I error. The r^2 for linear or non-linear regressions were not adjusted for the degrees of freedom. All data were tested against the assumption normality and equal variances using a Kolmogorov-Smirnov test. Statistics were conducted according to Zar (1984) using the SYSTAT library of computer programs (SYSTAT 2006).

2.6 QA/QC

A quality assurance and quality control program (QA/QC) included the use of chain of custody forms, taxonomic and laboratory QA/QC procedures and data review. Field notes were transcribed onto electronic spreadsheets and all transcriptions were compared with field notes to correct transcription errors. Some length, weight and age data were plotted against each other (e.g., weight-length regressions and length-age plots) to identify outliers that may have resulted from transcription errors. If errors could not be corrected by re-examination of field notes, then those data were excluded from analysis.

3. Results and Discussion

Engineers and Scientists

3. Results and Discussion

3.1 FISH HABITAT

3.1.1 Shoreline Habitat

Appendix 3.1-1 shows detailed habitat data for sites P2, P3, P4, P5 and REF.

Two habitat units were identified at site P2 (Figure 3.1-1). Both are dominated by fine sediment, which makes up 69% of the 12,016 m^2 of total shoreline area.

Twelve habitat units were identified as site P3 (Figure 3.1-2). The predominant substrates for the 14,952 m^2 of total shoreline area are gravel (45%) and cobble (27%) (Plate 3.1-1). Cobble is dominant in four of the units, and gravel is dominant in six units. One unit each is dominated by fines and boulders.

Plate 3.1-1. The dominant substrate types of the shoreline habitat at P3.

A total of 19 separate habitat units were identified at site P4 (Figure 3.1-3). This site is situated in a northeast facing cove which shelters shoreline habitat from prevailing winds. This has resulted in an accumulation of fine substrates (79% of the total area of 31,065 m^2). All other substrate types contribute only minor amounts of area: cobble (8%), boulder (7%), organics (4%), and gravel (2%). The sheltered environment also leads to decreased shoreline erosion, as evidenced by areas of infringing tundra (Plate 3.1-2).

The current location of P5 was expanded and shifted northward from the location surveyed in 2009 for a Deep Water Port option (Rescan 2010) (Figure 3.1-4 and Plate 3.1-3). Therefore, the site was re-surveyed in 2010, but produced similar results. Only one habitat unit was identified, covering 5,956 m^2 of littoral habitat. Substrates consist of 95% bedrock and 5% boulder.