Buskin River Marine Zone Study (BRiMS)

Year 1 Report:

2016 Chemical and Biological Studies

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Table of Contents

List of Tables

List of Figures

List of Acronyms

barrier bar	Buskin River barrier bar
BRiMS	Buskin River Marine Zone Study
cfs	cubic feet per second
ELW	extreme low water
HOBO	HOBO U24-002-C data logger
Kodiak Airport EIS	Environmental Impact Statement for Kodiak Airport Runway Safety Area Improvements
MHHW	mean higher high water
MLLW	mean lower low water
MSL	mean sea level
ppt	part per thousand
RSA	runway safety area

RWE	Runway End
STK	Sun’aq Tribe of Kodiak
USCG	U.S. Coast Guard

Executive Summary and Key Findings

As part of the Kodiak Airport Runway Safety Area Expansion, new armor rock was placed in the intertidal and subtidal area along the coastal edge of several runways. The Buskin River Marine Zone Study is a four-year, post-construction monitoring effort lead by the Sun'aq Tribe of Kodiak as part of the mitigation package for the Kodiak Airport Runway Safety Area Expansion project. New armor rock at Runway Ends 01 and 26 was monitored in 2016 to document recruitment and colonization of invertebrates and algae, and to provide information regarding the associated rate of increase in ecological function post-construction. Few data are available regarding colonization rates or recolonization rates post-disturbance in southcentral Alaska or high northern latitudes.

The new fill is being monitored for colonization rates, species abundance, and assemblage parameters (percent cover of algae and invertebrates). A reference site with similar habitat characteristics (substrate, exposure, depth, and salinity) is also being monitored. Sites will be sampled annually from 2016 to 2018. This study will provide information regarding nearshore marine disturbance recovery in hard-bottom habitats in southcentral Alaska. Because of the potential impacts of rock armor on aquatic habitats, on both a local scale and a cumulative landscape scale, the colonization rate of armor rock and the timeframe to which it develops higher ecological functions is important. The need and quantity of mitigation for projects that disturb marine substrates, or add new fill to existing substrates, is currently based on assumptions and this project will provide data to better inform mitigation decisions in the future.

And the end of year 1, both study sites showed extensive cover by early colonizing algae and invertebrates in both the intertidal and subtidal areas. Intertidal colonization was dominated by blue mussels (*Mytilus edulis*) at Runway End 01, whereas Runway End 26 was dominated by barnacles (*Balanus sp*. and *Cathalamus dalli*) and laver algae (*Porphyra spp*.). Runway End 26 had more bare rock than Runway End 01, but prominent bio-bands of monospecies were observed at Runway End 01. Study sites demonstrate typical early successional species diversity and abundance. As succession at the sites continues, species assemblages will likely change and the successional progression will increase the surface area for more stable community species.

Overall, reference sites had two to five times as many algae species as the study sites, further confirming the study sites are in early stages of succession. Reference sites also had two to three times as many sessile invertebrate species and 1.5 to three times as many mobile invertebrate species as the study sites. Several species of fish were observed using the new fill at Runway End 01, including juvenile black rockfish (*Sebastes melanops*) and great sculpin (*Myxocephalus polyacanthocephalus*).

In addition to colonization monitoring, salinity was also monitored to help determine the extent or change in the distribution of the Buskin River freshwater plume. Because the plume was thought to be largely driven by wind, it was anticipated the distribution of the plume may change when winds push the plume south into the new runway safety area off Runway End 26. Continuous water quality sensors were placed in the anticipated area of change modeled for the Kodiak Airport Runway Safety Area Expansion project. Ten probes were installed in the plume area to document conductivity and temperature. Monitoring stations were maintained monthly as weather allowed; probes were calibrated, anchors and moorings checked, and data downloaded and backed up. This study focused on the edges of modeled plume and areas with the highest potential variability to determine the distribution of the post-runway safety area plume.

Salinity in the study area ranged from a low of less than one parts per thousand (essentially freshwater), to a high of 30 parts per thousand (close to full seawater). The study confirmed the freshwater plume is largely driven by wind and does reach beyond the new fill at Runway End 26 under certain wind conditions. This means salmon smolts that rely on the freshwater plume for their migration to saltwater still have access to habitats south of the new fill when they are following the plume at the surface.

Introduction

The Buskin River Marine Zone Study (BRiMS) is a four-year post-construction monitoring effort lead by the Sun'aq Tribe of Kodiak (STK) as part of the mitigation package for the Kodiak Airport Runway Safety Area (RSA) Expansion project. BRiMS is focused on documenting four components of the Buskin River mouth and nearshore marine area: physical, chemical, biological, and cultural. This report summarizes the methods and initial results from year one of monitoring the chemical and biological components of BRiMS.

Project Area

The Buskin River enters Chiniak Bay just north of the Kodiak Airport (Figure 1). The nearshore marine area at the river mouth is mostly shallow sand to cobble-bottomed with varying levels of kelp density. The river mouth enters the nearshore area at the north end of the Buskin River barrier bar (barrier bar)—a sand and rock spit that has periodically migrated. Changes to the size and shape of the barrier bar, as well as the location of the outlet of the Buskin River, are evident in historical aerial photographs. The barrier bar provides a dynamic gently sloping, soft-bottomed area that is a nursery for a variety of fish species. Substrates in the Buskin River nearshore marine area become harder and more large-grained closer to Runway End (RWE) 26 and the further offshore (SWCA 2009). The area has moderate wave exposure and is mostly sheltered in Chiniak Bay.

The Buskin River freshwater plume exits the river mouth and is primarily driven by winds either north or south. The nearshore area is freshwater influenced and experiences varying levels of salinity, depending on wind, tides, and river flow (in descending importance to the distribution of the plume). Tidal range (difference between mean higher high water [MHHW] and mean lower low water [MLLW]) in Chiniak Bay is approximately 8.77 feet (Table 1).

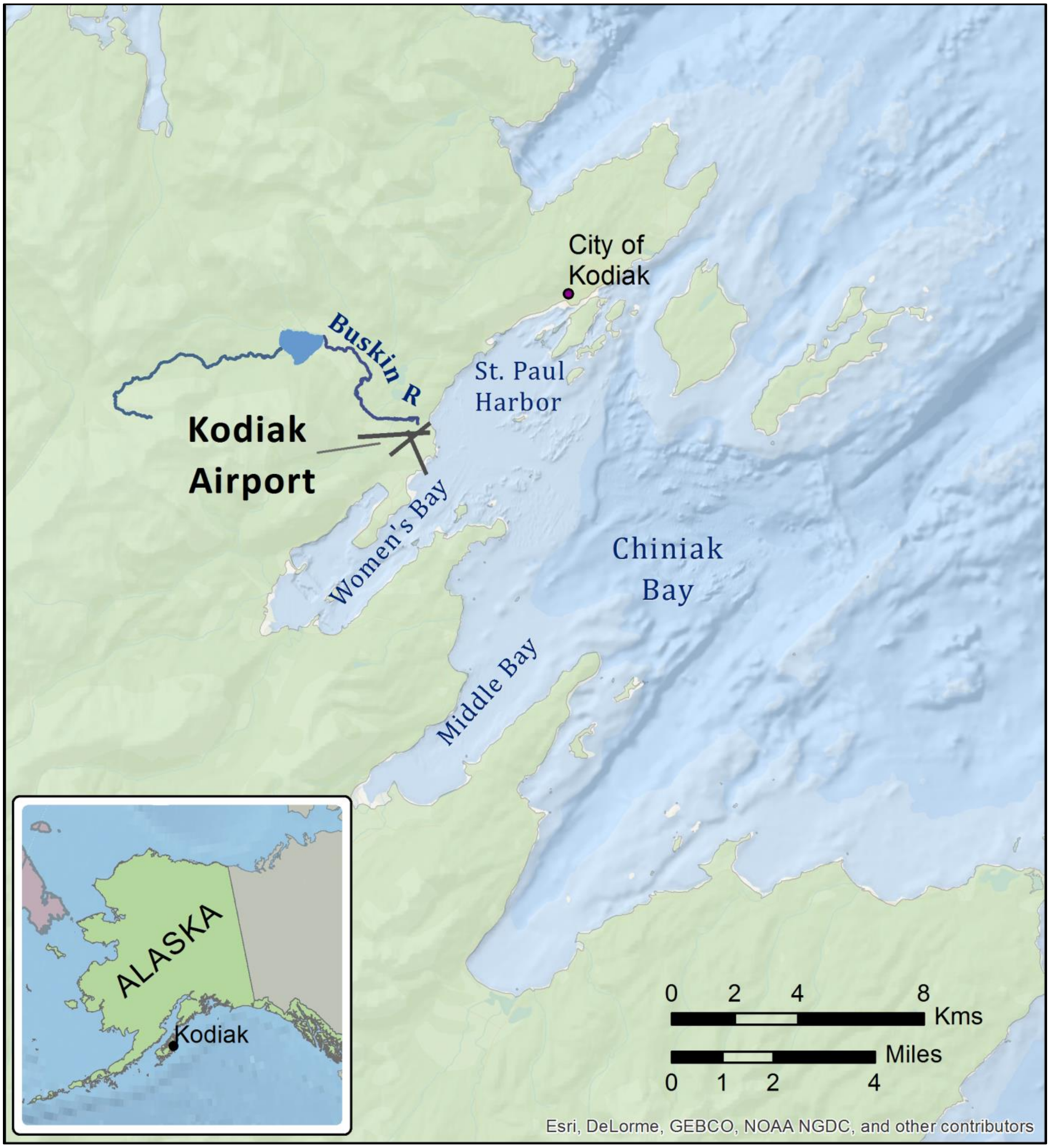
Table 1. Range of Tide Levels for Kodiak Island (NOAA 2007 in VAI 2008)

Tide Level	Project Survey (Feet-NAVD88)
Extreme High Water	14.06
High Tide Line	11.00
Mean Higher High Water	**9.53**
Mean High Water	8.63
Mean Tide Level	5.25
Mean Sea Level	5.25
Mean Low Water	1.87
Mean Lower Low Water 10	**0.76**
Extreme Low Water	-2.43

Note: Intertidal zone spans from mean higher high water to mean lower low water. Subtidal zone occurs below mean lower low water.

Average flow of the Buskin River is estimated at approximately 121 cubic feet per second (cfs), with a calculated low flow of 5.6 cfs (USGS 1990 in VAI 2008), a two-year peak discharge of 1,700 cfs, 10-year peak discharge of 2,870, and 100-year peak discharge of 4,480 (VAI 2008). On Kodiak Island, peak streamflow typically occurs in early- to mid-summer, when increased snowmelt during high temperatures combines with heavy rain events (VAI 2008). The river has a drainage area of 25.7 square miles.

Figure 1. Buskin River Area, Kodiak Island, Alaska



The Buskin River nearshore marine area is a popular subsistence use area, and the river upstream of the mouth is a popular sport fishery for a variety of salmonid species.

BRiMS study sites are described in reference to Kodiak Airport RWEs. The RSA expansion placed new fill and armor rock off RWEs 25 and 36 to create new RSAs; RWE 25 has since been renamed RWE 26, and RWE 36 has been renamed RWE 01 (Figure 2).

Figure 2. Kodiak Airport and the Buskin River Nearshore Marine Area

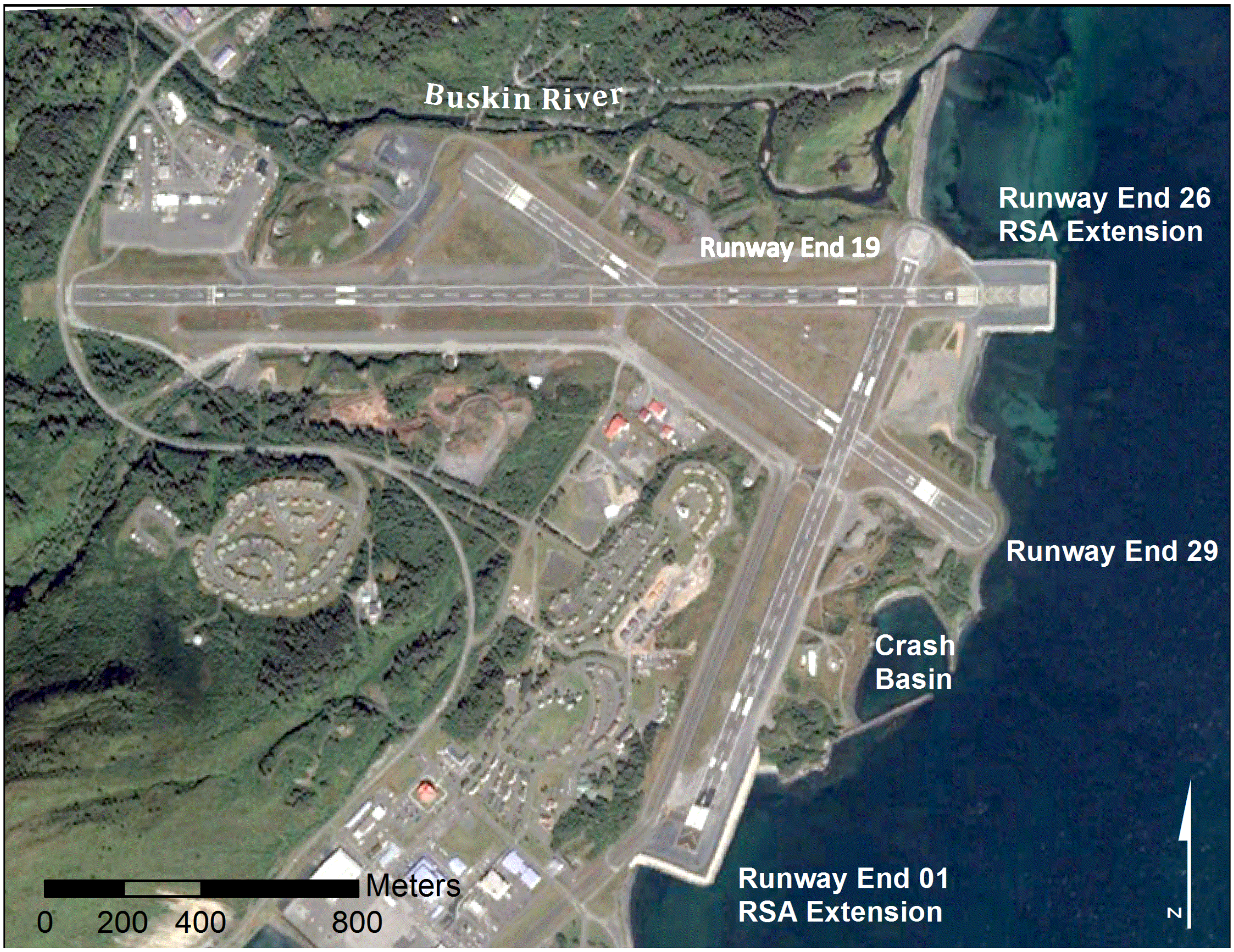


Figure 3. Runway Safety Area Expansion at Runway End 26, Showing the Buskin River and Buskin River Barrier Bar to the North

Chemical Study

Background and Need for Study

The existing Buskin River freshwater plume is driven primarily by wind and tide (Coastline Engineering and Dynamic Solutions International 2009). There are two primary wind patterns that occur at the Kodiak Airport: north-northwest (offshore) and east (onshore). The Buskin River freshwater plume was modeled for the Environmental Impact Statement for Kodiak Airport Runway Safety Area Improvements (Kodiak Airport EIS; FAA 2013). Model results indicate winds from the northwest to northeast push the freshwater plume south, and winds from the east to southwest push the plume north. Results also indicate the barrier bar area currently receives freshwater inflow (freshwater coming from the Buskin River) regardless of wind direction. As a result, the distribution of the plume extends from north of the river mouth, just east of Lake Louise, to just north of RWE 29. Because the RSA expansion occurred south of the river mouth, the southern distribution of the plume is the area of expected change and the focus of this study, i.e. east and south of RWE 26 (Figure 4).

Figure 4. Modeled Distribution of the Buskin River Freshwater Plume Pre-RSA Construction (Source: FAA 2013)

Figure 4 shows the overall distribution of the freshwater plume (approximately 102 acres) derived from vertically averaged salinities over a broad range of wind and tidal conditions. Changes to the Buskin River freshwater plume from RSA expansion alternatives were also modeled for the Kodiak Airport EIS (FAA 2013). Results indicate when the plume is blown south, it is expected to be pushed further offshore than pre-RSA conditions and not reach the shore south of RWE 26.

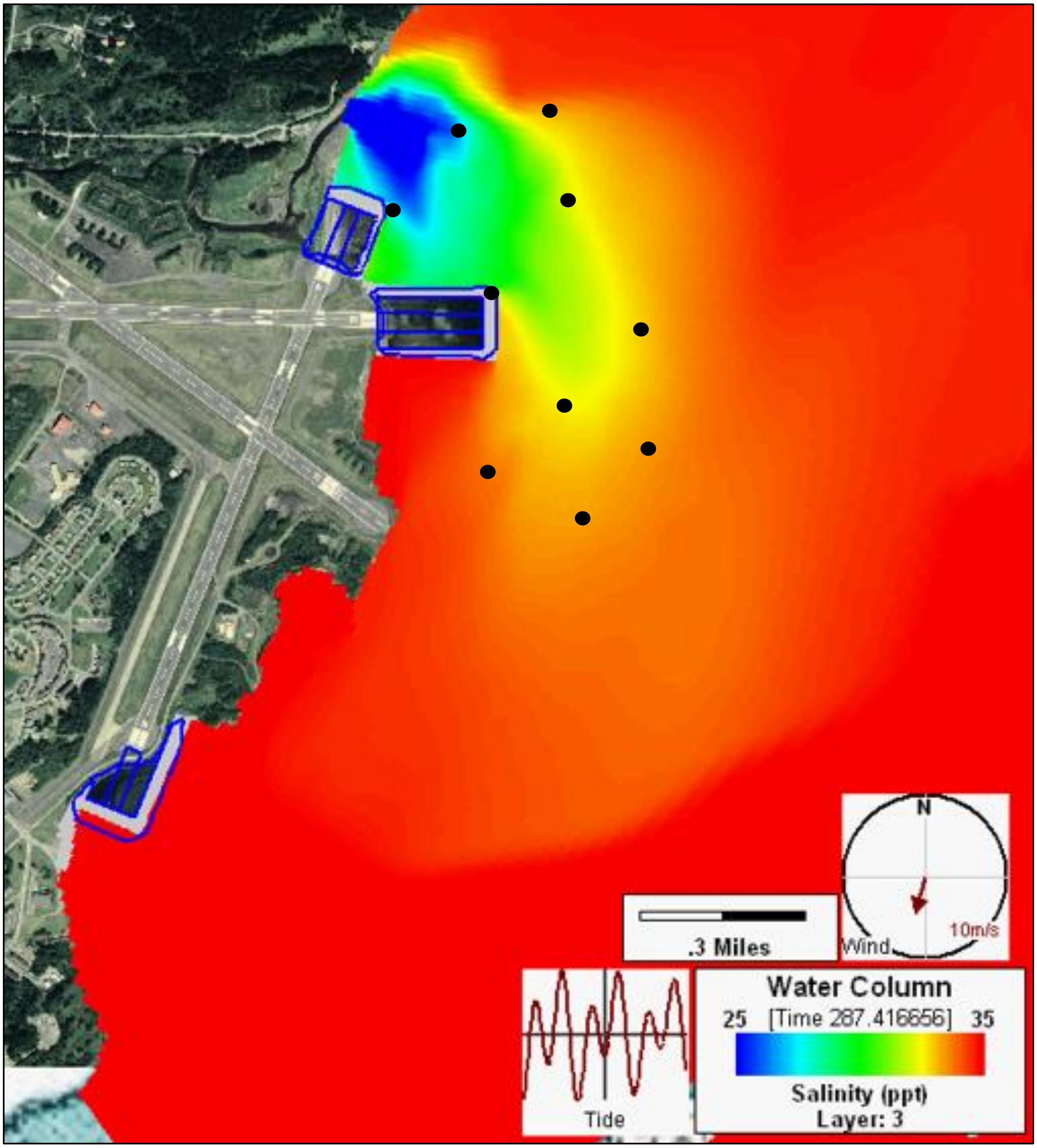
Objectives

Document the general distribution and concentration of the Buskin River freshwater plume after RSA construction.

Methods

This study focused on the edges of the modeled freshwater plume and areas with the highest potential for variability to determine the distribution of the plume post-RSA construction. Ten monitoring stations were established in October 2015 in the approximate locations shown in Figure 5, with the goal of capturing data in the area of greatest potential variability and to determine the edge of the plume.

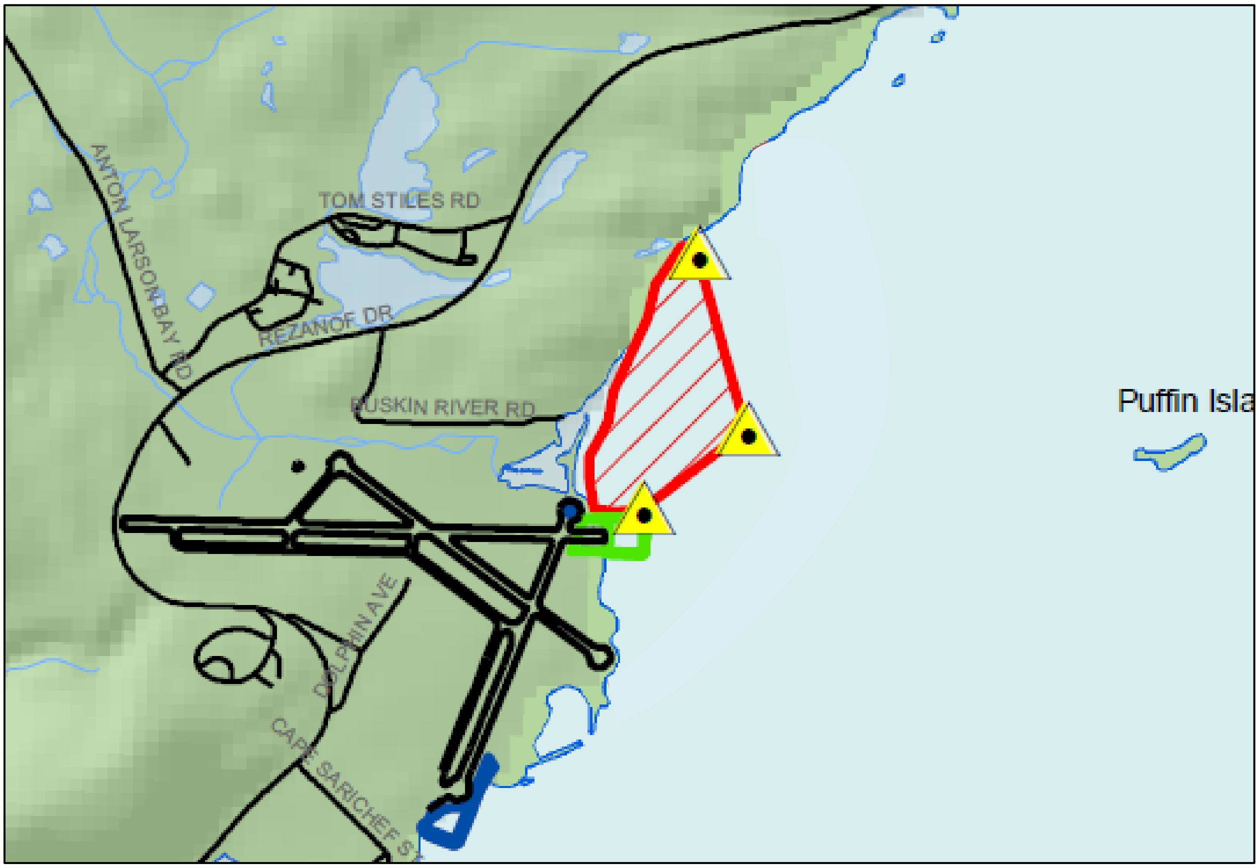
Figure 5. Modeled Changes to Buskin River Freshwater Plume Post-RSA Construction during North-Northeast Winds; Dots Depict 2016 Sample Locations



Note: Figure depicts conditions modeled for the Environmental Impact Statement for Kodiak Airport Runway Safety Area Improvements (FAA 2013) and includes an expansion to what is now Runway End 19 (the furthest north runway end shown), which was not selected as the preferred alternative and thus was not constructed. Source: Coastline Engineering and Dynamic Solutions International 2009.

Because the area of expected salinity change is partly within the subsistence fishing area, an adaptive management plan was developed to remove the stations during the fishing season if they were disrupting subsistence fishing, and reinstall them once the season closed. The stations within the subsistence exclusion area (the area where subsistence fishing is prohibited, Figure 6) would remain in place throughout the fishing season. No stations had to be removed. Because the season of greatest interest for this study is the smolt outmigration period (April through June), potentially removing the stations during adult subsistence harvest was not anticipated to affect the study.

Figure 6. Subsistence Fishing Exclusion Zone



Note: Solid red line depicts the subsistence closure area, triangles depict subsistence fishing exclusion points. Source: FAA 2013.

Ten monitoring stations were established to record hourly conductivity and temperature in the approximate locations shown in Figure 5. Stations were comprised of one HOBO U24-002-C data logger (HOBO) set at the water surface immediately below a buoy and anchored to the bottom by 1 to 3 anchors (Figure 7).

Figure 7. Monitoring Station Surface Conductivity and Temperature Arrays

The year-round monitoring stations were anchored to allow the HOBOs to remain near the surface of the water to capture the highest concentration of freshwater and to move with the tide. Specific anchoring protocols were developed and refined throughout the year as conditions warranted. Tidal range in Chiniak Bay is approximately 8.2 feet (Table 1). The subtidal area around the airport has water depths of 30 feet or less. GPS coordinates and photos were taken at each sampling station.

Monitoring stations were maintained on a monthly basis, or as weather allowed. Maintenance included:

- Checking the location of the station relative to the original GPS coordinates
- Checking the mooring line for stability, fouling, and hardware corrosion, and making any adjustments or cleaning as needed
- Calibrating the conductivity and temperature probes
- Ensuring stations were not disrupting subsistence fishing, otherwise removing stations during the subsistence fishing season and reinstalling following season closure
- Downloading data to a laptop and backing it up

Data were reviewed after each download and checked to ensure stations were functioning as needed and accurately placed to capture data from key locations or margins of the freshwater plume.

Mapping Methods

Tabular data were reviewed to identify prolonged periods of lower salinity. These data were used to interpolate salinity concentrations and distribution of the freshwater plume using grid inverse distance weighting IDW, (cell size 10 feet pixels). The ArcGIS XTOOLS extension was used to convert grid file to 2 foot contours. Wind data from NOAA (2016a, 2016b) were compared to the salinity data to assess potential drivers of salinity changes. Wind data were imported into WRPLOT wind rose plots software, and wind roses were created.

Results

Of the 10 HOBOs deployed in October 2015, only one remained in November 2016. Three of the original 10 HOBOs disappeared as early as November 2015; more were noted missing in April 2016. Four new hobos were deployed in July 2016, though several went missing again over the following months.

As of December 2016, four HOBOs were anchored and functional: stations 1, 6, 8, and 9 (Figure 8). Three of the four had previously been lost and retrieved and then redeployed. Examination of the retrieved HOBOs revealed the shackle connecting the anchors to the mooring chain had broken and appeared to be the main cause for the missing monitoring stations.

Of the data retained from the first year of monitoring, results support previous modeling for the Kodiak Airport EIS that indicated the distribution of the freshwater plume was largely driven by wind events. Several large northeasterly wind events occurred during the 2015 though 2016 data collection period and correlated to drops in salinity at the HOBO locations (Figures 9 and 10).

Wind events occurred in July and October 2016. The July wind event had two primary wind directions, northeast and northwest. As a result, the Buskin River freshwater plume was pushed north. In contrast, the October event saw winds from the northeast and east, which pushed the plume south and around the new RSA extension of RWE 26.

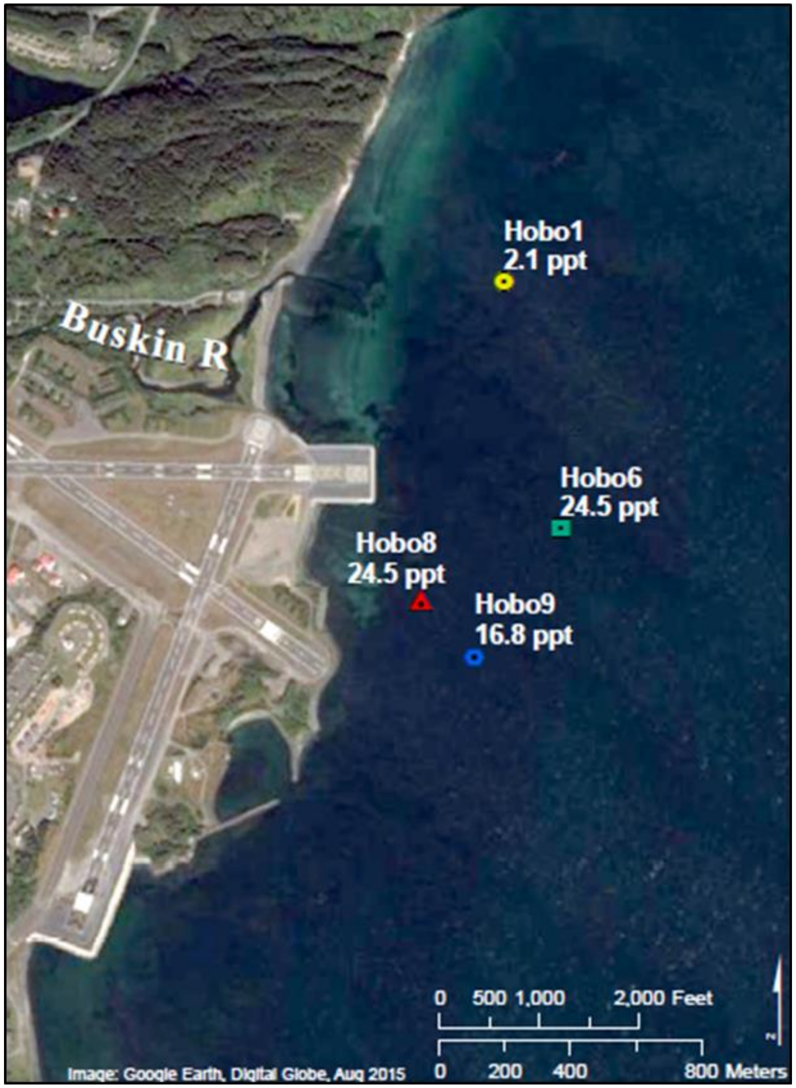
Salinity ranges for the four remaining HOBOs ranged from a low of less than 1 part per thousand (ppt) to a high of 30 ppt (Table 2). For reference, full seawater is 35 ppt. All HOBOs experienced salinities close to freshwater as well as those close to full seawater during the monitoring period, demonstrating the Buskin River freshwater plume can be pushed north and south of the river mouth depending on winds.

Table 2. Summary of HOBO data October 2015 to November 2016

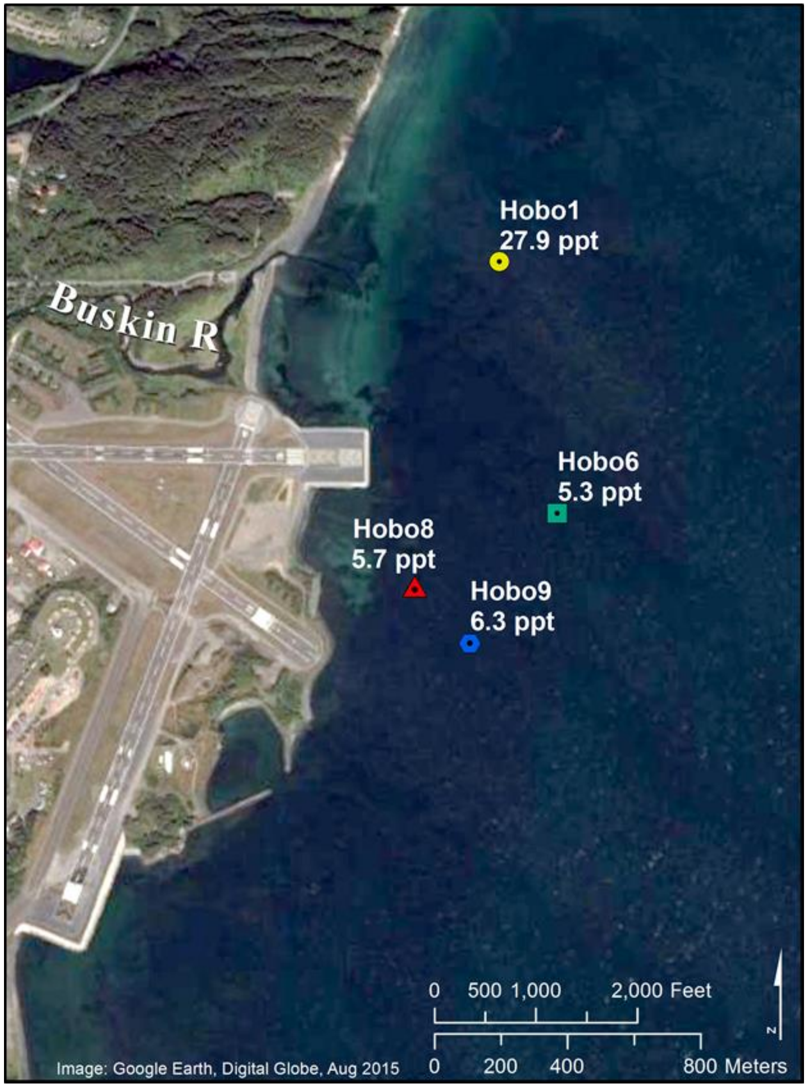
HOBO	Location Description	Minimum Salinity (ppt)	Maximum Salinity (ppt)	Median Salinity (ppt)
1	North of RWE 26	2	30	28
6	East of RWE 26	< 1	29	26
8	South of RWE 26	< 1	31	26
9	South of RWE 26	2	28	25

Notes: ppt (parts per thousand); RWE (runway end)

Figure 8. Locations of Salinity Monitoring Stations During Wind Events in July and October 2016

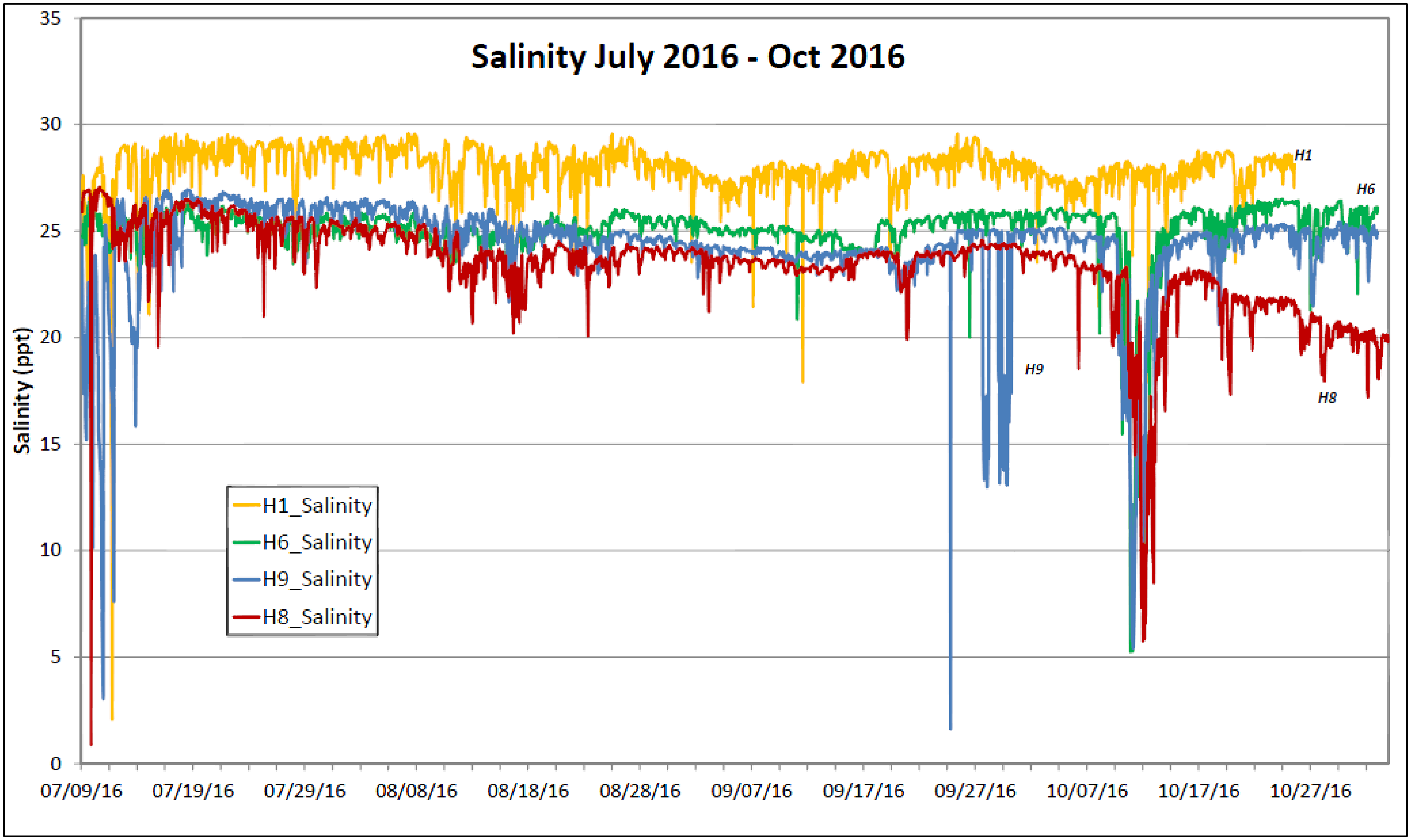


July 13, 2016



October 12, 2016

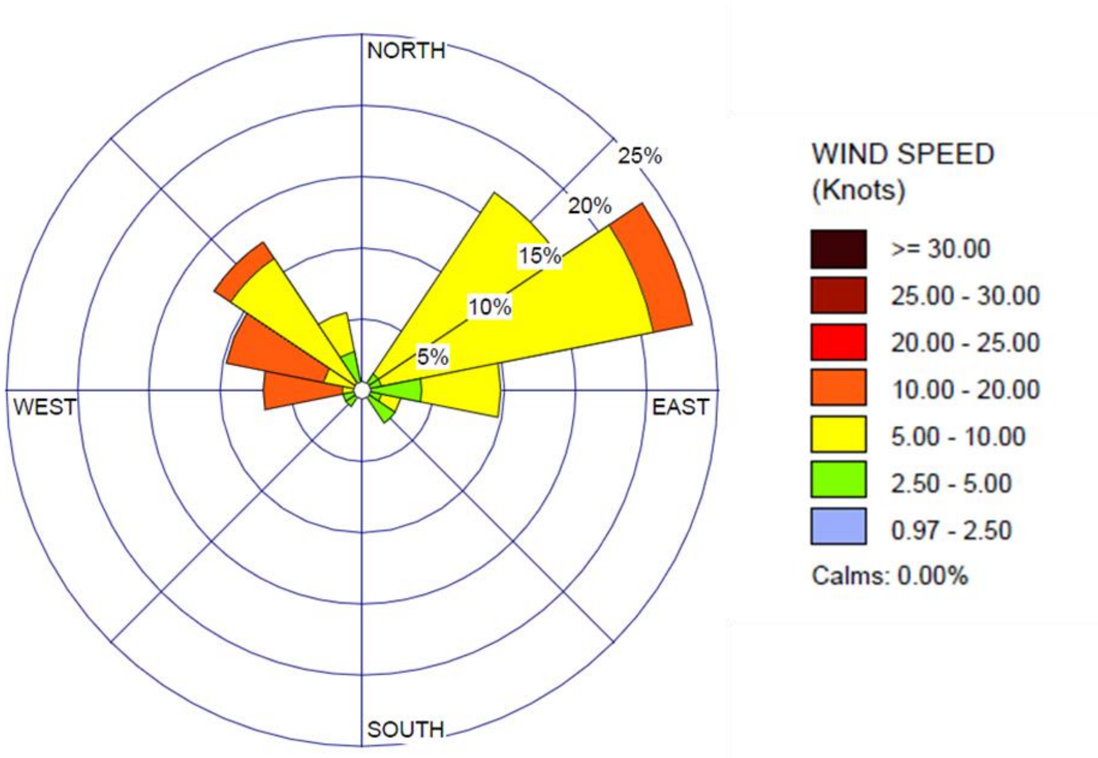
Figure 9. Salinity at Sampling Locations July through October 2016



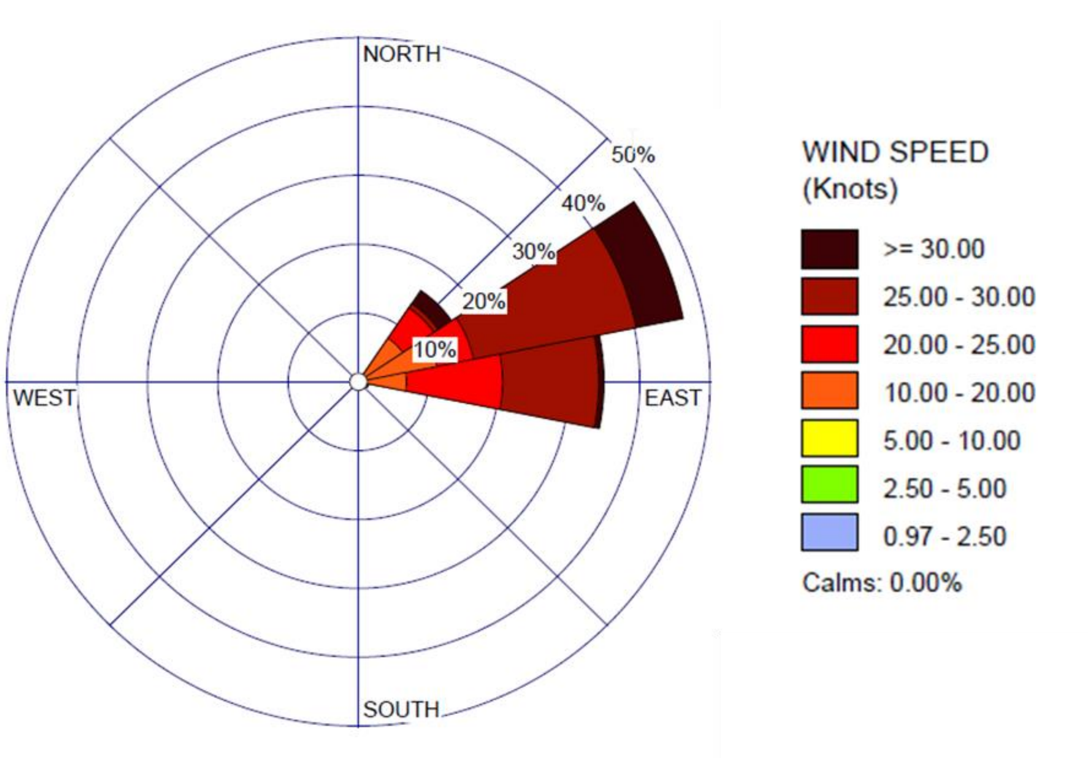
Note: ppt (parts per thousand), H (Hobo salinity meter).

Figure 10. Wind Roses for July and October 2016 Wind Events

Kodiak Airport - Wind Rose July 10-13 2016



Kodiak Airport - Wind Rose October 10-12, 2016



Discussion

The freshwater plume is driven by strong winds and waves and occurs over a dynamic shallow area, which infers the project area is inherently windblown, and experiences both active swells and wave chop. Thus, anchoring year-round monitoring equipment in the area is not only challenging, but the feasibility of maintaining the systems is limited by the very factors that drive the data being sought.

Because of these challenges with physical conditions in the project area, only four of 10 HOBOs remain deployed. This significantly reduces the amount and spread of data collected. Whether or not four data points are useful for achieving project objectives will be discussed during the winter of 2017. Should any of the HOBOs disappear during the 2017 winter, monitoring will likely be stopped due to insufficient data points.

Though the salinity dataset for BRIMS is incomplete due to challenges with anchoring the HOBO stations, and a complete map of the plume under various conditions in an annual wind cycle cannot be created with the minimal available data, some questions driving the study have been answered. The study has confirmed the freshwater plume does reach beyond the new fill at RWE 26 under certain wind conditions. This means salmon smolts that rely on the freshwater plume for their migration to saltwater still have access to habitats south of the new fill when they are following the plume at the surface.

Additionally, wind events occurred in July and October. The July event may have occurred when salmon smolts were still in the nearshore area. Juvenile coho (*Oncorhynchus kisutch)*, chum (*O. keta)*, and pink (*O. gorbuscha*) salmon, as well as juvenile and adult Dolly Varden (*Salvelinus malma)*, were common in the Buskin River nearshore area in surveys conducted in late June 2008 (SWCA 2009). Juvenile salmonids in estuarine and nearshore marine environments prefer shallow waters (less than 20 feet in depth) (Salo 1991) and are typically surface oriented (Moulton 1997; Shaffer 2002). Some species, such as pink and chum salmon, rapidly migrate to salt water and linger in the estuary or upper, less saline layers of the nearshore water column for at least several weeks until they have completed full transition to higher salinities. Therefore, wind events in July may affect smolts that are still in the nearshore area using habitats influenced by the Buskin River freshwater plume. Since the plume is reaching south of RWE 26, habitats south and east of the RWE are available to smolts, including the area of highest kelp density located just offshore between RWEs 26 and 29.

The observed data from this study and the modeled data from the Kodiak Airport EIS (Coastline Engineering and Dynamic Solutions International 2009) suggest that the Buskin River nearshore area has ecological mechanisms (salinity gradients, sediment and nutrient transport, etc.) to create estuarine conditions outside the Buskin River barrier bar. However, because the area is not enclosed, conditions are perhaps more dynamic than within a typical (enclosed) estuary system.

Lessons Learned and Next Steps

- The research team will reassess HOBO stations in the spring of 2017 and evaluate if four data points are sufficient for achieving project goals
- The research team will determine if the four stations remained intact for the duration of the winter in the spring of 2017
- If monitoring stations will remain in the field, they may be enhanced with a refined anchoring system

Biological Study

Background and Need for Study

RSA construction at what are now RWEs 26 and 01 began in the summer of 2014 and ended in March 2015. At RWE 26 a silt curtain was installed in August 2014 and removed post-construction in March of 2015. At RWE 01 the silt curtain was installed in Oct 2014 and removed post-construction in March of 2015.

Because of the potential impacts of rock armor on aquatic habitats, on both a direct local scale and a cumulative landscape scale, the colonization rate of new armor rock and the timeframe to which it develops higher ecological functions is important. Along the approximately 21-mile stretch of shoreline from north of the City of Kodiak to Womens Bay, approximately 33% of the shoreline is comprised of armor rock or impermeable human-made structure (Shorezone 2016).

Little data are available regarding colonization rates or recolonization rates post-disturbance in arctic or high northern latitudes. A study from Prudhoe Bay documented the initial recruitment of sessile organisms began after three years, but at less than 1% cover (Konar 2012). Less than 10% of boulder surfaces were colonized after seven years. A monitoring study from fill placed at the Sitka Airport RSA extension documented a faster than anticipated colonization of armor rock (Hart Crowser 2014). The study observed greater than 80% of pre-construction function in the construction area in year 2.

This study will provide information regarding recruitment and colonization of encrusting and sessile invertebrates, as well as algae, and thus provide information regarding the associated rate of increase in ecological function post-construction. The need and quantity of mitigation for projects that disturb marine substrates or add new fill to existing substrates is currently based on assumptions and this project will provide data to better inform future mitigation decisions.

Figure 11. Biological Monitoring Locations

Objectives

Quantify the colonization of newly placed armor rock at the Kodiak Airport over a four-year period and document species abundance and assemblage parameters (percent cover of algae and invertebrates) at the airport site and at a reference site of similar depth.

Methods

Three study sites and two reference sites were surveyed in June and July of 2016. Study sites occurred on the new fill at RWE 26 and 01 (Figure 11). The reference sites were outside of the construction footprint on existing armor rock that extends from the supratidal to subtidal with similar wave and salinity exposure as those within the construction area. Reference sites were established on either side of the entrance to the small boat basin, locally referred to as the crash basin, between RWEs 29 and 01 (Appendix A, Figure A10). (Though it is unknown when the crash basin was constructed, it was prior to 2002 aerial imagery. The initial construction of the airport and military facilities occurred in the 1940s.)

The Kodiak Airport is located on the U.S. Coast Guard (USCG) Base Kodiak. The USCG Base Kodiak wastewater treatment facility outfall is located approximately 1,062 feet offshore of the Crash Basin at about 11 feet below MLLW (Alaska Pollutant Discharge Elimination System permit number: AK0020648). The BRIMS reference sites are located on the outer jetties of the Crash Basin, approximately 872 to 910 feet outside of the 16 by 23 foot (4.9 by 6.9 meter) mixing zone for the outfall.

For all sites, base stations were marked with fluorescent, reflective, marine-grade paint above the high tide line so they could be readily located throughout the four-year study and GPS coordinates were captured. A 10-meter transect was marked from the base station down slope into the subtidal area, referred to as the base station line. Sampling at each site was comprised of quadrat and band sampling at up to four different elevational strata along the base station line: two or three in the intertidal depending on terrain (upper-, middle-, lower-intertidal) and one or two in the subtidal (upper and lower). Each elevational strata was marked on the base station line and a 20 meter perpendicular transect run laterally along the elevation contour (Figure 12; Appendix A, Figures A1 and A2).

Figure 12. Runway End 01 Sample Site with Base Station, Transect, and Elevational Sampling Lines Depicted (not to scale)

Intertidal Monitoring

Intertidal monitoring occurred roughly between MHHW; 9.53 feet) and extreme low water (ELW; -2.43 feet). Because the intertidal zone at the airport covers approximately nine to 12 feet of total elevation, at some sites, 2 strata were sufficient for data accuracy (Appendix A, Figure A3), and the need for two or three intertidal elevational strata was determined in the field. The general character of each intertidal elevational strata are described below.

- **Upper Intertidal**: 9.53 feet to 5.25 feet (MHHW to mean sea level [MSL], characterized by rockweed [*Fucus* sp.], laver algae [*Porphyra spp*.], and barnacles [*Balanus sp*. and *Cathalamus dalli]*; typically with low diversity and moderate productivity)
- **Middle Intertidal**: 5.25 feet to 0.76 feet (MSL to MLLW, characterized by brown and green algae with moderate diversity and moderate productivity)
- **Lower Intertidal**: 0.76 feet to -2.43 feet (MLLW to ELW, characterized by a matrix of red algae, kelps, and invertebrates)

At RWE 01, the upper- and mid-intertidal were sampled since there appeared to be homogeneity in habitat types and species assemblages and access to the lower intertidal was challenging. At RWE 26 and at the reference sites, all three intertidal strata were sampled.

Subtidal Monitoring
Intertidal monitoring occurred between ELW (-2.43 feet) and -10 feet (or the deepest extent of the new fill). Two potential elevational strata were identified for sampling.

- **Upper Subtidal**: -2.43 feet to -6 feet (characterized by kelps)
- **Lower Subtidal**: -6 feet to -10 feet

However, because the actual depth of the new fill did not extend into the lower subtidal at either study site, only the upper subtidal was sampled at RWE 01 and no subtidal transects were sampled at RWE 26. The new fill at RWE 26 extended approximately one foot into the subtidal zone before the substrate transitioned to sand.

For the subtidal elevational strata, the start and end points of the transects were located using a GPS and marked with buoys; a tape measure was strung as tightly as possible between them along the bottom (Appendix A, Figures A5 and A6). The elevation of the transect was located between the lower intertidal and the end of the new fill.

Monitoring Methods
Five randomly selected 0.25-meter quadrats along each elevation contour were sampled for percent cover of substrate type, algal species, and invertebrate species (Appendix A, Figures A4 and A7). The number of motile animals larger than 4 milimeters were documented. Photographs of each quadrat were taken and included a label showing date, transect number, and quadrat number. Very abundant species were subsampled by counting the number within a subset of the quadrat and extrapolating

to the remainder of the quadrat. Appendix A, *Study Photographs*, provides photographs of sampling sites and methods.

Band Transects

Three band transects (1 meter x 3 meters) along each 20 meter-long elevation contour (beginning at 0, 25, and 50 feet) were sampled to capture the number of larger animals that might be underrepresented in the quadrat sampling. Along each band transect, the number and relative size of animals were recorded (e.g. sea stars, urchins, crabs, chitons, etc.).

To minimize disturbance of mobile species, subtidal band transects were completed immediately upon establishing the depth benchmark and elevation strata. A tape measure was laid along the contour and a diver surveyed a 1-meter-wide band next to the tape and identified and counted species within a 3-meter-long band. Once mobile species were documented in the band transect, significant plants such as laminarian kelps (*Laminaria spp*.; adult and juvenile) were counted, photographs and video of the band captured, and the benthic assemblages characterized.

Results and Discussion

RWEs 26 and 01 were extended with different types of armor rock. RWE 26 has pre-cast concrete jacks or *dolos* (Appendix A, Figure A2) that begin in the upper intertidal and create the upslope extent of fill. The armor rock below the upper intertidal is medium-sized rock (Appendix A, Figure A8). This rock extends only about one foot into the subtidal at extreme low tides before the substrate becomes native sand from the Buskin River barrier bar (Figures 2 and 3). The seaward surface of RWE 01 is comprised entirely of large rock that range from refrigerator-sized to small car-sized. This armor rock has large chasms between individual rocks which make traversing the slope very difficult, especially in wet conditions (Appendix A, Figure A9). The armor rock extends into the upper subtidal and thus provides large interstitial spaces and cover for motile marine animals.

Both study sites showed extensive cover by early colonizing algae and invertebrates in both the intertidal and subtidal areas. Intertidal colonization was dominated by blue mussels (*Mytilus edulis*) at RWE 01, whereas RWE 26 was dominated by barnacles and laver algae. RWE 26 had more bare rock than RWE 01. Prominent biobands of monospecies were observed at RWE 01 (Appendix A, Figure A9).

Blue mussels are typical early successional species, followed by barnacle and algae, which are later successional species. Early succession favors species with planktonic larval stages that are fast growing. As concentrations mussel predators (e.g. sea stars and gastropods) move to occupy the new habitat (their movement is slower since they are not planktonic) and feed on the mussels, the sites will likely experience a sharp decline in mussels and an increase in bare rock. This successional progression opens up surface area for more stable community species, such as barnacles and algae.

Subtidal transects at RWE 01 showed relatively dense cover by a variety of algae, demonstrating potential for canopy forming algae to develop. Several species of fish were observed along the subtidal transects at RWE 01, including juvenile black rockfish (*Sebastes melanops*) and great sculpin (*Myxocephalus polyacanthocephalus*). Subtidal transects at RWE 26 were not sampled since there was little to no subtidal rock present. The majority of the new fill at RWE 26 is intertidal.

Overall, reference sites had two to five times as many algae species as the study sites (Appendix B, Table 1), further confirming the study sites are in early stages of succession. Reference sites also had two to three times as many sessile invertebrate species and 1.5 to three times as many mobile invertebrate species as the study sites. The species present at the study sites were generally less abundant than at the reference sites, except for subtidal algae at RWE 01. This area had a lower diversity of algae than the reference sites, but a higher density of the species were present.

Study sites had an average percent cover of 83% in the intertidal and 66% in the subtidal. Reference sites had an average percent cover of 81% in the intertidal and 66% in the subtidal.

Lessons Learned

- The large rock fill at the study sites made access and travel challenging due to large steep gaps between rocks and slippery terrain. Some areas were inaccessible due to safety concerns.
- Because the study and reference sites transition to soft substrate quickly in the subtidal, wind and waves substantially affect the practicability and visibility of subtidal work by churning up sand in the water column and creating waves that posed safety concerns with boat work.
- The practicable limits of wind speed and fetch on conducting safe and productive field work are now better understood.

Summary and Next Steps

Chemical

1. There are now four active stations collecting data.
2. Data from year 1 have been compiled and are being mapped.

Biological

1. Tabular data from year 1 have been compiled and received one round of quality control review.

2. Field photos have been organized and filed.
3. Initial data will be presented at the Alaska Marine Science Symposium in January 2017 (Anchorage, Alaska).
4. The potential effect of the USCG wastewater outfall on the reference sites versus the study sites will be examined.

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Appendix A

Study Photographs

Figure A1. Site Benchmark, Elevational Strata Line, and Mid-intertidal Transect Line (Runway End 01)

Figure A2. Site benchmark and Elevational Strata Line, Runway End 26

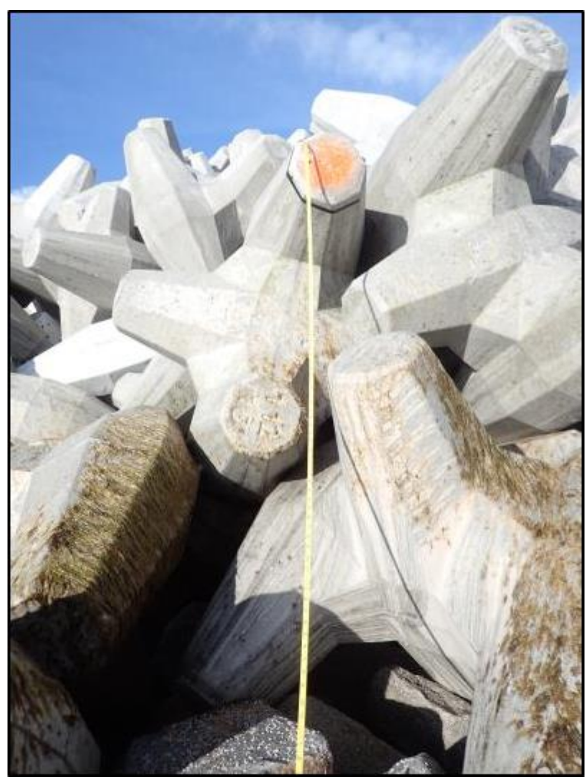
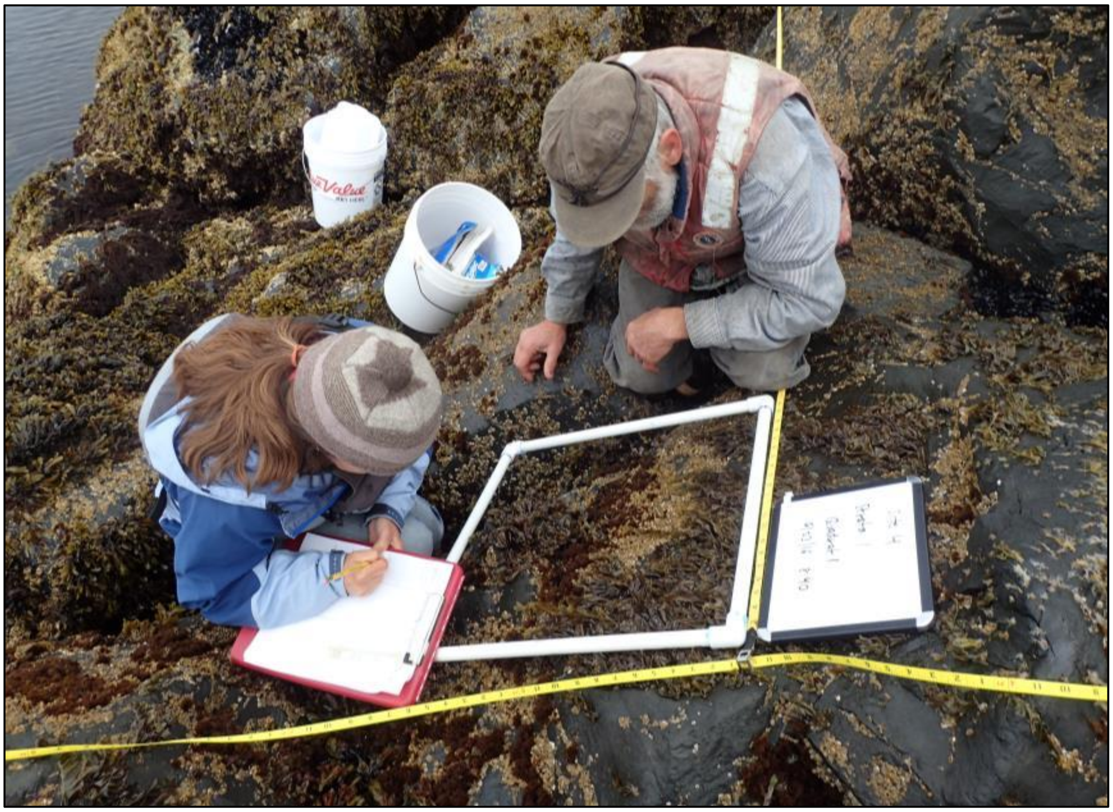


Figure A3. Lower Intertidal Transect at Reference Site

Figure A4. Intertidal Quadrat Sampling, Reference Site



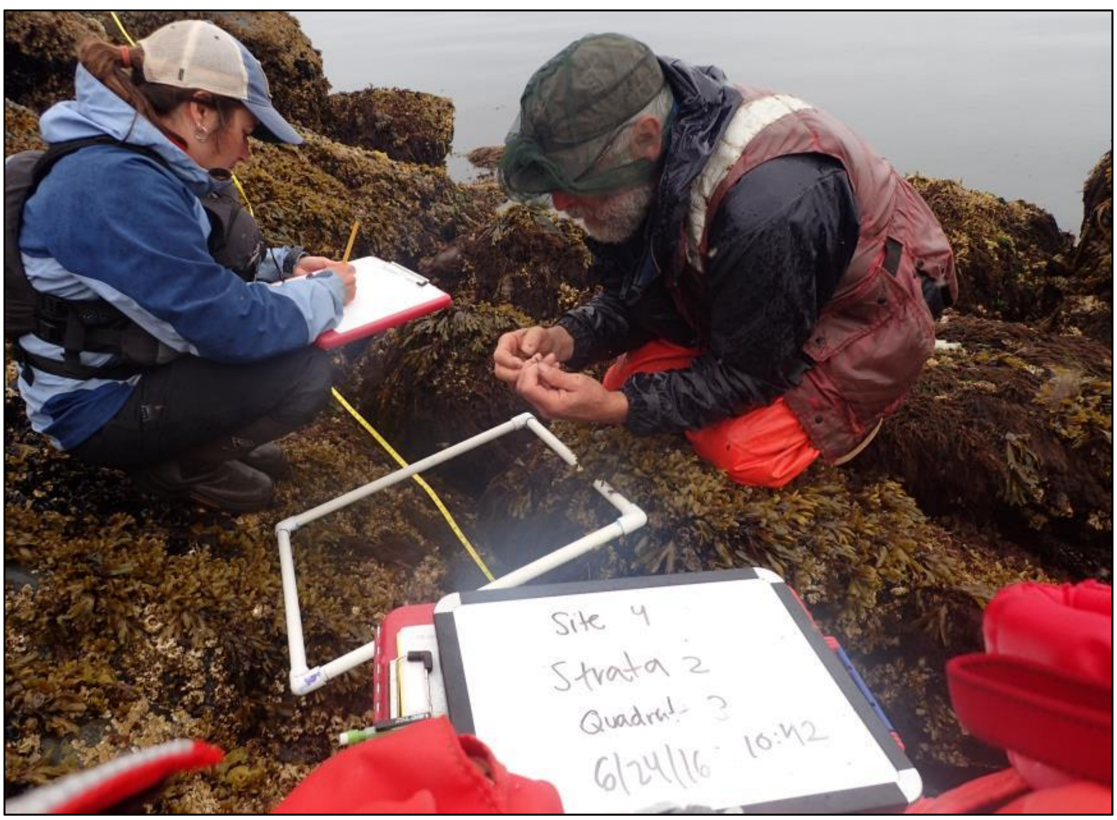


Figure A5. Establishing a Subtidal Transect at Runway End 01

Figure A6. Preparing a Subtidal Transect at Runway End 01

Figure A7. Subtidal Quadrat Sampling at Reference Site

Figure A8. Study Site 1 (Runway End 26) New Fill

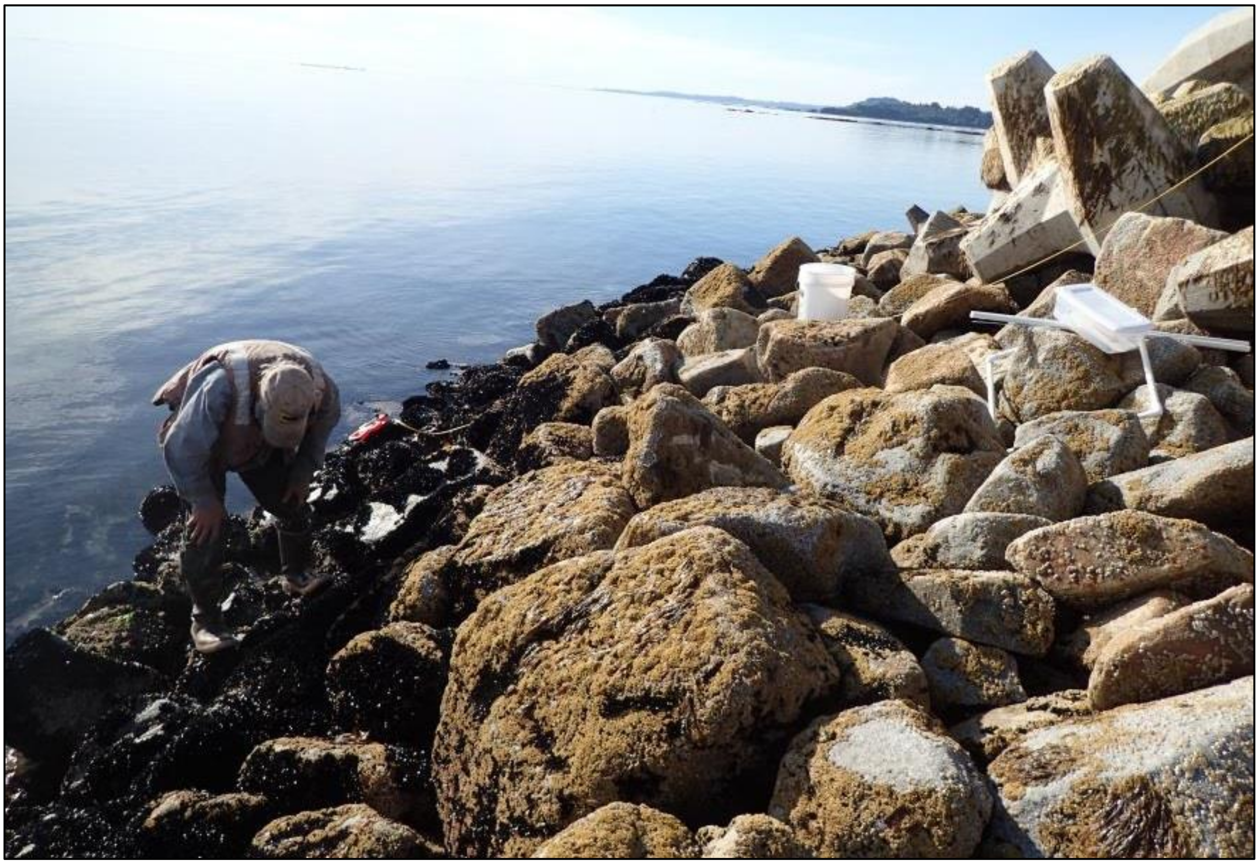


Figure A9. Study Site 2 (Runway End 01) New Fill

Figure A10. Reference Site (Crash Basin)

Appendix B

Species List and Data Tables

Table 1. Species Observed From Study Sites (Runway Ends 26 and 01) and Reference Sites (Airport Crash Basin Jetties)

Taxon	Common Name	Study Sites	Reference Sites
Algae			
Acrosiphonia arcta	Arctic sea moss	X	X
Alaria marginata	Ribbon kelp	X	X
Analipus japonicus	Bottlebrush seaweed		X
Bangia sp.	Black sea hair	X	X
Chordaria flagelliformis	Chocolate pencils		X
Cladophora sericea	Graceful green hair		X
Coralline unknown	Encrusting coralline red algae		X
Corallina frondescens	Enigmatic coral seaweed		X
Corallina vancouveriensis	Graceful coral seaweed		X
Desmarestia viridis	Stringy acid kelp	X	X
Endocladia muricata	Sea moss		X
Fucus distichus subsp. evanescens	Rockweed	X	X
Halosaccion glandiforme	Sea sac	X	X
Laminaria setchellii	Southern stiff-stiped kelp	X	
Laminaria yezoensis	Suction-cup kelp		X
Mastocarpus papillatus	Turkish washcloth		X
Mazzaella heterocarpa	Mazzaella		X
Microcladia sp. (Possibly *M. coulteri)*	Sea Lace		X
Neoptilota asplenioides	Sea fern		X
Neorhodomela larix	Black pine		X
Neorhodomela oregona	Oregon pine		X
Odonthalia floccosa	Sea brush		X
Palmaria callophylloides	Frilly red ribbon	X	X
Palmaria hecatensis	Stiff red ribbon	X	X
Palmaria sp.	Ribbon sp.	X	X
Palmaria mollis	Red ribbon	X	X
Petalonia fascia	False kelp		X
Porphyra sp. (possibly *P. psuedolanceolata)*	Porphyra sp.	X	
Porphyra fallax	False laver	X	
Porphyra fucicola	Rockweed laver		X
Porphyra perforata	Purple laver	X	X
Porphyra psuedolanceolata	Olive green winter laver	X	X
Porphyra sp.	Laver sp.		X

Taxon	Common Name	Study Sites	Reference Sites
Porphyra variegata	Kjellman's laver		X
Pterosiphonia bipinnata	Black tassel		X
Saccharina latissima	Sugar kelp	X	X
Saccharina sessilis	Sea cabbage		X
Scytosiphon lamentaria	Soda straws		X
Ulva lactuca (formerly *U. fenestrata)*	Sea lettuce	X	X
Ulva sp.	Ulva sp.	X	X
Unknown	Encrusting green algae		X
Unknown	Felty brown algae		X
Unknown	Felty red-brown brushy algae		X
Unknown	Red filamentous algae	X	
Unknown	Red finely-branched filamentous epiphytic algae		X
Total Number of Algae Species		**19**	**42**
Sessile Animals			
Aplidium coei	Sea Pork (tunicate)		X
Balanus sp. (Dead)	Acorn barnacle		X
*Balanus sp.**	Acorn barnacle	X	X
Chthamalus dalli	Little brown barnacle	X	X
Entodesma saxicola	Northwest ugly clam		X
Eudistylia vancouveri	Northern feather duster worm		X
Halichondria panicea	Crumb of bread sponge (green encrusting sponge)		X
Haliclona permollis	Purple encrusting sponge		X
Lagenicella punctulata	Bryozoan sp.		X
Mytilus edulis	Blue mussel	X	X
Semibalanus balanoides	White barnacle		X
Semibalanus cariosus	Thatched barnacle		X
Unknown sp.	Orange sponge	X	X
Unknown sp.	Anemone	X	X
Unknown sp.	Tiny red anemone		X
Urticina coriacea	Stubby rose anemone		X
Urticina grebelnyi	Christmas anemone, painted anemone		X
Total Number of Sessile Species		**5**	**17**
Motile Animals			
Amphissa columbiana	Wrinkled dove snail		X
Metacarcinus magister (formerly	Dungeness crab	X	

Taxon	Common Name	Study Sites	Reference Sites
Cancer magister)			
Evasterias troscheli	Mottled star	X	
Henricia leviuscula	Blood star		X
Katharina tunicata	Black gum boot chiton		X
Lacuna variegata	Variegated lacuna		X
Leptasterias hexactis	Rough six-armed sea star		X
Littorina plena	Black periwinkle	X	X
Littorina sitkana	Sitka periwinkle	X	X
Lottia digitalis	Fingered limpet	X	X
Lottia pelta	Shield limpet		X
Margarites pupillus	Puppet margarite	X	
Nereis vexillosa	Pile worm	X	
Notoplana sp.	Common flatworm		X
Nucella lima	File dogwinkle	X	X
Nucella lamellosa	Dogwinkle	X	X
Numerous species	Hermit crabs	X	X
Paranemertes peregrina	Ribbon worm	X	X
Pentidotea wosnesenskii	Rockweed sowbug		X
Searlesia dira	Dire whelk		X
Siphonaria thersites	Pacific false limpet		X
Spinulogammarus carinatus	Isopod, spiny beach flea	X	
Tectura persona	Mask Limpet	X	X
Tectura scuta	Plate limpet	X	X
Telmessus cheiragonus	Helmet crab	X	
Unknown sp.	7 rayed star		X
Total Number of Mobile Species		**15+**	**20+**
Band Transect Animals			
Ligia pallasi	Sea slater	X	X
Myxocephalus polyacanthocephalus	Great sculpin	X	X
Odocoileus hemionus sitkensis	Sitka black-tailed deer		X
Pugettia gracilis	Graceful kelp crab		X
Sebastes melanops	Juvenile black rockfish	X	
Unknown	Greenling		X
Unknown	Jellyfish		X
Vulpes vulpes	Red fox		X
Total Number of Mobile Band Transect Species		**3**	**7**

**Balanus* mats could include *Semibalanus*
+ Some rows could represent multiple species and thus totals presented are minimum numbers.

Table 2. Intertidal Species Abundance in 0.25 m^2 Quadrats from Study Sites (Runway Ends 26 and 01) and Reference Sites (Airport Crash Basin Jetties)

Taxon	Common Name	Reference Sites (n=2)			Total (n=6)	Study Sites (n=3)			Total (n=9)
		Transect 1 Upper Intertidal	Transect 2 Mid Intertidal	Transect 3 Lower Intertidal		Transect 1 Upper Intertidal	Transect 2 Mid intertidal	Transect 3 Lower Intertidal	
Algae (Percent Cover)									
Acrosiphonia arcta	Arctic sea moss	--	1.6	3.5	1.7	0.33	1	--	0.44
Alaria marginata	Ribbon kelp	--	0.1	2.6	0.9	--	0.33	--	0.11
Analipus japonicus	Bottlebrush seaweed	--	--	0.1	0.03	--	--	--	--
Bangia sp.	Black sea hair	--	--	--	--	--	--	--	--
Chordaria flagelliformis	Chocolate pencils	--	--	--	--	--	--	--	--
Cladophora sericea	Graceful green hair	--	--	--	--	--	--	--	--
Coralline unknown	Encrusting coralline red algae	--	0.1	0.9	0.03	--	--	--	--
Corallina frondescens	Enigmatic coral seaweed	--	--	0.4	0.03	--	--	--	--
Corallina vancouveriensis	Graceful coral seaweed	--	--	0.4	0.13	--	--	--	--
Desmarestia viridis	Stringy acid kelp	--	--	--	--	--	--	--	--
Endocladia muricata	Sea moss	--	0.2	--	0.07	--	--	--	--
Fucus distichus subsp. evanescens	Rockweed	9.3	23.4	2.3	11.67	0.07	--	--	0.02
Halosaccion glandiforme	Sea sac	--	--	--	--	--	--	--	--
Laminaria setchellii	Southern stiff-stiped kelp	--	--	--	--	--	--	--	--
Laminaria yezoensis	Suction-cup kelp	--	--	--	--	--	--	--	--
Mastocarpus papillatus	Turkish washcloth	0.1	--	--	0.03	--	--	--	--
Mazzaella heterocarpa	Mazzaella	--	--	--	--	--	--	--	--
Microcladia sp. (Possibly *M. coulteri*)	Sea Lace	--	--	0.5	0.17	--	--	--	--

Taxon	Common Name	Reference Sites (n=2)			Total (n=6)	Study Sites (n=3)			Total (n=9)
		Transect 1 Upper Intertidal	Transect 2 Mid Intertidal	Transect 3 Lower Intertidal		Transect 1 Upper Intertidal	Transect 2 Mid intertidal	Transect 3 Lower Intertidal	
Neoptilota asplenioides	Sea fern	--	--	--	--	--	--	--	--
Neorhodomela larix	Black pine	3.6	3.9	3.2	3.57	--	--	--	--
Neorhodomela oregona	Oregon pine	4.1	3.5	2	3.2	--	--	--	--
Odonthalia floccosa	Sea brush	0.5	--	3.8	1.43	--	--	--	--
Palmaria callophylloides	Frilly red ribbon	--	--	--	--	--	--	--	--
Palmaria hecatensis	Stiff red ribbon	--	--	--	--	--	--	0.2	0.02
Palmaria mollis	Red ribbon	--	0.1	0.3	0.13	--	--	--	--
Palmaria sp.	Ribbon sp.	--	0.2	--	0.07	--	0.07		0.02
Petalonia fascia	False kelp	--	0.3	--	0.1	--	--	--	--
Porphyra fallax	False laver	--	--	--	--	10.4	--	1	3.58
Porphyra fucicola	Rockweed laver	0.1	1.2	--	0.43	--	--	--	--
Porphyra perforata	Purple laver	--	--	0.3	0.10	--	--	--	--
Porphyra psuedolanceolata	Olive green winter laver	5.1	--	--	1.70	1.93	0.07	--	0.67
Porphyra sp. (possibly *P. psuedolanceolata)*	Porphyra sp.	--	--	--	--	2.2	--	--	0.73
Porphyra sp.	Laver sp.	--	0.3	--	0.10	--	--	--	--
Porphyra variegata	Kjellman's laver	--	--	--	--	--	--	--	--
Pterosiphonia bipinnata	Black tassel	3.3	--	--	1.1	--	--	--	--
Saccharina latissima	Sugar kelp	--	--	--	--	--	--	--	--
Saccharina sessilis	Sea cabbage	--	--	--	--	--	--	--	--
Scytosiphon lamentaria	Soda straws	--	--	--	--	--	--	--	--
Ulva lactuca (formerly *U. fenestrata)*	Sea lettuce	0.1	0.3	0.6	0.33	0.07	--	2.22	2.7
Ulva sp.	Ulva sp.	--	--	0.1	0.03	--	--	--	--

Taxon	Common Name	Reference Sites (n=2) Transect 1 Upper Intertidal	Reference Sites (n=2) Transect 2 Mid Intertidal	Reference Sites (n=2) Transect 3 Lower Intertidal	Total (n=6)	Study Sites (n=3) Transect 1 Upper Intertidal	Study Sites (n=3) Transect 2 Mid intertidal	Study Sites (n=3) Transect 3 Lower Intertidal	Total (n=9)
Unknown	Encrusting green algae	--	0.1	--	0.03	--	--	--	--
Unknown	Felty brown algae	--	0.6	0.5	0.37	--	--	--	--
Unknown	Felty red-brown brushy algae	--	0.3	--	0.1	--	--	--	--
Unknown	Red filamentous algae	--	--	--	--	0.27	--	--	0.09
Unknown	Red finely-branched filamentous epiphytic algae	--	--	--	--	--	--	--	--
Total Number of Algae Species		**9**	**16**	**16**	**26**	**7**	**4**	**3**	**10**
Sessile Animals (Percent Cover)									
Aplidium coei	Sea Pork (tunicate)	--	--	--	--	--	--	--	--
Balanus sp. (Dead)	Acorn barnacle	--	--	--	--	--	--	--	--
*Balanus sp.**	Acorn barnacle	21.5	17.8	30.2	23.17	49.73	16.53	29.6	25.38
Chthamalus dalli	Little brown barnacle	20.4	3	0.2	7.87	2.33	0.47	2	1.16
Entodesma saxicola	Northwest ugly clam	--	--	--		--	--	--	--
Eudistylia vancouveri	Northern feather duster worm	--	0.6	6.7	2.43	--	--	--	--
Halichondria panicea	Crumb of bread sponge (green encrusting sponge)	--	0.4	0.8	0.4	--	--	--	--
Haliclona permollis	Purple encrusting sponge	--	0.4	0.2	0.2	--	--	--	--
Katharina tunicata	Black gum boot chiton	0.1	0.3	0.7	0.37	--	--	--	--
Lagenicella punctulata	Bryozoan sp.	--	--	--	--	--	--	--	--
Lottia digitalis	Fingered limpet	--	--	--	--	--	--	--	--
Lottia pelta	Shield limpet	0.1	--	--	0.33	--	--	--	--
Mytilus edulis	Blue mussel	6.4	10.7	--	5.7	4	73.27	41	30.31

Taxon	Common Name	Reference Sites (n=2) Transect 1 Upper Intertidal	Transect 2 Mid Intertidal	Transect 3 Lower Intertidal	Total (n=6)	Study Sites (n=3) Transect 1 Upper Intertidal	Transect 2 Mid intertidal	Transect 3 Lower Intertidal	Total (n=9)
Semibalanus balanoides	White barnacle	--	--	0.6	0.2	--	--	--	--
Semibalanus cariosus	Thatched barnacle	--	15.6	10	8.53	--	--	--	--
Tectura persona	Mask Limpet	0.1	0.3	--	0.13	0.07	0.13	--	0.07
Tectura scuta	Plate limpet	--	--	0.1	0.03	--	--	--	--
Unknown sp.	Orange sponge	--	--	--	--	--	--	--	--
Unknown sp.	Anemone	--	--	0.7	0.23	--	--	--	--
Unknown sp.	Tiny red anemone	--	0.2	--	0.07	--	--	--	--
Urticina coriacea	Stubby rose anemone	--	--	0.5	0.17	--	--	--	--
Urticina grebelnyi	Christmas anemone, painted anemone	0.3	0.2	0.7	0.4	--	--	--	--
Total Number of Sessile Species		**7**	**11**	**12**	**16**	**4**	**4**	**3**	**4**
Motile Animals (Percent Cover)									
Amphissa columbiana	Wrinkled dove snail	--	--	0.2	0.07	--	--	--	--
Metacarcinus magister (formerly Cancer magister)	Dungeness crab	--	--	--	--	--	--	--	--
Evasterias trocheli	Mottled star	--	--	--	--	--	--	--	--
Henricia leviuscula	Blood star	--	0.2	0.1	0.1	--	--	--	--
Lacuna variegata	Variegated lacuna	--	--	--	--	--	--	--	--
Leptasterias hexactis	Rough six-armed sea star	--	--	0.1	0.03	--	--	--	--
Littorina plena	Black periwinkle	--	--	--	--	0.27	--	--	0.09
Littorina sitkana	Sitka periwinkle	--	--	--	--	--	--	--	--
Margarites pupillus	Puppet margarite	--	--	--	--	--	--	--	--
Notoplana sp.	Common flatworm	--	--	--	--	--	--	--	--
Nucella lima	File dogwinkle	--	0.4	0.6	0.33	--	0.07	1.2	0.16
Nucella lamellosa	Dogwinkle	--	--	0.2	0.07	--	--	--	--

Taxon	Common Name	Reference Sites (n=2)			Total (n=6)	Study Sites (n=3)			Total (n=9)
		Transect 1 Upper Intertidal	Transect 2 Mid Intertidal	Transect 3 Lower Intertidal		Transect 1 Upper Intertidal	Transect 2 Mid intertidal	Transect 3 Lower Intertidal	
Paranemertes peregrina	Ribbon worm	--	--	0.1	0.03	--	--	--	--
Pentidotea wosnesenskii	Rockweed sowbug	--	--	--	--	--	--	--	--
Nereis vexillosa	Pile worm	--	--	--	--	--	--	--	--
Searlesia dira	Dire whelk	--	--	--	--	--	--	--	--
Siphonaria thersites	Pacific false limpet	--	--	--	--	--	--	--	--
Spinulogammarus carinatus	Isopod, spiny beach flea	--	--	--	--	--	--	--	--
Telmessus cheiragonus	Helmet crab	--	--	--	--	--	--	--	--
Unknown	7 rayed star	--	--	--	--	--	--	--	--
Unknown – numerous species	Hermit crabs	--	--	--	--	--	--	--	--
Total number of Mobile Species		**1**	**2**	**6**	**6**	**1**	**1**	**1**	**2**
Band Transect Animals (Total Number of Animals)									
Ligia pallasii	Sea slater	--	1	--	1	--	1	--	--
Myxocephalus polyacanthocephalus	Great sculpin	--	1	--	1	--	--	--	--
Odocoileus hemionus sitkensis	Sitka black-tailed deer	--	--	--	--	--	--	--	--
Pugettia gracilis	Graceful kelp crab	--	--	1	1	--	--	--	--
Sebastes melanops	Juvenile black rockfish	--	--	--	--	--	--	--	--
Unknown	Greenling	--	--	--	--	--	--	--	--
Unknown	Jellyfish	--	--	--	--	--	--	--	--
Vulpes vulpes	Red fox	--	--	--	--	--	--	--	--
Total Number of Mobile Band Transect Species		**0**	**2**	**1**	**3**	**0**	**1**	**0**	**1**

Note: All transects have 5 quadrats
**Balanus* mats could include *Semibalanus*

Table 3. Subtidal Species Abundance in 0.25 m² Quadrats from Study Sites (Runway Ends 26 and 01) and Reference Sites (Airport Crash Basin Jetties)

Taxon	Common Name	Reference Sites (n=2)	Study Sites (n=2)
		Transect 1 Subtidal (Quadrats n=5)	Transect 1 Subtidal (Quadrats n=5)
Algae (Percent Cover)			
Acrosiphonia arcta	Arctic sea moss	--	--
Alaria marginata	Ribbon kelp	15.7	23
Analipus japonicus	Bottlebrush seaweed	--	--
Bangia sp.	Black sea hair	--	--
Chordaria flagelliformis	Chocolate pencils	2.5	--
Cladophora sericea	Graceful green hair	0.2	--
Coralline unknown	Encrusting coralline red algae	17.3	--
Corallina frondescens	Enigmatic coral seaweed	1	--
Corallina vancouveriensis	Graceful coral seaweed	1.9	--
Desmarestia viridis	Stringy acid kelp	2.1	17.3
Endocladia muricata	Sea moss	--	--
Fucus distichus subsp. evanescens	Rockweed	--	--
Halosaccion glandiforme	Sea sac	--	--
Laminaria setchellii	Southern stiff-stiped kelp	--	3
Laminaria yezoensis	Suction-cup kelp	0.35	--
Mastocarpus papillatus	Turkish washcloth	--	--
Mazzaella heterocarpa	Mazzaella	--	--
Microcladia sp. (Possibly *M. coulteri)*	Sea Lace	--	--
Neoptilota asplenioides	Sea fern	0.2	--
Neorhodomela larix	Black pine	--	--
Neorhodomela oregona	Oregon pine	--	--
Odonthalia floccosa	Sea brush	4.7	--
Palmaria callophylloides	Frilly red ribbon	0.5	--
Palmaria hecatensis	Stiff red ribbon	--	--
Palmaria sp.	Ribbon sp.	--	--
Palmaria mollis	Red ribbon	15.4	1.9
Petalonia fascia	False kelp	--	--
Porphyra sp. (possibly P. psuedolanceolata)	Porphyra sp.	--	--
Porphyra fallax	False laver	--	--
Porphyra fucicola	Rockweed laver	--	--
Porphyra perforata	Purple laver	--	1

Taxon	Common Name	Reference Sites (n=2)	Study Sites (n=2)
		Transect 1 Subtidal (Quadrats n=5)	Transect 1 Subtidal (Quadrats n=5)
Porphyra psuedolanceolata	Olive green winter laver	--	--
Porphyra sp.	Laver sp.	--	--
Porphyra variegata	Kjellman's laver	2.5	--
Pterosiphonia bipinnata	Black tassel	--	--
Saccharina latissima	Sugar kelp	2.75	8.8
Saccharina sessilis	Sea cabbage	1.2	--
Scytosiphon lamentaria	Soda straws	0.1	--
Ulva lactuca (formerly *U. fenestrata)*	Sea lettuce	0.4	0.3
Ulva sp.	Ulva sp.	--	0.3
Unknown	Encrusting green algae	--	--
Unknown	Felty brown algae	--	--
Unknown	Felty red-brown brushy algae	--	--
Unknown	Red filamentous algae	--	--
Unknown	Red finely-branched filamentous epiphytic algae	--	--
	Total Number of Algae Species	**17**	**7**
Sessile Animals (Percent Cover)			
Aplidium coei	Sea Pork (tunicate)	--	--
Balanus sp. (Dead)	Acorn barnacle	4	--
*Balanus sp.**	Acorn barnacle	30.7	20.2
Chthamalus dalli	Little brown barnacle	0.2	--
Entodesma saxicola	Northwest ugly clam	--	--
Eudistylia vancouveri	Northern feather duster worm	6.1	--
Halichondria panicea	Crumb of bread sponge (green encrusting sponge)	--	--
Haliclona permollis	Purple encrusting sponge	--	--
Katharina tunicata	Black gum boot chiton	0.1	--
Lagenicella punctulata	Bryozoan sp.	0.1	--
Lottia digitalis	Fingered limpet	--	--
Lottia pelta	Shield limpet	--	--
Mytilus edulis	Blue mussel	--	36.8
Semibalanus balanoides	White barnacle	--	--
Semibalanus cariosus	Thatched barnacle	--	--
Tectura persona	Mask Limpet	--	--
Tectura scuta	Plate limpet	0.1	--

Taxon	Common Name	Reference Sites (n=2) Transect 1 Subtidal (Quadrats n=5)	Study Sites (n=2) Transect 1 Subtidal (Quadrats n=5)
Unknown sp.	Orange sponge	--	--
Unknown sp.	Anemone	--	--
Unknown sp.	Tiny red anemone	--	--
Urticina coriacea	Stubby rose anemone	--	--
Urticina grebelnyi	Christmas anemone, painted anemone	--	--
	Total Number of Sessile Species	**6**	**2**
Motile Animals (Percent Cover)			
Amphissa columbiana	Wrinkled dove snail	--	--
Metacarcinus magister (formerly Cancer magister)	Dungeness crab	--	0.1
Henricia leviuscula	Blood star	--	--
Lacuna variegata	Variegated lacuna	--	--
Leptasterias hexactis	Rough six-armed sea star	--	--
Littorina plena	Black periwinkle	--	--
Littorina sitkana	Sitka periwinkle	--	--
Margarites pupillus	Puppet margarite	--	--
Nucella lima	File dogwinkle	0.1	--
Nucella lamellosa	Dogwinkle	--	--
Paranemertes peregrina	Ribbon worm	--	--
Pentidotea wosnesenskii	Rockweed sowbug	--	--
Evasterias trocheli	Mottled star	--	0.1
Nereis vexillosa	Pile worm	--	--
Searlesia dira	Dire whelk	--	--
Spinulogammarus carinatus	Isopod, spiny beach flea	--	--
Telmessus cheiragonus	Helmet crab	--	--
Notoplana sp.	Common flatworm	--	--
Siphonaria thersites	Pacific false limpet	--	--
Unknown	7 rayed star	--	--
Unknown – numerous species	Hermit crabs	--	--
	Total Number of Motile Species	**1**	**1**
Band Transect Animals (Total Number of Animals)			
Sebastes melanops	Juvenile black rockfish	--	10
Unknown	Greenling	3	--
Myxocephalus polyacanthocephalus	Great sculpin	2	1
Odocoileus hemionus sitkensis	Sitka black-tailed deer	--	--

Taxon	Common Name	Reference Sites (n=2)	Study Sites (n=2)
		Transect 1 Subtidal (Quadrats n=5)	Transect 1 Subtidal (Quadrats n=5)
Vulpes vulpes	Red fox	--	--
Pugettia gracilis	Graceful kelp crab	--	--
Ligia pallasii	Sea slater	--	--
Unknown	Jellyfish	--	--
Total Number of Mobile Band Transect Species		**2**	**11**

**Balanus* mats could include *Semibalanus*