Final Report for CIRCAC Intertidal Reconnaissance Survey in Upper Cook Inlet

Prepared for

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In memory of Papa Charlie Chuck Rediske,

Pilot, guide, and companion extraordinaire

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I. Introduction

An intertidal reconnaissance was conducted in upper Cook Inlet from 26 August to 1 September 2000 for the Cook Inlet Regional Citizens Advisory Council. During that period, we visited 24 sites in the upper inlet. These extended, on the west side of the inlet, from Chisik Island to the Beluga River, and, on the east side, from Clam Gulch to Chickaloon Bay. In the middle of the inlet, sites were visited from a shoal south of Kalgin Island to a shoal north north of the island and included four sites on the island. An additional site, Middle Ground Shoal, flooded by tide at the time of the initial survey attempt, was surveyed by CIRCAC staff on 29 September 2000.

A. Purpose of the Survey

The CIRCAC Environmental Monitoring Committee (EMC), created in response to the Oil Pollution Act of 1990, initiated several environmental studies between 1993 and 1997 as part of the overall Environmental Monitoring Program (EMP). The major objective of the EMP has been to determine if oil-industry operations in Cook Inlet are having adverse effects on the surrounding ecosystem. If such impacts were detected, these studies were also intended to document the sources and magnitude of the impacts and spatial and temporal trends.

To evaluate the influence of oil-industry operations in Cook Inlet, as determined by CIRCAC's EMP, Littoral Ecological & Environmental Services (LEES) conducted an extensive review of the database and summarized the findings (Lees et al. 1999). The goals of this analysis were to:

- Summarize, analyze, and synthesize a large portion of the existing data, including NPDES permits and reports;
- Evaluate the methods and approaches employed during the EMP;
- Determine the value of the existing database(s) for establishing baseline conditions; and
- Provide recommendations to CIRCAC regarding the design of further monitoring efforts to assess oil-related impacts to the ecosystems in Cook Inlet.

Based on these analyses, a dispersion modeling study, and the summary, LEES recommended a few modifications to CIRCAC' approach to monitoring the oil-industry operations in Cook Inlet. One of these recommendations was that CIRCAC should concentrate their monitoring efforts in intertidal habitats in regions closer to the oil production facilities in upper Cook Inlet. As part of this recommendation, LEES noted

that the biota of intertidal habitats in the middle and upper inlet and locations supporting potential sentinel organisms for monitoring effects of oil-industry operations were very poorly known and recommended conduct of a reconnaissance survey to fill these data gaps.

These data gaps were a major focus of this reconnaissance program. We placed emphasis on identifying populations of potential sentinel organisms that are large enough to support reliable and periodic monitoring to assess contamination from oil-industry operations.

B. Survey Objectives

1. Intertidal Ecology

The ecological objectives of this program were to:

- Provide general descriptions of the species composition and distribution of the intertidal biota at each site that was visited during this reconnaissance; and
- Identify populations of clams that could be utilized as sentinel species in either the long-term monitoring program for oil-industry operations or in the event of a catastrophic spill.

2. Coastal Geomorphology

The geomorphological objectives of this program were to:

- Provide site-specific geomorphological assessments of the various sites that are visited during this reconnaissance;
- Integrate the biological and geomorphological characterizations to provide a better understanding of the processes affecting intertidal communities.

3. Sediments

The objectives of the sediment collection element of the reconnaissance were to provide:

- Descriptions of particle grain size, Total Organic Carbon (TOC) and Total Kjeldahl Nitrogen (TKN); and
- Sediment samples for analysis of Polynuclear Aromatic Hydrocarbons (PAH) and aliphatic hydrocarbons.

4. Tissues

The objective of the tissue collection element of the reconnaissance was to provide insight into PAH and aliphatic hydrocarbons contamination in potential sentinel clams.

C. Survey Area and Sites Examined

The 25 sites examined during the intertidal reconnaissance survey are listed in Table 1-1. The general region and the specific location of each of these sites is indicated in Table 1-1 and Figure 1-1. Eleven sites were examined on the west side of the inlet, 8 sites in the middle of the inlet, and 6 sites on the east side of the inlet.

D. Logistics

As mentioned above, three modes of transportation were utilized to access survey sites. Where the road network permitted on the east side of the inlet, we accessed the selected sites by vehicle. Three sites on the east side of the inlet were accessed by wheeled vehicle.

Where beach landings were feasible for a light fixed-wing aircraft, we accessed the selected sites in a Cessna 207 chartered from the late Mr. Chuck (Papa Charlie) Rediske, Rediske Air. Eight sites (three in the middle and five on the west side of the inlet) were accessed in the Cessna 207.

Where neither of the other modes was feasible, we accessed the selected sites by rotary-wing aircraft. We traveled in a Bell Long Ranger (L-1) from Kenai Air, piloted by Mr. Larry Rogers. Fourteen sites (three on the east side, five in the middle, and six on the west side) were accessed by helicopter.

Table 1-1. Sites visited in during intertidal reconnaissance survey in upper Cook Inlet, August – September, 2000.

Location	GPS Coordinates	Location	GPS Coordinates
East Side of Inlet (6 sites)			
Clam Gulch*	N60° 13.796’ W151° 24.402’	Kalifornsky Beach*	N60° 25.869’ W151° 17.235’
Boulder Point**	N60° 46.383’ W151° 15.498’	Bishop Beach*	N60° 47.112’ W151° 04.645’
Moose Point**	N60° 57.145’ W150° 41.493’	Chickaloon Bay**	N60° 56.347’ W150° 14.943’
Middle of Inlet (8 sites)			
Shoal S. of Kalgin Island**	N60° 16.435’ W152° 01.971’	1.25 nm SW of SE point of Kalgin Island (Tripod Beach)***	N60° 21.742’ W151° 58.727’
NW corner of Oldmans Bay, Kalgin Island**	N60° 23.986’ W152° 00.883’	Shoal W. of Kalgin Island**	N60° 26.758’ W152° 04.379’
NE corner of Kalgin	N60° 28.982’	NW corner of Kalgin	N60° 30.632’

Island (Light Point)***	W151° 50.173’	Island***	W151° 54.994’
Shoal N. of Kalgin Island**	N60° 36.828’ W151° 49. 937’	Middle Ground Shoal**	N60° W151° 20

West Side of Inlet (11 sites)

NE Chisik Island***	N60° 10.958’ W152° 07.018’	North Tuxedni Bay***	N60° 13.249’ W152° 36.893’
Polly Creek***	N60° 16.569’ W152° 28.058’	No-name Creek***	N60° 21.386’ W152° 21.347’
Redoubt Creek Beach**	N60° 22.048’ W152° 18.427’	Harriet Point North**	N60° 23.908’ W152° 14.525’
Old Cannery Creek, 1.25 nm SW of Drift River**	N60° 34.634 W152° 10.059’	West Foreland South**	N60° 43.486’ W151° 46.229’
West Foreland North**	N60° 47.719’ W151° 45.710’	Nikolai Creek***	N61° 00.661’ W151° 26.034’
Beluga River SW**	N61° 7.728’ W151° 04.938’		

*Wheeled vehicle

**Helicopter

*** Light fixed-wing aircraft

Figure 1-1. Approximate locations for sites visited during August/September 2000 intertidal reconnaissance in upper Cook Inlet.

II. Methods and Materials

A. Physical Variables

The physical variable examined in this report and discussed in section include: station location and description; intertidal elevations; and sediment characteristics.

1. Station Location and Description

The preliminary site descriptions include discussions of the beach profiles as measured along an established transect, distribution of substrate types, and some biological information, especially information on the occurrences of potential sentinel species. The geomorphological features are relatively stable and therefore described in the present tense. The biological assemblages are less stable and are therefore described in the past tense. In some cases, the beach profile information extends beyond the limits of the transect. Transects were established to cover the portion of a site where samples were collected. We focused on the upper portions of the beaches for two reasons. First, those areas have a greater likelihood of exposure than lower zones during a major event. Second, the upper intertidal zones are easier to sample than lower zones and the period of emersion is greater and many can be accessed during neap as well as spring tides.

2. Intertidal Elevations

Elevations of various features or activities during these intertidal surveys were measured approximately down the beach from the level of the previous high tide wrack line. The elevation of the wrack line was estimated for each specific site based on the difference in predicted high-tide levels of the previous high tide at the nearest sites north and south of the study site and the proportion of the total distance between the predicted sites the measured site is from the southern predicted site. No effort was made to account for east-west offsets in the times or elevations.

The estimated level of the most recent flood tide and the low tide during which the survey was conducted are contained in Table 2-1. These estimates are used to estimate the tidal range experienced by the site on the day of the survey. This range provides a conservative notion of the larger tidal ranges experienced by the sites examined and the surrounding areas.

Table 2-1. Estimated level of most recent high and low tides* around surveys for specified locations and dates.

Region/Location	Date	Estimated Elevation of Most Recent High Tide (feet above MLLW)*	Estimated Elevation of Most Recent Low Tide (relative to MLLW)*	Estimated Tide Range (feet) During Survey
East Side of Cook Inlet				
Clam Gulch	8/26/00	19.3	-0.2	19.5
Kalifornsky Beach	8/27/00	21.6	-1.7	23.3
Boulder Point	8/29/00	25.4	-3.7	29.0
Bishop's Beach	8/27/00	25.0	-1.9	26.9
Moose Point	8/29/00	28.1	-4.0	32.1
Chickaloon Bay, SW corner	8/29/00	29.6	-4.1	33.7
Middle of Cook Inlet				
SE end of Kalgin	8/28/00	20.2	-3.8	24.0
Oldmans Bay, Kalgin Is.	9/1/00	20.6	-2.0	22.6
NW corner of Kalgin	8/31/00	22.0	-3.9	25.8
NE corner of Kalgin	8/28/00	20.7	-4.1	24.7
West Side of Cook Inlet				
NE corner of Chisik Island	8/28/00	19.3	-3.4	22.7
North Tuxedni Bay	8/31/00	21.0	-3.4	24.4
Redoubt Creek Beach	9/1/00	20.2	-1.9	22.1
Harriet Point North	8/30/00	21.8	-4.5	26.3
Old Cannery Creek	9/1/00	21.1	-2.2	23.2
West Foreland South	9/1/00	22.3	-2.1	24.4
West Foreland North	8/30/00	22.3	-4.7	27.0
Nikolai Creek	8/28/00	24.0	-3.9	28.0
Beluga River SW	8/30/00	26.0	-4.5	30.5

* Based on most recent flood and ebb tide levels predicted by Shio software (Anon. 1996) at points north and south of site and proportion of distance of specified site between predicted points

At sites where elevations were estimated, a transect line was laid from the wrack line perpendicularly across the beach toward the water line. A sight level was used to establish the elevation drop on a vertically oriented stadia rod. The position of the stadia

rod on the transect and the vertical drop were recorded for each measurement. Measurements were taken at each point where the slope of the beach or substrate type changed markedly. These data were used to construct the topographic profiles included in the physical description for most sites.

3. Sediment Characteristics

Sediment samples were collected at each site to permit analysis of the physical and chemical characteristics of the beach sediments. Approximately 500 g of sediment were placed in labeled clean glass jars. We collected up to three replicate samples at each location. These were collected in finer material below the base of the beachface at the same elevation at which infaunal and hydrocarbon samples were collected.

These samples were used to analyze for: 1) particle grain size (PGS), 2) TOC, TKN, 3) and polynuclear aromatic hydrocarbons (PAH), saturated aliphatic hydrocarbons (SHC), and steranes/triterpanes (S/T). Particle grain size distributions were determined using the ASTM 422 methodology. Sieve sizes employed were #4 (4.76 mm), #10 (2.0 mm), #20 (0.84 mm), #40 (0.42 mm), #60 (0.25 mm), #140 (0.105 mm), and #200 (0.74 mm). All sediment passing through the #200 sieve was classified as silt/clay. Phi equivalents used for determining the parametric values for sediments from each location were based on the equation,

$$\Phi = - \log_{(\text{base } 2)} (\text{sieve mesh size in mm}).$$

The numbers used in the tables and figures are based on analysis of two replicates from each site.

Estimates for the concentration of the organic constituents in the sediment were based on a single analysis for each site. TOC was analyzed using the ASTM 9060 protocol. TKN was determined by the ASTM 351.2 protocol in a semi-automated mode.

B. Biological Variables

1. Macrofauna

The major epibiotic and infaunal macrofaunal organisms at each site were identified by visual observation. Abundance of these organisms was estimated visually either on a relative basis or by enumeration in replicated 0.25 sq. m. quadrats. In the case of large clams such as razor clams, softshell clams, or Baltic macomas (called mud clams herein), estimates were based on counts of their specific surficial “shows”. In the case of razor clams, these “shows” are dimples in the sand that filled with water or retraced in response to stomping on the sand following placement of each quadrat. In the case of softshell clams, these “shows” are elongate narrow-waisted openings in the surface of the mud. In the case of the mud clams (Baltic macoma), the “shows” are either long meandering or starburst tracks in the mud.

Where abundance of algae or barnacles was evaluated, it was visually estimated as percent cover in the quadrats or as a qualitative description of overall cover in the habitat (Sparse, Moderate, or Abundant).

2. Infauna

Infaunal assemblages were described on the basis of core samples of sediment collected at most appropriate sites. The core sampler is a standard 10-cm diameter "clam gun". In areas where sediments were sufficiently loose to permit easy penetration, the length of the core samples was 15 cm. At many of the sites, however, the sediment contained considerable quantities of very fine particles or glacial flour and was therefore very compacted and cohesive. At such sites, it was difficult to force the core 15 cm into the sediment. Moreover, most of the infaunal organisms, other than those that could be enumerated in quadrats based on their "shows", were located in the upper few centimeters of sediment. Consequently, at most sites with this type of sediment, we collected five 3-cm long sections per replicate core sample. This provided increased accuracy in estimation of the abundance of the infaunal organisms at these sites. This approach was also employed at several sandy sites where preliminary digging indicated that the infaunal assemblages were impoverished (e.g., on the shoals in the middle of the inlet). The intent was to increase the surface area of each composited replicate sample.

Following collection, the samples were sieved on 1.0-mm sieves, and fixed with 10-percent buffered seawater-formalin solution in labeled bags. The samples were subsequently washed and preserved in an isopropyl alcohol solution. The samples were sorted and submitted to appropriate taxonomic specialists for identification and enumeration.

C. Chemical Variables

Samples were collected for several types of analyses for hydrocarbons in sediments, tissues, and suspected source materials, including Cook Inlet crude oil, coal particles collected from several intertidal locations, and eroded peat collected from Captain Cook State Park. All samples were frozen the day of collection and shipped in insulated coolers in three batches via overnight courier to the Woods Hole Group Environmental Laboratories in Raynham, MA. The Woods Hole Group Environmental Laboratories were responsible for all chemical analyses completed in the program. All shipments were completed under full chain-of-custody using proprietary electronic and hard copy chain-of-custody protocols. Upon receipt at the laboratory, all samples were inspected for temperature, breakage, and general condition, and sample labels and Chain-of-Custody/Analysis Request Forms were reconciled. All samples were received intact by the laboratory.

1. Sample Selection and Target Analytes

Upon receipt at the Woods Hole Group Environmental Laboratories, all sediment, tissue, and source-characterization (coal and eroded peat) samples were frozen and archived under full chain-of-custody until decisions regarding selection of individual samples for

hydrocarbon analyses could be made by CIRCAC and project team personnel. At that time, aliquots for TKN, PGS, and TOC determinations were removed from the selected sediment samples, and the remaining material was subjected to detailed PAH, SHC, and S/T analyses. All sediment samples were analyzed in duplicate for PAH and SHC; however, due to budget constraints, only one replicate was analyzed for S/T. Likewise, after the decisions regarding tissue sample selection were made, the samples were thawed, dissected, homogenized, and analyzed for PAH and SHC. No S/T analyses were undertaken on the tissue samples. Table 2-2 lists the selected analytes (PAH, SHC, and S/T) targeted for analyses in the program. The table also lists the abbreviations used to denote each analyte in all the histograms, graphics, and figures presented in this report.

In the Technical Evaluation of the Environmental Monitoring Program (EMP) report prepared by Lees et al. (1999), we presented a lengthy and detailed discussion concerning the fact that both of the laboratories previously used in the EMP had had occasional problems with laboratory blanks, and that electronic noise associated with the GC/MS selected ion monitoring (SIM) analyses at one lab caused some problems with low-concentration-level tissues and sediments. As a result, one laboratory consistently eliminated naphthalene from its database in determining total PAH (TPAH), and the other laboratory occasionally reported anomalously high values for TPAH because of the electronic noise problem in samples with high method detection limits (MDLs). Naphthalene was included in the overall database generated for CIRCAC by Lees et al. (1999) to generate a compatible database from the two laboratories that had been involved in the program. As a result, it makes up part of the TPAH reported with all the histograms by Lees et al. (1999). Fortunately, the Woods Hole Group Laboratories have not had any problems with naphthalene contamination in their procedural blanks, and they have not been plagued with the SIM GC/MS instrumental noise problem that contributed to the anomalously high TPAH values previously reported in the EMP. As a result, naphthalene is included in the target analyte list and, as will be discussed later, it is

Table 2-2. Target analytes and abbreviation designators used in figures in this report.

Polynuclear Aromatic Hydrocarbons (PAH)		**Saturated Hydrocarbons (SHC)**		**Steranes/Triterpanes (S/T)**	
Name	*Abbre.*	*Name*	*Abbre.*	*Name*	*Abbre.*
Naphthalene	N	n-Octane (C8)	C8	5a,14B,17B-pregnane	S/T1
C1-Naphthalenes	N1	n-Nonane (C9)	C9	5a,14B,17B,20-methylpregnane	S/T2
C2-Naphthalenes	N2	n-Decane (C10)	C10	13B,17a-diacholestane(20S)	S/T3
C3-Naphthalenes	N3	n-Undecane (C11)	C11	13B,17a-diacholestane(20R)	S/T4
C4-Naphthalenes	N4	n-Dodecane (C12)	C12	5a,14B,17B-cholestane(20R)	S/T5
Biphenyl	BI	n-Tridecane (C13)	C13	5a,14B,17B-cholestane(20S)	S/T6
Acenaphthylene	AC	n-Tetradecane (C14)	C14	5a,14B,17B,24-methylcholestane(20R)	S/T7
Acenaphthene	AE	n-Pentadecane (C15)	C15	5a,14B,17B,24-methylcholestane(20S)	S/T8
Fluorene	F	n-Hexadecane (C16)	C16	5a,14a,17a,24-ethylcholestane(20S)	S/T9
C1-Fluorenes	F1	n-Heptadecane (C17)	C17	5a,14B,17B,24-ethylcholestane(20R)	S/T10
C2-Fluorenes	F2	Pristane	Pristane	5a,14B,17B,24-ethylcholestane(20S)	S/T11
C3-Fluorenes	F3	n-Octadecane (C18)	C18	5a,14a,17a,24-ethylcholestane(20R)	S/T12
Dibenzothiophene	D	Phytane	Phytane	C20 Diterpane	S/T13
C1-Dibenzothiophenes	D1	n-Nonadecane (C19)	C19	C21 Diterpane	S/T14
C2-Dibenzothiophenes	D2	n-Eicosane (C20)	C20	C22 Diterpane	S/T15
C3-Dibenzothiophenes	D3	n-Heneicosane (C21)	C21	C23 Diterpane	S/T16
C4-Dibenzothiophenes	D4	n-Docosane (C22)	C22	C24 Diterpane	S/T17
Anthracene	A	n-Tricosane (C23)	C23	C25 Diterpane	S/T18
Phenanthrene	P	n-Tetracosane (C24)	C24	C24 Tetracyclic Terpane	S/T19
C1-Phenanthrenes/Anthracenes	P/A1	n-Pentacosane (C25)	C25	C26 Tricyclic Terpane (1)	S/T20
C2-Phenanthrenes/Anthracenes	P/A2	n-Hexacosane (C26)	C26	C26 Tricyclic Terpane (2)	S/T21
C3-Phenanthrenes/Anthracenes	P/A3	n-Heptacosane (C27)	C27	C28 Tricyclic Triterpane (1)	S/T22
C4-Phenanthrenes/Anthracenes	P/A4	n-Octacosane (C28)	C28	C28 Tricyclic Triterpane (2)	S/T23
Fluoranthene	FL	n-Nonacosane (C29)	C29	C29 Tricyclic Triterpane (1)	S/T24
Pyrene	PYR	n-Triacontane (C30)	C30	C29 Tricyclic Triterpane (2)	S/T25
C1-Fluoranthenes/Pyrenes	F/P1	n-Hentriacontane (C31)	C31	18a(H)-22,29,30-trisnorhopane(Ts)	S/T26
C2-Fluoranthenes/Pyrenes	F/P2	n-Dotriacontane (C32)	C32	17a(H)-22,29,30-trisnorhopane(Tm)	S/T27
C3-Fluoranthenes/Pyrenes	F/P3	n-Tritriacontane (C33)	C33	17B(H)-22,29,30-trisnorhopane	S/T28
C4-Fluoranthenes/Pyrenes	F/P4	n-Tetratriacontane (C34)	C34	17a(H),21B(H)-22,29,30-bisnorhopane	S/T29
Benzo(a)anthracene	BA	n-Pentatriacontane (C35)	C35	17a(H),21B(H)-30-norhopane	S/T30
Chrysene	C	n-Hexatriacontane (C36)	C36	18a(H)-30-Neonorhopane	S/T31
C1-Chrysenes	C1	n-Heptatriacontane (C37)	C37	17B(H),21a(H)-normoretane	S/T32
C2-Chrysenes	C2	n-Octatriacontane (C38)	C38	18a(H)-oleanane	S/T33
C3-Chrysenes	C3	n-Nonatriacontane (C39)	C39	17a(H),21B(H)-hopane - C30H52	S/T34
C4-Chrysenes	C4	n-Tetracontane (C40)	C40	17B(H),21a(H)-moretane	S/T35
Benzo(b)fluoranthene	BB			22S-17a(H),21B(H)-30-homohopane	S/T36
Benzo(k)fluoranthene	BK			22R-17a(H),21B(H)-30-homohopane	S/T37
Benzo(e)pyrene	BEP			17B(H),21B(H)-hopane	S/T38
Benzo(a)pyrene	BAP			17B(H),21a(H)-homomoretane	S/T39
Perylene	PER			Hop-22(29)-ene(diploptene)	S/T40
Indeno(1,2,3-cd)pyrene	IP			22S-17a(H),21B(H)-30-bishomohopane	S/T41
Dibenzo(a,h)anthracene	DA			22R-17a(H),21B(H)-30-bishomohopane	S/T42
Benzo(g,h,i)perylene	BP			17B(H),21a(H)-bishomomoretane	S/T43
				17B(H),21B(H)-30-homohopane	S/T44
				22S-17a(H),21B(H)-trishomohopane	S/T45
				22R-17a(H),21B(H)-trishomohopane	S/T46
				22S-17a(H),21B(H)-tetrakishomohopane	S/T47
				22R-17a(H),21B(H)-tetrakishomohopane	S/T48
				22S-17a(H),21B(H)-pentakishomohopane	S/T49
				22R-17a(H),21B(H)-pentakishomohopane	S/T50

an important PAH component in several of the sediment and tissue samples considered in the program.

In the previous CIRCAC Environmental Monitoring Programs, perylene was consistently omitted from the TPAH values reported for each study. This has been a common practice among hydrocarbon geochemists because perylene had been largely attributed to biological sources, and it is not a major component in petroleum (LaFlamme and Hites, 1978; Wakeman et al., 1980; Venkatesan, 1988). As discussed in detail by Lees et al. (1999); however, perylene is a major component in the relatively young and immature coal deposits that surround much of Cook Inlet. It was widely observed in most of the sediment samples examined in the EMP, and Lees et al. recommended that in future studies it should be reported in the text/table narratives and not just buried in the database. In this program, we have included both naphthalene and perylene in calculating TPAH to assist in tracing coal- and peat-derived signals in sediment and (to a lesser extent) tissue samples.

2. Laboratory Methods

The selected sediment, tissue, coal, and eroded peat samples were analyzed by the Woods Hole Group Environmental Laboratories using their standard operating procedures (SOPs) developed for NOAA National Status & Trends type applications and petroleum hydrocarbon studies. In this regard, the analytical methods were essentially identical to the previous EMP programs where similar NOAA National Status & Trends based procedures were employed.

Sediment, coal, and eroded peat samples were extracted using pressurized fluid extraction, and extracts were dried over sodium sulfate, concentrated, and then cleaned for sulfur content and polar organic compounds using activated copper and aminopropyl gel or deactivated alumina. Tissue samples were dissected, homogenized, and extracted using pressurized fluid extraction, and extracts were dried over sodium sulfate, concentrated, and subjected to silica gel fractionation for the removal of polar materials (fats and lipids). The aliphatic (F1) and aromatic (F2) fractions were then recombined, concentrated, and further analyzed by flame ionization detector gas chromatography (FID/GC) and selected ion monitoring GC/MS as described below.

Cleaned extracts were spiked with an internal standard and analyzed for SHC by FID/GC following modified EPA Method 8100. Extracts were also analyzed for the alkylated homologue series of PAHs and S/Ts following the Woods Hole Group Standard Operating Procedure *Analysis of Parent and Alkylated PAHs and Selected Heterocyclic Compounds by Gas Chromatography/Mass Spectrometry with Selected Ion Monitoring (Revision #1)*. Alaska North Slope crude oil and/or Cook Inlet crude oil were analyzed as part of each analysis run sequence to provide compositional reference alkylated PAH patterns.

In all cases, a minimum of 20 g (wet weight) sediment was extracted, however, limited numbers of certain organisms (Macoma balthica) at several sites resulted in slightly smaller sample sizes (generally 10-15 g wet weight, and 3.8 g on one occasion). To aid in graphical presentations and data analyses, sample-size dependent method detection limits (MDLs) are depicted on each plot to optimally convey relative abundance data for different alkylated PAH homologues, individual n-alkanes (plus pristane and phytane), and steranes and triterpanes observed in the samples.

3. Data Analysis and Quality Assurance/Quality Control

As each set of analyses was completed, the Woods Hole Group Environmental Laboratories provided electronic data deliverables (EDDs) as Y2K-compliant Excel files in addition to hardcopy reports. The EDDs were electronically transmitted to both Dr. Payne and Mr. Driskell for initial QA/QC review of data completeness, comparability, and compliance with laboratory QC protocols for precision and accuracy (acceptable surrogate recoveries, method detection limits, matrix spike and matrix spike duplicate (MS & MSD) analyses, standard reference material (SRM) and continuing calibration check sample analyses, acceptable laboratory method blanks, etc.). The hard copy reports and copies of FID/GC chromatograms were sent only to Dr. Payne for evaluation of integration procedures for Total Resolved Constituent (TRC) determinations and general overall GC profile analyses and interpretation. Mr. Driskell was responsible for incorporating all the data into a stand-alone database for data manipulation and developing the plotting routines (visual basic programs) used for pattern recognition analyses and the graphics presented in this report. Table 2-3 summarizes several other analytical chemistry descriptors used in the report along with a listing of the analytical method and data reduction required to generate the data.

Table 2-3. Other analytical chemistry descriptors used in this report.

Chemistry Descriptor	Analytical Method and Data Reduction	Abbreviation
Total n-Alkanes	Sum of specific C8-C40 n-alkanes from FID/GC	TALK
Total Resolved Constituents	Sum of all peaks from FID/GC	TRC
Total Petroleum Hydrocarbons	Sum of all peaks from FID/GC plus UCM	TPH
Total Polynuclear Aromatic Hydrocarbons	Sum of PAH[1] from Selected Ion Monitoring GC/MS	TPAH
Total Kjeldahl Nitrogen	ASTM 351.2 Protocol in semi-automated mode	TKN
Total Organic Carbon	ASTM 9060 Protocol	TOC
Particle Grain Size Analysis	ASTM 422 Method -- Sieve Analysis	PGS

Note 1: Includes naphthalene and perylene in the total.

D. Statistical Analysis

The biological data sets submitted to statistical analyses include observational macroinfaunal data and the infaunal cores. The infaunal core data were quantitative (counts of individuals of each species by replicate) while the macroinfauna observations were either quantitative (counts from quadrats) or semi-quantitative (none, sparse,

common, abundant). Both were sparse data sets (many table entries were empty). Because of the reconnaissance nature of this program, inferential testing was neither required nor employed, i.e., no hypotheses were established to test. Instead, the statistical approach for both data sets was to make the appropriate data transform and then simply run cluster analyses to look for distribution patterns. The core data were log (n+1) transformed; the macroinfaunal observations became dummy values, 0-3, corresponding to none, sparse, common, abundant, respectively.

For the quantitative cores, the data set was reduced to eliminate the "noise" species that occurred at only one or two stations. For both the cores and the macroinfauna data, two data matrices were constructed for each data set: one approach transformed the data into a Jaccard presence/absence data matrix, and the other approach produced a Bray-Curtis dissimilarity matrix. Each matrix was then clustered twice (once for station clusters and then separately for species clusters) using an unweighted, group-average, agglomerative hierarchical clustering algorithm. The Simclust software package from National Marine Fisheries Service was used for all analyses.

Following clustering, the resulting dendrogram graphs were interpreted for distribution patterns or groupings. Group membership implies a commonality with the fellow members, either with stations with similar species composition or with species that tended to co-occur. Hence, rearranging the station/species abundance table to reflect the cluster groupings facilitates finding the underlying common structure of the group. The final interpretations are made using additional data such as species richness, knowledge of individual species behavior, particle grain size, beach exposure, or other geographic factors.

Several sediment variables were subjected to regression analysis to assess the strength of relationships among them. These included median particle grain size, TOC, TKN, C:N ratios, and TPAH.