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Hydrocarbons and Fisheries Habitat in Berners Bay, Alaska: Baseline Monitoring Associated with the Kensington Gold Mine

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Baseline Monitoring Associated with the Kensington Gold Mine

by

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ABSTRACT

To establish a baseline of information for long-term monitoring associated with development of the Kensington Gold Mine near Juneau, Alaska, we measured hydrocarbon concentrations in seawater, sediment, and blue mussel (*Mytilus trossulus*) tissue near proposed marine terminal facilities in Berners Bay and at a control site outside of Berners Bay (Bridget Cove) in 2004. In addition, fish assemblages in eelgrass (*Zostera marina*) and understory kelp (e.g., *Laminaria* spp.) habitats were sampled with a beach seine at each site. Areas of eelgrass beds and shoreline extent of kelp beds were mapped with global positioning system technology. Hydrocarbon concentrations were very low or not detectable in most of the samples; only concentrations of pristane, a biogenic compound, were elevated. Twelve seine hauls yielded 9,653 fish comprising 24 species; 86% of the total catch was in Bridget Cove. Total fish catch was greater in eelgrass (6,993 fish) than in kelp (2,660 fish). Based on percent of total catch, the most abundant species were juvenile chum salmon (*Oncorhynchus keta*; 87%), juvenile coho salmon (*O. kisutch*; 6%), crescent gunnel (*Pholis laeta*; 3%), and Dolly Varden (*Salvelinus malma*; 1%). Other species captured that are important in sport or commercial fisheries were juvenile pink salmon (*O. gorbuscha*), Pacific herring (*Clupea pallasii*), and cutthroat trout (*O. clarkii*). The only eelgrass beds in Berners Bay are in Echo Cove−total area of eelgrass mapped along the eastern shore of Echo Cove was 0.81 ha. Total area of eelgrass mapped in Bridget Cove was 7.08 ha. Our initial findings after one year of baseline studies identify Berners Bay as a pristine environment with respect to hydrocarbons, and provides quality habitat for juvenile fishes of many species. At least one more year of baseline sampling is planned in 2005.

CONTENTS

INTRODUCTION

Several projects associated with development of the Kensington Gold Mine have been proposed in Berners Bay, Alaska. Daily ferry service would transport workers from marine terminals to be built at Cascade Point and Slate Creek Cove across Berners Bay (Fig. 1). Construction of these terminals and other infrastructure (e.g., access roads) could directly affect as many as 80 ha within the Berners Bay watershed (U.S. Department of Agriculture 2004). Degradation of marine waters could occur from fuel spills, chronic pollution from vessels, and parking lot runoff near the terminal facilities.

Among contaminants that could enter the watershed from boats and parking lot runoff, polynuclear aromatic hydrocarbons (PAHs) are some of the most toxic to aquatic life and the most persistent. Released into the environment through either combustion or weathering of oil products, some PAHs are known carcinogens and mutagens. Particularly sensitive to these large molecular weight hydrocarbons are eggs and larvae of fish such as Pacific herring (*Clupea pallasii*) and pink salmon (*Oncorhynchus gorbuscha*); weathered PAHs at concentrations less than or equal to 1.0 ppb may damage herring larvae and pink salmon embryos (Carls et al. 1999; Heintz et al. 1999). Thus, potential oil contamination of intertidal spawning areas for herring, salmon (*Oncorhynchus* spp.), eulachon (*Thaleichthys pacificus*), and capelin (*Mallotus villosus*) is a concern.

Sensitive habitats in Berners Bay that could be affected by physical disturbance or chronic PAH exposure include eelgrass (*Zostera marina*) and understory kelps (e.g., *Laminaria* spp.); these habitats support high fish diversity and abundance and appear to be especially important juvenile fish habitat (Johnson et al. 2003). Shoreline development within Berners Bay, including construction of the terminal facilities and increased wave disturbance from boat traffic, may contribute to changes in eelgrass and kelp communities (Lee et al. 2004).

Commercially important fish species and forage fish, marine mammals, and seabirds use Berners Bay as a feeding, rearing, or spawning area. Coho salmon (*O. kisutch*), chum salmon (*O. keta*), and pink salmon spawn in the Berners, Lace, and Antler Rivers (Fig. 1), and spend at least some time rearing in nearshore waters of Berners Bay before migrating out to sea. Berners Bay remains the major spawning ground for the depressed Lynn Canal Pacific herring stock. Herring have spawned in Berners Bay in 21 of the past 22 years and near Cascade Point in at least 8 of the past 22 years (M. Pritchett, Alaska Department of Fish and Game, 802 3rd St. Douglas, AK 99824. Pers. commun., November 2004). Each spring, spawning aggregations of eulachon and capelin attract large numbers of Steller sea lions *(Eumetopias jubatus*), harbor seals *(Phoca vitulina),* and bald eagles *(Haliaeetus leucocephalus*) to Berners Bay to pulse feed on this energy-rich food fish (Marston et al. 2002; Sigler et al. 2004). Slate Creek Cove, along the western shore of the bay (Fig. 1), also appears to be an important overwintering area for juvenile eulachon, capelin, and herring (J. J. Vollenweider, Auke Bay Laboratory, NMFS, 11305 Glacier Hwy., Juneau, AK 99801. Pers. commun., January 2005).

Objectives of this study were to collect baseline information on hydrocarbon concentrations, fish use, and size of marine habitats near the proposed terminal facilities in Berners Bay and at a control site outside of Berners Bay (Bridget Cove; Fig. 1) in 2004. Specifically, we measured hydrocarbon concentrations in seawater, sediment, and blue mussel (*Mytilus trossulus*) tissue. In addition, fish assemblages were sampled with a beach seine, and eelgrass and kelp habitats were mapped with global positioning system (GPS) technology. Sampling will be repeated in summer 2005, providing 2 years of baseline data. Periodic sampling of the same sites using the same protocols will be done during the construction, operation, and post-operation phase of the mine. The marine terminals will likely be in service beyond the proposed life of the mine (10 years; U.S. Department of Agriculture 2004), and thus, we anticipate a long-term monitoring project. This study should aid in the permitting process and in evaluating the long-term health of Berners Bay over the course of mine-related development.

STUDY AREA

Berners Bay is located approximately 65 km northwest of Juneau, Alaska. The mouth of the bay is bounded on the south by Point Bridget and on the north by Point St. Mary, and for purposes of this study includes Echo Cove (Fig. 1). Berners Bay is fed by two glacial rivers, the Antler and the Lace, and a clearwater river, the Berners. Other major streams flowing into the bay are Cowee Creek, Sawmill Creek, and Slate Creek. The control site at Bridget Cove is a small, relatively pristine cove located about 5 km south of Point Bridget (Fig. 1). Bridget Cove is bounded on the south by the Bridget Creek estuary and on the north by Mab Island. Berners Bay and Bridget Cove are popular recreation areas, and Echo Cove has a small boat ramp for public access. Earlier descriptions of the kelp communities near Cascade Point are provided in Calvin (1977) and Stekoll (1999). Some limited studies have also been done on eelgrass in Echo Cove and Bridget Cove over the last few years[1].

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[1]P. M. Harris, unpubl. data. Auke Bay Laboratory, Alaska Fisheries Science Center, 11305 Glacier Hwy., Juneau, AK 99801.

MATERIALS AND METHODS

Hydrocarbon Sampling

We utilized two sampling methods to determine baseline hydrocarbon concentrations in Berners Bay: passive sampling for a month using polyethylene membrane devices (PEMDs), and direct sampling of seawater, sediment, and blue mussel tissue. Passive sampling with PEMDs is more sensitive than direct sampling of seawater because PEMDs provide a concentrated time-integrated measure of freely dissolved PAHs in seawater that cannot be replicated with conventional sampling procedures. These devices are effective in sequestering the two- to five-ring PAHs, a molecular size range likely to be bioavailable to aquatic organisms. Auke Bay Laboratory (ABL) has developed and extensively tested PEMDs as an alternative to conventional semi-permeable membrane device passive samplers (Carls et al. 2004b).

A PEMD consists of a low density polyethylene strip stretched between aluminum posts inside an aluminum cylinder which is capped with perforated aluminum plating that allows unhindered movement of water through the device. Following ABL protocol, each polyethylene strip was pre-cleaned of hydrocarbons by sonication in pentane before it was inserted into the aluminum cylinder which had been rinsed with dichloromethane (Carls et al. 2004b).

Biologically available hydrocarbon concentrations in seawater were sampled at nine sites in Berners Bay and Bridget Cove (Fig. 1) with PEMDs deployed for approximately 30 days. Deployment of PEMDs occurred twice—in April and in July 2004. Positions of devices were recorded with GPS technology (Table 1), and sites were documented with digital photographs. Two PEMDs were deployed at each site, usually within several hundred meters of each other. Devices were attached to bedrock with anchor bolts at approximately the 1.8 m tide height. At this tide height, devices sampled PAHs in air for several hours on most days during low tide as well as PAHs in seawater during higher tides. Device visibility was minimized by placing them between boulders or in bedrock crevices to reduce the likelihood of tampering. Two lab blanks and two field blanks (PEMDs) provided quality controls at each deployment.

Seawater, sediment, and mussel tissue were also sampled for hydrocarbons by conventional methods near PEMD sites at Slate Creek Cove, Cascade Point, Echo Cove, and a control site in North Bridget Cove in May 2004 (Table 1). Seawater samples were collected in a dichloromethane-rinsed 4 L jug, which was lowered under the surface of the water with the lid on. The lid was then removed allowing water into the jar. The jug was then capped underwater, removed from the water column, and placed into a cooler with Blue Ice®. Seawater samples were spiked with six deuterated PAH surrogate standards and extracted with dichloromethane immediately after returning to the laboratory. A composite sediment sample was collected with a dichloromethane-rinsed spoon from three to four fine sediment areas adjacent to a PEMD site and placed in a hydrocarbon-free 125 ml glass jar. Fifteen blue mussels were collected by hand from four to six areas adjacent to each sediment collection site and placed in hydrocarbon-free jars. To prevent introduction of contaminants to tissues, care was taken not to pull out mussel byssal threads. Sediment and tissue samples were put into a cooler with Blue Ice® during transport (1 to 4 hours) to a freezer at the laboratory.

Hydrocarbon Analysis

Protocol developed by ABL was used to extract, purify, and analyze PEMD strips (Carls et al. 2004b). After deployment and retrieval, the PEMDs were spiked with six deuterated PAH surrogate standards just prior to sonic extraction with pentane/dichloromethane (80/20 v/v). The extracts were purified by silica chromatography. Likewise, sediment and tissue samples were spiked with six deuterated PAH and five deuterated alkane surrogate recovery standards prior to extraction with dichloromethane. Seawater, sediment, and mussel tissue extracts were purified and separated into aromatic (PAH) and alkane fractions by silica/alumina chromatography. Sediment and tissue extracts were further purified by high performance liquid chromatography. PAH extracts were analyzed by gas chromatography/mass spectroscopy (GC/MS) operated in selected ion mode (SIM) using the internal standard method detailed in Short et al. (1996). Alkane fractions were analyzed by gas chromatography coupled with flame ionization detection (GC/FID). A list of analytes in all matrices (PEMDs, seawater, sediment, mussel tissue) are shown in Table 2. Surrogate PAH recoveries were between 52% and 104% for all PEMD samples (Appendices 1-3) and generally ranged between 40% and 115% in seawater, sediment, and mussel tissue samples. Surrogate alkane recoveries ranged from 36% to 85%.

Fish Sampling

Fish assemblages were inventoried in Berners Bay and Bridget Cove in early June 2004. At each location, a total of six beach seine hauls were made—three in eelgrass and three in understory kelp habitats (Figs. 2 and 3). Within each habitat type, seine hauls were at least 50 m apart. All sampling occurred during daylight hours and within 2 hours of low tide (range +1.0 to −1.5 m below mean lower low water MLLW). Locations of seine sites were recorded with GPS technology (Table 1).

Fish were sampled with a 37-m long, variable-mesh beach seine that tapered from 5 m wide at the center to 1 m wide at the ends. Outer panels were each 10 m of 32-mm stretch mesh, intermediate panels were each 4 m of 6-mm square mesh, and the bunt was 9 m of 3.2-mm square mesh. We set the seine as a “round haul” by holding one end of the seine on the beach, backing around in a skiff with the other end along the beach about 18 m from the start, and pulling the seine onto shore. The seine had a lead line and a float line so that the bottom contacted the substrate and the top floated.

Captured fish were identified to species and enumerated. The number of fish in large catches was estimated gravimetrically. To achieve this, a random subsample of approximately 500 fish was removed from the total catch; the remainder of fish was collectively weighed to the nearest 0.1 kg. Fish in the subsample were weighed to the nearest gram and counted by species. A mean weight of fish determined from the subsample was used to estimate the number of fish in the total catch. The proportion of each species in the subsample was also used to determine the species composition of the total catch. Fork length (FL) was measured to the nearest millimeter for up to 50 individuals of selected species, primarily commercially important and forage fish species (e.g., chum salmon). Fish were anesthetized in a mixture of 1 part carbonated water to 2 parts seawater for identification and measurement. Smaller individuals (< 50 mm FL) of some families of fish (e.g., Cottidae, Hexagrammidae) that could not be easily identified to species in the field were grouped and recorded as juvenile cottids or juvenile greenling.

Habitat Mapping and Characteristics

Eelgrass beds along the eastern shore of Echo Cove (Fig. 2) and in Bridget Cove (Fig. 3) were mapped in July 2004. Seine sites were located in eelgrass beds that were mapped. Area of eelgrass beds was determined by walking and boating the perimeter of a bed with a backpack-mounted Trimble[2] TSC1 Asset Surveyor GPS (McKenzie et al. 2001). A PVC pipe (3.8 cm

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[2]Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

diameter, 1.5 m long) was driven into the substrate in each bed as a survey reference point. At extreme low tide, starting at the reference point, a person walked the exposed perimeter of the eelgrass bed following the edge of the bed as closely as possible with a portable GPS unit. Upon reaching the water's edge, the individual would then get in a small boat and motor around (1-2 kts) the subtidal perimeter of the bed keeping the GPS antenna over the visible edge. During our sampling, clear, calm water allowed for good viewing of the subtidal eelgrass boundary from the boat. The GPS unit collected real-time, differentially corrected positions one time per second while circumnavigating the eelgrass beds. Accuracy of positions collected was usually plus or minus 0.5 m. In addition, the linear extent of eelgrass beds along the western shore of Echo Cove and understory kelp near Cascade Point were determined by following the shoreline in a boat with a GPS unit at low tide and visually observing the start and end of vegetative cover (Fig. 2). The linear extent of kelp habitat in Bridget Cove was not determined.

Other eelgrass parameters that are sensitive to shoreline development (e.g., percent cover, canopy height, stem density, and biomass) were estimated at seine site 6 in Echo Cove (Fig. 2), and at seine site 11 and near seine site 12 in Bridget Cove (Fig. 3) following the methods of Duarte and Kirkman (2001). At these sites, a transect vertical to the waterline was established from the lower edge of the eelgrass bed to the upper edge and marked into 0.5-m blocks by tidal elevation. For example, if a bed extended from −1.0 m to +1.0 m tidal elevation relative to MLLW, four tidal blocks would be marked (−1.0 m to −0.5 m, −0.5 m to 0.0 m, 0.0 m to 0.5 m, and 0.5 m to 1.0 m). Tidal elevations were estimated using "Tides", a tide program developed at ABL. Using a random numbers table, five 0.5 m × 0.5 m quadrats were placed in each 0.5-m tidal block. Percent cover was the percentage of the quadrat covered by eelgrass shoots when blades were not floating (determined when beds were exposed). Reference percent cover photos were used to standardize estimates, and often two observers conferred to determine an estimate. Canopy height was the height in millimeters of 80% of the eelgrass shoots in the quadrat. Above ground stem density was determined by counting stems in a smaller subquadrat (0.25 m × 0.25 m) placed inside the upper left corner of the 0.5 m × 0.5 m quadrat (the larger quadrat was left in place at the location where percent cover and canopy height were determined). For biomass, we clipped all eelgrass shoots at the substrate surface for half of the subquadrat; epifauna and benthic fauna in each quadrat were recorded. At ABL, we rinsed the clippings and scraped off sediment, epiphytes, and epifauna; shoots were then dried at 60°C to constant weight and were weighed to the nearest 0.1 g.

Water Temperature and Salinity

Water temperature and salinity were measured at each seine site with a thermometer and hand-held refractometer at about 20 cm depth. In addition, four TidbiT[3] thermographs recorded water temperatures at about 3-m depth relative to MLLW every 2 hours at four sites in Berners Bay (Fig. 2) and at two sites in Bridget Cove (Fig. 3). Thermographs were attached to the midsection of a 1-m long piece of stainless steel cable or polypropylene line. A 10-kg anchor was attached on one end of the cable or line and a small float was attached on the other end. Locations of thermographs were recorded with GPS technology at the point of deployment (Table 1). Thermographs were deployed in June 2004 and were retrieved in April 2005.

Data Analysis

Concentrations of PAH analytes in PEMDs, seawater, sediment, and mussel tissue samples were summed to produce a total PAH (TPAH) concentration. Total PAHs in seawater

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[3]Onset Computer Corporation, Pocasset, Massachusetts.

can be estimated by applying concentration factors 10^4 to 10^5 to a PEMD volume of 2.46 cm^3 (membranes are 98 µm thick, 5.08 cm wide, and 0.5 m long; Carls et al. 2004b). This method should be used cautiously, however, because it estimates a mean of TPAH daily concentrations over the deployment period. At a site, TPAH may vary from day to day due to exposure temperature, extent of biofouling, and non-equilibrium conditions, all of which affect daily sampling rates. Similarly, concentrations of calibrated alkanes were summed to calculate total alkane concentrations for each sample.

For fish assemblages, total catch and catch per seine haul were determined for each habitat type in each location. Species richness refers to the total number of species found in a given habitat type or location. Species diversity was calculated using the Shannon-Weiner diversity index (H) described in the following equation:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i ,$$

where s is the number of species, and p_i is the proportion of the total number of individuals consisting of the i^{th} species (Poole 1974). Two components of diversity are combined in this index: 1) number of species, and 2) evenness in number of individuals among species. Unidentified juvenile greenling and cottids were counted in the total catch, but were not considered a "species" when species richness or diversity indices were calculated.

RESULTS

Hydrocarbons

All PAH concentrations were very low or not detectable in most of the samples. With PEMDs, some PAHs were detected, but usually at low levels. In the first PEMD deployment (13 April-13 May 2004), TPAHs were near detection limits; values ranged from 6 ng per PEMD at North Bridget Cove to 88 ng per PEMD at South Bridget Cove. Hydrocarbon concentrations less than100 ng per PEMD are considered to be background levels and are difficult to separate from minimum detection limits (mdl; the lowest concentration of an analyte that can be accurately detected and reported). In the second PEMD deployment (7 July-4 August 2004), TPAH values were still low, but could be detected from background levels; values ranged from 53 ng per PEMD at Cove Point to 302 ng per PEMD at North Bridget Cove. Hydrocarbon concentrations between 100 and 500 ng per PEMD indicate likely exposure to PAHs, but are difficult to fingerprint to potential PAH sources because not all of the individual analytes are significantly above the mdl. A summary of TPAHs sampled by PEMDs is given in Table 3; concentrations of individual analytes are reported in Appendices 1-3.

Direct sampling of seawater, sediment, and mussel tissue also revealed low PAH concentrations. In seawater samples, none of the individual PAH analytes were above the mdls (5-20 ng/l), and consequently, total PAH concentrations were at least three orders of magnitude less than the Alaska Water Quality Standard of 15 ppb PAH. Similarly, most sediment and tissue PAHs were at or below the mdls (0.3-3.5 ng/g, ppb). Total alkane hydrocarbon analyses of seawater, sediment, and tissue also indicated low concentrations; all analytes were near or below mdls (sediment and tissue < 5-30 ng/g) except for pristane (non-petrogenic hydrocarbon) and some n-alkanes (mostly odd numbered, C17, C25, C27, and C29) in sediment and tissue samples. Pristane was generally absent from sediments. A summary of TPAHs in seawater, sediment, and tissue is given in Table 3; concentrations of individual analytes are reported in Appendices 4 and 5.

Fish

Twelve seine hauls yielded 9,653 fish comprising 24 species; 86% of the total catch was in Bridget Cove (Table 4). Based on percent of total catch, the most abundant species were chum salmon (87%), juvenile coho salmon (6%), crescent gunnel (*Pholis laeta*; 3%), and Dolly Varden (*Salvelinus malma*; 1%). Other species captured that are important in sport or commercial fisheries were pink salmon, Pacific herring, and cutthroat trout (*O. clarkii*).

Catch varied considerably between habitat types and among locations within habitat types, often because of the patchy distribution of some species. Mean catch per seine haul ranged from 165 fish in kelp at Berners Bay to 2,056 fish in eelgrass at Bridget Cove (Table 4). Large catches were often dominated by chum salmon fry. Total fish catch was about six times greater in Bridget Cove than in Berners Bay (8,333 vs.1,320), mainly due to the large number of chum salmon fry caught in Bridget Cove. For all sites, total fish catch was greater in eelgrass (6,993) than in kelp (2,660).

The number of species caught by habitat type ranged from 11 to 15 between both locations (Table 4). Overall, 18 different species were captured in eelgrass and 16 in kelp. Regardless of habitat type, mean species diversity was higher in Berners Bay (> 0.94) than in Bridget Cove (≤ 0.50), largely due to the dominance of chum salmon fry in Bridget Cove (Table 4). The most ubiquitous species was juvenile coho salmon which were caught in every seine haul, although not always in great numbers. Crescent gunnels were captured at all eelgrass sites, whereas juvenile greenlings were captured at all kelp sites. Species found exclusively in eelgrass were snake prickleback (*Lumpenus sagitta*), tubesnout (*Aulorhynchus flavidus*), Pacific staghorn sculpin (*Leptocottus armatus*), starry founder (*Platichthys stellatus*), rock sole (*Lepidopsetta* spp.), threespine stickleback (*Gasterosteus aculeatus*), capelin, and juvenile cottids. Pacific herring, Pacific cod (*Gadus macrocephalus*), walleye pollock (*Theragra chalcogramma*), crested sculpin (*Blepsias bilobus*), and leister sculpin (*Enophyrys lucasci*) were only found in kelp.

Most fish captured were juveniles. For example, mean FL was 68.8 mm (n = 368, SE = 0.37) for chum salmon, 96.2 mm (n = 233, SE = 0.85) for coho salmon, 58.5 mm (n = 48, SE = 0.73) for pink salmon, and 129.3 mm (n = 6, SE = 10.10) for Pacific herring. For species important in sport fisheries, mean FL was 179.4 mm (n = 31, SE = 8.44) for Dolly Varden and 182.5 mm (n = 6, SE = 19.93) for cutthroat trout.

Habitat Mapping

The only eelgrass beds in Berners Bay are in Echo Cove. Along the east shore of the cove, eelgrass beds form a narrow fringe on soft sediments about −0.5 m to −1.0 m below MLLW (Fig. 2). Patchy areas of eelgrass are also present along the western shore and at the head of the cove; total linear length is 600 m for the eastern beds and about 900 m for the western beds. For all beds in Echo Cove, eelgrass percent cover ranged from 5% to 100%; sandy areas also supported scattered ephemeral algal species, *Ulva* and *Porphyra.*

Total area of eelgrass mapped along the eastern shore of Echo Cove was 0.81 ha (Fig. 2). Biological characteristics of the southernmost bed in this group (seine site 6) were typical of the eastern beds. Mean (n = 5) percent cover was 63%, mean canopy height was 697 mm, mean stem density was 214.4 stems/m^2, and mean biomass was 30.8 g/m^2.

Total area of eelgrass mapped in Bridget Cove was 7.08 ha. We divided the eelgrass beds in Bridget Cove into three units (north, central, and south) (Fig. 3). Area of eelgrass in the northern unit is 0.74 ha; most of this bed is in a small cove and is extremely patchy, especially at the southern end (Fig. 3). In the central unit, area of eelgrass is much less extensive (0.58 ha); beds are small and range from a few square meters to 0.30 ha. The southern unit consists of a very complex 5.76 ha bed at tidal elevations from less than −2.0 m to greater than 1.5 m, with several small patches in tide pools higher in the intertidal (estimated 2 m above MLLW). In the −0.5 m to −1.0 m tidal blocks in the southern and central beds, mean (n = 10) percent cover was 38.5%; mean canopy height was 364 mm, mean stem density was 316.4 stems/m^2, and mean biomass was 31.4 g/m^2.

The linear extent of kelp along the eastern shore of Berners Bay from the Echo Cove boat launch ramp to Cascade Point was 1,700 m (Fig. 2); kelp was dominated by *Laminaria* spp. and *Alaria marginata*. Other kelps present were *Desmarestia* spp., *Nereocystis luetkeana*, *Agarum clathratum*, and *Costaria costata.* Area of kelp coverage could not be determined because turbid water greatly reduced underwater visibility.

Juvenile blue mussels (0.5 mm to 1.0 mm in length) were the most ubiquitous and numerous epifauna in all eelgrass beds. Other common invertebrates were variegated chink (*Lacuna variegata*) adults and egg masses, bryozoans, isopods, amphipods, and polychaetes. Common epibenthic fauna were adult blue mussels, false white sea cucumbers (*Eupentacta pseudoquinquesemita*), six-armed sea stars (*Leptasterias epichlora*), green urchins (*Strongylocentrotus droebachiensis)*, and hermit crabs (*Pagurus* spp.).

Water Temperature and Salinity

Water temperatures in June were higher and salinities were lower in Berners Bay than in Bridget Cove. At Berners Bay, water temperatures ranged from 10° to12°C and salinities ranged from 21 to 22 practical salinity scale (PSS). At Bridget Cove, water temperatures ranged from 9.0° to 9.5°C and salinities ranged from 25 to 28 PSS.

DISCUSSION

All hydrocarbon concentrations were very low, indicating pristine conditions in Berners Bay and Bridget Cove; most hydrocarbons were at or below mdls in PEMDs, seawater, sediment, and blue mussel tissue. Total PAH concentrations in all matrices were below levels considered baseline for Prince William Sound, Alaska: 10 to 100 ng/l for water (Neff and Stubblefield 1995), 100 ng/g dry weight for sediment (Short and Babcock 1996), and 90 ng/g dry weight for mussel tissue (Carls et al. 2004a). Applying Carls' (2004b) concentration factors to a PEMD volume and using the highest TPAH value of 302 ng/device from the North Bridget Cove PEMD (July), the seawater TPAH concentration is estimated at 1-12 ng/l (ppt). These estimated TPAHs in seawater that was sampled by PEMDs are near or below the individual analyte mdl value and corroborate the non-detect PAH analyses of seawater samples.

The highest concentrations of PAHs observed in PEMDs were consistent with that of diesel fuel, as indicated by the absence of any PAH analytes larger than three rings. Identification is determined by comparing the relative proportions of analytes in the suite of compounds sequestered by the PEMDs. A possible explanation for the relatively lower PAH signal detected in the April versus the July PEMD samples may be increased vessel activity in summer. When PEMDs were retrieved in August, the salmon gillnet fleet was widely dispersed in areas adjacent to Bridget Cove and the entrance to Berners Bay in Lynn Canal. Bridget Cove (186-288 ng per PEMD in summer) is also used as a transient anchorage during the fishery. To put these values in perspective, PAH concentrations of 17,000 ng per PEMD and 33,000 ng per PEMD have been recorded in Douglas Harbor and Cordova Harbor, Alaska (S. D. Rice, Auke Bay Laboratory, 11305 Glacier Hwy., Juneau, AK 99801. Pers. commun., April 2005).

There was no indication of petroleum-derived alkanes. Sources of alkanes above the mdls were probably terrigenous plant waxes, marine plankton, and macrophytic algae. Pristane was the most prevalent alkane found in blue mussel tissue, and may have been produced by calanoid copepods and transferred through the food web to blue mussels (Short and Harris 1997).

Berners Bay and surrounding nearshore waters support a diverse assemblage of fishes. Many species that we captured are commercially important (e.g., chum salmon, coho salmon) and are included in a fisheries management plan (FMP) for Alaska (North Pacific Fishery Management Council 2002). Most fish captured were juveniles, suggesting that Berners Bay and Bridget Cove provide early rearing habitat; the length of time fish rear in these areas, however, is unknown.

Catch and species richness in Berners Bay and Bridget Cove were similar to other locations in northern inside waters of southeastern Alaska (Johnson et al. 2003). The large catch of chum salmon fry at Bridget Cove was likely the result of net pen releases of chum fry at Amalga Harbor, 8 km south of Bridget Cove; about 54 million chum fry were released from Amalga Harbor in mid-May 2004 (Rick Focht, Macaulay Salmon Hatchery, 2697 Channel Drive, Juneau, AK 99801. Pers. commun., January 2005). Some of the most abundant species that we captured (e.g., chum salmon, crescent gunnel, snake prickleback, and pink salmon) were also some of the most abundant species captured in other southeastern Alaska studies (Murphy et al. 2000, Johnson et al. 2003). The greater catch of fish in eelgrass than in kelp has been documented for 30 of the 50 most abundant species in shallow waters of southeastern Alaska (Johnson et al. 2005).

Because of the seasonality and aggregating behavior of many species (e.g., Pacific herring, capelin), more frequent sampling throughout the year is needed to fully identify all fish species that use Berners Bay. For example, we caught few herring and capelin and no eulachon in our beach seines. By the time we seined in early June, adults may have already left the area and young of the year may have been either too small to be caught in the seine or were not in areas that we sampled. Similarly, the large number of chum salmon fry that we captured in early June would not be present in fall and winter.

Based on habitat mapping, the eelgrass bed in south Bridget Cove is the largest bed in the City and Borough of Juneau (Harris and Neff in prep.). Total area of eelgrass in Echo Cove, however, is expected to be similar to Bridget Cove when the beds on the western shore of Echo Cove are mapped in 2005. Mean eelgrass stem densities and biomass in Echo Cove and Bridget Cove are lower than reported for other eelgrass beds in northern inside waters of southeastern Alaska (Johnson et al. 2003). Low stem densities and biomass, particularly in Echo Cove, may be the result of increased turbidity from glacial runoff (Antler and Lace Rivers) in summer; increased turbidity reduces light penetration and can inhibit eelgrass growth.

It is likely that we encountered more than one species of *Laminaria* and *Alaria* in the areas we surveyed in Berners Bay. Calvin (1977) lists two species of *Laminaria, L. saccharina* and *L. groenlandica* (*bongardinana*), and two species of *Alaria* at a site south of Cascade Point. At Cascade Point, Stekoll (1999) found *L. bongardinana* and *L. saccharina* in 57% and 75% of his sample quadrats; the most common species was *L. bongardinana*. Interestingly, Stekoll

(1999) does not report *Alaria* in his transects. We found *Alaria* to be the dominant species at Cascade Point and to the north for more than 400 m. Although not reported by others, we observed small patches of *Nereocystis luetkeana* (bull kelp) near Cascade Point.

Our initial findings after one year of baseline studies identify Berners Bay as a pristine environment that provides quality habitat for juvenile fishes of many species. Because high interannual variability in hydrocarbons, fish catch, and size of eelgrass beds has been noted in other studies (Karinen et al. 1993; Johnson and Thedinga in press), at least one more year of baseline sampling is planned in 2005. The same sampling sites and protocols will be followed as in 2004. In addition to sites sampled for hydrocarbons in 2004, samples will also be taken at the mouths of the Antler and Lace Rivers because they have been identified as eulachon and capelin spawning areas. Mapping of the linear extent of kelp beds will be extended to Bridget Cove, and further work will be done to identify kelp species with divers or grabs. The present study provides only a brief overview of the fishery resources and habitat of Berners Bay. Long-term monitoring will provide resource managers a wealth of information on any changes in fish use or habitat that may result from mine development.

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Table 1. – Locations and dates of polyethylene membrane device (PEMD) deployment; hydrocarbon sampling of seawater, sediment, and blue mussel (*Mytilus trossulus*) tissue; thermograph deployment; and beach seining in Berners Bay and Bridget Cove, Alaska, in 2004. Latitude and longitude are in decimal degrees. Sampling locations are shown in Figures 1-3.

Location/sampling	Lat. (N)	Long. (W)	Sampling date	Rationale
Cove Point				Juvenile forage fish habitat
PEMD 1	58.7538	135.0200	4/13, 7/7	
PEMD 2	58.7539	135.0190	4/13, 7/7	
Slate Creek Cove				Potential dock, fish habitat
PEMD 1	58.7797	135.0120	4/13, 7/7	
PEMD 2	58.2799	135.0120	4/13, 7/7	
Hydrocarbons	58.7797	135.0120	5/13	
North of Sawmill Cr.				Herring spawning area
PEMD 1	58.7423	134.9390	4/13, 7/7	
PEMD 2	58.7420	134.9390	4/13, 7/7	
North of Cascade Pt.				Potential dock/ferry activity
PEMD 1	58.7118	134.9460	4/13, 7/7	
PEMD 2	58.7116	134.9450	4/13, 7/7	
Seine 1	58.7057	134.9464	6/2	
Thermograph	58.7089	134.9460	5/19	
Cascade Point				Potential dock/ferry activity
PEMD 1	58.6985	134.9420	4/13, 7/7	
PEMD 2	58.6984	134.9410	4/13, 7/7	
Hydrocarbons	58.6985	134.9420	5/13	
South of Cascade Pt.				Potential dock/ferry activity
PEMD 1	58.6851	134.9260	4/13, 7/7	
PEMD 2	58.6849	134.9250	4/13, 7/7	

Location/sampling	Lat. (N)	Long. (W)	Sampling date	Rationale
Seine 2	58.6954	134.9356	6/2	
South of Cascade Pt.				
Seine 3	58.6941	134.9342	6/3	
Thermograph	58.6884	134.9360	5/19	
Echo Cove				Boat ramp/potential dock
PEMD 1	58.6645	134.9200	4/13, 7/7	
PEMD 2	58.6642	134.9200	4/13, 7/7	
Hydrocarbons	58.6645	134.9200	5/13	
Seine 4	58.6719	134.9148	6/2	
Seine 5	58.6693	134.9127	6/2	
Seine 6	58.6686	134.9121	6/2	
Thermograph	58.6605	134.9110	6/3	
Thermograph	58.6680	134.9200	6/2	
North Bridget Cove				Control for Cascade Pt. sites
PEMD 1	58.6378	134.9570	4/13, 7/7	
PEMD 2	58.6378	134.9570	4/13, 7/7	
Hydrocarbons	58.6378	134.9570	5/13	
Seine 7	58.6421	134.9556	6/3	
Seine 8	58.6419	134.9581	6/3	
Seine 9	58.6405	134.9551	6/3	
Seine 10	58.6386	134.9545	6/3	
Thermograph	58.6405	134.9550	6/1	
Thermograph	58.6418	134.9580	6/3	
Central Bridget Cove				Control for Echo and Slate Cr. Coves
Seine 11	58.6348	134.9480	6/4	
South Bridget Cove				Control for Echo and Slate Cr. Coves
PEMD 1	58.6321	134.9460	4/13, 7/7	
PEMD 2	58.6319	134.9460	4/13, 7/7	
Seine 12	58.6303	134.9449	6/4	

Table 2. – Polynuclear aromatic hydrocarbon (PAH) compounds determined in polyethylene membrane device, seawater, sediment, and blue mussel (*Mytilus trossulus*) tissue collected at sites in Berners Bay and Bridget Cove, Alaska, in 2004 (Table 1). In addition, alkane hydrocarbons listed were determined in seawater, sediment, and mussel tissue. Calibrated PAHs are indicated with an asterisk. All alkanes listed are calibrated.

Analytes		
PAHs		Alkanes
*Naphthalene	*Pyrene	C10- (n-decane)
C-1 naphthalenes	C-1 fluoranthenes/pyrenes	C11- (n-undecane)
C-2 naphthalenes	C-2 fluoranthenes/pyrenes	C12- (n-dodecane)
C-3 naphthalenes	C-3 fluoranthenes/pyrenes	C13- (n-tridecane)
C-4 naphthalenes	C-4 fluoranthenes/pyrenes	C14- (n-tetradecane)
*Biphenyl	*Benz-a-anthracene	C15- (n-pentadecane)
*Acenaphthylene	*Chrysene	C16- (n-hexadecane)
*Acenaphthene	C-1 chrysenes	C17- (n-heptadecane)
*Fluorene	C-2 chrysenes	Pristane
C-1 fluorenes	C-3 chrysenes	C18- (n-octadecane)
C-2 fluorenes	C-4 chrysenes	Phytane
C-3 fluorenes	*Benzo-b-fluoranthene	C19- (n-nonadecane)
C-4 fluorenes	*Benzo-k-fluoranthene	C20- (n-eicosane)
*Dibenzothiophene	*Benzo-e-pyrene	C21- (n-heneicosane)
C-1 dibenzothiophenes	*Benzo-a-pyrene	C22- (n-docosane)
C-2 dibenzothiophenes	*Perylene	C23- (n-tricosane)
C-3 dibenzothiophenes	*Indeno-123-cd-pyrene	C24- (n-tetracosane)
C-4 dibenzothiophenes	*Dibenzo-a,h-anthracene	C25- (n-pentacosane)
*Phenanthrene	*Benzo-g,h,i-perylene	C26- (n-hexacosane)
C-1 phenanthrenes/anthracenes		C27- (n-heptacosane)
C-2 phenanthrenes/anthracenes		C28- (n-octacosane)
C-3 phenanthrenes/anthracenes		C29- (n-nonacosane)
C-4 phenanthrenes/anthracenes		C30- (n-triacontane)
*Anthracene		C32- (n-dotriacontane)
*Fluoranthene		C34- (n-tetratriacontane)

Table 3. – Total polynuclear aromatic hydrocarbon (TPAH) concentrations in polyethylene membrane devices (PEMDs), seawater, sediment, and blue mussel (*Mytilus trossulus*) tissue from Berners Bay and Bridget Cove, Alaska, in 2004. The PEMDs were deployed for about 30 days in spring and summer. Lab blanks were collected in the lab when devices were prepared. Each field blank was exposed for 10-15 minutes during both deployment and retrieval, for a total exposure time of 20-30 minutes at each site. Total PAH concentrations for seawater, sediment, and mussel tissue are from four of the PEMD sites. Locations are shown in Table 1 and Figure 1. Concentrations below instrument minimum detection levels are reported as not detectable (nd).

	PEMD (ng/device)		Conventional samples		
	Deployments		Seawater (ng/l)	Sediment (ng/g)	Mussel (ng/g)
Location	4/13-5/13	7/7-8/4	5/13	5/13	5/13
Lab Blank 1	nd	nd	-	-	-
Lab Blank 2	76.31	nd	-	-	-
Field Blank 1[a]	42.29	96.83	-	-	-
Field Blank 2[b]	78.21	111.30	-	-	-
Slate Creek Cove 1	28.59	234.59	nd	nd	13.70
Slate Creek Cove 2	57.66	211.25	-	-	-
Cove Point 1	43.50	60.13	-	-	-
Cove Point 2	33.58	53.10	-	-	-
N. Sawmill Creek 1	57.08	119.32	-	-	-
N. Sawmill Creek 2	14.07	111.41	-	-	-
N. Cascade Point 1	25.27	105.93	-	-	-
N. Cascade Point 2	36.59	152.18	-	-	-
Cascade Point 1	52.41	122.18	nd	nd	nd
Cascade Point 2	44.49	155.97	-	-	-
S. Cascade Point 1	39.31	165.54	-	-	-
S. Cascade Point 2	47.77	160.54	-	-	-
Echo Cove 1	25.81	126.37	nd	1.97	nd
Echo Cove 2	37.41	153.77	-	-	-
N. Bridget Cove 1	61.11	301.68	nd	nd	5.03
N. Bridget Cove 2	5.77	288.42	-	-	-
S. Bridget Cove 1	72.77	185.85	-	-	-
S. Bridget Cove 2	87.50	212.53	-	-	-

[a]Field Blank 1 = Cascade Point, [b]Field Blank 2 = North Bridget Cove

Table 4. – Total catch of fish at eelgrass (*Zostera marina*) and kelp (mostly *Laminaria* spp.) sites in Berners Bay and Bridget Cove, southeastern Alaska, June 2004. Three beach seine hauls were made in each habitat type at each site (n = 12). Based on total catch, species are listed in decreasing order of abundance. An asterisk indicates that the species is included in a federal fishery management plan in Alaska.

		Berners Bay		Bridget Cove		
Common name	Scientific name	Eelgrass	Kelp	Eelgrass	Kelp	Total catch
Chum salmon*	*Oncorhynchus keta*	468	367	5,722	1,846	8,403
Coho salmon*	*Oncorhynchus kisutch*	85	73	179	284	621
Crescent gunnel*	*Pholis laeta*	182	9	87	3	281
Dolly Varden	*Salvelinus malma*	4	12	57	10	83
Pink salmon*	*Oncorhynchus gorbuscha*	0	0	42	6	48
Snake prickleback*	*Lumpenus sagitta*	34	0	0	0	34
Whitespotted greenling	*Hexagrammos stelleri*	6	9	13	4	32
Rock sole*	*Lepidopsetta* spp.	2	0	29	0	31
Juvenile greenling	*Hexagrammos* spp.	9	2	15	1	27
Northern sculpin	*Icelinus borealis*	9	3	0	4	16
Tubesnout	*Aulorhynchus flavidus*	12	0	3	0	15
Great sculpin*	*Myoxocephalus polyacanthocephalus*	4	1	6	2	13
Pacific staghorn sculpin	*Leptocottus armatus*	4	0	7	0	11
Cutthroat trout	*Oncorhynchus clarkii*	3	1	4	2	10
Pacific herring	*Clupea pallasii*	0	4	0	3	7
Silverspotted sculpin	*Blepsias cirrhosus*	1	5	1	0	7
Walleye pollock*	*Theragra chalcogramma*	0	3	0	0	3
Leister sculpin	*Enophyrys lucasci*	0	1	0	1	2
Pacific cod*	*Gadus macrocephalus*	0	2	0	0	2

Table 4. (cont.)--

		Berners Bay		Bridget Cove		
Common name	Scientific name	Eelgrass	Kelp	Eelgrass	Kelp	Total catch
Capelin*	*Mallotus villosus*	1	0	0	0	1
Crested sculpin	*Blepsias bilobus*	0	1	0	0	1
Juvenile cottids	Cottidae	1	0	0	0	1
Northern ronquil	*Ronquilus jordani*	0	1	0	0	1
Sockeye salmon	*Oncorhynchus nerka*	0	0	1	0	1
Starry flounder*	*Platichthys stellatus*	0	0	1	0	1
Threespine stickleback	*Gasterosteus aculeatus*	1	0	0	0	1
	Total catch	826	494	6,167	2,166	9,653
	Average catch per haul	275	165	2,056	722	804
	Species richness	15	15	14	11	24
	Diversity Index (Shannon-Weiner)	1.31	0.94	0.37	0.50	0.59

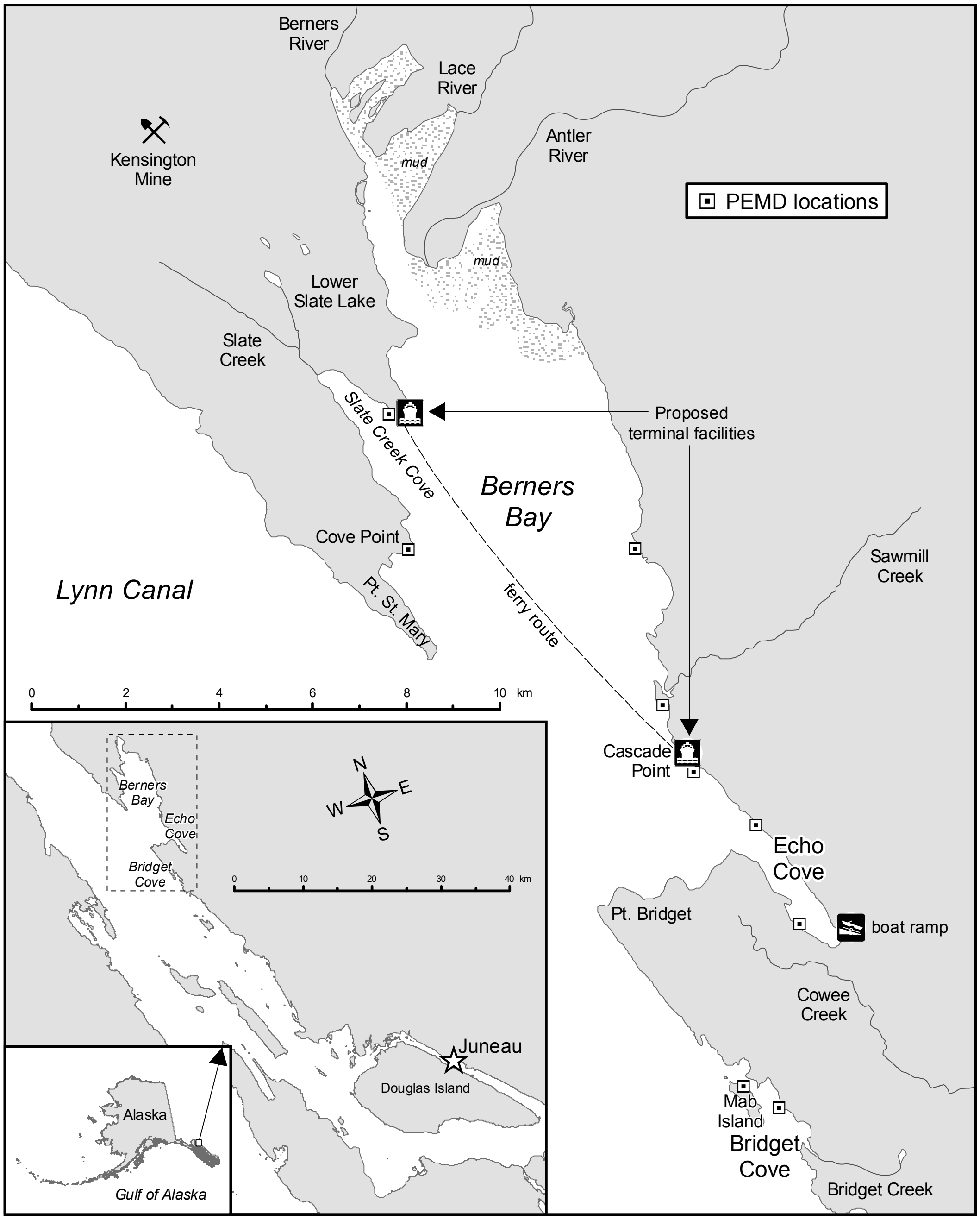

Figure 1.-Proposed terminal facilities and ferry route associated with development of the Kensington Gold Mine in Berners Bay, Alaska. Also shown are locations of polyethylene membrane devices (PEMDs) that sample hydrocarbons in seawater, integrated over a 30-day deployment period. Bridget Cove is a relatively undisturbed "control site" south of Berners Bay.

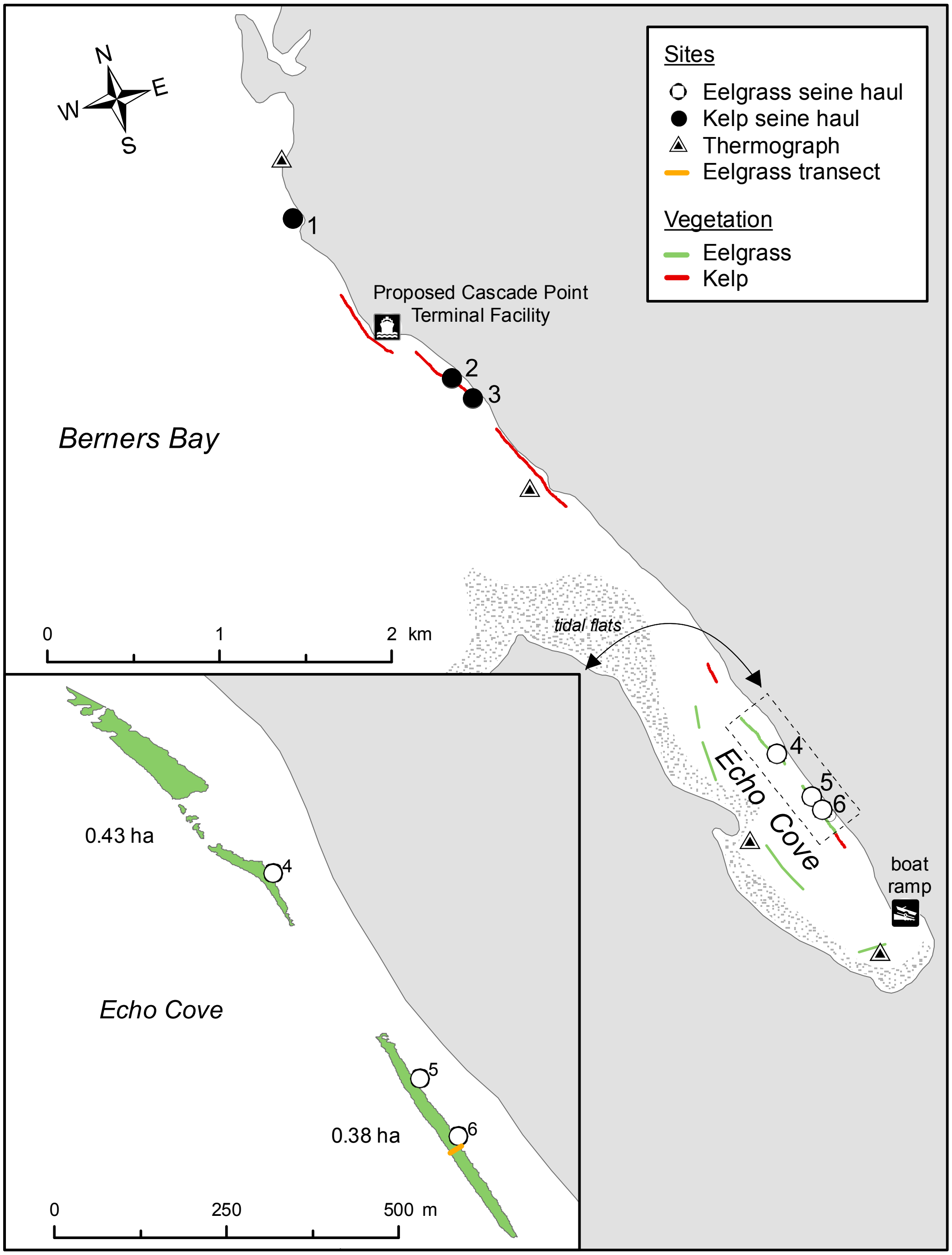

Figure 2.-Locations of seine sites by habitat type and thermographs in Berners Bay, Alaska, 2004. Also shown are eelgrass (*Zostera marina*) beds mapped with global positioning system technology, eelgrass area in hectares (ha), and the location of a transect to measure eelgrass characteristics (e.g., stem density).

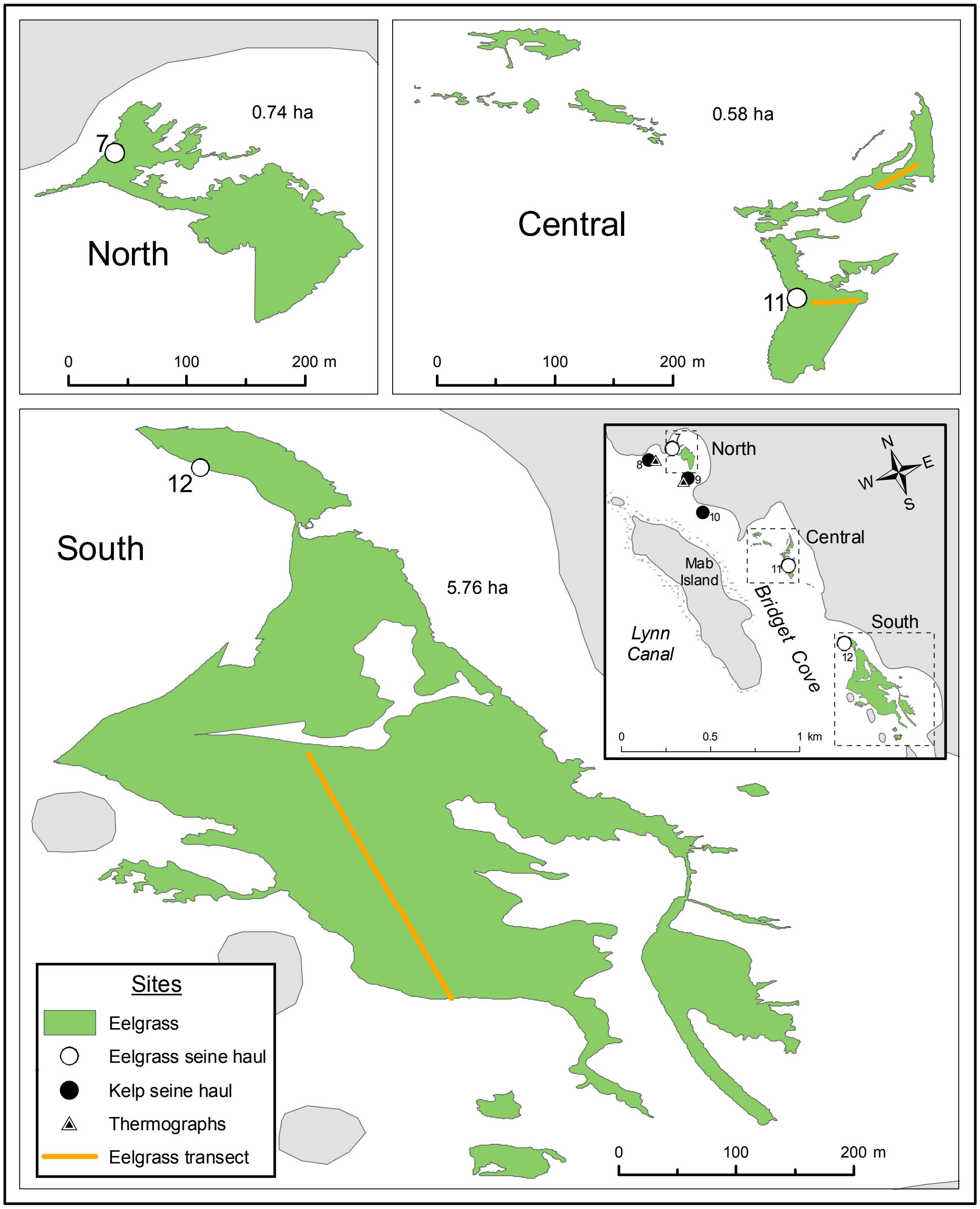

Figure 3.-Locations of beach seine sites by habitat type and thermographs in Bridget Cove, Alaska, 2004. Also shown are eelgrass (*Zostera marina*) beds mapped with global positioning system technology, eelgrass area in hectares (ha), and the location of transects to measure eelgrass characteristics (e.g., stem density). Eelgrass beds in Bridget Cove were divided into three sections for mapping: north, central, and south.

Appendix 1. – Laboratory and field blank concentrations (ng/device) of polynuclear aromatic hydrocarbon (PAH) analytes extracted from polyethylene membrane devices (PEMDs). Lab blanks represent possible contamination of devices in the laboratory prior to deployment, whereas field blanks represent possible contamination of devices during transport to and from deployment sites and during storage of device strips before analysis. Two lab blanks were deployed on 29 March and two on 30 June 2004. For each sampling period (4/13-5/13, 7/7-8/4), two field blanks were deployed, one at Cascade Point (device 1) and one at N. Bridget Cove (device 2). Each field blank was exposed for 10-15 minutes during both deployment and retrieval, for a total exposure time of 20-30 minutes. Concentrations below instrument minimum detection limits are reported as not detectable (nd).

	First deployment		Second deployment	
	Lab (3/29)	Field (4/13, 5/13)	Lab (6/30)	Field (7/7, 8/4)
Analyte	1, 2	1, 2	1, 2	1, 2
TPAH[a]	nd, 76.31	42.29, 78.21	nd, nd	96.83, 111.30
Naphthalene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 naphthalenes	nd, 30.59	nd, 17.86	nd, nd	18.26, 19.29
C-2 naphthalenes	nd, 30.24	20.66, 26.83	nd, nd	23.68, 24.72
C-3 naphthalenes	nd, 15.49	14.72, 22.77	nd, nd	21.11, 26.97
C-4 naphthalenes	nd, nd	6.91, 10.75	nd, nd	10.84, 13.42
Biphenyl	nd, nd	nd, nd	nd, nd	nd, nd
Aenaphthylene	nd, nd	nd, nd	nd, nd	nd, nd
Aenaphthene	nd, nd	nd, nd	nd, nd	nd, nd
Fluorene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd
C-2 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd
C-4 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzothiophene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd

	First deployment		Second deployment	
	Lab (3/29)	Field (4/13, 5/13)	Lab (6/30)	Field (7/7, 8/4)
Analyte	1, 2	1, 2	1, 2	1, 2
C-2 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd
C-4 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd
Phenanthrene	nd, nd	nd, nd	nd, nd	17.75, 19.50
C-1 phenanthrenes/anthracenes	nd, nd	nd, nd	nd, nd	5.21, 7.39
C-2 phenanthrenes/anthracenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 phenanthrenes/anthracenes	nd, nd	nd, nd	nd, nd	nd, nd
C-4 phenanthrenes/anthracenes	nd, nd	nd, nd	nd, nd	nd, nd
Anthracene	nd, nd	nd, nd	nd, nd	nd, nd
Fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd
Pyrene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd
C-2 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd
C-4 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd
Benz-a-anthracene	nd, nd	nd, nd	nd, nd	nd, nd
Chrysene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
C-2 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
C-4 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-b-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-k-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-e-pyrene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-a-pyrene	nd, nd	nd, nd	nd, nd	nd, nd
Perylene	nd, nd	nd, nd	nd, nd	nd, nd
Indeno-123-cd-pyrene	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzo-a, h-anthracene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-g, h, i-perylene	nd, nd	nd, nd	nd, nd	nd, nd
	Surrogate recovery[b]			
Naphthalene d-8	81.46, 75.94	82.14, 82.44	90.63, 85.26	79.10, 81.03
Acenaphthene d-10	85.69, 82.72	86.76, 86.81	90.04, 85.73	81.18, 81.45
Phenanthrene d-10	97.20, 88.94	96.76, 95.28	97.68, 91.09	84.26, 84.54
Chrysene d-12	95.31, 87.25	91.50, 92.56	96.19, 87.62	85.25, 86.42
Benzo-a-pyrene d-12	83.34, 80.17	80.99, 86.41	84.37, 76.80	73.72, 72.52
Perylene d-12	86.73, 84.10	87.67, 91.82	86.83, 79.81	81.59, 75.34

[a]TPAH is the sum of all PAH analytes in a sample.

[b]Surrogate recovery is the percentage of a known amount of compound introduced at the beginning of analysis that was recovered at the end of analysis.

Appendix 2. – Concentrations (ng/device) of polynuclear aromatic hydrocarbon (PAH) analytes extracted from polyethylene membrane devices (PEMDs) deployed at seven sites in Berners Bay, Alaska for two 30-day periods. Two PEMDs were deployed at each site (device 1, device 2). Concentrations below instrument minimum detection limits are reported as not detectable (nd).

	First deployment (4/13-5/13, 2004)						
Analyte	Slate Cr. Cove	Cove Pt.	N. Sawmill Cr.	N. Cascade Pt.	Cascade Pt.	S. Cascade Pt.	Echo Cove
TPAH[a]	28.59, 57.66	43.50, 33.58	57.08, 14.07	25.27, 36.59	52.41, 44.49	39.31, 47.77	25.81, 37.41
Naphthalene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 naphthalenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 naphthalenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 naphthalenes	nd, nd	11.23, nd	17.31, nd	nd, 9.88	8.06, nd	9.16, 14.28	nd, nd
C-4 naphthalenes	13.17, 22.59	19.39, 12.02	15.64, 6.72	12.23, 10.74	17.02, 16.08	13.75, 14.29	10.17, 13.81
Biphenyl	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Acenaphthylene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Acenaphthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Fluorene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzothiophene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Phenanthrene	nd, nd	nd, 13.36	14.56, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 phenanthrenes/anthracenes	8.97, 13.39	8.35, 8.2	9.57, 7.35	8.52, 9.98	13.00, 13.14	9.98, 12.67	10.47, 14.57
C-2 phenanthrenes/anthracenes	6.44, 12.49	4.53, nd	nd, nd	4.53, 5.99	9.81, 10.09	6.42, 6.53	5.17, 9.03
C-3 phenanthrenes/anthracenes	nd, 9.19	nd, nd	nd, nd	nd, nd	4.52, 5.18	nd, nd	nd, nd
C-4 phenanthrenes/anthracenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Anthracene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd

Analyte	Slate Cr. Cove	Cove Pt.	N. Sawmill Cr.	N. Cascade Pt.	Cascade Pt.	S. Cascade Pt.	Echo Cove
	First deployment (4/13-5/18, 2004)						
Benz-a-anthracene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Chrysene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-b-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-k-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-e-pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-a-pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Perylene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Indeno-123-cd-pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzo-a,h-anthracene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-g,h,i-perylene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
	Surrogate recovery[b]						
Naphthalene d-8	80.89, 57.52	56.80, 66.79	78.19, 80.51	85.43, 88.69	82.54, 74.83	74.47, 73.96	78.60, 73.45
Acenaphthene d-10	85.09, 75.42	69.71, 81.54	84.49, 82.01	89.08, 89.57	88.73, 83.54	82.87, 82.77	85.15, 79.15
Phenanthrene d-10	93.32, 93.62	77.83, 96.00	96.43, 90.09	99.54, 98.86	101.67, 93.41	98.99, 97.80	99.70, 90.19
Chrysene d-12	89.11, 90.61	78.84, 89.42	89.92, 89.39	99.91, 98.04	97.67, 90.04	94.51, 94.34	92.00, 88.58
Benzo-a-pyrene d-12	83.88, 83.05	73.37, 82.89	82.51, 85.80	90.57, 85.62	98.73, 87.77	87.60, 86.33	79.01, 77.14
Perylene d-12	85.16, 83.19	73.96, 85.81	85.68, 92.41	90.72, 89.54	99.89, 93.62	91.62, 90.37	84.05, 81.82
	Second deployment (7/7-8/4, 2004)						
TPAH[a]	234.59, 211.25	60.13, 53.10	119.32, 111.41	105.93, 152.18	122.18, 155.97	165.54, 160.54	126.37, 153.77
Naphthalene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 naphthalenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 naphthalenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 naphthalenes	18.11, 20.45	8.57, nd	16.36, 14.40	9.53, 17.05	16.36, 17.25	37.96, 36.74	17.82, 14.50
C-4 naphthalenes	62.77, 53.67	9.32, 10.46	14.25, 14.34	12.67, 18.08	17.09, 24.72	33.62, 33.79	19.34, 19.01
Biphenyl	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Acenaphthylene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Acenaphthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Fluorene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 fluorenes	36.70, 30.89	nd, nd	22.16, 23.06	22.96, 29.98	25.36, 29.99	24.73, 26.04	23.21, 30.76
C-3 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzothiophene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 dibenzothiophenes	12.11, 11.75	nd, nd	5.22, nd	5.02, 6.53	5.00, 6.67	5.34, 5.98	5.55, 6.34
C-2 dibenzothiophenes	16.68, 15.38	nd, nd	nd, nd	nd, 5.99	nd, 6.16	nd, nd	nd, 5.92

	Second deployment						
Analyte	Slate Cr. Cove	Cove Pt.	N. Sawmill Cr.	N. Cascade Pt.	Cascade Pt.	S. Cascade Pt.	Echo Cove
C-3 dibenzothiophenes	4.96, 4.93	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Phenanthrene	17.05, 14.53	15.58, 15.91	16.54, 16.38	15.72, 17.48	15.00, 14.79	15.03, 14.53	15.69, 16.60
C-1 phenanthrenes/anthracenes	29.96, 27.49	16.05, 16.25	23.12, 22.75	23.70, 28.56	23.19, 27.51	22.90, 22.92	24.45, 30.86
C-2 phenanthrenes/anthracenes	28.40, 24.64	10.61, 10.48	16.48, 16.11	16.32, 21.59	15.61, 21.73	15.21, 15.68	15.88, 22.60
C-3 phenanthrenes/anthracenes	7.85, 7.52	nd, nd	5.20, 4.37	nd, 6.93	4.59, 7.14	5.05, 4.86	4.44, 7.18
C-4 phenanthrenes/anthracenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Anthracene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	5.7, nd	nd, nd
C-1 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benz-a-anthracene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Chrysene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-1 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-2 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-3 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
C-4 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-b-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-k-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-e-pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-a-pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Perylene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Indeno-123-cd-pyrene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzo-a,h-anthracene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-g,h,i-perylene	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd	nd, nd
	Surrogate recovery[b]						
Naphthalene d-8	85.24, 82.58	87.68, 90.55	81.37, 82.66	80.42, 82.74	80.03, 90.26	75.10, 80.08	84.42, 77.38
Acenaphthene d-10	85.94, 83.11	88.16, 90.63	81.32, 82.10	79.92, 82.73	79.42, 90.44	77.84, 79.75	82.96, 78.00
Phenanthrene d-10	88.77, 87.64	90.83, 95.00	83.01, 83.76	81.94, 84.90	82.21, 93.36	85.01, 84.78	87.73, 85.22
Chrysene d-12	80.29, 80.09	82.96, 90.29	78.92, 77.47	75.45, 84.90	75.16, 89.79	75.67, 78.43	82.08, 77.48
Benzo-a-pyrene d-12	66.46, 67.66	64.35, 80.92	65.40, 60.55	60.63, 69.28	60.26, 77.75	52.13, 58.44	64.08, 63.47
Perylene d-12	71.15, 65.23	68.98, 84.83	73.72, 66.34	66.47, 78.08	64.79, 80.44	55.60, 66.92	70.00, 69.48

[a]TPAH is the sum of all PAH analytes in a sample.

[b]Surrogate recovery is the percentage of a known amount of compound introduced at the beginning of analysis that was recovered at the end of analysis.

Appendix 3. – Concentrations of polynuclear aromatic hydrocarbon (PAH) analytes extracted from polyethylene membrane devices (PEMDs) deployed at two sites in Bridget Cove, Alaska for two 30-day periods. Two PEMDs were deployed at each site (device 1, device 2). Concentrations below instrument minimum detection limits are reported as not detectable (nd).

	First deployment (4/13-5/13, 2004)		Second deployment (7/7-8/4, 2004)	
Analyte	N. Bridget Cove	S. Bridget Cove	N. Bridget Cove	S. Bridget Cove
TPAH[a]	61.11, 5.77	72.77, 87.50	301.68, 288.42	185.85, 212.53
Naphthalene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 naphthalenes	nd, nd	nd, nd	nd, nd	nd, nd
C-2 naphthalenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 naphthalenes	17.52, nd	15.71, 15.06	32.91, 29.85	16.69, 20.03
C-4 naphthalenes	20.12, nd	13.68, 15.77	55.95, 48.16	27.91, 33.37
Biphenyl	nd, nd	nd, nd	nd, nd	nd, nd
Acenaphthylene	nd, nd	nd, nd	nd, nd	nd, nd
Acenaphthene	nd, nd	nd, nd	nd, nd	nd, nd
Fluorene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 fluorenes	nd, nd	nd, nd	18.67, 19.23	nd, nd
C-2 fluorenes	15.39, nd	16.32, 22.53	37.89, 42.44	28.68, 34.31
C-3 fluorenes	nd, nd	nd, nd	15.27, nd	nd, nd
C-4 fluorenes	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzothiophene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 dibenzothiophenes	nd, nd	nd, nd	13.54, 14.35	10.59, 12.55
C-2 dibenzothiophenes	nd, nd	nd, nd	12.63, 13.15	10.18, 12.17
C-3 dibenzothiophenes	nd, nd	nd, nd	6.31, 5.27	nd, nd
C-4 dibenzothiophenes	nd, nd	nd, nd	nd, nd	nd, nd
Phenanthrene	nd, nd	16.94, 16.11	20.67, 21.72	19.52, 20.26
C-1 phenanthrenes/anthracenes	8.09, 5.77	10.12, 12.82	41.43, 46.22	36.14, 40.25
C-2 phenanthrenes/anthracenes	nd, nd	nd, 5.21	33.47, 36.43	26.29, 29.83
C-3 phenanthrenes/anthracenes	nd, nd	nd, nd	12.93, 11.59	9.84, 9.76
C-4 phenanthrenes/anthracenes	nd, nd	nd, nd	nd, nd	nd, nd
Anthracene	nd, nd	nd, nd	nd, nd	nd, nd
Fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd
Pyrene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd
C-2 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd
C-4 fluoranthenes/pyrenes	nd, nd	nd, nd	nd, nd	nd, nd

	First deployment (4/13-5/13, 2004)		Second deployment (7/7-8/4, 2004)	
Analyte	N. Bridget Cove	S. Bridget Cove	N. Bridget Cove	S. Bridget Cove
Benz-a-anthracene	nd, nd	nd, nd	nd, nd	nd, nd
Chrysene	nd, nd	nd, nd	nd, nd	nd, nd
C-1 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
C-2 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
C-3 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
C-4 chrysenes	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-b-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-k-fluoranthene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-e-pyrene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-a-pyrene	nd, nd	nd, nd	nd, nd	nd, nd
Perylene	nd, nd	nd, nd	nd, nd	nd, nd
Indeno-123-cd-pyrene	nd, nd	nd, nd	nd, nd	nd, nd
Dibenzo-a,h-anthracene	nd, nd	nd, nd	nd, nd	nd, nd
Benzo-g,h,i-perylene	nd, nd	nd, nd	nd, nd	nd, nd
	Surrogate recovery[b]			
Naphthalene d-8	79.12, 94.14	89.45, 76.15	88.35, 84.12	88.89, 86.25
Acenaphthene d-10	85.23, 94.75	91.21, 78.49	90.54, 83.27	90.40, 86.05
Phenanthrene d-10	94.79, 104.27	97.77, 90.05	96.83, 87.26	96.39, 90.93
Chrysene d-12	92.92, 101.38	96.55, 88.21	95.06, 82.77	92.82, 84.44
Benzo-a-pyrene d-12	92.11, 91.06	86.21, 76.68	90.37, 65.51	84.81, 69.35
Perylene d-12	93.95, 96.30	86.59, 79.41	89.26, 71.65	85.53, 75.11

[a]TPAH is the sum of all PAH analytes in a sample.

[b]Surrogate recovery is the percentage of a known amount of compound introduced at the beginning of analysis that was recovered at the end of analysis.

Appendix 4. – Concentrations of polynuclear aromatic hydrocarbon (PAH) analytes and alkane hydrocarbon analytes in seawater (ng/l) and sediment (ng/g dry wt) at three locations in Berners Bay (Slate Creek Cove 1, Cascade Point 1, Echo Cove 1) and one in Bridget Cove, Alaska, on 13 May 2004. Concentrations below instrument minimum detection limits are reported as not detectable (nd).

	Seawater PAHs			
PAH analyte	Slate Cr. Cove 1	Cascade Pt. 1	Echo Cove 1	N. Bridget Cove 1
TPAH[a]	nd	nd	nd	nd
Naphthalene	nd	nd	nd	nd
C-1 naphthalene	nd	nd	nd	nd
C-2 naphthalenes	nd	nd	nd	nd
C-3 naphthalenes	nd	nd	nd	nd
C-4 naphthalenes	nd	nd	nd	nd
Biphenyl	nd	nd	nd	nd
Acenaphthylene	nd	nd	nd	nd
Acenaphthene	nd	nd	nd	nd
Fluorene	nd	nd	nd	nd
C-1 fluorenes	nd	nd	nd	nd
C-2 fluorenes	nd	nd	nd	nd
C-3 fluorenes	nd	nd	nd	nd
C-4 fluorenes	nd	nd	nd	nd
Dibenzothiophene	nd	nd	nd	nd
C-1 dibenzothiophenes	nd	nd	nd	nd
C-2 dibenzothiophenes	nd	nd	nd	nd
C-3 dibenzothiophenes	nd	nd	nd	nd
C-4 dibenzothiophenes	nd	nd	nd	nd
Phenanthrene	nd	nd	nd	nd
C-1 phenanthrenes/anthracenes	nd	nd	nd	nd
C-2 phenanthrenes/anthracenes	nd	nd	nd	nd
C-3 phenanthrenes/anthracenes	nd	nd	nd	nd
C-4 phenanthrenes/anthracenes	nd	nd	nd	nd
Anthracene	nd	nd	nd	nd
Fluoranthene	nd	nd	nd	nd
Pyrene	nd	nd	nd	nd
C-1 fluoranthenes/pyrenes	nd	nd	nd	nd
C-2 fluoranthenes/pyrenes	nd	nd	nd	nd
C-3 fluoranthenes/pyrenes	nd	nd	nd	nd
C-4 fluoranthenes/pyrenes	nd	nd	nd	nd

PAH analyte	Seawater PAHs (cont.)--			
	Slate Cr. Cove 1	Cascade Pt. 1	Echo Cove 1	N. Bridget Cove 1
Benz-a-anthracene	nd	nd	nd	nd
Chrysene	nd	nd	nd	nd
C-1 chrysenes	nd	nd	nd	nd
C-2 chrysenes	nd	nd	nd	nd
C-3 chrysenes	nd	nd	nd	nd
C-4 chrysenes	nd	nd	nd	nd
Benzo-b-fluoranthene	nd	nd	nd	nd
Benzo-k-fluoranthene	nd	nd	nd	nd
Benzo-e-pyrene	nd	nd	nd	nd
Benzo-a-pyrene	nd	nd	nd	nd
Perylene	nd	nd	nd	nd
Indeno-123-cd-pyrene	nd	nd	nd	nd
Dibenzo-a,h-anthracene	nd	nd	nd	nd
Benzo-g,h,i-perylene	nd	nd	nd	nd

Alkane analyte	Seawater alkanes			
TAlkane[b]	10.51	232.94	nd	59.81
C10-(n-decane)	nd	nd	nd	nd
C11-(n-undecane)	nd	nd	nd	nd
C12-(n-dodecane)	nd	nd	nd	10.77
C13-(n-tridecane)	nd	nd	nd	nd
C14-(n-tetradecane)	nd	nd	nd	nd
C15-(n-pentadecane)	nd	nd	nd	nd
C16-(n-hexadecane)	nd	nd	nd	nd
C17-(n-heptadecane)	nd	nd	nd	nd
Pristane	nd	232.94	nd	49.04
C18-(n-octadecane)	nd	nd	nd	nd
Phytane	nd	nd	nd	nd
C19-(n-nonadecane)	nd	nd	nd	nd
C20-(n-eicosane)	nd	nd	nd	nd
C21-(n-heneicosane)	nd	nd	nd	nd
C22-(n-docosasne)	nd	nd	nd	nd
C23-(n-tricosane)	nd	nd	nd	nd
C24-(n-tetracosine)	nd	nd	nd	nd
C25-(n-pentacosane)	nd	nd	nd	nd
C26-(n-hexacosane)	nd	nd	nd	nd
C27-(n-heptacosane)	10.51	nd	nd	nd
C28-(n-octacosane)	nd	nd	nd	nd
C29-(n-nonacosane)	nd	nd	nd	nd
C30-(n-triacontane)	nd	nd	nd	nd
C32-(n-dotriacontane)	nd	nd	nd	nd
C34-(n-tetratriacontane)	nd	nd	nd	nd

PAH analyte	Sediment PAHs			
	Slate Cr. Cove 1	Cascade Pt. 1	Echo Cove 1	N. Bridget Cove 1
TPAH[a]	nd	nd	1.97	nd
Naphthalene	nd	nd	nd	nd
C-1 naphthalene	nd	nd	nd	nd
C-2 naphthalenes	nd	nd	nd	nd
C-3 naphthalenes	nd	nd	nd	nd
C-4 naphthalenes	nd	nd	nd	nd
Biphenyl	nd	nd	nd	nd
Acenaphthylene	nd	nd	nd	nd
Acenaphthene	nd	nd	nd	nd
Fluorene	nd	nd	nd	nd
C-1 fluorenes	nd	nd	nd	nd
C-2 fluorenes	nd	nd	nd	nd
C-3 fluorenes	nd	nd	nd	nd
C-4 fluorenes	nd	nd	nd	nd
Dibenzothiophene	nd	nd	nd	nd
C-1 dibenzothiophenes	nd	nd	nd	nd
C-2 dibenzothiophenes	nd	nd	nd	nd
C-3 dibenzothiophenes	nd	nd	nd	nd
C-4 dibenzothiophenes	nd	nd	nd	nd
Phenanthrene	nd	nd	nd	nd
C-1 phenanthrenes/anthracenes	nd	nd	nd	nd
C-2 phenanthrenes/anthracenes	nd	nd	nd	nd
C-3 phenanthrenes/anthracenes	nd	nd	nd	nd
C-4 phenanthrenes/anthracenes	nd	nd	nd	nd
Anthracene	nd	nd	nd	nd
Fluoranthene	nd	nd	nd	nd
Pyrene	nd	nd	nd	nd
C-1 fluoranthenes/pyrenes	nd	nd	nd	nd
C-2 fluoranthenes/pyrenes	nd	nd	nd	nd
C-3 fluoranthenes/pyrenes	nd	nd	nd	nd
C-4 fluoranthenes/pyrenes	nd	nd	nd	nd
Benz-a-anthracene	nd	nd	nd	nd
Chrysene	nd	nd	nd	nd
C-1 chrysenes	nd	nd	nd	nd
C-3 chrysenes	nd	nd	nd	nd
C-4 chrysenes	nd	nd	nd	nd
Benzo-b-fluoranthene	nd	nd	nd	nd
Benzo-k-fluoranthene	nd	nd	nd	nd
Benzo-e-pyrene	nd	nd	nd	nd
C-2 chrysenes	nd	nd	nd	nd
Benzo-a-pyrene	nd	nd	nd	nd
Perylene	nd	nd	1.97	nd

PAH analyte	Sediment PAHs (cont.)-- Slate Cr. Cove 1	Cascade Pt. 1	Echo Cove 1	N. Bridget Cove 1
Indeno-123-cd-pyrene	nd	nd	nd	nd
Dibenzo-a,h-anthracene	nd	nd	nd	nd
Benzo-g,h,i-perylene	nd	nd	nd	nd
Alkane analyte	**Sediment alkanes**			
TAlkane[b]	18.41	265.57	46.62	nd
C10-(n-decane)	nd	nd	nd	nd
C11-(n-undecane)	nd	nd	nd	nd
C12-(n-dodecane)	nd	nd	nd	nd
C13-(n-tridecane)	nd	nd	nd	nd
C14-(n-tetradecane)	nd	nd	nd	nd
C15-(n-pentadecane)	nd	nd	nd	nd
C16-(n-hexadecane)	nd	nd	nd	nd
C17-(n-heptadecane)	nd	33.70	nd	nd
Pristane	nd	170.47	nd	nd
C18-(n-octadecane)	nd	nd	nd	nd
Phytane	nd	nd	nd	nd
C19-(n-nonadecane)	nd	nd	nd	nd
C20-(n-eicosane)	nd	nd	nd	nd
C21-(n-heneicosane)	nd	nd	nd	nd
C22-(n-docosane)	nd	nd	nd	nd
C23-(n-tricosane)	nd	nd	nd	nd
C24-(n-tetracosine)	nd	nd	nd	nd
C25-(n-pentacosane)	nd	14.33	nd	nd
C26-(n-hexacosane)	nd	nd	nd	nd
C27-(n-heptacosane)	nd	26.74	23.94	nd
C28-(n-octacosane)	nd	nd	nd	nd
C29-(n-nonacosane)	18.41	20.33	22.68	nd
C30-(n-triacontane)	nd	nd	nd	nd
C32-(n-dotriacontane)	nd	nd	nd	nd
C34-(n-tetratriacontane)	nd	nd	nd	nd

[a]TPAH is the sum of all PAHs in a sample.

[b]TAlkanes is the sum of all alkanes, but does not include non-calibrated alkanes or unidentified alkane mixtures.

Appendix 5. – Concentrations (ng/g dry wt) of polynuclear aromatic hydrocarbon (PAH) analytes and alkane hydrocarbon analytes in blue mussel (*Mytilus trossulus*) tissue at three locations in Berners Bay (Slate Creek Cove 1, Cascade Point 1, Echo Cove 1) and one in Bridget Cove on May 13, 2004. Duplicate mussel samples were analyzed from Cascade Point 1 and Echo Cove 1 (replicate 1, replicate 2). Concentrations below instrument minimum detection limits are reported as not detectable (nd).

	PAHs			
PAH analyte	Slate Cr. Cove 1	Cascade Pt. 1	Echo Cove 1	N. Bridget Cove 1
TPAH[a]	13.70	nd, nd	nd, nd	5.03
Naphthalene	nd	nd, nd	nd, nd	nd
C-1 naphthalene	nd	nd, nd	nd, nd	nd
C-2 naphthalenes	13.70	nd, nd	nd, nd	5.03
C-3 naphthalenes	nd	nd, nd	nd, nd	nd
C-4 naphthalenes	nd	nd, nd	nd, nd	nd
Biphenyl	nd	nd, nd	nd, nd	nd
Acenaphthylene	nd	nd, nd	nd, nd	nd
Acenaphthene	nd	nd, nd	nd, nd	nd
Fluorene	nd	nd, nd	nd, nd	nd
C-1 fluorenes	nd	nd, nd	nd, nd	nd
C-2 fluorenes	nd	nd, nd	nd, nd	nd
C-3 fluorenes	nd	nd, nd	nd, nd	nd
C-4 fluorenes	nd	nd, nd	nd, nd	nd
Dibenzothiophene	nd	nd, nd	nd, nd	nd
C-1 dibenzothiophenes	nd	nd, nd	nd, nd	nd
C-2 dibenzothiophenes	nd	nd, nd	nd, nd	nd
C-3 dibenzothiophenes	nd	nd, nd	nd, nd	nd
C-4 dibenzothiophenes	nd	nd, nd	nd, nd	nd
Phenanthrene	nd	nd, nd	nd, nd	nd
C-1 phenanthrenes/anthracenes	nd	nd, nd	nd, nd	nd
C-2 phenanthrenes/anthracenes	nd	nd, nd	nd, nd	nd
C-3 phenanthrenes/anthracenes	nd	nd, nd	nd, nd	nd
C-4 phenanthrenes/anthracenes	nd	nd, nd	nd, nd	nd
Anthracene	nd	nd, nd	nd, nd	nd
Fluoranthene	nd	nd, nd	nd, nd	nd
Pyrene	nd	nd, nd	nd, nd	nd
C-1 fluoranthenes/pyrenes	nd	nd, nd	nd, nd	nd
C-2 fluoranthenes/pyrenes	nd	nd, nd	nd, nd	nd
C-3 fluoranthenes/pyrenes	nd	nd, nd	nd, nd	nd

PAH analyte	PAHs (cont.)-- Slate Cr. Cove 1	Cascade Pt. 1	Echo Cove 1	N. Bridget Cove 1
C-4 fluoranthenes/pyrenes	nd	nd, nd	nd, nd	nd
Benz-a-anthracene	nd	nd, nd	nd, nd	nd
Chrysene	nd	nd, nd	nd, nd	nd
C-1 chrysenes	nd	nd, nd	nd, nd	nd
C-2 chrysenes	nd	nd, nd	nd, nd	nd
C-3 chrysenes	nd	nd, nd	nd, nd	nd
C-4 chrysenes	nd	nd, nd	nd, nd	nd
Benzo-b-fluoranthene	nd	nd, nd	nd, nd	nd
Benzo-k-fluoranthene	nd	nd, nd	nd, nd	nd
Benzo-e-pyrene	nd	nd, nd	nd, nd	nd
Benzo-a-pyrene	nd	nd, nd	nd, nd	nd
Perylene	nd	nd, nd	nd, nd	nd
Indeno-123-cd-pyrene	nd	nd, nd	nd, nd	nd
Dibenzo-a,h-anthracene	nd	nd, nd	nd, nd	nd
Benzo-g,h,i-perylene	nd	nd, nd	nd, nd	nd

Alkane analyte	Alkanes			
TAlkane[b]	1406.08	1852.15, 17001.76	7736.04, 8205.51	2689.33
C10-(n-decane)	nd	nd, nd	nd, nd	nd
C11-(n-undecane)	nd	nd, nd	nd, nd	nd
C12-(n-dodecane)	nd	nd, nd	nd, nd	nd
C13-(n-tridecane)	nd	nd, nd	nd, nd	nd
C14-(n-tetradecane)	nd	nd, nd	nd, nd	nd
C15-(n-pentadecane)	nd	nd, nd	nd, nd	nd
C16-(n-hexadecane)	nd	nd, 1589.49	nd, nd	nd
C17-(n-heptadecane)	nd	148.26,1537.28	2214.98,2600.34	139.44
Pristane	101.28	1557.99, 13597.68	5521.06, 5605.17	2373.01
C18-(n-octadecane)	nd	nd, nd	nd, nd	nd
Phytane	nd	nd, nd	nd, nd	nd
C19-(n-nonadecane)	nd	nd, nd	nd, nd	nd
C20-(n-eicosane)	nd	nd, nd	nd, nd	nd
C21-(n-heneicosane)	nd	nd, nd	nd, nd	nd
C22-(n-docosasne)	nd	nd, nd	nd, nd	nd
C23-(n-tricosane)	nd	nd, nd	nd, nd	nd
C24-(n-tetracosine)	nd	nd, nd	nd, nd	nd
C25-(n-pentacosane)	6.63	nd, 277.32	nd, nd	nd
C26-(n-hexacosane)	8.75	nd, nd	nd, nd	nd
C27-(n-heptacosane)	9.51	nd, nd	nd, nd	nd
C28-(n-octacosane)	15.42	nd, nd	nd, nd	nd
C29-(n-nonacosane)	nd	145.91, nd	nd, nd	176.88
C30-(n-triacontane)	nd	nd, nd	nd, nd	nd
C32-(n-dotriacontane)	nd	nd, nd	nd, nd	nd
C34-(n-tetratriacontane)	nd	nd, nd	nd, nd	nd

[a]TPAH is the sum of all PAHs in a sample.

[b]TAlkanes is the sum of all alkanes, but does not include non-calibrated alkanes or unidentified alkane mixtures.