TECHNICAL REPORT 3163
August 2019

Eelgrass and Macroalgae in Vicinity of the Proposed Service Pier Extension at Naval Base Kitsap Bangor

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Administrative Note:

This report was approved through the Release of Scientific and Technical Information (RSTI) process in August 2018 and formally published in the Defense Technical Information Center (DTIC) in August 2019.

This report's content represents work performed under Space and Naval Warfare Systems Center Pacific (SSC Pacific). SSC Pacific formally changed its name to Naval Information Warfare Center Pacific (NIWC Pacific) in February 2019.

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ADMINISTRATIVE INFORMATION

The work was sponsored by described in this report was performed by the Energy & Environmental Sciences Branch (Code 71760) of the Advanced Systems & Applied Sciences Division (Code 71700), Space and Naval Information Warfare Center Pacific (NIWC Pacific), San Diego, CA. Additional Support was provided by Adam Young Consulting.

Released by
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Energy & Environmental Sustainability Branch

Under authority of
A. D. Ramirez, Head
Advanced Systems & Applied Sciences Division

ACKNOWLEDGMENTS

The active duty divers at the Puget Sound Naval Shipyard Intermediate Maintenance Facility provided vessel and dive support for this effort. Their assistance and professionalism are greatly appreciated. Mr. Clint Callanan of SSC PACIFIC (code 71750) also contributed to the field effort. This work was supported by Naval Facilities Engineering Command Northwest under funding document N0005218WR0031R.

EXECUTIVE SUMMARY

This report presents data collected by video and diver-surveys of the area near the Naval Base Kitsap Bangor Service Pier where a new pier structure extending the existing pier is proposed. The survey followed protocols developed by Naval Facilities Engineering Command Northwest and approved by the Army Corps of Engineers. The entire study area was investigated through boat-based video surveys, and then divers delineated the boundaries of and collected quantitative data within detected eelgrass (primarily *Zostera marina*) beds, as well as macroalgae beds of greater than 5% density that occurred within the maximum project extent boundary (which included the permanent pier footprint and a temporary work zone buffer).

Two eelgrass beds were detected by video and delineated and quantified by divers. Both beds occurred in the nearshore, outside of the maximum project extent:

The western bed covered:

0.15 acres (609 m^2), with an average density of 40.9 *Z. marina* shoots/m^2.

The eastern bed covered:

0.26 acres (1,036 m^2) with an average density of 6.7 *Z. marina* shoots/m^2.

Macroalgae quantified within the western eelgrass bed covered an average of 19.5% of benthic substrate, and was dominated by *Sarcodiotheca gaudichaudii*. Macroalgae within the eastern eelgrass bed covered an average of 43.3% of benthic substrate, and was dominated by *Ulva spp.* Overall, macroalgae of greater than 5% density covered approximately 2.2 acres (8,892 m^2) within the total survey area. Of this, 0.13 acres (520 m^2) occurred within the maximum project extent itself. Most of the area of macroalgae greater than 5% density that intersected the maximum project extent occurred in the temporary work area (510.4 m^2) whereas only 9.6 m^2 occurred within the permanent pier footprint. Therefore, only 5.7% and 0.1% of the total macroalgae area delineated within the total survey area falls inside the temporary work zone and permanent project footprint, respectively. Within the largest portion of the macroalgae bed that was delineated within the project footprint and temporary work area (a 514 m^2 bed), the dominant macroalga was kelp (notably *Laminaria sp.*). This bed had an average macroalgal percent cover (density) of 16.7% (Braun-Blanquet cover class #2).

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ACRONYMS

cm	Centimeter
DVR	Digital Video Recorder
GIS	Geographic Information System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
IMF	Intermediate Maintenance Facility
LED	Light Emitting Diode
m	Meter
MLLW	Mean Lower Low Water
NAVFAC	Naval Facilities Engineering Command
NAVBASE	Naval Base
NAVFAC NW	Naval Facilities Engineering Command Northwest
NW	Northwest
NIWC Pacific	Naval Information Warfare Center Pacific
PSNS	Puget Sound Naval Shipyard
PVC	Polyvinyl Chloride
SAIC	Science Applications International Corporation
SDS	Scientific Diving Services
SPAWAR	Space and Naval Warfare
SSC-PAC	Space and Naval Warfare Systems Center Pacific

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1. INTRODUCTION

Eelgrass beds provide important ecological services, including habitat (Heck and Orth, 1980), primary productivity and biogeochemical cycling (Marbà, Holmer, Gacia, and Barron, 2007), and sediment stabilization (Hansen and Reidenbach, 2012) in the nearshore environment. These ecosystems are particularly important to many fishery species in Puget Sound, including Dungeness crabs, geoducks, sole, forage fish and juvenile salmonids (Thayer and Phillips, 1977; Shreffler, Simenstad, and Thom, 1992; Fresh, 2006; Penttila, 2007). Similarly, nearshore macroalgae habitats in Puget Sound provide refuge, foraging, migration, spawning habitats for a variety of fish and invertebrate organisms (Mumford, 2007).

The U.S. Navy is proposing to construct an extension to the existing Service Pier at Naval Base (NAVBASE) Kitsap, Bangor, Washington. In support of the US Army Corps of Engineers (USACE) permit required to construct in-water projects, eelgrass surveys have historically been required to detect if *Zostera spp*. occur within or near the project area. However, for this project, the USACE, Seattle District, expanded the survey requirement to include macroalgae occurrence. Therefore, to meet the permitting requirements expressed by the USACE for the proposed project, a survey was completed to assess both eelgrass and macroalgae beds in the project vicinity.

This report describes the methodology and findings from conducting a submerged aquatic vegetation survey of the permanent project footprint, proposed temporary work zones and area between these areas and shoreline for the proposed Service Pier Extension project. The survey and reporting were completed by the Space and Naval Warfare Systems Center Pacific (SSC Pacific) Scientific Diving Services (SDS) team, with Geographic Information System (GIS) support from Adam Young Consulting.

The survey consisted of two main activities, described in the Eelgrass Survey Plan, NAVBASE Kitsap Bangor Service Pier, developed by Naval Facilities Engineering Command Northwest (NAVFAC NW) based on guidance from and approval by the U.S. Army Corps of Engineers (NAVFAC NW, 2018). The activities included: (1) an underwater video survey using live video of the bottom obtained from a boat while traversing pre-defined shore-perpendicular transects to detect eelgrass and macroalgae beds in the survey area, and (2) a diver-based survey aimed at delineating boundaries and quantifying eelgrass beds, macroalgae coverage inside eelgrass beds, and macroalgae beds within the project footprint and temporary work area.

Prior surveys in 2008 and 2012 detected nearshore macroalgae and two nearshore eelgrass beds of < 0.25 acres each, respectively, all shoreward of both the permanent project footprint and temporary work area (Science Applications International Corporation (SAIC), 2009; Anchor QEA, 2012). This survey was designed to provide updated and expanded data coverage regarding presence and abundance of eelgrass and macroalgae that might be affected by the NAVBASE Kitsap Bangor Service Pier Extension project.

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2. METHODS

2.1 SITE DESCRIPTION

The Service Pier is located on the eastern shoreline of Hood Canal at NAVBASE Kitsap Bangor, Kitsap County, Washington (Figure 1). The existing Service Pier is approximately 920 feet long, and oriented at a heading of about 38 degrees from north. A wave screen extends approximately 100 additional feet to the southwest of this structure on the same heading. A floating security barrier encloses the offshore area, starting from the end of the wave screen and extending approximately 1,800 feet from shore (Figure 2). The proposed Service Pier Extension project includes the proposed pier footprint (permanent impact area) and the temporary work area, with a 100-foot offset to the north of the proposed pier and a 20-foot offset to the south (nearshore) of the proposed pier where temporary impacts to marine vegetation may occur. The combined permanent project footprint and temporary work area span approximately 640 feet at a 68 degree heading from north (Figure 3). Southwest of the existing Service Pier and inshore of the proposed extension is Carlson spit, comprised of coarse and relatively steep sand embankments (Figure 2).

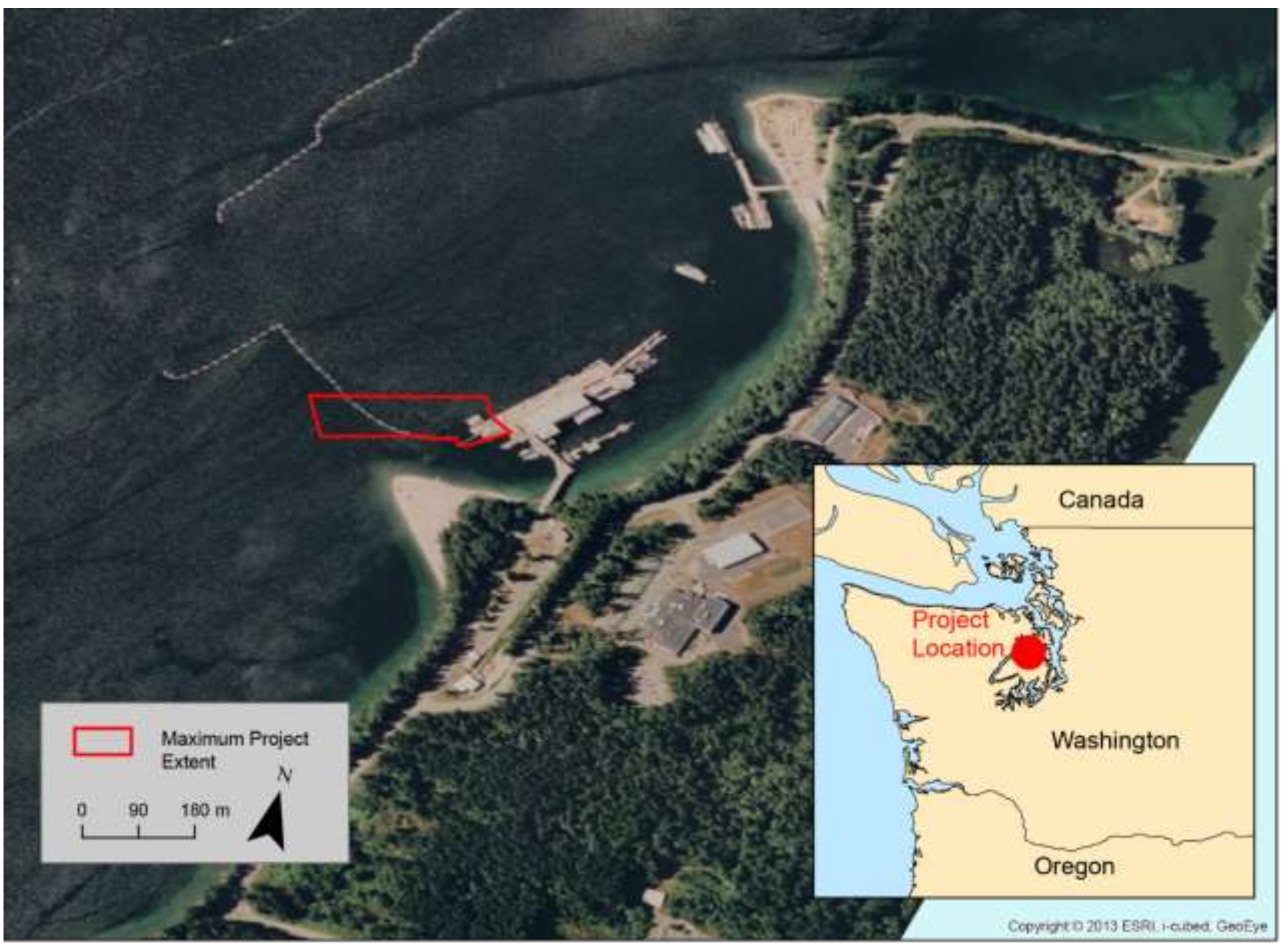

Figure 1: Vicinity map of Naval Base Kitsap Bangor Service Pier site.

Figure 2: Naval Base Kitsap Bangor Service Pier and immediate vicinity (Google Earth Imagery, 6/24/2017).

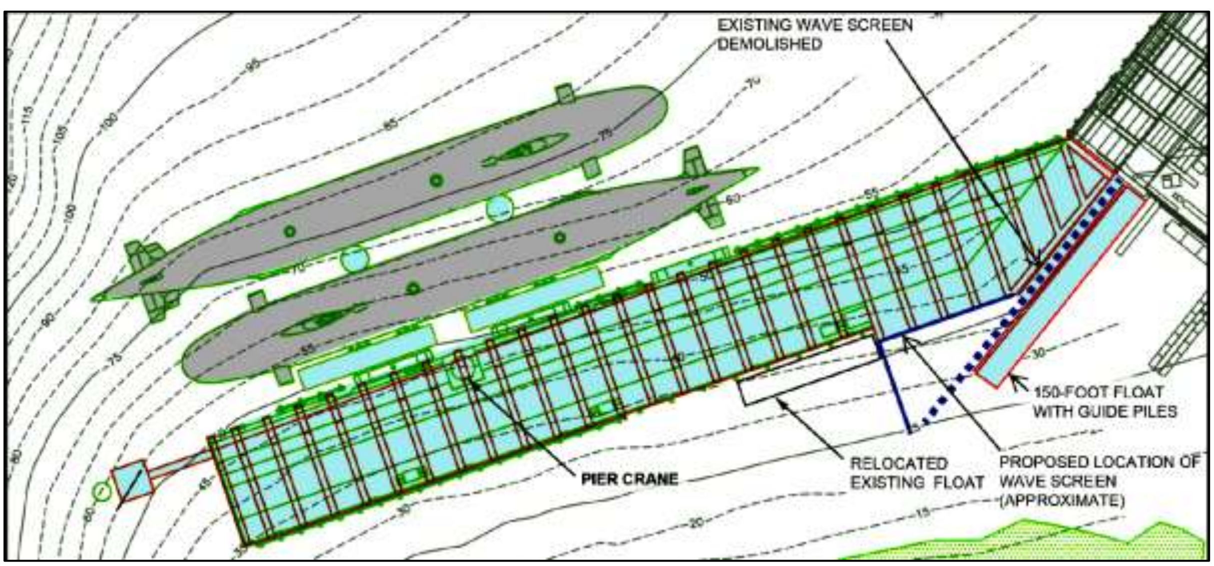

Figure 3: Proposed Project (Source: Modified from Naval Facilities Engineering Command).

Prior underwater video surveys detected two eelgrass beds shoreward of the project area: one near the end of Carlson Spit, and one to the northeast, mostly inshore of the existing pier and wave screen structure (Anchor QEA, 2012; Figure 4). In addition, extensive macroalgae beds were detected using underwater video in the nearshore area (SAIC, 2009; Figure 5).

Figure 4: 2012 Detected eelgrass beds. (Source: Anchor QEA, 2012).

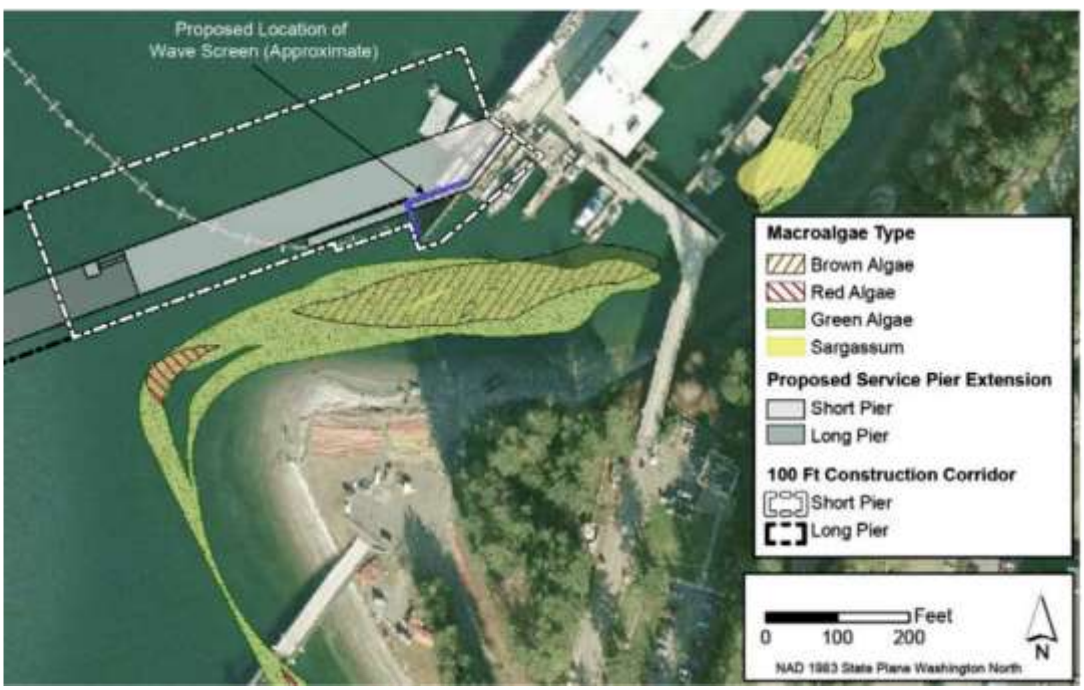

Figure 5: 2008 Detected Macroalgae (Source: SAIC, 2009).

2.1.1 Underwater Video survey

The underwater video survey of the site was comprised of using live video to monitor the benthos along pre-defined transects spaced 40 feet apart, perpendicular to the shoreline (Figure 6). The goal of this survey was to document and delineate potential eelgrass and macroalgae beds within the permanent project footprint and temporary work area, as well as between these survey areas and the shoreline near the site.

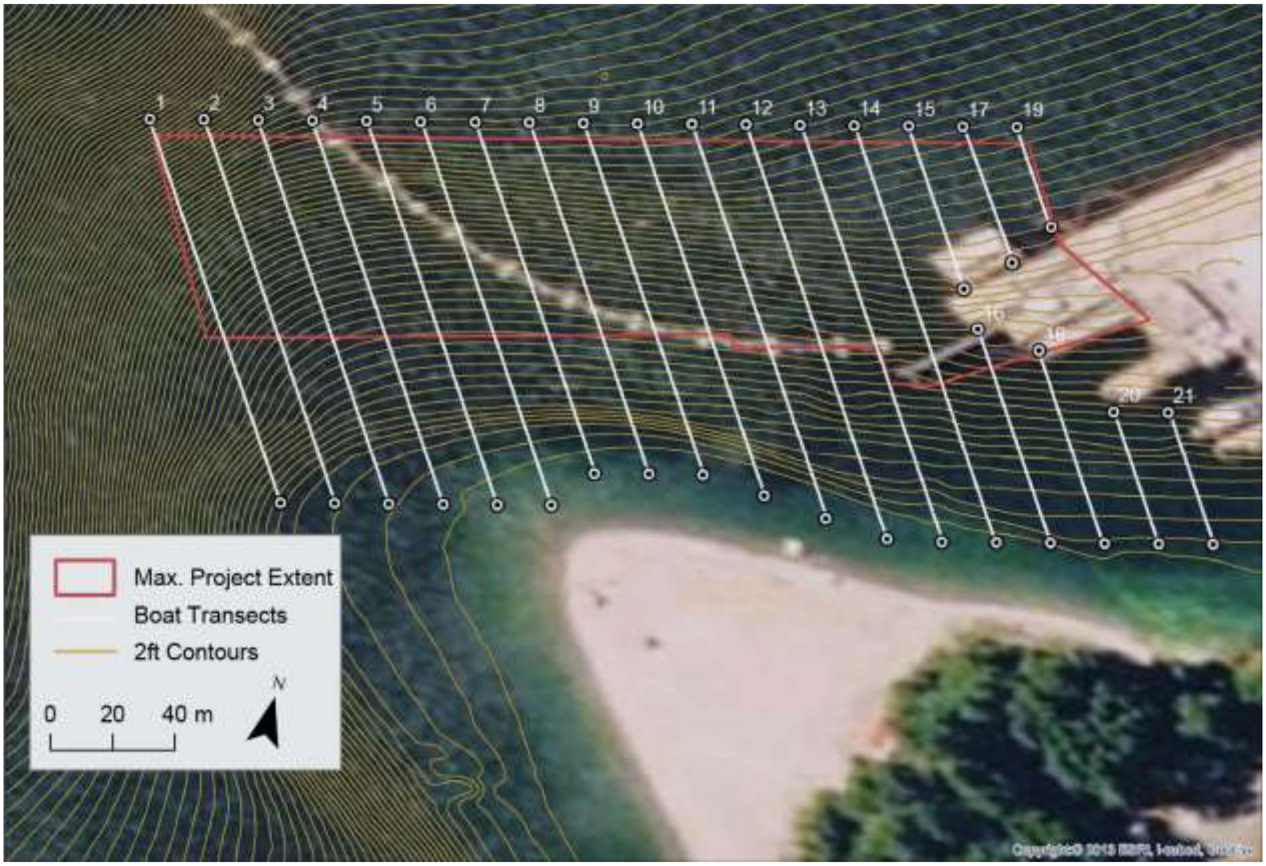

Figure 6: Target underwater video survey transects (white lines).

2.1.2 Field Equipment

2.1.2.1 Boat positioning

Transect start and end latitude and longitude locations (Appendix A) were entered into a Garmin Montana 600 WAAS-enabled Global Positioning System (GPS) unit, and a route between each of these points was planned on the GPS unit. This unit was used to both guide the boat driver navigating the vessel along the planned transect lines, and to record the boat position in real time, with readings recorded every 2 seconds.

2.1.2.2 Video equipment

A Delta Vision Industrial™ Underwater Point of View Camera System Pro Package – DVR (digital video recorder) manufactured by Ocean Systems, Inc. was used to view the benthos in real time, as well as record video of the surveyed transects. The system consists of a waterproof video camera head surrounded by adjustable-brightness Light Emitting Diode (LED) lights with a 200-foot-long cable, and a monitor screen, power and recording capabilities contained in a Pelican case.

The video camera head was securely mounted to a custom-built Polyvinyl Chloride (PVC) sled to maintain the camera at a fixed distance from the seafloor. The camera field of view, adjusted to accommodate site visibility, was approximately 75 centimeters (cm) wide in the cross-transect direction by 1 meter (m) long in the along-transect direction.

2.1.2.3 Data logging equipment

A HOBO™ U20L-02 level logger manufactured by Onset Computer Corporation was securely attached to the video camera sled, and set to log pressure every second in pounds per square inch (psi). The resulting data were adjusted to remove average ambient air pressure at sea level (14.7 psi), and then converted to water depth in feet by multiplying psi by -2.25 feet/psi. This provided a continuous record of the depth of the video camera sled during the survey. These depths were then corrected to be referenced to Mean Lower Low Water (MLLW) based on predicted tide height at NAVBASE Kitsap Bangor to give the sled depth at all times in relation to MLLW.

A Trimble GeoExplorer 6000 Global Navigation Satellite System (GNSS) unit with approximately 1-meter accuracy was used to log waypoints coincident with changes in benthic cover viewed on the video screen. The data library used included points associated with transitions to bare substrate (no eelgrass or macroalgae) and points associated with transitions to submerged aquatic vegetation (eelgrass or macroalgae), or from one density bin of macroalgae to another.

Datasheets were also used to keep track of detailed information about each waypoint transition and benthic coverage between each waypoint. Datasheets also captured information on transect survey dates, times, and directions, Trimble file numbers, and video times, as well as incidental observations.

2.1.3 2.2.2 Benthic type transition mapping

The cross-shore transects spanned water depths ranging from several feet near the shoreline to over 80 feet in some areas. To keep the video equipment on the bottom, the length of tow line varied along each transect, as did the horizontal distance between the camera sled and the boat. This survey method resulted in varying offset distances between the Trimble unit on the boat with which waypoints were recorded, and the video sled unit, from which video observations were being collected. Therefore, instead of using a fixed boat-sled offset distance, or the position information from the Trimble unit to locate the transitions between bottom types, the timestamps from those waypoints were used to determine the depth of the sled at the time of the waypoint capture. These timestamps were then used to determine the water depth of the sled, in relation to MLLW as described above, from the HOBO logger files. The approximate location of the transition denoted by each waypoint were then placed to be equivalent to the position along each planned boat survey transect where the water depth was equal to the depth at the time the waypoint was captured. A schematic representation of this workflow is shown in Figure 7.

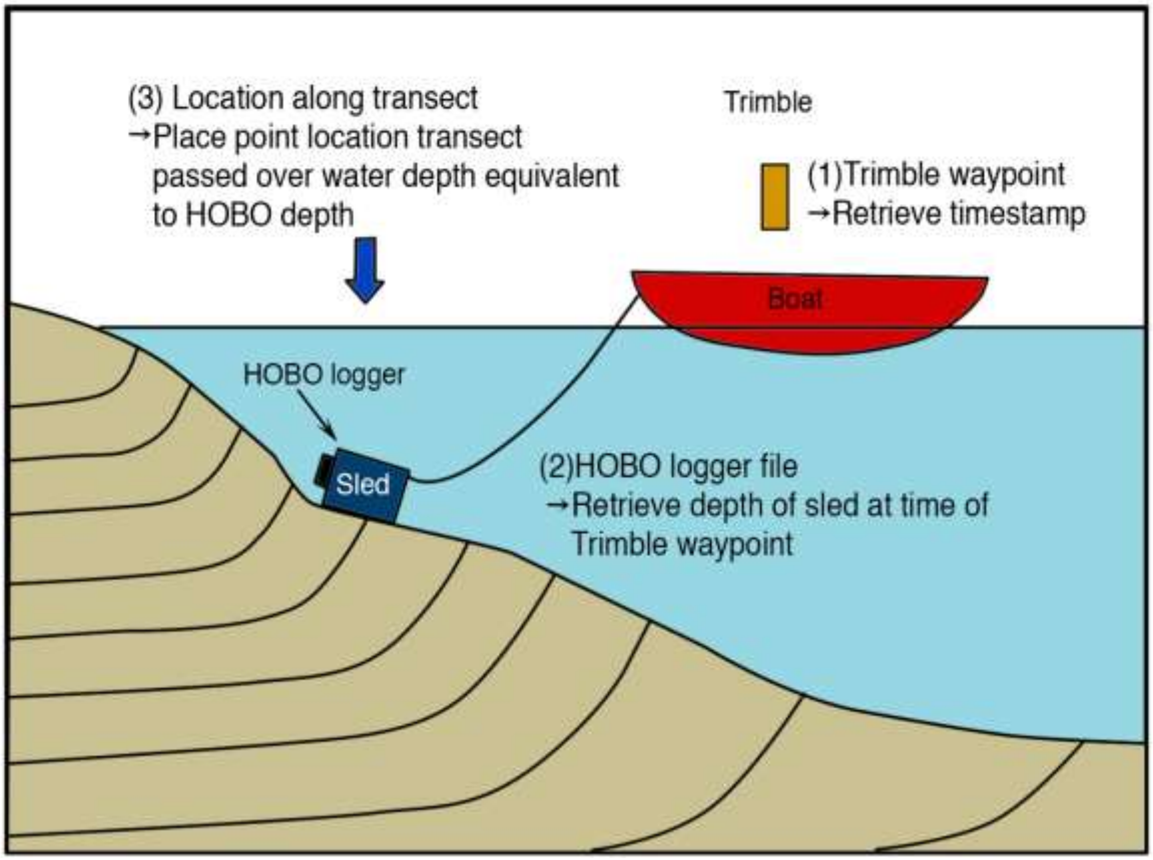

Figure 7: Schematic representation of video-transect geo-referencing methodology.

The resulting locations of benthic type transitions were mapped in ArcGIS, and sections between transition points were color-coded according to benthic type. Nearshore macroalgae coverage > 5% was delineated by determining the onshore extent of this category observed on each transect, then connecting straight lines between the first detection of each transect. The same was done for the offshore extent of macroalgae > 5% coverage where the bed transitioned to uncolonized sediment before reaching the offshore survey area.

2.2 DIVER SURVEY

2.2.1 Field equipment

2.2.1.1 Diver positioning

Diver positions were acquired through either or both of the two following systems:

1. **GPS Buoy Positioning System**

   For this system, a Garmin Montana 600 GPS unit was placed into a clear waterproof sleeve, and attached to the top of a fabric-covered donut buoy. A line was connected between the bottom of the donut buoy and the SDS diver. An active duty Navy diver from the Intermediate Maintenance Facility (IMF) dive locker, the command supporting this effort, was tasked with maintaining the GPS buoy over the SDS diver. The Garmin unit recorded the position of the GPS buoy every 2 seconds.

2. **SeaTrac Acoustic Positioning System**

   This system is comprised of a topside X150 beacon, a GPS puck unit, and an X110 diver modem transponder™ beacon. These three components are used together with the specialized "PinPoint" software program produced by the SeaTrac manufacturer (Blueprint Subsea). The software obtains the position of the boat at any given time from the GPS. The topside and diver beacons communicate acoustically, to provide the range and bearing between the boat and diver. Finally, the software uses all of this information to calculate and store estimated position information for the SDS diver throughout the time of each dive.

The GPS buoy system was used on all dives. The SeaTrac system was used in addition to the GPS buoy positioning system on most dives, excluding the eelgrass delineation dives.

2.2.1.2 Data collection

Data were collected during dives using (1) a Canon PowerShot® G7 X camera with a Recsea underwater camera housing by SEATOOL®, with time synced to the GPS systems, (2) underwater datasheets, and/or (3) an underwater notebook. In general, visibility was poor, typically ranging from one to four feet due, in part, to strong tidal currents resuspending sediments in the water column. Consequently, many photographs collected were of less than desirable quality. However, because data regarding macroalgae and eelgrass composition and coverage were collected in situ, photographs were primarily used to verify quadrat data collection location (by timestamp-matching photographs to diver GPS tracks), not for data analysis.

For those dives that used surface supply, or SCUBA with communication equipment, information was relayed to and datasheets were filled in by a topside scientist. Timestamps on photographs were used to mark relevant positional information underwater by matching to the GPS buoy and/or SeaTrac system diver tracks.

2.2.2 Eelgrass

2.2.2.1 Eelgrass bed diver delineation

The outer edges of eelgrass beds were delineated by divers using the surface-float GPS buoy system. Photographs of the diver notebook were used to indicate the start and stop times of the delineation swims. Representative photographs were also taken along the delineation swims.

2.2.2.2 Eelgrass bed transects

The .GPX files from the diver buoy system, clipped to the relevant time periods during which the divers were delineating beds, were imported into Google Earth in the field each day after dive efforts. Target transects spaced 25 feet apart in the alongshore direction, and oriented perpendicular to shore, were then placed to span the alongshore width of the delineated eelgrass beds. The coordinates for the ends of these transects were entered into the Trimble GNSS system. In addition, the distance along each transect between quadrats was determined based on the requirement to complete data collection from at least 30 quadrat locations per eelgrass bed.

The GNSS system was used to navigate to the target coordinates. When the bow of the boat reached the target point, a weight attached by a line to a buoy was deployed from the bow of the boat. The offshore and onshore points of several transects at a time were marked in this fashion, creating a grid of buoys. Rebar was then installed at the locations of these weights, and a fiberglass transect tape was strung taught between the rebar. For all transects except A, B, and C, the SDS diver corrected the underwater locations of the rebar/transects to ensure the transects started and stopped at approximately the onshore and offshore edges of the eelgrass beds to span the entire bed, and/or moved the transect locations alongshore if the boat-based transect placement missed the eelgrass bed altogether.

At each pre-determined quadrat location, triplicate turion (eelgrass shoot) counts of *Zostera marina* were completed in 0.25m^2 quadrats placed at 2 o'clock, 6 o'clock, and 10 o'clock positions. These counts were recorded on datasheets (example provided in Appendix B). Percent coverage of *Zostera japonica* was also visually estimated and recorded, if present. Next, a 1m^2 quadrat was placed over the same area as the eelgrass counts were completed, and percent cover for macroalgae rooted within the quadrat was visually estimated and recorded on the datasheets.

2.2.3 Macroalgae

Only macroalgae within the permanent project footprint and temporary work area was assessed for percent cover by divers, as stated in the USACE-approved survey plan (NAVFAC NW, 2018). Both scuba and surface-supplied diving modes were used to conduct the macroalgae surveys. Scuba was conducted using conventional regulators and MK-20 full face masks with communication cables to facilitate communication between the SSC Pacific scientific diver and the scientist topside (Figure 8).

Figure 8: MK 20 MOD O full face mask (Source: U.S. Navy Diving Manual, 2016).

When initial reconnaissance scuba surveys were conducted at deeper sites within the permanent project footprint and temporary work area to assess macroalgae observed via towed video, extremely strong currents associated with large tidal swings were encountered that exceeded the limitation of that diving mode. The dive team thus converted to surface-supplied diving mode utilizing the Kirby Morgan KM-37® diving helmet in strong currents, and timed dives to occur during smaller tidal swings each day to manage those environmental conditions. The KM-37® diving helmet weighs approximately 36 lbs; this extra weight helped the divers to stay on the survey site in high current conditions (Figure 9).

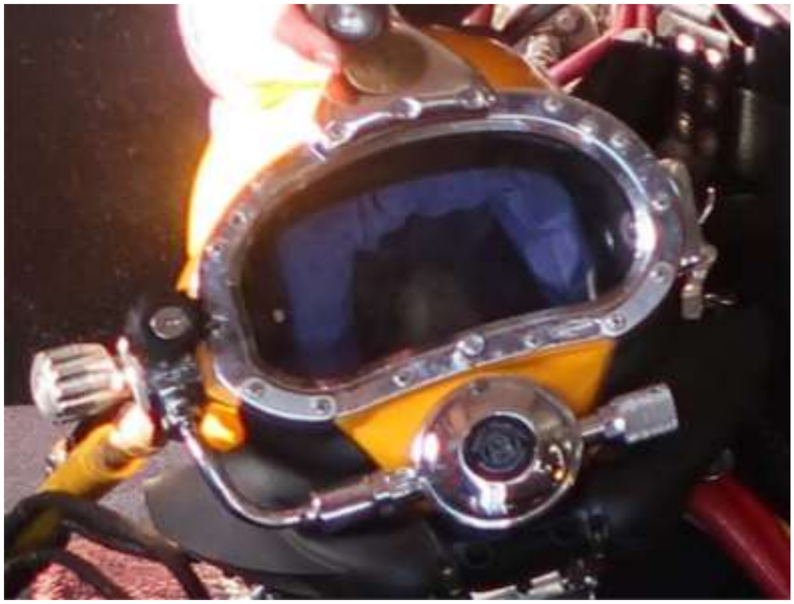

Figure 9: KM-37 diving helmet.

Additionally, for some surface-supplied diving, divers used an oxygen regulator console assembly (ORCA). This system provides 100% oxygen to the diver's umbilical. This was advantageous in that the system allowed for decompression dives which afforded longer bottom times and enabled the divers to cover more area on the seafloor in deeper areas of the project footprint where macroalgae was detected through towed video.

Two diving vessels were utilized for this survey. A larger vessel known as the Delta dive boat was the diving platform for the surface-supplied medium (Figure 10). A smaller boat was used for SCUBA and to access areas where the larger vessel was not capable of staying on site to cover the areas required for ground truthing.

Figure 10: Delta boat used for the surface-supplied diving platform.

2.2.3.1 Macroalgae delineation

The extent of nearshore macroalgae beds, where cover exceeded 5%, was located along underwater video transects as the transects approached the shoreline. Likewise, the offshore extent of the main nearshore macroalgae bed was delineated from the video survey data, where this occurred outside of the permanent project footprint and temporary work area. Where the offshore edge of the main nearshore macroalgae bed extended into this area, the dive team located and swam the offshore boundary of the bed, to delineate the extent where macroalgae coverage exceeded 5% within the temporary work zone and/or permanent project footprint.

Buoys were also placed at locations in deeper waters of the permanent project footprint and temporary work area where individual patches of macroalgae > 5% coverage were detected by video. Divers then conducted circle searches around these buoys using surface-supplied diving equipment to locate, with the goal to delineate and quantify, these apparent macroalgae beds.

This method enabled 360° coverage of approximately a 10 m radius around each site. The scientific diver also swam 50 feet in the north, south, east and west directions from the central point of each site, looking for macroalgae patches > 5% density.

2.2.3.2 Macroalgae quantification

Within the main delineated macroalgae bed in both the permanent project footprint and temporary work area, divers placed 1 m^2 quadrats along transects oriented approximately perpendicular to shore and spaced approximately 25 feet apart. Inside each quadrat, the percent-cover of each type of macroalgae rooted within the enclosed space was recorded, and a photograph was taken to allow georeferencing of the quadrats via timestamp matching to the diver GPS tracks. This then allowed SSC Pacific scientists to quantify macroalgae within the portion of the macroalgae bed that fell inside the permanent project footprint and the temporary work area.

In small patches of macroalgae elsewhere, an appropriate number of quadrats were placed in representative locations within the patch to quantify percent cover of macroalgae taxa within those smaller patches.

Although definitive identification of some marine algae require examination of all portions of an alga including the holdfast and reproductive structures by phycological experts, sometimes microscopically (Abbott, Isabella, and Hollenberg, 1992), this was not feasible during the field survey. The field biologists identified macroalgae to the lowest taxonomic level practicable during the field survey. Unrooted specimens of some species were photographed subaerially for comparison with phycological publications to aid with identification.

The underwater video portion of the survey, and the part of the diver survey focused on the detected eelgrass beds and macroalgae within those beds, were completed between June 4-June 15, 2018 (Table 1). During those dates, several dives within the permanent project footprint and temporary work area were attempted, with the goal to delineate macroalgae beds observed during the underwater video survey. These dives resulted in insufficient data, owing to intense currents and poor visibility conditions. A second field effort took place between July 12–19, 2018 to delineate and collect quantitative data from macroalgae beds within the project footprint. These dives were successful in accomplishing these objectives.

Table 1. Field effort dates and tasks completed.

Days	Tasks
4 JUNE 2018	Assembled video sled and deployed HOBO, GPS video monitoring system.
5 JUNE 2018	Started video transects.
6 JUNE 2018	Continued video transects.
7 JUNE 2018	Completed video transects. Initiated underwater diver eelgrass perimeter surveys.
8 JUNE 2018	Completed underwater diver eelgrass perimeter surveys.
9 JUNE 2018	Completed eelgrass transects A, B, C and D.
11 JUNE 2018	Attempted macroalgae perimeter survey in footprint. Completed eelgrass transect AB.
12 JUNE 2018	Attempted macroalgae perimeter survey in footprint. Completed eelgrass transect BC.
13 JUNE 2018	Attempted macroalgae perimeter survey in footprint. Completed eelgrass transects CD and N.
14 JUNE 2018	Completed eelgrass transects G, H, I and J.
15 JUNE 2018	Completed eelgrass transects K, L, M and O.
12–13 JULY 2018	Completed initial reconnaissance surveys of macroalgae patches in footprint.
16–19 JULY 2018	Completed delineation and quantification of macroalgae in project footprint.

3. RESULTS

3.1 UNDERWATER VIDEO SURVEY RESULTS

The boat transects were completed as accurately as possible, given the inherent challenges of the site, which included 15-foot tidal swings, wind, waves, and physical structural barriers.

Figure 11 shows the boat tracks completed, as recorded by the Garmin Montana GPS unit. Transects 4-14 had to be completed in at least 2 sections because of the floating US Navy security barrier at the project location that the boat could not pass through, as well as ongoing vessel traffic. Transects 20 and 21, as well as the shoreward portions of transects 10 and 14 were completed twice, because post-survey inspection of the GPS tracks indicated that the boat had drifted unacceptably far from the planned survey line.

Figure 11: Target and Actual Vessel Survey Transects.

Based on the June underwater video survey results, within the project footprint and temporary work area, most of the benthos consists of sand (or other unconsolidated sediments including shell hash), or sediment with between 1–5% macroalgae. Those areas within the maximum project extent appeared to contain macroalgae > 5% cover, were quantified with a diver survey in July 2018.

The underwater video survey also indicated that two areas between the maximum project extent and the shoreline contained eelgrass beds; one southwest of the end of Carlson spit, and one northeast of the end of the spit (Figure 12). These eelgrass beds are hereafter referred to as the western and eastern beds. The western bed appeared denser on the video transects, with sections on the transects that appeared to be dominated heavily by eelgrass with little to no macroalgae. The eastern bed, on the other hand, appeared patchier and less dense overall.

3.2 DIVER SURVEY RESULTS

3.2.1 Eelgrass beds

3.2.1.1 Bed extents

The western eelgrass bed was delineated at 0.15 acres (609 m^2), while the eastern bed was delineated at 0.26 acres (1,036 m^2; Figure 12). The minimum distance between the closest portion of each eelgrass bed and the temporary work zone is 23 m and 12 m for the western and eastern beds, respectively. The minimum distance between the closest portion of the permanent project footprint and each eelgrass bed is 31 m and 16 m, respectively.

3.2.1.2 Delineated Eelgrass Beds

Figure 12: Diver-delineated eelgrass bed extents, with average shoot density.

3.2.1.3 Eelgrass shoot density

The western eelgrass bed was denser than the eastern bed. *Zostera marina* shoot counts in the western bed ranged from 0–64 per 0.25 m^2 quadrat, or 0–256 shoots/m^2. Average shoot density throughout the bed was 10.2 shoots per 0.25 m^2 quadrat, or 40.9 shoots/m^2. Figure 13 depicts eelgrass density in a representative quadrat at this bed.

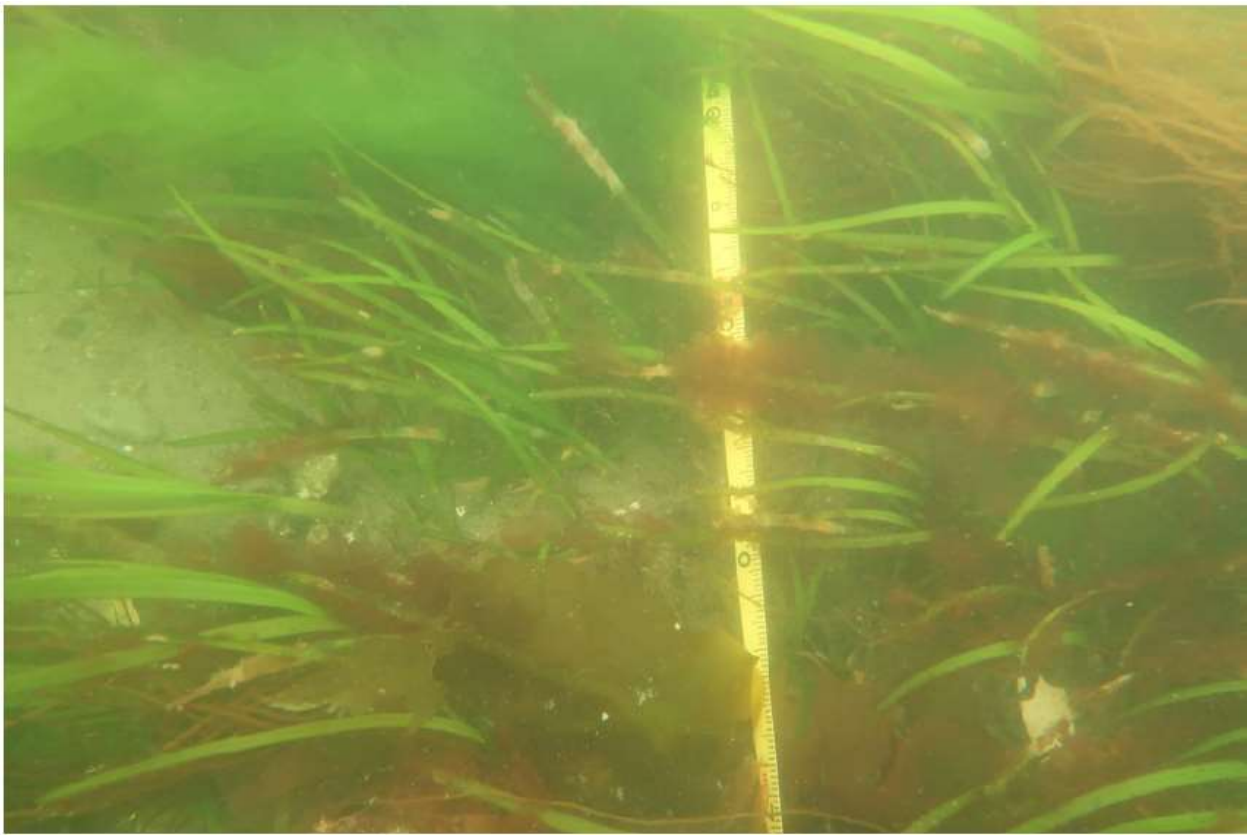

Figure 13: Representative photograph of quadrats with the densest coverage of seagrass in the western eelgrass bed.

In the eastern bed, *Z. marina* shoot counts ranged from 0–21 per 0.25 m^2 quadrat, or 0–84 shoots/m^2. Average shoot density throughout the bed was 1.7 shoots per 0.25m^2 quadrat, or 6.7 shoots/m^2.

Combining the average shoot density with bed sizes, the smaller western bed contained approximately 24,826 *Z. marina* shoots, while the much larger eastern bed contained approximately 7,048 *Z. marina* shoots.

Only one 0.25 m^2 quadrat may have contained *Z. japonica*. This was in the middle of transect B, near the western edge of the western bed, and potentially contained 1–10% *Z. japonica*.

Although the specimens observed had smaller leaf size, this is not a reliable indicator. *Z. marina* has roots in bundles and *Z. japonica* has roots in pairs at each rhizome node. In order to avoid disturbance to the bed, rhizomes were not exposed.

3.2.1.4 Macroalgae within eelgrass beds

Eight types of macroalgae were observed attached to the substrate within the eelgrass beds (Table 2). The eastern eelgrass bed had higher macroalgae density and diversity than the western bed (*Chondracanthus exasperatus* and *Urospora sp.* were not observed in the western bed). Total macroalgae percent coverage within 1 m^2 quadrats ranged from 2–45%, with an average of 19.5% coverage in the western bed, while coverage ranged from 6–100%, with an average of 43.3% coverage in the eastern bed (Figure 14). *Sarcodiotheca guadichaudii* was the most abundant macroalga in the western bed, while *Ulva* was the most common benthic macroalgae genus observed in the eastern bed (Figure 14). The brown seaweed *Sargassum muticum*, a competitor of native macroalgae species in Puget Sound (Britton-Simmons, 2004), was also observed.

Table 2. Macroalgae taxa observed rooted within delineated eelgrass beds (alphabetical).

Scientific Name	Common Name
Chondracanthus exasperatus	Turkish towel
Desmarestia aculeata	Acid weed, mermaid’s hair, landlady’s wig, and other names.
Laminaria sp. (possibly saccharina)	Sugar kelp
Sarcodiotheca gaudichaudii	Sea noodles
Sargassum muticum	Japanese wireweed
Ulva intestinalis	Gutweed or Grass kelp
Ulva sp. (possibly fenestrate)	Sea lettuce
Urospora sp.	Green hair

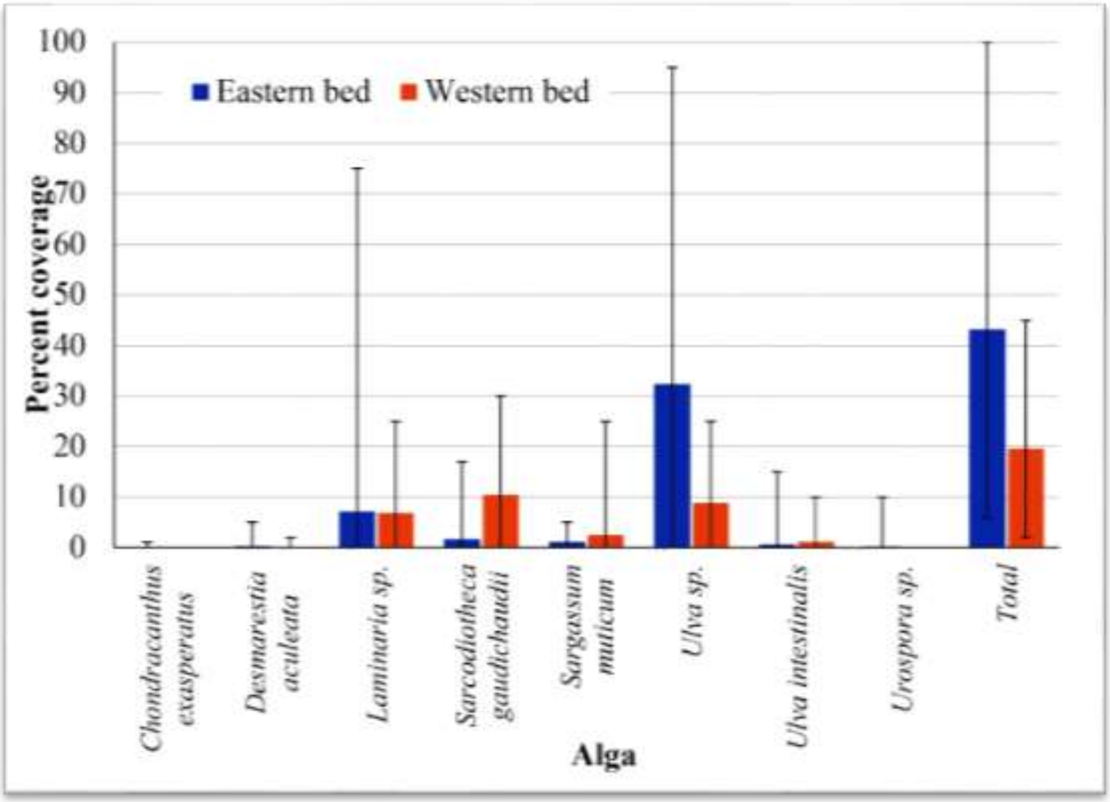

Figure 14: Average coverage of individual macroalgae taxa and all macroalgae ("Total") in each of the eelgrass beds surveyed. Error bars show the minimum and maximum coverage observed within individual quadrats.

In some locations throughout both eelgrass beds, a red alga was observed fouling the *Zostera marina* blades (Figure 15). These epiphytes were generally observed in quadrats within the densest patches of eelgrass. This alga has been tentatively identified as *Smithora naiadum*.

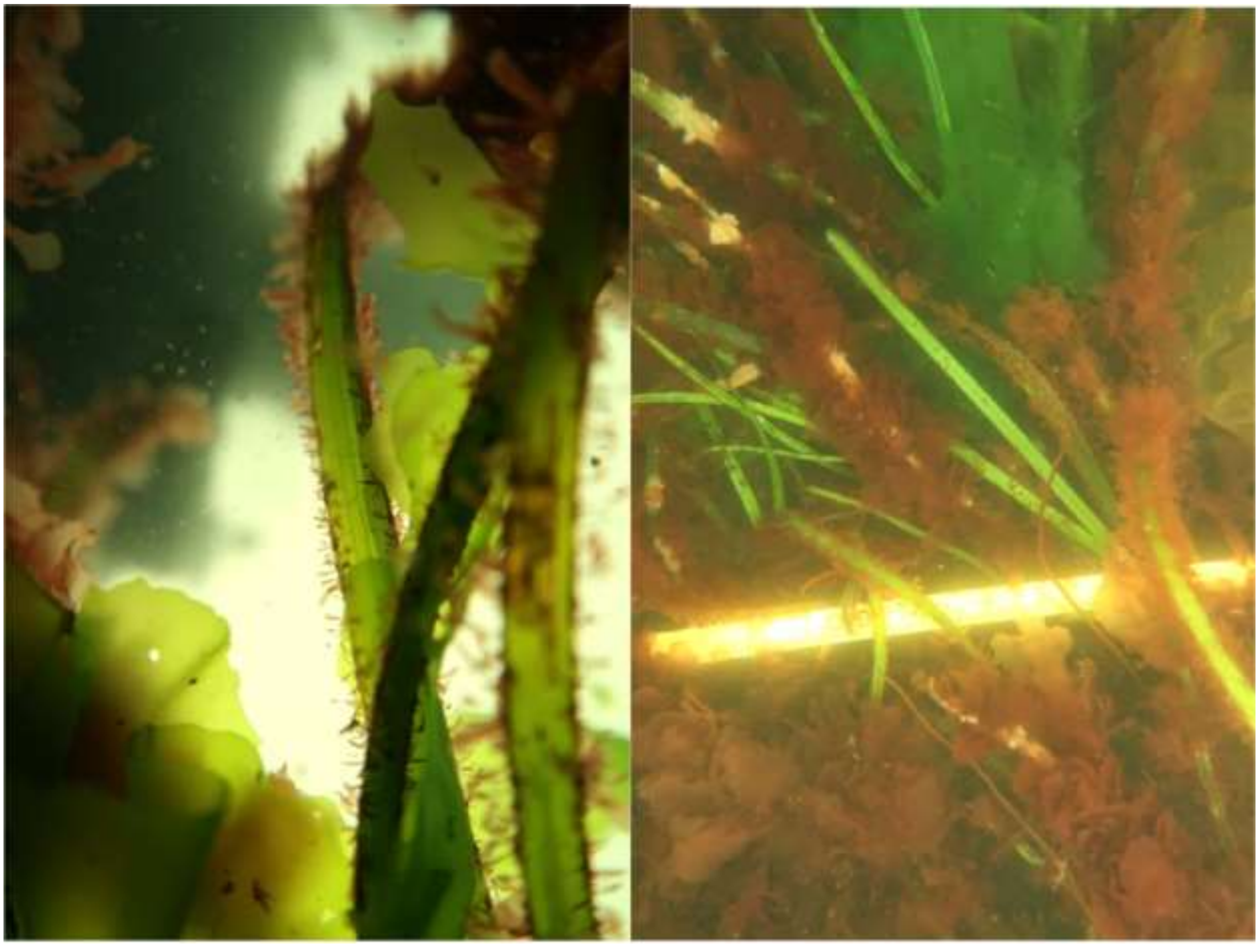

Figure 15: Red algal epiphytes on eelgrass.

3.2.2 Macroalgae in the permanent project footprint and temporary work area

Some video transects indicated preliminary detections of macroalgae in deeper portions of the permanent project footprint and temporary work area, but groundtruthing dives showed that most of the areas had no presence of macroalgae. There are several possible reasons why this apparent discrepancy occurred. During diving surveys, some macroalgae were observed attached to small hard substrate items such as bivalve shells; the macroalgae on these items could appear to be part of an actual rooted macroalgae bed on the video, but in reality they are not rooted and may move with the current (Figure 16). In other situations, a large blade of macroalgae (for example, Laminaria sp.) may have appeared to comprise more than 5% algae in a quadrat, but in reality covered less area as only single, widely spaced blades of kelp were observed in some areas. Further, some decomposing macroalgae may have settled on the bottom of the seafloor in drifts, which may have appeared to be beds of macroalgae during video acquisition, but were actually not attached to the substrate.

Figure 16: Example of macroalgae attached to shell; not rooted in substrate.

In the shallowest portion of the survey area, near Carlson spit, the seaward edge of the main nearshore macroalgae bed intersects the maximum project extent, with a very small portion of the bed intersecting the permanent project footprint (See Figure 1).

Overall, the portion of the main bed that intersects the maximum project extent covered 0.13 acres (514 m^2). Only 9.6 m^2 of this bed fell within the permanent project footprint. There were two other small patches of macroalgae, estimated at ~3 m^2 area (~2 m diameter) each in the temporary work area, for a total of 510.4 m^2 macroalgae within the temporary work area (Table 3).

The total area of macroalgae cover with greater than 5% coverage in the maximum project extent was 520 m^2 (0.13 acres), with 510.4 m^2 in the temporary work area and 9.6 m^2 in the permanent project footprint. This represents only ~5.7% and 0.1%, respectively, of the total delineated macroalgae bed at the site, including the area shoreward of the maximum project extent, where the bed extent was delineated by video.

Figure 17: Map of macroalgae in project area with > 5% density

Table 3. Macroalgae occurrence within the maximum project extent.

Deepwater Macroalgae Bed	Average Percent Cover	Area (m^2)		
		Permanent Project Footprint	Temporary Work Area	Total
Main bed	16.7%	9.6	504.4	514
Patch 1	60%	0	3	3
Patch 2	71%	0	3	3
Total	NA	9.6	510.4	520

Quadrats were placed on perpendicular-to-shore transects to quantify macroalgae within the maximum project extent. Quadrats closer to the shoreward edge of the temporary work area had denser macroalgae (Figure 18), which became sparser in the offshore direction towards and into the permanent project footprint (Figure 19).

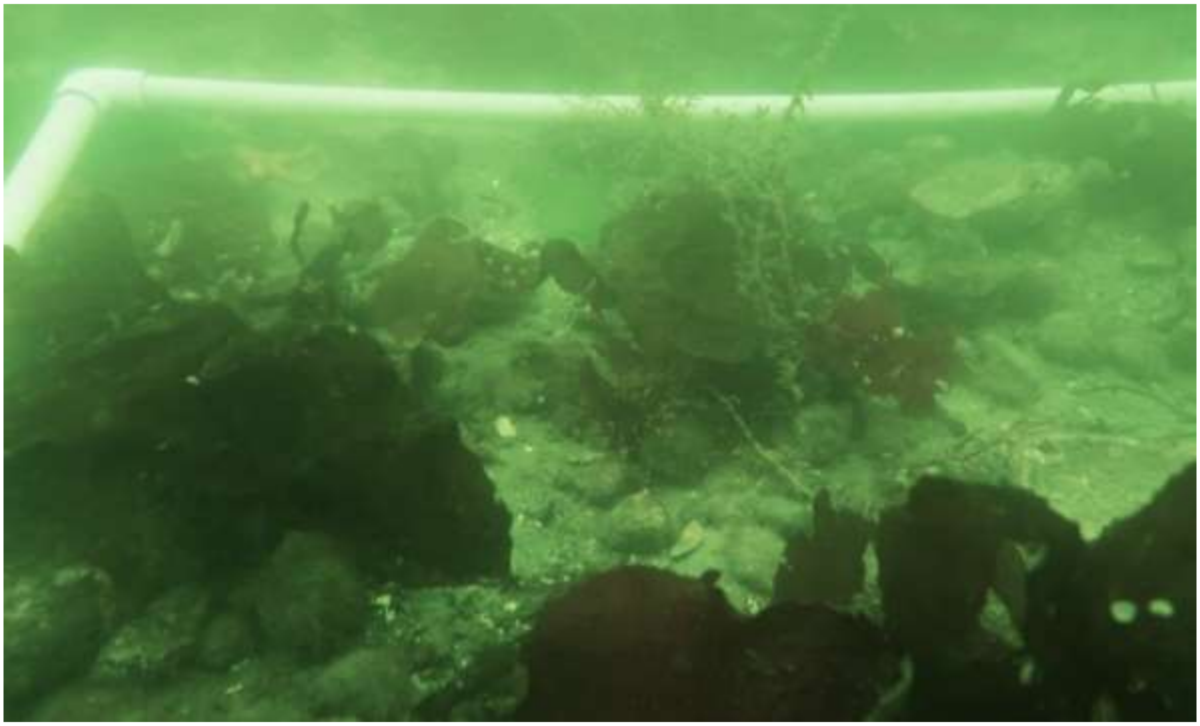

Figure 18: Representative macroalgae quadrat near the shoreward edge of the temporary work area.

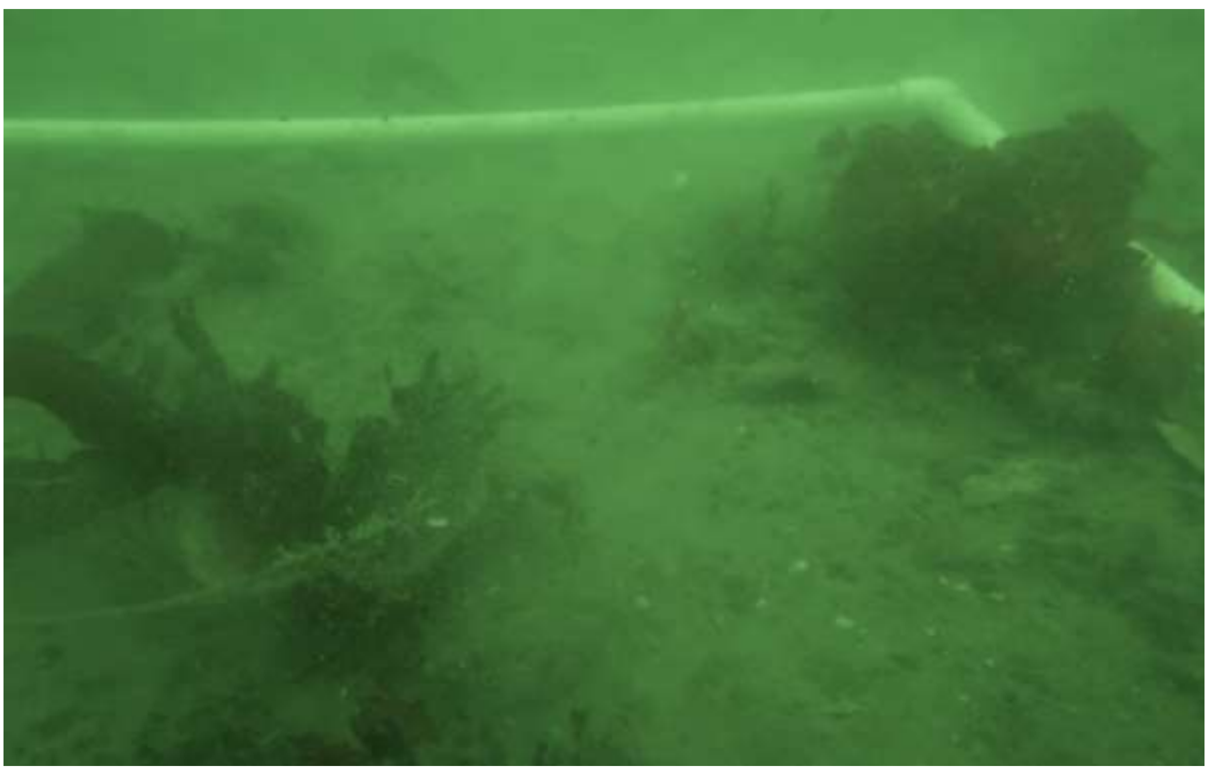

Figure 19: Representative macroalgae quadrat near the seaward boundary of the main macroalgae bed inside the maximum project extent.

A total of 41 quadrats were placed inside the main macroalgae bed delineated within the maximum project extent. This bed contains overall macroalgae densities that fall within Braun-Blanquet cover class #2. On average, the macroalgae bed surveyed contains 16.7% macroalgae, with minimum and maximum cover within individual quadrats ranging from 6-75%. Most of this was understory kelp (notably *Laminaria sp*.) at an average of 12.9% cover, followed by *Sarcodiotheca gaudichaudii* and *Ulva sp.* at 1.7 and 1.6%, respectively, and *Sargassum muticum* at 0.5%. There was also an unknown small alga, likely a red, that covered an average of 0.05% of the bed (Figure 20, Figure 21).

Figure 20: Unknown (possibly red) algae that covered < 0.05% of area in the main macroalgae bed within the maximum project extent.

The two small beds located within the temporary work area each contained approximately 60% and 71% average macroalgae cover (Braun-Blanquet cover class #4), mostly kelp and *Ulva spp.*, respectively; however, this value comes from only two quadrats in one the first and one quadrat in the second bed, because they were so small. No other patches were discovered during the diving survey that met the definition of a patch. All other surveyed areas either had no macroalgae, very sparse (< 5%) small macroalgae, or contained just single, widely spaced blades of understory kelp.

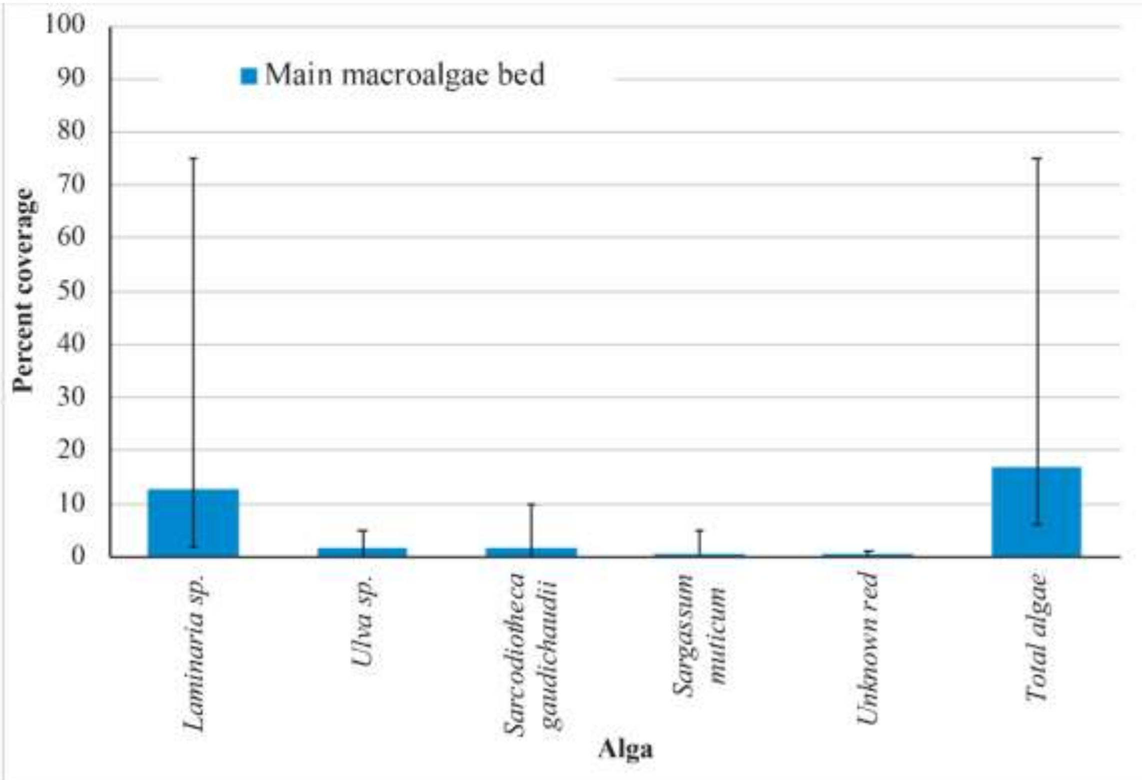

Figure 21: Average coverage of individual macroalgae taxa and all macroalgae in the main macroalgae bed within the maximum project extent.

3.2.3 Macrofauna observed at the project site

Table 4 lists macrofauna species observed incidentally and recorded during the underwater video and diver surveys. Figure 22 and Figure 23 show some of the macrofauna observed during data acquisition.

Table 4. Macrofauna observed at the project site during video and diver surveys.

Phylum	Scientific Name	Common Name
Chordata	*Phoca vitulina*	Harbor seal
	Syngnathus leptorhynchus	Bay pipefish
	Pholis ornata	Saddleback gunnel
	Platichthys stellatus	Starry flounder
	Lepidopsetta bilineata	Rock sole
Cnidaria	*Urticina Columbiana*	Columbia sand anemone
	Metridium giganteum	Giant plumose anemone

Table 4. Macrofauna observed at the project site during video and diver surveys. (Continued)

Phylum	Scientific Name	Common Name
Arthropoda	*Cancer gracilis*	Graceful rock crab
	Pugettia sp.	Kelp crab
	Family *Caprellidae*	Skeleton shrimp
Mollusca	*Hermissenda crassicornis*	Opalescent nudibranch
	Euspira lewisii	Moon snail
Echinodermata	*Evasterias troschelii*	Mottled seastar
	Pisaster brevispinus	Giant pink star
	Pisaster ochraceus	Ochre seastar
	Pycnopodia helianthoides	Sunflower seastar

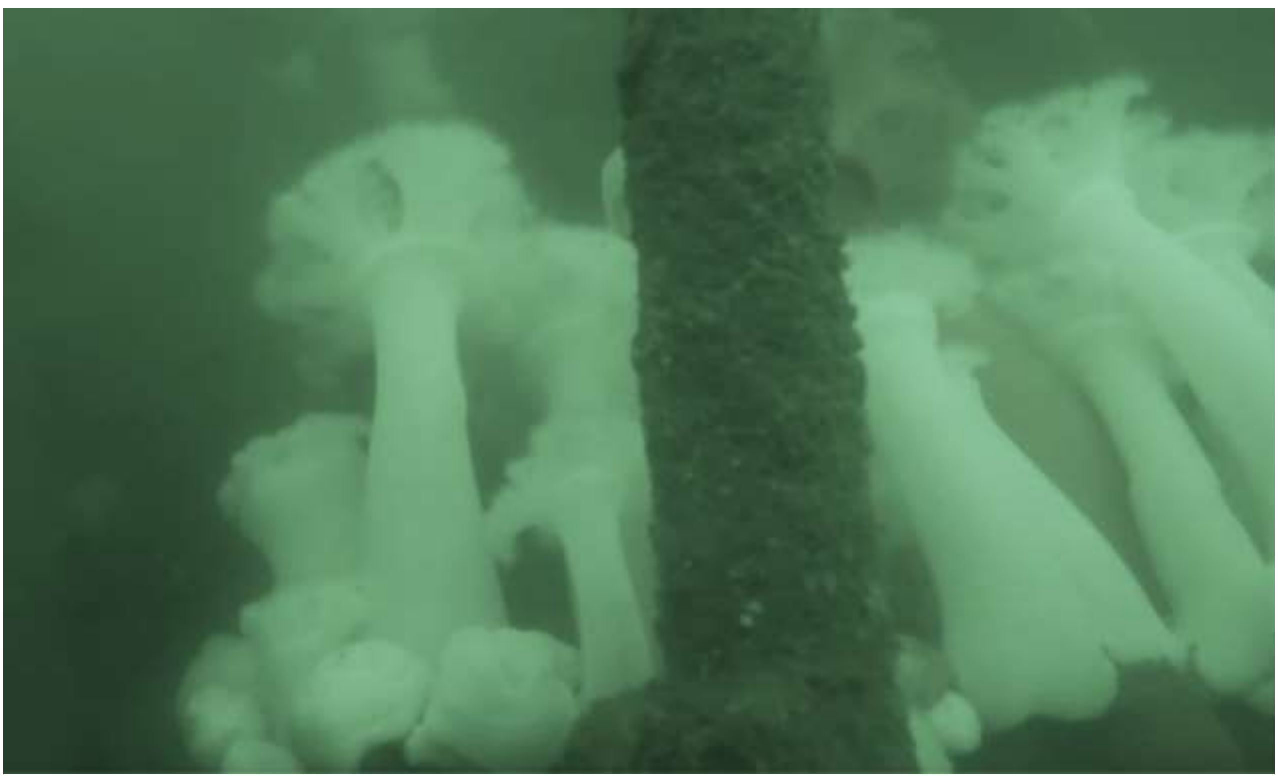

Figure 22: The Giant plumose anemone *Metridium giganteum*.

Figure 23: Ochre seastar, *Pisaster ochraceus*, and plumose anemone, *M. giganteum*.

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4. DISCUSSION

The last survey of eelgrass beds in this area was completed Sept 29, 2012 (Anchor QEA, 2012). At that time, the western bed (referred to as Area 2) covered approximately 0.14 acres (vs. 0.15 acres in 2018), and the eastern bed (termed Area 1) covered approximately 0.25 acres (vs. 0.26 acres in 2018). When compared with the bed boundaries denoted in this survey, it appears that the eelgrass beds may have shifted deeper since the prior survey (Figure 24), and that the eastern bed widened in the alongshore direction. The 2012 eelgrass survey (NAVFAC NW, 2018) quantified eelgrass density in the eastern bed (Anchor QEA, 2012). That survey found between 76-136 *Z. marina* shoots/m^2, with an average density of 102 shoots/m^2 in the eastern bed. That survey did not assess the shoot density of the western bed.

The 2012 eelgrass survey report states that shoot density was "high" and showed "good coverage within the [eastern] bed" (Anchor QEA, 2012). This contrasts strongly with the results from the 2018 survey, which found that the eastern bed was very sparse and patchy.

The size and shape of the western bed appears to have remained relatively stable, although the bed location as a whole seems to have shifted. This could represent a change in the location of this eelgrass bed in response to dynamic environmental conditions, or could represent differences in survey methods. The 2012 survey did not include a diver component for the western bed.

Figure 24: Comparison of eelgrass bed extents from surveys in 2012 surveys in 2018.

Laminaria sp. and *Ulva sp.* dominated the nearshore macroalgae quantified within both eelgrass beds. The former covered more surface area and quite often the leaf blades had to be moved in order to observe other algae such as *Sarcodiotheca gaudichaudii* and *Sargassum muticum* or eelgrass. Much of the kelp and *Ulva* were not attached, and had to be moved so that accurate data could be obtained regarding macroalgae rooted within quadrats.

Many portions of the surveyed area within the maximum project extent contained less than 5% algae and were dominated by shell debris/shell hash and a small rock/rubble mixture (Appendix C). Tire debris was also encountered at one point near the southwestern corner of the intended new pier structure.

Algae of at least 5 species from 5 genera were observed and quantified within the maximum project extent, in contrast to at least 8 species from genera 7 observed intermixed within the eelgrass beds. *Chondracanthus exasperatus, Desmarestia aculeata, Ulva intestinalis,* and *Urospora sp.* algae were not observed during the deeper dives conducted to quantify macroalgae in the maximum project extent. The seaward limit of the macroalgae beds may be driven by depth (below which not enough light penetrates for photosynthesis), and/or potentially strong currents. Divers observed that currents were much stronger in the deeper areas of the maximum project extent than in the shallower areas shoreward of the temporary work zone.

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APPENDIX A
GPS POSITIONS USED TO GUIDE BOAT-BASED VIDEO TRANSECTS (UNDERWATER VIDEO SURVEY)

A.1 OVERVIEW

The table presented in Appendix A shows the following details of the GPS positions used to guide boat-based video transections in the underwater video survey. Included in Table A-1 are Transect identification numbers, start and end position indicators, latitude and longitude locations and the transect length in feet.

A.2. VIDEO TRANSECTS TABLE

Table A-1. Video transects table.

Transect	Position	Latitude (N)	Longitude (W)	Transect Length (feet)
1	Start	47.73061798	122.7453501	389.9
	End	47.72964334	122.7446978	
2	Start	47.73065713	122.7451983	389.9
	End	47.72968252	122.744546	
3	Start	47.73069629	122.7450465	389.9
	End	47.7297217	122.7443942	
4	Start	47.73073544	122.7448947	389.9
	End	47.72976089	122.7442424	
5	Start	47.73077459	122.7447428	389.9
	End	47.72980007	122.7440906	
6	Start	47.73081375	122.744591	389.9
	End	47.72983925	122.7439388	
7	Start	47.7308529	122.7444392	357.1
	End	47.72996024	122.7438418	
8	Start	47.73089205	122.7442874	357.1
	End	47.72999946	122.74369	
9	Start	47.73093121	122.7441355	357.1
	End	47.73003868	122.7435382	
10	Start	47.73097036	122.7439837	378.1
	End	47.73002521	122.7433512	
11	Start	47.73100951	122.7438319	400.6
	End	47.73000821	122.7431618	
12	Start	47.73104867	122.7436801	421.0
	End	47.72999632	122.7429758	
13	Start	47.73108782	122.7435282	423.7
	End	47.73002884	122.7428195	

Table A-1. Video transects table. (Continued)

Transect	Position	Latitude (N)	Longitude (W)	Transect Length (feet)
14	Start	47.73112697	122.7433764	423.7
	End	47.73006799	122.7426677	
15	Start	47.73116613	122.7432246	165.5
	End	47.73075246	122.7429477	
16	Start	47.73064984	122.7428791	217.1
	End	47.73010715	122.7425159	
17	Start	47.73120528	122.7430728	102.0
	End	47.73095025	122.7429021	
18	Start	47.73063599	122.7426918	195.9
	End	47.7301463	122.742364	
19	Start	47.73124443	122.7429209	102.0
	End	47.73098944	122.7427503	
20	Start	47.73052155	122.7424371	134.5
	End	47.73018545	122.7422122	
21	Start	47.73056068	122.7422853	134.5
	End	47.7302246	122.7420604	

APPENDIX B
EXAMPLE DATASHEETS USED FOR DIVER DATA COLLECTION WITHIN THE STUDIED EELGRASS BEDS

B.1 OVERVIEW

Example datasheets used for diver data collection within the studied eelgrass beds (top) and macroalgae beds (bottom) are shown in Table B-1.

B.2 THE DIVER DATASHEETS DATA COLLECTION TABLE

Table B-1. Example datasheets used for diver data collection.

2018 NBK Bangor Service Pier Eelgrass survey								
								absent or 0%
Dive number						Density bins to use for JAPONICA and MACROALGAE		1-10% cover
Date								11-25% cover
Time								26-50% cover
Surveyor								> 50% cover
Transect	Quadrat location (m from start)	Water depth (ft)	Start/end time of quadrat placement/count		Eelgrass 1/4m quad Turion location	# of MARINA eelgrass shoots		% OR # of JAPONICA eelgrass shoots
					2:00			
Other observations					6:00			
					10:00			
				Macroalgae 1m quad	Macroalgae species in 1m quad	% cover of macroalgae species	Macroalgae species in 1m quadrat	% cover macroalgae species

2018 NBK Bangor Service Pier Macroalgae survey					
				absent or 0%	
Dive number (of the day)		Density bins MACROALGAE —>		1-5% cover	
Date				6-10% cover	
Time dive start/end				11-25% cover	
Surveyor	Don Marx, SSC PAC			26-50% cover	
				> 50% cover	
Transect	Quadrat location (m from start)	Water depth (ft)	Start/end time of quadrat placement/count		Swim direction (compass)
Macroalgae species		Percent cover in 1m2 quadrat		Other observations	

Transect	Quadrat location (m from start)	Water depth (ft)	Start/end time of quadrat placement/count		Swim direction (compass)
Macroalgae species		Percent cover in 1m2 quadrat		Other observations	

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APPENDIX C
PHOTOGRAPHS OF THE BENTHOS IN PORTIONS OF THE PROJECT AREA SURVEYED

C.1 OVERVIEW

This appendix contains two figures showing the Benthos.

C.2 BENTHOS PHOTOS

Representative photographs of the benthos in portions of the project area surveyed are shown in Figures C-1 and C-2.

Figure C-1. Image representative of some of the surveyed project footprint, showing unconsolidated sediment, shell hash, and < 5% macroalgae coverage.

Figure C-2. Representative image of bottom type in deeper survey areas closer to the Service pier.

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REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-01-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
August 2019	Final	

4. TITLE AND SUBTITLE

Eelgrass and Macroalgae in Vicinity of the Proposed Service Pier Extension at Naval Base Kitsap Bangor

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

6. AUTHORS

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7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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53560 Hull Street
San Diego, CA 92152–5001

8. PERFORMING ORGANIZATION REPORT NUMBER

TR 3163

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Naval Facilities Engineering Command, NW
1101 Tautog Circle, Suite 203
Silverdale, WA 98315-1101

10. SPONSOR/MONITOR'S ACRONYM(S)

NAVFAC NW

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT

DISTRIBUTION STATEMENT A: Approved for public release.

13. SUPPLEMENTARY NOTES

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14. ABSTRACT

This report presents data collected by video and diver-surveys of the area near the Naval Base Kitsap Bangor Service Pier where a new pier structure extending the existing pier is proposed. The survey followed protocols developed by Naval Facilities Engineering Command Northwest and approved by the Army Corps of Engineers. The entire study area was investigated via boat-based video surveys, and then divers delineated the boundaries of and collected quantitative data within detected eelgrass (primarily *Zostera marina*) beds, as well as macroalgae beds of greater than 5% density that occurred within the maximum project extent boundary (which included the permanent pier footprint and a temporary work zone buffer). Two eelgrass beds were detected by video and delineated and quantified by divers. Both beds occurred in the nearshore, outside of the maximum project extent. The western bed covered 0.15 acres (609 m^2), with an average density of 40.9 *Z. marina* shoots/m^2. The eastern bed covered 0.26 acres (1,036 m^2) with an average density of 6.7 *Z. marina* shoots/m2. Macroalgae quantified within the western eelgrass bed covered an average of 19.5% of benthic substrate, and was dominated by *Sarcodiotheca gaudichaudii*. Macroalgae within the eastern eelgrass bed covered an average of 43.3% of benthic substrate, and was dominated by *Ulva spp*. Overall, macroalgae of greater than 5% density covered approximately 2.2 acres (8,892 m^2) within the total survey area. Of this, 0.13 acres (520 m^2) occurred within the maximum project extent itself. Most of the area of macroalgae greater than 5% density that intersected the maximum project extent occurred in the temporary work area (510.4 m^2) whereas only 9.6 m^2 occurred within the permanent pier footprint. Therefore, only 5.7% and 0.1% of the total macroalgae area delineated within the total survey area falls inside the temporary work zone and permanent project footprint, respectively. Within the largest portion of the macroalgae bed that was delineated within the project footprint and temporary work area (a 514 m^2 bed), the dominant macroalga was kelp (notably *Laminaria sp.*). This bed had an average macroalgal percent cover (density) of 16.7% (Braun- Blanquet cover class #2).

15. SUBJECT TERMS

Data collection; site-level observations; geo-referencing; data analysis; eelgrass; macroalgae

16. SECURITY CLASSIFICATION OF: a. REPORT	b. ABSTRACT	c. THIS PAGE	17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON / 19B. TELEPHONE NUMBER *(Include area code)*
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