AKMAP 2006 - 2007 Aleutian Islands Coastal Survey

Statistical Summary

Prepared by:
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Preface

The Alaska Department of Environmental Conservation (DEC) conducted an Alaska Monitoring and Assessment Program (AKMAP) survey of the Aleutian Islands in 2006 and 2007. This survey focused on regions around the Aleutian Islands within the 20-meter contour lines. The ecological condition of this area was assessed using a spatial probabilistic survey design, developed under the U.S. Environmental Protection Agency Environmental Monitoring and Assessment Program. Over two summers 51 stations were surveyed. Results of the survey provide representative status conditions for water quality, habitat, and biological indices for the early summer period in the Aleutian Islands.

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The document can be downloaded at the following URL:

http://dec.alaska.gov/water/wqsar/monitoring/06-07Aleutian.htm

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Note that the design supports probability-based estimates of the percent area of target population surveyed for particular ecological status defined by measured values of assessment indicators. However, this design does not provide for detailed assessments of ecological status within a particular estuary or coast area.

Acknowledgments

The U.S. Environmental Protection Agency Office of Research and Development supported this study through Cooperative Agreement # R-82911501. Walt Nelson, Dixon Landers, Tony Olsen, and others with USEPA ORD enthusiastically supported our efforts and understood the importance of this pioneering endeavor in Alaska. We appreciate NOAA supporting Mandy Lindeberg on our team in 2006 and 2007, acting as the resident phycologist. Her enthusiasm over marine algae was contagious none the more so when we discovered the Golden V kelp, a new genus and species. We thank the members of the 2006-07 AKMAP dive team including: Reid Brewer, Héloïse Chenelot, Roger Clark, Roger Deffendall, Shawn Harper, and Max Hoberg for sampling, photography, and videography. Héloïse Chenelot's assistance with the benthic analyses is greatly appreciated. The staff at the National Wetlands Research Center / Gulf Breeze Project Office (NWRC/GBPO) did great work in helping us re-design the Aleutian Islands survey from an open ocean to a near shore design. Finally, Captain Paul Tate and the crew of the R/V *Norseman* provided their knowledge and expertise to help make the survey a success and to bring everyone home safely.

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Introduction

The Alaska Department of Environmental Conservation Alaska Monitoring and Assessment program (AKMAP) grew out of the U.S. Environmental Protection Agency (USEPA) Environmental Monitoring and Assessment Program (EMAP), which has become the EPA National Aquatic Resource Survey program. The goal of EMAP is "to monitor the condition of the Nation's ecological resources, to evaluate the cumulative success of current policies and programs, and to identify emerging problems before they become widespread or irreversible" (USEPA, 1997).

Background

From the Alaska Peninsula, the Aleutian Islands extend westward from Unimak Island to Attu Island over a distance of more than 1,900 km (Figure 1-1, includes sample stations). Over 200 Aleutian Islands totaling about 1.1 million hectares form an arc that separates the North Pacific Ocean from the Bering Sea (Banks et al., 2000). Five main island groups comprise the Aleutian Islands (Rennick, 1995): Fox Islands, closest to the Alaska Peninsula, includes the prominent islands of Unalaska, Umnak, and Akutan; Islands of Four Mountains includes Kagamil, Chuginadak, Carlisle, Herbert, Yunaska, and Amukta islands; Andreanof Islands includes Amlia, Atka, Great Sitkin, Adak, Kanaga, and Tanaga islands; Rat Islands includes Amchitka, Semisopochnoi, Little Sitkin and Kiska islands; and Near Islands, the most western group, includes Agattu and Attu islands. A smaller island group of the Semichi Islands, which includes Shemya, is a subset of the Near Island group. Further to the west of the Near Islands, the Commander or Komandorski Islands, Russia, continue the island arc and are biologically linked to the Kamchatka shelf and coast. On the southern edge of this submerged mountain range, of which the Aleutian Islands are the exposed peaks, is a curving submarine trench as deep as 7,600 m extending across the North Pacific for 3,200 km from the Gulf of Alaska to Kamchatka Peninsula (Merritt and Fuller, 1977).

The Aleutian Islands rose from the volcanic activity resulting from the convergence of the Pacific and North American plates. Today the Aleutian Islands remain one of the most seismically and volcanically active regions in the world. Topographically the region consists of steep hillsides, shoreside cliffs, glacially carved basins, and volcanic peaks as high as 2,080 meters. Islands are still being born out in the Aleutians, with Perry Island rising above sea level just over a hundred years ago (Johnson, 2003). The Pacific plate thrusts under the North American plate at a rate of 6-8 cm/year and sections of the Aleutian Islands are moving in a westerly direction at 2 to 3 cm/year (University of Alaska Fairbanks, 2002).

Climatically the Aleutian Islands are located in a maritime zone, which exhibits heavy precipitation, extreme winds, frequent storms, cool summers, and warm winters (Selkregg, 1976). The Aleutian low is a name given by meteorologists to the atmospheric pressure system that exerts the most influence on storms in this region during the winter time. During the winter season, when the Aleutian low is strong, an average of three to five storms move eastward along the Aleutian Chain (Johnson, 2003). In the summer, with periods of long daylight and high solar insulation, the Aleutian low is generally weak and the weather relatively, for this region, benign.

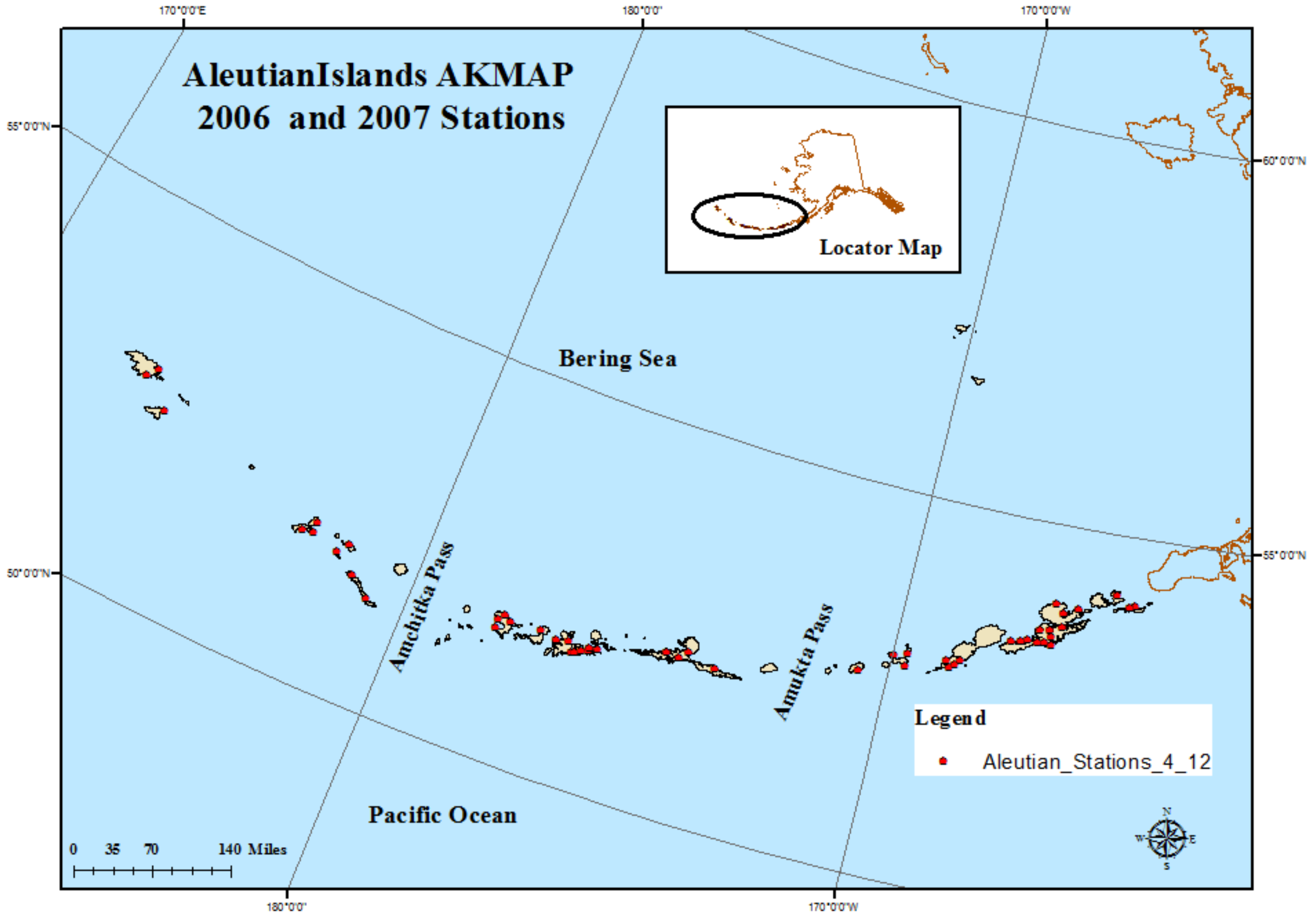

Figure 1-1: Overview of Aleutian Islands AKMAP 2006 and 2007 Sampled Stations

On their southern edge the Aleutian Islands are bounded by the strong Alaska Current flowing in a westerly direction, with the easterly flowing Aleutian North Slope Current to the north of the islands. Significant flow from the Alaska Current occurs through 14 passes, providing relatively fresh surface waters and warm subsurface waters (Stabeno et al., 1999) to the Bering Sea. Figure 1- 2 shows the principal currents (BEST, 2004).

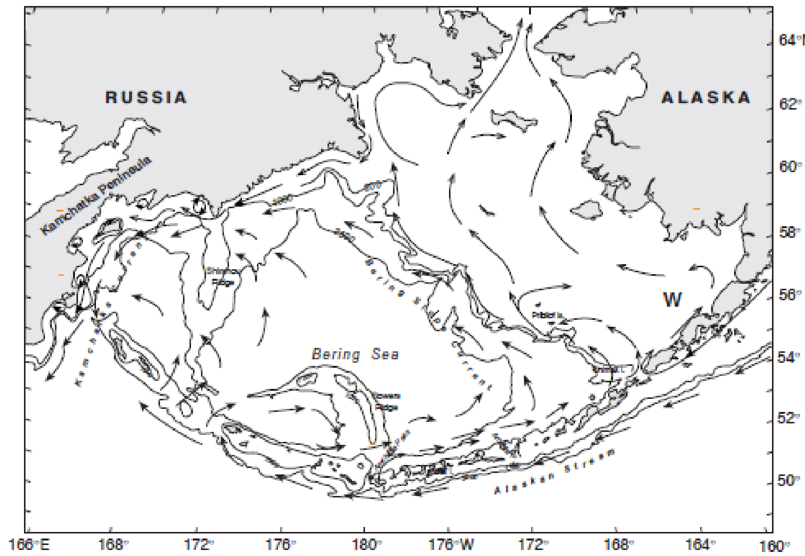

Figure 1-2: Principle Aleutian Currents (BEST, 2004)

Some of the most productive and biologically diverse marine ecosystems occur within the marine zones around the Aleutian Islands. Significant upwelling occurs in this region bringing nutrients to the surface creating create a “green belt” region of high levels of primary and secondary production along the Aleutian Arc (Springer et al., 1996). Numerous species of fish, mollusks and crustaceans, birds and marine mammals live in this region.

Fisheries harvests in this region, Aleutian Islands and Bering Sea, provide over 50% of the US and around 10% of the global marine harvest of fish and shellfish. Disregarding the North Pacific Ocean salmon harvest, the Bering Sea harvest of walleye pollock, cod and other groundfish is worth an estimated $1 billion per year (NOAA, 1998). The fisheries and seafood processing industries employ thousands of Alaskans and many small communities are completely dependent upon the income from commercial fishing.

The Aleutian Islands are within major migratory pathways of many subsistence food species used by the Aleut Natives. Aleut subsistence users harvest fish, marine mammals and other subsistence foods from around the Aleutian Islands. Gathering of subsistence foods is an important part of Aleut culture. Subsistence users in this region are concerned about their subsistence foods, with recent reports of global and local pollution sources and climate change impacts in this region (APIA, 2012).

Near the end of the 20th Century, large scale ecosystem impacts were documented in the Aleutian Island and Bering Sea region, which have been attributed to climate change and human impacts on the system (Barron et al., 2003; Johnson, 2003; Anthony et al., 1999; Bacon et al., 1999; NOAA, 1998; Estes et al., 1997). Effects of numerous anthropogenic stressors, ranging from commercial fisheries to invasive species, need to be understood if resource managers are to develop and practice adaptive management.

Numerous contaminated areas, consisting principally of petroleum products with PCB's and heavy metals, exist in this region, with many sites related to World War II and Cold War activities (Stout, 2001). Concern still lingers of possible radionuclide contamination of the marine food chain from the three underground nuclear test shots conducted on the central Aleutian island of Amchitka between 1965 and 1971 (Burger et al., 2004). In addition to the local contaminant inputs, both marine and atmospherically coupled routes have been identified as pathways for the transport of contaminants from Asian and other Pacific Rim countries (Nilsson et al., 2002). Many are concerned that these contaminants pose potential threats to the marine ecosystem in the Aleutians and Bering Sea regions (NOAA, 1998).

A major pacific shipping route transits hundreds of ships a year between the US West Coast and Asia through the Aleutian Islands. Shipwrecks in the past 15 years in this region have spilled over 440,000 gallons of oil (DEC, 2004). The most recent spill in 2004, the M/V *Selendang Ayu*, was carrying 450,000 gallons of heavy oil and lost an estimated 321,000 gallons of oil, in addition to 66,000 tons of soy beans (Anchorage Daily News, 2005; Figure 1-3). As the Arctic ice pack recedes due to climate change a major increase in shipping through this region is expected to occur as the Northern Sea routes open up (Johnson, 2003).

Figure 1-3: Slendang Ayu shipwreck near Unalaska Island

The AKMAP Coastal Survey in the Aleutian Islands provides DEC a better understanding of the status and, as future assessments are done, trends in contaminant levels and ecosystem changes in the region.

Goals

Goals of the 2006 – 2007 Aleutian Island AKMAP were 1) to assess the spatial extent of ecological conditions based on several measured indicators of marine environmental quality and 2) establish baseline measurements to evaluate future changes in environmental quality or condition. In doing so, specific questions can be further evaluated. For example:

What proportions of the measured indicators have contaminant levels that indicate potential ecotoxicological impacts?

What is the prevalence of chemical contaminant loads in fish tissues that indicate exposure to contaminant sources?

What proportions of the coastal waters have levels of nutrients, dissolved oxygen, or other water quality parameters that indicate poor water quality for resident benthic fish and invertebrates?

The AKMAP coastal assessment data can help evaluate these environmental concerns by providing background context data, such as toxic contaminants and benthic habitat, or by providing specific data, such as non-indigenous species or to extend geographic ranges of species.

Program Framework

The Aleutian Islands AKMAP survey utilized a spatial probabilistic survey design combined with a multi-tiered, integrated monitoring of selected environmental indicators that has been developed by EPA (USEPA, 2012). The sampling design utilizes a probabilistic, stratified-random approach enabling the interpretation of general ecological condition of large areas to be assessed with a relatively small number of sampling sites. Data is integrated from multiple environmental media, including water quality data, sediment data, biological, physical and chemical parameters. This provides a more complete evaluation and assessment of ecosystem condition than more traditional monitoring, which typically emphasizes a single media and a stand-alone approach.

Sample locations were selected by a probabilistic sampling scheme based on a target population of waters ≤ 20 m deep around the Aleutian Islands. The target population was broken into two strata; (1) estuary waters ≤ 20 meters and (2) open marine waters ≤ 20 m. Estuary sites comprised 60% of the total selected sites. Hexagon grids of equal sized cells were used by EPA in the spatial design. Fifty base sites and 50 alternate sites were selected. Figures 1-4 and 1-5 show the stations sampled in 2006 and 2007, respectively. Appendix A provides station latitude and longitude information and four larger scale maps of the stations and relative numbering from east to west.

In this design estuaries were defined as any water body that is tidally influenced, saline, having less than 50% of its perimeter adjacent to the ocean (USEPA, 2001). Open marine waters, the second target population stratum, are waters that do not meet the estuary definition.

Wetlands and littoral zones are not part of the targeted population. A review of the sites selected indicate the preponderance of sites encompass rocky benthic habitat common to the Aleutian Islands.

Sample Design

NCA protocols are designed for traditional soft sediment sampling methods, but the Aleutian Island consists of primarily rocky benthic habitat, which required a modification in survey methodology. Characterization of the coastal waters required the use of divers to conduct field surveys of rocky bottom habitat. AKMAP sampling in the Aleutians used modified versions of the methods adopted by Hawaii and Guam for soft and rocky bottom habitat (Jewett, et al., 2008).

The benthic survey assessment survey design incorporates the use of a transect line with three quadrats randomly placed along a transect line, collection of biological specimens and sediments, if present, occurred within a quadrat (Figure 1-6). Fish were collected typically by hook and line at each station. Water column profiles for temperature, salinity, dissolved oxygen, fluorescence (chlorophyll *a*); photosynthetically active radiation (PAR) and pressure were collected at each station. Water samples for total suspended solids, nutrients, chlorophyll *a*, pH, and dissolved oxygen were also taken at 1 m below the surface, mid-depth and approximately 1 m off the bottom.

Additional details on the methods and quality assurance/quality control (QA/QC) may be found in the 2006 – 2007 Quality Assurance Program Plan (DEC, 2007) and the NCA 2001 - 2004 QAPP (USEPA, 2001).

Data Management

Data sets will be entered into the DEC Alaska Quality Water Monitoring System database, which is then uploaded to the USEPA National STORET database for public access.

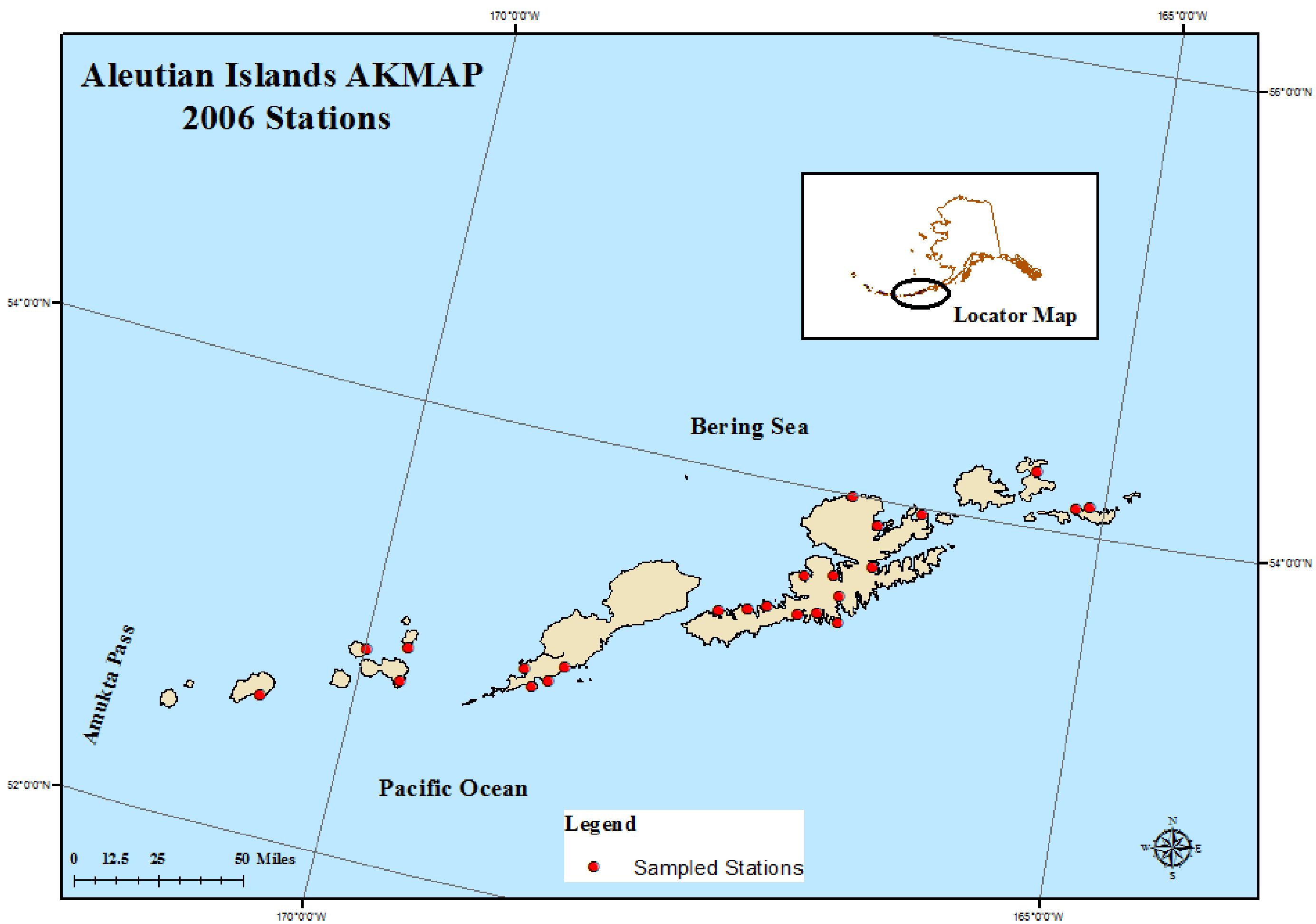

Figure 1-4: Aleutian Islands 2006 AKMAP Stations

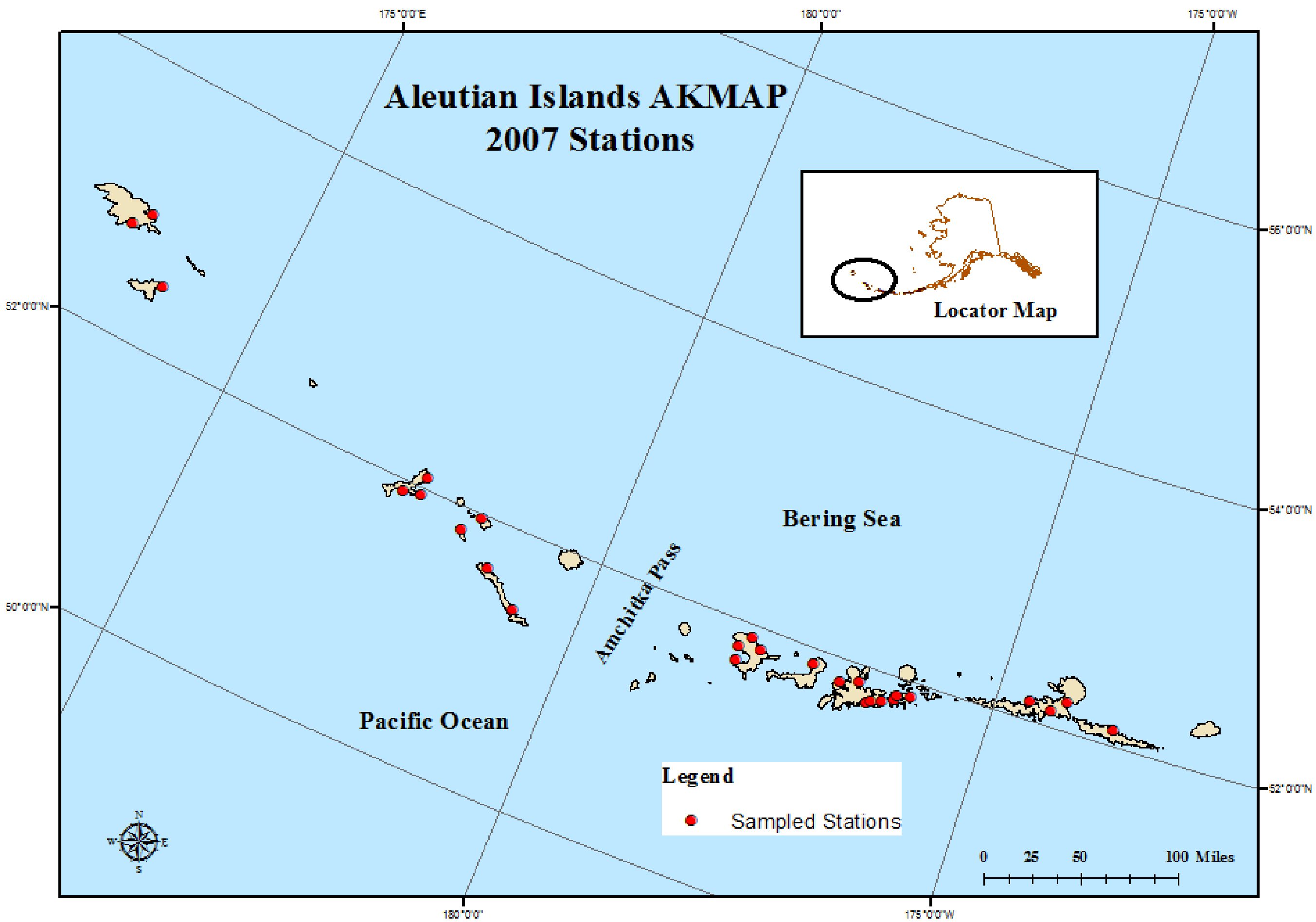

Figure 1-5: Aleutian Islands 2007 AKMAP Stations

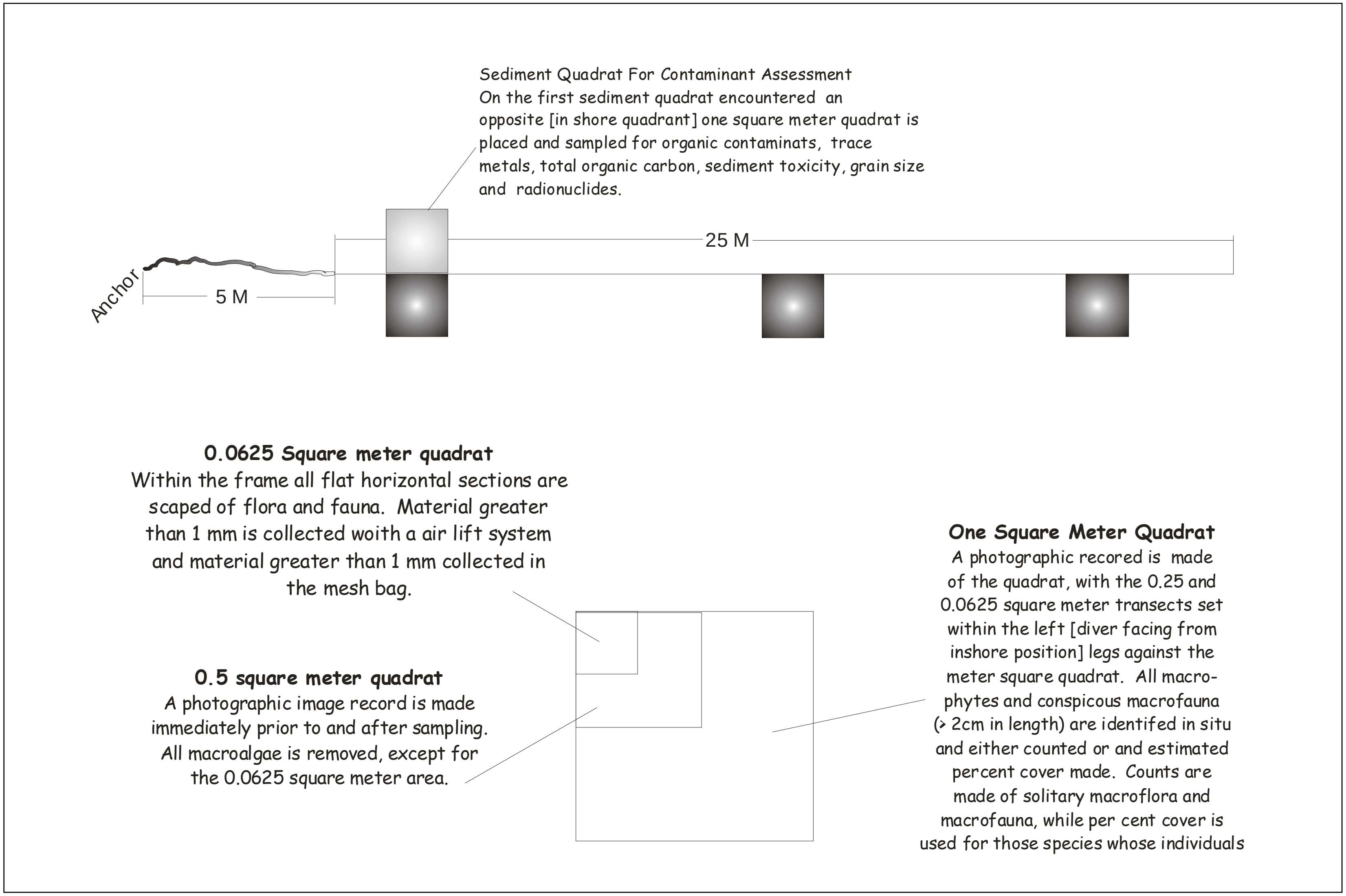

Figure 1-6: AKMAP Benthic Transect and Quadrat Layout

Chapter-1: Indicator Results

In this statistical summary observed water and benthic habitat condition and indicators are presented as Cumulative Distribution Functions (CDF), statistical summary table, X and Y graphic or a mix of these formats. Based on the survey design the condition and indicator results represent the target population and results can be presented relative to the cumulative percentage of the area surveyed.

CDFs used in this report represent the proportion (cumulative percentage area) of the study area that is above or below some threshold or indicator value (e.g. water quality standards). Our survey design allows for these statistical estimates, within known confidence limits. For example, Figure 2-1 represents a CDF of bottom dissolved oxygen (DO) measurements taken across the Aleutian Islands survey area. The X axis provides the estimated DO mg/L and the Y axis represents the cumulative percentage of the area surveyed. The solid black line, Estimate.P, represents the estimate of cumulative percentage area and its corresponding DO level. The dotted lines, Lower Confidence Bound 95 Perecntile (LCB95Pct.P) and Upper Confidence Bound 95 Percentile (UCB95Pct.P), show the upper and lower 95% confidence limits for the Estimate.P. For example, the median or 50% cumulative area line highlighted in blue indicates that 50% of the cumulative area targeted had a DO ≤ 9.10 mg/L, with upper and lower 95% confidence levels of ~ 60% or ~ 35% of the cumulative area having ≤ 9.1 mg/L. Based on this data Aleutian Islands estuaries and near shore areas do not have bottom dissolved oxygen concentrations lower than 4 mg/L or above 17 mg/L, which are the limits set in the State of Alaska's Water Quality Standards.

The DEC Alaska Water Quality Standards (AWQS) (18 Alaska Administrative Code 70) regulate human activities that result in alterations in waters within the state's jurisdiction (DEC, 2012). These standards include the designated uses (e.g., recreation, aquatic life), water quality criteria to protect designated uses (numeric pollutant concentrations and narrative requirements), and an antidegradation policy that is designed to maintain and protect existing uses and high quality waters. Standards are defined for several marine water uses including:

(A) Water supply
- (i) aquaculture;
- (ii) seafood processing;
- (iii) industrial;

(B) Water recreation
- (i) contact recreation;
- (ii) secondary recreation;

(C) Growth and propagation of fish, shellfish, other aquatic life, and wildlife; and
(D) Harvesting for consumption of raw mollusks or other raw aquatic life.

Generally the water quality numeric criteria fall into three categories: some as absolute threshold concentrations, some as concentration ranges, and others as limitations to the change that can be made above or below a natural background. When AWQS exist for a particular indicator, comparisons of the study area that do not meet that standard will be presented. In other cases, where AWQS have not been defined, other applicable comparison values will be discussed (e.g. Effects Range-Low and Effects Range–Median for sediments).

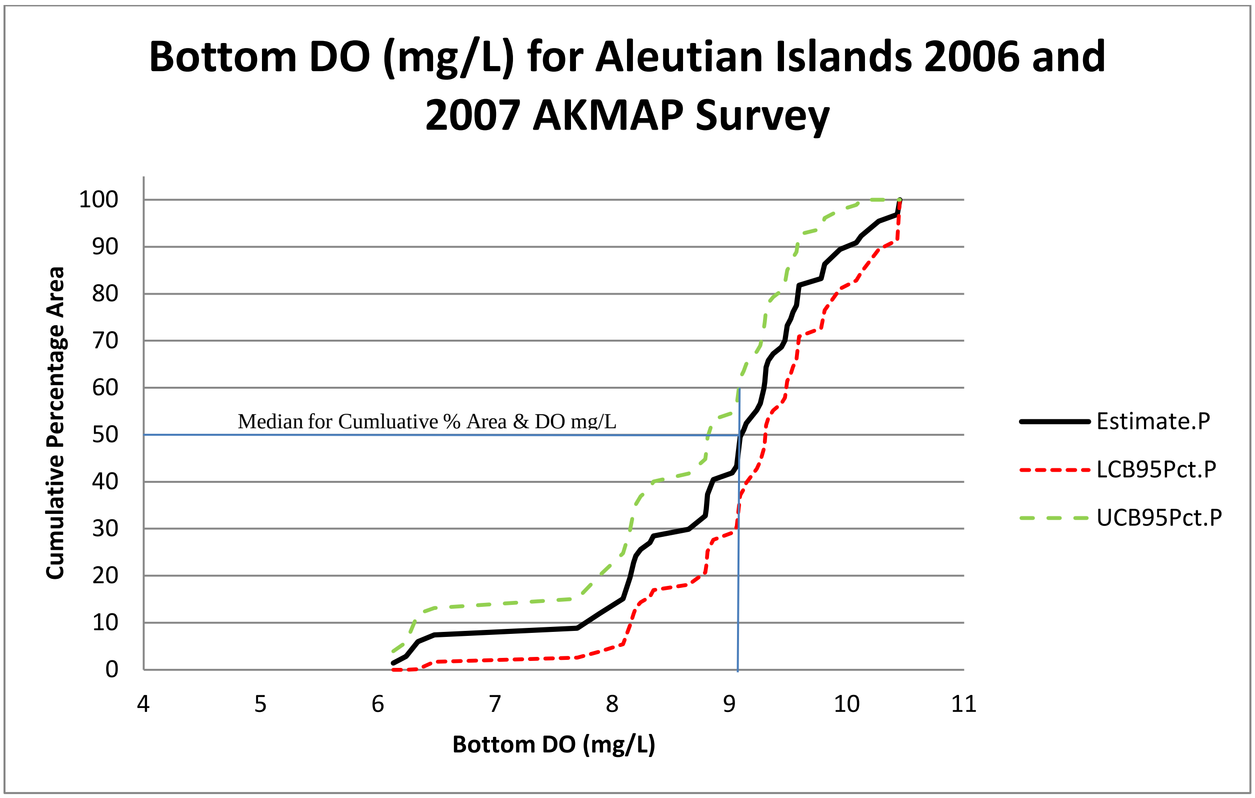

Figure 2-1: Example Cumulative Distribution Function (CDF)

Habitat Indicators

Water quality measurements were obtained continuously along the water column with a conductivity, temperature, and pressure (CTD) instrument or from discrete water samples taken at the surface, mid-depth, and about a 1 m off of the bottom. In the shallow (≤ 20 m) stations the waters are typically well mixed and the focus of this report is on the surface and bottom sample results. Table 2-1 presents statistical summaries of the data with the CTD data as averaged for surface (1 m depth range) and for the bottom (1 m depth range) measurements. Discrete water values are reported for the surface and bottom samples.

Depth, Meters

Across the 51 stations sampled, depths ranged from 5 to 27 m. Depths associated with each individual station are shown in Figure 2-2. The survey design constrained the target population to the bathometric 20 m contour shoreward. The bathometric mapping in the Aleutian Islands has limited accuracy, especially for the near shore regions, and it was not unexpected to encounter some depths greater than 20 m. Provided that the divers could safely operate stations were not moved if the depth were greater than 20 m depth. The sampled stations still reflected the near shore soft sediment or coralline algae habitats encountered through the survey region. This information is useful when comparing study area habitats among the various national regions and provinces included in the National Coastal Assessment.

Water Temperature

The two-year survey sampled a region covering more than 1,900 km (1,181 miles) and took place between late June and July each year. Temperature data at represents just a snapshot and is not meant to address differences between the years or climatic variations. The data set is relevant in the context of assessing other water quality variables, such as percent dissolved oxygen saturation, or benthic habitat status.

Overall the temperatures shown in Table 2-1 are representative of the mid-summer conditions in the region and depths sampled. Figures 2-3 and 2-4 provide CDFs for surface and bottom waters column temperature measurements, respectively.

pH

The surface and bottom water pH of the stations sampled indicate well-mixed waters. Summary statistics are shown in Table 2-1. Overall small percentage differences were observed between surface and bottom pH values, with a range from 81% to 102%. Figures 2-5 and 2-6 provide CDFs for surface and bottom water column pH measurements, respectively. Approximately 90% of the estuary and coastal waters sampled had surface pH ≤ 8.27 or bottom pH ≤ 8.23.

Salinity practical salinity units

Salinity influences water column density and, thus, the stability or stratification of the water column. This, in turn, can influence many other water quality factors. Salinity can also be an important influence on benthic community distribution and abundance. Salinity was measured throughout the water column during the conductivity temperature depth (CTD) cast, but as a water quality indicator it is presented here averaged for the surface and bottom only.

Surface salinity ranged from 26.16 to 33.53 practical salinity units (psu) across the study area. The lowest salinities occurred in surface water measurements at stations AKALE06-0028 and AKALE06-0030 at the heads of estuaries on Unalaska Island receiving freshwater runoff. The effects of the freshwater input in the regions sampled were not reflected in similar reductions in bottom salinities, which ranged from 31.95 to 33.29 psu. Figures 2-7 and 2-8 provide CDFs for surface and bottom water column salinity measurements. For bottom waters 90% of the area had salinities less than 33.25 and 5 % had salinities less than 32.03 psu.

Practical Salinity Units (PSU): A measure of the salt content of seawater (practical salinity), based upon electrical conductivity of a sample relative to a reference standard of sea water with a known salt content.

Overall differences between the sampled surface and bottom salinities were not statistically significant as determined by the Wilcoxon-Mann-Whitney non-parametric tests. At Samalga Pass the influence of the Alaska Coastal Current, which provides lower salinity waters derived from melting glaciers and river inputs along Alaska's coastal mainland regions to the southeast, lessens. Figure 2-9 shows the differences between salinities observed through stations 1-20 and then the remaining stations to the west of Samalga Pass (stations 21-51). Appendix A provides the station location numbers on an east to west axis.

Dissolved Oxygen

The cumulative percent area distribution of surface and bottom water column dissolved oxygen (Figures 2-10 and 2-11, respectively) shows that 100% of the study area met Alaska Water Quality Standards (AWQS) criteria for all marine water uses (i.e. aquaculture, growth and propagation of fish, shellfish, and other aquatic life and wildlife, and harvesting mollusks or other raw aquatic life). The lowest surface water DO value of 5.64 mg/L was observed at station AKALE07-DD00035. The lowest bottom water DO value of 6.13 mg/L was observed at station AKALE06-0024. For bottom waters 90% of the area had DO ≤ 9.99 mg/L and 5% had DO ≤ 6.31, with a lower 95% confidence level of 6.18 mg/L.

18AAC 70 Water Quality Standards (May 26, 2011)
Dissolved Gases for Marine Water Uses -
Growth and Propagation of Fish, Shellfish, Other Aquatic Life, and Wildlife
For estuaries

D.O. concentrations in estuaries and tidal tributaries may not be less than 5.0 mg/l except where natural conditions cause this value to be depressed. In no case may D.O. levels exceed 17 mg/l. The concentration of total dissolved gas may not exceed 110% of saturation at any point of sample collection.

Table 2-1: Summary Statistics for Habitat Indicators

Habitat Indicators	n	Mean	Std Dev	Median	Range (Min – Max)
Depth, Meters	51	13.2	4.7	12.1	5 - 27
Surface Water Temp. C	51	6.62	1.40	6.29	4.57 – 11.72
Bottom Water Temp. C	51	5.93	1.07	5.79	4.49 – 8.63
Surface pH	51	7.96	0.55	8.09	4.27 – 8.38
Bottom pH	51	8.09	0.37	8.16	4.26 – 8.32
Surface Salinity psu	51	32.40	1.05	32.50	26.16 – 33.53
Bottom Salinity psu	51	32.82	0.45	33.09	31.95 – 33.29
Surface Dissolved Oxygen mg/L	51	8.84	1.22	8.78	5.64 – 12.18
Bottom Dissolved Oxygen mg/L	51	8.92	1.00	9.10	6.13 – 10.45

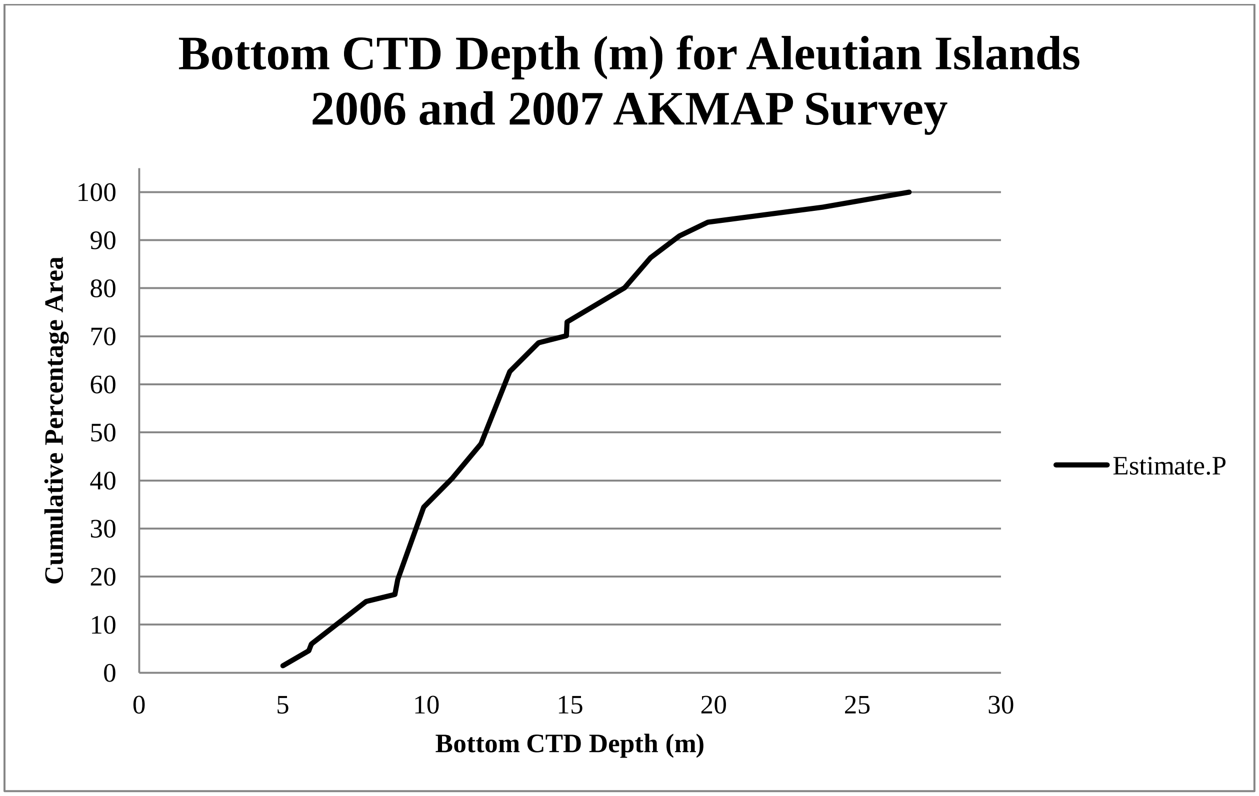

Figure 2-2: CTD Bottom Depth (m)

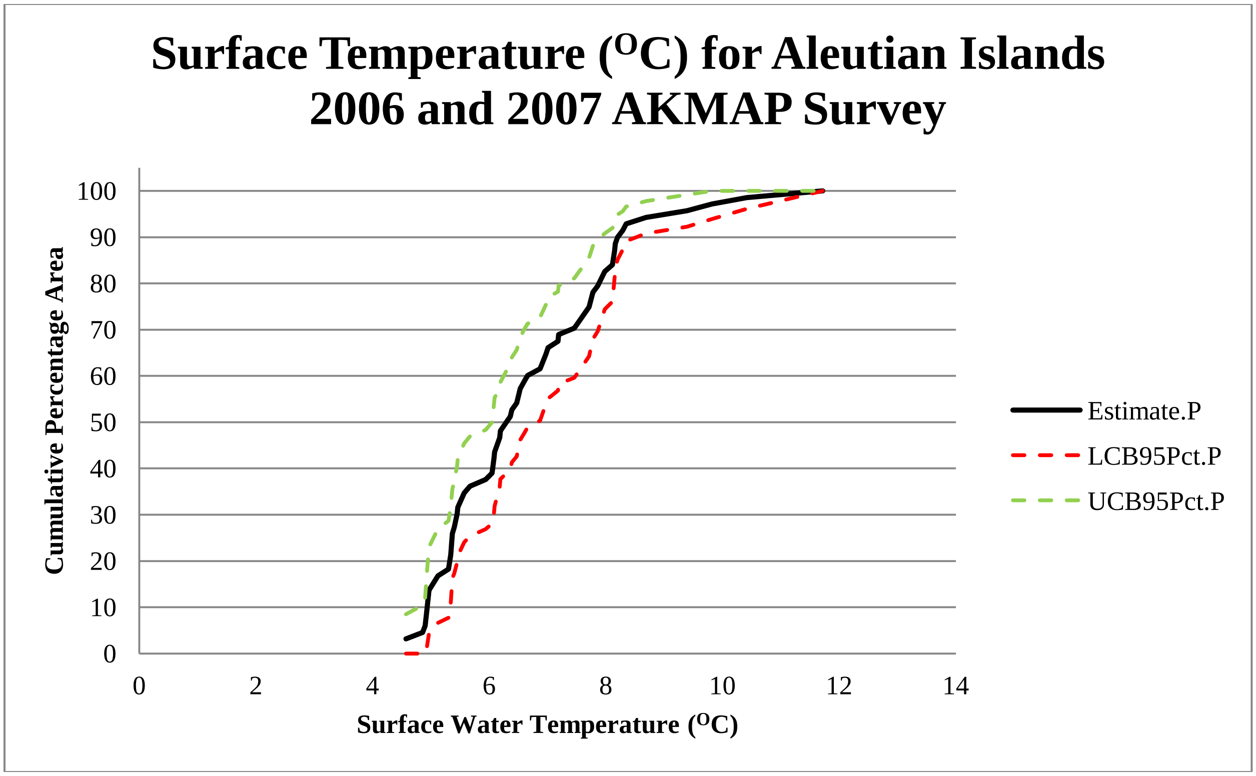

Figure 2-3: CDF Surface Water Temperatures (^{O}C)

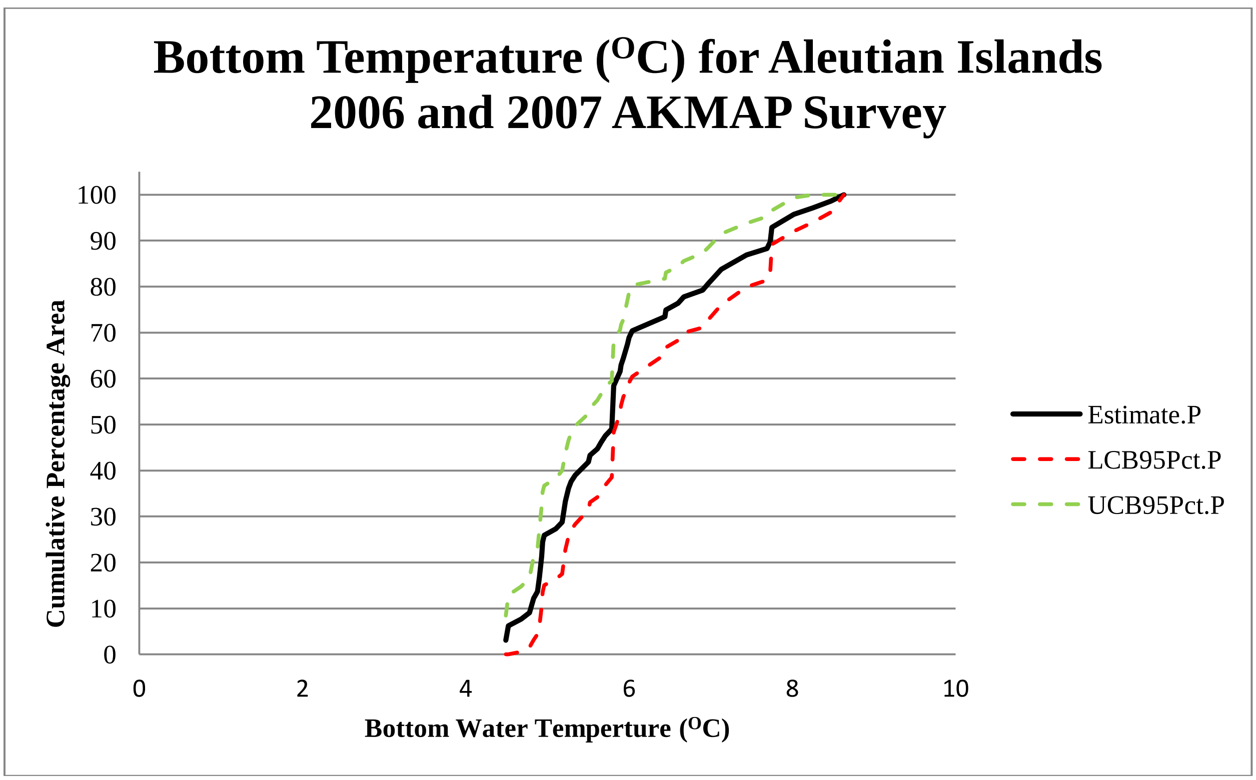

Figure 2-4: CDF Bottom Water Temperatures (^{O}C)

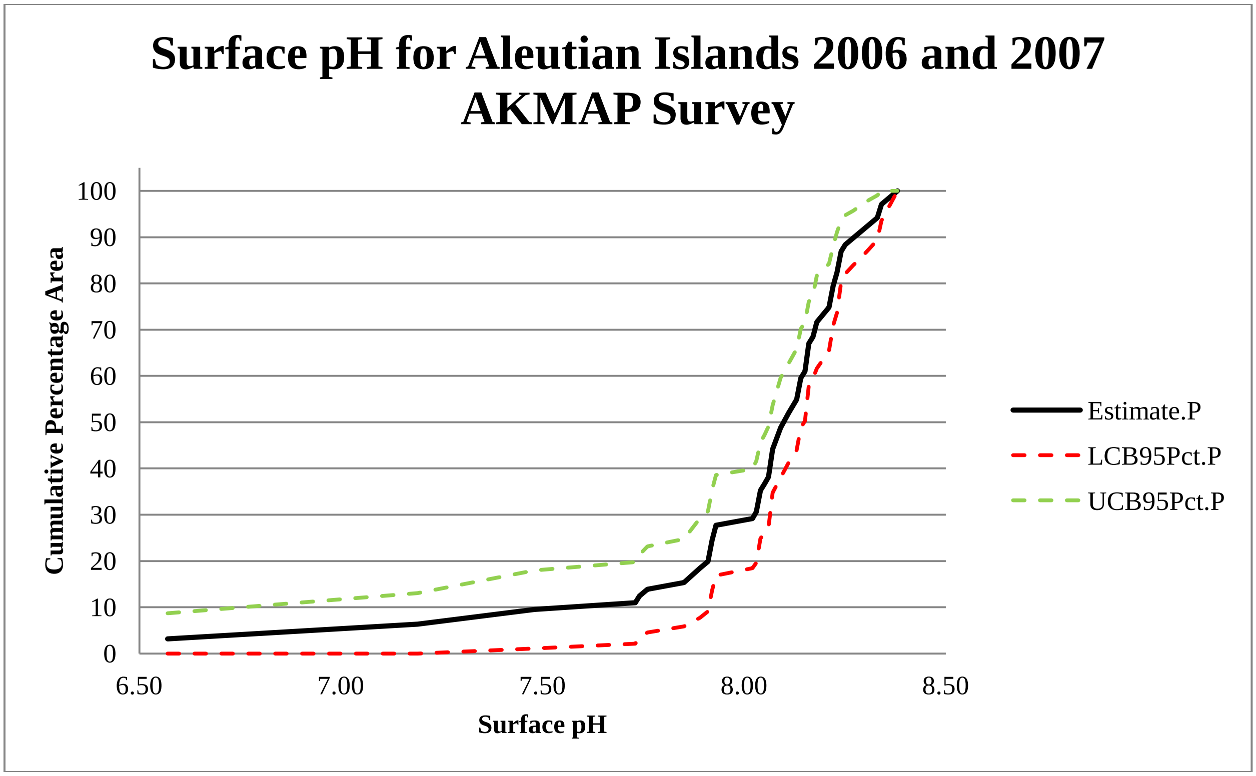

Figure 2-5: CDF Surface pH

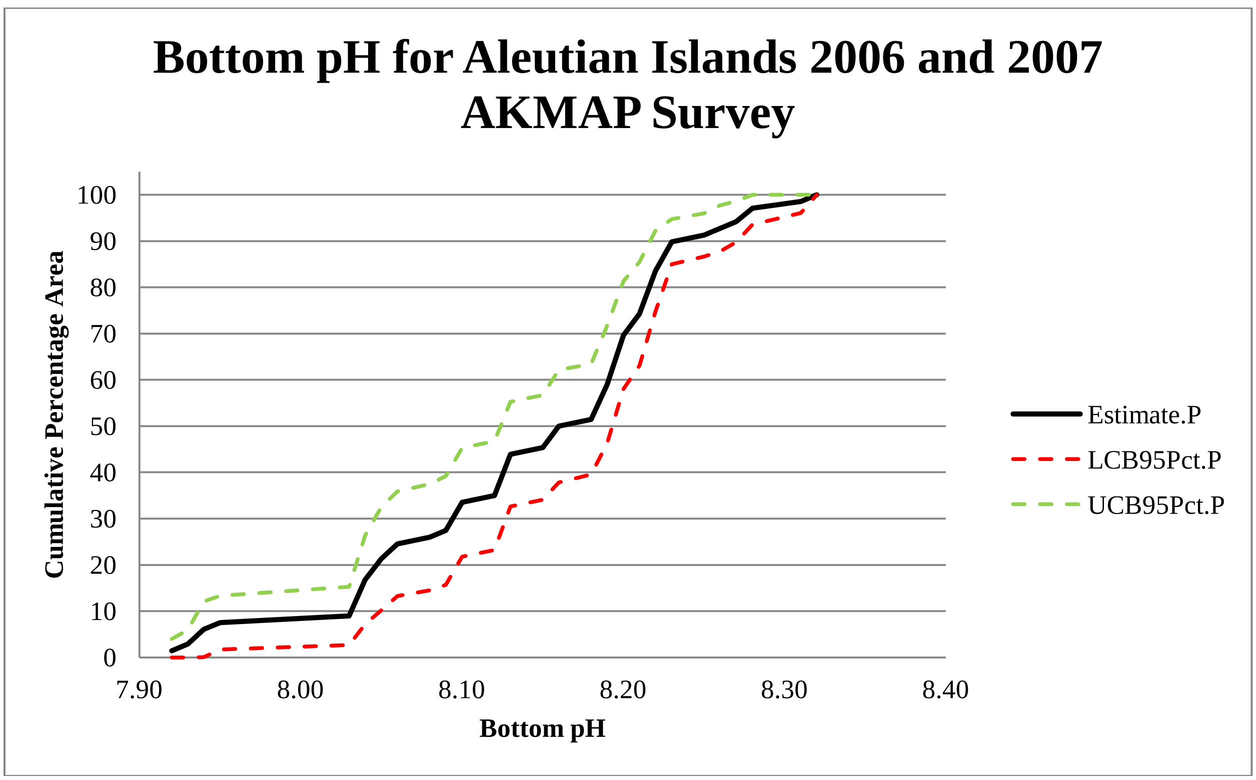

Figure 2-6: CDF Bottom pH

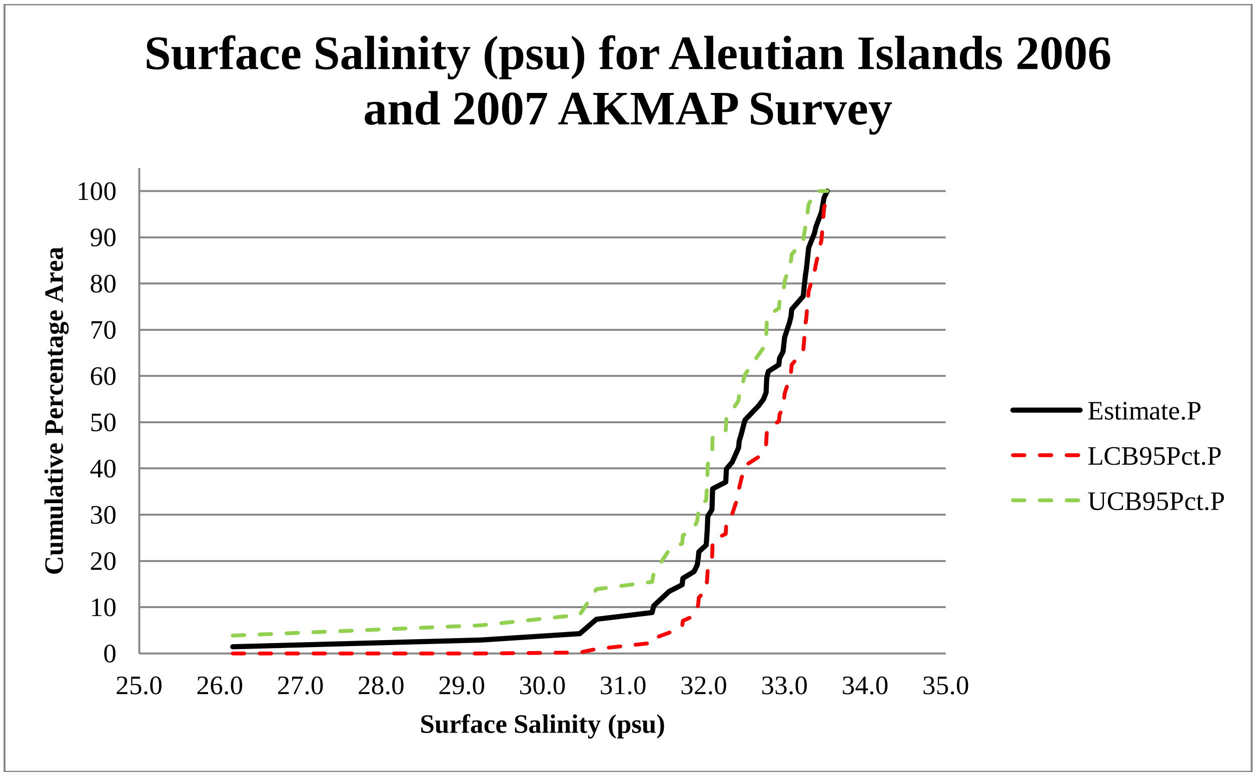

Figure 2-7: CDF Surface Salinity (psu)

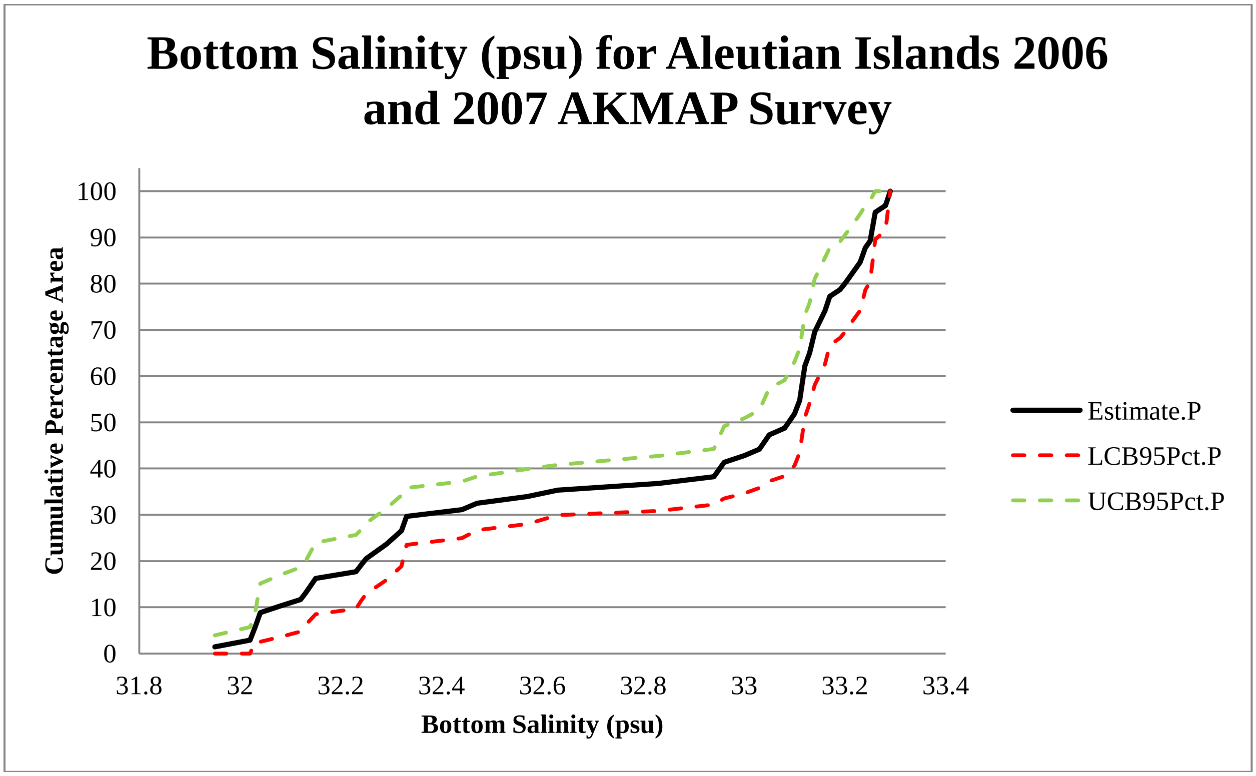

Figure 2-8: CDF Bottom Salinity (psu)

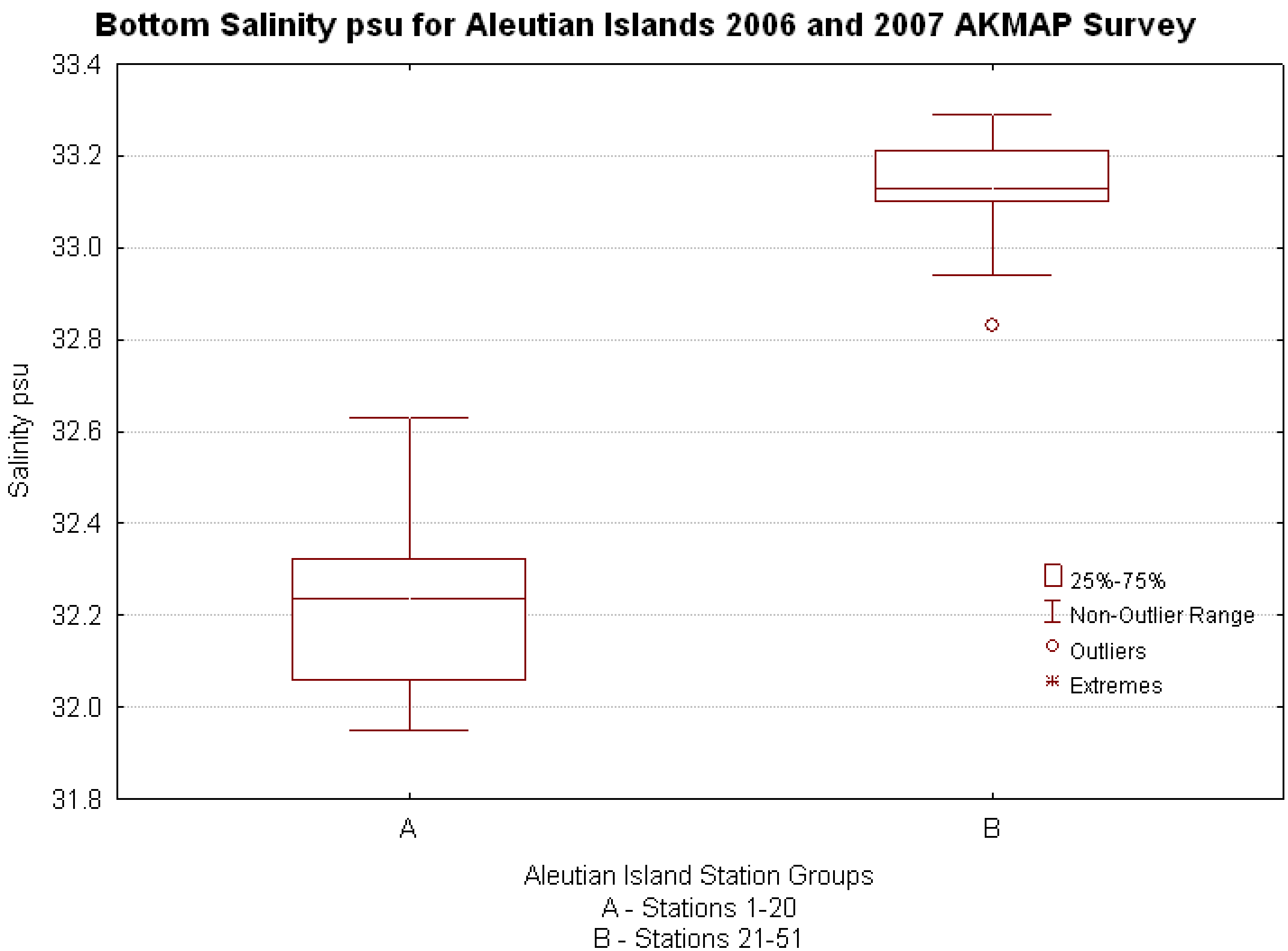

Figure 2-9: Box Plots of Bottom Salinity for Aleutian Island Station Groups A & B

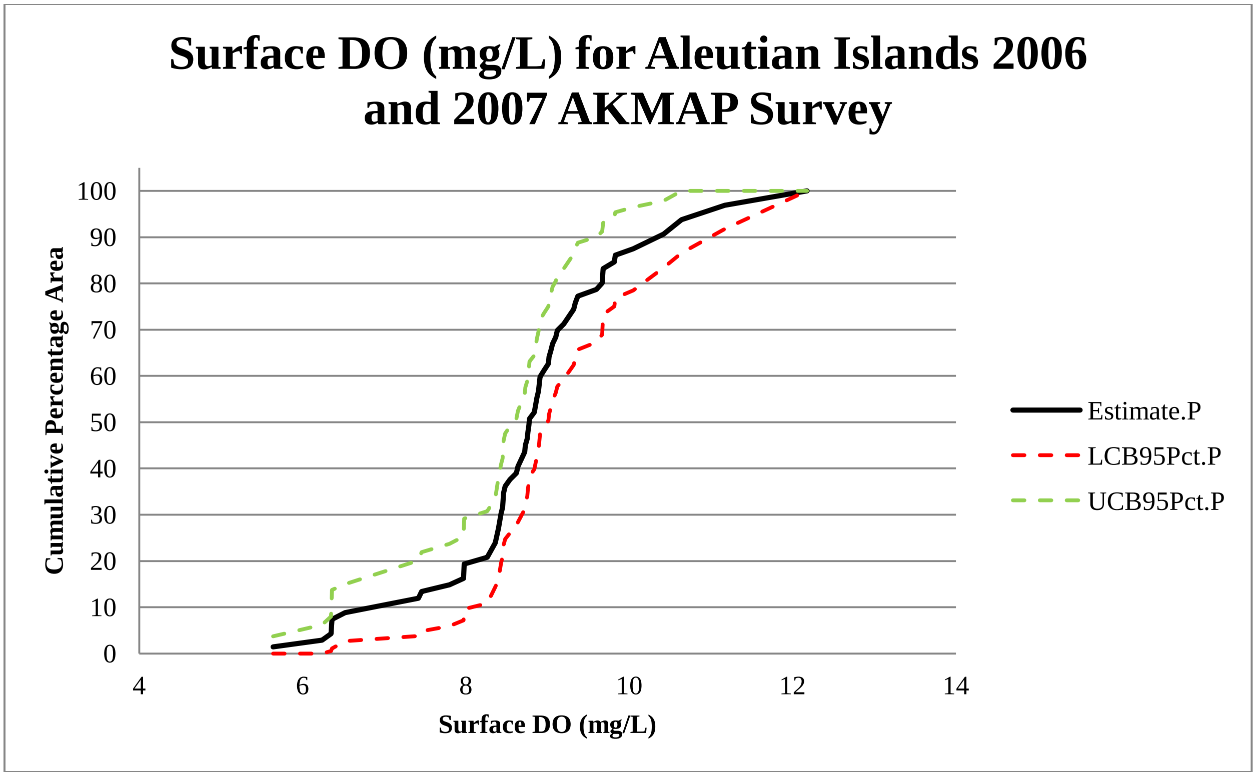

Figure 2-10: CDF Surface DO (mg/L)

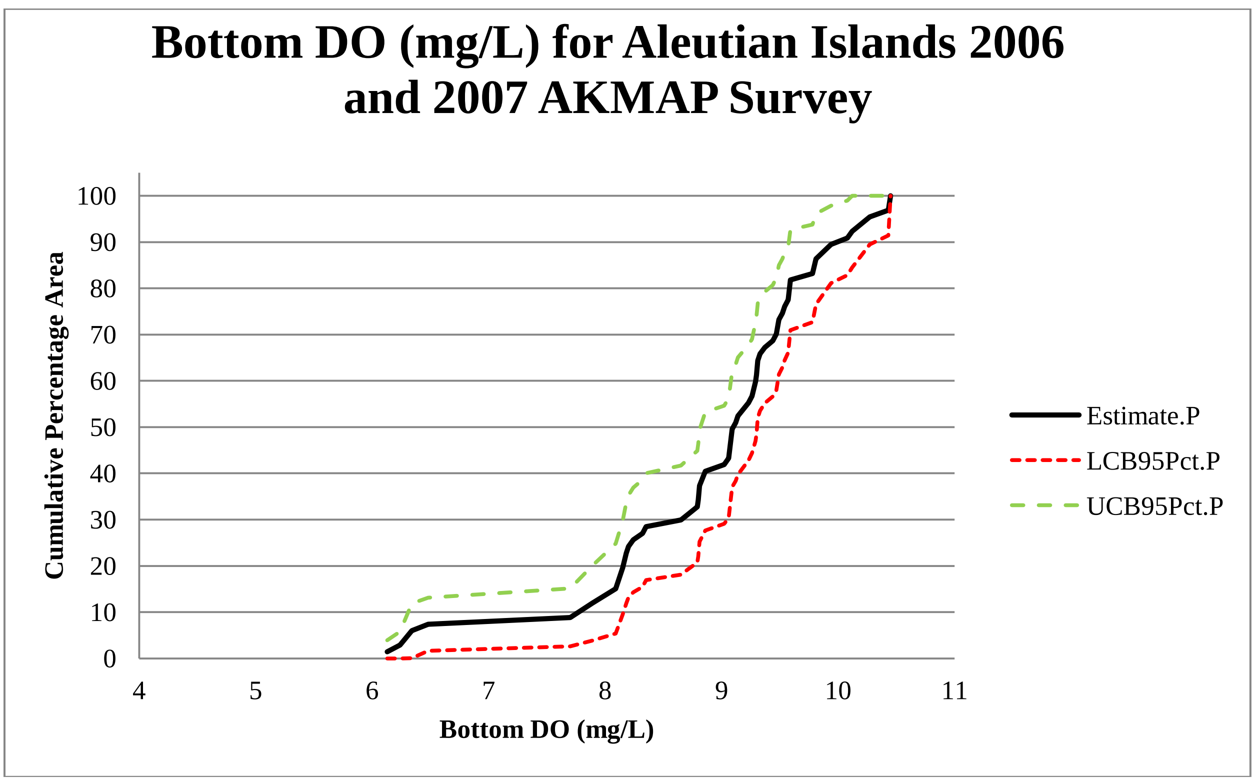

Figure 2-11: CDF Bottom DO (mg/L)

Water Quality Parameters

Dissolved Nutrients

Anthropogenic nutrient loading is contributing to degradation of coastal waters in much of the United States and is an important part of the national aquatic resource surveys (USEPA, 2012). The AKMAP 2006 and 2007 survey reflects nutrient inputs from ocean upwelling or regenerated nitrogen from the breakdown of organic matter. This conclusion is also supported by measured chlorophyll *a*, dissolved oxygen concentrations and water clarity, which are indicators of non- eutrophic conditions. Although nutrients in this study were measured only one time at each station the data can be interpreted in conjunction with other water quality parameters to provide a measure of whether eutrophication from nutrient loading is of concern in Aleutian Island estuaries and coastal areas. Summary statistics for nutrients, chlorophyll *a*, and total suspended solids (TSS) are shown in Table 2-2.

Orthophosphate

Orthophosphate concentrations in the Aleutian Islands near shore ranged from 0.02 – 0.22 mg/L in surface waters and 0.06 – 0.22 in bottom waters. Figures 2-12 and 2-13 show CDFs for orthophosphate at the surface and bottom of the water column, respectively. Orthophosphate concentrations were ≤ 0.17 mg/L and ≤0.19 mg/L, respectively in surface and bottom waters, for 90% of the total area surveyed.

Silicate

Silicate concentrations in the Aleutian Islands near shore ranged from 1.68 – 12.42 mg/L in surface waters and 2.0 – 12.55 mg/L in bottom waters. Figures 2-14 and 2-15 show CDFs for silicate at the surface and bottom of the water column, respectively. Silicate concentrations were ≤ 10.53 mg/L and ≤10.91 mg/L, respectively in surface and bottom waters, for 90% of the total area surveyed.

Nitrate + Nitrite

Nitrate + Nitrite Ammonium concentrations in the Aleutian Islands near shore ranged from 0.03 – 3.41 mg/L in surface and 0.29 – 3.46 mg/L bottom waters. Figures 2-16 and 2-17 show CDFs for nitrate + nitrite at the surface and bottom of the water column, respectively. Nitrate + nitrite concentrations were ≤ 2.75 mg/L and ≤ 2.87 mg/L, respectively in surface and bottom waters, for 90% of the total area surveyed. Note that Figures 2-18 to 2-21 show CDFs for NO_2 and NO_3.

Ammonium

Ammonium concentrations in the Aleutian Islands near shore ranged from ND – 0.06 mg/L in both surface and bottom waters. Figures 2-22 and 2-23 show CDFs for ammonium at the surface and bottom of the water column, respectively. Ammonium concentrations were ≤ 0.03 mg/L and ≤0.19 mg/L, respectively in surface and bottom waters, for 90% of the total area surveyed.

Total Dissolved Inorganic Nitrogen (DIN)

Total dissolved inorganic nitrogen (DIN) represents the sum measured Nitrate (NO_3-), Nitrite (NO_2-), and Ammonium (NH_4+), and is reported also as the sum of these nutrients as dissolved inorganic nitrogen (DIN).

DIN concentrations in the Aleutian Islands near shore ranged from 0.06 – 4.0 mg/L in surface waters and 0.41 – 4.12 mg/L in bottom waters. Figures 2-24 and 2-25 show CDFs for DIN at the surface and bottom of the water column, respectively. DIN concentrations were ≤ 3.33 mg/L and ≤ 3.41 mg/L, respectively in surface and bottom waters, for 90% of the total area surveyed.

DIN and Dissolved PO_4 Ratio

Total molar dissolved inorganic nitrogen (DIN, nitrate + nitrite + ammonium) is compared to the molar dissolved inorganic phosphate (DIP) for the surface and bottom of the water column in Figures 2-24 and 2-25. This provides information on which nutrient may be controlling primary production. A ratio ≥ 16 for N/P suggests that phosphorous controls, with a ratio ≤ 16 suggesting that nitrogen controls.

The ratio of N/P in the Aleutian Islands near shore ranged from 1.09 – 22.04 in surface waters and 5.11 – 22.87 in bottom waters. Figures 2-26 and 2-27 show CDFs for N/P at the surface and bottom of the water column, respectively. Ratios of N/P were ≤ 16.59 mg/L and ≤18.11 mg/L, respectively in surface and bottom waters, for 90% of the total area surveyed.

Table 2-2: Summary Statistics Water Quality Parameters

Water Quality Parameters	n	Mean	Std. Dev.	Median	Min	Max
Nutrients						
Surface NH_4 mg/L	48	0.01	0.01	0.01	ND	0.06
Bottom NH_4 mg/L	48	0.02	0.01	0.01	ND	0.06
Surface NO_3+NO_2 mg/L	48	1.53	0.92	1.55	0.03	3.41
Bottom NO_3+NO_2 mg/L	48	1.78	0.90	2.0	0.29	3.46
Surface DIN mg/L	48	1.89	1.06	1.91	0.06	4.0
Bottom DIN mg/L	48	2.20	1.01	2.39	0.41	4.12
Surface PO_4 mg/L	48	0.12	0.04	0.12	0.02	0.22
Bottom PO_4 mg/L	48	0.13	0.04	0.13	0.06	0.22
Surface SIO_4 mg/L	48	6.46	2.85	5.84	1.68	12.42
Bottom SIO_4 mg/L	48	6.77	2.93	6.22	2.0	12.55
Surface DIN/PO_4 µM	48	11.35	4.61	11.35	1.09	22.04
Bottom DIN/PO_4 µM	48	12.31	4.26	12.63	5.11	22.87
Surface Chlorophyll *a* µg/L	51	1.32	1.33	0.72	0.14	9.12
Bottom Chlorophyll *a* µg/L	49	1.74	1.71	1.09	0.11	10.25
Surface TSS mg/L	51	3.80	6.00	2.22	0.51	53
Bottom TSS mg/L	51	2.92	2.53	2.12	0.32	11.5

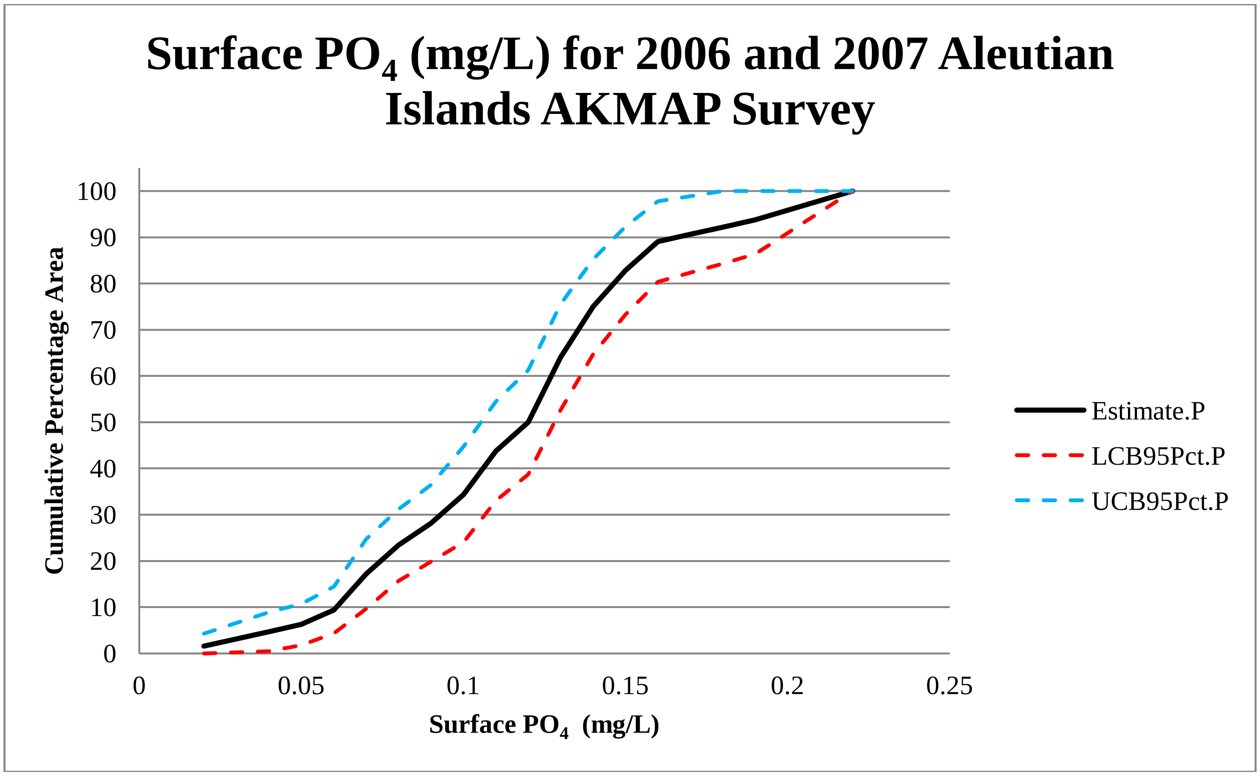

Figure 2-12: CDF Surface PO_4 (mg/L)

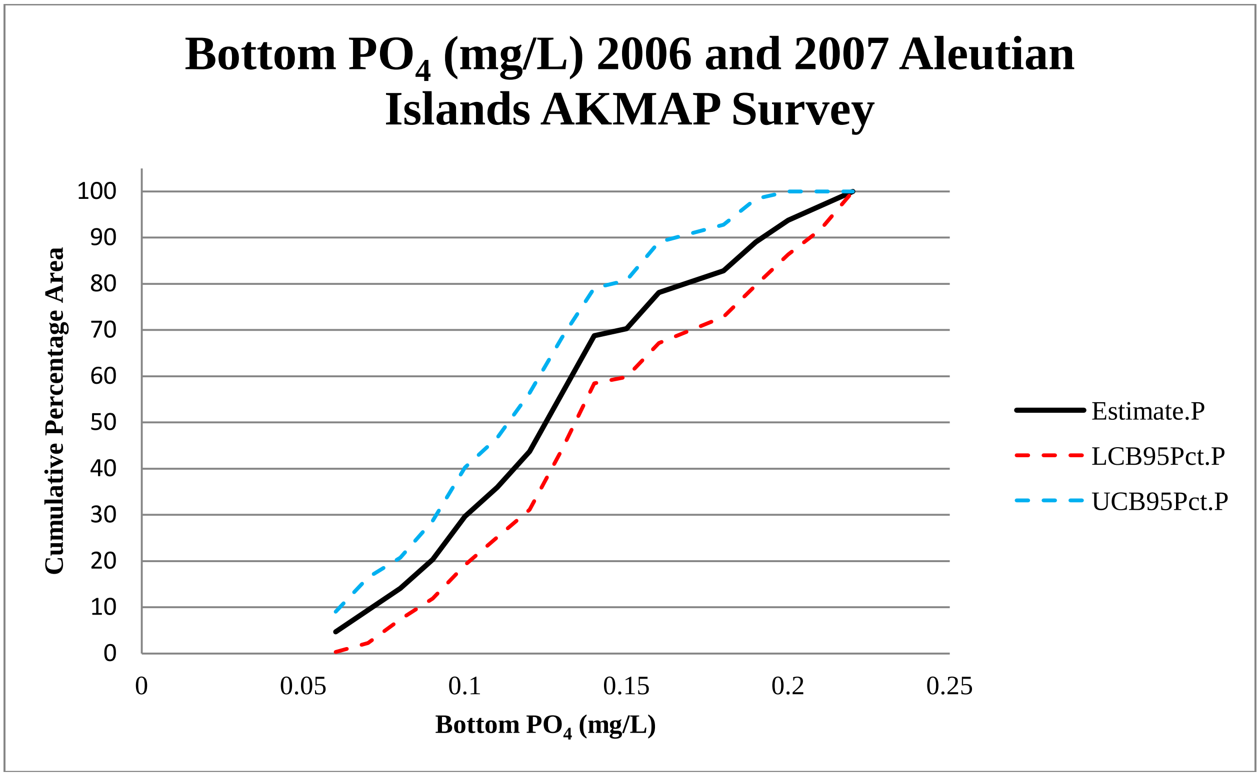

Figure 2-13: CDF Bottom PO_4 (mg/L)

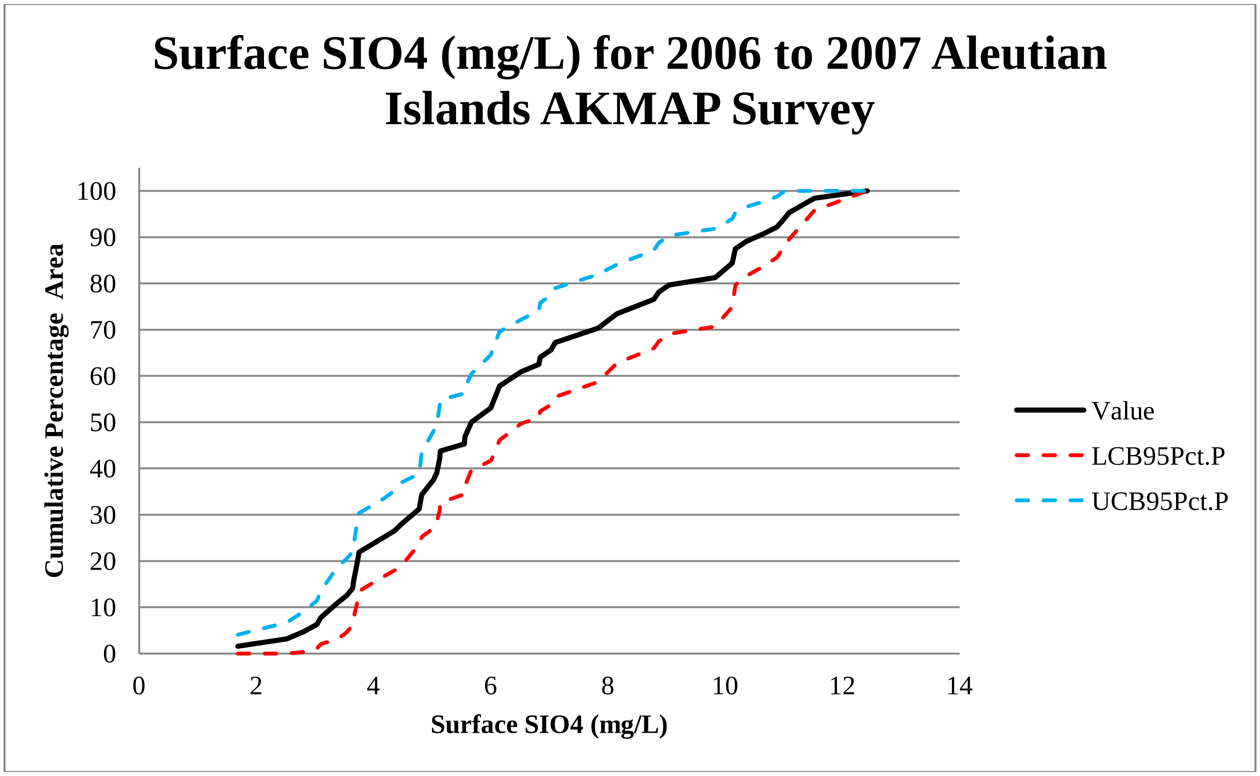

Figure 2-14: CDF Surface SIO_4 (mg/L)

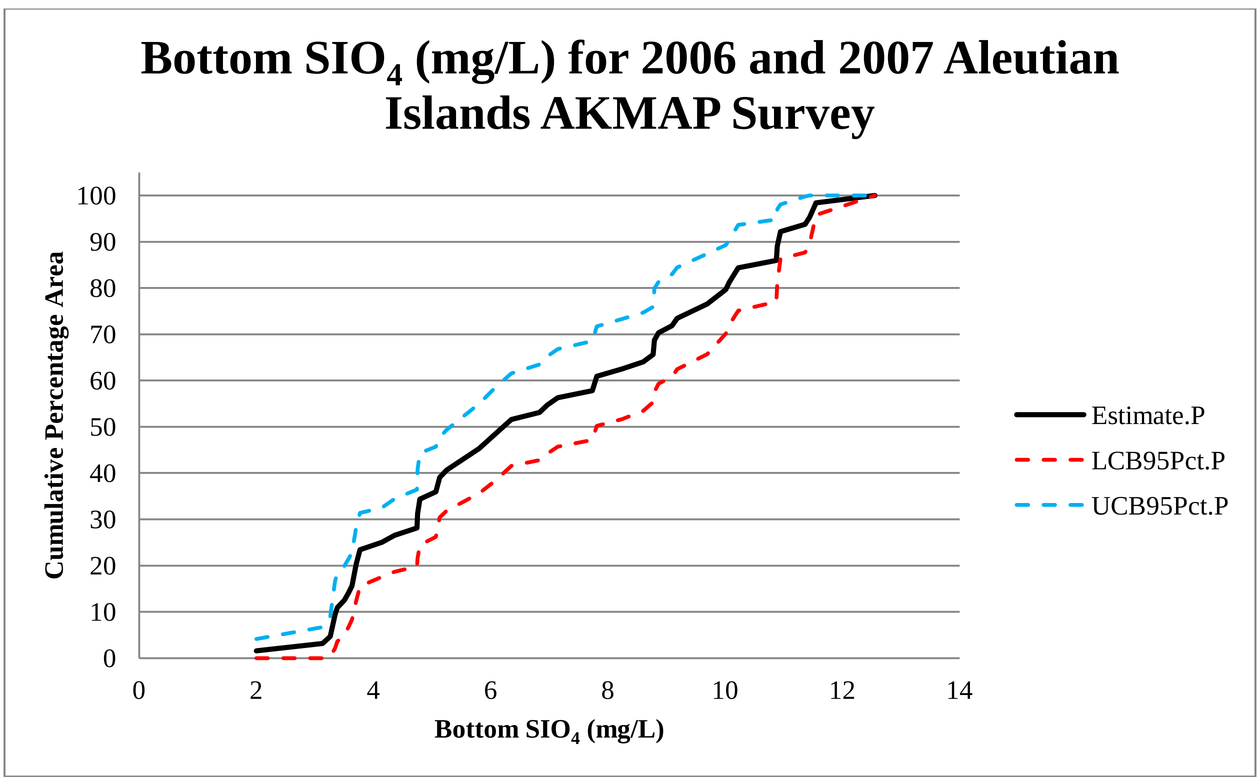

Figure 2-15: CDF Bottom SIO_4 (mg/L)

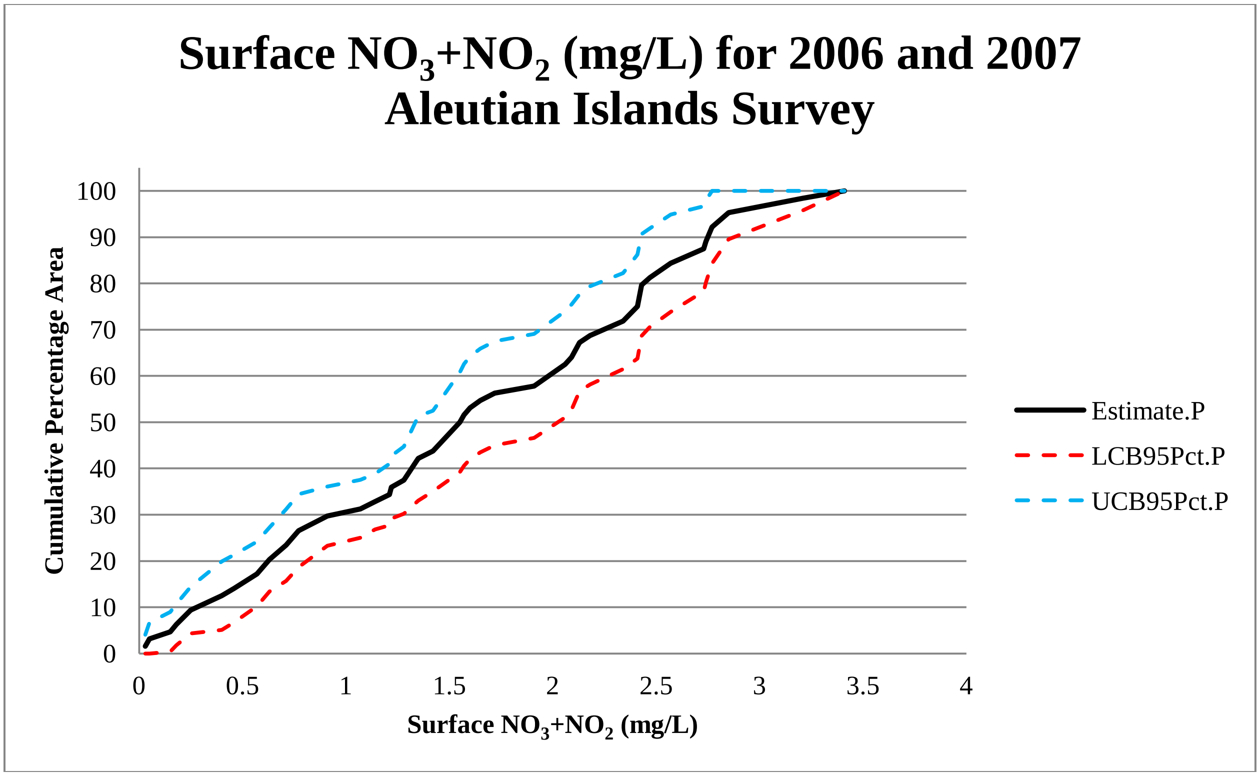

Figure 2-16: CDF Surface NO_3+NO_2 (mg/L)

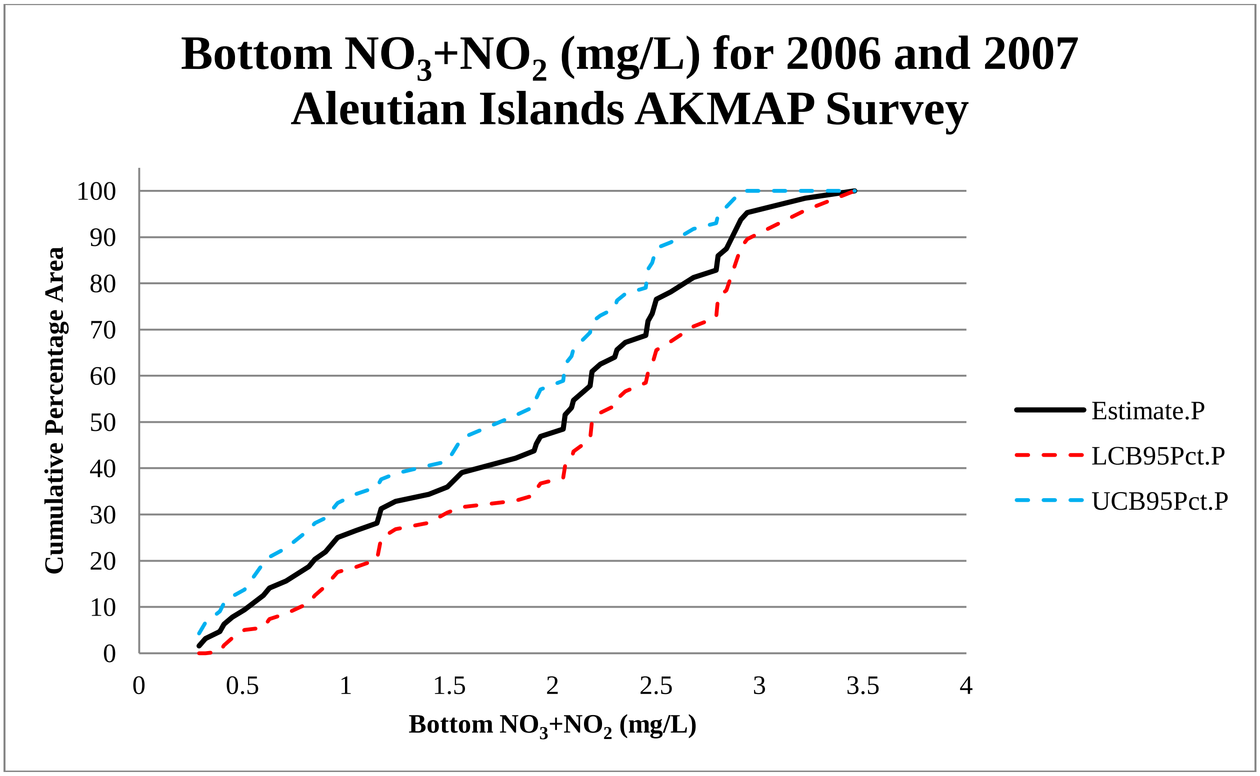

Figure 2-17: CDF Bottom NO_3+NO_2 (mg/L)

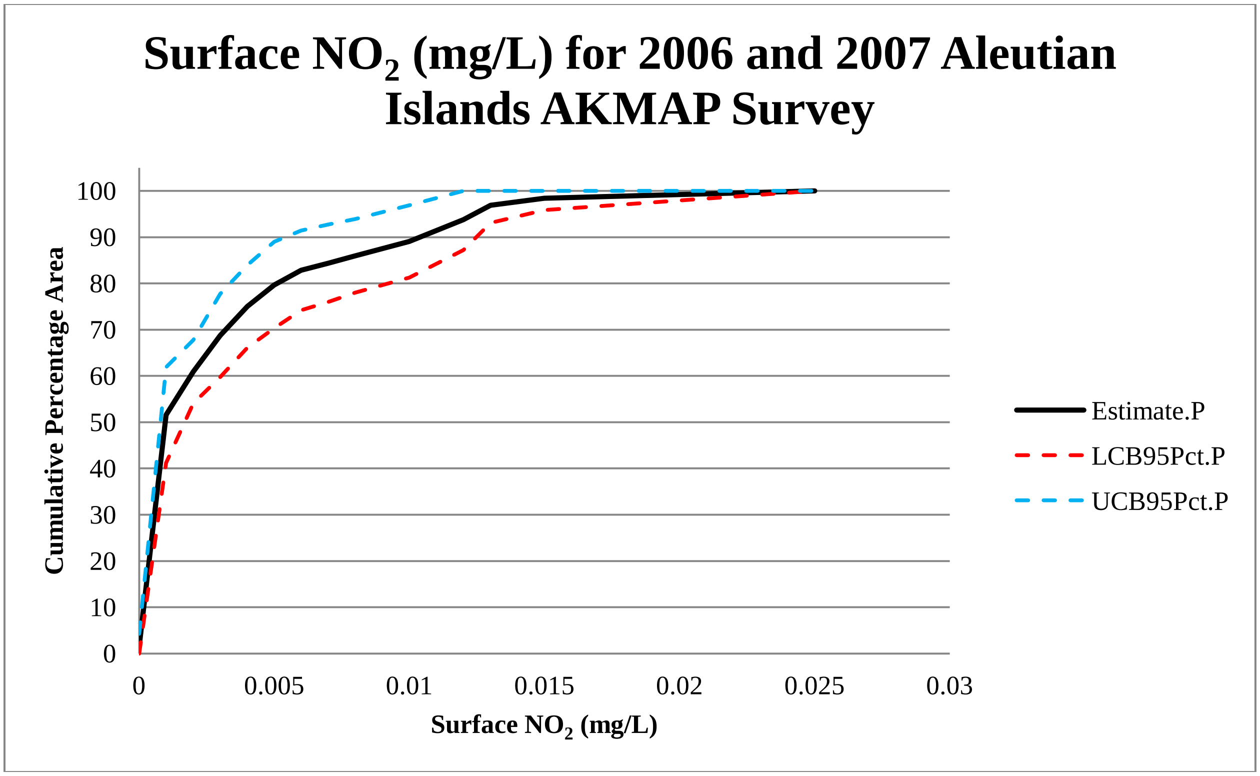

Figure 2-18: CDF Surface NO_2 (mg/L)

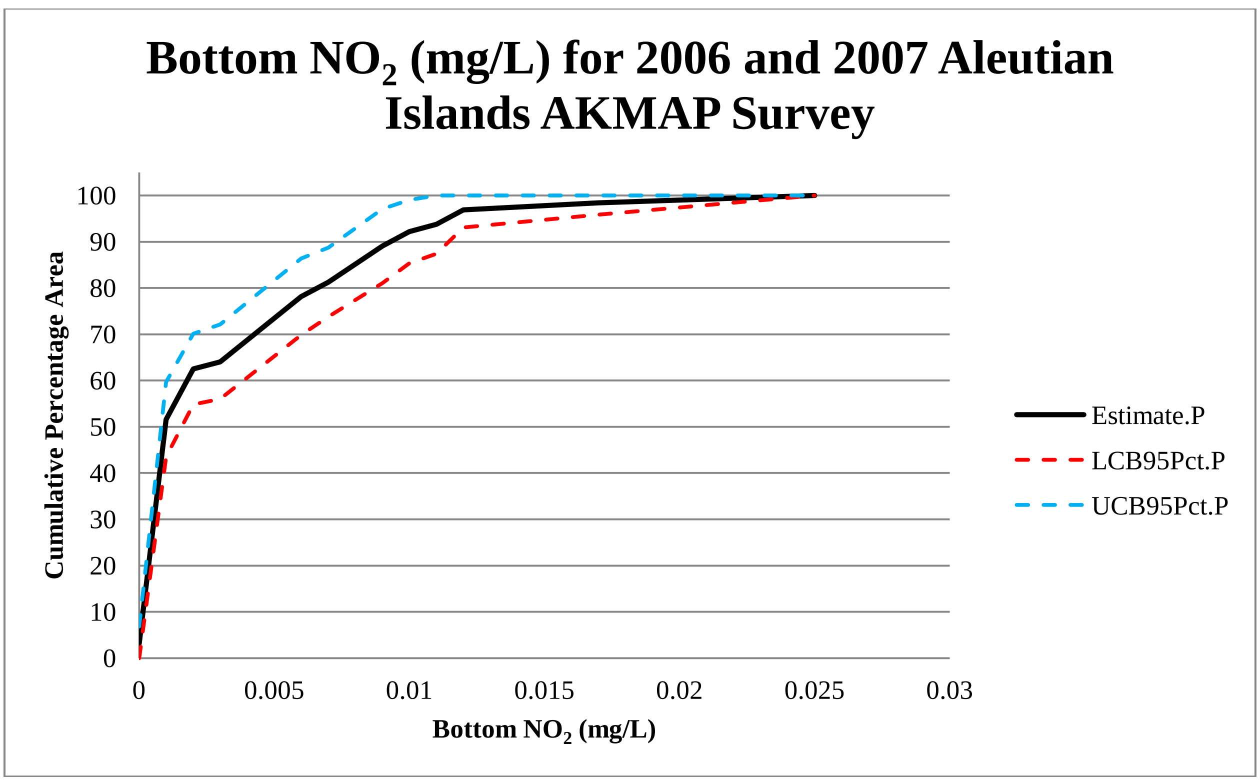

Figure 2-19: CDF Bottom NO_2 (mg/L)

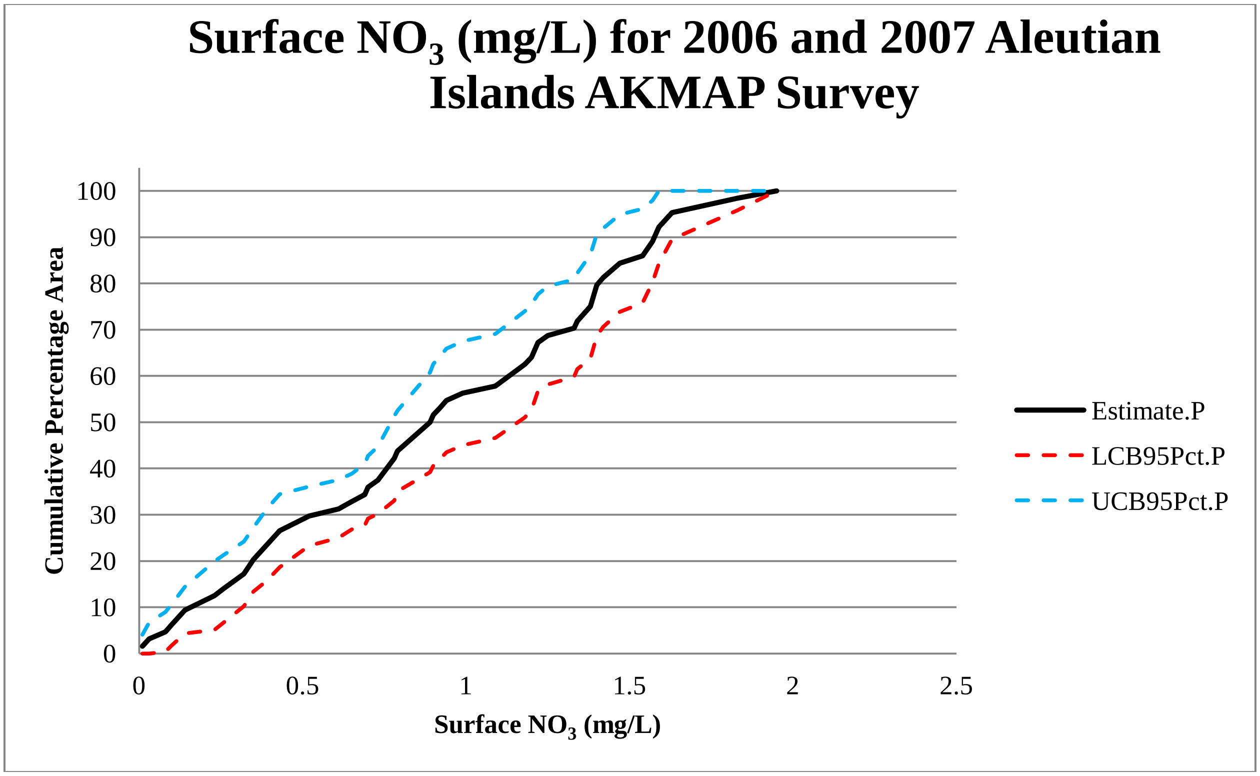

Figure 2-20: CDF Surface NO_3 (mg/L)

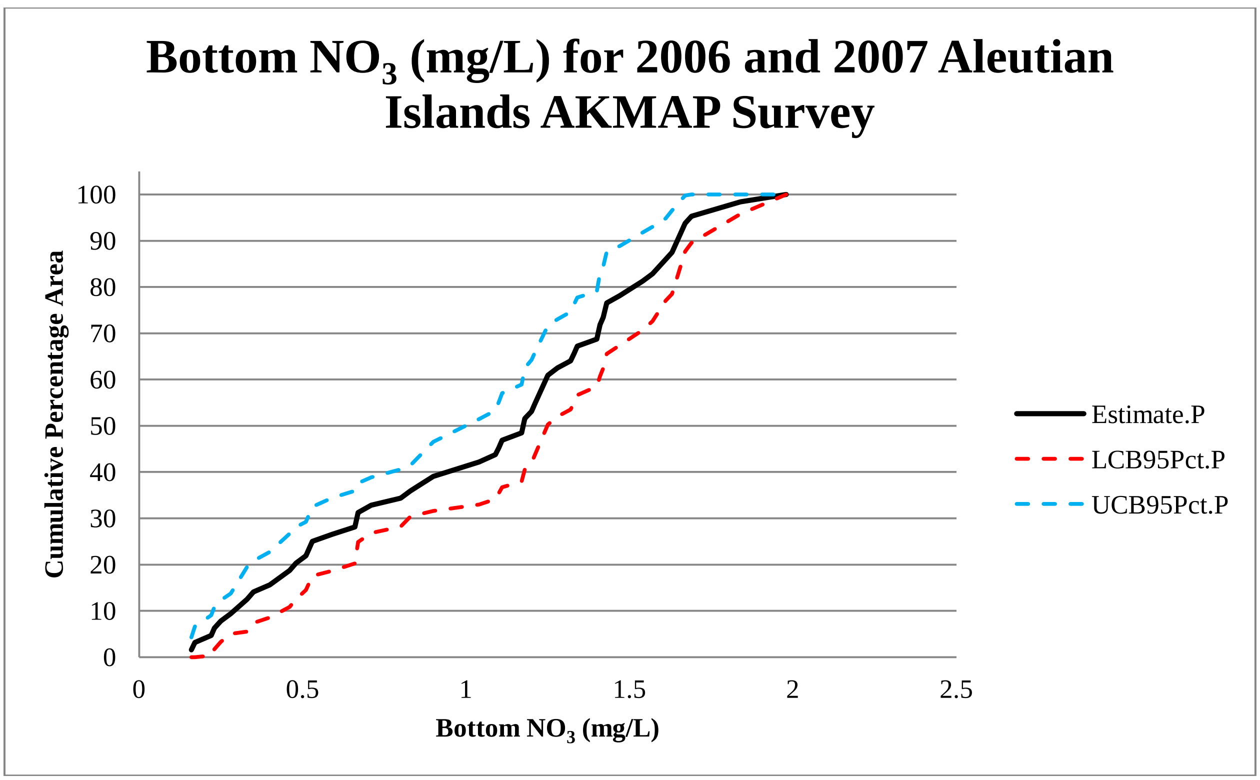

Figure 2-21: CDF Bottom NO_3 (mg/L)

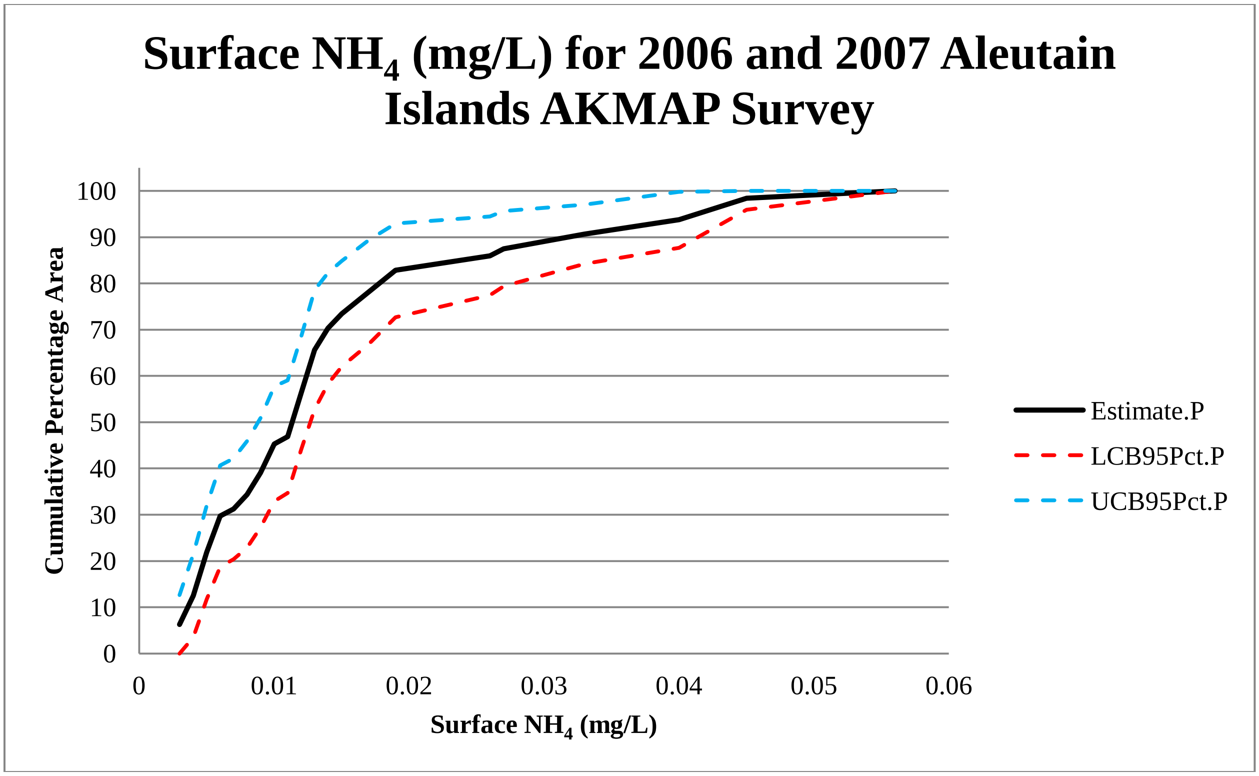

Figure 2-22: CDF Surface NH_4 (mg/L)

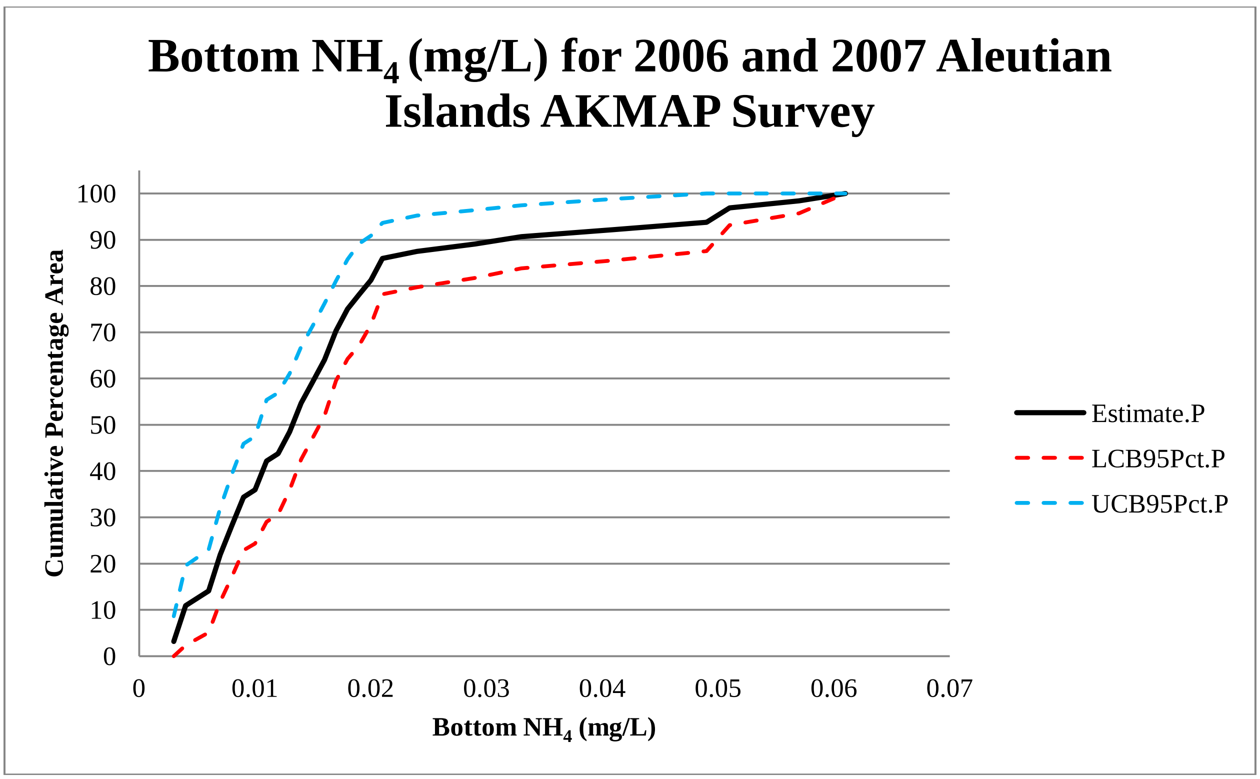

Figure 2-23: CDF Bottom NH_4 (mg/L)

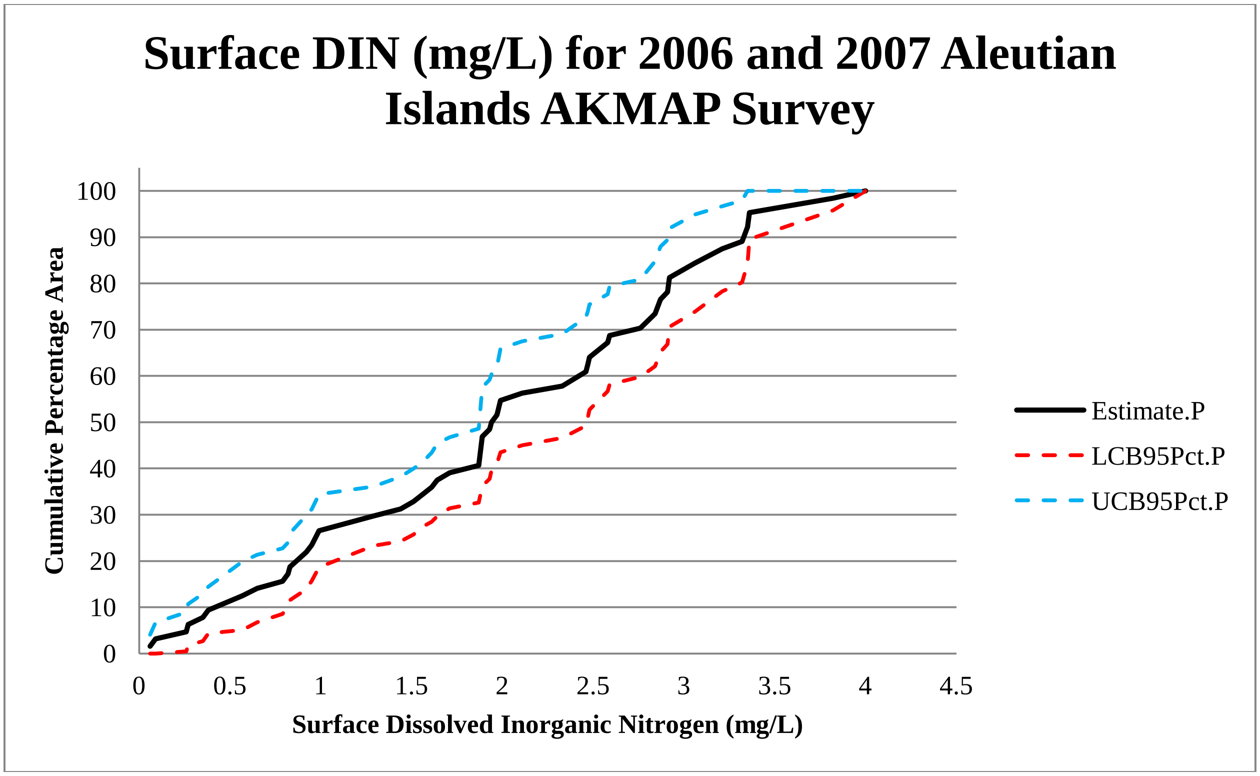

Figure 2-24: CDF Surface DIN (mg/L)

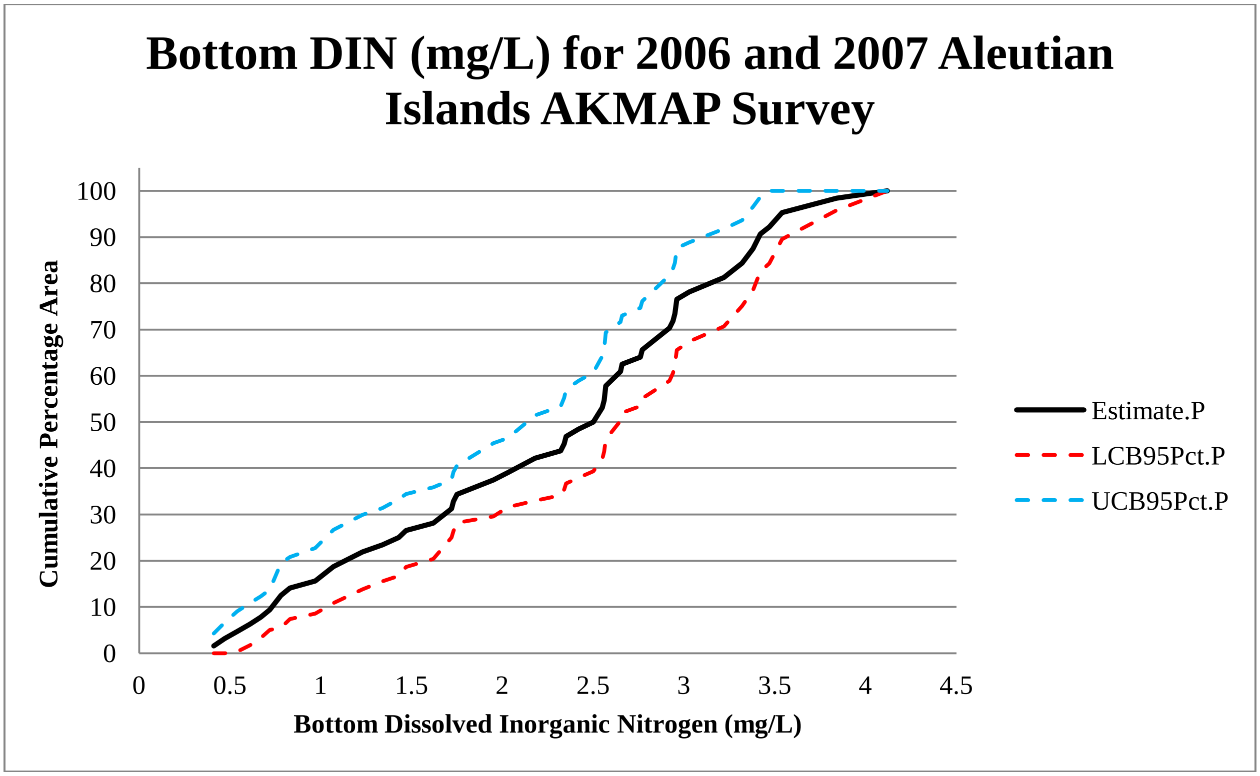

Figure 2-25: CDF Bottom DIN (mg/L)

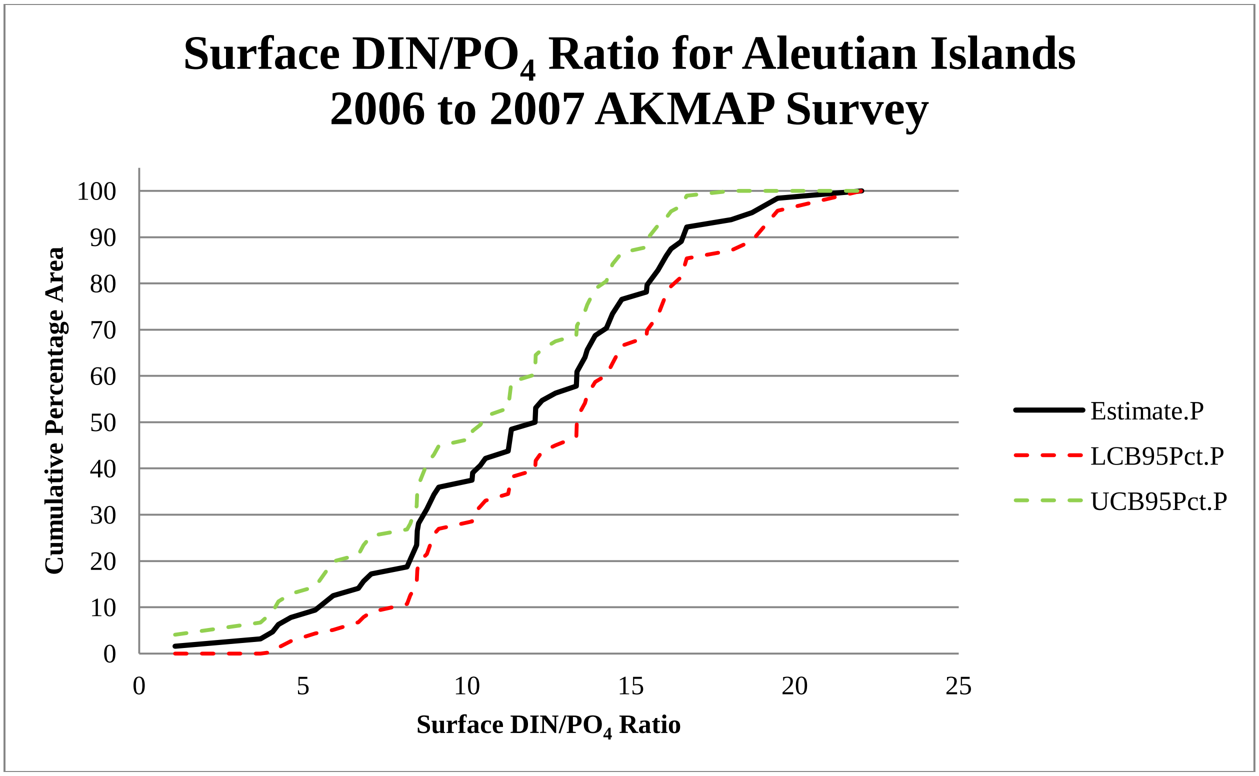

Figure 2-26: CDF Surface DIN/PO_4 Ratio

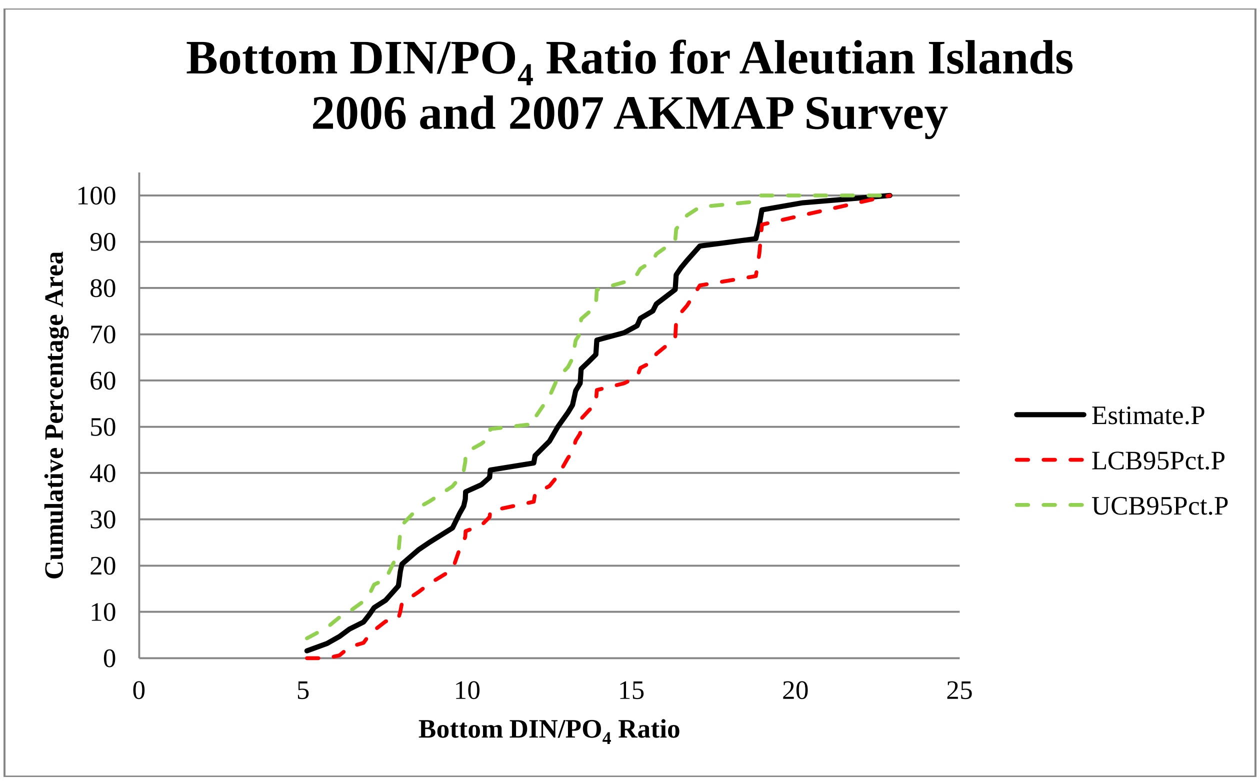

Figure 2-27: CDF Bottom DIN/PO_4 Ratio

Chlorophyll a

The concentration of the chlorophyll *a* pigment reflects phytoplankton standing stocks in the water column and can be used as one measure for evaluating eutrophication. Chlorophyll *a* concentrations in the Aleutian Islands near shore ranged from 0.14 to 9.12 µg/L in surface waters and 0.11 to 10.25 µg/L in bottom waters. Figures 2-28 and 2-29 show CDFs for Chlorophyll *a* at the surface and bottom of the water column. Chlorophyll *a* concentrations were ≤ 4.56 µg/L and ≤3.79 µg/L, respectively in surface and bottom waters, for 90% of the total area surveyed.

TSS

Total suspended solids (TSS) concentrations in the Aleutian Islands near shore ranged from 0.51 to 53.0 mg/L in surface waters and 0.32 to 11.5 mg/L in bottom waters. Figures 2-30 and 2-31 show CDFs for TSS at the surface and bottom of the water column, respectively. TSS concentrations were ≤ 5.82 mg/L and ≤6.06 mg/L, respectively in surface and bottom waters, for 90% of the total area surveyed.

Secchi Depth, Water Clarity and Light Attenuation

Two indices that reflect water clarity were measured. These included Secchi depth and Total Suspended Solids (TSS). Secchi depth alone (or converted to extinction coefficient or transmittance) cannot distinguish whether light attenuation is a result of suspended particulates or by colored substances in the water column (e.g. phaeopigments), thus a combination of transmittance and suspended particulate data help aid in interpreting the differences in available subsurface light across the study area. At 15 of the 51 stations surveyed the Secchi the disk was visible all the way to the bottom. The summary statistics in Table 2-3 are based on the 36 stations where a Secchi depth could be recorded.

The light attenuation coefficient k m^{-1} was calculated using the following equation

The constant *a* equals 1.7, representative of clear water estuaries, and Z_{Secchi} equals the Secchi depth in meters (Smith et al., 2006).

Table 2-3: Conversion of Secchi depth reading to Light Attenuation Coefficient

Measurement	n	Mean	Std Dev	Median	Range (Min – Max)
Secchi Depth, m	36	10	3.4	9.5	4.5 – 20.0
Light Attenuation Coefficient, (k) m^{-1}	36	0.20	0.08	0.18	0.09 – 0.38

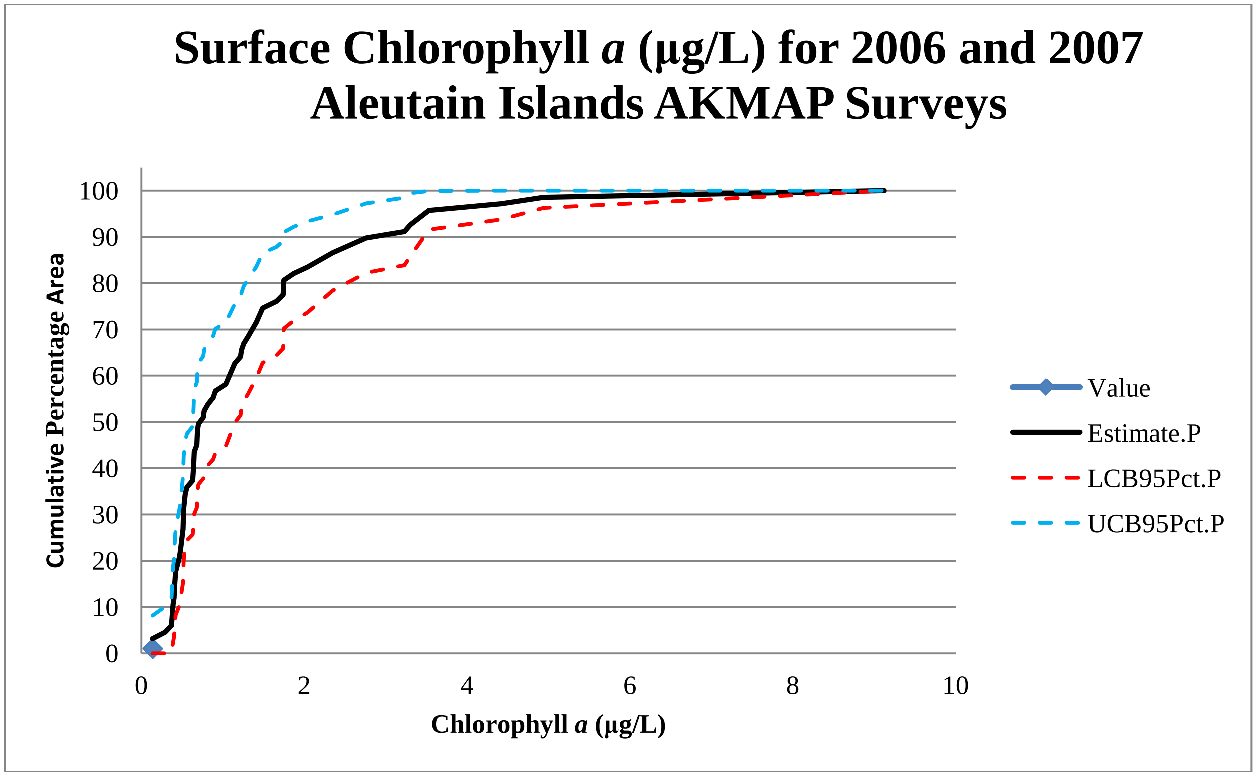

Figure 2-28: CDF Surface Chlorophyll *a* (µg/L)

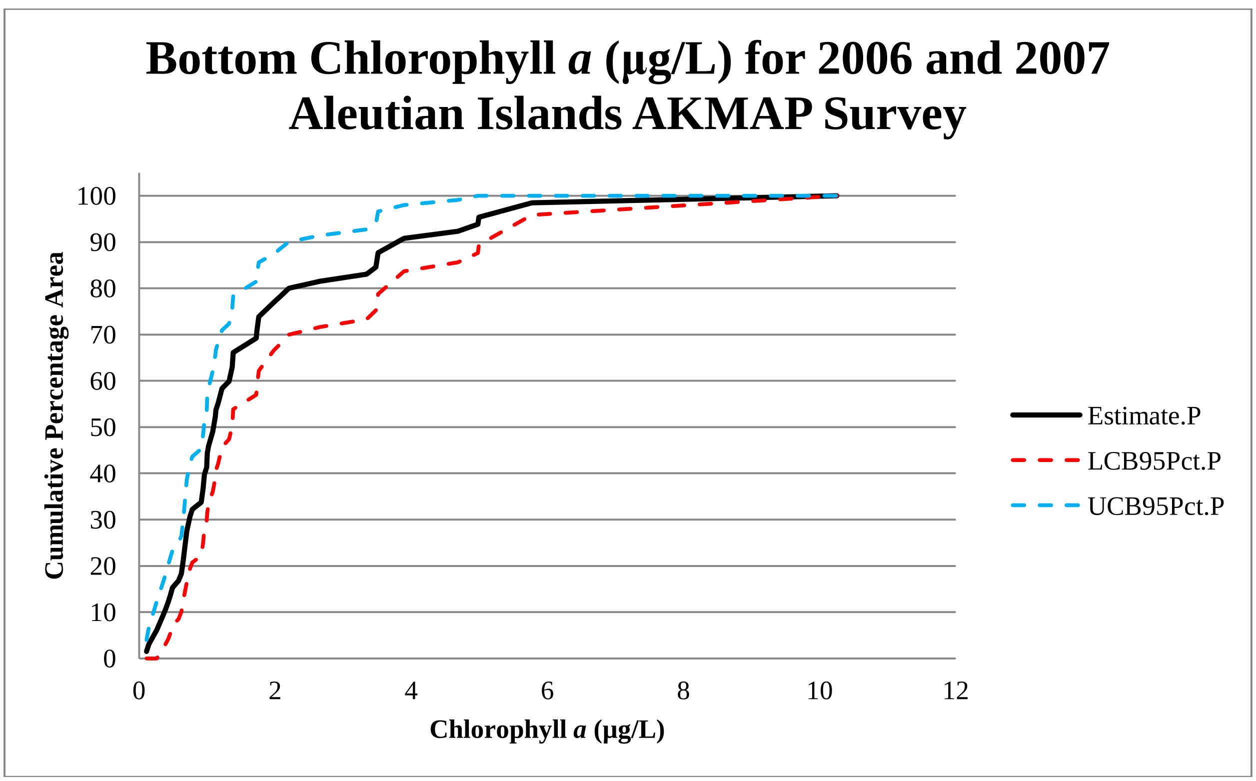

Figure 2-29: CDF Bottom Chlorophyll *a* (µg/L)

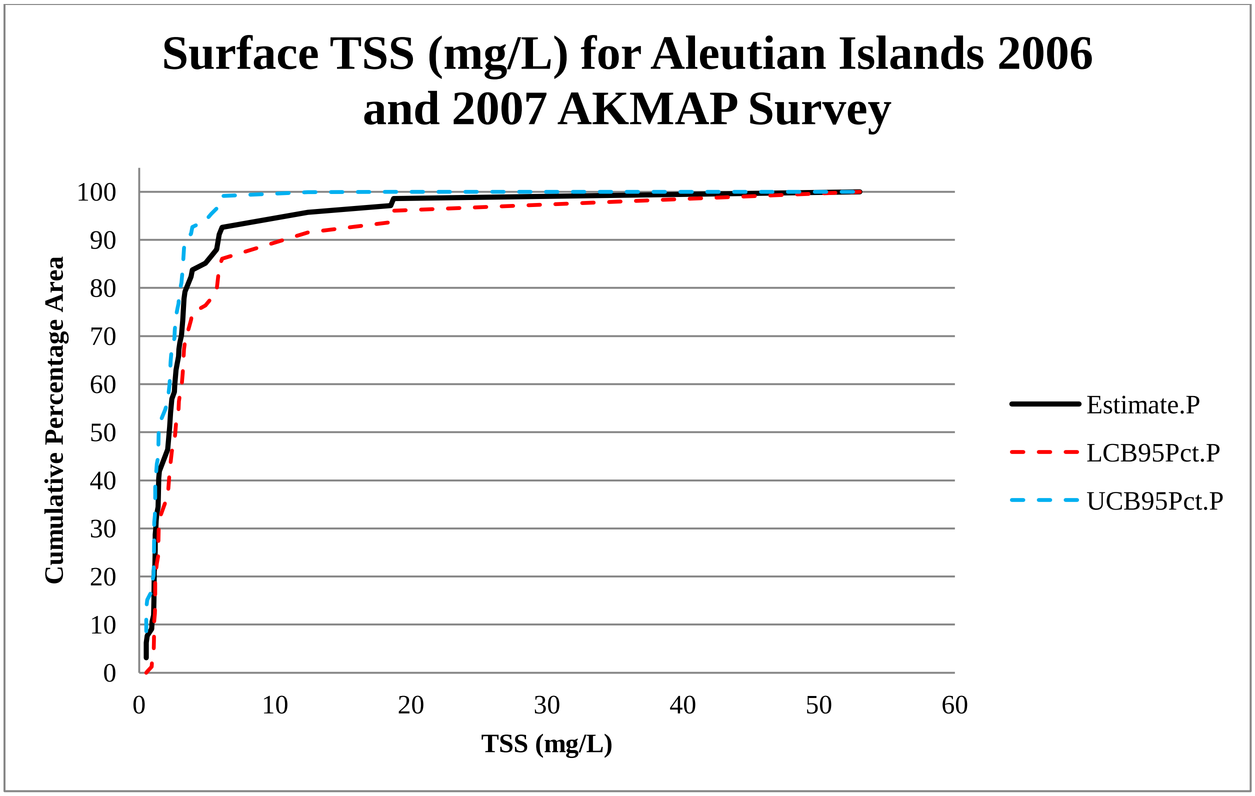

Figure 2-30: CDF Surface TSS (mg/L)

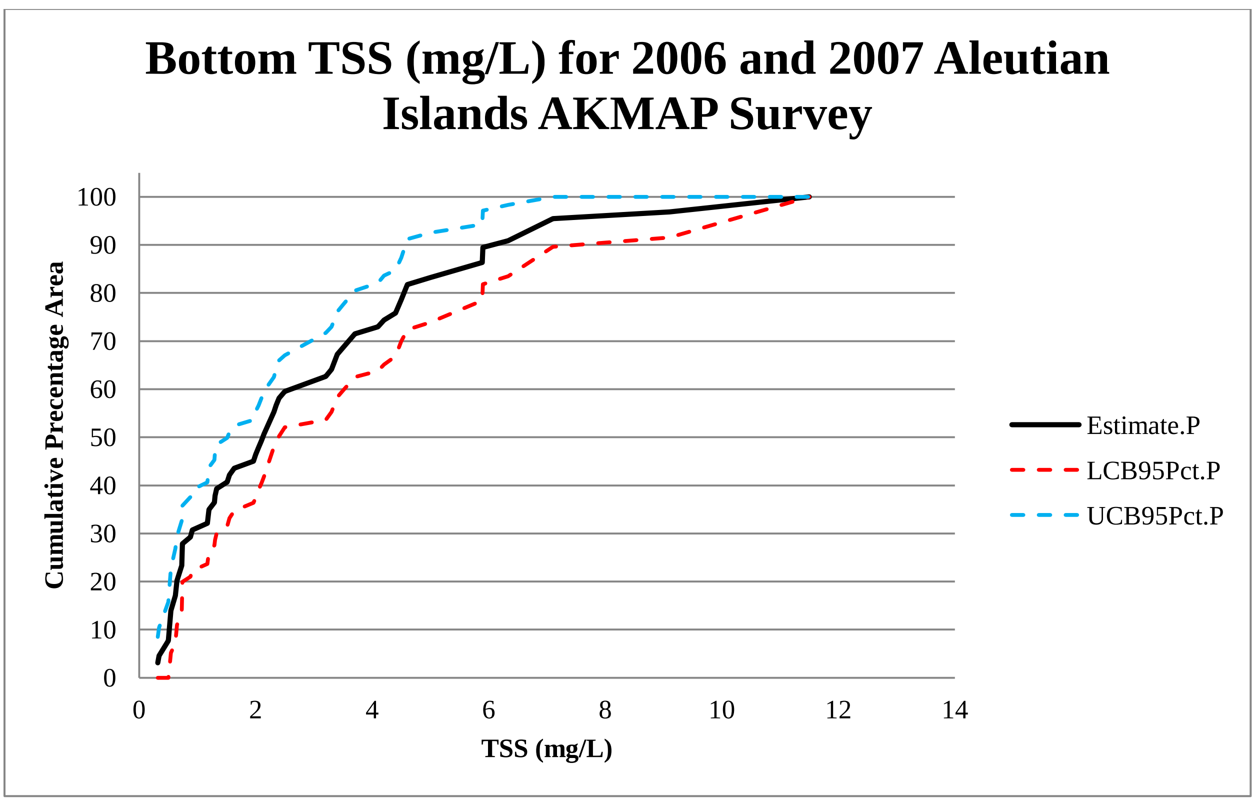

Figure 2-31: CDF Bottom TSS (mg/L)

Sediment Contaminants

Trace Metals

Sediment trace metals were run on the AKMAP 2006 and 2007 stations where we encountered soft sediments. As there were only 17 soft sediment stations a probabilistic assessment was not done. The results were compared with the National Oceanic Atmospheric Adminstrations (NOAA) sediment Screening Quick Refernce Table (SQuiRTs) (Buchman, 2008) Effects Range Low and Effect Range Median values for sediment trace metals. Note that for the 2006 sediments the trace metal results were reported in dry weight, which is the matrix condition used in the SQuiRTs. The 2007 sediment data was reported in wet weight and no laboratory sediment moisture determinations were done. For the 2007 sediment the ERL and ERM values are estimated based on using a total solids ratio of 0.66, which is comparable to the total solids ratio measured by the lab for the 2006 sediments.

For the 2006 reported sediment trace metal data the ERLs for arsenic (8,200 ng/g dw) and mercury (170 ng/g dw) were exceeded, but no ERMs were exceeded. Station AKALE06-024 had an arsenic value of 8,657 ng/g dw. Stations AKALE06-21 and AKALE06-24 had mercury values of 171 ng/g dw and 265 ng/g dw respectively.

In 2007 only mercury exceeded the ERM of 710 ng/g dw both as the wet weight and dry weight concentrations. AKALE07-045 had a mercury concentration of 1,100 ng/g wet weight or 1,666 ng/g drw weight, assuming 0.66 total solids. No other trace metals exceeded the respective ERLs or ERMs.

Organic Contaminants

Polyaromatic hydrocarbons (PAH), pesticides and organotins were also analyzed for and compared with the sediment quality guidelines. Sediment quality guidelines do not exist for all the contaminants analyzed. None of the NOAA SQuiRT ERLs or ERMs were exceeded in these sediments.

Habitat Condition – Bottom Type and Dominant Plants and Epifauna

Hard substrates dominated the stations with 33 (66%) of the 50 stations. Organisms on or over hard substrates often included brown algae (*Agarum* spp., *Eualaria (Alaria) fistulosa*, *Cymathere triplicata*, *Desmarestia* spp., *Laminaria yezoensis*, *Nereocystis lutkeana*, *Saccharina* spp., and *Thalassiophylum clathrum*), green algae (*Codium ritteri*, *Ulva* spp.), red algae (*Constantinea* spp., *Fauchea* sp., and encrusting corallines), invertebrates such sponges, sea anemones, giant Pacific chiton (*Cryptochiton stelleri*), horse mussel (*Modiolus modiolus*), blue mussel (*Mytilus trossulus*), rock jingle (*Pododesmus macrochisma*), Oregon triton (*Fusitriton oregonensis*), giant octopus (*Enteroctopus dofleini*), sea urchin (*Strongylocentrotus droebachiensis* and *S. polyacanthus*), and various sea stars. Although fish were less common, they included the territorial demersal greenlings (*Hexagrammos lagocephalus* and *H. decagrammus*), Irish lords (*Hemilepidotus jordani* and *H. hemilepidotus*) and dusky rockfish (*Sebastes ciliatus*).

A detailed assessment of the benthic community is provided in the *Benthic Condition Supplemental Report* in Appendix B. Characterizations of the dominant algae, epifauna, and fishes at each of the 50 stations are also presented in Appendix C.

Fish Tissue Contaminants

Fish were collected at50 of stations and analyzed for a set of metals, PCBS, and organochlorine pesticides. The specific analytes are listed in Appendix D. This statistical summary addresses the whole fish sample (fish was ground and sub-set of tissue removed for analysis). All fish were of sufficient size that compositing of several fish, as occurred in trawl studies in Southcentral and Southeast Alaska, was not necessary to obtain sufficient sample volume. A small subset of fish had fillets taken from one side before compositing the rest of the tissue to compare results, but that information has not be assessed. Fish were collected by hook and line from the vessel or by spear by divers. At some locations no fish were available for sampling. Preferred target fish was the Rockfish (Sebastidae), typically Black or Dusky, and Rock or Kelp Greenling (Hexagrammidae) were the secondary target group. If these fish were not present or limited in abundance other fish were captured, either Irish Lords or Sculpin (Cottidae) or Northern or Rock Sole (Pleuronectidae).

Statistical summaries are presented here rather than CDFs to estimate areas because of the uncertainty of mixing different species, age groups, sexes and varying lipid contents. Further effort will be required to assess the tissue concentrations on a CDF spatial context by normalizing across species by lipid content or a combination of factors. Tissue concentrations for the various analytes in many cases are below the detection limit. Addressing non-detects correctly—taking one-half the detection limit introduces to many errors—is critical to assessing trends or patterns that may be present.

The whole fish residues for metals (Arsenic and Mercury), DDT, and PCBs that were above the minimum detection limit (MDL) are summarized in Tables 2-4 to 2-5 for all fish species combined and for each fish family.

DDT

Total DDT had the second highest residue of all the organics contaminants sampled, with an average (when present ≥ MDL) over all fish species of 9.5 ng/g wet weight. Of the four DDT metabolites, 2,4'- DDD, 4,4'-DDD, 4,4'-DDE, and 4,4'-DDT, in all the fish reported 4,4'-DDD was the most prevalent followed by 4,4'-DDE. Figure 2-32 shows the breakdown of metabolites present in this group. The DDT metabolite 4,4'-DDE is considered one of the most toxic of the metabolites (Stout and Trust, 2002).

The ratio of ∑ p,p'-DDT/∑p,p'-DDE+DDD in some of the tissue samples ≥ 0.05 reflect recent DDT input (de Wit, et al., 2004

PCBs

Total PCBs had the highest residue of all organics sampled, with an average (when present ≥ MDL) over all fish species of 16.44 ng/g wet weight. PCB 138, 153 and 149 were the three most abundant PCB congeners, respectively averaging 20.1%, 18.8%, and 13.5%. Figure 2-33 shows the breakdown of the %Total PCBs detected ≥ the MDL.

Additional Pesticides

Whole fish analysis results for the other 25 additional pesticides, except for Hexachlorobenzene, Chlorodane-alpha and trans-Nonachlor, were below the MDL of 1 ng/g wet weight. Results of the fillet analysis are not reported here, but as lower detection levels were used in some instances the same or other pesticides were detected.

Table 2-4: Total Arsenic and Mercury (ng/g wet weight)

	Values presented are for when analyate is ≥ MDL				
Metal ng/g wet wt.	**Mean**	**Standard Deviation**	**Median**	**Maximum**	**Minimum**
All Fish (n)					
Arsenic (97)	**1.00**	**0.87**	**0.74**	**6.40**	**0.19**
Mercury (114)	**0.12**	**0.10**	**0.08**	**0.61**	**0.02**
Sebastidae					
Arsenic (36)	**0.64**	**0.30**	**0.63**	**1.30**	**0.19**
Mercury (41)	**0.12**	**0.10**	**0.08**	**0.42**	**0.02**
Hexagrammidae					
Arsenic (29)	**0.79**	**0.24**	**0.73**	**1.40**	**0.39**
Mercury (33)	**0.14**	**0.13**	**0.09**	**0.61**	**0.02**
Pleuronectidae					
Arsenic (15)	**2.40**	**1.35**	**2.00**	**6.40**	**1.10**
Mercury (15)	**0.06**	**0.03**	**0.06**	**0.14**	**0.02**
Cottidae					
Arsenic (17)	**0.92**	**0.61**	**0.90**	**2.90**	**0.30**
Mercury (24)	**0.11**	**0.09**	**0.08**	**0.44**	**0.02**

Table 2-5: Total DDT and PCB Concentrations (ng/g wet weight)

	Values presented are for when analyate is ≥ MDL				
Analyte ng/g wet wt.	**Mean**	**Standard Deviation**	**Median**	**Maximum**	**Minimum**
All Fish (n)					
∑DDT (34)	**9.5**	**10.5**	**3.0**	**35.5**	**1.0**
∑PCB (42)	**16.44**	**15.15**	**10.80**	**68.52**	**1.07**
Sebastidae					
∑DDT (16)	**9.1**	**12.6**	**2.7**	**35.5**	**1.0**
∑PCB (15)	**19.40**	**18.91**	**12.02**	**68.52**	**1.41**
Hexagrammidae					
∑DDT (10)	**10.0**	**8.6**	**6.7**	**21.1**	**1.4**
∑PCB (11)	**18.02**	**14.77**	**11.33**	**45.38**	**1.07**
Pleuronectidae					
∑DDT (2)	**10.7**	**--**	**10.7**	**20.3**	**1.1**
∑PCB (8)	**8.05**	**8.85**	**5.33**	**28.07**	**1.07**
Cottidae					
∑DDT (6)	**9.3**	**9.1**	**8.4**	**19.4**	**1.0**
∑PCB (8)	**17.08**	**11.62**	**17.63**	**31.92**	**3.69**

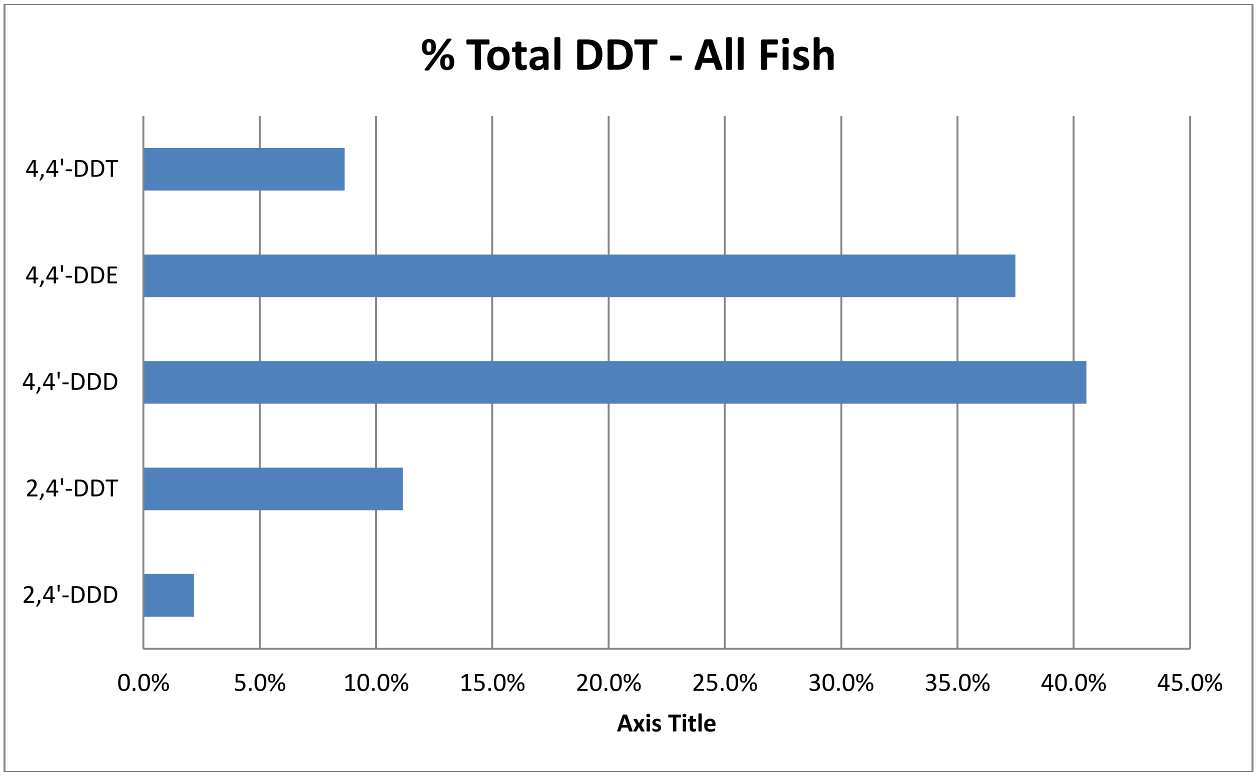

Figure 2-32: DDT Metabolites % Distribution in Fish Samples

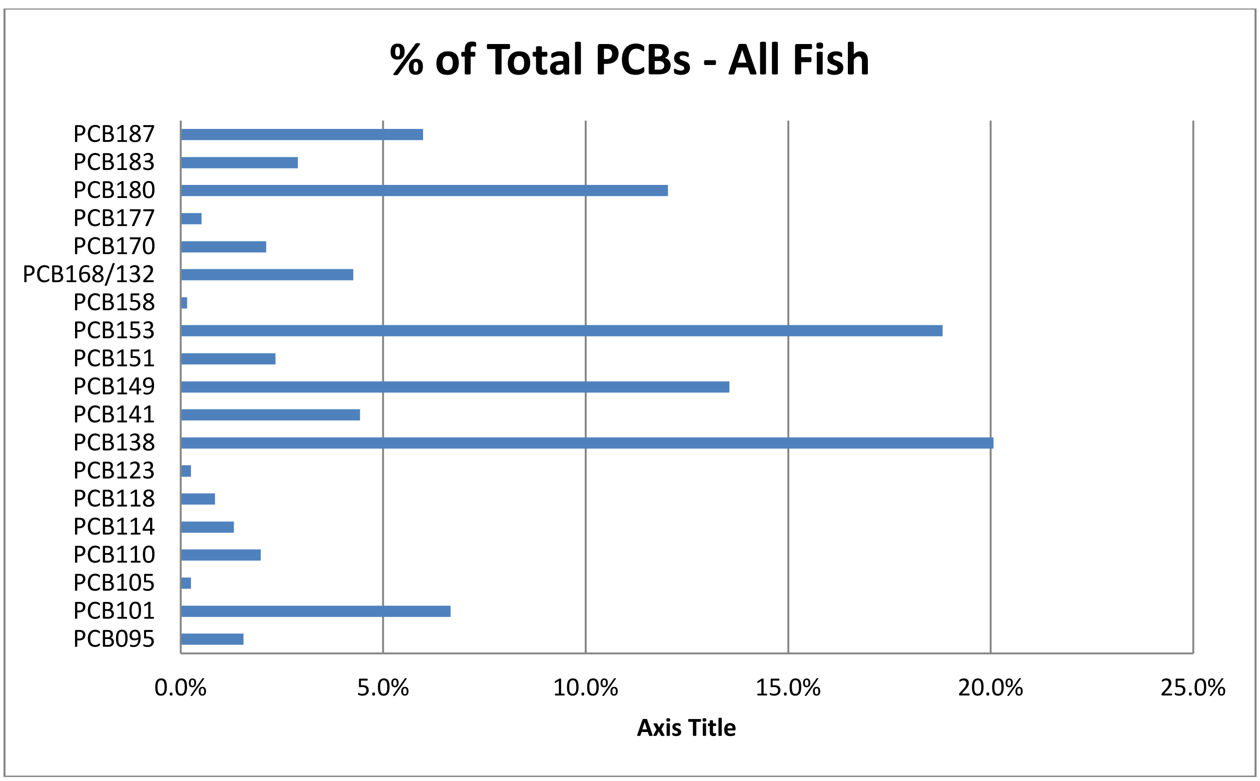

Figure 2-33: PCB Conger % Distribution in Fish Samples

Additional Datasets

Additional data described were collected for tritum (3H) in water, carbon and nitrogen isotpes in select fish tissue along with stomach prey analysis, samples of blue mussels for contaminant analysis (NOAA National Status and Trends Program), a limited set of blue mussel tissue was analysed for mercury, and a small set of marine algae was analyzed for trace metals. These data sets are not further analyzed in this document.

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Chapter-2: Appendix A - Aleutian Islands AKMAP Station Table and Maps

Remove AKALE07-0034; this station was not included in analyses

Appendix Table A-1: Information on stations locations

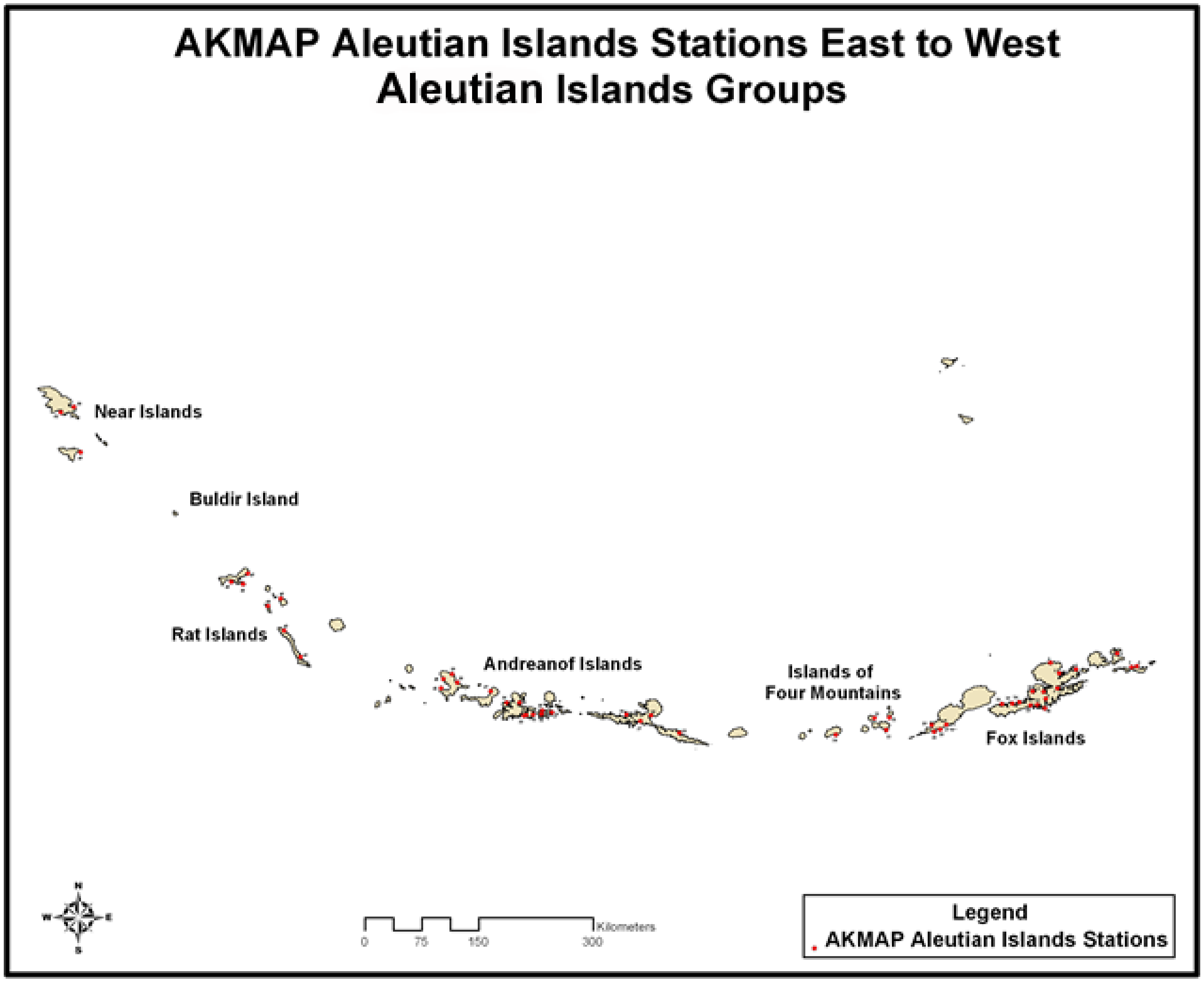
AKMAP Aleutian Islands Survey Stations for 2006 and 2007

Sorted by Stations Progressing East to West Across Aleutians

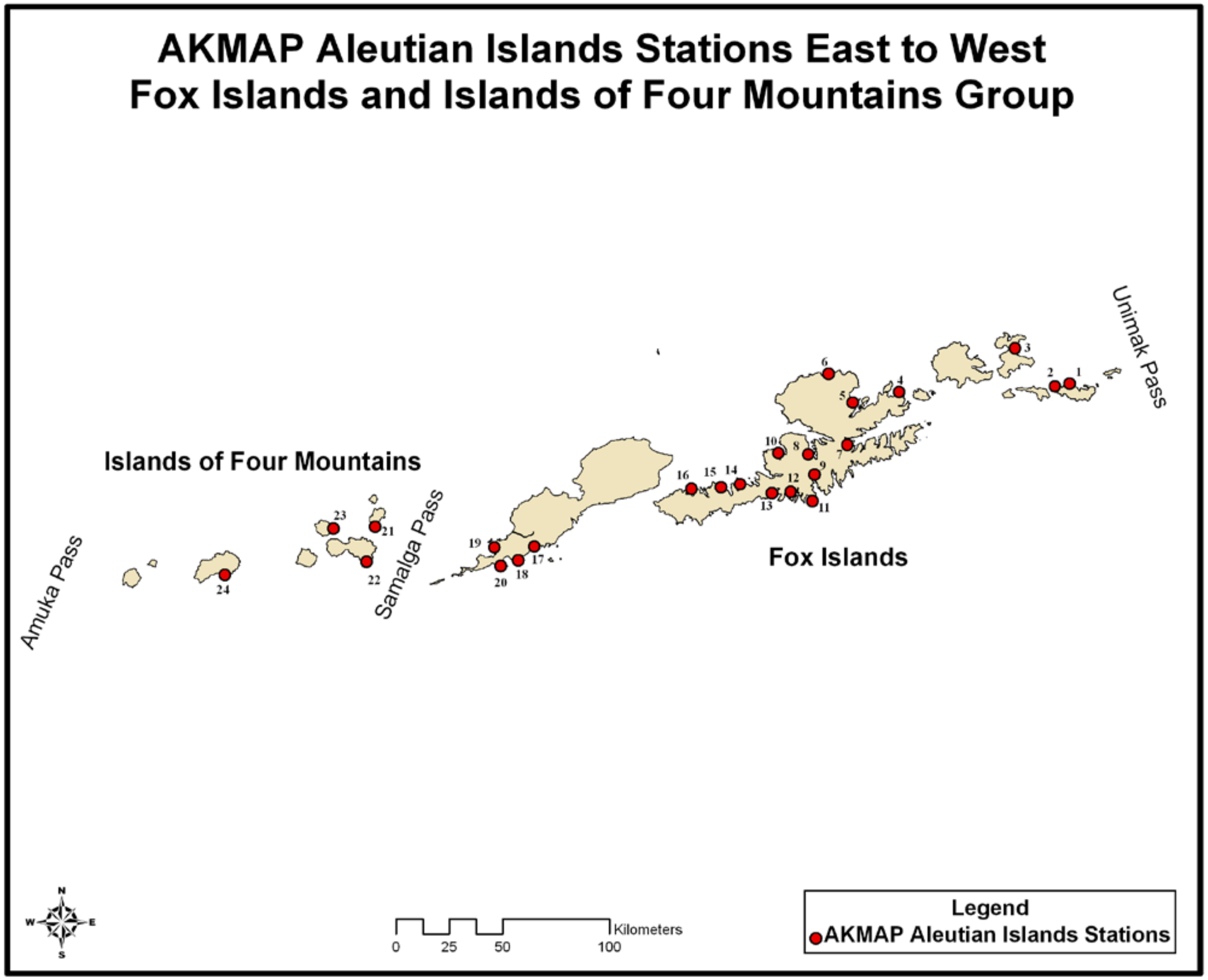
STATIONID	Station #	DATE	Year	LatDD	LongDD	ESTUARY	Location Name
AKALE06-0039	1	7/3/2006	2006	54.13	-165.11	Bering Sea	Tigalda Is., Tigalda Bay
AKALE06-0026	2	7/4/2006	2006	54.11	-165.21	Avatanak Strait	Tigalda Is., Avantanak Strait
AKALE06-0002	3	7/5/2006	2006	54.24	-165.54	Akun Bay	Akun Is., Heliathus Cove
AKALE06-ALT0002	4	7/22/2006	2006	53.97	-166.3	Kalekta Bay	Unalaska Is., Kalekta Bay
AKALE06-0021	5	7/7/2006	2006	53.89	-166.61	Unalaska Bay	Unalaska Is., Unalaska Bay, Nateekin Bay
AKALE06-0044	6	7/8/2006	2006	53.99	-166.82	Bering Sea	Unalaska Is., Driftwood Bay
AKALE06-0030	7	7/22/2006	2006	53.71	-166.59	Kisselen Bay	Unalaska Is., Beaver Inlet, Kisselen Bay
AKALE06-0007	8	7/9/2006	2006	53.64	-166.85	Naginak Cove	Unalaska Is., Makushin Bay, Naginak Bay
AKALE06-0028	9	7/21/2006	2006	53.56	-166.78	Usof Bay	Unalaska Is., Usof Bay
AKALE06-0020	10	7/10/2006	2006	53.62	-167.06	Skan Bay	Unalaska Is., West Arm Scan Bay
AKALE06-0023	11	7/21/2006	2006	53.45	-166.76	Usof Bay	Unalaska Is., Usof Bay
AKALE06-ALT0006	12	7/20/2006	2006	53.47	-166.92	Eagle Bay	Unalaska Is., Eagle Bay
AKALE06-ALT0012	13	7/20/2006	2006	53.45	-167.05	Kuliliak Bay	Unalaska Is., Kuliliak Bay
AKALE06-0012	14	7/13/2006	2006	53.46	-167.28	Kismaliuk Bay	Unalaska Is., Kismaliuk Bay
AKALE06-ALT0018	15	7/12/2006	2006	53.43	-167.41	Aspid Bay	Unalaska Is., Aspid Bay
AKALE06-0027	16	7/14/2006	2006	53.4	-167.61	Umnak Pass	Unalaska Is., Peacock Pt.
AKALE06-0043	17	7/19/2006	2006	53.02	-168.6	North Pacific Ocean	Umnak Is., Lookout Pt.
AKALE06-0025	18	7/18/2006	2006	52.95	-168.69	Traders Cove	Umnak Is., Traders Cove
AKALE07-0029	19	7/21/2007	2007	52.98	-168.87	Nikolski Bay	Umnak Is., Nikolski Bay
AKALE06-ALT0034	20	7/18/2006	2006	52.91	-168.8	North Pacific Ocean	Umnak Is., Cape Udak
AKALE06-0024	21	7/15/2006	2006	52.95	-169.71	Kagamil Pass	Kagamil Is., Kagamil Pass
AKALE06-0010	22	7/16/2006	2006	52.8	-169.71	Samalga Pass	Chuginadak Is., Samalga Pass
AKALE06-0011	23	7/15/2006	2006	52.9	-169.99	Carlisle Pass	Carlisle Is., Carlisle Pass
AKALE06-0037	24	7/17/2006	2006	52.6	-170.64	North Pacific Ocean	Yunaska Is.

AKMAP Aleutian Islands Survey Stations for 2006 and 2007
Sorted by Stations Progressing East to West Across Aleutians

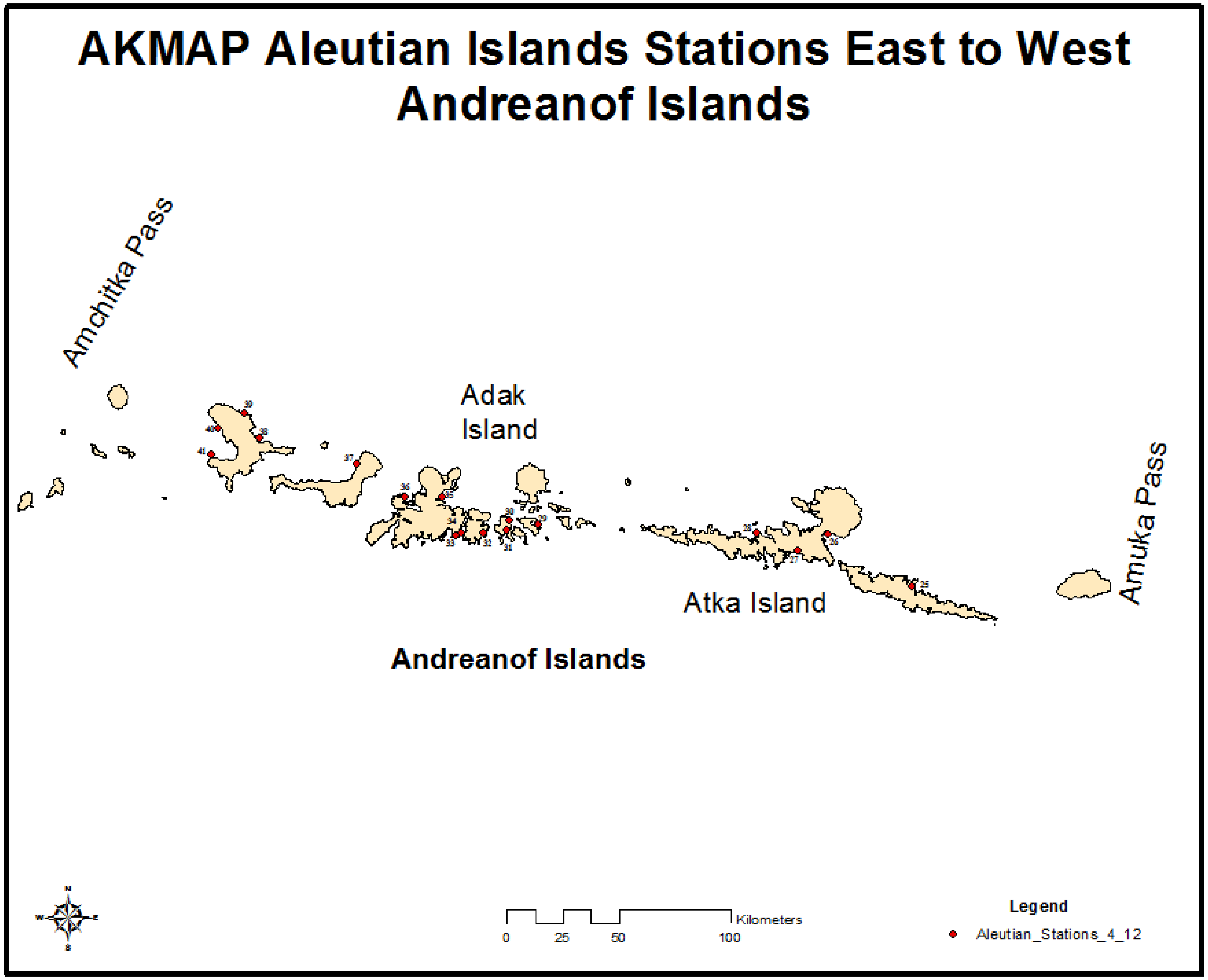
STATIONID	Station #	DATE	Year	LatDD	LongDD	ESTUARY	Location Name
AKALE07-0035	25	7/18/2007	2007	52.12	-173.54	Bering Sea	Amlia Is., S. of Cape Idalug
AKALE07-0008	26	7/17/2007	2007	52.22	-174.16	Nazan Bay	Atka Is., Nazan Bay
AKALE07-0032	27	7/16/2007	2007	52.12	-174.32	North Pacific Ocean	Atka Is., Vasilief Bay
AKALE07-0031	28	7/15/2007	2007	52.14	-174.61	Bering Sea	Atka Is., Deep Bay
AKALE07-0013	29	7/14/2007	2007	51.89	-175.97	Umak Bight	Umak Is., Umak Bight
AKALE07-0018	30	7/14/2007	2007	51.87	-176.15	Umak Pass	Little Tanaga Is., Umak Pass
AKALE07-A0005	31	7/13/2007	2007	51.83	-176.15	Chisak Bay	Little Tanaga Is., Chisak Bay
AKALE07-A0019	32	7/12/2007	2007	51.79	-176.29	Little Tanaga Strait	Kagalaska Is.
AKALE07-0047	33	7/10/2007	2007	51.74	-176.45	Bering Sea	Adak Is., SE
AKALE07-A0021	34	7/10/2007	2007	51.76	-176.42	Kagalaska Strait	Adak Is., S. Kagalaska Strait
AKALE07-A0014	35	7/12/2007	2007	51.87	-176.61	Kuluk Bay	Adak Is., Kuluk Bay, Gannet Rocks
AKALE07-0005	36	7/9/2007	2007	51.82	-176.84	Bay of Islands	Adak Is., Bay of Islands
AKALE07-A0028	37	7/8/2007	2007	51.88	-177.2	Kanaga Sound	Kanaga Is.
AKALE07-0050	38	7/6/2007	2007	51.84	-177.85	Bering Sea	Tanaga Is.
AKALE07-0042	39	7/6/2007	2007	51.91	-178	Bering Sea	Tanaga Is.
AKALE07-A0016	40	7/5/2007	2007	51.82	-178.12	Tanaga Pass	Tanaga Is.
AKALE07-DD003	41	7/7/2007	2007	51.71	-178.1	Bering Sea	Tanaga Is.
AKALE07-0016	42	7/2/2007	2007	51.43	179.22	Kirilof Bay	Amchitka Is., Kirilof Bay
AKALE07-DD002	43	7/3/2007	2007	51.64	178.75	Ogala Pass	Amchitka Is.
AKALE07-A0031	44	7/1/2007	2007	51.83	178.28	Bering Sea	Rat Is.
AKALE07-0045	45	7/1/2007	2007	51.97	178.45	Bering Sea	Little Sitkin Is., near Finger Pt.
AKALE07-0046	46	6/29/2007	2007	51.94	177.67	North Pacific Ocean	Little Kiska Is., E of Yug Pt.
AKALE07-A0048	47	6/30/2007	2007	52.08	177.67	Bering Sea	Kiska Is., Haycock Rock
AKALE07-0017	48	6/29/2007	2007	51.91	177.45	Vega Bay	Kiska Is., Vega Bay
AKALE07-0034	49	6/28/2007	2007	52.49	173.77	North Pacific Ocean	Agattu Is. (Fish, Water Column, no transect at this station.)
AKALE07-0019	50	6/25/2007	2007	52.93	173.25	Chichagof Harbor	Attu Is., Chichagof Harbor
AKALE07-0004	51	6/26/2007	2007	52.8	173.07	Temnac bay	Attu Is., Temnac Bay



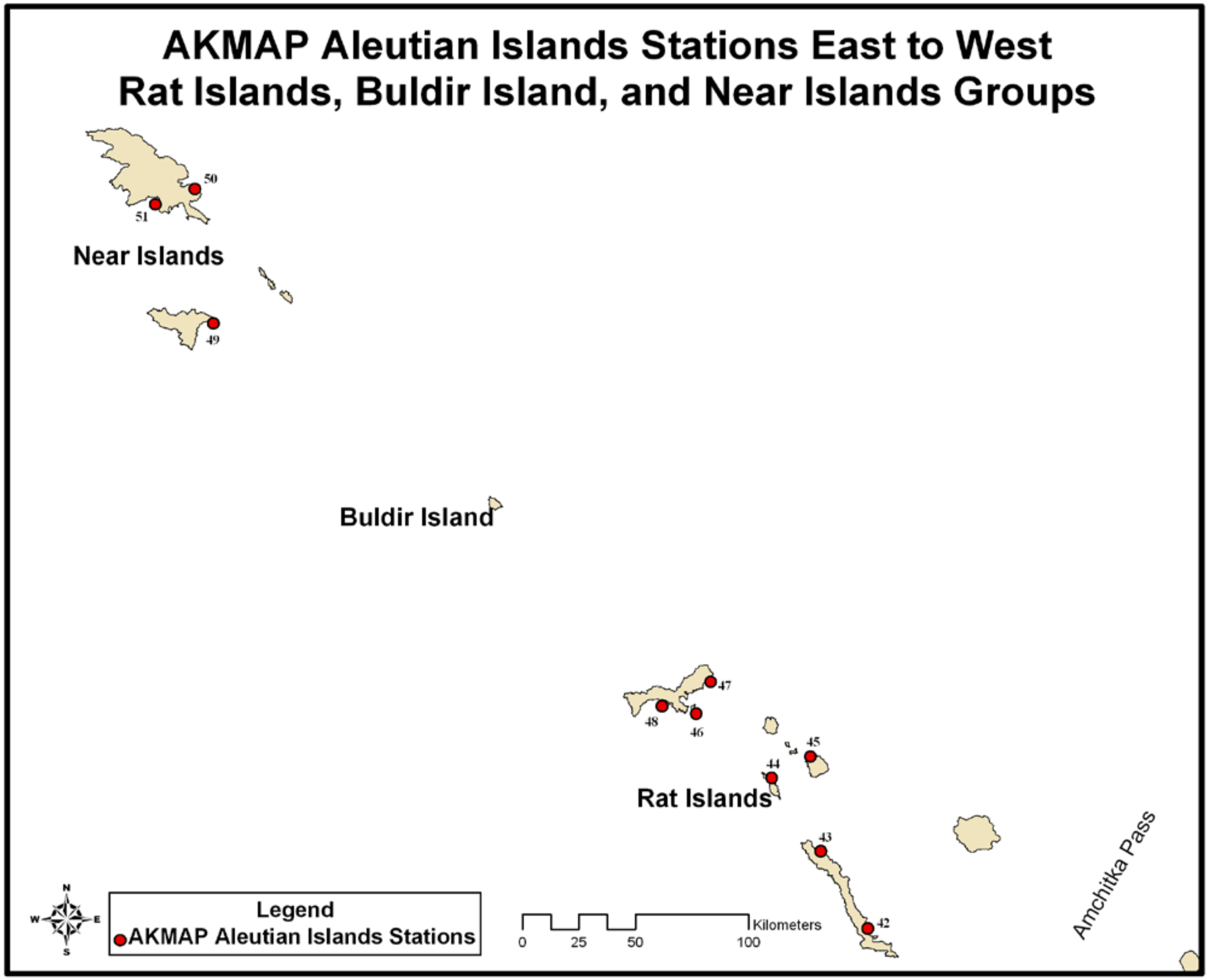
Appendix Figure A-1: Main Aleutain Island Groups



Appendix Figure A-2: Fox and Islands of Four Mountains Islands Group



Appendix Figure A-3: Andreanof Islands Group



Appendix Figure A-4: Rat, Buldir and Near Islands Group

Appendix B: Benthic Condition Supplemental Report

BENTHIC COMMUNITIES

Benthic invertebrates are frequently seen as good indicators for the overall health of the environment where they reside because of their sensitivity to environmental disturbance and pollution.

The objective of this investigation was to assess and compare the invertebrate communities (in terms of community assemblages, invertebrate abundance and species diversity) throughout the Aleutian Islands.

The Aleutian Islands consists of volcanic oceanic islands and the sub-littoral zones mainly consist of rocky substrates – although soft sediments also occur intermittently. The Aleutian nearshore environment provides very diverse habitats ranging from soft sediments to bedrock and from sea urchin barrens to dense kelp forests. Traditional NCA uses a multi-tiered sediment triad approach focused on fine-grain sediments that cannot properly characterize the status of this region's rocky benthic ecological resource.

The conventional EMAP methodology targeting soft sediments and using remote sampling gear (grabs and trawls) was therefore modified to fit the unique environmental conditions and species found in the Aleutian Islands. Benthic sampling for both types of substrate (hard and soft) was carried out using scuba and followed protocols adapted from those used in Hawaii EMAP (Nelson et al., 2007) and Guam EMAP (Guam EPA, 2004). The transect/quadrat techniques for sampling rocky regions were based on the Natural Geography in Shore Areas (NaGISA) protocol (Konar and Iken, 2003; Rigby et al., 2007).

METHODS

Sites

A total of 50 stations were sampled throughout the study area (Appendix Table B-1). Stations were scattered throughout the entire Aleutian chain and belonged to 3 different geographical regions, the East, Mid, and West Aleutians. The Eastern Aleutian stretched from the Alaska Penninsula to Samalga Pass, the Mid Aleutians include islands between Samalga and Amchitka Passes, and the Western Aleutians stretch from Amchitka to Attu Islands. Each station was categorized as either hard or soft substrate. Hard stations were usually characterized by bedrock covered with thick kelp or with crustose coralline algae. Soft stations were characterized by loose material, mostly sand, but the grain size ranged from fine to coarse pebbles. All stations were at a depth between 6-19 m. Stations were classified within 1 of 3 depth ranges, 6-10 m, 11-14 m, and 15-19 m.

Appendix Table B-1: Benthic Station Information Change Site ID to Station ID; Change Site to Station # to match APP A table

Sampling Date	Site ID	Site	Island, Bay	Lat and Long Decimal	Lat and Long (NAD 83)	Depth (m)	Depth Range	Substrate	Region	Number of replicates
07/03/06	AKALE06-0039	39	Tigalda Is., Tigalda Bay	54.125167° -165.110550°	N54 07.510 W165 06.633	6	6-10	Hard	East	3
07/04/06	AKALE06-0026	26	Tigalda Is., Avantanak Strait	54.106667° -165.211250°	N54 06.400 W165 12.675	15	15-19	Hard	East	3
07/05/06	AKALE06-0002	02	Akun Is., Heliathus Cove	54.240000° -165.543167°	N54 14.400 W165 32.590	15	15-19	Hard	East	3
07/07/06	AKALE06-0021	21	Unalaska Is., Unalaska Bay, Nateekin Bay	53.891500° -166.611817°	N53 53.490 W166 36.709	17	15-19	Soft	East	3
07/08/06	AKALE06-0044	44	Unalaska Is., Driftwood Bay	53.994817° -166.818600°	N53 59.689 W166 49.116	13	11-14	Hard	East	3
07/09/06	AKALE06-0007	07	Unalaska Is., Makushin Bay, Naginak Bay	53.638200° -166.852217°	N53 38.292 W166 51.133	15	15-19	Soft	East	3
07/10/06	AKALE06-0020	20	Unalaska Is., West Arm Scan Bay	53.616300° -167.055650°	N53 36.978 W167 03.339	16	15-19	Soft	East	3
07/12/06	AKALE06-A0018	A18	Unalaska Is., Aspid Bay	53.426000° -167.408167°	N53 25.560 W167 24.490	12	11-14	Soft	East	3
07/13/06	AKALE06-0012	12	Unalaska Is., Kismaliuk Bay	53.455183° -167.278133°	N53 27.311 W167 16.688	11	11-14	Soft	East	3
07/14/06	AKALE06-0027	27	Unalaska Is., Peacock Pt.	53.395050° -167.609983°	N53 23.703 W167 36.599	14	11-14	Hard	East	3
07/15/06	AKALE06-0011	11	Carlisle Is., Carlisle Pass	52.899550° -169.995500°	N52 53.973 W169 59.730	7	6-10	Hard	Mid	3
07/15/06	AKALE06-0024	24	Kagamil Is., Kagamil Pass	52.952067° -169.713400°	N52 57.124 W169 42.804	17	15-19	Soft	Mid	3
07/16/06	AKALE06-0010	10	Chuginadak Is., Samalga Pass	52.804817° -169.708767°	N52 48.289 W169 42.526	17	15-19	Hard	Mid	3
07/17/06	AKALE06-0037	37	Yunaska Is.	52.593400° -170.637417°	N52 35.604 W170 38.245	18	15-19	Soft	Mid	3
07/18/06	AKALE06-A0034	A34	Umnak Is., Cape Udak	52.911917° -168.797533°	N52 54.715 W168 47.852	14	11-14	Hard	East	3
07/18/06	AKALE06-0025	25	Umnak Is., Traders Cove	52.951517° -168.692433°	N52 57.091 W168 41.546	11	11-14	Hard	East	3
07/19/06	AKALE06-0043	43	Umnak Is., Lookout Pt.	53.017233° -168.599117°	N53 01.034 W168 35.947	14	11-14	Hard	East	3
07/20/06	AKALE06-A0012	A12	Unalaska Is., Kuliliak Bay	53.448283° -167.050700°	N53 26.897 W167 03.042	10	6-10	Hard	East	3
07/20/06	AKALE06-A0006	A06	Unalaska Is., Eagle Bay	53.466333° -166.923650°	N53 27.980 W166 55.419	10	6-10	Hard	East	3
07/21/06	AKALE06-0023	23	Unalaska Is., Usof Bay	53.454117° -166.757100°	N53 27.247 W166 45.426	15	15-19	Hard	East	3
07/21/06	AKALE06-0028	28	Unalaska Is., Usof Bay	53.563533° -166.775083°	N53 33.812 W166 46.505	17	15-19	Soft	East	3
07/22/06	AKALE06-0030	30	Unalaska Is., Beaver Inlet, Kisselen Bay	53.712233° -166.585517°	N53 42.734 W166 35.131	17	15-19	Hard	East	3
07/22/06	AKALE06-A0002	A02	Unalaska Is., Kalekta Bay	53.970567° -166.300883°	N53 58.234 W166 18.053	10	6-10	Soft	East	3
06/25/07	AKALE07-0019	19	Attu Is., Chichagof Harbor	52.931017° 173.254917°	N52 55.861 E173 15.295	8	6-10	Soft	West	3
06/26/07	AKALE07-0004	04	Attu Is., Temnac Bay	52.802733° 173.074783°	N52 48.164 E173 04.487	11	11-14	Soft	West	1
06/29/07	AKALE07-0017	17	Kiska Is., Vega Bay	51.914483° 177.447750°	N51 54.869 E177 26.865	14	11-14	Hard	West	3
06/29/07	AKALE07-0046	46	Little Kiska Is., E of Yug Pt.	51.940367° 177.667033°	N51 56.422 E177 40.022	16	15-19	Hard	West	3
06/30/07	AKALE07-A0048	A48	Kiska Is., Haycock Rock	52.077333° 177.670883°	N52 04.640 E177 40.253	11	11-14	Hard	West	3
07/01/07	AKALE07-0045	45	Little Sitkin Is., near Finger Pt.	51.970017° 178.453067°	N51 58.201 E178 27.184	11	11-14	Hard	West	3
07/01/07	AKALE07-A0031	A31	Rat Is.	51.826567° 178.277933°	N51 49.594 E178 16.676	14	11-14	Hard	West	3
07/02/07	AKALE07-0016	16	Amchitka Is., Kirilof Bay	51.430833° 179.223383°	N51 25.850 E179 13.403	7	6-10	Hard	West	3
07/03/07	AKALE07-DD0002	DD02	Amchitka Is.	51.642667° 178.748800°	N51 38.560 E178 44.928	15	15-19	Hard	West	3
07/05/07	AKALE07-A0016	A16	Tanaga Is.	51.821467° -178.120933°	N51 49.288 W178 07.256	8	6-10	Hard	Mid	3
07/06/07	AKALE07-0042	42	Tanaga Is.	51.912500° -178.003117°	N51 54.750 W178 00.187	16	15-19	Soft	Mid	3
07/06/07	AKALE07-0050	50	Tanaga Is.	51.844950° -177.853500°	N51 50.697 W177 51.210	13	11-14	Hard	Mid	3
07/07/07	AKALE07-DD0003	DD03	Tanaga Is.	51.710250° -178.103350°	N51 42.615 W178 06.201	12	11-14	Hard	Mid	3
07/08/07	AKALE07-A0028	A28	Kanaga Is.	51.881200° -177.204650°	N51 52.872 W177 12.279	15	15-19	Hard	Mid	3
07/09/07	AKALE07-0005	05	Adak Is., Bay of Islands	51.817050° -176.839750°	N51 49.023 W176 50.385	16	11-14	Hard	Mid	3
07/10/07	AKALE07-A0021	A21	Adak Is., S. Kagalaska Strait	51.755967° -176.423950°	N51 45.358 W176 25.437	11	11-14	Hard	Mid	3
07/10/07	AKALE07-0047	47	Adak Is.	51.735100° -176.453817°	N51 44.106 W176 27.229	10	6-10	Hard	Mid	3
07/12/07	AKALE07-A0014	A14	Adak Is., Kuluk Bay, Gannet Rocks	51.870250° -176.606383°	N51 52.215 W176 36.383	16	11-14	Hard	Mid	3
07/12/07	AKALE07-A0019	A19	Kagalaska Is.	51.792483° -176.290083°	N51 47.549 W176 17.405	13	11-14	Soft	Mid	3
07/13/07	AKALE07-A0005	A05	Little Tanaga Is., Chisak Bay	51.826717° -176.150017°	N51 49.603 W176 09.001	10	6-10	Soft	Mid	3
07/14/07	AKALE07-0018	18	Little Tanaga Is., Umak Pass	51.866750° -176.153867°	N51 52.005 W176 09.232	14	11-14	Hard	Mid	3
07/14/07	AKALE07-0013	13	Umak Is., Umak Bight	51.890417° -175.971367°	N51 53.425 W175 58.282	8	6-10	Hard	Mid	3
07/15/07	AKALE07-0031	31	Atka Is., Deep Bay	52.140900° -174.606817°	N52 08.454 W174 36.409	9	6-10	Hard	Mid	3
07/16/07	AKALE07-0032	32	Atka Is., Vasilief Bay	52.115150° -174.315850°	N52 06.909 W174 18.951	19	15-19	Soft	Mid	3
07/17/07	AKALE07-0008	08	Atka Is., Nazan Bay	52.223617° -174.161967°	N52 13.417 W174 09.718	9	6-10	Soft	Mid	3
07/18/07	AKALE07-0035	35	Amlia Is., S. of Cape Idalug	52.119650° -173.541400°	N52 07.179 W173 32.484	14	11-14	Soft	Mid	3
07/21/07	AKALE07-0029	29	Umnak Is., Nikolski Bay	52.982817° -168.873650°	N52 58.969 W168 52.419	13	11-14	Hard	East	3

Community Sampling

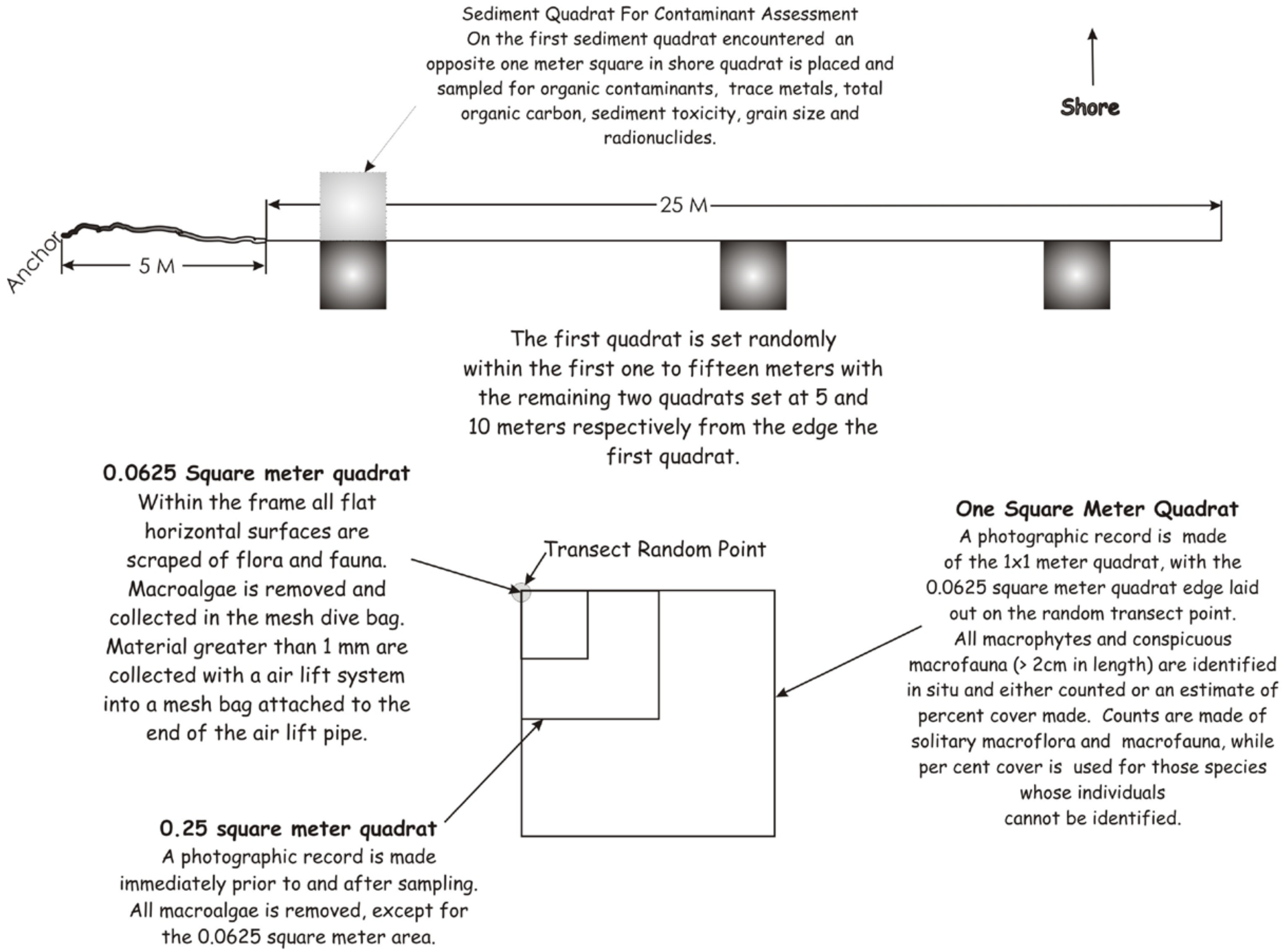
The randomly preselected stations were located by GPS and nautical charts, and surveyed for safety and acceptable depth range (< 20 m). A surface buoy marked each station. Below each station buoy a 25-m transect tape was deployed along a depth contour and three replicates of nested quadrats were placed at random distances along the transect (Appendix Figure B-1). Each set included 1 x 1-m (1 m^2), 50 x 50-cm (0.25 m^2), and 25 x 25-cm (0.06 m^2) quadrats. The percent cover of algae and sessile invertebrates, and counts for kelp stipes and understory macroinvertebrates (> 2 cm) were recorded within the 1 x 1-m frame. All algal material was collected from the 50 x 50-cm frame and was placed in labeled collection bags for later identification and weighing. The data from the 1x1-m and 50 x 50-cm quadrats are not presented in this study. On rocky substrates, the 25 x 25-cm frames were scrapped clear of all invertebrates and all algae (foliose and crustose). If the quadrats were on soft substrates, the sediments were dredged to a depth of 10 cm. The destructive samples were collected in labeled fine-mesh (500 µm), drawstring bags. All sampling of biota by divers was covered under the Fish Resource permits (CF-06-066 and CF-07-06) issued by the Alaska Department of Fish and Game.

A total of 148 samples were collected (3 replicates per station except at station AKLE07-0004 where 2 samples accidentally lost). Once on board the ship, the samples were sieved through a 1-mm mesh screen, and preserved in 10% buffered Formalin.

In addition to the destructive sampling, a video transect was recorded, photographs were taken, and detailed notes on the habitat characteristics were taken at each site. Hawaii and Guam EMAP studies conducted quantitative fish censuses by divers along a 4 x 25-m strip transect. However, after several dives to rehearse this fish sampling protocol, the Aleutian AKMAP team determined fish densities were too low and kelp forests were often too dense to justify the standard EMAP fish census along a strip transect. As an alternative, fish were recorded by video along the 1 x 25-m transect.

Laboratory Analysis

In the laboratory, the samples were rinsed and transferred to 50% Isopropanol before processing. Counts were recorded for solitary invertebrates. Colonial organisms were given a count of 1 so they could be included in the diversity and community analyses. All sorted invertebrates were identified to the lowest practical taxonomic. For the present analysis, challenging groups (mostly Porifera, Hydrozoa, Bryozoa, and Ascidiacea) were only identified at the phylum or class level. Also, *Strongylocentrotus droebachiensis* and *S. polyacanthus* were the two dominant sea urchin species. Because of the difficulty in identifying individuals to the species level, and until further taxonomic and genetic information become available, sea urchins were conservatively identified to the generic level. In addition, in order to prevent taxonomic ‘variability’ due to a improved taxonomic knowledge over time and to inconsistencies between samples verified by experts versus samples identified by staff members, we used a ‘least common denominator’ approach for our community analysis – i.e., questionable entries were combined under a common, conservative level of identification.



Appendix Figure B-1: Transect Details

Data Analysis

The biodiversity indices taxon richness (S), abundance of individual organisms (N), and the Shannon-Wiener Diversity Index (Shannon Index) (H', log base e) were calculated using Primer statistical software (PRIMER 6.0, Primer-E, Ltd. 2001). All diversity and abundance values were log(x +1) transformed prior to testing to satisfy assumptions of normality and equal variances. The statistical differences in those indices between the different habitat types, regions, or depth ranges were evaluated with one-way ANOVAs followed by Tukey's pairwise comparisons (PAST version 1.96 2009).

Non-metric multidimensional scaling (MDS) analyses were used to plot community similarity patterns based on mean abundance of invertebrate taxa at each site (PRIMER 6.0, Primer-E, Ltd. 2001). The data were log(x+1) transformed and the Bray-Curtis coefficient was used as a resemblance parameter. The multivariate patterns, in terms of habitat type resemblances, were depicted in ordination plots. The data were plotted in terms of substrate types, regions, or depth ranges.

The patterns depicted on MDS plots were derived from combined abundance data from individual taxa within each sample. The presence or absence, as well as the relative abundance, of certain influential species are responsible for the gradients observed (i.e. how closely or spread out samples are plotted). The Similarity Percentage routine (SIMPER; PRIMER 6.0, Primer-E, Ltd. 2001) was performed in order to detect and list which taxa were most significantly contributing to the separation between the different habitat types.

One-way Analysis of Similarity (ANOSIM, randomization/permutation procedure; PRIMER 6.0, Primer-E, Ltd., 2001) was carried out to assess the degree of difference in benthic invertebrate assemblages amongst several factors (substrate types, regions, or depth ranges). The Null hypothesis that there were no significant differences amongst groups was rejected if the significance level (p) was < 0.05. The R-statistic value was used to evaluate the extent of any significant difference. R-values close to 1.0 suggested that invertebrate communities of samples within a specific habitat were more similar to each other than to samples from another habitat.

RESULTS

Of the 50 sites surveyed 33 were located on hard substrate versus 17 on soft substrate; 20 were located in the Eastern Aleutians, 21 in the Mid, and 9 in the Western; and 13 were within the 6-10 m depth range, 21 were with 11-14 m, and 16 were within 15-19 m. There was no significant difference in mean depth between substrate types ($p = 0.1992$) or between regions ($p = 0.6518$).

The survey of 50 sites, for a total of 148, 0.06 m^2 quadrats, along the Aleutian Islands led to the collection of a total of 121,171 individual invertebrates belonging to a total of 961 different taxa. A total of 465 genera, 275 families, 74 orders, 34 classes, and 16 phyla were recorded. The most abundant phyla were Annelida (72,878 individuals), Arthropoda (31,475 individuals), and Mollusca (7,007 individuals). Some invertebrate groups were taxonomically challenging and several identifications remained at the phylum or class level (i.e. Ascidiacea, Bryozoa, Hydrozoa, Porifera). A complete list of all taxa encountered during this study can be found on the Alaska Department of Environmental Conservations Alaska Monitoring and Assessment Program web site - http://dec.alaska.gov/water/wqsar/monitoring/06-07Aleutian.htm. Also, to assure that the level of taxonomic identification remained consistent throughout the samples, we used a more conservative level of identification for some invertebrates. This conservative list was the basis for our data analyses.

The values for the different biodiversity indices varied greatly amongst samples. The number of taxa or taxa richness (S) ranged from 2 to 118 taxa per 25 x 25-cm quadrat, while the number of individuals (N) varied from 8 to 8,346 invertebrate individuals, and the Shannon Diversity Index (H') fluctuated from 0.377 to 3.757. The mean values and standard errors for each of those indices are presented by region and substrate types in Appendix Table B-2. No significant differences were observed for any of those indices between samples from different regions (p = 0.1918 for S, p = 0.2768 for N, p = 0.2648 for H') or from different depth ranges (p = 0.4230 for S, p = 0.6300 for N, p = 0.8294 for H'). However significant differences were observed for samples collected from hard versus soft substrate (p = <0.0001 for S, p = 0.0498 for N, p = 0.0255 for H'). No significant interactions were seen between those 3 different factors, substrate, region, and depth range ($p > 0.05$ for all).

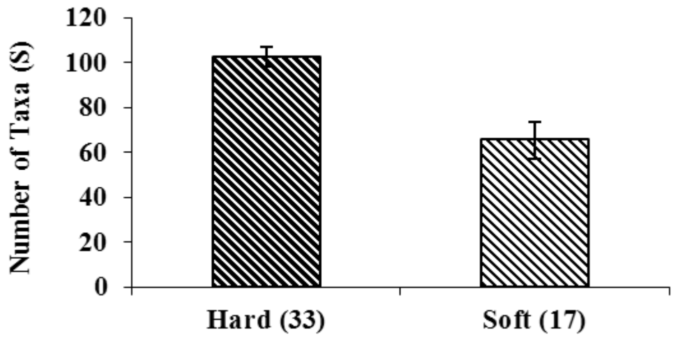
Appendix Table B-2: Mean and (Standard Error) Values for Indices of taxa richness (S), number of individuals (N), and Shannon Diversity (H') by Region and Substrate

	S	*N*	*H'(loge)*
East-Hard	112.15	890.44	3.25
(n=13)	(6.27)	(154.05)	(0.11)
East-Soft	82.14	867.57	2.63
(n=7)	(15.74)	(421.86)	(0.25)
Mid-Hard	104.69	954.82	2.83
(n=13)	(7.46)	(240.48)	(0.18)
Mid-Soft	55.00	862.67	2.63
(n=8)	(7.70)	(677.64)	(0.20)
West-Hard	81.86	346.00	2.84
(n=7)	(6.88)	(93.91)	(0.22)
West-Soft	49.50	549.17	2.27
(n=2)	(24.50)	(410.17)	(0.04)

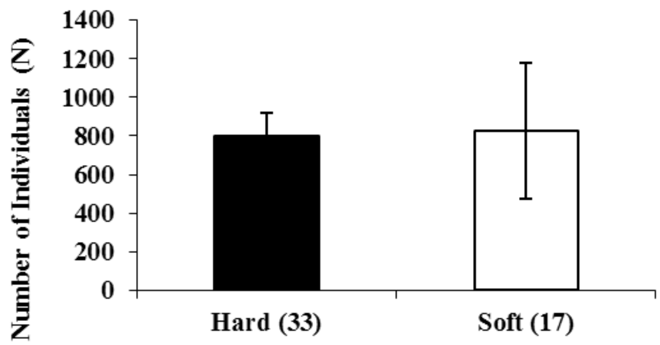
Note: Surface area at each site = 3 x 0.006 m^2 - except for Site 04 where only 1 quadrat was sampled.

Data not transformed

The mean taxa richness (S) was significantly higher for hard bottom sites (102.79 ± 4.47 taxa per quadrat; mean ± SE) than for soft bottom sites (65.53 ± 8.19) ($p < 0.001$; Appendix Figure B-2a). The mean number of individuals was not significantly different between hard (800.31 ± 119.00) and soft (827.80 ± 352.00) habitats (p = 0.0539; Appendix Figure B-2b). The Shannon Diversity Index (H') takes into account both the number of taxa as well as the number of individuals within each taxon. Invertebrate diversity was significantly higher within hard bottom sites (2.99 ± 0.10) than soft bottom sites (2.59 ± 0.14) (p = 0.0263; Appendix Figure B-2c).



Appendix Figure B-2a: Mean Taxa Richness Hard versus Soft Bottom



Appendix Figure B-2b: Mean Number of Individuals Hard versus Soft Bottom

Appendix Figure B-2c: Shannon Diversity Index (H') Hard versus Soft Bottom

Some taxonomic groups (Polychaeta, Crustacea, Bivalvia, Gastropoda) were very prominent and were found at 96-100% of the sites (Appendix Table B-3). Other groups (Phoronida, Aplacophora, Priapula) were quite rare and were found at only 2 out 50 sites. Most groups that occurred at most sites also totaled for a large number of individuals; in contrast, phoronids accounted for a total of 2,687 individuals, but were encountered at only 2 sites. A list of invertebrate families and their respective abundance and percentage (with respect to the total number of invertebrates) for the entire study area is presented in Appendix Table B-4. Some major groups were more prominent and abundant on one specific type of substrate (hard versus soft) and some were entirely absent from the hard or soft substrate habitat (Appendix Table B-5). Polychaetes, crustaceans and gastropods were found at all sites and were overall abundant on both substrates. In contrast, hemichordates were completely absent from hard substrate, while aplacophorans, brachiopods, and leaches were not found at any of the soft substrate site.

A list of the 20 most abundant families (Appendix Table B-6a) and most abundant taxa (Appendix Table B-6b) within each substrate type shows that polychaetes and amphipods were abundant in both habitat types, but certain families were often specific to each habitat. Spionids were the most dominant families in both habitats, but *Polydora/Dipolydora* complex was characteristic of hard substrate, whereas *Pygospio elegans* was the most abundant spionid in soft substrate. In contrast, other polychaete families (Terebellidae and Sabellidae) were abundant on hard substrate, while oweniids and orbiniids were more abundant in soft sediments. Bivalves were abundant in both hard bottoms and soft sediments, with thyasirids being found predominantly in soft sediments, and mytilids and hiatellids being more characteristic of hard substrate. Strongylocentrodid urchins and acrocirrid polychaetes were almost exclusively associated with hard bottom habitat.

Appendix Figure B-3 lists the relative abundance of the major taxonomic groups of invertebrates collected from 33 hard bottom Aleutian sites (a) versus invertebrates collected from 17 soft bottom sites (b).

<u>Community Analysis</u>

Overall invertebrate community structure, as displayed with MDS plots, suggested discernible differences between soft-sediment and hard-substrate communities (Appendix Figure B-4a). Samples collected from soft-sediment sites were quite spread out on the plots, suggesting great variability in invertebrate community composition within that habitat, especially compared to the samples collected from hard bottom sites. ANOSIM results validated the graphical observations that community compositions were significantly different between habitat types and that samples collected from similar habitats were more similar to each other than to samples from other habitat types (p = 0.001; Global R-value = 0.681). No clear patterns are observed when plotting the invertebrate abundances by region or by depth range (Appendix Figure B-4b, c). No significant differences in the community structure were observed between the different regions (p = 0.058; Global R-value = 0.074) or different depth ranges (p = 0.298; Global R-value = 0.012).

Of the many taxa collected during the survey, some contributed most to the divergence observed in community composition between the different habitats. Examples of influential species that are highly typical of a particular substrate type or habitat are presented below. Good discriminating taxa are not necessarily abundant, but they tend to be consistently present (or in higher numbers) within samples characteristic of one habitat and absent (or in lower numbers) from samples from other habitats. Lists of groups (at the higher taxonomic level, at family level, or at the taxa level) that strengthen the similarity of samples within a particular substrate type and **that influence the dissimilarity between those habitat types are presented in Appendix Table B-7.**

Appendix Table B-3: Prominent Taxonomic Groups

	Abundance	**Occurrence**
Taxonomic Group	**Total Individuals (# and %)**	**Stations (# and %)**
Polychaeta	71,634 (59.118)	50 (100)
Crustacea	30,320 (25.022)	50 (100)
Bivalvia	3,911 (3.228)	48 (96)
Phoronida	2,687 (2.218)	2 (4)
Gastropoda	2,451 (2.023)	50 (100)
Echinodermata	2,362 (1.949)	48 (96)
Ascidiacea	1,916 (1.581)	41 (82)
Oligochaeta	1,237 (1,021)	30 (60)
Arachnida	1,086 (0.896)	28 (56)
Cnidaria	829 (0.684)	41 (82)
Nemertinea	756 (0.624)	48 (96)
Polyplacophora	638 (0.527)	40 (80)
Ectoprocta	410 (0.338)	41 (82)
Porifera	318 (0.262)	37 (74)
Platyhelminthes	258 (0.213)	14 (28)
Sipuncula	137 (0.113)	20 (40)
Echiura	88 (0.073)	19 (38)
Pycnogonida	69 (0.057)	19 (38)
Brachiopoda	28 (0.023)	10 (20)
Hemichordata	16 (0.013)	3 (6)
Aplacophora	7 (0.006)	2 (4)
Hirudinea	7 (0.006)	6 (12)
Priapula	6 (0.005)	2 (4)

Appendix Table B-4: List of Invertebrate Families and Respective Abundance and % of all Invertebrates

Higher Taxonomic Group	Family	Total Abundance	% of all Inverts
Aplacophora	Neomeniidae	6	0.005
	Proneomeniidae	1	0.001
Arachnida	Acarida	1,086	0.896
Ascidiacea	Ascidiacea	1,878	1.550
	Didemnidae	38	0.031
Bivalvia	Mytilidae	1,748	1.443
	Hiatellidae	757	0.625
	Thyasiridae	701	0.579
	Lasaeidae	158	0.130
	Tellinidae	154	0.127
	Carditidae	137	0.113
	Limidae	129	0.106
	Anomiidae	36	0.030
	Bivalvia	30	0.025
	Veneridae	24	0.020
	Myidae	10	0.008
	Astartidae	7	0.006
	Thraciidae	6	0.005
	Unqulinidae	4	0.003
	Cardiidae	2	0.002
	Mactridae	2	0.002
	Lucinidae	1	0.001
	Nuculanidae	1	0.001
	Nuculidae	1	0.001
	Pectinidae	1	0.001
	Turtoniidae	1	0.001
	Yoldiidae	1	0.001
Brachiopoda	Cancellothyrididae	13	0.011
	Laqueidae	5	0.004
	Terebratulida	5	0.004
	Brachiopoda	4	0.003
	Craniidae	1	0.001
Cnidaria	Actiniidae	525	0.433
	Cnidaria	86	0.071
	Hydrozoa	62	0.051
	Sertulariidae	42	0.035
	Actiniaria	26	0.021
	Alcyoniidae	25	0.021
	Lucernariidae	20	0.017
	Metridiidae	19	0.016
	Cerianthidae	7	0.006
	Corynidae	6	0.005
	Plumulariidae	6	0.005
	Edwardsiidae	4	0.003
	Anthozoa	1	0.001
Crustacea	Amphipoda	10,280	8.484
	Caprellidae	3,805	3.140
	Munnidae	3,026	2.497
	Pontogeneiidae	1,479	1.221
	Ostracoda	1,371	1.131
	Pleustidae	1,182	0.975

Higher Taxonomic Group	Family	Total Abundance	% of all Inverts
	Tanaidae	717	0.592
	Isaeidae	654	0.540
	Janiridae	650	0.536
	Tanaidacea	555	0.458
	Melitidae	482	0.398
	Hippolytidae	476	0.393
	Balanidae	466	0.385
	Hyalidae	450	0.371
	Epialtidae	429	0.354
	Corophiidae	423	0.349
	Eusiridae	286	0.236
	Calliopiidae	279	0.230
	Uristidae	274	0.226
	Sessilia	270	0.223
	Diastylidae	245	0.202
	Lampropidae	194	0.160
	Phoxocephalidae	190	0.157
	Oedicerotidae	173	0.143
	Paguridae	165	0.136
	Stenothoidae	164	0.135
	Lithodidae	161	0.133
	Ampithoidae	156	0.129
	Odiidae	147	0.121
	Lysianassidae	130	0.107
	Haustoriidae	120	0.099
	Leuconidae	114	0.094
	Dexaminidae	89	0.073
	Cancridae	79	0.065
	Crangonidae	78	0.064
	Bodotriidae	76	0.063
	Oregoniidae	67	0.055
	Isopoda	54	0.045
	Anisogammaridae	46	0.038
	Podoceridae	42	0.035
	Synopiidae	38	0.031
	Idoteidae	37	0.031
	Joeropsididae	32	0.026
	Ampeliscidae	22	0.018
	Nannastacidae	21	0.017
	Nebaliidae	19	0.016
	Leptocheliidae	17	0.014
	Pandalidae	15	0.012
	Expanathuridae	14	0.012
	Atelecyclidae	13	0.011
	Archaeobalanidae	11	0.009
	Leucothoidae	10	0.008
	Argissidae	6	0.005
	Anthuridae	5	0.004
	Arcturidae	4	0.003
	Phliantidae	4	0.003
	Majidae	2	0.002
	Pontoporeiidae	2	0.002
	Amphilochidae	1	0.001
	Cumacea	1	0.001

Higher Taxonomic Group	Family	Total Abundance	% of all Inverts
	Paratanaidae	1	0.001
	Talitridae	1	0.001
Echinodermata	Strongylocentrotidae	1,297	1.070
	Amphiuridae	338	0.279
	Ophiactidae	184	0.152
	Cucumariidae	126	0.104
	Asteriidae	90	0.074
	Phyllophoridae	70	0.058
	Echinoidea	55	0.045
	Chiridotidae	44	0.036
	Dendrochirotida	28	0.023
	Fibulariidae	28	0.023
	Holothuroidea	23	0.019
	Echinarachniidae	19	0.016
	Ophiuridae	16	0.013
	Echinasteridae	12	0.010
	Ophiuroidea	9	0.007
	Asteroidea	7	0.006
	Ganeriidae	5	0.004
	Ophiurida	4	0.003
	Solasteridae	3	0.002
	Goniasteridae	2	0.002
	Ophiothricidae	2	0.002
Echiura	Bonelliidae	81	0.067
	Echiuridae	5	0.004
	Echiuroinea	2	0.002
Ectoprocta	Lichenoporidae	179	0.148
	Ectoprocta	97	0.080
	Tubuliporidae	42	0.035
	Alcyonidiidae	29	0.024
	Flustrellidridae	28	0.023
	Calpensiidae	21	0.017
	Bugulidae	14	0.012
Gastropoda	Rissoidae	1,119	0.923
	Trochidae	246	0.203
	Gastropoda	144	0.119
	Lottiidae	138	0.114
	Lepetidae	108	0.089
	Columbellidae	96	0.079
	Littorinidae	95	0.078
	Capulidae	58	0.048
	Naticidae	46	0.038
	Conidae	41	0.034
	Cylichnidae	38	0.031
	Turbinidae	37	0.031
	Muricidae	27	0.022
	Velutinidae	26	0.021
	Buccinidae	24	0.020
	Pyrimidellidae	24	0.020
	Cerithiopsidae	21	0.017
	Diaphanidae	21	0.017
	Nudibranchia	20	0.017
	Scissurellidae	20	0.017
	Sacoglossa	15	0.012

Higher Taxonomic Group	Family	Total Abundance	% of all Inverts
	Barleeiidae	14	0.012
	Dendronotidae	8	0.007
	Onchidorididae	8	0.007
	Fissurellidae	7	0.006
	Pyramidellidae	7	0.006
	Aglajidae	6	0.005
	Eulimidae	6	0.005
	Calyptraeidae	5	0.004
	Philinidae	5	0.004
	Cerithiidae	4	0.003
	Ranellidae	4	0.003
	Retusidae	3	0.002
	Cancellariidae	2	0.002
	Dotoidae	2	0.002
	Turridae	2	0.002
	Chromodorididae	1	0.001
	Flabellinidae	1	0.001
	Vitrinellidae	1	0.001
Hemichordata	Harrimaniidae	15	0.012
	Enteropneusta	1	0.001
Hirudinea	Hirudinea	7	0.006
Nemertinea	Nemertinea	756	0.624
Oligochaeta	Oligochaeta	1,237	1.021
Phoronida	Phoronida	2,687	2.218
Platyhelminthes	Platyhelminthes	258	0.213
Polychaeta	Spionidae	38,357	31.655
	Syllidae	7,188	5.932
	Oweniidae	6,853	5.656
	Serpulidae	5,439	4.489
	Sabellidae	3,079	2.541
	Terebellidae	1,794	1.481
	Capitellidae	1,535	1.267
	Lumbrineridae	870	0.718
	Saccocirridae	860	0.710
	Acrocirridae	785	0.648
	Cirratulidae	758	0.626
	Ampharetidae	581	0.479
	Orbiniidae	547	0.451
	Nereididae	497	0.410
	Maldanidae	334	0.276
	Polynoidae	323	0.267
	Pholoidae	319	0.263
	Phyllodocidae	247	0.204
	Polygordiidae	225	0.186
	Dorvilleidae	209	0.172
	Goniadidae	122	0.101
	Opheliidae	120	0.099
	Pectinariidae	118	0.097
	Paraonidae	98	0.081
	Hesionidae	96	0.079
	Glyceridae	42	0.035
	Sphaerodoridae	32	0.026
	Chaetopteridae	29	0.024
	Chrysopetalidae	27	0.022

Higher Taxonomic Group	Family	Total Abundance	% of all Inverts
	Flabelligeridae	27	0.022
	Scalibregmatidae	24	0.020
	Sabellariidae	21	0.017
	Nephtyidae	20	0.017
	Polychaeta	16	0.013
	Arenicolidae	15	0.012
	Magelonidae	6	0.005
	Pisionidae	6	0.005
	Amphictenidae	5	0.004
	Eunicidae	4	0.003
	Euphrosinidae	2	0.002
	Cossuridae	1	0.001
	Nerillidae	1	0.001
	Onuphidae	1	0.001
	Trichobranchidae	1	0.001
Polyplacophora	Ischnochitonidae	446	0.368
	Tonicellidae	85	0.070
	Polyplacophora	67	0.055
	Leptochitonidae	29	0.024
	Mopaliidae	9	0.007
	Acanthochitonidae	2	0.002
Porifera	Grantiidae	132	0.109
	Calcarea	117	0.097
	Porifera	30	0.025
	Demospongiae	17	0.014
	Chalinidae	11	0.009
	Halichondriidae	10	0.008
	Acmaeidae	1	0.001
	Tetillidae	1	0.001
Priapula	Priapulidae	6	0.005
Pycnogonida	Pycnogonida	69	0.057
Sipuncula	Phascoliidae	49	0.040
	Golfingiidae	40	0.033
	Phascolosomtidae	38	0.031
	Sipuncula	10	0.008

Appendix Table B-5: Major Group Distribution and Occurrence at Stations Hard versus Soft Bottom (headings need adjustment below)

Substrate	Taxonomic Groups	Total Abundance	Mean Density (#/m2)	Occurrence (out of 50 Sites)
Hard (n=33)	Aplacophora	7	0.004 (0.004)	2 (6.061)
	Arachnida	587	0.371 (0.173)	23 (69.697)
	Ascidiacea	787	0.497 (0.239)	31 (93.939)
	Bivalvia	2,168	1.369 (0.340)	33 (100)
	Brachiopoda	28	0.018 (0.008)	10 (30.303)
	Cnidaria	714	0.451 (0.077)	33 (100)
	Crustacea	23,543	14.863 (3.099)	33 (100)
	Echinodermata	2,057	1.299 (0.194)	33 (100)
	Echiura	61	0.039 (0.011)	17 (51.515)
	Ectoprocta	351	0.222 (0.039)	32 (96.970)
	Gastropoda	1,340	0.846 (0.123)	33 (100)
	Hemichordata	0	0 (0)	0 (0)
	Hirudinea	7	0.004 (0.002)	6 (18.182)
	Nemertinea	499	0.315 (0.048)	33 (100)
	Oligochaeta	819	0.517 (0.201)	22 (66.667)
	Phoronida	2,672	1.687 (1.687)	1 (3.030)
	Platyhelminthes	183	0.116 (0.023)	9 (27.273)
	Polychaeta	42,298	26.703 (4.469)	33 (100)
	Polyplacophora	615	0.388 (0.065)	33 (100)
	Porifera	311	0.196 (0.041)	32 (96.970)
	Priapula	2	0.001 (0.001)	1 (3.030)
	Pycnogonida	51	0.032 (0.013)	13 (39.394)
	Sipuncula	131	0.083 (0.023)	18 (54.545)

Substrate	Taxonomic Groups	Total Abundance	Mean Density (#/m2)	Occurrence (out of 50 Sites)
Soft (n=17)	Aplacophora	0	0.000 (0)	0 (0)
	Arachnida	499	0.612 (0.446)	5 (29.412)
	Ascidiacea	1,129	1.384 (1.252)	10 (58.824)
	Bivalvia	1,743	2.143 (0.928)	15 (88.235)
	Brachiopoda	0	0.000 (0)	0 (0)
	Cnidaria	115	0.151 (0.115)	8 (47.059)
	Crustacea	6,777	8.585 (2.376)	17 (100)
	Echinodermata	305	0.376 (0.166)	15 (88.235)
	Echiura	27	0.033 (0.027)	2 (11.765)
	Ectoprocta	59	0.072 (0.051)	9 (52.941)
	Gastropoda	1,111	1.388 (0.575)	17 (100)
	Hemichordata	16	0.020 (0.013)	3 (17.647)
	Hirudinea	0	0.000 (0)	0 (0)
	Nemertinea	257	0.315 (0.098)	15 (88.235)
	Oligochaeta	418	0.512 (0.276)	8 (47.059)
	Phoronida	15	0.018 (0.018)	1 (5.882)
	Platyhelminthes	75	0.092 (0.077)	5 (29.412)
	Polychaeta	29,336	35.966 (20.349)	17 (100)
	Polyplacophora	23	0.028 (0.014)	7 (41.176)
	Porifera	7	0.009 (0.004)	5 (29.412)
	Priapula	4	0.005 (0.005)	1 (5.882)
	Pycnogonida	18	0.022 (0.010)	6 (35.294)
	Sipuncula	6	0.007 (0.005)	2 (11.765)

Appendix Table B-6a: Twenty Most Abundant Families within each Substrate Type

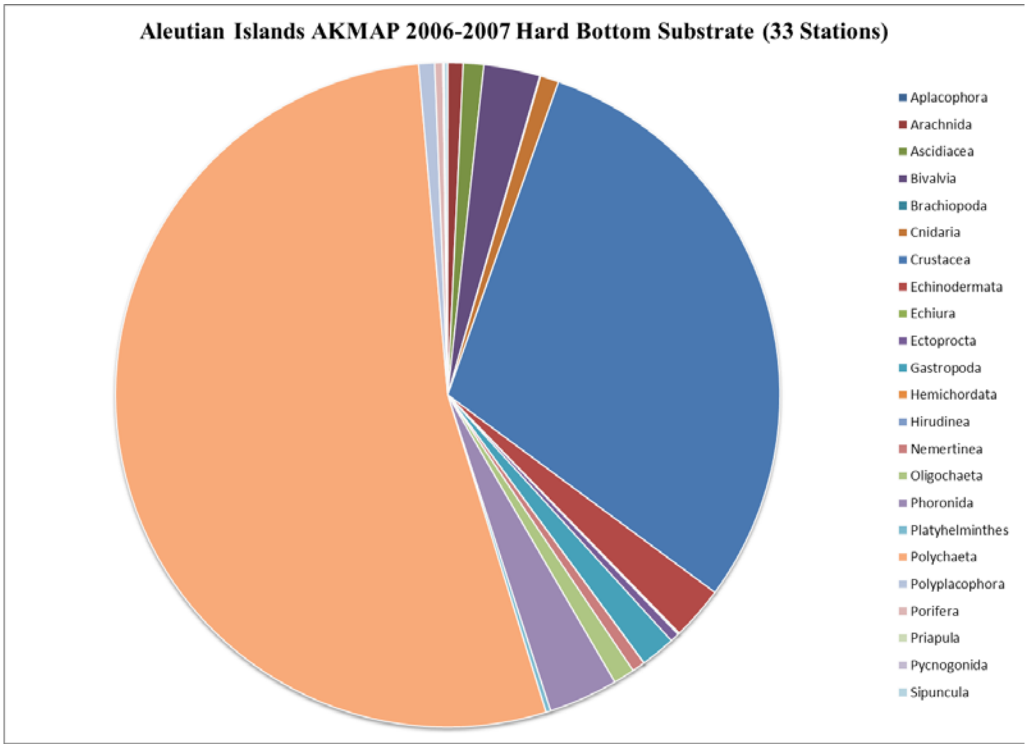
Substrate	Family	Total Abundance
Hard	Spionidae	22,386
(n=33)	Amphipoda unid. fam.	8,826
	Syllidae	5,980
	Serpulidae	4,472
	Caprellidae	3,699
	Sabellidae	2,905
	Phoronida unid. fam.	2,672
	Munnidae	2,562
	Terebellidae	1,734
	Strongylocentrotidae	1,264
	Mytilidae	1,227
	Capitellidae	1,081
	Pleustidae	1,006
	Oligochaeta unid. fam.	819
	Pontogeneiidae	811
	Acrocirridae	782
	Ascidiacea unid. fam.	749
	Hiatellidae	741
	Tanaidae	682
	Janiridae	619

Substrate	Taxon	Total Abundance
Hard	*Polydora/Dipolydora* complex	21,629
(n=33)	Amphipoda	4,426
	Gammaridea	4,400
	Serpulidae	3,990
	Phoronis sp.	2,672
	Munna sp.	2,430
	Sabellidae	2,417
	Caprella spp.	2,339
	Exogone naidina	2,259
	Caprellidae	1,360
	Typosyllis sp.	1,109
	Pleustidae	1,006
	Capitella capitata	936
	Strongylocentrotus spp.	928
	Terebellidae	891
	Oligochaeta	819
	Acrocirrus sp.	782
	Ascidiacea	749
	Hiatella arctica	741
	Sphaerosyllis sp.	727

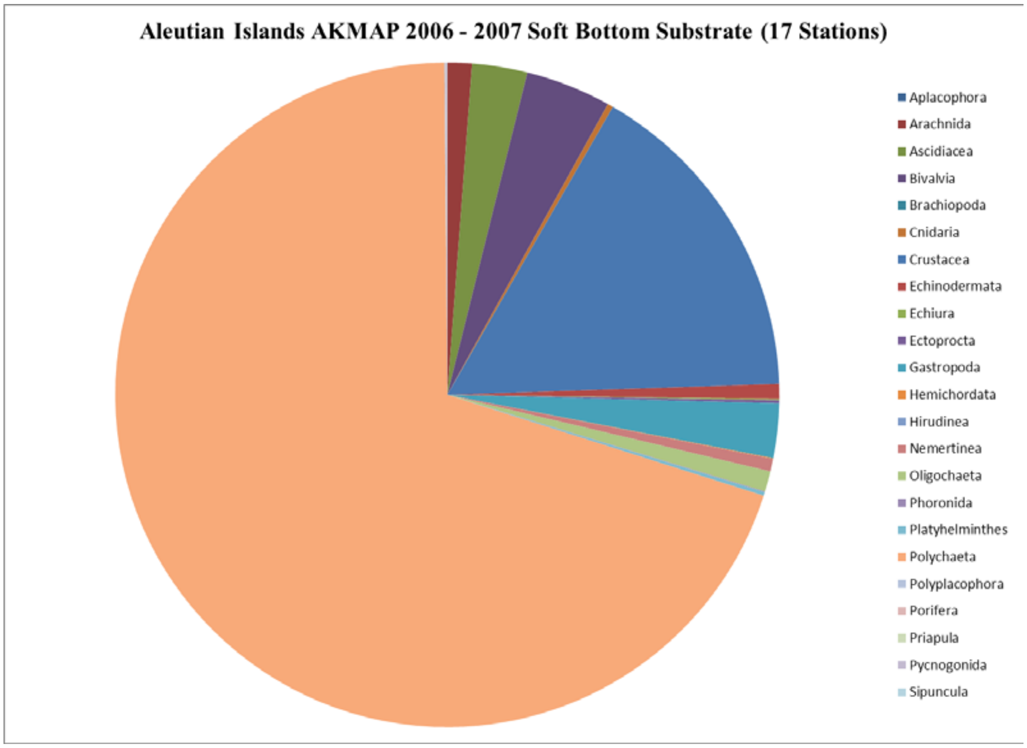
Appendix Table B-6b: Twenty Most Abundant Taxa within each Substrate Type

Substrate	Family	Total Abundance
Soft	Spionidae	15,971
(n=17)	Oweniidae	6,852
	Amphipoda unid. fam.	1,454
	Syllidae	1,208
	Ascidiacea unid. fam.	1,129
	Ostracoda unid. fam.	1,097
	Serpulidae	967
	Saccocirridae	860
	Rissoidae	842
	Thyasiridae	701
	Pontogeneiidae	668
	Mytilidae	521
	Orbiniidae	503
	Acarida unid. fam.	499
	Munnidae	464
	Capitellidae	454
	Oligochaeta unid. fam.	418
	Corophiidae	416
	Lumbrineridae	346
	Pholoidae	293

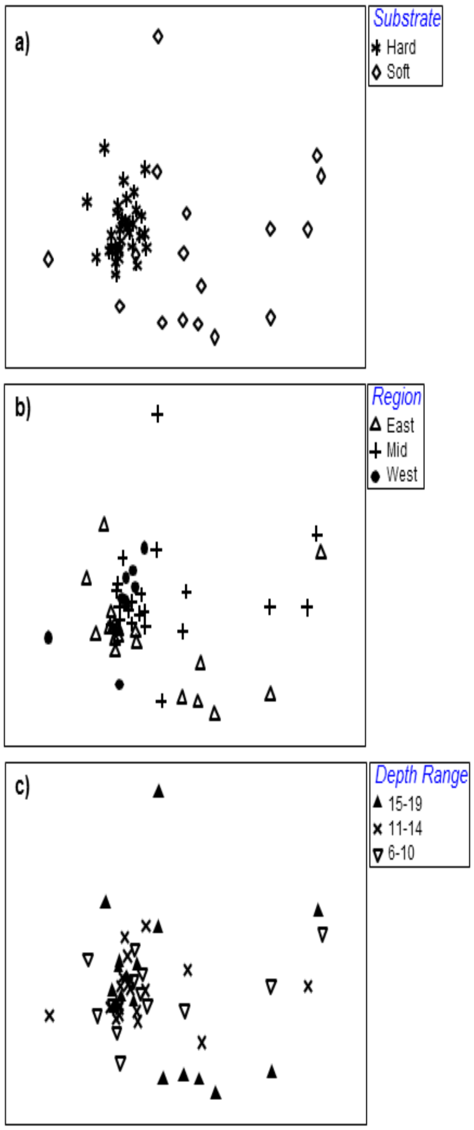
Substrate	Taxon	Total Abundance
Soft	*Pygospio elegans*	8,370
(n=17)	Oweniidae	6,580
	Rhynchospio glutaea	4,228
	Polydora/Dipolydora complex	2,041
	Ascidiacea	1,129
	Ostracoda	1,097
	Serpulidae	946
	Saccocirrus sp.	860
	Exogone naidina	766
	Amphipoda	740
	Gammaridea	714
	Axinopsida serricata	698
	Prionospio steenstrupi	665
	Rissoidae	535
	Pontogeneia sp.	513
	Acarida	499
	Oligochaeta	418
	Crassicorophium crassicorne	416
	Solamen columbianum	414
	Scoloplos armiger alaskensis	391



Appendix Figure B-3a: Relative Abundance of Major Taxonomic Groups for Hard Bottom



Appendix Figure B-3b: Relative Abundance of Major Taxonomic Groups for Soft Bottom



MDS plots of benthic fauna composition based on abundance data of invertebrates from 50 Aleutian sites. The community similarity patterns are plotted **a)** by substrate types, Hard and Soft Soft, **b)** by regions, East, Mid, West, and **c)** by depth ranges, 6-10m, 11-14m, 15-19m. The data were log(x+1) transformed and resemblance was based on Bray-Curtis similarities (2D Stress = 0.13).

Appendix Figure B-34 MDS Plot

DISCUSSION

In many marine systems, highly heterogeneous habitats have been shown to support highly diverse floral and faunal communities (McCoy and Bell 1991; Coleman and Williams 2002; Steller et al. 2003). Tropical coral reefs are recognized as the most productive and diverse marine ecosystem and support the highest number of species per unit area (Knowlton 2001; Groombridge and Jenkins 2002; Roberts et al. 2002). In temperate and sub-boreal regions, kelp forests (North 1971; Foster and Shiel 1985; Graham 2004), and rhodolith beds (Foster 2001; Steller et al. 2003; Kamenos et al. 2004) also sustain high invertebrate biodiversity. Those rich and diverse ecosystems all provide highly complex and heterogeneous physical environments. Kelp forests provide 3D complexity by extending the benthic habitat upward in the water column and offer high substrate heterogeneity to very diverse fish and invertebrate communities (Feder et al. 1974; Hicks 1980; Ebeling and Laur 1985; Bodkin 1988). The holdfasts of brown algae in particular harbor a great variety of organisms (Ghelardi 1971; Smith et al. 1996; Anderson et al. 2005).

The Aleutian nearshore region supports a very diverse benthic community. A total of 35 animal phyla have been recorded from the entire world's ocean, all habitats, depths, latitudes, and longitudes combined (Groombridge and Jenkins 2002). During the investigation of the nearshore region of the Aleutian Islands, AKMAP encountered a total of 16 benthic marine phyla or 707 taxa of invertebrates. Considering the relatively narrow bathymetry (6-20 m) explored, short coastal distance travelled (1,900 km), and relatively modest number of sites surveyed (50), the species richness of this Aleutian region is high. Those numbers are in fact comparable, if not richer, to previous AKMAP investigations. A total of 14 phyla and 441 taxa were collected in Southcentral Alaska in 2002 and 14 phyla and 531 taxa were collected by AKMAP in Southeast Alaska in 2004 (Unpublished data). However, those samples (n = 50 from each region) were only collected from soft sediments, ranging in depth from 3.5 to 503 m, using a 0.1 m^2 van Veen grab and most organisms were identified to the species level. Once the taxonomic resolution for the Aleutian samples is achieved to the species level, the number of taxa recorded from the Aleutian Islands will be even greater. Some of the most common types of habitats encountered during the AKMAP of the Aleutian Islands were soft sediments, kelp beds, and urchin barrens and their associated crustose coralline communities.

The compositions of invertebrate communities found within each of the three habitats were significantly different and were dominated by different groups of organisms. The communities observed within Holdfast and TCC habitats were more similar to each other than to Soft-sediment communities. Both crustose coralline algae and kelp require hard substrate to develop and grow and both types of habitat are often found adjacent to one another. In our study, grazers such as chitons, limpets and urchins were obviously more abundant in our hard-substrate than soft-sediment samples. Urchins (*Strongylocentrotus* spp.) were the most conspicuous herbivores observed in the shallow hard-sediment habitats throughout the Aleutian Islands. Urchin barrens are often seen as an alternate state of lush kelp forests (Lawrence 1975; Steneck 1986, Estes et al. 2010). Many studies have demonstrated that in productive environments with intense herbivory, algal crusts dominate, but when herbivores are removed, larger canopy-forming macroalgae overgrow coralline crusts and diversity increases again (Paine and Vadas 1969; Lawrence 1975; Steneck 1982, 1986).

To date, 11 peer-reviewed publications have emerged from the 2006-07 AKMAP research, with 2 more in preparation (Appendix Table B-8). These publications focused on descriptions of new species (19 species and 1 pending; Kawai et al., 2008, Clark and Jewett, 2010, Clark and Jewett, 2011a, b, Eash-Loucks et al., 2010, Jewett and Clark, 2011, Riosmena-Rodriguez et al., in prep.), descriptions of benthic communities (Chenelot et al., 2008, 2011, Brewer et al., 2011, Jewett et al., 2012, in prep.), and a technique paper (Jewett et al., 2008).

Appendix Table B-7: List of Groups that Strengthen Similarity of Samples within a Substrate Type and Influence Dissimilarities Between Habitat Types

	Similarity	Taxonmomic Groups	Contribution %	Similarity	Families	Contribution %	Similarity	Species	Contribution %
Hard	73.40	Polychaeta	23.22	50.23	Spionidae	8.14	39.03	*Poly/Dipolydora*	7.96
		Crustacea	19.65		Syllidae	7.37		*Exogone naidina*	5.10
		Echinodermata	9.85		Amphipoda	5.92		*Munna* sp.	5.06
		Gastropoda	8.77		Serpulidae	5.20		Serpulidae	4.99
		Bivalvia	7.18		Munnidae	4.95		Gammaridae	4.69
			68.67%			31.59%			27.81%
Soft	58.99	Crustacea	31.19	25.55	Spionidae	11.81	15.63	Gammaridae	7.88
		Polychaeta	29.53		Amphipoda	7.90		Nemertinea	6.56
		Gastropoda	11.12		Syllidae	4.93		Oedicerotidae	5.07
		Bivalvia	10.43		Nemertinea	4.63		Amphipoda	4.41
		Echinodermata	6.66		Oedicerotidae	4.23		Pleustidae	3.73
			88.94%			33.51%			27.65%

	Dissimilarity	Taxonmomic Groups	Contribution %	Dissimilarity	Families	Contribution %	Dissimilarity	Species	Contribution %
Hard vs. Soft	39.98	Polychaeta	9.99	72.25	Serpulidae	2.75	82.62	*Poly/Dipolydora*	2.75
		Echinodermata	8.73		Spionidae	2.70		Serpulidae	1.94
		Bivalvia	8.45		Syllidae	2.61		*Munna* sp.	1.72
		Crustacea	7.62		Amphipoda	2.38		*Exogone naidina*	1.60
		Cnidaria	7.21		Munnidae	2.22		Amphipoda	1.58
			42.00%			12.64%			9.59%

Appendix Table B-8: List of Papers Published and in Preparation from the Aleutian Island AKMAP Project

Brewer, R., H. Chenelot, S. Harper & S.C. Jewett. 2011. Sea Life of the Aleutians – an underwater photo journey. Alaska Sea Grant, SG-ED-71, Fairbanks, 156 p.

Chenelot, H., S. Jewett, & M. Hoberg. 2008. Invertebrate communities associated with various substrates in the nearshore eastern Aleutian Islands, with emphasis on thick crustose coralline algae. *In*: Bruggeman, P. and N.W. Pollock, (Eds), Diving for Science 2008. Proceedings of the 27th American Academy of Underwater Sciences Symposium, Dauphin Island, AL: AAUS, 13-36 pp.

Chenelot, H., Jewett, S.C., & M.K. Hoberg. 2011. Macrobenthos of the nearshore Aleutian Archipelago, with emphasis on invertebrates associated with *Clathromorphum nereostratum* (Rhodophyta, Corallinaceae). Marine Biodiversity. 41: 413-424.

Clark, R.N. & S.C. Jewett. 2010. A new genus and thirteen new species of sea stars (Asteroidea: Echinasteridae) from the Aleutian Island Archipelago. Zootaxa 2571: 1-36.

Clark, R.N. & S.C. Jewett. 2011a. Three new sea stars (Asteroidea: Solasteridae & Pterasteridae) from the Aleutian Islands. Zootaxa 3051: 1-13.

Clark, R.N. & S.C. Jewett. 2011a. A new genus of *Hippasteria* (Asteroidea: Goniasteridae) from the Aleutian Islands. Zootaxa 2963: 48-54.

Eash-Loucks W., Jewett, S., Fautin, D., M. Hoberg & H. Chenelot. 2010. *Ptychodactis aleutiensis,* a new species of ptychodactiarian sea anemone (Cnidaria: Anthozoa: Actiniaria) from the Aleutian Islands, Alaska. Marine Biology Research 6(6): 570-578.

Jewett, S.C., R. Brewer, H. Chenelot, R. Clark, D. Dasher, S. Harper, & M. Hoberg. 2008. Scuba techniques for the Alaska Monitoring and Assessment Program (AKMAP) of the Aleutian Islands, Alaska. *In*: Bruggeman, P. and N.W. Pollock, (Eds), Diving for Science 2008. Proceedings of the 27th American Academy of Underwater Sciences Symposium, Dauphin Island, AL: AAUS, 71-89 pp.

Jewett, S.C. & R.N. Clark. 2011. Discoveries of new nearshore plants and invertebrates of the Aleutian Islands. *In*: N.W. Pollock, (Ed), Diving for Science 2011. Proceedings of the 30th American Academy of Underwater Sciences Symposium, Dauphin Island, AL: AAUS, 91-109.

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Kawai, H., T. Hanyuda, M. Lindeberg, & S.C. Lindstrom. 2008. Morphology and molecular phylogeny of *Aureophycus aleuticus* Gen. et sp. Nov. (Laminariales, Phaeophyceae) from the Aleutian Islands. Journal of Phycology 44: 1013-1021.

Riosmena-Rodríguez, R., Socrates Martínez, J., Chenelot, H. & Jewett, S.C. In Prep. A new species of the genus *Sporolithon* (Sporolithales, Rhodophyta) for the North Pacific with a discussion of the diagnostic features to delimit species. Cryptogamie Algologie.

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Appendix C – Aleutian AKMAP 2006 and 2007 Benthic Transect Characterizations

AKMAP Aleutians Project 2006
Site Characterizations

GENERAL
The following site characterizations were based on observations made by six UA divers (noted below) while sampling various biological parameters along a 25-m transect across the substrate. Algal identifications were assisted by Mandy Lindeberg of NOAA. The characterizations were supplemented by digital still and video records. Each site was surveyed for 45-60 minutes.

AKALE06-0039
July 3, 2006

This site is on the north side of Tigalda Island. This was a shallow site of only 19 ft on a substrate of boulders that was densely covered with *Laminaria yezoenis*, *L. longipi*, *L. bongardiana*, *Alaria fistulosa*, and thin encrusting coralline alga. The macrofauna was dominated by *Tonicella lineata* and *Ophiopholis aculeate*. Bottom temperature was 6 C and visibility was excellent. There was little to no bottom current. One Steller sea lion made a few close passes as we sampled.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE06-0026
July 4, 2006

This site is on the northwest side of Tigalda Island. The depth at this site was 49 ft. on a substrate of kelp-covered boulders. There was no current at depth. Bottom temperature was 6 C. The dominant kelp was *Thalassiophyllum* sp. and the most numerous macrofauna were *Tonicella lineata*, *Ophiopholus aculeata*, and *Ceremaster arcticus*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0002
July 5, 2006

This site is along the east side of Akun Island in Akun Bay. The buoy end of the 40 ft. anchor chain at this site was on coarse sand, however, the anchor and the 25 m transect tape was actually on cobble/boulder substrate in 48 ft of water. Where the anchor chain began, on sand, sand dollars were present. There was no current at depth. Bottom temperature was 6.5 C. High winds were blowing toward shore and visibility on bottom was only about 6 ft. Nevertheless, the biota here was fairly diverse. The kelp were mainly an even mixture of *Agarum* sp., *Cymathere triplicata*, and *Laminaria bongardiana*. The macrofauna were dominated by *Pododesmus macrochisma*, *Margarites pupillus*, and *Tonicella insignis*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0021
July 7, 2006

This site is near Dutch Harbor on Unalaska Island in Nateekin Bay. At 55 ft. the visibility was about 35 ft. Bottom temperature was 6 C. There was no current at depth. The substrate was composed of coarse sand with sand dollars (*Echinarachnius parma*) the dominant macroinvertebrate and juvenile flatfish (2-3 cm) the dominant the fish. Other less dominant fauna included tiny white sacs (5 x 2.5 cm) attached at one end to the sand by mucus. These may be squid eggs. Several dead squid were on the beach, so a squid spawning event probably occurred. Other fauna included hermit crabs (2 species), pinkneck clams (*Mactromerus polynyma*), and seastars (*Pycnopodia helianthodes*, and *Evasterias troschelli*).

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0044
July 8, 2006

This site is on the north shore of Unalaska Island, adjacent and northeast of Driftwood Bay and Irishmans Hat. The anchor fell on a pinnacle with a flat top with a depth of 35 ft. The transect was laid out around the rim of the pinnacle and it covered only a small portion of the circumference of the pinnacle. There was no current at depth. The substrate was bedrock with a small *Alaria fistulosa* on top. Below at a depth of 55 ft. the substrate was sand with no obvious biota. Other dominant kelp included *Desmarestia ligulata*, and *Thalassiophyllum* sp. Dominant macrofauna included *Balanus nubilus*, *Strongylocentrotus droebachiensis*, and flat orange sponge. Several dead squid were on the beach in Driftwood Bay, so a squid spawning event probably recently occurred.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0007
July 9, 2006

This site is in Naginak Cove, an inner embayment of Makushin Bay along the westcoast of Unalaska Island. The anchor was dropped on shell/gravel/sand at 43 ft. As the transect was laid out the substrate transitioned to fine sand on a gradual slope. All three quads were on sand. Bottom temperature was 6.5 C and visibility of 15-20 ft. Two dives were made; the second was for fish & photos. The only kelps visible were patches of *Dictyosiphon foeniculaceus* and *Agarum* sp. wherever a hard substrate was present. Dominant fauna included *Pycnopodia*, juvenile *Chionoecetes bairdi*, *Pagurus ochotensis*, *Elassochirus tenuimanus*, juvenile flatfishes and sculpins. Less dominant fauna included large, black, tube-dwelling polychaete (possibly *Myxicola infundibulum*), *Metridium senile*, *Urticina crassicornis*, *Chlamys rubida*, *Stenosemus sharpii*, *Cyrptonatica aleutica*, *Fusitriton oregonensis*, *Lebbeus grandimanus*, *Hyas lyratus*, *Elassochirus gilli*, *Evasterias troschelii*, *Solaster endica*, *S. stimpsoni*, *Lepidopsetta polyxystra*, *Myoxocephalus* sp., *Hemilepidotus hemilepidotus*, and *Icelinus borealis*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0020
July 10, 2006

This site was moved into the West Arm of Scan Bay from a more exposed area where high waves hindered CTD/diving operations. The substrate at 53 ft was shell and sand. Portions of the transect were easily stirred up, thus visibility was 10-15 ft. Bottom temperature was 6 C. There were numerous dead bivalves at the surface, e.g., *Macromerus*, *Serripes*, *Clinocardium*, but no visible siphons. The dominant fauna were unidentified tube-dwelling polychaetes. Less common organisms included *Tonicella lineata*, mysids, unidentified hermit crabs, *Oregonia gracilis, Solaster stimpsoni, S. dawsoni, Crossaster papposus*, *Pycnopodia*, *Evasterias*, and juvenile flatfish.

Divers: R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-ALT0018
July 12, 2006

This is an alternate site, 0018, in Aspid Bay, NW Unalaska Island. It is in 39 ft on a mixed substrate of sand/gravel/cobble/shell-hash. Apparently this site is quite dynamic as evidenced by sparse algal cover and some small plants rolled under attached rocks. Bottom visibility was about 20 ft and temperature was 7 C. The site was immediately inside of a small surface canopy of *Nereocystis/Alaria*. The dominant algae were *Lithothamnia, Constantinea* spp*., Cymathere triplicata, Laminaria bongardiana*. Dominant macrofauna included *Tonicella insignis, Pugettia gracilis, Elassochirus gilli*, and *E. tenuimanus*. Less common taxa included *Clathromorphum, Thalassiophyllum, Urticina crassicornis , Tonicella lineata, Margarites, Lacuna, Acmaea mitra, Pagurus kennerlyri, Strongylocentrotus* sp., *Evasterias echinosoma, Henricia leviuscula, Enophrys lucasi,* juvenile snailfish, and *Popothecus accipserinus*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0012
July 13, 2006

Site 0012 is in Kismliuk Bay on NW Unalaska Is. This site is similar to ALT0018. The depth was 35 ft. in sand/gravel/cobble. Few kelps were present; however, many of those that were present had the holdfast buried in sand, evidence of high dynamics of incoming waves from the north. Bottom temperature was 8 C and visibility was about 20 ft. No kelps were dominant. Dominant macrofauna included *Pycnopodia*, juvenile *Chionoecetes bairdi* (2 cm total width), two anemones (possibly *Edwardsia* and *Peachia*), *Elassocheirus tenuimanus*, and sand-encased, solitary ascidians (possibly *Aplidium* sp.). Juvenile flatfish and gadids were also dominant fishes.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0027
July 14, 2006

This site was off Peacock Point on NW Unalaska Is. The target site exceeded 115 ft, therefore, we moved from the end of the point toward the mainland and found a sampleable depth at 47 ft between two small islands. The site was adjacent to a dense bed of *Alaria*. The substrate was boulder/bedrock with a lush canopy of kelps. Bottom temperature was 7 C and visibility approximated 30 ft. Dominant kelps included *Laminaria bongardiana*, *L. longipes*, *Agarum* sp., and *Thalassiophyllum sp.* Dominant macrofauna included *Juvenichiton saccharinus* and *Musculus vernicosa*.
Dominant fishes were rock greenling (*Hexagrammos lagocephalus*), kelp greenling (*H. decagrammus*), black rockfish (*Sebastes melanops*), and red Irish lord (*Hemilepidotus hemilepidotus*). Also, there were dense clouds of mysids near bottom among the kelp.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0011
July 15, 2006

Site 0011 was in Carlisle Pass off Carlisle Bay. There was a surface canopy of *Alaria fistulosa* to negotiate to the site. At a depth of only 23 ft. the substrate was boulders that were thickly encrusted with *Clathromorphium nereostratum*. In addition to these dominant algae were *Ulva fenestrata, Codium ritteri*, and *Lithothamnion* sp. The dominant macrofauna included *Strongylocentrotus droebachiensis,* and

Crucigera sp. Fishes, although few, included *Hexagrammos lagocephalus* and *Sebastes melanops.* Bottom temperature and visibility was 5 C and about 75 ft (distance from the end of the tape to the anchor line), respectively.
Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0024
July 15, 2006

Site 0024 was located in Kagamil Pass off Kagamil Island. The depth was 55 ft. on a substrate of fine sand covered with a veneer of detritus. Small sand waves were oriented perpendicular to shore. Visibility at depth was about 75 ft, the length of the transect tape. Bottom temperature was 5 C. No algae were present. The dominant macroinvertebrate was *Echinarachnius parma*; the dominant fish was *Lepidopsetta polyxystra*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0010
July 16, 2006

Site 0010 was located in Samalga Pass off the east coast of Chuginadak Island. The site was on the outside edge of a surface canopy of *Alaria fistulosa*. The depth was 56 ft. on a boulder subsrate covered with *Clathromorphium nereostratum.* Bottom visibility was 75-80 ft. Bottom temperature was 5 C. Overall this site seemed very diverse, however, the biota was dominant by the algae *C. nereostratum* and *A. fisulosa*, the green sea urchin (*Strongylocentrotus droebachiensis)*, and the fishes rock greenling (*Hexagrammos lagocephalus*), kelp greenling (*H. decagrammus*), dusky rockfish (*Sebastes ciliatus*), and red Irish lord (*Hemilepidotus hemilepidotus*).

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0037
July 17, 2006

This site was on the south side of Yunaska Is, adjacent to lava bluffs and caves. The target site was actually in about 110 ft of water, so, we moved it toward shore and set the site in 60 ft. The visibility was about 50 ft. and the temperature was 5 C. At depth the substrate was mixed, with large boulders to coarse black gravel. The boulders were covered with thin coralline algae, *Lithothamnion* sp., but the gravel had no obvious biota. In fact, the gravel appeared to be quite steril. The dominant algae, besides *Lithothamnion*, were two reds, *Schizymenia* sp. and an unidentified one with a large leathery blade. The dominant macrofauna was *Strongylocentrotus droebachiensis*. Dominant fishes were the hexagrammids *Pleurogrammos monopterigious, Hexagrammos lagocephalus,* and *H. decagrammus.* One small of school of about 30 *Pleurogrammos* (Atka mackerel) were seen near bottom.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-ALT0034
July 18, 2006

Alternate site 0034 was off Cape Udak on the SW side of Umnak Island. It was located within a sparse surface canopy of *Nereocystis* where the depth was 47 ft on a boulder substrate. The bottom temperature was 7.5 C. Visibility was only about 20-25 ft. The dominant kelps were the browns, *Agarum* sp., and *Thalassiophyllum clathrus,* and the reds, *Lithothamnion* sp. and *Clathromorphium nereostratum*. The green sea urchin *Strongylocentrotus droebachiensis* dominanted the macrofauna. For fishes, kelp greenling, *Hexagrammos decagrammus*, dominated.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0025
July 18, 2006

Site 0025 was located in Traders Cove on the SW portion of Umnak Island. At a depth of 36 ft. the substrate was boulders and bedrock. A sparse surface canopy of *Nereocystis* was present. The overstory of brown (*Laminaria bongardiana, L. yezoensis, L. longipes, Agarum* sp., and *Nereocystis luetkeana*) and red algae (*Neoptilota asplenioides, Odonthalia* sp., and *Lithothamnion* sp.) was dense. That coupled with considerable swell made sampling more difficult. The tiny bivalve *Musculus discors* was commonly found on the brown algae. Few fishes were seen, except for a couple of red Irish lord, *Hemilepidotus hemilepidotus*. Bottom visibility was only about 20 ft. Bottom temperature was 7.5 C.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0043
July 19, 2006

Site 0043 was located near Lookout Point on SW Umnak Island. The site was within a surface canopy of *Nereocystis* in 47 ft of water. The transect was laid parallel and to shore along the base of a shelf that stepped up 2-3 m. The transect was laid on bedrock. There were several pockets of drift kelp along the transect, so that drift material had to be removed to sample some quadrats. Bottom temperature was 8 C; visibility was limited, about 15 ft. The dominant algae were *Laminaria bongardiana*, *L. yezoensis, Thalassiophyllum clathrus,* and *Lithothamnion* sp. Less dominant algae included *Odonthalia setacea, Saccharina latisama*, and *Alaria fistulosa*. There were numerous juvenile Laminariales attached to the bedrock. Although no macroinvertebrates or fishes dominated along the transect, the shelf wall did have a variety of sponges and a few *Hemilepidotus hemilepidotus*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-ALT0012
July 20, 2006

Alternate site 0012 was located in Kuliliak Bay (SW Unalaska Island), just inside the inner portion of the bay to the NW. The anchor was dropped near some large (2-3 m diameter) boulders, however, the transect was laid on flat bedrock in 33 ft. Bottom temperature was 8 C. The visibility was about only about 20 ft., due mainly to the heavy swell that stirred up the bottom. The swell also hindered sampling. The algae were dominated by *Laminaria longipes*, *L. yezoensis*, L. *bongardiana,* and *Lithothamnion* sp. The red algae *Porphyra gardneri* was attached to outer margin of some blades of *L. longipes* and *L bongardiana*. This was the first observation of this parasitic red on *Laminaria*. The macrofauna was dominated by an unidentified small unstalked ascidian we called “Little Piggies”. Although there were few fish on the transect, there were several large dark rockfish and rock greenling and one octopus hanging around the boulders.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-ALT0006
July 20, 2006

Alternate site 0006 was located on the east arm of Eagle Bay on the south side of Unalaska Island. The transect was laid at 33 ft. along a fairly steep wall, but not vertical. The substrate was coarse gravel, cobble, and boulders. There was evidence of slumping along the transect, as some rocks had no growth on the top side. Bottom temperature was 9 C. Visibility was about 15 ft, limited by fine particulate matter. The dominant algae were *Agarum clathratum, Constantinea subulifera, Lithothamnion*, and *Schizoporella unicornis*. Dominant macrofauna included *Margarites pupillus, Amphissa Columbiana, Tonicella lineata, T. insignis*, *Pandalus stenolepis*, unidentified hermit crabs and *Balanus* sp. A few kelp greenling, *Hexagrammos decagrammus*, were seen. Note: the video from this site has the incorrect date (7/12/06).

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0023
July 21, 2006

Site 0023 was located near the west mouth of Usof Bay (Unalaska Island), just inside Cape Prominence. While enroute to this site we encountered several large schools of Atka mackerel feeding at the surface off Cape Prominence. They appeared to be feeding on small fish, which may have been feeding on mysids. Dense swarms of mysids were noted near the feeding Atka mackerel. We took videos of the Atka mackerel. Site 23 had a boulder substrate at 50 ft. Small (2 m wide) patches of coarse white sand/shell were scattered between the boulders. Visibility was about 40 ft. Bottom temperature was 9 C. This was a diverse area. The dominant algae were *Saccharina latisama, Laminaria bongardiana*, *Agarum* sp. and *Neoptilota asplenioides.* Dominant macroinvertebrates included at least 4 species of bryozoans, *Acmaea mitra*, and the unidentified small unstalked ascidian we called "Little Piggies". Dominant fishes included dark-colored rockfish and kelp greenling, *Hexagrammos decagrammus*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0028
July 21, 2006

Site 28 was located at the head of Usof Bay (Unalaska Island) on a silty-sand bottom at 55 ft. Visibility was about 25 ft. and temperature was 9 C. Although no algae dominated, tube worms densely protruded from the sediment. Other common macroinvertebrates included large *Metridium* sp., which were attached to the occasional protruding rocks, and juvenile (< 10 mm carapace width) tanner crab, *Chionoecetes bairdi*. Fishes were dominated by snake pricklebacks, *Lumpenus sagitta*, and juvenile flatfishes and sculpins.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-0030
July 22, 2006

Site 30 was located in Kisselan Bay, Beaver Inlet, Unalaska Island. The site was situated at 55 ft. along an unstable slope. There was evidence of recent slides of rock and terrestrial sod. Visibility was only about 15 ft. Temperature was 7 C. Dominant algae was *Agarum clathratum*. Dominant invertebrates included *Tonicella insignis, Strongylocentrotus droebachiensis*, calcarious tube worms (*Crucigera* spp.) and sponges.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE06-ALT0002
July 22, 2006

Alternate site 2 was located in Kalekta Bay, Unalaska Island. At a depth of 34 ft. the substrate was fine sand with ripples and a darker detrital layer. The horizontal visibility was about 25 m (the length of the transect tape). Bottom water temperature was 7 C. The biota was dominated by sand dollars, *Echinarachnius parma*, and northern rock sole, *Lepidopsetta polyxystra*.

Divers: R. Brewer, R. Clark, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKMAP Aleutians Project 2007
Site Characterizations

GENERAL
The following site characterizations were based on observations made by seven UA divers (noted below) while sampling various biological parameters along a 2 x 25-m transect across the substrate. Algal identifications were assisted by Mandy Lindeberg of NOAA. The characterizations were supplemented by digital still and video records. Each site was surveyed for 45-60 minutes.

AKALE07-0019
Attu Island
June 25, 2007

This site is on the northeast side of Attu Island in Chichagof Harbor. This was a shallow site of only 24 ft on a substrate of fine gravel with occasional boulders. Few flora and fauna were present presumably due to frequent high-energy waves. There was an occasional *Laminaria bongardiana* and thin encrusting coralline alga on the boulders. Often the holdfast was covered by sand. The macrofauna, although few, was dominated by the chitons *Tonicella submarmorea* and *Boreochiton beringensis*, and the green sea urchin *Strongylocentrotus* sp. and rock sole. Bottom temperature was 6 C and visibility was about 5 m. One yellow Irish lord (*Hemilepidotus jordani*) was taken.

Divers: R. Brewer, R. Deffendall, Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-0004
Attu Island
June 26, 2007

This site is on the south side of Attu Island in Temnac Bay. The original site was outside of Savage Island, but it was too rough to sample. So, we drew a straight line and sampled inside Savage Island. The depth at this site was 36 ft. on a mixed substrate of coarse sand near buoy to coarse gravel/boulders near end of transect. There was little current at depth. Coralline alga was present, even the small gravel rocks, suggesting that this region does not get disturbed often. Bottom temperature was 6 C. Although no algae dominant, occasionally there were *Desmarestia* sp., *Alaria fistulosa*, *Codium ritterii*, *Bossiella* sp., *Laingia aleutica,* and a fuzzy red. The dominant fauna included *Strongylocentrotus* sp., various calcareous tube worms, and encrusting sponge, possibly *Halichondria* sp.. One sea, *Pteraster tessalatus*, was on the transect. One rock sole (*Lepidopsetta* sp.) and 1 kelp greenling (*Hexagrammos lagocephalus*) were taken.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, M., S. Jewett

AKALE07-0017
Kiska Island
June 29, 2007

This site is on the southcentral side of Kiska Island in Vega Bay. The depth at this site was 47 ft. on a coarse substrate of rock, encrusted with coralline algae. Bottom temperature was 5 C. Visibility was 15-20 ft. – not good. There were no dominant alga, other than encrusting coralline *Lithothamnion* sp. and *Clathromorphum nereostratum*), although occasionally *Agarum turneri*, *Desmarestia aculeate*, *Laminaria bongardiana* and *Alaria fistulosa* was observed on the transect. The fauna were dominated mainly *Pododesmus* and small *Strongylocentrotus* sp., orange sponges, both vase and flat. No fish were seen.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-0046
Little Kiska Island
June 29, 2007

This site is on the south side of Little Kiska Island in east of Yug Point. The depth at this site was 49 ft. on a coarse substrate of bedrock, encrusted with coralline algae. Bottom temperature was 5 C. Visibility was 20-25 ft. No alga dominant other than encrusting coralline, although a leathery red, and a bladed red - Kallymeniaceae, *Desmerestia* sp., *Agarum turneri*, and *Alaria fistulosa* were present in small quantities. The fauna were dominated mainly by small *Strongylocentrotus* sp. and an occasional orange vase sponge. No fish were seen.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-A0048
Kiska Island
June 30, 2007

This site is on the northeast side of Kiska Island, adjacent to Haycock Rock. The depth at this site was 32 ft. on a coarse substrate of boulders, mostly encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 5 C. Visibility was approximately 40 ft. The dominant alga, other than encrusting coralline, included *Alaria fistulosa* and *Desmerestia virdis*. Fauna were dominated mainly by small (some large) *Strongylocentrotus* sp. and sponges. Fish taken (7) included 2 rock greenling (*Hexagrammos lagocephalus*), 1 kelp greenling (*Hexagrammos decagrammus*), 2 dusky rockfish (*Sebastes ciliatus*), and 2 red Irish lords (*Hemilepidotus hemilepidotus)*.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-0045
Little Sitkin Island
July 1, 2007

This site is on the northwest side of Little Sitkin Island, adjacent to Finger Point. One sea otter was seen at this site when setting the buoy. The depth at this site was 35 ft. on a coarse substrate of boulders, mostly encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Sand was between the boulders. Bottom temperature was 5 C. Visibility was approximately 40 ft. The dominant alga was encrusting coralline. Fauna were dominated mainly by mainly small *Strongylocentrotus* sp., orange encrusting sponge and upright yellow and orange sponges, branching hydroids, white anemone, walking anemone, bryozoan – *Microporina borealis, Tectura scutum* (limpet), and *Ophiopholis aculeata*. Fish taken (4) included 1 rock greenling (*Hexagrammos lagocephalus*), 2 dusky rockfish (*Sebastes ciliatus*), and 1 red Irish lord (*Hemilepidotus hemilepidotus)*.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-A0031
Rat Island
July 1, 2007

This site is on the north side of Rat Island. It was adjacent to an *Alaria* bed. The depth at this site was 43 ft. on a coarse substrate of boulders, mostly encrusted with coralline alga *Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 5 C. Visibility was approximately 40 ft. The dominant algae, other than encrusting coralline, included *Desmerestia* sp. A branched red – Kallymeniaceae was occasionally seen along the transect. Fauna were dominated mainly by small (some large) *Strongylocentrotus* sp. and vase sponges. Fish taken (7) included 5 dusky rockfish (*Sebastes ciliatus*), 1 yellow Irish lord (*Hemilepidotus jordani*) and 1 red Irish lord (*Hemilepidotus hemilepidotus)*.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-0016
Amchitka Island
July 2, 2007

This site is on the northeast side of Amchitka Island. It was west of Bat Island and adjacent to an *Alaria* bed. The depth at this site was only 23 ft. on a coarse substrate of rock and some boulders, mostly encrusted with coralline algae (*Lithothamnion* sp.). Bottom temperature was 5 C. Visibility was approximately 20 ft. The dominant algae, other than encrusting coralline, included *Desmerestia viridis*, *Alaria fistulosa*, and a bladed red – probably Kallymeniaceae. Fauna were dominated mainly by small (some large) *Strongylocentrotus* sp., tube worms - *Pileolaria* sp., *Tonicella submarmorea*, *Leptasterias camtchatica*, *Ophiopholis aculeatea* and orange compound ascidian. Fish taken (2) included 1 female rock greenling (*Hexagrammos lagocephalus*) and 1 red Irish lord (*Hemilepidotus hemilepidotus)*.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-DD002
Amchitka Island
July 3, 2007

This site is on the northwest side of Amchitka Island, in Ogala Pass near AKALE07-0006. It was within an *Alaria fistulosa* bed. The depth at this site was 33 ft. on a coarse substrate of bedrock and some boulders, mostly encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 5 C. Visibility was approximately 50 ft. There was no current or swell. The dominant algae, other than encrusting coralline, included *Desmarestia viridis*, *Alaria fistulosa*, and a leathery red. Fauna were dominated mainly by small (some large) *Strongylocentrotus* sp., *Tonicella stelleri* and *Ophiopholis aculeata*. Fish taken (5) included 1 female rock greenling (*Hexagrammos lagocephalus*), 2 dusky rockfish (*Sebastes ciliatus*) and 2 yellow Irish lord (*Hemilepidotus jordani*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, S. Harper, S. Jewett

AKALE07-A0016
Tanaga Island
July 5, 2007

This site is on the west side of Tanaga Island, in Tanaga Pass. One sea otter was seen when setting the buoy. The site was within an *Alaria fistulosa* bed. The depth at this site was 30 ft. on a coarse substrate of bedrock and boulders, mostly encrusted with coralline algae (*Lithothamnion* sp.). There was some sand along the transect. Bottom temperature was 5 C. Visibility was approximately 25 ft. There was a little current and big swell. The dominant algae, other than encrusting coralline, included *Alaria fistulosa*, *Agarum turneri*, *Constantinea subulifera*, bladed red – Kallymeniaceae, and leathery red. Fauna were dominated mainly by small (some large) *Strongylocentrotus* sp., orange vase sponge and yellow nipple sponge (*Polymastia* sp.). Fish taken (5) included 1 female and 1 male rock greenling (*Hexagrammos lagocephalus*), and 3 red Irish lord (*Hemilepidotus hemilepidotus)*.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-0042
Tanaga Island
July 6, 2007

This site is on the north side of Tanaga Island. The site was within an *Alaria fistulosa* bed. The depth at this site was 48 ft. on a coarse substrate of large boulders with patches of sand between boulders. The sand had parallel rows to the shoreline, with a detritus layer on top. A thin layer of encrusted coralline algae covered the boulders. Bottom temperature was 5 C. Visibility was approximately 60 ft. Conditions were good with a small swell. The dominant algae, other than encrusting coralline, included *Alaria fistulosa*, bladed reds – probably *Sparlingia* sp., leathery red, and Kallymeniacae, a branched red – probably *Laingia* sp. Fauna were dominated by *Strongylocentrotus polyacanthus*. Fish taken (5) included 1 female kelp greenling (*Hexagrammos decagrammus*), 2 female rock greenling (*Hexagrammos lagocephalus*), 1 yellow Irish lord (*Hemilepidotus jordani*) and 1 red Irish lord (*Hemilepidotus hemilepidotus)*.

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-0050
Tanaga Island
July 6, 2007

This site is on the north side of Tanaga Island near Pillbox Rock. The site was within an *Alaria fistulosa* bed on boulders and bedrock. The depth at this site was 25 ft. on a coarse substrate of mainly large boulders, mostly encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 6 C. Visibility was approximately 60 ft. There was a little current and no swell. The dominant algae, other than encrusting coralline, included *Agarum turnerii* and *Alaria fistulosa*. Fauna were dominated mainly by small (some large) *Strongylocentrotus* sp. Fish taken (2) included 2 female rock greenling (*Hexagrammos lagocephalus*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-DD0003
Tanaga Island
July 7, 2007

This site is on the southwest side of Tanaga Island. The site was adjacent to an *Alaria fistulosa* bed. The depth was 38 ft. on a mixed substrate of boulders and bedrock. Most substrate was encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 5 C. Visibility was approximately 50 ft. There was a little current and no swell. The dominant algae, other than encrusting coralline, included *Agarum turnerii* and *Constantinea rosamarina.* Fauna were dominated mainly by small (some large) *Strongylocentrotus* sp. Fish taken (4) included 2 yellow Irish lord (*Hemilepidotus jordani*) and 2 dusky rockfish (*Sebastes ciliatus*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-A0028
Kanaga Island
July 8, 2007

This site is on the northeast side of Kanaga Island. The depth was 46 ft. on a substrate of large boulders. Most substrate was encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 5 C. Visibility was > 46 ft. There was a no current and swell. The dominant algae, other than encrusting coralline, included *Agarum turnerii* and *Codium ritteri* and an unidentified encrusting red. Fauna were dominated mainly by the chitons *Tonicella submarmorea* and *Boreochiton beringensis,* and small (some large) sea urchins *Strongylocentrotus* sp. Fish taken (5) included 1 yellow Irish lord (*Hemilepidotus jordani*), 1 female rock greenling (*Hexagrammos lagocephalus*), and 3 dusky rockfish (*Sebastes ciliatus*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-0005
Adak Island
July 9, 2007

This site is on the western side of Adak Island, in Bay of Islands. The site was off Green Island in the western portion of Bay of Islands. The target site was too deep to dive, > 60 ft, so we moved toward the island until be arrived at the target depth of 35 ft. The substrate large boulders with most encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 5 C. Visibility was approximately 30 ft. There was a little current and no swell. The dominant algae, other than encrusting coralline, included *Agarum turnerii* and *Alaria fistulosa.* Fauna were dominated unidentified encrusting sponge, Abietinaria sp.(hydroids), Cribrinopsis fernaldi and Urticina sp. (anemones), *Tonicella submarmorea* (chiton), *Strongylocentrotus* sp. and *Ophiopholis aculeate* (brittle star). Fish taken (2) included 1 dusky rockfish (*Sebastes ciliatus*) and 1 black rockfish (*Sebastes melanops*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-A0021
Adak Island
July 10, 2007

This site is on the southeast side of Adak Island, in south Kagalaska Strait. The substrate was mainly cobble among occasional boulders with most boulders encrusted with coralline alga (*Lithothamnion* sp.

and *Clathromorphum nereostratum*). Bottom temperature was 6 C at 26 ft. Visibility was approximately 30 ft. There was a little current and no swell. No algae dominated, although *Alaria fistulosa* and *Codium ritteri* was present. Fauna were dominated *Abietinaria* sp. (hydroids), burrowing anemones, *Boreochiton beringensis* and *Tonicella submarmorea* (chitons), Pododesmus cacrochisma (rock jingle), *Strongylocentrotus* sp. and *Ophiopholis aculeate* (brittle star). Fish taken (8) included 3 dusky rockfish (*Sebastes ciliatus*), 1 black rockfish (*Sebastes melanops*), and 4 female rock greenling (*Hexagrammos lagocephalus*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-0047
Adak Island
July 10, 2007

This site is on the southeast side of Adak Island. The substrate was mainly cobble among occasional boulders with most boulders encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 6 C at 30 ft. Visibility was approximately 50+ ft. There was a no current or swell. The dominant algae were *Ulva* spp. and a bladed red (*Kallymeniopsis* sp.). Fauna were dominated by the chitons *Tonicella lineate* and *T. submarmorea*, and *Strongylocentrotus* sp. and *Crossaster papposus*. Fish taken (5) included 1 dusky rockfish (*Sebastes ciliatus*), 1 black rockfish (*Sebastes melanops*), 1 yellow Irish lord (*Hemilepidotus jordani*), 1 rock sole (*Lepidopsetta* sp.) and 1 female rock greenling (*Hexagrammos lagocephalus*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-A0014
Adak Island
July 12, 2007

This site is outside Sweeper Cove in Kuluk Bay. The target site was on a pinnacle; however, it could not be sampled. So, it was set adjacent to Gannet Rocks in Kuluk Bay. The substrate was mainly large boulders and bedrock encrusted with some coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 6 C at 41 ft. Visibility was approximately 30 ft. There was a lot of flocculant material in the water column. There was a no current or swell. There were no dominant algae, although *Alaria fistulosa, Desmarestia* sp., *Agarum turneri* were present. Fauna were dominated by anemones (*Cribrinopsis fernaldi, Metridium senile*), *Pododesmus macrochisma,* and *Strongylocentrotus* sp. Fish taken (4) included all dusky rockfish (*Sebastes ciliatus*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-A0019
Kagalaska Island
July 12, 2007

The target site was actually on land, so it had to be relocated. The new site was midway into an unnamed bay on the east side of Kagalaska Island. The substrate was mainly silty sand and small boulders. Some boulders were encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*), but it did not dominate. Bottom temperature was 6 C at 36 ft. Visibility was poor, with only about 10 ft. Because of the soft substrate it was easily stirred up and visibility dropped considerably. Also, there was a lot of flocculant material in the water column. There was a no current or swell. The dominant algae were *Cymathere triplicate* and *Thalassiophyllum clathrus*. Fauna were dominated by Spaghetti worms and juvenile flatfish. Only one fish was taken, a female rock greenling (*Hexagrammos lagocephalus*).

Divers: R. Brewer, R. Deffendall, R. Clark, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-A0005
Little Tanaga Island
July 13, 2007

This site was located in the back of Chisak Bay. The substrate was mixed – from mud to silty sand to shell hash. Bottom temperature was 6 C at 34 ft. Visibility was poor, with only about 15 ft. Because of the soft substrate it was easily stirred up and visibility dropped considerably when the bottom was touched. Poor visibility made it difficult to obtain the understory and invertebrate counts. Also, there was a lot of flocculant material in the water column. There was a no current or swell. The dominant algae were *Desmarestia aculeate, Cymathere triplicate* and a filamentous red. Fauna were dominated and tiny unidentified shrimps and stalked jellyfish (probably *Haliclystus stejnrgeri*). *Solaster endica* and unidentified bivalves (siphons showing) were present along the transect. *Macoma* sp. and *Serripes groenlandica* shells were present. Also at this site, although off transect were several *Telmessus cheiragonus, Pycnopodia helianthodes* and 2 octopi. Only one fish was taken on site, a red Irish lord (*Hemilepidotus hemilepidotus).*

Divers: R. Brewer, R. Deffendall, H. Chenelot, M. Hoberg, S. Jewett

AKALE07-00018
Little Tanaga Island
July 14, 2007

This site was located in the north side of Little Tanaga Island, in Umak Pass. The substrate was mixed cobble and boulder encrusted with coralline alga (*Lithothamnion* sp.). Bottom temperature was 6 C at 55 ft. Visibility was good, with about 60+ ft. There was no current or swell since the timing was at low tide. The dominant alga was *Agarum turneri* and *Codium ritteri*. The dominant animals were *Podocesmus macrochisma* and *Strongylocentrotus* sp. Two octopi were seen here, off transect. Fish taken include 1 yellow Irish lord (*Hemilepidotus jordani*), 1 red Irish lord (*Hemilepidotus hemilepidotus)* and 1 female rock greenling (*Hexagrammos lagocephalus*).

Divers: R. Brewer, R. Deffendall, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE07-00013
Umak Island
July 14, 2007

This site was located in the northeast side of Umak Island, in Umak Bight. The substrate was mixed with cobble and boulder that were encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). Bottom temperature was 6 C at 35 ft. Visibility was good, with about 60+ ft. There was no current or swell. The dominant alga was *Agarum turneri* and *Codium ritteri*. The dominant animals were *Podocesmus macrochisma, Fusitriton oregonensis*, *Strongylocentrotus* sp. Off transect there was clusters of *Modiolus modiolus*. Fishes included 5 female rock greenling (*Hexagrammos lagocephalus*) and 1 dusky rockfish (*Sebastes ciliatus*).

Divers: R. Brewer, R. Deffendall, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE07-00031
Atka Island
July 15, 2007

This site was located in the north side of the island, in Deep Bay. The substrate was boulder and bedrock that were encrusted with coralline alga (*Lithothamnion* sp. and *Clathromorphum nereostratum*). This topography at this site had numerous canyons and pinnacles with a relief of 10-15 ft. Bottom temperature was 6 C. Visibility was excellent, with about 60+ ft. There was no current or swell. Species diversity was seemingly high. A myriad of tiny epifauna, mainly crustaceans and chitons, was present on all algae and sponges. The dominant algae, in addition to the corallines, were *Agarum turneri* and *Codium ritteri*. The dominant animals were sponges, hydroids, anemones, chiton (*Juvenichiton saccharinus*), unidentified hermit crabs and *Strongylocentrotus* sp. Only one female rock greenling (*Hexagrammos lagocephalus*) was taken.

Divers: R. Brewer, R. Deffendall, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE07-00032
Atka Island
July 16, 2007

This site was located in the south side of the island, in Vasilief Bay. The topography here at a depth of 60 ft had no relief on a flat, silty-sand bottom. Bottom temperature was 6 C and visibility was limited to about 25 ft at depth. There was a little current and no swell. Species diversity was seemingly low, although numerous infaunal organisms were obvious based on various holes and sea cucumber and echiurid feeding appendages. No algae dominated, although a variety of drift algae was present, e.g., *Ulva*, *Alaria*, *Desmarestia*, *Cymanthere*, *Codium*, and reds. The dominant animals were sea cucumbers (*Eupentacta* sp. and other genera or species), echiurid (*Bonelliopsis alaskana*) and juvenile flatfish. Four large rock sole (*Lepidopsetta* sp.) were collected.

Divers: R. Brewer, R. Deffendall, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE07-0008
Atka Island
July 17, 2007

This site was located in the east side of the island, along the north side of Nazan Bay. This site was within sight of the village of Atka. The topography here at a depth of 29 ft had no relief on a flat sand bottom. Bottom temperature was 6 C and visibility was limited to about 20 ft at depth. There was a substantial surface current to the west, but no swell. Species diversity was seemingly low. No algae dominated, although some pieces of drift algae were present. The dominant animals were sand dollars (*Echinarachnius parma*) and juvenile flatfish and adult rock sole (*Lepidopsetta* sp.). Five large rock sole were collected.

Divers: R. Brewer, R. Deffendall, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE07-0035
Amlia Island
July 18, 2007

This site was located in the north side of the island, at the head of an unnamed bay south of Cape Idalug. The topography here at a depth of 45 ft had no relief on a flat sand bottom. Bottom temperature was 6 C and visibility was limited to about 25 ft at depth. There was little surface current to the north, but no swell. Species diversity was seemingly low. No algae dominated, although some pieces of drift algae were present. The dominant animals were sand dollars (*Echinarachnius parma*), pinkneck clams (*Mactromeris polynyma*), and juvenile flatfish and adult rock sole (*Lepidopsetta* sp.). One large rock sole were collected.

Divers: R. Brewer, R. Deffendall, H. Chenelot, S. Harper, M. Hoberg, S. Jewett

AKALE07-0029
Umnak Island
July 21, 2007

This site was located in the northwest side of the island, in Nikolski Bay, within sight of the Village of Nikolski. Bottom temperature was 7 C and visibility was limited to about 20 ft at depth of 31-43 ft. There was little surface current to the north, but a fair swell. The substrate was cobble and boulders and bedrock. The algae was dominated by *Alaria fistulosa, Nereocysistis luetkeana, Laminaria bongardiana* and *Lithothamnion* sp. The dominant animal was *Pycnopodia helianthodes.*

Divers: R. Brewer, H. Chenelot, R. Clark, S. Harper, M. Hoberg, S. Jewett

Appendix D – Contaminant Analytes

Appendix D - Specific Parameters tissue.	
Inorganic Element Aluminum,, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Mercury, Nickel, Selenium, Silver, Tin, Zinc	*PCB Congeners* PCB Numbers 8, 18, 28, 44, 52, 66, 101, 105, 110/77, 118, 126, 128, 138, 153, 170, 180, 187, 195, 206, 209
Polynuclear Aromatic hydrocarbons (PAH) Acenaphthene, Acenaphthylene, Anthracene, Benz(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Biphenyl, Benzo(k)fluoranthene, Benzo(g,h,i)perylene, Chrysene, Dibenz(a,h)anthracene, Dibenzothiophene, Fluoranthene, Fluorene, 2,6-dimethylnaphthalene, Indeno(1,2,3-c,d)pyrene, Naphthalene, Pyrene, 1-methylnaphthalene, 1 -methyphenanthrene, 2-methylnaphthalene, 2,3,5-trimethylnaphthalene, 2,6-dimethylnaphthalene	**Chlorinated pesticides other than DDT** Aldrin, Alpha-chlorodane, Dieldrin, Endosulfan I, Endosulfan II, Endosulfan sulfate, Endrin, Heptachlor, Heptachlor epoxide, Hexachlorobenzene, Lindane (gamma-BHC), Mirex, Toxaphene, Trans-Nonachlor *DDT and Metabolites* 2,4’ -DDD 4,4’ -DDD 2,4’ -DDE 4,4’ -DDE 2,4’ -DDT 4,4’ -DDT