APPENDIX AIR10-C

Technical Data Reports Containing Habitat Maps at Local and Regional Scales

TDR DAS-1 - Subtidal Benthic Infauna and Epidfauna Surveys for Disposal at Sea Site Characterisation TDR

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ROBERTS BANK TERMINAL 2
TECHNICAL DATA REPORT
Subtidal Benthic Infauna and Epifauna Surveys for Disposal at Sea Site Characterisation

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Technical Report / Technical Data Report Disclaimer

The Canadian Environmental Assessment Agency determined the scope of the proposed Roberts Bank Terminal 2 Project (RBT2 or the Project) and the scope of the assessment in the Final Environmental Impact Statement Guidelines (EISG) issued January 7, 2014. The scope of the Project includes the project components and physical activities to be considered in the environmental assessment. The scope of the assessment includes the factors to be considered and the scope of those factors. The Environmental Impact Statement (EIS) has been prepared in accordance with the scope of the Project and the scope of the assessment specified in the EISG. For each component of the natural or human environment considered in the EIS, the geographic scope of the assessment depends on the extent of potential effects.

At the time supporting technical studies were initiated in 2011, with the objective of ensuring adequate information would be available to inform the environmental assessment of the Project, neither the scope of the Project nor the scope of the assessment had been determined.

Therefore, the scope of supporting studies may include physical activities that are not included in the scope of the Project as determined by the Agency. Similarly, the scope of supporting studies may also include spatial areas that are not expected to be affected by the Project.

This out-of-scope information is included in the Technical Report (TR)/Technical Data Report (TDR) for each study, but may not be considered in the assessment of potential effects of the Project unless relevant for understanding the context of those effects or to assessing potential cumulative effects.

EXECUTIVE SUMMARY

The Roberts Bank Terminal 2 Project (RBT2 or Project) is a proposed new three-berth marine terminal at Roberts Bank in Delta, B.C. that could provide 2.4 million TEUs (twenty-foot equivalent units) of additional container capacity annually. The Project is part of Port Metro Vancouver's Container Capacity Improvement Program (CCIP), a long-term strategy to deliver projects to meet anticipated growth in demand for container capacity to 2030.

The RBT2 Project will require the introduction of estuarine sediments to the estuarine marine environment of the Fraser River delta at Roberts Bank, including infill materials for construction phases and disposed dredge residuals. Two specific receiving areas of interest from an ecological effects perspective are the intermediate transfer pit (ITP) and the candidate Disposal at Sea (DAS) sites. The ITP, an area formerly used during the construction phases of the Deltaport Third Berth project, is located within the subtidal zone of the inter-causeway area, at the southern edge of the turning basin, where sandy textured maintenance dredgeate from the lower ~15 km of the Fraser River navigational channel will be stockpiled prior to placement into the RBT2 footprint. The candidate DAS area is the proposed area in which a DAS site will be located pending permit approval, and where dredgeate residuals will be discharged. The candidate area (approximately 6.38 km^2) was defined from a practical engineering design perspective based on distance from the proposed RBT2 Project location (effective dredge residual piping distance: generally less than 2 km), depth (along the delta foreslope at depths greater than -5 m CD), at a sufficient distance from the Canada-USA border to prevent concerns about the direct or indirect transport of sediments from dredging into US water, and away from existing submarine cables south of the proposed terminal.

The introduction of dredgeate will result in the deposition over existing marine sediments, with possible implications for subtidal habitats and the marine benthic community that they support. As such, an understanding of the fish and invertebrate species and communities that occur within and adjacent to the proposed DAS sites was required. The objectives of this study were to document the current seasonal use of these areas by key bottom-dwelling (benthic) species including Dungeness crabs (*Metacarcinus magister*), orange sea pens (*Ptilosarcus gurneyi*), fish species such as flatfishes (Order: Pleuronectiformes), and macroinvertebrates. The specific goals of this study were to characterise each of the following:

- Distribution, densities and abundance of benthic fish and invertebrate species in the candidate DAS area through remote operated vehicle (ROV) video survey;
- Abundance and diversity of benthic infaunal macroinvertebrates in the candidate DAS and ITP areas through sediment grab sampling (0.1 m^2 Van Veen grab); and
- Presence of highly mobile, buried or cryptic species through Rake Trawl survey.

Such information will help to inform project activities including the location of dredgeate residual disposal in order to minimise disturbance to the benthic communities and resources.

ROV Survey Results

Underwater video was collected by maneuvering an ROV equipped with a video camera along four linear transects following the 45 m, 60 m, 75 m and 90 m depths contours along the delta foreslope within the candidate DAS area. An additional exploratory transect, spanning depths from 75 m to 40 m, was also completed to better understand notable sediment features and areas of interest. Total densities of Dungeness crabs and sea pens were highest at the 45 m transect (0.048 indiv./m^2 and 0.19 indiv./m^2, respectively). The reverse was observed for other invertebrates which had highest densities at the 75 m and 90 m transects (0.050 indiv./m^2 and 0.057 indiv./m^2, respectively). Total flatfish densities were highest in the 45 m and 60 m transects (0.061 indiv./m^2 and 0.068 indiv./m^2, respectively). Total finfish and cartilaginous fish densities were highest at the 60 m, 75 m and 90 m transects (0.086 indiv./m^2, 0.078 indiv./m^2, and 0.088 indiv./m^2 respectively). Perch (*Embiotocidae*) school sightings were observed at the 45 m, 60 m and 75 m transects, with large schools sighted at the 45 m and 60 m depths. Herring school (*Clupea pallasii*) sightings were observed in all four depth contour transects, including a single large school at the 45 m transect. Four observations of derelict fishing gear (90 m and 75 m) as well as one instance of a crab trap with fresh bait (60 m), a giant Pacific octopus (*Enteroctopus dofleini*) (75 m), and the occurrence of *Beggiatoa* mats (90 m) were all noted.

Infaunal Macroinvertebrates Survey Results

A total of 16 stations were sampled without replication for benthic macroinvertebrates: ten samples in the candidate DAS area, and six samples in the ITP area using a 0.1 m^2 Van Veen grab. Across all sampled DAS sites (n=10 grabs), there was an average infaunal macroinvertebrate density of 1466 indiv./m^2. The most numerically abundant species found in the candidate DAS area was a marine snail *Solariella obscura*, which represented 33.4% of infaunal community abundance. The densities of infaunal macrofauna at the ITP sites (n=6) were much higher than in the candidate DAS area, with an average 8807 indiv./m^2. The most numerically abundant species found was the bivalve mollusc *Axinopsida serricata*, which represented 42.4% of species abundance by total count for the six ITP sampling sites. Mean diversity were comparable for the DAS and ITP areas (Shannon-Weaver index score 2.19 and 2.66, respectively). Greater variability was observed between the DAS sites (1.75 to 4.03) than for ITP sites (2.21 to 3.30).

Rake Trawl Survey Results

The Rake Trawl survey component consisted of ten night-time rake trawls over a two day period in April. The average fish catch rate (# fish per hour) in the ITP site was approximately 2.74 times higher than that within the candidate DAS area. Differences in species assemblages were observed between the two sites. Generally, the diversity of invertebrate species (or species groups) found within the ITP and the candidate DAS area was similar, and included all major taxonomic groups, with the exception of echinoderms: the Giant California sea cucumber (*Parastichopus californicus*), found only within the ITP area. Overall, a much higher mass (i.e., net wet weight) of each representative invertebrate group was obtained for transects conducted in the ITP relative to the candidate DAS area.

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1.0 INTRODUCTION

1.1 PROJECT BACKGROUND

The Roberts Bank Terminal 2 Project (RBT2 or Project) is a proposed new three-berth marine terminal at Roberts Bank in Delta, B.C. that could provide 2.4 million TEUs (twenty-foot equivalent units) of additional container capacity annually. The Project is part of Port Metro Vancouver's Container Capacity Improvement Program (CCIP), a long-term strategy to deliver projects to meet anticipated growth in demand for container capacity to 2030.

Port Metro Vancouver has retained Hemmera to undertake environmental studies to inform a future effects assessment for the Project. This technical data report describes the results of a series of studies undertaken to characterise the benthic subtidal communities at the candidate disposal at sea (DAS) and intermediate transport pit (ITP) areas, which will potentially be disturbed by construction activities.

1.2 STUDY OVERVIEW AND OBJECTIVES

A review of the existing state of knowledge was completed for this *Subtidal Benthic Infauna and Epifauna Surveys for DAS Area Characterisation* study to identify data gaps and areas of uncertainty within the general RBT2 area. Additional studies described herein were initiated to address key data gaps and provide site specific information at the Project site. This technical data report presents the results and conclusions for key components identified from this gap analysis. A brief overview of specific study components and their respective objectives is provided in **Table 1**.

Various proposed RBT2 Project components will require the introduction of sediments to the marine receiving environment. Such components include the handling of infill materials for terminal construction and the disposition of dredge residuals, resulting in localised disturbance of existing marine sediments and the seabed which provide subtidal habitats for a wide diversity of benthic species.

Of particular interest are those species which have been consistently documented within the Roberts Bank study area (Triton 2004, Archipelago 2014*a*, *b*, Hemmera 2014*b*) or are expected to occur based on identified habitat preferences (Robinson et al. 2013). Such species include commercially and ecologically valued Dungeness crabs (*Metacarcinus magister*), orange sea pens (*Ptilosarcus gurneyi*), and benthic fish species, such as flatfishes (Order: Pleuronectiformes) and Pacific sand lance (*Ammodytes hexapterus*). An understanding of the dredgeate-receiving environment as subtidal habitat is required, therefore, to enable predictions of the effects of stockpiled and disposed dredge materials on key species known to spend a portion of their lifecycle in the benthic subtidal environment.

Table 1 Subtidal Benthic Productivity Survey Study Components and Objectives

Component	Major Objective	Brief Overview
1) ROV Survey	• *Characterise the distribution, densities and abundance of benthic fish and invertebrate species in the candidate DAS area.*	Remotely-Operated Vehicle (ROV) surveys were conducted in November 2013 in the subtidal area of Roberts Bank adjacent to the proposed RBT2 project. Surveys were conducted within the candidate DAS area of interest and consisted of transects following the 45m, 60m, 75m and 90m depths contours. Video review was used to identify and enumerate finfish and invertebrate species found in the subtidal environment. Relative densities were assessed by depth and by east-west position relative to the Canada-USA border and the transect start position.
2) Infaunal Macroinvertebrate Community Survey	• *Characterise the relative diversity and abundance of benthic infaunal macroinvertebrates in the candidate DAS and ITP areas.*	Benthic macroinvertebrate surveys were conducted in November 2013 in the subtidal areas of Roberts Bank adjacent to the proposed RBT2 project and in the intermediate transfer pit (ITP). Van Veen sediment grab samples were collected from 10 sites in the candidate DAS area and 6 sites in the ITP area. Sediment grab samples were sieved (>1.0 mm) were sieved and macroinvertebrate samples sorted and enumerated to asses for count and taxonomy. Relative abundance and diversity were assessed for the candidate DAS and ITP sites.
3) Rake Trawl Survey	• *Characterise the presence of highly mobile, buried or cryptic species otherwise not easily identified through ROV surveys.*	Benthic rake trawl surveys were conducted in April 2014 in the subtidal areas of Roberts Bank adjacent to the proposed RBT2 project and in the ITP. Trawl surveys were conducted along 6 transects in the candidate DAS area and 4 transects at the ITP site. Captured fish and invertebrate species were enumerated, measured, weighed and identified to the lowest taxonomic grouping possible. For each transect, invertebrate contents of each trawl were pooled and weighed of invertebrates to obtain a net wet weight for each taxonomic grouping.

Specific receiving areas (**Figure 1**) considered in the Subtidal Benthic Productivity Survey for DAS Area Characterisation study include:

- ITP area, used to stockpile maintenance dredged material from the Fraser River prior to placement into the RBT2 footprint; and
- Candidate DAS area, where dredgeate residuals will be discharged.

Three Project specific field study components were undertaken, in order to improve the current state of knowledge about the distribution and diversity fish and invertebrate species within the candidate DAS and ITP study areas at Roberts Bank:

(i) A Remotely Operated Vehicle (ROV) survey was employed to quantitatively assess the distribution, abundance and densities of benthic invertebrate and fish species in the candidate DAS area at depths up to 90 m.

(ii) Sediment sampling was carried out using a 0.1 m^2 Van Veen grab to characterise infaunal macroinvertebrate diversity at sampling locations within the candidate DAS area and the ITP area.

(iii) Rake Trawl transects was conducted in the candidate DAS area and ITP area to document the presence of highly mobile or cryptic species not easily identified through ROV video review. As the ROV study component was carried out in the Fall (November) and the Rake Trawl survey in the Spring (April), this component was employed to provide some qualitative information on DAS area-specific seasonal variance in species diversity.

The data collected through this study will be used to inform and assist in the refinement of DAS site selection within the candidate DAS area; for example, by the exclusion of specific areas (i.e. those of high ecological importance) from further detailed assessment. These data will further provide information needed to assess and establish mitigation measures, when required, to minimise potential effects associated with site-specific sediment re-suspension. Ecological characterisation results will also be used in conjunction with other results on key species (or species groups) of interest to facilitate predictions of future conditions, with or without completion of the RBT2 project. The information provided herein is in addition to complementary information provided in the Marine Benthic Subtidal Study Technical Data Report (Hemmera 2014*b*)**.**

Figure 1 Overview of Study Area

2.0 REVIEW OF EXISTING LITERATURE AND DATA

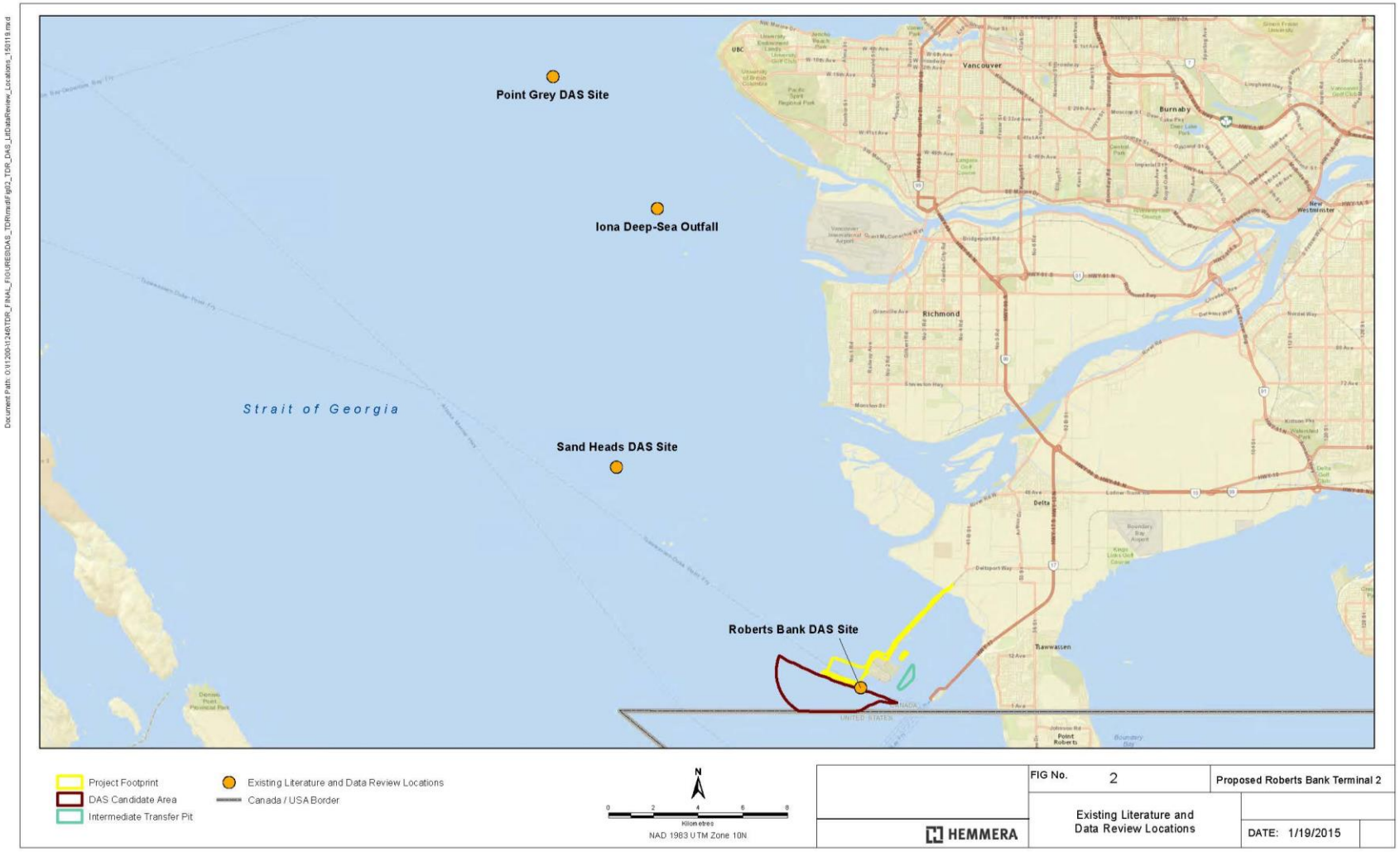
2.1 STRAIT OF GEORGIA, REGIONAL CONTEXT

A regional overview for benthic invertebrate faunal communities found in the southern Strait of Georgia (**Figure 2**) is provided by Burd, Barnes, et al. (2008), and Burd, Macdonald, et al. (2008). The purpose of these reviews was to investigate trends in benthic infaunal diversity and abundance relating to differences in site-specific physical habitat characteristics, and to identify potential trends in biological communities that may be indicative of anthropogenic impacts within this region. Site specific variation in benthic community composition, as a result of anthropogenic activities, including existing DAS and sewage outfall at sites (**Figure 2**) in proximity to the proposed Project and candidate DAS area, are further discussed in **Section 2.1.2** and **Section 2.1.3**.

Within the southern Strait of Georgia, benthic infaunal composition is highly variable throughout the subtidal environment. Benthic infaunal community structure was shown to vary with water depth, substrate type, and sediment organic content. While predictive relationships are not easily defined, other sedimentation features that may influence the occurrence and distribution of infaunal species include the quality and proportions of organic and inorganic materials, patterns of local sediment accumulation, and sediment flux rates from natural and anthropogenic sources (Burd, Macdonald, et al. 2008). Overall, dominant species groups include ophiuroids, crustaceans, bivalves and polychaetes, with species abundance and diversity generally increasing with depth, peaking from 60 m to 80 m, and declining at depths greater than 100 m (Burd, Macdonald, et al. 2008). In general, polychaetes were diverse and shown to be the dominant fauna in areas where sedimentation and organic flux were low (Burd, Macdonald, et al. 2008).

The benthic macrofauna community found in mid-depth (30 to 100 m) sand/silt habitats (representative of the depth range and sediment type at which the candidate DAS area is proposed) was observed to be dominated by bivalves (50% of total biomass) with *Axinopsida serricata* and *Macoma carlottensis* comprising 40–60% and 10% of the total faunal abundance, respectively (Burd, Macdonald, et al. 2008). This information is derived from samples collected in the Fraser River estuary north of Roberts Bank, however, with a specific focus on the Iona Island waste water treatment plant outfall, in seabed areas with a silty sand texture. The observations, therefore, may not be generalisable to other areas of the Fraser River delta foreslope, including the Roberts Bank foreslope. The remaining biomass within this depth zone, based on sampling in the vicinity of the Iona outfall, was dominated by echinoderms, primarily the brittlestar *Amphiodia sp.* and the sea cucumber *Molpadia intermedia*. In contrast, infaunal crustaceans were less abundant, comprising less than 1% of the total faunal abundance and biomass (McPherson et al. 2007).

Figure 2 Existing Literature and Data Review Locations



The benthic macrofauna community found in mid-depth (30–100 m) sand habitats included burrowing bivalves and polychaetes, mat-forming tubicolous polychaetes, ophiuroids, crustaceans (including Dungeness crabs), orange sea pens and sea whips in higher current areas, and some attached forms of epifaunal invertebrates occurring on larger fauna and debris (Palsson et al. 2003, Burd, Barnes, et al. 2008, Burd, Macdonald, et al. 2008, McPherson et al. 2011).

2.2 IONA SEWAGE OUTFALL

Primary treated wastewater has been discharged into the subtidal environment in the Strait of Georgia from the Iona Deep-sea Outfall, at depths ranging from 72 to 106 m, since 1998 (Burd et al. 2012). As a result, the benthic environment within this area experiences higher rates of sedimentation and organic matter flux to the seabed relative to background levels throughout the Strait of Georgia (Burd et al. 2012). For example, depositions near the Iona outfall terminus contain approximately 30 % organic carbon relative to the <1 % observed for Fraser River sediments (McPherson et al. 2011, Burd et al. 2012). Effluent deposition is affected by the local current regime, which results in a net northward transport of effluent and effluent solids, with areas to the north of the outfall experiencing the highest deposition of outfall effluents (McPherson et al. 2011).

Annual sampling to monitor the benthic infaunal community and to assess for possible effects of Iona discharge has occurred since 2000 (McPherson et al. 2011). Characterisation of the benthic community has included assessments of species abundance, species richness, and community diversity. In general, faunal diversity and trophic structure did not show a clear response to outfall exposure, suggesting that despite local losses or gains in species abundance, similar community structure was maintained throughout the greater study area (Burd et al. 2012). However, significant differences in faunal composition and species richness were observed closer to the outfall relative to surrounding areas. The benthic community at the Iona site is generally dominated by bivalves, with *A. serricata* and *M. carlottensi*s being among most abundant species found. In contrast, reference samples showed a lower number of bivalves and greater abundance of small polychaetes (McPherson et al. 2011; Burd et al 2012). Loss of crustaceans and echinoderms in proximity to the outfall and increases in a low oxygen tolerant polychaete was also observed in the high deposition zone (Burd et al. 2012).

2.3 NEARBY DISPOSAL AT SEA SITES

2.3.1 Point Grey DAS Benthos Reviews

The Point Grey (PG) Disposal site is located at a depth of 210 m on the slope of the Fraser River delta. The site is the largest disposal site in Canada, receiving over 450,000 m^3 of material each year, and has been used for ocean disposal continuously since the 1930s (Environment Canada 2006). The PG site receives material predominantly dredged from forest industry sites on the Fraser River. Disposed material is made up of approximately 80% sediment and silt, with 20% bark and wood fiber, and occasional logs or

larger solid wood pieces (Martin 2008). Annual monitoring for over 25 years has showed no cumulative environmental impacts, including no significant changes to sediment contaminant levels, and no significant biological responses (as determined by whole sediment laboratory toxicity testing) (Environment Canada 2006).

The Fisheries and Oceans Canada (DFO) has used the Remotely Operated Platform for Ocean Sciences (ROPOS), a remotely operated submersible, to conduct physical monitoring work of the benthic environment within and adjacent to the PG disposal area site. Video review of PG site was conducted to assess potential relationships between woody debris amount and complexity with benthic macrofauna density and diversity. The most abundant benthic macrofauna observed were the galatheid crab ("Squat Lobster") *Munida quadrispina*, various shrimp species, the spot prawn *Pandalus platyceros*, unidentified marine snails, plumose anemones (likely *Metridium sp*.), cerianthid anemones, and the crimson anemone *Cribrinopsis fernaldi*. The most abundant finfish species was the spotted ratfish *Hydrolagus colliei*, flatfishes (Pleuronectiformes) and rockfishes (Scorpaenidae) (Martin 2008). The results indicate that increasing presence of woody debris changed the community composition of benthic macrofauna, with higher species diversities observed in areas moderate in both debris coverage and complexity (Martin 2008). Abundance of species including squat lobsters, prawns, snails, plumose anemones and rockfish tended to increase markedly with increasing area coverage and complexity of woody debris, whereas increasing debris complexity tended to a decrease in the density of flatfish and spotted ratfish (Martin 2008).

2.3.2 Sand Heads DAS benthos reviews

The Sand Heads site is located at a depth of 70 m on the foreslope of the Fraser River delta in the subtidal area offshore from the main arm of the Fraser River. The site has been in use since 1974 (Environment Canada 2006). In October 2004, the DFO conducted ROV surveys using ROPOS as part of ongoing physical monitoring work to document the benthic macrofauna diversity within and adjacent to the Sand Heads DAS site, as described in Environment Canada's *Compendium of Monitoring Activities at Disposal at Sea Sites in 2004-2005* (Environment Canada 2006). The objective of the study was to document the benthic conditions at the disposal site, including biological and geophysical changes resulting from disposed materials, local currents and Fraser River discharges (Environment Canada 2006). However, detailed results from the video studies at the Sand Heads DAS site were not published as part of the annual compendium report and no further follow-up reporting of the data is available. At present, there is no known information on the benthic subtidal community available for this site.

2.3.3 Roberts Bank DAS Site

The subtidal area (below the 40 m contour line) adjacent to the existing Roberts Bank terminals has been historically used as a DAS site during Deltaport Third Berth (DP3) development activities. The location is not a routinely used as a DAS site and is only considered available for Deltaport Terminal development (pers comm. Sean Standing, as reported in Lachmuth et al. 2010). No benthic community data appear to be available for the historical Roberts Bank DAS locations.

2.4 RECENT STUDIES AT PROJECT SITE

There is limited information available on the benthic subtidal community in the vicinity of the proposed DAS and ITP project sites. Prior to Project related baselines field studies (as discussed below), no site-specific studies on benthic subtidal species were conducted. Quarterly benthic monitoring has previously taken place at Robert Banks for the Deltaport Third Berth Adaptive Management Strategy (AMS) (Hemmera et al. 2012), which includes both subtidal and intertidal monitoring stations located in the inter-causeway area, as well as two reference stations off of Westham island. Further information relating to the AMS benthic sampling results are not presented in this report, as previously sampled locations are located beyond the potential candidate DAS areas. Results from this program are discussed as existing information in the Hemmera 2014*b*.

Studies characterising the benthic subtidal community at the proposed RBT2 site have been conducted as a part of field studies documenting existing conditions within the study area. Towed video surveys (Subtidal Imaging and Mapping System (SIMS)) conducted as part of the RBT2 Marine Fish Habitat Characterisation Studies (Archipelago 2014*a*) indicated that Dungeness crabs and flatfish species comprised the most abundant species (or species group) identified across all depths sampled (up to 35 m) within subtidal environment at Roberts Bank. The surveys also corroborated previous studies (Gartner Lee 1992, Triton 2004, Archipelago Marine Research Ltd 2009) and identified a large aggregation of orange sea pens at the delta front slope between depths of 2.5 to 18 m (west of the Westshore Terminals), within the footprint of the proposed RBT2 footprint (Archipelago 2014*a*). Subsequent towed underwater video and dive surveys in 2011, also identified a second dense aggregation ranging from 3 to 19 m deep located at the southern edge of Westshore Terminals (Hemmera and Archipelago 2014). In addition, further effort was directed at quantifying habitat variables within the subtidal sea pen bed, including current velocity and wave direction measurements, CTD casts and sediment sample analysis (Hemmera and Archipelago 2014).

Benthic finfish diversity within the subtidal zone at Roberts Bank has also been documented through seasonal bottom trawl surveys (Archipelago 2014*b*). The surveys were consistent with previous findings, reporting that flatfish species, specifically starry flounder (*Platichthys stellatus)*, English sole (*Parophrys vetulus*), rock sole (*Lepidopsetta bilineata)*, sand sole (*Psettichthys melanostictus)* and Pacific sanddab (*Citharichthys sordidus)* were among the most abundant species sampled within the Roberts Bank study

area (Archipelago 2014*b*). However, the distribution of fish species within deeper ranges (>25 m) of the subtidal environment, beyond the maximum depth accessible by bottom trawls, could not be investigated (Archipelago 2014*b*).

In 2013, as part of the Marine Benthic Subtidal Study (Hemmera 2014b) SCUBA surveys were conducted to address existing data gaps on gravid female Dungeness crab distribution and densities within, and adjacent to the RBT2 footprint. While the results of the survey indicated that gravid female Dungeness crabs were present in the study area, no brooding aggregations were identified along survey transects, which were limited to shallow dive depths above 18 m (Hemmera 2014b). As part of the same study, ROV transect surveys were conducted to quantitatively assess the distributions, densities and habitat preferences of key species among different depth zones within the benthic subtidal environment at Roberts Banks (Hemmera 2014b).

Orange sea pens were widely distributed throughout the study area and were the most abundant invertebrates species identified during the ROV surveys. Consistent with previous studies, Dungeness crabs were second in overall species abundance, and flatfish comprised the highest proportion of total finfish observations, with the highest densities within the 20-30 m depth zone. This survey, however, was limited to areas within and immediately adjacent to the proposed Project footprint and to a maximum depth of approximately 40 m (Hemmera 2014*b*). Detailed methods and results, as well as reviews of relevant literature, existing data and information relevant to each of these studies are documented in the respective technical data reports.

While collectively the other RBT2 studies provide some information on benthic community composition and species abundance in the subtidal zone at Roberts Bank, complete and consistent coverage across the full area and depth ranges relating to the greater candidate DAS area, including the ITP site, remains a data gap.

3.0 REMOTELY OPERATED VEHICLE STUDY COMPONENT

3.1 OVERVIEW

The objective of the ROV study component was to document the current use of the benthic subtidal environment encompassed within the candidate DAS area at Roberts Bank. For each transect, benthic invertebrates and finfish were identified and enumerated, and species (or species group) densities were determined for each depth zone.

ROV video footage was also used to identify geomorphic and physical seabed features within the DAS area, and sediment sampling was carried out during the survey to quantify sediment grain size and to cross validate observational data on substrate type. Detailed methods and results relating to physical characterisation are provided in the Sediment PCB Concentrations and Sediment Thresholds for Increased Uptake in Southern Resident Killer Whales Technical Report (Hemmera 2014*a*).

3.2 STUDY AREA

The study area for the ROV survey includes the subtidal zone of Roberts Bank, specifically the area identified as the candidate DAS area (**Figure 3**). The candidate DAS area spans approximately 6.38 km^2 (638 ha) on the delta foreslope adjacent to the current Roberts Bank terminals and the proposed RBT2 Project, at depths ranging from 40 m to 100 m. The candidate DAS study area boundaries were defined following input from engineering consultants based on four criteria:

- At a distance of ≤ 2 km from the RBT2 seaward berth face, the maximum effective dredge residual piping distance;
- At a depth of greater than 40 m;
- At an area away from existing submarine power cables; and,
- At a sufficient distance from the Canada-USA border to prevent concerns about the direct or indirect transport of sediments from dredging into US waters.

Figure 3 ROV Survey Transects in the Candidate DAS Area

3.3 TEMPORAL SCOPE

The timing of the ROV survey intended to capture the existing conditions within the study area to inform selection of a DAS site. As such, ROV transects were conducted during a five-day period between November 19th to November 22nd, 2013. The physical seabed components of interest are expected to show limited variation over decadal or longer time spans. As biotic components are expected to show seasonal variation in abundance, and/or depth distribution, the present ROV survey component was intended to supplement seasonal data on subtidal faunal density and diversity collected during previous benthic trawl, SIMS, SCUBA, and ROV studies discussed in **Section 2.1.4**).

3.4 STUDY METHODS

ROV surveys were selected as a suitable study method for the present study as ROVs can operate at greater depths than SCUBA and SIMS survey and allows for making real-time adjustments and recording observations during video collection. Furthermore, ROV is recognised by Environment Canada for use in DAS site characterisation. For a more detailed discussion of the advantages and uses of ROV survey methodology refer to Hemmera 2014*b*.

3.4.1 ROV Operations

ROV surveys were conducted over five consecutive days in November 2013 by contract staff from Ocean Dynamics Inc. aboard the contractor's 34 ft. research vessel, the MV "Crown Royal". ROV transects were completed during daylight hours to coincide with a period during which the difference between daytime high and low tides was minimal, thus allowing for relatively weak tidal current conditions. Van Veen grabs samples were collected aboard the same vessel prior to the commencement of the ROV survey to obtain sediment and infauna samples for the Infaunal Macroinvertebrate Study Component (**Section 4.0**). Sediment sampling was carried out over the course of four days (November 19th to 22nd); additional methods and results relating to sediment characterisation are provided in the Sediment PCB Concentrations and Sediment Thresholds for Increased Uptake in Southern Resident Killer Whales Technical Report (Hemmera 2014*a*).

The ROV survey consisted of four linear transects carried out within the candidate DAS area (**Figure 3**). Transects were designed to follow the 45 m, 60 m, 75 m, and 90 m depths contours and varied in length at each depth, running 5,005 m, 4,600 m, 5,300 m, and 3,000 m, respectively (**Figure 3**). For each transect, start points were set just south of Canada-USA border in order to increase the potential to observe historical DAS deposits at the Roberts Bank DAS site (**Section 2.1.3**); end points were set just westward of the candidate DAS area, within a 2 km radius of the western-most corner of the proposed Project area. As defined, the study area boundaries included historical dredge spoil areas on the delta foreslope adjacent to the existing Roberts Bank terminals. The 45 m transect was defined to pass through these areas to provide visual assessment of these sites.

ROV tracks were also run away from the linear transects to follow underwater ridges, especially to develop a better understanding of the characteristics and the extent of finer scale (i.e. metre to decimetre long) seabed forms within the study area. An additional exploratory transect running a total length of 1,800 m, was adapted at the time of ROV field activities based on preliminary results (**Figure 4**). This transect covered depths ranging from 70 m to 45 m and was conducted to revisit sediment features noted at the 45 m and 60 m linear transects and to gain additional coverage within the historical DAS areas.

Each transect was surveyed by Ocean Dynamics using an experienced boat driver and an ROV pilot, two trained biologists to capture real time observations from the video feed, and a deck hand to aid in deployment and retrieval of the ROV. The ROV used in this survey was a Seaeye Falcon© 12127, rated to a depth of 300 m. The ROV was deployed using a hydraulic marine winch system and remained attached to the support vessel via a 450 m (max) umbilical, tethered to the winch cable with duct tape. A clump weight was fixed to the winch cable at the location where the ROV was first tethered in order to allow for the weight to absorb current drag. A 25 pound clump weight was used at lesser depths and lighter current conditions, and a 300 pound weight used for stronger current conditions. The weight was fixed at a distance of 30 m from the ROV to give 30 m of flying tether.

Efforts were made to run all ROV transects at an average speed of 0.2 metres per second (m/sec), following a constant linear heading, and avoiding off-bottom events and stoppages. Efforts were also made to survey either during ebb or slack tide, when tidal currents are less severe in the study area, as it has been previously observed that visibility improves closer to slack tide (Marine Benthic Subtidal Study Technical Data Report (Hemmera 2014*b*)). When strong currents and/or poor visibility conditions were encountered, survey starts were delayed until the currents decreased, or an increase in visibility was observed.

Video was recorded using two cameras, a fixed wide angle camera (Seaeye Colour Camera CAM04N) and a colour zoom camera (Kongsberg OE14-115), on a 180° tilt platform with 10:1 zoom. Video was relayed in real-time along with heading, depth, compass, rate gyro, and time (hours:minutes:seconds) to the support vessel. The ROV was equipped with scaling lasers set at a distance of 0.2 m apart to accurately estimate distance and size of features captured within the field of view during post video processing, as well as with 5 LED lights (total 10,000 lumens) to illuminate the field of view. Video files were obtained from Ocean Dynamics upon completion of daily field activities and stored on the Hemmera file server. Further detail on the review and analysis of video files is described in **Section 3.4.2**.

Underwater positioning was obtained using an ORE Trackpoint II Ultra Short BaseLine (USBL) base navigation system, consisting of an acoustic transducer attached to a pole over the side of the boat communicated with a transponder attached to the ROV to give the relative position of the ROV as x,y,z coordinates. Differential Global Positioning System (DGPS) locations were obtained using a Trimble TSC1 Asset Surveyor. Ship heading and gyro (compass heading) was relayed using a TCM2 3-Axis

Compass Module. Workboat by Seanav (www.seanav.com) was used as an on board navigation software. The USBL information, as well as the DGPS, TCM2, and ROV telemetry (ROV depth, heading, pitch, roll) and sensor position offsets fed into the Workboat software. ROV depth fed from Workboat back into Trackpoint II to be used as a given depth and to assist with the relative position solution. Workboat displayed the vessel to scale and the ROV position in real time (every second). A velocity filter in Workboat, usually set to 2 m/s, was used in real time to help the pilot and vessel skipper with ROV location. Logged unfiltered data for the ROV final position solution, depth, and heading were recorded every second. The unfiltered position data was obtained from Ocean Dynamics upon completion of daily field activities and stored on the Hemmera file server. Position data were analysed as described in **Section 3.5.1**.

3.4.2 Field Data Observations

In addition to the Ocean Dynamics crew, a trained environmental scientist from Hemmera served as an on board video-reviewer and field data recorder to capture detailed observations in real time.

The field laptop clock was synchronised to the ROV video clock to the nearest second prior to starting the transect run and on each day of ROV surveying. As species were observed in the ROV field of view during the ROV operations, identification was made by the ROV pilot and feature count number, and identification was verbally communicated to the field data recorder. The video-reviewer immediately recorded the exact time the observation was relayed in a field observation data log in Microsoft Excel©, and recorded the relevant observations in the features columns corresponding to the time entry row. In this way, physical and biological observations were entered with an exact date and time stamp (m/dd/yyyy hh:mm:ss), which could be linked to an exact position using the GPS coordinate relayed at the same second.

Field observations were recorded for the following categories:

- Water column characteristics:
  - Visibility (<1 m, 1-3 m, >3 m)
  - Bottom water clarity (i.e., clear and featureless, minimal suspended particulates, abundant suspended particulates)
- Seabed Geomorphic and Physical features:
  - Visually evident changes in sediment appearance (texture, colour)
  - Possible historical dredge residuals
  - Dune-like features
  - Ripples or Waves in Seabed
  - Canyons/turbidity flows

- Evidence of slumping or jumbled sediments
- Organic flocs or fluff at sediment/water interface

- Biological Observations:
  - Number of sea pens
  - Number of Dungeness crabs
  - Numbers of other invertebrates
  - Number of flatfish
  - Number of finfish (small and large demersals, include skates)
  - Schools of fish (occurrence only)
- Other: incidental observations including debris from natural and anthropogenic sources (i.e., crab traps, derelict fishing gear, woody debris), sediment clumps, and rocky outcrops were described within the 'other' category of the field data log.

Exact numbers for observed feature counts were recorded whenever observations allowed. In cases where accurate numbers could not be counted, as for the case of schools of multiple fish in water column, rough counts were estimated for classification into size groupings, such that results could be reported semi quantitatively (small/medium/large), as described further in **Section 3.4.3**.

Species counts were only recorded while the ROV was running at a steady forward rate and did not include periods were operations were paused to create new video files. The single exception was the observation of a giant Pacific octopus (*Enteroctopus dofleini*), which was sighted while waiting out strong bottom currents at the start point of the exploratory transect (**Section 3.6.5**).

3.5 DATA ANALYSIS

3.5.1 GPS Data Filtering

Detailed position data were provided by Ocean Dynamics unfiltered and unprocessed. A final survey path line was generated by selecting the median X and Y coordinates from the 10 seconds preceding and following each given time entry (20 seconds total). This located the position of any given field observation while filtering out outliers. The median coordinates were used to plot the actual survey path as followed by the ROV for each transect.

3.5.2 Video Review and Field of View Calculation

Video footage was reviewed using Microsoft Windows Media Player software. Field of view was determined at four minute intervals for each transect. The distance between the 20 cm scaling lasers as displayed on the video player screen was measured using a handheld ruler. In instances where the four-minute interval mark fell on a moment where the scaling lasers were not visible (i.e., due to lighting and/or suspended particles), a measurement was taken at the closest time to the four-minute interval (before or after) at which the lasers were able to be seen. This was necessary for the 75 m and 90 m transects, as the video footage from these transects had poorer visibility conditions compared to the 45 m and 60 m

transects. This methodology may bias towards smaller field of view calculations in sections with poor visibility, as the lasers were generally more visible when the ROV was closer to the sea floor. Subsequently, this may bias toward higher estimates of species density than is accurate for transects with poor visibility conditions. This bias should not affect estimates of relative density among different species.

Field of view was then calculated using the measured laser distance, the video player screen width (21.6 cm) and the original scaling laser width (20 cm), using the following formula:

$$Field\ of\ View\ (cm) = \ Actual\ Lasers\ Distance\ (cm) \times \frac{Video\ Player\ Screen\ Width\ (cm)}{Lasers\ Distance\ on\ Screen(cm)}$$

$$Field\ of\ View\ (cm) = \ 20\ cm \times \frac{21.6\ (cm)}{Lasers\ Distance\ on\ Screen(cm)}$$

Calculated field of view measurements were averaged for each 200 m segment of the transect. The averaged field of views were multiplied by the segment length to develop estimates of the visually surveyed area (area = length x width). Segments were generally 200 m in length, except at the NW ends of the linear transects and for the exploratory transect. The 200 m averaged field of views were used in subsequent biota density calculations.

3.5.3 Field Observation Data Processing

Post-survey processing of the field observation log was performed to group organism sightings into relevant categories and a compatible format for geospatial-based analysis. Observations stored as text entries were represented as numerical values to allow for density calculations using ArcGIS. Counts of Dungeness crabs, sea pens, and flatfish were used directly as recorded in the field. All remaining invertebrates, including other crabs, squat lobsters, crayfish, nudibranchs, sponges, anemones, shrimp, prawns, sea stars, clam siphons, biogenic holes, and sea cucumbers, were summed into a single ‘other invertebrates’ grouping. Small and large demersal fish were summed as a single ‘finfish or cartilaginous fish’ category. Counts were summed for each 200 m segment and used in subsequent density calculations.

Accurate counts of the number of individuals in mobile schools of fish including perch (*Embiotocidae*) and herring (*Clupea pallasii*) could not be obtained because fish moved in and out of the field of view and the whole school was rarely visible in the camera field of view. As such, schools of fish were assessed semi-quantitatively. Video footage was reviewed at timestamps where fish schools were sighted, and the schools were assigned to a relative size class based on count estimates. Perch observations were classified into small (approximately 1-10 fish), medium (approximately 11-50 fish), and large (approximately 51-100 fish) school sizes. Herring observations were classified into small (approximately 1-100 fish), medium (approximately 101-200 fish), and large (approximately 201-500 fish) school sizes.

Video stills of representative species, as well as notable observations were extracted from the ROV video files as cataloged in **Table 2** and found in **Appendix A: Representative ROV Video Stills**.

Table 2 Sample Stills of Biological Observation from ROV Video Footage

Ecological Observation Represented	Transect	Photo Timestamp	Appendix Figure #
Invertebrates			
Dungeness crabs	45 m	11/23/2013 9:54	A1
Sea pens	45 m	11/23/2013 14:36	A2
Shrimp	75 m	11/25/2013 9:17	A3
Prawns	60 m	11/24/2013 12:01	A4
Rock Crab	60 m	11/24/2013 12:30	A5
Small Crab	60 m	11/24/2013 10:43	A6
Tanner Crab	75 m	11/25/2013 9:27	A7
Squat Lobster	60 m	11/24/2013 10:29	A8
Different Crab	75 m	11/25/2013 14:27	A9
Decorator Crab	90 m	11/27/2013 12:57	A10
Anemone	Exploratory, 60 to 75 m	11/26/2013 12:44	A11
Nudibranch	45 m	11/23/2013 15:24	A12
Sea cucumber	45 m	11/23/2013 14:40	A13
Brittle Star	45 m	11/23/2013 11:07	A14
Sponges	Exploratory, 50 m	11/27/2013 14:14	A15
Giant Pacific octopus	Exploratory, 80 m	11/26/2013 09:55	A16-A18
Fish and Fish Schools			
Flatfish	45 m	11/23/2013 9:54	A19
Smaller Demersal Fish	45 m	11/23/2013 11:02	A20
Larger Demersal Fish	45 m	11/23/2013 14:41	A21
Skate egg	45 m	11/23/2013 10:24	A22
Perch, small (1-10)	45 m	11/23/2013 11:05	A23
Perch, medium (11-50)	60 m	11/24/2013 10:47	A24
Perch, large (51-100) (full school not captured in field of view)	Exploratory, 60 m	11/26/2013 11:05	A25
Herring, small (1-15)	60 m	11/24/2013 9:22	A26
Herring, medium (16-200)	75 m	11/25/2013 11:55	A27
Herring, large (201-500)	45 m	11/23/2013 15:51	A28
Incidental Observations			
Derelict fishing net with crab covered in barnacles	75 m	11/24/2013 15:26	A29
Beggiatoa (with gas release bubbles)	90 m	11/26/2013 14:46	A30
Derelict fishing net	90 m	11/26/2013 15:02	A31
Crab trap, partially buried	90 m	11/26/2013 15:50	A32
Derelict crab trap	90 m	11/27/2013 13:05	A33
Derelict crab trap with bait and 12 live crabs	Exploratory, 60 m	11/26/2013 11:20	A34

3.6 RESULTS

3.6.1 Transect Overview

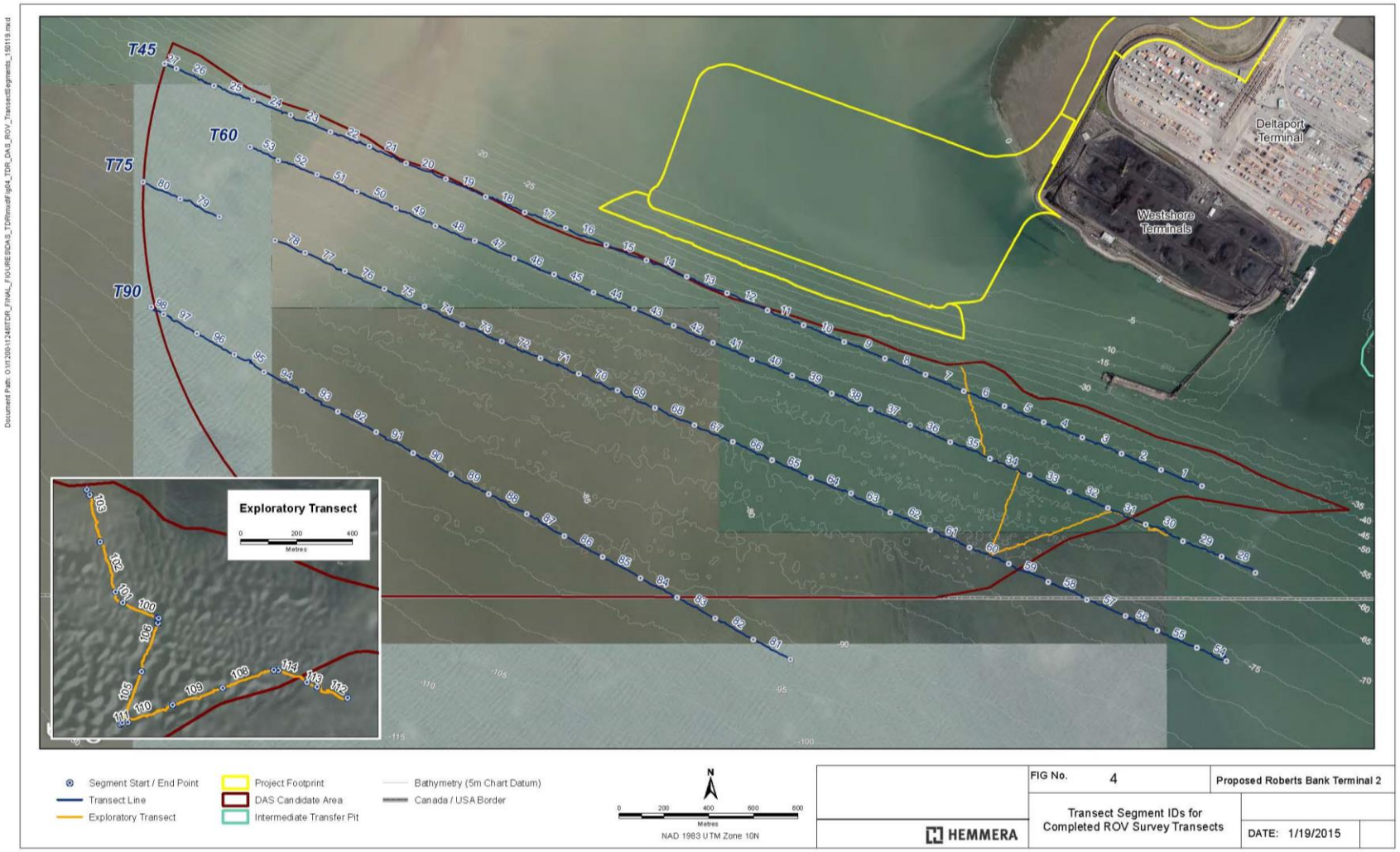
The survey dates, depth ranges, and total distance covered by each transect are summarised in **Table 3**. Transect distance results are presented as the distance drawn as a straight line between the transect start and end points, as well as the total distance by the actual path taken by the ROV. In total, the ROV surveyed a path totalling 28,529 m along the seabed floor within the candidate DAS area (**Table 3**).

Table 3 ROV Transects Survey Path Distances

Transect	Date(s) Surveyed	Transect Segments	Approximate Depth Surveyed (m)	Distance Between Start and End Points (m)	Actual Distance Surveyed (m)
45 m Linear Transect	November 23, 2013	T45, total	45	5,004	5,265
60 m Linear Transect	November 24, 2013	T60, total	60	4,879	5,150
75 m Linear Transect	November 24 and 25, 2013	T75, total	75	5,293	5,333
		T75, south	75	4,647	4,946
		T75, north	75	375	387
		T75, gap	75	271	0
90 m Linear Transect	November 26 and 27, 2013	T90	90	3,261	3,473
Exploratory Transect	November 26, 2013	Total	40 to 75	1,769	1,987
		Z3_1	40 to 60	527	622
		Z4_3	60 to 75	396	423
		Z4_7	60 to 75	579	628
		Z5_7	60	267	315
All Transects			45 to 90	27,268	28,529

Organism counts per 200 m or other segment (**Figure 4**) were calculated and plotted to visually assess the differences between species density across depth zones within the candidate DAS study area (**Figures 5** to **Figure 9**).

Figure 4 Transect Segment IDs for Completed ROV Survey Transects



For each linear transect, species densities are presented as the total number of organisms observed per total area of ROV transect (indiv./m^2) (**Table 4**, **Table 6**, and **Table 8**), and for individual segments for each section of the exploratory transect (**Table 5**, **Table 7**, and **Table 9**). The complete linear transect results broken out by individual segment and the complete exploratory transect results are provided in **Appendix B: ROV Density Results by Transect Segment**.

3.6.2 Invertebrate Count and Density Results

Dungeness crabs were observed in all four linear transects following the 45 m, 60 m, 75 m, and 90 m contours. While no statistical analyses were performed to assess whether relationships exist between species density and/or abundance and depth, the total number of Dungeness crabs sightings were greatest at the 45 m depth contour (n=336), with greater counts observed in the north-west third of the 45 m transect and midway along the 60 m and 75 m transects (**Figure 5; Table 4**). Dungeness crabs abundance was generally greater in the areas on the delta foreslope adjacent to and off the northwest corner of the proposed Project, and relatively lower in the area immediately south of the existing Westshore Terminals, as well as the site of previous disposal at sea activities for DP3 construction (**Figure 5**). Total crab density was highest at shallower depth in 45 m transect (0.048 indiv./m^2), lower in the 60 m and 75 m transects (0.039 indiv./m^2 and 0.032 indiv./m^2, respectively), and was the lowest at deepest depth in the 90 m transect (0.005 indiv./m^2) (**Table 4**). The greatest difference in Dungeness crab density was observed between depths of 75 m and 90 m.

Dungeness crab density results along the exploratory transect (includes multiple depth contours) is consistent with the densities observed among the pre-determined linear transects. Crab densities were higher with greater depth in the 60 m to 75 m transect section (ranging from 0.00 indiv./m^2 to 0.06 indiv./m^2), and highest in the 60 m to 40 m transect section (0.053 indiv./m^2 to 0.097 indiv./m^2) (**Figure 5**). While the average crab density for exploratory transect segments that parallels the 60 m depth contour (0.029 indiv./m^2) (**Table 5**) was less than the average density observed across the 60 m linear transect (0.085 indiv./m^2) (**Table 4**), results are within the range of densities observed in the 60 m linear transect (0.005 indiv./m^2 to 0.099 indiv./m^2) (**Table 4**).

Orange sea pens were also found in all four linear transects. Sea pen abundance and density where highest at shallow depths and lowest at deeper depths. Sea pen density was highest in the 45 m transect (0.019 indiv./m^2) and 60 m (0.010 indiv./m^2) transects, and lowest in the 75 m (0.003 indiv./m^2) and 90 m (0.002 indiv./m^2) transects (**Table 4**). The greatest difference in sea pen density was observed between the 45 m to 60 m transects. In general, sea pen counts were slightly higher at the north-west end of the 45 m transect and south-east end of the 60 m transect (**Figure 6**). Total sea pen sightings were concentrated in two 200 m segments of the 45 m transect located adjacent to the south-east corner of the proposed Project (**Figure 6**).

In general, sea pen density results along the exploratory transect were consistent with the densities observed among the linear transects. While average sea pen density along the exploratory transect section parallel to the 60 m depth contour (0.005 indiv./m^2) (**Table 5**) was less than the average density observed across the pre-determined 60 m linear transect (0.032 indiv./m^2), results are within the observed density range (from 0.000 indiv./m^2 to 0.052 indiv./m^2) (**Table 4**). Low sea pen densities were observed in the 60 m to 75 m transect sections (ranging from 0.000 to 0.011 indiv./m^2) (**Table 5**). Highest sea pen densities in the exploratory transect were observed along the 60 m to 40 m transect section (0.16 indiv./m^2 and 0.11 indiv./m^2) at segments corresponding to the same location of concentrated sea pens noted in the 45 m transect (**Table 5; Figure 6**).

Other invertebrates were observed at all depths. In general, organism counts where higher at deeper depth contours with greatest densities observed in the 75 m and 90 m transects. Higher densities were also observed along the 45 m, 60 m and 75 m contours in the area immediately south of the existing Westshore Terminals, and the site of previous disposal at sea activities for DP3 construction (**Figure 7**). Total invertebrate densities were lowest overall at the 45 m and 60 m transects (0.015 indiv./m^2 and 0.016 indiv./m^2, respectively), and highest at the 75 m and 90 m transects (0.050 indiv./m^2 and 0.057 indiv./m^2, respectively) (**Table 4**).

Results from the exploratory transect support the general results observed in the linear transects. Other invertebrate densities were greater at deeper depths in the 60 m to 75 m transect sections (ranging from 0.052 indiv./m^2 to 0.36 indiv./m^2) and lower in the 60 m to 40 m (0.11 indiv./m^2 to 0.00 indiv./m^2) transect section (**Table 5**). Given the diversity of species included in the invertebrate counts, the relationship between invertebrate density and depth is difficult to infer. Any qualitative assessment of density relative to depth are likely influenced by the increased in presence of shrimp and prawns, which make up a large proportion of counts for this grouping and are generally found in deeper habitats.

Figure 5 Dungeness Crab Observations by ROV Survey in the Candidate DAS Area

Figure 6 Sea Pen Observations by ROV Survey in the Candidate DAS Area

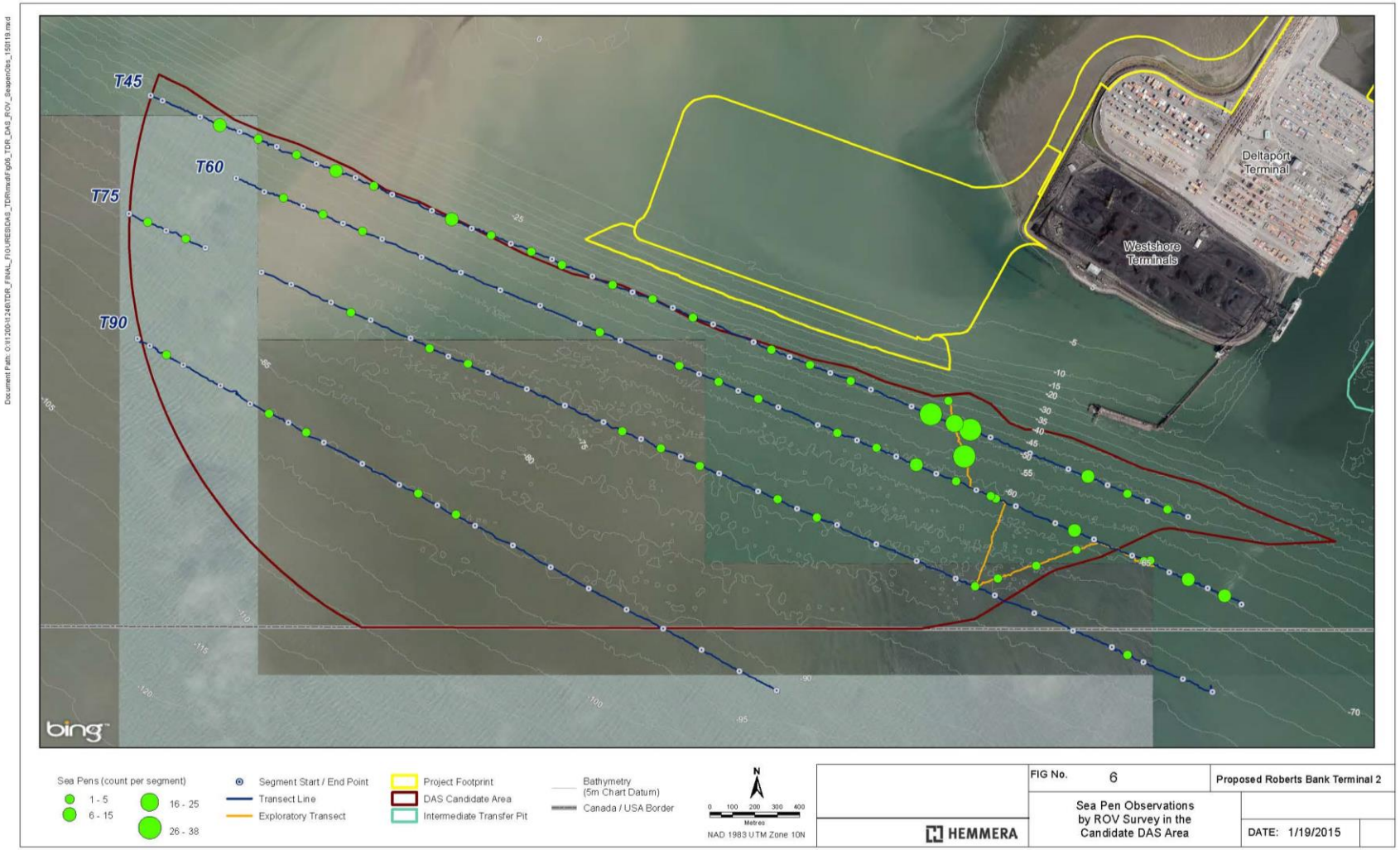


Figure 7 Other Invertebrate Observations by ROV Survey in the Candidate DAS Area

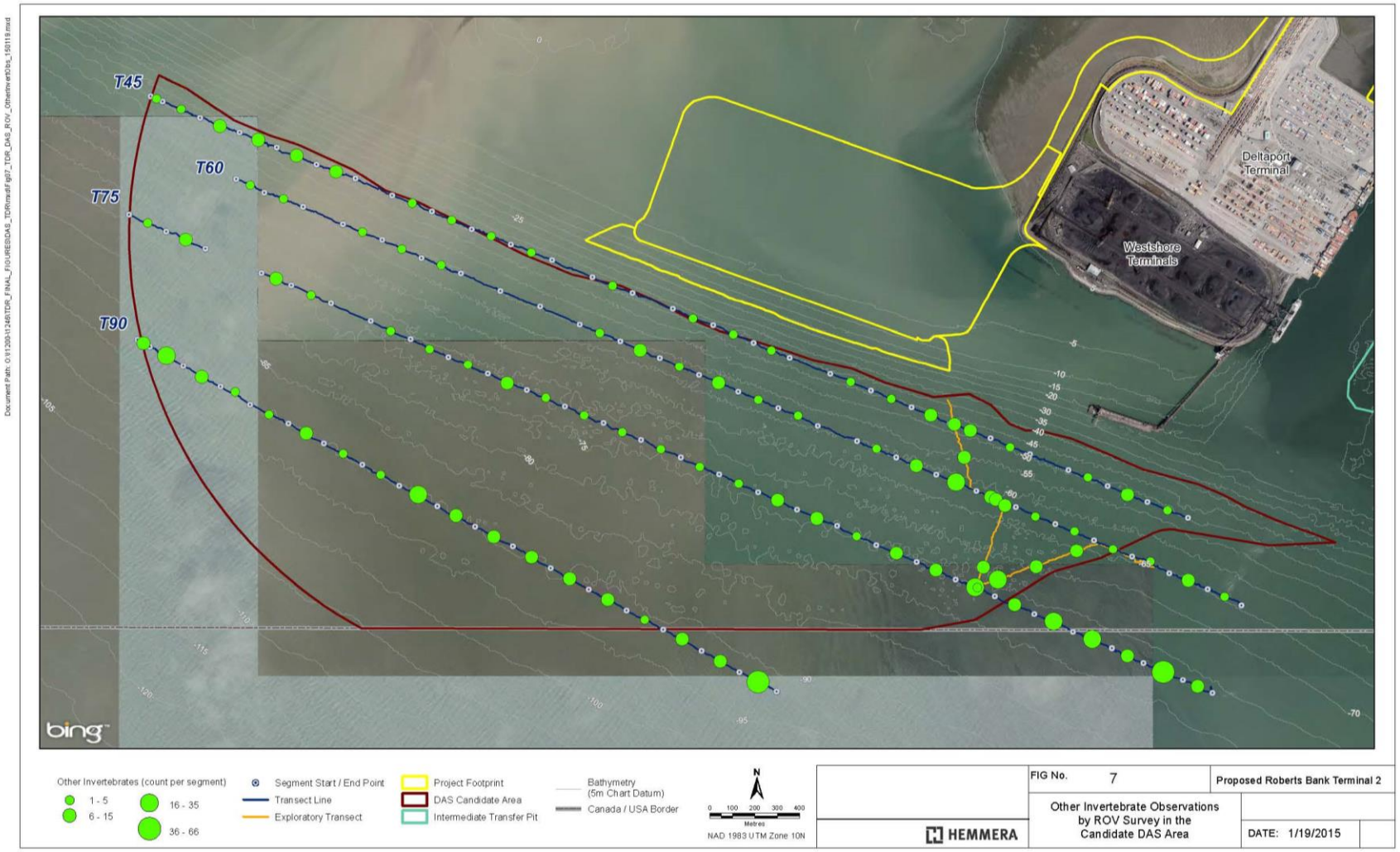


Table 4 Summary Data for Invertebrate Counts and Densities for the 45 m, 60 m, 75 m, and 90 m Linear Transects

Transect	Total Length (m)	Total Area (m^2)	Summary Data	Dungeness Crabs		Sea Pens		Other Invertebrates	
				No.	Density (#/m^2)	No.	Density (#/m^2)	No.	Density (#/m^2)
45 m Transect	**5265**	**7066.5**	Min*	1	0.012	0	0.000	0	0.000
			Max*	52	0.186	38	0.167	12	0.045
			Average*	12	0.047	5	0.021	4	0.015
			SD*	11	0.039	9	0.042	4	0.015
			Total**	**336**	**0.048**	**136**	**0.019**	**104**	**0.015**
60 m Transect	**5150**	**5926.5**	Min	1	0.005	0	0.000	0	0.000
			Max	19	0.099	10	0.052	16	0.099
			Average	21	0.041	7	0.012	7	0.019
			SD	62	0.025	25	0.016	19	0.023
			Total	**232**	**0.039**	**59**	**0.010**	**95**	**0.016**
75 m Transect	**5333**	**5187.4**	Min	0	0.000	0	0.000	0	0.000
			Max	18	0.101	3	0.013	66	0.312
			Average	6	0.030	1	0.003	10	0.052
			SD	6	0.029	1	0.004	14	0.072
			Total	**168**	**0.032**	**16**	**0.003**	**261**	**0.050**
90 m Transect	**3473**	**3898.2**	Min	0	0.000	0	0.000	3	0.011
			Max	4	0.014	2	0.013	39	0.183
			Average	1	0.004	0	0.002	12	0.063
			SD	1	0.004	1	0.004	10	0.054
			Total	**18**	**0.005**	**7**	**0.002**	**223**	**0.057**

***** *per segment*
** *across all segments in transect*

Table 5 Summary Data for Invertebrate Counts and Densities for the Exploratory Transect

Transect Section	Segment				Dungeness Crabs		Sea Pens		Other Invertebrates	
	Approx. Depth (m)	Length (m)	Area (m^2)	ID	No.	Density (#/m^2)	No.	Density (#/m^2)	No.	Density (#/m^2)
Z5_7	60, Constant Depth	159.5	136.3	112	4	0.029	2	0.015	0	0.000
		40.5	34.3	113	2	0.058	0	0.000	0	0.000
		115.5	101.6	114	0	0.000	0	0.000	0	0.000
				Min*	0	0.000	0	0.000	0	0.000
				Max*	4	0.058	2	0.015	0	0.000
				Average*	2.0	0.029	0.7	0.005	0.0	0.000
				SD*	2.0	0.029	1.2	0.009	0.0	0.000
	Total	**315.5**	**272.2**	**Total****	**6**	**0.022**	**2**	**0.007**	**0**	**0.000**
Z4_7	60 to 75, Shallow to Deep	200.0	181.5	108	3	0.017	2	0.011	11	0.061
		200.0	150.4	109	1	0.007	1	0.007	6	0.040
		200.0	137.6	110	1	0.007	1	0.007	23	0.168
		27.9	20.6	111	0	0.000	0	0.000	5	0.243
				Min	0	0.000	0	0.000	5	0.040
				Max	3	0.017	2	0.011	23	0.243
				Average	1.3	0.008	1.0	0.006	11.3	0.128
				SD	1.3	0.007	0.8	0.005	8.3	0.095
	Total	**627.9**	**490.1**	**Total**	**5**	**0.010**	**4**	**0.008**	**45**	**0.092**
Z4_3	75 to 60, Deep to Shallow	200.0	155.1	105	0	0.000	0	0.000	8	0.052
		200.0	148.1	106	3	0.021	0	0.000	0	0.000
		22.5	16.7	107	1	0.060	0	0.000	6	0.360
				Min	0	0.000	0	0.000	0	0.000
				Max	3	0.060	0	0.000	8	0.360
				Average	1.3	0.027	0.0	0.000	4.7	0.137
				SD	1.5	0.030	0.0	0.000	4.2	0.195
	Total	**422.5**	**319.8**	**Total**	**4**	**0.013**	**0**	**0.000**	**14**	**0.044**
Z3_1	60 to 40, Deep to Shallow	143.1	126.9	100	8	0.063	3	0.024	14	0.110
		56.9	56.9	101	3	0.053	0	0.000	0	0.000
		200.0	196.5	102	19	0.097	31	0.158	13	0.066
		200.0	201.5	103	11	0.055	21	0.105	10	0.050
		21.6	21.8	104	2	0.092	1	0.046	0	0.000
				Min	2	0.053	0	0.000	0	0.000
				Max	19	0.097	31	0.158	14	0.110
				Average	8.6	0.072	11.2	0.067	7.4	0.045
				SD	6.9	0.021	14.0	0.064	6.9	0.047
	Total	**621.6**	**603.4**	**Total**	**43**	**0.071**	**56**	**0.093**	**37**	**0.061**

***** *per segment*
*** across all segments in transect*

3.6.3 Fish Count and Density Results

Flatfish were observed in all four linear transects following the 45 m, 60 m, 75 m, and 90 m contours (**Figure 8**, **Table 6**). Total flatfish counts were greatest at the 45 m (n=432) and 60 m (n=403) depth contours, with the greatest counts observed in both the south-east and north-west thirds of these two transects (**Figure 8**). Total flatfish densities were also highest in the 45 m and 60 m transects (0.061 indiv./m^2 and 0.068 indiv./m^2, respectively), and lowest in the 75 m and 90 m transects (0.027 indiv./m^2 and 0.022 indiv./m^2, respectively) (**Table 6**). The greatest difference in flatfish density was observed between the 60 m and 75 m transects.

Flatfish density results for the exploratory transect are consistent with the depth trends observed in the linear transects. While the average flatfish density among the exploratory transect section that parallels the 60 m depth contour (0.029 indiv./m^2) (**Table 7**) was less than the average density observed across the 60 m linear transect (0.070 indiv./m^2), results are within the observed range (0.028 indiv./m^2 to 0.12 indiv./m^2) (**Table 6**). In general, flatfish density were lower in the 60 m to 75 m transect sections (ranging from 0.00 indiv./m^2 to 0.062 indiv./m^2), and higher in the 60 m to 40 m transect section (ranging from 0.055 indiv./m^2 to 0.21 indiv./m^2) (**Table 7**).

Finfish or cartilaginous fish were observed in all four linear transects following the 45 m, 60 m, 75 m, and 90 m contours (**Figure 9**, **Table 6**). Total sightings were the lowest in the 45 m transect (n=73) and greatest at the 60 m transect (n=508), with the greatest counts observed in the south-east half of the 60 m transect. Higher counts were also observed in the south-east end of the 75 m transect and midway along the 90 m transects. Total densities were highest at the 60 m, 75 m, and 90 m transects (0.086 indiv./m^2, 0.078 indiv./m^2, and 0.088 indiv./m^2 respectively) and lowest at the 45 m transect (0.010 indiv./m^2). The greatest difference in finfish or cartilaginous fish density was between the 45 m and 60 m transects.

Finfish and cartilaginous fish density results for the exploratory transect further support the density results observed in the linear transects. While the average density for segments of the transect at the 60 m depth contour of the transect (0.029 indiv./m^2) (**Table 7**) were less than the average density observed across the 60 m linear transect (0.099 indiv./m^2), results are within the observed range (0.006 indiv./m^2 to 0.57 indiv./m^2) (**Table 6**). Densities for the 60 m to 75 m transect section (ranging from 0.049 indiv./m^2 to 0.180 indiv./m^2) were within the ranges observed for the 60 m and 75 m linear transects (0.006 indiv./m^2 to 0.57 indiv./m^2 and 0.007 indiv./m^2 to 0.31 indiv./m^2), respectively. Densities were lowest in the 60 m to 40 m transect section (0.11 indiv./m^2 to 0.00 indiv./m^2) (**Table 7**).

Figure 8 Flat Fish Count Observations by ROV Survey in the Candidate DAS Area

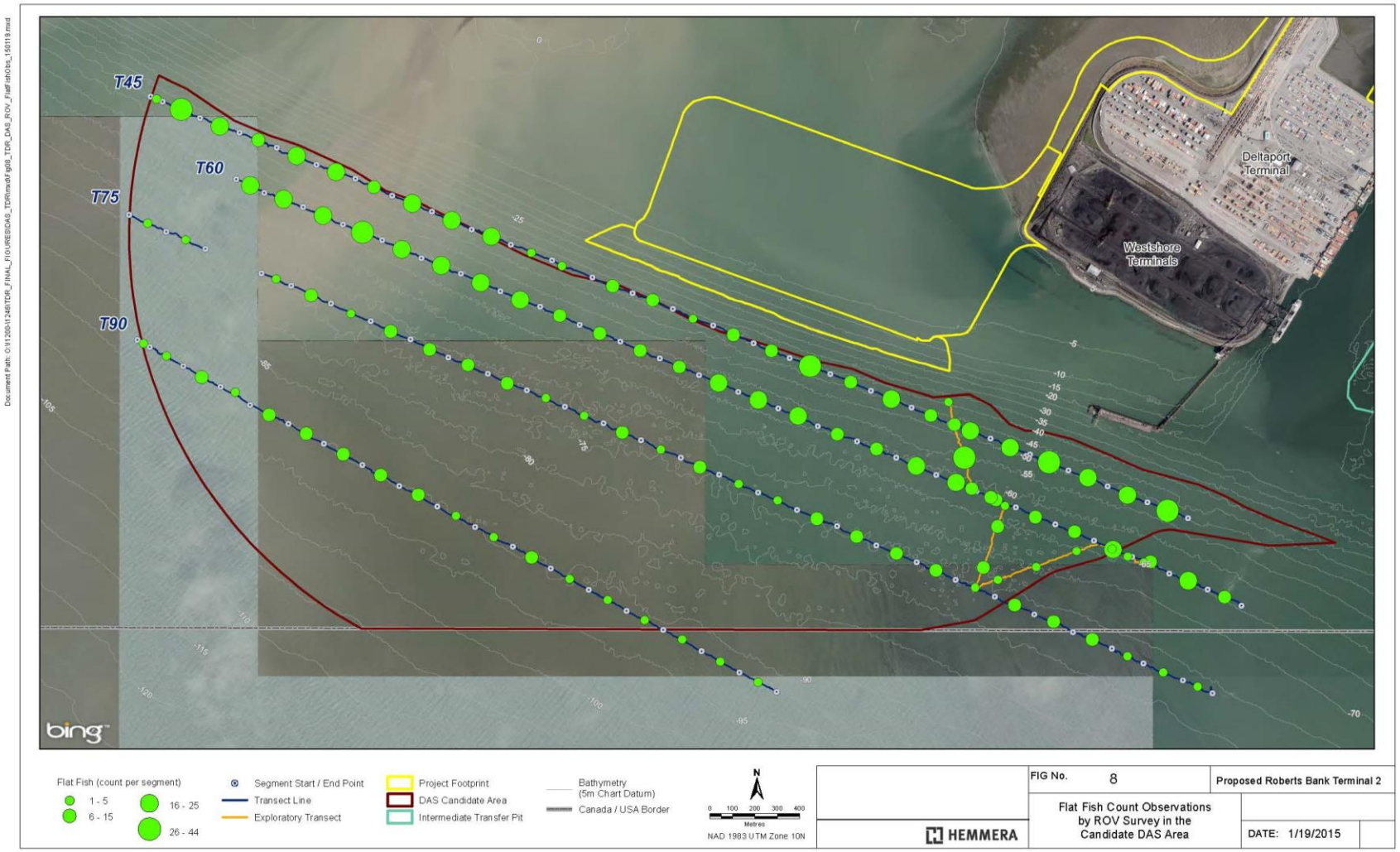


Figure 9 Finfish and Cartilaginous Fish Count Observations by ROV Survey in the Candidate DAS Area

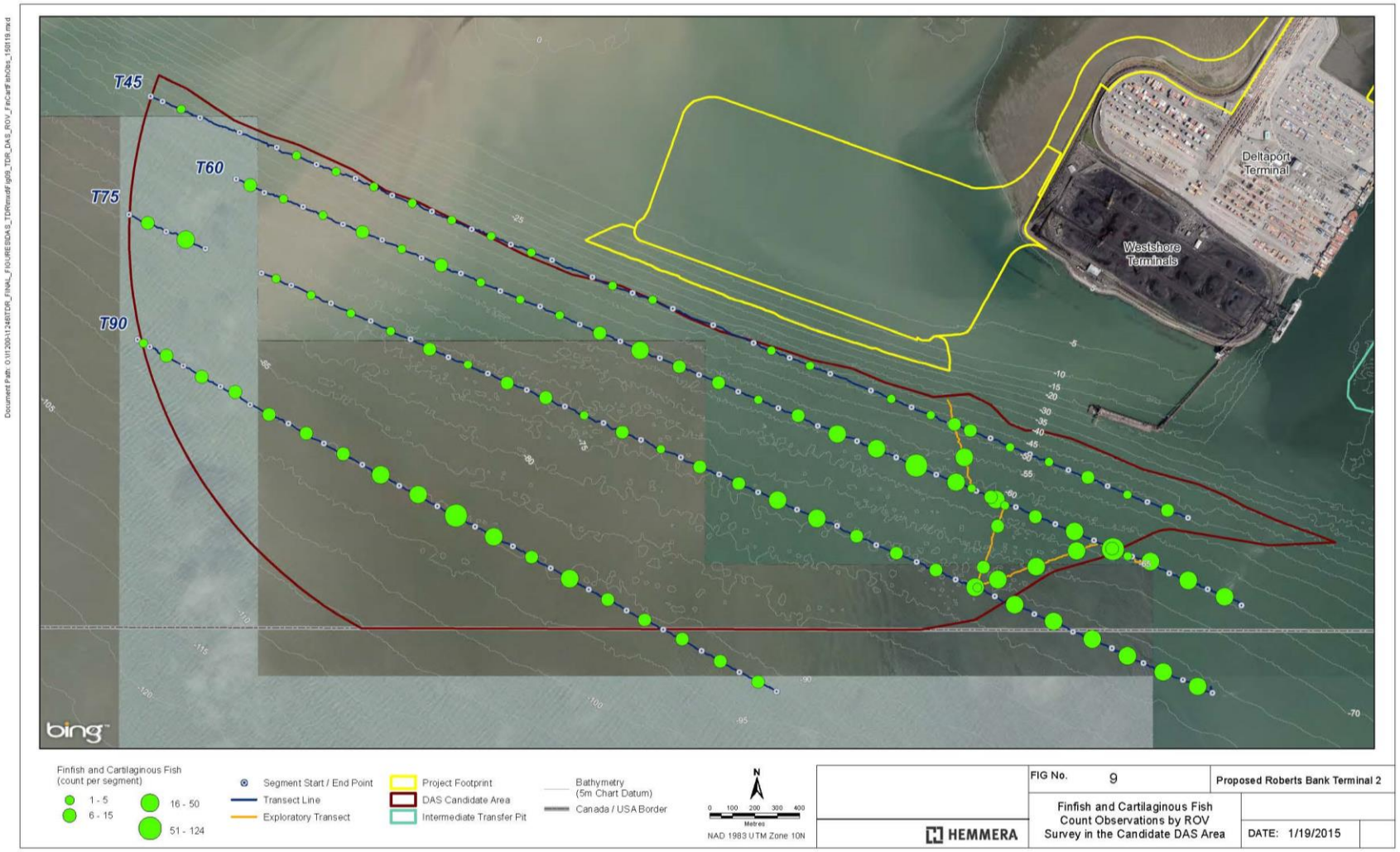


Table 6 Summary Data for Fish Counts and Densities for the 45 m, 60 m, 75 m, and 90 m Linear Transects

Transect	Total Length (m)	Total Area (m2)	Summary Data	Flatfish		Finfish and Cartilaginous Fish		All Fish	
				No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)
45 m Transect	5265	7066.5	Min*	1	0.003	0	0.000	1	0.003
			Max*	44	0.180	13	0.057	47	0.224
			Average*	16	0.063	3	0.011	19	0.075
			SD*	11	0.045	3	0.014	12	0.054
			Total**	**432**	**0.061**	**73**	**0.010**	**505**	**0.071**
60 m Transect	5150	5926.5	Min	6	0.028	2	0.006	10	0.034
			Max	29	0.120	124	0.574	149	0.683
			Average	30	0.070	21	0.095	51	0.164
			SD	79	0.030	31	0.146	94	0.160
			Total	**403**	**0.068**	**508**	**0.086**	**911**	**0.154**
75 m Transect	5333	5187.4	Min	1	0.006	1	0.007	2	0.014
			Max	11	0.062	47	0.309	53	0.348
			Average	5	0.028	15	0.081	20	0.109
			SD	2	0.013	12	0.074	12	0.074
			Total	**140**	**0.027**	**404**	**0.078**	**544**	**0.105**
90 m Transect	3473	3898.2	Min	1	0.004	2	0.028	3	0.042
			Max	10	0.055	119	0.438	120	0.441
			Average	5	0.022	19	0.081	24	0.103
			SD	3	0.012	26	0.092	25	0.089
			Total	**85**	**0.022**	**342**	**0.088**	**427**	**0.110**

***** *per segment*
** *across all segments in transect*

Table 7 Summary Data for Fish Counts and Densities for the Exploratory Transect

Transect Section	Segment				Flatfish		Finfish and Cartilaginous Fish		All Fish	
	Approx. Depth (m)	Length (m)	Area (m2)	ID	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)
Z5_7	60, Constant Depth	159.5	136.3	112	4	0.029	0	0.000	4	0.029
		40.5	34.3	113	1	0.029	1	0.029	2	0.058
		115.5	101.6	114	3	0.030	6	0.059	9	0.089
				Min*	1	0.029	0	0.000	2	0.029
				Max*	4	0.030	6	0.059	9	0.089
				Average*	2.7	0.029	2.3	0.029	5.0	0.059
				SD*	1.5	0.000	3.2	0.030	3.6	0.030
	Total	**315.5**	**272.2**	**Total****	**8**	**0.029**	**7**	**0.026**	**15**	**0.055**
Z4_7	60 to 75, Shallow to Deep	200.0	181.5	108	4	0.022	23	0.127	27	0.149
		200.0	150.4	109	5	0.033	23	0.153	28	0.186
		200.0	137.6	110	5	0.037	18	0.132	23	0.168
		27.9	20.6	111	0	0.000	1	0.049	1	0.049
				Min	0	0.000	1	0.049	1	0.049
				Max	5	0.037	23	0.153	28	0.186
				Average	3.5	0.023	16.3	0.115	19.8	0.138
				SD	2.4	0.017	10.4	0.046	12.7	0.062
	Total	**627.9**	**490.1**	**Total**	**14**	**0.029**	**65**	**0.133**	**79**	**0.161**
Z4_3	75 to 60, Deep to Shallow	200.0	155.1	105	6	0.039	9	0.058	15	0.097
		200.0	148.1	106	9	0.062	14	0.097	23	0.159
		22.5	16.7	107	1	0.060	3	0.180	4	0.240
				Min	1	0.039	3	0.058	4	0.097
				Max	9	0.062	14	0.180	23	0.240
				Average	5.3	0.054	8.7	0.112	14.0	0.165
				SD	4.0	0.013	5.5	0.062	9.5	0.072
	Total	**422.5**	**319.8**	**Total**	**16**	**0.050**	**26**	**0.081**	**42**	**0.131**
Z3_1	60 to 40, Deep to Shallow	143.1	126.9	100	7	0.055	14	0.110	21	0.166
		56.9	56.9	101	12	0.211	3	0.053	15	0.264
		200.0	196.5	102	27	0.138	18	0.092	45	0.229
		200.0	201.5	103	9	0.045	6	0.030	15	0.075
		21.6	21.8	104	3	0.138	0	0.000	3	0.138
				Min	3	0.045	0	0.000	3	0.075
				Max	27	0.211	18	0.110	45	0.264
				Average	11.6	0.117	8.2	0.057	19.8	0.174
				SD	9.2	0.068	7.6	0.045	15.5	0.075
	Total	**621.6**	**603.4**	**Total**	**58**	**0.096**	**41**	**0.068**	**99**	**0.164**

***** *per segment*
*** *across all segments in transect*

3.6.4 Fish School Count Results

Observations of fish schools were plotted as a single observation along each 200 m segment of the ROV transects (**Figure 10**). In cases where more than one school was observed along a 200 m subsection, multiple schools are plotted such that each school sighting is represented.

Perch school sightings were observed at the 45 m, 60 m, and 75 m transects, with no sightings observed in the 90 m transect (**Figure 10**, **Table 8**). Three large schools were observed along the north-west half of the 45 m transect (**Figure 10**). A fourth large school was observed at the 60 m depth contour of the exploratory transect (**Table 9**). Medium schools were observed at the south-east half of both 45 m and 60 m transects (**Figure 10**). Perch observations at the 75 m transect were limited to small schools sighted within the middle third of the 75 m transect.

Herring school sightings were observed in all four depth contour transects (**Figure 10**, **Table 8**). A single large school was observed at the south-east end of the 45 m transect. Sightings at the 75 m and 90 m transects were limited to small schools. Two medium schools were observed within the middle third of the 75 m transect. Herring observations at the 90 m transect were limited to a single small school. No additional herring schools were sighted in the exploratory transect (**Table 9**).

Figure 10 Fish School Observations by ROV Survey in the Candidate DAS Area

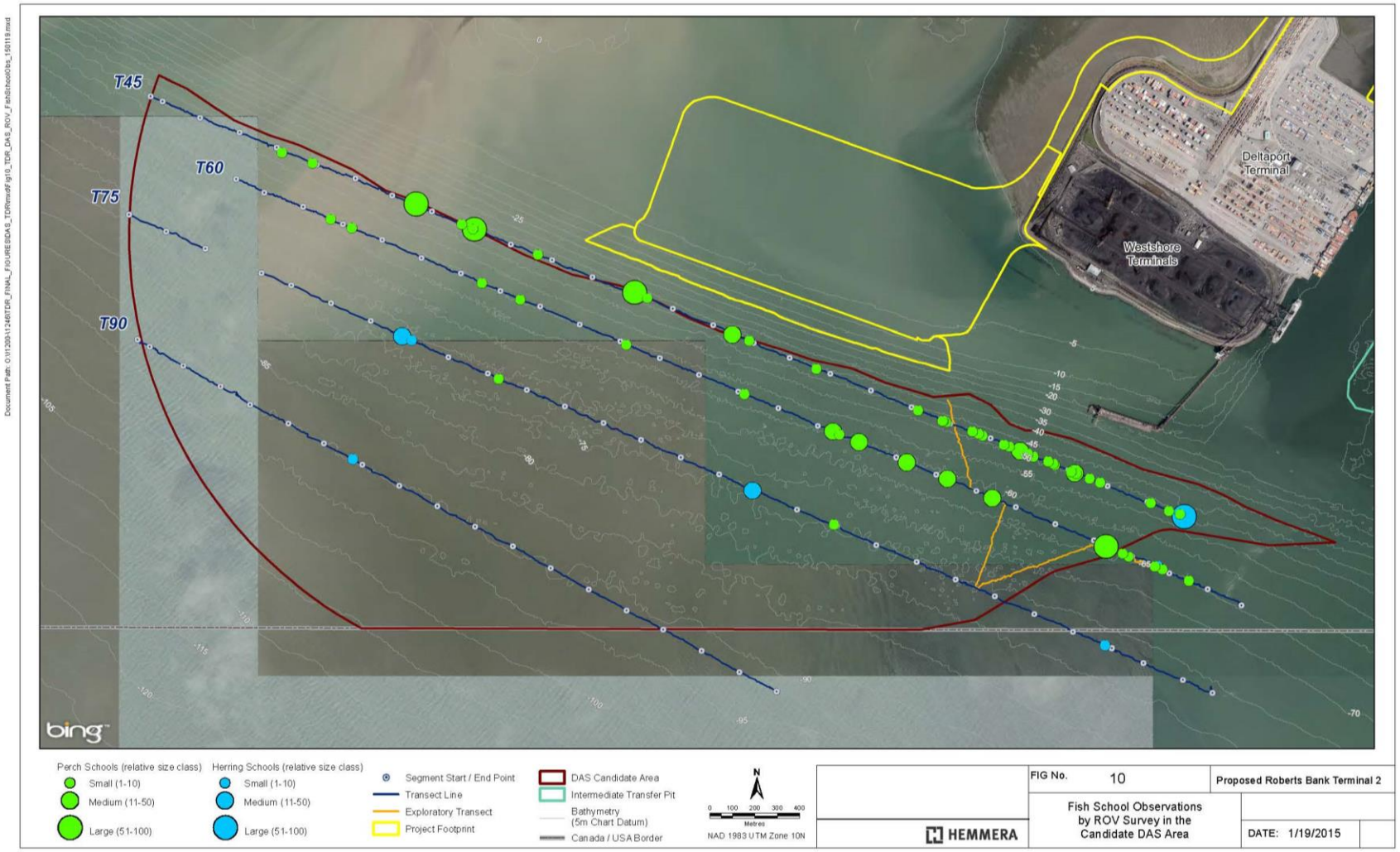


Table 8 Fish School Count Summary Data for the 45 m, 60 m, 75 m, and 90 m Linear Transects

Transect	Total Length (m)	Total Area (m2)	Summary Data	Perch Schools			Herring Schools		
				No. Small (1-10)	No. Medium (11-50)	No. Large (51-100)	No. Small (1-15)	No. Medium (16-200)	No. Large (201-500)
45 m Transect	5265	7066.5	Min*	0	0	0	0	0	0
			Max*	4	1	1	0	0	1
			Average*	1.1	0.1	0.1	0.0	0.0	0.0
			SD*	1.4	0.3	0.3	0.0	0.0	0.2
			Total**	**29**	**3**	**3**	**0**	**0**	**1**
60 m Transect	5150	5926.5	Min	0	0	0	0	0	0
			Max	1	1	0	1	0	0
			Average	0.3	0.2	0.0	0.0	0.0	0.0
			SD	0.5	0.4	0.0	0.2	0.0	0.0
			Total	**9**	**5**	**0**	**1**	**0**	**0**
75 m Transect	5333	5187.4	Min	0	0	0	0	0	0
			Max	1	0	0	1	1	0
			Average	0.1	0.0	0.0	0.1	0.1	0.0
			SD	0.3	0.0	0.0	0.3	0.3	0.0
			Total	**2**	**0**	**0**	**2**	**2**	**0**
90 m Transect	3473	3898.2	Min	0	0	0	0	0	0
			Max	0	0	0	1	0	0
			Average	0.0	0.0	0.0	0.1	0.0	0.0
			SD	0.0	0.0	0.0	0.2	0.0	0.0
			Total	**0**	**0**	**0**	**1**	**0**	**0**

***** *per segment*
*** across all segments in transect*

Table 9 Fish School Count Data for the Exploratory Transect

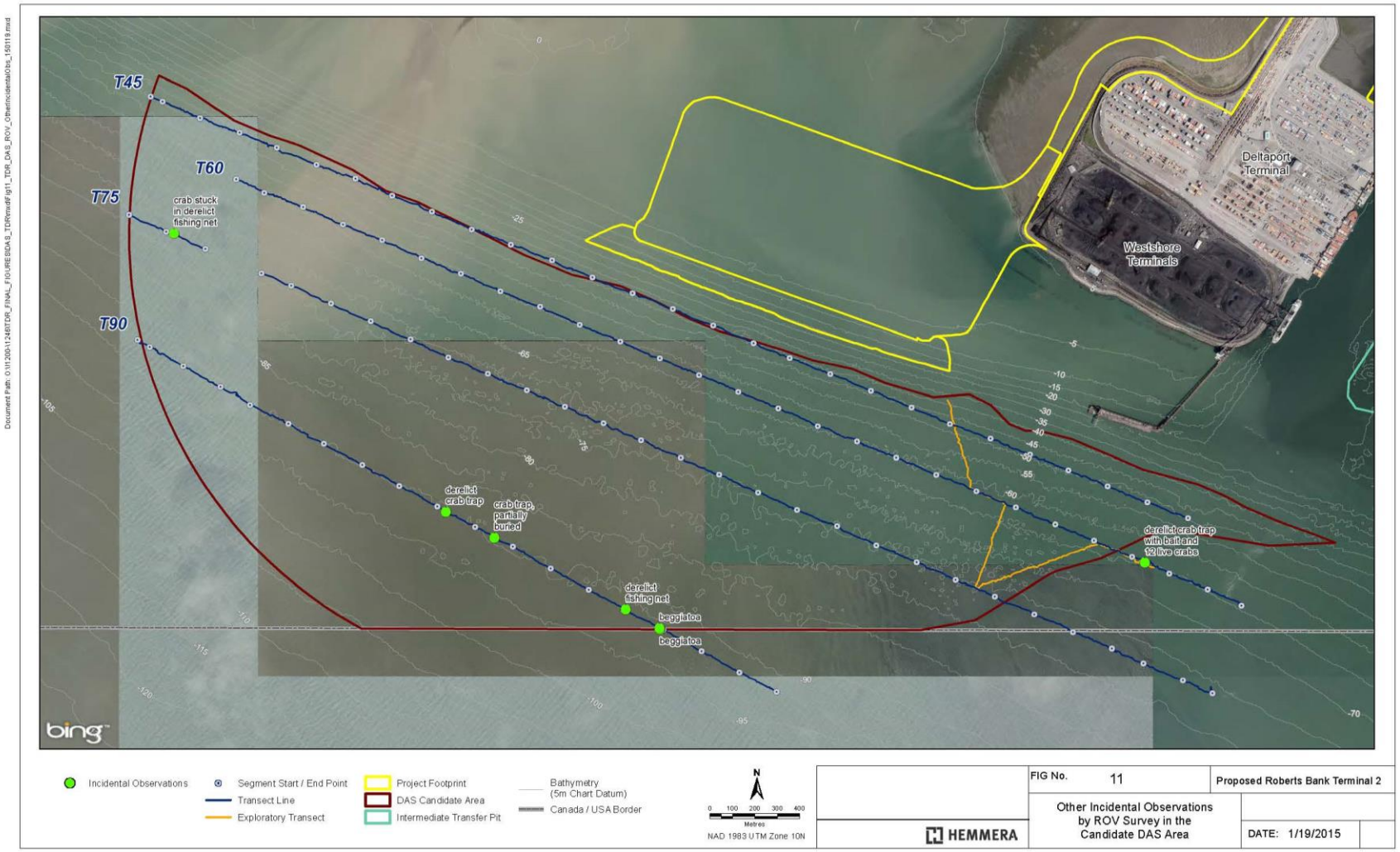
Transect Section	Segment				Perch Schools			Herring Schools		
	ID	Approx. Depth (m)	Length (m)	Area (m^2)	No. Small (1-10)	No. Medium (11-50)	No. Large (51-100)	No. Small (1-15)	No. Medium (16-200)	No. Large (201-500)
Z5_7	112	60	159.5	136.3	1	0	0	0	0	0
	113	60	40.5	34.3	1	0	0	0	0	0
	114	60	115.5	101.6	1	0	1	0	0	0
Z4_7	108	60 to 75	200.0	181.5	0	0	0	0	0	0
	109	60 to 75	200.0	150.4	0	0	0	0	0	0
	110	60 to 75	200.0	137.6	0	0	0	0	0	0
	111	60 to 75	27.9	20.6	0	0	0	0	0	0
Z4_3	105	75 to 60	200.0	155.1	0	0	0	0	0	0
	106	75 to 60	200.0	148.1	0	0	0	0	0	0
	107	75 to 60	22.5	16.7	0	0	0	0	0	0
Z3_1	100	60	143.1	126.9	0	0	0	0	0	0
	101	60 to 40	56.9	56.9	0	0	0	0	0	0
	102	60 to 40	200.0	196.5	0	0	0	0	0	0
	103	60 to 40	200.0	201.5	0	0	0	0	0	0
	104	60 to 40	21.6	21.8	0	0	0	0	0	0

3.6.5 Other Observations

Additional biological features and notable debris were observed in the DAS study area (**Figure 11**) Derelict fishing gear was observed at multiple locations. Several derelict fishing nets were observed, one with a trapped Dungeness crab covered in barnacles (**Appendix A: Figure 24**), as well as derelict crab traps. A single crab trap (with no surface float) containing fresh bait and over ten live crabs was observed at 60 m depth immediately south of the existing Westshore Terminals. These sightings are indicative of other anthropogenic influences effecting species abundance in the candidate DAS area.

A large giant Pacific octopus (*Enteroctopus dofleini)* was observed at 75 m while waiting out strong bottom currents and poor visibility before beginning video collection for the exploratory transect. Fortunately, the ROV operator was recording video at the time and the sighting was captured on file. It is difficult to accurately estimate the size of the organism, given that the ROV camera feed was switched between high and regular zoom as the octopus changed position and moved away from the ROV quickly, and the field of view size changed continuously as the ROV was piloted off-bottom to follow the octopus. As a result, the scaling lasers are never clearly visible on the bottom while the full octopus is in view.

Figure 11 Other Incidental Observations by ROV Survey in the Candidate DAS Area



Finally, the occurrence of a *Beggiatoa* bacterial mat was observed at a location along the 90 m depth transect. *Beggiatoa* mats are often observed growing as a biofilm on sulphide rich sediments, since this bacterial genera is capable of sulphide oxidising chemoautotrophy (Preisler et al. 2007). This metabolic mode is facultative, however, and the genera are also capable of aerobic organic matter breakdown (heterotrophy). *Beggiatoa* mats were not observed along the major portion of the 90 m ROV track, and the observation appears to reflect localised conditions. No obvious debris, decomposing materials or other organic inputs were observed at the location where the bacterial mat was observed.

3.6.6 Data Gaps and Limitations

Due to the large amount of video collected, the field of view was measured at four minute intervals and averaged over the 200 m segment. This method does not account for off-bottom events or video stoppage. During off-bottom events, species could not be sighted, and as a result, densities may be underestimated; however, this bias is expected to be consistent across transects and should not impact an assessment of spatial or depth trends. Video stoppages should have negligible impacts on density calculations as species counts were not recorded in the field observation log when the ROV was paused to investigate a feature of interest and not moving.

A notable limitation in the ROV study component is that survey methods were not designed to account for fish reactions to the ROV. Laidig et al. (2013) reported that 57% of observed fish react to ROVs operated in rock and mud habitats off central California, where a reaction is defined as either movement greater than one body length away from original position for benthic or hovering individuals, or as a change in swimming speed for swimming individuals. Species (or species group) abundance could therefore be over- or under-estimated if fish reactions are not quantified and corrected for in survey results (Laidig et al. 2013).

The objective of this study was not to provide quantitative abundance estimates for individual species, but rather to provide a basis for the relative comparison of species presence-absence and diversity between transects and sub-areas within the larger candidate DAS area. This is based on the assumption that any bias resulting from fish reactions to the ROV will be consistent on an individual species basis, particularly given the consistency in seabed characteristics observed and its influence on ROV movement. Any potential impact on species abundance is assumed to be consistently biased across the sub-areas, thereby not altering the relative comparison.

4.0 INFAUNAL MACROINVERTEBRATES STUDY COMPONENT

4.1 OVERVIEW

Sediment sampling was undertaken to assess infaunal marcoinvertebrate characteristics within the subtidal environment at sampling locations within the candidate DAS area (including the adjacent historical dredge spoil area) and the ITP area. The characteristics of particular interest were community composition, numerical abundance per square metre of seabed (or density), and biodiversity – measured as Shannon diversity.

4.2 STUDY AREA

The infaunal macroinvertebrates component study area includes the subtidal zone of Roberts Bank, specifically the areas identified as the candidate DAS area and the ITP (**Figure 1**). A detailed description including study area boundary criteria for the candidate DAS area is provided in **Section 3.2**.

The ITP is located within the subtidal zone of the inter-causeway area, at the southern edge of the turning basin. The area has been used as a temporary storage area for infill materials during construction phases for the DP3 expansion project.

4.3 TEMPORAL SCOPE

The timing of the infaunal macroinvertebrate survey was intended to capture existing conditions within the study area. The benthic community is expected to show minimal seasonal variation. In consideration of such limited temporal variability, sediment samples were collected during a single ROV event over a three day period from November 19th to 21st, 2013.

4.4 STUDY METHODS

Sediment samples for infaunal macroinvertebrates enumeration were collected over a three day period, performed in conjunction with sediment sampling (Hemmera 2014*a*). Benthic macrofauna samples were obtained from 16 stations, including 10 sampling locations in the candidate DAS area and 6 in the ITP (**Figure 12**). Sampling stations in the candidate DAS area ranged in depth from approximately 53 m to 99 m, and included sampling stations at historical dredge spoil areas on the delta foreslope adjacent to the existing Roberts Bank terminals. In the ITP area, sampling stations ranged in depth from approximately 16 m to 19 m (**Table 10**).

A single replicate sample of sediment was obtained from each station using a 0.1 m^2 stainless steel Van Veen grab deployed from a surface vessel via cable and power winch. The maximum depth of penetration of grab in the seabed is approximately 30 cm. Upon retrieval of the deployed grab on deck, the grab contents were visually examined via the hinged top doors. The depth of the sediment in the grab was measured and grabs with less than ~10 cm of recovered sediment were discarded and additional

casts were completed until a grab sample that reflected adequate seabed penetration, without washout during recover, was retained. In all cases, the sediment water interface was reasonably well preserved. For successful grab samples, the full contents were emptied into a large plastic container and the entire sample was subsequently sieved through a 1.0 mm stainless steel screen to separate infaunal macroinvertebrates from the sediment. Samples were labelled immediately upon collection using waterproof paper and pencil to ensure the labels will not fade in preservative.

Onboard sample sieving and preservation was performed by a contract biologist from Biologica Environmental Services (Biologica). The sediment sample was gently washed, small portions at a time, using filtered seawater. Samples were washed using a moderate flow (1.5-2.5 gallons per minute) to preserve tissue and structure integrity of samples, and to separate specimens from the sediment. Once washing was complete, samples were transferred to 500 mL or 1 L plastic jars with screw top lids. Samples were preserved in 5-10% formalin solution (prepared from full-strength formaldehyde (37%) diluted directly with seawater, and buffered to pH 7.0 with Borax). The sample was adequately mixed by gently inverting the container several times. A chain of custody and/or sample list was prepared for each container of samples, including: Sample ID, Number of Jars, Date Sampled, presence of a picking vial (with delicate organisms), plus any applicable instructions and/or notes. The samples were transferred within the same week as sampling to Biologica's laboratory in Victoria, BC, for further sorting, enumeration, and taxonomic identification.

At Biologica, samples were transferred from the fixative solution (buffered formalin) to ethanol within a minimum of 24 hours to a maximum of 6 days of initial preservation. Sorting was done with a dissecting scope at 10-40x magnification, and various stains (e.g. Methyl Green) were used where appropriate. During sorting, small amounts of debris (enough to cover a square petri dish in a single layer; <5mL) were sorted at one time. The sample was then washed gently and kept covered and wet throughout the sorting of the whole sample.

All organisms were identified by technicians trained in marine taxonomy to their major taxonomic grouping (e.g. Phylum for rare taxa, Class for Mollusca and Annelida, and Order for Crustacea, as convention). During sorting, organisms were separated into major groups (Arthropoda, Annelida, Mollusca, Echinodermata, Other) for transfer to the appropriate taxonomist. To minimise sorter bias, samples were distributed among trained personnel such that no person sorted all the replicates of a given sample, and/or no one person sorted >25% of a particular project. Spot-checks were generally performed on 25% of the sample to ensure a >95% average estimated sorting efficiency (percent of total organisms recovered). Preliminary data and notes were recorded by taxonomists using bench sheets during the sorting process. Data were entered into a spreadsheet and double-checked against bench sheets for entry errors.

Figure 12 Infaunal Macroinvertebrate Sampling Locations in the Candidate DAS and ITP Areas

4.5 RESULTS

4.5.1 Field Observations

A summary of field observations, including sampling dates, positions, and depth for infaunal macroinvertebrate sampling, is provided in **Table 10**. Depths were read from the boat's depth sounder by the boat captain at the time of sampling and recorded in a field notebook along with site location and time of sampling.

Table 10 Field Sampling Summary Information

Area	Station ID	Date	Location		
			Latitude	Longitude	Field Depth From Water Surface (m)*
Candidate DAS area	DAS-2	11/20/2013	49.003425	123.20466	99.0
	DAS-11	11/20/2013	49.00575667	123.173895	73.2
	DAS-12	11/20/2013	49.00573167	123.1705333	70.0
	DAS-16	11/20/2013	49.00792833	123.2114933	95.0
	DAS-20	11/20/2013	49.00802833	123.1841433	73.0
	DAS-22	11/20/2013	49.00801833	123.1703517	58.0
	DAS-33	11/20/2013	49.01243833	123.2183117	89.0
	DAS-35	11/21/2013	49.01243167	123.2046217	75.0
	DAS-46	11/21/2013	49.01687333	123.2114767	66.0
	DAS-51	11/21/2013	49.021425	123.2181983	53.0
ITP	ITP-2	11/19/2013	49.01266333	123.150225	19.0
	ITP-5	11/19/2013	49.01311333	123.1475433	15.7
	ITP-6	11/19/2013	49.01465167	123.1481683	16.3
	ITP-9	11/19/2013	49.01519667	123.1460683	16.3
	ITP-13	11/19/2013	49.01591	123.1433133	16.3
	ITP-15	11/19/2013	49.01729167	123.1435833	15.7

** depths not adjusted for tidal elevation at sampling time and should not be confused with bottom depths relative to chart datum (CD)*

4.5.2 Infaunal Macroinvertebrate Abundance

Raw count data (no./0.1 m^2) for each sediment sample was provided by Biologica for each life stage (adults, intermediate, and juveniles) or by colony count for colonising species (**Table 11**). Total numerical abundance was calculated as the sum total of each life stage and/or colonies for each sampling location (**Figure 13**). A total of 1,466 organisms were found at the DAS site (n=10 stations), and a total of 5,284 at the ITP site (n=6 stations). The complete data are provided in **Appendix C: Tables 1** and **2**.

Table 11 Summary of DAS Site Numerical Abundance Results

Area	Sample ID	Sample Depth (m)	Total Sample Count	Total Count – All Stations	Average Site Count (no./m^2)
DAS	DAS-2	99.0	112	1,466	146.6
	DAS-11	73.2	120		
	DAS-12	70.0	118		
	DAS-16	95.0	93		
	DAS-20	73.0	119		
	DAS-22	58.0	41		
	DAS-33	89.0	97		
	DAS-35	75.0	202		
	DAS-46	66.0	58		
	DAS-51	53.0	506		
ITP	ITP-2	19.0	998	5,284	880.7
	ITP-5	15.7	1,070		
	ITP-6	16.3	1,241		
	ITP-9	16.3	896		
	ITP-13	16.3	396		
	ITP-15	15.7	683		

** depths not adjusted for tidal elevation at sampling time and should not be confused with bottom depths relative to chart datum (CD)*

Candidate DAS Site

A total of 156 infaunal macroinvertebrate species representing nine Phyla (Annelida, Arthropoda, Bryozoa, Chordata, Cnidaria, Echinodermata, Kamptozoa, Mollusca, Nemertea, Platyhelminthes, Sipuncula) were documented from samples collected at the candidate DAS area stations (**Appendix C: Table 1**). The infaunal benthic community in the candidate DAS area is dominated by marine Gastropod snails, amphipods, Polychaete worms, and a species of brittle star. The most numerically abundant species found was the marine snail *Solariella obscura* which ranged from 1 to 92 individuals per 0.1 m^2 grab, representing 33.4% on average of species abundance (**Table 12**). Three species of Amphipod, *Orchomenella minuta*, *Rhepoxynius boreovariatus*, and *Gammaropsis* sp. were the second, third and fourth most abundant species at the DAS site. *Orchomenella minuta* ranged from 1 to 16 individuals per 0.1 m^2, comprising 4.9% of species abundance. *Rhepoxynius boreovariatus* ranged from 1 to 22 individuals per 0.1 m^2, comprising 4.0% of species abundance. *Gammaropsis* sp. ranged from 7 to 44 individuals per 0.1 m^2, comprising 3.5% of species abundance.

Table 12 Summary of 20 Most Abundant Benthic Macrofauna by Species Count for Candidate DAS Stations

Species Taxonomy					Min	Max	Average	Count (all stations)	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Total								**1466**	**100%**	
Mollusca	Gastropoda		Trochidae	*Solariella obscura*	1	92	24.5	490	33.4%	33.4%
Arthropoda	Malacostraca		Lysianassidae	*Orchomenella minuta*	1	16	7.2	72	4.9%	38.3%
Arthropoda	Malacostraca		Phoxocephalidae	*Rhepoxynius boreovariatus*	1	22	8.4	59	4.0%	42.4%
Arthropoda	Malacostraca		Photidae	*Gammaropsis* sp.	7	44	25.5	51	3.5%	45.8%
Annelida	Polychaeta	Sedentaria	Syllidae	*Exogone dwisula*	1	34	17.5	35	2.4%	48.2%
Echinodermata	Ophiuroidea		Amphiuridae	*Amphiodia urtica*	1	6	1.9	31	2.1%	50.3%
Annelida	Polychaeta	Sedentaria	Spionidae	*Prionospio (Minuspio) lighti*	1	14	5.4	27	1.8%	52.2%
Annelida	Polychaeta	Sedentaria	Nereidae	*Nereis pelagica*	2	13	8.7	26	1.8%	54.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	*Ampharete* nr. *acutifrons*	1	9	3.6	25	1.7%	55.7%
Arthropoda	Malacostraca		Phoxcephalidae	*Majoxiphalus maximus*	1	4	2.1	25	1.7%	57.4%
Arthropoda	Malacostraca		Aoridae	*Aoroides* sp.	1	18	7.0	21	1.4%	58.8%
Annelida	Polychaeta	Errantia	Nereididae	*Platynereis bicanaliculata*	3	12	6.3	19	1.3%	60.1%
Annelida	Polychaeta	Sedentaria	Orbiniidae	*Scoloplos armiger*	1	4	1.6	19	1.3%	61.4%
Annelida	Polychaeta	Sedentaria	Paraonidae	*Aricidea wassi*	1	4	2.7	19	1.3%	62.7%
Bryozoa	Gymnolaemata		Hippothoidae	*Celleporella hyalina*	19	19	19.0	19	1.3%	64.0%
Arthropoda	Malacostraca		Phoxocephalidae	*Rhepoxynius* sp.	1	6	2.8	17	1.2%	65.1%
Annelida	Polychaeta	Sedentaria	Capitellidae	*Mediomastus californiensis*	1	8	2.0	16	1.1%	66.2%
Annelida	Polychaeta	Sedentaria	Capitellidae	*Decamastus* nr. *gracilis*	1	8	2.5	15	1.0%	67.3%
Annelida	Polychaeta	Sedentaria	Magelonidae	*Magelona longicornis*	1	10	3.5	14	1.0%	68.2%
Annelida	Polychaeta	Sedentaria	Paraonidae	*Cirrophorus branchiatus*	1	5	2.6	13	0.9%	69.1%

Table 13 Summary of 20 Most Abundant Benthic Macrofauna by Species Count for ITP Stations

Species Taxonomy					Min	Max	Average	Count	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Total								**5284**	**100%**	
Mollusca	Bivalvia		Thyasiridae	*Axinopsida serricata*	62	423	186.8	2242	42.4%	42.4%
Mollusca	Bivalvia		Montacutidae	*Kurtiella tumida*	1	59	17.8	213	4.0%	46.5%
Annelida	Polychaeta	Sedentaria	Orbiniidae	*Leitoscoloplos pugettensis*	1	43	12.0	192	3.6%	50.1%
Arthropoda	Ostracoda		Philomedidae	*Euphilomedes producta*	7	70	37.0	185	3.5%	53.6%
Mollusca	Bivalvia		Nuculidae	*Ennucula tenuis*	3	36	13.5	162	3.1%	56.7%
Annelida	Polychaeta	Errantia	Lumbrineridae	*Scoletoma luti*	3	29	9.3	140	2.6%	59.3%
Mollusca	Bivalvia		Thyasiridae	*Parvalucina tenuisculpta*	1	34	7.9	134	2.5%	61.8%
Mollusca	Bivalvia		Tellinidae	*Macoma* sp.	6	45	19.7	118	2.2%	64.1%
Mollusca	Bivalvia		Tellinidae	*Macoma carlottensis*	2	21	10.3	103	1.9%	66.0%
Mollusca	Bivalvia		Veneridae	*Nutricola* sp.	1	39	12.9	103	1.9%	68.0%
Cnidaria	Hydrozoa		Campanulariidae	*Campanularia* sp.	2	35	20.2	101	1.9%	69.9%
Annelida	Polychaeta	Sedentaria	Spionidae	*Spiophanes berkeleyorum*	1	14	5.4	98	1.9%	71.7%
Chordata	Ascidiacea		Ascidiidae	*Ascidia columbiana*	1	62	14.0	98	1.9%	73.6%
Mollusca	Scaphopoda		Pulsellidae	*Pulsellum salishorum*	1	34	15.3	92	1.7%	75.3%
Mollusca	Bivalvia		Tellinidae	*Macoma elimata*	2	17	6.3	63	1.2%	76.5%
Annelida	Polychaeta	Errantia	Lumbrineridae	*Lumbrineris cruzensis*	1	13	4.9	59	1.1%	77.6%
Mollusca	Bivalvia		Nuculidae	*Acila castrensis*	1	21	6.9	55	1.0%	78.7%
Annelida	Polychaeta	Sedentaria	Oweniidae	*Galathowenia oculata*	1	15	5.8	46	0.9%	79.6%
Annelida	Polychaeta	Sedentaria	Maldanidae	*Praxillella praetermissa*	1	9	4.3	39	0.7%	80.3%
Annelida	Polychaeta	Errantia	Nephtyidae	*Bipalponephtys cornuta*	1	26	4.8	38	0.7%	81.0%

ITP Area

A total of 169 infaunal macroinvertebrate species, representing nine Phyla (Annelida, Arthropoda, Chordata, Cnidaria, Echinodermata, Mollusca, Nemertea, Platyhelminthes, and Sipuncula), were documented from samples collected in the ITP area (**Appendix C: Table 2**). The infaunal macorinvertebrate community at the ITP site was dominated by two species of bivalve molluscs and a polycheate worm. The most numerically abundant species found was the bivalve *Axinopsida serricata* which ranged from 62 to 423 individuals per 0.1 m^2 grab sample, comprising 42.4% of total infaunal macroinvertebrate abundance for the six ITP sampling stations (**Table 13**). A second bivalve *Kurtiella tumida* and a polychaete worm *Leitoscoloplos pugettensis* were the second and third most abundance species at the ITP site, respectively. *Kurtiella tumida* ranged from 1 to 59 individuals per 0.1 m^2 grab sample and represented 4.0 % of species abundance. *Leitoscoloplos pugettensis* ranged from 1 to 43 individuals per 0.1 m^2 grab sample and represented 3.6 % of species abundance.

4.5.3 Diversity

Species diversity was calculated and reported using the Shannon-Weaver Diversity Index (**Table 14**). The Shannon-Weaver Diversity Index is a quantitative measure which accounts for the abundance of species present and the evenness of species distribution in the community. This measure is commonly used to characterise species diversity in a community, where the index value increases as both abundance and evenness increase. Benthic macrofauna community diversity was calculated using the Shannon Weaver-Diversity Index according to the following formula:

$$H' = -\sum_{i=1}^{R} Pi \ln Pi$$

Where *Pi* is the proportion of individuals belonging to the i^{th} species in the dataset.

Mean species diversity was comparable for the DAS and ITP areas (**Figure 14**). An average site diversity mean of 2.19 for n=10 sampling locations was observed in the DAS area, and a site mean of 2.66 for n=6 sampling locations was observed in the ITP area (**Table 14**). A broader range in species diversity was observed in the DAS area sampling locations. Species diversity indices for the DAS sampling locations ranged from 1.75 to 4.03 where the ITP area ranged from 2.21 to 3.30 (**Table 14**).

Table 14 Summary of Diversity by Site Location

Area	Sample ID	Diversity Index	Average Site Diversity
DAS	DAS-2	2.50	2.19
	DAS-11	1.75	
	DAS-12	2.29	
	DAS-16	1.94	
	DAS-20	1.39	
	DAS-22	2.10	
	DAS-33	1.77	
	DAS-35	1.91	
	DAS-46	2.21	
	DAS-51	4.03	
ITP	ITP-2	3.30	2.67
	ITP-5	3.01	
	ITP-6	2.76	
	ITP-9	2.22	
	ITP-13	2.33	
	ITP-15	2.39	

Figure 13 Infaunal Macroinvertebrate Abundance in the Candidate DAS and ITP Areas

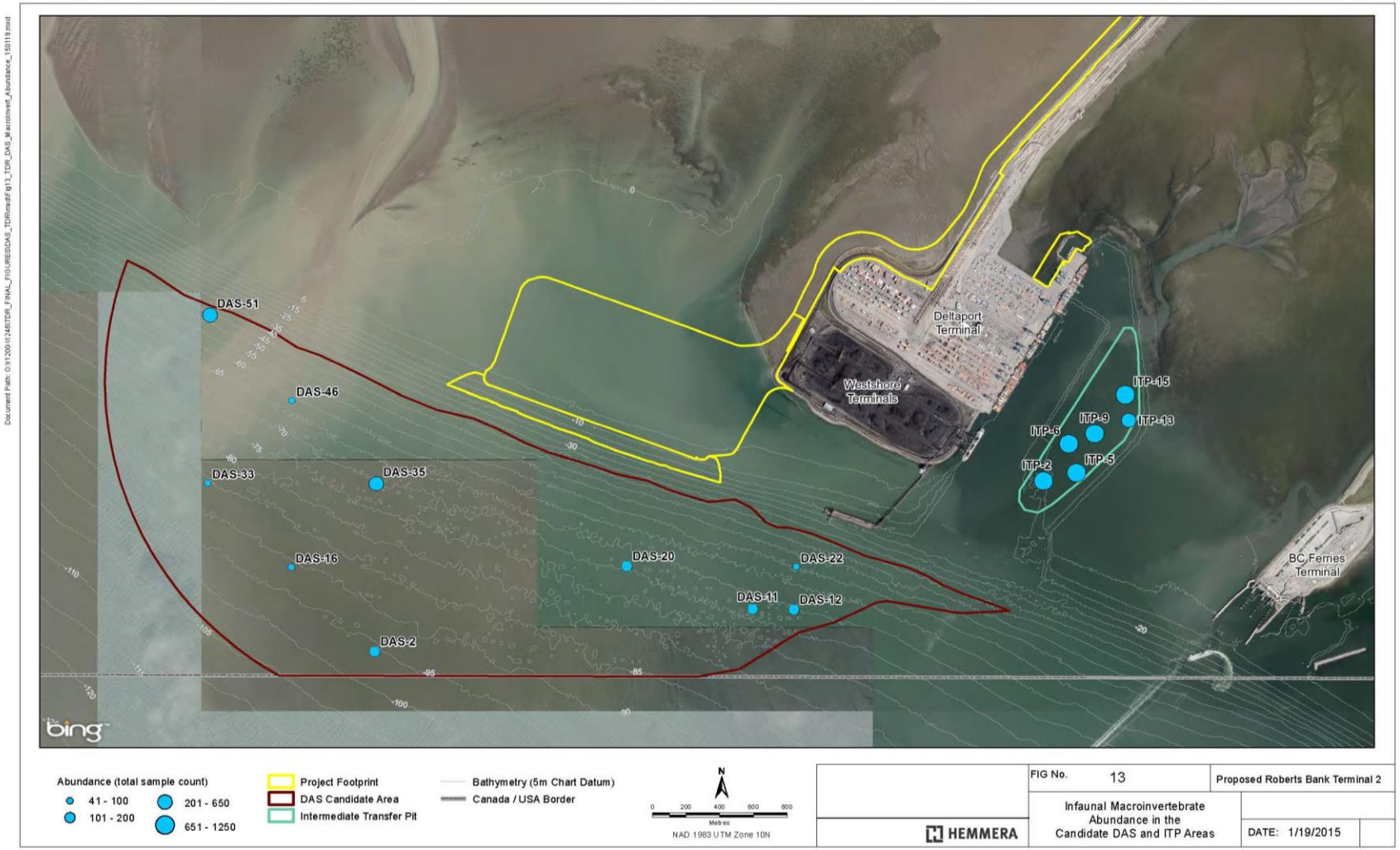
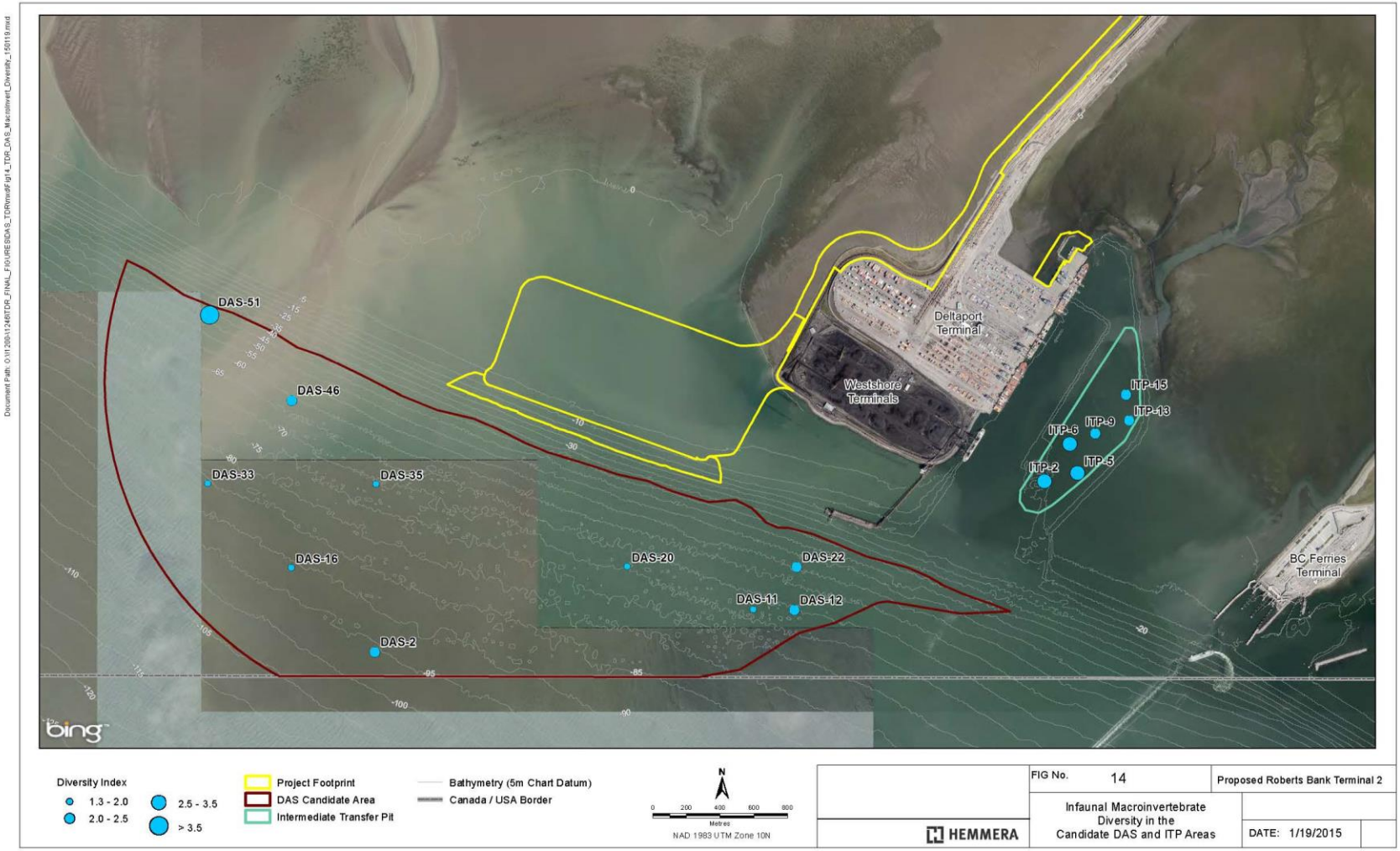


Figure 14 Infaunal Macroinvertebrate Diversity in the Candidate DAS and ITP Areas



5.0 RAKE TRAWL STUDY COMPONENT

5.1 OVERVIEW

The objective of the Rake Trawl study component was to document the presence of highly mobile or cryptic species not easily identified through ROV video review, within the candidate study areas (DAS and ITP) at Roberts Bank. For each survey transect, captured benthic invertebrates and finfish species were identified and enumerated to supplement data on species diversity and abundance collected in the ROV (**Section 3.0**) and Infaunal Macroinvertebrates (**Section 4.0**) study components of the present report.

5.2 STUDY AREA

The Rake Trawl component study area includes the subtidal zone of Roberts Bank, specifically the areas identified as the candidate DAS area and the ITP (**Figure 1**). A detailed description including study area boundary criteria for the candidate DAS area is provided in **Section 3.2** and in **Section 4.2** for the ITP.

5.3 TEMPORAL SCOPE

The timing of the Rake Trawl surveys was intended to capture existing conditions within the study area. Trawls were conducted during two sampling events over a two day period from April 1st to April 2nd, 2014, to avoid the seasonal opening of the Dungeness crab commercial fishery, thus minimising entanglement in crab trap gear. Trawling was also planned to coincide with the tail end of the winter period during which Pacific sand lance (*Ammodytes hexapterus*) are expected to exhibit nocturnal sediment burial behavior.

5.4 STUDY METHODS

Following two test trawls, fish and invertebrate samples were collected through completion of ten rake trawl tows during night-time over a two day period in April, 2014. Trawl effort was split between the candidate DAS and ITP areas, with six trawls in DAS and four in the ITP site (**Figure 15**).

Figure 15 Rake Trawl Transects in the Candidate DAS and ITP Areas

In order to collect transient species which bury themselves in sediment, trawls were conducted using a rake trawl (a modified scallop dredge consisting of a metal box frame with skids and a trailing net). The 'rake' was created by fixing 14 cm tines to the bottom leading edge of the frame which digs into sediment causing fish and invertebrates to swim up and be swept into the net (**Figure 16**). To ensure the tines dug into the sediment, a 30 lb cannon ball was attached to each side of the frame of the trawl near the mouth of the net. The trawl mouth dimensions measured 1.18 m wide by 0.15 m tall, with a 3.45 m net (mouth to cod end). Net mesh was primarily ¼ inch stretch mesh, with the first 30 cm on the bottom constructed of 2.45 inch stretch mesh to prevent excess substrate from being retained in the cod end. For further description of the rake trawl standard equipment, see Section 6.4 in Taylor and Perrin (2005). The trawl was deployed and recovered using a hydraulic drum of a fishing trawler. Data collected for each trawl included start and end location, start and end speed, water depth, duration (amount of time the trawl net was on the bottom), and catch.

Figure 16 Photo of Rake Trawl (Taylor and Perrin 2005)

Contents from the cod end of the net were emptied into a Rubbermaid® tote following each trawl, and biologists processed the catch on board. Fish were then removed from the trawl catch and sorted in trays, identified to the lowest possible taxonomic level, weighed, and length measured. Accurate fish density (number of fish caught per unit distance or area trawled) results cannot be calculated as the total distance or total area swept during each trawl transect was only approximated. Instead, catch rate is used as a means of comparison, expressed as the number of fish caught per duration of trawl (# fish/hour; see **Table 15**). While this provides a measure of the effectiveness of catch, given that average trawl speed varied between trawls (from 0.95 to 1.65 knots), this is an approximate metric and should be interpreted with some degree of caution. The trawl speed and tracking was highly influenced by tidal current variations over the sampling period, such that trawl capture effectiveness may have been quite variable for different trawls, and any spatial variability in trawl results should be interpreted in light of this.

The remaining contents (sediment and macroinvertebrates) collected at the trailing end of the net (cod end) were processed by sieving on board by a contract staff from Biologica. Sediments were gently washed, small portions at a time, into a 1.0 mm screen using filtered seawater. Samples were washed using a moderate flow (1.5-2.5 gallons per minute) to preserve tissue and structure integrity of the samples and to separate the specimens from sediment. Once washing was complete, macroinvetebrates were sorted to their major taxonomic grouping (e.g. Phylum for rare taxa, Class for Mollusca and Annelida, and Order for Crustacea, as convention) by Biologica staff. Invertebrate contents of each trawl were pooled for each site (i.e., DAS, ITP) and wet weight (g) of each taxonomic group was measured. Notes were taken on taxonomic identification where possible.

5.5 RESULTS

Trawl depths differed between the two sampling sites due to the nature of the bathymetry in the area, with the ITP trawls occurring on average at 15 m and the candidate DAS area trawls occurring between average depths of 48 and 60 m. Depth in the candidate DAS site area extends from approximately 35 m to 100 m; however, the trawl could not be successfully operated deeper than 60 m.

The average fish catch rate (# fish per hour) in the ITP site was 2.74 times higher than that within the candidate DAS area (**Table 15**). A summary of the fish species caught at each site shows some differences in species assemblages (**Table 16**). For example, the ITP site trawls contained six species which were not found in the DAS site, including arrow goby (*Clevelandia ios*), bay pipefish (*Syngnathus leptorhyncus*), crescent gunnel (*Pholis laeta*), plainfin midshipman (*Porichthys notatus*), shiner perch (*Cymatogaster aggregata*), snake prickleback (*Lumpenus sagitta*), and skate sp. In comparison, the candidate DAS area trawls contained five species which were not found in the ITP site, including English sole (*Parophrys vetulus*), Northern ronquil (*Ronquilus jordani*), Pacific sandlance (*Ammodytes hexapterus*), padded sculpin (*A. fenestralis*), and rock sole (*Lepidopsetta bilineata*).

Generally, the diversity of invertebrate species (or species groups) found within the ITP was greater than in the candidate DAS area. All major taxonomic groups (i.e., Arthropoda, Mollusca, Nemertean, Polychaeta) were observed in both areas, with the exception of Echinoderms, specifically the Giant California sea cucumber (*Parastichopus californicus)*, which was only found within the ITP area. A greater number of species within each phyla were observed in the ITP area trawls. Overall, a much higher biomass (i.e., net wet weight) of each representative invertebrate group was obtained for transects conducted in the ITP relative to the candidate DAS area (**Table 17**).

Table 15 Rake Trawl Summary Data by Site and Trawl Number

Trawl #	DAS					ITP				
	Average Depth (m)	Distance (approx. m)	Total # Fish (count)	Duration (hour)	Catch Rate (# fish/hour)	Average Depth (m)	Distance (approx. m)	Total # Fish (count)	Duration (hour)	Catch Rate (# fish/hour)
3	50.38	500	4	0.35	11.4	-	-	-	-	-
4	48.46	503	1	0.38	2.6	-	-	-	-	-
5	50.75	546	1	0.43	2.3	-	-	-	-	-
6	-	-	-	-		15.64	523	24	0.15	160.0
7	-	-	-	-		15.36	516	11	0.23	47.8
8	-	-	-	-		15.91	534	1	0.18	5.6
9	-	-	-	-		16.00	515	20	0.18	111.1
10	48.19	549	30	0.20	150.0	-	-	-	-	-
11	56.78	616	1	0.42	2.4	-	-	-	-	-
12	60.53	589	2	0.22	9.1	-	-	-	-	-
	Average Catch Rate				**29.6**	**Average Catch Rate**				**81.1**

Table 16 Fish Rake Trawl Catch Summary Data by Site

Common Name	DAS				ITP			
	Total # (count)	Average Length (cm)	Average Weight (g)	Photo	Total # (count)	Average Length (cm)	Average Weight (g)	Photo
arrow goby	-	-	-	-	2	10.3	7.5	D9, D10
Bay pipefish	-	-	-	-	2	10.8	3	
blackbelly eelpout	1	21	38	-	8	13.1	17.5	D11, D12, D13, D14, D15, D16, D17, D18, D19, D20
butter sole	2	13.3	15	-	1	7	2	-
crescent gunnel	-	-	-	-	1	7	1	-
English sole	1	30	239	D1, D2	-	-	-	-
Northern ronquil	1	16	26	D3, D4	-	-	-	-

Common Name	DAS				ITP			
	Total # (count)	Average Length (cm)	Average Weight (g)	Photo	Total # (count)	Average Length (cm)	Average Weight (g)	Photo
Pacific sanddab	5	16.3	59.8		3	7.3	3	-
Pacific sand lance	1	13	10	D5, D6	-	-	-	-
Pacific staghorn	6	20.8	112.8	-	1	16.5	50	-
Padded sculpin	1	9.5	12	-	-	-	-	-
Plainfin midshipman	-	-	-	-	13	5.0	1.9	D21
Pygymy poacher	2	6.3	2	D7	1	3.5	<1	-
Rock sole	3	9.2	7		-	-	-	-
Shiner perch	-	-	-	-	2	7.8	9	-
Snake prickleback	-	-	-	-	8	12.2	4	-
Speckled sanddab	13	11.5	13.2	-	1	6.5	2	-
Unknown sculpin	1	<1	<1	-	1	3	<1	-
Unknown skate	1	36	320	-	-	-	-	-
Unknown sanddab	1	24.5	142	D8	-	-	-	-
Unknown sole	-	-	-	-	5	2.9	0.8	-
Unknown goby	-	-	-	-	1	10	6	D22
Unknown gunnel	-	-	-	-	1	7	1	D23
Unknown prickleback	-	-	-	-	1	11.5	2	-
Unknown saddab	-	-	-	-	1	2	<1	-
Unknown staghorn	-	-	-	-	1	17	55	-
Unknowns	-	-	-	-	2	3.25	0.5	D24

Table 17 Macroinvertebrate Rake Trawl Catch by Site and Classification

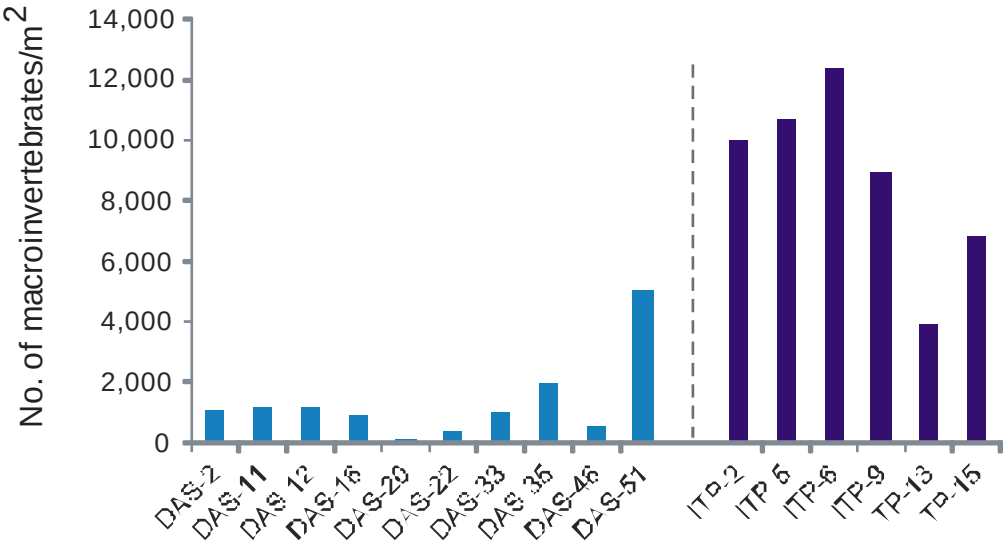
Site	Taxonomic Classification	Species Composition	Net Weight (g)
DAS	Arthropoda	Amphipods, Cumaceans, Isopods, Mysidae, Shrimp (*Crangon* sp, *Eualus* sp, *Pandalus* sp, *Hepatocarpus* sp, *Spirontocaris* sp), hermit crabs	250
	Mollusca	Nutricola, Nudibranch, Astyris, Trochoidae	2
	Nemertean	Nemertean/Anthozoa	4
	Polychaeta	Polynoidae	0
ITP	Echinoderms	Ophiuroidia, pentamera	2
		Holothuroidea (*Parastichopus californicus*)	not weighed (> 300g)
	Mollusca	Nudibranchs (*Armina californica* (large nudibranch with white stripes) and *Aeolidina* sp (possibly *Flabellina* sp. and/or *Cuthona* sp.)	206
		Nutricola, Axiopsida, Cuculana, Pandora, Ennacule, Macoma, Yoldia	10
		Astyris gausapata, flying snail (*Gastropteron pacificum*), turbonilla	179
	Polychaeta	Polynoidae	22
		Tubeworms (*Eudistylia sp*)	222
	Arthropoda	amphipods, pinniza, mysidae, shrimp (*Crangon* sp, *Eualus* sp, *Pandalus* sp, *Hepatocarpus* sp, *Spirontocaris* sp), cumacean, hermit crabs, isopods	208
		Unknown	150
		Unknown crab sp.	8
		Unknown	155
	Nemerteans	Unknown	<1

6.0 DISCUSSION AND CONCLUSIONS

Bottom-dwelling fauna that inhabit delta foreslope (or delta front) environments have been poorly studied worldwide in comparison to bottom-dwelling fauna of various other estuarine and marine bottom types (Ayranci et al. 2014). Prodeltas, including foreslope areas, are zones of massive organic matter burial and organic matter decomposition (Bonifácio et al. 2014). Rhoads et al. (1985) concluded that the marine benthic macrofauna off river mouths reflect the interplay between (i) reductions in benthic macroinvertebrates as a result of high sedimentation and burial rates as well as sediment instability; and (ii) enhanced productivity further offshore as a result of moderate organic enrichment from terrigenous (land-based) riverine inputs. This might account for a maximum value in the numerical abundance of infaunal macroinvertebrates at depths of approximately -70 to -80 m CD in the southern Strait of Georgia (or Salish Sea) as discussed by (Burd, Barnes, et al. 2008).

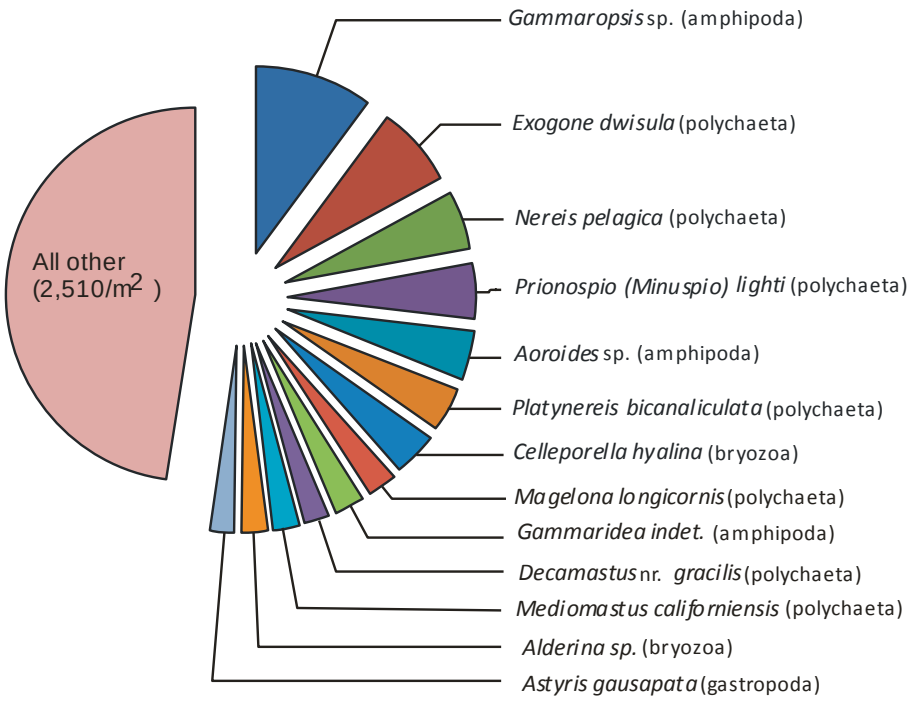
The abundance of infaunal macroinvertebrates was much greater at the ITP than candidate DAS area stations (**Figure 17**).

Figure 17 Comparison of Numerical Abundance Across Stations



For the candidate DAS area stations, the macroinvertebrate abundance at station DAS-51 was much higher than for the other delta foreslope areas, and the taxonomic composition completely different than for the other nine stations (**Figure 18**).

Figure 18 Dominant Macroinvertebrate Taxa - Station DAS-51

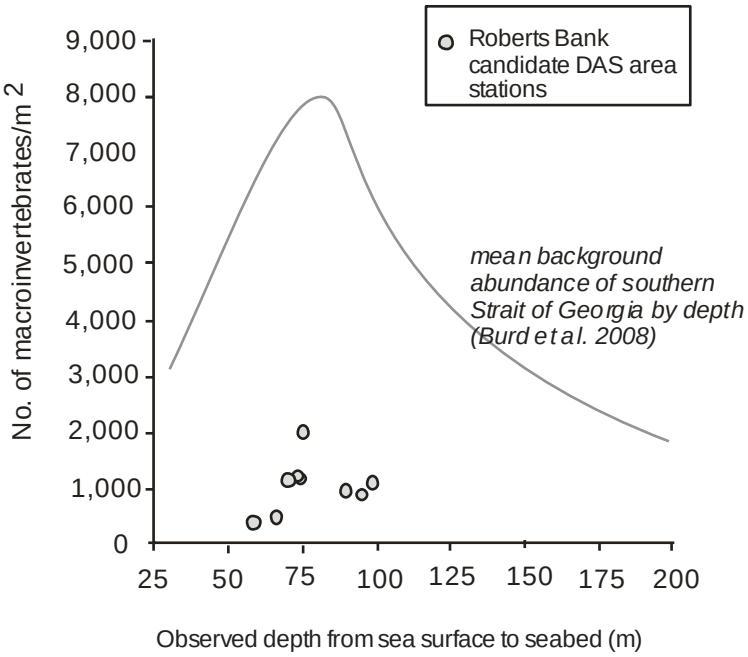


In contrast to the species composition in the sample from station DAS-51, the taxa listed in **Figure 18** cumulatively accounted for less than 1% on average of the total infaunal macroinvertebrate abundance at the other nine stations in the candidate DAS area.

The most abundant benthic infauna at the candidate DAS area stations exclusive of station DAS-51 included the trochoid gastropod *Solariela obscura* (51% of total macroinvertebrate abundance), the lysianassid amphipod *Orchmenella minuta* (7% of total abundance), the phoxocephalid amphipod *Rhepoxynius boreovariatus* (6% of total abundance), and the ophuirod brittle star *Amphioda urtica* (3% of total abundance). An additional 72 species cumulatively accounted for less than 35% of the average abundance, and these can be considered as rare (in the sense of having few local representatives), and broadly dispersed taxa within the candidate DAS area.

The highest numerical abundance of infaunal macroinvertebrates for the candidate DAS area stations was observed at a depth of approximately -70 to -80 m CD, and this is consistent with trends with depth for the larger southern Strait of Georgia, as documented by Burd et al. (2008), as illustrated in **Figure 19**. The total infaunal macroinvertebrate abundance at the candidate DAS area sites, however, is much lower than previously observed for equivalent depths on the Sturgeon Bank delta front and elsewhere in the southern Strait of Georgia (Burd, Barnes, et al. 2008). The range of abundance observed in the candidate DAS area was similar to that observed by Bonifácio et al. (2014) for the Rhone River delta in France: significant seasonal variability associated with river discharge stage and interannual variability in benthic community composition and abundance was observed by Bonifácio et al. (2014), at stations along a transect along the Rhone River delta front from 24 m to 76 m in depth. Nonetheless, the overall range of observed abundance was 144 to 1,700 individuals/m^2.

Figure 19 Macroinvertebrate Abundance with Depth (excluding station DAS-51)



The observed soft-sediment macroinvertebrate community composition in the nine candidate DAS area stations other than station DAS-51 is unique in that there is no similar soft-bottom community composition described in the existing scientific literature. In particular, the small marine snail *S. obscura* has been described as a minor contributor to faunal abundance in a large number of marine biogeography and benthic ecology studies. *S. obscura* has a broad circumpolar distribution in the northern hemisphere, and is routinely observed in samples from coastal soft sediment environments throughout both the Atlantic and Pacific Oceans (Gofas 2014). To the best of our knowledge, however, this species has not been observed as the dominant macroinvertebrate in coastal embayments and estuaries, at densities observed in this study (90 to 1,260 individuals/m^2). Furthermore, this community is markedly different than that observed farther north on the delta foreslope near the Iona wastewater treatment plant outfall, in which the bivalves *Axinopsida serricata* and *Macoma carlottensis* were among the numerical dominants (Burd, Barnes, et al. 2008).

Bonifácio et al. (2014), in their study of sediment characteristics and benthic macrofauna of the Rhone River delta, France, observed prodeltaic communities mainly composed of polychaetes (80% of overall abundance) followed by crustaceans and molluscs (7% for each), which is also very different than that observed for the candidate DAS area.

It is noteworthy that neither *S. obscura* nor the second and third most abundant taxa (the amphopods *O. minuta* and *R. boreovariatus* are filter feeders, which appear to be under-represented in the candidate DAS area benthic community. Ayrancia et al. (2012) describe a series of sediment gravity flows that occurred on the upper slope of the Fraser River delta in 2008 during the Fraser River freshet period. These events were recorded with instrumentation associated with the VENUS underwater observation network, at a depth of -41 m CD at 1.5 m above the seabed, in the area of the Fraser River Main Channel discharge beyond the tideflat. The gravity flows comprised the down-slope transport of sediment laden (highly turbid), warm and low salinity Fraser River waters, and such events probably routinely deposit fine grained sands and silts to the Fraser River delta front to depths of at least -50 m CD. Ayrancia et al. (2012) propose that the Fraser delta forefront routinely experiences sustained gravity flows during periods when the freshet coincides with the spring tide. Such gravity flows have not been observed since 2008 when the instrument was re-deployed to a depth of -107 m CD along the VENUS observational network, suggesting "*that the maximum depth to which the gravity flow extends is limited to between 40 and 100 m"* (Ayrancia et al. 2012). Such gravity flows could strongly limit the presence of filter-feeding and more stationary macroinvertebrates along the upper foreslope, while it is conceivable that *S. obscura, O. minuta, R. boreovariatus*, and *A. urtica* can withstand episodic, smaller scale gravity flows through temporary displacement, and have feeding strategies that are less sensitive to suspended sediment loads and smothering. Although there are no published studies on the ecology of *S. obscura,* it is likely to be a surface sediment grazing herbivore, or perhaps detritivore, based on the attributes of the Trochoidea gastropod superfamily to which it belongs.

Overall, the observed macroinvertebrate community structure, in concert with the available information on upper Fraser delta seabed instability and sedimentation rates, support the theory that benthic macroinvertebrate productivity in the candidate DAS area is limited by physical stressors, as proposed by Rhoads et al. (1985), with a decreasing influence with depth.

Results from rake trawl surveys (**Section 5**) generally corroborate the findings of the benthic macroinvertebrate collections: Both the biodiversity and abundance of macrofaunal and megafaunal invertebrates and fish were substantially higher in the ITP area than the candidate DAS area. Few fish or invertebrates were captured in rake trawls completed in the candidate DAS area, and the dominant invertebrate taxa observed were amphipods and other crustacean, trochoid gastropods (probably *S. obscura*) and few other taxa. Less than 500 grams wet weight of invertebrate tissue biomass was capture in six rake trawls in the candidate DAS area, over a cumulative trawl line length of 3.3 km (**Table 15**).

A total of 39 individual fish were captured in the candidate DAS area over this trawl line length (**Table 16**), of which 13 were speckled sanddab, 5 were Pacific sanddab, and 6 were Pacific staghorn sculpins. A single pacific sand lance was captured even though the trawl used and survey period (nighttime) were selected to maximise the probability of capturing this species. It is conceivable that the delta front in the

candidate DAS area provides suitable habitat for various bottom fish that – being mobile – are less influenced by suspended sediments as seabed stability; however, the limited available biomass of infaunal and epifaunal macro- and megafaunal invertebrates likely restricts foraging opportunities and local secondary productivity for many fish species.

The ROV surveys provide insights about the spatial variation within the candidate DAS area of Dungeness crabs, sea pens, shrimp, and various fish, as well as small scale geomorphic features of the seabed, which provide further insights into the influence of bottom currents. Adult Dungeness crabs tend to occur on the upper portions of the delta front at depths < -45 m to > -75 m CD. Observed densities of other macroscopically discernible invertebrates were very low along all transect depths (-45 m, -60 m, -75 m, -90 m CD). Observations of fish were more numerous, with the highest densities occurring along the -60 m CD transect. There was a general shift with depth in the dominance of flatfish at shallower depths and finfish and cartilaginous fish at greater depths.

The benthic fauna observed in the ITP reflect recovery of the benthic community following the use of the ITP area for stockpiling of Fraser River sand borrow material during the construction of DP3 in the late 2000s. The abundance and diversity of macrofauna was generally similar to other undisturbed areas within the Strait of Georgia that accumulate finer textured sediments and detrital organic matter.

7.0 CLOSURE

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9.0 STATEMENT OF LIMITATIONS

This report was prepared by Hemmera, based on fieldwork conducted by Hemmera, for the sole benefit and exclusive use of Port Metro Vancouver. The material in it reflects Hemmera's best judgment in light of the information available to it at the time of preparing this Report. Any use that a third party makes of this Report, or any reliance on or decision made based on it, is the responsibility of such third parties. Hemmera accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this Report.

Hemmera has performed the work as described above and made the findings and conclusions set out in this Report in a manner consistent with the level of care and skill normally exercised by members of the environmental science profession practicing under similar conditions at the time the work was performed.

This Report represents a reasonable review of the information available to Hemmera within the established Scope, work schedule and budgetary constraints. The conclusions and recommendations contained in this Report are based upon applicable legislation existing at the time the Report was drafted. Any changes in the legislation may alter the conclusions and/or recommendations contained in the Report. Regulatory implications discussed in this Report were based on the applicable legislation existing at the time this Report was written.

In preparing this Report, Hemmera has relied in good faith on information provided by others as noted in this Report, and has assumed that the information provided by those individuals is both factual and accurate. Hemmera accepts no responsibility for any deficiency, misstatement or inaccuracy in this Report resulting from the information provided by those individuals.

APPENDIX A
ROV Video Stills

Figure A1 Dungeness crabs

Figure A2 Sea pens

Figure A3 Shrimp

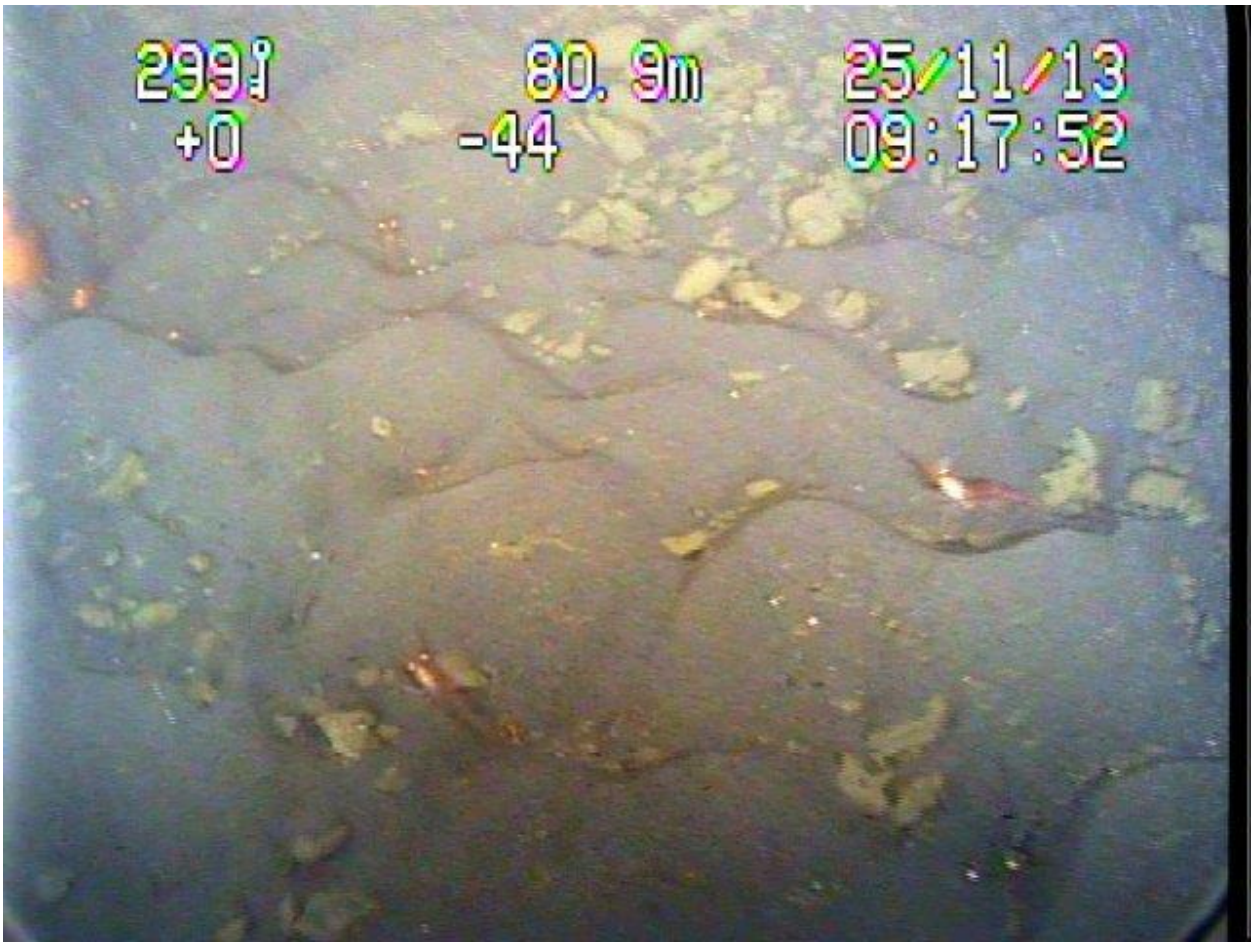

Figure A4 Prawns

Figure A5 Rock Crab

Figure A6 Small Crab

Figure A7 Tanner Crab

Figure A8 Squat Lobster

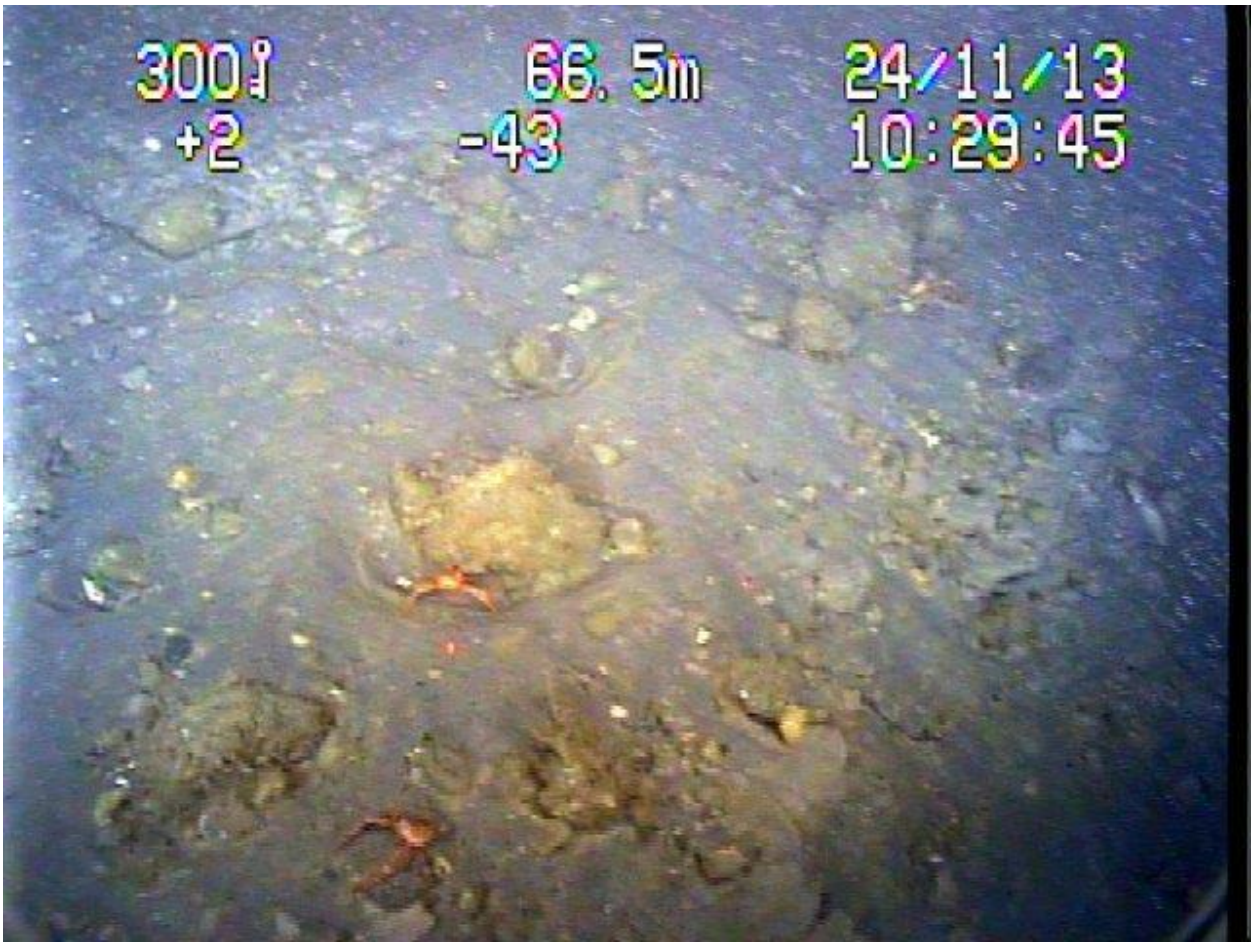

Figure A9 Different Crab

Figure A10 Decorator Crab

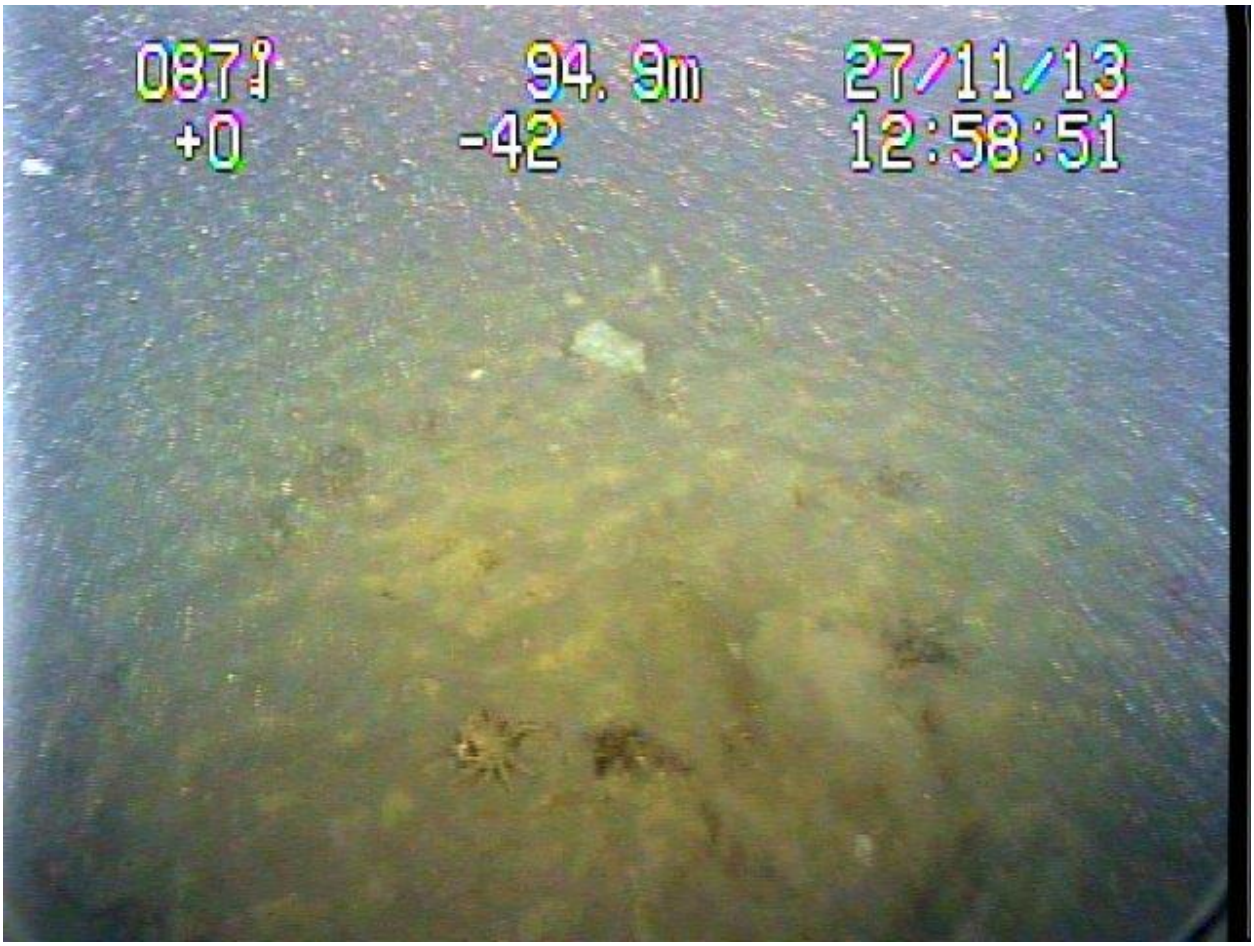

Figure A11 Anemone

Figure A12 Nudibranch

Figure A13 Sea cucumber

Figure A14 Brittle Star

Figure A15 Sponges

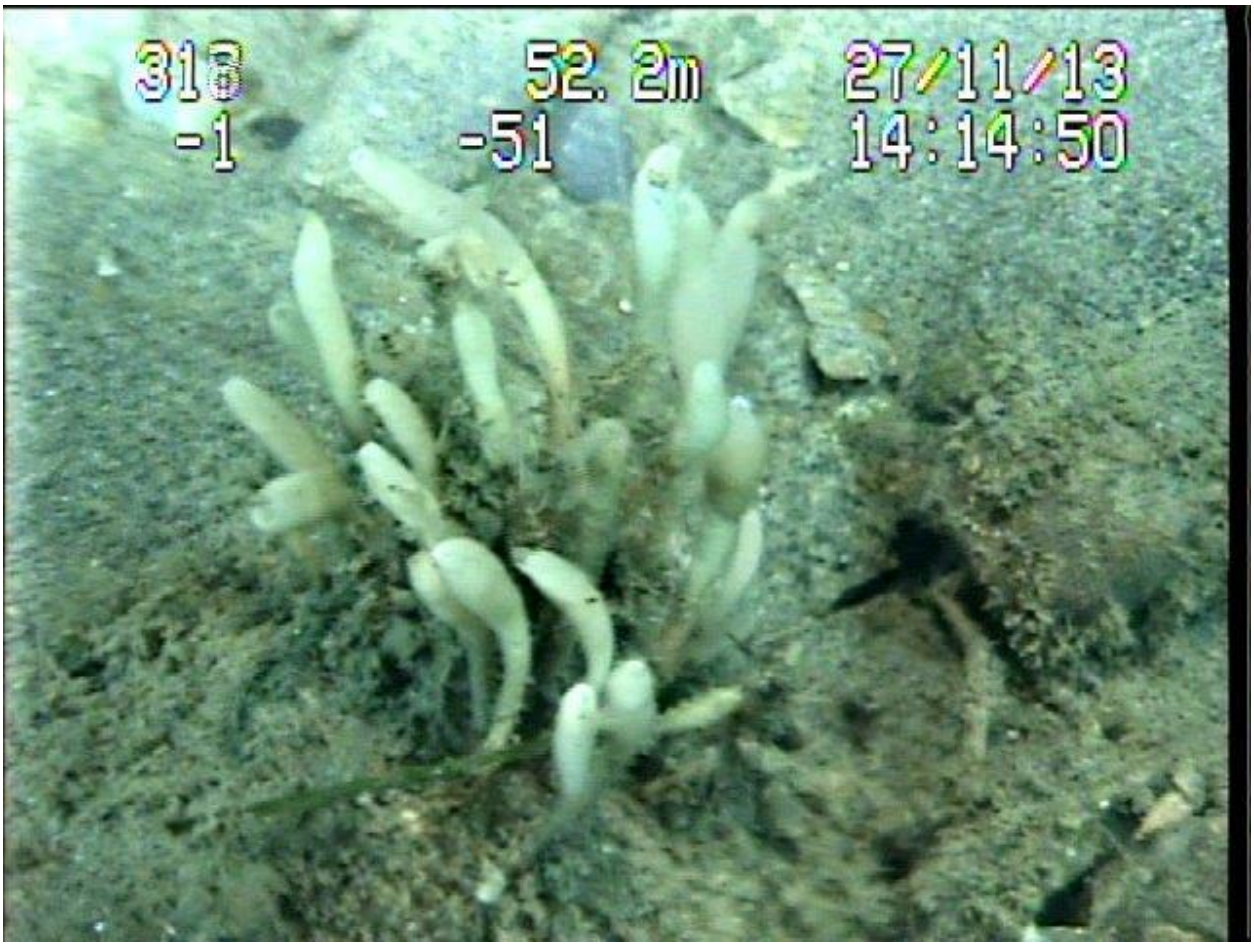

Figure A16 Giant Pacific octopus

Figure A17 Giant Pacific octopus

Figure A18 Giant Pacific octopus

Figure A19 Flatfish

Figure A20 Smaller Demersal Fish

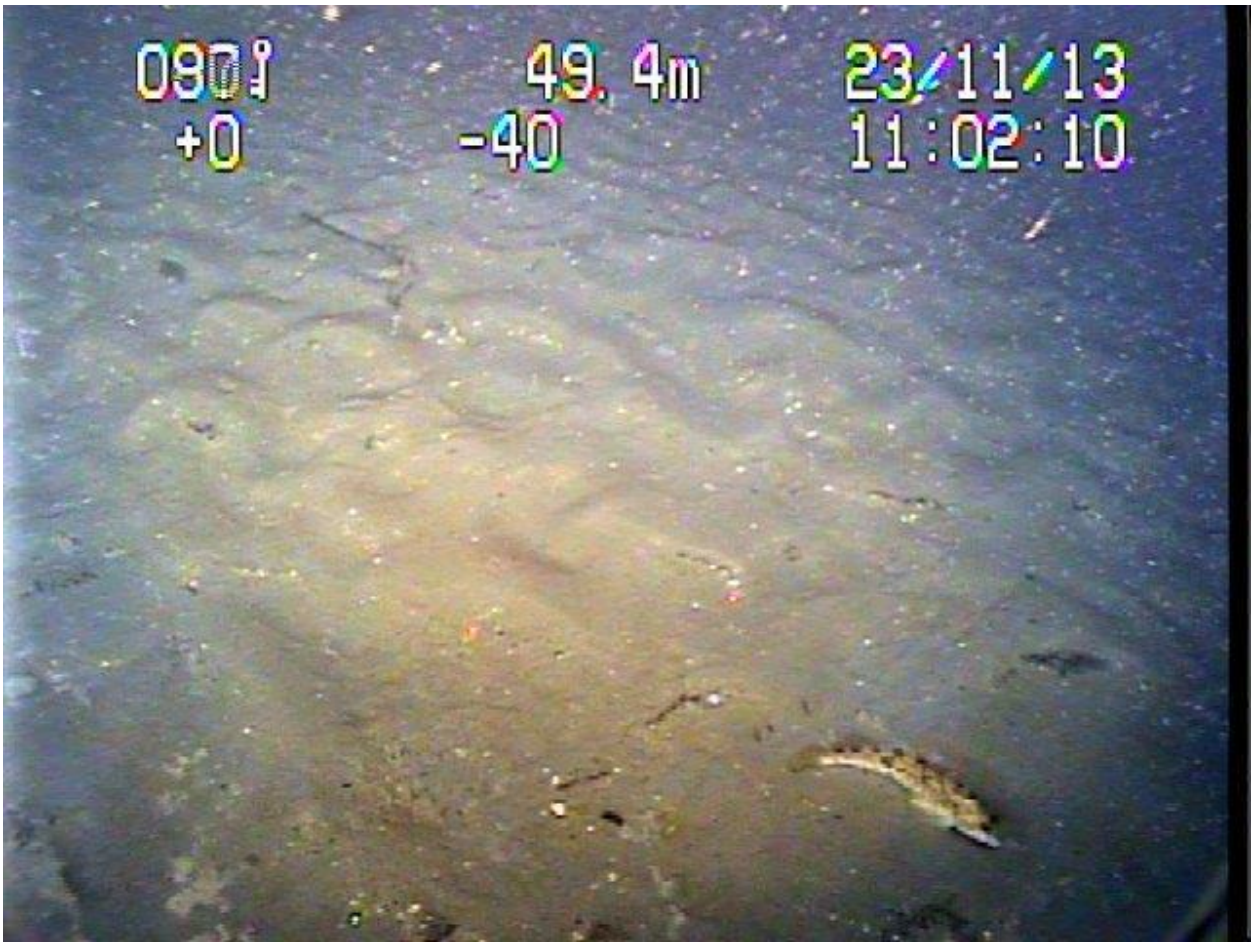

Figure A21 Larger Demersal Fish

Figure A22 Skate egg

Figure A23 Perch, small (1-10)

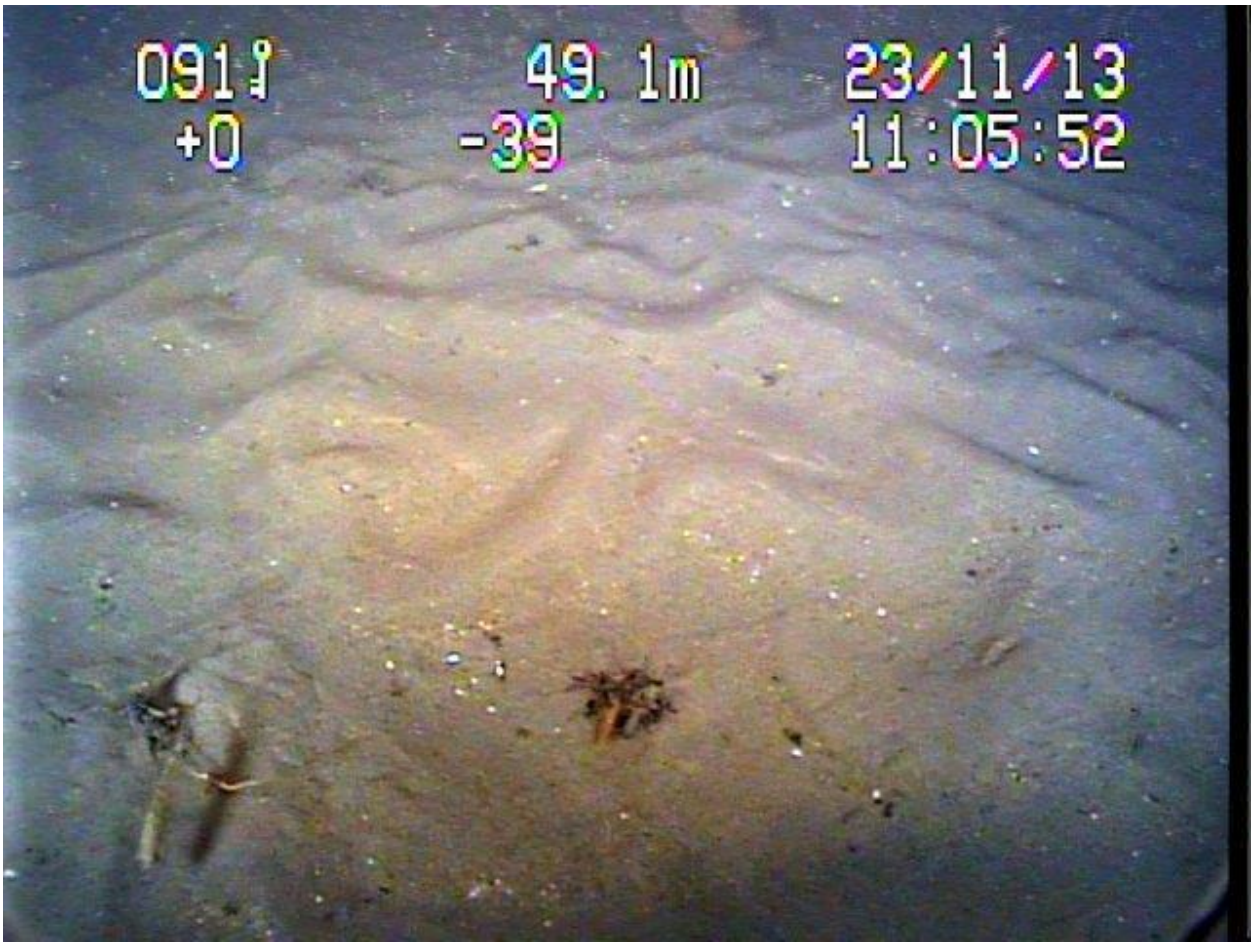

Figure A24 Perch, medium (11-50)

Figure A25 Perch, large (51-100) (full school not captured in field of view)

Figure A26 Herring, small (1-15)

Figure A27 Herring, medium (16-200)

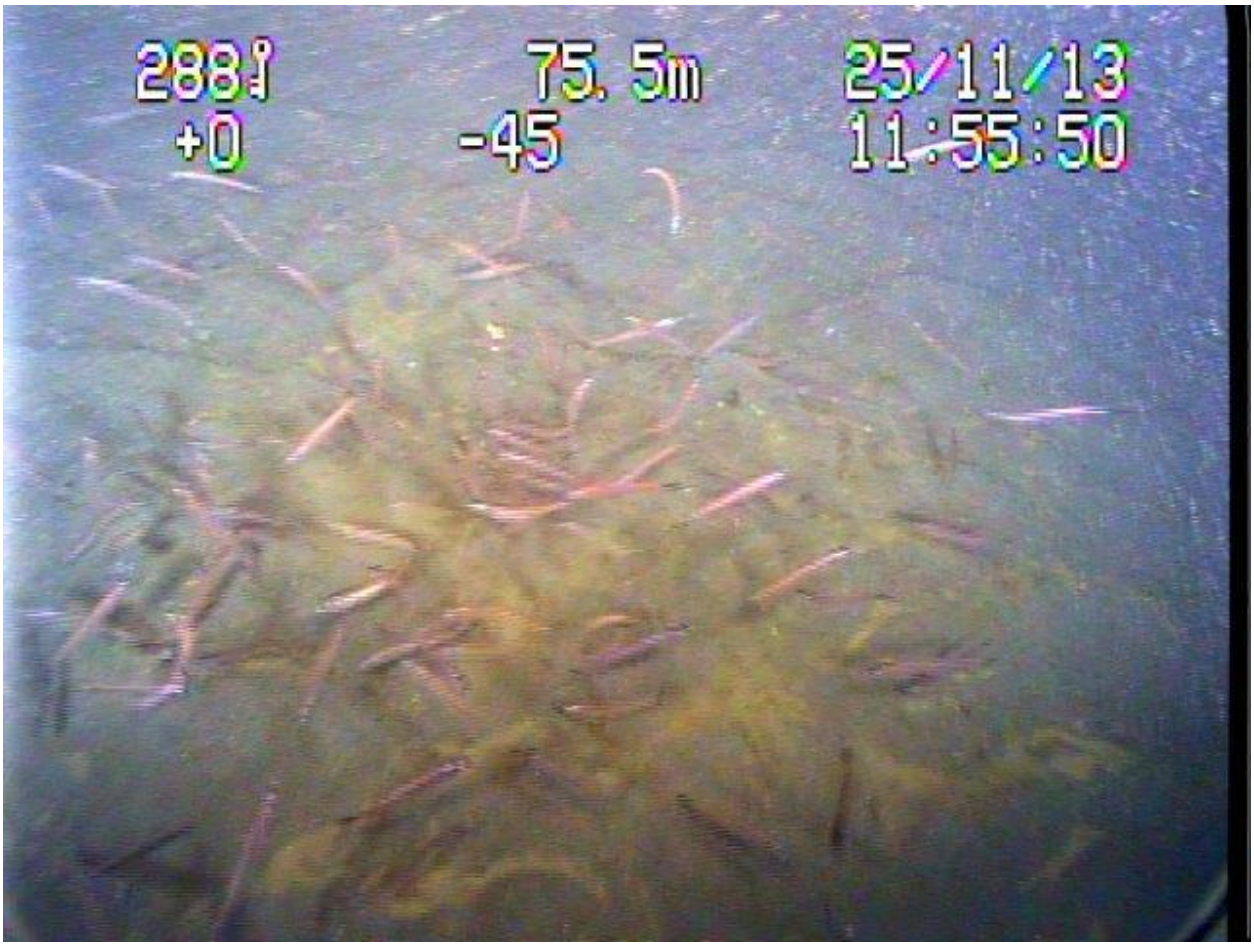

Figure A28 Herring, large (201-500)

Figure A29 Derelict fishing net with crab covered in barnacles

Figure A30 Beggiatoa (with gas release bubbles)

Figure A31 Derelict fishing net

Figure A32 Crab trap, partially buried

Figure A33 Derelict crab trap

Figure A34 Derelict crab trap with bait and 12 live crabs

APPENDIX B

ROV Density Results by Transect Segment

APPENDIX B: ROV Density Results by Transect Segment - Linear Transects

Transect Depth (m)	Segment				Dungeness Crabs		Sea Pens		Other Invertebrates		Flatfish		Finfish and Cartilegenous Fish		All Fish		Perch Schools			Herring Schools		
	ID	Entpoint Distance from Transect Start (m)	Field of View (m)	Segment Area (m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No. Small (1-10)	No. Medium (11-50)	No. Large (51-100)	No. Small (1-15)	No. Medium (16-200)	No. Large (201-500)
45	1	200	1.05	210.1	4	0.019	3	0.014	5	0.024	35	0.167	12	0.057	47	0.224	3	0	0	0	0	1
45	2	400	1.11	221.8	4	0.018	3	0.014	10	0.045	21	0.095	3	0.014	24	0.108	0	0	0	0	0	0
45	3	600	1.14	227.5	11	0.048	0	0.000	1	0.004	22	0.097	4	0.018	26	0.114	3	1	0	0	0	0
45	4	800	1.33	265.2	10	0.038	0	0.000	0	0.000	29	0.109	2	0.008	31	0.117	4	0	0	0	0	0
45	5	1000	1.30	259.3	9	0.035	7	0.027	5	0.019	16	0.062	7	0.027	23	0.089	4	1	0	0	0	0
45	6	1200	1.03	204.2	19	0.093	34	0.167	9	0.044	15	0.073	3	0.015	18	0.088	4	0	0	0	0	0
45	7	1400	1.20	240.8	8	0.033	38	0.158	10	0.042	20	0.083	13	0.054	33	0.137	3	0	0	0	0	0
45	8	1600	1.70	340.2	4	0.012	1	0.003	2	0.006	8	0.024	0	0.000	8	0.024	0	0	0	0	0	0
45	9	1800	1.13	225.6	8	0.035	0	0.000	1	0.004	23	0.102	3	0.013	26	0.115	0	0	0	0	0	0
45	10	2000	1.23	241.7	10	0.041	1	0.004	1	0.004	8	0.033	4	0.017	12	0.050	0	0	0	0	0	0
45	11	2200	1.23	245.0	6	0.024	1	0.004	0	0.000	44	0.180	2	0.008	46	0.188	1	0	0	0	0	0
45	12	2400	1.92	384.7	16	0.042	2	0.005	3	0.008	1	0.003	0	0.000	1	0.003	0	0	0	0	0	0
45	13	2600	1.26	251.3	5	0.020	0	0.000	3	0.012	6	0.024	0	0.000	6	0.024	1	1	0	0	0	0
45	14	2800	1.19	238.0	15	0.063	2	0.008	2	0.008	12	0.050	2	0.008	14	0.059	0	0	0	0	0	0
45	15	3000	1.16	232.1	13	0.056	2	0.009	0	0.000	7	0.030	1	0.004	8	0.034	1	0	1	0	0	0
45	16	3200	1.40	279.3	52	0.186	1	0.004	5	0.018	3	0.011	1	0.004	4	0.014	1	0	0	0	0	0
45	17	3400	1.19	238.5	31	0.130	3	0.013	0	0.000	5	0.021	0	0.000	5	0.021	0	0	0	0	0	0
45	18	3600	1.18	235.7	17	0.072	6	0.025	4	0.017	16	0.068	2	0.008	18	0.076	1	0	0	0	0	0
45	19	3800	1.68	336.0	31	0.092	5	0.015	2	0.006	18	0.054	3	0.009	21	0.063	1	0	1	0	0	0
45	20	4000	1.52	303.7	14	0.046	4	0.013	0	0.000	6	0.020	3	0.010	9	0.030	0	0	0	0	0	0
45	21	4200	1.50	300.6	12	0.040	0	0.000	1	0.003	22	0.073	4	0.013	26	0.087	0	0	1	0	0	0
45	22	4400	1.54	305.6	7	0.023	4	0.013	12	0.039	8	0.026	0	0.000	8	0.026	0	0	0	0	0	0
45	23	4600	1.33	265.0	9	0.034	5	0.019	6	0.023	24	0.091	1	0.004	25	0.094	2	0	0	0	0	0
45	24	4800	1.77	353.4	7	0.020	8	0.023	11	0.031	17	0.048	2	0.006	19	0.054	0	0	0	0	0	0
45	25	5000	1.34	265.7	6	0.023	0	0.000	1	0.004	26	0.098	1	0.004	27	0.102	0	0	0	0	0	0
45	26	5200	1.66	331.3	7	0.021	6	0.018	8	0.024	19	0.057	0	0.000	19	0.057	0	0	0	0	0	0
45	27	5265	1.00	64.3	1	0.016	0	0.000	2	0.031	1	0.016	0	0.000	1	0.016	0	0	0	0	0	0
45 m Transect	**Min**				**1**	**0.012**	**0**	**0.000**	**0**	**0.000**	**1**	**0.003**	**0**	**0.000**	**1**	**0.003**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**52**	**0.186**	**38**	**0.167**	**12**	**0.045**	**44**	**0.180**	**13**	**0.057**	**47**	**0.224**	**4**	**1**	**1**	**0**	**0**	**1**
	Average				**12**	**0.047**	**5**	**0.021**	**4**	**0.015**	**16**	**0.063**	**3**	**0.011**	**19**	**0.075**	**1.1**	**0.1**	**0.1**	**0.0**	**0.0**	**0.0**
	SD				**11**	**0.039**	**9**	**0.042**	**4**	**0.015**	**11**	**0.045**	**3**	**0.014**	**12**	**0.054**	**1.4**	**0.3**	**0.3**	**0.0**	**0.0**	**0.2**
	Total	**5265**		**7066.5**	**336**	**0.048**	**136**	**0.019**	**104**	**0.015**	**432**	**0.061**	**73**	**0.010**	**505**	**0.071**	**29**	**3**	**3**	**0**	**0**	**1**

APPENDIX B: ROV Density Results by Transect Segment - Linear Transects

Transect Depth (m)	Segment				Dungeness Crabs		Sea Pens		Other Invertebrates		Flatfish		Finfish and Cartilegenous Fish		All Fish		Perch Schools			Herring Schools		
	ID	Entpoint Distance from Transect Start (m)	Field of View (m)	Segment Area (m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No. Small (1-10)	No. Medium (11-50)	No. Large (51-100)	No. Small (1-15)	No. Medium (16-200)	No. Large (201-500)
60	28	200	0.79	156.6	5	0.032	6	0.038	5	0.032	9	0.057	20	0.128	29	0.185	0	0	0	0	0	0
60	29	400	1.10	218.9	6	0.027	0	0.000	1	0.005	25	0.114	124	0.566	149	0.681	0	0	0	0	0	0
60	30	600	0.90	180.0	6	0.033	3	0.017	2	0.011	11	0.061	22	0.122	33	0.183	1	0	0	1	0	0
60	31	800	0.87	173.5	8	0.046	9	0.052	7	0.040	19	0.109	23	0.133	42	0.242	1	0	0	0	0	0
60	32	1000	1.27	253.9	5	0.020	0	0.000	3	0.012	7	0.028	8	0.032	15	0.059	0	0	0	0	0	0
60	33	1200	1.09	218.0	9	0.041	6	0.028	5	0.023	6	0.028	16	0.073	22	0.101	0	0	0	0	0	0
60	34	1400	0.81	162.0	16	0.099	5	0.031	16	0.099	16	0.099	21	0.130	37	0.228	0	1	0	0	0	0
60	35	1600	0.98	196.6	10	0.051	5	0.025	6	0.031	8	0.041	18	0.092	26	0.132	0	1	0	0	0	0
60	36	1800	1.05	210.0	14	0.067	3	0.014	4	0.019	6	0.029	19	0.090	25	0.119	0	1	0	0	0	0
60	37	2000	1.00	200.5	19	0.095	10	0.050	10	0.050	22	0.110	115	0.574	137	0.683	0	1	0	0	0	0
60	38	2200	1.21	241.8	3	0.012	0	0.000	3	0.012	17	0.070	8	0.033	25	0.103	0	0	0	0	0	0
60	39	2400	1.28	256.2	10	0.039	2	0.008	0	0.000	15	0.059	21	0.082	36	0.141	1	1	0	0	0	0
60	40	2600	1.01	202.0	11	0.054	2	0.010	7	0.035	22	0.109	10	0.049	32	0.158	0	0	0	0	0	0
60	41	2800	1.16	231.3	9	0.039	1	0.004	1	0.004	21	0.091	3	0.013	24	0.104	1	0	0	0	0	0
60	42	3000	1.08	216.5	19	0.088	0	0.000	13	0.060	12	0.055	18	0.083	30	0.139	1	0	0	0	0	0
60	43	3200	1.18	234.8	9	0.038	2	0.009	3	0.013	9	0.038	10	0.043	19	0.081	0	0	0	0	0	0
60	44	3400	1.45	290.4	13	0.045	0	0.000	0	0.000	8	0.028	2	0.007	10	0.034	0	0	0	0	0	0
60	45	3600	1.06	211.9	13	0.061	1	0.005	2	0.009	13	0.061	9	0.042	22	0.104	0	0	0	0	0	0
60	46	3800	1.28	254.9	5	0.020	0	0.000	0	0.000	16	0.063	3	0.012	19	0.075	1	0	0	0	0	0
60	47	4000	1.76	346.6	4	0.012	0	0.000	0	0.000	18	0.052	2	0.006	20	0.058	1	0	0	0	0	0
60	48	4200	1.12	222.8	8	0.036	0	0.000	3	0.013	19	0.085	5	0.022	24	0.108	0	0	0	0	0	0
60	49	4400	1.58	315.3	12	0.038	0	0.000	1	0.003	16	0.051	8	0.025	24	0.076	0	0	0	0	0	0
60	50	4600	1.13	224.9	3	0.013	1	0.004	0	0.000	20	0.089	4	0.018	24	0.107	1	0	0	0	0	0
60	51	4800	1.21	242.6	5	0.021	1	0.004	1	0.004	29	0.120	9	0.037	38	0.157	1	0	0	0	0	0
60	52	5000	1.33	199.0	1	0.005	0	0.000	1	0.005	19	0.095	8	0.040	27	0.136	0	0	0	0	0	0
60	53	5150	1.33	265.5	9	0.034	2	0.008	1	0.004	20	0.075	2	0.008	22	0.083	0	0	0	0	0	0
60 m Transect	**Min**				**1**	**0.005**	**0**	**0.000**	**0**	**0.000**	**6**	**0.028**	**2**	**0.006**	**10**	**0.034**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**19**	**0.099**	**10**	**0.052**	**16**	**0.099**	**29**	**0.120**	**124**	**0.574**	**149**	**0.683**	**1**	**1**	**0**	**1**	**0**	**0**
	Average				**21**	**0.041**	**7**	**0.012**	**7**	**0.019**	**30**	**0.070**	**21**	**0.095**	**51**	**0.164**	**0.3**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**
	SD				**62**	**0.025**	**25**	**0.016**	**19**	**0.023**	**79**	**0.030**	**31**	**0.146**	**94**	**0.160**	**0.5**	**0.4**	**0.0**	**0.2**	**0.0**	**0.0**
	Total	**5150**		**5926.5**	**232**	**0.039**	**59**	**0.010**	**95**	**0.016**	**403**	**0.068**	**508**	**0.086**	**911**	**0.154**	**9**	**5**	**0**	**1**	**0**	**0**

APPENDIX B: ROV Density Results by Transect Segment - Linear Transects

Transect Depth (m)	Segment				Dungeness Crabs		Sea Pens		Other Invertebrates		Flatfish		Finfish and Cartilegenous Fish		All Fish		Perch Schools			Herring Schools		
	ID	Entpoint Distance from Transect Start (m)	Field of View (m)	Segment Area (m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No. Small (1-10)	No. Medium (11-50)	No. Large (51-100)	No. Small (1-15)	No. Medium (16-200)	No. Large (201-500)
75	54	200	0.77	152.8	0	0.000	0	0.000	6	0.039	4	0.026	29	0.190	33	0.216	0	0	0	0	0	0
75	55	400	0.84	164.2	1	0.006	2	0.012	9	0.055	3	0.018	29	0.177	32	0.195	0	0	0	0	0	0
75	56	600	1.06	211.5	0	0.000	0	0.000	66	0.312	4	0.019	38	0.180	42	0.199	0	0	0	0	0	0
75	57	800	0.85	169.5	0	0.000	0	0.000	28	0.165	6	0.035	36	0.212	42	0.248	0	0	0	0	0	0
75	58	1000	0.76	152.3	0	0.000	0	0.000	24	0.158	6	0.039	47	0.309	53	0.348	0	0	0	1	0	0
75	59	1200	0.87	173.2	1	0.006	1	0.006	33	0.191	1	0.006	19	0.110	20	0.115	0	0	0	0	0	0
75	60	1400	0.93	185.8	0	0.000	0	0.000	8	0.043	6	0.032	17	0.092	23	0.124	0	0	0	0	0	0
75	61	1600	1.01	201.6	2	0.010	0	0.000	8	0.040	6	0.030	15	0.074	21	0.104	0	0	0	0	0	0
75	62	1800	0.78	156.7	0	0.000	0	0.000	13	0.083	6	0.038	10	0.064	16	0.102	0	0	0	0	0	0
75	63	2000	1.07	213.2	6	0.028	2	0.009	7	0.033	7	0.033	17	0.080	24	0.113	1	0	0	0	0	0
75	64	2200	0.91	181.4	3	0.017	0	0.000	4	0.022	6	0.033	12	0.066	18	0.099	0	0	0	0	0	0
75	65	2400	1.07	214.3	13	0.061	0	0.000	2	0.009	3	0.014	11	0.051	14	0.065	0	0	0	0	1	0
75	66	2600	1.04	208.8	12	0.057	1	0.005	7	0.034	3	0.014	22	0.105	25	0.120	0	0	0	0	0	0
75	67	2800	1.21	242.1	13	0.054	1	0.004	3	0.012	3	0.012	3	0.012	6	0.025	0	0	0	0	0	0
75	68	3000	1.20	239.2	15	0.063	3	0.013	2	0.008	7	0.029	9	0.038	16	0.067	0	0	0	0	0	0
75	69	3200	1.02	203.2	11	0.054	0	0.000	2	0.010	5	0.025	5	0.025	10	0.049	0	0	0	0	0	0
75	70	3400	0.90	179.0	18	0.101	1	0.006	1	0.006	6	0.034	8	0.045	14	0.078	0	0	0	0	0	0
75	71	3600	1.17	234.7	17	0.072	0	0.000	11	0.047	11	0.047	6	0.026	17	0.072	1	0	0	0	0	0
75	72	3800	1.09	217.9	14	0.064	0	0.000	1	0.005	4	0.018	6	0.028	10	0.046	0	0	0	0	0	0
75	73	4000	1.12	222.1	9	0.041	1	0.005	4	0.018	6	0.027	10	0.045	16	0.072	0	0	0	1	0	0
75	74	4200	0.92	184.7	13	0.070	1	0.005	4	0.022	8	0.043	2	0.011	10	0.054	0	0	0	0	0	0
75	75	4400	0.77	153.8	4	0.026	1	0.007	0	0.000	5	0.033	5	0.033	10	0.065	0	0	0	0	0	0
75	76	4600	0.81	161.3	4	0.025	0	0.000	2	0.012	10	0.062	3	0.019	13	0.081	0	0	0	0	1	0
75	77	4800	0.96	139.7	0	0.000	0	0.000	6	0.043	1	0.007	1	0.007	2	0.014	0	0	0	0	0	0
75	78	5000	0.78	155.0	2	0.013	0	0.000	1	0.006	6	0.039	3	0.019	9	0.058	0	0	0	0	0	0
75	79	5200	1.15	229.3	6	0.026	1	0.004	7	0.031	2	0.009	26	0.113	28	0.122	0	0	0	0	0	0
75	80	5333	1.28	240.1	4	0.017	1	0.004	2	0.008	5	0.021	15	0.062	20	0.083	0	0	0	0	0	0
75 m Transect	**Min**				**0**	**0.000**	**0**	**0.000**	**0**	**0.000**	**1**	**0.006**	**1**	**0.007**	**2**	**0.014**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**18**	**0.101**	**3**	**0.013**	**66**	**0.312**	**11**	**0.062**	**47**	**0.309**	**53**	**0.348**	**1**	**0**	**0**	**1**	**1**	**0**
	Average				**6**	**0.030**	**1**	**0.003**	**10**	**0.052**	**5**	**0.028**	**15**	**0.081**	**20**	**0.109**	**0.1**	**0.0**	**0.0**	**0.1**	**0.1**	**0.0**
	SD				**6**	**0.029**	**1**	**0.004**	**14**	**0.072**	**2**	**0.013**	**12**	**0.074**	**12**	**0.074**	**0.3**	**0.0**	**0.0**	**0.3**	**0.3**	**0.0**
	Total	**5333**		**5187.4**	**168**	**0.032**	**16**	**0.003**	**261**	**0.050**	**140**	**0.027**	**404**	**0.078**	**544**	**0.105**	**2**	**0**	**0**	**2**	**2**	**0**

APPENDIX B: ROV Density Results by Transect Segment - Linear Transects

Transect Depth (m)	Segment				Dungeness Crabs		Sea Pens		Other Invertebrates		Flatfish		Finfish and Cartilegenous Fish		All Fish		Perch Schools			Herring Schools		
	ID	Entpoint Distance from Transect Start (m)	Field of View (m)	Segment Area (m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No. Small (1-10)	No. Medium (11-50)	No. Large (51-100)	No. Small (1-15)	No. Medium (16-200)	No. Large (201-500)
90	81	200	1.07	213.3	1	0.005	0	0.000	39	0.183	2	0.009	10	0.047	12	0.056	0	0	0	0	0	0
90	82	400	1.34	268.5	0	0.000	0	0.000	8	0.030	2	0.007	15	0.056	17	0.063	0	0	0	0	0	0
90	84	600	0.95	188.6	0	0.000	0	0.000	4	0.021	4	0.021	6	0.032	10	0.053	0	0	0	0	0	0
90	83	800	1.04	207.8	2	0.010	0	0.000	13	0.063	3	0.014	7	0.034	10	0.048	0	0	0	0	0	0
90	85	1000	1.14	228.4	1	0.004	0	0.000	15	0.066	4	0.018	12	0.053	16	0.070	0	0	0	0	0	0
90	87	1200	1.11	221.1	1	0.005	0	0.000	10	0.045	7	0.032	15	0.068	22	0.099	0	0	0	0	0	0
90	86	1400	1.12	224.2	1	0.004	0	0.000	9	0.040	4	0.018	18	0.080	22	0.098	0	0	0	0	0	0
90	89	1600	1.37	271.8	0	0.000	2	0.007	9	0.033	1	0.004	119	0.438	120	0.441	0	0	0	0	0	0
90	88	1800	1.25	249.9	2	0.008	0	0.000	13	0.052	3	0.012	30	0.120	33	0.132	0	0	0	0	0	0
90	90	2000	1.34	267.5	1	0.004	1	0.004	34	0.127	8	0.030	19	0.071	27	0.101	0	0	0	0	0	0
90	92	2200	1.42	283.2	4	0.014	0	0.000	3	0.011	7	0.025	12	0.042	19	0.067	0	0	0	1	0	0
90	91	2400	1.46	290.1	1	0.003	0	0.000	4	0.014	7	0.024	21	0.072	28	0.097	0	0	0	0	0	0
90	94	2600	0.86	171.4	1	0.006	1	0.006	3	0.018	6	0.035	14	0.082	20	0.117	0	0	0	0	0	0
90	93	2800	1.26	249.4	1	0.004	1	0.004	13	0.052	8	0.032	12	0.048	20	0.080	0	0	0	0	0	0
90	96	3000	0.92	183.4	2	0.011	0	0.000	12	0.065	10	0.055	9	0.049	19	0.104	0	0	0	0	0	0
90	95	3200	0.78	152.6	0	0.000	0	0.000	3	0.020	3	0.020	6	0.039	9	0.059	0	0	0	0	0	0
90	97	3400	0.81	155.2	0	0.000	2	0.013	18	0.116	5	0.032	15	0.097	20	0.129	0	0	0	0	0	0
90	98	3473	1.00	71.9	0	0.000	0	0.000	13	0.181	1	0.014	2	0.028	3	0.042	0	0	0	0	0	0
90 m Transect	**Min**				**0**	**0.000**	**0**	**0.000**	**3**	**0.011**	**1**	**0.004**	**2**	**0.028**	**3**	**0.042**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**4**	**0.014**	**2**	**0.013**	**39**	**0.183**	**10**	**0.055**	**119**	**0.438**	**120**	**0.441**	**0**	**0**	**0**	**1**	**0**	**0**
	Average				**1**	**0.004**	**0**	**0.002**	**12**	**0.063**	**5**	**0.022**	**19**	**0.081**	**24**	**0.103**	**0.0**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**
	SD				**1**	**0.004**	**1**	**0.004**	**10**	**0.054**	**3**	**0.012**	**26**	**0.092**	**25**	**0.089**	**0.0**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**
	Total	**3473**		**3898.2**	**18**	**0.005**	**7**	**0.002**	**223**	**0.057**	**85**	**0.022**	**342**	**0.088**	**427**	**0.110**	**0**	**0**	**0**	**1**	**0**	**0**

APPENDIX B: ROV Density Results by Transect Segment - Exploratory Transect

Transect Section	Segment				Dungeness Crabs		Sea Pens		Other Invertebrates		Flatfish		Finfish and Cartilegenous Fish		All Fish		Perch Schools			Herring Schools		
	ID	Approx. Depth (m)	Length (m)	Area (m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No.	Density (#/m2)	No. Small (1-10)	No. Medium (11-50)	No. Large (51-100)	No. Small (1-15)	No. Medium (16-200)	No. Large (201-500)
Z5_7	112	60	159.5	136.3	4	0.029	2	0.015	0	0.000	4	0.029	0	0.000	4	0.029	1	0	0	0	0	0
	113	60	40.5	34.3	2	0.058	0	0.000	0	0.000	1	0.029	1	0.029	2	0.058	1	0	0	0	0	0
	114	60	115.5	101.6	0	0.000	0	0.000	0	0.000	3	0.030	6	0.059	9	0.089	1	0	1	0	0	0
	Min				**0**	**0.000**	**0**	**0.000**	**0**	**0.000**	**1**	**0.029**	**0**	**0.000**	**2**	**0.029**	**1**	**0**	**0**	**0**	**0**	**0**
	Max				**4**	**0.058**	**2**	**0.015**	**0**	**0.000**	**4**	**0.030**	**6**	**0.059**	**9**	**0.089**	**1**	**0**	**1**	**0**	**0**	**0**
	Average				**2.0**	**0.029**	**0.7**	**0.005**	**0.0**	**0.000**	**2.7**	**0.029**	**2.3**	**0.029**	**5.0**	**0.059**	**1.0**	**0.0**	**0.3**	**0.0**	**0.0**	**0.0**
	SD				**2.0**	**0.029**	**1.2**	**0.009**	**0.0**	**0.000**	**1.5**	**0.000**	**3.2**	**0.030**	**3.6**	**0.030**	**0.0**	**0.0**	**0.6**	**0.0**	**0.0**	**0.0**
	Total		**315.5**	**272.2**	**6**	**0.022**	**2**	**0.007**	**0**	**0.000**	**8**	**0.029**	**7**	**0.026**	**15**	**0.055**	**3**	**0**	**1**	**0**	**0**	**0**
Z4_7	108	60 to 75	200.0	181.5	3	0.017	2	0.011	11	0.061	4	0.022	23	0.127	27	0.149	0	0	0	0	0	0
	109	60 to 75	200.0	150.4	1	0.007	1	0.007	6	0.040	5	0.033	23	0.153	28	0.186	0	0	0	0	0	0
	110	60 to 75	200.0	137.6	1	0.007	1	0.007	23	0.168	5	0.037	18	0.132	23	0.168	0	0	0	0	0	0
	111	60 to 75	27.9	20.6	0	0.000	0	0.000	5	0.243	0	0.000	1	0.049	1	0.049	0	0	0	0	0	0
	Min				**0**	**0.000**	**0**	**0.000**	**5**	**0.040**	**0**	**0.000**	**1**	**0.049**	**1**	**0.049**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**3**	**0.017**	**2**	**0.011**	**23**	**0.243**	**5**	**0.037**	**23**	**0.153**	**28**	**0.186**	**0**	**0**	**0**	**0**	**0**	**0**
	Average				**1.3**	**0.008**	**1.0**	**0.006**	**11.3**	**0.128**	**3.5**	**0.023**	**16.3**	**0.115**	**19.8**	**0.138**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	SD				**1.3**	**0.007**	**0.8**	**0.005**	**8.3**	**0.095**	**2.4**	**0.017**	**10.4**	**0.046**	**12.7**	**0.062**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Total		**627.9**	**490.1**	**5**	**0.010**	**4**	**0.008**	**45**	**0.092**	**14**	**0.029**	**65**	**0.133**	**79**	**0.161**	**0**	**0**	**0**	**0**	**0**	**0**
Z4_3	105	75 to 60	200.0	155.1	0	0.000	0	0.000	8	0.052	6	0.039	9	0.058	15	0.097	0	0	0	0	0	0
	106	75 to 60	200.0	148.1	3	0.021	0	0.000	0	0.000	9	0.062	14	0.097	23	0.159	0	0	0	0	0	0
	107	75 to 60	22.5	16.7	1	0.060	0	0.000	6	0.360	1	0.060	3	0.180	4	0.240	0	0	0	0	0	0
	Min				**0**	**0.000**	**0**	**0.000**	**0**	**0.000**	**1**	**0.039**	**3**	**0.058**	**4**	**0.097**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**3**	**0.060**	**0**	**0.000**	**8**	**0.360**	**9**	**0.062**	**14**	**0.180**	**23**	**0.240**	**0**	**0**	**0**	**0**	**0**	**0**
	Average				**1.3**	**0.027**	**0.0**	**0.000**	**4.7**	**0.137**	**5.3**	**0.054**	**8.7**	**0.112**	**14.0**	**0.165**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	SD				**1.5**	**0.030**	**0.0**	**0.000**	**4.2**	**0.195**	**4.0**	**0.013**	**5.5**	**0.062**	**9.5**	**0.072**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Total		**422.5**	**319.8**	**4**	**0.013**	**0**	**0.000**	**14**	**0.044**	**16**	**0.050**	**26**	**0.081**	**42**	**0.131**	**0**	**0**	**0**	**0**	**0**	**0**
Z3_1	100	60	143.1	126.9	8	0.063	3	0.024	14	0.110	7	0.055	14	0.110	21	0.166	0	0	0	0	0	0
	101	60 to 40	56.9	56.9	3	0.053	0	0.000	0	0.000	12	0.211	3	0.053	15	0.264	0	0	0	0	0	0
	102	60 to 40	200.0	196.5	19	0.097	31	0.158	13	0.066	27	0.138	18	0.092	45	0.229	0	0	0	0	0	0
	103	60 to 40	200.0	201.5	11	0.055	21	0.105	10	0.050	9	0.045	6	0.030	15	0.075	0	0	0	0	0	0
	104	60 to 40	21.6	21.8	2	0.092	1	0.046	0	0.000	3	0.138	0	0.000	3	0.138	0	0	0	0	0	0
	Min				**2**	**0.053**	**0**	**0.000**	**0**	**0.000**	**3**	**0.045**	**0**	**0.000**	**3**	**0.075**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**19**	**0.097**	**31**	**0.158**	**14**	**0.110**	**27**	**0.211**	**18**	**0.110**	**45**	**0.264**	**0**	**0**	**0**	**0**	**0**	**0**
	Average				**8.6**	**0.072**	**11.2**	**0.067**	**7.4**	**0.045**	**11.6**	**0.117**	**8.2**	**0.057**	**19.8**	**0.174**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	SD				**6.9**	**0.021**	**14.0**	**0.064**	**6.9**	**0.047**	**9.2**	**0.068**	**7.6**	**0.045**	**15.5**	**0.075**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
	Total		**621.6**	**603.4**	**43**	**0.071**	**56**	**0.093**	**37**	**0.061**	**58**	**0.096**	**41**	**0.068**	**99**	**0.164**	**0**	**0**	**0**	**0**	**0**	**0**
All	**Min**				**0**	**0.000**	**0**	**0.000**	**0**	**0.000**	**0**	**0.000**	**0**	**0.000**	**1**	**0.029**	**0**	**0**	**0**	**0**	**0**	**0**
	Max				**19**	**0.097**	**31**	**0.158**	**23**	**0.360**	**27**	**0.211**	**23**	**0.180**	**45**	**0.264**	**1**	**0**	**1**	**0**	**0**	**0**
	Average				**3.9**	**0.037**	**4.1**	**0.025**	**6.4**	**0.077**	**6.4**	**0.062**	**9.3**	**0.078**	**15.7**	**0.140**	**0.2**	**0.0**	**0.1**	**0.0**	**0.0**	**0.0**
	SD				**5.2**	**0.033**	**9.1**	**0.046**	**6.9**	**0.105**	**6.6**	**0.056**	**8.4**	**0.055**	**12.4**	**0.072**	**0.4**	**0.0**	**0.3**	**0.0**	**0.0**	**0.0**
	Total		**1987.5**	**1685.5**	**58**	**0.034**	**62**	**0.037**	**96**	**0.057**	**96**	**0.057**	**139**	**0.082**	**235**	**0.139**	**3**	**0**	**1**	**0**	**0**	**0**

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APPENDIX C

Infaunal Macroinvertebrates Summary Results

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Appendix C1: Summary Data for Benthic Macrofauna Abundance as Total Count at DAS Site

DAS Site										
Species Taxonomy					Min	Max	Average	Count	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Total								**1466**	**100%**	
Mollusca	Gastropoda		Trochidae	Solariella obscura	1	92	24.5	490	33.4%	33.4%
Arthropoda	Malacostraca		Lysianassidae	Orchomenella minuta	1	16	7.2	72	4.9%	38.3%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius boreovariatus	1	22	8.4	59	4.0%	42.4%
Arthropoda	Malacostraca		Photidae	Gammaropsis sp.	7	44	25.5	51	3.5%	45.8%
Annelida	Polychaeta	Sedentaria	Syllidae	Exogone dwisula	1	34	17.5	35	2.4%	48.2%
Echinodermata	Ophiuroidea		Amphiuridae	Amphiodia urtica	1	6	1.9	31	2.1%	50.3%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Minuspio) lighti	1	14	5.4	27	1.8%	52.2%
Annelida	Polychaeta	Sedentaria	Nereidae	Nereis pelagica	2	13	8.7	26	1.8%	54.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete nr. acutifrons	1	9	3.6	25	1.7%	55.7%
Arthropoda	Malacostraca		Phoxcephalidae	Majoxiphalus maximus	1	4	2.1	25	1.7%	57.4%
Arthropoda	Malacostraca		Aoridae	Aoroides sp.	1	18	7.0	21	1.4%	58.8%
Annelida	Polychaeta	Errantia	Nereididae	Platynereis bicanaliculata	3	12	6.3	19	1.3%	60.1%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Scoloplos armiger	1	4	1.6	19	1.3%	61.4%
Annelida	Polychaeta	Sedentaria	Paraonidae	Aricidea wassi	1	4	2.7	19	1.3%	62.7%
Bryozoa	Gymnolaemata		Hippothoidae	Celleporella hyalina	19	19	19.0	19	1.3%	64.0%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius sp.	1	6	2.8	17	1.2%	65.1%
Annelida	Polychaeta	Sedentaria	Capitellidae	Mediomastus californiensis	1	8	2.0	16	1.1%	66.2%
Annelida	Polychaeta	Sedentaria	Capitellidae	Decamastus nr. gracilis	1	8	2.5	15	1.0%	67.3%
Annelida	Polychaeta	Sedentaria	Magelonidae	Magelona longicornis	1	10	3.5	14	1.0%	68.2%
Annelida	Polychaeta	Sedentaria	Paraonidae	Cirrophorus branchiatus	1	5	2.6	13	0.9%	69.1%
Arthropoda	Malacostraca			Gammaridea indet.	13	13	13.0	13	0.9%	70.0%
Arthropoda	Malacostraca		Lysianassidae	Wecomedon wecomus	2	5	3.0	12	0.8%	70.8%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius fatigans	1	6	2.4	12	0.8%	71.6%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Leitoscoloplos pugettensis	1	3	1.6	11	0.8%	72.4%
Bryozoa	Gymnolaemata		Calloporidae	Alderina sp.	11	11	11.0	11	0.8%	73.1%
Mollusca	Gastropoda		Columbellidae	Astyris gausapata	11	11	11.0	11	0.8%	73.9%
Annelida	Polychaeta	Sedentaria	Spionidae	Spiophanes berkeleyorum	1	4	2.0	10	0.7%	74.6%
Arthropoda	Malacostraca		Isaeidae	Gammaropsis thompsoni	10	10	10.0	10	0.7%	75.2%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Chaetozone nr. setosa	1	2	1.1	9	0.6%	75.9%
Annelida	Polychaeta	Sedentaria	Sabellidae	Chone duneri	1	2	1.5	9	0.6%	76.5%
Annelida	Polychaeta	Sedentaria	Spionidae	Dipolydora socialis	3	6	4.5	9	0.6%	77.1%
Annelida	Polychaeta	Sedentaria	Oweniidae	Galathowenia oculata	1	5	2.7	8	0.5%	77.6%
Arthropoda	Malacostraca		Paguridae	Pagurus sp.	1	5	2.0	8	0.5%	78.2%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius barnardi	8	8	8.0	8	0.5%	78.7%
Arthropoda	Ostracoda		Philomedidae	Euphilomedes carcharodonta	1	6	2.7	8	0.5%	79.3%
Cnidaria	Hydrozoa		Campanulariidae	Perigonimus repens	8	8	8.0	8	0.5%	79.8%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eumida tubiformis	1	6	3.5	7	0.5%	80.3%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Prionospio) jubata	1	3	1.8	7	0.5%	80.8%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Prionospio) sp.	1	6	3.5	7	0.5%	81.2%
Mollusca	Gastropoda			Gastropoda indet.	1	3	2.3	7	0.5%	81.7%
Annelida	Polychaeta	Errantia	Onuphidae	Diopatra ornata	6	6	6.0	6	0.4%	82.1%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Naineris cf. grubei	6	6	6.0	6	0.4%	82.5%
Annelida	Polychaeta	Sedentaria	Sphaerodoridae	Sphaerosyllis ranunculus	6	6	6.0	6	0.4%	82.9%
Arthropoda	Malacostraca		Aoridae	Aoroides inermis	6	6	6.0	6	0.4%	83.4%
Mollusca	Gastropoda		Pyramidellidae	Odostomia sp.	1	2	1.2	6	0.4%	83.8%
Annelida	Polychaeta	Sedentaria	Maldanidae	Praxillella praetermissa	1	2	1.3	5	0.3%	84.1%
Annelida	Polychaeta	Sedentaria	Spionidae	Scolelepis squamata	1	3	1.7	5	0.3%	84.4%
Annelida	Polychaeta	Sedentaria	Spionidae	Spiophanes bombyx	1	1	1.0	5	0.3%	84.8%
Annelida	Polychaeta	Sedentaria	Terebellidae	Terebellidae indet.	5	5	5.0	5	0.3%	85.1%
Mollusca	Bivalvia		Mytilidae	Mytilidae indet.	5	5	5.0	5	0.3%	85.5%
Mollusca	Bivalvia		Veneridae	Nutricola sp.	1	2	1.3	5	0.3%	85.8%
Nemertea	Enopla		Amphiporidae	Amphiporus bimaculatus	1	3	1.7	5	0.3%	86.2%
Nemertea	Enopla		Amphiporidae	Amphiporus imparispinosus	5	5	5.0	5	0.3%	86.5%
Annelida	Polychaeta	Errantia	Glyceridae	Glycera nana	1	2	1.3	4	0.3%	86.8%
Annelida	Polychaeta	Errantia	Pholoidae	Pholoides asperus	4	4	4.0	4	0.3%	87.0%
Annelida	Polychaeta	Sedentaria	Phyllodocidae	Phyllodocidae indet.	4	4	4.0	4	0.3%	87.3%
Annelida	Polychaeta	Sedentaria	Syllidae	Autolytinae indet.	1	3	2.0	4	0.3%	87.6%
Arthropoda	Malacostraca		Aoridae	Grandidierella japonica	2	2	2.0	4	0.3%	87.9%
Arthropoda	Malacostraca		Melitidae	Desdimelita desdichada	1	3	2.0	4	0.3%	88.1%
Arthropoda	Malacostraca		Oedicerotidae	Americhelidium shoemakeri	1	1	1.0	4	0.3%	88.4%
Arthropoda	Malacostraca		Oedicerotidae	Pacifoculodes spinipes	1	1	1.0	4	0.3%	88.7%
Arthropoda	Maxillopoda			Balanomorpha indet.	1	3	2.0	4	0.3%	88.9%
Cnidaria	Hydrozoa		Campanulariidae	Campanularia sp.	2	2	2.0	4	0.3%	89.2%
Echinodermata	Ophiuroidea			Ophiuroidea indet.	1	2	1.3	4	0.3%	89.5%
Mollusca	Bivalvia		Tellinidae	Macoma golikovi	1	3	2.0	4	0.3%	89.8%
Mollusca	Bivalvia		Thyasiridae	Axinopsida serricata	1	2	1.3	4	0.3%	90.0%
Nemertea	Enopla		Lineidae	Cerebratulus californiensis	1	2	1.3	4	0.3%	90.3%
Nemertea	Enopla		Tetrastemmatidae	Tetrastemma candidum	1	3	2.0	4	0.3%	90.6%
Annelida	Polychaeta	Errantia	Onuphidae	Onuphis iridescens	1	1	1.0	3	0.2%	90.8%
Annelida	Polychaeta	Errantia	Phyllodocidae	Phyllodoce longipes	1	2	1.5	3	0.2%	91.0%
Annelida	Polychaeta	Errantia	Polynoidae	Tenonia kitsapensis	3	3	3.0	3	0.2%	91.2%
	Polychaeta	Errantia	Syllidae	Opisthodonta sp.	1	1	1.0	3	0.2%	91.4%
Annelida	Polychaeta	Sedentaria	Opheliidae	Ophelina acuminata	1	1	1.0	3	0.2%	91.6%
Annelida	Polychaeta	Sedentaria	Sabellidae	Oriopsis minuta	1	2	1.5	3	0.2%	91.8%
Arthropoda	Malacostraca		Ampeliscidae	Ampelisca unsocalae	1	1	1.0	3	0.2%	92.0%
Arthropoda	Malacostraca			Lysianassoidea indet.	1	2	1.5	3	0.2%	92.2%
Arthropoda	Ostracoda		Philomedidae	Euphilomedes producta	1	2	1.5	3	0.2%	92.4%
Mollusca	Bivalvia		Nuculidae	Ennucula tenuis	1	2	1.5	3	0.2%	92.6%
Mollusca	Bivalvia		Tellinidae	Macoma elimata	3	3	3.0	3	0.2%	92.8%
Mollusca	Bivalvia		Tellinidae	Macoma yoldiformis	1	1	1.0	3	0.2%	93.0%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde armigera	1	1	1.0	2	0.1%	93.2%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde picta	1	1	1.0	2	0.1%	93.3%
Annelida	Polychaeta	Errantia	Hesionidae	Gyptis brevipalpa	1	1	1.0	2	0.1%	93.5%
Annelida	Polychaeta	Errantia	Lumbrineridae	Scoletoma luti	2	2	2.0	2	0.1%	93.6%
Annelida	Polychaeta	Sedentaria	Capitellidae	Mediomastus ambiseta	2	2	2.0	2	0.1%	93.7%
Annelida	Polychaeta	Sedentaria	Chrysopetalidae	Paleanotus bellis	2	2	2.0	2	0.1%	93.9%
Annelida	Polychaeta	Sedentaria	Pectinariidae	Pectinaria granulata	1	1	1.0	2	0.1%	94.0%
Annelida	Polychaeta	Sedentaria	Polynoidae	Malmgreniella macginitiei	1	1	1.0	2	0.1%	94.1%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Minuspio) multibranchiata	1	1	1.0	2	0.1%	94.3%
Annelida	Polychaeta	Sedentaria	Spionidae	Spio cirrifera	1	1	1.0	2	0.1%	94.4%
Annelida	Polychaeta	Sedentaria	Terebellidae	Eupolymnia heterobranchia	2	2	2.0	2	0.1%	94.5%
Annelida	Polychaeta	Sedentaria	Terebellidae	Polycirrus californicus	2	2	2.0	2	0.1%	94.7%
Arthropoda	Malacostraca		Hippolytidae	Eualus pusiolus	1	1	1.0	2	0.1%	94.8%
Arthropoda	Malacostraca		Isaeidae	Photis brevipes	2	2	2.0	2	0.1%	95.0%

Appendix C1: Summary Data for Benthic Macrofauna Abundance as Total Count at DAS Site

DAS Site										
Species Taxonomy					Min	Max	Average	Count	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Arthropoda	Ostracoda		Cylindroliberididae	Cylindroliberididae indet.	1	1	1.0	2	0.1%	95.1%
Bryozoa	Gymnolaemata		Bugulidae	Dendrobeania lichenoides	2	2	2.0	2	0.1%	95.2%
Cnidaria	Anthozoa		Edwardsiidae	Edwardsiidae indet.	2	2	2.0	2	0.1%	95.4%
Cnidaria	Hydrozoa		Bougainvillidae	Obelia sp.	2	2	2.0	2	0.1%	95.5%
Cnidaria	Hydrozoa		Sertulariidae	Thuiaria sp.	2	2	2.0	2	0.1%	95.6%
Echinodermata	Ophiuroidea		Amphiuridae	Amphiuridae indet.	2	2	2.0	2	0.1%	95.8%
Mollusca	Bivalvia		Montacutidae	Kurtiella tumida	1	1	1.0	2	0.1%	95.9%
Mollusca	Bivalvia		Nuculidae	Acila castrensis	1	1	1.0	2	0.1%	96.0%
Mollusca	Bivalvia		Tellinidae	Tellina sp.	1	1	1.0	2	0.1%	96.2%
Mollusca	Bivalvia		Yoldiidae	Yoldia sp.	1	1	1.0	2	0.1%	96.3%
Nemertea	Anopla		Lineidae	Lineidae indet.	2	2	2.0	2	0.1%	96.5%
Nemertea				Nemertea indet.	1	1	1.0	2	0.1%	96.6%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys caecoides	1	1	1.0	1	0.1%	96.7%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys ciliata	1	1	1.0	1	0.1%	96.7%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete labrops	1	1	1.0	1	0.1%	96.8%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete sp.	1	1	1.0	1	0.1%	96.9%
Annelida	Polychaeta	Sedentaria	Capitellidae	Barantolla americana	1	1	1.0	1	0.1%	96.9%
Annelida	Polychaeta	Sedentaria	Capitellidae	Notomastus hemipodus	1	1	1.0	1	0.1%	97.0%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Chaetozone sp.	1	1	1.0	1	0.1%	97.1%
Annelida	Polychaeta	Sedentaria	Hesionidae	Hesionidae indet.	1	1	1.0	1	0.1%	97.1%
Annelida	Polychaeta	Sedentaria	Maldanidae	Euclymene nr. zonalis	1	1	1.0	1	0.1%	97.2%
Annelida	Polychaeta	Sedentaria	Opheliidae	Armandia brevis	1	1	1.0	1	0.1%	97.3%
Annelida	Polychaeta	Sedentaria	Opheliidae	Ophelina breviata	1	1	1.0	1	0.1%	97.3%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Scoloplos acmeceps	1	1	1.0	1	0.1%	97.4%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia johnsoni	1	1	1.0	1	0.1%	97.5%
Annelida	Polychaeta	Sedentaria	Paraonidae	Paraonella spinifera	1	1	1.0	1	0.1%	97.5%
Annelida	Polychaeta	Sedentaria	Pholoidae	Pholoe sp. N-1	1	1	1.0	1	0.1%	97.6%
Annelida	Polychaeta	Sedentaria	Sabellidae	Sabellidae indet.	1	1	1.0	1	0.1%	97.7%
Annelida	Polychaeta	Sedentaria	Spionidae	Microspio sp.	1	1	1.0	1	0.1%	97.7%
Annelida	Polychaeta	Sedentaria	Terebellidae	Polycirrus sp. complex	1	1	1.0	1	0.1%	97.8%
Arthropoda	Malacostraca		Callianassidae	Neotrypaea sp.	1	1	1.0	1	0.1%	97.9%
Arthropoda	Malacostraca		Cancridae	Glebocarcinus oregonesis	1	1	1.0	1	0.1%	98.0%
Arthropoda	Malacostraca		Cylindroliberididae	Haliophasma geminata	1	1	1.0	1	0.1%	98.0%
Arthropoda	Malacostraca		Hippolytidae	Hippolytidae indet.	1	1	1.0	1	0.1%	98.1%
Arthropoda	Malacostraca		Lampropidae	Hemilamprops sp.	1	1	1.0	1	0.1%	98.2%
Arthropoda	Malacostraca		Leptocheliidae	Leptochelia savignyi	1	1	1.0	1	0.1%	98.2%
Arthropoda	Malacostraca		Lysianassidae	Orchomenella pacificus	1	1	1.0	1	0.1%	98.3%
Arthropoda	Malacostraca		Oedicerotidae	Westwoodilla tone	1	1	1.0	1	0.1%	98.4%
Arthropoda	Malacostraca		Photidae	Photis sp.	1	1	1.0	1	0.1%	98.4%
Arthropoda	Malacostraca		Pinnotheridae	Pinnixa occidentalis sp. complex	1	1	1.0	1	0.1%	98.5%
Arthropoda	Malacostraca		Podoceridae	Dyopedos arcticus	1	1	1.0	1	0.1%	98.6%
Arthropoda	Malacostraca			Brachyura indet.	1	1	1.0	1	0.1%	98.6%
Arthropoda	Maxillopoda		Balanidae	Balanus sp.	1	1	1.0	1	0.1%	98.7%
Arthropoda	Pycnogonida		Ammotheidae	Achelia sp.	1	1	1.0	1	0.1%	98.8%
Bryozoa	Gymnolaemata		Vesiculariidae	Bowerbankia gracilis	1	1	1.0	1	0.1%	98.8%
Bryozoa	Gymnolaemata			Ctenostomata indet.	1	1	1.0	1	0.1%	98.9%
Cnidaria	Hydrozoa		Corynidae	Coryne sp.	1	1	1.0	1	0.1%	99.0%
Cnidaria	Hydrozoa		Lafoeidae	Lafoea sp.	1	1	1.0	1	0.1%	99.0%
Cnidaria	Hydrozoa		Sertulariidae	Abietinaria sp.	1	1	1.0	1	0.1%	99.1%
Cnidaria	Hydrozoa		Sertulariidae	Sertularella sp.	1	1	1.0	1	0.1%	99.2%
Cnidaria	Hydrozoa		Sertulariidae	Sertularella tricuspidata	1	1	1.0	1	0.1%	99.2%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera pseudocalcigera	1	1	1.0	1	0.1%	99.3%
Echinodermata	Ophiuroidea		Amphiuridae	Amphiodia sp.	1	1	1.0	1	0.1%	99.4%
Kamptozoa	Entoprocta		Pedicellinidae	Myosoma spinosa	1	1	1.0	1	0.1%	99.5%
Mollusca	Bivalvia		Tellinidae	Macoma sp.	1	1	1.0	1	0.1%	99.5%
Mollusca	Bivalvia		Yoldiidae	Yoldia seminuda	1	1	1.0	1	0.1%	99.6%
Nemertea	Anopla			Anopla sp. D (SCAMIT)	1	1	1.0	1	0.1%	99.7%
Nemertea	Enopla		Amphiporidae	Amphiporus sp.	1	1	1.0	1	0.1%	99.7%
Nemertea	Enopla		Emplectonematidae	Paranemertes peregrina	1	1	1.0	1	0.1%	99.8%
Nemertea	Enopla		Tetrastemmatidae	Tetrastemma sp.	1	1	1.0	1	0.1%	99.9%
Nemertea	Palaeonemertea		Tubulanidae	Tubulanus polymorphus	1	1	1.0	1	0.1%	99.9%
Nemertea	Palaeonemertea		Tubulanidae	Tubulanus sp.	1	1	1.0	1	0.1%	100.0%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde polygnatha	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Hesionidae	Micropodarke dubia	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Lumbrineridae	Errano lagunae	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Lumbrineridae	Lumbrineris cruzensis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Lumbrineridae	Lumbrineris sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Nephtyidae	Bipalponephtys cornuta	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys caeca	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys ferruginea	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Nereididae	Nereis sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Onuphidae	Epidiopatra hupferiana monroi	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone californica	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone leptotes	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone longa complex	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone spilotus	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Phyllodocidae	Phyllodoce hartmanae	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Phyllodocidae	Phyllodoce multiseriata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Pilargidae	Pilargis berkeleyae	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Sphaerodoridae	Sphaerodoropsis sphaerulifer	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Syllidae	Exogone molesta	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete finmarchia	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete indet.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Anobothrus gracilis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Melinna elisabethae	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Melinna oculata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Capitellidae	Heteromastus filobranchus	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Aphelochaeta monilaris	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Aphelochaeta sp. N-1	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Cossuridae	Cossura bansei	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Cossuridae	Cossura pygodactylata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Flabelligeridae	Brada sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Maldanidae	Euclymeninae indet.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Maldanidae	Praxillella pacifica	0	0	n/a	0	0.0%	100.0%

Appendix C1: Summary Data for Benthic Macrofauna Abundance as Total Count at DAS Site

DAS Site										
Species Taxonomy					Min	Max	Average	Count	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Annelida	Polychaeta	Sedentaria	Nereidae	Nereis procera	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Phylo felix	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia collaris	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia fusiformis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Paraonidae	Levinsenia gracilis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Phyllodocidae	Phyllodoce groenlandica	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Sabellidae	Euchone analis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Dipolydora cardalia	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Laonice cirrata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Paraprionospio pinnata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Polydora socialis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Prionospio) steenstrupi	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio pinnata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Spio filicornis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Spiophanes sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Sternaspidae	Sternaspis nr. fossor	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Trichobranchidae	Terebellides californica	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Trichobranchidae	Terebellides horikoshii	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Trichobranchidae	Terebellides indet.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Anarthruridae	Araphura breviaria	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Corophiidae	Cheirimedeia macrocarpa	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Crangonidae	Crangon sp.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Isaeidae	Protomedeia grandimana	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Leuconidae	Eudorella pacifica	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Phoxocephalidae	Heterophoxus affinis	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Pinnotheridae	Pinnixa schmitti	0	0	n/a	0	0.0%	100.0%
Arthropoda	Ostracoda		Philomedidae	Euphilomedes sp.	0	0	n/a	0	0.0%	100.0%
Chordata	Ascidiacea		Ascidiidae	Ascidia columbiana	0	0	n/a	0	0.0%	100.0%
Cnidaria	Anthozoa		Halcampidae	Halcampa decemtentaculata	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Bougainvillidae	Bougainvillidae indet.	0	0	n/a	0	0.0%	100.0%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera populifera	0	0	n/a	0	0.0%	100.0%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera rigida	0	0	n/a	0	0.0%	100.0%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera sp.	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Cardiidae	Clinocardium sp.	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Hiatellidae	Hiatella arctica	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Lucinidae	Lucinoma annulatum	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Lyonsiidae	Lyonsia californica	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Mytilidae	Solamen columbianum	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Nuculanidae	Nuculana hamata	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Nuculanidae	Nuculana minuta	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Nuculanidae	Nuculana sp.	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Pandoridae	Pandora bilirata	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Solenidae	Solen sicarius	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Tellinidae	Macoma carlottensis	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Tellinidae	Macoma nasuta	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Tellinidae	Tellina modesta	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Thyasiridae	Parvalucina tenuisculpta	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Thyasiridae	Thyasira flexuosa	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Veneridae	Compsomyax subdiaphana	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia		Yoldiidae	Megayoldia sp.	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia			Bivalvia indet.	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia			Lucinoida indet.	0	0	n/a	0	0.0%	100.0%
Mollusca	Bivalvia			Veneroida indet.	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Cylichnidae	Acteocina culcitella	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Cylichnidae	Acteocina sp.	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Cylichnidae	Cylichna attonsa	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Diaphanidae	Diaphana californica	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Haminoeidae	Haminoea sp.	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Pyramidellidae	Turbonilla sp.	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Rissoidae	Alvania compacta	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Rissoidae	Alvania rosana	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Trochidae	Lirularia succincta	0	0	n/a	0	0.0%	100.0%
Mollusca	Scaphopoda		Pulsellidae	Pulsellum salishorum	0	0	n/a	0	0.0%	100.0%
Mollusca	Scaphopoda		Rhabdidae	Rhabdus rectius	0	0	n/a	0	0.0%	100.0%
Platyhelminthes	Rhabditophora		Leptoplanidae	Leptoplanidae indet.	0	0	n/a	0	0.0%	100.0%
Platyhelminthes	Rhabditophora		Stylochidae	Stylochus exiguus	0	0	n/a	0	0.0%	100.0%
Sipuncula	Sipunculidea		Golfingiidae	Thysanocardia nigra	0	0	n/a	0	0.0%	100.0%

Appendix C2: Summary Data for Benthic Macrofauna Abundance as Total Count at ITP Site

ITP Site										
Species Taxonomy					Min	Max	Average	Count	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Total								**5284**	**100%**	
Mollusca	Bivalvia		Thyasiridae	Axinopsida serricata	62	423	186.8	2242	42.4%	42.4%
Mollusca	Bivalvia		Montacutidae	Kurtiella tumida	1	59	17.8	213	4.0%	46.5%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Leitoscoloplos pugettensis	1	43	12.0	192	3.6%	50.1%
Arthropoda	Ostracoda		Philomedidae	Euphilomedes producta	7	70	37.0	185	3.5%	53.6%
Mollusca	Bivalvia		Nuculidae	Ennucula tenuis	3	36	13.5	162	3.1%	56.7%
Annelida	Polychaeta	Errantia	Lumbrineridae	Scoletoma luti	3	29	9.3	140	2.6%	59.3%
Mollusca	Bivalvia		Thyasiridae	Parvalucina tenuisculpta	1	34	7.9	134	2.5%	61.8%
Mollusca	Bivalvia		Tellinidae	Macoma sp.	6	45	19.7	118	2.2%	64.1%
Mollusca	Bivalvia		Tellinidae	Macoma carlottensis	2	21	10.3	103	1.9%	66.0%
Mollusca	Bivalvia		Veneridae	Nutricola sp.	1	39	12.9	103	1.9%	68.0%
Cnidaria	Hydrozoa		Campanulariidae	Campanularia sp.	2	35	20.2	101	1.9%	69.9%
Annelida	Polychaeta	Sedentaria	Spionidae	Spiophanes berkeleyorum	1	14	5.4	98	1.9%	71.7%
Chordata	Ascidiacea		Ascidiidae	Ascidia columbiana	1	62	14.0	98	1.9%	73.6%
Mollusca	Scaphopoda		Pulsellidae	Pulsellum salishorum	1	34	15.3	92	1.7%	75.3%
Mollusca	Bivalvia		Tellinidae	Macoma elimata	2	17	6.3	63	1.2%	76.5%
Annelida	Polychaeta	Errantia	Lumbrineridae	Lumbrineris cruzensis	1	13	4.9	59	1.1%	77.6%
Mollusca	Bivalvia		Nuculidae	Acila castrensis	1	21	6.9	55	1.0%	78.7%
Annelida	Polychaeta	Sedentaria	Oweniidae	Galathowenia oculata	1	15	5.8	46	0.9%	79.6%
Annelida	Polychaeta	Sedentaria	Maldanidae	Praxillella praetermissa	1	9	4.3	39	0.7%	80.3%
Annelida	Polychaeta	Errantia	Nephtyidae	Bipalponephtys cornuta	1	26	4.8	38	0.7%	81.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete nr. acutifrons	1	14	3.9	35	0.7%	81.7%
Annelida	Polychaeta	Sedentaria	Spionidae	Paraprionospio pinnata	1	8	3.7	33	0.6%	82.3%
Annelida	Polychaeta	Errantia	Sphaerodoridae	Sphaerodoropsis sphaerulifer	1	12	4.8	29	0.5%	82.9%
Annelida	Polychaeta	Sedentaria	Capitellidae	Heteromastus filobranchus	1	6	2.9	29	0.5%	83.4%
Annelida	Polychaeta	Sedentaria	Magelonidae	Magelona longicornis	4	13	9.3	28	0.5%	83.9%
Echinodermata	Ophiuroidea		Amphiuridae	Amphiodia urtica	1	6	2.5	28	0.5%	84.5%
Mollusca	Gastropoda		Pyramidellidae	Odostomia sp.	1	7	3.5	28	0.5%	85.0%
Annelida	Polychaeta	Sedentaria	Sternaspidae	Sternaspis nr. fossor	1	6	2.1	25	0.5%	85.5%
Annelida	Polychaeta	Errantia	Glyceridae	Glycera nana	1	6	2.6	23	0.4%	85.9%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio pinnata	1	8	3.8	23	0.4%	86.3%
Mollusca	Bivalvia		Nuculanidae	Nuculana hamata	1	8	4.2	21	0.4%	86.7%
Nemertea	Palaeonemertea		Tubulanidae	Tubulanus polymorphus	1	4	1.9	21	0.4%	87.1%
Sipuncula	Sipunculidea		Golfingiidae	Thysanocardia nigra	1	6	2.9	20	0.4%	87.5%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia fusiformis	1	6	2.1	19	0.4%	87.9%
Nemertea	Enopla		Lineidae	Cerebratulus californiensis	1	4	1.9	19	0.4%	88.2%
Annelida	Polychaeta	Sedentaria	Pholoidae	Pholoe sp. N-1	1	4	2.3	18	0.3%	88.6%
Cnidaria	Hydrozoa		Bougainvillidae	Bougainvillidae indet.	1	6	3.0	18	0.3%	88.9%
Mollusca	Bivalvia		Cardiidae	Clinocardium sp.	1	11	3.6	18	0.3%	89.3%
Mollusca	Bivalvia		Nuculanidae	Nuculana minuta	2	10	4.5	18	0.3%	89.6%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde armigera	1	7	2.4	17	0.3%	89.9%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde picta	1	5	2.4	17	0.3%	90.2%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Minuspio) lighti	1	8	2.7	16	0.3%	90.5%
Arthropoda	Malacostraca		Pinnotheridae	Pinnixa schmitti	1	7	3.2	16	0.3%	90.8%
Mollusca	Bivalvia		Tellinidae	Tellina sp.	1	4	2.0	16	0.3%	91.1%
Annelida	Polychaeta	Sedentaria	Cossuridae	Cossura pygodactylata	1	9	3.0	15	0.3%	91.4%
Mollusca	Bivalvia		Veneridae	Compsomyax subdiaphana	1	10	3.0	15	0.3%	91.7%
Mollusca	Bivalvia		Tellinidae	Macoma nasuta	1	4	2.8	14	0.3%	92.0%
Annelida	Polychaeta	Errantia	Pilargidae	Pilargis berkeleyae	1	6	2.0	12	0.2%	92.2%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia collaris	1	6	4.0	12	0.2%	92.4%
Annelida	Polychaeta	Errantia	Polynoidae	Tenonia kitsapensis	1	3	2.2	11	0.2%	92.6%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Prionospio) jubata	1	10	5.5	11	0.2%	92.8%
Mollusca	Bivalvia			Bivalvia indet.	1	3	2.0	10	0.2%	93.0%
Arthropoda	Malacostraca		Leptocheliidae	Leptochelia savignyi	1	3	1.8	9	0.2%	93.2%
Mollusca	Bivalvia		Lyonsiidae	Lyonsia californica	1	6	2.3	9	0.2%	93.4%
Mollusca	Bivalvia		Yoldiidae	Yoldia seminuda	1	3	1.8	9	0.2%	93.5%
Annelida	Polychaeta	Errantia	Lumbrineridae	Errano lagunae	1	3	2.0	8	0.2%	93.7%
Annelida	Polychaeta	Errantia	Phyllodocidae	Phyllodoce multiseriata	1	4	2.0	8	0.2%	93.8%
Annelida	Polychaeta	Sedentaria	Spionidae	Laonice cirrata	1	4	2.0	8	0.2%	94.0%
Mollusca	Gastropoda		Trochidae	Lirularia succincta	2	4	2.7	8	0.2%	94.2%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde polygnatha	1	6	3.5	7	0.1%	94.3%
Annelida	Polychaeta	Errantia	Nereididae	Platynereis bicanaliculata	1	2	1.8	7	0.1%	94.4%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone californica	1	3	1.4	7	0.1%	94.5%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Chaetozone nr. setosa	1	2	1.2	7	0.1%	94.7%
Mollusca	Bivalvia		Mytilidae	Mytilidae indet.	1	4	2.3	7	0.1%	94.8%
Mollusca	Gastropoda		Haminoeidae	Haminoea sp.	1	6	3.5	7	0.1%	94.9%
Annelida	Polychaeta	Sedentaria	Paraonidae	Levinsenia gracilis	1	4	2.0	6	0.1%	95.1%
Annelida	Polychaeta	Sedentaria	Pectinariidae	Pectinaria granulata	1	2	1.2	6	0.1%	95.2%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Prionospio) steenstrupi	1	2	1.5	6	0.1%	95.3%
Annelida	Polychaeta	Sedentaria	Spionidae	Spio cirrifera	6	6	6.0	6	0.1%	95.4%
Arthropoda	Ostracoda		Philomedidae	Euphilomedes carcharodonta	2	4	3.0	6	0.1%	95.5%
Mollusca	Bivalvia		Pandoridae	Pandora bilirata	1	2	1.5	6	0.1%	95.6%
Annelida	Polychaeta	Errantia	Onuphidae	Onuphis iridescens	1	4	2.5	5	0.1%	95.7%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Aphelochaeta monilaris	1	1	1.0	5	0.1%	95.8%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Aphelochaeta sp. N-1	1	1	1.0	5	0.1%	95.9%
Arthropoda	Malacostraca		Leuconidae	Eudorella pacifica	1	3	1.7	5	0.1%	96.0%
Echinodermata	Ophiuroidea		Amphiuridae	Amphiuridae indet.	1	3	1.7	5	0.1%	96.1%
Echinodermata	Ophiuroidea			Ophiuroidea indet.	1	4	2.5	5	0.1%	96.2%
Mollusca	Bivalvia		Solenidae	Solen sicarius	1	4	2.5	5	0.1%	96.3%
Mollusca	Bivalvia		Tellinidae	Macoma golikovi	2	3	2.5	5	0.1%	96.4%
Mollusca	Gastropoda		Columbellidae	Astyris gausapata	1	4	2.5	5	0.1%	96.5%
Annelida	Polychaeta	Errantia	Hesionidae	Micropodarke dubia	1	3	2.0	4	0.1%	96.6%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone leptotes	1	2	1.3	4	0.1%	96.6%
Annelida	Polychaeta	Errantia	Phyllodocidae	Phyllodoce hartmanae	2	2	2.0	4	0.1%	96.7%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete finmarchia	1	2	1.3	4	0.1%	96.8%
Annelida	Polychaeta	Sedentaria	Capitellidae	Barantolla americana	1	1	1.0	4	0.1%	96.9%
Annelida	Polychaeta	Sedentaria	Capitellidae	Mediomastus californiensis	1	2	1.3	4	0.1%	96.9%
Annelida	Polychaeta	Sedentaria	Maldanidae	Euclymeninae indet.	1	3	2.0	4	0.1%	97.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Dipolydora cardalia	1	1	1.0	4	0.1%	97.1%
Annelida	Polychaeta	Sedentaria	Spionidae	Polydora socialis	4	4	4.0	4	0.1%	97.2%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Prionospio) sp.	1	2	1.3	4	0.1%	97.2%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius fatigans	2	2	2.0	4	0.1%	97.3%
Mollusca	Bivalvia		Lucinidae	Lucinoma annulatum	1	1	1.0	4	0.1%	97.4%
Mollusca	Bivalvia		Tellinidae	Tellina modesta	4	4	4.0	4	0.1%	97.5%
Mollusca	Bivalvia		Yoldiidae	Megayoldia sp.	1	2	1.3	4	0.1%	97.5%

Appendix C2: Summary Data for Benthic Macrofauna Abundance as Total Count at ITP Site

ITP Site										
Species Taxonomy					Min	Max	Average	Count	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Mollusca	Bivalvia		Yoldiidae	Yoldia sp.	1	1	1.0	4	0.1%	97.6%
Mollusca	Gastropoda		Cylichnidae	Acteocina sp.	1	3	2.0	4	0.1%	97.7%
Mollusca	Gastropoda		Rissoidae	Alvania compacta	1	2	1.3	4	0.1%	97.8%
Platyhelminthes	Rhabditophora		Stylochidae	Stylochus exiguus	1	3	2.0	4	0.1%	97.8%
Annelida	Polychaeta	Errantia	Hesionidae	Gyptis brevipalpa	1	2	1.5	3	0.1%	97.9%
Annelida	Polychaeta	Errantia	Lumbrineridae	Lumbrineris sp.	1	1	1.0	3	0.1%	98.0%
Annelida	Polychaeta	Errantia	Onuphidae	Epidiopatra hupferiana monroi	1	2	1.5	3	0.1%	98.0%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete labrops	1	1	1.0	3	0.1%	98.1%
Annelida	Polychaeta	Sedentaria	Maldanidae	Euclymene nr. zonalis	1	1	1.0	3	0.1%	98.1%
Annelida	Polychaeta	Sedentaria	Maldanidae	Praxillella pacifica	1	1	1.0	3	0.1%	98.2%
Annelida	Polychaeta	Sedentaria	Opheliidae	Armandia brevis	1	1	1.0	3	0.1%	98.2%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Phylo felix	3	3	3.0	3	0.1%	98.3%
Annelida	Polychaeta	Sedentaria	Trichobranchidae	Terebellides horikoshii	1	2	1.5	3	0.1%	98.4%
Arthropoda	Malacostraca		Isaeidae	Protomedeia grandimana	1	2	1.5	3	0.1%	98.4%
Arthropoda	Maxillopoda		Balanidae	Balanus sp.	1	2	1.5	3	0.1%	98.5%
Mollusca	Gastropoda		Pyramidellidae	Turbonilla sp.	1	2	1.5	3	0.1%	98.5%
Annelida	Polychaeta	Errantia	Goniadidae	Glycinde sp.	2	2	2.0	2	0.0%	98.6%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys ferruginea	1	1	1.0	2	0.0%	98.6%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone longa complex	1	1	1.0	2	0.0%	98.6%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eteone spilotus	1	1	1.0	2	0.0%	98.7%
Annelida	Polychaeta	Errantia	Syllidae	Exogone molesta	1	1	1.0	2	0.0%	98.7%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Anobothrus gracilis	1	1	1.0	2	0.0%	98.8%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Melinna elisabethae	1	1	1.0	2	0.0%	98.8%
Annelida	Polychaeta	Sedentaria	Capitellidae	Decamastus nr. gracilis	1	1	1.0	2	0.0%	98.8%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Scoloplos acmeceps	2	2	2.0	2	0.0%	98.9%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia johnsoni	2	2	2.0	2	0.0%	98.9%
Annelida	Polychaeta	Sedentaria	Phyllodocidae	Phyllodoce groenlandica	1	1	1.0	2	0.0%	98.9%
Annelida	Polychaeta	Sedentaria	Spionidae	Spio filicornis	2	2	2.0	2	0.0%	99.0%
Annelida	Polychaeta	Sedentaria	Terebellidae	Terebellidae indet.	1	1	1.0	2	0.0%	99.0%
Arthropoda	Malacostraca		Phoxocephalidae	Heterophoxus affinis	1	1	1.0	2	0.0%	99.1%
Arthropoda	Ostracoda		Cylindroliberididae	Cylindroliberididae indet.	1	1	1.0	2	0.0%	99.1%
Cnidaria	Anthozoa		Edwardsiidae	Edwardsiidae indet.	2	2	2.0	2	0.0%	99.1%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera rigida	1	1	1.0	2	0.0%	99.2%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera sp.	1	1	1.0	2	0.0%	99.2%
Mollusca	Bivalvia		Thyasiridae	Thyasira flexuosa	1	1	1.0	2	0.0%	99.2%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys caeca	1	1	1.0	1	0.0%	99.3%
Annelida	Polychaeta	Errantia	Nereididae	Nereis sp.	1	1	1.0	1	0.0%	99.3%
Annelida	Polychaeta	Errantia	Phyllodocidae	Phyllodoce longipes	1	1	1.0	1	0.0%	99.3%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete indet.	1	1	1.0	1	0.0%	99.3%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Ampharete sp.	1	1	1.0	1	0.0%	99.3%
Annelida	Polychaeta	Sedentaria	Ampharetidae	Melinna oculata	1	1	1.0	1	0.0%	99.4%
Annelida	Polychaeta	Sedentaria	Capitellidae	Mediomastus ambiseta	1	1	1.0	1	0.0%	99.4%
Annelida	Polychaeta	Sedentaria	Cossuridae	Cossura bansei	1	1	1.0	1	0.0%	99.4%
Annelida	Polychaeta	Sedentaria	Flabelligeridae	Brada sp.	1	1	1.0	1	0.0%	99.4%
Annelida	Polychaeta	Sedentaria	Nereidae	Nereis procera	1	1	1.0	1	0.0%	99.4%
Annelida	Polychaeta	Sedentaria	Opheliidae	Ophelina acuminata	1	1	1.0	1	0.0%	99.5%
Annelida	Polychaeta	Sedentaria	Oweniidae	Owenia sp.	1	1	1.0	1	0.0%	99.5%
Annelida	Polychaeta	Sedentaria	Sabellidae	Euchone analis	1	1	1.0	1	0.0%	99.5%
Annelida	Polychaeta	Sedentaria	Spionidae	Spiophanes sp.	1	1	1.0	1	0.0%	99.5%
Annelida	Polychaeta	Sedentaria	Syllidae	Exogone dwisula	1	1	1.0	1	0.0%	99.5%
Annelida	Polychaeta	Sedentaria	Trichobranchidae	Terebellides californica	1	1	1.0	1	0.0%	99.5%
Annelida	Polychaeta	Sedentaria	Trichobranchidae	Terebellides indet.	1	1	1.0	1	0.0%	99.6%
Arthropoda	Malacostraca		Anarthruridae	Araphura breviaria	1	1	1.0	1	0.0%	99.6%
Arthropoda	Malacostraca		Callianassidae	Neotrypaea sp.	1	1	1.0	1	0.0%	99.6%
Arthropoda	Malacostraca		Corophiidae	Cheirimedeia macrocarpa	1	1	1.0	1	0.0%	99.6%
Arthropoda	Malacostraca		Crangonidae	Crangon sp.	1	1	1.0	1	0.0%	99.6%
Arthropoda	Malacostraca		Oedicerotidae	Westwoodilla tone	1	1	1.0	1	0.0%	99.7%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius boreovariatus	1	1	1.0	1	0.0%	99.7%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius sp.	1	1	1.0	1	0.0%	99.7%
Arthropoda	Ostracoda		Philomedidae	Euphilomedes sp.	1	1	1.0	1	0.0%	99.7%
Cnidaria	Anthozoa		Halcampidae	Halcampa decemtentaculata	1	1	1.0	1	0.0%	99.7%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera populifera	1	1	1.0	1	0.0%	99.8%
Echinodermata	Holothuroidea		Phyllophoridae	Pentamera pseudocalcigera	1	1	1.0	1	0.0%	99.8%
Mollusca	Bivalvia		Hiatellidae	Hiatella arctica	1	1	1.0	1	0.0%	99.8%
Mollusca	Bivalvia		Mytilidae	Solamen columbianum	1	1	1	1	0.0%	99.8%
Mollusca	Bivalvia		Nuculanidae	Nuculana sp.	1	1	1	1	0.0%	99.8%
Mollusca	Bivalvia		Tellinidae	Macoma yoldiformis	1	1	1	1	0.0%	99.8%
Mollusca	Bivalvia			Lucinoida indet.	1	1	1	1	0.0%	99.9%
Mollusca	Bivalvia			Veneroida indet.	1	1	1	1	0.0%	99.9%
Mollusca	Gastropoda		Cylichnidae	Acteocina culcitella	1	1	1	1	0.0%	99.9%
Mollusca	Gastropoda		Cylichnidae	Cylichna attonsa	1	1	1	1	0.0%	99.9%
Mollusca	Gastropoda		Diaphanidae	Diaphana californica	1	1	1	1	0.0%	99.9%
Mollusca	Gastropoda		Rissoidae	Alvania rosana	1	1	1	1	0.0%	100.0%
Mollusca	Scaphopoda		Rhabdidae	Rhabdus rectius	1	1	1	1	0.0%	100.0%
Platyhelminthes	Rhabditophora		Leptoplanidae	Leptoplanidae indet.	1	1	1	1	0.0%	100.0%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys caecoides	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Nephtyidae	Nephtys ciliata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Onuphidae	Diopatra ornata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Pholoidae	Pholoides asperus	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Phyllodocidae	Eumida tubiformis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Errantia	Syllidae	Opisthodonta sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Capitellidae	Notomastus hemipodus	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Chrysopetalidae	Paleanotus bellis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Cirratulidae	Chaetozone sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Hesionidae	Hesionidae indet.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Nereidae	Nereis pelagica	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Opheliidae	Ophelina breviata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Naineris cf. grubei	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Orbiniidae	Scoloplos armiger	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Paraonidae	Aricidea wassi	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Paraonidae	Cirrophorus branchiatus	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Paraonidae	Paraonella spinifera	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Phyllodocidae	Phyllodocidae indet.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Polynoidae	Malmgreniella macginitiei	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Sabellidae	Chone duneri	0	0	n/a	0	0.0%	100.0%

Appendix C2: Summary Data for Benthic Macrofauna Abundance as Total Count at ITP Site

ITP Site										
Species Taxonomy					Min	Max	Average	Count	% of Total Count	Cumulative % Total
Phylum	Class	Sub Class	Family	Taxon						
Annelida	Polychaeta	Sedentaria	Sabellidae	Oriopsis minuta	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Sabellidae	Sabellidae indet.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Sphaerodoridae	Sphaerosyllis ranunculus	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Dipolydora socialis	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Microspio sp.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Prionospio (Minuspio) multibranchiata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Scolelepis squamata	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Spionidae	Spiophanes bombyx	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Syllidae	Autolytinae indet.	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Terebellidae	Eupolymnia heterobranchia	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Terebellidae	Polycirrus californicus	0	0	n/a	0	0.0%	100.0%
Annelida	Polychaeta	Sedentaria	Terebellidae	Polycirrus sp. complex	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Ampeliscidae	Ampelisca unsocalae	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Aoridae	Aoroides inermis	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Aoridae	Aoroides sp.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Aoridae	Grandidierella japonica	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Cancridae	Glebocarcinus oregonesis	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Cylindroliberididae	Haliophasma geminata	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Hippolytidae	Eualus pusiolus	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Hippolytidae	Hippolytidae indet.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Isaeidae	Gammaropsis thompsoni	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Isaeidae	Photis brevipes	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Lampropidae	Hemilamprops sp.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Lysianassidae	Orchomenella minuta	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Lysianassidae	Orchomenella pacificus	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Lysianassidae	Wecomedon wecomus	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Melitidae	Desdimelita desdichada	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Oedicerotidae	Americhelidium shoemakeri	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Oedicerotidae	Pacifoculodes spinipes	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Paguridae	Pagurus sp.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Photidae	Gammaropsis sp.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Photidae	Photis sp.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Phoxcephalidae	Majoxiphalus maximus	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Phoxocephalidae	Rhepoxynius barnardi	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Pinnotheridae	Pinnixa occidentalis sp. complex	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca		Podoceridae	Dyopedos arcticus	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca			Brachyura indet.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca			Gammaridea indet.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Malacostraca			Lysianassoidea indet.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Maxillopoda			Balanomorpha indet.	0	0	n/a	0	0.0%	100.0%
Arthropoda	Pycnogonida		Ammotheidae	Achelia sp.	0	0	n/a	0	0.0%	100.0%
Bryozoa	Gymnolaemata		Bugulidae	Dendrobeania lichenoides	0	0	n/a	0	0.0%	100.0%
Bryozoa	Gymnolaemata		Hippothoidae	Celleporella hyalina	0	0	n/a	0	0.0%	100.0%
Bryozoa	Gymnolaemata		Vesiculariidae	Bowerbankia gracilis	0	0	n/a	0	0.0%	100.0%
Bryozoa	Gymnolaemata			Ctenostomata indet.	0	0	n/a	0	0.0%	100.0%
Bryozoa	Gymnolaemata		Calloporidae	Alderina sp.	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Bougainvillidae	Obelia sp.	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Campanulariidae	Perigonimus repens	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Corynidae	Coryne sp.	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Lafoeidae	Lafoea sp.	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Sertulariidae	Abietinaria sp.	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Sertulariidae	Sertularella sp.	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Sertulariidae	Sertularella tricuspidata	0	0	n/a	0	0.0%	100.0%
Cnidaria	Hydrozoa		Sertulariidae	Thuiaria sp.	0	0	n/a	0	0.0%	100.0%
Echinodermata	Ophiuroidea		Amphiuridae	Amphiodia sp.	0	0	n/a	0	0.0%	100.0%
Kamptozoa	Entoprocta		Pedicellinidae	Myosoma spinosa	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda		Trochidae	Solariella obscura	0	0	n/a	0	0.0%	100.0%
Mollusca	Gastropoda			Gastropoda indet.	0	0	n/a	0	0.0%	100.0%
Nemertea	Anopla		Lineidae	Lineidae indet.	0	0	n/a	0	0.0%	100.0%
Nemertea	Anopla			Anopla sp. D (SCAMIT)	0	0	n/a	0	0.0%	100.0%
Nemertea	Enopla		Amphiporidae	Amphiporus bimaculatus	0	0	n/a	0	0.0%	100.0%
Nemertea	Enopla		Amphiporidae	Amphiporus imparispinosus	0	0	n/a	0	0.0%	100.0%
Nemertea	Enopla		Amphiporidae	Amphiporus sp.	0	0	n/a	0	0.0%	100.0%
Nemertea	Enopla		Emplectonematidae	Paranemertes peregrina	0	0	n/a	0	0.0%	100.0%
Nemertea	Enopla		Tetrastemmatidae	Tetrastemma candidum	0	0	n/a	0	0.0%	100.0%
Nemertea	Enopla		Tetrastemmatidae	Tetrastemma sp.	0	0	n/a	0	0.0%	100.0%
Nemertea	Palaeonemertea		Tubulanidae	Tubulanus sp.	0	0	n/a	0	0.0%	100.0%
Nemertea				Nemertea indet.	0	0	n/a	0	0.0%	100.0%

APPENDIX D
Rake Trawl Species Photos

Figure D1 English sole

Figure D2 English sole

Figure D3 Northern ronquil

Figure D4 Northern ronquil

Figure D5 Pacific sand lance

Figure D6 Pacific sand lance

Figure D7 Pygymy poacher

Figure D8 Unknown sanddab

Figure D9 **Arrow goby**

Figure D10 **Arrow goby**

Figure D11 Blackbelly eelpout

Figure D12 Blackbelly eelpout

Figure D13 Blackbelly eelpout

Figure D14 Blackbelly eelpout

Figure D15 Blackbelly eelpout

Figure D16 Blackbelly eelpout

Figure D17 Blackbelly eelpout

Figure D18 Blackbelly eelpout

Figure D19 Blackbelly eelpout

Figure D20 Blackbelly eelpout

Figure D21 Plainfin midshipman

Figure D22 Unknown goby

Figure D23 Unknown gunnel

Figure D24 Unknown