National Park Service
U.S. Department of the Interior

Natural Resource Program Center

Nearshore Marine Vital Signs Monitoring in the Southwest Alaska Network of National Parks

Natural Resource Technical Report NPS/SWAN/NRTR—2009/252

ON THE COVER
USGS M/V Alaskan Gyre in Aialik Bay, Kenai Fjords National Park, Alaska.
Photograph by: Dr. Allan Fukuyama

Nearshore Marine Vital Signs Monitoring in the Southwest Alaska Network of National Parks

Natural Resource Technical Report NPS/SWAN/NRTR —2009/252

Heather A. Coletti
National Park Service
240 W 5th Avenue
Anchorage, AK 99501

James L. Bodkin
US Geological Survey
Alaska Science Center
4210 University Dr
Anchorage, AK 99508

Thomas A. Dean
Coastal Resources Associates Inc.
302a Pier View Way
Oceanside, CA 92054

Kimberly A. Kloecker
US Geological Survey
Alaska Science Center
4210 University Dr
Anchorage, AK 99508

September 2009

U.S. Department of the Interior
National Park Service
Natural Resource Program Center
Fort Collins, Colorado

The Natural Resource Publication series addresses natural resource topics that are of interest and applicability to a broad readership in the National Park Service and to others in the management of natural resources, including the scientific community, the public, and the NPS conservation and environmental constituencies. Manuscripts are peer-reviewed to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and is designed and published in a professional manner.

The Natural Resource Technical Reports series is used to disseminate the peer-reviewed results of scientific studies in the physical, biological, and social sciences for both the advancement of science and the achievement of the National Park Service's mission. The reports provide contributors with a forum for displaying comprehensive data that are often deleted from journals because of page limitations. Current examples of such reports include the results of research that addresses natural resource management issues; natural resource inventory and monitoring activities; resource assessment reports; scientific literature reviews; and peer reviewed proceedings of technical workshops, conferences, or symposia.

Views, statements, findings, conclusions, recommendations and data in this report are solely those of the author(s) and do not necessarily reflect views and policies of the U.S. Department of the Interior, NPS. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the National Park Service.

This report is available from the Southwest Alaska I&M Network website (http://science.nature.nps.gov/im/units/SWAN/) and the Natural Resource Publications Management website (http://www.nature.nps.gov/publications/NRPM).

Please cite this publication as:

Coletti, H., J. Bodkin, T. Dean, and K. Kloecker. 2009. Nearshore marine vital signs monitoring in the Southwest Alaska Network of National Parks. Natural Resource Technical Report NPS/SWAN/NRTR—2009/252. National Park Service, Fort Collins, Colorado.

NPS 953/100437, September 2009

Contents

Page

Figures vi

Tables viii

Appendices x

Abstract xi

Acknowledgements xii

Introduction 1

New Metrics for 2008 5

Contaminants 6

Methods *6*

Results and Discussion *9*

Recommendations *15*

Mussel Bed Sampling 16

Methods *16*

Results *17*

Discussion *21*

Recommendations *21*

Eelgrass Bed Sampling 22

Methods *22*

Results *25*

Discussion *27*

Recommendations *27*

Winter Marine Bird Survey in KEFJ 28

Methods *28*

Results *28*

Discussion *31*

Recommendations *32*

Sea Otter Aerial Survey in KATM 33

Methods *33*

Results *33*

Discussion *37*

Recommendations *37*

Three Year Analysis 38

Intertidal Invertebrates and Algae 39

Methods *39*

Results *41*

Discussion *50*

Recommendations *50*

Marine Birds 51

Methods *51*

Results *53*

Discussion *55*

Recommendations *56*

Black Oystercatcher 57

Methods *58*

Results *59*

Discussion *63*

Recommendations *64*

Sea Otter 65

Methods *66*

Results *69*

Discussion *72*

Recommendations *73*

Literature Cited 74

Figures

page

Figure 1. Sampling locations for the SWAN nearshore vital signs monitoring. 3

Figure 2. Locations of sites where mussels were collected in KEFJ in 2007. 7

Figure 3. Locations of sites where mussels were collected in KATM in 2007. 8

Figure 4. Mean densities (se) of mussels visible to the unaided eye obtained from 25.4 mm diameter cores obtained from each of five mussel beds at KATM in 2008. 17

Figure 5. Mean densities (se) of mussels visible to the unaided eye obtained from 25.4 mm diameter cores obtained from each of five mussel beds sites at KATM in 2008. 18

Figure 6. Mean densities (se) of mussels > 20 mm at each of five mussel beds in KATM in 2008. 18

Figure 7. Mean densities (se) of mussels > 20 mm at each of five mussel beds in KEFJ in 2008. 19

Figure 8. Mean sizes (se) of mussels > 20 mm at each of five mussel beds in KATM in 2008. 19

Figure 9. Mean sizes (se) of mussels > 20 mm at each of five mussel beds in KEFJ in 2008. 20

Figure 10. Mean proportion of mussels > 20 mm at each of five mussel beds in KATM in 2008. 20

Figure 11. Mean proportion of mussels > 20 mm at each of five mussel beds in KEFJ in 2008. 21

Figure 12. Location of eelgrass and soft sediment (gravel sand/gravel beaches) intertidal sampling sites in Katmai National Park. 23

Figure 13. Location of eelgrass and soft sediment (gravel sand/gravel beaches) intertidal sampling sites in Kenai Fjords National Park. 24

Figure 14. Sampling transect locations for high density, shallow water (less than 40 m, in orange) and low density, deeper water (40 m to 100 m in depth, in blue) strata used in the aerial survey of sea otter abundance at KATM in 2008. 35

Figure 15. Distribution and relative abundance of sea otters at KATM in 2008..... 36

Figure 16. Locations of rocky intertidal sites (RI1 - RI5) sampled in KATM 2007through 2008. 40

Figure 17. Mean percent cover of *Alaria marginata* in the lower intertidal at KATM 2006-2008. 42

Figure 18. Mean percent cover of *Mytilus trossulus* and barnacles in the mid intertidal at KATM 2006-2008. 43

Figure 19. Detection probability, estimated number of species, complement of extinction probability, and complement of the turnover rate for sessile invertebrates and algae in the lower intertidal at KATM from 2006 through 2008. 47

Figure 20. Mean lengths (mm) of *Lottia persona* at KATM from 2006 through 2008..... 49

Figure 21. Nest density across all GRTS transects by year. 59

Figure 22. The number of black oystercatcher eggs plus chicks per active nest in KATM from 2006 through 2008. 60

Figure 23. Mean size comparison of *L. persona* 62

Figure 24. Mean size comparison of *M. trossulus* 63

Figure 25. The locations of areas delineated for the collection of sea otter forage data (buffers) associated with each of the established rocky intertidal sites 68

Figure 26. Mean size of prey items recovered by prey type for sea otters foraging in Block10, KATM, 2006-2008. 71

Tables

Table 1. Concentrations of organics in the tissue of mussels collected from KATM in 2007. ... 10

Table 2. Concentrations of organics in the tissue of mussels collected from KEFJ in 2007..... 10

Table 3. Comparison of total PAH concentrations in tissue of mussels from Aialik Bay 2007 vs. Aialik Bay from 1993-1997, and from KATM and KEFJ sites in 2007, 3 Gulf of Alaska reference sites in 1993-1997 (Payne et al.1998)..... 11

Table 4. Comparison of ranges in concentrations of organics in tissue of mussels from KATM and KEFJ in 2007 vs. five Gulf of Alaska (GOA) sites sampled by NOAA mussel watch (Kimbrough et al. 2008)..... 12

Table 5. Mean concentration and "High" values (those that exceed one standard deviation of the mean for log-transformed data) based on oyster and mussel tissue samples taken from sites (generally in industrialized urban areas) throughout the United States between 1986 and 1993..... 12

Table 6. Concentrations of metals in the tissue of mussels collected from KATM in 2007 13

Table 7. Concentrations of metals in the tissue of mussels collected from KEFJ in 2007..... 13

Table 8. Comparison of ranges in concentrations of selected metals in tissue of mussels from KATM and KEFJ in 2007 vs. five Gulf of Alaska (GOA) sites sampled by NOAA mussel watch (Kimbrough et al. 2008)..... 14

Table 9. Mean concentration and "High" values (those that exceed one standard deviation of the mean for log-transformed data) based on oyster and mussel tissue samples taken from sites (generally in industrialized urban areas) throughout the United States between 1986 and 1993 compared to maximum concentrations observed in KATM or KEFJ in 2007. 15

Table 10. Percent of observations with sparse (less than 25%), dense (equal to or greater than 25%), or total (sparse plus dense) eelgrass at sites in KATM and KEFJ in 2008. 26

Table 11. Estimates of cover by eelgrass from three replicate surveys conducted over an area of approximately one half of the Aialik site in 2008..... 26

Table 12. Nearshore statistics from marine bird surveys conducted during March of 2008 in KEFJ. Species highlighted in yellow are species of interest for trend analysis..... 29

Table 13. Offshore statistics from marine bird surveys conducted during March of 2008 in KEFJ. Species highlighted in yellow are species of interest for trend analysis..... 31

Table 14. Summary of information on KATM sea otter aerial survey in June 2008. 34

Table 15. Mean percent cover of dominant taxa of sessile invertebrates and algae (those occupying more than 10% cover) and median coefficients of variation in the lower and mid intertidal zone on sheltered rocky shorelines in KATM from 2006 through 2008..... 42

Table 16. Community dynamics metrics for sessile species in the intertidal at KATM 44

Table 17. Community dynamics metrics for motile species in the intertidal at KATM..... 45

Table 18. Mean lengths (mm) of limpets (*Lottia persona*) in the upper intertidal at KATM from 2006 through 2008. 48

Table 19. Mean densities, SEs, CV and 95% CIs for each species or species group by habitat classification and year..... 54

Table 20. Nest density (nests/km) for in KATM from 2006 - 2008. 59

Table 21. The number of black oystercatcher eggs plus chicks per active nest in KATM from 2006 through 2008. 60

Table 22. Proportion, SE and CV of eight different prey species by year in black oystercatcher nests in KATM from 2006 - 2008. 61

Table 23. Mean size, SE and CV by year of both *L. persona* and *M. trossulus* collected at black oystercatcher nest sites on GRTS transects in KATM from 2006-2008..... 62

Table 24. Summary of sea otter foraging observations in KATM from three years of nearshore monitoring data collection. The bout is the sampling unit for data analysis..... 69

Table 25. Proportion, SE and CV of eight different prey categories by year in sea otter diets in KATM..... 70

Table 26. Mean size, SE and CV by year of seven different prey categories by year in sea otter diets in KATM from 2006-2008..... 72

Appendices

Appendix A Contaminant Analysis Reports from TDI Brooks 85

Appendix B Intertidal Algae and Sessile Invertebrates 149

Appendix C Temperature Data – KATM & KEFJ 162

Appendix D Marine Bird Summer Survey Data from KEFJ 166

Appendix E Black Oystercatcher – KEFJ 168

Appendix F Sea Otter Diet – KEFJ 169

Appendix G Sea otter Age-at-death 172

Appendix H Monitoring Changes in the Distribution and Abundance of Canopy-forming Subtidal Kelps 174

Abstract

In 2008, we successfully completed a third year of protocol development and field sampling for the Southwest Alaska Network's (SWAN) Nearshore Vital Signs monitoring program. The protocol narrative for the program was revised, standard operating procedures (SOPs) were revised based on 2007 sampling, and standardized data entry and database management functions were further developed. In addition, sampling was conducted in accordance with protocols set forth for each of six vital signs (kelp and seagrass, marine intertidal invertebrates, marine birds, black oystercatcher, sea otter, and marine water chemistry and quality).

At both Katmai National Park and Preserve (KATM) and Kenai Fjords National Park (KEFJ), we tested newly developed preliminary sampling protocols for mussel beds and eelgrass beds; measured water temperature; deployed salinity measuring devices; and continued sampling of marine intertidal invertebrates and algae, marine birds, black oystercatchers and sea otters. In addition, we conducted an aerial survey of sea otter abundance at KATM. Methods for evaluating the abundance of mussels and eelgrass provided sufficient confidence to allow us to continue developing a SOP for implementation of monitoring in 2009. We were unable to develop a method to estimate abundance of subtidal, canopy forming kelps that would provide an acceptable level of precision at a reasonable cost. Mussel tissues that were obtained from six sites in KATM and five sites in KEFJ in 2007 were analyzed for a suite of heavy metal and organic toxicants. With the exception of high chlordane concentrations in Amalik Bay, none of the concentrations of either organics or metals appeared to be sufficiently high to be indicative of local or region-wide sources of contamination that are of ecological concern. As a result, we recommend resampling of mussel tissue at Amalik in 2009. At the other sites, we recommend that sampling of concentrations of metal and organic concentrations be measured at 5 year intervals, except in those instances when there is a reasonable cause for concern such as an oil spill or heavy ash fall from volcanoes.

Sampling in 2008 at KATM represented the third year of data collection for vital signs including intertidal invertebrates and algae; marine bird surveys; black oystercatcher diet and productivity; and sea otter diet. For each of these, we presented coefficients of variation (CVs) to evaluate the extent of spatial and temporal variation for each metric and to evaluate our ability to detect reasonable levels of change. For most metrics, the data suggests that methods used will allow us to detect levels of change that are ecologically important. Exceptions were for the abundance of small motile invertebrates at rocky intertidal sites and for several bird species that displayed a great deal of spatial variation. We intend to either discontinue sampling (in the case of small motile invertebrates) or modify sampling protocols (in the case of bird abundance) to increase our ability to detect changes for these metrics.

In 2009, we plan to continue revision of the sampling protocol and SOPs, continue to develop data entry and data management procedures, and continue sampling of vital signs at both KATM and KEFJ.

Acknowledgements

The National Park Service, SWAN, KATM, KEFJ and the USGS Alaska Science Center supported this work. We would like to thank Bill Thompson of SWAN NPS for his continued technical support; Alan Bennett, Michael Shephard, Dorothy Mortenson and Cuyler Smith of SWAN NPS for their support. We would like to recognize the exceptional cooperation by the staff of KATM, KEFJ and SWAN and, in particular, Meg Hahr (KEFJ) for her field assistance as well assistance in acquiring permits, Claudette Moore (SWAN) for her field assistance and logistical support, Ralph Moore (KATM) for his field assistance and Daniel Noon (KATM) for his assistance in obtaining NPS permits. This work could not have been completed without the field assistance of Allan Fukuyama, George Esslinger, and Ashley Coletti. We also thank Greg Snedgen and George Esslinger for their skilled operation of the R/V Alaskan Gyre in KEFJ and KATM. Thank you to Bill Thompson and Allan Fukuyama for their thoughtful reviews.

Introduction

In 2006 and 2007 we implemented the nearshore monitoring protocol in Katmai National Park and Preserve (KATM), and Kenai Fjords National Park (KEFJ) in the Southwest Alaska Network of National Parks (SWAN) (Figure 1). The protocol incorporates sampling of six SWAN vital signs; Marine water quality, kelps and seagrasses, marine invertebrates, marine birds, black oystercatcher (*Haematopus bachmani*), and sea otter (*Enhydra lutris*). Also in 2006 and 2007 we prepared comprehensive annual reports that provided descriptive statistics and graphics summarizing data related to each of these vital signs (Bodkin et al. 2007, Bodkin et al. 2008). In 2008 we continued revision and implementation of the nearshore protocol at KATM and KEFJ. Taken collectively, data describing each of these vital signs over time will provide a powerful tool to both describe change in nearshore ecosystems, and provide inference about the cause of those changes. Following is a brief description of each of these "vital signs". One or more standard operating procedures (SOP) provide explicit detail on methods to estimate specific vital sign metrics (Dean and Bodkin 2006).

Marine water chemistry, including temperature and salinity, are critical to intertidal fauna and flora and are likely to be important determinants of both long-term and short-term fluctuations in the intertidal biotic community. Basic water quality parameters provide a record of environmental conditions at the time of sampling and are used in assessing the condition of biological assemblages.

Kelps and seagrasses are "living habitats" that serve as a nutrient filter, provide structural habitat for planktivorous and predatory fish, clams, urchins, and a physical substrate for other invertebrates and algae. The kelps and seagrasses also provide spawning and nursery habitats for forage fish and juvenile crustaceans. Kelps and seagrasses are major primary producers in the marine nearshore and because they are located in shallow water they could be significantly impacted should there be an oil spill or other contaminant exposure. Other stresses include activities that disturb the beds directly such as dredging and anchor scars, and events that reduce the ability for light to penetrate into the water column, such as runoff (increased turbidity) or nutrient addition.

Marine intertidal invertebrates provide a critical prey resource for shorebirds, ducks, fish, bears, sea otters, and other marine invertebrate predators. Benthic invertebrates are ecologically diverse in terms of habitat and trophic requirements; have a wide range of physiological tolerances and feeding modes; are relatively sedentary and have short generation times. They integrate environmental conditions over relatively long periods of time (up to decades) and are therefore good biological indicators of change.

Marine birds are predators near the top of marine nearshore food webs. Marine birds are long-lived, conspicuous, abundant, widespread members of the marine ecosystem and are sensitive to environmental change. Relations between environmental conditions and sea bird behavior, diet, productivity, and survival are well documented. Public concern exists for the welfare of seabirds because they are affected by human activities like oil pollution and commercial fishing. Because of these characteristics marine birds are good indicators of change in the marine ecosystem.

Black oystercatchers are well suited for inclusion into a long term monitoring program of nearshore habitats because they are long-lived; reside and rely exclusively on intertidal habitats; consume a diet dominated by mussels, limpets, and chitons; and provision chicks near nest sites for extended periods. Additionally, as a conspicuous species sensitive to disturbance, the black oystercatcher would likely serve as a sentinel species in detecting change in nearshore community resulting from human or other disturbances.

Sea otters (Western Alaska Stock) were federally listed in October 2005 as threatened under the Endangered Species Act. Sea otters dramatically affect the structure and complexity of the nearshore ecological community and are a prime example of the top-down cascade type of interaction web where the highest trophic level can determine the populations of the lower trophic levels. Sea otter tend to be relatively sedentary in comparison to other marine mammals; eat large amounts of food and are readily observable; may be susceptible to contaminant associated disease; and have broad appeal to the public.

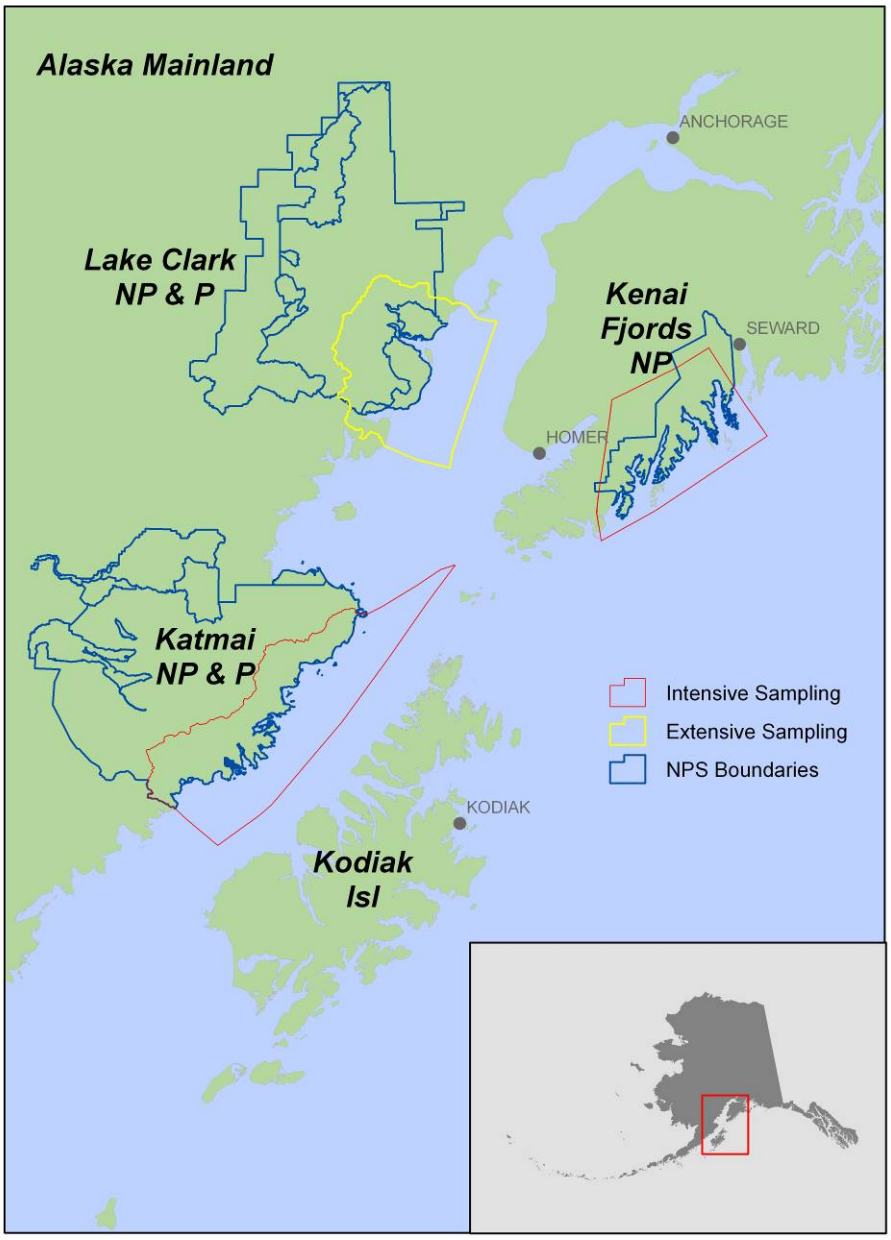


Figure 1. Sampling locations for the SWAN nearshore vital signs monitoring. Intensive sampling blocks (indicated in red) are locations for monitoring of all vital signs. Less frequent monitoring of a limited number of vital signs is to be conducted in the extensive block at LACL (indicated in yellow). Park boundaries are indicated in blue.

In addition to the field testing of the nearshore monitoring protocol and associated SOPs', several other tasks were identified under the 2008 Inter-Agency Agreement between the National Park Service and the U.S. Geological Service Alaska Science Center (USGS, ASC). These included: 1) Review and revision of the draft monitoring protocol; 2) Review and revision of each of the SOPs'; and 3) Design, development, and testing of data management plans specific to the protocol and each SOP. In the following we summarize the progress made toward completion of these tasks.

In 2008 we completed revision of the monitoring protocol narrative for sampling nearshore vital signs in SWAN National Parks. The protocol revision incorporated review comments from NPS SWAN staff and results of the trial implementation of the protocol from 2006-2008. We continue to revise the SOP's associated with each vital sign, based on both peer review and experiences gained through trial implementation of each SOP during this same period.

We have two primary objectives in this annual report. We will first focus on presenting summary statistics and graphics for metrics associated with sampling initiated in 2008. These include initial results of contaminant sampling in mussels from KATM and KEFJ, mussel bed sampling at KATM and KEFJ, eelgrass bed surveys at KATM and KEFJ, winter marine bird surveys in KEFJ, and sea otter aerial surveys in KATM.. The second objective is to present results of analysis for metrics under those vital signs where we have acquired three continuous years of data. These include rocky intertidal invertebrates and algae, marine bird and mammal surveys, black oystercatcher surveys and diet, and sea otter diet. The focus is placed on evaluating the extent of spatial and temporal variation in key metrics for these vital signs and to evaluate our ability to detect ecologically meaningful levels of change with the sampling designs employed.

New Metrics for 2008

In this section, we report results from analyses of contaminants in mussels collected in 2007 and from several sampling programs initiated in 2008. The latter include: mussel bed sampling implemented to examine mussel densities and size distribution, eelgrass bed sampling to assess changes in the extent of eelgrass over time, a winter marine bird survey conducted in KEFJ during March of 2008 (a similar survey had not been completed during the winter months in KEFJ since 1989, following the Exxon Valdez Oil Spill), and an aerial survey in KATM in 2008 to estimate sea otter abundance along the park's coastline For each of these new metrics we primarily report descriptive statistics that include sample size, mean, range, standard error, and coefficients of variation. In some instances we report comparable data from other locations (e.g. contaminants and sea otter densities) to provide context.

Contaminants

High concentrations of contaminants, including polycyclic aromatic hydrocarbons (PAHs), organic pesticides, polychlorinated biphenyls (PCBs), and metals have long been recognized as having deleterious effects on nearshore communities worldwide (Valiella 2006). High concentrations are often the result of human activities such as oil spills, pesticide use, or mining activities. Their effects on nearshore organisms can range from acute (e.g. death caused by short term exposure to high concentrations) to those that are more subtle and longer-term (e.g. reductions in reproductive capacity or reductions in long term survival). Nearshore communities along the KEFJ and KATM have been subject to injury from oil spills (Spies et al. 1996) and are potentially threatened by a variety of human activities (future oil spills, mining, and inputs of airborne pollutants) and natural disturbances (e.g. earthquakes and volcanic eruptions).

In this section, we examine contaminant data from tissues of Pacific blue mussels (*Mytilus trossulus*) collected in summer 2007 at five locations in KEFJ and six locations in KATM. Mussel tissue was selected for examination because: 1) mussels tend to be integrators of contaminant loads and are likely to be less temporally variable than those measured in seawater and less spatially variable than those measured in sediments (Widdows and Donkin 1992), 2) mussels are an important component of the nearshore food web and therefore provide a potential pathway of contamination to a variety of other nearshore species including sea ducks, sea stars, black oystercatchers, and sea otters (O'Clair and Rice 1985, Esler et al. 2000, Bodkin et al. 2002), and 3) mussel tissue has been widely used in contaminant analysis in the Gulf of Alaska (Karinen et al. 1993, Short and Babcock 1996, Payne et al. 1998), elsewhere in the U.S. (O'Connor and Lauenstein 2006, Kimbrough et al. 2008) and the world (Farrington and Tripp 1995) and these historical data provide a benchmark for examining temporal trends, making geographic comparisons, and evaluating potential environmental risks.

Methods

We collected and analyzed tissue of mussels from five sites in KEFJ and six sites in KATM (Figures 2 and 3). All were sheltered rocky shorelines and were generally the same as sites used for sampling of rocky intertidal invertebrates and algae. In some cases where larger mussels (≥ 25 mm) were unavailable at the rocky intertidal site (Kinak Bay in KATM and Aialik Bay in KEFJ) we collected mussels from the nearest location where larger mussels could be found.

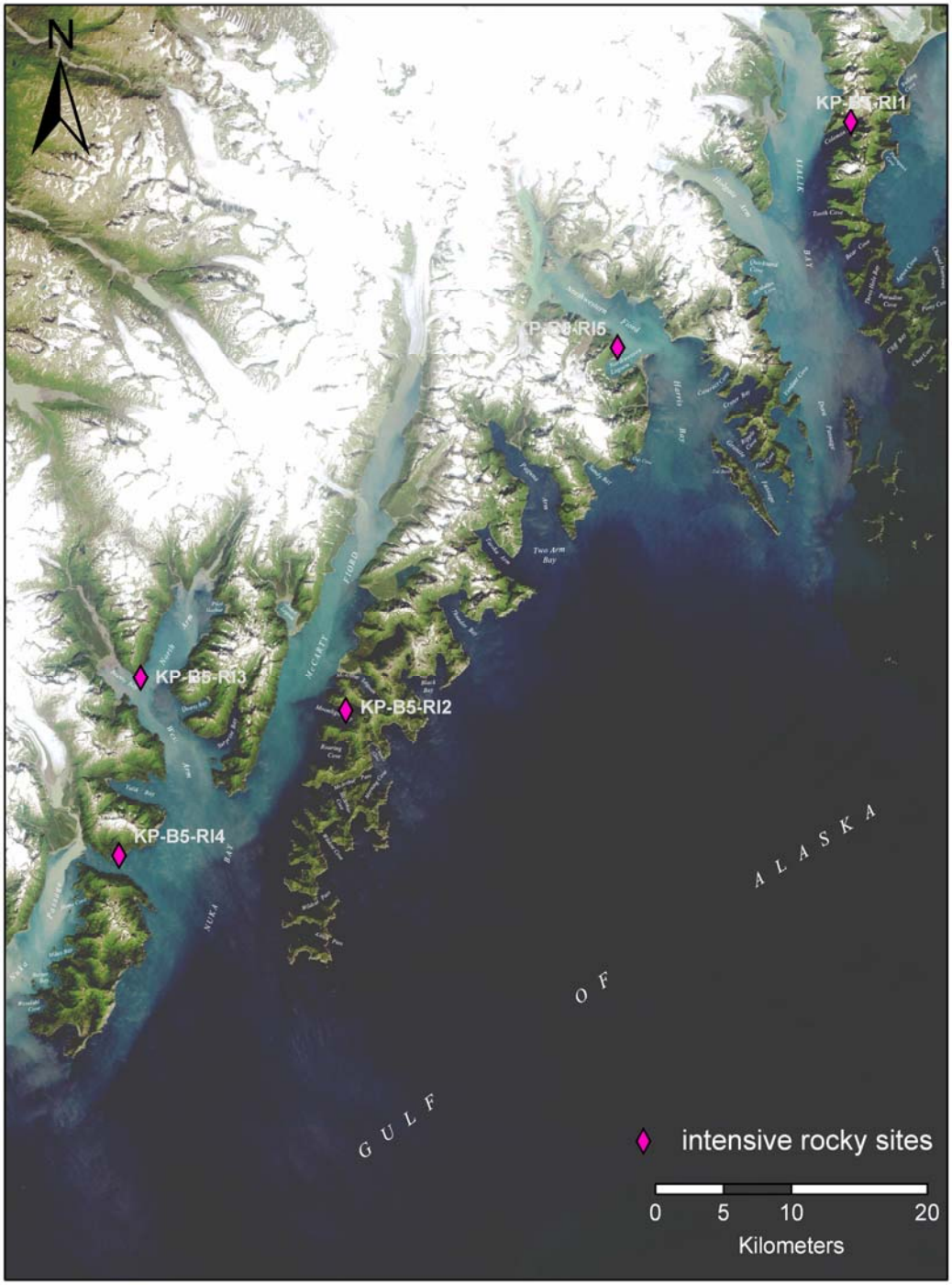


Figure 2. Locations of sites where mussels were collected in KEFJ in 2007.

Figure 3. Locations of sites where mussels were collected in KATM in 2007.

Methods for collection and analysis followed guidelines provided by the National Status and Trends Mussel Watch Program of NOAA (Lauenstein et al, 1993a, b, c, d, 1998). At each site we collected a minimum of 67 mussels that were larger than 25 mm in length. Collections at each site were approximately equally divided among ten equally spaced locations within a 50 m stretch of shoreline. Mussels were collected from a tidal elevation where mussels were most abundant at each site, generally 2 - 3 m above MLLW. Collections were made by hand using contaminant-free rubber gloves and were composited into a single Teflon collection bag for each site. The bags were labeled and frozen aboard the vessel and later transferred to a low temperature freezer (-62 °C [-80 °F]) prior to analysis.

Samples were shipped to TDI-Brooks International Laboratory for analysis. The samples were analyzed for 58 PAH compounds, eight individual alkyl isomers, 70 organochlorine compounds (including 39 PCP isomers), and 15 metals (Appendix A). Specific references for various analytical procedures and minimum detection limits are given in Appendix A.

Results and Discussion

Most of the individual PAH compounds were found at concentrations that were either undetected or below detection limits (Appendix A). Exceptions were for C-1 benzothiophene, acenapthene, dibenzofuran, C-1 flourenes, and phenanthrene that were consistently above detection limits. Of the individual PAH compounds, C-1 benzothiphene contributed the most to total PAH concentrations at each site. Because benzothiophenes have not been reported as contributors to Total PAH in previous studies (Payne et al. 1998, Kimbrough et al. 2008) and are likely to be present as a result of natural inputs unrelated to human activity, we have excluded benzothiophenes from our reporting of total PAH concentrations in the results tabulated below.

Total PAH concentrations in mussel tissues collected in 2007 ranged from 81 to 107 ng/dry g and from 74 to 86 ng/dry g at KATM and KEFJ respectively (Tables 1 and 2). All of the concentrations were generally at the lower end of the ranges reported for other sites in the Gulf of Alaska (Tables 3). At Aialik Bay, the one site that we sampled for which there are historical data, the concentration of Total PAHs in 2007 was 72 ng/g dry weight, at the low end of the range of 56 to 292 ng/g dry weight observed over nine sampling periods between 1993 and 1997 (Table 3). Concentrations of Total PAHs at all KATM and KEFJ sites were also low relative to those observed at other sites in the Gulf of Alaska (Table 2) and are at or below those generally considered as “background” levels representative of contaminant free sites (O’Connor and Lauenstein 2006).

Table 1. Concentrations of organics in the tissue of mussels collected from KATM in 2007. All concentrations are given as ng/dry g. Total PAH concentrations exclude benzothiophenes. Chlor. = Chlordanes.

Site Name	Site Number	Total PAH	Total HCH	Total Chlor.	Total DDT	Total PCB
Ninagiak Island	AP-B10-RS1	107	0.76	0.65	0.25	4.51
Kukak Bay	AP-B10-RI1	105	1.05	0.75	0.31	6.41
Kaflia Bay	AP-B10-RI2	98	0.15	0.29	0.14	3.33
Kinak Bay	AP-B10-RI3	81	0.45	0.32	0.15	5.03
Amalik Bay	AP-B10-RI4	92	0.00	13.55	0.24	9.65
Takli Island	AP-B10-RI5	100	0.18	0.49	0.13	4.74
Mean		97	0.43	2.68	0.20	5.61

Table 2. Concentrations of organics in the tissue of mussels collected from KEFJ in 2007. All concentrations are given as ng/dry g. Total PAH concentrations exclude benzothiophenes. PAH = polycyclic aromatic hydrocarbons, HCH = total halogenated hydrocarbons, Chlor. = Chlordanes.

Site Name	Site Number	Total PAH	Total HCH	Total Chlor.	Total DDT	Total PCB
Aialik Bay	KP-B5-RI1	72	0.19	0.21	0.26	5.92
McCarty Fjord	KP-B5-RI2	86	0.54	0.58	0.25	5.38
Harris Bay	KP-B5-RI5	74	0.80	1.19	0.23	4.94
Nuka Bay	KP-B5-RI3	81	0.55	0.81	0.43	4.73
Nuka Passage	KP-B5-RI4	76	0.96	0.91	0.25	5.01
Mean		78	0.61	0.74	0.34	5.20

Table 3. Comparison of total PAH concentrations in tissue of mussels from Aialik Bay 2007 vs. Aialik Bay from 1993-1997, and from KATM and KEFJ sites in 2007, 3 Gulf of Alaska reference sites in 1993-1997 (Payne et al.1998). All concentrations are given as ng/dry g. Total PAH concentrations exclude benzothiophenes. PAH = polycyclic aromatic hydrocarbons.

	Number of sites	Number of sampling dates	Total PAH range	Total PAH mean
Aialik 2007	1	1	72	72
Aialik 1993-1997	1	9	55-292	127
KEFJ 2007	5	1	72-86	78
KATM 2007	6	1	81-105	97
RCAC Central GOA reference sites 1993-1997	3	9	70-369	230

Organochlorine concentrations, including DDTs, PCBs, and a variety of organic pesticides were generally low at sites within KATM and KEFJ. Most were well below what are considered to be of biological significance and generally were similar to those observed elsewhere in Alaska (Table 4) and well below the national median for tissue of mussels or oysters (O'Connor 1996). The lone exception was for Chlordane at Amalik Bay (AP-B10-RI4) in KATM, where the concentration of total chlordane was 13.55 ng/g dry weight. This was well above the high end of the range for mussels elsewhere in Alaska (Table 4) and higher than the median from sites throughout the U.S (median =6.4 ng/g) but well below the 31 ng/g concentration that was considered "high" in nationwide surveys.

Table 4. Comparison of ranges in concentrations of organics in tissue of mussels from KATM and KEFJ in 2007 vs. five Gulf of Alaska (GOA) sites sampled by NOAA mussel watch (Kimbrough et al. 2008). All concentrations are given as ng/dry g. Total PAH concentrations exclude benzothiophenes. PAH = polycyclic aromatic hydrocarbons, HCH = total halogenated hydrocarbons, Chlor. = Chlordanes.

	No. sites	No. dates	Total PAH	Total HCH	Total Chlor	Total DDT	Total PCB
KEFJ 2007	5	1	72-86	0.2-1.0	0.2-1.2	0.2-0.4	4.7-5.9
KATM 2007	6	1	81-105	0.0-0.8	0.3-14	0.1-0.3	3.3-9.7
GOA sites	5	1	152-441		0.5-2.6	0.3-1.7	3.5-11

Table 5. Mean concentration and "High" values (those that exceed one standard deviation of the mean for log-transformed data) based on oyster and mussel tissue samples taken from sites (generally in industrialized urban areas) throughout the United States between 1986 and 1993. Data are from O'Connor (1996).). PAH = polycyclic aromatic hydrocarbons, Cdane = Chlordanes.

Chemical	US Mean	US "High"	KEFJ/KATM Maximum
Organics (ng/g)			
total PCB	110	470	9.7
total DDT	37	120	0.4
total Cdane	14	31	14
total PAH	260	890	105

A summary of concentrations of metals in mussel tissue are given in tables 6 and 7. Complete results are given in Appendix A. Of those of most concern with respect to ecological effects (mostly heavy metals), concentrations were generally low, were similar among sites in KATM and KEFJ, and were within the range observed elsewhere in Alaska (Table 8). The lone exception was for tin (SN) at Aialik Bay, which was almost 50% higher than the maximum observed at sites elsewhere in Alaska. Maximum concentrations of Cadmium, Nickel, Selenium, Copper, and Chromium at KATM and KEFJ in 2007 exceeded those considered "high" in nationwide surveys (Table 8). However, for the two elements for which we have data from other Alaska sites (Cadmium and Copper), the concentrations are similar to elsewhere in Alaska. Based on their wide-spread occurrence, the high concentrations appear to be naturally occurring or from some distant source.

Table 6. Concentrations of metals in the tissue of mussels collected from KATM in 2007. All concentrations are given as mg/dry g.

Site Name	Site No.	Ag	Pb	Se	Sn	Al	As	Cd	Cr	Cu	Fe	Mn	Ni	Si	Zn	Hg
Ninagiak Island	AP-B10-RS1	0.0986	0.28	3.16	0	292	8.76	2.53	0.566	10.3	420	15.3	7.66	321	74	0.064
Kukak Bay	AP-B10-RI1	0.075	0.288	3.46	0.143	372	12.1	3.11	1.52	9.49	516	22.8	3.07	410	71.1	0.0693
Kaflia Bay	AP-B10-RI2	0.0953	0.422	4.09	0.19	83.7	11.8	6.38	1.79	11.6	196	10.5	1.57	112	98	0.0851
Kinak Bay	AP-B10-RI3	0.117	0.214	3.73	0	56.8	8.75	4.89	0.557	7.64	163	8.65	1.06	75.8	72.9	0.05
Amalik Bay	AP-B10-RI4	0.0915	0.239	4.02	0	60.2	9.65	3.27	0.542	9.04	151	9.8	5.79	102	94.1	0.0596
Takli Island	AP-B10-RI5	0.136	0.244	3.93	0	45.2	11	4.45	0.574	8	141	7.73	2.73	61.2	86.3	0.0846
Mean		0.1022	0.281	3.73	0.056	152	10.3	4.11	0.925	9.35	265	12.5	3.65	180	82.7	0.0688

Table 7. Concentrations of metals in the tissue of mussels collected from KEFJ in 2007. All concentrations are given as mg/dry g.

Site Name	Site No.	Ag	Pb	Se	Sn	Al	As	Cd	Cr	Cu	Fe	Mn	Ni	Si	Zn	Hg
Aialik Bay	KP-B5-RI1	0.125	0.945	4.79	2.16	314	10.9	4.42	6.18	32.9	519	13.1	4.32	345	87.3	0.0808
McCarty Fjord	KP-B5-RI2	0.0904	0.658	4.69	0	151	13.4	5.18	2.19	11.1	295	12	7.18	125	104	0.126
Harris Bay	KP-B5-RI5	0.0457	0.717	4.52	0.114	587	12.6	2.98	2.32	13.9	889	23.5	8.38	574	117	0.143
Nuka Bay	KP-B5-RI3	0.0839	1.14	4.49	0.347	455	12.9	4.28	1.97	16.3	919	32.4	8.94	366	91.9	0.178
Nuka Passage	KP-B5-RI4	0.0618	0.772	3.86	0	346	10.6	3.5	1.42	10.4	724	19.5	4.63	242	87.9	0.119
Mean		0.0814	0.846	4.47	0.524	371	12.1	4.07	2.816	16.9	669	20.1	6.69	330	97.6	0.1294

Table 8. Comparison of ranges in concentrations of selected metals in tissue of mussels from KATM and KEFJ in 2007 vs. five Gulf of Alaska (GOA) sites sampled by NOAA mussel watch (Kimbrough et al. 2008).

	No. sites	No. dates	As		Cd		Cu		Hg		Ni		Pb		Sn		Zn	
			Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
KEFJ 2007	5	1	10.6	13.4	3.0	5.2	10.4	32.9	0.08	0.18	4.32	8.94	0.66	1.14	0	2.16	87.3	117
KATM 2007	6	1	8.8	12.1	2.5	6.4	7.6	11.6	0.05	0.09	1.06	7.66	0.21	0.42	0	0.19	71.1	98.0
GOA sites	5	1	9.2	12.0	1.7	7.1	6.0	33.0	0.06	0.12	1.20	8.90	0.59	2.10	0	1.4	72	108

Table 9. Mean concentration and "High" values (those that exceed one standard deviation of the mean for log-transformed data) based on oyster and mussel tissue samples taken from sites (generally in industrialized urban areas) throughout the United States between 1986 and 1993 compared to maximum concentrations observed in KATM or KEFJ in 2007. US mean and 'High" data are from O'Connor (1996).

Chemical (concentrations in µg/g)	US Mean	US "High"	KEFJ/KATM Maximum
Metals			
Arsenic	10	17	13
Cadmium	2.7	5.7	6.4
Mercury	0.09	0.24	0.18
Nickel	1.7	3.3	8.9
Selenium	2.5	3.5	4.9
Silver	0.17	0.58	0.14
Copper	8.9	11	32.9
Zinc	130	190	117
Lead	1.8	4.3	1.1
Chromium	1.7	3.0	6.2

Recommendations

With the exception of high Chlordane levels observed at Amalik Bay, none of the concentrations of either organics or metals appeared to be sufficiently high to be indicative of local or region-wide sources of contamination that are of ecological concern. We intend to resample mussels to examine levels of chlordane at Amalik in 2009. For all other contaminants, we recommend that sampling of mussels for concentrations of metals and organics be conducted every five years, except in those instances when there is a reasonable cause for concern such as an oil spill or heavy ash fall from volcanoes.

Mussel Bed Sampling

Pacific blue mussels (*Mytilus trossulus*) are a dominant invertebrate in the intertidal zone and are critically important prey for a variety of organisms including sea otters, black oystercatchers, harlequin ducks, Barrows goldeneye, and several species of sea stars (O'Clair and Rice 1985, O'Clair and O'Clair 1988, VanBlaricom 1988, Andres and Flaxa 1995, Esler et al. 2002, Bodkin et al. 2002). Mussels are widely distributed in many intertidal habitats, but also form relatively monotypic stands of larger individuals that are termed mussel beds. The goal of mussel bed sampling is to assess changes in the size of beds and in the size of mussels within those beds over time. These data are primarily to be used as an indicator of mussel abundance as prey for various vertebrate predators (sea stars, sea ducks and sea otters). Specifically, the objectives of this task are to estimate: 1) the density of mussels within these beds, 2) the density of large mussels within these beds, and 3) the size distribution of larger mussels within the beds (those generally consumed by black oystercatchers, sea ducks and sea otters. Sampling will be conducted in sheltered rocky habitats within KATM and KEFJ. We define mussel beds as sites with relatively high densities of Pacific blue mussels. Specifically, mussel beds are defined as areas with greater than approximately 10% cover by mussels within contiguous 0.25 m^2 quadrats over areas of 100 m^2 or greater. Metrics used to evaluate change over time will include the area of individual mussel beds (in m^2), average density of large mussels (greater than 20 mm in length), and the mean size of mussels >20 mm.

Methods

Sampling sites are defined as 50 m of coastline with contiguous mussel beds. These sites were selected following intensive searches in 2008 for the presence of mussel beds adjacent to the randomly selected rocky intertidal sites (see intertidal invertebrates and algae section). The closest mussel bed to the randomly selected rocky intertidal site was selected for sampling.

A transect 50 m in length was established through the mid point of the bed, relative to tidal elevation, and at the left end of the bed, as observed from the water. Permanent bolts were placed at this location and at 5 m intervals along the 50 m length of the horizontal transect to establish benchmarks for future sampling. Ten vertical transects were then established at systematic intervals based on a random starting point along the horizontal transect length, and the distance from the upper most margin of the bed to the lower margin (or the zero tidal elevation) were measured.

Estimates of mussel density are made within quadrats that are randomly located along each vertical transect. Quadrat dimensions are dependent on the density of mussels $\geq$ 20 mm within 1 m of the predetermined random point along the vertical transect, and determined at the time of sampling. The quadrat size can range from .0025 m^2 to 1.00 m^2 (5 cm to 100 cm on a side) with the size dependent on obtaining an optimal collection of 20 mussels $\geq$ 20 mm in length. This results in a sample of approximately 200 mussels to estimate size distributions. All mussels $\geq$ 20 mm are collected from within the quadrat and later counted and measured, and densities of large mussels are calculated. Densities of all mussels (of a size that is visually detectable, approximately 5 mm) are estimated from a 25.4 mm diameter (551 mm^2) core located adjacent to the tape at the same random number that defined the vertical quadrat, but on the opposite side of the tape from the origin of the quadrat.

Results

In 2008 we estimated the abundance and sizes of mussels at five sites in Katmai National Park and Preserve and at five sites in Kenai Fjords National Park. The mean density of mussels obtained from all cores at KATM was 13,683/ m^2 (se=4,615), and at KEFJ was 47,733/ m^2 (se=20231). At KATM, mean densities of mussels ranged from 4,694/ m^2 (se=2,289) at Kinak Bay (RI-3) to 31,026 (se=10,647) at Takli Island (RI-5) (Figure 4). At KEFJ, the range in mean densities was from 6,523/ m^2 (se=3,769) at Aialik Bay (RI-1) to 108,890 (se=22,083) at Nuka Bay (RI-3) (Figure 5). Coefficients of variation in mussel densities derived from cores were 0.75 among the five KATM sites and 0.95 among the KEFJ sites.

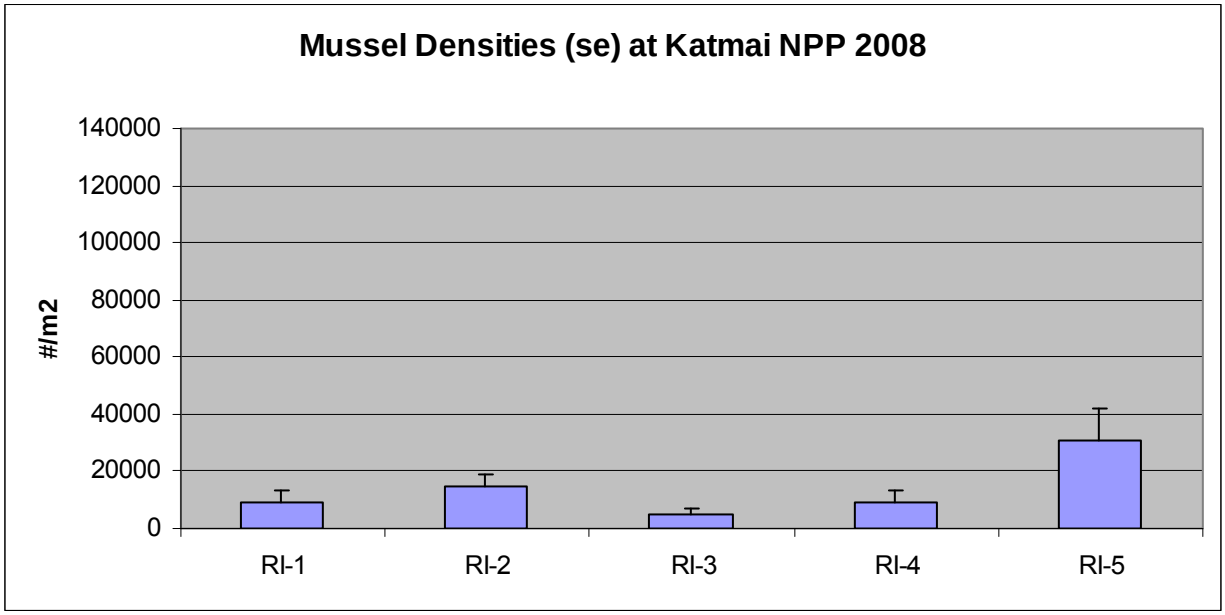


Figure 4. Mean densities (se) of mussels visible to the unaided eye obtained from 25.4 mm diameter cores obtained from each of five mussel beds at KATM in 2008.

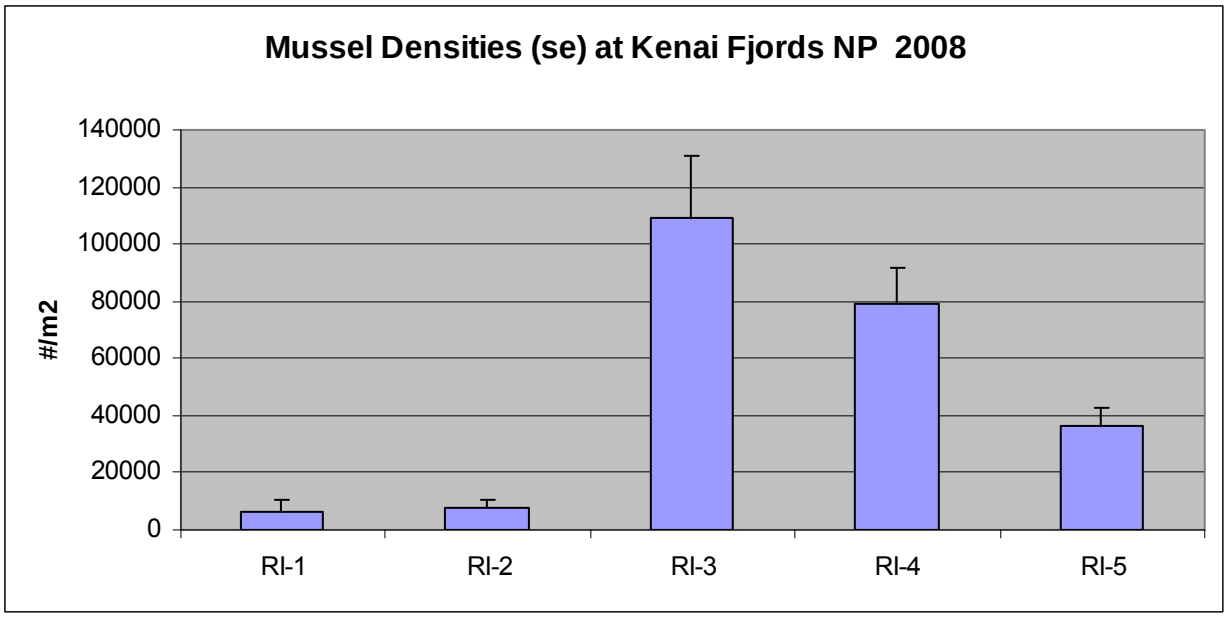


Figure 5. Mean densities (se) of mussels visible to the unaided eye obtained from 25.4 mm diameter cores obtained from each of five mussel beds sites at KATM in 2008.

The mean density of mussels ≥ 20mm obtained KATM was 1,056/ m^2 (se=301), and at KEFJ was 2,958/ m^2 (se=1072). At KATM, mean densities ranged from 204/ m^2 (se=143) at Takli Island (RI-5) to 1,695 (se=529) at Kinak Bay (RI-3) (Figure 6). At KEFJ, mean densities ranged from 788/ m^2 (se=250) at Aialik Bay (RI-1) to 6,053 (se=2506) at Nuka Passage (RI-4) (Figure 7). Coefficients of variation in large mussel densities derived from quadrats were 0.62 among the five KATM sites and 0.81 among the KEFJ sites.

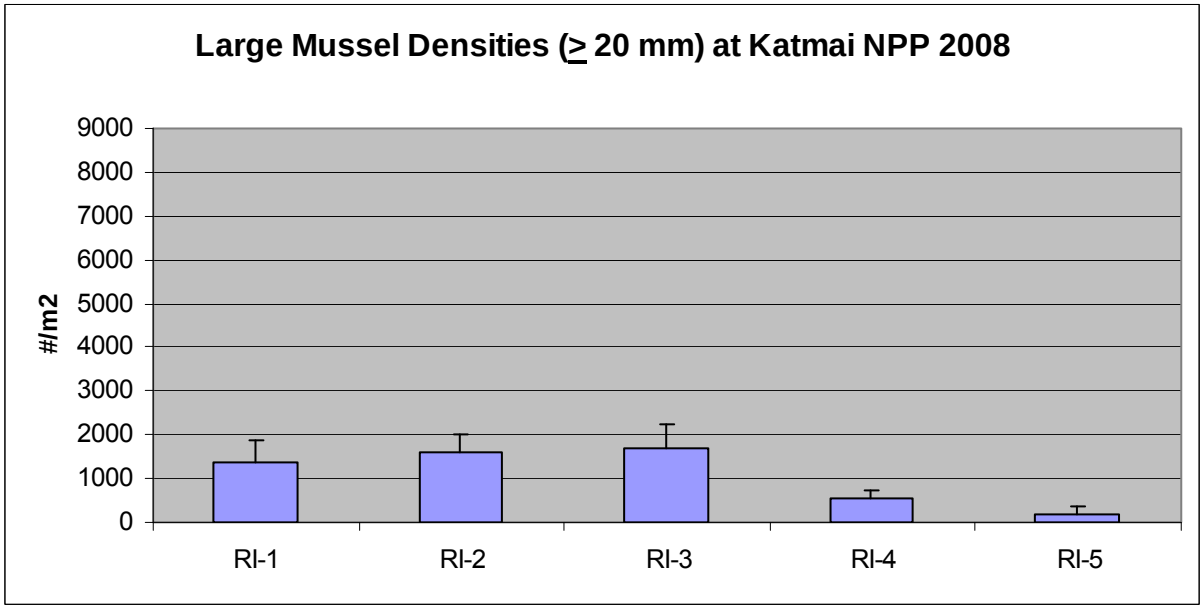


Figure 6. Mean densities (se) of mussels ≥ 20 mm at each of five mussel beds in KATM in 2008.

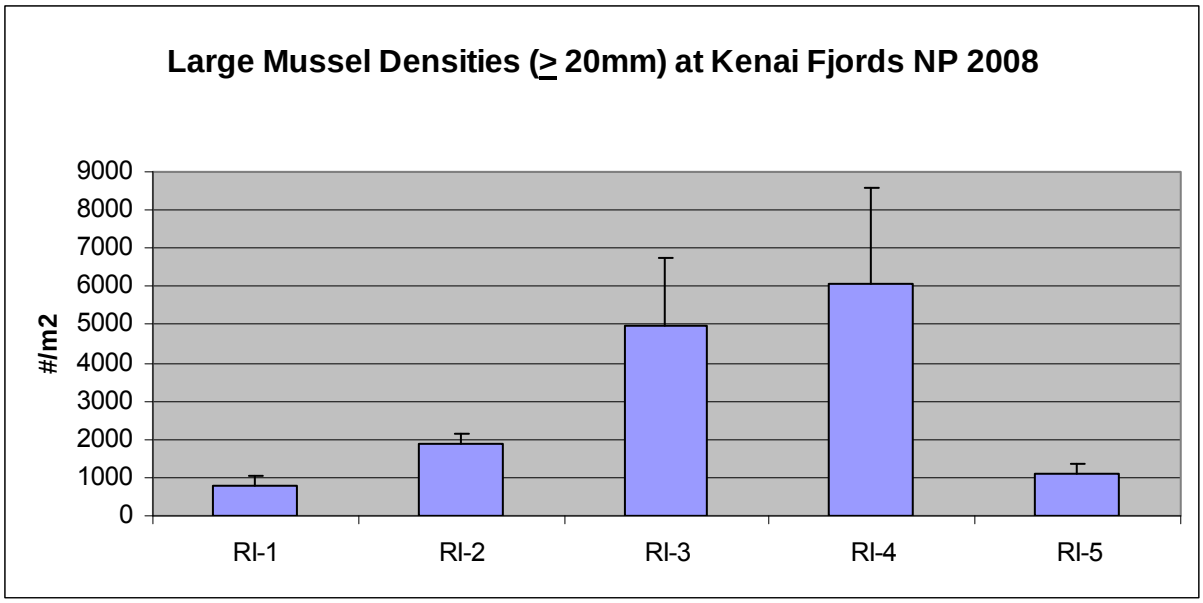


Figure 7. Mean densities (se) of mussels ≥ 20 mm at each of five mussel beds in KEFJ in 2008.

The mean size of mussels ≥ 20 mm was 27.3 mm (se=2.0) at KATM and 24.8 mm (se=0.6) at KEFJ. At KATM, the mean size of mussels ≥ 20 mm ranged from 24.2 mm (se=3.11) at Takli Island (RI-5) to 35.0 (se=10.7) at Kinak (RI-3) (Figure 8). At KEFJ, mean sizes of mussels ≥ 20 mm ranged from 23.3 mm (se=3.4) at Nuka Bay (RI-3) to 26.2 (se=4.4) at McCarty Fjord (RI-2) (Figure 9). Coefficients of variation in the mean sizes of mussels ≥ 20 mm derived from quadrats were 0.16 among the five KATM sites and 0.05 among the KEFJ sites.

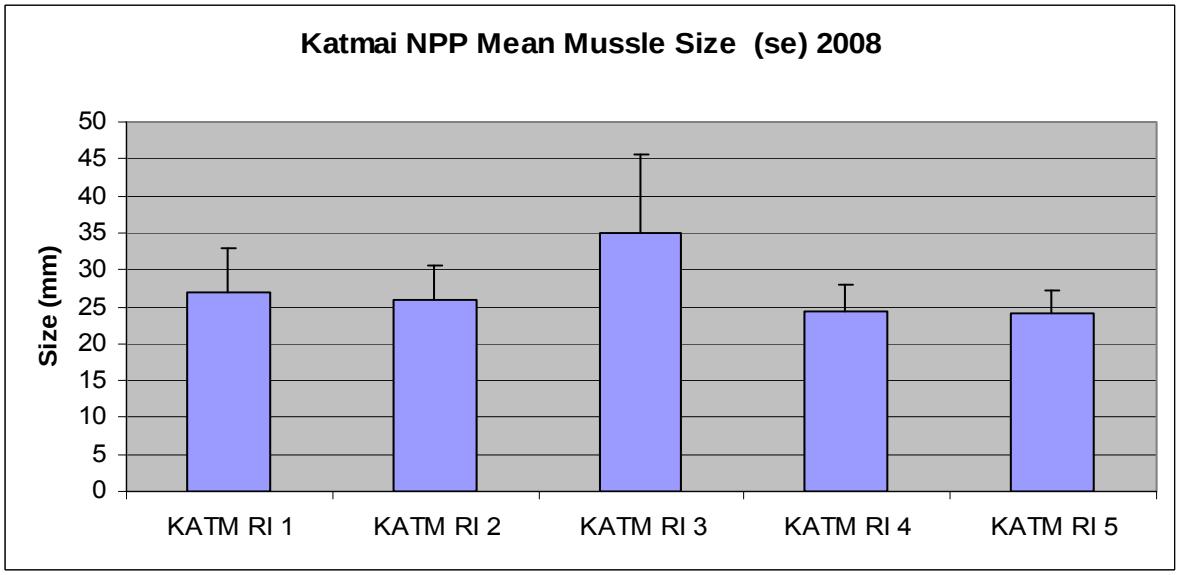


Figure 8. Mean sizes (se) of mussels ≥ 20 mm at each of five mussel beds in KATM in 2008.

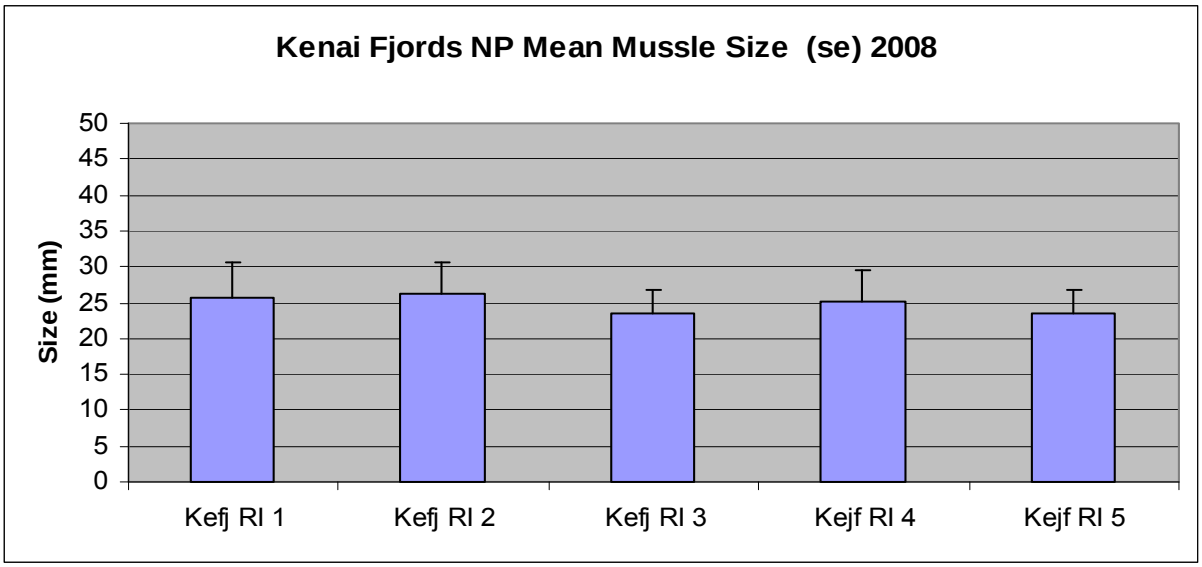


Figure 9. Mean sizes (se) of mussels ≥ 20 mm at each of five mussel beds in KEFJ in 2008.

Mean sizes of mussels ≥ 20mm were relatively uniform among all sites with a difference of 3.5 mm between 9 of the 10 sites (Figures 10 and 11). At Kinak Bay (RI-3) in KATM, the mean size was nearly 10 mm greater than the mean at the other nine sites.

The mean proportion of mussels > 20 mm was 0.14 (se=0.06) at KATM and 0.10 (se=0.04) at KEFJ. At KATM the proportion of mussels ≥ 20 mm ranged from 0.01 at Takli Island (RI-5) to 0.36 at Kinak Bay (RI-3) (Figure 10). At KEFJ the proportion of mussels ≥ 20 mm ranged from 0.03 at Harris Bay (RI-5) to 0.25 at Aialik Bay (RI-1) (Figure 11).

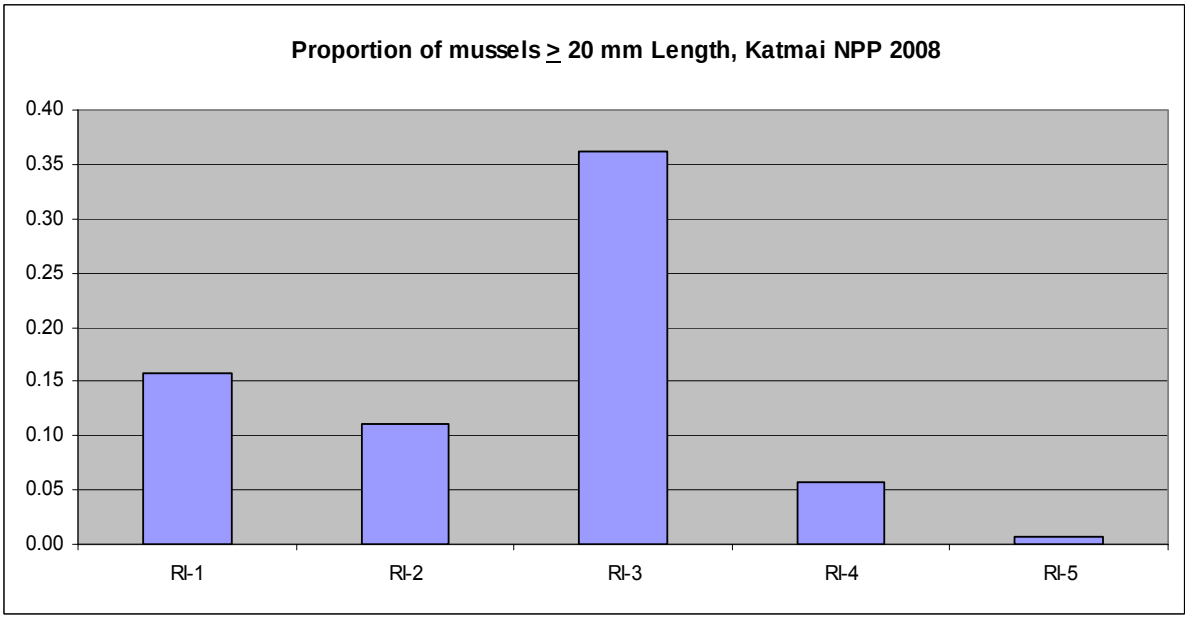


Figure 10. Mean proportion of mussels ≥ 20 mm at each of five mussel beds in KATM in 2008.

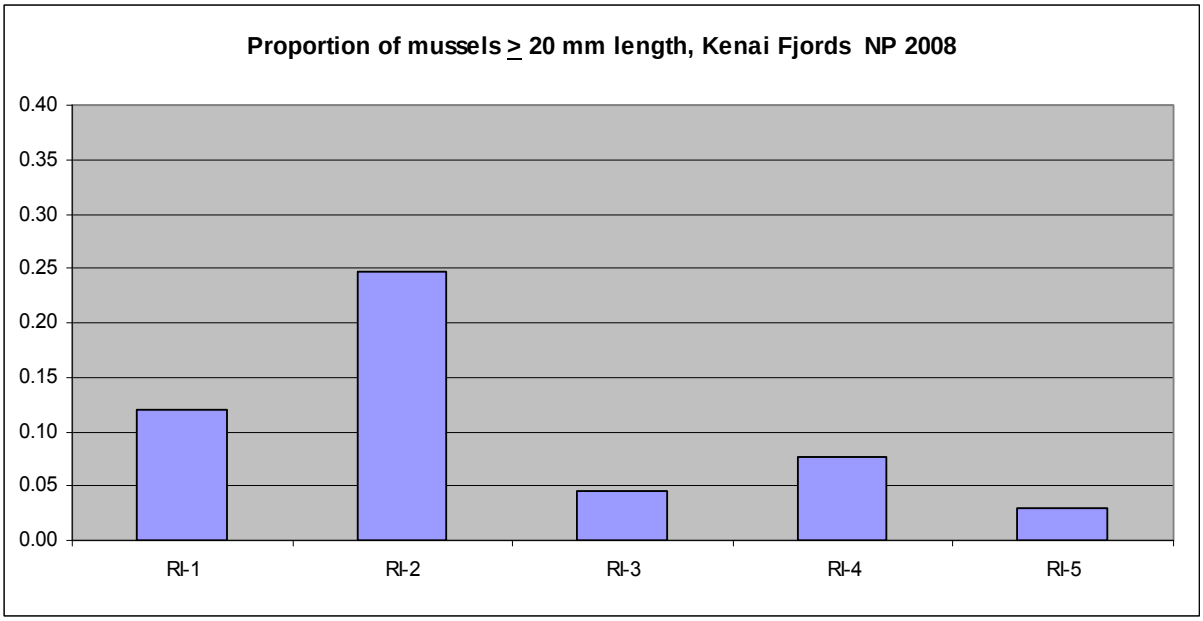


Figure 11. Mean proportion of mussels ≥ 20 mm at each of five mussel beds in KEFJ in 2008.

Discussion

Suitable mussel beds (> 50 m in horizontal length) were located in association with each of the five intensive rocky intertidal sites at KATM and KEFJ. Using the methods described above we were able to estimate densities of mussels, the sizes of mussels ≥ 20 mm, and the proportion of mussels ≥ 20 mm. Mussel densities varied greatly among sites, by more than an order of magnitude, both in terms of all mussels and those ≥ 20 mm. The high uniformity in mean sizes and low variance among sites, suggest perhaps a common mechanism structuring the sizes of mussels in the parks. While evaluating variance estimates of mussel densities and sizes for sensitivity to detect change will require additional years of data, the relatively low variation in mean sizes of large mussels across sites (CV's of 0.16 at KATM and 0.05 at KEFJ) suggests that mussel size may provide a statistically powerful metric to detect change over time

Recommendations

Our initial descriptive analysis indicates that the method produces relatively precise estimates of abundance, within sites, and that sizes of mussels may provide a metric sensitive to change both among and within sites. We recommend the continuation of annual mussel bed sampling.

Eelgrass Bed Sampling

Eelgrass (*Zostera marina*) is the dominant seagrass in protected waters of the Gulf of Alaska and is broadly distributed in sheltered embayments, especially in habitats dominated by soft sediments where they often form “beds” or relatively monotypic stands that can cover much of the shallow (0 to 5 m depth) subtidal zone (McRoy 1968, 1970). Eelgrass is an important "living habitat" that serves as a nutrient filter, provides shelter for fish and a variety of invertebrates, and provides physical substrate for invertebrates and algae (Thayer and Phillips 1977, Jewett et al. 1999, Dean et al. 2000, Bostrom et al. 2006). Eelgrass is a major primary producer in the marine nearshore (McConnaughey and McRoy1979) and because it is located in shallow water, is susceptible to oil spills and other human disturbances (Short and Wiley-Eschevaria 1996, Dean et al. 1998, Duarte 2002, Larkum et al. 2006, Short et al. 2006). Eelgrass is especially susceptible to dredging, anchor scars, and events that reduce light penetration into the water column such as runoff (increased turbidity) or nutrient addition (Walker et al. 1989, Oleson 1996, Neckles et al. 2005, Terrados et al. 2006).

The purpose of this task is to assess changes in the extent of eelgrass over time. Specifically, the objectives of this task are to: 1) assess changes in the cover and relative abundance of eelgrass, and 2) assess changes in the lower depth limit of eelgrass over time. In this report, we examine results from an initial year of using underwater video to estimate cover of eelgrass in KATM and KEFJ. Sampling is designed to examine smaller spatial (within beds of approximately 1 km^2) and temporal scale (several year) changes within eelgrass beds. These results are to be complemented by use of aerial imagery that examines changes in the distribution of eelgrass over the entire shore of each park on a less frequent basis (approximately once every 10 to 12 years) (Harper and Morris 2004).

Methods

We sampled the percent cover of eelgrass at four sites in KATM (Figure 12) and five sites in KEFJ in 2008 (Figure 13). All were in sheltered bays and were at eelgrass beds in closest proximity to sites selected for sampling of invertebrates on sand/gravel beaches that were chosen using a GRTS procedure (Stevens and Olsen 2004). All beds were identified in aerial shorezone mapping surveys (Harper and Morris 2004) or were observed during previous field sampling in 2006 and 2007. A fifth site in KATM (Kinak) was not sampled in 2008 because of poor weather, but is planned for sampling in future years.

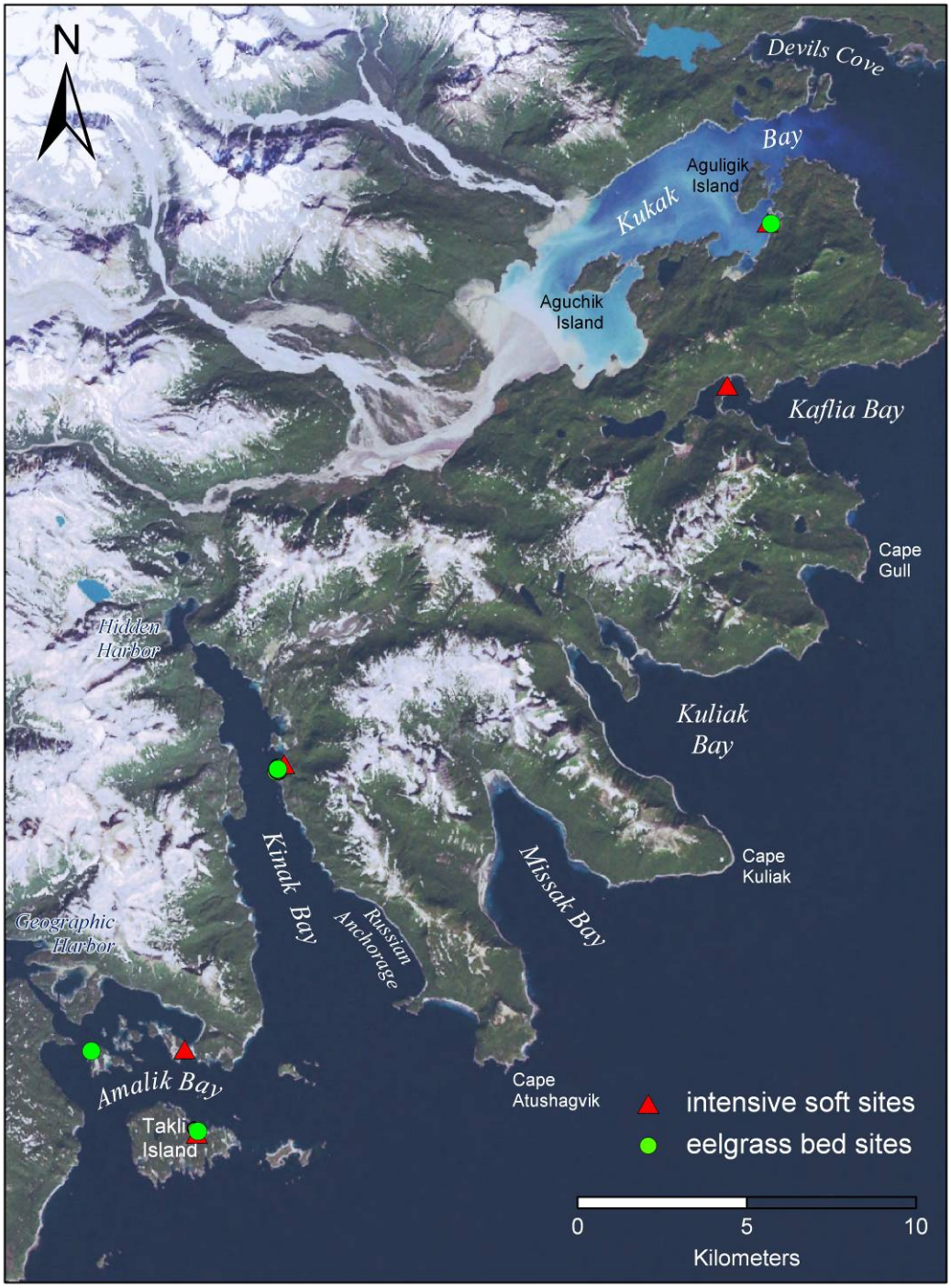


Figure 12. Location of eelgrass and soft sediment (gravel sand/gravel beaches) intertidal sampling sites in Katmai National Park.

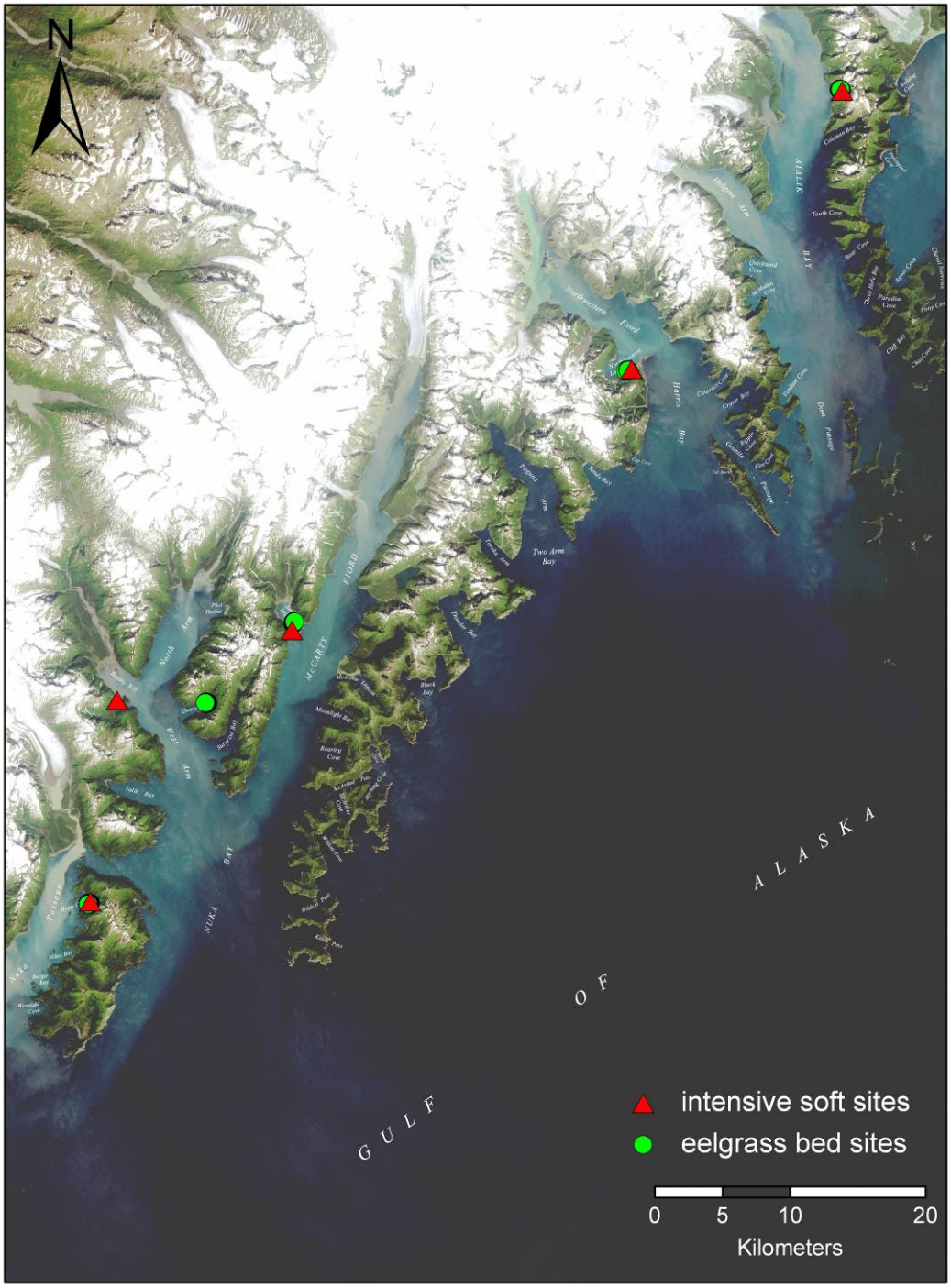


Figure 13. Location of eelgrass and soft sediment (gravel sand/gravel beaches) intertidal sampling sites in Kenai Fjords National Park.

At each site we sampled eelgrass within a prescribed shoreline of approximately 200 m in length. The width of each bed examined depended on the depth contour at each site, but was generally on the order of 50 - 100 m. The areas sampled were bounded by an approximately 200-m long segment of shoreline over which eelgrass was observed and extended offshore to a distance approximately 15 m beyond the last observed eelgrass. The percent cover of eelgrass within this area was estimated by recording the presence or absence of eelgrass at prescribed distances along a series of transects running perpendicular to shore that were spaced approximately 20 m apart. Presence or absence was estimated using a dropped underwater video camera lowered from a small inflatable boat. The methods have been shown to provide precise estimators of eelgrass cover at this scale and are generally more cost effective than aerial, diver, or sonar methods (Norris et al. 1997, Precision Identification 2002, Shultz 2008). Observations were made at 6 second intervals with the vessel running at a low speed. Positions of the observation points were recorded using a GPS linked to a computer with dLog2 (Ford 2004) positioning software. Navigation along the transects was aided using small temporary buoys anchored along the inshore edge of the eelgrass bed (spaced at approximately 20-m intervals along the shore) and at offshore buoys placed approximately 15 m offshore of the furthest offshore extent of eelgrass on left and right boundaries and in the center of the bed. The coordinates of the corner buoys were obtained using a GPS. At each observation point we recorded whether eelgrass was present or not and recorded whether eelgrass was sparse (less than and estimated 25% cover) or dense (equal to or greater than 25% cover). All surveys were conducted at or near high tide so that the boat could navigate over the inshore extent of each bed which typically extends to near mean lower-low water.

In addition, we conducted triplicate surveys over a portion of the Aialik Bay site to help estimate the precision and accuracy of the survey method. The area surveyed was approximately half the area surveyed during our routine sampling. Mean percent cover of eelgrass from these replicated surveys were compared to provide an estimate of precision of the survey method.

Results

The total area sampled within each eelgrass bed ranged from 7,535 m^2 to 19,970 m^2 and the percent of observations with eelgrass present ranged from 20% to 70% (Tables 10 and 11). At most sites, observation points with dense eelgrass present were greater than those with sparse eelgrass. Exceptions were at Kinak and Amalik where most observation points had sparse eelgrass.

Table 10. Percent of observations with sparse (less than 25%), dense (equal to or greater than 25%), or total (sparse plus dense) eelgrass at sites in KATM and KEFJ in 2008.

Site name	Site No.	Area surveyed (m^2)	% observations sparse	% observations dense	% with observations eelgrass present (total)
KATM					
Kukak	AP-B10-EI1	15,374	8	62	70
Kaflia	AP-B10-EI2	None	-	-	-
Kinak	AP-B10-EI3	8,648	12	8	20
Amalik	AP-B10-EI4	8,680	17	9	26
Takli	AP-B10-EI5	13,144	19	30	49
KEFJ					
Aialik	KP-B5-EI1	7,535	6	12	18
McCarty	KP-B5-EI2	11,428	9	23	32
Nuka Bay	KP-B5-EI3	18,550	5	56	61
Nuka Passage	KP-B5-EI4	19,760	30	32	62
Harris	KP-B5-EI5	19,918	15	52	67

Table 11. Estimates of cover by eelgrass from three replicate surveys conducted over an area of approximately one half of the Aialik site in 2008.

Replicate number		% observations sparse	% observations dense	% with observations eelgrass present (total)
1		4	16	20
2		3	25	28
3		5	24	29
Mean		4	22	26
Std		0.6	4.8	4.4
CV		15	22	17
90% CI		3.5 - 4.5	13.5-20.5	15.8-24.2

The three replicate samples made over approximately half of the site at Aialik had percentages of observations with eelgrass present ranging from 20 to 29% (Table 11). The mean of the three replicates was 26% with a coefficient of variation of 17%. The 90% confidence interval for the total observations with eelgrass present was 15.8% to 24.2%.

Discussion

Data from our three replicate surveys at Aialik Bay suggest that the methods employed provided reasonable precision with a CV of 17%. Although further evaluation of inter-annual variation in cover by eelgrass is needed, these data suggest we will have a reasonable chance of detecting changes in eelgrass cover that are ecologically relevant (on the order of 25% or greater, Dean and Bodkin 2009) and the goal of our sampling is to detect levels of change that are on this order.

Recommendations

Annual sampling is recommended in the future. However, acquisition of high-resolution aerial photography continues to be a goal of this program to monitor larger scale changes in eelgrass beds over time.

Winter Marine Bird Survey in KEFJ

Marine birds are predators near the top of marine nearshore food webs. They are long-lived, conspicuous, abundant, widespread members of the marine ecosystem and are sensitive to change. Because of these characteristics marine birds are good indicators of change in the marine ecosystem. Many studies have documented that their behavior, diets, productivity, and survival change when environmental conditions change either as a result of human induced (Irons et al. 2000) or natural (Springer 1998) causes. Public concern exists for the welfare of seabirds because they are affected by human activities like oil pollution and commercial fishing.

The purpose of winter marine bird surveys is to characterize the density, distribution and species composition of marine birds within the SWAN parks during the winter. Only one late winter survey had been conducted in KEFJ prior to 2008 - a survey before and after oil reached KEFJ (Exxon- Valdez oil spill) in 1989 (Vequist and Nishimoto 1990). Additional late winter baseline data did not exist prior to this survey.

Methods

Standardized surveys of marine birds and mammals were conducted in KEFJ in March, 2008. Counts of birds were made along 45 transects. Thirty-eight of these were nearshore and seven were offshore (at least 500 m from shore, generally running perpendicular to the shoreline). Transect lengths ranged from 1.0 km to 15.1 km and averaged 5.5 km. Nearshore transects surveyed represent approximately 19% of the 770 km of shoreline within KEFJ. Detailed descriptions of methods and procedures can be found in the Marine Bird and Mammal Survey SOP (Dean and Bodkin 2006). The methods used to survey marine birds in the winter are the same as those methods employed during summer skiff-based surveys of marine birds and mammals. Densities were calculated using weighted averages by transect length.

Results

The most common birds observed on the nearshore transects were the harlequin duck (17.1/km^2, se=1.74), and the Barrow's goldeneye (15.33/km^2, se=5.43, Table 12). The most common birds observed on the offshore transects were the common murre (28.22/km^2, se=22.44) and the marbled murrelet (5.79/km^2, se=3.85, Table 13). Harbor seals had the highest density of the marine mammals at 4.92/km^2 (se=2.55), followed by sea otters with a density of 2.50/km^2 (se=0.46), including pups (Tables 12 and 13).

Table 12. Nearshore statistics from marine bird surveys conducted during March of 2008 in KEFJ. Species highlighted in yellow are species of interest for trend analysis.

Species	# of groups observed	Min	Max	Sum	Average density (#/km^2)	SE
Bald eagle (*Haliaeetus leucocephalus*)	58	1	2	68	1.91	0.23
Barrow's goldeneye *(Bucephala islandica)*	50	1	100	447	15.33	5.43
Black-billed magpie *(Pica hundsonia)*	5	1	1	5	0.13	0.06
Black-legged kittiwake (*Rissa tridactyla*)	2	1	1	2	0.05	0.03
Black oystercatcher (*Haematopus bachmani*)	2	1	1	2	0.06	0.05
Black scoter *(Melanitta nigra)*	4	1	30	46	0.88	0.52
Bufflehead *(Bucephala albeola)*	13	1	12	58	1.23	0.58
Canada goose *(Branta canadensis)*	1	5	5	5	0.08	0.07
Common goldeneye *(Bucephala clangula)*	9	1	8	30	0.57	0.29
Common loon *(Gavia immer)*	20	1	2	25	0.75	0.19
Common merganser (*Mergus merganser*)	19	1	10	42	1.42	0.49
Common murre (*Uria aalge*)	10	1	5	15	0.45	0.18
Common raven *(Corvus corax)*	3	1	2	4	0.10	0.06
Double-crested cormorant (*Phalacrocorax auritus*)	18	1	10	36	1.59	0.79
Glaucous-winged gull (*Larus glaucescens*)	36	1	11	72	2.49	0.74
Harlequin duck (*Histrionicus histrionicus*)	195	1	14	606	17.70	1.74
Horned grebe (*Podiceps auritus*)	50	1	4	69	2.07	0.48
Kittlitz's murrelet (*Brachyramphus brevirostris*)	6	1	2	7	0.19	0.11
Long-tailed duck (*Clagula hyemalis*)	4	1	2	5	0.15	0.07
Mallard (*Anas platyrhynchos*)	6	1	15	26	0.66	0.42
Marbled murrelet (*Brachyramphus marmoratus*)	27	1	4	41	1.20	0.33
Mew gull (*Larus canus*)	4	1	3	6	0.09	0.06
Northern crow (*Corvus caurinus*)	10	1	13	56	1.62	0.61
Northern goshawk *(Accipter gentilis)*	1	1	1	1	0.02	0.01
Pacific loon (*Gavia pacifica*)	1	6	6	6	0.16	0.15
Pelagic cormorant (*Phalacrocorax pelagicus*)	169	1	22	349	11.77	1.91
Pigeon guillemot (*Cepphus columba*)	9	1	3	14	0.39	0.18
Red-breasted merganser (*Mergus serrator*)	1	3	3	3	0.05	0.04
Red-faced cormorant (*Phalacrocorax urile*)	25	1	48	296	8.75	4.89
Red-necked grebe (*Podiceps grisegena*)	5	1	1	5	0.14	0.07
Rock sandpiper (*Calidris ptilocnemis*)	1	80	80	80	2.08	1.91
Surf scoter (*Melanitta perspicillata*)	27	1	50	215	5.87	2.20

Unid. cormorant (*Phalacrocoracidae sp.*)	29	1	30	95	5.13	2.33
Unid. duck (*Anatidae sp.*)	2	1	1	2	0.05	0.03
Unid. goldeneye *(Bucephala sp.)*	10	1	40	154	2.81	1.26
Unid. grebe *(Podiceps sp.)*	1	1	1	1	0.03	0.03
Unid. gull (*Laridae sp.*)	14	1	2	13	0.40	0.11
Unid. merganser (*Mergus sp.*)	8	1	10	23	0.57	0.29
Unid. murrelet (*Brachyramphus sp.*)	6	1	2	8	0.26	0.11
Unid. scoter (*Melanitta sp.*)	2	2	7	9	0.27	0.20
Unid. shorebird (*Scolopacidae sp.*)	1	50	50	50	1.40	1.29
White-winged scoter (*Melanitta fusca*)	1	1	1	1	0.03	0.03
Harbor seal (*Phoca vitulina*)	53	1	81	218	5.78	2.77
River otter (*Lontra canadensis*)	3	1	1	3	0.08	0.05
Sea otter (adult) (*Enhydra lutris*)	72	1	2	80	2.31	0.41
Sea otter (pup) (*Enhydra lutris*)	5	1	1	5	0.12	0.06
Steller sea lion (*Eumetopias jubatus*)	9	1	8	20	0.95	0.60
Unid. whale *(Cetacean sp.)*	1	2	2	2	0.16	0.15
Mountain goat (*Oreamnos americanus*)	2	1	3	4	0.11	0.10
Coyote *(Canis latrans)*	1	1	1	1	0.03	0.03

Table 13. Offshore statistics from marine bird surveys conducted during March of 2008 in KEFJ. Species highlighted in yellow are species of interest for trend analysis.

Species	# of groups observed	Min	Max	Sum	Average density (#/km^2)	SE
Black scoter *(Melanitta nigra)*	1	1	1	1	0.24	0.24
Common goldeneye *(Bucephala clangula)*	1	1	1	1	0.24	0.24
Common loon *(Gavia immer)*	1	1	1	1	0.19	0.19
Common merganser (*Mergus merganser*)	1	1	1	1	0.24	0.24
Common murre (*Uria aalge*)	15	1	80	123	28.22	22.44
Common raven *(Corvus corax)*	1	2	2	2	0.44	0.44
Glaucous-winged gull (*Larus glaucescens*)	7	1	2	10	2.04	1.11
Harlequin duck (*Histrionicus histrionicus*)	3	2	6	14	2.50	2.08
Herring gull (*Larus argentatus*)	1	1	1	1	0.19	0.19
Horned grebe (*Podiceps auritus*)	1	1	1	1	0.29	0.29
Marbled murrelet (*Brachyramphus marmoratus*)	9	1	8	24	5.79	3.85
Mew gull (*Larus canus*)	2	1	1	2	0.48	0.48
Pacific loon (*Gavia pacifica*)	1	7	7	7	2.69	2.69
Pelagic cormorant (*Phalacrocorax pelagicus*)	1	1	1	1	0.24	0.24
Rock sandpiper (*Calidris ptilocnemis*)	1	1	1	1	0.24	0.24
Unid. cormorant (*Phalacrocoracidae sp.*)	5	1	2	6	1.26	0.38
Unid. duck (*Anatidae sp.*)	2	5	7	12	2.46	2.11
Unid. gull (*Laridae sp.*)	4	1	1	4	1.06	0.55
Unid. murre (*Uria sp.*)	1	1	1	1	0.19	0.19
Unid. shorebird (*Scolopacidae sp.*)	1	1	1	1	0.24	0.24
Harbor seal (*Phoca vitulina*)	1	1	1	1	0.24	0.24
Sea otter (adult) (*Enhydra lutris*)	8	1	2	11	2.60	1.43
Sea otter (pup) (*Enhydra lutris*)	1	1	1	1	0.29	0.29
Steller sea lion (*Eumetopias jubatus*)	3	1	2	5	1.11	0.76

Discussion

Gull densities within KEFJ in the winter were lower than summer densities, whereas sea duck densities were comparably higher in the winter than summer. For example, the 2008 summer nearshore density of Glaucous-winged gulls was 116.61/km^2 (se=36.65) whereas nearshore winter density was only 2.49/km^2 (se=0.74). The converse is true for Barrow's goldeneye which had a 2008 nearshore summer density of 1.61/km^2 (se=0.96) and a nearshore winter density of 15.33/km^2 (se=5.43). The distribution of these birds is also quite different. Gulls tended to use offshore, exposed rocky areas, typically where colonies were established in KEFJ. Over-

wintering sea ducks, in particular goldeneye spp., tended to be observed on transects considered to be in protected areas (less exposure to weather-related events such as storms coming in from the Gulf of Alaska, swell, southerly winds) of the park.

Shoreline skiff surveys provide an initial description of the species composition, distribution and relative abundance of the winter marine bird and mammal fauna that occur in the nearshore waters of KEFJ. Because we are primarily focusing our efforts within a 200 m strip contiguous with the shoreline, some species that occupy shallow nearshore habitats >200 m offshore may be underrepresented.

Recommendations

Based on preliminary analysis of three years of summer marine bird survey data from KATM (see Three Year Analysis, Marine Birds section), as well as the distribution of the winter birds that we observed in KEFJ in 2008, future winter survey efforts should be reallocated to appropriate habitat with an increased emphasis on overwintering sea duck habitats, such as bays and lagoons. Winter surveys provide estimates of observed density for those species that use the Gulf of Alaska as over wintering habitat as well as to provide a winter perspective on the distribution of resident species. The data derived from these transects will increase our ability to draw inference between the intertidal algae and invertebrate data and those marine bird and mammals that prey upon them.

Sea Otter Aerial Survey in KATM

Because sea otters commonly occur outside the dimensions of the skiff-based shoreline marine bird and mammal surveys, and because detection is not estimated during the skiff-based surveys, we conduct sightability corrected aerial surveys to estimate sea otter abundance within each Park. Aerial surveys were planned for KATM and KEFJ in 2007 but completed only in KEFJ (Bodkin et al. 2008) due to limited aircraft availability. Here we report on the aerial survey conducted at KATM in 2008.

Methods

The survey follows protocols described in detail in Bodkin and Udevitz (1999) and are summarized below. The survey is conducted from a small, single engine, float equipped aircraft with the pilot and observer able to observe out each side of the aircraft. The airplane is flown at a speed of 100 kph (60 mph) and at an elevation of 91 m (300 ft). The survey design consists of systematic sampling of 400 m wide transects that are uniformly placed throughout the survey area. Selection and sampling of transects is proportional to expected sea otter abundance with most survey effort taking place over waters less than 40 m in depth where higher densities of sea otters are generally observed. The remaining survey effort is over deeper waters (40-100 m depth) where lower densities are generally observed (Figure 14). Intensive searches are periodically conducted within transects to estimate the proportion of sea otters not detected on strips or transects. Strip counts are adjusted for the area not surveyed and by a detection correction factor to obtain an adjusted population size estimate. Groups larger than about 20 individuals are circled until a complete count is obtained and are treated as a separate stratum, uncorrected in the analysis.

In 2008, we surveyed 1,450 km^2 of sea otter habitat between 18 and 22 June. A total of 252 transects representing 939 linear km in the shallow water and deep water strata were surveyed (Figure 14).

Results

In 2008, 98% of all sea otters were observed on high density transects (depths of 40 m or less). We observed 821 sea otters in 13 large groups at KATM. The estimated detection probability along transects was 0.81 resulting in a correction factor of 1.24 and a total estimated population size of 7,095 sea otters (se = 922). The density of sea otters at KATM across all habitats sampled was 4.89 km^2 (Table 14, Figure 15). Complete counts are made of all large groups of otter (>30 animals). Detection correction factors are not applied to complete counts.

Table 14. Summary of information on KATM sea otter aerial survey in June 2008.

Region	Stratum	Counts	Correction Factor	Population size	SE	Proportional SE	Density #/km^2
Katmai NP	High	1120	1.24	4316	399	0.09	4.38
	Low	23	1.24	225	97	0.43	0.48
	Complete counts	821	NA	2554	825	0.32	2.59
	Total	**1964**		**7095**	**922**	**0.13**	**4.89**

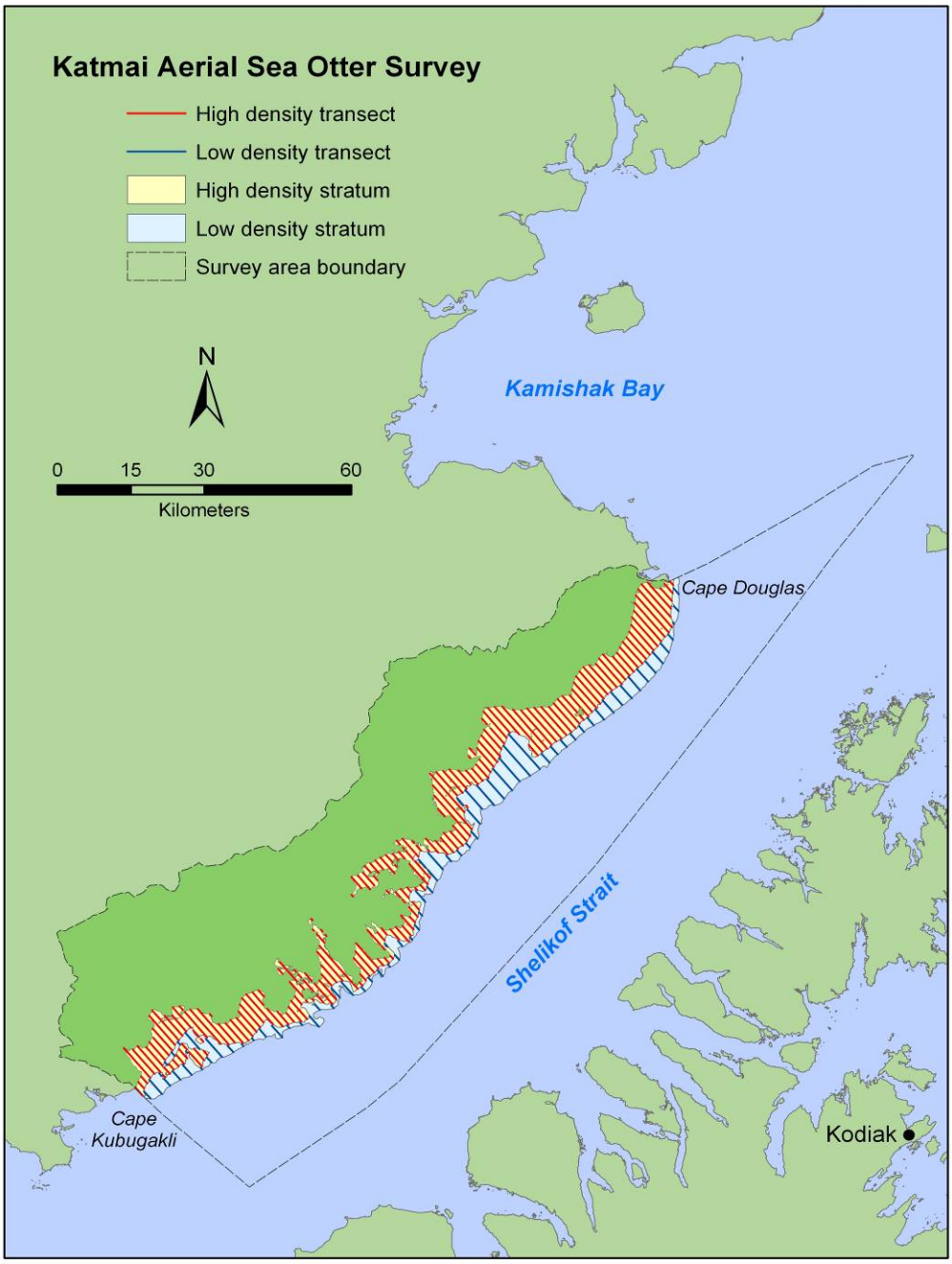


Figure 14. Sampling transect locations for high density, shallow water (less than 40 m, in orange) and low density, deeper water (40 m to 100 m in depth, in blue) strata used in the aerial survey of sea otter abundance at KATM in 2008.

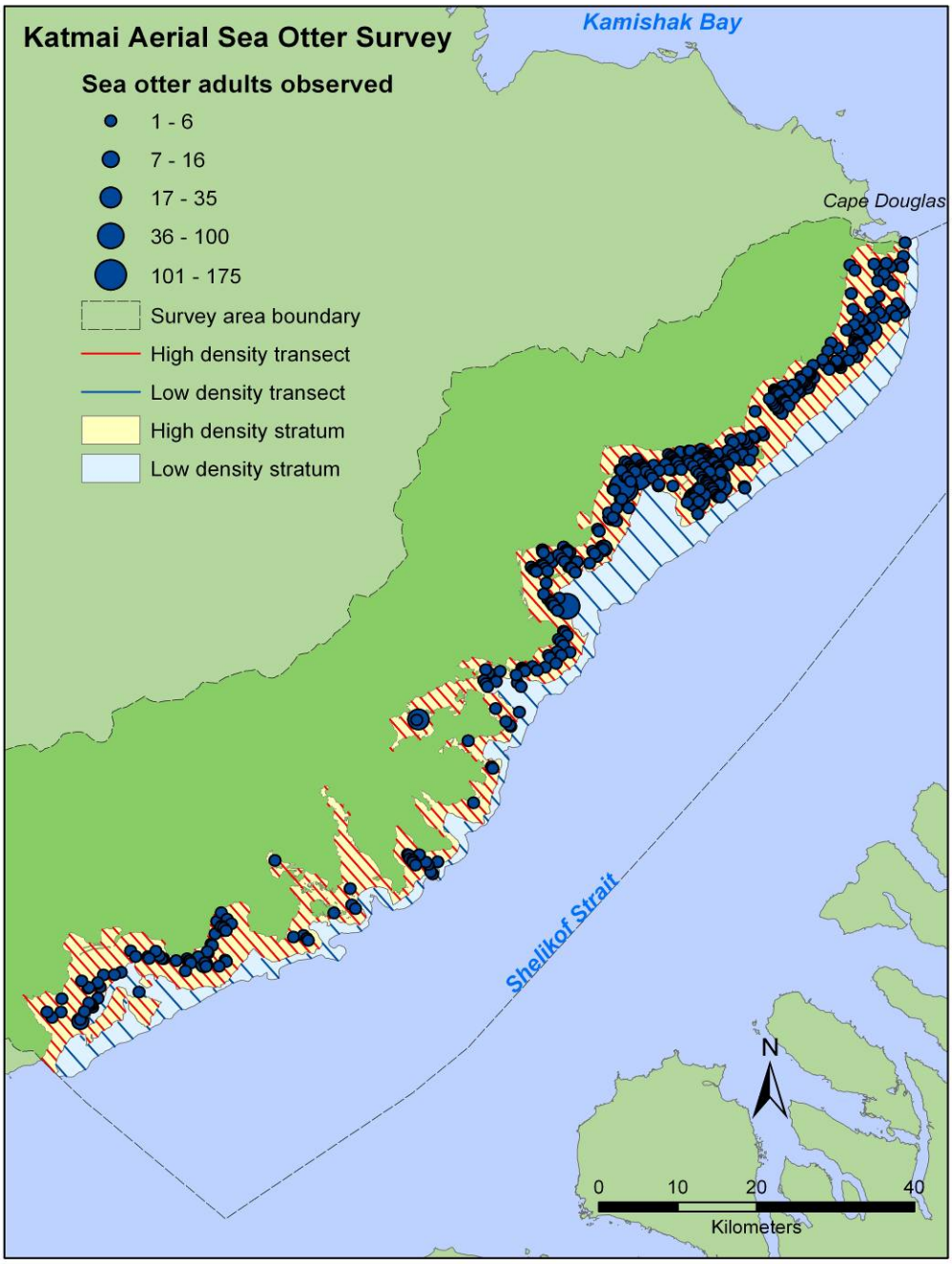


Figure 15. Distribution and relative abundance of sea otters at KATM in 2008.

Discussion

This is the first systematic survey of the KATM sea otter population designed to estimate population size so we are unable to compare 2008 abundance with prior surveys. However, there are unpublished reports of counts of sea otters along the KATM coast that provide some historic perspective on the process of recovery of sea otters following their extirpation from most of their range during the commercial fur harvest period that ended in 1911 (Kenyon 1969). The first report of sea otters along the KATM coast are from 1965 when 102 individuals were observed by Karl Kenyon in the region of Douglas reef, near Cape Douglas (Goatcher 1994). Subsequent reports include maximum counts of 443 in June of 1971 near Shakun Is. south of Douglas reef (Prasil 1971), and Goatcher (1994) reported 400-600 sea otters along the KATM coast in 1989. The origin of the initial recolonization of the KATM coast by sea otters is unknown, but most probably resulted from the Kodiak Archipelago, the nearest population known to have survived the commercial fur harvest period.

The sea otter population that inhabits nearshore waters of KATM in 2008 occurs at a high density of nearly 5 individuals per km^2. This is substantially higher than the approximate density of 1 individual per km^2 observed elsewhere in the Gulf of Alaska (Bodkin et al. 2008, Bodkin and Udevitz 1999) where populations are thought to be near equilibrium densities. The high density and number of large groups encountered (13) with an average size of 61 and a maximum of 175 individuals is consistent with a population increasing in abundance and possibly above long-term equilibrium density.

The KATM sea otter population occurs within the geographic bounds of the Southwest Alaska stock of sea otters (Gorbics and Bodkin 2001) that extends from Cook Inlet to Attu Island in the Western Aleutians. In 2005 this stock was listed as Threatened under the Endangered Species Act (FWS 2005), largely as a result of declines observed in the Aleutian Archipelago and both north and south of the Alaska Peninsula (Doroff et al. 2003). The high density of sea otters we found at KATM strongly suggests that this region currently lies outside the area of decline and that the eastern extent of the decline lies west of KATM. Research underway supported by the North Pacific Research Board and the US Geological Survey, is designed to delineate the eastern boundary of this decline and the similarity of cause within the range of decline (Estes and Bodkin 2007). As part of this research additional data within the KATM coast on sea otter diet, abundance, survival, health and benthic habitats and invertebrate populations are being gathered and will be included in future NPS reports.

Recommendations

We recommend the continuation of aerial surveys to calculate sea otter abundance in all SWAN parks. Surveys are to be conducted every 2 – 3 years for each park.

Three Year Analysis

In cases of metrics that have three years of data (intertidal invertebrates and algae; marine bird surveys; black oystercatcher diet and productivity; and sea otter diet), coefficients of variation were calculated to look at within year and among year variation. These calculations will be used to determine if sampling effort is sufficient enough to detect biologically and ecologically significant trends for each vital sign.

Intertidal Invertebrates and Algae

Intertidal invertebrate and algal communities provide an important source of production; are an important conduit of energy, nutrients, and pollutants between terrestrial and marine environments; provide resources for subsistence, sport, and commercial harvests; and are important for recreational activities such as wildlife viewing and fishing. The intertidal is particularly susceptible to human disturbance including oil spills; trampling by recreational visitors; harvesting activities; pollutants from terrestrial, airborne and marine sources; and shoreline development. Changes in the structure of the intertidal community serve as valuable indicators of disturbance, both natural (e.g. Dayton 1971, Sousa 1979) and human induced (e.g. Barry et al. 1995; Lewis 1996, Keough and Quinn 1998, Jamieson et al. 1998; Shiel and Taylor 1999; Sagarin et al. 1999; Peterson et al. 2001, 2003).

Intertidal invertebrates and algae (including intertidal kelps) were sampled annually at KATM from 2006 through 2008, and at KEFJ in 2008. Sampling of intertidal invertebrates and algae at these sites is designed to detect changes in these communities over time as part of the SWAN Vital Signs Monitoring program. The specific objectives of this sampling on rocky shores are to assess changes in: 1) the relative abundance of algae, sessile invertebrates, and motile invertebrates in the intertidal zone, 2) the diversity of algae and invertebrates 3) the size distribution of limpets (*Lottia persona*) and mussels (*Mytilus trossulus*), and 4) the concentration of contaminants in mussel tissue, and temperature (either sea or air depending on tidal stage). In this section, we focus on those metrics where we have data from the three years of sampling at five rocky intertidal sites in KATM. The purpose is to examine trends in several key metrics and to determine if the sampling protocols used to measure these provide estimates that can be used to detect ecologically relevant changes in long-term monitoring. The metrics to be examined are: 1) abundance estimates for dominant taxa of sessile invertebrates and algae, 2) measures of community dynamics including species richness, and rates of extinction, colonization, and species turnover, and 3) size distributions of the limpet *Lottia persona*. Contaminant and temperature data are reported in other sections of this report.

Methods

Sampling was conducted at five sites in sheltered rocky habitats within KATM annually from 2006 through 2008 (Figure 16). These sites were selected using a GRTS sampling protocol (Stevens and Olsen 2004) designed to provide a random, spatially balanced distribution.

Figure 16. Locations of rocky intertidal sites sampled in KATM 2007through 2008.

Detailed descriptions of the methods used to sample intertidal algae and invertebrates are available in Dean and Bodkin 2008. The following is a general description of the methods employed. Sampling of abundance and species composition of algae and invertebrates was conducted along 50-m (in 2007 and 2008) to 100-m long (in 2006) transects at each site. These ran parallel to the shoreline and originated at permanent markers placed at 0.5 m and 1.5 m tidal elevations respectively. The percent cover of algae, percent cover of sessile invertebrates, and number of individuals of motile invertebrates were estimated within 12 evenly spaced ¼ m^2 quadrats placed along transects. Quadrats were placed at a random start points and at equally spaced intervals thereafter. In addition, a minimum of 100 individual limpets (*Lottia persona*) were measured at each site for estimation of size distributions.

The analyses presented here focuses on estimates of abundance of dominant taxa at each tidal elevation, community dynamics measures, and on size distributions of limpets. The dominant taxa include barnacles (*Balanus spp., Semibalanus spp.* and *Chthamalus dalli*), mussels (*Mytilus trossulus*), and three algal taxa (*Fucus distichus, Alaria marginata*, and *Neorhodomela spp.*). Means, coefficients of variation, and 90% confidence intervals are reported for each site in each year and for all KATM sites in a given year. Community dynamics measures include estimates of species richness for each site and year, and rates of local (within site) extinction, colonization, and turnover for each site over each successive two-year period. The community dynamics measures were calculated using the COMDYN software package (Hines et al. 1999) as described by Nichols et al. (1998). The estimates and 95% confidence intervals are presented along with goodness-of-fit statistics for the underlying models. Mean sizes (shell length) and 90% confidence intervals are given for limpets.

Results

The intertidal communities on sheltered rocky shores in KATM are typical of those found elsewhere in the Gulf of Alaska (Haven 1971; Feder and Kaiser 1980; O'Clair and Zimmerman 1986; Highsmith et al. 1994, 1996) and are characterized by the algae *Fucus distichus, Alaria marginata*, and *Neorhodomela* spp) and barnacles in the lower intertidal (0.5 m) and by *Fucus*, barnacles, and mussels (*Mytilus trossulus*) in the mid intertidal zone (1.5 m) (Table 15 and Appendix B). Each of these dominants occupied greater than 10% cover on average at each tidal elevation respectively. Slightly more than 10% of the substrate was bare at both elevations.

Means and coefficients of variation (CVs) for these dominant species at each site and year are given in Appendix B. CVs ranged widely among sites and year for each species, but generally were lowest for barnacles and highest for *Neorhodomela* spp. and bare substrate. Median CVs ranged from 42 to 135% (Table 15). These values suggest that we will have a reasonable probability of detecting changes on the order of a 50% reduction or a doubling in mean percent cover over time.

Table 15. Mean percent cover of dominant taxa of sessile invertebrates and algae (those occupying more than 10% cover) and median coefficients of variation in the lower and mid intertidal zone on sheltered rocky shorelines in KATM from 2006 through 2008.

	Low		Mid	
	Mean	CV	Mean	CV
Barnacles	32	69	56	42
Fucus distichus	15	111	35	71
Alaria marginata	29	94	-	-
Neorhodomela spp.	11	135	-	-
Mytilus trossulus	-	-	12	115
Bare substrate	11	132	13	117

Trends in abundance for dominant taxa from 2006 to 2008 are given in Appendix B. While there are clearly insufficient data to currently detect long-term trends, several short-term changes are suggested (as indicated by the lack of overlap in 90% confidence intervals for 2006 and 2008). In the lower intertidal, mean percent cover of *Alaria marginata* at all KATM sites increased from 14 to 43% (Figure 17) and increases were noted at four of the five sites sampled (Appendix B). In the mid intertidal, cover by *Mytilus trossulus* increased from 5 to 18% and cover by barnacles decreased from 59 to 42% (Figure 18). For both *Mytilus* and barnacles, the short-term changes were observed at three of five sites (Appendix B).

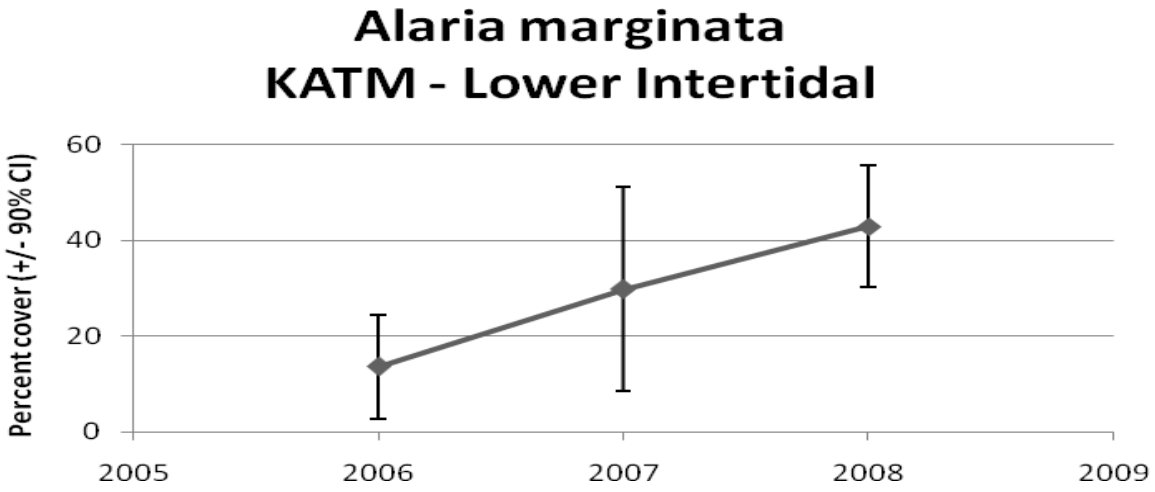


Figure 17. Mean percent cover of *Alaria marginata* in the lower intertidal at KATM 2006-2008.

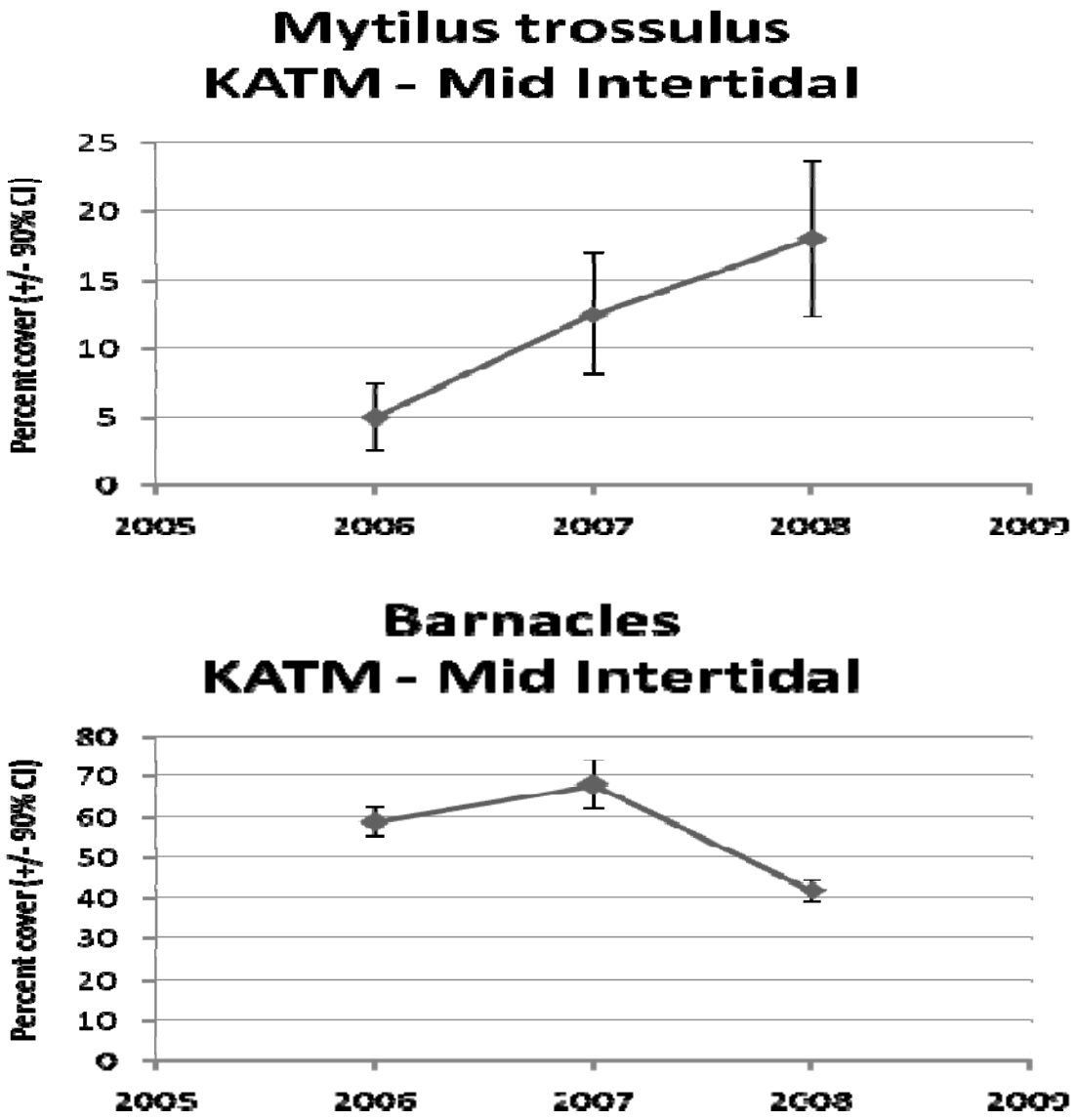


Figure 18. Mean percent cover of *Mytilus trossulus* and barnacles in the mid intertidal at KATM during 2006-2008.

Metrics used to estimate changes in community attributes based on the presence or absence of various species (including estimated probabilities of detection, number of species, and rates of local colonization, extinction, and turnover) are summarized in Table 16. Goodness-of-fit tests suggest that there was a reasonable fit to underlying models of distribution for sessile species in the lower intertidal zone, but not for sessile species in the mid intertidal or for motile invertebrates at either tidal elevation. The lack of fit indicates that estimates for the various metrics may be unreliable and as a result, we will not discuss results for motile species of sessile species in the mid intertidal further.

Table 16. Community dynamics metrics for sessile species in the intertidal at KATM. p = detection probability, N=estimated number of species, Phi = complement of extinction probability, Gamma = complement of the turnover rate, Lambda = rate of change in species richness, and B = number of colonizing species. GOF = probabilities associated with goodness of fit tests for observed number of species and frequencies in each sample (N), for test of unequal detection limits based on observed frequencies (p), and for observed number of species and frequencies in subsets of species observed in both samples(subsets A and B).

Sessile invertebrates and algae - lower intertidal

		2006				2007				2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
p	0.90	0.78	1.00		0.88	0.62	1.00		0.89	0.63	1.00
N	38.95	35.00	44.88		42.57	37.00	51.85		37.47	33.00	50.54
GOF (N)		0.67				0.10				0.41	

		2006-2007				2007-2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
Phi	0.90	0.73	1.00		0.85	0.69	1.00
Gamma	0.84	0.66	1.00		0.97	0.81	1.00
Lambda	1.10	0.88	1.43		0.89	0.68	1.24
B	7.73	0.00	18.33		4.27	0.00	14.61
GOF (p)		0.89				0.15	
GOF (subset A)		0.10				0.49	
GOF (subset B)		0.52				0.49	

Sessile invertebrates and algae - mid intertidal

		2006				2007				2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
p	0.86	0.61	1.00		0.84	0.61	1.00		0.86	0.70	1.00
N	38.66	33.00	53.52		35.23	29.00	46.82		43.24	37.00	52.55
GOF (N)		0.16				0.08				0.01	

		2006-2007				2007-2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
Phi	0.77	0.55	1.00		0.92	0.72	1.00
Gamma	0.85	0.67	1.00		0.79	0.59	1.00
Lambda	0.92	0.65	1.30		1.24	0.83	1.62
B	6.30	0.00	24.46		10.93	0.00	25.36
GOF (p)		0.35				0.65	
GOF (subset A)		0.21				0.14	
GOF (subset B)		0.66				0.07	

Table 17. Community dynamics metrics for motile species in the intertidal at KATM where p = detection probability, N=estimated number of species, Phi = complement of extinction probability, Gamma = complement of the turnover rate, Lambda = rate of change in species richness, and B = number of colonizing species. GOF = probabilities associated with goodness-of-fit tests for observed number of species and frequencies in each sample (N), for test of unequal detection limits based on observed frequencies (p), and for observed number of species and frequencies in subsets of species observed in both samples(subsets A and B).

Motile invertebrates - lower intertidal

		2006				2007				2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
p	0.74	0.41	1.00		0.88	0.62	1.00		0.56	0.37	1.00
N	22.82	16.00	38.28		19.55	17.00	26.53		33.97	18.00	48.71
GOF (N)		0.16				0.08				0.01	

		2006-2007				2007-2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
Phi	0.90	0.61	1.00		0.89	0.53	1.00

Gamma	0.89	0.64	1.00		0.77	0.42	1.00
Lambda	0.91	0.50	1.46		1.74	0.97	2.60
B	1.84	0.00	9.90		16.38	0.29	32.78
GOF (p)		0.59				0.65	
GOF (subset A)		0.04				0.23	
GOF (subset B)		0.02				0.12	

Motile invertebrates - mid intertidal

		2006				2007				2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
p	0.75	0.39	1.00		0.88	0.57	1.00		0.85	0.52	1.00
N	25.71	17.00	43.28		14.60	13.00	22.70		15.74	13.00	24.24
GOF (N)		<0.01				0.13				0.98	

		2006-2007				2007-2008	
	Mean	Lower 95% CL	Upper 95% CL		Mean	Lower 95% CL	Upper 95% CL
Phi	0.82	0.52	1.00		0.93	0.70	1.00
Gamma	0.96	0.76	1.00		0.89	0.63	1.00
Lambda	0.62	0.35	1.02		1.06	0.67	1.75
B	0.39	0.00	4.89		2.25	0.00	10.89
GOF (p)		0.08				0.61	
GOF (subset A)		0.08				0.99	
GOF (subset B)		<0.01				0.12	

For sessile species of invertebrates and algae, estimated probabilities of detection of species ranged from 0.88 to 0.90, with the lower 95% confidence limits ranging from 0.62-0.78. Means of the estimated number of sessile species in the lower intertidal ranged from 37.5 to 42.6 and there was no apparent short-term change in number of species over time (Figure 19). Confidence intervals (95%) suggest that we should be able to detect changes in the number of species that are on the order of 50%. We should also be able to detect increases in extinction rate and turnover rate on the order of 50%. Confidence intervals for colonization rates are so high that it is unlikely these can be used to detect changes.

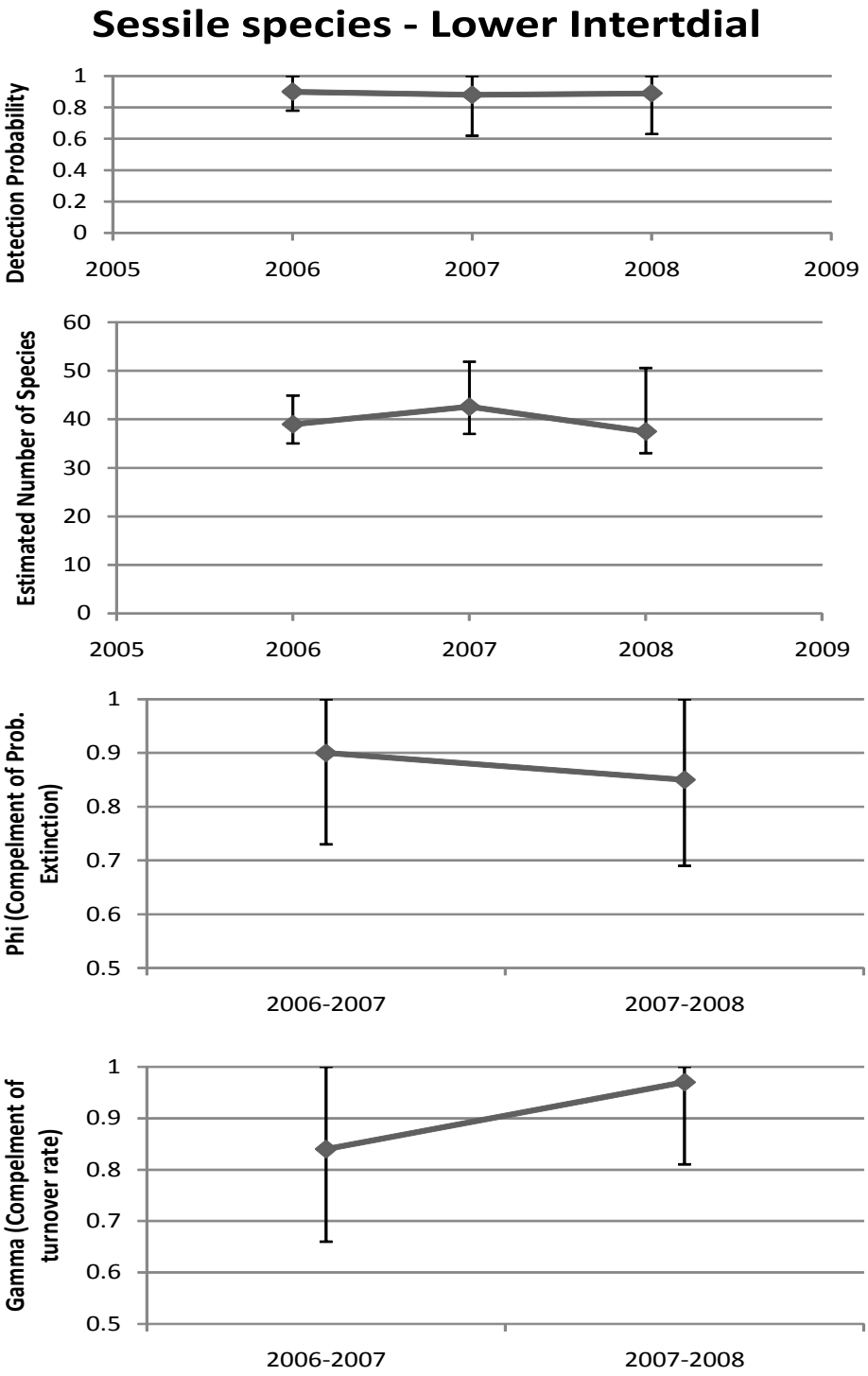


Figure 19. Detection probability, estimated number of species, complement of extinction probability, and complement of the turnover rate for sessile invertebrates and algae in the lower intertidal at KATM from 2006 through 2008.

Mean lengths of limpets (*Lottia persona*) in the upper intertidal zone at KATM ranged from 11.08 to 19.05 mm (Table 17). Coefficients of variation for all sites were less than 28%, suggesting a high probability of detecting changes in mean size that are on the order of 20% or less.

Table 18. Mean lengths (mm) of limpets (Lottia persona) in the upper intertidal at KATM from 2006 through 2008.

Site	Year	n	Mean	STD	CV	Lower 90% CI	Upper 90% CI
Kukak	2006	240	19.05	4.99	26.21	18.52	19.58
Kaflia	2006	240	11.83	3.29	27.79	11.48	12.18
Kinak	2006	260	13.47	3.11	23.08	13.15	13.78
Amalik	2006	266	13.85	2.77	19.98	13.57	14.12
Takli	2006	240	14.06	2.30	16.37	13.82	14.31
KATM		5	14.45	2.72	18.80	12.45	16.45
Kukak	2007	120	17.00	3.87	22.74	16.42	17.58
Kaflia	2007	120	11.08	2.36	21.27	10.73	11.44
Kinak	2007	120	13.66	2.85	20.87	13.23	14.09
Amalik	2007	108	13.14	2.87	21.81	12.69	13.59
Takli	2007	120	12.83	2.84	22.16	12.41	13.26
KATM		5	13.54	2.16	15.96	11.95	15.13
Kukak	2008	100	16.11	3.37	20.93	15.56	16.66
Kaflia	2008	120	11.81	2.18	18.43	11.48	12.14
Kinak	2008	100	14.28	3.27	22.92	13.74	14.82
Amalik	2008	100	13.82	3.14	22.73	13.30	14.34
Takli	2008	120	14.47	2.60	17.98	14.08	14.86
KATM		5	14.10	1.54	10.95	12.96	15.23

At Kukak, the mean size of limpets declined from 19.05 to 16.11 mm between 2006 and 2007 (Figure 20). There were no apparent changes in mean size of limpets over time at other sites or for the KATM region as a whole.

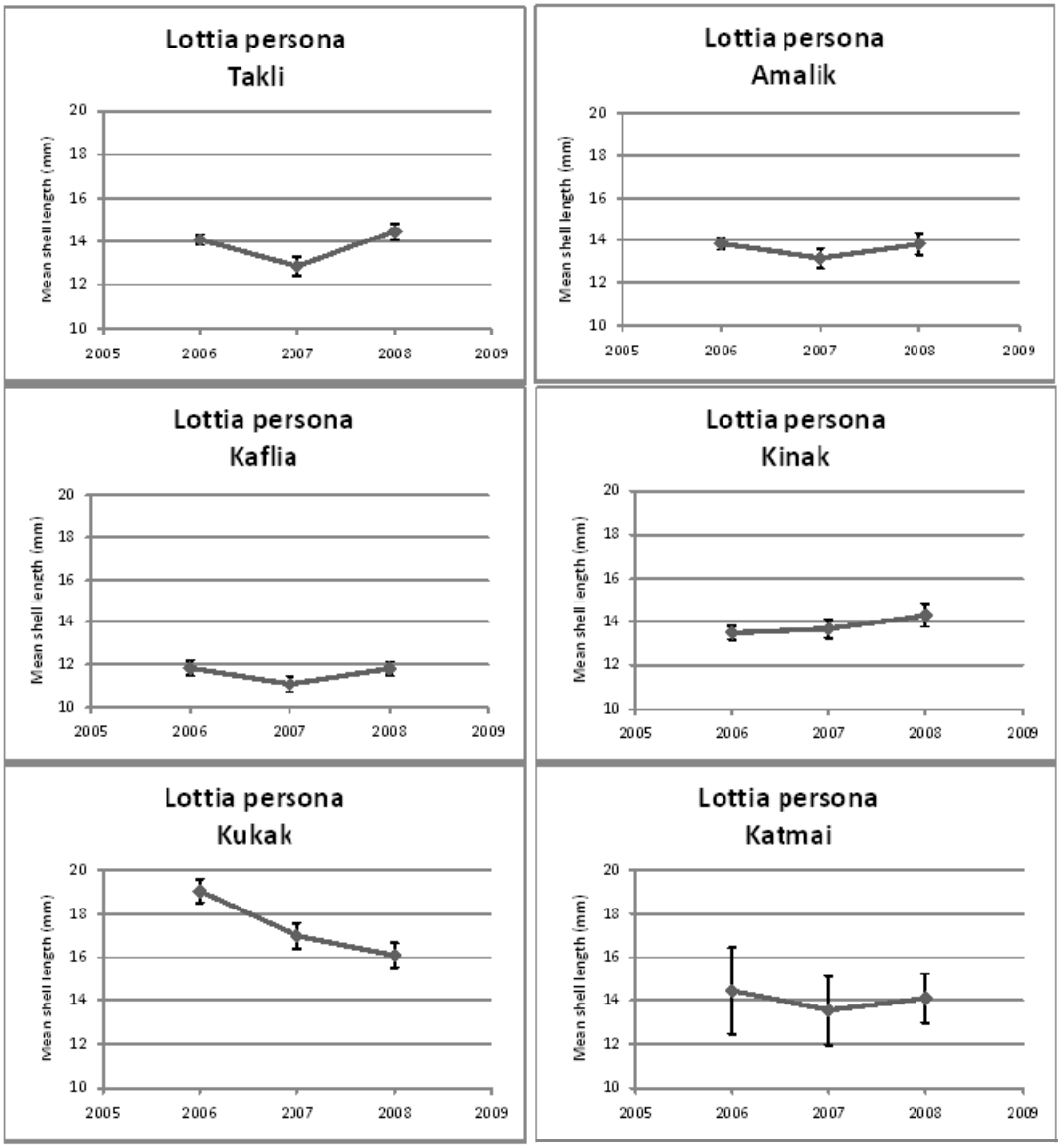


Figure 20. Mean lengths (mm) of *Lottia persona* at KATM from 2006 through 2008.

Discussion

The primary purpose of this section was to evaluate various metrics with respect to our ability to detect ecologically meaningful levels of change in the sheltered rocky intertidal habitats given the sampling program adopted and to suggest possible modifications to our sampling regime. Levels of change that are ecologically important were based on examination of levels of inter-annual variability in what are considered healthy communities and on the levels of changed deemed important in prior studies of changes within the intertidal community (Dean and Bodkin 2009). Eventually (after a sufficient number of annual observations have been obtained), we plan on evaluating trends based on information theoretic trend models selected based on an information-theoretic approach (e.g. Burnham and Anderson 2002, 2004). However, we can make some reasonable judgments as to our ability to detect the levels of change deemed ecologically important based on the data obtained to date. In general, the data collected to date suggest that we will have a reasonable chance of detecting ecologically relevant changes in percent cover of dominant sessile invertebrates and algae in the lower and mid intertidal zone. In fact, we were able to detect some changes (increases in percent cover of *Alaria marginata* in the lower zone, and an increase in benthic invertebrate cover by mussels and decrease in cover by barnacles in the mid intertidal) over the period from 2006 through 2008. Whether these represent long-term trends or normal interannual variation remains to be seen, but confirm our ability to detect meaningful changes should such changes occur. Changes in community metrics, and especially species richness, appear to be useful indicators of change for sessile invertebrates and algae in the lower intertidal but not in the mid intertidal. Community metrics offer little hope of detecting reasonable levels of change for motile invertebrates. Changes in sizes of limpets in the upper intertidal provide a powerful tool for detecting change.

Recommendations

Based on these results, we recommend continued sampling of sessile invertebrates and algae and limpets. However, based on the high degree of variability and lack of power, we recommend discontinuing sampling of smaller motile invertebrates. All other sampling should continue as described here.

Marine Birds

Marine birds and mammals are important constituents of marine ecosystems and are sensitive to variation in marine conditions. Our focus on nearshore marine bird monitoring will be on species that are relatively abundant and trophically linked to the nearshore food web where the kelps and seagrasses contribute substantially to primary productivity and benthic invertebrates such as clams, mussels and snails, and transmit that energy to higher level trophic level fishes, birds and mammals. Species of focus in the nearshore food web include black oystercatchers, cormorants, glaucous-winged gulls, goldeneyes, harlequin ducks, mergansers, pigeon guillemots, and scoters. Because other birds and mammals will be encountered in the course of monitoring nearshore species, observations of all marine birds and mammals are recorded and reported.

The sea ducks and black oystercatcher were selected for focus because of their reliance on habitats and prey associated with nearshore marine communities. These species are top-level consumers of nearshore invertebrates such as mussels, clams, snails, and limpets that are being monitored under the algal and intertidal invertebrate SOP. Because these species are recognized to play important roles as consumers of marine invertebrates (Draulans 1982, Marsh 1986a and b, Meire 1993, Lindberg et al. 1998, Hamilton and Nudds 2003, Lewis et al. 2007), understanding cause(s) of change in abundance over time of these nearshore seabirds will be facilitated through the direct estimates of their prey populations provided through nearshore invertebrate monitoring. Moreover, monitoring trends in abundance of the various guilds of other marine birds (e.g. pigeon guillemots, black-legged kittiwakes, and cormorants) that occupy other food webs or habitats may improve the ability to discriminate among potential causes of change in seabird populations and the nearshore ecosystem. For example, concurrent changes in sea ducks, which forage on nearshore invertebrates, and the pigeon guillemots that forage on small fish, may suggest a common cause(s) of change, one that may be independent of food. Such an approach may provide insights related to competing hypotheses relative to cause of change within or among populations (Petersen et al. 2003). In addition many of these species, including the harlequin duck, Barrow's goldeneye, and black oystercatcher were impacted by the *Exxon Valdez* oil spill, and exhibited protracted recovery periods as a consequence of lingering oil in nearshore habitats in Prince William Sound (Andres 1999, Trust et al. 2000, Esler et al. 2000, Esler et al. 2002). Long-term monitoring of these species at different locations will likely provide increased confidence in assessment of the status of these populations relative to restoration and recovery from the 1989 spill. Additionally, existing data collected using comparable methods are available from other nearshore habitats in the Gulf of Alaska for periods up to 20 years (Irons et al.1988, Irons et al. 2000). Long-term monitoring of these species at different locations will likely provide increased confidence in assessment of the status of these populations relative to restoration and recovery from the 1989 spill.

In this section, we examine three years of summer bird survey data from KATM. The primary focus is on evaluation of methods and a determination of whether we will likely be able to detect ecologically important levels of change given the methods employed.

Methods

Standardized surveys of marine birds were conducted in KATM from 2006-2008 through late June and into early July. Detailed descriptions of methods and procedures can be found in the Marine Bird and Mammal Survey SOP (Dean and Bodkin 2006). Following is a brief review of those methods. Surveys are conducted from small vessels (5-8 m length) that are navigated

along selected sections of coastline that represent independent transects at speeds of 8-12 knots. Transect width is 200 m and two observers searched each side of the vessel out 100 m. All marine birds and mammals within the 200 m transect width that includes 100 m ahead of, behind, and over the vessel are identified and counted. One observer navigates the skiff, and generally surveys the offshore portion of the transect. The second observer counts birds and mammals on the shore side of the survey transect, and a third member of the team is responsible for entering observations into a computer program (dLOG2) designed specifically for these surveys (Dean and Bodkin 2006), and assists in observations. All transects considered in this analysis are run 100 m offshore and parallel to the shoreline.

The survey design consists of a series of transects along shorelines such that a minimum of 20% of the shoreline is surveyed. Transects are systematically selected beginning at a random starting point from the pool of contiguous 2.5-5 km transects that are adjacent to the mainland or islands, plus the lengths of transects that were associated with islands or groups of islands with less than 5 km of shoreline.

Data analysis focuses on nine taxa identified as important to nearshore food webs and as important indicators of change (Dean and Bodkin 2009). Several species were grouped into higher order taxa (e.g., cormorants, mergansers, and scoters) because identification to species within these groups was not always possible. Cormorant species included pelagic, red-faced, and double-crested cormorants. Mergansers included common, and red-breasted. Scoters included surf, black, and white-winged scoters. In this report, we use the three existing years of nearshore survey data to examine within and among year variation in density for each of the species at the spatial scale of the park. This analysis allows us to determine minimum levels of change that we are likely able to detect based on our current sampling design. By comparing these minimum levels to those deemed to be of ecological importance (Dean and Bodkin 2009 Draft protocol) we can evaluate the adequacy of the current sampling design. Coefficients of variation in excess of levels deemed to be ecologically important may indicate a need to alter our sampling design.

Due to inclement weather in 2008, some transects could not be surveyed. Multiple imputation (Rubin 1987) was performed using SAS (SAS Institute, Cary, NC) to provide estimates of missing values.

Coefficients of variation were estimated both without habitat stratification and with transects stratified into several habitat classifications. The later analyses were conducted in an effort to reduce variation among transects and was based on our examination of the distribution patterns of the various taxa which indicated clear preferences for various shoreline types by most species. We grouped the transects into similar habitat types based on the Environmental Sensitivity Index (ESI) data (NOAA 1997). This resulted in a classification of the marine bird transects into three different habitat types: exposed – rocky; exposed – soft; and protected – rocky. Coefficients of variation were compared from grouped and ungrouped habitats to evaluate the potential for minimizing variance and increasing power to detect trends. Power analysis for liner regression (Gerrodette 1993) was used to evaluate levels of change in focal species densities that could be detected over time.

Results

Initial analyses were performed to calculate means, SEs, CIs and CVs for each of the nine taxa for each year without grouping by habitat. These first analyses resulted in CVs well over 0.50 (range of values from: 1.27 to 4.00) for all taxa, therefore confidence intervals for almost all species in all three years encompassed zero, indicating little possibility to detect trends over time at our current sampling intensity. In an attempt to reduce CVs post data collection, subpopulation (domain) analysis was conducted.

When stratified by habitat type, most taxa had CVs from about 0.20 – 0.50 in all three years in one or more specific habitat type (Table 18). The exception was for mergansers that had CVs of greater than 0.50 in most cases. Five of the nine taxa examined (black-legged kittiwakes, black oystercatchers, cormorants, Glaucous-winged gulls, and pigeon guillemots) had highest abundances and lowest CVs in exposed-rocky habitats. Harlequin ducks were found in almost equal abundance in all habitat types with CVs from 0.22-0.45 in exposed and sheltered rocky habitats. Scoters were most abundant and had lowest CVs in exposed soft habitats.

Table 19. Mean densities, SEs, CV and 95% CIs for each species or species group by habitat classification and year. Species highlighted in yellow have CVs ≤ 0.50 with the one exception of black oystercatchers in 2006 having a CV of 0.51.

YEAR	TYPE	Species	Mean density (km^2)	SE	CV	95% CI (+)	95% CI (-)
2006	exposed - rocky	Black-legged kittiwake	124.73	47.85	0.38	218.52	30.94
2007	exposed - rocky	Black-legged kittiwake	92.36	45.89	0.50	182.30	2.42
2008	exposed - rocky	Black-legged kittiwake	11.54	5.27	0.46	21.88	1.20
2006	exposed - soft	Black-legged kittiwake	9.01	3.74	0.42	16.35	1.67
2007	exposed - soft	Black-legged kittiwake	124.03	87.48	0.71	295.49	-47.44
2008	exposed - soft	Black-legged kittiwake	2.00	2.55	1.27	7.00	-2.99
2006	protected - rocky	Black-legged kittiwake	3.02	1.88	0.62	6.70	-0.66
2007	protected - rocky	Black-legged kittiwake	22.59	11.86	0.52	45.83	-0.65
2008	protected - rocky	Black-legged kittiwake	1.69	2.19	1.30	5.98	-2.61
2006	exposed - rocky	Black oystercatcher	3.33	1.70	0.51	6.66	0.00
2007	exposed - rocky	Black oystercatcher	1.96	0.39	0.20	2.74	1.19
2008	exposed - rocky	Black oystercatcher	2.60	0.97	0.37	4.49	0.70
2006	exposed - soft	Black oystercatcher	0.88	0.54	0.61	1.94	-0.17
2007	exposed - soft	Black oystercatcher	2.44	1.48	0.61	5.34	-0.45
2008	exposed - soft	Black oystercatcher	1.92	0.68	0.35	3.25	0.59
2006	protected - rocky	Black oystercatcher	1.12	0.61	0.54	2.31	-0.07
2007	protected - rocky	Black oystercatcher	1.31	0.58	0.44	2.45	0.18
2008	protected - rocky	Black oystercatcher	1.14	0.56	0.49	2.24	0.04
2006	exposed - rocky	Cormorant	39.25	12.24	0.31	63.24	15.26
2007	exposed - rocky	Cormorant	21.79	9.00	0.41	39.43	4.15
2008	exposed - rocky	Cormorant	0.28	0.07	0.25	0.42	0.14
2006	exposed - soft	Cormorant	0.00	0.00		0.00	0.00
2007	exposed - soft	Cormorant	0.03	0.02	0.73	0.06	-0.01
2008	exposed - soft	Cormorant	0.05	0.05	1.03	0.16	-0.05
2006	protected - rocky	Cormorant	0.00	0.00		0.00	0.00
2007	protected - rocky	Cormorant	0.10	0.05	0.50	0.19	0.00
2008	protected - rocky	Cormorant	0.14	0.06	0.42	0.26	0.03
2006	exposed - rocky	Glaucous-winged gull	128.83	33.01	0.26	193.53	64.12
2007	exposed - rocky	Glaucous-winged gull	155.73	40.96	0.26	236.01	75.45
2008	exposed - rocky	Glaucous-winged gull	147.15	50.26	0.34	245.66	48.63
2006	exposed - soft	Glaucous-winged gull	47.36	13.58	0.29	73.98	20.74
2007	exposed - soft	Glaucous-winged gull	109.72	33.73	0.31	175.84	43.61
2008	exposed - soft	Glaucous-winged gull	35.12	27.26	0.78	88.56	-18.32
2006	protected - rocky	Glaucous-winged gull	8.59	5.74	0.67	19.84	-2.66
2007	protected - rocky	Glaucous-winged gull	15.14	8.80	0.58	32.40	-2.11
2008	protected - rocky	Glaucous-winged gull	15.53	17.30	1.11	49.43	-18.37
2006	exposed - rocky	Harlequin duck	16.30	3.73	0.23	23.61	8.99
2007	exposed - rocky	Harlequin duck	35.96	12.23	0.34	59.94	11.98
2008	exposed - rocky	Harlequin duck	25.72	11.49	0.45	48.24	3.19
2006	exposed - soft	Harlequin duck	19.31	5.85	0.30	30.78	7.83
2007	exposed - soft	Harlequin duck	27.31	7.93	0.29	42.85	11.78
2008	exposed - soft	Harlequin duck	50.04	29.59	0.59	108.03	-7.95
2006	protected - rocky	Harlequin duck	14.16	5.45	0.39	24.85	3.47

2007	protected - rocky	Harlequin duck	23.05	5.05	0.22	32.95	13.15
2008	protected - rocky	Harlequin duck	50.19	22.30	0.44	93.91	6.48
2006	exposed - rocky	Merganser	0.17	0.08	0.50	0.33	0.00
2007	exposed - rocky	Merganser	0.34	0.20	0.58	0.73	-0.05
2008	exposed - rocky	Merganser	6.84	2.52	0.37	11.79	1.90
2006	exposed - soft	Merganser	8.26	3.84	0.46	15.78	0.74
2007	exposed - soft	Merganser	4.86	3.27	0.67	11.26	-1.55
2008	exposed - soft	Merganser	2.93	2.54	0.87	7.91	-2.05
2006	protected - rocky	Merganser	0.05	0.03	0.75	0.11	-0.02
2007	protected - rocky	Merganser	2.71	1.47	0.54	5.58	-0.16
2008	protected - rocky	Merganser	12.00	7.34	0.61	26.38	-2.38
2006	exposed - rocky	Pigeon guillemot	12.97	2.86	0.22	18.58	7.36
2007	exposed - rocky	Pigeon guillemot	12.64	4.01	0.32	20.49	4.78
2008	exposed - rocky	Pigeon guillemot	23.07	6.94	0.30	36.69	9.46
2006	exposed - soft	Pigeon guillemot	3.16	2.19	0.69	7.45	-1.13
2007	exposed - soft	Pigeon guillemot	1.08	0.49	0.45	2.03	0.12
2008	exposed - soft	Pigeon guillemot	5.21	3.76	0.72	12.57	-2.15
2006	protected - rocky	Pigeon guillemot	3.70	1.94	0.52	7.50	-0.11
2007	protected - rocky	Pigeon guillemot	3.38	1.35	0.40	6.02	0.74
2008	protected - rocky	Pigeon guillemot	5.52	2.82	0.51	11.04	-0.01
2006	exposed - rocky	Scoter	0.00	0.00		0.00	0.00
2007	exposed - rocky	Scoter	0.23	0.17	0.76	0.57	-0.11
2008	exposed - rocky	Scoter	5.79	2.25	0.39	10.20	1.39
2006	exposed - soft	Scoter	2.28	0.94	0.41	4.11	0.44
2007	exposed - soft	Scoter	0.54	0.25	0.46	1.04	0.05
2008	exposed - soft	Scoter	10.86	4.36	0.40	19.40	2.31
2006	protected - rocky	Scoter	0.26	0.15	0.56	0.55	-0.03
2007	protected - rocky	Scoter	4.71	2.85	0.60	10.29	-0.87
2008	protected - rocky	Scoter	1.75	1.58	0.90	4.84	-1.34

Discussion

Dean and Bodkin (2009) identify ecological important levels of change among most nearshore marine bird species that range from 0.40-0.50. The primary goal in this section was to examine within and among year variation in densities of several nearshore reliant species of marine birds. Initial analyses conducted without grouping by habitat type resulted in high (>.50) CVs and confidence intervals that encompassed zero in almost all cases. These analyses suggest that because of the high variability in abundance between the transects surveyed, it would be unlikely that we could detect the levels of ecologically important change identified by Dean and Bodkin (2009) given our current sampling intensity.

Subpopulation (domain) analysis was suggested as an alternative to potentially reduce variation post data collection. Based on ESI (NOAA 1997) data, differences in exposure and substrate type exist across the transects. We expect to observe individual species in specific nearshore habitat types (exposure, sediment type) based on the ecology of each species. Classification into these specific habitat types or domains reduced the variability of the density estimates and improved the power to detect change. For example, black-legged kittiwakes are colonial cliff face nesters that breed during the summer months (Whittam and Siegel-Causey 1981, Golet et al.

1998). A majority of the black-legged kittiwake survey observations at KATM during the last three years have been along transects classified as exposed, rocky habitat. We would also expect that there may be some habitat types that are less suitable for specific species and that within those habitats we would expect high CVs and poor power to detect change. However, in eight of nine cases where a species was observed in all three habitat types, at least one of the habitat strata resulted in density estimates with CVs ≤0.50, suggesting that stratification by habitat improves the power to detect change. Mergansers were the only group with CVs consistently >0.50. Detecting trends in densities for mergansers may be difficult based on our current survey design and intensity.

A result of conducting subpopulation (domain) analysis post survey is that the original sample size (number of transects) is reduced by grouping the transects into different habitat types. In surveys similar to ours in Glacier Bay, AK, Drew et al. (2008) found that sample size was an important factor in determining CV's. Domain based designs generally have large samples sizes (Lehtonen and Pahkinen 2004), and by grouping each transect by habitat type prior to analysis, we are essentially reducing the sample size of the original survey, possibly increasing the variance. However, in our grouped analysis we detected a decrease in variance, despite reduced sample sizes, that resulted in an improved power to detect change. For all nearshore focal species we expect to detect annual rates of change of ≤ 0.20, at ≥ 0.80 power (alpha = 0.10), over periods of 5-10 years, when transects are stratified prior to analysis (Gerrodette 1993).

Recommendations

We recommend that survey effort currently stay the same until further analysis can be completed. After 2009, we will have an additional year of survey data from KEFJ and will examine these data to suggest what levels of change we can reasonably expect to detect. We will also explore the possibility of re-allocating sampling efforts to specific habitat types (especially exposed rocky habitats) that may enhance our ability to detect trends for most species of interest.

Black Oystercatcher

The black oystercatcher is a common and conspicuous member of the rocky and gravel intertidal marine communities of eastern Pacific shorelines and is completely dependent on nearshore marine habitats for all critical life history components including foraging, breeding, chick-rearing, and resting (Andres and Falxa 1995). During the late spring and summer breeding season pairs establish and defend both nest and forage areas, and these territories and nest sites can persist over many years (Groves 1984, Hazlitt and Butler 2001) with individual life expectancy exceeding 15 years (Andres and Falxa 1995). The diet consists primarily of mussels (*Mytilus* sp.) and a variety of limpets (*Lottia, Acmea*, and *Colisella* sp.) (Andres and Falxa 1995), which are ecologically and culturally important constituents of the intertidal community. The species is considered a Management Indicator Species by the Chugach National Forest and a species of concern nationally (Brown et al. 2001), and regionally (Alaska Shorebird Working Group 2000) and is widely recognized as a species representative of nearshore habitats. Because of their complete reliance on intertidal habitats, their reproductive biology, and foraging ecology, black oystercatchers are particularly amenable to long-term monitoring (Lentfer and Maier 1995, Andres 1998).

As a "keystone" species (Power et al. 1996), the black oystercatcher has a large influence on the structure of intertidal communities that is disproportionate to its abundance. The black oystercatcher receives its recognition as a keystone species through a three-trophic-level cascade initiated by the oystercatcher as a top-level consumer in the nearshore (Marsh 1986a and b, Hahan and Denny 1989, Falxa 1992) whose diet consists largely of gastropod (limpets) and bivalve (mussels) mollusks that are ecologically important in the intertidal community. As a consequence of oystercatcher foraging, large numbers of herbivorous limpets can be removed (Frank 1982, Lindberg et al. 1987), resulting in shifts in limpet species composition and reduced size distribution (Marsh 1986a, Lindberg et al. 1987). Reduced limpet densities and their diminished grazing intensity leads to increased production and survival of algal populations (Marsh 1986a, Meese 1990, Wootton 1992, Lindberg et al. 1998). Additionally, the oystercatcher's diet consists of a large fraction of mussels, an important filter feeding bivalve that provides energy to a wide array of invertebrate, avian, and mammalian predators in the nearshore (Knox 2000, Menge and Branch 2001). Because black oystercatchers bring limpets, mussels and other prey back to its nest to provision chicks (Webster 1941, Frank 1982, Hartwick 1976, Lindberg et al. 1987), collections of those shell remains at nests provides an opportunity to obtain an independent sample of the species composition and size distribution of common and important nearshore invertebrate prey species that are directly estimated under intertidal algal and invertebrate vital signs (Intertidal Invertebrates and Algae section of this report). The collection of black oystercatcher diet and prey data offers a unique perspective into processes structuring nearshore communities (Marsh 1986a and b, Lindberg et al. 1987), including the potential consequences of anticipated increases in human presence and disturbance (Lindberg et al. 1998). Further, contrasting relative abundances and size-class composition of invertebrates collected under two independent protocols should increase our understanding of the processes responsible for change in nearshore ecosystems.

At a global scale, intertidal communities have been impacted by human activities (Liddle 1975, Kingsford et al. 1991, Povery and Keough 1991, Keough et al. 1993, Menge and Branch 2001) and one of the primary capabilities and intents of the nearshore monitoring program is to provide

early detection of change in nearshore communities and to separate human from natural causes of change. Because of the critical nature of intertidal habitats for both breeding and foraging, black oystercatchers are particularly sensitive indicators to disturbances in the nearshore (Lindberg et al. 1998). Specifically, black oystercatchers nest exclusively in the intertidal, where eggs are laid in exposed nests consisting of depressions in pebbles, sand, gravel, and shell materials. During the 26-32 d incubation phase of reproduction, eggs are susceptible to predation by other birds (primarily Corvids; Lentfer and Meier 1995) and mammals (Vermeer et al. 1992), as well as human disturbance and trampling. Similar disturbance effects occur during the chick rearing stage, which lasts approximately 38 d (Andres and Falxa 1995). Thus, for several months during May-August, typically when human presence in nearshore habitats in Alaska is highest, black oystercatchers are actively incubating or caring for young in a habitat that affords little protection from human induced disturbances. Chronic disturbance from human activities poses a significant threat to breeding black oystercatchers, either preventing nesting altogether, causing nest abandonment after eggs have been laid (Andres 1998), or through direct mortality of eggs or chicks. Monitoring of black oystercatcher density, breeding territory density and occupancy, and prey will provide a potentially powerful tool in identifying the magnitude and causes of inevitable change in Gulf of Alaska nearshore habitats and communities, particularly in response to the anticipated increased use and influence of those habitats by humans.

In this section, we examine three years of data for black oystercatcher density, productivity, and diet from KATM. The primary focus is on evaluation of methods and a determination of whether we will likely be able to detect ecologically important levels of change given the methods employed.

Methods

There are three components to the sampling related to black oystercatchers: estimation of breeding pair density and nest occupancy through oystercatcher-specific surveys; estimation of species composition and size distributions of prey returned to provision chicks; and estimation of density of breeding and non-breeding black oystercatchers observed during the marine bird and mammal surveys. Results regarding the black oystercatcher density estimates are given in the marine bird survey section of this report. Detailed survey methods for estimation of nest occupancy and diet can be found in the black oystercatcher breeding territory occupancy and chick diet SOP (Dean and Bodkin 2006). The detailed methods used to obtain marine bird densities can be found in the marine bird SOP (Dean and Bodkin 2006) and in Bodkin et al.(2006 and 2007).

Black oystercatcher breeding territory density, nest occupancy, and prey data were collected along five 20 km transects each centered on the randomly (GRTS) rocky intertidal algal and invertebrate sites at KATM since 2006. Survey methods used do not provide for estimating detection of oystercatchers or nests on transects and we assume detection approximates 1.0. Nest sites were located by surveying the shoreline in a small boat. All accessible nest sites were visited to record the number of chicks and or eggs present and all prey items (e.g. mussel or limpet shells) present at a nest site were collected. All prey were measured. Here, we present size data for only two of the most abundant prey species, Pacific blue mussels (*Mytilus trossulus*) and the limpet (*Lottia persona*). In this report, we present three existing years of data from KATM to calculate coefficients of variation (CVs) to examine within year and between year

variation for each metric and to estimate levels of change that we can expect to detect based on our current sampling design. Power analysis for liner regression (Gerrodette 1993) was used to evaluate levels of change in focal species densities that could be detected over time.

Results

All five GRTS selected black oystercatcher transects were analyzed at the park level for productivity (chicks + eggs/nest) and nest density (nest/km). The mean density of active black oystercatcher nest sites at KATM ranged from 0.10 to 0.11 per km of shoreline over the three years of sampling and CVs for nest density among sites within a year ranged from 0.10 to 0.35 (Table 19 and Figure 21). Using a mean CV of 0.21, annual change from 0.15-0.20 could be detected in five years or less with power > 0.80 and alpha =0.10.

Table 20. Nest density (nests/km) for in KATM from 2006 - 2008.

Year	Mean	St Dev	St Err	CV
2006	0.10	0.08	0.04	0.35
2007	0.11	0.04	0.02	0.18
2008	0.11	0.02	0.01	0.10

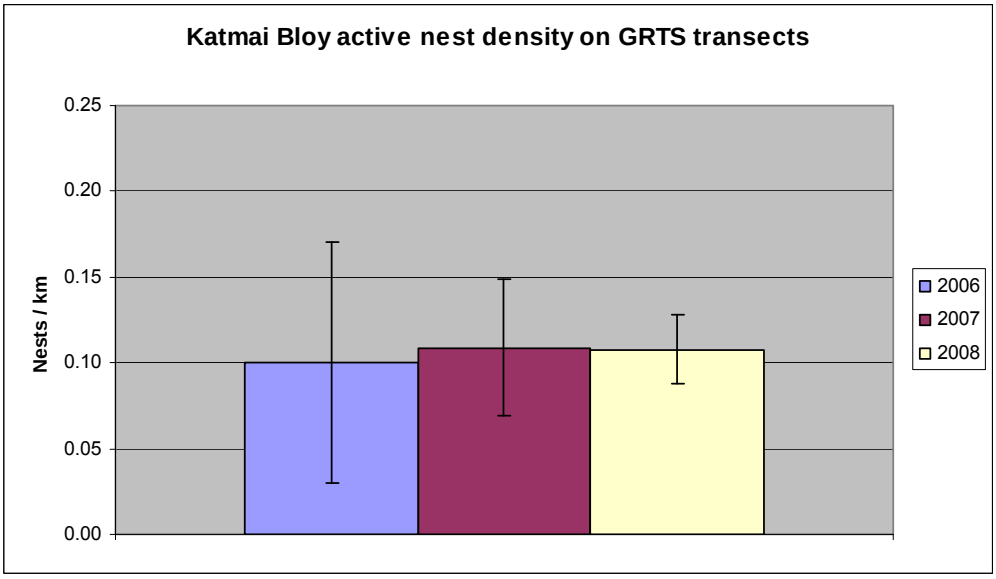


Figure 21. Nest density across all GRTS transects by year. Error bars indicate 95% CI's.

The mean number of eggs plus chicks observed at each nest site (an index of productivity) ranged from 1.42 in 2006 to 2.3 in 2007. CVs for sites within each year ranged from 0.09 to 0.39. Using a mean CV of 0.25, a 0.20 annual change could be detected in five years or less with power > 0.90 and alpha =0.10.

Table 21. The number of black oystercatcher eggs plus chicks per active nest in KATM from 2006 through 2008.

Year	Mean	St Dev	St Err	CV
2006	1.42	1.23	0.55	0.39
2007	2.30	0.45	0.20	0.09
2008	1.83	1.11	0.49	0.27

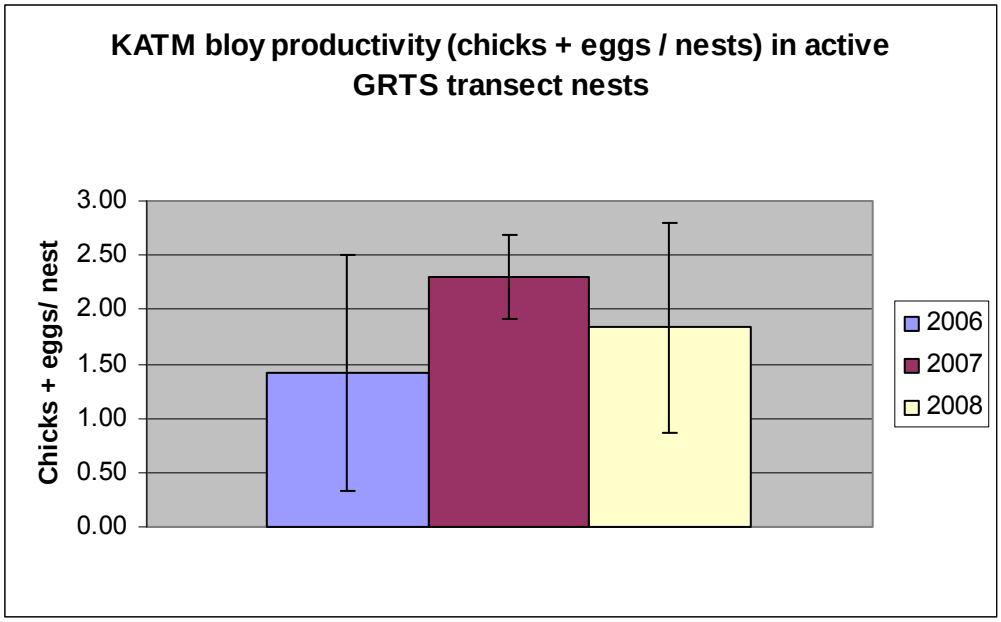


Figure 22. The number of black oystercatcher eggs plus chicks per active nest in KATM from 2006 through 2008. Error bars indicate 95% CI's.

Diet

Three species of limpets *(Lottia persona, Lottia persona, and Lottia scutum*) and the Pacific blue mussel (*Mytilus trossulus)* were the predominant prey items found at black oystercatcher nest sites (Table 21). Together these species represented over 0.97 of prey items found at KATM nest sites in any given year. CVs for the proportion of total prey represented by each of these predominant species within a given year ranged from 0.25 to 0.53. Due to high variance estimates, power to detect change in the proportion of prey brought to nest is relatively low. However, for mussels the dominant prey, assuming a CV of 0.32, we expect to detect annual change of .020 over a five year period, with power > 0.80 and alpha = 0.10.

Table 22. Proportion, SE and CV of eight different prey species by year in black oystercatcher nests in KATM from 2006 - 2008. Species highlighted in yellow are also sampled at rocky intertidal sites and mussel beds.

YEAR	SPECIES	Proportion in Diet	SE	CV
2006	*K. tunicata*	0.0012	0.0010	0.8367
2007	*K. tunicata*	0.0009	0.0008	0.8660
2008	*K. tunicata*	0.0055	0.0042	0.7746
2006	*L. digitalis*	0.0000	0.0000	.
2007	*L. digitalis*	0.0000	0.0000	.
2008	*L. digitalis*	0.0063	0.0048	0.7746
2006	*L. pelta*	0.0469	0.0227	0.4844
2007	*L. pelta*	0.1811	0.0852	0.4705
2008	*L. pelta*	0.2594	0.0964	0.3716
2006	*L. persona*	0.3224	0.1181	0.3661
2007	*L. persona*	0.2422	0.1020	0.4213
2008	*L. persona*	0.0935	0.0495	0.5298
2006	*L. scutum*	0.1306	0.0374	0.2867
2007	*L. scutum*	0.0912	0.0467	0.5118
2008	*L. scutum*	0.4318	0.1273	0.2947
2006	*M. trossulus*	0.4698	0.1159	0.2468
2007	*M. trossulus*	0.4800	0.1723	0.3590
2008	*M. trossulus*	0.2521	0.0859	0.3409
2006	*Nucella spp.*	0.0000	0.0000	.
2007	*Nucella spp.*	0.0037	0.0032	0.8660
2008	*Nucella spp.*	0.0039	0.0030	0.7746
2006	Other	0.0291	0.0217	0.7449
2007	Other	0.0009	0.0008	0.8660
2008	Other	0.0016	0.0012	0.7746

Mean sizes of two of the predominant prey (*L. persona* and *M. trossulus*) are given in Table 22. *L. persona* sizes ranged from 19.46 to 23.02 mm and mussel sizes ranged from 40.15 to 45.05 mm. All CVs for each species within a given year were 0.11 or less. Prey size is measured for all species. However, we report only on the size distribution of two intertidal invertebrate species, *L. persona* and *M. trossulus.* Both these species are also sampled for density and size distribution in separate sampling regimes (rocky intertidal invertebrate sampling and mussel bed sampling). Comparisons are made between random size distribution data collected at rocky intertidal sites and mussel bed sites with the prey sizes that the black oystercatchers use to provision chicks with. In the last three years, data indicates that black oystercatchers tend to choose the larger size classes of both *L. persona* and *M. trossulus*. (Figures 23-24). CVs for both *L. persona* and *M. trossulus* are low (Table 22) indicating little interannual variation in prey size selection by the black oystercatcher. Due to the low CV's associated with prey sizes we expect to detect annual change of about 0.10 over five years with power > 0.80 and alpha = 0.10.

Table 23. Mean size, SE and CV by year of both L. persona and M. trossulus collected at black oystercatcher nest sites on GRTS transects in KATM from 2006-2008.

Year	Species	Mean Size	Std Err	CV (SE)
2006	*L. persona*	20.26	1.78	0.09
2007	*L. persona*	19.46	1.46	0.08
2008	*L. persona*	23.02	2.34	0.10
2006	*M. trossulus*	45.05	3.26	0.07
2007	*M. trossulus*	40.95	4.25	0.10
2008	*M. trossulus*	40.15	4.33	0.11

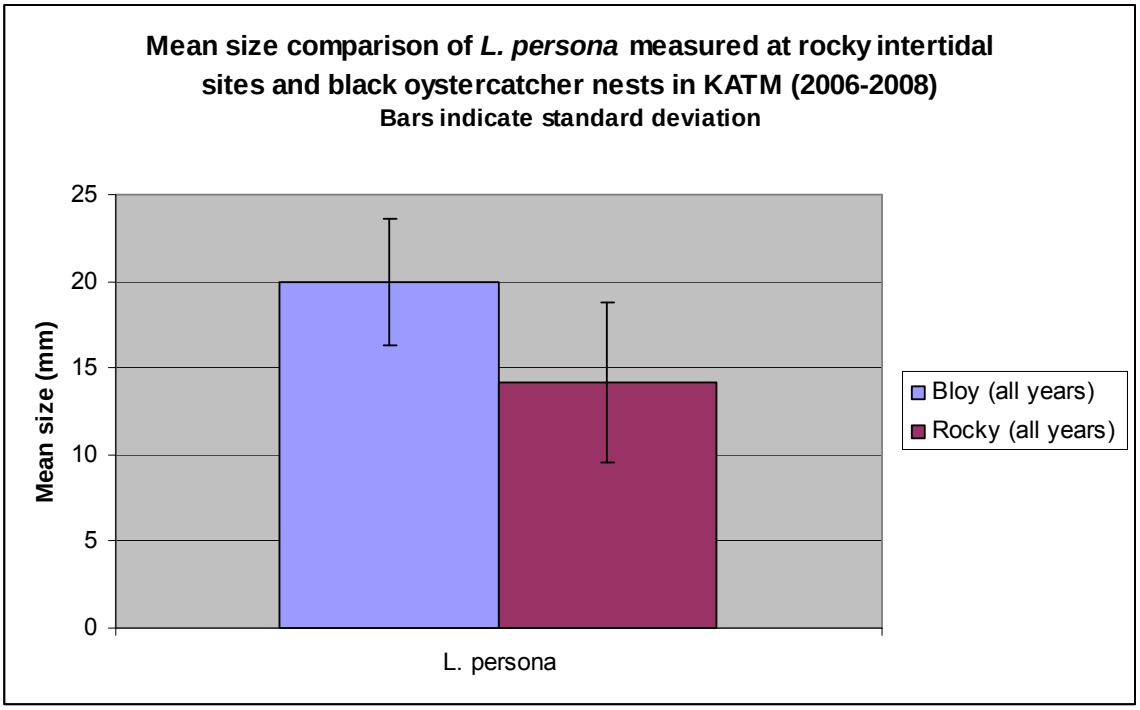


Figure 23. Mean size comparison of *L. persona*

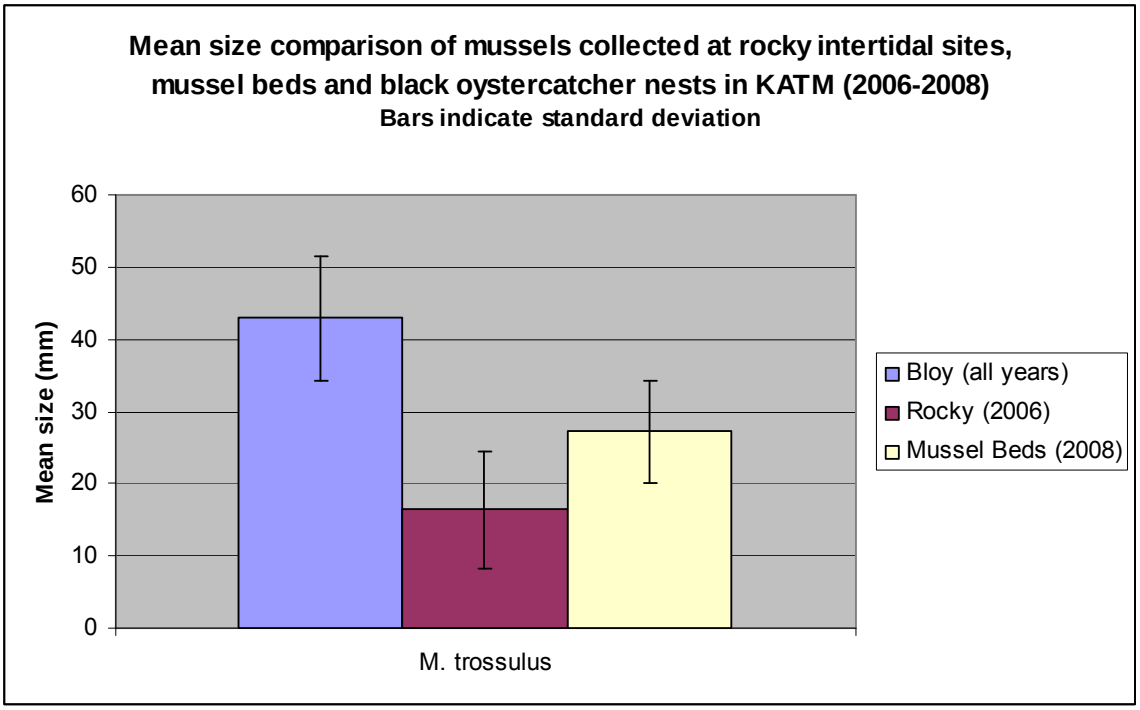


Figure 24. Mean size comparison of *M. trossulus*

Discussion

Currently, based on our calculated CVs of nest density and productivity and the inter-annual variation observed, our survey intensity should allow detection of changes in density and productivity on the order of 0.10-0.20 over five years, with power > 0.80. These levels of change are deemed ecologically important based on our preliminary analysis (Dean and Bodkin 2009).

The proportion of predominant prey items found at nest sites varied substantially from year to year. For example, the proportion of *Mytilus trossulus* and *Lottia persona* of total prey found at nest sites declined by 0.47 and 0.72 respectively between 2006 and 2008. This high inter-annual variation and the relatively high CVs within a given year (generally 0.30 or greater) suggest that we will be able to detect only relatively large differences in the proportion of prey The levels of change in proportions of most prey we will be able to detect maybe somewhat higher than the levels of change deemed ecologically important (on the order of 50%, Dean and Bodkin 2009). However, preliminary examination of our data suggest that there is considerably less inter-annual variation in prey composition if examined at the level of an individual nest site (Bodkin et al. 2008) and accounting for nest site (using an appropriate repeated measures design) may enhance our ability to detect somewhat smaller changes.

The mean sizes of the *L. persona* and *M. trossulus* provided some of the lowest CVs of our black oystercatcher data. Changes in size distribution on the order of 0.30 (30% increase or decrease in mean size) are considered to be ecologically important by Dean and Bodkin 2009 Draft Protocol. Our current sampling indicates that a ~10% change in size distribution of *M. trossulus* and *L. persona* is detectable at the current survey efforts. *M. trossulus* and *L. persona* brought to

nests by oystercatchers continue to be near the largest sizes measured under the intertidal invertebrate sampling (Figures 23-24) suggesting size selective predation by the adult oystercatchers. Hence, the low variation in the sizes is not surprising, but may be a key metric for monitoring purposes. Measurements of sea otter prey, pre- and post arrival of sea otters in Glacier Bay, AK, have indicated a decline in prey sizes correlated with the increased occupation of Glacier Bay proper with sea otters (Bodkin et al. 2007). A similar result may possibly occur as densities in nesting black oystercatchers changes. Lower densities of black oystercatchers may lead to increased densities of larger size classes of mussels and limpets sampled at the rocky intertidal sites and mussel beds or nest sites. The reverse may also be possible. Increased black oystercatcher densities may decrease the densities of the larger size classes of prey.

Recommendations

Surveys of black oystercatcher abundance, nest density, and diet as reflected through prey remains brought to provision chicks has been successfully implemented in KATM and has shown that at appropriate spatial scales of analysis, our data should continue to be collected with little revision. Methods to calculate detection bias should be considered and implemented if logistically feasible. Sampling at the current intensity should allow us to detect trends in changes of nest density, productivity and diet (especially prey size) of the black oystercatcher. It appears as though breeding pairs may have multiple nests at a nest site and care should continue to be taken to recognize these as comprising the same nest site. It will be important to conduct future surveys as close as possible in time to these initial surveys and care must continue to be taken to minimize the disturbance to nests during sampling.

Sea Otter

Sea otters (*Enhydra lutris*) are a common, conspicuous, and important component of the nearshore trophic food web throughout the North Pacific. They occupy all types of nearshore habitats from sheltered bays, estuaries, and fjords to exposed rocky coastlines (Kenyon 1969), but are constrained by their diving ability to habitats shallower than 100 m depth (Bodkin et al. 2004) and a near exclusive dietary reliance on benthic invertebrate prey (Riedman and Estes 1991). As a consequence of their nearshore distribution and relatively small home ranges, a rich literature exists on the biology, behavior, and ecology of the species. The sea otter provides one of the best documented examples of top-down forcing effects on the structure and function of nearshore marine ecosystems in the North Pacific Ocean (Kenyon 1969, VanBlaricom and Estes 1988, Riedman and Estes 1990, Estes and Duggins 1995) and are widely regarded as a "keystone" species in coastal marine ecosystems (Power et al. 1996). They cause well described top-down cascading effects on community structure by altering abundance of prey (e.g. sea urchins) which can in turn alter abundance of lower trophic levels (e.g. kelps). Sea otters generally have smaller home ranges than other marine mammals; eat large amounts of food; are susceptible to contaminants such as those related to oil spills; and have broad appeal to the public. Recent declines in sea otters have been observed in the Aleutian Islands. As a result, the Western Alaska stock of sea otters, which occurs from Cook Inlet to the Western Aleutian Islands and includes KATM as well as Aniakchak National Monument and Preserve, was federally listed on September 2005 as threatened.

For the reasons outlined above, several metrics related to sea otters are incorporated under this vital sign. They include: aerial surveys to estimate population abundance, carcass collections to evaluate the age structure of the dying population, and observations of sea otter foraging. Because sea otters occur over a much larger are in than nearshore than sampled under the marine bird and mammal surveys and detection from skiffs is less than 1.0, aerial surveys designed specifically to provide accurate and precise estimates of sea otter abundance (Bodkin and Udevitz 1999) are incorporated into the nearshore monitoring program.

As a result of their nearshore distribution and relatively high density, moribund sea otters often haul out ashore, or their carcasses drift onto beaches. Annual collections of sea otter carcasses provide a record of the ages of dying individuals through analysis of dentin deposition in teeth (Bodkin et al. 1997). The age distributions of dying sea otters generated from annual carcass collections can provide a baseline against which future distributions can be compared and potentially provide inference regarding causes for change in population abundance , behavior, or diet (Monson et al. 2000).

Sea otter population abundance and trends are frequently influenced by the type and quantity of available prey (Kenyon 1969, Monson et al. 2000a). Observations of foraging sea otters provide information on food habits, foraging success, (mean proportion of feeding dives that are successful) and efficiency (mean kcal/dive) based on prey numbers, types and sizes obtained by feeding animals. Because sea otter populations are often prey limited, data on foraging behavior will be useful in evaluating potential causes for differences in sea otter densities or trends among regions or years (Estes et al. 1982, Gelatt et al. 2002, Dean et al. 2002, Bodkin et al. 2002).

Due to high spatial variability in marine invertebrate populations (e.g. extreme patchiness) and difficulty in sampling underwater prey populations, foraging sea otters provide an alternative method to direct sampling of subtidal invertebrates. Following a successful foraging dive, sea otters return to the surface to consume their prey. This provides the opportunity to identify, enumerate, and estimate the size of the benthic organisms they consume. Therefore sea otter foraging data will provide data on species composition and sizes of subtidal invertebrate prey populations that are difficult to obtain directly. Observations collected over time may allow inference to changes in the species composition and sizes of the nearshore benthic invertebrate communities.

Our objectives in this section of the report are to evaluate the power to detect change in the various metrics associated with sea otter foraging data collected over the three year period 2006-2008 at KATM. The methods and results of the 2008 sea otter aerial survey are reported in the sea otter aerial survey section, and the two years of age at death data (2006 and 2007) resulting from carcass collections at KATM are provided in Appendix G.

Methods

Food habits, foraging success and energy recovery rates were obtained from shore based observations of randomly selected foraging otters. Shore-based observations limited data collection to sea otters feeding within approximately 1 km of shore. High powered telescopes (Questar Corp., Hew Hope, PA.) and 10X binoculars were used to record prey type, number, and size during foraging bouts of focal animals. A bout consisted of observations of repeated dives for a focal animal while it remains in view and continues to forage (Calkins 1978). Assuming each foraging bout records the feeding activity of a unique individual, bouts were considered independent while dives within bouts will not. Thus the length of any one foraging bout was limited to 20 dives, or one hour, after which a new focal animal was chosen. Within each bout sampled the following metadata were recorded: date, start and end time, age, sex, and reproductive status of the individual, location coordinates. Foraging data collected include dive and inter-dive times, success, prey species, number and size, and if prey were given or taken (typically given to a pup, or taken by a con-specific). The sampling design included the acquisition of foraging data within a 10 km radius of each of the five established rocky intertidal invertebrate and algal sites (Figure 25). The objective was to annually obtain data from 10 individuals within each of these 10 km buffers, a total of 50 bouts per year.

Sea otters in the study areas were generally not individually identifiable. In addition, some foraging areas may have been used more than others by individuals and by otters living in the area in general. Therefore individual sea otters may have been observed more than once leading to potential bias toward individuals sampled more than once. To minimize this potential, observers use characteristics such as sex, sizes, coloration, and reproductive status to identify individuals. If more than one animal was observed foraging, selection was based on proximity, alternating between closest and furthest.

Of the various metrics measured in regards to the sea otter vital sign, only foraging observations and carcass collections have been collected in KATM since 2006. At the time of preparing this report, the age data from the carcasses were not yet available. Here we will be reporting only on the analyses associated with data acquired directly from observations of foraging sea otters.

One of the objectives for this monitoring program was to be able to detect levels of change deemed ecologically important (Dean and Bodkin 2009, Draft Protocol). For the sea otter foraging data we have established a 0.35 change in the proportion of dominant prey categories, a 0.50 change in prey size and a 0.20 increase or 0.33 decrease in the number of hours needed to meet energetic requirements as ecologically relevant changes to detect. Programming capable of providing variance estimates of energy recovery rates is presently in revision, precluding power analysis for this metric at KATM. Power analysis for liner regression (Gerrodette 1993) was used to evaluate levels of change in focal species densities that could be detected over time. Forage data are analyzed at the spatial scale of KATM. Future analyses may include finer spatial resolution analyses as sample sizes increase within each of the five buffers associated with the intertidal sites and should include caloric recovery rate power analyses.

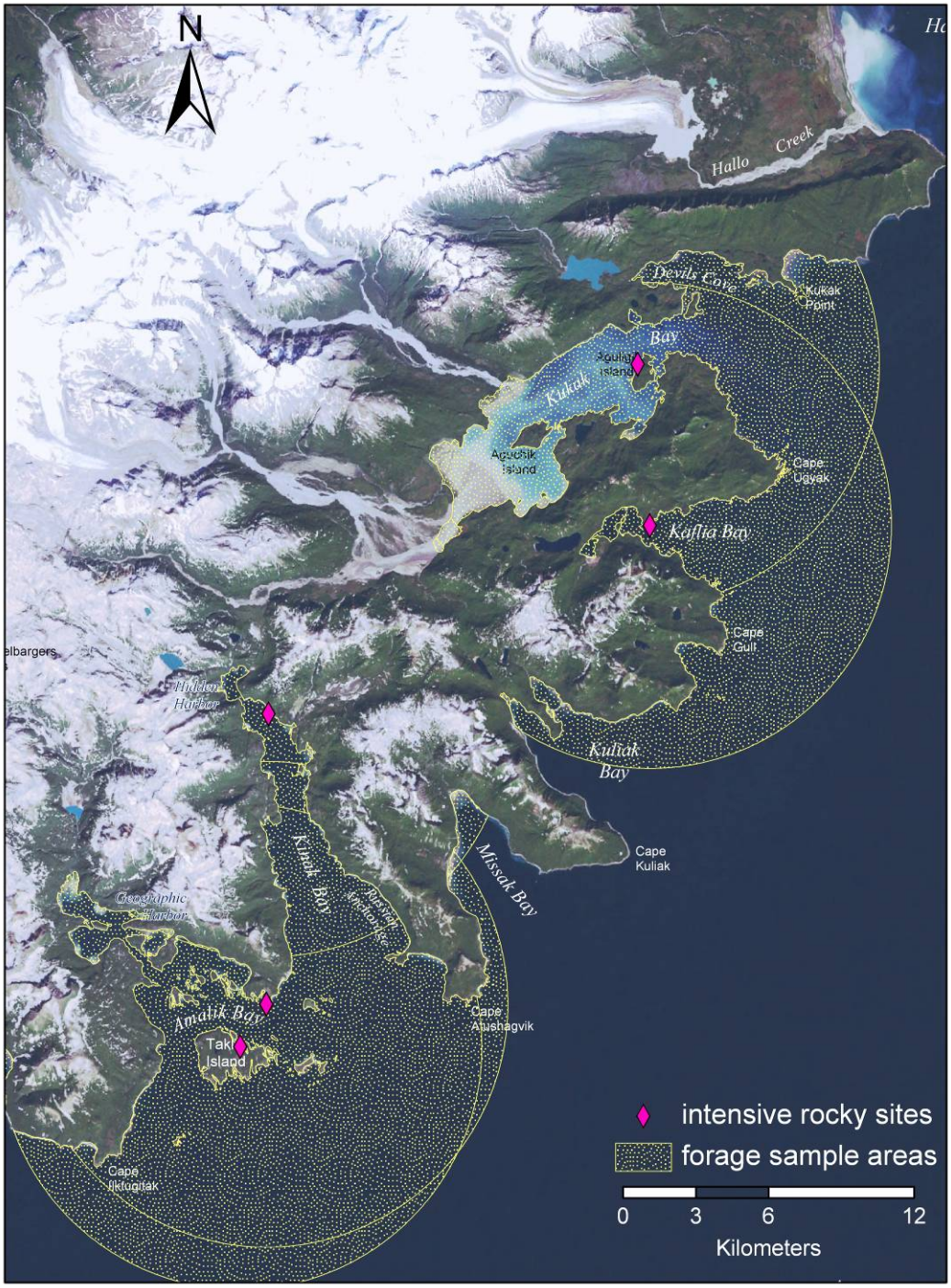


Figure 25. The locations of areas delineated for the collection of sea otter forage data (buffers) associated with each of the established rocky intertidal sites (see intertidal invertebrates and algal section this report).

Results

During 2006-2008 we obtained data from 147 independent sea otter foraging bouts, representing 1,304 dives (Table 23). The prey recovery success rate was 88% for dives with known results (range 0.87-91). Prey specific success rates varied with higher rates for small, easily accessible prey such as blue mussels (1.00) and lower rates for larger, more difficult to retrieve items such as octopus (0.92) and clams (0.91). In all three years sea otter diet composition was dominated by clams (0.60-0.71) (Table 24). In 2006 octopus accounted for 0.12 of identified prey and in 2008 chitons were 0.15. Otherwise, chitons, crabs, mussels, octopus, snails, sea stars, sea urchins, and other prey each comprised less than 0.10 of the of prey recovered. Based on mean CVs, with alpha = 0.10 and power = 0.80, the required number of years to detect a significant difference of 0.35 in the proportion of prey type in the diet range from seven years for clams to > 25 years for all remaining prey types (Table 24). Under the same assumptions, a 0.20 annual change in proportions of prey in diet would be statistically significant in four years for clams, to 13 years for crab and mussels (Table 24).

Table 24. Summary of sea otter foraging observations in KATM from three years of nearshore monitoring data collection. The bout was the sampling unit for data analysis.

Year	Number of bouts observed	Number of dives observed	Mean number of dives per bout	St. dev. number of dives per bout
2006	60	442	6.85	5.1
2007	53	478	7.55	5.4
2008	34	384	8.43	5.6
2006-2008	147	1304	7.57	5.4

Sizes of prey captured by foraging sea otters varied by species (Figure 26). The predominant prey, clams, averaged 58 mm over all sites combined. Snails and mussels (and unidentified prey items) were generally the smallest prey, averaging about 33 mm. Crabs and urchins averaged 48 mm. Chitons averaged 56 mm, and stars 126 mm. It is difficult to estimate a mean size for the octopus we observed the otters eating. All were larger than our largest estimated size class (based on paw width of an 'average' sea otter) of 156 mm. Based on mean CVs, and alpha = 0.10 and power = 0.80, the required number of years to detect a significant difference of 0.50 in the mean size of prey in the diet range from 18 years for crabs, 27 years for clams and >37 years for other taxa.(Table 25). Under the same assumptions, a 0.20 annual change in proportions of prey in diet would be statistically significant in six years for crab, seven years for clam to eight or nine years for other taxa (Table 25).

Table 25. Proportion, SE and CV of eight different prey categories by year in sea otter diets in KATM. All prey taxa are also sampled at intertidal sites. Years to 0.35 change use mean annual CVs and power = 0.80 and alpha = 0.10. Years to detect trend assume an annual rate of change, use mean CVs and power = 0.80 and alpha = 0.10.

YEAR	SPECIES	Proportion in Diet	SE	CV	Years to 0.35 change	Years to detect trend
2006	Chiton	0.04	0.02	0.51		
2007	Chiton	0.06	0.03	0.44	>25	8
2008	Chiton	0.15	0.05	0.31		
2006	Clam	0.66	0.06	0.09		
2007	Clam	0.71	0.06	0.08	7	4
2008	Clam	0.60	0.08	0.15		
2006	Crab	0.03	0.02	0.67		
2007	Crab	0.01	0.01	0.95	>25	13
2008	Crab	0.00	0.00	0.83		
2006	Mussel	0.00	0.00	1.00		
2007	Mussel	0.05	0.03	0.58	>25	13
2008	Mussel	0.03	0.02	0.77		
2006	Octopus	0.12	0.05	0.36		
2007	Octopus	0.05	0.03	0.61	>25	10
2008	Octopus	0.04	0.03	0.79		
2006	Snail	0.08	0.03	0.36		
2007	Snail	0.02	0.01	0.50	>25	9
2008	Snail	0.04	0.04	0.64		
2006	Star	0.05	0.03	0.56		
2007	Star	0.01	0.01	0.63	>25	10
2008	Star	0.05	0.03	0.57		
2006	Urchin	0.03	0.02	0.78		
2007	Urchin	0.08	0.04	0.42	>25	10
2008	Urchin	0.07	0.04	0.42		

Clams are the predominate prey class of sea otters in KATM across all sample years.

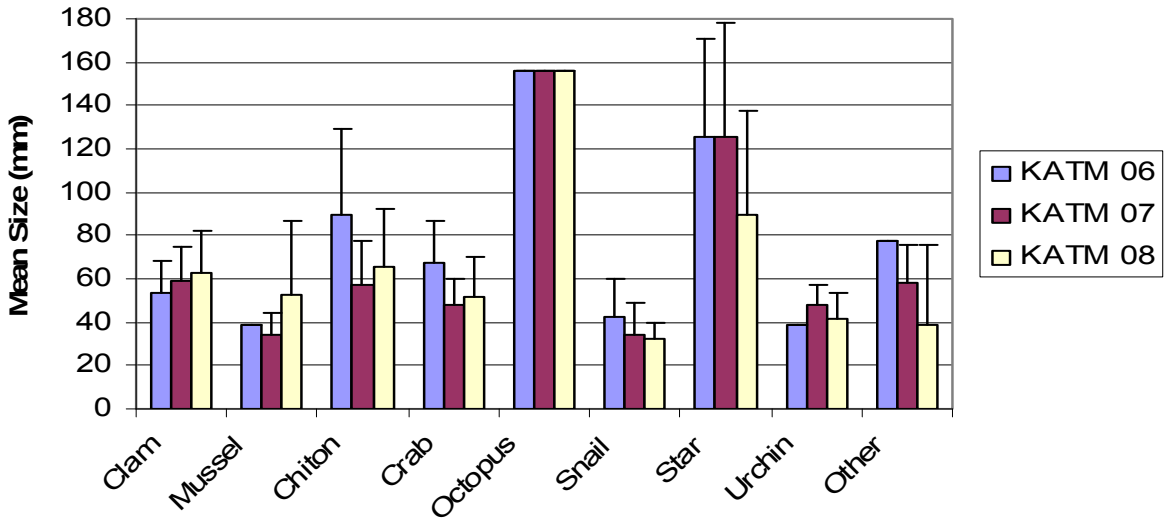


Figure 26. Mean size of prey items recovered by prey type for sea otters foraging in Block10, KATM, 2006-2008.

Table 26. Mean size, SE and CV by year of seven different prey categories by year in sea otter diets in KATM from 2006-2008. Octopus have not been included because size determinations have not been standardized yet for prey larger than 4 otter paw widths. Years to 0.50 change use mean annual CVs and power = 0.80 and alpha = 0.10. Years to detect trend assume an annual rate of change, use mean CVs and power = 0.80 and alpha = 0.10.

YEAR	SPECIES	Mean Size (mm)	SE	CV	Years to detect 0.50 change	Years to detect trend
2006	Chiton	89.70	39.20	0.44		
2007	Chiton	57.50	20.30	0.35	>30	8
2008	Chiton	65.40	26.50	0.41		
2006	Clam	53.50	15.00	0.28		
2007	Clam	59.10	15.70	0.27	27	7
2008	Clam	62.90	18.90	0.30		
2006	Crab	67.60	19.10	0.28		
2007	Crab	47.70	12.30	0.26	18	6
2008	Crab	52.00	18.40	0.35		
2006	Mussel	39.00	.	.		
2007	Mussel	33.90	10.70	0.32	>30	9
2008	Mussel	52.30	34.10	0.65		
2006	Snail	42.50	17.80	0.42		
2007	Snail	33.80	15.50	0.46	>30	8
2008	Snail	32.50	7.50	0.23		
2006	Star	125.70	44.80	0.36		
2007	Star	125.70	52.50	0.42	>30	9
2008	Star	89.10	48.30	0.54		
2006	Urchin	39.00	0.00	0.00		
2007	Urchin	47.70	9.70	0.20		
2008	Urchin	42.00	11.60	0.28		

Discussion

Metrics available to evaluate sea otters as a nearshore "vital sign" consist of methods and approaches that are well described in the literature, including; 1) estimates of abundance from aerial surveys (Bodkin and Udevitz 1999, Bodkin et al. 2002), 2) age distribution of beach cast carcasses (Monson et al. 2000), and 3) direct observation of foraging sea otters that provide data on forage success and prey species and sizes, and estimates of energy recovery rates (Dean et al. 2002). Although in this section we have limited our analysis to the three years of forage data obtained from KATM, other published work can be drawn on to evaluate power to detect change over time in the aerial survey and age at death metrics.

The aerial sea otter survey method provides relatively precise and unbaised estimates of abundance, with proportional standard errors typically around 0.10 to 0.15 (Bodkin et al 2002, USGS unpublished data). Using CVs of 0.20, with power = 0.80 and alpha = 0.10, a change of 0.50 in abundance would be detected over six years of annual surveys. Under the same set of assumptions, annual change of 0.20 would attain statistical significance in fours years of annual

surveys. Based on survey data from other areas we expect good power detect ecologically important levels of change in sea otter abundance using the prescribed methods.

Age at death data obtained from beach cast sea otter carcasses has been used to estimate age specific mortality rates (Udevitz and Ballachey 1998) and to describe changes in mortality associated with the 1989 *Exxon Valdez* oil spill in Prince William Sound (Monson et al. 2000). Using a sample of ages at death gathered prior to and following the spill, demographic models and maximum likelihood methods, Monson et al (2000) were able to identify changes in age dependent mortality that were consistent with a long-term effect from spilled oil. The use of age at death data to estimate or detect change in vital rates requires relatively large sample sizes because the sea otter is relatively long lived (dozens to hundreds). During 2006-2008 we have obtained at KATM 114 ages at death from beach cast carcasses. This sample size exceeds that used by Udevitz and Ballachey (1998) to generate age specific mortality rates, and approximate those by Monson et al. 2000 to identify changes in age dependent mortality. We therefore expect that the age at death data obtained at KATM will provide similar capability to infer survival rates and detect change in age dependent mortality.

Observations of foraging sea otters provide data that can be used to quantify foraging effort, success, species composition, number and size of prey (Dean et al. 2002). Combining these data sets can provide estimates of rates of energy recovery that can then be used to estimate forage time budgets, which can be a sensitive indicators of the status of a population relative to food resources (Bodkin et al. 2007). Using methods identical to those employed at KATM, Dean et al. (2002) identified significant differences of less than two hour per day (~ 0.20 of forage time) in the amount of time required to meet energetic requirements between two sea otter populations, with sample sizes of about 100 forage bouts. From 2006-2008 we have accumulated data from 147 forage bouts and expect to have power > 0.80 to detect a 0.33 increase in the number of forage hours required daily. We expect to have revised models to estimate energy recovery rates and time budgets and associated variances in 2010.

Our analyses indicate seven years are required to detect ecologically important change (> 0.50, with 0.80 power) in the proportion of the dominant prey in the sea otters diet at KATM (clams) but relatively poor power to detect change in the proportions of other prey. We estimate four years are required to detect an annual change of 0.20 in the proportion of clams in the diet over time, but also require longer time to achieve the same power for other prey types. Based on the similarity of diet observed over time at other locations (e.g., Prince William Sound; Calkins 1975, Dean et al. 2002) we suspect changes in the proportions of prey in the sea otters diet would be ecologically meaningful. Our analyses indicate relatively poor power (or long periods of time) to detect significant change in the mean sizes of prey recovered by sea otters, although trends in prey sizes of 0.20 annually may be evident in less than ten years for all prey. We expect that power to detect change in forage related metrics will improve as sample sizes increase with time.

Recommendations

Based on the demonstrated power to detect ecologically important, and statistically significant differences in the sea otter vital sign metrics, both among and within populations, we recommend continued monitoring at the prescribed intensity and methods.

Literature Cited

Alaska Shorebird Working Group. 2000. Alaska shorebird conservation plan. Unpublished Report, U. S. Fish and Wildlife Service, Anchorage, AK. 47 pp.

Andres, B. and G. A. Falxa. 1995. Black Oystercatcher (*Haematopus bachmani*) In The Birds of North America, No. 155 The Academy of Natural Sciences, Philadelphia, and The American Ornithologists' Union, Washington, DC, Philadelphia, PA.

Andres, B. A. 1998. Shoreline habitat use of Black Oystercatchers breeding in Prince William Sound, Alaska. Journal of Field Ornithology 69(4): 626-634.

Andres, B. A. 1999. Effects of persistent shoreline oil on breeding success and chick growth in black oystercatchers. The Auk 116:640-650.

Barry, J. P., C. H. Baxter, R. D. Sagarin, and S. E. Gilman. 1995. Climate-related, long-term faunal changes in a California rocky intertidal community. Science 267(5198): 672-675.

Bodkin, J.L., J.A. Ames, R.J. Jameson, A.M. Johnson and G.M. Matson. 1997. Accuracy and precision in estimating age of sea otters using cementum layers in the first premolar. Journal of Wildlife Management 61(3):967-973.

Bodkin, J. L. and M.S. Udevitz. 1999. An aerial survey method to estimate sea otter abundance. in: Garner, G.W., S.C. Amstrup, J.L. Laake, B.F.J. Manly, L.L. McDonald, and D.G. Robertson, (eds.) Marine mammal survey and assessment methods. Balkema Press, Netherlands pg. 13-26.

Bodkin, J.L., B. Ballachey, T.A. Dean, A.K. Fukuyama, S.C. Jewett, L.L. McDonald, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Sea otter population status and the process of recovery following the 1989 *Exxon Valdez* oil spill. Marine Ecology Progress Series 241:237-253.

Bodkin, J.L., G.G. Esslinger and D.H. Monson. 2004. Foraging depths of sea otters and implications to coastal marine communities. Marine Mammal Science 20(2):305-321.

Bodkin, J.L., D.H. Monson, and G.G. Esslinger. 2007. Population status and activity budgets derived from time-depth recorders in a diving mammal. Journal of Wildlife Management 71(6):2034-2044.

Bodkin, J. L., T. A. Dean, and H. A. Coletti. 2007. Nearshore Marine Monitoring in the Southwest Alaska Network of National Parks. National Park Service. Anchorage, AK. 102 pg.

Bodkin, J.L., T.A. Dean, H.A. Coletti, and K.A. Kloecker. 2008. Nearshore marine vital signs monitoring in the Southwest Alaska network of National Parks. Annual report to the US National Park Service, Anchorage, AK. 176 pp.

Bodkin, J.L., B.E. Ballachey, G.G. Esslinger, K.A. Kloecker, D.H, Monson, and H.A.Coletti. 2007. Perspectives on an invading predator—Sea otters in Glacier Bay, *in* Piatt, J.F., and Gende, S.M., eds., Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004: U.S. Geological Survey Scientific Investigations Report 2007-5047, p. 133-136.

Bostrom, C., Jackson, E.L., Simenstad, C.A., 2006. Seagrass landscapes and their effects on associated fauna: a review. Estuarine Coastal and Shelf Science. 68, 383–403.

Brown, S., C. Hickey, B. Harrington, and R. Gill. 2001. The U.S. Shorebird Conservation Plan, 2nd ed. Brown, S., Hickey, C., Harrington, B., Gill, R. eds. Brown Manomet Center for Conservation Sciences, Manomet, MA.

Burnham, K.P. and D.R. Anderson. 2002. Model selection and multimodel inference. 2nd Ed. Springer-Verlag, NY.

Burnham, K.P. and D.R. Anderson. 2004. Multimodel inference: understanding AIC and BIC in model selection. Sociological Methods in Research 33:261-304.

Calkins, D.G. 1978. Feeding behavior and major prey species of the sea otter, Enhydra lutris, in Montague Strait, Prince William Sound, Alaska. Fishery Bulletin 76:125-131.

Dayton, P. K. 1971. Competition, disturbance and community organization: the provision and subsequent utilization of space in a rocky intertidal community. Ecological Monographs 41(4): 351-89.

Dean, T.A. M.S. Stekoll, S.C. Jewett, R.O. Smith, J.E. Hose. 1998. Eelgrass (*Zostera marina* L.) in Prince William Sound, Alaska: Effects of the *Exxon Valdez* oil spill. Marine Pollution Bulletin 36:201-210

Dean T.A., L. Haldorson, D.R. Laur, S.C. Jewett, A. Blanchard. 2000. The distribution of nearshore fishes in kelp and eelgrass communities in Prince William Sound, Alaska: associations with vegetation and physical habitat characteristics. Environmental Biology of Fishes 57: 271-287.

Dean, T.A., J.L. Bodkin, A.K. Fukuyama, S.C. Jewett, D.H. Monson, C.E. O'Clair, and G.R. VanBlaricom. 2002. Food limitation and the recovery of sea otters in Prince William Sound. Marine Ecology Progress Series. 241:255-270.

Dean, T. A. and J. L Bodkin. 2006. Protocol for Marine Nearshore Ecosystem Monitoring Southwest Alaska Network of National Parks. US Geological Survey, Alaska Science Center, Anchorage, AK.

Dean, T. and J. Bodkin. 2009. Draft Protocol Narrative for Marine Nearshore Ecosystem Monitoring, Southwest Alaska Network. Report to the National Park Service. Anchorage, AK. 57 pp.

Doroff, A. M., Estes, J. A., Tinker, M. T., Burn, D. M. & Evans, T. J. (2003) Sea otter population declines in the Aleutian archipelago. Journal of Mammalogy, 84, 55-64.

Draulans, D. 1982. Foraging and Size Selection of Mussels by the Tufted Duck, *Aythya fuligula*. Journal of Animal Ecology 51(3): 943-956.

Drew, G. S., S. G. Speckman, J. F. Piatt, J. M. Burgos, J. L. Bodkin. 2008. Survey design considerations for monitoring marine predator populations in Glacier Bay, Alaska: Results and post-hoc analysis of surveys conducted on 1999-2003. USGS Final Report.

Duarte, C.M., 2002. The future of seagrass meadows. Environmental. Conservation. 29, 192–206.

Esler, D., J. A. Schmutz, R. L. Jarvis and D. M. Mulcahy. 2000. Winter survival of adult female harlequin ducks in relation to history of contamination by the *Exxon Valdez* oil spill. Journal of Wildlife Management 64(3): 839-847.

Esler D., T.D. Bowman, C.E. O'Clair, T.A. Dean, L.L. McDonald. 2000. Densities of Barrow's Goldeneyes during winter in Prince William Sound, Alaska, in relation to habitat, food, and history of oil contamination. Water Birds 23:423-429

Esler, D., T. D. Bowman, K. A. Trust, B. E. Ballachey, T. A. Dean, S. C. Jewett, and C. O. O'Clair. 2002. Harlequin Duck Population Recovery Following the *Exxon Valdez* Oil Spill: Progress, Process, and Constraints. Marine Ecology Progress Series 241:271-286.

Estes, J.A., R.J. Jameson, and E.B. Rhode. 1982 Activity and prey selection in the sea otter: influence of population status on community structure. American Naturalist 120:242-258.

Estes, J.A. and G..R. VanBlaricom. 1988. The Community Ecology of Sea Otters. Springer Verlag, Berlin, Germany.

Estes, J.A. and D.O. Duggins. 1995. Sea otters and kelp forests in Alaska: generality and variation in a community ecology paradigm. Ecological Monographs 65:75-100.

Estes, J.A. and J.L. Bodkin. 2007. Threatened southwest Alaska sea otter stock: delineating the causes and constraints to recovery of a keystone predator in the North Pacific Ocean. North Pacific Research Board Research Project 717. Anchorage, AK.

Farrington, J.W. and B. W. Tripp. (Eds.) 1995. International Mussel Watch Project: Initial implementation phase final report. NOAA technical memorandum NOS ORCA 95. US Dept. of Commerce.

Faxla, G.A., 1992. Prey choice and habitat use by foraging black oystercatchers. Unpublished Ph.D. dissertation, University of California, Davis.

Feder, H. M., and G. E. Kaiser. 1980. Intertidal biology. J.M. Colonell (ed.) In: J.M. Colonell (ed.), Port Valdez, Alaska: Environmental studies 1976-1979. University of Alaska, Institute of Marine Science, Fairbanks. University of Alaska, Institute of Marine Science, Fairbanks.

Fish and Wildlife Service. 2005. 70 Federal Register Notice R 46366, 9 August 2005.

Ford, R.G. 2004. DLog2 Software for Biological Surveys. Portland, OR.

Frank, P. W. 1982. Effects of Winter Feeding on Limpets by Black Oystercatchers, *Haematopus bachmani*. Ecology 63(5): 1352-1362.

Gelatt, T. S., D. B. Siniff, and J. A. Estes. 2002. Activity patterns and time budgets of the declining sea otter population at Amchitka Island, Alaska. Journal of Wildlife Management 66:29-39.

Gerrodette, T. 1993. Trends: Software for a power analysis of linear regression. Wildlife Society Bulletin 21:515-516.

Goatcher, B. 1994. Sea otter (Enhydra lutris) Information Consolidation Report. Katmai National Park and Preserve. Unpub. Report. King Salmon, AK. 8pp.

Gorbics, C and J.L. Bodkin. 2001. Stock Identity of sea otters in Alaska. Marine Mammal Science 17(3):632-647.

Golet, G.H., D. B. Irons and J. A. Estes. 1998. Survival Costs of Chick Rearing in Black-Legged Kittiwakes. Journal of Animal Ecology, Vol. 67, No. 5, pp. 827-841.

Hahn, T. and M. Denny. 1989. Tenacity-mediated selective predation by oystercatchers on intertidal limpets and its role in maintaining habitat partitioning by *Collisella scabra* and *Lottia digitalis*. Marine Ecology Progress Series. Oldendorf 53(1): 1-10.

Hamilton, D., and T. Nudds. 2003. Effects of predation by common eiders (*Somateria mollissima*) in an intertidal rockweed bed relative to an adjacent mussel bed. Marine Biology 142(1): 1-12.

Harper, J. R., and M.C. Morris. 2004. ShoreZone mapping protocol for the Gulf of Alaska (ver 1.0). CORI Project: 02-33 EVOS Project: 030641. Report to the *Exxon Valdez* Trustee Council, Anchorage, AK

Hartwick, E. B. 1976. Foraging of the black oyster catcher (*Haematopus bachmani Audubon*). Canadian Journal of Zoology 54(2): 142-155.

Haven, S. B. 1971. Effects of land-level changes on intertidal invertebrates, with discussion of post earthquake ecological succession. In: The great Alaska earthquake of 1964. Vol. 4, Biology. National Academy of Science, Washington, DC. pp. 82-126.

Highsmith, R. C., M. S. Stekoll, W. E. Barber, L. McDonald, D. Strickland, W.P. Erickson. 1994. Comprehensive assessment of coastal habitat. *Exxon Valdez* oil spill state/federal natural resource damage assessment. Final report of coastal habitat study 1A. Exxon Valdez Oil Spill Trustee Council, Anchorage, AK.

Highsmith, R. C., T. L. Rucker, M. S. Stekoll, S. M. Saupe, M. R. Lindeberg, R. N. Jenne, W. P. Erickson. 1996. Impact of the Exxon Valdez oil spill on intertidal biota. In: Rice SD, Spies RB, Wolfe DA, Wright BA (eds.). Proceedings of the *Exxon Valdez* oil spill symposium. American Fisheries Society Symposium 18, pp. 212-237.

Hines, J.E., T. Boulinier, Nichols, J.D., J.R. Sauer, and K.H. Pollock. 1999. COMDYN: Software to study dynamics of animal communities using a capture-recapture approach. Bird Study 46 (suppl.):s209-217.

Irons, D. B., D. R. Nysewander and J. L. Trapp. 1988. Prince William Sound Sea Otter Distribution in Respect to Population Growth and Habitat Type. Prepared by Alaska Investigations Field Office (Branch of Wetlands and Marine Ecology) and Wildlife Assistance (Marine Bird Project).

Irons, D.B., S.J. Kendall, W.P. Erickson, L.L. McDonald, and B.K. Lance. 2000. Nine years of Exxon Valdez oil spill. Effects of marine birds in Prince William Sound. Condor:120:723-737.

Jamieson, G. S., E. D. Grosholz, D. A. Armstrong, and R. W. Elner. 1998. Potential Ecological Implications from the Introduction of the European Green Crab, *Carcinus maenas* (Linneaus), to British Columbia, Canada, and Washington, USA. Journal of Natural History 32(10-11): 1587-1598.

Jewett, S.C., T.A. Dean, R.O. Smith, A. Blanchard. 1999. The *Exxon Valdez* oil spill: Impacts and recovery in the soft-bottom benthic community in and adjacent to eelgrass beds. Marine Ecology Progress Series 185:59-83.

Karinen, J.F. M.M. Babcock, D.W. Brown, W.D. MacLeod Jr., L.S. Ramos, and J.W. Short. Hydrocarbons in intertidal sediments and mussels from Prince William Sound, AK 1997-1980. Characterization and probable sources. NOAA Technical Memorandum NMFS-AFSC-9. US Dept. of Commerce, National Marine Fisheries Service.

Kenyon, K. W. 1969. N. American Fauna 68: The Sea Otter in the Eastern Pacific Ocean. US Fish and Wildlife Service. pp. 352.

Keough, M. J., G. P. Quinn and A. King. 1993. Correlations between human collection and intertidal mollusk populations on rocky shores. Conservation Biology 7(2): 378-390.

Keough, M. J. and G. P. Quinn. 1998. Effects of periodic disturbances from trampling on rocky intertidal algal beds. Ecological Applications 8(1): 141-161.

Kimbrough, K. L., W. E. Johnson, G. G. Lauenstein, J. D. Christensen and D. A. Apeti. 2008. An Assessment of Two Decades of Contaminant Monitoring in the Nation's Coastal Zone. Silver Spring, MD. NOAA Technical Memorandum NOS NCCOS 74. 105 pp. NOAA.

Kingsford, M. J., A. J. Underwood and S. J. Kennelly. 1991. Humans as predators on rocky reefs in New South Wales, Australia. Marine Ecology Progress Series. Oldenforf 72(102): 1-14.

Knox, G. A. 2000. The Ecology of Seashores. CRC Press LLC, Boca Raton, FL. 557 pp.

Larkum, W.D., Orth, R.J., Duarte, C.M., 2006. Seagrasses: Biology Ecology and Conservation. Springer, The Netherlands.

Lauenstein, G.G., and A.Y. Cantillo. 1993a. Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Overview and Summary of Methods, Volume I NOAA Technical Memorandum NOS ORCA 71 Silver Spring, MD.

Lauenstein, G.G., and A.Y. Cantillo (eds.). 1993b. Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Comprehensive Descriptions of Complementary Measurements, Volume II NOAA Technical Memorandum NOS ORCA 71 Silver Spring, MD.

Lauenstein, G.G., and A.Y. Cantillo (eds.). 1993c. Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Comprehensive Descriptions of Elemental Analytical Methods, Volume III NOAA Technical Memorandum NOS ORCA 71 Silver Spring, MD.

Lauenstein, G.G., and A.Y. Cantillo (eds.). 1993d. Sampling and Analytical Methods of the National Status and Trends Program National Benthic Surveillance and Mussel Watch Projects 1984-1992: Comprehensive Descriptions of Trace Organic Analytical Methods, Volume IV. NOAA Technical Memorandum NOS ORCA 71 Silver Spring, MD.

Lauenstein, G.G., and A.Y. Cantillo, 1998. Analytical Methods of the National Status and Trends Program Mussel Watch Project - 1993 -1997 Update. NOAA Technical Memorandum NOS ORCA 130 Silver Spring, MD.

Lehtonen, R. and Erkki Pahkinen. 2004. Practical Methods for Design and Analysis of Complex Surveys: Second Edition. John Wiley and Sons, 349 pages.

Lentfer, H. P. and A. J. Maier. 1995. Breeding ecology of the black oystercatcher in the Beardslee Island region of Glacier Bay National Park. In Proceedings of the Third Glacier Bay Science Symposium Proceedings of the Third Glacier Bay Science Symposium.

Lewis, J. 1996. Coastal benthos and global warming: strategies and problems. Marine Pollution Bulletin 32:698-700.

Lewis, T. L., D. Esler, and W. S. Boyd. 2007. Effects of predation by sea ducks on clam abundance in soft-sediment intertidal habitats. Marine Ecology Progress Series 329:131-144.

Liddle, M. J. 1975. A selective review of the ecological effects of human trampling on natural ecosystems. Biological Conservation 7: 17-36.

Lindberg, D. R., K. I. Warheit and J. A. Estes. 1987. Prey Preference and Seasonal Predation by Oystercatchers on Limpets at San Nicolas Island, California USA. Marine Ecology. 39: 105-113.

Lindberg, D. R., J. A. Estes and K. I. Warheit. 1998. Human influences on trophic cascades along rocky shores. Ecological Applications 8(3): 880-890.

Marsh, C. P. 1986a. The impact of avian predators on high intertidal limpet populations. Journal of Experimental. Marine Biology and Ecology. 104: 185-201.

Marsh, C. P. 1986b. Rocky Intertidal Community Organization: The Impact of Avian Predators on Mussel Recruitment. Ecology 67(3): 771-786.

McConnaughey, T. & McRoy, C. P. 1979. C13 label identifies eelgrass (**Zostera marina** L.) carbon in an Alaskan estuarine food web. Marine Biology. 53, 263-269.

McRoy, C.P. 1968. The distribution and biography of *Zostera marina* L. (eelgrass) in Alaska. Pacific Science. 22, 507-513.

McRoy, C. P. 1970. Standing stocks and other features of eelgrass (*Zostera marina* L.) populations on the coast of Alaska. Journal of the Fisheries Research Board of Canada. 27, 1811-1821.

McRoy, C. P. & Williams, S.L. 1977. Sublethal effects (of hydrocarbons) on seagrass photosynthesis. Final report to NOAA, Outer Continental Shelf Environmental Assessment Program, Contract No. 03-5-022-56, Task Order No. 17, R.U. No. 305:35.

Meese, R. J. 1990. Effects of Predation by Birds on Rocky Intertidal Community Structure. Bulletin of the Ecological Society of America. 71 (2): 250.

Meire, P. M. 1993. The Impact of Bird Predation on Marine and Estuarine Bivalve Populations: A selective Review of Patterns and Underlying Causes Bivalve Filter Feeders in Estuary. In Bivalve Filter Feeders in Estuarine and Coastal Ecosystem Processes. Vol. G33 Heidelberg, Germany: Springer Verlag.

Menge, B. A. and G. M. Branch. 2001. Rocky intertidal communities. in Marine Community Ecology M. D. G. S. D. H. M. E. Bertness, Brown University, University of California at Santa Barbara, Georgia Institute of Technology. Marine Community Ecology. Sinauer Associates, Inc., Sunderland, MA.

Monson, D.H., D.F. Doak, B.E. Ballachey, A. Johnson, and J.L. Bodkin. 2000. Long-term impacts of the *Exxon Valdez* oil spill on sea otters, assessed through age-dependent mortality patterns. Proceedings National Academy of Sciences, USA.97(12):6562-6567.

Monson, D.H., J.A. Estes, J.L. Bodkin and D.B. Siniff. 2000a. Life history plasticity and population regulation in sea otters. Oikos. 90:3 457-468.

National Oceanic and Atmospheric Administration (NOAA), 1997. Office of Ocean Resources Conservation and Assessment, Seattle, Washington 98115; and Research Planning, Inc. (RPI), 1200 Park Street, Post Office Box 328, Columbia, SC 29202 .

Neckles, H.A., Short, F.T., Barker, S., Kopp, B.S., 2005. Disturbance of eelgrass *Zostera marina* by commercial mussel *Mytilus edulis* harvesting in Maine: dragging impacts and habitat recovery. Marine Ecology Progress Series. 285, 57–73.

Neilson, R., S. Howlin and L. McDonald. 2003. Bootstrapping to investigate effects of sample size on variance and bias of estimated species totals for Prince William Sound Marine Bird Survey. West, Inc unpub. report.

Nichols, J.D., T. Boulinier, J.E. Hines, K.H. Pollock, and J.R. Sauer. 1998. Estimating rates of local species extinction, colonization, and turnover in animal communities. Ecological Applications. 8:1213-1225.

Norris, J.G., Wyllie-Echeverria, S., Mumford, T., Bailey, A., Turner, T., 1997. Estimating basal area coverage of subtidal seagrass beds using underwater videography. Aquatic Botany. 58, 269–287.

O'Clair, C.E. and S. D. Rice. 1985. Depression of feeding and growth rates of the seastar *Evasterias troschelii* during long-term exposure to the water-soluble fraction of crude oil. Marine Biology 84: 331-340.

O'Clair, C. E., and S. T. Zimmerman. 1986. Biogeography and Ecology of Intertidal and Shallow Subtidal Communities.: in The Gulf of Alaska: physical environment and biological resources. NOAA, U.S. Department of Commerce, Washington, DC

O'Clair, R.M and C.E. O'Clair. 1988. Southeast Alaska Rocky Shores: Animals. Plant Press, Auke Bay, AK.

O'Connor, T.P. 1996. Trends in chemical concentrations in mussels and oysters collected along the U.S. Coast from 1986 to 1993. Marine Environmental Research. 41:183-200

O'Connor T.P. and G.G. Lauenstein. 2006. Trends in chemical concentrations in mussels and oysters collected on the U.S. coast: update to 2003. Marine Environmental Research 62:261-285.

Olesen, B., 1996. Regulation of light attenuation and eelgrass *Zostera marina* depth distribution in a Danish embayment. Marine Ecology Progress Series. 134, 187–194.

Payne, J.R., W. B. Driskell, and D.C. Lees. 1998. Final Report: LTEMP data analysis of hydrocarbons in intertidal mussels and marine sediments, 1993-1996. Report to the Prince William Sound Regional Citizens Advisory Council. Valdez, AK. 97 pp. plus appendices.

Peterson, C. H. 2001. The "*Exxon Valdez*" oil spill in Alaska: acute, indirect and chronic effects on the ecosystem. Advances in Marine Biology 39: 1-103.

Peterson, C. H., S. D. Rice, J. W. Short, D. Esler, J. L. Bodkin, B. E. Ballachey, and D. B. Irons. 2003. Long-term ecosystem response to the *Exxon Valdez* oil spill. Science 302: 2082-2086.

Povey, A. and M. J. Keough. 1991. Effects of trampling on plant and animal populations on rocky shores. Oikos 61(3): 355-368.

Power, M. E., D. Tilman, J. A. Estes, B. A. Menge, W. J. Bond, L. S. Mills, G. Daily, J. C. Castilla, J. Lubchenco, and R. T. Paine. 1996. Challenges in the quest for keystones. BioScience 46(8): 609-620.

Prasil, R. 1971. Sea and Coastline Surveys Katmai National Monument, July 1969 through June 26, 1971. National Park Service, Alaska Region Natural Resources Survey and Inventory Report AR-71/02. National Park Service, Anchorage, AK. 9pp.

Precision Identification. 2002. Eelgrass mapping review: Methods and case studies. Report to Canadian Wildlife Service, Environment Canada. 25pp.

Riedman, M.L. and J.A. Estes. 1990. The sea otter (*Enhydra lutris*): Behavior, ecology and natural history. U.S. Fish and Wildlife Service. Biological Report 90(14). 126pp.

Rubin, D. B. 1987. *Multiple Imputation for Nonresponse in Surveys,* New York: John Wiley & Sons, Inc.

Sagarin R. D., Barry J. P., Gilman S. E., and Baxter C. H. 1999. Climate related changes in an intertidal community over short and long time scales. Ecological Monographs 69(4): 465-490.

SAS Institute. 2000. SAS/SYSTAT user's guide. Vol. 2. version 8. SAS Institute, Inc. Cary, NC

Schiel, D. R., and D. I. Taylor. 1999. Effects of trampling on a rocky intertidal algal assemblage in southern New Zealand. J. Exp. Mar. Biol. & Ecol. 235(2): 213-235Schultz, S.T. 2008. Seagrass monitoring by underwater videography: Disturbance regimes, sampling design, and statistical power. Aquatic Botany. 88: 228-238.

Short, J.W.and M.M. Babcock. 1996. Prespill and postspill concentrations of hydrocarbons in mussels and sediments in Prince William Sound. In S.D. Rice, R.B. Spies, D.A. Wolfe, and B.A. Wright, Eds. Proceedings of the *Exxon Valdez* Oil Spill Symposium. American Fisheries Society Symposium 18. PP 149-166.

Short, F. T., and S. Wyllie-Echeverria. 1996. Natural and human-induced disturbance of seagrasses. Environmental Conservation 23(1): 17-27.

Short, F.T., Koch, E.W., Creed, J.C., Magalhaes, K.M., Fernandez, E., Gaeckle, J.L., 2006. Seagrass net monitoring across the Americas: case studies of seagrass decline. Marine Ecology. 27, 277–289.

Sousa, W. P. 1979. Experimental Investigations of Disturbance and Ecological Succession in a Rocky Intertidal Algal Community. Ecological Monographs. 49(3): 227-254.

Spies, R.B., S.D. Rice, D.A. Wolfe, and B.A. Wright. 1996. The Effects of the Exxon Valdez oil spill on the Alaskan Coastal Environment. Pp 1-16 In: Rice, S.D., Spies, R.B., D.A. Wolfe, and B.A. Wright (eds.). Proceedings of the *Exxon Valdez* Oil Spill Symposium. American Fisheries Society, Bethesda, MD.

Springer, A.M. 1998. Is it all climate change? Why marine bird and mammal populations fluctuate in the North Pacific. P 109-119. In: G. Holloway, P. Mueller, D. Henderson (eds.) Biotic impacts of extratropical climate variation in the Pacific: Proceedings of the Tenth 'AHA Huliko'a Hawaiian Winter Workshop, January 25-29, 1998. University of Hawaii at Monoa, School of Ocean and Earth Science and Technology, Honolulu, HI.

Stevens, D.L. and A.R. Olsen. 2004. Spatially Balanced Sampling of Natural Resources. Journal of the American Statistical Association 99:262-278.

Terrados, J., Grau-Castella, M., Pinol-Santina, D., Riera-Fernandez, P., 2006. Biomass and primary production of a 8–11 m depth meadow versus 3 m depth meadows of the seagrass *Cymodocea nodosa* (Ucria) Ascherson. Aquatic Botany 84, 324–332.

Thayer, J. K. & Phillips, R. C. 1977. Importance of eelgrass beds in Puget Sound. Marine Fisheries Review. 36, 27-39.

Trust, K. A., D. Esler, B. R. Woodin and J. J. Stegeman. 2000. Cytochrome P450 1A induction in sea ducks inhabiting nearshore areas of Prince William Sound, Alaska. Marine Pollution Bulletin 40(5): 397-403.

Udevitz, M. S. & Ballachey, B. E. 1998. Estimating survival rates with age structure data Journal of Wildlife Management. 62, 779–792.

Walker, D. L., Lukatelich, R. J., Bastyan, G. & McComb, A. J. 1989. Effect of boat moorings on seagrass beds around Perth, Western Australia. Aquatic Botany. 36, 69-77.

Webster, J. D. 1941. Feeding habitats of the black oyster-catcher. The Condor 43: 175-180.

Whittam, T. S. and D. Siegel-Causey. 1981. Species Interactions and Community Structure in Alaskan Seabird Colonies. Ecology, Vol. 62, No. 6, pp. 1515-1524

Widdows, J. and P. Donkin. 1992. Mussels and environmental contaminants: bioaccumulation and physiological aspects. Pp 383-424. In: Gosling, E., Ed. The Mussel *Mytilus*: Ecology, Physiology, Genetics, and Culture. Elsevier, Amsterdam.

Wootton, J. T. 1992. Indirect Effects, Prey Susceptibility, and Habitat Selection: Impacts of Birds on Limpets and Algae. Ecology 73(3): 981-991.

Valiela, I. 2006. Global Coastal Change. Blackwell Publishing. Malden, MA. 368 p.

VanBlaricom., G.R. 1988. Effects of foraging by sea otters on mussel-dominated intertidal communities. Pages 48-91 *in* G.R. VanBlaricom and J.A. Estes (eds.) The Community Ecology of Sea Otters. Springer Verlag, Berlin, Germany.

Vermeer, K., K. H. Morgan and G. E. J. Smith. 1992. Black oystercatcher habitat selection, reproductive success, and their relationship with Glaucous-winged gulls. Colonial Waterbirds 15(1): 14-23.

Viquist, G.W. and M. Nishimoto. 1990. Seabird survey on the coast of Kenai Fjords during the *Exxon Valdez* Oil Spill. Natural Resources Final Report AR_90/04. National Park Service.

Appendices

Appendix A Contaminant Analysis Reports from TDI Brooks

TDI-Brooks International, Inc.
"Providing Scientific Services On A Global Basis"

Cook Inlet RCAC
Mussel Watch Project 2007

Determination of:
Polycyclic Aromatic Hydrocarbons, Organochlorine Pesticides, Polychlorinated Biphenyls in Tissues
and
Grain Size in Sediments

May 5, 2008

Technical Report 08-2066

1902 Pinon, College Station, TX 77845
Ph: (979) 693-3446 Fax: (979) 693-6389
Visit us on the Web at: www.tdi-bi.com

B&B Laboratories, Inc.

Narrative

Technical Report 08-2066
Cook Inlet RCAC
Mussel Watch Project 2007

May 5, 2008

Introduction

B&B Laboratories received three (3) coolers on September 21, 2007, which contained eleven (11) grain size samples and eleven (11) bivalve samples in sample delivery group (SDG) 07092101. Samples arrived in good condition on ice with internal cooler temperatures of 11.7°C (grain size), -16.9°C and -52.5°C (organic and inorganic). The samples were logged, measured, processed and stored according to B&B Laboratories standard operating procedure (B&B 1009). Tissue samples were stored frozen (-20°C) and sediment samples were stored refrigerated (4°C) in the dark until processing.

Eleven (11) tissue samples were analyzed for polycyclic aromatic hydrocarbons (PAH) by GC/MS-SIM, organochlorine pesticides (OC) and polychlorinated biphenyls (PCBs) by GC/ECD at B&B Laboratories in College Station, Texas. Eleven (11) grain size samples were sent to Azimuth Geo Services in Austin, TX. The results for grain size, PAH, organochlorine pesticides and PCB analyses are included in this report. Trace metals will follow in a separate report.

Analytical Methods

The analytical methods employed have been used or are currently being used for similar analytical studies provided to the other US government agencies, state agencies and private clients. Table 1 lists the Standard Operating Procedures (SOPs) for each matrix and analytical test.

Table 1. Standard Operating Procedures for each analytical test.

Matrix	Grain Size
Sediment	GS-92-01

Table 1. Continued. Standard Operating Procedures for each analytical test.

Matrix	Org Prep	Org Extract	PAH	OC/PCBs
Tissue	B&B 1012	B&B 1010	B&B 1006	B&B 1007

Data Reporting

The reporting unit for each analyte is listed in Table 2. The data for organics are provided on a dry weight basis. The method detection limit (MDL) for each analyte is listed in Table 3. Analytes that are detected below the method detection limit are qualified with a “J”. Analytes that are detected in the procedural blanks greater than 3X MDL are qualified with a “B”. Analytical interferences that are detected in the sample are qualified with an “I”. Analytes not detected in the samples are qualified with a “U”. RPD for analytes in duplicate samples that are <10X MDL are qualified with a “X”. Spiked levels of analytes in matrix spikes that are <50% of the native levels are considered invalid spikes and are qualified with a “Y”. A qualifier of “NA” constitutes an item in the data report, which is “not applicable” to that field. Any QC result reported to be outside the corresponding QC criteria is discussed in the QA/QC variance section of this report.

Table 2. Analytical reporting units.

Matrix	Grain Size
Sediment	%

Table 2. Continued. Analytical reporting units.

Matrix	PAH	OC/PCBs
Tissue	ng/dry g	ng/dry g

Table 3. Method Detection Limits.

PAH	Tissue
Sample size	2.07 g
Unit of measure	ng/dry g
Decalin	5.9
C1-Decalin	5.9
C2-Decalin	5.9
C3-Decalin	5.9
C4-Decalin	5.9
Naphthalene	9.0
C1-Naphthalenes	9.0
C2-Naphthalenes	9.0
C3-Naphthalenes	9.0
C4-Naphthalenes	9.0
Benzothiophene	3.9
C1-Benzothiophene	3.9
C2-Benzothiophene	3.9
C3-Benzothiophene	3.9
Biphenyl	2.5
Acenaphthylene	2.2
Acenaphthene	2.1
Dibenzofuran	2.2
Fluorene	2.5
C1-Fluorenes	2.5
C2-Fluorenes	2.5
C3-Fluorenes	2.5
Anthracene	1.2
Phenanthrene	3.6
C1-Phenanthrenes/Anthracenes	3.6
C2-Phenanthrenes/Anthracenes	3.6
C3-Phenanthrenes/Anthracenes	3.6
C4-Phenanthrenes/Anthracenes	3.6
Dibenzothiophene	1.8
C1-Dibenzothiophenes	1.8
C2-Dibenzothiophenes	1.8
C3-Dibenzothiophenes	1.8
Fluoranthene	9.0
Pyrene	5.7
C1-Fluoranthenes/Pyrenes	9.0
C1-Fluoranthenes/Pyrenes	9.0
C1-Fluoranthenes/Pyrenes	9.0
Naphthobenzothiophene	2.9
C1-Naphthobenzothiophene	2.9
C2-Naphthobenzothiophene	2.9
C3-Naphthobenzothiophene	2.9
Benz(a)anthracene	3.2
Chrysene	5.1
C1-Chrysenes	5.1
C2-Chrysenes	5.1
C3-Chrysenes	5.1
C4-Chrysenes	5.1

PAH	Tissue
Sample size	2.07 g
Unit of measure	ng/dry g
Benzo(b)fluoranthene	3.8
Benzo(k)fluoranthene	2.8
Benzo(e)pyrene	2.7
Benzo(a)pyrene	1.6
Perylene	5.4
Indeno(1,2,3-c,d)pyrene	3.3
Dibenzo(a,h)anthracene	2.4
C1-Dibenzo(a,h)anthracene	2.4
C2-Dibenzo(a,h)anthracene	2.4
C3-Dibenzo(a,h)anthracene	2.4
Benzo(g,h,i)perylene	2.4
2-Methylnaphthalene	8.7
1-Methylnaphthalene	5.3
2,6-Dimethylnaphthalene	3.5
1,6,7-Trimethylnaphthalene	1.0
1-Methylphenanthrene	1.2
C29-Hopane	12.5
18a-Oleanane	12.5
C30-Hopane	12.5

Table 3. Continued. Method Detection Limits.

Pesticides	**Tissue**
Sample size	2.09 g
Unit of measure	ng/dry g
Aldrin	0.24
Dieldrin	0.22
Endrin	0.21
Heptachlor	0.25
Heptachlor-Epoxide	0.23
Oxychlordane	0.28
Alpha-Chlordane	0.23
Gamma-Chlordane	0.27
Trans-Nonachlor	0.22
Cis-Nonachlor	0.24
Alpha-HCH	0.23
Beta-HCH	0.23
Delta-HCH	0.23
Gamma-HCH	0.22
DDMU	0.22
2,4'-DDD	0.22
4,4'-DDD	0.20
2,4'-DDE	0.21
4,4'-DDE	0.22
2,4'-DDT	0.25
4,4'-DDT	0.21
1,2,3,4-Tetrachlorobenzene	0.33
1,2,4,5-Tetrachlorobenzene	0.30
Hexachlorobenzene	0.25
Pentachloroanisole	0.18
Pentachlorobenzene	0.22
Endosulfan II	0.25
Endosulfan I	0.25
Endosulfan Sulfate	0.27
Mirex	0.23
Chlorpyrifos	0.25

Table 3. Continued. Method Detection Limits.

PCBs	**Tissue**
Sample size	2.09 g
Unit of measure	ng/dry g
PCB8/5	0.36
PCB18	0.44
PCB28	0.22
PCB29	0.25
PCB31	0.44
PCB44	0.40
PCB45	0.24
PCB49	0.24
PCB52	0.24
PCB56/60	0.24
PCB66	0.34
PCB70	0.24
PCB74/61	0.24
PCB87/115	0.39
PCB95	0.32
PCB99	0.32
PCB101/90	0.32
PCB105	0.33
PCB110/77	0.22
PCB118	0.25
PCB128	0.54
PCB138/160	0.43
PCB146	0.43
PCB149/123	0.43
PCB151	0.43
PCB153/132	0.48
PCB156/171/202	0.43
PCB158	0.43
PCB170/190	0.32
PCB174	0.24
PCB180	0.24
PCB183	0.24
PCB187	0.31
PCB194	0.27
PCB195/208	0.27
PCB199	0.27
PCB201/157/173	0.26
PCB206	0.29
PCB209	0.24

Quality Assurance/Quality Control

Grain Size

A duplicate sample is analyzed per analytical batch of no more than 20 samples. The QC criterion for valid duplicates is ± 30%.

PAH, Pesticides and PCBs

A rigorous program including the analyses of a method blank, duplicate, matrix spike/matrix spike duplicate and standard reference material (SRM) or certified reference material (CRM) per analytical batch of no more than 20 samples assures quality control. SRMs are only used if an applicable one is available. Method blanks are used to determine that sample preparation and analyses are free of contaminants. Duplicate samples are used to determine precision. Spiked samples are used to determine the accuracy and precision of sample preparation and analyses. An SRM is a material for which a mean and confidence interval are certified for specific analytes. SRMs are selected based on matrix similarities as well as type and level of certified analytes. SRMs are used to verify analytical accuracy. All blank, duplicate, spiked samples and SRMs are subject to the identical preparation and analysis steps as samples. Matrix spikes are samples fortified with known amounts of target analytes. The QC criteria for blanks specify that no more than 2 target analytes exceed 3X the method detection limits. The QC criteria for spiked samples specify recoveries between 40-120% for individual target analytes of valid spikes with an average recovery of 80-120% for all valid spike recoveries with the exception of endosulfan sulfate and chlorpyrifos. The recoveries of these two analytes are lower due to their loss during extraction. Control charts will be maintained to determine QC criteria based on performance. The QC criterion for valid duplicates and spiked duplicates is ± 30% for individual analytes. The SRM QC criterion for PAHs and organochlorines is ± 30% the certified limit.

Surrogate solutions equivalent to 5-10X the MDL are prepared for various hydrocarbon analyses. The appropriate surrogate solution is added to every sample including quality control samples. The data are corrected based on surrogate recovery. The QC criteria for surrogate recoveries are between 50-150% with the exception of perylene.

The following exceptions were noted for this sample set:

Quality Assurance/Quality Control Variances

Sediments

Grain Size

Laboratory Duplicates

Observation

- No variances are reported.

Tissues

PAHs

Surrogate

Observation

- Naphthalene-d8 recovery for ENV1699A exceeded the QC criteria of 50-150%.

Comments

- It is unknown why this analyte exceeded the QC criteria.

Blank

Observation

- No variances are reported.

Laboratory Duplicate

Observation

- No variances are reported.

Matrix Spike/Matrix Spike Duplicate

Observation

- No variances are reported.

Standard Reference Material

Observation

- No variances are reported.

OCs

Surrogate

Observation

- No variances are reported.

Blank

Observation

- No variances are reported.

Laboratory Duplicate

Observation

- No variances are reported.

Matrix Spike/Matrix Spike Duplicate

Observation

- The recovery of Endosulfan II exceeded the QA criteria (40-120%) in matrix spike ENV1764C and matrix spike duplicate ENV1764D.

Comments

- Endosulfan II is a labile compound and consequently recoveries are often low. Studies in our laboratory show that this analyte is lost when samples are processed through clean-up steps (alumina/silica gel columns and HPLC) as well as during the various concentration steps.

Standard Reference Material

Observation

- No variances are reported.

It is our judgement that these QA/QC variances do not impact the overall quality of the data submitted in this report.

We appreciate the opportunity to serve your analytical needs and please do not hesitate to contact us should you have any questions.

Juan A. Ramirez
Project Manager

Susanne J. McDonald
Laboratory Quality Manager

Sample/Analyses Description

Cook Inlet RCAC
Mussel Watch Project 2007
Sample Inventory

Laboratory File Number	Client Identification	Collection Date	Receive Date	Analysis	Matrix
RCA0001	AP-B10-SI1 Kukak Bay	07/03/07	09/21/07	GS	SED
RCA0002	AP-B10-SI2 Kaflia Bay	07/02/07	09/21/07	GS	SED
RCA0003	AP-B10-SI3 Kinak Bay	07/02/07	09/21/07	GS	SED
RCA0004	AP-B10-SI4 Amalik Bay	06/29/07	09/21/07	GS	SED
RCA0005	AP-B10-SI5 Takli Island	06/28/07	09/21/07	GS	SED
RCA0006	AP-B10-SS1 Ninagiak Island	07/04/07	09/21/07	GS	SED
RCA0007	KP-B5-SI1 Aailik Bay	06/18/07	09/21/07	GS	SED
RCA0008	KP-B5-SI2 McCarty Fjord	06/16/07	09/21/07	GS	SED
RCA0009	KP-B5-SI3 Nuka Bay	06/14/07	09/21/07	GS	SED
RCA0010	KP-B5-SI4 Nuka Passage	06/12/07	09/21/07	GS	SED
RCA0011	KP-B5-SI5 Harris Bay	06/17/07	09/21/07	GS	SED
RCA0012	AP-B10-RI1 Kukak Bay	07/03/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0013	AP-B10-RI2 Kaflia Bay	07/02/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0014	AP-B10-RI3 Kinak Bay	07/01/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0015	AP-B10-RI4 Amalik Bay	06/29/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0016	AP-B10-RI5 Takli Island	06/28/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0017	AP-B10-RS1 Ninagiak Island	07/04/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0018	KP-B5-RI1 Aailik Bay	06/19/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0019	KP-B5-RI2 McCarty Fjord	06/15/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0020	KP-B5-RI3 Nuka Bay	06/14/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0021	KP-B5-RI4 Nuka Passage	06/12/07	09/21/07	PAH, OC, BT, TM	TISSUE
RCA0022	KP-B5-RI5 Harris Bay	06/17/07	09/21/07	PAH, OC, BT, TM	TISSUE

Sediment Samples

Percent Grain Size

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Grain Size
Client Submitted Samples

Sample Name	RCA0001	RCA0002	RCA0003	RCA0004
Client Name	AP-B10-SI1 Kukak Bay	AP-B10-SI2 Kaflia Bay	AP-B10-SI3 Kinak Bay	AP-B10-SI4 Amalik Bay
Matrix	Sediment	Sediment	Sediment	Sediment
Collection Date	07/03/07	07/02/07	07/02/07	06/29/07
Received Date	09/21/07	09/21/07	09/21/07	09/21/07
Analysis Date	10/17/07	10/17/07	10/17/07	10/17/07
Method	GS	GS	GS	GS
Sample Weight (g)	60.69	26.22	58.32	51.97
Target Compounds	%	%	%	%
%GRAVEL	11.40	19.18	73.26	47.68
%SAND	74.83	58.12	26.57	51.45
%SILT	6.76	12.21	0.17	0.29
%CLAY	6.51	10.49	0.00	0.58

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Grain Size
Client Submitted Samples

Sample Name	RCA0005	RCA0006	RCA0007	RCA0008
Client Name	AP-B10-SI5 Takli Island	AP-B10-SS1 Ninagiak Island	KP-B5-SI1 Aailik Bay	KP-B5-SI2 McCarty Fjord
Matrix	Sediment	Sediment	Sediment	Sediment
Collection Date	06/28/07	07/04/07	06/18/07	06/16/07
Received Date	09/21/07	09/21/07	09/21/07	09/21/07
Analysis Date	10/17/07	10/17/07	10/17/07	10/17/07
Method	GS	GS	GS	GS
Sample Weight (g)	58.78	51.70	68.27	69.50
Target Compounds	%	%	%	%
%GRAVEL	7.52	45.63	26.73	11.98
%SAND	81.16	53.50	64.11	84.26
%SILT	7.83	0.48	5.35	2.13
%CLAY	3.49	0.39	3.81	1.63

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Grain Size
Client Submitted Samples

Sample Name	RCA0009	RCA0010	RCA0011
Client Name	KP-B5-SI3 Nuka Bay	KP-B5-SI4 Nuka Passage	KP-B5-SI5 Harris Bay
Matrix	Sediment	Sediment	Sediment
Collection Date	06/14/07	06/12/07	06/17/07
Received Date	09/21/07	09/21/07	09/21/07
Analysis Date	10/17/07	10/17/07	10/17/07
Method	GS	GS	GS
Sample Weight (g)	53.09	32.33	78.26
Target Compounds	%	%	%
%GRAVEL	70.12	47.16	56.69
%SAND	25.45	42.17	39.48
%SILT	3.11	6.96	2.30
%CLAY	1.32	3.71	1.53

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Grain Size
Laboratory Duplicate Report

Sample Name	RCA0011		RCA0011 DUP			
Client Name	KP-B5-SI5 Harris Bay		KP-B5-SI5 Harris Bay			
Matrix	Sediment		Sediment			
Collection Date	06/17/07		06/17/07			
Received Date	09/21/07		09/21/07			
Analysis Date	10/17/07		10/17/07			
Method	GS		GS			
Sample Weight (g)	78.26		77.98			
Target Compounds	%	Q	%	Q	%RPD	Q
%GRAVEL	56.69		57.08		1	
%SAND	39.48		39.12		1	
%SILT	2.30		2.34		0	
%CLAY	1.53		1.46		5	

Qualifiers (Q): J=Below the MDL, U=Not detected, I=Interference, NA=Not Applicable, *=Outside QA limits, refer to narrative

Tissue Samples

Polycyclic Aromatic Hydrocarbon Concentration

Cook Inlet RCAC
Mussel Watch Project 2007
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Sample Name	RCA0012	RCA0013	RCA0014	RCA0015	RCA0016	RCA0017
Client Name	AP-B10-RI1 Kukak Bay	AP-B10-RI2 Kaflia Bay	AP-B10-RI3 Kinak Bay	AP-B10-RI4 Amalik Bay	AP-B10-RI5 Takli Island	AP-B10-RS1 Ninagiak Island
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Species	ME	ME	ME	ME	ME	ME
Collection Date	07/03/07	07/02/07	07/01/07	06/29/07	06/28/07	07/04/07
Received Date	09/21/07	09/21/07	09/21/07	09/21/07	09/21/07	09/21/07
Extraction Date	10/08/07	10/08/07	10/08/07	10/08/07	10/08/07	10/08/07
Extraction Batch	ENV1699	ENV1699	ENV1699	ENV1699	ENV1699	ENV1699
Date Acquired	12/02/07	12/02/07	12/02/07	12/02/07	12/02/07	12/02/07
Method	PAH-2002	PAH-2002	PAH-2002	PAH-2002	PAH-2002	PAH-2002
Sample Dry Weight (g)	1.5	1.3	1.5	1.9	1.4	1.8
Sample Wet Weight (g)	12.5	12.2	12.6	12.2	12.5	12.0
% Dry	12	11	11	15	11	15
% Moisture	88	89	89	85	89	85
% Lipid (dry)	15.9	11.0	13.5	14.1	10.5	14.5
% Lipid (wet)	1.9	1.2	1.6	2.2	1.2	2.2
Dilution	NA	NA	NA	NA	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q
Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C1-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C4-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Naphthalene	6.6	J	6.8	J	6.4	J	7.9	J	7.9	J	9.0	J
C1-Naphthalenes	6.6	J	7.7	J	7.1	J	7.7	J	8.3	J	9.3	J
C2-Naphthalenes	9.8	J	10.5	J	10.1	J	10.1	J	9.2	J	10.6	
C3-Naphthalenes	10.5	J	11.2	J	10.2	J	8.2	J	9.1	J	9.3	J
C4-Naphthalenes	6.3	J	7.8	J	4.6	J	9.2	J	6.6	J	4.4	J
Benzothiophene	0.0	U	2.4	J	2.4	J	2.8	J	2.3	J	2.1	J
C1-Benzothiophene	26.5		14.1		18.2		27.5		13.7		31.2	
C2-Benzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Benzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Biphenyl	3.5	J	4.2		3.3	J	2.4	J	3.8		2.9	
Acenaphthylene	0.2	J	0.0	U	0.2	J	0.3	J	0.0	U	0.3	J
Acenaphthene	13.8		7.1		6.8		8.2		4.9		10.3	
Dibenzofuran	3.9		4.2		4.1		3.6		4.5		4.7	
Fluorene	3.2	J	3.9	J	3.0	J	2.5	J	3.6	J	3.4	
C1-Fluorenes	3.6		3.6	J	3.0	J	3.2		3.6	J	3.3	
C2-Fluorenes	6.7		6.5		5.5		4.4		6.3		5.5	
C3-Fluorenes	6.0		0.0	U	0.0	U	5.9		6.7		5.5	
Anthracene	0.4	J	0.3	J	0.2	J	0.8	J	0.3	J	0.5	J
Phenanthrene	7.7		7.9		5.8		4.9		8.3		8.2	
C1-Phenanthrenes/Anthracenes	3.6	J	4.0	J	2.7	J	2.5	J	4.0	J	4.0	J
C2-Phenanthrenes/Anthracenes	4.0	J	3.7	J	2.8	J	2.9	J	3.5	J	3.7	J
C3-Phenanthrenes/Anthracenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C4-Phenanthrenes/Anthracenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Dibenzothiophene	1.0	J	0.8	J	0.9	J	0.7	J	1.1	J	1.0	J
C1-Dibenzothiophenes	1.8	J	2.1	J	1.5	J	1.9	J	2.5	J	2.5	
C2-Dibenzothiophenes	2.3	J	2.2	J	1.5	J	1.9	J	2.8		2.8	
C3-Dibenzothiophenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Fluoranthene	0.9	J	1.2	J	0.7	J	0.7	J	0.9	J	1.2	J
Pyrene	0.5	J	0.8	J	0.5	J	0.5	J	0.5	J	0.7	J
C1-Fluoranthenes/Pyrenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Fluoranthenes/Pyrenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Fluoranthenes/Pyrenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C1-Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benz(a)anthracene	0.2	J	0.3	J	0.3	J	0.1	J	0.4	J	0.8	J
Chrysene	0.8	J	0.4	J	0.3	J	0.1	J	0.4	J	0.7	J
C1-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C4-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benzo(b)fluoranthene	0.4	J	0.0	U	0.0	U	0.0	U	0.0	U	0.9	J
Benzo(k)fluoranthene	0.3	J	0.0	U	0.0	U	0.0	U	0.0	U	0.6	J
Benzo(e)pyrene	0.6	J	0.0	U	0.0	U	0.0	U	0.0	U	0.5	J
Benzo(a)pyrene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.3	J
Perylene	0.0	U	1.2	J	0.0	U	0.9	J	1.1	J	0.0	U
Indeno(1,2,3-c,d)pyrene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C1-Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benzo(g,h,i)perylene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Total PAHs	132		115		102		122		116		140	
Individual Alkyl Isomers												
2-Methylnaphthalene	6.7	J	7.8	J	6.9	J	7.8	J	8.2	J	9.8	J
1-Methylnaphthalene	3.8	J	4.4	J	4.3	J	4.4	J	5.0	J	5.1	J
2,6-Dimethylnaphthalene	4.5	J	4.6	J	4.5	J	3.9	J	4.4	J	4.9	
1,6,7-Trimethylnaphthalene	1.1	J	0.8	J	0.9	J	1.2		0.6	J	0.7	J
1-Methylphenanthrene	1.1	J	0.9	J	0.6	J	0.6	J	1.0	J	1.1	J
C29-Hopane	112.0		0.0	U	54.8		32.4		25.0		7.5	J
18a-Oleanane	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C30-Hopane	122		0.0	U	44.6		56.0		22.1		6.0	J

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
Naphthalene-d8	92	73	79	66	63	71
Acenaphthene-d10	96	94	87	83	90	88
Phenanthrene-d10	78	68	75	69	64	64
Chrysene-d12	66	57	65	59	52	52
Perylene-d12	75	62	69	60	64	55

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not Applicable,*=Outside QA limits, refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Polycyclic Aromatic Hydrocarbon Data
Client Submitted Samples

Sample Name	RCA0018	RCA0019	RCA0020	RCA0021	RCA0022
Client Name	KP-B5-RI1 Aailik Bay	KP-B5-RI2 McCarty Fjord	KP-B5-RI3 Nuka Bay	KP-B5-RI4 Nuka Passage	KP-B5-RI5 Harris Bay
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue
Species	ME	ME	ME	ME	ME
Collection Date	06/19/07	06/15/07	06/14/07	06/12/07	06/17/07
Received Date	09/21/07	09/21/07	09/21/07	09/21/07	09/21/07
Extraction Date	10/08/07	10/08/07	10/08/07	10/08/07	10/08/07
Extraction Batch	ENV1699	ENV1699	ENV1699	ENV1699	ENV1699
Date Acquired	12/02/07	12/02/07	12/02/07	12/02/07	12/02/07
Method	PAH-2002	PAH-2002	PAH-2002	PAH-2002	PAH-2002
Sample Dry Weight (g)	1.9	1.8	1.7	1.9	1.8
Sample Wet Weight (g)	12.9	12.6	12.2	12.1	12.3
% Dry	15	14	14	15	15
% Moisture	85	86	86	85	85
% Lipid (dry)	12.0	10.7	15.0	15.1	16.3
% Lipid (wet)	1.8	1.5	2.1	2.3	2.4
Dilution	NA	NA	NA	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q
Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C1-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C4-Decalin	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Naphthalene	6.0	J	6.2	J	8.7	J	7.8	J	9.7	J
C1-Naphthalenes	6.3	J	6.6	J	8.8	J	7.0	J	8.6	J
C2-Naphthalenes	7.4	J	8.2	J	10.3	J	11.2		9.4	J
C3-Naphthalenes	7.8	J	9.4	J	9.4	J	8.8	J	9.2	J
C4-Naphthalenes	3.0	J	4.8	J	4.0	J	4.4	J	5.7	J
Benzothiophene	1.8	J	11.5		7.1		7.4		3.0	J
C1-Benzothiophene	16.4		12.2		20.6		26.4		14.5	
C2-Benzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Benzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Biphenyl	2.7		4.6		2.7	J	4.2		2.6	J
Acenaphthylene	0.3	J	0.3	J	0.2	J	0.3	J	0.0	U
Acenaphthene	5.7		1.8	J	4.2		1.5	J	1.6	J
Dibenzofuran	2.8		4.4		4.3		4.2		4.0	
Fluorene	2.2	J	3.4		3.2		3.1		2.3	J
C1-Fluorenes	3.0		3.9		4.4		3.1		3.3	
C2-Fluorenes	4.0		5.6		5.1		4.6		3.6	
C3-Fluorenes	5.0		5.9		0.0	U	4.0		4.5	
Anthracene	0.2	J	0.3	J	0.5	J	0.2	J	0.8	J
Phenanthrene	5.0		6.4		5.9		4.2		3.8	J
C1-Phenanthrenes/Anthracenes	2.6	J	3.5	J	2.8	J	2.8	J	2.7	J
C2-Phenanthrenes/Anthracenes	1.9	J	2.5	J	2.8	J	2.2	J	0.0	U
C3-Phenanthrenes/Anthracenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C4-Phenanthrenes/Anthracenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Dibenzothiophene	0.8	J	1.2	J	0.8	J	0.6	J	0.6	J
C1-Dibenzothiophenes	1.7	J	2.2		1.8	J	1.1	J	1.3	J
C2-Dibenzothiophenes	1.5	J	2.9		0.0	U	0.0	U	0.0	U
C3-Dibenzothiophenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Fluoranthene	0.7	J	1.0	J	0.7	J	0.7	J	0.6	J
Pyrene	0.3	J	0.5	J	0.3	J	0.4	J	0.3	J
C1-Fluoranthenes/Pyrenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Fluoranthenes/Pyrenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Fluoranthenes/Pyrenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C1-Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Naphthobenzothiophene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benz(a)anthracene	0.3	J	0.4	J	0.5	J	0.0	U	0.0	U
Chrysene	0.2	J	0.2	J	0.2	J	0.0	U	0.0	U
C1-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C4-Chrysenes	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benzo(b)fluoranthene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benzo(k)fluoranthene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benzo(e)pyrene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benzo(a)pyrene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Perylene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Indeno(1,2,3-c,d)pyrene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C1-Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C2-Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C3-Dibenzo(a,h)anthracene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Benzo(g,h,i)perylene	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
Total PAHs	89.6		110		109		110		92.1	
Individual Alkyl Isomers										
2-Methylnaphthalene	6.3	J	6.5	J	8.7	J	7.0	J	8.6	J
1-Methylnaphthalene	3.6	J	4.0	J	5.2	J	4.1	J	5.0	J
2,6-Dimethylnaphthalene	3.5	J	4.2		4.9		4.4		4.6	
1,6,7-Trimethylnaphthalene	0.8	J	0.5	J	0.5	J	0.3	J	1.2	
1-Methylphenanthrene	0.6	J	0.9	J	0.6	J	0.7	J	0.7	J
C29-Hopane	0.0	U	0.0	U	0.0	U	11.0	J	0.0	U
18a-Oleanane	0.0	U	0.0	U	0.0	U	0.0	U	0.0	U
C30-Hopane	0.0	U	0.0	U	0.0	U	14.8		0.0	U

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
Naphthalene-d8	74	68	67	64	63
Acenaphthene-d10	93	82	82	72	81
Phenanthrene-d10	69	68	68	73	89
Chrysene-d12	53	52	51	52	65
Perylene-d12	59	59	56	50	65

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not Applicable,*=Outside QA limits, refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Polycyclic Aromatic Hydrocarbon Data
Procedural Blank Report

Sample Name	ENV1699A
Client Name	Procedural Blank
Matrix	Tissue
Species	ME
Collection Date	NA
Received Date	NA
Extraction Date	10/08/07
Extraction Batch	ENV1699
Date Acquired	12/01/07
Method	PAH-2002
Sample Dry Weight (g)	2.1
Sample Wet Weight (g)	13.1
% Dry	NA
% Moisture	NA
% Lipid (dry)	NA
% Lipid (wet)	NA
Dilution	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Q	3X MDL	Actual MDL
Decalin	0.0	U		17.7	5.9
C1-Decalin	0.0	U		17.7	5.9
C2-Decalin	0.0	U		17.7	5.9
C3-Decalin	0.0	U		17.7	5.9
C4-Decalin	0.0	U		17.7	5.9
Naphthalene	5.2	J		27.1	9.0
C1-Naphthalenes	2.2	J		27.1	9.0
C2-Naphthalenes	0.0	U		27.1	9.0
C3-Naphthalenes	0.0	U		27.1	9.0
C4-Naphthalenes	0.0	U		27.1	9.0
Benzothiophene	0.0	U		11.8	3.9
C1-Benzothiophene	0.0	U		11.8	3.9
C2-Benzothiophene	0.0	U		11.8	3.9
C3-Benzothiophene	0.0	U		11.8	3.9
Biphenyl	1.5	J		7.4	2.5
Acenaphthylene	0.0	U		6.7	2.2
Acenaphthene	0.0	U		6.4	2.1
Dibenzofuran	0.0	J		6.7	2.2
Fluorene	0.6	J		7.4	2.5
C1-Fluorenes	1.5	J		7.4	2.5
C2-Fluorenes	0.0	U		7.4	2.5
C3-Fluorenes	0.0	U		7.4	2.5
Anthracene	0.1	J		3.5	1.2
Phenanthrene	1.0	J		10.9	3.6
C1-Phenanthrenes/Anthracenes	0.0	U		10.9	3.6
C2-Phenanthrenes/Anthracenes	0.0	U		10.9	3.6
C3-Phenanthrenes/Anthracenes	0.0	U		10.9	3.6
C4-Phenanthrenes/Anthracenes	0.0	U		10.9	3.6
Dibenzothiophene	0.0	U		5.3	1.8
C1-Dibenzothiophenes	0.0	U		5.3	1.8
C2-Dibenzothiophenes	0.0	U		5.3	1.8
C3-Dibenzothiophenes	0.0	U		5.3	1.8
Fluoranthene	0.4	J		27.0	9.0
Pyrene	0.1	J		17.1	5.7
C1-Fluoranthenes/Pyrenes	0.0	U		27.0	9.0
C1-Fluoranthenes/Pyrenes	0.0	U		27.0	9.0
C1-Fluoranthenes/Pyrenes	0.0	U		27.0	9.0
Naphthobenzothiophene	0.0	U		8.8	2.9
C1-Naphthobenzothiophene	0.0	U		8.8	2.9
C2-Naphthobenzothiophene	0.0	U		8.8	2.9
C3-Naphthobenzothiophene	0.0	U		8.8	2.9
Benz(a)anthracene	0.0	U		9.5	3.2
Chrysene	0.0	U		15.3	5.1
C1-Chrysenes	0.0	U		15.3	5.1
C2-Chrysenes	0.0	U		15.3	5.1
C3-Chrysenes	0.0	U		15.3	5.1
C4-Chrysenes	0.0	U		15.3	5.1
Benzo(b)fluoranthene	0.0	U		11.5	3.8
Benzo(k)fluoranthene	0.0	U		8.4	2.8
Benzo(e)pyrene	0.0	U		8.0	2.7
Benzo(a)pyrene	0.0	U		4.9	1.6
Perylene	1.3	J		16.1	5.4
Indeno(1,2,3-c,d)pyrene	0.0	U		10.0	3.3
Dibenzo(a,h)anthracene	0.0	U		7.1	2.4
C1-Dibenzo(a,h)anthracene	0.0	U		7.1	2.4
C2-Dibenzo(a,h)anthracene	0.0	U		7.1	2.4
C3-Dibenzo(a,h)anthracene	0.0	U		7.1	2.4
Benzo(g,h,i)perylene	0.0	U		7.2	2.4
Total PAHs	13.9				
Individual Alkyl Isomers					
2-Methylnaphthalene	2.1	J		26.1	8.7
1-Methylnaphthalene	1.4	J		15.9	5.3
2,6-Dimethylnaphthalene	0.0	U		10.6	3.5
1,6,7-Trimethylnaphthalene	0.0	U		2.9	1.0
1-Methylphenanthrene	0.0	U		3.6	1.2
C29-Hopane	0.0	U		37.6	12.5
18a-Oleanane	0.0	U		37.6	12.5
C30-Hopane	0.0	U		37.6	12.5

Surrogate (Su)	Su Recovery (%)	
Naphthalene-d8	40	*
Acenaphthene-d10	65	
Phenanthrene-d10	63	
Chrysene-d12	61	
Perylene-d12	41	

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not Applicable, *=Outside QA limits, refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Polycyclic Aromatic Hydrocarbon Data
Laboratory Duplicate Report

Sample Name	NST2425	ENV1699E
Client Name	LORC	LORC
Matrix	Tissue	Tissue
Species	ME	ME
Collection Date	09/10/07	09/10/07
Received Date	09/11/07	09/11/07
Extraction Date	10/08/07	10/08/07
Extraction Batch	ENV1699	ENV1699
Date Acquired	12/02/07	12/01/07
Method	PAH-2002	PAH-2002
Sample Dry Weight (g)	1.1	1.1
Sample Wet Weight (g)	12.2	12.1
% Dry	9	9
% Moisture	91	91
% Lipid (dry)	15.2	15.9
% Lipid (wet)	1.4	1.4
Dilution	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	RPD (%)	Q	Q	10 X MDL	MDL
Decalin	0.0	U	0.0	U				114.64	11.46
C1-Decalin	0.0	U	0.0	U				114.64	11.46
C2-Decalin	0.0	U	0.0	U				114.64	11.46
C3-Decalin	0.0	U	0.0	U				114.64	11.46
C4-Decalin	0.0	U	0.0	U				114.64	11.46
Naphthalene	11.0	J	12.8	J				175.53	17.55
C1-Naphthalenes	10.2	J	11.1	J				175.53	17.55
C2-Naphthalenes	13.7	J	14.8	J				175.53	17.55
C3-Naphthalenes	15.5	J	19.9		25		X	175.53	17.55
C4-Naphthalenes	7.7	J	6.0	J				175.53	17.55
Benzothiophene	39.7		44.5		11		X	76.63	7.66
C1-Benzothiophene	0.0	U	0.0	U				76.63	7.66
C2-Benzothiophene	0.0	U	0.0	U				76.63	7.66
C3-Benzothiophene	0.0	U	0.0	U				76.63	7.66
Biphenyl	3.7	J	4.9		28		X	47.71	4.77
Acenaphthylene	2.9	J	3.0	J				43.17	4.32
Acenaphthene	2.4	J	2.7	J				41.28	4.13
Dibenzofuran	5.8		7.3		23		X	43.21	4.32
Fluorene	6.1		6.8		11		X	48.23	4.82
C1-Fluorenes	6.9		8.6		22		X	48.23	4.82
C2-Fluorenes	14.5		16.0		10		X	48.23	4.82
C3-Fluorenes	22.3		28.7		25		X	48.23	4.82
Anthracene	3.0		3.2		6		X	22.87	2.29
Phenanthrene	19.0		23.8		22		X	70.57	7.06
C1-Phenanthrenes/Anthracenes	12.2		13.8		12		X	70.57	7.06
C2-Phenanthrenes/Anthracenes	17.2		20.0		15		X	70.57	7.06
C3-Phenanthrenes/Anthracenes	17.3		22.7		27		X	70.57	7.06
C4-Phenanthrenes/Anthracenes	13.1		12.7		3		X	70.57	7.06
Dibenzothiophene	1.8	J	2.1	J				34.57	3.46
C1-Dibenzothiophenes	3.8		3.4	J				34.57	3.46
C2-Dibenzothiophenes	7.1		7.6		7		X	34.57	3.46
C3-Dibenzothiophenes	6.6		7.7		15		X	34.57	3.46
Fluoranthene	37.2		45.0		19		X	175.32	17.53
Pyrene	18.5		24.2		27		X	111.06	11.11
C1-Fluoranthenes/Pyrenes	19.6		23.9		20		X	175.32	17.53
C2-Fluoranthenes/Pyrenes	10.3	J	13.2	J				175.32	17.53
C3-Fluoranthenes/Pyrenes	6.3	J	7.2	J				175.32	17.53
Naphthobenzothiophene	8.5		9.2		8		X	57.11	5.71
C1-Naphthobenzothiophene	8.3		10.5		23		X	57.11	5.71
C2-Naphthobenzothiophene	6.2		8.3		29		X	57.11	5.71
C3-Naphthobenzothiophene	3.6	J	3.7	J				57.11	5.71
Benz(a)anthracene	11.2		14.2		24		X	61.36	6.14
Chrysene	24.4		32.3		28		X	98.86	9.89
C1-Chrysenes	15.7		20.5		27		X	98.86	9.89
C2-Chrysenes	12.3		13.5		9		X	98.86	9.89
C3-Chrysenes	0.0	U	0.0	U				98.86	9.89
C4-Chrysenes	0.0	U	0.0	U				98.86	9.89
Benzo(b)fluoranthene	31.2		35.3		12		X	74.50	7.45
Benzo(k)fluoranthene	14.9		18.0		19		X	54.74	5.47
Benzo(e)pyrene	26.5		30.0		12		X	52.10	5.21
Benzo(a)pyrene	11.3		13.4		17		X	31.73	3.17
Perylene	22.2		26.7		18		X	104.06	10.41
Indeno(1,2,3-c,d)pyrene	6.7		8.5		24		X	65.03	6.50
Dibenzo(a,h)anthracene	0.7	J	0.9	J				45.85	4.59
C1-Dibenzo(a,h)anthracene	0.0	U	0.0	U				45.85	4.59
C2-Dibenzo(a,h)anthracene	0.0	U	0.0	U				45.85	4.59
C3-Dibenzo(a,h)anthracene	0.0	U	0.0	U				45.85	4.59
Benzo(g,h,i)perylene	8.0		9.7		19		X	46.50	4.65
Total PAHs	567		672						
Individual Alkyl Isomers									
2-Methylnaphthalene	10.3	J	11.2	J				169.4	16.94
1-Methylnaphthalene	5.9	J	6.3	J				102.93	10.29
2,6-Dimethylnaphthalene	5.7	J	6.7	J				68.59	6.86
1,6,7-Trimethylnaphthalene	1.3	J	1.3	J				18.58	1.86
1-Methylphenanthrene	3.4		3.9		14		X	23.37	2.34
C29-Hopane	58.3		66.7		13		X	243.83	24.38
18a-Oleanane	49.8		64.8		26		X	243.83	24.38
C30-Hopane	114		90.3		23		X	243.83	24.38

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)
Naphthalene-d8	80	63
Acenaphthene-d10	98	83
Phenanthrene-d10	84	64
Chrysene-d12	75	58
Perylene-d12	80	60

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not Applicable, X=<10x MDL, *=Outside QA Limits,refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Polycyclic Aromatic Hydrocarbon Data
Matrix Spike Report

Sample Name	NST2420	ENV1699C	ENV1699D
Client Name	LELR	LELR	LELR
Matrix	Tissue	Tissue	Tissue
Species	ME	ME	ME
Collection Date	09/07/07	09/07/07	09/07/07
Received Date	09/08/07	09/08/07	09/08/07
Extraction Date	10/08/07	10/08/07	10/08/07
Extraction Batch	ENV1699	ENV1699	ENV1699
Date Acquired	12/02/07	12/01/07	12/01/07
Method	PAH-2002	PAH-2002	PAH-2002
Sample Dry Weight (g)	1.3	1.4	1.3
Sample Wet Weight (g)	12.4	12.8	12.3
% Dry	11	11	11
% Moisture	89	89	89
% Lipid (dry)	13.7	14.2	14.0
% Lipid (wet)	1.5	1.5	1.5
Dilution	NA	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Q	Su Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Q	RPD (%)	Q	Spike Amout (ng)
Decalin	23.5		NA					NA							
C1-Decalins	39.8		NA					NA							
C2-Decalins	72.3		NA					NA							
C3-Decalins	0.0	U	NA					NA							
C4-Decalins	0.0	U	NA					NA							
Naphthalene	8.8	J	99.3		82			117		94			16		150
C1-Naphthalenes	10.3	J	138					165							
C2-Naphthalenes	20.2		NA					NA							
C3-Naphthalenes	41.6		NA					NA							
C4-Naphthalenes	29.1		NA					NA							
Benzothiophene	0.0	U	69.5		63			77.7		68			11		150
C1-Benzothiophenes	0.0	U	NA					NA							
C2-Benzothiophenes	0.0	U	NA					NA							
C3-Benzothiophenes	0.0	U	NA					NA							
Biphenyl	3.8	J	81.2		70			95.4		80			16		150
Acenaphthylene	1.3	J	68.3		61			75.7		65			10		150
Acenaphthene	2.4	J	79.2		70			87.2		74			10		150
Dibenzofuran	5.5		90.1		77			103		85			13		150
Fluorene	4.4		89.3		77			100		83			11		150
C1-Fluorenes	6.0		NA					NA							
C2-Fluorenes	15.7		NA					NA							
C3-Fluorenes	17.7		NA					NA							
Anthracene	2.7	J	101		89			109		93			8		150
Phenanthrene	20.3		125		95			140		104			11		150
C1-Phenanthrene/Anthracenes	19.5		NA					NA							
C2-Phenanthrene/Anthracenes	25.8		NA					NA							
C3-Phenanthrene/Anthracenes	25.6		NA					NA							
C4-Phenanthrene/Anthracenes	11.6	J	NA					NA							
Dibenzothiophene	3.9	J	112		98			122		103			9		150
C1-Dibenzothiophenes	8.3		NA					NA							
C2-Dibenzothiophenes	9.4		NA					NA							
C3-Dibenzothiophenes	8.1		NA					NA							
Fluoranthene	27.1	J	145		108			160		116			10		150
Pyrene	15.6	J	114		90			127		97			11		150
C1-Fluoranthenes/Pyrenes	12.4	J	NA					NA							
C2-Fluoranthenes/Pyrenes	9.4	J	NA					NA							
C3-Fluoranthenes/Pyrenes	7.3	J	NA					NA							
Naphthobenzothiophene	7.2	J	NA					NA							150
C1-Naphthobenzothiophenes	7.1	J	NA					NA							
C2-Naphthobenzothiophenes	5.6	J	NA					NA							
C3-Naphthobenzothiophenes	0.0	U	NA					NA							
Benz(a)anthracene	6.4	J	91.9		78			113		93			21		150
Chrysene	18.9	J	124		96			143		108			14		150
C1-Chrysenes	10.5	J	NA					NA							
C2-Chrysenes	20.3	J	NA					NA							
C3-Chrysenes	0.0	U	NA					NA							
C4-Chrysenes	0.0	U	NA					NA							
Benzo(b)fluoranthene	23.7		140		106			161		120			14		150
Benzo(k)fluoranthene	6.4	J	120		103			132		109			10		150
Benzo(e)pyrene	17.3		144		115			146		112			1		150
Benzo(a)pyrene	6.2	J	110		94			128		106			15		150
Perylene	5.7	J	131		114			128		107			2		150
Indeno(1,2,3-c,d)pyrene	6.0	J	99.4		85			114		94			14		150
Dibenzo(a,h)anthracene	1.1	J	98.4		88			108		93			9		150
C1-Dibenzo(a,h)anthracenes	0.0	U	NA					NA							
C2-Dibenzo(a,h)anthracenes	0.0	U	NA					NA							
C3-Dibenzo(a,h)anthracenes	0.0	U	NA					NA							
Benzo(g,h,i)perylene	7.6	J	113		96			126		103			11		150
Average % Recovery					89					96					
Individual Alkyl Isomers															
2-Methylnaphthalene	9.6	J	120		100			144		117			18		150
1-Methylnaphthalene	6.7	J	100		85			118		97			17		150
2,6-Dimethylnaphthalene	8.0	J	97.4		81			112		91			14		150
1,6,7-Trimethylnaphthalene	6.8		79.9		66			94.9		77			17		150
1-Methylphenanthrene	7.0		111		94			124		102			11		150
C29-Hopane	16.1	J	NA					NA							
18a-Oleanane	18.8	J	NA					NA							
C30-Hopane	38.8	J	NA					NA							

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
Naphthalene-d8	81	74	65
Acenaphthene-d10	98	97	90
Phenanthrene-d10	93	66	63
Chrysene-d12	76	63	55
Perylene-d12	76	65	55

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not Applicable,Y=Invalid Spike,*=Outside QA limits, refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Polycyclic Aromatic Hydrocarbon Data
Standard Reference Material Report

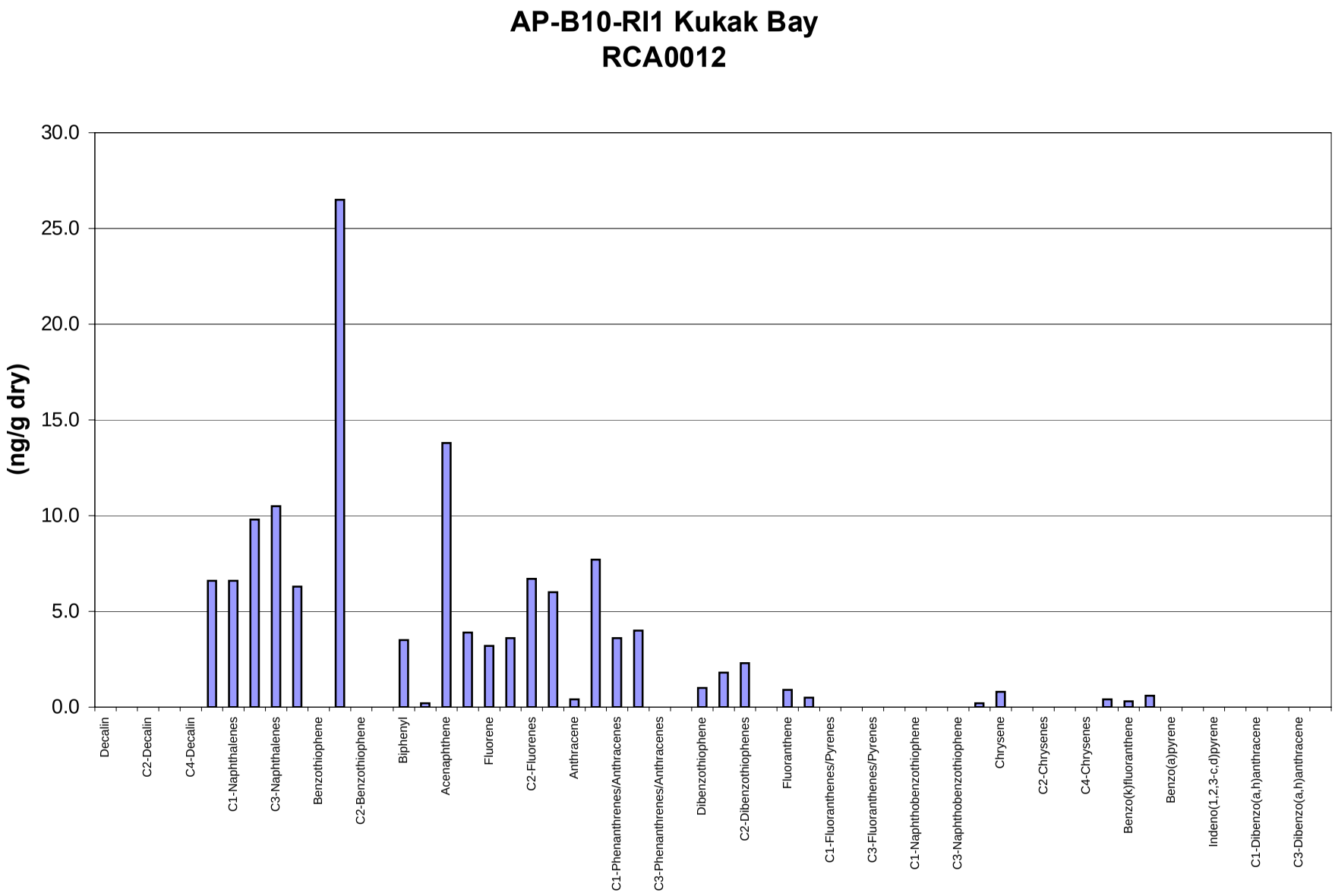
Sample Name	ENV1699B
Client Name	SRM1974b
Matrix	Tissue
Species	ME
Collection Date	NA
Received Date	NA
Extraction Date	10/8/2007
Extraction Batch	ENV1699
Date Acquired	12/1/2007
Method	PAH-2002
Sample Dry Weight (g)	0.6
Sample Wet Weight (g)	5.0
% Dry	10
% Moisture	90
% Lipid (dry)	5.4
% Lipid (wet)	0.6
Dilution	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Q	SRM 1974b Certified Conc. (ng/dry g)	-30% Conc. (ng/dry g)	+30% Conc. (ng/dry g)
Decalin	0.0	U				
C1-Decalin	0.0	U				
C2-Decalin	0.0	U				
C3-Decalin	0.0	U				
C4-Decalin	0.0	U				
Naphthalene	24.8	J		24± 1.2	16.0	32.8
C1-Naphthalenes	16.3	J				
C2-Naphthalenes	15.0	J				
C3-Naphthalenes	29.7	J				
C4-Naphthalenes	20.8	J				
Benzothiophene	0.0	U				
C1-Benzothiophene	0.0	U				
C2-Benzothiophene	0.0	U				
C3-Benzothiophene	0.0	U				
Biphenyl	6.6	J				
Acenaphthylene	3.4	J				
Acenaphthene	3.4	J				
Dibenzofuran	11.0					
Fluorene	5.9	J		4.88± 0.36	3.2	6.8
C1-Fluorenes	15.3					
C2-Fluorenes	37.5					
C3-Fluorenes	86.8					
Anthracene	6.0			5.2± 0.71	3.1	7.7
Phenanthrene	26.9			25.5± 1.1	17.1	34.6
C1-Phenanthrenes/Anthracenes	26.1					
C2-Phenanthrenes/Anthracenes	76.5					
C3-Phenanthrenes/Anthracenes	104					
C4-Phenanthrenes/Anthracenes	44.2					
Dibenzothiophene	3.1	J				
C1-Dibenzothiophenes	17.3					
C2-Dibenzothiophenes	38.8					
C3-Dibenzothiophenes	40.7					
Fluoranthene	151			169± 7	113.4	228.8
Pyrene	141			178± 6	120.4	239.2
C1-Fluoranthenes/Pyrenes	111					
C2-Fluoranthenes/Pyrenes	55.2					
C3-Fluoranthenes/Pyrenes	22.1	J				
Naphthobenzothiophene	32.0					
C1-Naphthobenzothiophene	26.8					
C2-Naphthobenzothiophene	24.7					
C3-Naphthobenzothiophene	11.1	J				
Benz(a)anthracene	40.2			46.8± 5.2	29.1	67.6
Chrysene	75.0			104.9± 17	61.5	158.5
C1-Chrysenes	39.4					
C2-Chrysenes	20.1					
C3-Chrysenes	6.9	J				
C4-Chrysenes	0.0	U				
Benzo(b)fluoranthene	82.2			63.8± 5.8	40.6	90.5
Benzo(k)fluoranthene	43.9			60.7± 4.7	39.2	85.0
Benzo(e)pyrene	125			102± 11	63.7	146.9
Benzo(a)pyrene	22.0			27.6± 3.8	16.7	40.8
Perylene	7.0	J		9.8± 1.4	5.9	14.6
Indeno(1,2,3-c,d)pyrene	17.1			21.1± 1.1	14.0	28.9
Dibenzo(a,h)anthracene	4.0	J		3.21± 0.31	2.0	4.6
C1-Dibenzo(a,h)anthracene	0.0	U				
C2-Dibenzo(a,h)anthracene	0.0	U				
C3-Dibenzo(a,h)anthracene	0.0	U				
Benzo(g,h,i)perylene	26.0			30.8± 3.3	19.3	44.3
Total PAHs	1744					
Individual Alkyl Isomers						
2-Methylnaphthalene	16.8	J				
1-Methylnaphthalene	9.0	J				
2,6-Dimethylnaphthalene	7.0	J				
1,6,7-Trimethylnaphthalene	3.4	J				
1-Methylphenanthrene	7.7					
C29-Hopane	82.4					
18a-Oleanane	12.1	J				
C30-Hopane	92.4					

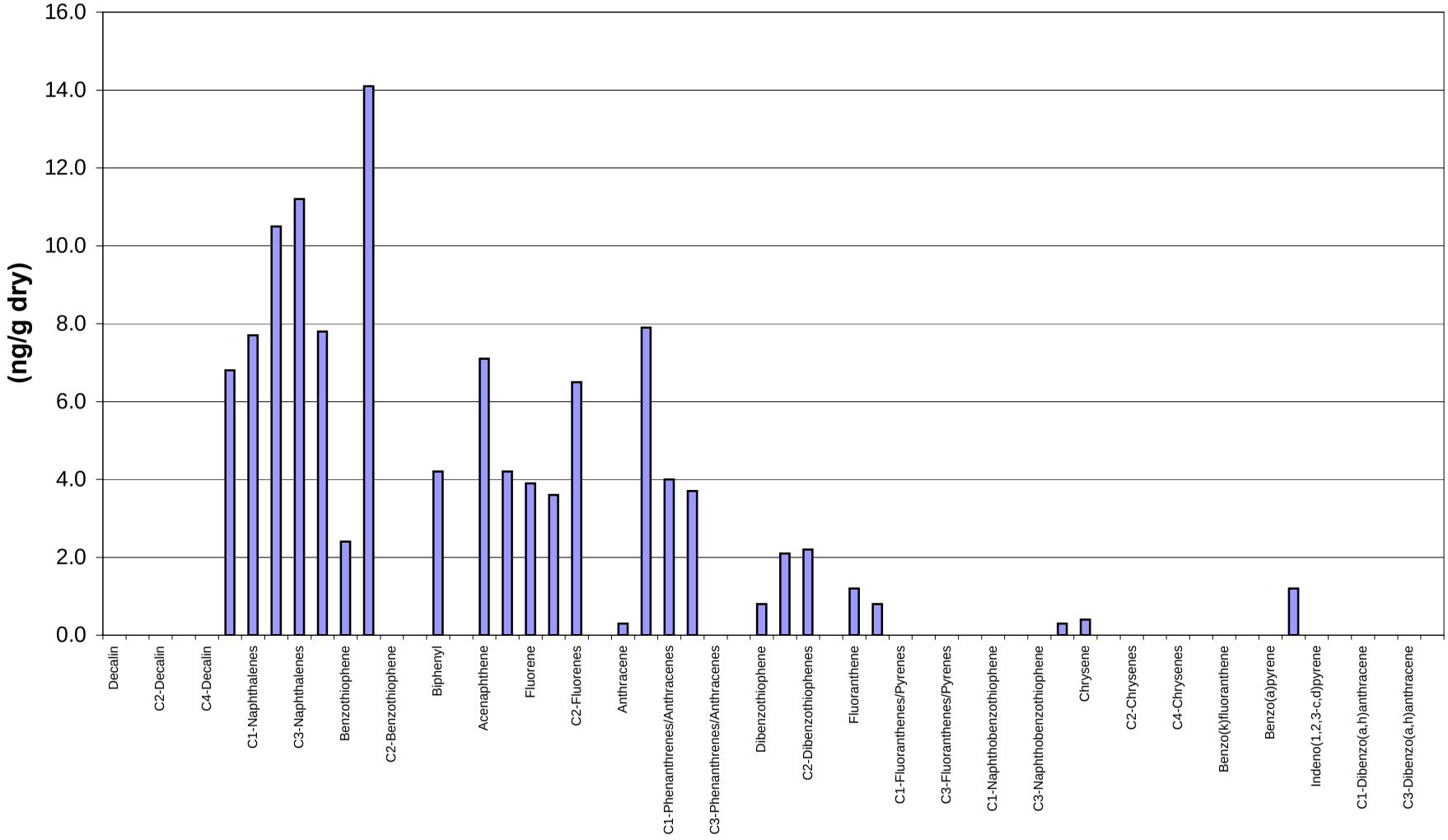
Surrogate (Su)	Su Recovery (%)
Naphthalene-d8	52
Acenaphthene-d10	89
Phenanthrene-d10	69
Chrysene-d12	66
Perylene-d12	83

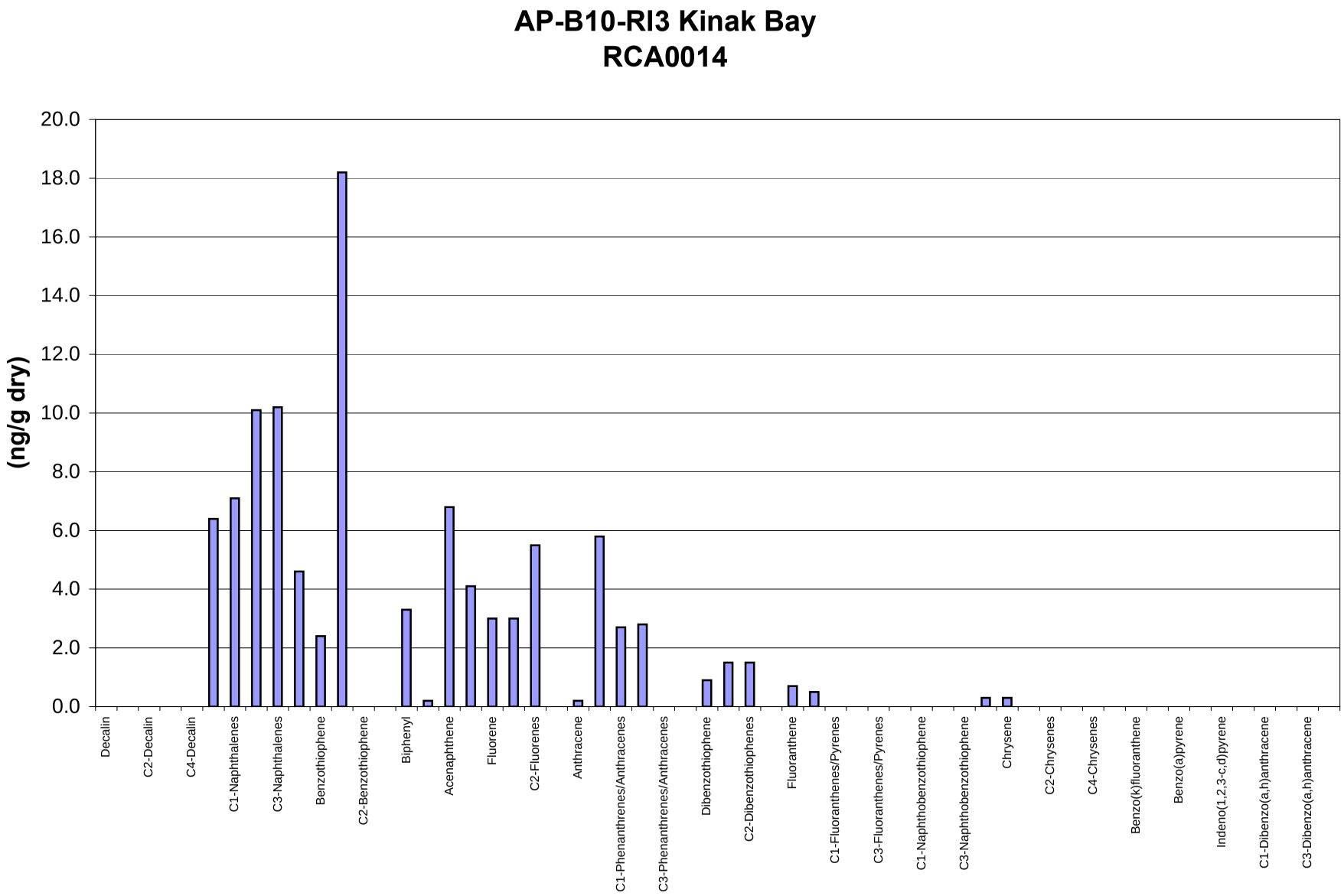
Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not Applicable,*=Outside QA limits, refer to narrative

Polycyclic Aromatic Hydrocarbon Histograms

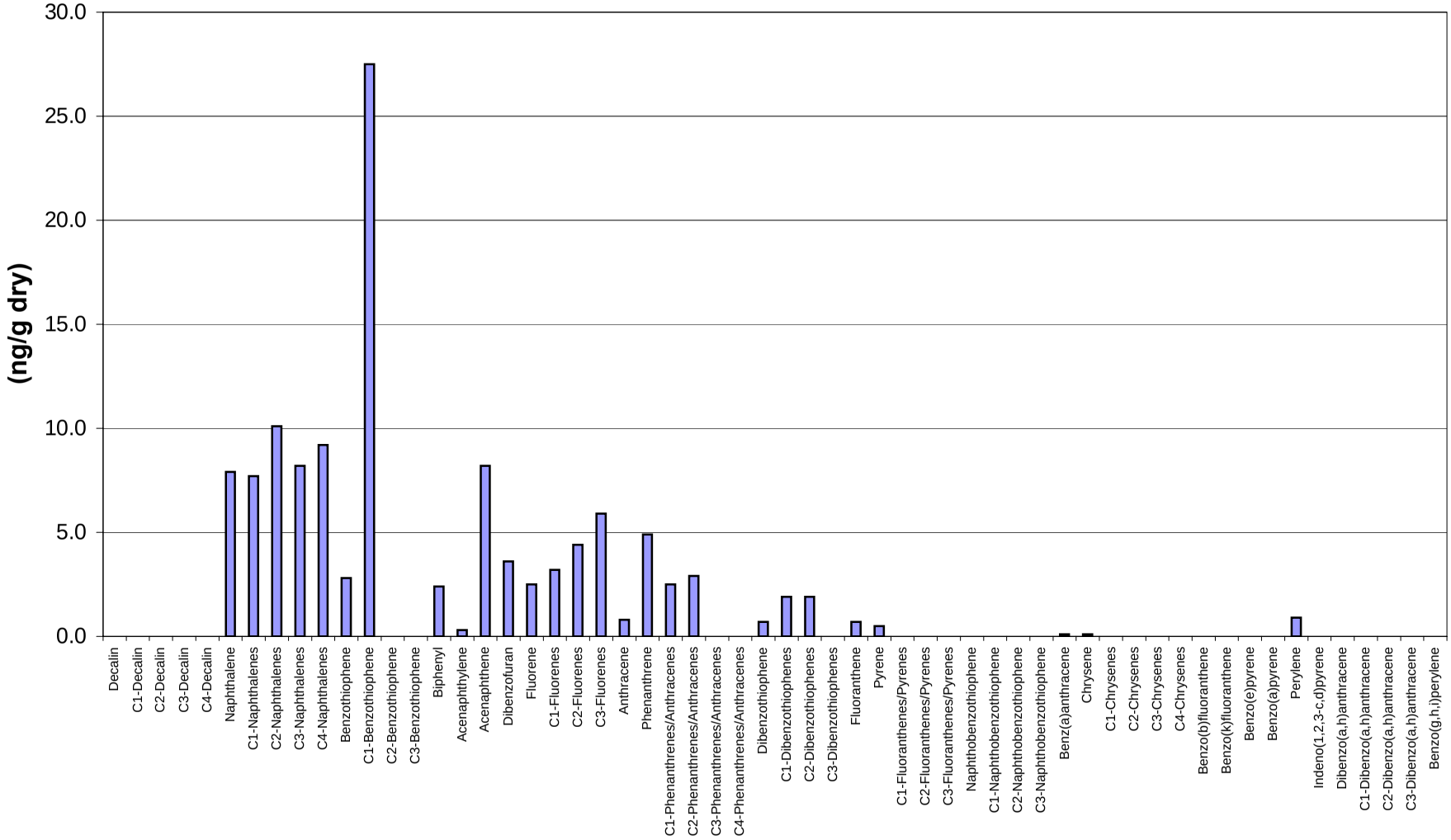

AP-B10-RI1 Kukak Bay
RCA0012
(ng/g dry)
30.0
25.0
20.0
15.0
10.0
5.0
0.0
Decalin
C2-Decalin
C4-Decalin
C1-Naphthalenes
C3-Naphthalenes
Benzothiophene
C2-Benzothiophene
Biphenyl
Acenaphthene
Fluorene
C2-Fluorenes
Anthracene
C1-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
Dibenzothiophene
C2-Dibenzothiophenes
Fluoranthene
C1-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
C1-Naphthobenzothiophene
C3-Naphthobenzothiophene
Chrysene
C2-Chrysenes
C4-Chrysenes
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-c,d)pyrene
C1-Dibenzo(a,h)anthracene
C3-Dibenzo(a,h)anthracene

AP-B10-RI2 Kaflia Bay
RCA0013

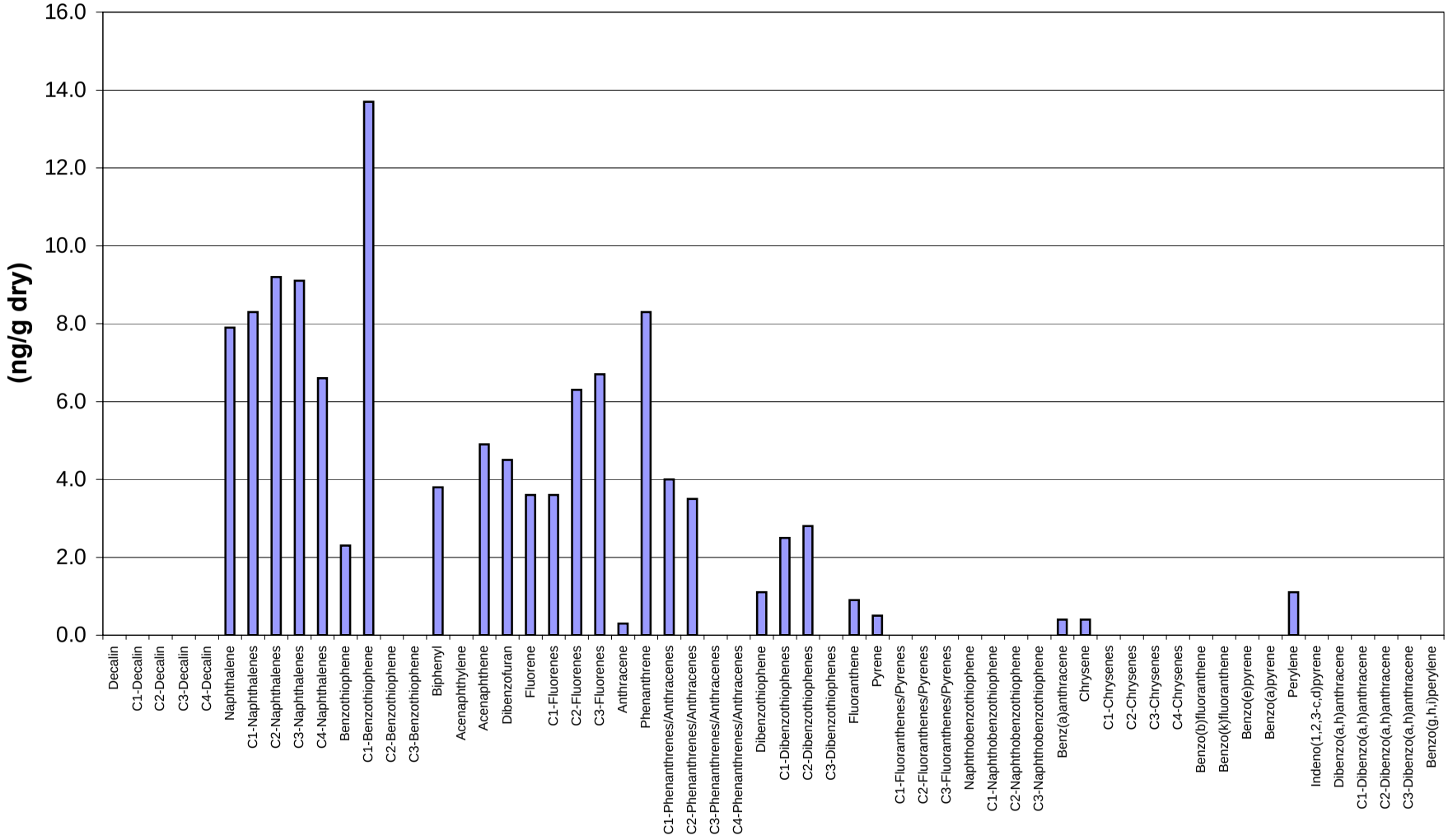



AP-B10-RI3 Kinak Bay
RCA0014
(ng/g dry)
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Decalin
C2-Decalin
C4-Decalin
C1-Naphthalenes
C3-Naphthalenes
Benzothiophene
C2-Benzothiophene
Biphenyl
Acenaphthene
Fluorene
C2-Fluorenes
Anthracene
C1-Phenanthrenes/Anthracenes
C3-Phenanthrenes/Anthracenes
Dibenzothiophene
C2-Dibenzothiophenes
Fluoranthene
C1-Fluoranthenes/Pyrenes
C3-Fluoranthenes/Pyrenes
C1-Naphthobenzothiophene
C3-Naphthobenzothiophene
Chrysene
C2-Chrysenes
C4-Chrysenes
Benzo(k)fluoranthene
Benzo(a)pyrene
Indeno(1,2,3-c,d)pyrene
C1-Dibenzo(a,h)anthracene
C3-Dibenzo(a,h)anthracene

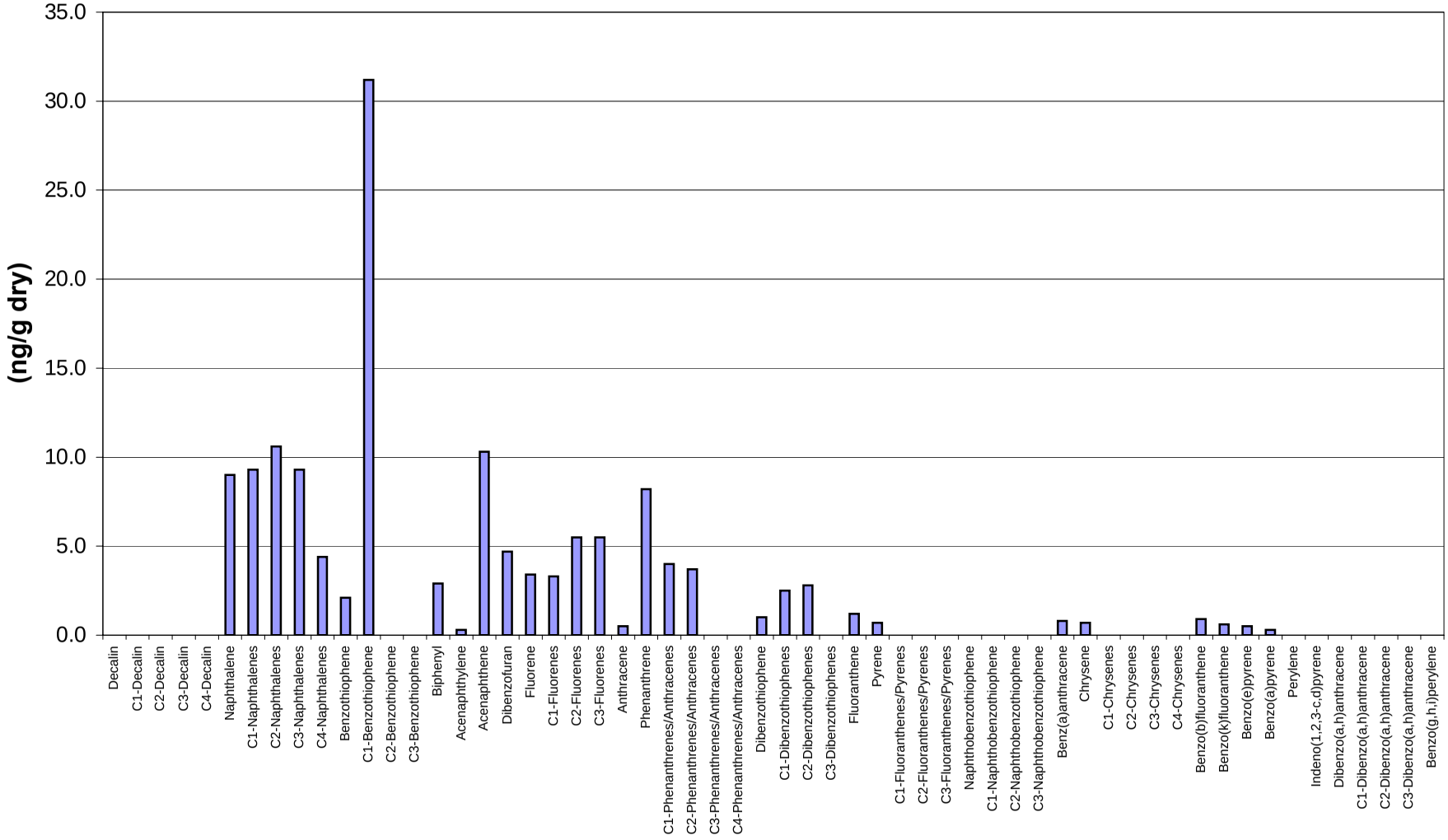
AP-B10-RI4 Amalik Bay
RCA0015



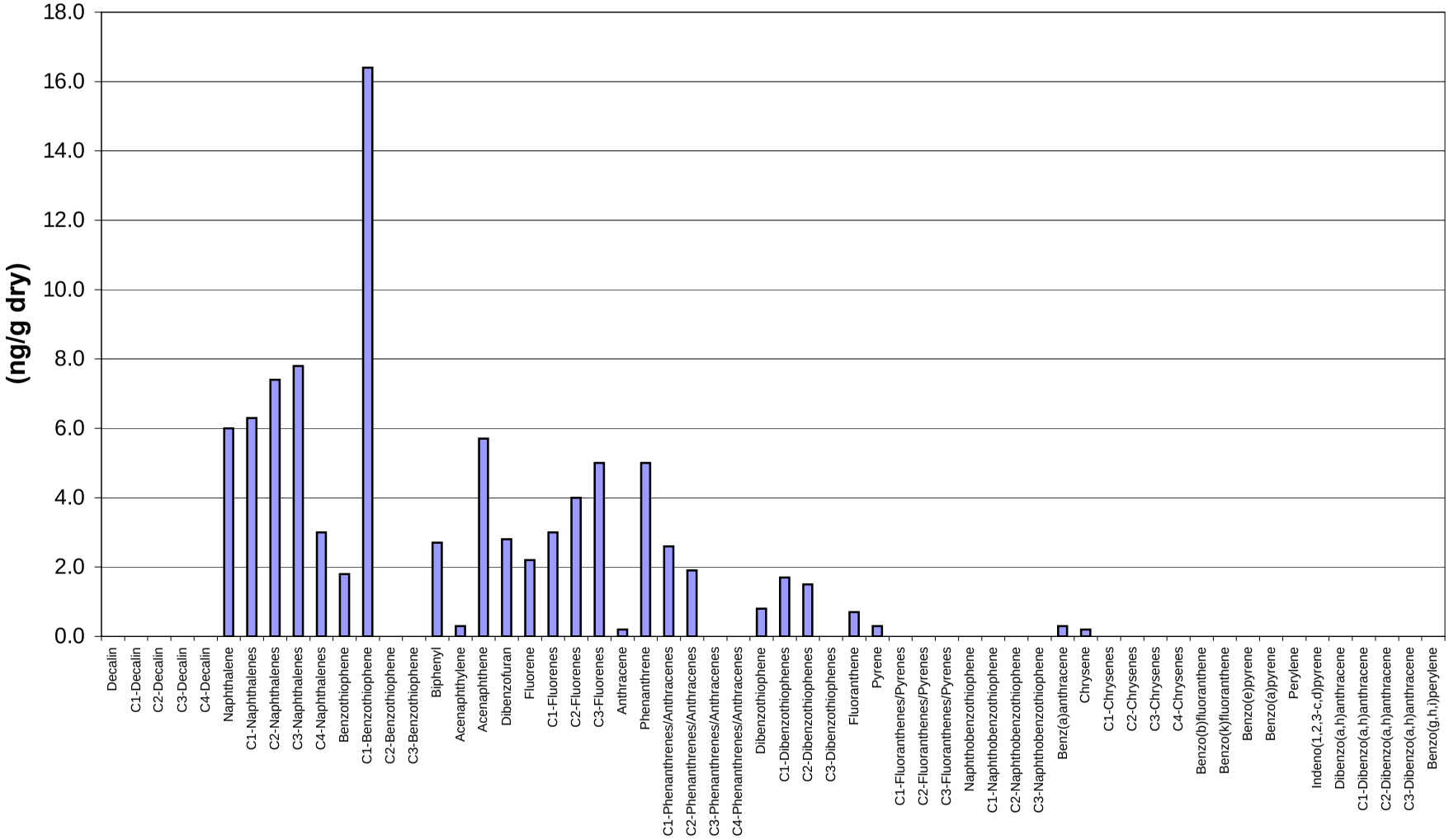
AP-B10-RI5 Takli Island
RCA0016



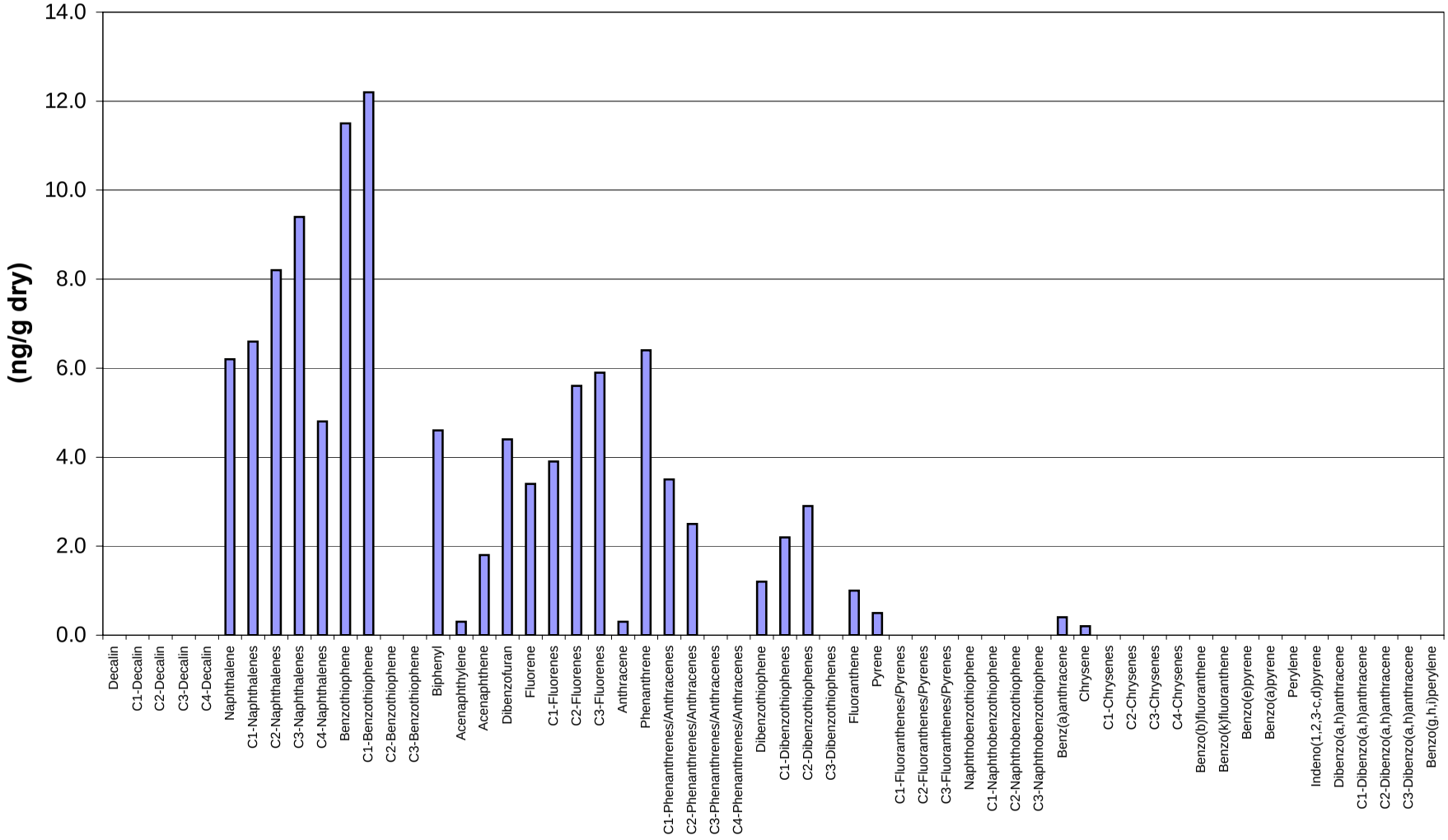
AP-B10-RS1 Ninagiak Island
RCA0017



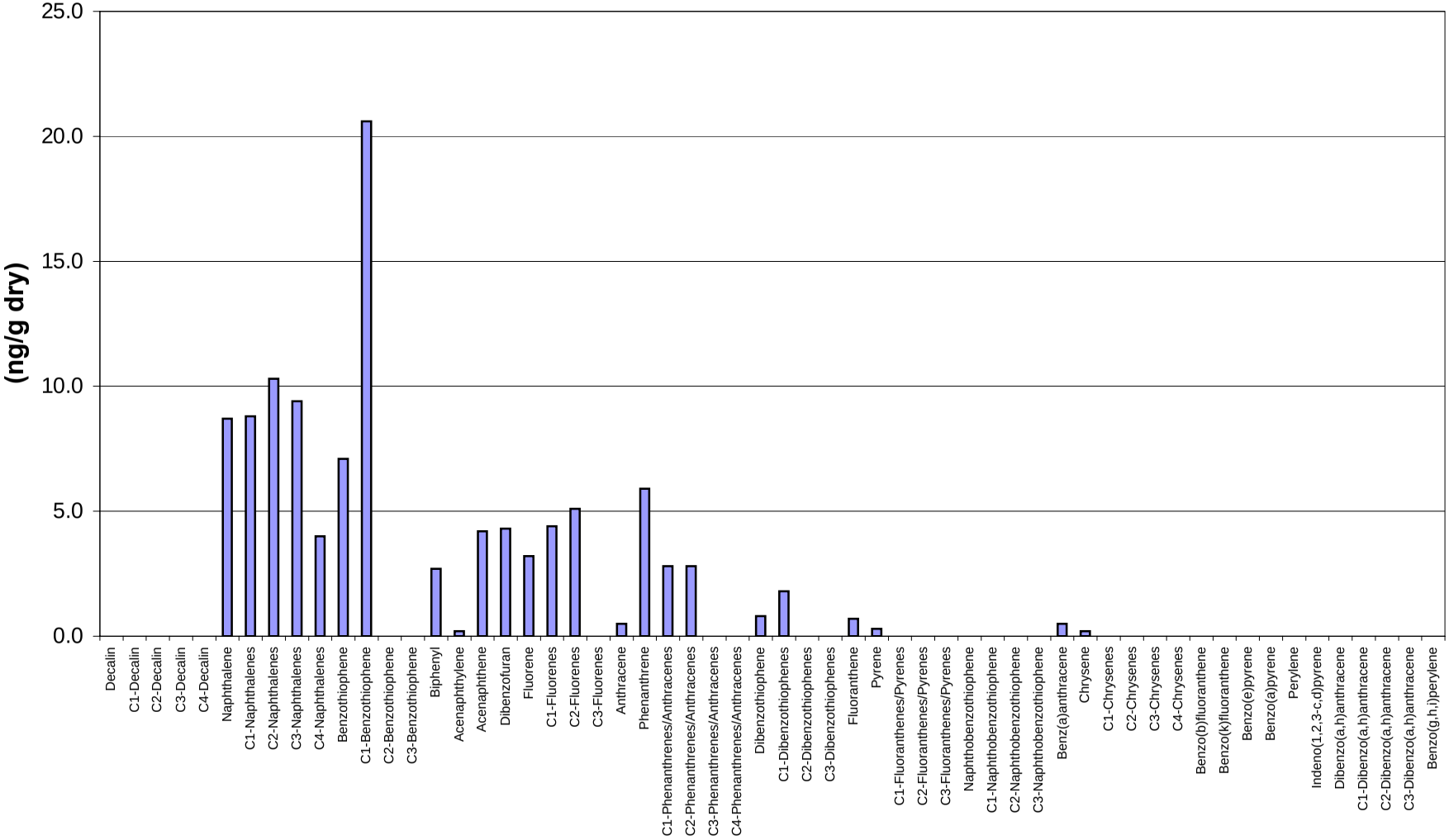
KP-B5-RI1 Aailik Bay
RCA0018



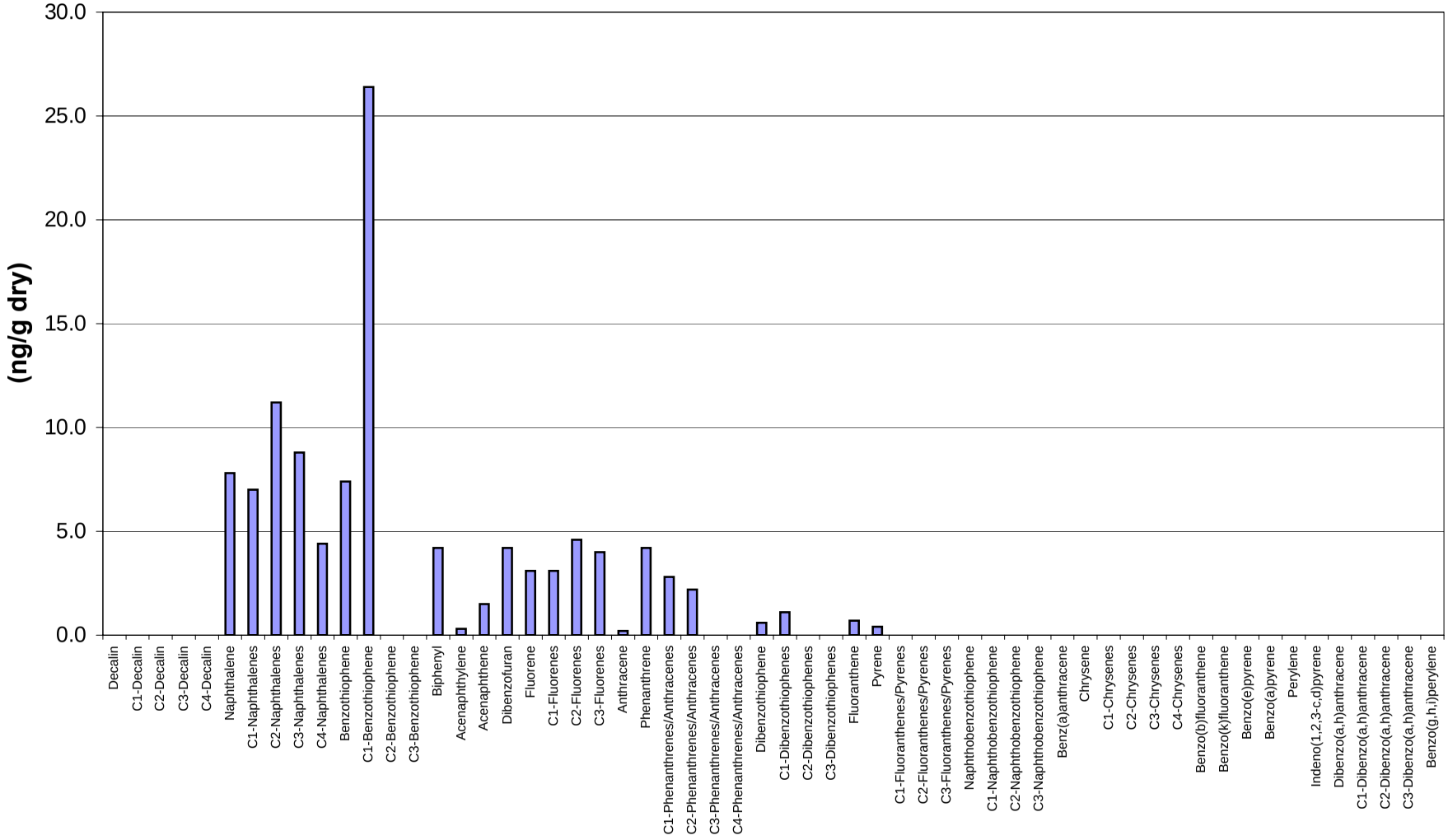
KP-B5-RI2 McCarty Fjord
RCA0019



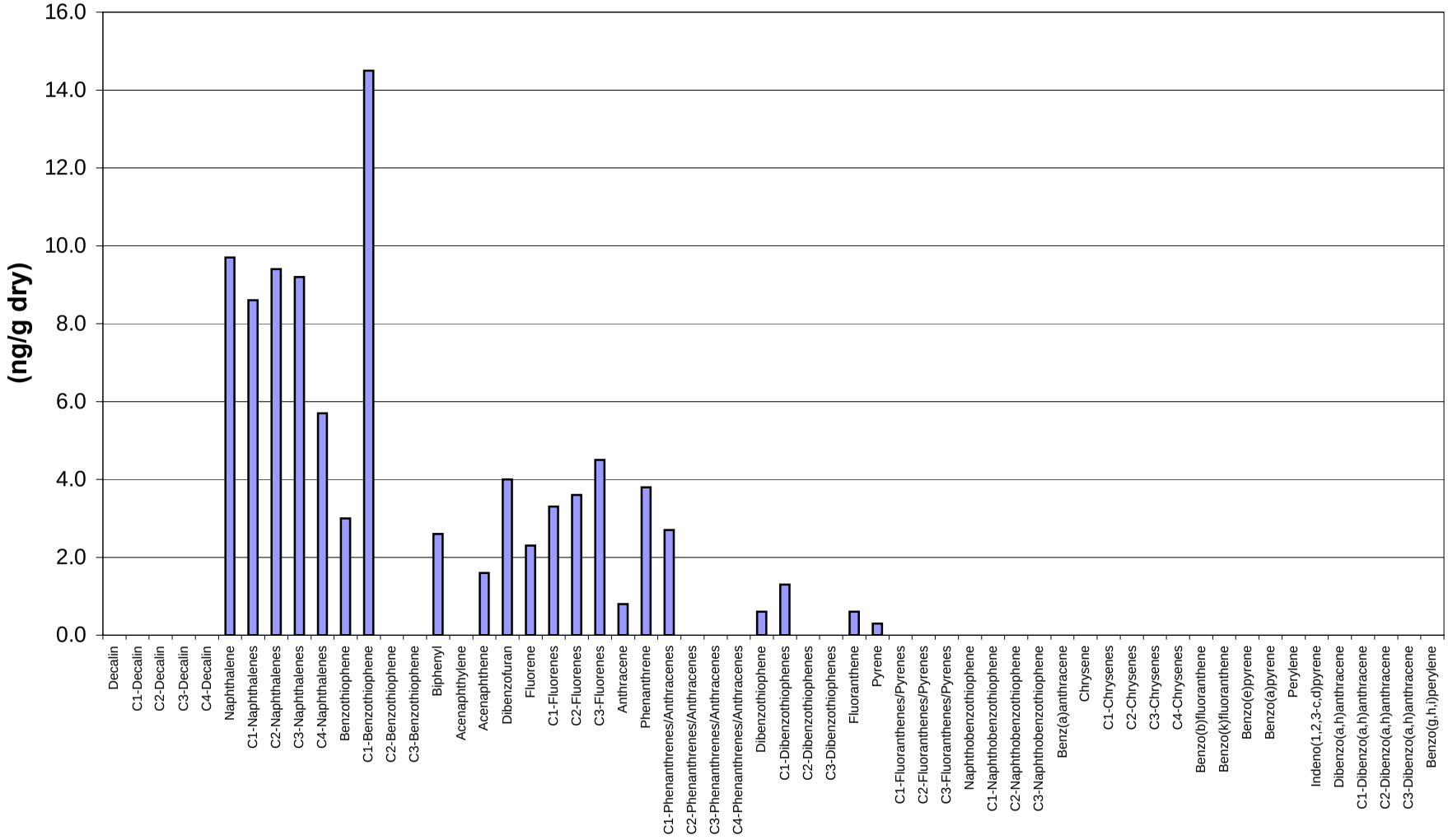
KP-B5-RI3 Nuka Bay
RCA0020



KP-B5-RI4 Nuka Passage
RCA0021



KP-B5-RI5 Harris Bay
RCA0022



Organochlorine Concentration

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Organochlorine Data
Client Submitted Samples

Sample Name	RCA0012	RCA0013	RCA0014	RCA0015	RCA0016	RCA0017
Client Name	AP-B10-RI1 Kukak Bay	AP-B10-RI2 Kaflia Bay	AP-B10-RI3 Kinak Bay	AP-B10-RI4 Amalik Bay	AP-B10-RI5 Takli Island	AP-B10-RS1 Ninagiak Island
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue	Tissue
Species	ME	ME	ME	ME	ME	ME
Collection Date	07/03/07	07/02/07	07/01/07	06/29/07	06/28/07	07/04/07
Received Date	09/21/07	09/21/07	09/21/07	09/21/07	09/21/07	09/21/07
Extraction Date	02/06/08	02/06/08	02/06/08	02/06/08	02/06/08	02/06/08
Extraction Batch	ENV1764	ENV1764	ENV1764	ENV1764	ENV1764	ENV1764
Date Acquired	03/13/08	03/13/08	03/13/08	03/13/08	03/13/08	03/13/08
Method	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M
Sample Dry Weight (g)	1.5	1.3	1.5	0.3	1.4	1.9
Sample Wet Weight (g)	12.6	12.7	12.7	2.2	12.6	12.6
% Dry	12	11	11	15	11	15
% Moisture	88	89	89	85	89	85
% Lipid (dry)	13.6	8.1	8.5	10.9	8.1	12.2
% Lipid (wet)	1.6	0.9	1.0	1.7	0.9	1.9
Dilution	NA	NA	NA	NA	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q
Aldrin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dieldrin	0.56		0.30	J	0.31	J	0.37	J	0.26	J	0.40	
Endrin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Heptachlor	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Heptachlor-Epoxide	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Oxychlordane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Alpha-Chlordane	0.34		0.23	J	0.24	J	5.66		0.30	J	0.38	
Gamma-Chlordane	0.08	J	0.06	J	0.08	J	4.93		0.06	J	0.09	J
Trans-Nonachlor	0.33		0.00	U	0.00	U	2.06		0.13	J	0.18	J
Cis-Nonachlor	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Alpha-HCH	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Beta-HCH	0.57		0.00	U	0.26	J	0.00	U	0.00	U	0.44	
Delta-HCH	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Gamma-HCH	0.48		0.15	J	0.18	J	0.00	U	0.18	J	0.31	
DDMU	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2,4'-DDD	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4,4'-DDD	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2,4'-DDE	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4,4'-DDE	0.31		0.14	J	0.15	J	0.24	J	0.13	J	0.20	J
2,4'-DDT	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.05	J
4,4'-DDT	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,3,4-Tetrachlorobenzene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,4,5-Tetrachlorobenzene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Hexachlorobenzene	0.62		0.27	J	0.38		0.50	J	0.30	J	0.51	
Pentachloroanisole	0.29		0.15	J	0.14	J	0.51	J	0.18	J	0.24	
Pentachlorobenzene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Endosulfan II	0.10	J	0.07	J	0.08	J	0.00	U	0.00	U	0.00	U
Endosulfan I	0.14	J	0.02	J	0.00	U	0.00	U	0.01	J	0.02	J
Endosulfan Sulfate	0.15	J	0.00	U	0.00	U	0.00	U	0.00	U	0.08	J
Mirex	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Chlorpyrifos	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB8/5	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB18	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB28	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB29	0.00	U	0.00	U	0.07	J	0.00	U	0.00	U	0.00	U
PCB31	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB44	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB45	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB49	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB52	0.27	J	0.21	J	0.18	J	0.53	J	0.17	J	0.17	J
PCB56/60	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB66	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB70	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB74/61	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB87/115	0.05	J	0.04	J	0.08	J	0.00	U	0.00	U	0.08	J
PCB95	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB99	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB101/90	0.15	J	0.12	J	0.19	J	1.00	J	0.12	J	0.13	J
PCB105	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB110/77	0.11	J	0.07	J	0.00	U	0.00	U	0.00	U	0.00	U
PCB118	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB128	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB138/160	1.02		0.00	U	0.58	J	1.35	J	0.67		0.43	J
PCB146	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB149/123	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB151	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB153/132	0.43	J	0.15	J	0.18	J	0.53	J	0.21	J	0.25	J
PCB156/171/202	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB158	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB170/190	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB174	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB180	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB183	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB187	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB194	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB195/208	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB199	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB201/157/173	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB206	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB209	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Total HCH	1.05		0.15		0.45		0.00		0.18		0.76	
Total Chlordane	0.75		0.29		0.32		13.55		0.49		0.65	
Total DDT	0.31		0.14		0.15		0.24		0.13		0.25	
Total PCB	6.41		3.33		5.03		9.65		4.74		4.51	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
DBOFB	72	73	70	75	75	75
PCB 103	74	73	72	76	77	77
PCB 198	79	76	76	80	80	82

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not applicable, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Organochlorine Data
Client Submitted Samples

Sample Name	RCA0018	RCA0019	RCA0020	RCA0021	RCA0022
Client Name	KP-B5-RI1 Aailik Bay	KP-B5-RI2 McCarty Fjord	KP-B5-RI3 Nuka Bay	KP-B5-RI4 Nuka Passage	KP-B5-RI5 Harris Bay
Matrix	Tissue	Tissue	Tissue	Tissue	Tissue
Species	ME	ME	ME	ME	ME
Collection Date	06/19/07	06/15/07	06/14/07	06/12/07	06/17/07
Received Date	09/21/07	09/21/07	09/21/07	09/21/07	09/21/07
Extraction Date	02/06/08	02/06/08	02/06/08	02/06/08	02/06/08
Extraction Batch	ENV1764	ENV1764	ENV1764	ENV1764	ENV1764
Date Acquired	03/13/08	03/14/08	03/14/08	03/14/08	03/14/08
Method	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M
Sample Dry Weight (g)	1.8	1.8	1.5	2.1	1.9
Sample Wet Weight (g)	13.1	12.7	10.9	13.7	12.7
% Dry	15	14	14	15	15
% Moisture	85	86	86	85	85
% Lipid (dry)	10.0	9.7	12.9	13.0	13.7
% Lipid (wet)	1.5	1.4	1.8	2.0	2.0
Dilution	NA	NA	NA	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q
Aldrin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Dieldrin	0.25	J	0.28		0.40		0.43		0.52	
Endrin	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Heptachlor	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Heptachlor-Epoxide	0.00	U	0.00	U	0.00	U	0.13	J	0.13	J
Oxychlordane	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Alpha-Chlordane	0.15	J	0.23	J	0.35		0.36		0.44	
Gamma-Chlordane	0.05	J	0.08	J	0.23	J	0.20	J	0.28	J
Trans-Nonachlor	0.00	U	0.23	J	0.23	J	0.22		0.28	
Cis-Nonachlor	0.00	U	0.05	J	0.00	U	0.00	U	0.05	J
Alpha-HCH	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Beta-HCH	0.00	U	0.32		0.28	J	0.59		0.41	
Delta-HCH	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Gamma-HCH	0.19	J	0.23	J	0.28	J	0.38		0.39	
DDMU	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2,4'-DDD	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4,4'-DDD	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
2,4'-DDE	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4,4'-DDE	0.15	J	0.25	J	0.19	J	0.22		0.17	J
2,4'-DDT	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
4,4'-DDT	0.10	J	0.00	U	0.23	J	0.03	J	0.05	J
1,2,3,4-Tetrachlorobenzene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
1,2,4,5-Tetrachlorobenzene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Hexachlorobenzene	0.21	J	0.28	J	0.32	J	0.42		0.43	
Pentachloroanisole	0.19	J	0.19	J	0.21	J	0.20		0.17	J
Pentachlorobenzene	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Endosulfan II	0.04	J	0.09	J	0.00	U	0.08	J	0.09	J
Endosulfan I	0.00	U	0.00	U	0.00	U	0.00	U	0.04	J
Endosulfan Sulfate	0.04	J	0.11	J	0.00	U	0.11	J	0.20	J
Mirex	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Chlorpyrifos	0.00	U	0.00	U	0.06	J	0.00	U	0.00	U
PCB8/5	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB18	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB28	0.34		0.00	U	0.00	U	0.00	U	0.00	U
PCB29	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB31	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB44	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB45	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB49	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB52	0.15	J	0.23	J	0.00	U	0.29		0.29	
PCB56/60	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB66	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB70	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB74/61	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB87/115	0.08	J	0.00	U	0.04	J	0.10	J	0.03	J
PCB95	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB99	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB101/90	0.12	J	0.15	J	0.32	J	0.20	J	0.20	J
PCB105	0.03	J	0.01	J	0.07	J	0.01	J	0.01	J
PCB110/77	0.00	U	0.00	U	0.07	J	0.04	J	0.07	J
PCB118	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB128	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB138/160	0.65		0.74		0.46	J	0.45		0.48	
PCB146	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB149/123	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB151	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB153/132	0.18	J	0.33	J	0.25	J	0.24	J	0.24	J
PCB156/171/202	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB158	0.04	J	0.00	U	0.00	U	0.00	U	0.00	U
PCB170/190	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB174	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB180	0.17	J	0.00	U	0.00	U	0.00	U	0.00	U
PCB183	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB187	0.00	U	0.00	U	0.03	J	0.00	U	0.00	U
PCB194	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB195/208	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB199	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB201/157/173	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB206	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
PCB209	0.00	U	0.00	U	0.00	U	0.00	U	0.00	U
Total HCH	0.19		0.54		0.55		0.96		0.80	
Total Chlordane	0.21		0.58		0.81		0.91		1.19	
Total DDT	0.26		0.25		0.43		0.25		0.23	
Total PCB	5.92		5.38		4.73		5.01		4.94	

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
DBOFB	76	74	73	72	75
PCB 103	77	76	72	72	75
PCB 198	81	79	79	77	79

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not applicable, *=Outside QA limits, refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Organochlorine Data
Procedural Blank Report

Sample Name	ENV1764A
Client Name	Procedural Blank
Matrix	Tissue
Species	NA
Collection Date	NA
Received Date	NA
Extraction Date	02/06/08
Extraction Batch	ENV1764
Date Acquired	03/12/08
Method	ECDDUAL.M
Sample Dry Weight (g)	2.1
Sample Wet Weight (g)	NA
% Dry	NA
% Moisture	NA
% Lipid (dry)	NA
% Lipid (wet)	NA
Dilution	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Q	3X MDL	Actual MDL
Aldrin	0.00	U		0.73	0.24
Dieldrin	0.00	U		0.67	0.22
Endrin	0.00	U		0.62	0.21
Heptachlor	0.00	U		0.76	0.25
Heptachlor-Epoxide	0.00	U		0.68	0.23
Oxychlordane	0.00	U		0.84	0.28
Alpha-Chlordane	0.00	U		0.70	0.23
Gamma-Chlordane	0.00	U		0.81	0.27
Trans-Nonachlor	0.00	U		0.66	0.22
Cis-Nonachlor	0.00	U		0.72	0.24
Alpha-HCH	0.00	U		0.69	0.23
Beta-HCH	0.00	U		0.68	0.23
Delta-HCH	0.00	U		0.69	0.23
Gamma-HCH	0.00	U		0.66	0.22
DDMU	0.00	U		0.65	0.22
2,4'-DDD	0.00	U		0.67	0.22
4,4'-DDD	0.00	U		0.60	0.20
2,4'-DDE	0.00	U		0.63	0.21
4,4'-DDE	0.00	U		0.65	0.22
2,4'-DDT	0.00	U		0.74	0.25
4,4'-DDT	0.00	U		0.62	0.21
1,2,3,4-Tetrachlorobenzene	0.00	U		1.00	0.33
1,2,4,5-Tetrachlorobenzene	0.00	U		0.89	0.30
Hexachlorobenzene	0.00	U		0.76	0.25
Pentachloroanisole	0.05	J		0.55	0.18
Pentachlorobenzene	0.02	J		0.65	0.22
Endosulfan II	0.00	U		0.75	0.25
Endosulfan I	0.00	U		0.75	0.25
Endosulfan Sulfate	0.00	U		0.81	0.27
Mirex	0.00	U		0.68	0.23
Chlorpyrifos	0.00	U		0.75	0.25
PCB8/5	0.00	U		1.08	0.36
PCB18	0.00	U		1.32	0.44
PCB28	0.00	U		0.65	0.22
PCB29	0.00	U		0.76	0.25
PCB31	0.00	U		1.32	0.44
PCB44	0.00	U		1.21	0.40
PCB45	0.00	U		0.72	0.24
PCB49	0.00	U		0.72	0.24
PCB52	0.00	U		0.72	0.24
PCB56/60	0.00	U		0.72	0.24
PCB66	0.00	U		1.02	0.34
PCB70	0.00	U		0.72	0.24
PCB74/61	0.00	U		0.72	0.24
PCB87/115	0.00	U		1.16	0.39
PCB95	0.00	U		0.97	0.32
PCB99	0.00	U		0.97	0.32
PCB101/90	0.00	U		0.97	0.32
PCB105	0.00	U		1.00	0.33
PCB110/77	0.00	U		0.67	0.22
PCB118	0.00	U		0.75	0.25
PCB128	0.00	U		1.62	0.54
PCB138/160	0.30	J		1.29	0.43
PCB146	0.00	U		1.29	0.43
PCB149/123	0.00	U		1.29	0.43
PCB151	0.00	U		1.29	0.43
PCB153/132	0.00	U		1.45	0.48
PCB156/171/202	0.00	U		1.29	0.43
PCB158	0.00	U		1.29	0.43
PCB170/190	0.00	U		0.97	0.32
PCB174	0.00	U		0.73	0.24
PCB180	0.00	U		0.73	0.24
PCB183	0.00	U		0.73	0.24
PCB187	0.00	U		0.94	0.31
PCB194	0.00	U		0.80	0.27
PCB195/208	0.00	U		0.80	0.27
PCB199	0.00	U		0.80	0.27
PCB201/157/173	0.00	U		0.79	0.26
PCB206	0.00	U		0.87	0.29
PCB209	0.00	U		0.73	0.24
Total HCH	0.00				
Total Chlordane	0.00				
Total DDT	0.00				
Total PCB	2.85				

Surrogate (Su)	Su Recovery (%)
DBOFB	61
PCB 103	63
PCB 198	62

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not applicable, *=Outside QA limits, refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Organochlorine Data
Laboratory Duplicate Report

Sample Name	RCA0013	ENV1764E
Client Name	AP-B10-RI2 Kaflia Bay	AP-B10-RI2 Kaflia Bay
Matrix	Tissue	Tissue
Species	ME	ME
Collection Date	07/02/07	07/02/07
Received Date	09/21/07	09/21/07
Extraction Date	02/06/08	02/06/08
Extraction Batch	ENV1764	ENV1764
Date Acquired	03/13/08	03/13/08
Method	ECDDUAL.M	ECDDUAL.M
Sample Dry Weight (g)	1.3	1.4
Sample Wet Weight (g)	12.7	12.8
% Dry	11	11
% Moisture	89	89
% Lipid (dry)	8.1	7.5
% Lipid (wet)	0.9	0.8
Dilution	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	RPD (%)	Q	Q	10 X MDL	MDL
Aldrin	0.00	U	0.00	U				3.78	0.38
Dieldrin	0.30	J	0.29	J				3.43	0.34
Endrin	0.00	U	0.00	U				3.18	0.32
Heptachlor	0.00	U	0.00	U				3.91	0.39
Heptachlor-Epoxide	0.00	U	0.00	U				3.53	0.35
Oxychlordane	0.00	U	0.00	U				4.31	0.43
Alpha-Chlordane	0.23	J	0.24	J				3.63	0.36
Gamma-Chlordane	0.06	J	0.07	J				4.16	0.42
Trans-Nonachlor	0.00	U	0.00	U				3.39	0.34
Cis-Nonachlor	0.00	U	0.00	U				3.72	0.37
Alpha-HCH	0.00	U	0.00	U				3.56	0.36
Beta-HCH	0.00	U	0.00	U				3.52	0.35
Delta-HCH	0.00	U	0.00	U				3.54	0.35
Gamma-HCH	0.15	J	0.19	J				3.42	0.34
DDMU	0.00	U	0.00	U				3.36	0.34
2,4'-DDD	0.00	U	0.00	U				3.47	0.35
4,4'-DDD	0.00	U	0.00	U				3.10	0.31
2,4'-DDE	0.00	U	0.00	U				3.23	0.32
4,4'-DDE	0.14	J	0.15	J				3.38	0.34
2,4'-DDT	0.00	U	0.00	U				3.80	0.38
4,4'-DDT	0.00	U	0.00	U				3.19	0.32
1,2,3,4-Tetrachlorobenzene	0.00	U	0.00	U				5.15	0.51
1,2,4,5-Tetrachlorobenzene	0.00	U	0.00	U				4.60	0.46
Hexachlorobenzene	0.27	J	0.25	J				3.91	0.39
Pentachloroanisole	0.15	J	0.16	J				2.85	0.28
Pentachlorobenzene	0.00	U	0.00	U				3.37	0.34
Endosulfan II	0.07	J	0.07	J				3.85	0.39
Endosulfan I	0.02	J	0.00	J				3.85	0.39
Endosulfan Sulfate	0.00	U	0.00	U				4.19	0.42
Mirex	0.00	U	0.00	U				3.49	0.35
Chlorpyrifos	0.00	U	0.00	U				3.85	0.38
PCB8/5	0.00	U	0.00	U				5.59	0.56
PCB18	0.00	U	0.00	U				6.80	0.68
PCB28	0.00	U	0.00	U				3.33	0.33
PCB29	0.00	U	0.00	U				3.93	0.39
PCB31	0.00	U	0.00	U				6.80	0.68
PCB44	0.00	U	0.00	U				6.25	0.62
PCB45	0.00	U	0.00	U				3.70	0.37
PCB49	0.00	U	0.00	U				3.70	0.37
PCB52	0.21	J	0.24	J				3.70	0.37
PCB56/60	0.00	U	0.00	U				3.70	0.37
PCB66	0.00	U	0.00	U				5.26	0.53
PCB70	0.00	U	0.00	U				3.70	0.37
PCB74/61	0.00	U	0.00	U				3.70	0.37
PCB87/115	0.04	J	0.05	J				5.97	0.60
PCB95	0.00	U	0.00	U				4.98	0.50
PCB99	0.00	U	0.00	U				4.98	0.50
PCB101/90	0.12	J	0.15	J				4.98	0.50
PCB105	0.00	U	0.00	U				5.14	0.51
PCB110/77	0.07	J	0.06	J				3.43	0.34
PCB118	0.00	U	0.00	U				3.90	0.39
PCB128	0.00	U	0.00	U				8.38	0.84
PCB138/160	0.00	U	0.00	U				6.65	0.66
PCB146	0.00	U	0.00	U				6.65	0.66
PCB149/123	0.00	U	0.00	U				6.65	0.66
PCB151	0.00	U	0.00	U				6.65	0.66
PCB153/132	0.15	J	0.20	J				7.50	0.75
PCB156/171/202	0.00	U	0.00	U				6.65	0.66
PCB158	0.00	U	0.00	U				6.65	0.66
PCB170/190	0.00	U	0.00	U				5.00	0.50
PCB174	0.00	U	0.00	U				3.76	0.38
PCB180	0.00	U	0.00	U				3.76	0.38
PCB183	0.00	U	0.00	U				3.76	0.38
PCB187	0.00	U	0.00	U				4.85	0.49
PCB194	0.00	U	0.00	U				4.15	0.41
PCB195/208	0.00	U	0.00	U				4.15	0.41
PCB199	0.00	U	0.00	U				4.15	0.41
PCB201/157/173	0.00	U	0.00	U				4.06	0.41
PCB206	0.00	U	0.00	U				4.50	0.45
PCB209	0.00	U	0.00	U				3.79	0.38
Total HCH	0.15		0.19						
Total Chlordane	0.29		0.31						
Total DDT	0.14		0.15						
Total PCB	3.33		3.57						

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)
DBOFB	73	75
PCB 103	73	75
PCB 198	76	77

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not applicable, X =< 10x MDL,*=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Organochlorine Data
Matrix Spike Report

Sample Name	RCA0014	ENV1764C	ENV1764D
Client Name	AP-B10-RI3 Kinak Bay	AP-B10-RI3 Kinak Bay	AP-B10-RI3 Kinak Bay
Matrix	Tissue	Tissue	Tissue
Species	ME	ME	ME
Collection Date	07/01/07	07/01/07	07/01/07
Received Date	09/21/07	09/21/07	09/21/07
Extraction Date	02/06/08	02/06/08	02/06/08
Extraction Batch	ENV1764	ENV1764	ENV1764
Date Acquired	03/13/08	03/13/08	03/13/08
Method	ECDDUAL.M	ECDDUAL.M	ECDDUAL.M
Sample Dry Weight (g)	1.5	1.5	1.5
Sample Wet Weight (g)	12.7	13.1	12.8
% Dry	11	11	11
% Moisture	89	89	89
% Lipid (dry)	8.5	8.4	8.4
% Lipid (wet)	1.0	1.0	1.0
Dilution	NA	NA	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Su Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Q	Su Corrected Conc. (ng/dry g)	Q	Recovery (%)	Q	Q	RPD (%)	Q	Spike Amout (ng)
Aldrin	0.00	U	37.16		93			38.44		94			3		40
Dieldrin	0.31	J	43.75		109			43.56		106			0		40
Endrin	0.00	U	47.01		118			48.68		119			3		40
Heptachlor	0.00	U	40.34		101			43.38		106			7		40
Heptachlor-Epoxide	0.00	U	39.21		98			39.07		96			0		40
Oxychlordane	0.00	U	38.86		97			46.81		115			19		40
Alpha-Chlordane	0.24	J	40.80		101			40.34		98			1		40
Gamma-Chlordane	0.08	J	36.46		91			36.81		90			1		40
Trans-Nonachlor	0.00	U	41.16		103			40.90		100			1		40
Cis-Nonachlor	0.00	U	40.92		102			40.81		100			0		40
Alpha-HCH	0.00	U	36.25		91			38.69		95			7		40
Beta-HCH	0.26	J	40.39		100			41.05		100			2		40
Delta-HCH	0.00	U	40.05		100			41.45		102			3		40
Gamma-HCH	0.18	J	39.47		98			41.69		102			5		40
DDMU	0.00	U	45.83		115			46.80		115			2		40
2,4'-DDD	0.00	U	45.70		114			46.15		113			1		40
4,4'-DDD	0.00	U	45.80		115			46.18		113			1		40
2,4'-DDE	0.00	U	41.91		105			42.39		104			1		40
4,4'-DDE	0.15	J	41.21		103			40.92		100			1		40
2,4'-DDT	0.00	U	40.27		101			40.48		99			1		40
4,4'-DDT	0.00	U	41.76		104			41.98		103			1		40
1,2,3,4-Tetrachlorobenzene	0.00	U	27.91		70			29.26		72			5		40
1,2,4,5-Tetrachlorobenzene	0.00	U	27.10		68			29.03		71			7		40
Hexachlorobenzene	0.38		36.42		90			39.95		97			9		40
Pentachloroanisole	0.14	J	39.16		98			42.24		103			8		40
Pentachlorobenzene	0.00	U	33.28		83			36.33		89			9		40
Endosulfan II	0.08	J	1.19		3	*		1.33		3	*		11		40
Endosulfan I	NA		NA					NA							
Endosulfan Sulfate	0.00	U	42.30		106			41.84		103			1		40
Mirex	0.00	U	42.10		105			42.21		103			0		40
Chlorpyrifos	0.00	U	29.11		73			26.14		64			11		40
PCB8/5	0.00	U	38.71		97			41.69		102			7		40
PCB18	0.00	U	37.55		94			39.80		98			6		40
PCB28	0.00	U	40.49		101			41.35		101			2		40
PCB29	0.07	J	41.19		103			43.38		106			5		40
PCB31	0.00	U	NA					NA							
PCB44	0.00	U	41.24		103			42.64		104			3		40
PCB45	0.00	U	NA					NA							
PCB49	0.00	U	NA					NA							
PCB52	0.18	J	41.77		104			46.74		114			11		40
PCB56/60	0.00	U	NA					NA							
PCB66	0.00	U	44.33		111			45.35		111			2		40
PCB70	0.00	U	NA					NA							
PCB74/61	0.00	U	NA					NA							
PCB87/115	0.08	J	43.65		109			44.17		108			1		40
PCB95	0.00	U	NA					NA							
PCB99	0.00	U	NA					NA							
PCB101/90	0.19	J	43.81		109			44.90		110			2		40
PCB105	0.00	U	46.72		117			46.96		115			1		40
PCB110/77	0.00	U	44.19		110			44.60		109			1		40
PCB118	0.00	U	46.25		116			45.89		112			1		40
PCB128	0.00	U	46.13		115			46.24		113			0		40
PCB138/160	0.58	J	43.00		106			43.42		105			1		40
PCB146	0.00	U	NA					NA							
PCB149/123	0.00	U	NA					NA							
PCB151	0.00	U	NA					NA							
PCB153/132	0.18	J	43.86		109			44.78		109			2		40
PCB156/171/202	0.00	U	NA					NA							
PCB158	0.00	U	NA					NA							
PCB170/190	0.00	U	45.15		113			46.01		113			2		40
PCB174	0.00	U	NA					NA							
PCB180	0.00	U	45.09		113			44.96		110			0		40
PCB183	0.00	U	NA					NA							
PCB187	0.00	U	43.77		109			44.67		109			2		40
PCB194	0.00	U	NA					NA							
PCB195/208	0.00	U	44.78		112			44.04		108			2		40
PCB199	0.00	U	45.02		113			44.99		110			0		40
PCB201/157/173	0.00	U	NA					NA							
PCB206	0.00	U	42.68		107			42.76		105			0		40
PCB209	0.00	U	43.77		109			43.67		107			0		40
			Average % Recovery		101			Average % Recovery		101					

Surrogate (Su)	Su Recovery (%)	Su Recovery (%)	Su Recovery (%)
DBOFB	70	69	74
PCB 103	72	71	72
PCB 198	76	77	76

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not applicable, Y=Invalid Spike, *=Outside QA limits, refer to narrative

Cook Inlet RCAC
Mussel Watch Project 2007
Organochlorine Data
Standard Reference Material Report

Sample Name	ENV1764B
Client Name	SRM 1974b
Matrix	Tissue
Species	ME
Collection Date	NA
Received Date	NA
Extraction Date	02/06/08
Extraction Batch	ENV1764
Date Acquired	03/13/08
Method	ECDDUAL.M
Sample Dry Weight (g)	0.5
Sample Wet Weight (g)	5.2
% Dry	10
% Moisture	90
% Lipid (dry)	5.4
% Lipid (wet)	0.5
Dilution	NA

Target Compounds	Su Corrected Conc. (ng/dry g)	Q	Q	SRM 1974b Certified Conc. Conc. (ng/dry g)	-30% Conc. Conc. (ng/dry g)	+30% Conc. Conc. (ng/dry g)
Aldrin	0.00	U				
Dieldrin	5.63					
Endrin	0.00	U				
Heptachlor	0.00	U				
Heptachlor-Epoxide	0.00	U				
Oxychlordane	0.00	U				
Alpha-Chlordane	12.02			13.4 ± 1	9.38	17.42
Gamma-Chlordane	10.30			11.3 ± 1.7	7.91	14.69
Trans-Nonachlor	12.40			12.8 ± 1.4	8.96	16.64
Cis-Nonachlor	7.83					
Alpha-HCH	0.00	U				
Beta-HCH	0.00	U				
Delta-HCH	0.00	U				
Gamma-HCH	0.00	U				
DDMU	0.00	U				
2,4'-DDD	12.40			10.8 ± 1.6	7.56	14.04
4,4'-DDD	30.63			33 ± 2.2	23.10	42.90
2,4'-DDE	3.04			3.32 ± 0.43	2.32	4.32
4,4'-DDE	38.88			41 ± 3.8	28.70	53.30
2,4'-DDT	9.27					
4,4'-DDT	3.57					
1,2,3,4-Tetrachlorobenzene	0.00	U				
1,2,4,5-Tetrachlorobenzene	0.00	U				
Hexachlorobenzene	0.42	J				
Pentachloroanisole	0.88					
Pentachlorobenzene	0.00	U				
Endosulfan II	0.00	U				
Endosulfan I	0.00	U				
Endosulfan Sulfate	0.00	U				
Mirex	0.60	J				
Chlorpyrifos	1.53					
PCB8/5	3.82					
PCB18	10.48			8.3 ± 1.3	5.81	10.79
PCB28	40.99			33.9 ± 2.5	23.73	44.07
PCB29	0.00	U			0.00	0.00
PCB31	29.04			28.4 ± 2.3	19.88	36.92
PCB44	41.13			38 ± 2	26.60	49.40
PCB45	5.26					
PCB49	70.30			55.9 ± 2.3	39.13	72.67
PCB52	71.41			61.8 ± 3.7	43.26	80.34
PCB56/60	33.26					
PCB66	56.71			62.9 ± 3.7	44.03	81.77
PCB70	76.60			59.3 ± 2.2	41.51	77.09
PCB74/61	42.26			35 ± 2.3	24.50	45.50
PCB87/115	47.07			42.7 ± 3.6	29.89	55.51
PCB95	77.24			59.6 ± 3.6	41.72	77.48
PCB99	73.91			58.4 ± 2.7	40.88	75.92
PCB101/90	124.15			106 ± 11	74.20	137.80
PCB105	45.26			39.5 ± 1.8	27.65	51.35
PCB110/77	115.65			99.1 ± 7.1	69.37	128.83
PCB118	130.36			102 ± 4	71.40	132.60
PCB128	22.36			17.7 ± 1.2	12.39	23.01
PCB138/160	115.87			91 ± 14	63.70	118.30
PCB146	21.65			19 ± 1.6	13.30	24.70
PCB149/123	67.86			69.2 ± 2.8	48.44	89.96
PCB151	21.07			18.4 ± 1.6	12.88	23.92
PCB153/132	182.95			145 ± 10.5	101.50	188.50
PCB156/171/202	9.12			7.09 ± 0.79	4.96	9.22
PCB158	12.12			9.86 ± 0.95	6.90	12.82
PCB170/190	2.51			2.66 ± 0.34	1.86	3.46
PCB174	0.00	U				
PCB180	12.81			11.5 ± 1	8.05	14.95
PCB183	15.62			12.3 ± 0.3	8.61	15.99
PCB187	34.20			29 ± 1.5	20.30	37.70
PCB194	0.74	J				
PCB195/208	0.00	U				
PCB199	0.00	U				
PCB201/157/173	4.34					
PCB206	0.00	U				
PCB209	0.00	U				
Total HCH	0.00					
Total Chlordane	42.56					
Total DDT	97.79					
Total PCB	1975.28					

Surrogate (Su)	Su Recovery (%)
DBOFB	73
PCB 103	71
PCB 198	80

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, D=Diluted value, NA=Not applicable, *=Outside QA limits, refer to narrative

Displacement Data

Cook Inlet RCAC
Mussel Watch Project 2007
Displacement Data

Coast	Station	Lab ID		Initial Displacements (shell and body in mL)	Final Displacements (shells only in mL)	Wet Sample Amount (g)	Average Individual Body Mass (g)	Average Displacement Volume (shell only in mL)	Average Displacement Volume (body in mL)	Number of Bivalves	Max Shell Length (cm)
NA	AP-B10-RI1-KukakBay	RCA0012	MS	NA	NA	149.27	1.29	NA	NA	116	4.6
NA	AP-B10-RI2-KafliaBay	RCA0013	MS	NA	NA	278.71	2.58	NA	NA	108	4.8
NA	AP-B10-RI3-KinakBay	RCA0014	MS	NA	NA	571.43	4.84	NA	NA	118	5.7
NA	AP-B10-RI4-AmalikBay	RCA0015	MS	NA	NA	34.92	0.30	NA	NA	115	2.7
NA	AP-B10-RI5-TakliIsland	RCA0016	MS	NA	NA	214.67	2.90	NA	NA	74	8.3
NA	AP-B10-RS1-NinagiakIsland	RCA0017	MS	NA	NA	48.82	0.73	NA	NA	67	4.5
NA	KP-B5-RI1-AailikBay	RCA0018	MS	NA	NA	90.83	0.66	NA	NA	137.0	3.7
NA	KP-B5-RI2-McCartyFjord	RCA0019	MS	NA	NA	61.87	0.54	NA	NA	115	3.8
NA	KP-B5-RI3-NukaBay	RCA0020	MS	NA	NA	29.03	0.27	NA	NA	107	3.0
NA	KP-B5-RI4-NukaPassage	RCA0021	MS	NA	NA	70.66	0.61	NA	NA	115	2.9
NA	KP-B5-RI5-HarrisBay	RCA0022	MS	NA	NA	58.53	0.35	NA	NA	166	3.5

Cook Inlet RCAC
Mussel Watch Project 2007
Displacement Data

Coast	Station	Lab ID		Min Shell Length (cm)	Avg Shell Length (cm)	Std Dev. Shell Length	Comments
NA	AP-B10-RI1-KukakBay	RCA0012	MS	2.9	3.7	0.4	Individuals Gapping Displacement could not be determined
NA	AP-B10-RI2-KafliaBay	RCA0013	MS	2.2	3.6	0.5	Individuals Gapping Displacement could not be determined
NA	AP-B10-RI3-KinakBay	RCA0014	MS	2.7	4.4	0.7	Individuals Gapping Displacement could not be determined
NA	AP-B10-RI4-AmalikBay	RCA0015	MS	1.5	2.0	0.3	Individuals Gapping Displacement could not be determined
NA	AP-B10-RI5-TakliIsland	RCA0016	MS	2.4	4.2	0.9	Individuals Gapping Displacement could not be determined
NA	AP-B10-RS1-NinagiakIsland	RCA0017	MS	1.2	2.6	0.8	Individuals Gapping Displacement could not be determined
NA	KP-B5-RI1-AailikBay	RCA0018	MS	2.1	2.8	0.4	Individuals Gapping Displacement could not be determined
NA	KP-B5-RI2-McCartyFjord	RCA0019	MS	2.0	2.7	0.4	Individuals Gapping Displacement could not be determined
NA	KP-B5-RI3-NukaBay	RCA0020	MS	1.8	2.3	0.3	Individuals Gapping Displacement could not be determined
NA	KP-B5-RI4-NukaPassage	RCA0021	MS	2.0	2.4	0.2	Individuals Gapping Displacement could not be determined
NA	KP-B5-RI5-HarrisBay	RCA0022	MS	1.7	2.5	0.3	Individuals Gapping Displacement could not be determined

This is the last page of this report

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Client Submitted Samples

LAB ID	T7092-007		T7092-008		T7092-009		T7092-010	
SampleID	RCA0012		RCA0013		RCA0014		RCA0015	
Site	AP-B10-RI1 Kukak Bay		AP-B10-RI2 Kaflia Bay		AP-B10-RI3 Kinak Bay		AP-B10-RI4 Amalik Bay	
Collection date	07/03/07		07/02/07		07/01/07		06/29/07	
Receipt Date	09/21/07		09/21/07		09/21/07		09/21/07	
Matrix	Tissue		Tissue		Tissue		Tissue	
% DRY	14		12		12		17	
% MOISTURE	86		88		88		83	
Method	ICP-MS		ICP-MS		ICP-MS		ICP-MS	
Batch	5978		5978		5978		5978	
Prep Date	10/30/07		10/30/07		10/30/07		10/30/07	
Analysis Date	10/06/08		10/06/08		10/06/08		10/06/08	
Weight	0.207		0.208		0.203		0.204	
UNITS	ppm	Q	ppm	Q	ppm	Q	ppm	Q
Ag	0.075		0.0953		0.117		0.0915	
Pb	0.288		0.422		0.214		0.239	
Se	3.46		4.09		3.73		4.02	
Sn	0.143		0.19		0	U	0	U

Method	ICP		ICP		ICP		ICP	
Batch	6068		6068		6068		6068	
Prep Date	10/30/07		10/30/07		10/30/07		10/30/07	
Analysis Date	11/13/07		11/13/07		11/13/07		11/13/07	
Weight	0.207		0.208		0.203		0.204	
UNITS	ppm	Q	ppm	Q	ppm	Q	ppm	Q
Al	372		83.7		56.8		60.2	
As	12.1		11.8		8.75		9.65	
Cd	3.11		6.38		4.89		3.27	
Cr	1.52		1.79		0.557		0.542	
Cu	9.49		11.6		7.64		9.04	
Fe	516		196		163		151	
Mn	22.8		10.5		8.65		9.8	
Ni	3.07		1.57		1.06		5.79	
Si	410	B	112	B	75.8	B	102	B
Zn	71.1		98		72.9		94.1	

Method	C-T-AA		C-T-AA		C-T-AA		C-T-AA	
Batch	5990		5990		5990		5990	
Prep Date	10/25/07		10/25/07		10/25/07		10/25/07	
Analysis Date	10/25/07		10/25/07		10/25/07		10/25/07	
Weight	0.021		0.026		0.024		0.022	
UNITS	ppm	Q	ppm	Q	ppm	Q	ppm	Q
Hg	0.0693		0.0851		0.05		0.0596	

Method	gravimetry		gravimetry		gravimetry		gravimetry	
Batch	5914		5914		5914		5914	
Prep Date	10/15/07		10/15/07		10/15/07		10/15/07	
Analysis Date	10/15/07		10/15/07		10/15/07		10/15/07	
Weight	1		1		1		1	
UNITS	%	Q	%	Q	%	Q	%	Q
MOIST	86		88		88		83	

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Client Submitted Samples

LAB ID	T7092-011		T7092-012		T7092-013		T7092-014	
SampleID	RCA0016		RCA0017		RCA0018		RCA0019	
Site	AP-B10-RI5 Takli Island		AP-B10-RS1 Ninagiak Island		KP-B5-RI1 Aailik Bay		KP-B5-RI2 McCarty Fjord	
Collection date	06/28/07		07/04/07		06/19/07		06/15/07	
Receipt Date	09/21/07		09/21/07		09/21/07		09/21/07	
Matrix	Tissue		Tissue		Tissue		Tissue	
% DRY	9		17		15		14	
% MOISTURE	92		83		85		86	
Method	ICP-MS		ICP-MS		ICP-MS		ICP-MS	
Batch	5978		5978		5978		5978	
Prep Date	10/30/07		10/30/07		10/30/07		10/30/07	
Analysis Date	10/06/08		10/06/08		10/06/08		10/06/08	
Weight	0.207		0.205		0.208		0.204	
UNITS	ppm	Q	ppm	Q	ppm	Q	ppm	Q
Ag	0.136		0.0986		0.125		0.0904	
Pb	0.244		0.28		0.945		0.658	
Se	3.93		3.16		4.79		4.69	
Sn	0	U	0	U	2.16		0	U
Method	ICP		ICP		ICP		ICP	
Batch	6068		6068		6068		6068	
Prep Date	10/30/07		10/30/07		10/30/07		10/30/07	
Analysis Date	11/13/07		11/13/07		11/13/07		11/13/07	
Weight	0.207		0.205		0.208		0.204	
UNITS	ppm	Q	ppm	Q	ppm	Q	ppm	Q
Al	45.2		292		314		151	
As	11		8.76		10.9		13.4	
Cd	4.45		2.53		4.42		5.18	
Cr	0.574		0.566		6.18		2.19	
Cu	8		10.3		32.9		11.1	
Fe	141		420		519		295	
Mn	7.73		15.3		13.1		12	
Ni	2.73		7.66		4.32		7.18	
Si	61.2	B	321	B	345	B	125	B
Zn	86.3		74		87.3		104	
Method	C-T-AA		C-T-AA		C-T-AA		C-T-AA	
Batch	5990		5990		5990		5990	
Prep Date	10/25/07		10/25/07		10/25/07		10/25/07	
Analysis Date	10/25/07		10/25/07		10/25/07		10/25/07	
Weight	0.022		0.023		0.024		0.021	
UNITS	ppm	Q	ppm	Q	ppm	Q	ppm	Q
Hg	0.0846		0.064		0.0808		0.126	
Method	gravimetry		gravimetry		gravimetry		gravimetry	
Batch	5914		5914		5914		5914	
Prep Date	10/15/07		10/15/07		10/15/07		10/15/07	
Analysis Date	10/15/07		10/15/07		10/15/07		10/15/07	
Weight	1		1		1		1	
UNITS	%	Q	%	Q	%	Q	%	Q
MOIST	92		83		85		86	

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Client Submitted Samples

LAB ID	T7092-015		T7092-016		T7092-017	
SampleID	RCA0020		RCA0021		RCA0022	
Site	KP-B5-RI3 Nuka Bay		KP-B5-RI4 Nuka Passage		KP-B5-RI5 Harris Bay	
Collection date	06/14/07		06/12/07		06/17/07	
Receipt Date	09/21/07		09/21/07		09/21/07	
Matrix	Tissue		Tissue		Tissue	
% DRY	16		18		17	
% MOISTURE	84		82		83	
Method	ICP-MS		ICP-MS		ICP-MS	
Batch	5978		5978		5978	
Prep Date	10/30/07		10/30/07		10/30/07	
Analysis Date	10/06/08		10/06/08		10/06/08	
Weight	0.204		0.203		0.209	
UNITS	ppm	Q	ppm	Q	ppm	Q
Ag	0.0839		0.0618		0.0457	
Pb	1.14		0.772		0.717	
Se	4.49		3.86		4.52	
Sn	0.347		0	U	0.114	

Method	ICP		ICP		ICP	
Batch	6068		6068		6068	
Prep Date	10/30/07		10/30/07		10/30/07	
Analysis Date	11/13/07		11/13/07		11/13/07	
Weight	0.204		0.203		0.209	
UNITS	ppm	Q	ppm	Q	ppm	Q
Al	455		346		587	
As	12.9		10.6		12.6	
Cd	4.28		3.5		2.98	
Cr	1.97		1.42		2.32	
Cu	16.3		10.4		13.9	
Fe	919		724		889	
Mn	32.4		19.5		23.5	
Ni	8.94		4.63		8.38	
Si	366	B	242	B	574	B
Zn	91.9		87.9		117	

Method	C-T-AA		C-T-AA		C-T-AA	
Batch	5990		5990		5990	
Prep Date	10/25/07		10/25/07		10/25/07	
Analysis Date	10/25/07		10/25/07		10/25/07	
Weight	0.020		0.025		0.030	
UNITS	ppm	Q	ppm	Q	ppm	Q
Hg	0.178		0.119		0.143	

Method	gravimetry		gravimetry		gravimetry	
Batch	5914		5914		5914	
Prep Date	10/15/07		10/15/07		10/15/07	
Analysis Date	10/15/07		10/15/07		10/15/07	
Weight	1		1		1	
UNITS	%	Q	%	Q	%	Q
MOIST	84		82		83	

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Procedural Blank Report

TERL ID	Blank29155				
SampleID	Blank				
Site	NA				
Collection date	NA				
Receipt Date	NA				
Matrix	Tissue				
% DRY	NA				
% MOISTURE	NA				
Method	ICP-MS				
Batch	5978				
Prep Date	10/30/07				
Analysis Date	10/06/08				
Weight	1				
UNITS	Total micrograms	Q	3X MDL	Q	Actual MDL
Ag	0.00197		0.0057		0.0019
Pb	0	U	0.02853		0.00951
Se	0	U	0.114		0.038
Sn	0	U	0.057		0.019

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Al	NA
As	NA
Cd	NA
Cr	NA
Cu	NA
Fe	NA
Mn	NA
Ni	NA
Si	NA
Zn	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Hg	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Procedural Blank Report

TERL ID	Blank29518
SampleID	Blank
Site	NA
Collection date	NA
Receipt Date	NA
Matrix	Tissue
% DRY	NA
% MOISTURE	NA
Method	NA
Batch	
Prep Date	
Analysis Date	
Weight	
UNITS	
Ag	
Pb	
Se	
Sn	

Method	ICP				
Batch	6068				
Prep Date	10/30/07				
Analysis Date	11/13/07				
Weight	1				
UNITS	Total micrograms	Q	3X MDL	Q	Actual MDL
Al	0.108		0.3		0.1
As	0	U	1.14		0.38
Cd	0	U	0.114		0.038
Cr	0	U	0.285		0.095
Cu	0	U	0.285		0.095
Fe	0	U	0.57		0.19
Mn	0	U	0.114		0.038
Ni	0	U	0.285		0.095
Si	1.03	B	0.57	>3X MDL	0.19
Zn	0.038	U	0.114		0.038
	0				

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Hg	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Procedural Blank Report

TERL ID	Blank29178
SampleID	Blank
Site	NA
Collection date	NA
Receipt Date	NA
Matrix	Tissue
% DRY	NA
% MOISTURE	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Ag	NA
Pb	NA
Se	NA
Sn	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Al	NA
As	NA
Cd	NA
Cr	NA
Cu	NA
Fe	NA
Mn	NA
Ni	NA
Si	
Zn	NA

Method	C-T-AA				
Batch	5990				
Prep Date	10/25/07				
Analysis Date	10/25/07				
Weight	1				
UNITS	Total micrograms	Q	3X MDL	Q	Actual MDL
Hg	0.0001	U	0.0003		0.0001

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Blank Spike Report

TERL ID	LCS29156
SampleID	BS-t2004
Site	NA
Collection date	NA
Receipt Date	NA
Matrix	Tissue
% DRY	NA
% MOISTURE	NA

Method	ICP-MS					
Batch	5978					
Prep Date	10/30/07					
Analysis Date	10/06/08					
Weight	1					
UNITS	Total micrograms	Q	% REC	Q	MDL	SPIKE AMT
Ag	0.966		97		0.00191	1
Pb	2.03		102		0.00957	2
Se	0.981		98		0.0383	1
Sn	4.28		107		0.0191	4

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Al	NA
As	NA
Cd	NA
Cr	NA
Cu	NA
Fe	NA
Mn	NA
Ni	NA
Si	NA
Zn	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Hg	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not Applicable, Y=Invalid Spike, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Blank Spike Report

TERL ID	LCS29519
SampleID	BS-t2004
Site	NA
Collection date	NA
Receipt Date	NA
Matrix	Tissue
% DRY	NA
% MOISTURE	NA

Method						
Batch						
Prep Date						
Analysis Date						
Weight						
UNITS						
Ag						
Pb						
Se						
Sn						

Method	ICP					
Batch	6068					
Prep Date	10/30/07					
Analysis Date	11/13/07					
Weight	1					
UNITS	Total micrograms	Q	% REC	Q	MDL	SPIKE AMT
Al	43.9		110		0.1	40
As	4.07		102		0.38	4
Cd	1.04		104		0.0383	1
Cr	4.11		103		0.096	4
Cu	4.04		101		0.096	4
Fe	45.4		114		0.191	40
Mn	10.5		105		0.038	10
Ni	2.04		102		0.096	2
Si	1.13		N/A		0.19	
Zn	20.5		103		0.038	20

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Hg	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not Applicable, Y=Invalid Spike, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Matrix Spike Report

TERL ID	T7092-011		T7092-011S					
SampleID	RCA0016		RCA0016					
Site	AP-B10-RI5 Takli Island		AP-B10-RI5 Takli Island					
Collection date	06/28/07		06/28/07					
Receipt Date	09/21/07		09/21/07					
Matrix	Tissue		Tissue					
% DRY	9		9					
% MOISTURE	92		92					
Method	ICP-MS		ICP-MS					
Batch	5978		5978					
Prep Date	10/30/07		10/30/07					
Analysis Date	10/06/08		10/06/08					
Weight	0.207		0.208					
UNITS	ppm	Q	ppm	Q	% REC	Q	MDL	SPIKE AMT
Ag		0.136		4.45	90		0.00873	4.798
Pb		0.244		9.87	100		0.0436	9.597
Se		3.93		9.49	116		0.175	4.798
Sn		0.0876		19.8	103		0.0873	19.194
Method	ICP		ICP					
Batch	6068		6068					
Prep Date	10/30/07		10/30/07					
Analysis Date	11/13/07		11/13/07					
Weight	0.207		0.208					
UNITS	ppm	Q	ppm	Q	% REC	Q	MDL	SPIKE AMT
Al		45.2		260	112		0.436	191.939
As		11		31.1	105		1.75	19.194
Cd		4.45		9.66	109		0.175	4.798
Cr		0.574		20.2	102		0.436	19.194
Cu		8		27.9	104		0.436	19.194
Fe		141		368	118		0.873	191.939
Mn		7.73		59.2	107		0.175	47.985
Ni		2.73		12.4	101		0.436	9.597
Si		61.2		80.5	N/A		0.87	.
Zn		86.3		192	110		0.175	95.969
Method	NA		NA					
Batch	NA		NA					
Prep Date	NA		NA					
Analysis Date	NA		NA					
Weight	NA		NA					
UNITS	NA		NA					
Hg	NA		NA					
Method	NA		NA					
Batch	NA		NA					
Prep Date	NA		NA					
Analysis Date	NA		NA					
Weight	NA		NA					

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not Applicable, Y=Invalid Spike, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Matrix Spike Report

TERL ID	T7092-012	T7092-017S
SampleID	RCA0017	RCA0017S
Site	AP-B10-RS1 Ninagiak Island	AP-B10-RS1 Ninagiak Island
Collection date	07/04/07	07/04/07
Receipt Date	09/21/07	09/21/07
Matrix	Tissue	Tissue
% DRY	17	17
% MOISTURE	83	83

Method	NA	NA
Batch	NA	NA
Prep Date	NA	NA
Analysis Date	NA	NA
Weight	NA	NA
UNITS	NA	NA
Ag	NA	NA
Pb	NA	NA
Se	NA	NA
Sn	NA	NA

Method	NA	NA
Batch	NA	NA
Prep Date	NA	NA
Analysis Date	NA	NA
Weight	NA	NA
UNITS	NA	NA
Al	NA	NA
As	NA	NA
Cd	NA	NA
Cr	NA	NA
Cu	NA	NA
Fe	NA	NA
Mn	NA	NA
Ni	NA	NA
Si	NA	NA
Zn	NA	NA

Method	C-T-AA		C-T-AA					
Batch	5990		5990					
Prep Date	10/25/07		10/25/07					
Analysis Date	10/25/07		10/25/07					
Weight	0.030		0.025					
UNITS	ppm	Q	ppm	Q	% REC	Q	MDL	SPIKE AMT
Hg	0.143		3.77		94		0.004	3.842

Method	NA	NA
Batch	NA	NA
Prep Date	NA	NA
Analysis Date	NA	NA
Weight	NA	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not Applicable, Y=Invalid Spike, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Standard Reference Material Report

TERL ID	SRM29157
SampleID	2976
Site	NA
Collection date	NA
Receipt Date	NA
Matrix	Tissue
% DRY	NA
% MOISTURE	NA

Method	ICP-MS					
Batch	5978					
Prep Date	10/30/07					
Analysis Date	10/06/08					
Weight	0.203					
UNITS	ppm	Q	SRM amount	SRM REC%	Q	MDL
Ag	0.00911		0.011	83		0.00894
Pb	1.22		1.19	103		0.0447
Se	1.92		1.8	107		0.179
Sn	0.09		0.096	94		0.0894

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Al	NA
As	NA
Cd	NA
Cr	NA
Cu	NA
Fe	NA
Mn	NA
Ni	NA
Si	NA
Zn	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Hg	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, X =< 10x MDL, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Standard Reference Material Report

TERL ID	SRM29520
SampleID	2976
Site	NA
Collection date	NA
Receipt Date	NA
Matrix	Tissue
% DRY	NA
% MOISTURE	NA

Method						
Batch						
Prep Date						
Analysis Date						
Weight						
UNITS						
Ag						
Pb						
Se						
Sn						

Method	ICP					
Batch	6068					
Prep Date	10/30/07					
Analysis Date	11/13/07					
Weight	0.203					
UNITS	ppm	Q	SRM amount	SRM REC%	Q	MDL
Al	96.4		134	72	*	0.447
As	13.2		13.3	99		1.79
Cd	0.862		0.82	105		0.179
Cr	0	U	0.5			0.447
Cu	3.99		4.02	99		0.447
Fe	176		171	103		0.894
Mn	36.6		33	111		0.179
Ni	0.868		0.93	93		0.447
Si	48.6			N/A		0.89
Zn	138		137	101		0.179

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Hg	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, X =< 10x MDL, *=Outside QA limits, refer to narrative

B&B Laboratories
Project J07651
Report 08-2066

Cook Inlet RCAC
Mussel Watch Project 2007
Trace Element Tissue Data
Standard Reference Material Report

TERL ID	SRM29179
SampleID	DOLT-3
Site	NA
Collection date	NA
Receipt Date	NA
Matrix	Tissue
% DRY	NA
% MOISTURE	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Ag	NA
Pb	NA
Se	NA
Sn	NA

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA
UNITS	NA
Al	NA
As	NA
Cd	NA
Cr	NA
Cu	NA
Fe	NA
Mn	NA
Ni	NA
Si	NA
Zn	NA

Method	C-T-AA					
Batch	5990					
Prep Date	10/25/07					
Analysis Date	10/25/07					
Weight	0.015					
UNITS	ppm	Q	SRM amount	SRM REC%	Q	MDL
Hg	2.86		3.37	85		0.0066

Method	NA
Batch	NA
Prep Date	NA
Analysis Date	NA
Weight	NA

Qualifiers (Q): J=Below the MDL, U=Not detected, B=In procedural blank > 3x MDL, I=Interference, NA=Not applicable, X =< 10x MDL, *=Outside QA limits, refer to narrative

Appendix B Intertidal Algae and Sessile Invertebrates

Means and descriptive statistics for dominant sessile invertebrates and algae in the lower and mid intertidal at KATM form 2006 through 2008.

Percent Cover - bare substrate

Lower intertidal								Mid intertidal						
Site	year	n	Mean	STD	CV	90% CI		Site	year	n	Mean	STD	CV	90% CI
Amalik	2006	12	10.54	14.11	133.80	6.70		Amalik	2006	12	9.69	9.42	97.15	4.47
Kaflia	2006	12	27.89	28.59	102.50	13.57		Kaflia	2006	12	19.39	9.98	51.47	4.74
Kinak	2006	12	1.19	1.62	135.94	0.77		Kinak	2006	12	13.10	17.78	135.77	8.44
Kukak	2006	12	12.76	11.74	92.07	5.58		Kukak	2006	12	31.63	17.78	56.21	8.44
Takli	2006	12	29.76	14.20	47.73	6.74		Takli	2006	12	11.05	8.77	79.29	4.16
KATM	2006	5	16.43	9.63	58.64	7.09		KATM	2006	5	16.97	4.62	27.20	3.40
Amalik	2007	12	8.16	21.37	261.77	10.15		Amalik	2007	12	13.27	18.63	140.47	8.85
Kaflia	2007	12	10.20	10.04	98.35	4.77		Kaflia	2007	12	10.88	14.47	132.90	6.87
Kinak	2007	12	1.87	2.95	157.46	1.40		Kinak	2007	12	2.89	4.12	142.64	1.96
Kukak	2007	12	1.87	2.68	143.06	1.27		Kukak	2007	12	2.72	4.47	164.11	2.12
Takli	2007	12	10.03	11.53	114.88	5.47		Takli	2007	12	2.21	2.81	127.29	1.34
KATM	2007	5	6.43	7.66	119.12	5.63		KATM	2007	5	6.39	7.16	112.02	5.27
Amalik	2008	12	6.00	11.38	189.63	5.40		Amalik	2008	12	26.00	25.67	98.73	12.19
Kaflia	2008	12	25.67	23.60	91.95	11.21		Kaflia	2008	12	11.33	13.30	117.38	6.32
Kinak	2008	12	0.67	1.56	233.55	0.74		Kinak	2008	12	6.33	7.13	112.52	3.38
Kukak	2008	12	2.67	3.94	147.71	1.87		Kukak	2008	12	4.67	7.40	158.61	3.51
Takli	2008	12	8.67	11.42	131.77	5.42		Takli	2008	12	28.00	27.77	99.16	13.18
KATM	2008		8.73	8.61	98.53	6.33		KATM	2008		15.27	9.89	64.81	7.28

Percent Cover - barnacles

Lower intertidal								Mid intertidal						
Site	Year	n	Mean	STD	CV	90% CI		Site	Year	n	Mean	STD	CV	90% CI
Kukak	2006	12	2.59	3.46	133.95	1.64		Kukak	2006	12	26.22	22.64	86.35	10.75
Kaflia	2006	12	66.87	28.26	42.25	13.42		Kaflia	2006	12	69.42	15.53	22.37	7.37
Kinak	2006	12	1.39	1.84	131.76	0.87		Kinak	2006	12	59.73	25.75	43.12	12.23
Amalik	2006	12	60.75	23.40	38.53	11.11		Amalik	2006	12	72.82	15.70	21.56	7.45
Takli	2006	12	36.94	17.01	46.04	8.08		Takli	2006	12	65.51	14.95	22.82	7.10
KATM	2006	5	33.71	11.80	34.99	8.68		KATM		5	58.74	4.96	8.44	3.65
Takli	2007	12	34.56	23.92	69.23	11.36		Takli	2007	12	64.83	22.45	34.62	10.66
Amalik	2007	12	54.97	23.84	43.38	11.32		Amalik	2007	12	48.33	35.51	73.48	16.86
Kinak	2007	12	14.49	27.21	187.81	12.92		Kinak	2007	12	66.19	21.53	32.53	10.22
Kaflia	2007	12	78.61	14.23	18.10	6.76		Kaflia	2007	12	82.35	14.17	17.21	6.73
Kukak	2007	12	25.03	23.78	95.00	11.29		Kukak	2007	12	77.76	17.30	22.24	8.21
KATM	2007	5	41.53	4.90	11.80	3.60		KATM	2007	5	67.89	8.16	12.02	6.00
Takli	2008	12	19.73	17.96	90.99	8.53		Takli	2008	12	28.40	14.57	51.31	6.92
Amalik	2008	12	46.40	24.33	52.44	11.55		Amalik	2008	12	48.07	20.64	42.94	9.80
Kinak	2008	12	2.07	3.17	153.48	1.51		Kinak	2008	12	25.40	23.46	92.35	11.14
Kukak	2008	12	0.73	1.15	157.46	0.55		Kukak	2008	12	50.40	22.72	45.09	10.79
Kaflia	2008	12	36.07	23.23	64.40	11.03		Kaflia	2008	12	56.73	23.78	41.92	11.29
KATM	2008	5	21.00	11.07	52.69	8.14		KATM	2008	5.00	41.80	3.81	9.12	2.81

Percent Cover- Fucus gardneri

Lower intertidal								Mid intertidal						
Site	Year	n	Mean	STD	CV	90% CI		Site	Year	n	Mean	STD	CV	90% CI
Amalik	2006	12	10.47	16.84	160.77	8.00		Amalik	2006	12	32.92	22.63	68.75	10.75
Kaflia	2006	12	1.29	1.84	142.38	0.87		Kaflia	2006	12	16.26	16.95	104.27	8.05
Kinak	2006	12	20.34	22.43	110.29	10.65		Kinak	2006	12	29.35	27.39	93.30	13.00
Kukak	2006	12	29.69	16.01	53.92	7.60		Kukak	2006	12	34.11	23.31	68.32	11.07
Takli	2006	12	25.95	25.91	99.83	12.30		Takli	2006	12	77.10	14.08	18.26	6.68
KATM	2006	5	17.55	11.62	66.22	8.55		KATM	2006	5	37.95	23.01	60.63	16.92
Amalik	2007	12	9.96	11.17	112.13	5.30		Amalik	2007	12	5.71	12.85	224.99	6.10
Kaflia	2007	12	7.07	8.14	115.06	3.86		Kaflia	2007	12	28.16	24.54	87.13	11.65
Kinak	2007	12	29.35	26.88	91.59	12.76		Kinak	2007	12	53.50	22.94	42.87	10.89
Kukak	2007	12	9.62	10.38	107.88	4.93		Kukak	2007	12	24.10	20.61	85.51	9.79
Takli	2007	12	38.54	24.05	62.41	11.42		Takli	2007	12	76.43	31.29	40.93	14.86
KATM	2007	5	18.91	14.15	74.82	10.41		KATM	2006	5	37.58	27.61	73.46	20.31
Amalik	2008	12	5.10	7.06	138.40	3.35		Amalik	2008	12	42.28	29.28	69.26	13.90
Kaflia	2008	12	16.77	18.67	111.36	8.87		Kaflia	2008	12	45.85	30.15	65.76	14.32
Kinak	2008	12	4.10	6.15	149.99	2.92		Kinak	2008	12	17.96	22.29	124.13	10.58
Kukak	2008	12	3.43	5.87	170.89	2.79		Kukak	2008	12	15.77	24.39	154.68	11.58
Takli	2008	12	16.77	18.36	109.48	8.72		Takli	2008	12	32.10	22.76	70.89	10.81
KATM	2008	5	9.23	6.90	74.76	5.08		KATM	2006	5	30.79	13.70	44.50	10.08

Percent Cover- Alaria marginata

Lower intertidal								Mid intertidal						
Site	Year	n	Mean	STD	CV	90% CI								
Amalik	2006	12	36.56	33.61	91.93	19.01								
Kaflia	2006	12	0.50	0.69	136.12	0.39								
Kinak	2006	12	17.85	18.04	101.06	10.21								
Kukak	2006	12	11.61	19.17	165.14	10.84								
Takli	2006	12	1.35	2.36	174.10	1.33								
KATM	2006	5	13.57	14.75	108.68	10.85								
Amalik	2007	12	76.01	31.22	41.07	17.67			Not given due to low percent cover					
Kaflia	2007	12	4.07	6.38	156.57	3.61								
Kinak	2007	12	29.07	29.75	102.34	16.83								
Kukak	2007	12	34.01	28.75	84.54	16.27								
Takli	2007	12	5.78	10.25	177.41	5.80								
KATM	2007	5	29.79	29.12	97.77	21.42								
Amalik	2008	12	65.33	34.77	53.22	19.67								
Kaflia	2008	12	38.67	30.96	80.06	17.51								
Kinak	2008	12	55.33	36.64	66.22	20.73								
Kukak	2008	12	22.00	20.55	93.42	11.63								
Takli	2008	12	33.00	31.13	94.34	17.61								
KATM	2008	5	42.87	17.40	40.58	12.80								

Percent Cover- Mytilus trossulus

Not given due to low percent cover

Mid intertidal

Site	Year	n	Mean	STD	CV	90% CI
Amalik	2006	12	3.44	4.12	120.04	1.96
Kaflia	2006	12	3.10	4.88	157.69	2.32
Kinak	2006	12	2.24	2.75	122.58	1.31
Kukak	2006	12	5.31	6.24	117.69	2.97
Takli	2006	12	10.75	11.37	105.82	5.40
KATM	2006	5	4.97	3.32	66.93	2.44
Amalik	2007	12	15.17	17.39	114.63	8.26
Kaflia	2007	12	2.76	5.37	195.02	2.55
Kinak	2007	12	11.26	11.43	101.50	5.43
Kukak	2007	12	21.12	21.16	100.17	10.05
Takli	2007	12	12.11	13.53	111.76	6.43
KATM	2007	5	12.48	5.99	48.02	4.41
Amalik	2008	12	5.07	11.03	217.73	5.24
Kaflia	2008	12	28.73	29.56	102.89	14.04
Kinak	2008	12	12.40	12.65	102.01	6.01
Kukak	2008	12	28.73	12.59	43.81	5.98
Takli	2008	12	15.07	19.25	127.74	9.14
KATM	2008	5	18.00	7.70	42.76	5.66

Percent Cover- Neorhodomela spp.

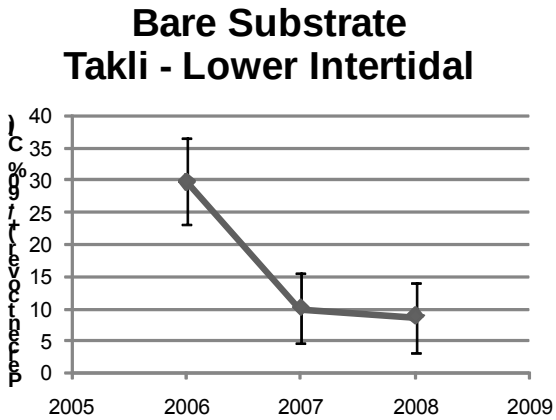
Lower intertidal

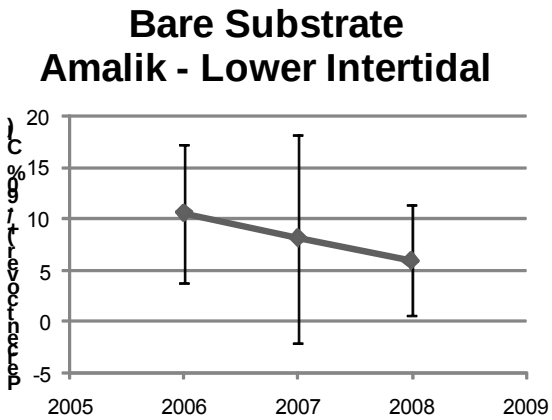
Site	year	n	Mean	STD	CV	90% CI
Amalik	2006	12	3.27	6.37	194.93	3.02
Kaflia	2006	12	3.10	5.33	172.07	2.53
Kinak	2006	12	3.44	7.71	224.37	3.66
Kukak	2006	12	8.71	11.77	135.13	5.59
Takli	2006	12	30.99	22.78	73.53	10.82
KATM	2006	5	9.90	7.14	72.10	5.25
Amalik	2007	12	4.46	10.95	245.84	5.20
Kaflia	2007	12	2.41	4.12	170.77	1.96
Kinak	2007	12	30.65	32.48	106.00	15.42
Kukak	2007	12	22.14	13.09	59.10	6.21
Takli	2007	12	13.13	16.75	127.55	7.95
KATM	2007	5	14.56	10.56	72.53	7.77
Amalik	2008	12	32.73	24.80	75.77	11.78
Kaflia	2008	12	0.73	1.15	157.46	0.55
Kinak	2008	12	0.40	0.00	0.00	0.00
Kukak	2008	12	10.07	14.21	141.21	6.75
Takli	2008	12	2.40	3.19	132.95	1.52
KATM	2008	5	9.27	10.64	114.80	7.83

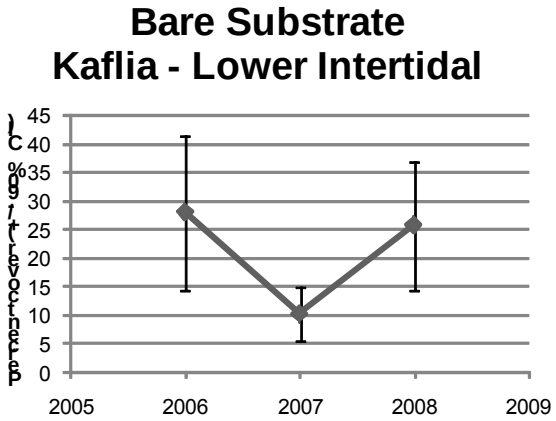
Mid intertidal

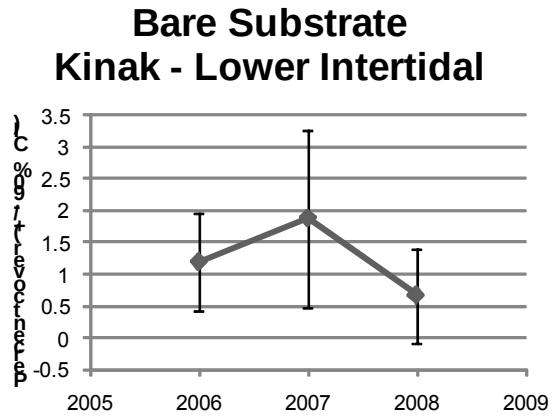
Site	year	n	Mean	STD	CV	90% CI
Amalik	2006	12	11.60	15.77	135.97	7.49
Kaflia	2006	12	6.84	10.41	152.28	4.94
Kinak	2006	12	2.24	4.08	181.82	1.94
Kukak	2006	12	8.71	15.92	182.87	7.56
Takli	2006	12	22.65	25.65	113.24	12.18
KATM	2006	5	10.41	7.96	76.44	5.85
Amalik	2007	12	2.41	6.42	265.92	3.05
Kaflia	2007	12	6.67	10.07	151.01	4.78
Kinak	2007	12	12.11	14.58	120.43	6.92
Kukak	2007	12	7.01	9.74	139.04	4.63
Takli	2007	12	10.75	18.68	173.80	8.87
KATM	2007	5	7.79	4.78	61.30	3.51
Amalik	2008	12	13.73	19.09	139.04	9.07
Kaflia	2008	12	0.73	1.15	157.46	0.55
Kinak	2008	12	4.40	7.43	168.97	3.53
Kukak	2008	12	8.07	12.47	154.59	5.92
Takli	2008	12	14.07	19.56	139.02	9.29
KATM	2008	5	8.2	7.84	95.65	5.77

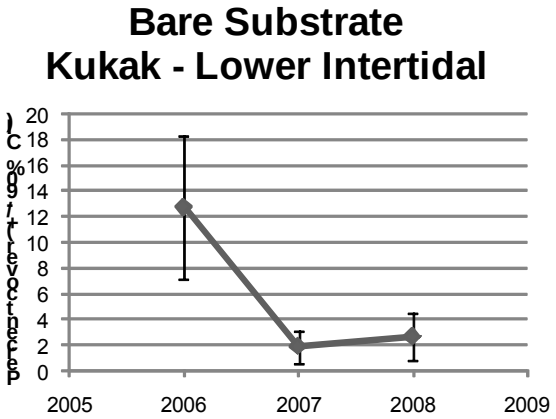
Charts of mean percent cover of bare substrate and dominant intertidal sessile invertebrates and algae in KATM.

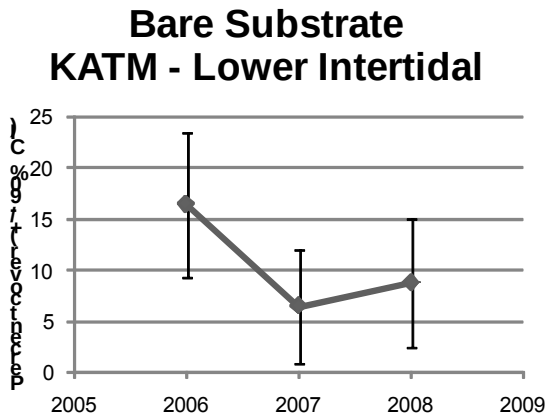


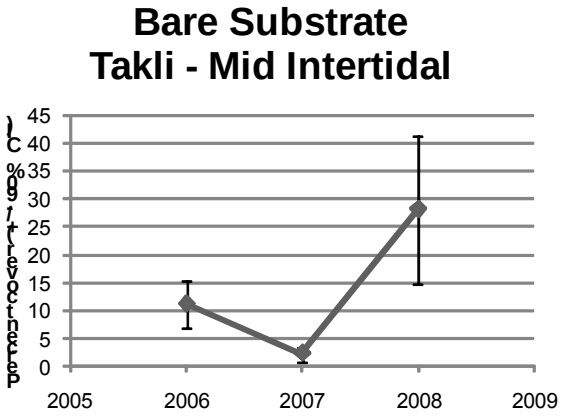


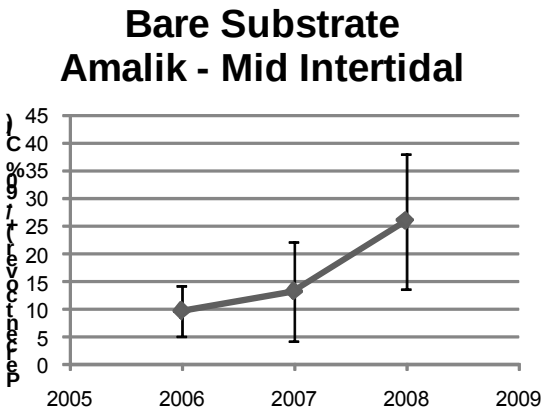


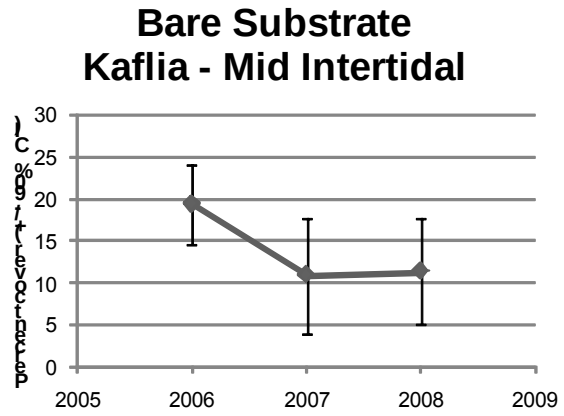


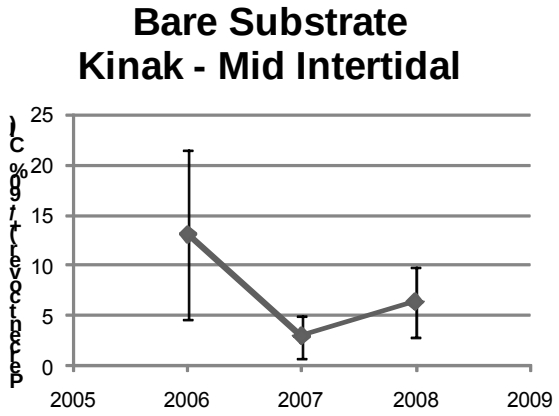


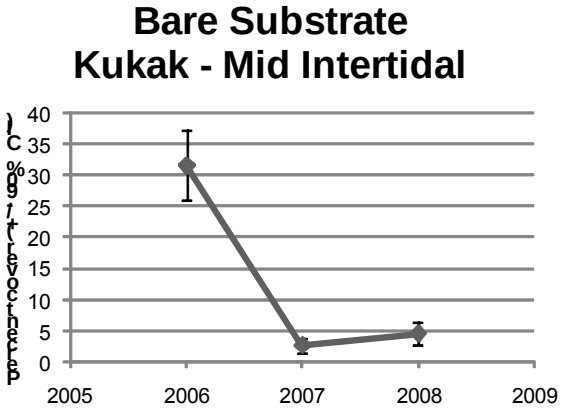


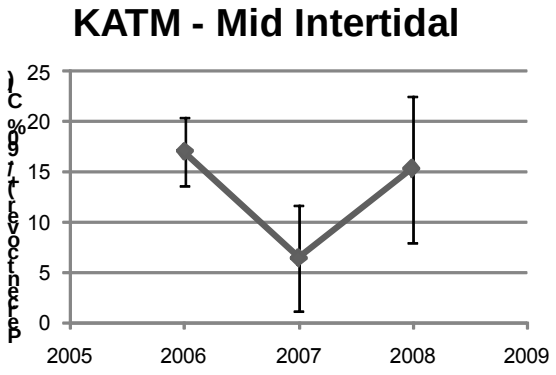

Bare Substrate
Takli - Mid Intertidal
Percent Cover
45
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

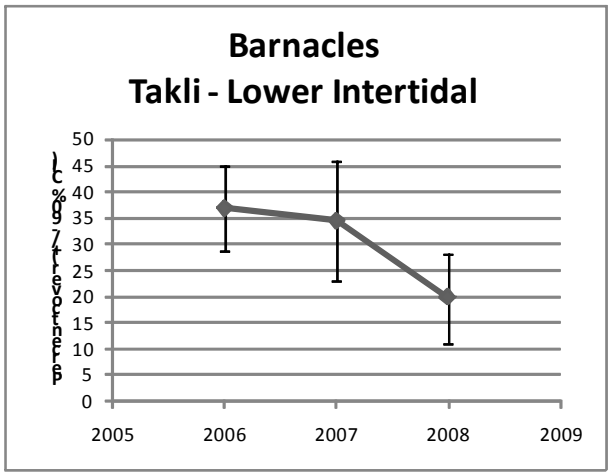

Bare Substrate
Amalik - Mid Intertidal
Percent Cover
45
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

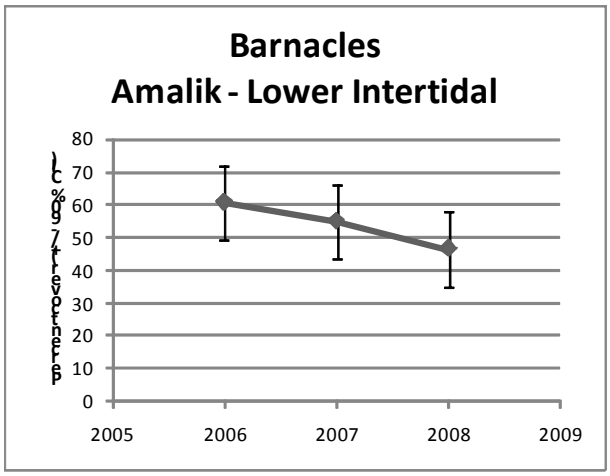

Bare Substrate
Kaflia - Mid Intertidal
Percent Cover
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

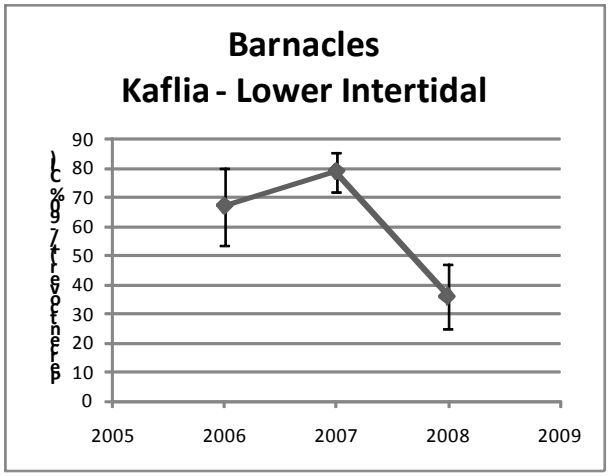

Bare Substrate
Kinak - Mid Intertidal
Percent Cover
25
20
15
10
5
0
2005
2006
2007
2008
2009

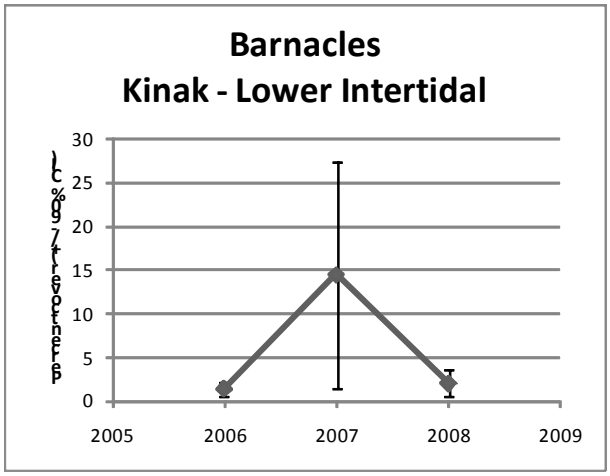

Bare Substrate
Kukak - Mid Intertidal
Percent Cover
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

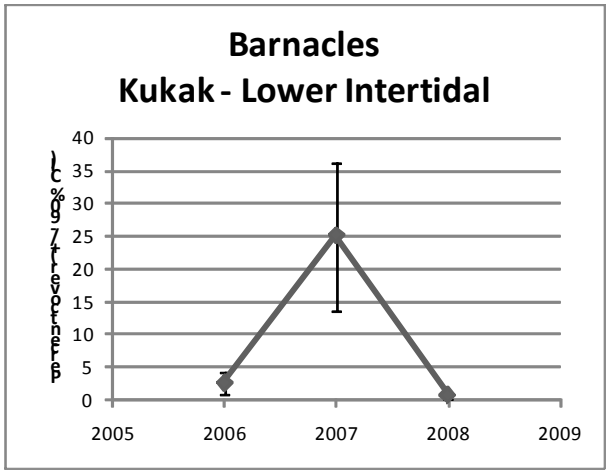

Bare Substrate
KATM - Mid Intertidal
Percent Cover
25
20
15
10
5
0
2005
2006
2007
2008
2009

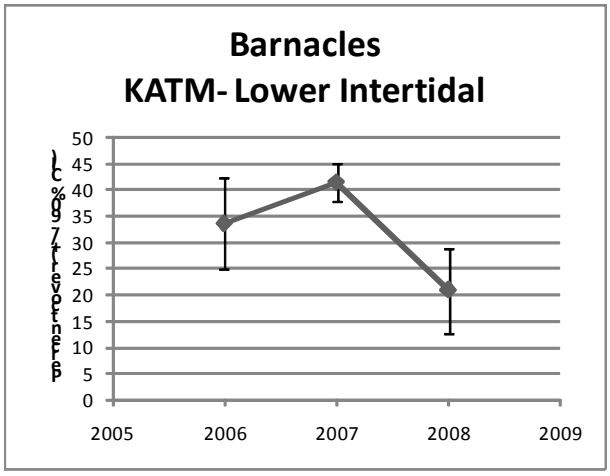

Barnacles
Takli - Lower Intertidal
50
45
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

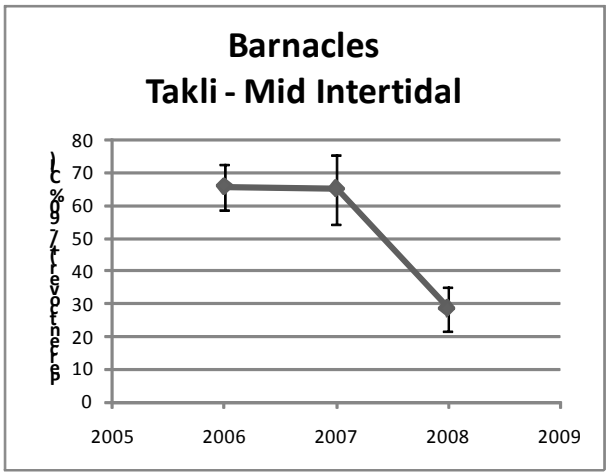

Barnacles
Amalik - Lower Intertidal
80
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

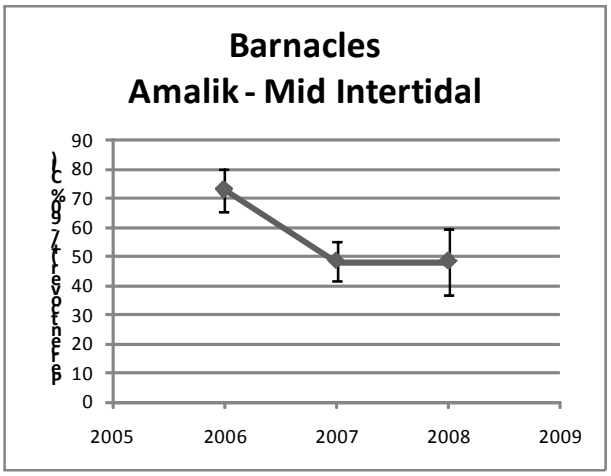

Barnacles
Kaflia - Lower Intertidal
90
80
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

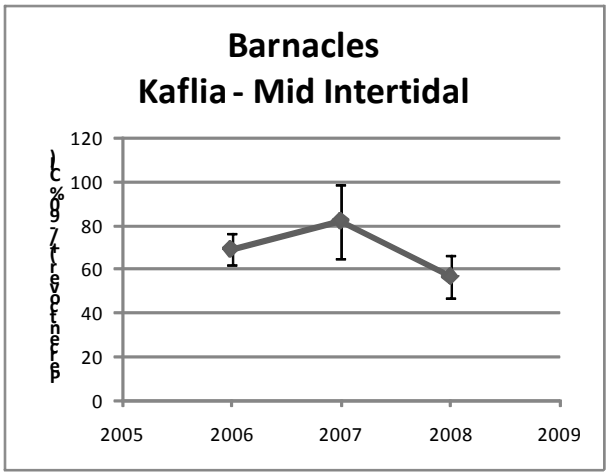

Barnacles
Kinak - Lower Intertidal
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

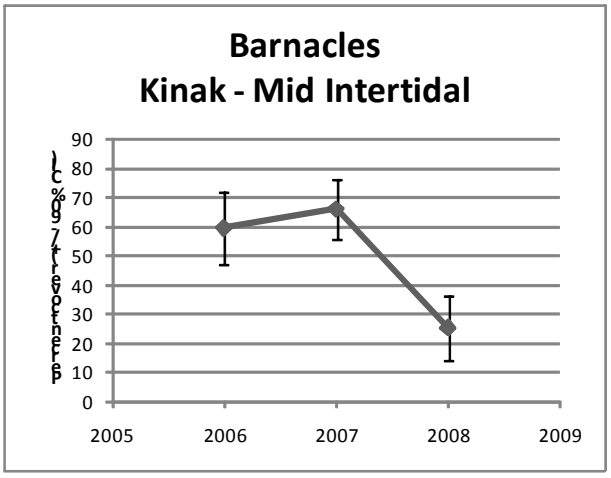

Barnacles
Kukak - Lower Intertidal
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

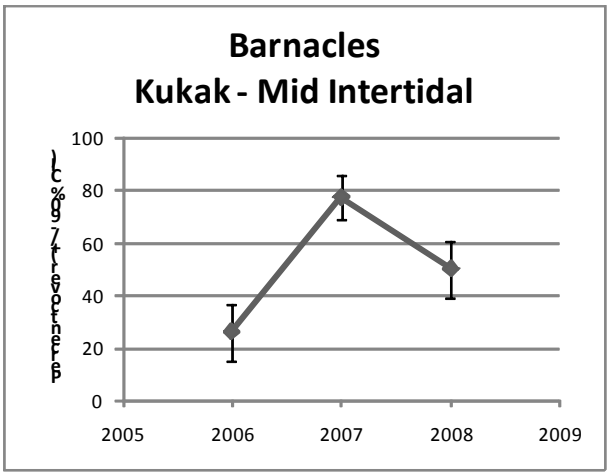

Barnacles
KATM- Lower Intertidal
50
45
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

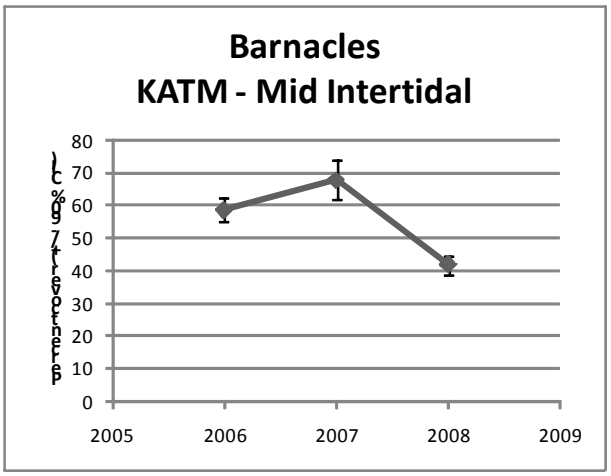

Barnacles
Takli - Mid Intertidal
80
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

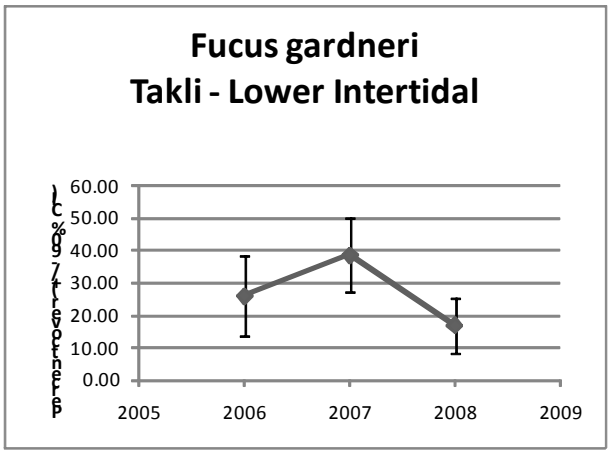

Barnacles
Amalik - Mid Intertidal
90
80
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

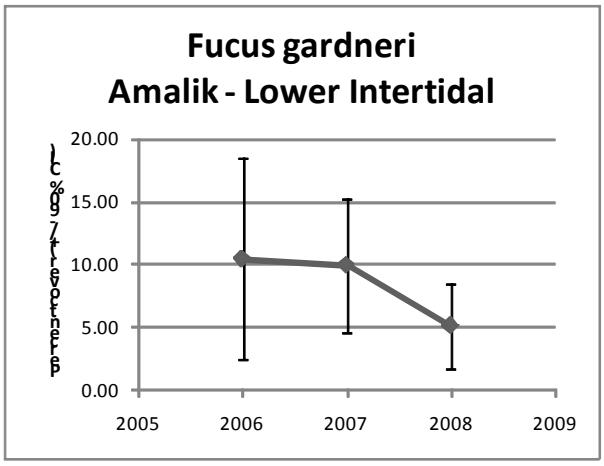

Barnacles
Kaflia - Mid Intertidal
120
100
80
60
40
20
0
2005
2006
2007
2008
2009

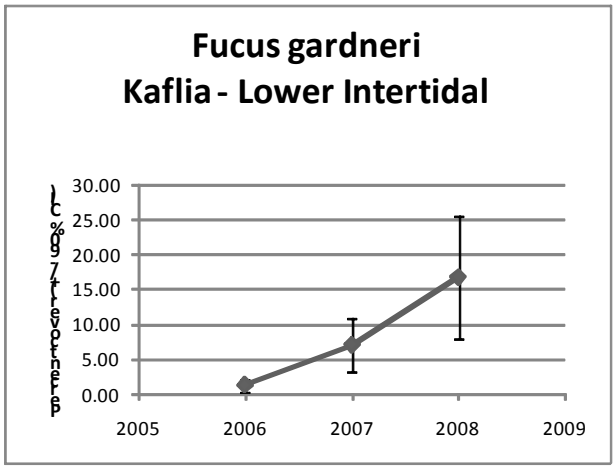

Barnacles
Kinak - Mid Intertidal
90
80
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

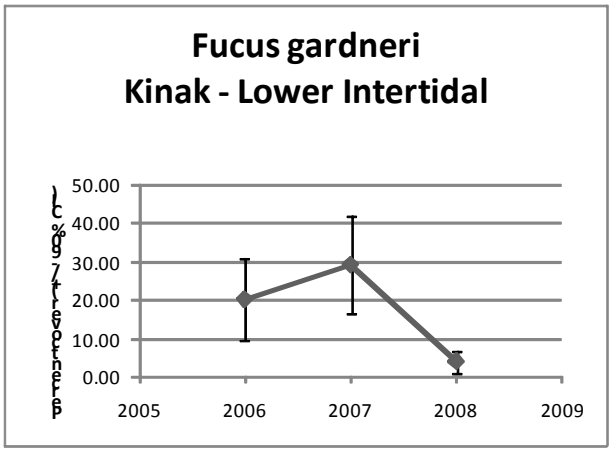

Barnacles
Kukak - Mid Intertidal
100
80
60
40
20
0
2005
2006
2007
2008
2009

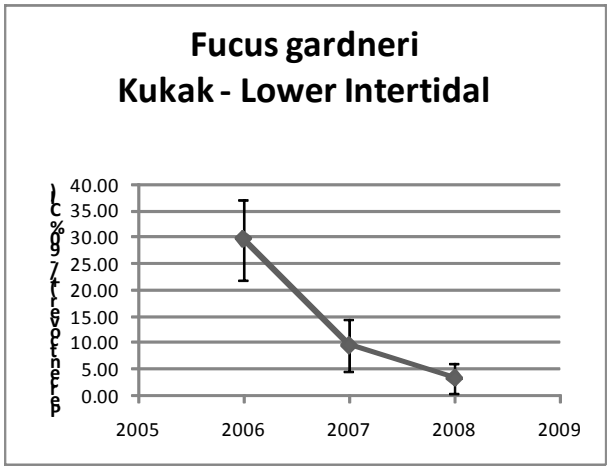

Barnacles
KATM - Mid Intertidal
80
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

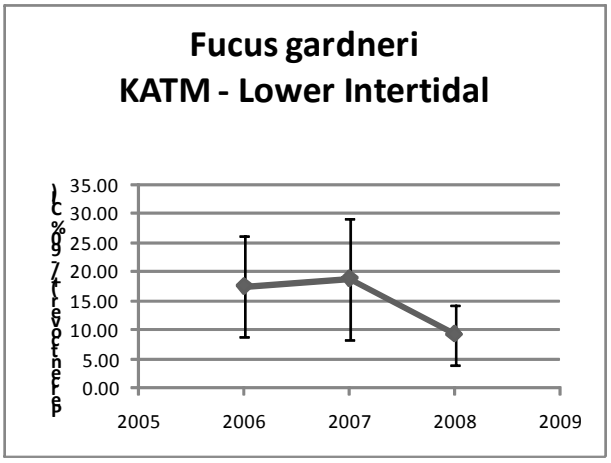

Fucus gardneri
Takli - Lower Intertidal
60.00
50.00
40.00
30.00
20.00
10.00
0.00
2005
2006
2007
2008
2009

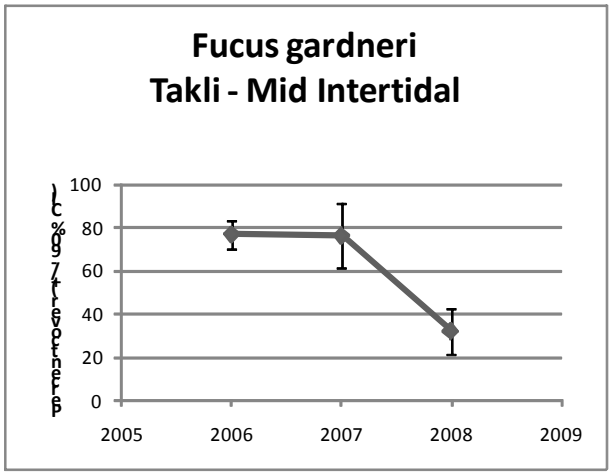

Fucus gardneri
Amalik - Lower Intertidal
20.00
15.00
10.00
5.00
0.00
2005
2006
2007
2008
2009

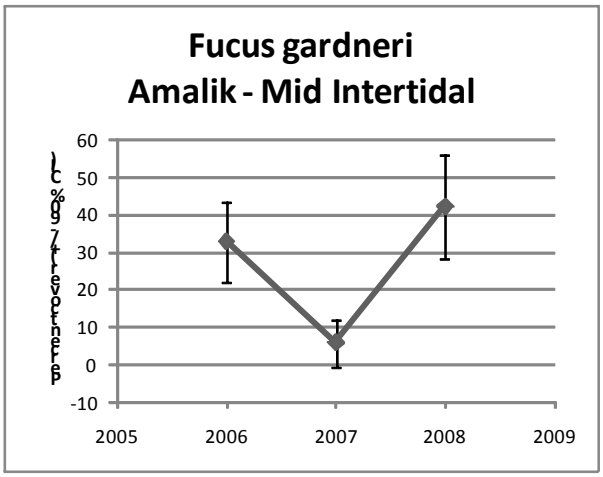

Fucus gardneri
Kaflia - Lower Intertidal
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2005
2006
2007
2008
2009

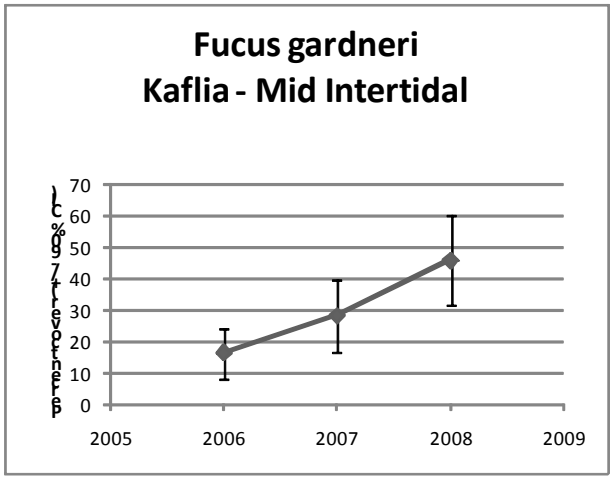

Fucus gardneri
Kinak - Lower Intertidal
50.00
40.00
30.00
20.00
10.00
0.00
2005
2006
2007
2008
2009

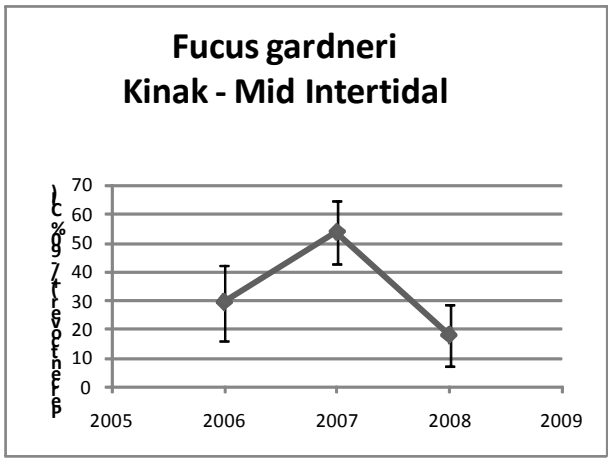

Fucus gardneri
Kukak - Lower Intertidal
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2005
2006
2007
2008
2009

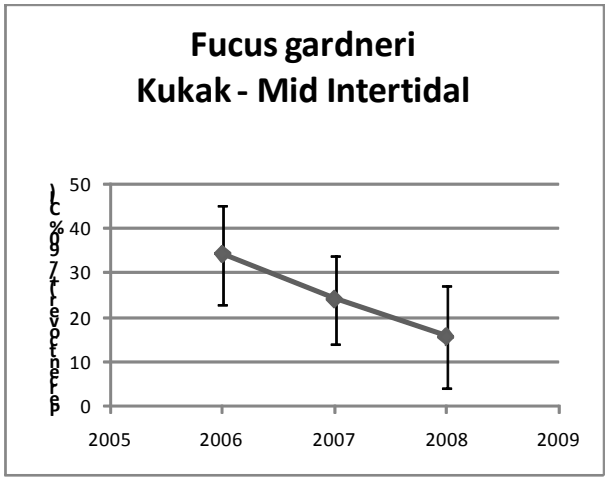

Fucus gardneri
KATM - Lower Intertidal
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
2005
2006
2007
2008
2009

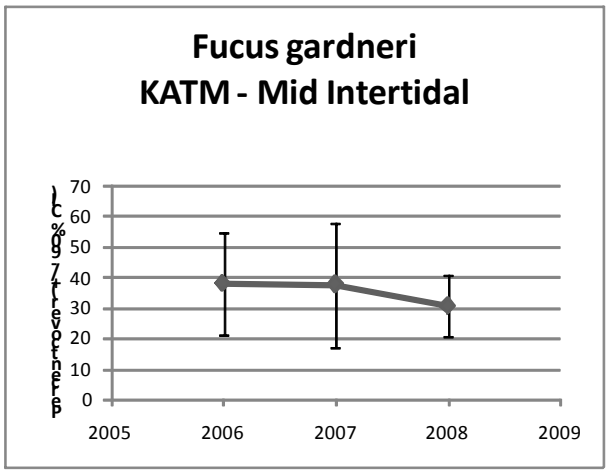

Fucus gardneri
Takli - Mid Intertidal
100
80
60
40
20
0
2005
2006
2007
2008
2009

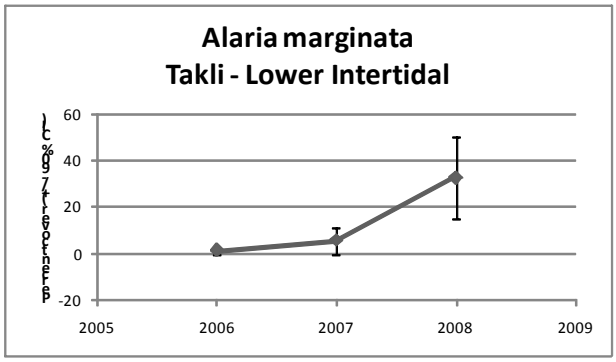

Fucus gardneri
Amalik - Mid Intertidal
60
50
40
30
20
10
0
-10
2005
2006
2007
2008
2009

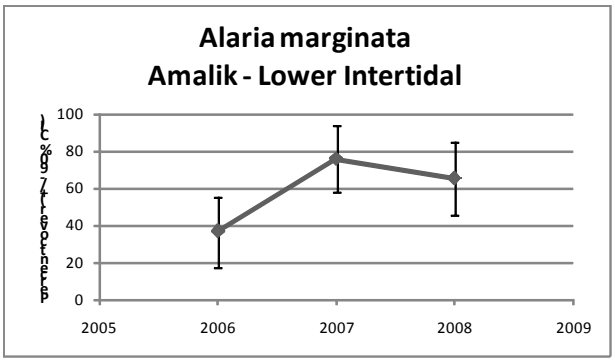

Fucus gardneri
Kaflia - Mid Intertidal
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

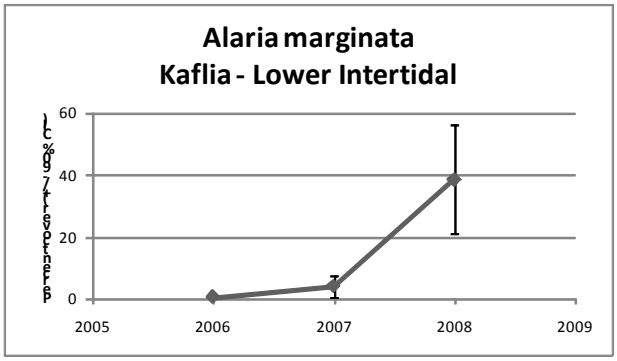

Fucus gardneri
Kinak - Mid Intertidal
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

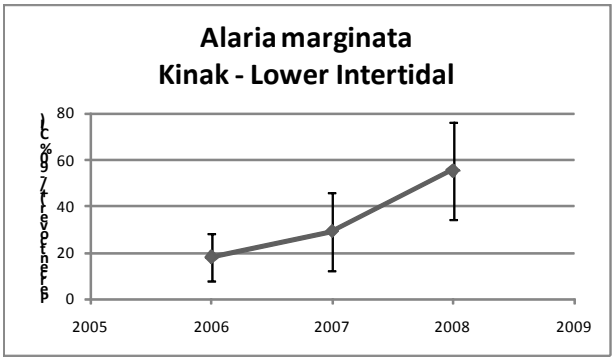

Fucus gardneri
Kukak - Mid Intertidal
50
40
30
20
10
0
2005
2006
2007
2008
2009

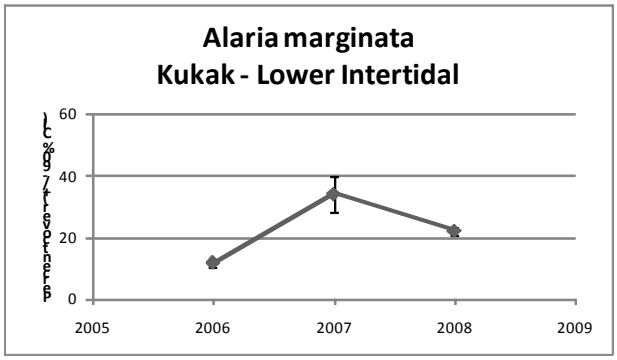

Fucus gardneri
KATM - Mid Intertidal
70
60
50
40
30
20
10
0
2005
2006
2007
2008
2009

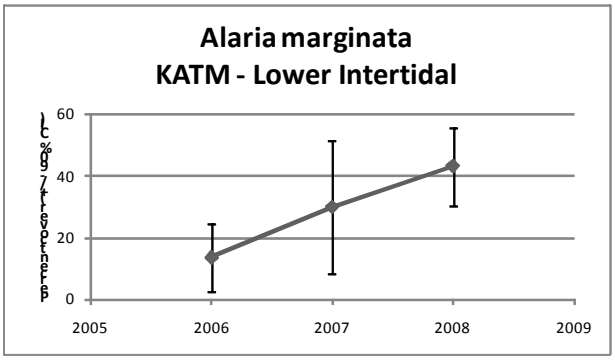

Alaria marginata
Takli - Lower Intertidal
60
40
20
0
-20
2005
2006
2007
2008
2009

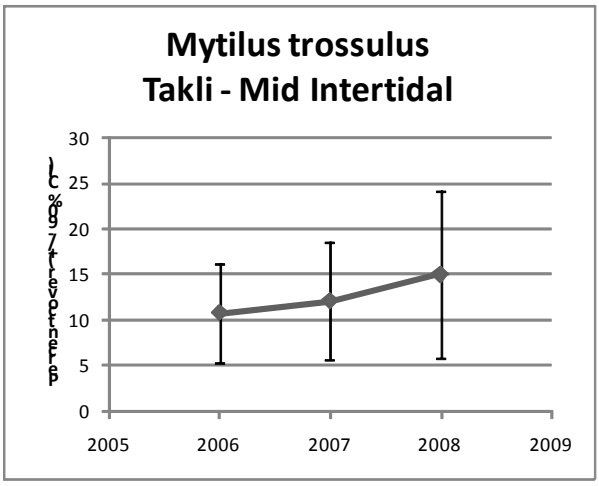

Alaria marginata
Amalik - Lower Intertidal
100
80
60
40
20
0
2005
2006
2007
2008
2009

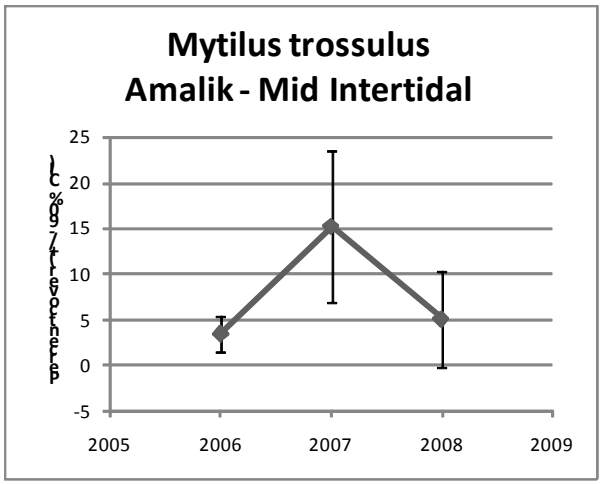

Alaria marginata
Kaflia - Lower Intertidal
60
40
20
0
2005
2006
2007
2008
2009

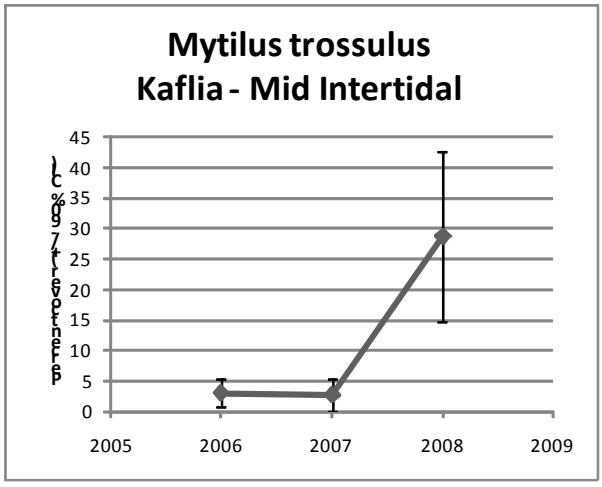

Alaria marginata
Kinak - Lower Intertidal
80
60
40
20
0
2005
2006
2007
2008
2009

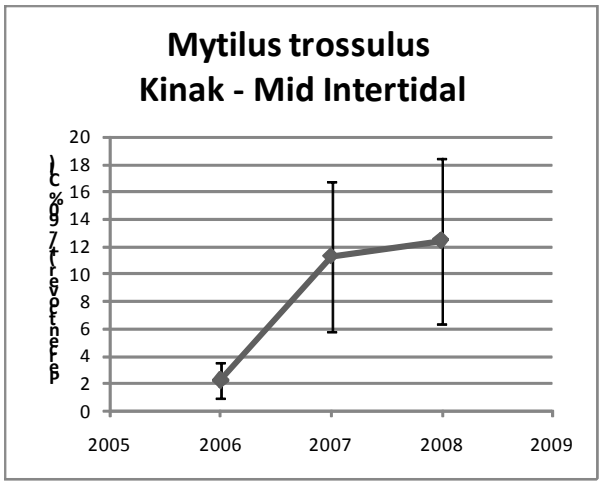

Alaria marginata
Kukak - Lower Intertidal
60
40
20
0
2005
2006
2007
2008
2009

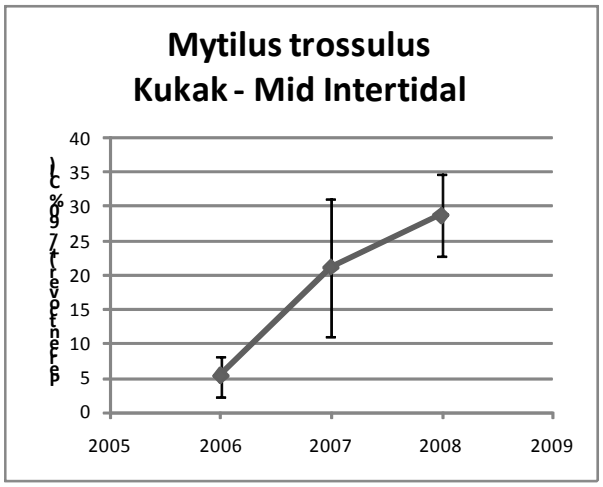

Alaria marginata
KATM - Lower Intertidal
60
40
20
0
2005
2006
2007
2008
2009

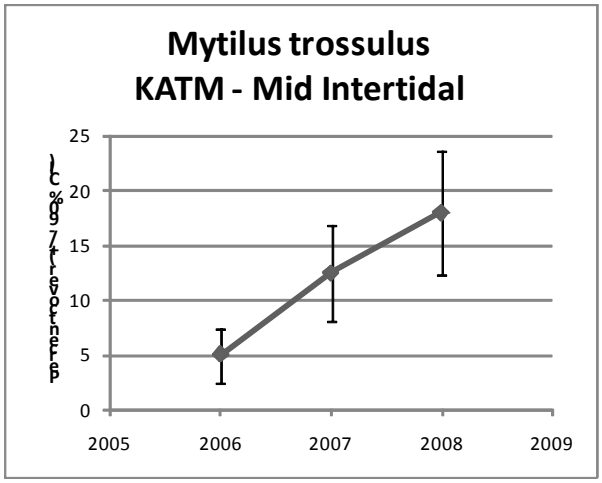

Mytilus trossulus
Takli - Mid Intertidal
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

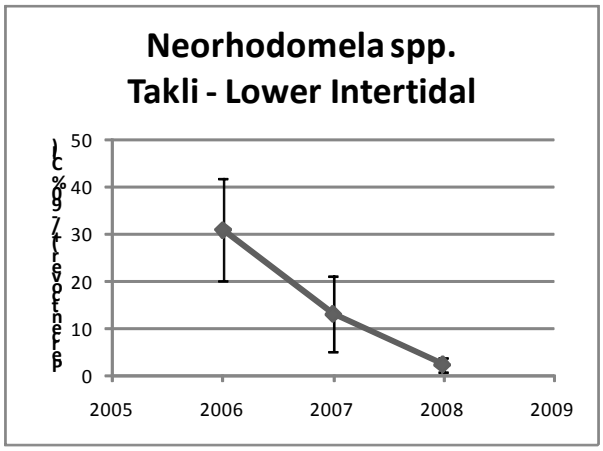

Mytilus trossulus
Amalik - Mid Intertidal
25
20
15
10
5
0
-5
2005
2006
2007
2008
2009

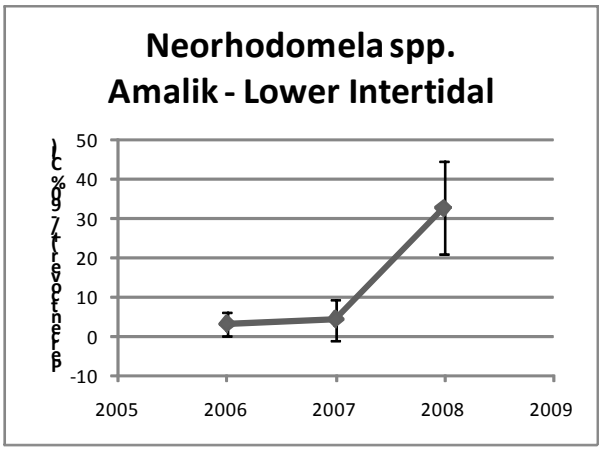

Mytilus trossulus
Kaflia - Mid Intertidal
45
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

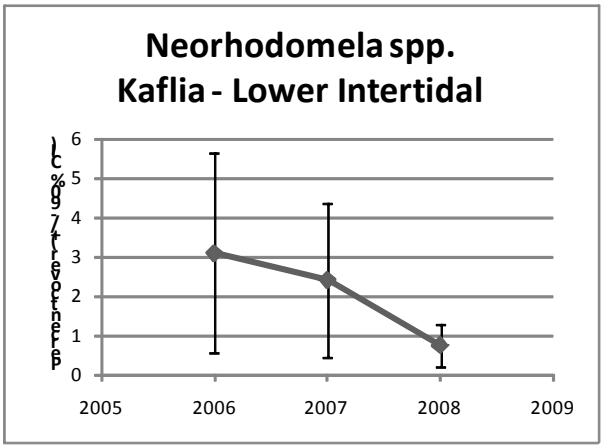

Mytilus trossulus
Kinak - Mid Intertidal
20
18
16
14
12
10
8
6
4
2
0
2005
2006
2007
2008
2009

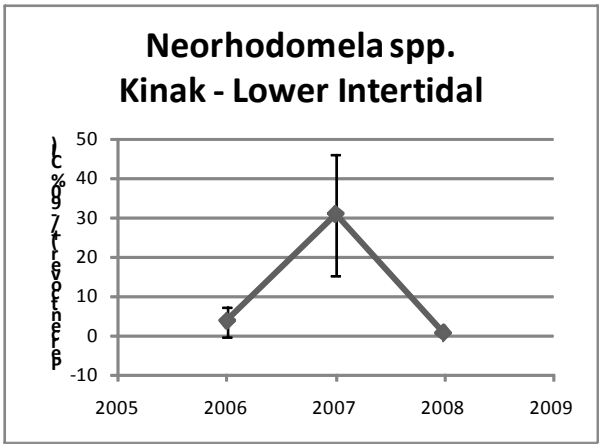

Mytilus trossulus
Kukak - Mid Intertidal
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

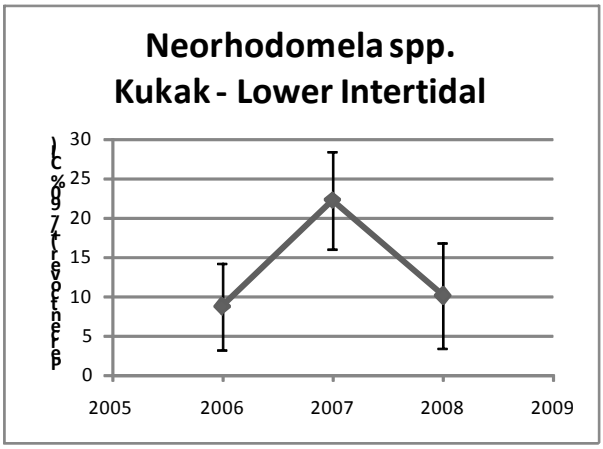

Mytilus trossulus
KATM - Mid Intertidal
25
20
15
10
5
0
2005
2006
2007
2008
2009

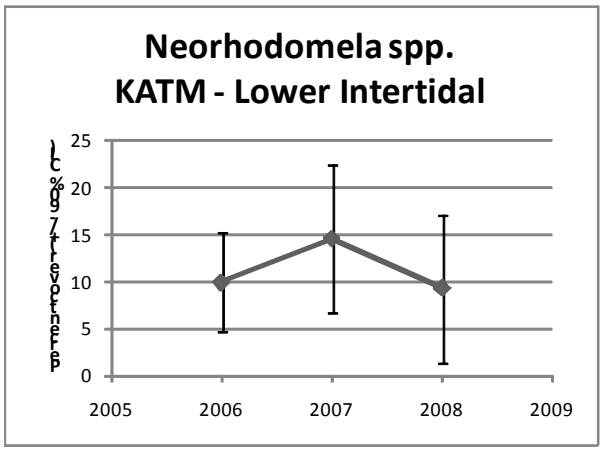

Neorhodomela spp.
Takli - Lower Intertidal
50
40
30
20
10
0
2005
2006
2007
2008
2009

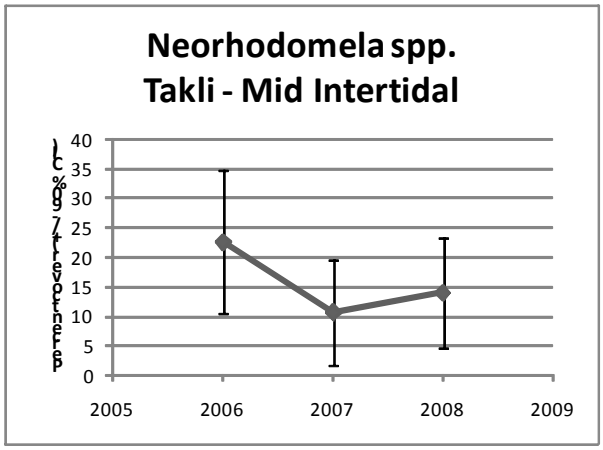

Neorhodomela spp.
Amalik - Lower Intertidal
50
40
30
20
10
0
-10
2005
2006
2007
2008
2009

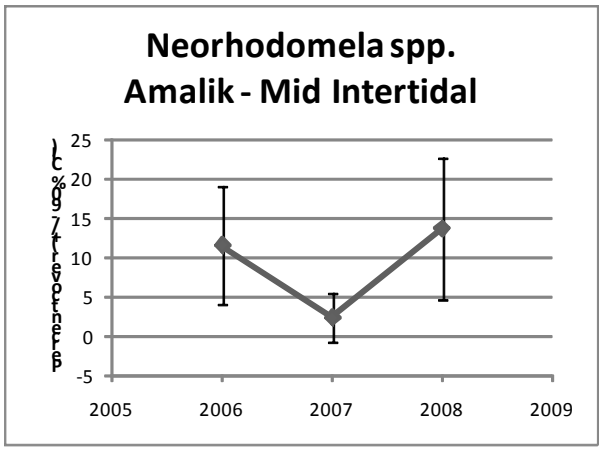

Neorhodomela spp.
Kaflia - Lower Intertidal
6
5
4
3
2
1
0
2005
2006
2007
2008
2009

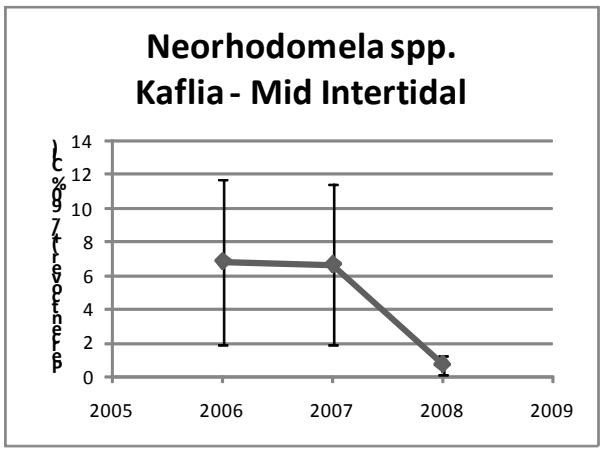

Neorhodomela spp.
Kinak - Lower Intertidal
50
40
30
20
10
0
-10
2005
2006
2007
2008
2009

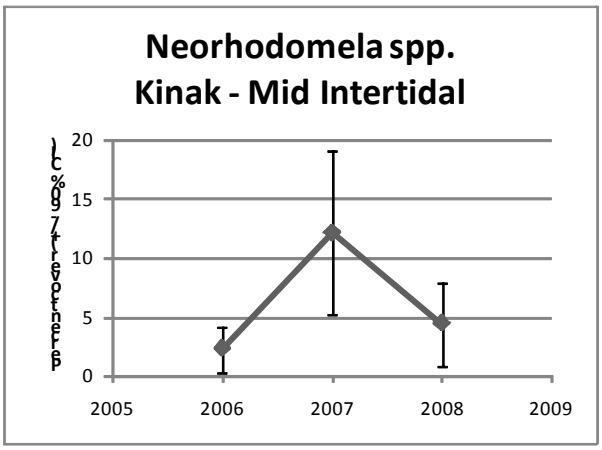

Neorhodomela spp.
Kukak - Lower Intertidal
30
25
20
15
10
5
0
2005
2006
2007
2008
2009

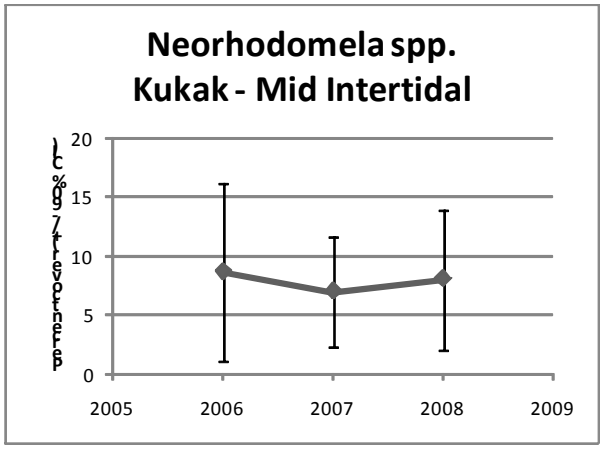

Neorhodomela spp.
KATM - Lower Intertidal
25
20
15
10
5
0
2005
2006
2007
2008
2009

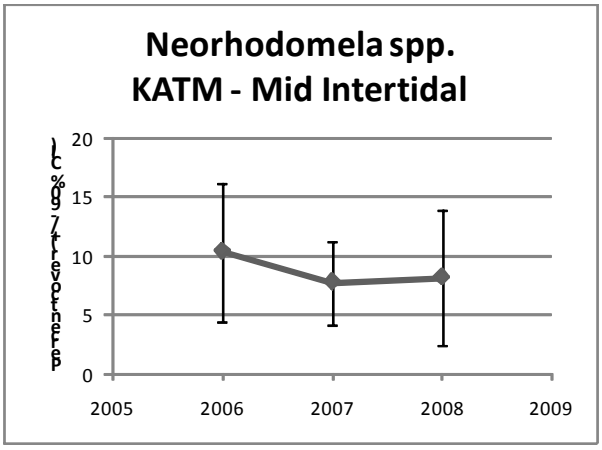

Neorhodomela spp.
Takli - Mid Intertidal
40
35
30
25
20
15
10
5
0
2005
2006
2007
2008
2009


Neorhodomela spp.
Amalik - Mid Intertidal
25
20
15
10
5
0
-5
2005
2006
2007
2008
2009


Neorhodomela spp.
Kaflia - Mid Intertidal
14
12
10
8
6
4
2
0
2005
2006
2007
2008
2009


Neorhodomela spp.
Kinak - Mid Intertidal
20
15
10
5
0
2005
2006
2007
2008
2009


Neorhodomela spp.
Kukak - Mid Intertidal
20
15
10
5
0
2005
2006
2007
2008
2009


Neorhodomela spp.
KATM - Mid Intertidal
20
15
10
5
0
2005
2006
2007
2008
2009

Appendix C Temperature Data – KATM & KEFJ

INTRODUCTION

Temperature is often a key determinant of the distribution and abundance of nearshore species and especially intertidal invertebrates and algae. Temperatures contribute substantially in determining the geographic ranges of various species. Intertidal species are particularly influenced by temperature as they are exposed to air during lower tides, and are therefore exposed to a wide range of temperatures. Both extreme high and low temperatures can cause large die offs of intertidal organisms. In addition, future changes in temperature are anticipated, and warming in particular has been shown to be correlated with changing species composition and relative abundance in the intertidal (Barry et al. 1995, Sagarin et al. 1999). Water temperature is also a important to other nearshore organisms and can serve as an important correlate of other water quality measures (especially nitrogen content) that influences nearshore primary production. In this section, we report temperatures measured in the intertidal zone (0.5 m MLLW) at rocky intertidal sites.

METHODS

Hobo temperature loggers were deployed at 0.5m MLLW at five intertidal sites at KATM in summer 2006. Instruments were recovered from Takli Island and Kinak Bay in 2007 while instruments placed at Kukak Bay, Kaflia Bay, and Amalik Bay were lost. In 2007, we deployed new instruments at each of the six rocky sites in KATM and five sites in KEFJ. In summer 2008, we retrieved instruments from all sites but Kukak Bay in KATM, and all but Aialik and Nuka Bays in KEFJ. The instruments recorded temperature at one hour intervals.

We present mean, minimum, and maximum temperatures observed at each site. We also present water temperatures (temperatures observed when tidal levels are 1.5 m or greater above MLLW).

RESULTS

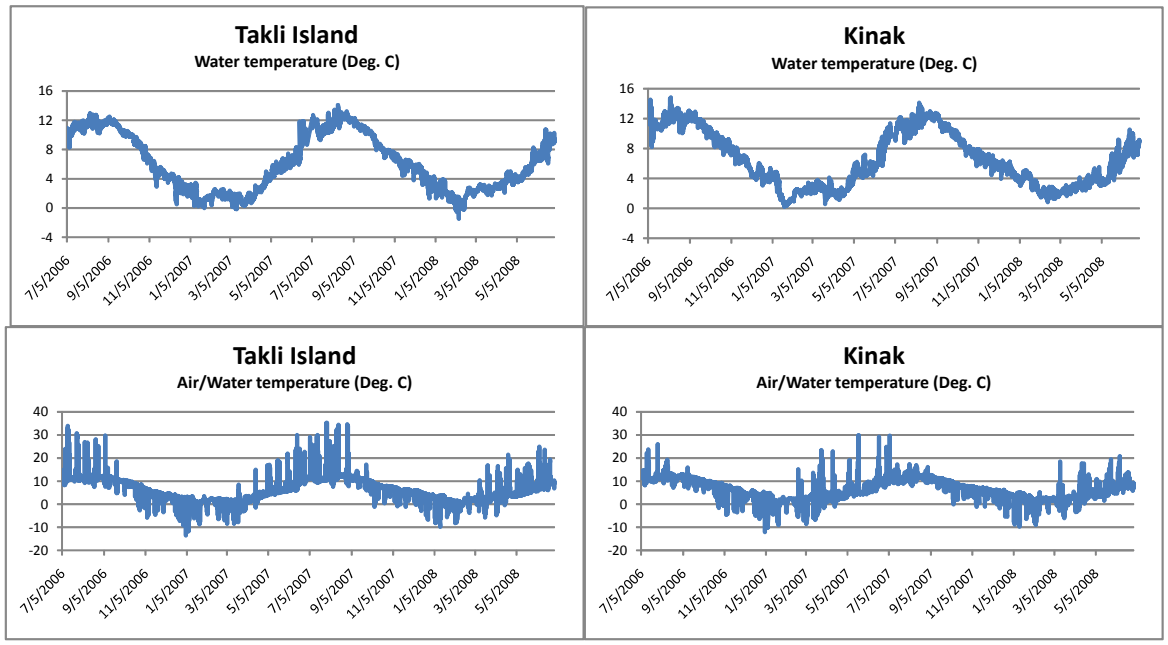
Mean, minimum, and maximum temperatures for each site are given in table x.1. There was a wide range of temperatures observed at all sites, with the maximum yearly range of over 45° C (from less than -13° C to greater than 33° C). Mean, maximum, and minimum air/water temperatures differed among sites, with both the coldest and warmest temperatures being recorded at Takli Island. Water temperatures were far less variable. However there were still notable differences among sites. Mean temperatures were lowest at Ninagiak Island in KATM and highest at McCarty Fjord in KEFJ.

Two years of data were available from Takli Island and Kinak Bay in KATM (Figure x.1). Seasonal patterns of temperature were similar at both sites with highest temperatures occurring in August and lowest in December through February. At both sites, mean air/water and water temperatures were higher in period from July 2007 through June 2008 than in the previous year. The lower mean temperature from July 2006 through June 2007 was primarily due to an extended cold spell that occurred at both sites from December 2006 through March 2007.

Mean, minimum, and maximum yearly air/water and water temperature (degrees C) at 0.5 M MLLW at rocky intertidal sites in KATM and KEFJ.

				Air/Water				**Water**	
Park	**Site**	**Interval**	**Mean**	**Min**	**Max**		**Mean**	**Min**	**Max**
KATM	Takli	July 2006 - June 2007	5.86	-13.50	33.97		5.93	-0.17	12.97
		July 2007 - July 2008	6.38	-9.78	35.26		6.34	-1.47	14.09
	Kinak	July 2006 - June 2007	6.24	-12.05	29.97		6.49	0.22	14.84
		July 2007 - July 2008	6.37	-9.71	29.64		6.57	0.21	14.12
	Amalik	July 2007 - July 2008	6.44	-10.33	28.07		6.48	-0.73	15.05
	Kaflia	July 2007 - July 2008	6.20	-11.04	31.28		6.17	-6.87	15.68
	Ninagiak	July 2007 - July 2008	5.42	-16.57	30.37		5.62	-8.23	14.86
KEFJ	Harris	July 2007 - July 2008	6.47	-6.83	34.26		6.53	-6.55	13.45
	McCarty	July 2007 - July 2008	7.50	-6.01	19.91		7.54	2.26	15.44
	Nuka Pass	July 2007 - July 2008	7.29	-8.76	30.90		7.29	1.86	15.77

Temperature at Takli Island and Kinak Bay from July 2006 through July 2008. Air/Water temperature is the temperature recorded at 0.5 m MLLW and represents air or water temperature depending on tidal level. Water temperatures are those recorded when tidal levels were 1.5 m or greater.



DICUSSION

At all sites, extreme daily variation in temperature occurred during spring tides when the 0.5m tidal elevation was exposed to air for several hours. In spring and summer (April through August), when air temperatures generally exceed water temperatures, deviations during spring tides were generally positive. In fall and winter (October through February), when air temperatures were generally lower than water temperatures, deviations were generally negative. There were considerable differences between sites with respect to the ranges in temperature observed. We suspect that differences were due to a combination of local climatic conditions, general orientation of each sites, as well as the specific placement of the instrument at a site (e.g. fully exposed to direct sunlight vs. in a crevice or shaded by nearby rocks) that can greatly influence air temperature. Variation due to specific placements of instruments is likely substantial, and as a result, the recorded minimum and maximum air/water temperatures may not be indicative of conditions at the site in general. However, since the placement of instruments is fixed at each location, recorded air/water temperatures allow us to evaluate annual differences at a particular site and relative annual difference at all sites within the region.

Water temperatures are not as susceptible to differences due to orientation and placement of instruments and generally reflect local oceanographic conditions at each site. The colder temperatures observed at Ninagiak for example suggest that this site is subject to a different (more oceanic) oceanographic regime than other sites.

REFERENCES

Barry J. P., Baxter C. H., Sagarin R. D., and Gilman S. E. 1995. Climate-related, long-term faunal changes in a California rocky intertidal community. Science 267:672-675.

Sagarin R. D., Barry J. P., Gilman S. E., and Baxter C. H. 1999. Climate related changes in an intertidal community over short and long time scales. Ecological Monographs 69:465-490.

Appendix D Marine Bird Summer Survey Data from KEFJ

Table D-1. Nearshore statistics for KEFJ 2008. Species highlighted in yellow have been identified as species that will be monitored for trend analysis over time.

Species	# of groups observed	Min	Max	Sum	Average density (#/km^2)	SE
Bald eagle (*Haliaeetus leucocephalus*)	34	1	2	38	1.00	0.21
Barrow's goldeneye (*Bucephala islandica*)	7	1	23	65	1.61	0.96
Black-billed magpie (*Pica pica*)	1	1	1	1	0.03	0.03
Black-legged kittiwake (*Rissa tridactyla*)	41	1	110	845	28.13	23.06
Black oystercatcher (*Haematopus bachmani*)	18	1	2	24	0.52	0.17
Black scoter (*Melanitta nigra*)	1	1	1	1	0.03	0.03
Common loon (*Gavia immer*)	3	1	2	5	0.10	0.06
Common merganser (*Mergus merganser*)	8	2	16	41	1.85	1.09
Common murre (*Uria aalge*)	67	1	80	709	22.01	15.43
Crested auklet (*Aethia cristatella*)	3	1	8	11	0.24	0.24
Double-crested cormorant (*Phalacrocorax auritus*)	20	1	10	43	1.05	0.39
Glaucous-winged gull (*Larus glaucescens*)	321	1	240	4671	116.61	36.65
Harlequin duck (*Histrionicus histrionicus*)	28	1	88	408	19.88	12.57
Horned puffin (*Fratercula corniculata*)	108	1	28	370	9.35	3.67
Kittlitz's murrelet (*Brachyramphus brevirostris*)	6	1	3	10	0.16	0.11
Mallard (*Anas platyrhynchos*)	2	25	33	58	1.36	1.36
Marbled murrelet (*Brachyramphus marmoratus*)	122	1	100	362	9.18	3.10
Mew gull (*Larus canus*)	12	1	18	33	0.75	0.34
Northern crow (*Corvus caurinus*)	20	1	3	25	0.67	0.22
Pelagic cormorant (*Phalacrocorax pelagicus*)	55	1	56	429	10.05	3.99
Pigeon guillemot (*Cepphus columba*)	118	1	14	207	9.96	1.23
Red-faced cormorant (*Phalacrocorax urile*)	48	1	74	234	6.18	3.57
Surf scoter (*Melanitta perspicillata*)	1	6	6	6	0.15	0.15
Tufted puffin (*Fratercula cirrhata*)	160	1	113	1156	30.89	15.84
Unid. Cormorant (*Phalacrocoracidae sp.*)	31	1	12	76	1.89	0.66
Unid. Duck (*Anatidae sp.*)	2	1	3	4	0.10	0.07
Unid. Murrelet (*Brachyramphus sp.*)	6	1	14	20	0.46	0.30
Unid. scoter (*Melanitta spp.*)	1	63	63	63	1.31	1.31
White-winged scoter (*Melanitta fusca*)	1	23	23	23	0.59	0.59

Harbor seal (*Phoca vitulina*)	60	1	21	188	4.85	1.43
Humpback whale *(Megaptera novaeangliae)*	7	1	2	8	0.18	0.09
River otter *(Lontra canadensis)*	1	1	1	1	0.03	0.03
Sea otter (adult) (*Enhydra lutris*)	50	1	8	87	2.15	0.79
Sea otter (pup) (*Enhydra lutris*)	17	1	5	27	0.69	0.31
Steller sea lion (*Eumetopias jubatus*)	19	1	126	270	7.02	4.16
Black bear *(Ursus americanus)*	2	1	2	3	0.08	0.06

Table D-2. Offshore statistics for KEFJ 2008. Species highlighted in yellow have been identified as species that will be monitored for trend analysis over time.

Species	# of groups observed	Min	Max	Sum	Average density (#/km^2)	SE
Black-legged kittiwake (*Rissa tridactyla*)	12	1	2	13	1.29	0.71
Common murre (*Uria aalge*)	1	1	1	1	0.13	0.13
Glaucous-winged gull (*Larus glaucescens*)	11	1	2	12	1.77	0.96
Horned puffin (*Fratercula corniculata*)	1	3	3	3	0.60	0.60
Kittlitz's murrelet (*Brachyramphus brevirostris*)	1	1	1	1	0.13	0.13
Marbled murrelet (*Brachyramphus marmoratus*)	25	1	6	50	8.60	2.21
Pelagic cormorant (*Phalacrocorax pelagicus*)	1	1	1	1	0.20	0.20
Pigeon guillemot (*Cepphus columba*)	8	1	2	9	1.42	0.43
Tufted puffin (*Fratercula cirrhata*)	1	3	3	3	0.60	0.60
Unid. Murrelet (*Brachyramphus sp.*)	14	1	6	28	4.32	2.17
Sea otter (adult) (*Enhydra lutris*)	8	1	2	9	1.16	0.67
Sea otter (pup) (*Enhydra lutris*)	4	1	1	4	0.51	0.34
Black bear *(Ursus americanus)*	1	1	1	1	0.07	0.07

Appendix E Black Oystercatcher – KEFJ

Table E-1. Black oystercatcher nest site numbers, nest status, number of adults, number of eggs, number of chicks and the sum of eggs and chicks per nest at KEFJ 2008. A = active nest; O = occupied nest (adult pair but no chicks or eggs found); F = failed nest, IA = inactive nest. U = unknown status or number.

Site	Length	Nest site #	Status	# Adults	# Eggs	# Chicks	Prey collected
KP B5 RI1	20 km	1-07	O	2	0	0	Y[a]
		1-08	A	2	2	0	N
		2-07	O	2	0	0	Y[a]
		2-08	O	2	0	0	N
		3-07	A	2	3	0	N
		3-08	IA	1	0	0	Y[a]
		4-07	IA	0	0	0	N
KP B5 RI2	20 km	.	.	.	.	.	.
KP B5 RI3	20 km	1-07	F	0	1	0	Y
		1-08	O	2	0	0	N
KP B5 RI4	20 km	1-07	A	2	3	0	Y
		1-08	U	1	U	U	N
KP B5 RI5	20 km	1-07	IA	1	0	0	N
		1-08	A	1	3	0	N
		2-08	A	2	1	0	N

[a] Prey remains from prior year

Table E-2. Black oystercatcher nest density and numbers of eggs and chicks per active nest summarized by transect, KEFJ 2008. Nests with unknown chick numbers were not used in chick per nest calculations. Means include nest density and number of eggs and chicks per nest and are inclusive of all transects.

Site	Active or occupied nest density (#/km)	# eggs	Eggs/nest	# chicks	Chicks/nest	Eggs + Chicks/ nest
KP B5 RI1	0.25	5	1.00	0	0.00	1.00
KP B5 RI2	0.00	0	0.00	0	0.00	0.00
KP B5 RI3	0.05	0	0.00	0	0.00	0.00
KP B5 RI4	0.05	3	3.00	0	0.00	3.00
KP B5 RI5	0.10	4	2.00	0	0.00	2.00
Means (#/km)	**0.09**		**1.20**		**0.00**	**1.20**
Se	**0.04**		**0.43**		**0.00**	**0.43**

Appendix F Sea Otter Diet – KEFJ

Analysis

For each site where foraging data were collected, we calculated (1) prey composition as the proportion of dives that resulted in the recovery of at least one of nine different prey types (clam, mussel, chiton, crab, octopus, snail, sea star, urchin, or other,); (2) mean number of prey items captured per dive; (3) mean size of prey captured per dive; and (4) success rate. We report summary statistics (mean and sd where appropriate) for the latter three variables, on a per bout basis.

Results

In KEFJ during 2008, we observed 56 sea otter foraging bouts consisting of 376 dives. The mean number of dives per bout was 5.8 (sd 5). Sea otters successfully recovered prey on 95% of these dives. Success rates varied by prey item, for example otters were successful 100% of the time when they were feeding on urchins, and 99% and 83% when feeding on mussels and clams, respectively. There was insufficient data to calculate prey specific success rates for other prey types. Mean dive time for successful dives was 68.7 seconds (s) and mean surface interval was 62.1s. Mean dive and surface times varied by prey type (Figures F-1 and F-2).

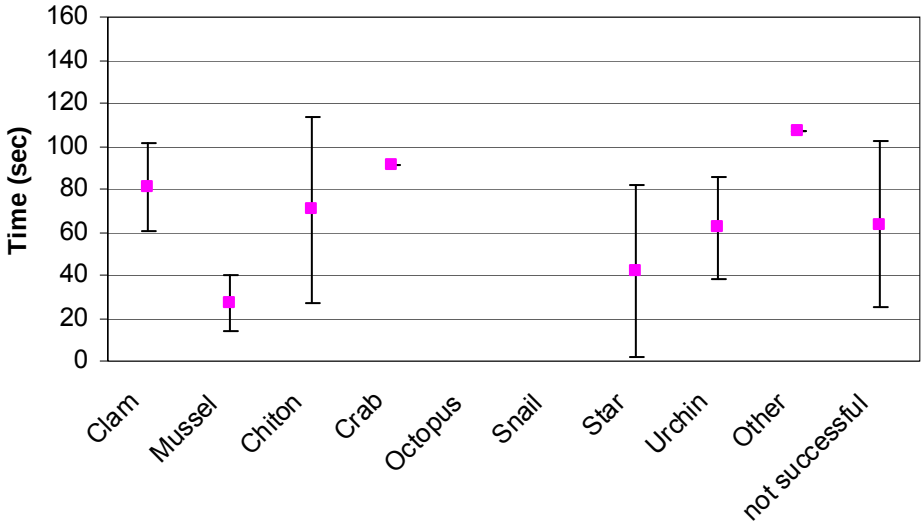


Figure F-1. Dive time in seconds for successful feeding dives by prey type and unsuccessful dives.

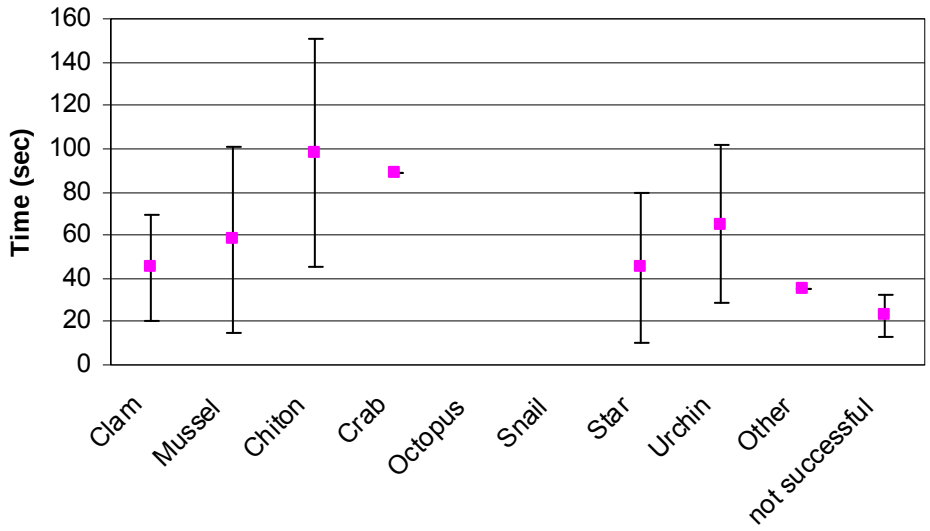


Figure F-2. Duration of surface interval in seconds for successful feeding dives by prey type and unsuccessful dives.

Prey Composition

Species composition of sea otter diet in KEFJ in 2008 is presented in Figure F-3. We identified more than 10 different prey items. Overall diet was composed of 78% mussel, 13% clam, 5% urchin, <2% chiton, <2% sea star, and <1% crab and other prey. All proportions are based on identified prey items only.

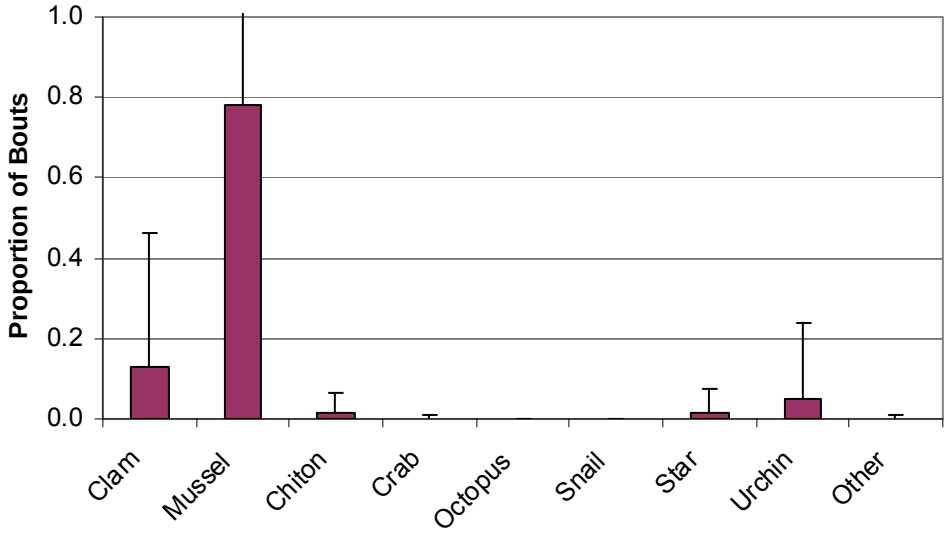


Figure F-3. Prey composition of sea otter foraging dives in Kenai Fjords National Park during 2008. Sea otter ages and sexes are combined.

Prey Number and Size

On dives when specific prey types were recovered, we computed the mean number of individuals of that prey type and the sizes of those individuals (Figures F-3 and F-4). On average, sea otters recovered 3.7 prey items per successful dive. Otters retrieved an average (sd) of 1.6 clams (0.8), 1.1 chitons (0.2), or 16.6 mussels (12.5) per dive. The visually estimated mean size (sd) of clams recovered was 53.1mm (13.9), chitons: 80.6mm (53.1), mussels: 24.2mm (6.4), sea stars: 130mm (22.5), and urchins: 39.7mm (3.6).

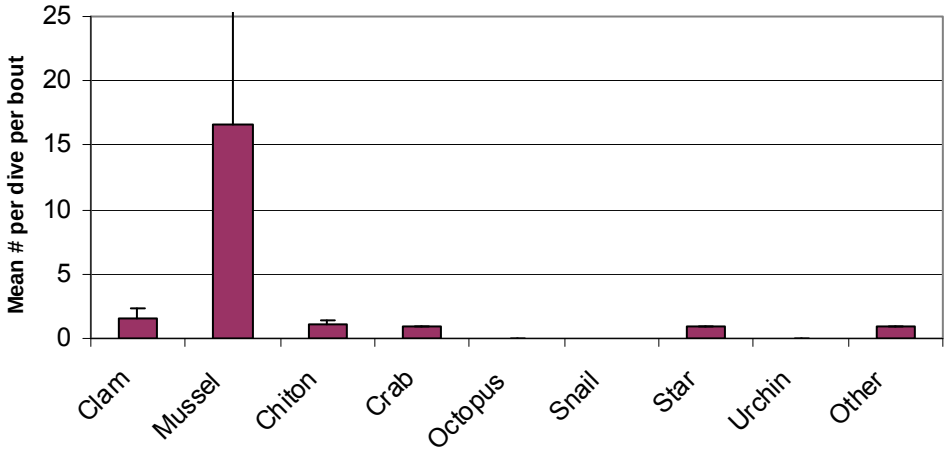


Figure F-3. Mean number per dive and standard deviations of the primary prey items recovered by sea otters during observations of foraging behavior in Kenai Fjords National Park in 2008.

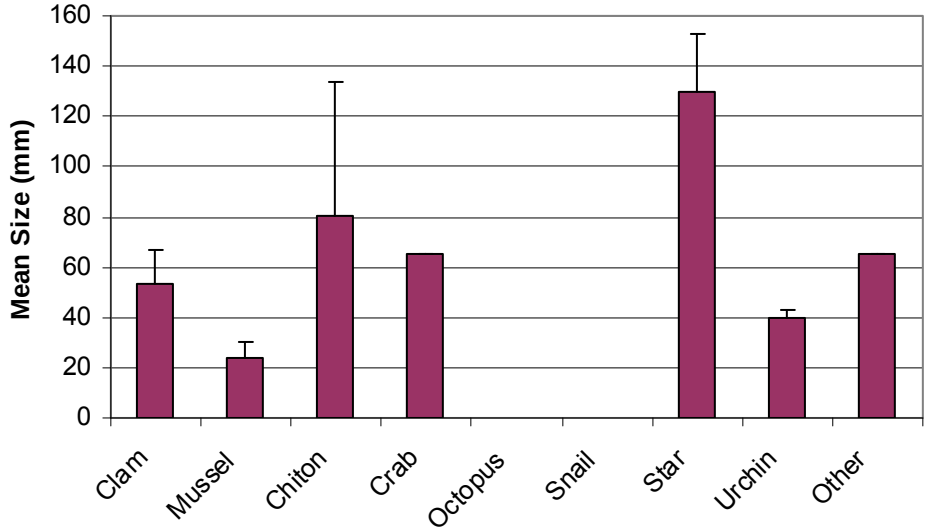


Figure F-4. Mean size and standard deviations of the primary prey items recovered by sea otters during observations of foraging behavior in Kenai Fjords National Park in 2008.

Appendix G Sea otter Age-at-death

For age at death data, a 40% change in the proportion of any age class has been established as the ecologically important level to detect. Forty-four carcasses were found along beaches and haulouts in KATM in 2007. Only one carcass was found in KEFJ in 2007.

Figure G 1. Age classes of sea otter carcasses found dead on beaches and haulout sites in 2007, KATM

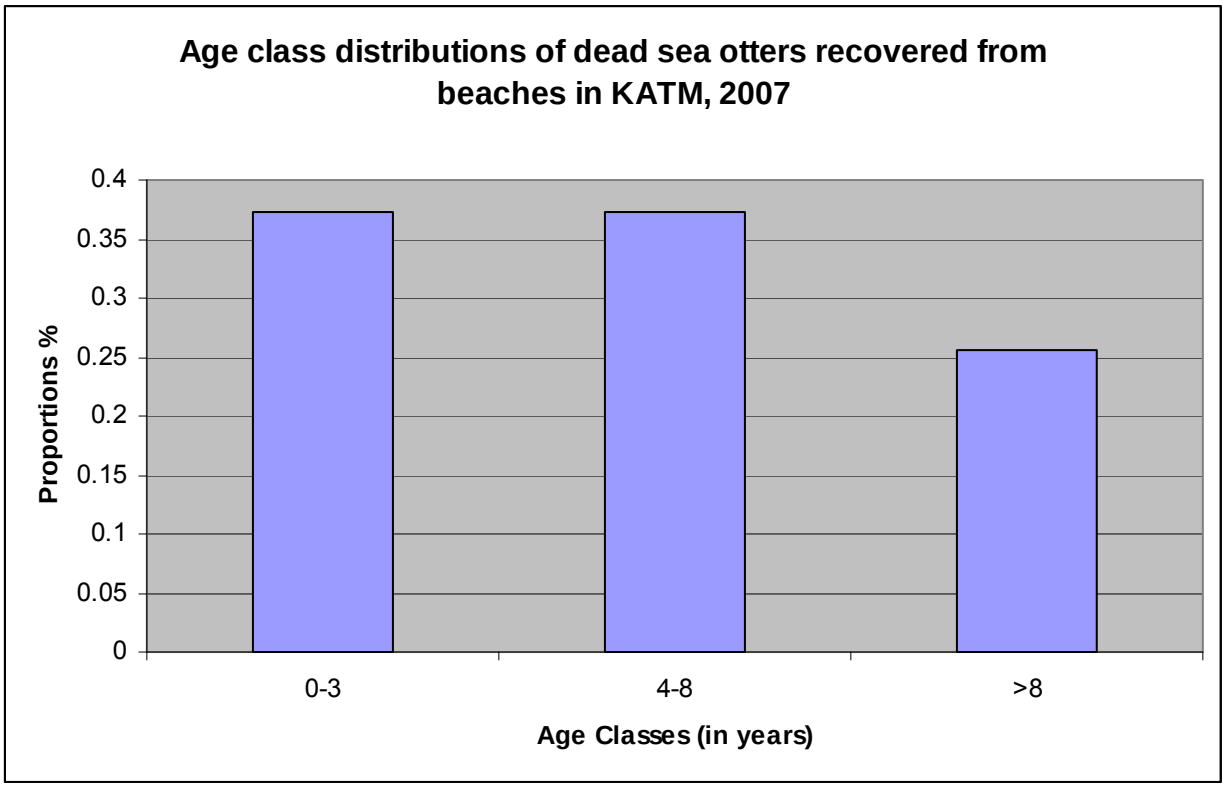


Table G-1. Age estimate results from sea otter carcasses collected in 2007 in KATM and KEFJ. Results are from Matson's Laboratory (Milltown, MT). X indicates a damaged tooth and no data is available. APD refers to carcasses collected along the KATM coast while KPD refers to carcasses collected along the KEFJ coast.

Date	Tooth ID	Age	Age Range	Tooth ID	Age	Age Range
Jun-Jul 2007	APD-0701	5	5	APD-0724	6	6-7
Jun-Jul 2007	APD-0702	1	1	APD-0725	3	3-4
Jun-Jul 2007	APD-0703	5	5	APD-0726	11	10-13
Jun-Jul 2007	APD-0704	0	.	APD-0727	1	1-2
Jun-Jul 2007	APD-0705	13	13	APD-0728	6	.
Jun-Jul 2007	APD-0706	1	1	APD-0729	X	X
Jun-Jul 2007	APD-0707	3	3	APD-0730	0	.
Jun-Jul 2007	APD-0708	7	7-8	APD-0731	2	.
Jun-Jul 2007	APD-0709	12	12	APD-0732	8	7-9
Jun-Jul 2007	APD-0710	2	2	APD-0733	11	10-12
Jun-Jul 2007	APD-0711	1	1	APD-0734	16	16-17
Jun-Jul 2007	APD-0712	4	4-5	APD-0735	10	9-11
Jun-Jul 2007	APD-0713	1	.	APD-0736	10	10-11
Jun-Jul 2007	APD-0714	16	15-17	APD-0737	7	7-8
Jun-Jul 2007	APD-0715	8	8-9	APD-0738	6	6-7
Jun-Jul 2007	APD-0716	6	6-7	APD-0739	0	.
Jun-Jul 2007	APD-0717	8	7-9	APD-0740	3	3-4
Jun-Jul 2007	APD-0718	7	7-8	APD-0741	0	.
Jun-Jul 2007	APD-0719	9	8-10	APD-0742	0	.
Jun-Jul 2007	APD-0720	0	0-1	APD-0743	6	6-7
Jun-Jul 2007	APD-0721	16	15-17	APD-0744	11	12-14
Jun-Jul 2007	APD-0722	8	8-9	KPD-0701	10	10-11
Jun-Jul 2007	APD-0723	7	6-8			

Appendix H Monitoring Changes in the Distribution and Abundance of Canopy-forming Subtidal Kelps

Kelps are large brown algae of the order Laminariales. They are generally associated with rocky habitats and extend from the lower intertidal zone to depths on the order of tens of meters. In KATM and KEFJ, the predominant kelps include *Alaria marginata* which occurs in the lower intertidal and very shallow subtidal, a variety of lower growing (generally less than several meters in height) kelps that occur in the subtidal zone (e.g. *Agarum clatharatum*, various *Laminaria* species), and two larger canopy forming species (the bull kelp *Nereocystis luetkeana*, and the dragon kelp *Alaria fistulosa*). Kelps are important nearshore resources as they are a major source of primary production in the nearshore and provide important habitat for a variety of invertebrates and fishes. As a result, kelps have been identified as a Vital Sign to be monitored as part of the SWAN nearshore monitoring program.

Monitoring of kelps in the SWAN program includes monitoring of inter-annual variation in intertidal species (and especially *Alaria marginata*, see section on intertidal algae and invertebrates on rocky shores), and infrequent, broad-scale monitoring of canopy forming kelps via shorezone mapping (Harper and Morris 2004). In this section we focus on monitoring of inter-annual variation in canopy forming kelps and evaluate methods for determining the relative abundance of canopy forming kelps.

Methods

There are several widely accepted methods for monitoring the abundance of canopy forming kelps. These can generally be broken in five broad categories: imagery from satellites (e.g. Stekoll et al. 2006), imagery from fixed-wing aircraft or helicopters (e.g. Tegner et al.1996, Harper and Morris 2004), sonar surveys (e.g. Zabloudil et al. 1991, Hass and Bartsch 2008), underwater video imaging (e.g. Harper and Berry 2001), and diver surveys (e.g. Dayton et al. 1984). Each method can provide has its strengths and weaknesses (summarized in Table x).

Table H-1. Strengths and weaknesses of various methods for the monitoring of canopy forming kelps.

Method	Strengths	Weaknesses
Satellite imagery	Can provide broad spatial coverage with a single of few images	Costly to achieve images in some cases
	Can provide an estimate of biomass	Costly to interpret
		Image quality dependent on cloud cover, sun glint, turbidity
		Canopy area detected depends greatly on tidal stage, turbidity of water, and currents
		Can provide little spatial

		resolution
Fixed-wing or helicopter imagery	Can provide cost effective assessments of canopy cover	Image quality dependent on cloud cover, sun glint, turbidity
		Canopy area detected depends greatly on tidal stage, turbidity of water, and currents
		Logistics in remote areas may be difficult
		Precise geo-referencing can be difficult
		Difficult to distinguish species
Sonar surveys	Can provide precise estimates of abundance	Requires specialized (often expensive) equipment and vessel support
	Can evaluate presence of species when not on the surface.	Electronic equipment difficult to maintain in adverse weather
	Accuracy and precision are relatively independent of cloud cover, sun glint, turbidity, tides, and currents	Costly to interpret
Underwater video surveys	Can provide precise estimates of species composition and abundance	Requires specialized (often expensive) equipment and vessel support
	Can evaluate presence of species when not on the surface.	Electronic equipment difficult to maintain in adverse weather
	Accuracy and precision are relatively independent of cloud cover, sun glint, tides, and currents	Difficult to navigate and deploy cameras in dense kelp beds
Diver surveys	Can provide precise estimates of species composition and abundance	Requires specialized (often expensive) equipment, training of personnel, and logistical support (especially in remote areas)
	Can evaluate presence of species when not on the surface.	Provides information at a limited geographic scale
	Accuracy and precision are relatively independent of cloud cover, sun glint, tides, and currents	
	Can provide ancillary	

	information on size, reproductive state, biomass	

While any of these methods can be used to estimate the relative (or in some cases absolute) abundance of kelp, conducting surveys in KATM and KEFJ presents additional hurdles. These include:

1) Frequent cloud cover that limits times when satellite or aerial imagery can be obtained.
2) An extreme tidal range and strong currents that can greatly affect the amount of kelp visible at the surface.
3) High turbidity that can limit diver opportunities and can limit penetration of surface waters with satellite or aerial imagery.
4) The seasonal nature of canopy forming kelps (most are essentially annuals and canopy formation is highly seasonal) that requires multiple surveys per year or (at the least) that surveys be done in a restricted time window during summer when abundances are highest and canopies largest.
5) The often poor weather and remote nature of these sites makes it expensive to conduct aerial surveys or dedicated vessel based surveys.
6) Weather and sea conditions often make surveying with electronic equipment (sonar or underwater video) difficult.

Over the past several years we have evaluated these various methods for use in routine monitoring of subtidal canopy-forming kelps at KATM and KEFJ. Evaluations ranged from exploring method limitations and costs to conducting preliminary field evaluations. The following is a summary of our evaluations.

Results and Discussion

Several forms of satellite imagery have been evaluated as a tool in estimating kelp abundance. Spot and Landsat imagery are costly to obtain and coastlines are often obscured by clouds. In addition, resolution is poor (20 m or greater) and estimates of canopy areas can be very dependent on tidal stage and currents. As a result, we will not pursue use of these types of imagery further. Some Ikonos imagery is currently available for KEFJ. Ikonos images offer better resolution, but are plagued by problems with cloud cover and estimates of canopy cover are subject to biases associated with tide stage and currents. This imagery is being obtained by SWAN for purposes other than monitoring of kelp canopies, and we will continue to evaluate images as they become available.

Video surveys of entire coastlines of KEFJ and KATM were conducted in 2001 and 2002 (Harper and Morris 2004). These surveys provide the estimate of the broad-scale distribution of kelp canopies along the coast, but only provide estimates of presence or absence of kelp along particular coastline segments. They do not provide information of sizes of individual kelp canopies. These surveys are very costly and are scheduled to be conducted only at intervals of once a decade or longer. We have explored obtaining imagery of a number of kelp beds along the KEFJ and KATM coast from a fixed wing aircraft, but because of the remote nature of our sites, these have proved too costly.

We have explored mapping kelp canopy areas using a GPS in a small skiff and by counting individual plants visible at the surface. However, these methods have proved inaccurate due to dependence of measured canopy area on tides and currents.

We have also explored using an underwater video and digital fathometer to assess kelp density in several selected kelp beds. These show some promise, but currently we do not have the appropriate fathometer equipment to obtain good sonar images. Systems using sonar and video equipment linked to GPS navigation devices are currently available commercially and have been used to successfully map kelp elsewhere. We continue to assess cost, availability, and feasibility of using a combination of sonar and video to estimate kelp abundance.

Diver surveys can also be used to estimate abundance, but require extensive dive time to obtain reasonable estimates. Given the logistics and time necessary to conduct diver surveys, these do not appear feasible.

In summary, we currently have no cost effective means of estimating canopy area or kelp density in kelp beds at KATM and KEFJ. However, we will continue to pursue use of Ikonos imagery and sonar/video survey methods.

References

Anderson,R.J., A Rand, MD Rothman, A Share, and JJ Bolton. 2007. Mapping and quantifying the South African kelp resource. African Journal of Marine Science 29: 369–378.

Dayton, P.K., V. Currie, T. Gerrodette, B. Keller, R. Rosenthal, and D. Ven Tresca. 1984. Patch Dynamics and Stability of Some California Kelp Communities. Ecological Monographs 54: 254-289

Harper, J.R. and H.D. Berry. 2001. Examples of application of ShoreZone mapping data from the state of Washington. Proceedings of the 2001 Puget Sound Research Conference, Seattle, Washington [Abstract].

Harper, J. R., and M.C. Morris. 2004. ShoreZone mapping protocol for the Gulf of Alaska (ver 1.0). CORI Project: 02-33 EVOS Project: 030641. Report to the Exxon Valdez Trustee Council, Anchorage, AK

Hass, H. C., Bartsch, I. 2008. Kelp mapping and seafloor classification using acoustic means: a geo-bio approach at the rocky coast off Helgoland (SE North Sea), 33rd International Geological Congress, Oslo, Norway, August 6-14, 2008.

Stekoll, M.S., L.E. Deysher, and M. Hess. 2006. A remote sensing approach to estimating harvestable kelp biomass. J. Appl. Phycol. 18:323-334.

Tegner, M.J., P.K. Dayton, P.B. Edwards, and K.L. Riser. 1996. Is there evidence for long-term climatic change in Southern California kelp forests? CalCOFl Rep., Vol. 37.

Zabloudil, K., J. Reitzel, S. Schroeter, J. Dixon, T. Dean, T. Norall. 1991. Sonar mapping of giant kelp density and distribution. Pages 391-406. In Coastal Zone '91. Coastal Zone Society, Washington DC.

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

NPS 953/100437, September 2009

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
1201 Oakridge Drive, Suite 150
Fort Collins, CO 80525

www.nature.nps.gov