A Geo-referenced Benthic Habitat Survey in Support of Natural Resource Management:

Port Graham Bay, Alaska

Alaskan native communities depend on natural resources for subsistence. This king salmon graced many dinner tables in the Village of Port Graham Alaska, in keeping with the community's communal culture.

NOAA Technical Memorandum NOS NCCOS 119

Citation for this Report
Burke, J. S., and A. Malhotra. 2010. A Geo-referenced Benthic Habitat Survey in Support of Natural Resource Management: Port Graham Bay, Alaska. NOAA Technical Memorandum NOS NCCOS 119. 36p.

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A Geo-referenced Benthic Habitat Survey in Support of Natural Resource Management: Port Graham Bay, Alaska

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NOAA Technical Memorandum NOS NCCOS 119

August 2010

United States Department of Commerce	National Oceanic and Atmospheric Administration	National Ocean Service
Gary Locke	Jane Lubchenco	David Kennedy
Secretary	Administrator	Assistant Administrator

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1. INTRODUCTION

The impact of recent changes in climate on the arctic environment and its ecosystems appear to have a dramatic affect on natural populations (National Research Council Committee on the Bering Sea Ecosystem 1996) and pose a serious threat to the continuity of indigenous arctic cultures that are dependent on natural resources for subsistence (Peterson D. L., Johnson 1995). In the northeast Pacific, winter storms have intensified and shifted southward causing fundamental changes in sea surface temperature patterns (Beamish 1993, Francis et al. 1998). Since the mid 1970's surface waters of the central basin of the Gulf of Alaska (GOA) have warmed and freshened with a consequent increase in stratification and reduced winter entrainment of nutrients (Stabeno et al. 2004). Such physical changes in the structure of the ocean can rapidly affect lower trophic levels and indirectly affect fish and marine mammal populations through impacts on their prey (Benson and Trites 2002). Alaskan natives expect continued and perhaps accelerating changes in resources due to global warming (DFO 2006).and want to develop strategies to cope with their changing environment.

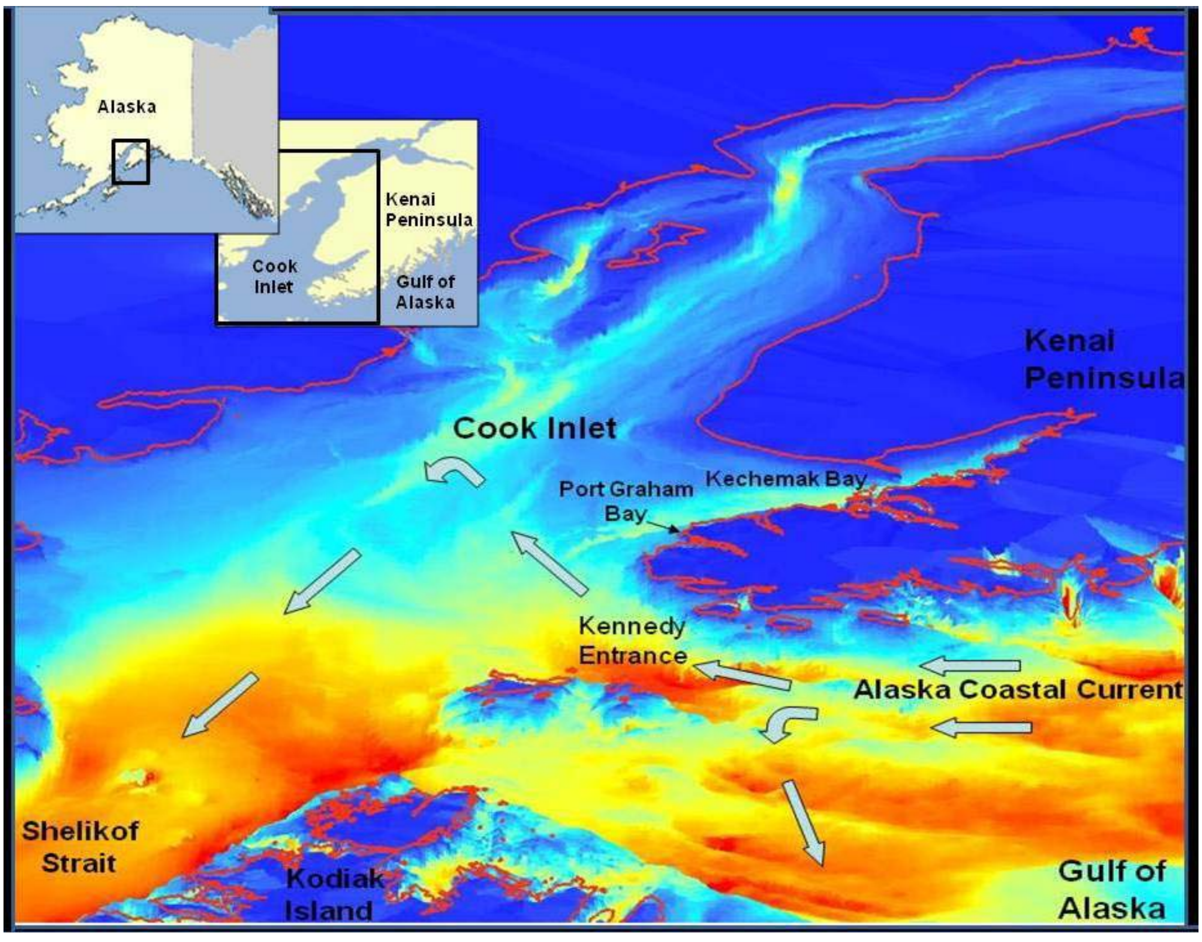


Figure 1. Location of the study area and bathymetric representation of the Cook Inlet/Gulf of Alaska transition zone showing flow of the Alaska Coastal Current. Depth is indicated by color with red representing deepest depths. Vertical scale is exaggerated 50x.

The Alutiiq, a southern Alaskan native people that inhabit coastal villages in the transition zone between the Gulf of Alaska (GOA) and Cook Inlet (CI), have been impacted by many of the changes that accompanied and continue in the wake of the regime shift in the mid 70s. The continental shelf of the GOA supports one of the world's richest ecosystems, characterized by large inputs of freshwater runoff and strong winds (Stabeno et al. 2004). Circulation and transport of nutrients and plankton on the continental shelf are dominated by the Alaska Coastal Current (ACC) whose width, speed and depth changes near the mouth of CI. As the ACC approaches CI (Fig. 1) its' width is diminished by the submarine topology, resulting in relatively high current speeds that persist throughout the year (Stabeno et al. 2004). As the ACC enters the macrotidal environment of CI (8.7 m tidal range) through the Kennedy Entrance there appears to be significant mixing of deep, nutrient rich GOA waters with shelf waters. This mixing may be due to vertical shear resulting from the relatively shallow depth of the shelf behind the entrance and extremely high tidal currents in this area (tidal current > 70 cm s^{-1}, Stabeno et al. 2004). Clear, cold, nutrient rich waters are pushed along the eastern shore of CI and are further mixed as they move northward forming a transition zone between marine and estuarine waters (Speckman et al. 2005). Mixing of nitrite-rich GOA waters and iron-rich estuarine water provides a steady supply of nutrients to surface waters and makes Lower Cook Inlet one of the most productive high latitude shelf regions in the world (Sambrotto and Lorenzen 1987).

The Village of Port Graham, an Alutiiq community readily accessible only by air or water, is located on a fjord (Port Graham Bay, 59^{o} 21 ʿ N,, 151^{o} 49 ʿ W) near the end of the Kenai Peninsula (Fig. 1). It seems likely that the village was established in this location to take advantage of the abundant natural resources that the dynamic physical and biological activity of lower CI provides. Subsistence harvest of natural resources remains an important component of the village economy. The fjord supports natural runs of several salmonid species which spawn in the Port Graham River and rely on fjord habitats as nursery grounds during their early life history. The village of Port Graham runs a commercial salmon hatchery and stocks salmon for ocean ranching. In the recent past the fjord was fished commercially for crabs. Subsistence mollusk fisheries that exploit the intertidal areas are of cultural importance. In recent years the sustainability of subsistence resources has come into question as residents have noted declines in harvested species.

In response to perceived declines in natural resources, the Port Graham Village Council requested that NOAA provide assistance in addressing this problem. During a meeting held in Port Graham in November of 2004, NOAA researchers from the Center for Coastal Fisheries and Habitat Research met with the village council and discussed specific strategies aimed at coping with ecosystem change. One of the recommendations approved by the council was the construction of a map from a geo-referenced survey of the bay that could be used in the management of its natural resources. As an initial step in the assessment of the natural resources of the fjord, we conducted a survey of the system in 2005. This report describes the survey and construction of a Geographic Information System (GIS) map of the bay that describes its habitats and divides the benthic landscape into zones. This GIS provides a base line from which change in the status of the system can be judged and a tool which resource managers can use to make more holistic and informed decisions when managing the natural resources of Port Graham Bay.

2. MATERIALS AND METHODS

2.1. Aerial photography

Geo-rectified aerial photographs form the base layer of the GIS, providing a geographic delineation of the shoreline and visual signatures of benthic habitats in the intertidal and shallow subtidal zones of the bay. To acquire photos of the study area, three missions were flown; July 6, August 6, and September 2, 2005. Different dates were needed to overcome loss of GPS control for the photography in June and cloud cover in July within parts of the study area. The photos (Kodak Aero-color 2444) were taken at a nominal scale of 1:24,000 with 60% end-lap and 30% side-lap. Differential Global Positioning System (DGPS) data and data from an Inertial Measurement System were collected during the flights for geo-referencing the aerial photography. The photos were scanned at 1 m resolution and converted to digital orthophotos. To reduce the number of images, every other image was used leaving an overlap of 10% between adjacent images. The horizontal spatial accuracy of the orthophotos obtained was in the range of 25 to 30 m due to the lack of an accurate digital elevation model for the area.

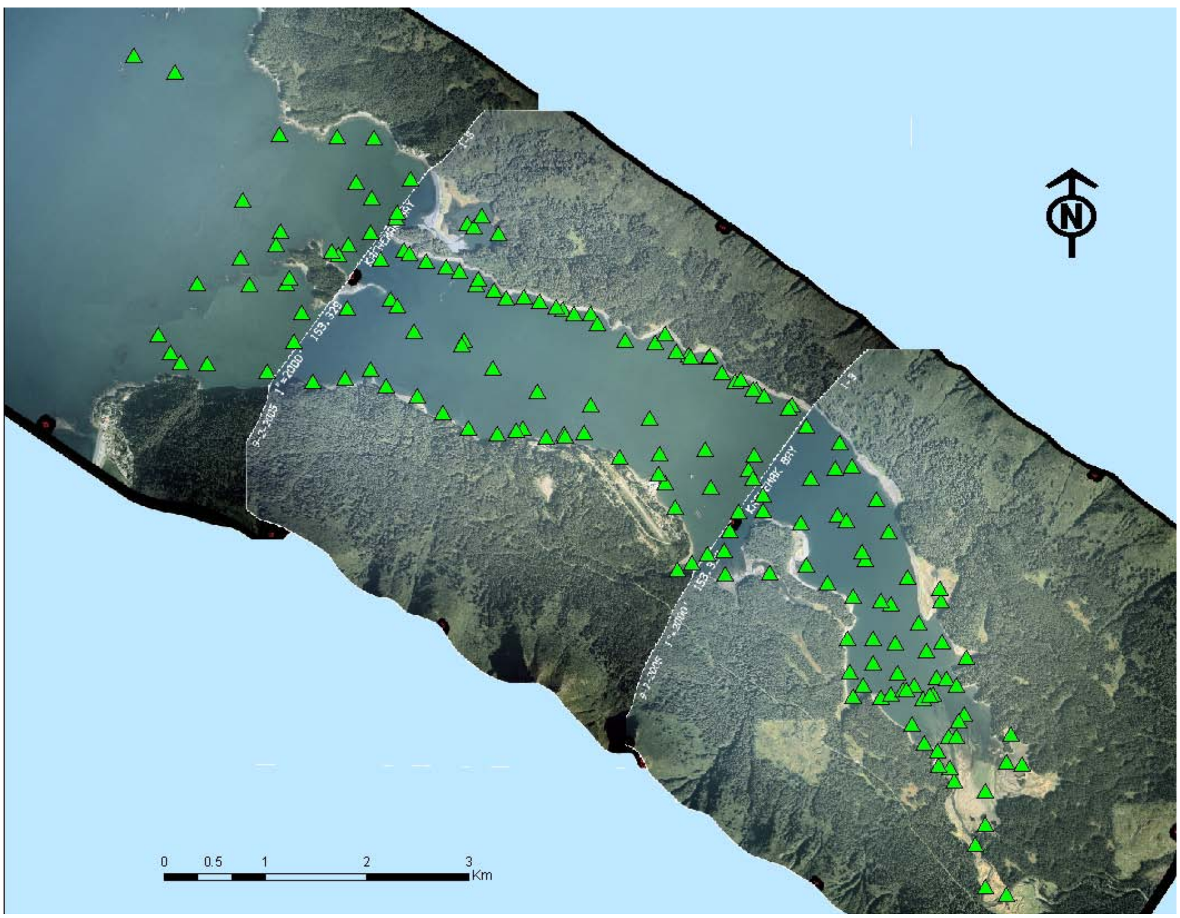


Figure 2. Mosaic of geo-referenced aerial photographs collected in September, 2005 used to construct a benthic habitat survey that included 170 stations (triangles) from Port Graham Bay..

Spatial accuracy of the orthophotos was improved to 3 to 6 m by rectifying the images relative to ground control points and image-to-image rectification relative to United States Geologic Survey (USGS) imagery of the area. For the easternmost image, ground control points were used for rectification as readily identifiable landmarks were available in the image. Five DGPS ground control points were collected using a Trimble Pro XR unit on well-established landmarks. Ground control points were established using GPS data collected every second for three minutes. Accuracy for the ground control points were 2 to 3 m. Due to logistical considerations and lack of established landmarks in the areas covered in the other two images, spatial accuracy of these was improved by image to image rectification using USGS black and white digital orthophoto quadrangles. The photos for the USGS product were acquired in September 1996. They were acquired as 7.5 minute quads with a pixel size of 1 m. Although a rigorous check of the spatial accuracy of the USGS product has not been performed for the area, work by Kachemak Bay National Estuarine Research Reserve personnel, doing spot checks of the USGS product with DGPS indicated that the overall spatial accuracy of the product was within 3 to 6 m. The 2005 scanned aerial photos of the Port Graham study area were image-to-image rectified to the USGS black and white product using ArcGIS 9.1. The resulting orthophoto mosaic was georeferenced to Universal Transverse Mercator (UTM) zone 5 North, on North American Datum 1983 (Fig. 2).

2.2. Bathymetry

To provide a bathymetric layer for the GIS, data from the National Ocean Service (NOS) Hydrographic Survey Data Base (NOSHDB) were utilized. NOSHDB contains data digitized from smooth sheets of hydrographic surveys completed prior to 1965, and from survey data acquired digitally on NOS survey vessels since 1965. NOSHDB bathymetric data were interpolated using an inverse distance weighted algorithm at 100 m resolution. The bathymetric data were projected to UTM zone 5 North to correspond to the orthophotos. Bathymetry data were projected to a 3-dimensional grid to better visualize the topography of Port Graham Bay (Fig. 3).

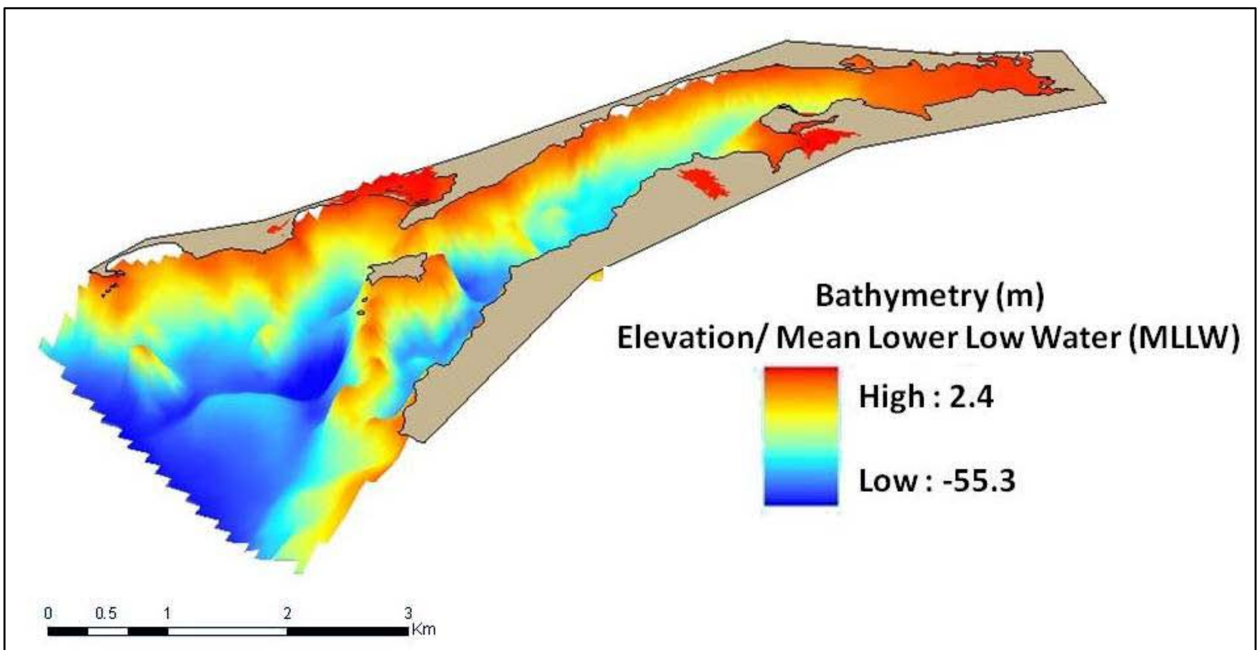


Figure 3. 3-dimensional bathymetric model (vertical dimension x20) used to visualize Port Graham Bay. The model shows typical fjord characteristics, including steep side walls and deep basins separated by sills.

2.3. Benthic habitat survey

The benthic habitat survey utilized synchronized collection of video imagery and DGPS data in a wide range of locations within Port Graham Bay. Field work was conducted August 18-23, 2005, from a 6m skiff piloted by Martin Norman, a Port Graham native with a life-long knowledge of the bay. Video records were collected at virtually all the survey sites with a waterproof color video camera (Seaview, SMM-50C), equipped with a 60m cable. The “drop camera” was constructed by mounting the video camera in a stainless steel frame (Fig. 4) that was raised and lowered with a commercial fishing spooler. The video output from the drop camera was viewed and recorded on a digital video recorder/viewer (Sony, GV-D900 walkman).

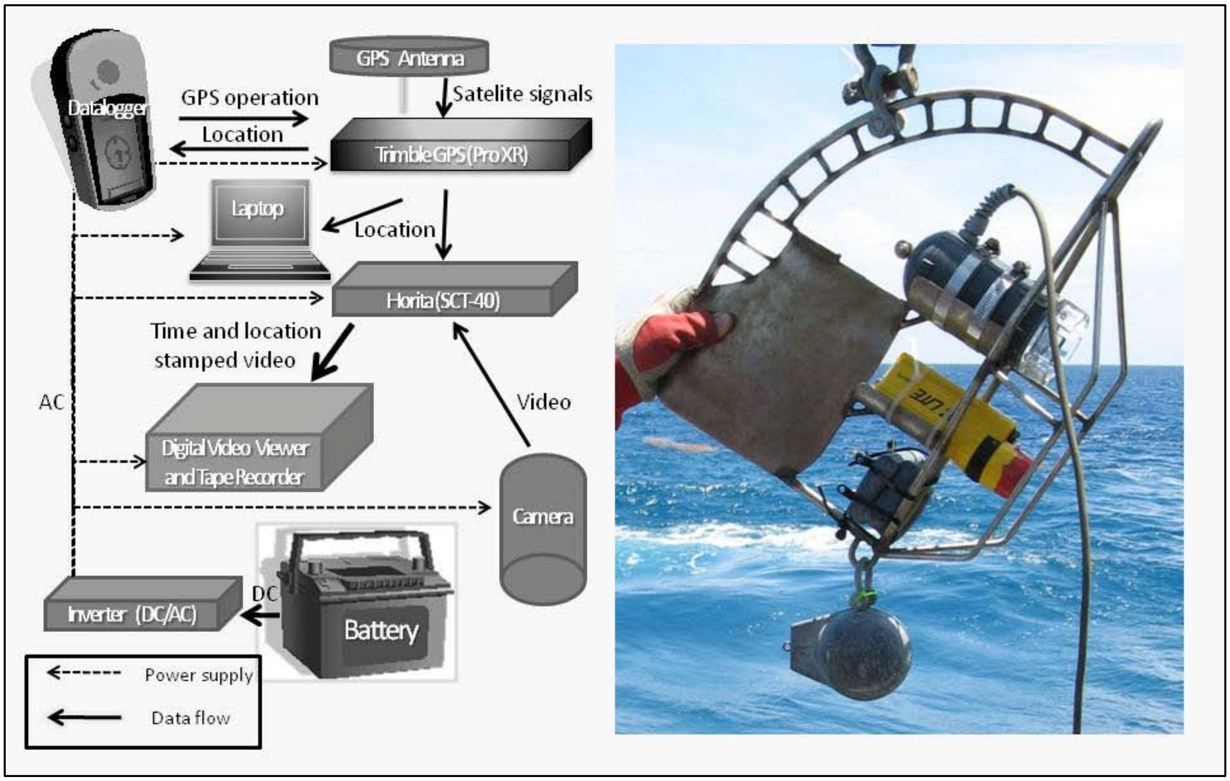


Figure 4. Electronic component schematic of the **field recording system used to collect and stamp video with time and location data and a photograph of the drop camera system used to provide benthic imagery.**

A field recording system (Fig. 4) utilized a video labeling device (Horita, SCT-50) to “stamp” each video frame with the date, time and DGPS coordinates. Geographic position was provided by a DGPS receiver (Trimble, Pro XR DGPS) that allowed collection of data at 2-3 m accuracy. The DGPS receiver’s antenna was mounted on the gunwale of the boat, and the video camera suspended directly below it. A hand held depth sounder was used to determine water depth at sampling locations.

Station locations were chosen to encompass the physical and geographic variation of Port Graham Bay. The majority of the 170 stations visited (Fig. 2) were nearshore in the intertidal and shallow sub-tidal. These shallow samples provided ground truth data that could be used to identify the visual signatures of benthic habitats apparent in the aerial photography. In addition to these relatively shallow sites a series of stations along the main axis of the fjord and locations of particular interest to the tribe (fishing grounds, areas of extreme depth) were also visited. At each location the drop camera was lowered to the bottom and video collected. At many sites the skiff was allowed to drift to provide data on habitat variability at the site. Video output was monitored by a biologist who directed the adjustment of the position of the camera relative to the bottom and made field notes on benthic characteristics. In addition to surveys conducted from the boat, walking surveys were conducted at low tide in the exposed intertidal zone to delineate seagrass and algal beds. A researcher outfitted with a DGPS receiver walked along the margin of vegetation beds to create a record of their extent (Fig. 5).

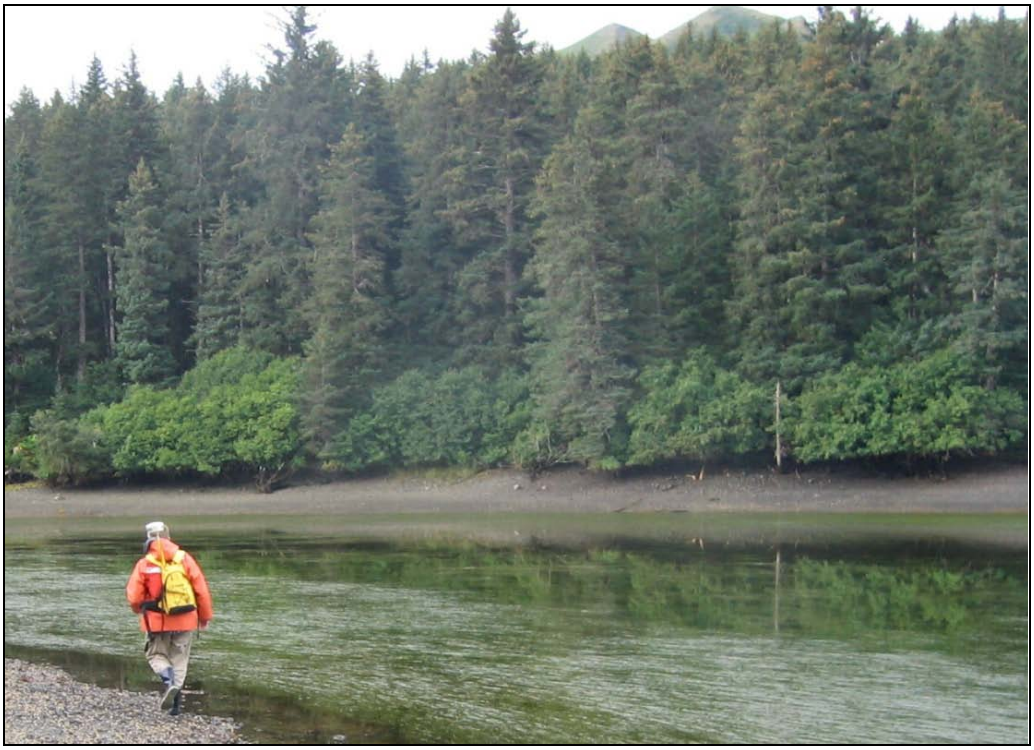


Figure 5. NOAA scientist tracing the margins of a seagrass bed using a Trimble ProXR GPS unit.

2.4. Benthic classification system and data processing

To provide benthic classification for the entire bay, we identified landscape zones based on morphological features typical of fjords (Farmer and Freeland 1983) as defined by the depth model and the in-situ survey. Five landscape zones were defined; Shore/Slope, Basin, Reef, Delta and Lagoon Zones. Within these general landscape zones we delineated specific habitat types based on DGPS locations, underwater video and interpretation of the aerial photography. Video collected in the field was viewed in the laboratory to assign habitat characteristics to DGPS locations. For short drift transects in uniform habitat a single DGPS location was marked on the digital map. For long drift transects in uniform habitat, DGPS locations at the beginning and end of the drift were marked. Drift transects conducted in areas of variable habitat were often long in duration and multiple DGPS locations were marked on the map, each representing a transition from one habitat to another. Still images were captured from video from all drift transects where light and turbidity allowed creation of an interpretable image. To provide point locations for specific habitat types and habitat transitions, DGPS locations were entered into a geographic data base that included a habitat description and in situ depth data (Appendix 1). Resulting geo-referenced data were superimposed on aerial photography.

Polygons of habitat types were constructed in the laboratory through interpretation of aerial photography based on the geo-referenced data. Habitat type corresponding to a specific visual signature was determined and its extent defined in the GIS with an editing tool. Construction of habitat polygons was limited to shallow or intertidal areas where aerial photography provided a clear benthic signature. In addition to defining polygons for specific habitat types (e.g. dense sea grass bed), a polygon of intertidal area was defined based on banding patterns consistently visible in the aerial photography along the shore whose locations were expected to approximate the mean high and low elevation of the tide.

3. RESULTS

3.1. Landscape zones

Examination of the depth model indicated Port Graham Bay can be classified as a typical fjord (Fig. 3); a long, narrow, steep sided coastal inlet with a river discharging at the head and relatively deep basins separated by sills or rises in bathymetry (Farmer and Freeland 1983). Based on this morphology, as defined by the depth model, five landscape zones were identified; Shore/Slope, Basin, Reef, Delta and Lagoon Zones. Collectively these five landscape zones accounted for the entire area of the bay (Fig. 6). Their areas, the percentage they represent of the bay's total area are provided (Table 1). Maps showing the distribution of stations in each zone (Figs. 7a; 8a,b.c,; 9a; 10a; 11a,b) and further description of benthic habitat and communities within the five zones follow. Station geographic locations and a brief description of the benthic habitats observed are presented in Appendix 1.

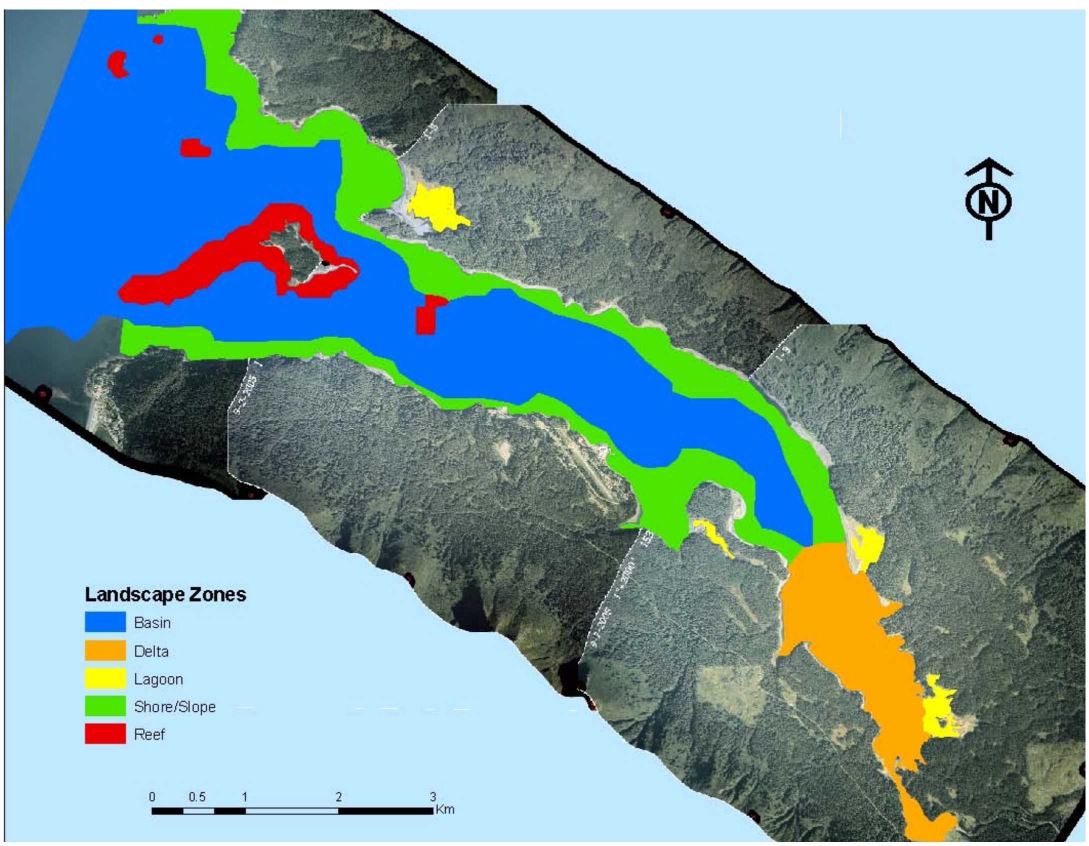


Figure 6. Distribution of landscape zones defined for Port Graham Bay based a benthic survey in August of 2005.

Table 1. Landscape zones recognized for Port Graham Bay, Alaska (total area is approximately 22 km^2) listed in terms of total area. The area of each zone, the percentage this area represents relative to the total area of the bay and the principal flora of each zone in provided

Landscape Zones	Area (km^2)	% of bay area	Principal floral coverage
Basin	13.2	60	Diatom mat
Shore/Slope	5.0	23	Kelp, green and red algae
Delta	2.1	10	Seagrass, red and green algae
Reef	1.2	5	Kelp
Lagoon	0.5	2	Seagrass, diatom mat

3.1a. Basin Zone

The Basin Zone was surveyed by sampling twenty eight stations in a roughly defined transect along the main axis of the fjord (Fig. 7a). Depth at the deepest station B3 was

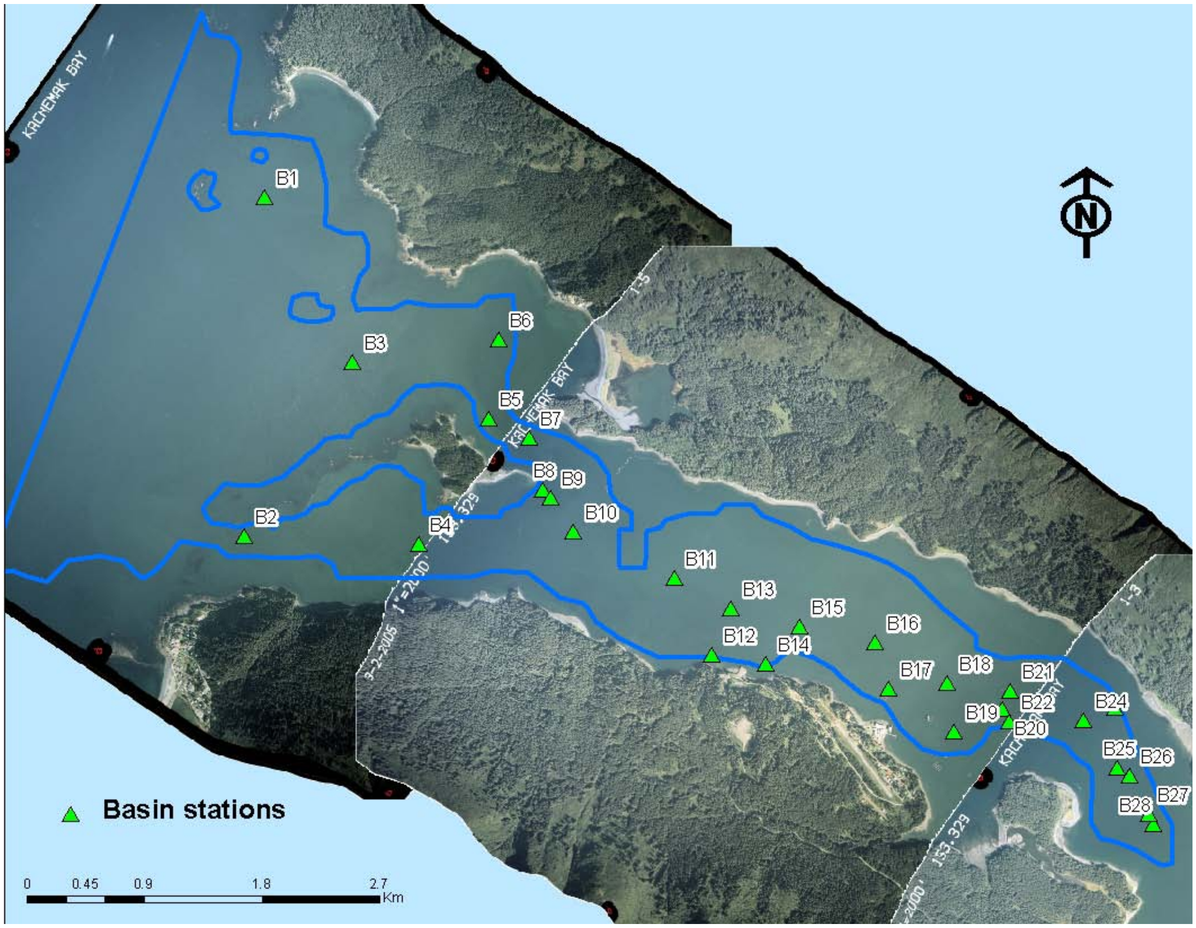


Figure 7a. Map of the extent of the Basin Zone and the distributions of basin stations sampled in Port Graham Bay, Alaska during August 2005.

approximately 50 meters. At this depth light was insufficient to provide video of sufficient quality to produce an interpretable still image. Depth at stations B7 and B9, was approximately 40 m. The majority of stations were between 20 and 30 m and their depth tended to decrease towards the head. Drop camera observations indicated the Basin Zone was a depositional environment, characterized by sorted unconsolidated sediments. Particle size varied from mud (Fig. 7b) to gravel and shell (Fig. 7c). The two shallowest locations had gravel substrates (B8, B22). Gravel substrates were also observed at some of the deeper sites towards the mouth, suggesting scouring by strong tidal currents (B1, B7, B12). Towards the head of the fjord the bottom appeared to become increasingly depositional in nature and some areas supported high densities of benthic invertebrates (Fig. 7d). The relatively flat landscape of the basins generally lacked macroalgae, likely due to the absence of appropriate substrate for attachment of kelps and relatively low light levels in deeper areas. Repeated camera drifts indicated the transition between the rocky slopes of the side of the fjord and the unconsolidated sediments of the Basin Zone occurred at a depth of about 20 m.

7b. Video image from B 4 a deep station with muddy substrate and unidentified flatfish.

7c. Video image from B 12 with shell/gravel substrate and sunflower sea stars (*Pycnopodia helianthoides)* **at the basin margin.**

7d. Video image from B 15 showing a sea anemone and polychaete tubes in fine sediment.

3.1b. Shore/Slope Zone

The Shore/Slope Zone, encompassing the sides of the fjord, extended from the high tide line to the unconsolidated sediments of the basin along the north and south shores of the bay. Drop camera observations showed that the Shore/Slope Zone included a range of topography from steep rock slopes to intertidal sand, gravel or cobble flats along the shore. Where rocky, the Shore/Slope Zone was generally densely vegetated with a variety of macro-algal species. Drift surveys across the Shore/Slope Zone to the deep basins of the bay frequently showed an abrupt transition at a depth of approximately 20 m where the rocky vegetated grade of the Shore/Slope Zone submerged in the relatively flat unconsolidated sediments of the bay's basins. The zone was sampled relatively intensively to help define the distribution of habitat along the shore and with depth on the slope. Stations are referenced relative to the North (SN) or South (SS) sides and their position relative to the mouth of the fjord (Fig. 8a, 8b, 8c). Forty six stations were visited along the north shore, 33 along the south. Shore/Slope habitats ranged from rocky slope colonized by macroalgae (SN14, SN19; SS17, SS19, Fig. 8d) to intertidal or subtidal sand flats (SN6; SS6, Fig. 8e). Mixed substrates of gravel, shell and sand were also abundant on both shores and tended to be more common towards the head of the fjord (SN38; SS32, Fig. 8f). Sea-grass was rarely encountered but was found in the relatively shallow waters on both shores (SN25, SN26; SS8, SS23). Drift transects across the shore/shelf zone indicated that kelps were generally restricted to the rocky sub-tidal slopes of the zone. A diversity of fishes were observed in the shore/shelf zone (SN9, SN28, SN34, SN37, SN42, SN44; SS1, SS4, SS11, SS12, SS14, SS15, SS16, SS23, SS27, SS29, SS31, Fig. 8g) and the majority were sighted towards the head of the fjord and on the southern (sighted at >30% of stations) rather than northern shore (sighted at <15% of stations). Two schools of what appeared to be pink salmon fry were observed; both along the south shore (Fig. 8h).

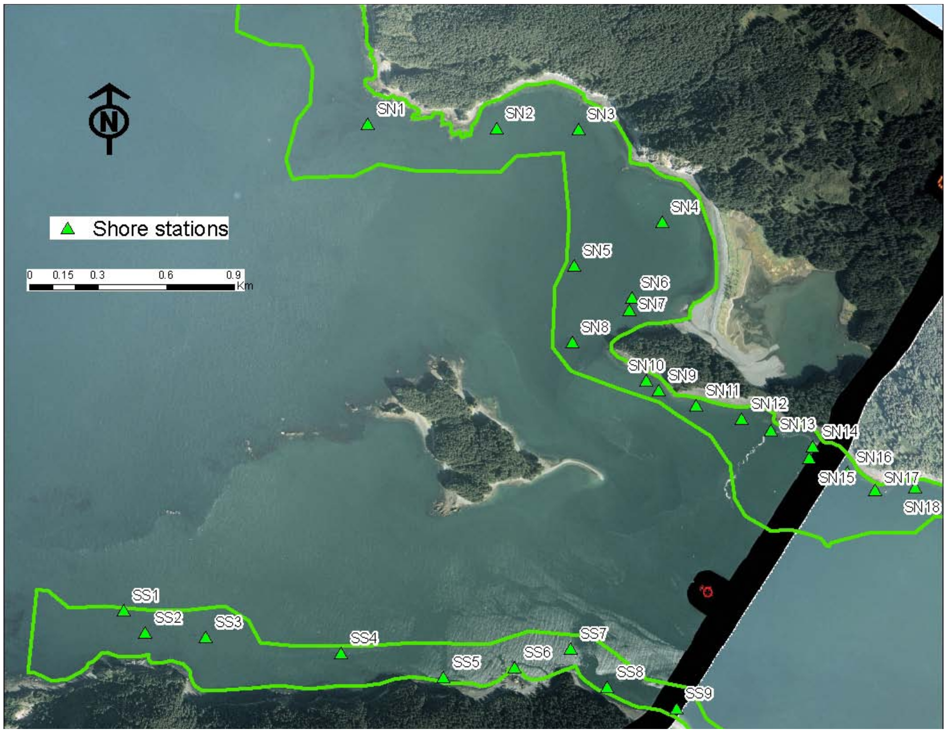
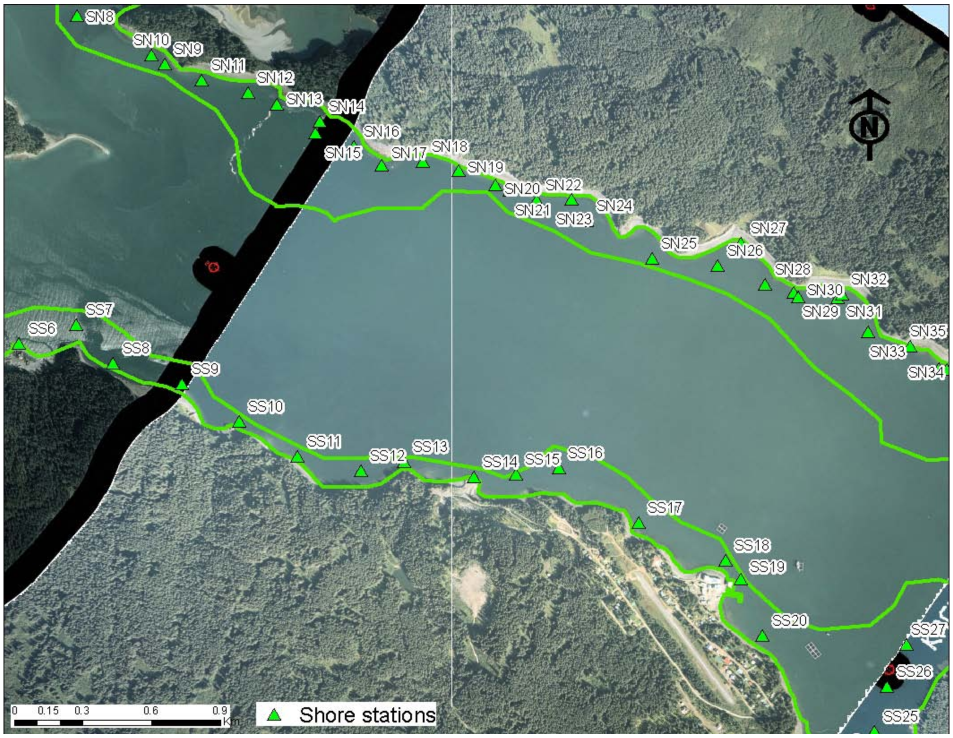
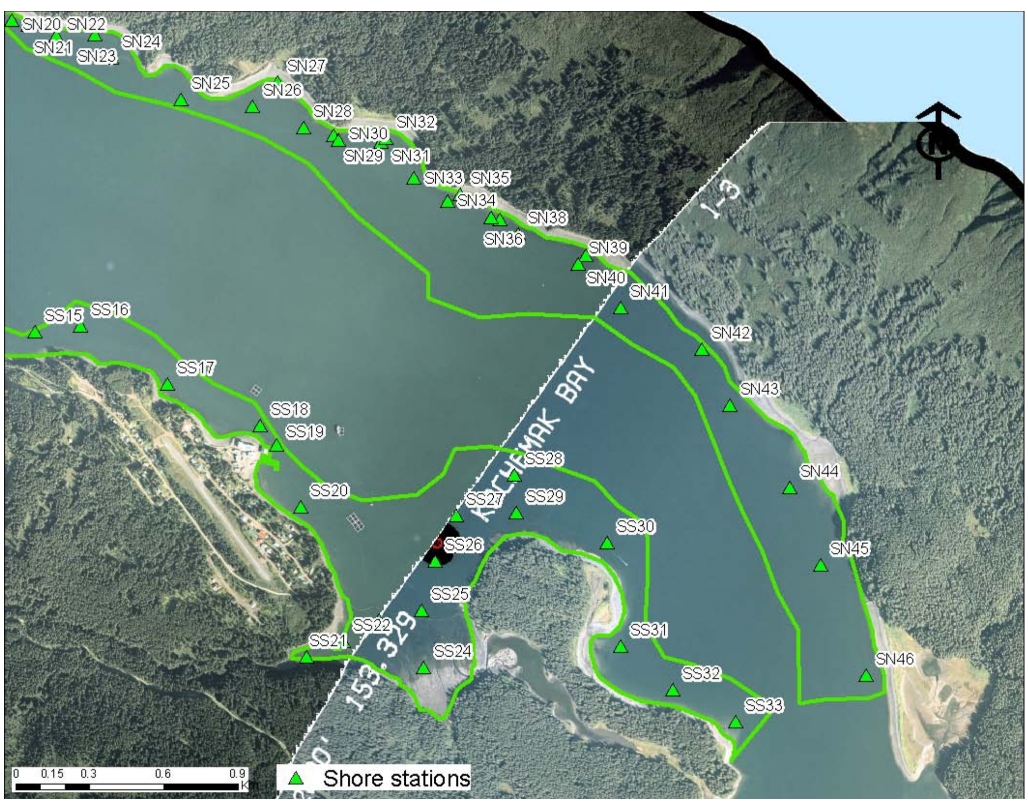


Figure 8a. Chart showing the west section of the Shore/Slope Zone in Port Graham Bay and the distributions of stations sampled during August 2005.



8b. Chart showing the mid section of the Shore/Slope Zone in Port Graham Bay and the distributions of stations sampled during August 2005.



8c. Chart showing the east section of the Shore/Slope zone in Port Graham Bay and the distributions of stations sampled during August 2005.

8d. Video image from SN 19,showing macroalgae and a sunflower seastar on a rocky slope.

8e. Video image from SS 6 a sand flat station..

8f. Video image from SS 32 showing sunflower seastar on mixed substrate of sand and shell.

8g. Video image from SS 15 showing a kelp greenling over rocky macroalgal habitat.

8h. Video image from SS 1 showing presumed school of pink salmon fry.

3.1c. Delta Zone

The Delta Zone originated along the fjord's main axis where deeper waters of the Basin Zone shoaled abruptly. The Delta Zone includes both intertidal and subtidal habitats ranging in slope from flats to steeper grades as the Delta descended to the Basin Zone. Thirty nine stations were visited representing a wide range of habitat types (Fig. 9a). The northern end of the delta grades to the deeper waters of the basin and appears to be a depositional environment. The deepest site visited (13 m, D1) was unvegetated with a mixed substrate of fine particles and shell. Substrate at other deep sites (D2, D3, D5, D6, D7) was similar but much of the bottom was covered with brown and red macroalgae. Polychaete coIonies were observed in fine sediment and an extensive polychaete tube lawn (Friedrichs etal. 2000) was developed at station D10 (Fig 9b). Much of the middle section of the Delta was dominated by mixed (D12, D13, D18, D20, D23) and dense seagrass beds (D14, D15, D16, D21, D22, D24, D25) and filamentous algae became a conspicuous part of the benthic flora (D10, D17, D23, Fig. 9c). Moving towards the mouth of the Port Graham River, substrate increased in particle size and consolidation. Rock weed (*Fucus sp.*) mussel beds and barnacle colonies were increasingly visible (D26, D31, D32, D34, D36). Channels dominated by green algae (*Ulva sp.*) were recognized as a distinct habitat and the rocks that make up the channel floor increased in size as the delta narrows to the Port Graham River (D27, D33, D35, D38, D39, Fig. 9d).

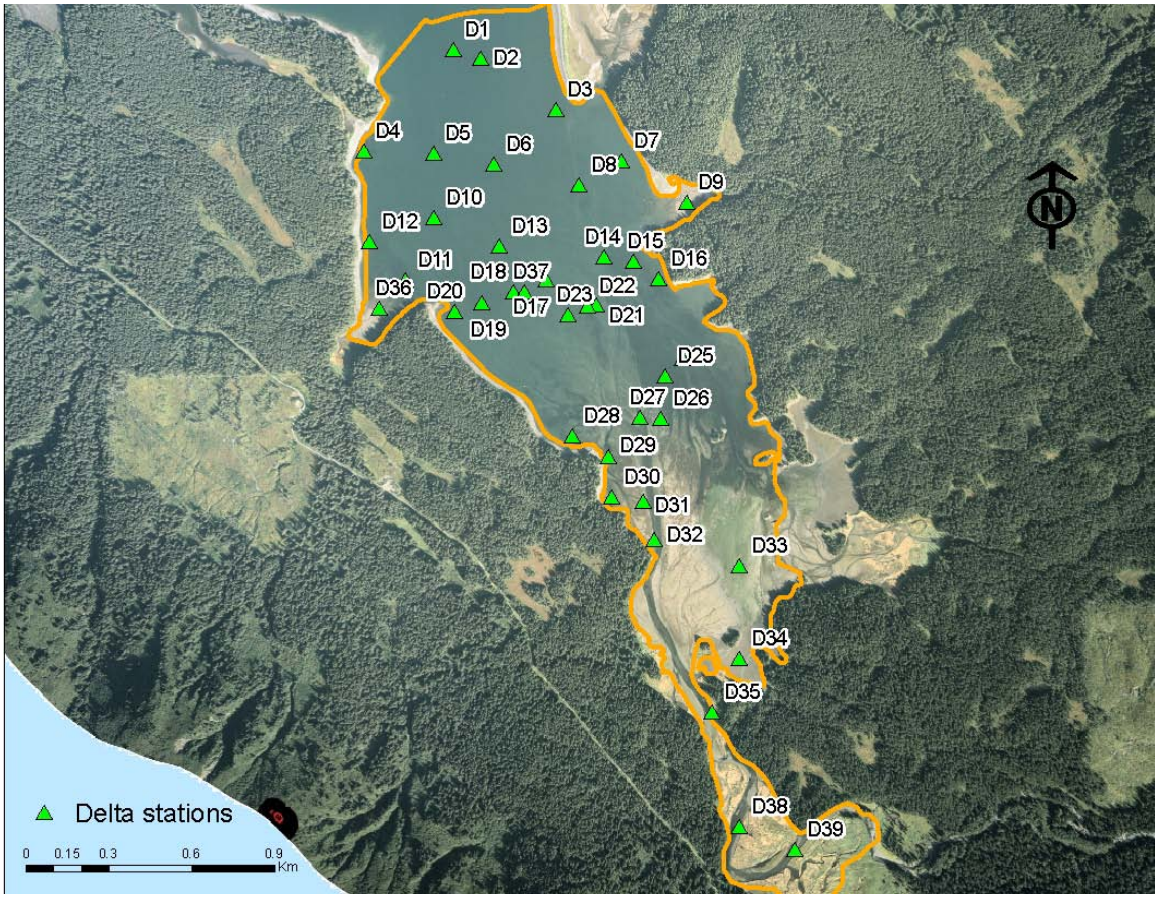


Figure 9a. Chart showing the extent of the Delta Zone and the distribution of Delta stations sampled in Port Graham Bay, Alaska during August 2005.

9b. Video image from D 10 showing a close up view of an extensive polychaete tube lawn.

9c. Video image from D 23 showing patchy seagrass and filamentous algae.

9d. Video image from D 38 showing pink salmon (*Oncorhynchus gorbusch***) over boulder river bed.**

3.1d. Reef Zone

The Reef Zone were comprised of rocky outcrops and sills, emergent from the Basin Zone or extending out from the Shore/Slope Zone into the main axis of the bay. Observations of these emergent features suggested an environment scoured by tidal currents. Fourteen Reef Zone stations were sampled, most clustered around the Bird Rock Island, a part of the main sill of the fjord (Fig. 10a). Outcrops and sills were generally comprised of consolidated mounds of rock

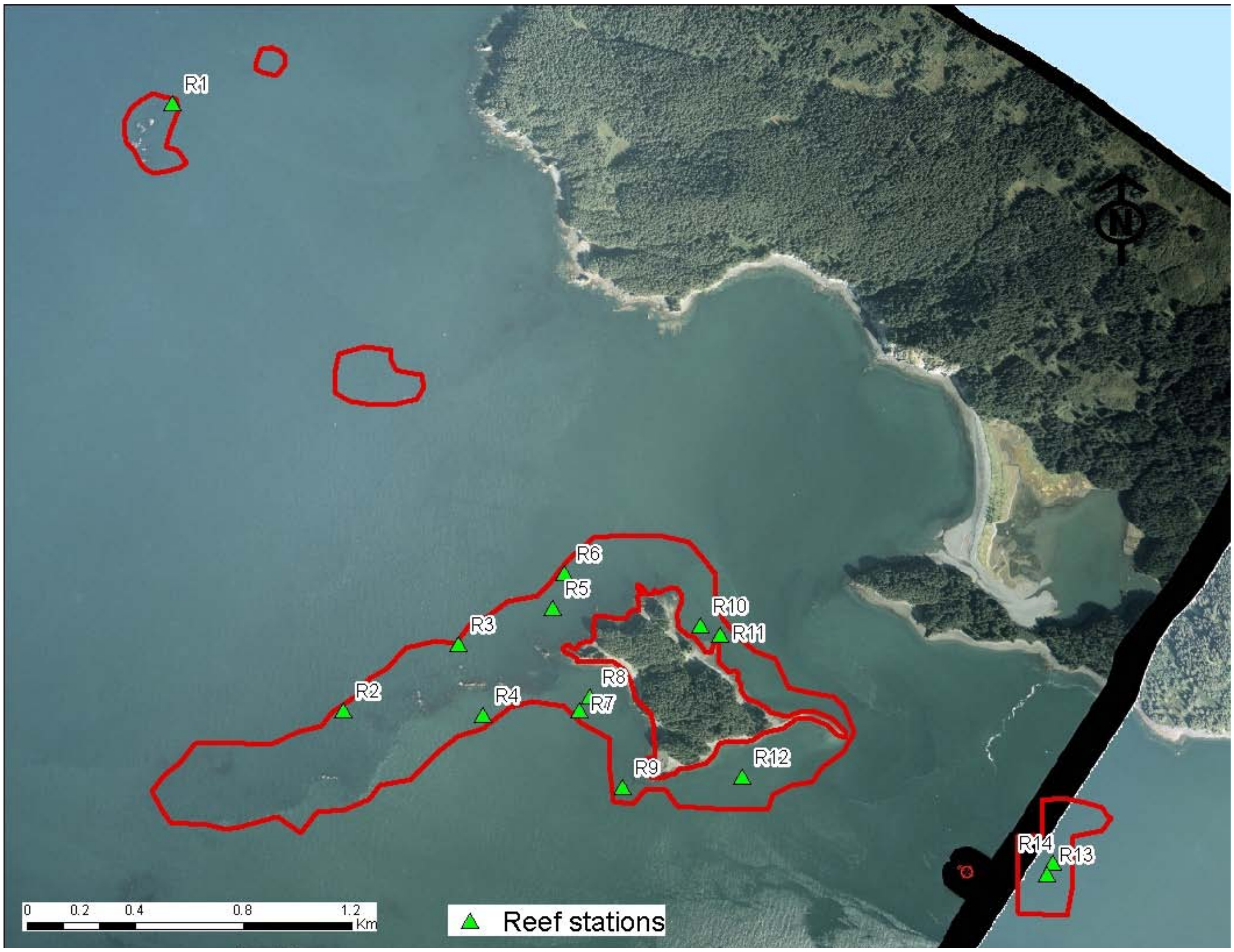
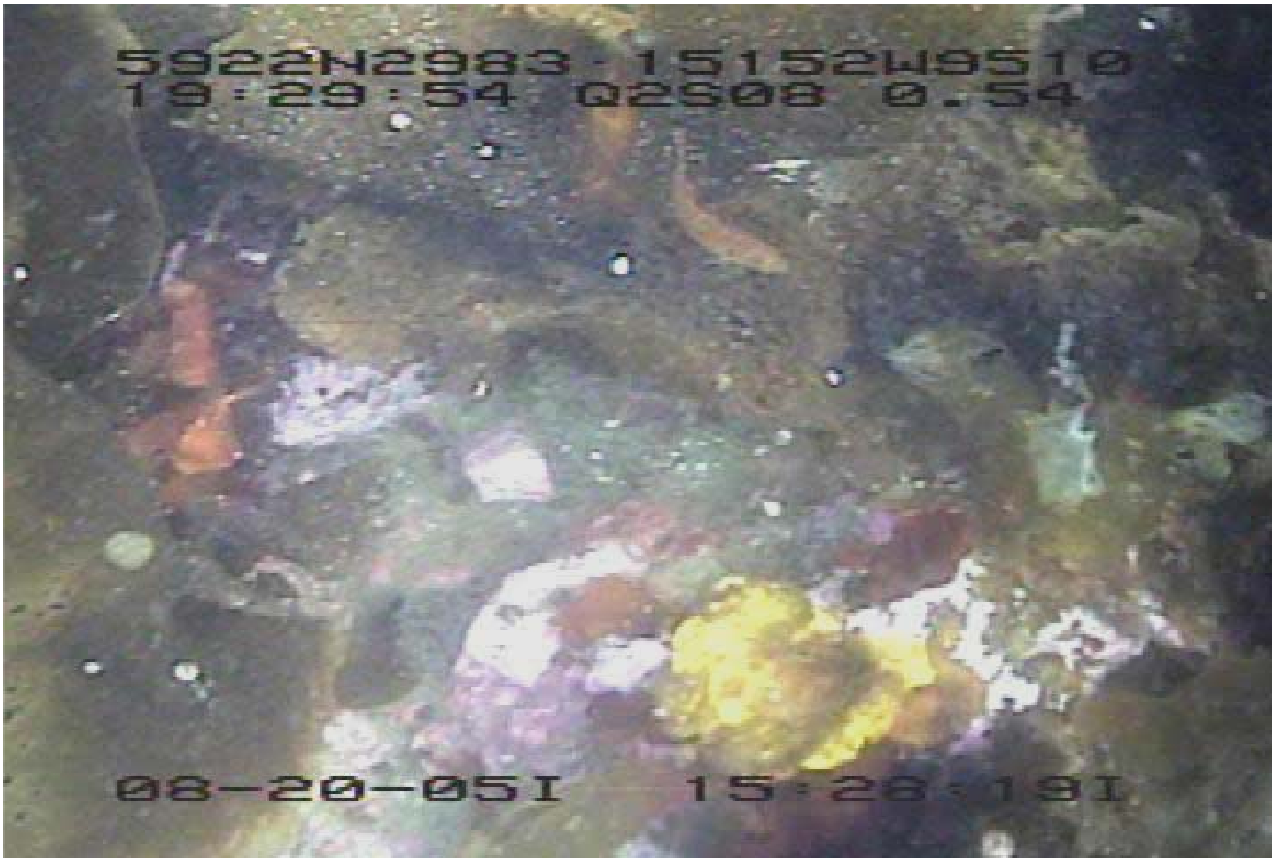


Figure 10a. Chart showing the extent of the Reef Zones in Port Graham Bay and the distributions of stations sampled during August 2005.

and finer substrate, colonized primarily by kelps. Most of these sites appeared to be subjected to intense current limiting the type of macrophytes to kelps adapted to high energy (10b). At some locations high densities of attached invertebrates (10c) and high diversity of macrophytes and fishes (10d) were observed.

10 b. Video image from R 1 showing current swept bottom with kelp.

10 c. Video image from R 9 showing anemone 'forest'.



10 d. Video image from R 9 showing diverse benthic community and unidentified fish.

3.1e. Lagoon Zone

The Lagoon Zone occurred in topographically complex shoreline locations where water exchange with the larger system was restricted due to the presence of a topographic barrier. Four areas were identified and a total of 10 Lagoon Zone drift stations sampled (Fig. 11a, b).
The area shoreward of these barriers was largely or entirely separated from the bay at low tide but inundated by the flood tide. Buffering of the fjords energy by these barriers creates a relatively quiescent inter-tidal environment, characterized by fine sediments and a landscape distinct from the more exposed shoreline of the fjord. Habitats in the deeper interior of lagoons were typically soft bottom in nature covered by diatom mats and seagrass beds. Lagoon habitats appeared to serve as nursery grounds for a variety of fishes which were frequently observed associated with both algal mats (Fig. 11c) and grass beds (Fig. 11d).

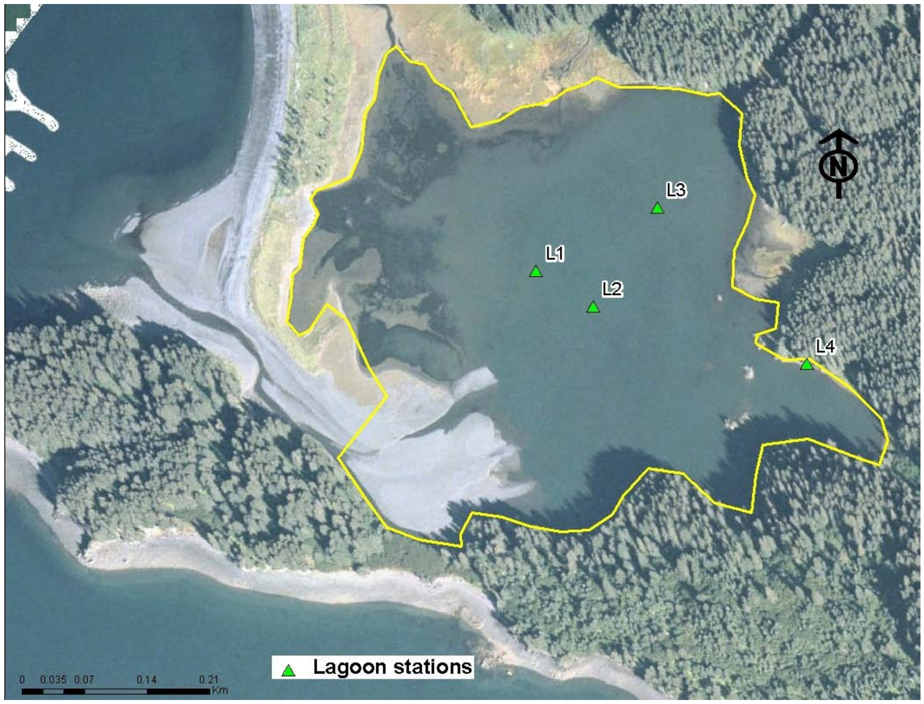


Figure 11a. Aerial photographs showing polygons and the distributions of stations sampled during August 2005 in the four areas that made up the west Lagoon Zone in Port Graham Bay.

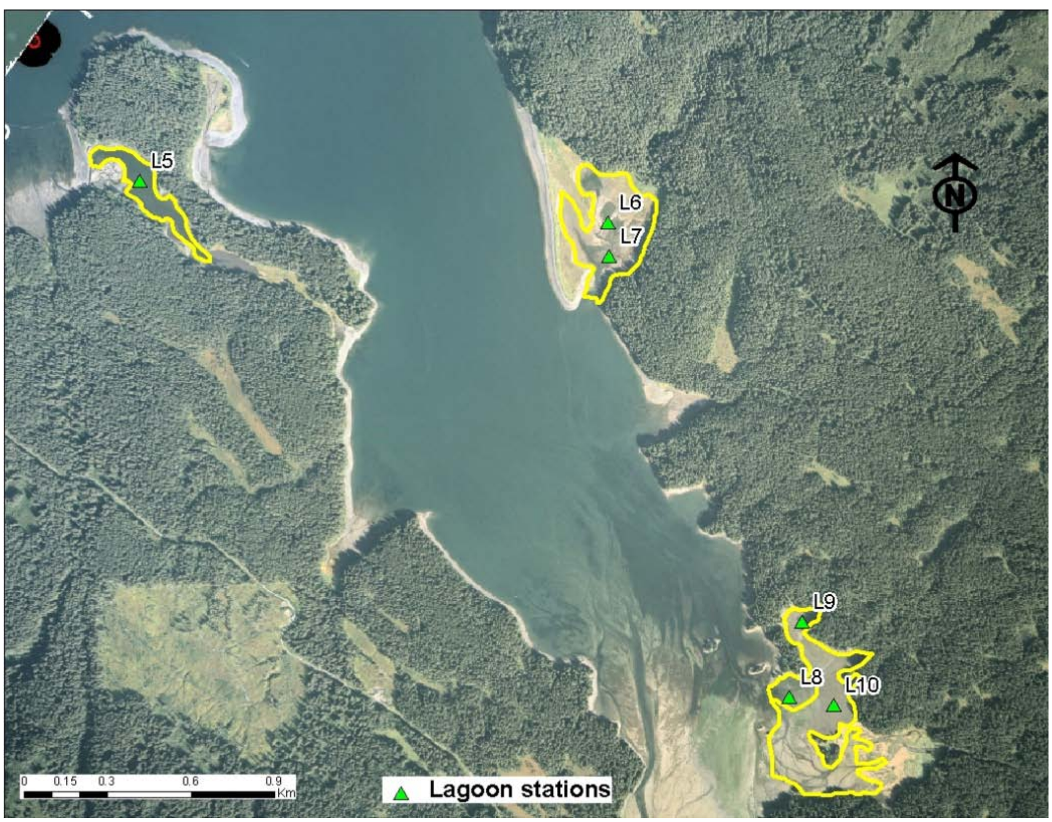


Figure 11b. Aerial photographs showing polygons and the distributions of stations sampled during August 2005 in the four areas that made up the east Lagoon Zone in Port Graham Bay.

11c. Video image from L 9 showing a Pacific staghorn sculpin on fine substrate with an algal mat.

11d. Video image from L 2 showing Zoster marina bed and an unknown Gadid species

3.2. Habitat Classification

Generally the benthic habitats of the shallow waters of Port Graham Bay were highly variable spatially and significant areas of uniform habitat were the exception rather than the rule. We were able to define four habitat types that occurred in areas large enough to delimit habitat polygons. Based on consistent signatures along the shore line, we also defined an intertidal polygon which represents the area from the mean high to mean low water. Though the accuracy of this polygon needs verification, we felt that a preliminary estimate of the extent of the intertidal zone would be useful. The habitat types and intertidal polygon are described below. Estimates of the areas of respective habitats (Table 2) and their distribution within the bay are presented (Fig. 12).

1) <u>Dense seagrass beds</u> of *Zoster marina* (>50% cover) were generally located in soft substrates of the Delta and Lagoon Zones. Some dense beds were also observed in embayments of the Shore/Slope zone
2) <u>Mixed vegetation beds</u> of *Z. marina* and various macroalgae were located in intertidal or shallow subtidal areas of the Shore/slope, Delta and Lagoon Zones.
3) <u>Rockweed beds</u> were located in the intertidal area primarily in the Delta and Shore/slope Zones primarily on gravel or coble deposits but were also observed on intertidal boulders.
4) <u>Channel with green algae</u> was defined only on the Delta Zone in the main river discharge channel. It seems likely that this habitat remains submerged even during low tide due to fresh-water discharge from the river. Similar habitats may be found at stream and lagoon discharge channels.
5) <u>Intertidal Polygon</u> bridges all zones with the exception of the Basin. Habitat within the polygon was variable due to variation in substrate and exposure which in turn limit if and what type of vegetation is present.

Table 2. Benthic habitats quantified for Port Graham, Alaska. The total area of each habitat type, the percentage this area represents relative to the area of the bay (total area approximately 22 sq km) and the principal macrophyte(s) of each habitat in provided.

Benthic Habitat	Area(sq km)	% of area	Principal floral coverage
Dense seagrass	0.5	2	*Zoster marina*
Mixed vegetation bed	0.90	4	*Z. marina*, various macroalgae
Rockweed	0.4	2	*Fucus sp.*
Channel with algae	0.1	<1	*Ulva sp.*
Total habitat polygons	*1.9*	*9*	-
Intertidal area	2.9	13	Dependant on substrate and exposure

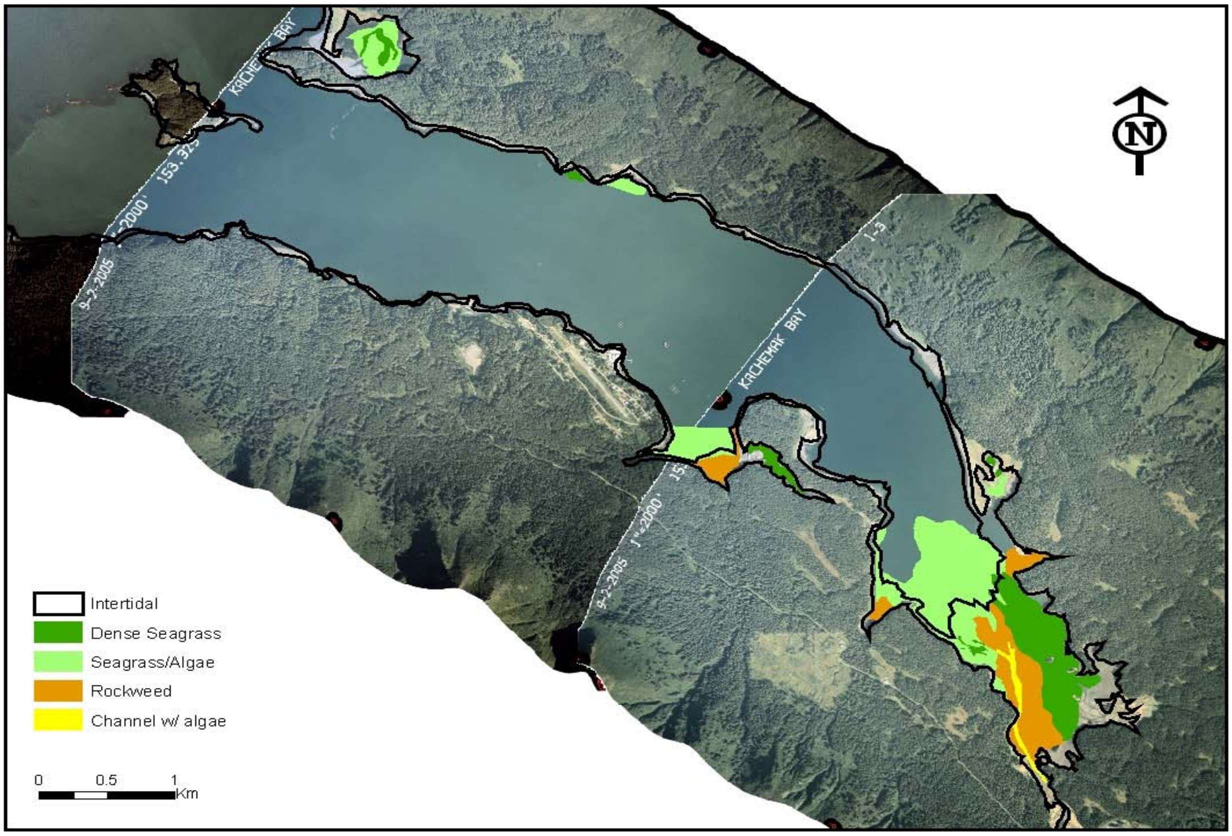


Figure 12. Map showing habitat and an intertidal polygons constructed from visual interpretation of aerial photography and ground truth sampling conducted in Port Graham Bay during August 2005.

4. DISCUSSION

The Geographic Information System (GIS) describing Port Graham Bay was developed to provide a management tool for the aquatic resources upon which the community of Port Graham has traditionally depended. The bay's long narrow morphology, steep side walls and deep basins separated by sills indicates the system can be classified as a shallow-silled fjord (Burrell 1987; Fig. 3). The fjord's complex morphology interacts with the macrotidal range of the region (tidal range exceeded 7 m in Port Graham Bay during the study period) and input of fresh water from the Port Graham River and basin streams, to sustain a wide range of benthic habitats. The resulting habitat mosaic supports a diverse aquatic animal community upon which Alaskan natives have traditionally depended for subsistence. Despite the bay's isolated location and low human population density, residents of the Village of Port Graham have reported declines in aquatic animal populations traditionally important for their subsistence. To develop appropriate management strategies to reverse these apparent declines will require assessment of targeted animal distribution, abundance and vital rates as well as the distribution and resilience of the habitats upon which these populations depend. Practically, such assessments are only feasible if the bay can be stratified geographically to allow efficient and unbiased sampling.

The landscape zones defined for Port Graham Bay provides a simple model of the entire bay that can be modified according to research goals. The five landscape zones can be expected to be distinguished by collective differences in factors such as exposure, slope, depth, substrate and light. Overlap in these parameters among zones and wide variation within some zones suggests that modification of the simple model is likely to be required for specific management questions. Modification of the model can easily be done based on data already incorporated in the GIS or by adding a new data layer. For example, if a researcher is interested in a resource known to be limited to subtidal soft-bottom habitats it will likely be useful to subdivide the Basin Zone. The majority of the bays' benthic area falls within the Basin Zone and consists of unconsolidated substrate (Table 1). Drop camera sampling suggests spatial variability in substrate type and bathymetric data indicates the presence of sub-basins due to their partial separation by sills within the Basin Zone (Fig. 16). Conditions in these sub-basins are likely to vary spatially and seasonally due to differences in factors such as proximity to the sea, rainfall etc. Utilization patterns of sub-basins by animals can be expected to vary accordingly. In May of 2005,

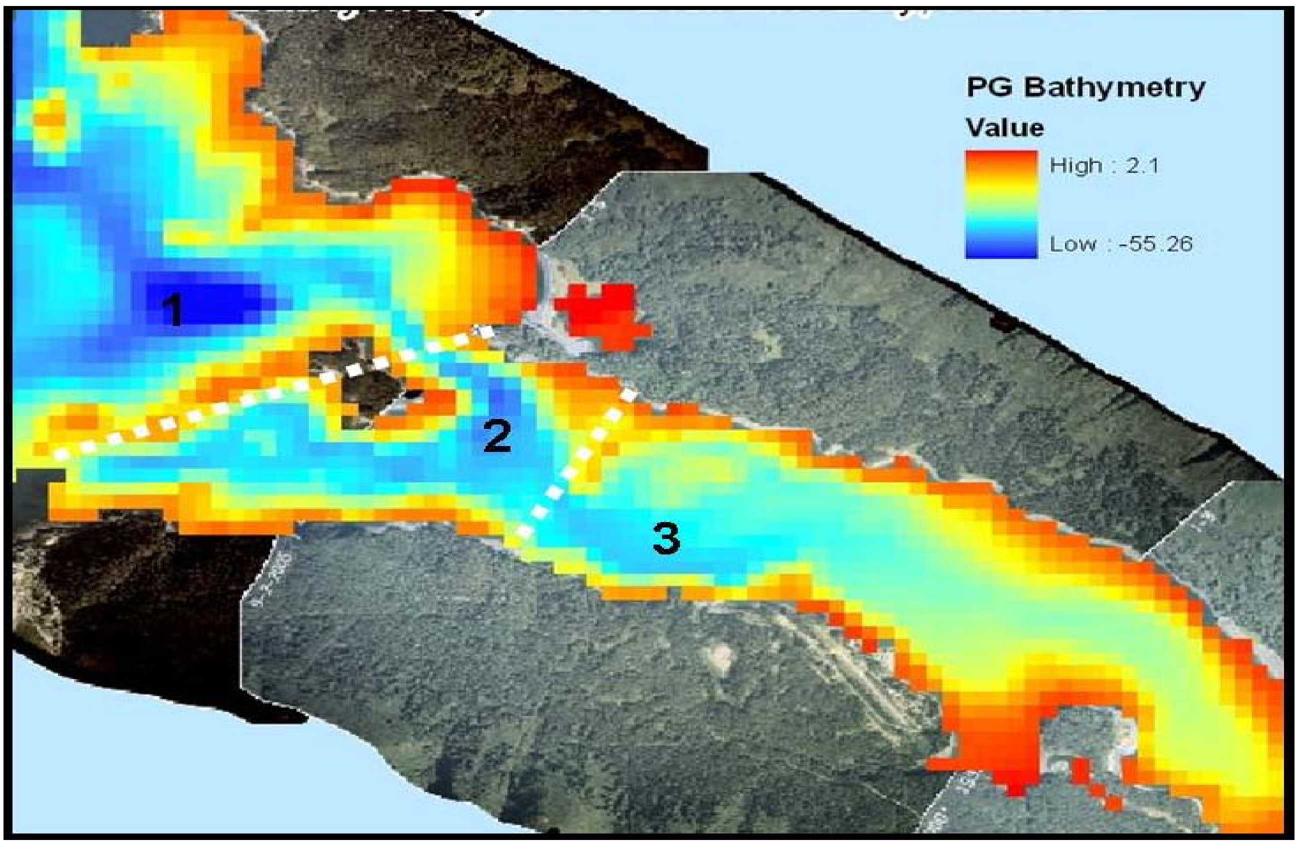


Figure 13. Bathymetry model showing how the Basin Zone could be divided into sub-basins. Dashed white lines indicate approximate location of the sills that separate sub-basins 1-3.

preliminary drop camera work in sub-basin 3 (Fig. 13) indicated the presence of high densities of juvenile halibut. Halibut were not observed in this basin during our more extensive sampling in August but were observed in sub-basin 2. These observations suggest that halibut are utilizing the Basin Zone as a nursery ground but suggests that utilization pattern may vary seasonally. Similarly an investigator interested in the distribution of bidarki or black chiton, *Katharina* *tunicate*, a resident of shallow rocky waters and a traditional food of Port Graham residents, might subdivide the Shore/Slope Zone by depth, slope and substrate to document those areas critical in bidarki life history.

In addition to providing a GIS tool for investigating natural resources of the bay, the benthic survey provides a benchmark against which change in its habitats can be assessed. Point and transect records of specific habitat types provide a basis for monitoring change within all five landscape zones. Quantitative estimates of the area of specific habitat types were made for the Delta and Lagoon zones as these areas are primarily intertidal (Fig. 12). In situ sampling indicated that seagrass beds were largely limited to these zones and consequently the areas provided represent a reasonable estimate of the total area of this valuable habitat in the bay during August 2005 (Table 2). Comparison of the distribution of seagrass beds in our survey and from the Alaska Shore Zone Coastal Mapping survey conducted in May 2001 (NOAA Fisheries 2010) suggests that distribution of this resource was similar in 2001 and 2005.

The effectiveness of the GIS map as a tool in management and restoration of aquatic resources of the Bay can be enhanced by incorporating new and historical information on the bay. To increase the geo-referencing accuracy of the aerial photography more ground control points could be collected. Currently, we estimate that spatial accuracy is within six meters based on ground control points collected in August 2005. A habitat classification accuracy assessment was not conducted as all collected ground truth data was used in the classification process. Addition of surveys of shoreline elevation, detailed bathymetry and tidal variability could improve estimates of distribution and aerial extent of intertidal habitat. Incorporation of abiotic data from the bay (temperature, salinity, dissolved oxygen, flow) could provide insight to how these factors affect distribution of resources and provide benchmarks for change analysis. More detailed spatial characterization of the sub-tidal habitats should soon be available from the recent hydrographic survey conducted in the region by the NOAA Ship Rainier (Hydropalooza 2010). Multi-beam sonar bathymetry and backscatter data in concert with video observations can be used to map benthic habitats in areas where depth precludes photo interpretation of aerial photography. Determination of fine scale bathymetry and inference on flow conditions provided by substrate type may be important for Port Graham Bay because of its' complex morphology. Water quality problems are known to develop within isolated basins of fjord systems. Within Port Graham Bay localized anoxic conditions may have developed in the past in association with fisheries operations (Chief Patrick Norman, Port Graham Village Council, Port Graham Alaska, personal communication). Information on past conditions such as development of anoxic conditions, distributions of resources relative to habitat type and season could be incorporated as a historical layer within the GIS and will require participation by the Alaskan natives who have depended on the bay for subsistence. Traditional ecological knowledge possessed by Alaskan natives can include traditional resource management techniques as well as observations of the environment that have been passed down through generations.

In addition to providing a tool for the monitoring and managing Port Graham Bay, it is hoped that the proposed landscape zones will prove useful in a more general investigation of the contribution of fjords to the regional ecosystem. There is increasing appreciation of the importance of physical and biological interactions between the fringing fjords and the coastal zone of the GOA (Burrell 1987). Dependence of such critical ecosystem players as salmonids on such systems (Simenstad et al 1981) is recognized and recent studies suggest that a variety of ecologically important species (Muter and Norcross 1994; Nielsen et al. 2007) have evolved life histories that exploit the physical and biological conditions provided by fjords (Etherington et al.

2007). Variation in the extent of landscape zones within fjords can be expected to influence productivity at a variety of trophic levels and consequently the nature and importance of linkages with the larger coastal ecosystem. Improving our understanding of these linkages and the impact of environmental variation on them appears urgent in light of the impact of climate change in the region.

5. ACKNOWLEDGEMENTS

We gratefully acknowledge the guidance and support of Chief Patrick Norman, the Tribal council and people of Port Graham, Alaska. Special thanks to our field work Captain, Martin Norman for sharing his extensive local knowledge, critical in the survey of features of interest within the bay and navigating the system with its powerful tides and strong winds.. Thanks are due also to Manager Ephim Ananahok, Paul McCollum, and Jerry Robart of the Port Graham Hatchery for their support. We are particularly grateful to Annette and Eric Singh and "Grandma" for sheltering and feeding us during the project.

NOAA's Amit Malhotra and Port Graham's Martin Norman celebrate the completion of field work.

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7. APPENDIX I

Table of geographic locations and benthic habitat description from video collected at drift station during a benthic habitat survey in Port Graham Bay, Alaska conducted in August 2005. Multiple locations along a drift are described where high variability in habitat was observed. Drift station correspond to those shown on figures in the text. SG indicates the presence of *Zoster marina*. Different substrate types are listed in order of their perceived abundance and in some cases the presence of benthic invertebrates is indicated in the benthic description. Depth was determined at the time of sampling and is not corrected for tidal stage.

Drift Station	Longitude	Lattitude	Depth (m)	Benthic description
B1	-151.90849142700	59.38686714000	27	gravel
B1	-151.90915384100	59.38761881400	27	gravel
B2	-151.91265697100	59.36450485300	29	sand
B3	-151.89766113800	59.37626691690	47	too dark for camera
B4	-151.88900680100	59.36378965400	27	mud
B4	-151.88924603800	59.36370942400	27	mud
B5	-151.87957071800	59.37222127500	26	coarse sand
B6	-151.87799827900	59.37767331980	25	gravel shell
B7	-151.87429804300	59.37046837500	37	coarse sand
B7	-151.87426491300	59.37052569700	37	gravel shell
B7	-151.87413784700	59.37088765000	37	shell
B8	-151.87236189400	59.36733500900	13	gravel
B9	-151.87139339200	59.36676028500	37	sand
B9	-151.87082907400	59.36720853200	37	sand
B10	-151.86844816000	59.36443032900	31	sand
B11	-151.85493361300	59.36113043700	28	sand
B12	-151.85023042500	59.35597303100	30	sand
B12	-151.85022331800	59.35589501900	30	shell
B12	-151.84999833700	59.35578296500	21	shell sand
B13	-151.84730005600	59.35898125300	27	sand
B14	-151.84285736900	59.35514458000	30	sand
B15	-151.83861924300	59.35739827800	28	sand
B15	-151.83813234200	59.35766187800	28	sand shell
B16	-151.82833304500	59.35623437700	25	sand anemone
B16	-151.82805189600	59.35646364800	25	sand
B17	-151.82638364800	59.35331915500	23	mud
B18	-151.81805660600	59.35334712500	24	sand
B18	-151.81842564300	59.35357688800	24	sand
B19	-151.81761460300	59.35024092300	18	mud
B20	-151.81112158900	59.35178171100	21	mud
B21	-151.80997830900	59.35301333600	26	sand
B22	-151.81027679800	59.35091899000	17	gravel
B22	-151.80896717600	59.35023310300	13	gravel
B23	-151.79978337900	59.35346194400	25	mud
B23	-151.79601149000	59.35171608200	21	mud
B24	-151.80026682000	59.35085681100	24	mud

B25	-151.79578011900	59.34756612500	25	mud
B26	-151.79422407700	59.34707152800	22	mud
B27	-151.79165424800	59.34435399000	20	mud
B28	-151.79106868500	59.34366858400	22	mud
D1	-151.78866556000	59.33995597300	13	shell gravel
D2	-151.78692474100	59.33964149300	11	kelp on gravel
D3	-151.78220796100	59.33793520500	-	patchy algae on gravel
D4	-151.79419322400	59.33705708100	-	seagrass algae
D4	-151.79433862500	59.33692862700	-	dense seagrass
D4	-151.79439420100	59.33685975600	-	patchy seagrass
D4	-151.79445677300	59.33671812600	-	dense seagrass
D5	-151.79002791000	59.33661066600	6	red macroalgae
D6	-151.78620223700	59.33620880700	9	red macroalgae
D6	-151.78621071700	59.33617291300	6	red macroalgae shell
D7	-151.77808619200	59.33623413900	-	patchy algae mud
D8	-151.78081375200	59.33548663500	5	sparse seagrass macroalgae
D9	-151.77401100400	59.33486923500	-	gravel
D9	-151.77378877600	59.33478652400	-	dense yellow rockweed
D10	-151.79004975400	59.33451599900	5	mud, worm colony
D11	-151.79193460000	59.33250794000	4	sparse seagrass
D12	-151.79417149900	59.33375925900	-	patchy seagrass mud
D13	-151.78593152900	59.33353944800	5	patchy seagrass
D13	-151.78580742500	59.33337411600	5	sand
D13	-151.78584445000	59.33334962000	5	seagrass rockweed
D13	-151.78568628500	59.33313878600	5	sand
D13	-151.78562890900	59.33306026700	5	seagrass
D13	-151.78555732900	59.33294937500	5	gravel shell
D13	-151.78528839700	59.33279586100	5	seagrass ulva
D13	-151.78500640200	59.33255207500	5	seagrass
D13	-151.78484441100	59.33221065400	5	seagrass
D13	-151.78462383400	59.33176568500	5	patchy seagrass
D14	-151.77928802300	59.33314920100	4	dense seagrass
D15	-151.77744554900	59.33299198700	-	dense seagrass
D16	-151.77589022000	59.33239669000	-	dense seagrass
D17	-151.78305325900	59.33241313100	5	sand
D18	-151.78513152400	59.33204070300	5	sand diatom mat
D18	-151.78515064700	59.33203126900	5	patchy seagrass diatom mat
D19	-151.78712687300	59.33170648200	5	patchy seagrass
D20	-151.78886053400	59.33144383300	4	sparse algae diatom mat
D21	-151.77984850100	59.33159231200	-	seagrass
D22	-151.78579563700	59.33397254600	5	sparse seagrass & algae
D22	-151.78044800600	59.33153870700	3	dense seagrass
D23	-151.78169669800	59.33127113000	6	sparse seagrass diatom mat
D23	-151.78181683400	59.33103641300	6	sparse seagrass diatom mat
D24	-151.77447291900	59.32980985300	-	dense seagrass
D25	-151.77556516800	59.32922165400	2	dense seagrass
D26	-151.77588848700	59.32786375200	5	patchy algae on sand
D26	-151.77540249800	59.32811161900	5	dense seagrass

D27	-151.77722302900	59.32790445600	5	green filamentus algae
D28	-151.78157303000	59.32733208100	-	sand diatom mat
D28	-151.78196406100	59.32735373500	5	sparse seagrass
D29	-151.77930150700	59.32665781300	4	seagrass algae
D29	-151.77933793800	59.32674695900	4	dense seagrass
D29	-151.77949943100	59.32708157800	4	dense seagrass
D29	-151.77952848300	59.32712156700	4	gravel barnacles
D29	-151.77962097700	59.32726815600	4	gravel barnacles mussels
D30	-151.77909454600	59.32533354700	3	patchy seagrass
D31	-151.77713990900	59.32516856500	3	rockweed barnacles on gravel
D32	-151.77648155600	59.32392751100	4	rockweed cobble barnacles
D33	-151.77109894500	59.32302488400	2	dense seagrass
D33	-151.77206840200	59.32275884700	2	seagrass rockweed
D33	-151.77219057700	59.32270884500	2	sand
D33	-151.77413034500	59.32179195800	3	rockweed
D33	-151.77450698500	59.32159954800	3	dense rockweed
D33	-151.77473188400	59.32150888600	3	dense rockweed
D33	-151.77552945700	59.32121793200	3	patchy rockweed on gravel sand
D33	-151.77575269900	59.32114102400	3	filamentous green algae on gravel
D33	-151.77586256900	59.32108915100	3	cobble
D33	-151.77595133800	59.32104030600	4	dense fliamentous algae
D33	-151.77598933600	59.32095771800	4	sparse algae cobble
D34	-151.77117053700	59.32002404700	-	mud flat
D35	-151.77292996800	59.31819511000	3	sand
D35	-151.77300493700	59.31830172200	3	patchy algae frond ulva
D36	-151.79362088200	59.33160746400	-	patchy algae barnacles
D37	-151.78438453100	59.33206442200	5	patchy seagrass
D37	-151.78430871500	59.33196567400	5	sand filamentous algae
D37	-151.78470144100	59.33202184200	5	patchy seagrass
D37	-151.78493133600	59.33200912500	5	sand filamentous algae
D38	-151.77137879600	59.31457451000	-	gravel
D39	-151.76790199500	59.31381106600	-	cobble
L1	-151.85791595600	59.37365910300	3	seagrass with bryzoans
L1	-151.85886664600	59.37391049100	1	gravel
L2	-151.85755904500	59.37356155500	-	seagrass
L2	-151.85775246200	59.37354047200	-	seagrass diatom mat
L2	-151.85687708400	59.37332859500	-	dense seagrass
L3	-151.85645281200	59.37452302100	2	seagrass diatom mat
L4	-151.85356091900	59.37292431600	3	diatom mat
L4	-151.85300604400	59.37259051100	3	diatom mat
L5	-151.80775188700	59.34255804680	-	1
L6	-151.77829357300	59.34095596300	-	dense seagrass
L6	-151.77827865200	59.34094568700	-	sand
L6	-151.77814046000	59.34084760300	-	dense seagrass
L7	-151.77827540000	59.33986971100	-	patchy algae on sand
L7	-151.77875612400	59.33969949600	-	patchy seagrass on sand
L7	-151.77874487900	59.33935585100	-	gravel mussel barnacles
L8	-151.76744012300	59.32556201600	4	dense seagrass
L9	-151.76653940900	59.32799404700	2	mud diatom mat

L10	-151.76463245200	59.32528236500	4	sparse seagrass mud
L10	-151.76533127200	59.32529505000	4	sparse seagrass, mud
R1	-151.91623089200	59.38919385000	18	kelp on rock
R2	-151.90582839000	59.36901944600	18	kelp on rock
R3	-151.89822585200	59.37113563690	17	kelp on rock
R4	-151.89675005100	59.36878373300	15	red macroalgae on gravel
R5	-151.89210295500	59.37226652500	18	red macroalgae
R6	-151.89130149500	59.37343911400	18	red macroalgae on gravel
R7	-151.89052046900	59.36885917100	23	red macroalgae on gravel
R8	-151.88980930900	59.36933403500	15	red macroalgae cobble
R9	-151.88778339400	59.36632056200	18	sand
R10	-151.88250727300	59.37163862000	4	red macroalgae in bull kelp bed on rock
R11	-151.88128171000	59.37130324900	3	bull kelp
R12	-151.87997684100	59.36660021100	6	dense red macroalgae
R13	-151.86031452500	59.36319510500	8	red macroalgae on sand
R14	-151.85990800100	59.36357836700	-	red macroalgae shell
SN1	-151.89118012300	59.38197038120	5	kelp on rock
SN2	-151.88123924800	59.38170642060	3	kelp on rock
SN3	-151.87490937500	59.38161735750	-	sand
SN4	-151.86856795100	59.37791346600	-	sand
SN4	-151.86736793500	59.37626282100	-	bare sand
SN5	-151.87541408400	59.37625915900	17	sand diatom mat
SN6	-151.87103549200	59.37494500500	13	sand
S	-151.87121855900	59.37445280400	-	sand
S	-151.87107632800	59.37430256600	-	sparse algae
SN8	-151.87569470800	59.37325913700	-	dense red macroalgae
SN9	-151.86729483200	59.37073252800	6	red macroalgae on sand
SN9	-151.86903324800	59.37129878100	4	Fine sand
SN9	-151.86936793400	59.37146525200	4	red macroalgae on sand
SN9	-151.86960301500	59.37152772400	4	red macroalgae on rock
SN9	-151.87088308200	59.37183159900	4	red macroalgae on sand
SN10	-151.87000609400	59.37166984800	6	dense red macroalgae
SN10	-151.87008905200	59.37158481900	8	sand
SN10	-151.87023131700	59.37135683500	11	sand
SN11	-151.86619183600	59.37065791600	6	fine sand shell
SN11	-151.86703748600	59.37056874200	6	fine sand worm tubes
SN12	-151.86267078700	59.37011698200	3	red macroalgae on sand
SN12	-151.86303905000	59.37026160900	3	red macroalgae on gravel
SN13	-151.86047892300	59.36964714300	3	red macroalgae on sand
SN14	-151.85721001400	59.36896822400	4	red macroalgae on cobble
SN15	-151.85752138000	59.36851958900	9	patchy algae on sand
SN16	-151.85462503100	59.36793979000	3	red macroalgae on coarse sand
SN17	-151.85250201300	59.36720682500	2	red macroalgae on coarse sand
SN18	-151.84937021700	59.36730724800	4	red macroalgae on sand shell
SN19	-151.84663078100	59.36692003200	3	red macroalgae on rock
SN20	-151.84383713700	59.36634091300	1	red macroalgae on coarse sand, rocks
SN21	-151.84270640600	59.36613269900	5	dense algae on rock cobble

SN22	-151.84068888000	59.36573311000	8	red macroalgae on sand
SN23	-151.83795405200	59.36574181600	5	dense algae
SN24	-151.83682270900	59.36489730700	2	barnacles patchy algae on rock
SN24	-151.83701726900	59.36475287000	5	kelp on rock
SN25	-151.83205094100	59.36389201100	5	dense seagrass
SN25	-151.83200497700	59.36389244100	5	dense seagrass
SN25	-151.83204019600	59.36386630900	8	red macroalgae
SN25	-151.83190549300	59.36335843000	11	sand
SN26	-151.82684618100	59.36305077700	-	patchy seagrass mud
SN27	-151.82505257200	59.36390222400	5	gravel
SN27	-151.82469654200	59.36365635600	5	patchy algae cobble
SN27	-151.82435181700	59.36353386900	5	dense algae
SN27	-151.82412906900	59.36336788900	5	patchy algae cobble
SN27	-151.82450123400	59.36342871700	5	dense algae
SN27	-151.82490536900	59.36353263200	-	
SN27	-151.82488461200	59.36346755800	5	patchy seagrass
SN27	-151.82482187300	59.36329957300	5	sand
SN28	-151.82325828900	59.36226159300	6	red macroalgae on sand
SN29	-151.82108524500	59.36193688100	10	algae on rock
SN30	-151.82074188800	59.36175580200	6	red macroalgae on sand
SN31	-151.81772783400	59.36169073300	4	red macroalgae on sand
SN32	-151.81738310100	59.36182095810	8	
SN33	-151.81542779200	59.36035257800	6	red macroalgae on sand
SN34	-151.81311120300	59.35950790900	-	red macroalgae cobble
SN35	-151.81218906500	59.35973666480	-	
SN36	-151.81000116200	59.35885752200	14	red macroalgae on sand
SN36	-151.80932096600	59.35847226500	12	red macroalgae
SN36	-151.80869622000	59.35823360200	12	red macroalgae on gravel
SN36	-151.80680398600	59.35747139100	11	sand
SN36	-151.80663681700	59.35740730600	11	patchy red macroalgae
SN37	-151.80939787900	59.35879699700	-	algae cod
SN38	-151.80812189900	59.35824433300	3	red macroalgae on sand with some shell
SN39	-151.80387610800	59.35712303500	4	red macroalgae on shell
SN40	-151.80332154000	59.35741933600	-	dense algae
SN40	-151.80320040900	59.35739863800	-	patchy algae
SN40	-151.80261781700	59.35724476400	-	gravel
SN41	-151.80094357500	59.35553158500	10	red macroalgae
SN41	-151.79923935000	59.35445399800	10	red macroalgae on gravel
SN42	-151.79522229600	59.35396350300	-	patchy algae on sand
SN43	-151.79326148700	59.35188766200	8	patchy algae on sand
SN44	-151.78912857700	59.34889264600	-	sand
SN44	-151.78910693600	59.34887094200	-	patchy algae on sand
SN45	-151.78704649700	59.34606301800	-	patchy algae on sand
SN46	-151.78397063400	59.34201929100	-	sand diatom mat
SN46	-151.78380880000	59.34164627200	-	patchy algae on sand
SS1	-151.91068044500	59.36297706300	17	sand
SS2	-151.90902457100	59.36208055900	-	sand diatom mat
SS3	-151.90434942400	59.36188499900	7	bull kelp

SS4	-151.89392421500	59.36113139100	-	patchy algae sand
SS5	-151.88608547200	59.36013269000	7	red macroalgae
SS6	-151.88055546500	59.36046060600	3	sand
SS7	-151.87616976300	59.36115899700	6	sand
SS8	-151.87340721500	59.35963947600	2	sand
SS9	-151.86813181800	59.35876417800	6	sand
SS9	-151.86766065100	59.35862406900	6	red macroalgae
SS10	-151.86377159000	59.35727546300	10	dense red macroalgae shell
SS11	-151.85934929100	59.35585840300	8	kelp
SS12	-151.85448088800	59.35525310400	12	patchy red macroalgae cobble
SS12	-151.85455820700	59.35490195600	5	red macroalgae
SS13	-151.85118750500	59.35556686300	13	kelp
SS14	-151.84586593900	59.35493042800	9	red macroalgae on sand
SS15	-151.84259248600	59.35501221100	24	red macroalgae on gravel sand
SS15	-151.84206204100	59.35497262700	15	algae shell
SS15	-151.84179552700	59.35487557500	9	algae
SS16	-151.83931725900	59.35521418400	14	algae shell
SS16	-151.83785857100	59.35490914100	12	algae
SS17	-151.83325349500	59.35302296700	7	algae
SS17	-151.83300569400	59.35302510800	7	sand
SS17	-151.83289401900	59.35300929800	7	sand
SS17	-151.83266550200	59.35299116500	7	algae
SS18	-151.82666475800	59.35147679300	-	sparse algae on sand gravel
SS18	-151.82610437900	59.35125258800	-	sand with diatom mat dead salmon
SS18	-151.82552213100	59.35106904400	-	cobble
SS19	-151.82553632800	59.35075391600	13	cobble
SS19	-151.82523857100	59.35074992000	17	sand
SS20	-151.82390295600	59.34851041100	9	algae on gravel
SS20	-151.82237382400	59.34765428700	9	algae on gravel
SS21	-151.82369579900	59.34306441600	3	patchy seagrass on sand
SS21	-151.82323937900	59.34313154400	3	patchy seagrass on sand
SS22	-151.82145881800	59.34353421100	3	gravel shell
SS22	-151.82108738200	59.34357780100	4	mud
SS22	-151.82092101200	59.34360386000	4	mud
SS22	-151.82082675400	59.34358005100	4	patchy seagrass
SS22	-151.82052401400	59.34362930700	4	patchy seagrass
SS22	-151.82047119500	59.34363268400	4	mud
SS22	-151.82028653400	59.34372684100	4	mud
SS23	-151.81850167000	59.34433213300	6	mud diatom mat shells
SS23	-151.81828078600	59.34395854900	6	mud
SS23	-151.81822919000	59.34393380400	6	patchy algae
SS23	-151.81800052200	59.34375952700	6	patchy algae
SS23	-151.81797196000	59.34372560000	6	sparse seagrass algae
SS23	-151.81792420600	59.34367603200	6	dense seagrass
SS23	-151.81786697600	59.34362842800	6	patchy seagrass algae
SS23	-151.81779718000	59.34354841400	6	dense seagrass
SS23	-151.81760823600	59.34342095400	6	patchy seagrass algae
SS23	-151.81755952800	59.34339440800	6	patchy algae

SS23	-151.81746309500	59.34333633700	6	mud
SS23	-151.81741935900	59.34330830500	6	patchy seagrass algae
SS24	-151.81535642400	59.34258703600	2	patchy rockweed on sand
SS24	-151.81526905800	59.34259328500	2	patchy rockweed on sand
SS24	-151.81449784900	59.34256381900	2	patchy rockweed on sand
SS25	-151.81545794700	59.34467984600	-	gravel diatom fillamentous algae
SS25	-151.81482009100	59.34454890500	-	gravel
SS25	-151.81339236100	59.34462264400	-	gravel
SS25	-151.81335453400	59.34463071900	-	patchy seagrass
SS25	-151.81321714400	59.34466455200	-	gravel mud
SS26	-151.81443012900	59.34643043600	6	patchy kelp
SS26	-151.81285876100	59.34624353000	6	patchy kelp
SS27	-151.81288116600	59.34807450900	-	kelp cobble
SS27	-151.81192957200	59.34804959800	-	kelp cobble
SS28	-151.80866126400	59.34951721700	9	red macroalgae on gravel
SS28	-151.80815559300	59.34984540000	11	patchy red macroalgae on gravel
SS28	-151.80807189900	59.34989704400	11	gravel
SS29	-151.80862364600	59.34813980000	9	dense red macroalgae
SS29	-151.80859001500	59.34778195700	7	red macroalgae cobble
SS30	-151.80217079800	59.34698388900	7	dense red macroalgae
SS30	-151.80161365700	59.34653380300	9	red macroalgae on sand
SS30	-151.80091216900	59.34601712000	9	red macroalgae on sand
SS30	-151.80006724600	59.34536274200	17	patchy algae on sand
SS30	-151.79988593300	59.34518940800	18	muddy sand
SS30	-151.79972830500	59.34502916700	20	mud
SS31	-151.80135830600	59.34324314300	-	gravel
SS31	-151.80112620600	59.34298568000	-	red macroalgae shell
SS32	-151.79768064900	59.34162518600	-	red macroalgae shell
SS33	-151.79330254400	59.34043685400	6	red and green algae
SS33	-151.79318585100	59.34010566200	6	gravel
SS33	-151.79267921600	59.33967983100	11	red macroalgae on sand

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