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Fate of Spilled Oil in Prince William Sound: Diary of a Forensic Geology Study

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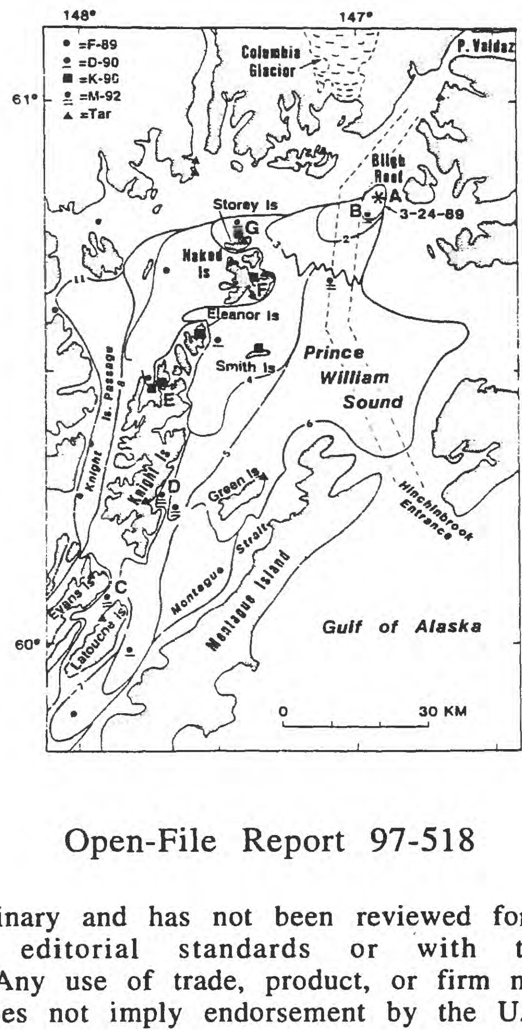

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Preface

In May 1899, the Harriman expedition sailed to Alaska to begin a two month investigation of the many fjords and glaciers of this remote land (Harriman Alaska Expedition, 1902). While in Prince William Sound, one of the 126 expedition members, Charles Keeler, director of the museum of the California Academy of Sciences, San Francisco, composed the following poem which, to those of us presently studying Prince William Sound, is still quite apropos (98 years later).

ALASKA

Fjords of the far west shore, where peaks sublime
Are cloudward thrust 'neath folds of glistening snow,
With hoar and frigid streams that tideward flow,
Sculpturing their cliffs and crags which mount and climb
Full in the sight of heaven--grim heirs of time,
Stern children of eternity, that grow
Austere and terrible 'mid storms that blow
Their lusty trumpets in the tempest's prime.
What joy is this to float upon thy tide,
So blue, so beautiful, to gentle glide
'Mid islets forested, past shores that stand,
Dark portals opening to enchantment's land,
Where is all but a dream, soon to be
Lost in the purple mist of memory.

INTRODUCTION

a) Purpose The primary purpose of this report is to document the evolution of our study of the *EXXON VALDEZ* oil spill, so that if another large spill occurs in Prince William Sound, future researchers will have a ready historical data archive of sample locations and analytical results. This report includes: (i) a narrative of the project from start (1989) to finish (1997), (ii) a discussion of the collection of 427 samples and the laboratory techniques applied to 257 of these samples, (iii) a list of papers and abstracts produced, (iv) maps and tables of sample locations, and (v) an appendix of sample locations, descriptions, and results of chemical analyses. This report also includes a listing of samples collected in the last two years of the study that are currently undergoing analyses and have not been reported in previous publications.

b) Physical Setting Prince William Sound is a spectacularly beautiful, fjord-like estuary created by active tectonism. The collision of the Pacific and North American plates resulted in episodes of mountain building that in turn generated regional cooling and coastal glaciation. The multiple ice advances that reached thicknesses of 2,000 m in the Sound (von Huene et al., 1967) carved deep basins. During the intervening retreats the glaciers deposited gravels, sands, and muds that comprise the insular slopes. Melt-water from the retreating glaciers, both within the Sound and in the Copper River drainage basin, continues to contribute glacial flour to the thick diatom-rich mud (Carlson et al., 1991; Carlson and Kvenvolden, 1996) that has been accumulating in the basins, often at water depths greater than 800 m. In many places submerged glacial morainal ridges consist of relict gravelly mud (Carlson and Reimnitz, 1990). These moraines as well as the numerous islands play a role in modifying the water circulation in the Sound. Circulation in the Sound, however, is most strongly influenced by a signficant portion of the Alaska Coastal Current that enters the Sound through Hinchinbrook Entrance (Royer et al., 1990). The incoming water contributes to a mid-Sound cyclonic circulation cell (Muench and Schmidt, 1975) which is maintained by fresher water entering from fjords located around the perimeter of the Sound complex. Much of this counterclockwise flowing water moves southwesterly along both sides of Knight Island eventually exiting the Sound through Montague, LaTouche and other straits at the southwestern part of Prince William Sound (Royer et al., 1990).

TECHNIQUES FOR COLLECTING HYDROCARBON SAMPLES

a)Shipboard In May 1989, onboard the *M/V FARNELLA,* we sampled bottom sediment by box coring at 20 stations. No visible oil was seen when the box cores were being subsampled, and, when viewed under ultraviolet light, no fluorescence was observed. The upper 8 cm of sediment from the box core was subsampled for hydrocarbons with an acetone-rinsed stainless steel tube (~5 cm i.d.) as soon as the corer was brought on deck. The samples were extruded into sterilized jars, sealed, and placed in a freezer. In 1990, on the NOAA ship *DAVIDSON,* we resampled nine of the 1989 sites using the same techniques.

In 1990 on the USGS *R/V KARLUK*, we ran high-resolution acoustic profiles down the insular slopes of six islands selected because they were in the path of the spilled oil and had been heavily impacted by the oil. We used a van Veen sediment sampler to collect bottom sediment at shallower water sites (5-125 m water depth) than were accessible with the two larger vessels. The insular slopes were mostly devoid of fine sediment, but small depressions containing thin deposits were identified and sampled. The sediment ranged from mud through sandy mud to pebbly sandy mud (Carlson *et al.*, 1991). A subsample was collected by pushing an acetone cleaned stainless steel tube through a small "trapdoor" in the top of the sampler. The sediment was extruded into a sterilized glass jar which was then capped and stored on dry ice in an insulated cooler, or in the boat's freezer, until returned to the laboratory. This technique was used whenever possible on the subsequent cruises; however, in some cases the sediment sampler was not sufficiently full to allow sub-coring, so an acetone-rinsed stainless spoon was used to carefully collect the sample without scraping the sides of the sampler. The type of sampler varied depending on availability and also on the substrate. Other ships and (samplers) used were *McARTHUR* (Smith-McIntyre), *RAINIER* (Shipek and Smith-McIntyre), *AUKLET* (van Veen). In a few instances, on the *KARLUK*, we took a sample from the ship's anchor. In addition, we received sections of six gravity cores from Kinetics Lab. The types of samplers are identified for each of the subaqueous samples listed in Appendix 2. We analyzed a total of 78 subaqueous samples.

b)Beach We collected our first beach samples in August 1990 when we visited six beaches that had been heavily oiled. We made no pretense of systematic sampling. We collected what we deemed to be the best samples, sometimes the only sample, of oiled rocks or oiled finer sediment available on a given beach. Each sample was carefully collected with a sterilized spoon or knife, wrapped in heat-treated aluminum foil, described and labelled. The oily samples were transferred later to pre-cleaned glass jars and refrigerated. For the tar ball and tar mat samples we often had to use a knife blade to pry the sample off the cobble or boulder to which they had become attached, sometimes so firmly as to resemble asphalt paving. The tar samples were collected whenever found on visits to various beaches throughout the sound. They too were wrapped in sterilized foil and then in sample bags for transit. A total of 112 beach samples were analyzed.

LABORATORY METHODS

1) Oil and Tar Samples

a) Carbon-Isotopic Analyses Oil-like residues (112 samples) from shorelines of Prince William Sound (Fig. 1) and a sample of North Slope crude oil, impounded from the tanker *EXXON VALDEZ* immediately after the 1989 oilspill, were dissolved in dichloromethane. In addition, 54 samples of oil products used in Alaska for construction and pavements, three samples related to natural oil seeps onshore of the Gulf of Alaska, and nine samples from California for comparison, were also dissolved in this solvent. The resulting solutions were filtered through glass wool and the solvent removed by evaporation; a portion (40 to 90 mg) of each extract was then recovered for a determination of carbon-isotopic composition. For this determination, at least a 4 mg portion of each extract was placed in an evacuated quartz tube with cupric oxide and a strip of silver metal, and was combusted with oxygen to 840°C. The resulting CO_2 was purified under vacuum by differential temperature transfer and measured by isotope-ratio mass spectrometry. The results are reported in delta (δ) notation in parts per thousand ‰ relative to the PeeDee belemnite (PDB) standard.

b) Adsorption Chromatography Remaining portions of the extracts (20 to 40 mg) were redissolved in dichloromethane and filtered through a column of activated copper to remove any elemental sulfur. These resulting extract solutions were fractionated by adsorption chromatography to obtain a mixture of aliphatic hydrocarbons. This fractionation involved exchanging the dichloromethane solvent with hexane and separating this mixture on a column that was layered from bottom to top with 2.5 g of deactivated (5% water) neutral alumina and with 2.5 g of Davison No. 62 and 5 g of Davison No. 923 activated silica gels. The column was eluted sequentially with 25-35 mL of each of the following solvents: hexane; 20, 40, and 60% benzene in hexane; benzene; and methanol to produce six fractions, only the first of which is considered here. The first, or hexane, fraction yielded a mixture containing *n*-alkanes, isoprenoid hydrocarbons (including pristane and phytane), and alicyclic biomarkers.

c) Gas Chromatography and Mass Spectrometry (GC/MS) A portion of each hexane fraction was first analyzed for the distributions of alkanes by gas chromatography with flame-ionization detection, utilizing a 30-m x 0.3-mm DB-1 bonded-phase, fused-silica capillary column and the following instrument parameters: initial temperature, 90°C for 3 min with a ramp of 4°C/min to 310°C and a final hold for 20 min; injector and detector temperatures, 300°C; column-inlet pressure, 10 psi of helium; and splitless injection. After gas chromatography, a second portion of each hexane fraction was analyzed for alicyclic biomarkers by gas chromatography/mass spectrometry, utilizing a 30-m x 0.3-mm SE-54 bonded-phase, fused-silica capillary column with splitless injection and the following instrument parameters: initial temperature, 150°C with ramps of 30°C/min to 200°C and 1°C/min to 300°C. Alicyclic biomarkers were analyzed by selected ion monitoring of mass-to-charge (m/z) ratios of 177 for 25-norhopanes, 191 for terpanes (tricyclic and tetracyclic terpanes and pentacyclic triterpanes), and 217 for steranes (including diasteranes). Identification of 25-norhopanes was based on the work by Curiale et al. (1985); compound identifications of terpanes and steranes were based in part on a previous study of North Slope crude oil (Kvenvolden et al., 1985).

Selected ratios of terpanes and steranes were calculated from peak heights on mass chromatograms.

Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane. This ratio was proposed as both a source and maturity parameter by Seifert and Moldowan (1978).

Triplet, [C_{26}-tricyclic terpane (S?) + C_{26}-tricyclic terpane (R?)]/C_{24}-tetracyclic terpane. This source parameter was first noticed in a study of North Slope crude oil (Kvenvolden et al., 1985), in which the ratio is ~2. *Exxon Valdez* oil (an Alaskan North Slope crude oil) and its residues have triplet ratios of ~2; in contrast, tar balls of the Sound have triplet ratios of ~5 (Tables 1-7; Appendix 2).

C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane. This ratio was used by Palacas et al. (1984) as a source-rock parameter.

C_{31} S/(S+R), 17α,21β(H)-homohopane (22S)/17α,21β(H)-homohopane (22S) + (22R). This epimer ratio is a typical terpane-maturity parameter used extensively in petroleum geochemistry (Ensminger et al., 1974; Mackenzie, 1984).

BTO, 17α,18α,21β(H)-28,30-bisnorhopane, 17α,18α,21β(H)-25,28,30-trisnorhopane (the dominant 25-norhopane), and oleanane. These compounds are absent in the Alaskan North Slope crude oil, spilled from the *Exxon Valdez* tanker, but are present in tar balls of the sound and in oil products that originally came from crude oils produced in California and likely sourced from the Monterey Formation (Kvenvolden et al., 1993).

C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S) + (20R). This sterane-epimer ratio is commonly used in petroleum geochemistry as a maturity parameter (Mackenzie, et al., 1980).

C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R). This source parameter has been modified from discussions of Grantham and Wakefield (1988) and Waples and Machihara (1991).

All of these ratios have been adapted from petroleum-geochemical applications and applied by us for correlation and differentiation among the sample sets.

We used the terpane and sterane maturity parameters as source parameters because the spill oil is not expected to undergo significant maturation processes during the short time of the spill history. Thus we used conventional polycyclic aliphatic hydrocarbon source and maturity parameters to track the spill oil into the sediments of the Sound.

2)-Subaqueous Sediment Samples

Sediment samples were collected in deep water sites (125-755 m) in Prince William Sound and (65-276 m) in the adjacent Gulf of Alaska from large sampling vessels and on shallow-water insular slope sites (5-125 m) from shallow draft boats in the sound. The sediment samples were kept frozen until they were dried and then ground to pass a 32 mesh (0.5mm) screen. For each sample 100 gms of sediment was extracted three times with dichloromethane by shaking and centrifuging. The combined extracts from each sample were concentrated to <5ml on a rotary evaporator and passed through activated copper to remove elemental sulphur. The sulfur-free extract was analysed by gas chromatography in a manner similar to that of the oil and tar extracts previously discussed. A total of 78 sediment samples were analyzed.

Tracking oil residues from the Exxon Valdez oil spill into the sediment record of Prince William Sound involved geochemical criteria based on both molecular and isotopic measurements (Kvenvolden *et al.*, 1993a; 1993b). Isotopic measurements were made only on tars and oils; molecular (biomarker) measurements were made on tars, oils, and sediment extract. These kinds of measurements, made initially on a sample of North Slope crude oil impounded immediately after the oil spill, provide the basis for tracking the spilled oil. This oil contains a mixture of *n*-alkanes and isoprenoid hydrocarbons (pristane and phytane) that was rapidly degraded as the oil was weathered in the environments of the Sound. In the oil, the *n*-alkanes dominate and decrease in relative concentration with increasing molecular weight, ranging from about n-C_{11} to at least n-C_{40}. Residues from the beaches of various islands show losses in both *n*-alkanes and isoprenoid hydrocarbons and the development of an unresolved complex mixture (UCM) of hydrocarbons. These results demonstrated that distributions of *n*-alkanes and isoprenoid hydrocarbons are very limited in their application to tracking the presence of the spilled oil. In contrast to the *n*-alkanes and isoprenoids, the polycyclic aliphatic hydrocarbons are less susceptible to rapid biodegradation (Volkman, 1984) and were found to be more useful in tracking the spilled oil (Kvenvolden *et al.*, 1993a; Hostettler and Kvenvolden, 1994).

NARRATIVE OF THE OIL SPILL PROJECT

EXXON VALDEZ TANKER SPILL AND PROJECT INCEPTION

March 24, 1989 shortly after midnight, the *T/V EXXON VALDEZ* went aground on a bedrock pinnacle which was part of Bligh Reef, an obstacle to tanker traffic located about 2.5 km east of the in-bound traffic lane at the lower end of Valdez Arm (Fig. 1). The tanker had left the conventional out-bound lane to avoid ice that had calved from the retreating Columbia Glacier and was present in the western part of the Arm. Due to a series of errors of commission or omission, the vessel did not turn in time to avoid the very hard rocks that formed one of the numerous pinnacles that comprise this reef, which was marked with a navigation buoy. As the tanker collided with the reef, the hard rock ripped large holes in the hull and crude oil began to escape. As the oil spread throughout the northern part of the sound, various methods were attempted to control and recover the North Slope crude that eventually reached a volume of 11 million gallons (43.9 million liters). Rapidly deteriorating weather after the first three days compounded the recovery problem. As the oil was carried toward the southwestern part of Prince William Sound by the natural circulation of this large water body, the shorelines of many of the islands located in the western and southwestern parts of Sound (Fig. 1) had their beaches besmirched with the crude oil. As the media invaded the area, television pictures of the oiled beaches and oiled and dying animals and marine biota captured the interest of the viewing public worldwide.

Perhaps Tom Clancy's description in "The Hunt for Red October" was the way most TV viewers imagined the scene in Prince William Sound after the spill. "The water was coated with the bilge oil of numberless ships, filth that would not evaporate in the low temperature and that left a black ring on the rocky walls of the fjord as though from the bath of a slovenly giant." Indeed, when we made our second visit to the Sound on the USGS *R/V KARLUK,* the draft of which allowed us to motor close to the rocky walls, we saw a prominent "ring around the bathtub" which we and many others attributed to the oil spill. Upon closer examination, however, we discovered that although in some cases the black ring was oil, in many more cases the black ring was due to the presence of the black lichen *Verrucaria*, the base of which marks the approximate high-high tide waterline (Hooten and Highsmith, 1996). This example was a valuable lesson--we learned not jump to conclusions about the contamination of the Sound without carefully investigating all the evidence. Half of the Sound was completely untouched by the spilled oil.

The hue and cry of the angered and shocked public drove the system and resulted in the invasion of the beaches by swarms of clean-up workers, public officials, scientists, and more news media. We of the USGS wondered what contribution we might make. We decided to divert to Prince William Sound, a research vessel of opportunity, the *M/V FARNELLA*, that the USGS was planning to use in the Gulf of Alaska on a sea-floor mapping project. The large ship (length 260') had the capability of obtaining large box cores from the deep parts (as much as 800 m water depth) of the sound. We decided to study the sediment on the floor of the Sound in the deeper water areas because, as we understood the situation, the beaches and intertidal areas were being investigated by many other scientists. Our plan was to attempt to determine whether any of the spilled oil was reaching the seafloor of Prince William Sound. As the next port for the *FARNELLA* was to be Kodiak, we also decided to collect samples between the Sound and Kodiak Island, after collecting bottom samples in the deeper parts of the Sound. Thus, the wheels were set in motion to mount a seafloor sampling cruise to Prince William Sound in early May 1989.

1989 CRUISE --*M/V FARNELLA* --F-5-89; 5/11/--5/14/89

The *FARNELLA* cruise (Carlson and Reimnitz, 1990) began sampling in the southwestern part of Prince William Sound in Montague Strait, near the exit point where the spilled oil left the sound and flowed into the Gulf of Alaska (Fig. 1). At each planned sample site we ran a track line using a 3.5kHz very high-resolution acoustic profiling system to determine the character of the seabed and areas of relatively thick accumulations of modern sediment (e.g. Fig. 2). Box cores sampled post-glacial, unconsolidated, diatom-rich mud which is accumulating in the deep basins of the Sound today (Fig. 2A). Some sites were selected on seafloor highs, principally glacial moraine substrate (Fig. 2C). Cores from these sites contained pebbly sandy muds (Carlson and Reimnitz, 1990). We collected a total of 29 cores in water depths ranging from 125 to 755 m, at a total of 15 stations (Fig. 1; Appendix 2). The sample sites were chosen within the spill trajectory, including both sides of

Knight Island, based on data obtained from multiple overflight maps showing the sequential spill trajectory as recorded by personnel from EXXON and NOAA. After completing our circumnavigation of the western islands, we followed the spill trajectory west along the Kenai Peninsula (Fig. 3), intending to sample all the way to Kodiak Island. However, high seas made the sampling too hazardous, so the sampling was suspended about 100 km west of Resurrection Bay after four sites had been sampled (Fig. 3).

The box cores provided information about sedimentary depositional processes and 14 subsamples were analyzed for hydrocarbons (Table 1), radionuclides, benthic foraminifers, and benthic sediment respiration rates (see chapters in Carlson and Reimnitz (eds), 1990). Of the 15 sites in Prince William Sound, only sediment extract from site 15, near the southwestern end of the Sound, contained indicators of possible oil contamination (Rapp et al., 1990). Measurement of ^{7}Be at sites 2, 3, 4, & 15 (Fig. 1) indicated moderate accumulations of suspended matter making these sites potential candidates for oil contamination (Grebmeier, 1990). ^{210}Pb measurements of two cores in the southern part of the sound (sites 2 & 4) yielded sediment accumulation rates of >3mm/yr (Bothner et al., 1990), values in general agreement with those reported by Klein (1983) of about 3.5 mm/yr (assuming no bioturbation--thus, maximum values) for the central part of the sound.

1990 CRUISES --*R/V DAVIDSON* D-1-90; 4/28/--5/11/90:
--*R/V KARLUK* K-3-90; 8/8--8/15/90

The cruise on the NOAA ship *DAVIDSON* occupied 11 stations in Prince William Sound, nine of which were re-occupations of 1989 sites visited on the *M/V FARNELLA*. The use of this large NOAA ship provided us opportunity to re-sample with a large box corer in some of the deeper parts of the sound (Fig. 1). The cruise on the USGS *R/V KARLUK*, a 42' long vessel, was designed to visit some of the beaches that were heavily impacted by the spilled oil and to see if any oil was moving off the beaches into the subtidal zone (Carlson, 1991). We sampled the oil that still resided on seven island beaches (Fig. 4). At each island, we then ran a high-resolution acoustic profiler line (towed 900 Joule Geopulse and a hull-mounted 3.5 kHz transducer-transponder) at right angles to the beach. As we traversed the insular slope, we looked for accumulations of modern sediment (Fig. 5) that might contain evidence of hydrocarbons that could have been washed off the oiled beach by wave action and/or by the washing action from the high-pressure water hoses used to attempt to clean the beaches. A total of 27 van Veen grab samples and five small gravity cores of modern sediment were collected in water as deep as 125 m. We also collected six samples from the ship's anchor and 14 samples from the seven beaches (Appendix 2).

The samples were analyzed for hydrocarbons (31 samples, Table 2), sediment particle size and sand fraction composition, and benthic foraminifers (See chapters in Carlson, 1991). A variety of forms of oil on the beaches included oil-sheens on water percolating from beach sediment, thin coatings of oil on sediment and rocks, brown sticky mousse-like patches, and tar or asphalt patches on rocks. Most of the oiled beach samples gave chemical fingerprints that related to the spilled oil. However, chemical fingerprints of two tar samples found 100 km apart on Storey and Elrington Islands (Fig. 4), were not Exxon Valdez Oil (EVO) spill (Kvenvolden et al., 1991, 1993a&b). Of the 11 deep-water sites analyzed from the *DAVIDSON*, only D-10 (90-51) (Fig. 1, Table 2) showed a hint of contamination by spill oil in 1990. The shallow water sites sampled from the *R/V KARLUK*, on the other hand, showed possible chromatographic evidence in 12 samples (Table 2) of the spill oil in the sediment (Kvenvolden et al., 1991). The thin pockets of modern sediment (<10 m thick) present on the gravelly insular slopes, consist primarily of gravelly, muddy sand and the thick deposits (to 200 m) in the deep basins are comprised principally of diatom-rich soft mud (Carlson et al., 1991). Four species of foraminifers that were found in relatively high abundance in northern Prince William Sound suggest reduced oxygen content in the northern sound (Quinterno and Carkin, 1991).

1991 DATA ANALYSIS AND PROJECT REDIRECTION

In 1991, we began in earnest to investigate the non-EVO tar samples that we had collected at two beaches. We submitted samples of the tar to the Denver USGS isotope geochemistry laboratory, which analyzed the tar for $\delta^{13}C$, and we discovered that these tar samples were definitely not EVO spill material ($\delta^{13}C$=-29.2 ‰), but a much heavier oil product, yielding $\delta^{13}C$ values of -23.8 to -23.9 ‰ (Kvenvolden et al., 1993a). Further inquiries led us to Nancy and Jim Lethcoe of Valdez, Alaska, who, in their travels throughout Prince William Sound, had observed tar on some beaches in the northern most parts of the sound. Nancy had contacted EXXON with her information and questions. After EXXON had followed up on the lead provided by the Lethcoes, the oil company personel concluded that this tar was not part of the EVO spill and thus of no immediate concern of theirs. Nancy passed on to us copies of the maps and correspondence that Exxon had sent to her. We concluded that the presence of these other spilled hydrocarbons should be futher investigated along with our follow-up on the fate of the EVO spill material. Thus, we proposed further sampling work in PWS for 1992 and beyond.

1992 CRUISE --*R/V McARTHUR* - M-1-92; 5/27--6/4/92

In 1992, we became involved in a cooperative cruise with National Marine Fisheries Service (NMFS) personnel on the NOAA ship *McARTHUR*. Our agenda was designed to fit into the plan of the fisheries personnel: excellent cooperation by the NMFS scientists and the ship's personnel made this a very successful cruise. Enroute to joining the *McARTHUR*, we stopped at Whittier, a community that had been seriously damaged by the 1964 earthquake. Some petroleum storage tanks had been destroyed and we wondered if they could be a source for the tar. Two city officials, Linda Hyce and John Labowe helped us find sites to collect old asphalt from three of the city streets for comparison to the asphalt in the sound. Upon arrival in Valdez, Nancy Lethcoe brought us to the old town site of Valdez where we sampled an extensive band or "reef" of asphalt (Fig. 6) that we concluded originated from leaking tanks of the original asphalt plant. The destruction of the tanks was caused by a combination of shaking from the 1964 earthquake, the resulting seiching of fjord water, and the mass failure of the delta upon which the town was built (Coulter and Migliaccio, 1966). The $\delta^{13}C$ values for the Whittier (-24.3 to 24.8 ‰) and Valdez (-23.6 ‰) samples were not in the EVO range of -29.2 ‰, but yielded values closer to the island tars.

On the *McARTHUR* cruise that sailed from Valdez 5/27/92, we resampled, with a Smith-McIntyre grab sampler, several deep-water sites that we first sampled in 1989. Using a small boat from the *McARTHUR,* we also visited several new beaches in search of hydrocarbon residues. Deep-sea sediment was resampled at six stations extending southwest from Bligh Reef (site 7) to site 15 at the upper end of LaTouche Passage (Fig. 7). At sites 4 and 15 we found traces of EVO based on the occurrence of a hydrocarbon triplet signature (Table 3) on the GC/MS profile (92-23=1.9 and 92-33D=2.0) (Carlson and Kvenvolden, 1996). We explored ten beaches, extending from Olsen Bay east of the EVO spill trajectory, where we found no hydrocarbon residue on the beach, to Latouche Island in the southwestern part of the Sound, where we found hydrocarbons that were apparently related to a mining operation (Fig. 7; Table 3). Between those two extremes we found several tar samples on Naked Island, a tar sample and some sticky oil on the northeast end of Green Island, and oil and tar samples on the beaches in both arms of Snug Harbor (Fig. 7; Kvenvolden et al., 1993b). In the south arm of Snug Harbor, we found some EVO in the cracks of some fissile metashale that cropped out on the beach. Pieces of rock had to be pried out of the outcrop; this type of oiled beach would greatly resist cleaning, even with a high pressure water jet. Therefore, in this type of environment, the oil might reside for an extended period of time before oil eating bacteria could remove it. This is perhaps a micro-environment that should receive more study to determine how long traces of oil might remain.

In summer after the cruise, we received several samples of hard, conchoidally fracturing tar that Jim and Nancy Lethcoe had collected for us from the beaches in the northern Sound (Table 3). The $\delta^{13}C$ values for these samples matched the two tars we had discovered on Elrington and Story Island beaches (Kvenvolden et al., 1993b).

In September, we presented papers about our oil spill studies at the AAAS meeting in Valdez (Carlson and Kvenvolden, 1992; Kvenvolden and Carlson, 1992). At this meeting we discussed the two kinds of hydrocarbons present in PWS and made plans with the Lethcoe's to visit additional beaches that may contain either or both types of hydrocarbons. During the September visit, they also took us to two sites east of the Valdez harbor where we collected two more tar samples (Table 3).

1993 CRUISE --*M/V TLINGIT* T-1-93; 5/26--5/31/93

For our 1993 sampling cruise, we chartered the Lethcoe's vessel out of Valdez and also obtained their extensive skills as guides to the island beaches of Prince William Sound. They have lived in the Sound for many years, and their local knowledge was superb, as is documented in several books they have written (e.g. Lethcoe and Lethcoe, 1989. Cruising guide to the Western Part of Prince William Sound, Alaska, v. I). These books also were very useful for our planning over our several years of investigation. Our first stops on the cruise were several beaches in Port Valdez and Valdez Arm (Fig. 8) where we collected tar samples that were firmly attached to rocks primarily in the upper high tide zone. All of these samples (Table 4), located north and east of Bligh Rock, were hard tar; their $\delta^{13}C$ values (-23.6 to -23.8 ‰) indicated non-EVO hydrocarbons, which we eventually determined to be from California Monterey Formation that has uniquely heavy carbon isotopic values ranging from -21 to -24 ‰ (Magoon and Isaacs, 1983; Kvenvolden et al, 1993a). After investigating Valdez Arm, we began sampling the beaches of the islands southwest of the EVO spill, starting at Peak Island and extending southwest down Knight Island passage as far as the northeast tip of Chenaga Island. Along this portion of the Sound, which was in the trajectory of the EVO spill, we found both kinds of hydrocarbons on several of the beaches (Fig. 8; Table 4). In general, the old tar characteristically adhered more firmly to the cobbles, fractured conchoidally, and was harder. Therefore, we rather optimistically thought we could easily determine the two kinds of residues. However, we found that we often could be mislead, because the old tar sometimes became softer as the sun beat down on it. In some instances, the EVO also fooled us because in some instances it was present in tar ball form, was quite firm, and adhered quite strongly to the rocks. A subsequent study (Hostettler and Kvenvolden, 1994) showed that degradation processes change the physical appearance of residual EVO. At the end of the *TLINGIT* cruise we stopped at Growler Island just south of Columbia Glacier (Fig. 8; Table 4), where we collected tar samples from four beach areas. The numerous tar samples along the south side of Port Valdez and the presence of both kinds of hydrocarbons along the same general trajectory throughout the main part of the sound, suggested to us that the tar was released from ruptured tanks in the area of old Valdez during the 1964 earthquake (Kvenvolden et al., 1993b). In subsequent literature searches, we found a map in a National Academy of Science report by Wilson and Tørum (1972) that showed ~30% of the fjord (east end, off old Valdez) was covered by floating asphalt. Four successive seiches, one directly associated with the earthquake (5:36 pm), the second within ten minutes after the earthquake's strong ground motion ceased, and two late evening seiches (11:45 pm & 1:45 pm) struck the old town water front (Coulter and Migliaccio, 1966). This violent wave activity in the fjord likely carried the bulk of the tar west and out of Valdez fjord where it became swept up in the normal counter-clock-wise circulation of the sound and was carried to the southwest in a similar fashion to the EVO spill material. However, others have suggested that the tar could have come from multiple sources around the Sound; to investigate these other possible sources, such as hatcheries, canneries, salteries, lumber mills, mines, and old villages, we proposed additional studies of beachs and historic installation sites to attempt to eliminate or confirm some of these potential sources.

1994 CRUISES --*M/V TLINGIT* T-1-94; 5/15--5/19/94:
--*R/V RAINIER* R-1-94; 9/5--9/9/94

The 1994 *TLINGIT* cruise concentrated on the southwestern part of the sound where there was a hatchery, an abandoned cannery, a mine, and an Indian village (Fig. 8). Sleepy Bay at the northeast end of Latouche Island is a natural reentrant (Fig. 8) that proved to be a splendid trap for the spilled oil. Of six Sleepy Bay samples analyzed, four were EVO and two were the old tar (Table 5) (Kvenvolden, et al., in press). At the transplanted Indian Village of Chenaga (Fig. 8) we found hydrocarbon residue in an old dump. Larry Evanoff of Chenaga took us in his skiff to some broken leaking tanks at Port Ashton. However, the Port Ashton residue seemed to be confined to the slope and rocky cliffs below the tank. Evanoff then transported us to northeast Evans Island where we found three EVO samples and one old tar in the high tide zone (Fig. 8; Table 5). On the return trip to Valdez on the *TLINGIT*, we visited the west side of Squire Island where a glacially grooved and striated notch cut in altered greenstone bedrock was a repository for numerous splotches of tar (Fig. 8). Three samples were analyzed as old tar (all = -23.7 ‰). In July we received three samples of tar from the Lethcoe's that they had found in the northern part of the Sound--Sawmill Bay off Valdez Arm, West Twin Bay at Perry Island, and west side of Eickelberg Bay (Fig. 8; Table 5)--suggesting that the tar extended further north in the Sound than did the EVO trajectory.

Our first "piggy-back" cruise on the *RAINIER* (1994) was concentrated in the northern part of the Sound, the area around Glacier Island, south of the Columbia Glacier (Fig. 8), because that was the NOAA hydrographers work area. Our use of the *RAINIER* as a sampling platform and use of one of the small boats to reach the beaches was predicated upon working without interferring with the ship's mission. This worked very well because of the great cooperation we got from the entire ship's complement. We collected deepwater sediment grab samples from the *RAINIER,* reoccupying four of the original 1989 sample stations (6, 7, 8 & 9). These four deep water (285-747 m) grab samples all consisted of gray mud that did not show any evidence of contamination by EVO (Table 5).

Using the ship's Boston Whaler, we circumnavigated Glacier Island visiting island beaches and beaches on the mainland to the north. Of the 14 areas explored, we found tar at five (Fig. 8); Irish Cove, Flent Pt., sw Buyers Cove, Elf Pt/Emerald Cove, and the remains of an old cannery in Unakwik Inlet. We also met Jim Lethcoe enroute, who gave us two tar samples that he and Nancy had recently collected at a small island near Mueller Cove along the west side of Unakwik Inlet and at Cabin Bay on Naked Island (Fig. 8; Table 5). The Mueller Cove sample represents the farthest north excursion of any of EVO spill residue. We explain this anomaly as an aberant isolated patch that separated from the main trajectory and floated north to be stranded on the west shore of Mueller Cove (Kvenvolden et al., 1995).

Our two cruises in 1994 allowed us to obtain samples from the southwest and the northern most portions of the sound and to visit not only beaches, but also potential sources of spilled hydrocarbons, such as the canneries at Port Ashton and Unakwik Inlet. Geochemical results on samples from these cruises did nothing to dispell our hypothesis that the heavier tar, that had its original source in the Monterey Formation of California (Kvenvolden, et al., 1993a), was introduced into the waters of Prince William Sound following destruction of tanks of asphalt at old Valdez, a by-product of the 1964 Great Alaska Earthquake (Kvenvolden, et al., 1993b).

1995 SAMPLING HELICOPTER --*ERA* E-1-95; 5/28--5/31/95
CRUISE --*R/V RAINIER* R-1-95; 9/8--9/15/95

In 1995, we proposed checking an hypothesis by EXXON Scientists that much of the background hydrocarbon signature throughout Prince William Sound was caused by yet a third source, oil seeps that occurred on the coastal plain from Katalla east to Icy Bay and perhaps as far as Yakutat Bay (Page, D.S. et al., 1995). Because the Katalla area was not readily accessible by boat, we chartered a helicopter to fly us to the abandoned oil field of Katalla located about 100 km east of the sound so we could sample the seep oil. In spite of inclement weather, we sampled seep oil at Katalla, and also collected tar samples from building remnants at the abandoned village of Chilkat, the Cordova airport runway, the former community of Port Etches, and wharf pilings at the former mining town of Ellamar (Fig. 9; Table 6).

In 1995, the *R/V RAINIER* was to be working in the northwestern part of the sound near Whittier and Port Wells. NOAA accepted our proposal to "piggyback" again on their hydrography project, "in a manner not to interfere." On this cruise we again planned to visit beaches near historical sites where industrial use of hydrocarbons had been reported. We used information from Lethcoe and Lethcoe (1994) plus USGS maps and NOAA charts, to identify potential sites to visit. Our first site visited (9/9/95) was the abandoned McClure Bay cannery in Port Nellie Juan (Fig. 9) which was destroyed, and three people were killed by 1964 earthquake generated seismic sea waves (Lethcoe and Lethcoe, 1994). Here we found five samples in the ruins. The samples included creosote on pilings, lubricant on equipment at the mid-tide line, tar used to seal a corrugated shed, oil within the spigot of the fuel tank for a large boiler, and hydrocarbon residue (tar) that was cascading down the rocky cliff from the cannery's boiler (Fig. 9; Table 6). The next day we collected two samples--tar on corrugated metal and tar coating on roofing fabric from a beached vessel (former Washington State Ferry and then a fish processor (Lethcoe and Lethcoe, 1994) in Shotgun Cove. In the town of Whittier we collected one sample of new road asphalt and two samples at the fjord end of the gravel airstrip (tar/macadam used as riprap and tar with gravel by pilings at edge of the runway) (Fig. 9; Table 6). The following day (9/11), in a wet, wave-tossed, open-boat ride across Perry Passage, we visited a former fox farm, now an oyster farm, at the head of South Bay on Perry Island (Fig. 9). We collected three samples, a small spot of tar on a granite cliff face above high tide line, tar used as calking from old chimney flashing on a barn, and tar or creosote on a pole at a boat shed (Table 6). On 9/12, an abreviated day because of hydrography program needs, we investigated Blackstone Bay, but found no hydrocarbon residue. A visit to Pigot Bay yielded good tar samples--some shiny tar on a timber in the storm tide area on the north shore and chimney flashing tar on a Forest Service cabin on the south shore of the bay (Fig. 9; Table 6). This day was shortened because we had to make an emergency detour to assist one of the NOAA hydrographic survey boats. The day of 9/14 was a beautiful sunny day, so we were permitted to take a longer trip up Port Wells fjord to visit two former gold mining sites (Fig. 9). At Golden, where 150 miners lived in 1913, (Lethcoe and Lethcoe, 1994) we found the remains of a cabin, but, other than some tarpaper on a partially buried and highly weathered board, we observed no hydrocarbon residue. Across Port Wells on the west side, we found two hydrocarbon samples, seemingly both associated with activity at the Granite Mine (1914-1922), second in total gold production in all the sound (Lethcoe and Lethcoe, 1994). The first sample was a messy grease in a barrel at the high tide line and the second, some calking tar from metal sheets in a small work shed on the beach above the high tide line. On our way back to the *RAINIER"s* anchorage in Cochrane Bay, we stopped at the modern Wally Noerenberg Hatchery, located at the south end of Esther Island where the manager gave us a graveled roofing base shingle (Table 6). Shortly after we reached the *RAINIER,* she raised anchor and left the Wells Passage work area, headed for Seward. Enroute we were able to collect Shipek grab samples at seven stations which were re-sampling sites that we first visited in 1989 on the *M/V FARNELLA*. We sampled at F-89 sites #10, 5, 4, 3, 15, 2, and 1 (Fig. 9). These sites range in water depth from 65m to 320m and in sediment type from a pebbly mud at the shallowest station #4 near Snug Harbor and a pebbly muddy sand at #1, in the southwest end of Montague Strait to olive gray mud containing some soft-bodied organisms at the deepest station #10 north of Perry Island. The hydrocarbon triplet ratios of 1.7 and 1.9 at stations near Snug Harbor (Table 6) suggest possible contamination by EVO continued to be present at these sites.

1996 CRUISES--*M/V AUKLET* A-1-96; 5/19--5/22/96
--*R/V RAINIER* R-1-96; 8-26--9/7/96

To check further the influence of Katalla seep oil in Prince William Sound, we chartered the *AUKLET,* a small boat (65' long), to sample at the north end of a shallow pass between Hawkins and Hinchinbrook Islands (Fig. 9). Here, as shown on satellite imagery (Fig. 10), much suspended and bottom sediment carried into the Gulf of Alaska from the Copper River is being incorporated into the Alaskan Coastal Current, some of which is being transported into Prince William Sound. Some of this sediment is accumulating north of the pass as a small delta that is building into the sound. We hypothesized that if droplets of seep oil are being incorporated into the suspended sediment of the Copper River, as suggested by EXXON scientists (Page et al., 1995), the modern sediment forming part of the small delta should show a build-up of Katalla oil products. Thus, we sampled in as shallow water as possible, at the north edge of the delta (Fig. 9). Satellite imagery (Fig. 10) and high-resolution seismic-reflection profiles (Fig. 11) also showed sediment coming into the sound via Hinchinbrook Entrance. Thus, we also sampled along the northwestern shore of the island where imagery showed the sediment plume hugging the shore (Fig. 10). Subsequently we sampled near Port Etches and across Hinchinbrook Entrance in Rocky Bay (Fig. 9).

The *AUKLET* samples collected at Hawkins cutoff and along the northwest side of Hinchinbrook Island, in Port Etches and in Rocky Bay, all have hydrocarbon ratios (Table 7) which differ from the ratios in samples of Katalla oil (93-27, Table 4; 95-02, Table 6), suggesting that the Katalla imprint is not overwhelming around Hinchinbrook where the sediment supposedly carrying seep oil is coming thru into Prince William Sound.

The second phase of the *AUKLET* cruise was to visit beaches in this lower end of the sound, beginning at Rocky Bay where two sites yielded hydrocarbon residues (Fig. 9, Table 7). The first was along the south shore of the bay where we found soft tar present on some of the Cretaceous metasediments. The second site was inside a small lagoon where we found EVO residue on numerous pebbles. The next day we visited Point Helen at the southern end of Knight Island, an area that had been very hard hit by the 1989 spill. Here in the high tide zone, sheltered behind some large rock outcrops, we found pebbles and cobbles coated with EVO. Our next stop that day was in Thumb Bay (Fig. 9) where we found remains of tanks and equipment from an old (1912) saltery (Lethcoe and Lethcoe, 1994). We collected a sample of tar that was oozing down the side of a cliff below the tank remains. Then we motored to the old town of Chenaga where we walked the beach and found one sample of EVO. The following day we visited an old cannery at Port Audrey in upper Drier Bay where we sampled tar that had trickled down a cliff face from an apparent broken pipe.

We continued up Knight Island passage and visited some areas that, according to our Skipper, David Janka, had been heavily oiled by the 1989 spill. Between Knight and Disk Islands we sampled what seemed to be two different kinds of hydrocarbons. Isotope analyses confirmed that hypothesis; side-by-side, we sampled Monterey tar, that was very hard and showed good conchoidal fracture and sticky EVO mousse (Fig. 9, Table 7). Thus, we have additional evidence that both the old Monterey tar spilled in 1964 and the young EVO spilled in 1989, followed much the same trajectory through the western part of Prince William Sound.

In 1996, the NOAA ship *RAINIER* was again going to be doing hydrographic surveys in Prince William Sound, so we proposed another "piggy-back cruise". Because the question of the Katalla seep oil still lingered, our request this time was somewhat different. We proposed to ride the ship from Seattle so we could collect seafloor grab samples on the Gulf of Alaska shelf between Cross Sound and Prince William Sound. NOAA obliged, so we collected nine Shipek bottom samples (Fig.12), two east of Yakutat, to provide information out of the seep areas (i.e.-background samples), and seven between Bering Trough and Hinchinbrook Entrance (a distance of ~200 km) to cover the discharge areas of the Katalla District and to the east where other seep oil has been reported (Blasko, 1966) and conjectured by EXXON (Page et al., 1995) to be entering the Gulf and then into the Sound. The water depths of the shelf samples varied from 55 to 174 m; the sediment was primarily mud with some sand and occasional pebbles. The samples showed some variance with the two sample stations located SE of Yakutat exhibiting values different from the shelf stations further to the west (Table 7). The shelf samples collected between the Bering Trough and Prince William Sound (Fig. 12), the areas into which the Katalla and more easterly seeps would be draining, were different in key mass spectral ratios (Table 7) than either the Katalla and other seep samples and the sediment samples collected in Prince William Sound. Our preliminary analysis of the hydrocarbon geochemistry does not unequivocally support a Katalla source for the background hydrocarbons of Prince William Sound.

The hydrography targets for this *RAINIER* leg were centered around the lower end of Knight Island Passage; the ship, anchored in Thumb Bay, limited our beach and deep-water sampling sites to the southwestern part of the sound. On one day when the *RAINIER* left the anchorage to obtain sound velocity profiles for calibrating the hydrographic data, we were given the opportunity to re-occupy three of the 1989 sites (3, 4, and 15) and we added a new site off the heavily oiled re-entrant of Sleepy Bay at the northeast end of Latouche Island (Fig. 12). We used a Shipek grab sampler to collect bottom sediment at water depths that ranged from 120 to 264 m. The re-occupation of *FARNELLA* site 15 produced a sample (96-43a) with hydrocarbon ratios, similar to samples collected in previous years (Tables 6 and 7). We sampled a new site off Sleepy Bay resulting in a hydrocarbon ratios that may indicate some contamination with EVO. However, two samples off Snug Harbor (old 89-03 and 04) did not show contamination this time, whereas they had shown some traces of possible EVO in previous resamplings (Table 1 and 7).

From the anchorage in Thumb Cove, we were provided a boat and driver for three days in which we visited beaches on each side of Knight Island Passage. While exploring 17 beaches (Fig. 12), we found hydrocarbon residue (Table 7) on eight of them, six beaches on the east side and two of three beaches visited on the west side of the passage. On the east side beaches, we found old Monterey-type tar at five sites (Table 7). One east side beach had a small patch of EVO tar in a small pocket beach just south of Mummy Bay. The two samples on the west side (Fig. 12) were both EVO; at the northeast part of Evans Island, near the high tide line we found sticky brown mousse beneath a thin tar crust and at the north end of Fleming Island, a steep cobble beach, we found another sticky brown mousse that was covered by a thin tar (Table 7), where a 1990 EXXON map (Unpublished data) showed moderate oiling had occurred.

1997 SAMPLING

In 1997 we returned to Alaska to wrap-up our project in Prince William sound. We interviewed a number of Alaskans who could provide insight on the occurrences of tar residues in the Sound: John Kelsey, John Devens, Dianne Munson, Brad Philips, Nancey and Jim Lethcoe, and Bill Wyatt. As part of our trip, we collected a total of six tar residue samples, one sample from a path at Portage Glacier viewpoint, two samples from a beach at Eagle Island, and three samples from a cove in Finski Bay of Glacier Island. In addition, we received portions of 11 samples obtained by Jeff Short of NOAA (Table 8).

DISCUSSIONS OF THE TWO SPILLS

One big difference between the 1964 earthquake related spill and the 1989 spill caused by a tanker running aground was the centerpoint of concentration for each event. In 1989, the spill was central in all minds--the people responsible for the spill, people responsible for the cleanup, as well as the ever-present media, and the viewing public. We all got daily TV updates on the progress of the oil slick as it coursed through the sound. In 1964, the severity of this magnitude 8.4-8.6 great earthquake (original estimate, Coulter and Migliaccio, 1966), since upgraded to 9.2 (Kanamoori, 1977), controlled the mindset of the people within the affected areas, and the primary feeling undoubtedly was to survive this calamity. Those of us in the lower 48 states read about it and saw pictures in the newspapers, and those with TV saw some of the devastation. The people in Valdez were really in a survival mode as much of their town was in shambles. Therefore, the chance of someone observing tar floating in the water in Port Valdez, was much less than it would have been solely under a spill scenario, and likely the chances of photographing tar or oil in the water was not high. We must also remember that our environmental acuity was not nearly as established as it has become in recent times. The only record that we have been able to document was a sketch map in a report by Wilson and Tørum (1972) that showed the inner part of the Port Valdez fjord afloat with tar. We also visited the archives of the National Geological and Geophysical Data Center (10/30/96) and were able to make copies of a few colored slides that show some of the tanks burning and one slide that seems to show a small mass of tar apparently flowing away from the burning tanks.

We recently (7/28/97) visited with John Kelsey (his family owned the former docks in Old Valdez and maintained the Standard Oil of California tank farm). He told us that indeed many of the Standard Oil tanks, most with capacities of 420,000 gallons were filled with asphalt that was used for road construction etc. He remembered that one of the asphalt tanks had ruptured, but he does not recollect large quantities of asphalt escaping into the fjord. To the south of the Standard Oil tank farm was the Union Oil tank farm which contained mostly lighter, more volatile hydrocarbons and some of these tanks caught fire. Mr. Kelsey did say that as quickly as possible (as soon as the next day, he thought) dikes were constructed around the Standard Oil tank areas where leaking might occur. All but four of the Standard Oil tanks were drained into container trucks, and the tanks were then removed to the planned new town site. We have an aerial photo showing the four remaining tanks one year later with oil sheens in the water outside the berms that surrounded the tanks. Kelsy remembered that the high spring tides within the year following the earthquake had flooded part of the waterfront. These incidents of flooding plus the four seismic sea waves that struck the beach within eight hours of the earthquake, could have been the transporting agents that moved the asphalt off the old-town beach, down the fjord, and out into the Sound. Thus, it seems that we do not have to depend for an explanation on just the four waves that struck the old Valdez waterfront after the earthquake. Subsequent periods of high water could also have been instrumental in carrying the asphalt into the greater Prince William Sound where it would then be at the mercy of the vagaries of the Prince William Sound circulation system which has been described by Royer et al. (1990) as counterclockwise and strongly influenced by precipitation and stream runoff.

After sampling tar from many of the beaches along the south side of the Port Valdez fjord and from beaches along the southeast side of Valdez Arm and throughout much of the northwest and western part of Prince William Sound, we believe that much of the old tar found on the beaches in the western part of the Sound, originated from tanks in Old

Valdez that were damaged during the delta failure resulting from the great earthquake of March 27, 1964.

Conclusions about the fate of the oil spilled in 1989 may be partially influenced by the fate of the 1964 spill; however, we must keep in mind the character of the two hydrocarbon residues. The tar spilled in 1964 still can be found throughout the beaches of Prince William Sound, but it is in the form of asphalt, a product that we use on the streets, which we expect to last for a long time. The crude oil spilled at Bligh Reef from the tanker *EXXON VALDEZ* was much more volatile and unless it collected on the beach as a residual product, especially in the high-tide zone (buried beyond tidal action), which it apparently has in some places, will not likely be around in 25 years. The cleansing forces of nature are quite efficient and are likely much more thorough than the cleanup efforts of man.

None-the-less, on some beaches sheltered by large cobbles and boulders, we were still able to find EVO in 1996, as brown mousse beneath a thin tar crust, and similar material persisted in 1997 as reported in the August 17, 1997 edition of *We Alaskans,* the Anchorage Daily News Magazine. They show a picture (p. H-11) of EVO beneath a protected "cobblestone armor" on the beach at Sleepy Bay. This beach and some others on the "Chenaga Lands" were extensively cleaned this summer by Chenaga Bay residents under a program sponsored by the Exxon Valdez Oil Spill Trustee Council. Perhaps others will have to explore those cleaned beaches in subsequent years to determine if any of the EVO still manages to persist in spite of the efforts of man aided by the forces of nature.

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Possible connection between two Alaskan catastrophes occurring 25 yr. apart (1964 and 198

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THE NEW YORK TIMES, WEDNESDAY, DECEMBER 1, 1993

...nce Puts a New Slant on Exxon Valdez Spill

...m First Business Page

made assessments of the ... and a half years, evapo... cleansing action of sea ... ther natural effects have ... ost of the Exxon Valdez ... surface of the sound's ... disputes continue over ... re are still significant ... residue from the spill ... surface.

...nd researchers from the ...ska and Federal agencies ...ly over whether subsur... ...ts in large quantities and ...he ecology of Prince Wil... Exxon says the damage ...and its animal life is less ...vernment contends and ...animal populations have...

...vidence

Dr. Kvenvolden, who ... sound by Paul Carl... ...hief for the Geologi...

substance whose characteristics vary with time and place. Measuring these characteristics provides a distinctive "fingerprint" for different kinds of oils.

Photographs by United States Geological Survey

Particles of asphalt from a spill in 1964 cling to a rock. The residue is significantly richer in carbon 13 than the Valdez residue.

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Keith A. Kvenvolden sampling oily residue le... ...ns spilled by the Exxon Valdez in Prince Willi...

Hydrocarbons in Oil Residues on Beaches of Islands of Prince William Sound, Alaska

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Published in Environmental Scie...

Ubiquitous Tar Balls with a California-Source Signature on the Shorelines of Prince William Sound, Alaska

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American Fisheries Society Sympos...

Tracking *Exxon Valdez* Oil from Beach to Deepwater Sediment... Prince William Sound, Alaska

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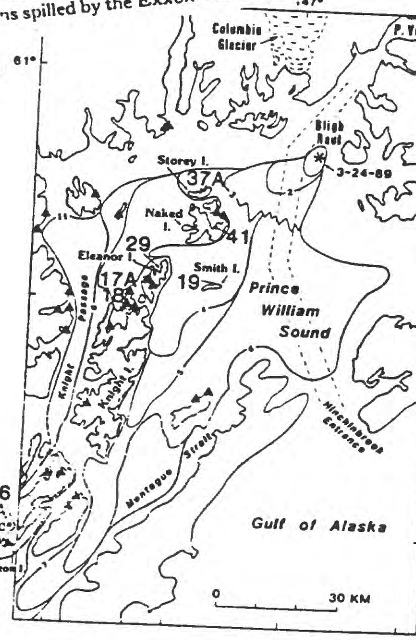

Geochemical changes in crude oil spilled from the *Exxon Valdez* supertanker into Prince William Sound, Alaska

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PROJECT PUBLICATIONS

a). Articles

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b.) Abstracts

Carlson, P.R., and Kvenvolden, K.A. 1992. Sediment of Prince William Sound: the aftermath of the *EXXON VALDEZ* oil spill, *in* AAAS (American Association for the Advancement of Science) Environmental Change: Natural and Man-Made, Arctic Science Conference, 43rd Valdez, AK, 1992, Program and Proceedings. Fairbanks, AK, University of Alaska Fairbanks, p. 128.

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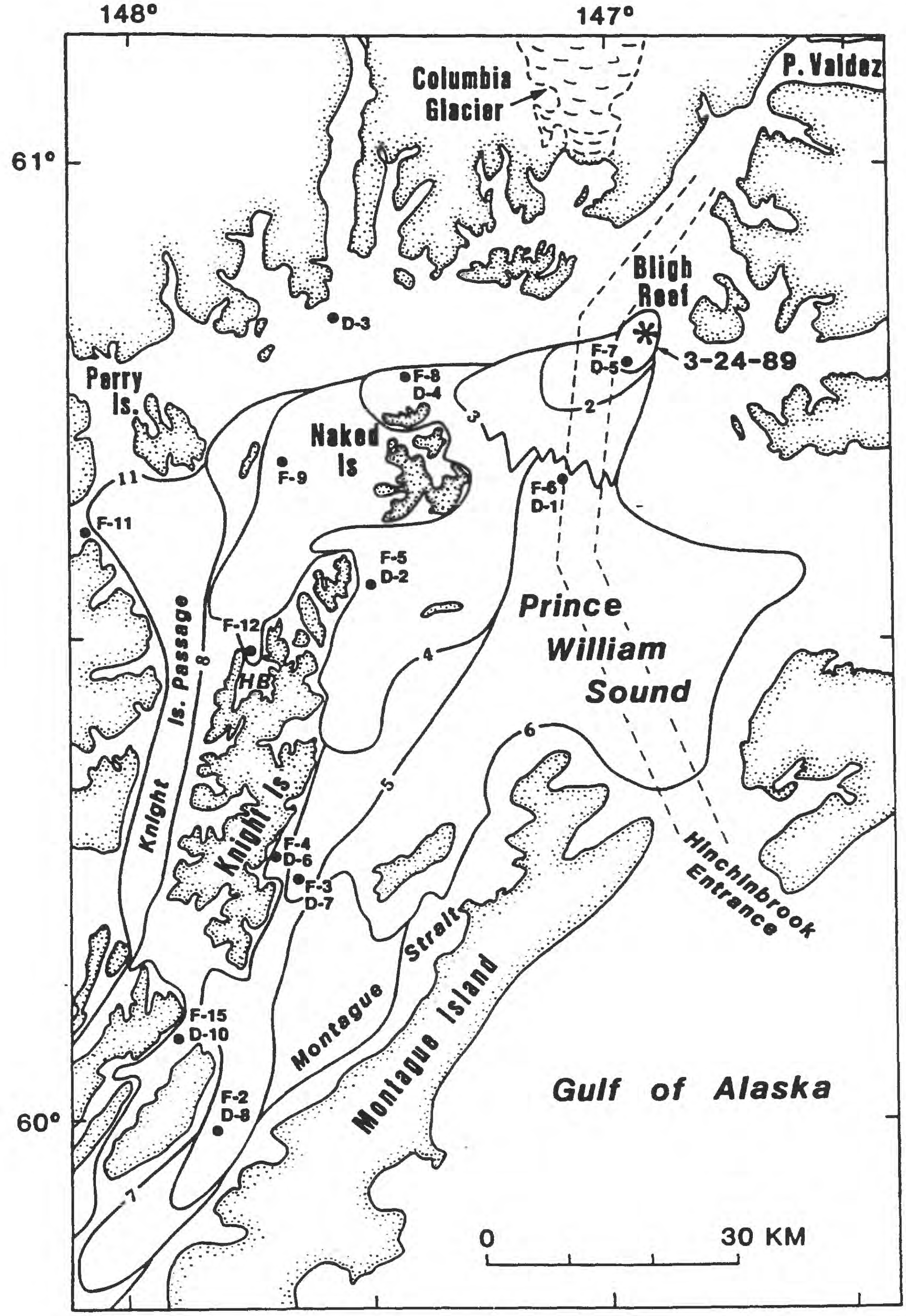


Figure 1. Location map of Prince William Sound (PWS) showing sampling sites of *M/V FARNELLA* (1989; F-1--F-15) and NOAA ship *DAVIDSON* (1990; D-1--D-10) cruises. The numbered lines show the position of the oil spill front at days 1-8 & 11 after the spill at Bligh Reef on 3/24/89. See Tables 1 & 2 for precise locations, sample descriptions, and geochemistry.

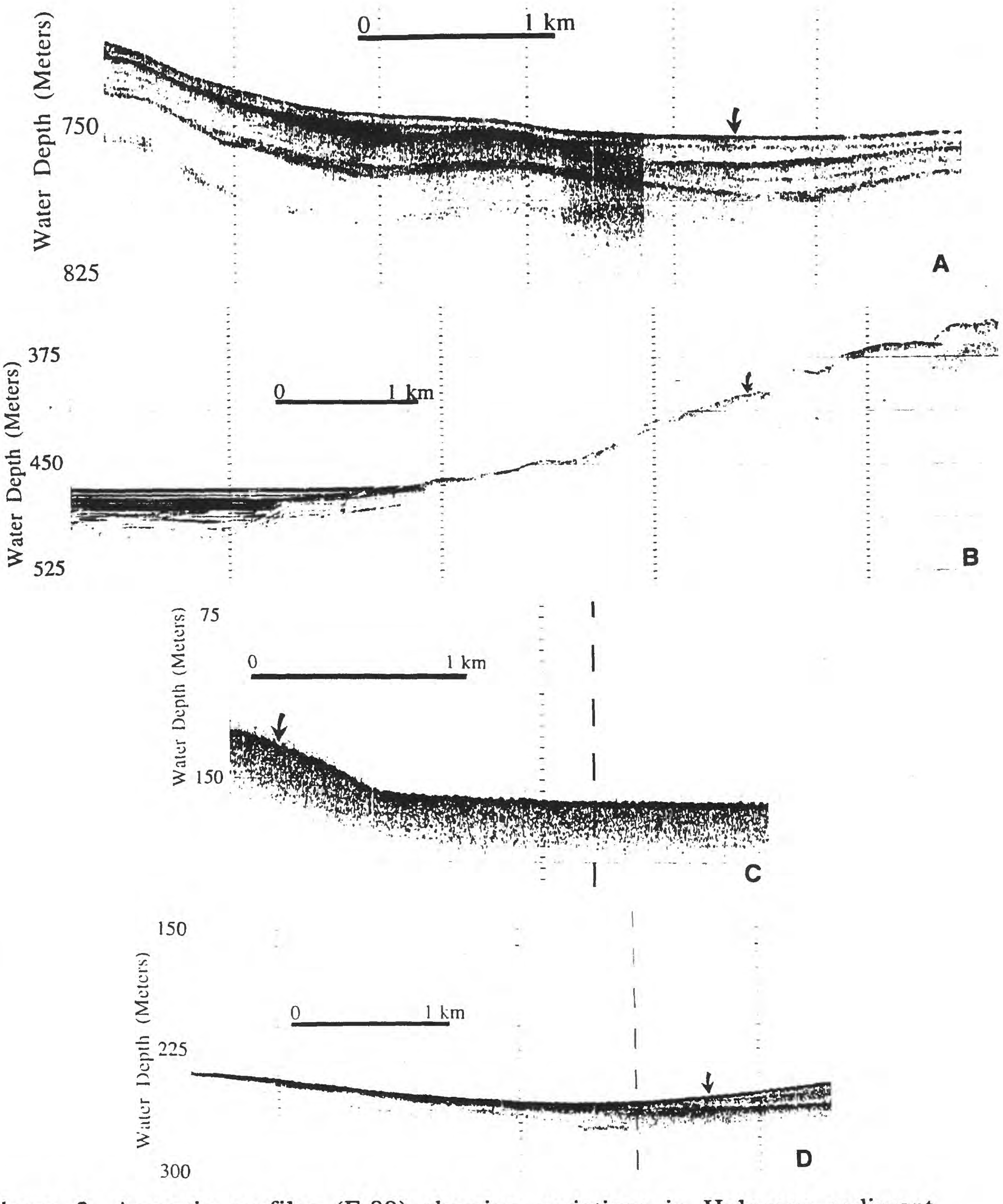


Figure 2. Acoustic profiles (F-89) showing variations in Holocene sediment thickness and fjord floor morphology in Prince William Sound. Vertical exaggeration =~10X. Arrows show where box cores were collected.

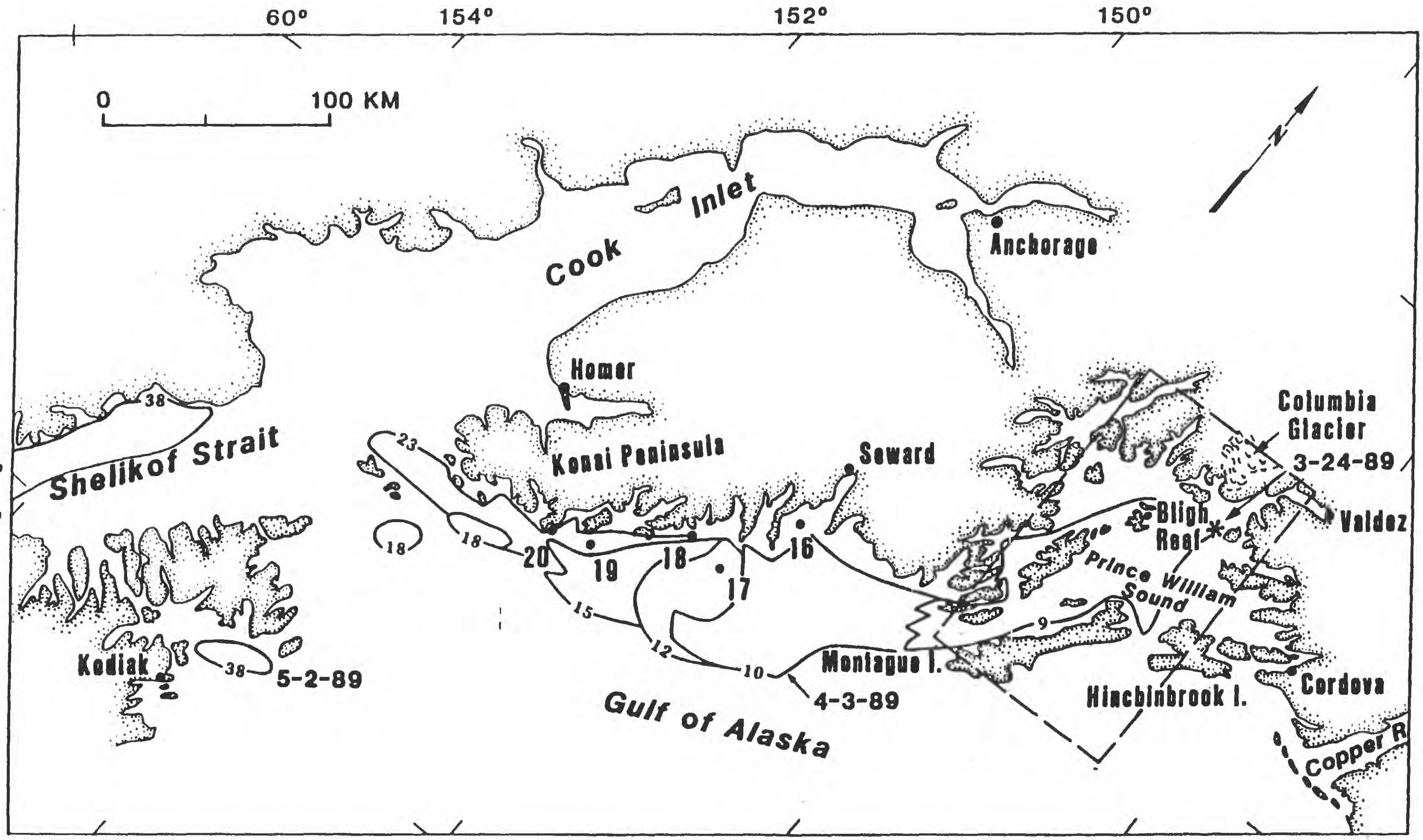


Figure 3. Map of *M/V FARNELLA* (F-89) sample sites in Gulf of Alaska. Lines with smaller numbers show leading edge of spill and number of days since the spill occurred. See Table 1 for precise locations, sample descriptions, and geochemistry.

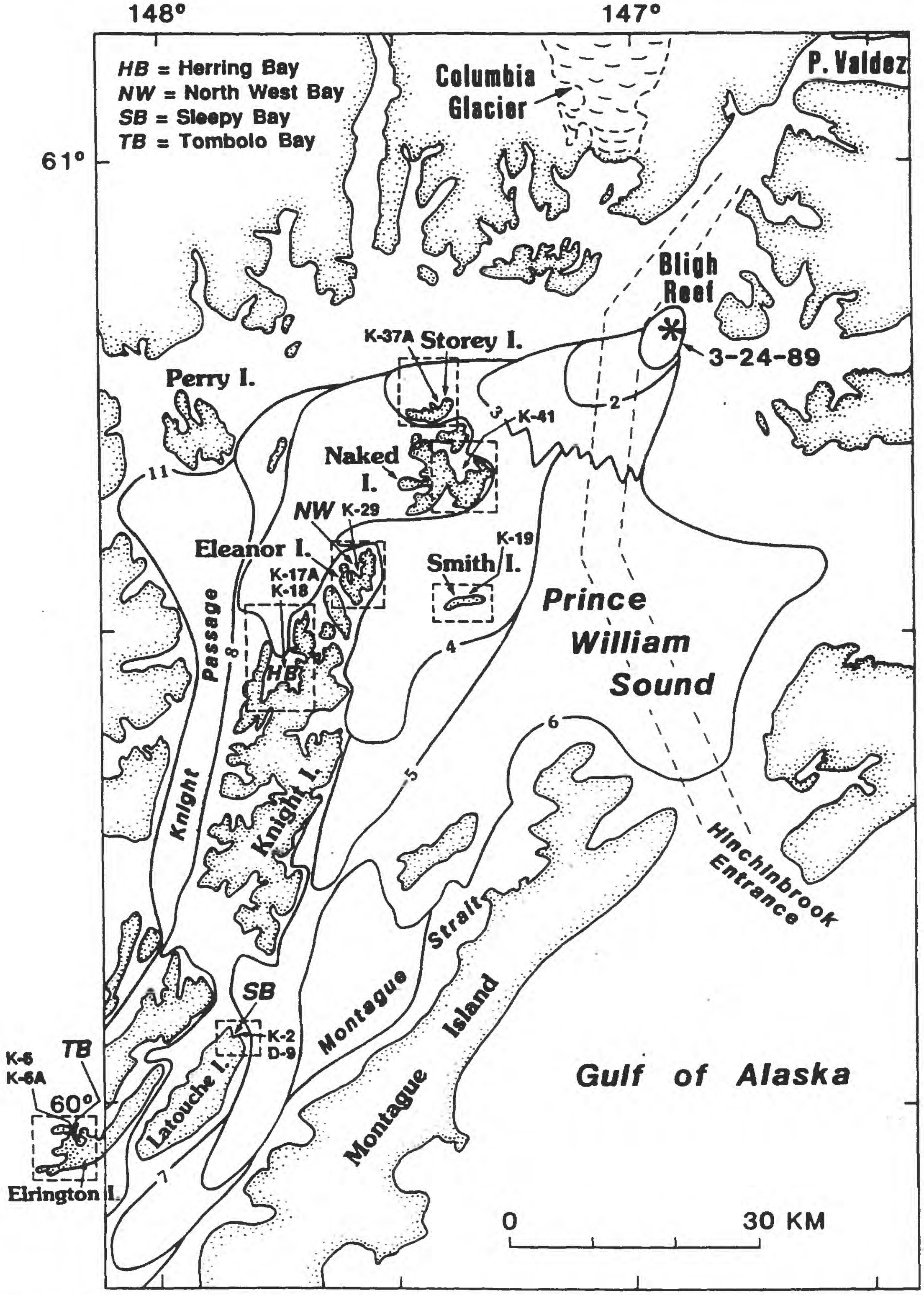


Figure 4. Map of *R/V KARLUK* (K-90) sampling sites throughout Prince William Sound. See table 2 for precise locations, sample descriptions, and geochemistry.

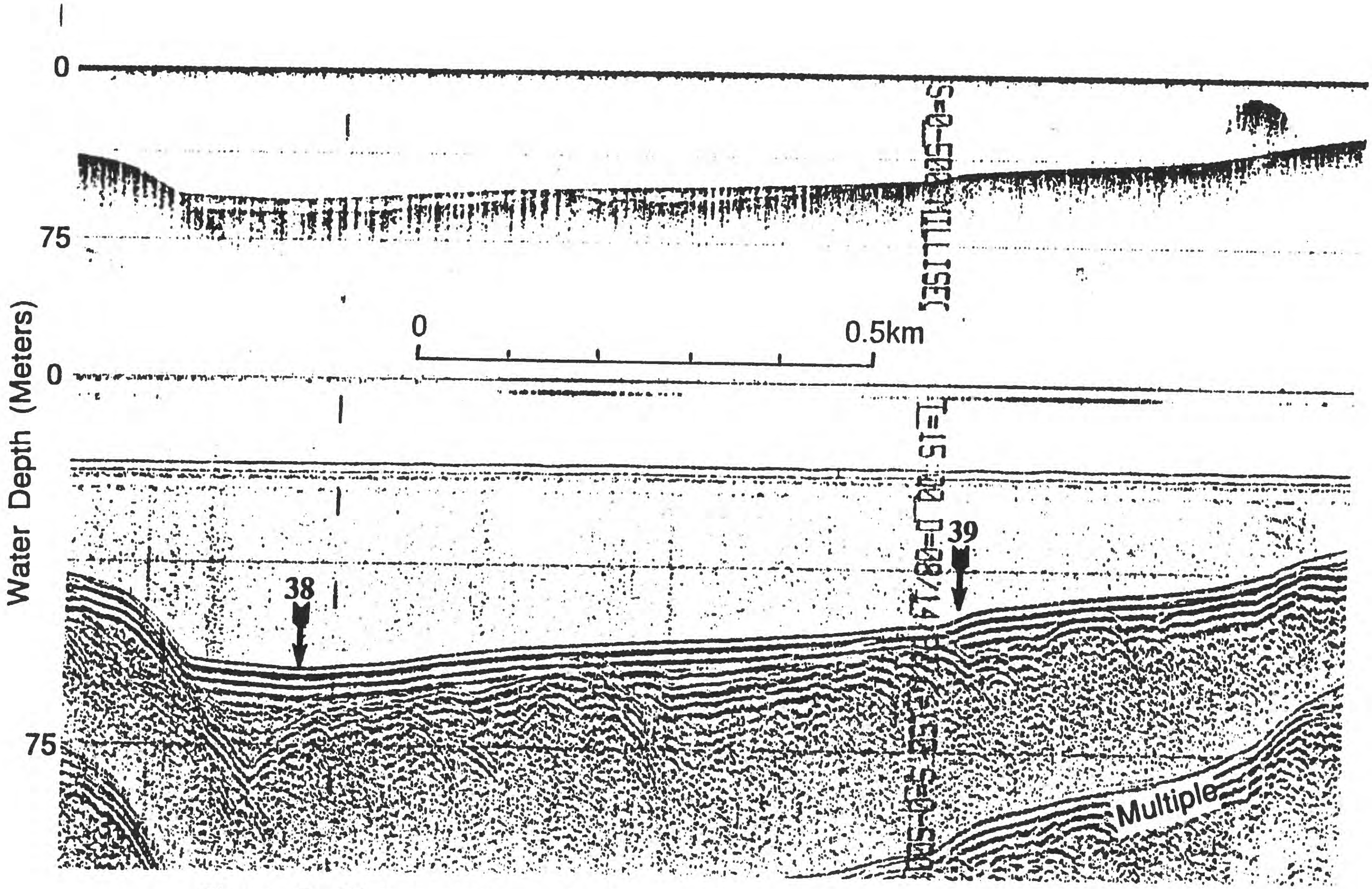


Figure 5. High-resolution seismic-reflection profiles from northeast side of Naked Island collected on *R/V KARLUK* (K-90) cruise. Top--3.5 kHz (Vertical exaggeration = 2.7X) and bottom--900 J Geopulse (Vertical exaggeration = 5.4X) showing shallow sill at left with basin at landward side. Numbered arrows indicate sampling sites.

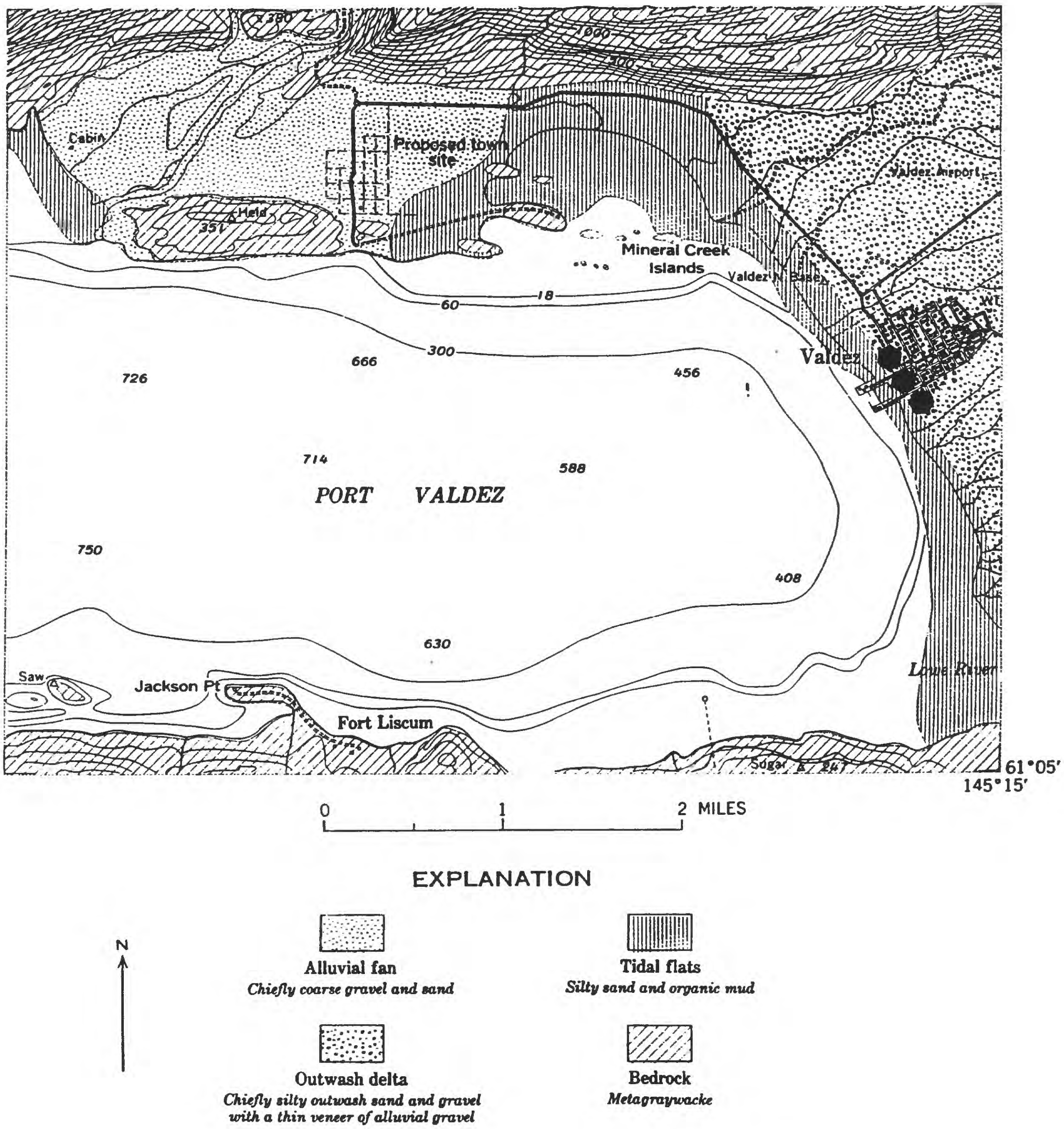


Figure 6. Map of Port Valdez showing location of Old Valdez. Base map from Coulter and Migliaccio (1966). Hexagons mark position of asphaltic reefs at original site of Old Valdez, samples 92-06, 95-11B,C (tables 3&6)

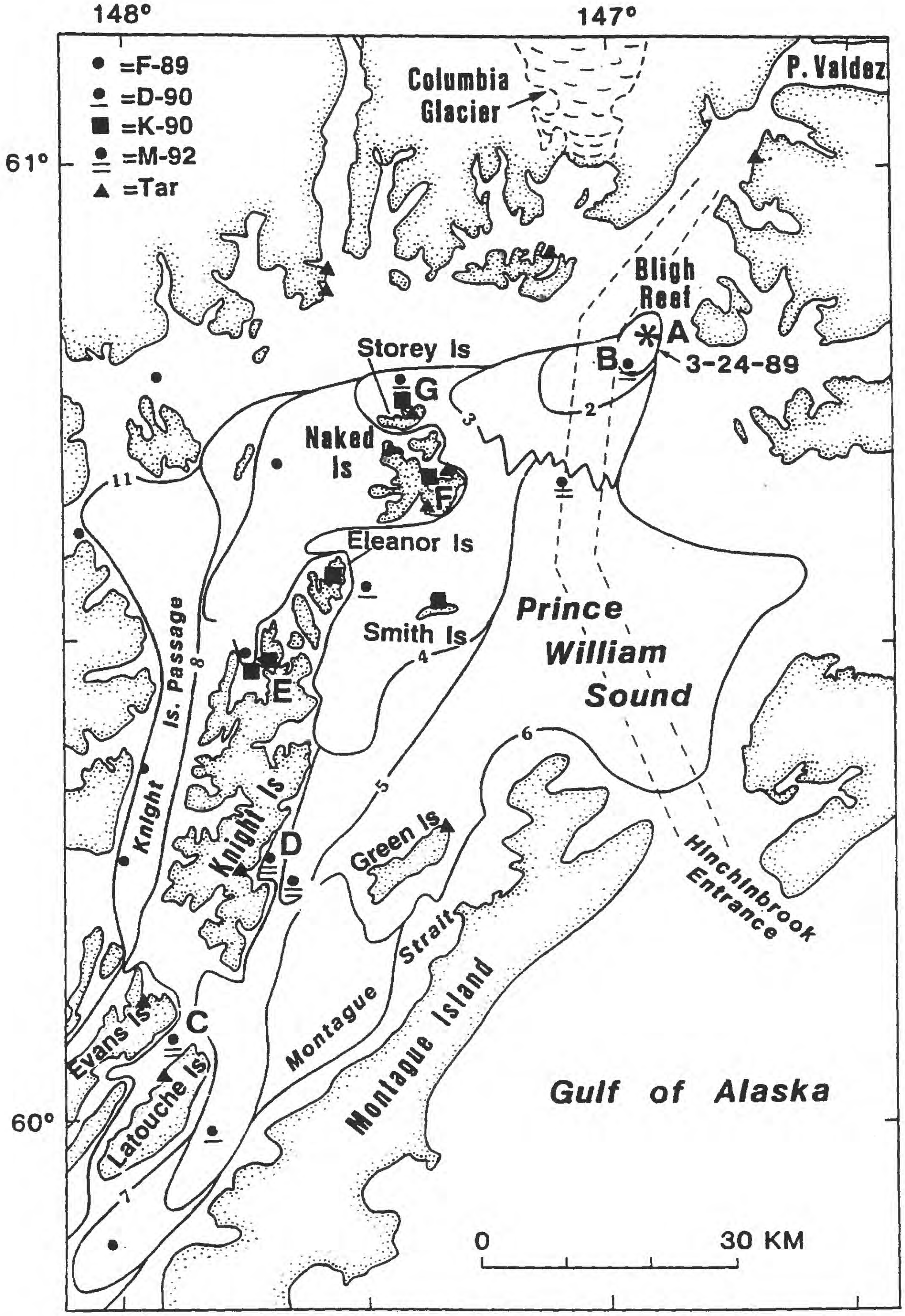


Figure 7. Map of Prince William Sound showing sites re-occupied on NOAA ship *McARTHUR* (M-92) cruise plus sites previously sampled from *FARNELLA DAVIDSON*, and *KARLUK*. Note how at this time (1993) we had found a pattern of the old tar samples following the EVO spill trend. See tables 1, 2, & 3 for precise locations, sample descriptions, and geochemistry.

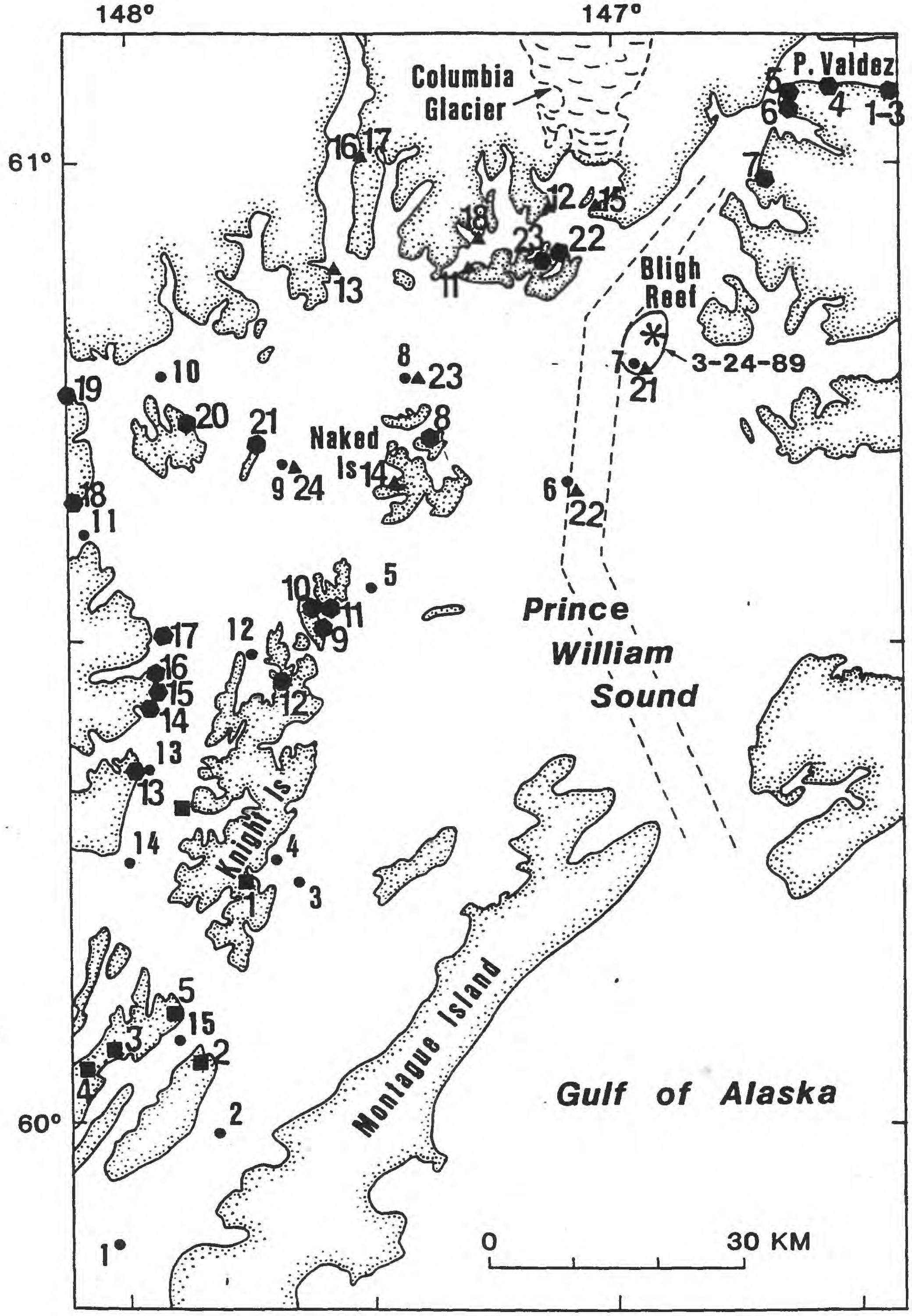


Figure 8. Map of Prince William Sound showing beach sampling sites for *M/V TLINGIT* 1993 (1-23) Hexagons; 1994 (1-7) Squares, and *NOAA RAINIER* 1994 beach.(11-18) and deep-water (21-24) Triangles. Numbered dots show *M/V FARNELLA* 1989 deep-water sites (1-15). See tables 4 & 5 for precise locations, sample descriptions, and geochemistry.

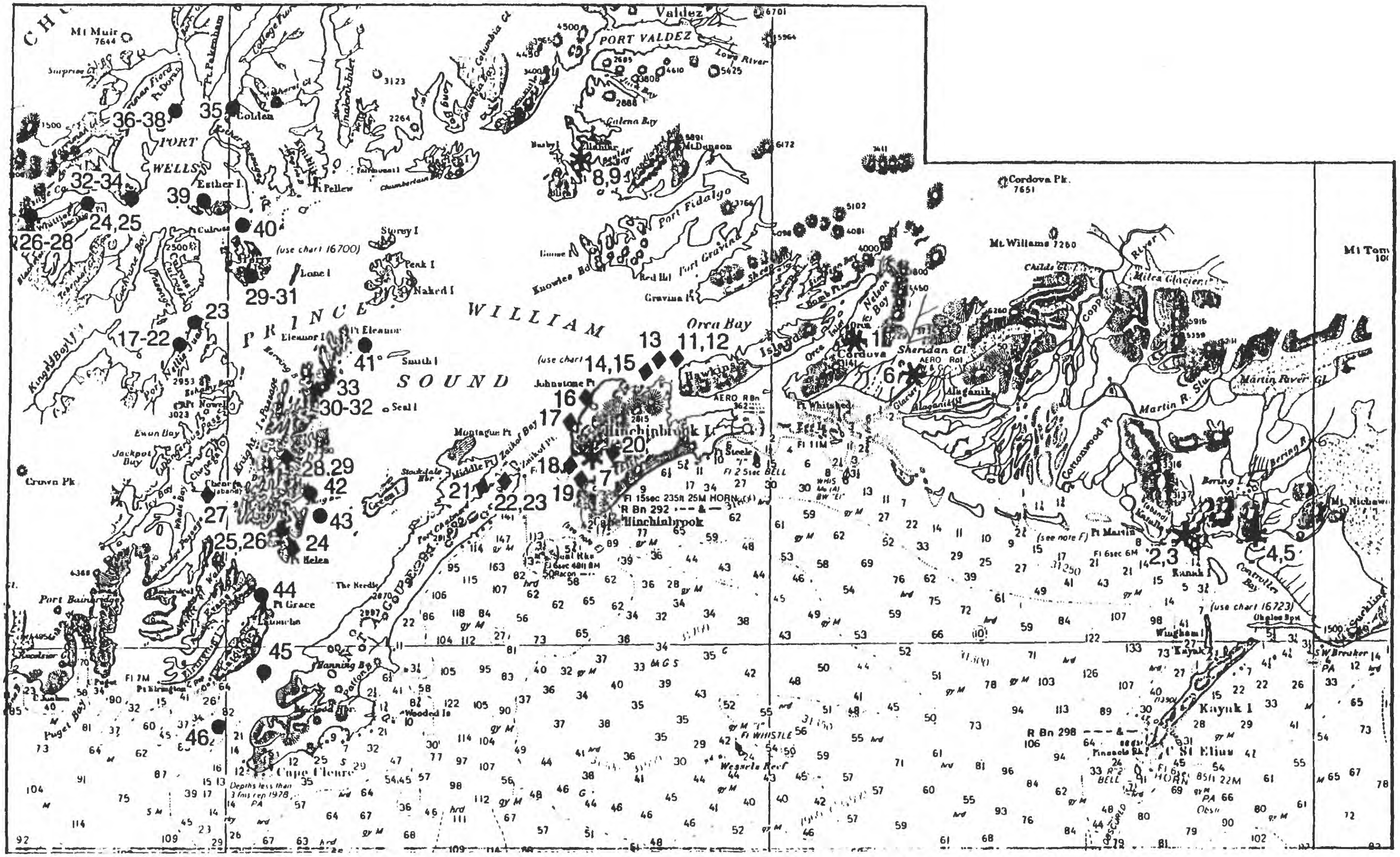
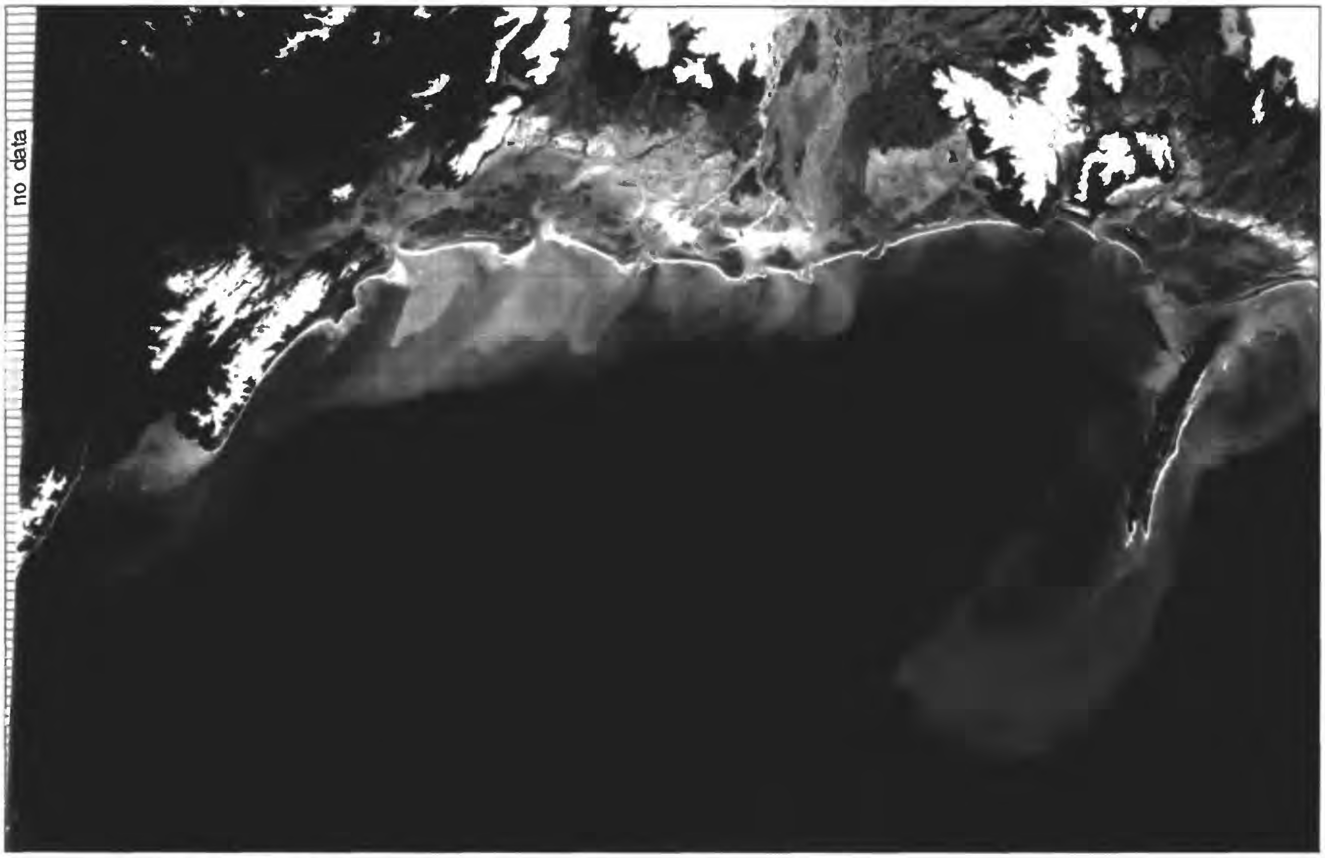


Figure 9. Map of Prince William Sound and area east to Bering Glacier showing sample sites for Helicopter work 1995 (1-9) Stars; *NOAA RAINIER* 1995 (17-46) Circles; and *M/V AUKLET* 1996 (11-33) Diamonds. See tables 6 & 7 for precise locations, sample descriptions, and geochemistry.

Figure 10. Sketch of satellite image (MSS band 5 of ERTS image taken October 12, 1972) showing Copper River plume of suspended sediment being transported into Prince William Sound through Hawkins Cutoff (H.C.) and Hinchinbrook Entrance (H.E.). Dashed lines mark plume boundaries. The plume of suspended sediment entering from the right contains meltwater from the large piedmont glaciers further to the east (Bering and Malaspina). This sediment is being carried in the Alaska Coastal Current around Kayak Island and into a complex gyre that occupies the area between Kayak Island and the Copper River. Drift drogues have been caught in this gyre for as long as 30 days (Royer et al., 1979).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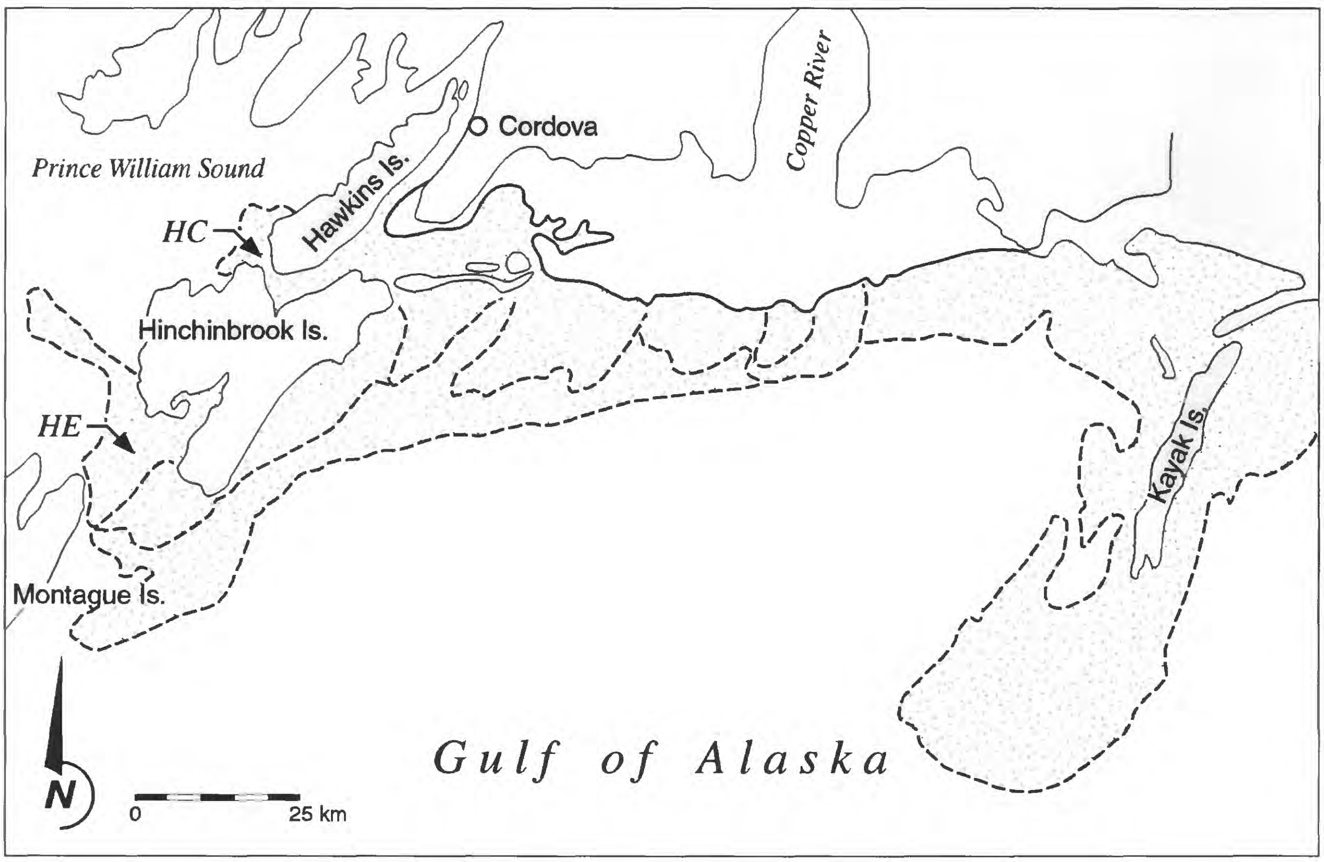
Prince William Sound
Cordova
Copper River
Hawkins Is.
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Hinchinbrook Is.
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Montague Is.
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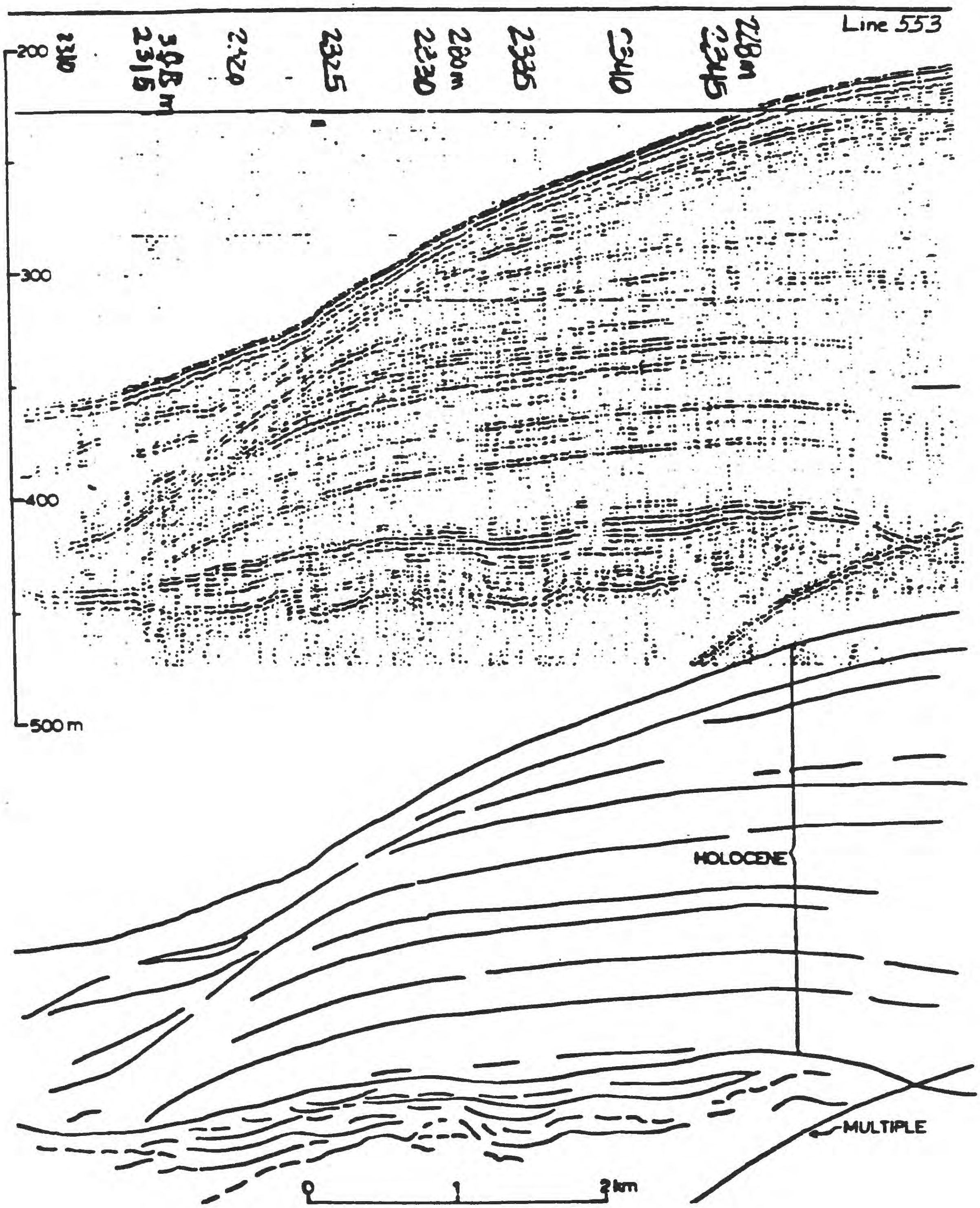

Figure 11. Minisparker profile in Hinchinbrook Entrance showing wedge of sediment prograding into entrance. Much of the sediment is being supplied by the Copper River as bedload and suspended sediment, which, as it enters the Gulf of Alaska, is being transported in a counterclockwise (westerly) direction by the Alaska Coastal Current.

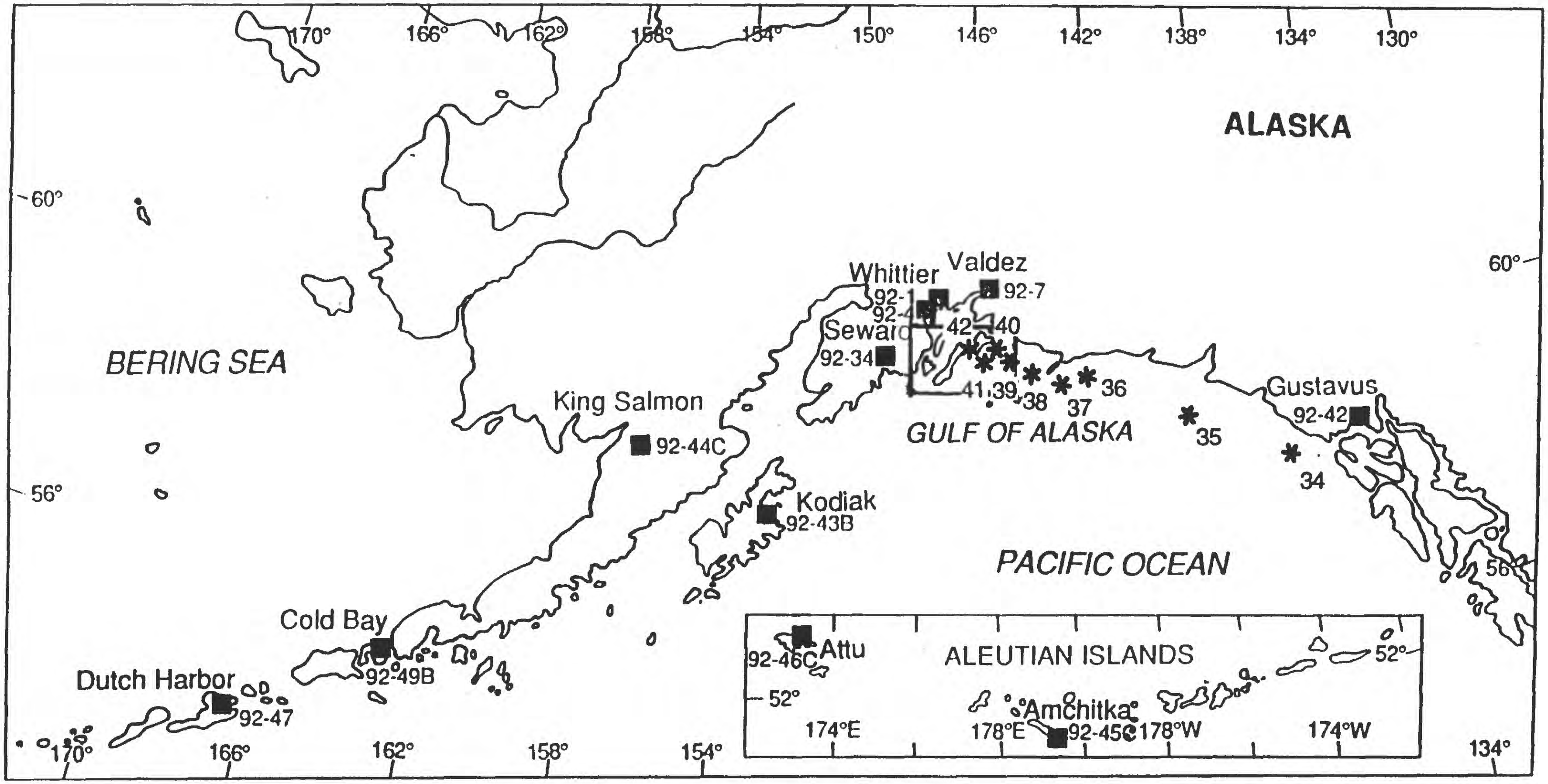

Figure 12a. Map of sample sites (34-54, Stars) occupied on the 1996 NOAA ship *RAINIER* cruise in the Gulf of Alaska See Table 7 for more precise locations, descriptions and geochemistry. The numbered squares (e.g. 92-47) mark runway and street pavement sites sampled as miscellaneous products. See Table 3 for more precise locations.

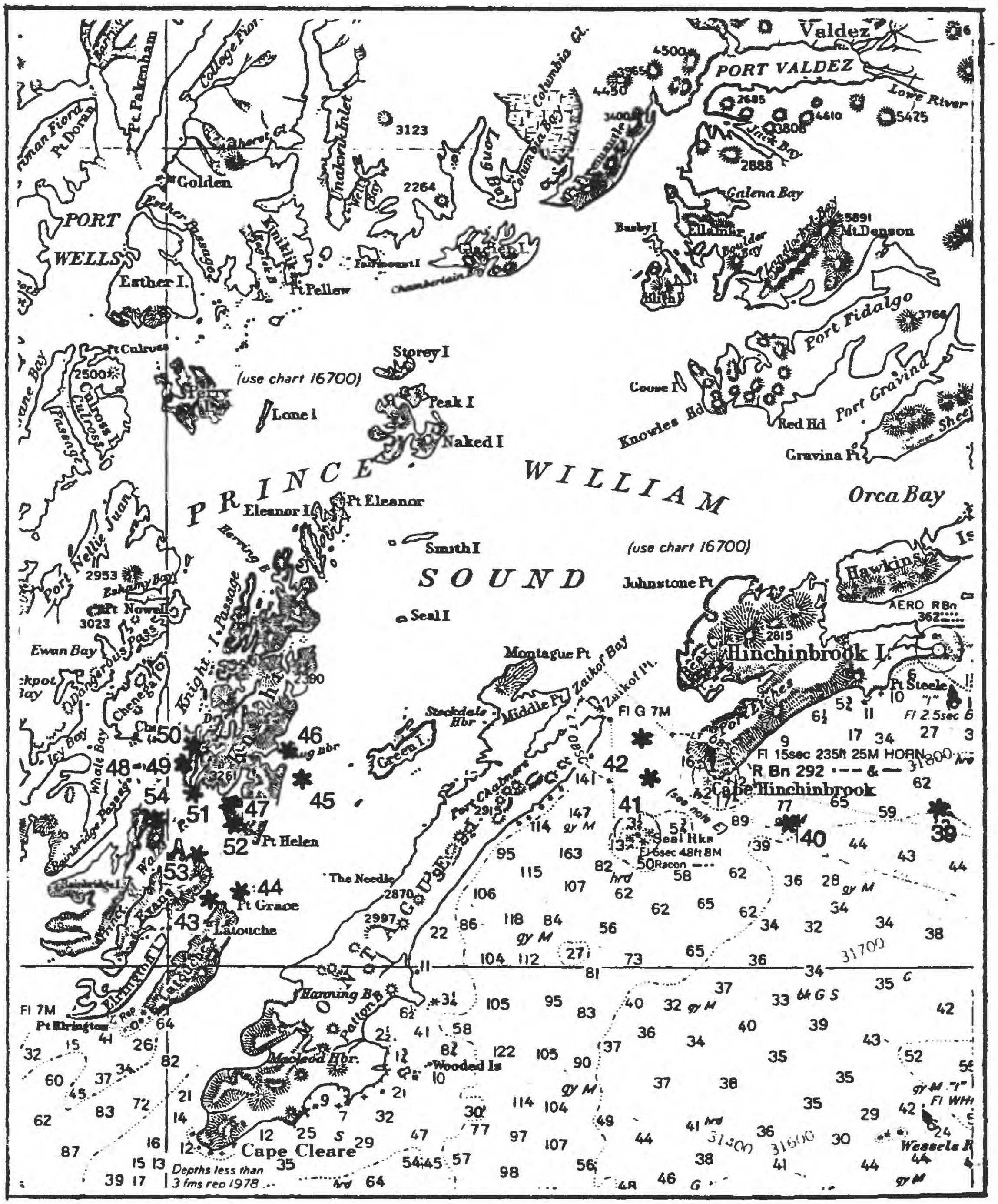

Figure 12b Detailed map of Prince William Sound and adjacent Gulf of Alaska sites (39-54, Stars) occupied during the 1996 NOAA ship *RAINIER* cruise See table 7 for precise locations, sample descriptions, and geochemistry.

LIST OF TABLES: CRUISES OR SAMPLING TRIPS, (YEAR)

Table 1. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of sediment extracts from Prince William Sound, Alaska (1989), *Farnella* cruise, including reference sample (*Exxon Valdez*).

					m/z 191					m/z 217	
Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	C_{29} $\frac{S}{S+R}$	C_{28}/C_{29}
***Farnella* cruise subaqueous samples**											
89-01	Montague Strait	59° 52.3′ 148° 01.2′	BX; 160m; *Far*: gray diamict.		6.2	0.88	1.6	0.16	-B, -T, +O	0.21	0.27
89-02A	Montague Strait	59° 58.6′ 147° 48.7′	BX; 246m; *Far*: gray clayey silt		2.0	0.86	1.9	0.49	?B, -T, +O	0.25	0.61
89-03A	Knight Island	60° 14.8′ 147° 38.8′	BX; 268m; *Far*: soft slt clay; off Snug Harbor		2.1	1.1	1.7	0.45	-B, -T, +O	0.27	0.69
89-04A	Knight Island	60° 16.4′ 147° 42.1′	BX; 125m; *Far*: gray clayey silt; Snug Harbor		1.9	1.5	1.7	0.50	?B, -T, +O	0.34	0.70
89-05A	Eleanor Island	60° 32.9′ 147° 30.4′	BX;197m; *Far*: gray silty clay		2.2	1.2	1.5	0.51	-B, -T, +O	0.30	0.62
89-06	Naked Island	60° 40.0′ 147° 06.1′	BX; 400m; *Far*: gray mud		2.7	0.69	1.6	0.47	-B, -T, +O	0.21	0.63
89-07C	Bligh Reef	60° 47.2′ 146° 57.2′	BX; 394m; *Far*: very soft gray mud		2.0	0.57	1.6	0.50	-B, -T, +O	0.18	0.65
89-08B	Storey Island	60° 46.2′ 147° 26.2′	BX; 480m; *Far*: gray silty clay		2.2	1.2	1.6	0.48	-B, -T, +O	0.25	0.56
89-09A	Lone Island	60° 41.1′ 147° 41.1′	BX; 755m; *Far*: olive-gray mud		2.3	0.82	1.6	0.52	-B, -T, +O	0.24	0.69
89-11A	Port Nellie Juan	60° 36.6′ 148° 07.2′	BX; 400m; *Far*: light gy clay; near entrance		2.0	1.3	1.5	0.45	lo B, -T, +O	0.31	0.74
89-12B	Knight Island	60° 28.9′ 147° 45.6′	BX; 205m; *Far*: soupy gray mud; Herring Bay		2.0	0.88	1.9	0.50	lo B, -T, +O	0.24	0.65
89-15A	Latouche Pass.	60° 05.1′ 147° 53.5′	BX; 240m; *Far*: diamict sand/pebbles		1.7	3.6	1.3	0.53	(+)	0.43	0.78
89-16B	Resurrec. Bay	59° 51.0′ 149° 28.0′	BX; 277m; *Far*: silty clay		2.1	0.99	1.6	0.54	lo B, -T, +O	0.28	0.73
89-17B	Gulf of Alaska	59° 31.2′ 149° 43.9′	BX; 115m; *Far*: muddy crs sd; near Chiswell Is.		2.5	0.83	1.7	0.56	lo B, -T, +O	0.27	0.68
Reference sample											
89-00[1]	Bligh Reef	60° 51.3′ 146° 52.5′	North Slope crude oil, tanker *Exxon Valdez*	-29.2	1.4	2.0	1.4	0.60	(-)	0.45	0.63

Table 1. (Continued)

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[1]Obtained from D.G. Shaw, Institute of Marine Science, University of Alaska, Fairbanks.

Sediment Samplers: BX, Box core; GC, Gravity core.
Vessels: *Far*, *Farnella* (USGS charter).

Table 2. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of tar balls and sediment extracts from Prince William Sound, Alaska (1990), *Karluk* and *Davidson* cruises.

					m/z 191					m/z 217	
Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	C_{29} $\frac{S}{S+R}$	C_{28}/C_{29}
***Karluk* cruise subaqueous samples**											
90-02 (~90-50)	Latouche I.	60° 04.1′ 147° 50.3′	VV; 18m; *Kar*: gy muddy fine sand; Sleepy Bay		1.5	1.6	1.5	0.57	(-)	0.53	0.48
90-08A	Elrington Island	59° 58.0′ 148° 09.3′	GC; 53m; *Kar*:gy sandy mud; Tombolo Bay		2.2	2.8	1.7	0.57	?B, ?T, +O	0.41	0.83
90-13	Knight Island	60° 25.7′ 147° 46.9′	VV; 42m; *Kar*: sdy mud w/ rx frag.; Herring Bay		1.4	1.8	1.3	0.62	(-)	0.50	0.61
90-15	Knight Island	60° 27.3′ 147° 43.2′	VV; 77m; *Kar*: olive gray mud; Herring Bay		2.6	1.8	1.6	0.59	-B, -T, +O	0.33	0.60
90-22	Smith Island	60° 32.2′ 147° 21.8′	VV; 95m; *Kar*: olive gray mud		2.1	1.6	1.6	0.49	-B, -T, +O	0.36	0.56
90-23	Smith Island	60° 32.5′ 147° 21.3′	VV; 125m; *Kar*: olive gray mud		3.0	1.7	1.3	0.50	-B, -T, +O	0.26	0.45
90-26	Eleanor Island	60° 33.0′ 147° 36.1′	VV; 41m; *Kar*: olive gray sandy mud; NW Bay		2.0	1.7	1.7	0.49	-B, -T, +O	0.35	0.65
90-35	Storey Island	60° 44.2′ 147° 25.1′	VV; 33m; *Kar*: pebbly muddy sand		2.0	2.0	1.5	0.48	-B, -T, +O	0.39	0.71
90-36	Storey Island	60° 44.5′ 147° 25.3′	VV; 50m; *Kar*: pebbly muddy sand		2.0	1.7	1.7	0.46	?B, ?T, +O	0.32	0.65
90-38A	Naked Island	60° 39.1′ 147° 22.3′	GC; 58m; *Kar*: olive gray sandy mud		2.0	1.7	1.6	0.49	-B, -T, +O	0.34	0.70
90-39	Naked Island	60° 39.7′ 147° 22.5′	VV; 48m; *Kar*: sandy mud w/rock frag.		1.8	1.6	1.5	0.44	-B, -T, +O	0.35	0.64
90-40	Naked Island	60° 39.3′ 147° 22.5′	VV; 20m; *Kar*: muddy sand		1.7	1.9	1.5	0.56	+B, ?T, +O	0.37	1.1
***Davidson* cruise subaqueous samples**											
90-42 (=89-06)	Naked Island	60° 40.3′ 147° 06.0′	BX;316m; *Dav*: gray silty clay		2.4	0.71	1.6	0.50	?B, -T, +O	0.22	0.61
90-43 (=89-05)	Eleanor Island	60° 32.8′ 147° 30.7′	BX; 217m; *Dav*: gray silty clay		2.1	1.3	1.5	0.49	-B, -T, +O	0.32	0.61
90-44	L. Axel Lind I.	60° 48.2′ 147° 36.6′	BX; 498m; *Dav*: gray silty clay		2.4	1.0	1.6	0.50	-B, -T, +O	0.26	0.61
90-45 (=89-08)	Storey Island	60° 46.2′ 147° 26.6′	BX; 478m; *Dav*: gray silty clay		2.3	0.86	1.5	0.46	-B, -T, +O	0.26	0.65
90-46 (=89-07)	Bligh Reef	60° 47.2′ 146° 57.5′	BX; 397m; *Dav*: gray silty clay		2.6	0.69	1.7	0.47	-B, -T, +O	0.23	0.65
90-47 (=89-04)	Knight Island	60° 16.5′ 147° 42.1′	BX; 113m; *Dav*: pebbly sandy mud; Snug Harbor		2.0	1.4	1.5	0.49	-B, -T, +O	0.35	0.62

90-48 (=89-03)	Knight Island	60° 14.7′ 147° 38.5′	BX; 260m; *Dav*: gy slty clay; off Snug Harbon		2.4	1.1	1.7	0.49	-B, -T, +O	0.31	0.66
90-49 (=89-02)	Montagne Strait	59° 59.7′ 147° 48.7′	BX; 272m; *Dav*: sandy silty clay		1.6	1.0	1.6	0.50	-B, -T, +O	0.30	0.66
90-50 (~90-02)	Latouche I.	60° 05.1′ 147° 51.0′	BX; 66m; *Dav*: gy grvly mdy sand; Sleepy Bay		1.6	2.6	1.5	0.53	?B, -T, +O	0.43	0.76
90-51 (=89-15)	Latouche Pass.	60° 04.2′ 147° 55.2′	BX; 126m; *Dav*: clayey silty sand		1.8	2.4	1.5	0.55	?B, -T, +O	0.43	0.65
90-52 (=89-16AB)	Ressurec. Bay	59° 52.1′ 149° 28.1′	BX 269m; *Dav*: gy slty clay; near bay mouth		2.3	0.84	1.5	0.53	-B, -T, +O	0.25	0.61
Beach samples											
90-06	Elrington Island	59° 58.2′ 148° 10.5′	Oiled sand; south end of Tombolo Bay	-29.3	1.4	2.0	1.4	0.60	(-)	0.48	0.67
90-06A	Elrington Island	59° 58.2′ 148° 10.5′	Tar on rock; south end of Tombolo Bay	-23.8	1.7	4.3	1.9	0.56	(+)	0.30	1.0
90-17A	Knight Island	60° 27.4′ 147° 42.4′	Solid oil on cobble; beach in Herring Bay	-25.3	1.3	2.0	1.4	0.59	(-)	0.53	0.50
90-18	Knight Island	60° 27.6′ 147° 43.4′	Oily pebbly loam; Herring Bay	-29.2	1.4	2.0	1.3	0.59	(-)	0.49	0.46
90-19	Smith Island	60° 31.7′ 147° 22.6′	Oiled cobbles; north shore of island	-29.4	1.4	2.2	1.6	0.60	(-)	0.48	0.61
90-29	Eleanor Island	60° 34.1′ 147° 34.4′	Solid oil on rock; Northwest Bay	-29.1	1.4	2.0	1.4	0.61	(-)	0.45	0.68
90-37A	Storey Island	60° 43.9′ 147° 24.7′	Tar on cobble; beach on north shore of island	-23.9	1.5	5.1	1.8	0.57	(+)	0.32	1.0
90-41	Naked Island	60° 39.4′ 147° 22.9′	Oiled cobbles; beach on McPherson Bay	-29.4	1.5	2.2	1.4	0.62	(-)	0.48	0.61

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

Sediment Samplers: AN, Anchor grab; BX, Box core; GC, Gravity core; VV, Van Veen grab.
Vessels: *Dav*, *Davidson* (NOAA); *Kar*, *Karluk* (USGS).

Table 3. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of tar balls and sediment extracts from Prince William Sound, Alaska (1992), *McArthur* cruise, including miscellaneous samples.

					m/z 191					m/z 217	
Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} S/(S+R)	BTO	C_{29} S/(S+R)	C_{28}/C_{29}
***McArthur* cruise subaqueous samples**											
92-09 (=89-07)	Bligh Reef	60° 47.2′ 146° 57.4′	SM; 395m; *McA* : olive-gray mud		2.5	0.67	1.5	0.48	-B, -T, +O	0.24	0.78
92-10 (=89-06)	Naked Island	60° 39.9′ 147° 06.9′	SM; 275m; *McA* : olive-gray mud		2.6	0.84	1.5	0.49	-B, -T, +O	0.26	0.71
92-14	Olsen Bay	60° 44.0′ 146° 13.1′	SM; 30m; *McA* : olive green mud		1.7	0.79	1.4	0.21	-B, -T, +O	0 no S	0 no C_{28}
92-23 (=89-04)	Knight Island	60° 16.4′ 147° 42.2′	SM; 114m; *McA* : olive-gray mud		1.7	1.9	1.6	0.56	(-), ?O	0.46	0.62
92-24 (=89-03)	Knight Island	60° 15.0′ 147° 38.6′	SM; 262m; *McA* : olive-gray mud		2.0	1.2	1.7	0.51	-B, -T, +O	0.33	0.61
92-33D (=89-15)	Latouche Pass.	60° 04.9′ 147° 53.5′	SM; 240m; *McA* : olive-gray mud w/ rocks		1.7	2.0	1.4	0.54	-B, -T, +O	0.49	0.83
Beach samples											
92-05[2]	Valdez Arm	61° 00.0′ 146° 47.7′	Tar on rock; east shore	-23.7	1.7	5.3	1.9	0.55	(+)	0.32	1.2
92-06	Old Valdez	61° 07.0′ 146° 16.5′	Tar mats; site of old asphalt-storage plant	-23.6	1.6	5.0	1.9	0.540	(+)	0.31	1.0
92-16	Naked Island	60° 40.3′ 147° 19.9′	Tar on rocks; east side, McPherson Bay	-23.7	1.7	5.4	1.7	0.54	(+)	0.32	1.1
92-18C	Naked Island	60° 40.6′ 147° 20.7′	Tar on rocks; NE point of McPherson Bay	-23.8							
92-19	Green Island	60° 18.2′ 147° 21.3′	Oil on rock; northeast shore of island	-26.6	2.5	1.4	1.1	0.59	-B, -T, +O	0.54	0.90
92-20	Green Island	60° 18.2′ 147° 21.3′	Tar on rock; northeast shore of island	-23.8	1.6	5.0	1.8	0.55	(+)	0.34	1.1
92-22	Knight Island	60° 14.2′ 147° 43.5′	Oily fissile meta-shale; S arm of Snug Harbor	-29.5	1.3	1.9	1.4	0.57	(-)	0.50	0.69
92-25	Knight Island	60° 15.8′ 147° 46.1′	Tar on rock; north arm of Snug Harbor	-23.8	1.5	5.3	1.7	0.54	(+)	0.33	1.2
92-26	Knight Island	60° 15.7′ 147° 46.2′	Solid oiled mat; north arm of Snug Harbor	-29.4	1.3	2.1	1.4	0.59	(-)	0.50	0.73
92-28	Evans Island	60° 06.5′ 147° 58.0′	Solid oiled mat; SW end of Shelter Bay	-29.3	0.83	2.0	1.5	0.61	(-)	0.65	0.43

92-29	Evans Island	60° 06.5′ 147° 57.7′	Tar on rock; SE end of Shelter Bay	-23.7	1.6	5.4	2.0	0.53	(+)	0.34	1.1
92-35[2]	Glacier Island	60° 54.0′ 147° 09.0′	Tar on rock; Eagle Bay	-23.8	1.7	4.9	1.9	0.53	(+)	0.32	1.0
92-36B[2]	Olsen Island	60° 52.2′ 147° 34.0′	Tar on rock; Exxon site 6	-23.8	1.5	5.2	1.8	0.55	(+)	0.33	1.1
92-37[2]	Olsen Cove	60° 52.1′ 147° 35.5′	Tar on rock; Exxon site 7	-23.8							
92-38[2]	Naked Island	60° 39.0′ 147° 23.0′	Tar on meta-shale; NE end of Bass Harbor	-23.9	1.6	5.9	1.9	0.55	(+)	0.34	1.1
92-39[2]	Naked Island	60° 42.0′ 147° 26.5′	Matted tar; north shore of island	-23.9							
92-40	Valdez Harbor	61° 07.6′ 146° 20.1′	Tar on rock; Outer Point	-24.0	1.6	5.4	1.7	0.55	(+)	0.32	1.1
92-41	Valdez Harbor	61° 07.7′ 146° 19.9′	Tar on rock; Dock Point	-23.6	1.9	4.6	1.9	0.54	(+)	0.31	1.1
Product samples											
92-01	Whittier	60° 46.3′ 148° 41.2′	Street pavement, >20 yr old; near Hodge Bldg.	-24.8	1.1	2.5	1.5	0.54	(+)	0.41	1.0
92-03	Whittier	60° 46.5′ 148° 40.3′	Asphalt, tar paper; Buckner Building	-24.9							
92-04	Whittier	60° 46.5′ 148° 40.3′	Driveway paved before 1964; Buckner Building	-24.3	1.3	4.2	1.7	0.52	(+)	0.39	1.1
92-07	Valdez	61° 07.9′ 146° 14.5′	Tar from new airport runway	-27.2	1.5	2.1	1.9	0.58	(-)	0.39	0.74
92-08	Valdez	61° 08.3′ 146° 12.5′	Tar from Glacier Road, paved in 1971	-27.7							
92-30	Latouche I.	60° 03.2′ 147° 54.1′	Tar in Blackbird Mine dump on island	-24.8							
92-31	Latouche I.	60° 03.2′ 147° 54.1′	Oil at toe of Blackbird Mine dump on island	-24.3							
92-32	Latouche I.	60° 03.2′ 147° 54.1′	Tar on telephone pole at mine dump	-23.6							
92-34	Seward	60° 07.7′ 149° 27.0′	Tar from new airport runway	-28.1	1.2	1.8	1.8	0.58	(-)	0.46	0.63
92-42[3]	Gustavus	58° 29.0′ 135° 42.0′	Old section of airport runway	-23.5							
92-43B[4]	Kodiak	57° 45.0′ 152° 30.7′	Navy air terminal parking pad	-27.1							
92-44C[4]	King Salmon	56° 41.4′ 156° 38.7′	North apron of airport runway	-29.6							

92-45C[4]	Amchitka	51° 23.4′ 179° 19.8′ E	World War II airport reactivated runway C	-23.4							
92-46C[4]	Attu	52° 49.4′ 173° 10.4′ E	World War II deactivated runway	-22.8							
92-47[4]	Dutch Harbor	53° 53.8′ 166° 32.2′	Tar from new airport runway	-29.1	1.5	1.6	1.5	0.56	(-)	0.45	0.62
92-49B[4]	Cold Bay	55° 12.9′ 162° 43.9′	End of oil airport runway	-22.7	2.7	6.1	1.4	0.54	(+)	0.34	1.2

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[2]Obtained from J. and N. Lethcoe, Alaska Wilderness Sailing Safaris; [3]obtained from C. Schroth, National Park Service; [4]obtained from J. Reeve Ogle, Reeve Aleutian Airways, Inc..

Sediment Samplers: SM, Smith-McIntyre grab.
Vessels: *McA*, *McArthur* (NOAA).

Table 4. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of tar balls from Prince William Sound, Alaska (1993), including miscellaneous and reference samples.

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
Beach samples											
93-01	Port Valdez	61° 05.3´ 146° 26.2´	Tar mat at Salmon Creek	-23.6	1.6	4.9	2.0	0.55	(+)	0.34	1.1
93-03	Port Valdez	61° 05.2´ 146° 26.0´	Tar mat near Salmon Creek	-23.7							
93-04	Port Valdez	61° 04.7´ 146° 33.9´	Tar on rocks; Anderson Bay	-23.7	1.6	5.7	2.0	0.54	(+)	.33	1.0
93-05	Valdez Narrows	61° 04.3´ 146° 38.5´	Tar on rock; east shore of narrows	-23.7							
93-06	Valdez Narrows	61° 04.3´ 146° 38.5´	Tar mat cementing rock; east shore of narrows	-23.7	1.7	5.2	2.0	0.55	(+)	0.32	0.96
93-07A	Valdez Arm	60° 59.5´ 146° 41.6´	Tar on rock; east shore of arm	-23.8							
93-07B	Valdez Arm	60° 59.5´ 146° 41.6´	Sticky tar mat; east shore of arm	-23.7	1.7	5.2	2.0	0.52	(+)	0.31	1.0
93-08	Peak Island	60° 42.3´ 147° 23.9´	Soft tar on rock; north shore of island	-23.7	1.7	5.3	1.9	0.50	(+)	0.31	1.0
93-09A	Ingot Island	60° 31.9´ 147° 37.7´	Tar on rock; archeologic site	-24.0	1.3	5.1	2.1	0.55	(+)	0.43	1.1
93-09B	Ingot Island	60° 31.9´ 147° 37.7´	Solid, oiled mat; archeologic site	-29.6	1.2	1.9	1.6	0.60	(-)	0.62	0.46
93-10A	Ingot Island	60° 32.0´ 147° 37.7´	Soft tar on beach; north shore of island	-23.7							
93-10B	Ingot Island	60° 32.0´ 147° 37.7´	Hard tar on beach; north shore of island	-23.8							
93-11	Block Island	60° 31.9´ 147° 36.5´	Sticky tar on cobble beach	-23.7	1.6	5.6	1.8	0.53	(+)	0.33	1.2
93-12A	Knight Island	60° 27.5´ 147° 42.6´	Tar on rocks; Herring Bay	-23.9	1.6	3.8	1.9	0.52	(+)	0.35	1.1
93-12B	Knight Island	60° 27.5´ 147° 42.6´	Solid oiled mat; Herring Bay	-29.4	1.3	1.7	1.5	0.60	(-)	0.62	0.40
93-13A	Chenega Island	60° 22.8´ 148° 00.5´	Sticky tar on rock; north shore of island	-24.3	1.6	4.8	1.9	0.53	(+)	0.35	1.2
93-13B	Chenega Island	60° 22.8´ 148° 00.5´	Sticky tar in cracks of rock; north shore of isl.	-29.3	1.3	1.9	1.5	0.57	(-)	0.44	0.50

93-13C	Chenega Island	60° 22.8´ 148° 00.5´	Semi-sticky tar on rock; north shore of island	-29.3	1.3	2.0	1.6	0.57	(-)	0.47	0.61
93-14A	Granite Cove	60° 25.1´ 147° 57.7´	Semi-sticky tar on rock and in crack	-29.2	1.3	1.9	1.6	0.58	(-)	0.53	0.47
93-14B	Granite Cove	60° 25.1´ 147° 57.7´	Tar on rock; north shore of cove	-23.7	1.5	5.7	2.0	0.51	(+)	0.33	0.97
93-14C	Granite Cove	60° 25.1´ 147° 57.7´	Sticky tar on rock; north shore of cove	-23.7							
93-14E	Granite Cove	60° 25.1´ 147° 57.7´	Lustrous tar on rock; north shore of cove	-23.5							
93-15A	Point Nowell	60° 26.5´ 147° 56.2´	Sticky tar on rock on beach facing Sound	-23.8							
93-15B	Point Nowell	60° 26.5´ 147° 56.2´	Oily matted organic debris	-29.4	1.3	2.0	1.6	0.58	(-)	0.48	0.54
93-15D	Point Nowell	60° 26.5´ 147° 56.2´	Tar that breaks with brittle fracture	-23.7	1.7	4.8	1.9	0.54	(+)	0.31	1.0
93-16A	Eshamy Bay	60° 27.9´ 147° 57.6´	Weathered, tar-cemented barnacles	-29.3							
93-16B	Eshamy Bay	60° 27.9´ 147° 57.6´	Sticky tar on bldr beach, south entrance to bay	-23.7	1.8	4.9	1.9	0.55	(+)	0.35	1.1
93-16C	Eshamy Bay	60° 27.9´ 147° 57.6´	Tar-matted organic debris	-29.3	1.3	1.6	1.6	0.60	(-)	0.52	0.44
93-16D	Eshamy Bay	60° 27.9´ 147° 57.6´	Soft tar on beach; south entrance to bay	-23.7							
93-17A	Crafton Island	60° 30.5´ 147° 56.5´	Tar on rock; west shore of north point of island	-23.7	1.5	5.9	1.9	0.54	(+)	0.36	1.1
93-18A	Culross Island	60° 38.5´ 148° 07.0´	Sticky tar on cobble beach; SE shore of isl.	-23.8	1.8	5.3	1.9	0.53	(+)	0.33	1.1
93-18B	Culross Island	60° 38.5´ 148° 07.0´	Sticky oil among beach cobbles; SE shore of isl.	-29.3	1.4	1.9	1.6	0.59	(-)	0.48	0.62
93-19	Culross Island	60° 44.9´ 148° 10.7´	Sticky oil on slate; beach on Culross Bay	-27.8	1.0	1.2	1.2	0.60	-B, -T, +O	0.46	0.42
93-20	Perry Island	60° 42.8´ 147° 52.6´	Tar on jointed granite; E shore, Day Care Cove	-23.8	1.4	4.7	1.9	0,53	(+)	0.31	0.99
93-21	Lone Island	60° 41.8´ 147° 44.9´	Sticky tar on rocks; north shore of island	-23.7	1.6	5.4	1.8	0.54	(+)	0.34	1.0
93-22A	Growler Island	60° 54.1´ 147° 06.8´	Tar on cobbles; east shore of island	-23.7	1.7	5.1	1.7	0.55	(+)	0.33	1.1
93-22B	Growler Island	60° 54.1´ 147° 06.8´	Tar-cemented conglom-erate; east shore of isl.	-23.7							

93-23A	Glacier Island	60° 54.3′ 147° 08.8′	Tar on rock; west shore of Elder Bay	-23.6	1.8	4.5	1.7	0.55	(+)	0.34	1.1
93-24[2]	Disk Island	60° 29.3′ 147° 40.2′	Tar on rock in anchorage	-23.7	1.5	5.0	2.0	0.54	(+)	0.38	0.96
93-25[2]	Ingot Island	60° 30′ 147° 38′	Tar on rock; southwest shore of isl.	-23.7							
93-26A[2]	Green Island	60° 17.6′ 147° 25.8′	Tar on rock;.north shore of island	-23.9							
93-26B[2]	Green Island	60° 17.6′ 147° 24.6′	Tar-like residue on rock	-29.2	0.85	2.0	1.7	0.62	(-)	0.73	0.58
93-23B (=92-35)	Glacier Island	60° 54.0′ 147° 09.0′	Tar on rock at Eagle Bay	-23.7	1.7	4.7	1.6	0.53	(+)	0.34	1.2
93-30[6]	Knight Island	60° 09.8′ 147° 45.4′	Oily pebbles; Point Helen	-29.4	1.4	2.1	1.5	0.59	(-)	0.47	0.56
Reference samples											
93-27[5]	Katalla	60° 12.0′ 144° 25.0′	Composite oil sample, R165-036		0.77	3.4	1.9	0.56	-B, -T, +O	0.49	1.0
93-28[5]	Samovar Hills	60° 07.5′ 140° 46.0′	Oil sample, R165-037; Sec. 3, T21S, R27E		5.7	0 (no C26)	1.4	0.57	-B, -T, +O	0.47	0.17
93-29[5]	Johnston Creek	60° 01.7′ 141° 53.3′	Oil sample, R165-036; Sec. 7, T22S, R21E		3.9	0 (no C26)	1.7	0.56	-B, -T, +O	0.46	0.18

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[2]Obtained from J. and N. Lethcoe, Alaska Wilderness Sailing Safaris; [5]obtained from L.B. Magoon, Energy Team, U.S. Geological Survey; [6]obtained from L.J. Evans, Alaska Department of Environmental Conservation; .

Table 5. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of tar balls and sediment extracts from Prince William Sound, Alaska (1994), *Rainier* cruise, including miscellaneous and reference samples.

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} S/(S+R)	BTO	m/z 217 C_{29} S/(S+R)	C_{28}/C_{29}
***Rainier* cruise samples**											
94-21 (=89-07)	Bligh Reef	60° 47.2′ 146° 57.2′	SM; 390m; *Rai*: gray-blue mud		2.4	0.82	1.5	0.50	?B, -T, +O	0.27	0.63
94-22 (=89-06)	Naked Island	60° 40.0′ 147° 06.0′	SM; 285m; *Rai*: gray-blue mud		2.2	0.79	1.6	0.49	?B, -T, +O	0.25	0.65
94-23 (=89-08)	Storey Island	60° 46.2′ 147° 26.5′	SM; 477m; *Rai*: gray-blue mud		2.5	1.0	1.5	0.47	?B, -T, +O	0.26	0.46
94-24 (=89-09)	Lone Island	60° 41.1′ 147° 41.0′	SM; 747m; *Rai*: gray-blue mud		2.6	1.2	1.5	0.5	?B, -T, +O	0.33	0.58
Beach samples											
94-2A	Latouche I.	60° 03.9′ 147° 50.4′	Live oil on pebble; Sleepy Bay	-29.5	1.4	1.8	1.4	0.58	(-)	0.48	0.63
94-2B	Latouche I.	60° 03.9′ 147° 50.4′	Oil-like patina on cobble; Sleepy Bay	-29.3							
94-2C	Latouche I.	60° 03.9′ 147° 50.4′	Oil mat-like pavement; Sleepy Bay	-29.4	1.3	1.9	1.4	0.61	(-)	0.50	0.59
94-2D	Latouche I.	60° 03.9′ 147° 50.5′	Oil-cemented pebbles; Sleepy Bay	-29.4							
94-2F	Latouche I.	60° 04.0′ 147° 50.5′	Tar w/pine needles on rock; Sleepy Bay	-24.1	1.6	3.8	1.9	0.55	(+)	0.36	0.99
94-5A	Evans Island	60° 06.7′ 147° 53.4′	Sticky oil on pebbles near Bishop Rock	-29.4	1.3	2.0	1.4	0.58	(-)	0.50	0.64
94-5B	Evans Island	60° 06.7′ 147° 53.4′	Oil in pocket of rock near Bishop Rock	-29.5	1.6	2.0	1.5	0.57	(-)	0.46	0.60
94-5C	Evans Island	60° 06.7′ 147° 53.4′	Tar on rock near Bishop Rock	-23.8	1.6	5.7	1.6	0.54	(+)	0.33	1.2
94-5D	Evans Island	60° 06.7′ 147° 53.4′	Tar with pine needles on rock near Bishop Rock	-29.3	1.4	2.0	1.4	0.58	(-)	0.49	0.62
94-6A	Squire Island	60° 14.9′ 147° 56.9′	Tar with old pine needles on rock; west shore	-23.7	1.6	5.3	1.6	0,53	(+)	0.36	1.2
94-6B	Squire Island	60° 14.9′ 147° 56.9′	Tar with fresh needles on rock; west shore	-23.7							
94-6C	Squire Island	60° 14.9′ 147° 56.9′	Tar on rocks; west shore	-23.7							
94-07[2]	Valdez Arm	61° 02.5′ 146° 47.4′	Tar on rock; Sawmill Bay	-23.7	1.6	5.2	1.7	0.52	(+)	0.35	1.2
94-8[2]	Perry Island	60° 43.5′ 147° 58.0′	Scattered tar on rocks; West Twin Bay	-23.8							

94-10[2]	Glacier Pass.	60° 54.0´ 147° 19.9´	Tar on rock; beach W of Eickelberg Bay	-23.7							
94-11	Glacier Island	60° 52.9´ 147° 18.1´	Tar on rock; Irish Cove	-23.7	1.7	4.9	1.5	0.53	(+)	0.33	1.2
94-13[2]	Unakwik Inlet	60° 52.8´ 147° 35.0´	Sticky tar patch; Mueller Cove	-29.4	1.5	2.1	1.5	0.60	(-)	0.47	0.47
94-14[2]	Naked Island	60° 39.3´ 147° 26.4´	Tar on rock; Cabin Bay	-23.6							
94-15	Columbia Bay	60° 56.8´ 147° 03.0´	Tar on large rock; north side of Elf Point	-22.8	1.6	5.6	1.8	0.51	(+)	0.33	1.0
94-18A	Glacier Pass.	60° 55.2´ 147° 16.7´	Tar on rock west of Buyers Cove	-23.7							
Product samples											
94-2E	Latouche I.	60° 04.0´ 147° 50.6´	Tar caulking on log; Sleepy Bay	-23.6	1.8	4.7	1.8	0.52	(+)	0.32	1.1
94-3A	Evans Island	60° 04.0´ 148° 00.5´	Sticky oil mat in dump; Chenega Bay	-24.3	2.7	2.8	1.4	0.56	(+)	0.37	1.1
94-4	Evans Island	60° 03.5´ 148° 03.2´	Oil from storage tanks; Port Ashton	-23.4	2.6	4.4	1.6	0.50	(+)	0.34	1.3
94-12	Columbia Bay	60° 56.6´ 147° 08.2´	Tar on timber on beach north of Flent Point	-23.7							
94-16	Unakwik Inlet	61° 00.5´ 147° 31.5´	Tar paper from roof of abandoned cannery	-23.3							
94-17	Unakwik Inlet	61° 00.5´ 147° 31.5´	Tar caulking on beam at abandoned cannery	-23.0	2.3	7.5	1.6	0.53	(+)	0.35	1.4
94-19[7]	Bethel	60° 47.5´ 161° 45.0´	Airport asphalt in leaking storage drums	-23.3	1.9	5.0	2.1	0.51	(+)	0.28	1.1
Reference sample											
94-20	California	35° 10.6´ 120° 37.0´	Oil seep; near Pismo Beach, Price Canyon Rd	-21.0	3.4	5.1	1.5	0.50	+B, -T, +O	0.28	1.4

Table 5. (Continued)

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[2]Obtained from J. and N. Lethcoe, Alaska Wilderness Sailing Safaris; [7]obtained from W. Stokes, Alaska Department of Environmental Conservation.

Sediment Samplers: SM, Smith-McIntyre grab.
Vessels: *Rai*, *Rainier* (NOAA).

Table 6. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of tar balls and sediment extracts from Prince William Sound, Alaska (1995), *Rainier* cruise, including miscellaneous and reference samples.

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} S/S+R	BTO	m/z 217 C_{29} S/S+R	m/z 217 C_{28}/C_{29}
***Rainier* cruise and other subaqueous samples**											
95-40 (=89-10)	Wells Passage	60° 46.0´ 147° 56.1´	SH; 325m; *Rai*: gray green silty mud		2.5	1.2	1.9	0.45	lo B, -T, +O	0.29	0.58
95-41 (=89-05)	Eleanor Island	60° 32.9´ 147° 30.6´	SH; 204m; *Rai*: gray green silty mud		2.0	1.4	1.7	0.48	?B, -T, +O	0.30	0.56
95-42 (=89-04)	Knight Island	60° 15.6´ 147° 42.0´	SM; 65m; *Rai*: gy-gr mud w/ gv; Snug Harbor		1.9	1.9	1.8	0.49	lo B, -T, +O	0.38	0.56
95-43 (=89-03)	Knight Island	60° 14.0´ 147° 39.0´	SM; 271m; *Rai*: blue gn mud; off Snug Harbor		1.9	1.7	1.8	0.50	?B, -T, +O	0.32	0.55
95-44 (=89-15)	Latouche Pass.	60° 04.6´ 147° 53.7´	SH; 105m; *Rai*: gray green silt		1.7	3.1	1.8	0.49	-B, -T, +O	0.41	0.73
95-45 (=89-02)	Montague Strait	59° 58.4´ 147° 49.9´	SH; 249m; *Rai*: olive sandy mud		1.7	1.2	1.9	0.50	lo B, -T, +O	0.33	0.48
95-46 (=89-01)	Montague Strait	59° 52.3´ 148° 01.5´	SH; 150m; *Rai*: mudy sdy gvl; SW end of str.		1.5	0.63	1.9	0.53	?B, -T, +O	0.29	0.48
95-64[10]	Knight Island	60° 27.3´ 147° 31.7´	GC; 212m; 90-100cm; NW of Seal Island		2.7	0.30	1.9	0.43	-B, -T, +O	0.21	0.48
95-66[10]	Knight Island	60° 18.9´ 147° 27.9´	GC; 217m; 30-40cm; off of Marsha Bay		3.0	0.30	1.8	0.44	-B, -T, +O	0.25	0.49
95-68[10]	Ingot Island	60° 32.3´ 147° 43.5´	GC; 693m; 106-116cm; NW of island		2.9	0.27	1.9	0.43	-B, -T, +O	0.20	0.54
Beach samples											
95-08A	Ellamar	60° 53.7´ 146° 42.1´	Tar cobble on beach near abandoned dock	-22.4							
95-11B	Old Valdez	61° 06.8´ 146° 16.0´	Tar on large cobble at site of tank farm	-23.5	1.8	4.7	2.0	0.60	(+)	0.32	1.0
95-11C	Old Valdez	61° 06.8´ 146° 16.0´	Piece of tar at site of tank farm	-23.4							
95-13[6]	Elrington Island	59° 58.5´ 148° 11.0´	Tar cemented sand; ER 11A, 8/94	-29.1							
95-14[6]	Ingot Island	60° 30.0´ 147° 38.7´	Tar cemented cobbles; IN 31A, 7/93	-23.6							
95-15[6]	Eleanor Island	60° 33.8´ 147° 34.5´	Tar splatter scraped off rock; EL 58B, 5/92	-24.1							
95-29	Perry Island	60° 41.1´ 147° 55.2´	Tar on rock at old wharf site at oyster farm	-22.3							

95-52[8]	Shuyak Island	58° 38.0′ 152° 21.9′	NOAA beach sample; R95-06, 603606	-29.3							
95-56[8]	Shuyak Island	58° 33.9′ 152° 39.0′	NOAA beach sample; R95-06, 603610	-29.3							
95-58[8]	Kodiak Island	57° 42.4′ 153° 54.3′	NOAA beach sample; R95-06, 603612	-29.3							
Product samples											
95-04	Chilkat	60° 11.3′ 144° 13.0′	Tar on chimney flashing; Bering River	-22.9							
95-05	Chilkat	60° 11.3′ 144° 13.0′	Tar paper from old house on Bering River	-22.9							
95-06A	Cordova	60° 29.6′ 145° 28.4′	Tar on old taxiway at main airport	-29.2							
95-06B	Cordova	60° 29.6′ 145° 28.4′	Tar on active taxiway at main airport	-22.3							
95-07	Nuchek	60° 20.0′ 146° 38.5′	Tar on timber on beach north of houses	-24.0							
95-08B	Ellamar	60° 53.7′ 146° 42.1′	Tar on piling of abandoned dock	-23.4	3.8	2.4	1.6	0.59	(+)	0.31	1.1
95-09	Ellamar	60° 53.7′ 146° 42.1′	Tar on cable binding on piling of new pier	-23.3							
95-10	Old Valdez	61° 06.9′ 146° 16.2′	Tar at keel of abandoned *Emerald Pacific*	-29.3	1.2	2.5	2.0	0.62	(-)	0.42	0.52
95-12	Palmer	61° 35.7′ 149° 06.3′	Tar from parking pad at airport	-29.3	1.6	1.5	1.8	0.59	(-)	0.39	0.49
95-17	McClure Bay	60° 32.9′ 148° 09.8′	Tar on piling of abandoned West Gable cannery	-23.6	15.	0.37	0.88	0.55	(+)	0.33	0.92
95-19	McClure Bay	60° 32.9′ 148° 09.8′	Grease on rusted equipment at cannery	-23.7							
95-20	McClure Bay	60° 32.9′ 148° 09.8′	Tar on roofing of power plant at cannery	-23.8							
95-21	McClure Bay	60° 32.9′ 148° 09.8′	Oil residue in valve of fuel tank at cannery	-23.8	2.2	3.7	1.6	0.58	(+)	0.32	1.1
95-22	McClure Bay	60° 32.9′ 148° 09.8′	Oil residue cascading down rock at cannery	-23.7							
95-23A	Port Nellie Juan	60° 35.5′ 148° 06.7′	Oil inside container in cabin; Chevron SAE 30	-27.7							
95-24	Passage Canal	60° 47.8′ 148° 31.8′	Tar on roof of shipwreck, *St. Elias Ocean Product*	-24.8							
95-25	Passage Canal	60° 47.8′ 148° 31.8′	Tar coating on fabric on roof of shipwreck barge	-22.9	2.5	4.5	1.8	0.60	(+)	0.34	1.2
95-26	Whittier	60° 46.5′ 148° 42.8′	Road tar from newly paved road near dump	-29.4							

95-27	Whittier	60° 46.5´ 148° 43.0´	Tar pieces at end of gravel runway	-29,4							
95-28	Whittier	60° 46.5´ 148° 43.0´	Tar w/ gravel from near end of runway by pilings	-24.2							
95-30	Perry Island	60° 41.1´ 147° 55.2´	Tar on old chimney flashing at oyster farm	-28.7							
95-31	Perry Island	60° 41.1´ 147° 55.2´	Tar on pole of boat shed at oyster farm	-24.8							
95-32	Port Wells	60° 50.5´ 148° 19.3´	Tar on plank near mining equi.; N shore Pigot Bay	-23.7							
95-34	Port Wells	60° 50.4´ 148° 23.2´	Roof tar, Forest Ser. cabin; S side, Pigot Bay	-25.4							
95-37	Port Wells	60° 57.9´ 148° 12.3´	Grease from barrel on beach near Granite Mine	-25.4							
95-38	Port Wells	60° 58.3´ 148° 11.9´	Tar on metal shed roof; north of Granite Mine	-26.1							
95-39	Ester Island	60° 48,0´ 148° 05.0´	Roofing material from W. Noerenberg Hatchery	-27.3							
Reference samples											
95-02	Katalla	60° 11.2´ 144° 25.3´	Seep in moss below drilling rig	-24.7	0.93	3.1	1.8	0.60	-B, -T, +O	0.44	0.84
95-60[9]	California	40° 34.5´ 124° 21.0´	Tar ball; 400m south of Centerville Beach	-26.7	1.4	0.62	0.96	0.57	-B, -T, +O	0.35	0.58
95-61[9]	California	40° 34.3´ 124° 21.1´	Tar ball; 800m south of Centerville Beach	-26.7							

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[6]Obtained from L.J. Evans, Alaska Department of Environmental Conservation; [7]obtained from W. Stokes, Alaska Department of Environmental Conservation; [8]obtained from J.W. Short, NOAA, Auke Bay Laboratory; [9]obtained from J. Lesh, California Department of Fish & Game, Oil Spill Prevention & Response Office; [10]obtained from J.M. Kennedy, Kinnetic Laboratories, Inc.

Sediment Samplers: SH, Shipek grab; SM, Smith-McIntyre grab.
Vessels: *Rai, Rainier* (NOAA)

Table 7. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of tar balls and sediment extracts from Prince William Sound, Alaska (1996), *Auklet* and *Rainier* cruise, including miscellaneous and reference samples.

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} S/(S+R)	BTO	m/z 217 C_{29} S/(S+R)	m/z 217 C_{28}/C_{29}
***Auklet* and *Rainier* cruises and other subaqueous samples**											
96-12	Hawkins Cutoff	60° 31.9′ 146° 16.8′	VV; 12m; *Auk*: gy mud; edge of Middle Gd. Shoal		3.2	0.50	1.7	0.34	-B, -T, +O	0.23	0.47
96-13	Hawkins Cutoff	60° 32.3′ 146° 22.3′	VV; 18m; *Auk*: gy mud; edge of Middle Gd. Shoal		2.6	0.60	1.7	0.45	-B, -T, +O	0.20	0.56
96-15	Hinchinbrook I.	60° 28.4′ 146° 26.3′	VV; 12m; *Auk*: gray green mud; north shore		2.7	0.67	1.2	0.17	-B, -T, +O	0.21	0.48
96-16	Hinchinbrook I.	60° 28.5′ 146° 38.3′	VV; 31m; *Auk*: olive gy mud; off Johnstone Pt.		2.5	0.58	1.7	0.27	-B, -T, +O	0.23	0.56
96-18	Hinchinbrook I.	60° 20.1′ 146° 41.2′	VV; 34m; *Auk*: gy mud, near Bear Cape		2.5	0.42	1.9	0.47	-B, -T, +O	0.21	0.52
96-19	Hinchinbrook I.	60° 17.6′ 146° 40.8′	VV; 14m; *Auk*: gray sdy mud; English Bay		2.5	0.43	1.8	0.48	-B, -T, +O	0.21	0.49
96-21	Montaque I.	60° 21.0′ 147° 05.4′	VV; 76m; *Auk*: gy mud; inside Rocky Bay		2.0	1.1	1.9	0.45	-B, -T, +O	0.28	0.60
96-34A	Gulf of Alaska	58° 13.0′ 137° 25.4′	SH; 134m; *Rai*: olive-gy mud; W, Cape Spencer		1.8	2.9	2.0	0.50	-B, -T, +O	0.44	0.00
96-35A	Gulf of Alaska	59° 14.0′ 140° 20.9′	SH; 138m; *Rai*: gy mud; south of Yakutat Bay		3.0	1.1	2.2	0.42	-B, -T, +O	0.35	0.00
96-36B	Gulf of Alaska	59° 44.8′ 143° 34.1′	SH; 308m; *Rai*: gy mud; Bering Trough		3.0	0.3	1.8	0.50	+B, -T, +O	0.18	0.55
96-37B	Gulf of Alaska	59° 44.0′ 144° 00.5′	SH; 120m; *Rai*: gy mud; Kayak I./Bering Trough		3.2	0.30	1.9	0.50	+B, -T, +O	0.17	0.55
96-38	Gulf of Alaska	59° 55.8′ 145° 04.5′	SH; 159m; *Rai*: gy mud; west of Kayak Island		2.9	0.24	1.8	0.52	+B, -T, +O	0.17	0.56
96-39	Gulf of Alaska	60° 10.8′ 145° 46.8′	SH; 119m; *Rai*: gy mud south of Pt. Whitney		2.8	0.32	1.8	0.51	+B, -T, +O	0.20	0.56
96-40	Gulf of Alaska	60° 12.9′ 146° 06.7′	SH; 106m; *Rai*: gy mud; south, Hinchinbrook Is.		2.9	0.35	1.8	0.51	-B, -T, +O	0.19	0.54
96-41	Gulf of Alaska	60° 11.9′ 146° 25.2′	SH; 128m; *Rai*: gy mud ESE, Cape Hinchinbr.		1.8	0.37	1.7	0.52	+B, -T, +O	0.19	0.55
96-42A	Hinchinbr. Ent.	60° 18.2′ 146° 47.8′	SH; 270m; *Rai*: gy mud; west of Pt. Etches		2.7	0.47	1.9	0.50	+B, -T, +O	0.21	0.52
96-43A (=89-15)	Latouche Pass.	60° 05.7′ 147° 53.5′	SH; 225m; *Rai*: sd mud; north end of passage		1.6	3.7	1.5	0.53	(+)	0.43	0.77

96-44	Latouche I.	60° 04.8′ 147° 49.6′	SH; 145m; *Rai* : sd mud; off of Sleepy Bay		2.0	1.8	1.9	0.50	(+) (lo B, T)	0.35	0.59
96-45 (=89-03)	Knight Island	60° 14.7′ 147° 38.9′	SH; 264m; *Rai* : olive-gy mud; off of Snug Harbor		2.3	1.4	1.9	0.50	?B, -T, +O	0.31	0.55
96-46 (=89-04)	Knight Island	60° 16.4′ 147° 42.1′	SH; 120m; *Rai* : olive-gy mud; Snug Harbor		2.5	1.1	1.8	0.47	?B, -T, +O	0.29	0.61
96-55[8]	Hinchinbrook I.	60° 21.3′ 146° 39.5′	NOAA sample 601508; Constantine Harbor		7.6	0.75	1.5	0.06	-B, -T, ?O	0 no sterane	0 no sterane
Beach samples											
96-22	Montaque I.	60° 20.6′ 147° 02.3′	Tar w/ fresh needles on rock; Rocky Bay	-26.9	1.4	2.2	1.5	0.61	(+) (lo)	0.40	0.54
96-24	Knight Island	60° 09.5′ 147° 45.5′	Dead oil on rock at high tide line; Point Helen	-29.2							
96-27	Chenega Island	60° 16.8′ 147° 04.7′	Oil cemented fissile shale; Old Chenega	-29.2							
96-30	Knight Island	60° 28.0′ 147° 40.6′	Tar on rock; shore of Louis Bay	-23.7							
96-31	Knight Island	60° 28.0′ 147° 40.6′	Mousse on rock; shore of Louis Bay	-29.3							
96-47	Knight Island	60° 12.1′ 147° 49.6′	Tar on beach cobble; south side, Mummy Bay	-23.6							
96-49	Squire Island	60° 14.0′ 147° 57.1′	Tar blob on rock; SW side of island	-23.7							
96-50	Squire Island	60° 16,2′ 147° 55.4′	Tar w/ twigs and gran-ules; north end of island	-23.6							
96-51	Knight Island	60° 13.5′ 147° 54.5′	Tar lump w/ pine needles near Italian Bay	-23.5							
96-52	Knight Island	60° 11.6′ 147° 50.2′	Tar patch on rock out-crop; south, Mummy Bay	-29.2							
96-53	Evans Island	60° 07.8′ 147° 56.1′	Tar in among rocks, sd; south of Shelter Bay	-29.2	1.2	2.0	1.7	0.60		0.47	0.54
96-54	Fleming Island	60° 11.0′ 148° 01.5′	Tar on beach cliff w/ br. mousse; north end of isl.	-28.9	1.3	2.3	1.7	0.60		0.44	0.56
Product samples											
96-09	Cordova	60° 29.6′ 145° 28.4′	Tar from storm drain in old runway	-28.3							
96-10	Cordova	60° 29.6′ 145° 28.4′	Tar from parking ramp of new (1994) runway	-29.4							
96-25	Knight Island	60° 13.0′ 147° 48.6′	Tar on rock below fuel tank; Thumb Bay	-22.3							
96-29	Knight Island	60° 20.7′ 147° 46.0′	Tar on rock from old fuel tanks, head of Drier Bay	-22.6	2.6	6.2	1.8	0.60	(+)	0.42	1.1

Reference samples											
96-01[11]	California	34° 50´ 120° 30´	Crude oil from Santa Maria field; Unocal	-23.2	2.2	4.9	0.91	0.58	(+)	0.33	1.5
96-03[11]	California	39° 20´ 123° 40´	Tar from Mackerricher Beach State Park	-26.5	1.8	1.6	0.92	0.57	(+)	0.39	0.57
96-04[11]	California	35° 00´ 119° 30´	Crude oil from San Joaquin; Benicia, CA	-24.6	1.6	5.0	0.91	0.56	(+)	0.44	1.2
96-05[11]	California	35° 00´ 119° 30´	Bunker fuel oil from Huntway Ref.; Benicia	-24.5	1.8	4.3	0.9	0.58	(+)	0.36	1.0
96-07[11]	California	34° 50´ 120° 30´	No. 6 fuel oil from Unocal; Rodeo, CA	-22.9	6.0	2.8	1.6	0.55	+B, -T, +O	0.31	1.0

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[8]Obtained from J.W. Short, NOAA, Auke Bay Laboratory; [11]obtained from W.T. Castle, California Department of Fish & Game, Petroleum Chemistry Laboratory.

Sediment Samplers: SH, Shipek grab; VV, Van Veen grab.
Vessels: *Auk*, *Auklet* (USGS charter); *Rai*, *Rainier* (NOAA).

Table 8. Listing of all analyzed samples with carbon-isotopic and biomarker parameters of tar balls and sediment extracts from Prince William Sound, Alaska (1997), including miscellaneous samples.

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
Subaqueous samples											
97-1[8]	Bering River	60° 19.9′ 144° 12.1′	NOAA 806807; sediment near Chilkat		1.0	0.74	1.6	0.52	-B, -T, +O	0.30	0.47
97-2[8]	Bering Lake	60° 19.0′ 144° 20.1′	NOAA 806808; sediment from lake		n.d.	n.d.	? 1.0	0.09	(-)	0.20	0.62
97-3[8]	Shepard Creek	60° 18.2′ 144° 14.4′	NOAA 806809; sediment from creek		n.d.	n.d.	n.d.	n.d.	(-)	0.08	0.27
97-4[8]	Kushtaka Lake	60° 23.8′ 144° 07.6′	NOAA 806810; sediment #1 from lake		1.1	1.0	1.2	n.d.	(-)	0.33	0.60
97-5[8]	Kushtaka Lake	60° 24.0′ 144° 07.0′	NOAA 806811; sediment #2 from lake		0.66	? 2.5	1.1	0.59	?B, -T, ?O	0.41	? 0.80
97-6[8]	Berg Lake	60° 34.9′ 143° 52.3′	NOAA 806812; sediment #1 from lake		1.4	0.55	1.2	? 0.48	(-)	0.21	0.58
97-7[8]	Dachtoth River	60° 05.0′ 142° 30.7′	NOAA 806814; sediment from east bank of river		2.2	0.26	2.1	0.57	?B, -T, +O	0.27	0.37
97-8[8]	Cape Yakutaga	60° 04.8′ 142° 30.7′	NOAA 806815; sediment from beach at cape		2.7	0.25	1.9	0.55	+B, -T, +O	0.20	0.42
Coal samples											
97-9[8]	Katalla	60° 11.2′ 144° 31.2′	NOAA 806822; coal/ sediment from beach		10.3	0	1.8	0.46	+B, -T, +O	0.12	0.12
97-10[8]	Queen Vein	60° 24′ 144° 10′	NOAA 806827; coal from mine		0.78	1.2	1.3	0.6	?B, ?T, +O	0.38	0.50
97-11[8]	Carbon Ridge	60° 24′ 144° 10′	NOAA 806828; coal from mine		0.78	1.1	1.2	0.57	?B, ?T, +O	0.49	0.85
Beach samples											
97-16	Eagle Island	60° 54.7′ 147° 10.0′	Tar on rock of cobble beach; SE side of island	-24.1	1.6	5.3	2.1	0.59	(+)	0.27	0.91
97-17	Eagle Island	60° 54.7′ 147° 10.0′	Tar-cemented gravel on beach; SE side of island	-23.7	1.6	5.2	2.0	0.59	(+)	0.28	0.85
Product samples											
97-12	Portage Glacier	60° 47.4′ 148° 50.0′	Tar from path behind gift shop	-26.3	1.5	0.76	1.8	0.6	low +	0.34	0.55
97-13	Glacier Island	60° 53.8′ 147° 05.1′	Tar-like material on piling; east side Finski Bay	-23.5	3.8	0.68	1.0	0.58	(+)	0.34	0.86
97-14	Glacier Island	60° 53.8′ 147° 05.1′	Tar on lath in debris; east side Finski Bay	-23.8	1.6	5.4	2.2	0.60	(+)	0.30	0.94

97-15	Glacier Island	60° 53.8′ 147° 05.1′	Tar w/ gravel on pallett; east side Finski Bay	-23.7	1.6	5.1	2.1	0.59	(+)	0.26	0.95

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[8]Obtained from J.W. Short, NOAA, Auke Bay Laboratory.

APPENDIX 1 Letter received from Nancy and Jim Lethcoe, Valdez, AK, 8/11/97. Synopsis of Lethcoe interest in oil on PWS beaches.

Pre-1987: Lethcoes noted tar balls at Eshamy Bay (west side of Knight Island Passage). In conversation, Dave Janka reported finding tar balls on Glacier Island. Lethcoes speculated the tar was from spills by commercial fishing boats/tenders or by sinking boats near Glacier Island (see Lethcoe, J. and Lethcoe, N. 1985, p. 94-103).

Spring 1988: Lethcoes found tar balls on Naked Island during PWS Conservation Alliance Spring Cleanup. Nancy reported to Dan Lawn at DEC-Valdez. Lawn indicated prior to startup of the Alyeska Marine Terminal a survey had found tar balls along the tanker route. He attributed the tar balls to seepage of oil in the Gulf of Alaska.

Summer 1989: Nancy found tar balls at Olsen Cove, Olsen Island, Culross Island, Port Nellie Juan and other places. Since these were in places not reported by EVOS, she wrote a letter to Federal On-Scene-Coordinator Admiral Ciangalini indicating the presence of oil on these beaches and asking that it be investigated. Nancy was concerned that some of the slicks of EVO had separated from the main stream and been carried ashore in other areas which were not subsequently mapped as "oiled".

December, 1990: Nancy received a letter and report from Exxon indicating that although they had not expected to find the reported oil, they nevertheless had dispatched a team to survey the non-oiled northern and western shorelines of PWS. To their surprise they found oil; to their relief it was not EVO. The report documented their study of the tar ball's characteristics. The Lethcoes then speculated that the oil had been spilled from a variety of sources during the 1964 earthquake and possible from a refueling barge out of Whittier that had hit a rock in Olsen Passage the winter of 1979.

The work by Carlson, Kvenvolden, and other (1993-1997) finally solved the long-standing mystery of the peregrinations of the pre-EVOS tar balls found on PWS beaches. Because of the significance and local interest in this topic, the Lethcoes included a reference to this research in their *History of Prince William Sound* (Lethcoe and Lethcoe,1994, p. 138).

APPENDIX 2. Data table of samples, locations and geochemistry

All samples have been organized to group categories of samples. All of the sample tables are organized by year of collection. The first entry is the field number which begins with the year and they are numbered consecutively, with each year beginning with #01, with regard to sample collection time, except the first sample of North slope crude (89-00) impounded from the tanker after it was impaled on the reef. We received this sample from David G. Shaw of University of Alaska, Fairbanks, some few months after the first cruise on the M/V Farnella in May 1989. Forty-four of the samples were supplied by someone other than the authors, and the collectors are identified by the small superscript number following the sample number; they are listed at the end of the appendix. The location column uses the most obvious geographic locality name. The latitude and longitude are located to the nearest 0.1 of a minute. We used GPS when available to locate the subaqueous samples. Otherwise we used radar. The beach samples were plotted directly on working maps; we used USGS 1:63,360 quads and several scales of NOAA charts. The sample description column includes the type of sampler if subaqueous (BX=Box corer; GC=gravity corer; SH=Shipek grab; SM=Smith-McIntyre grab; VV=vanVeen grab); this information is also given at the end of the various tables, but, mentioned here as an aid to the researcher studying the report. Vessel names are also given in the description in abbreviated form (i.e. *Far= Farnella*)--also keyed at end of tables. In the descriptions of beach samples we used the name of the bay or small island as appropriate. The product samples include tar or oil leaking from storage tanks, pieces of road and runway asphalt, asphalt shingles, tar used to patch cracks in buildings and seal chimney flues etc. They are located by the most obvious feature. Reference oil samples from Alaska and California are also included.

Appendix 2. Listing of all samples and of carbon-isotopic and biomarker parameters of tar balls and sediment extracts from Prince William Sound, Alaska (1989-1997), including miscellaneous and reference samples.

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} S/(S+R)	BTO	m/z 217 C_{29} S/(S+R)	m/z 217 C_{28}/C_{29}
89-00[1]	Bligh Reef	60° 51.3′ 146° 52.5′	North Slope crude oil, tanker *Exxon Valdez*	-29.2	1.4	2.0	1.4	0.60	(-)	0.45	0.63
89-01	Montague Strait	59° 52.3′ 148° 01.2′	BX; 160m; *Far*: gray diamict.		6.2	0.88	1.6	0.16	-B, -T, +O	0.21	0.27
89-02A	Montague Strait	59° 58.6′ 147° 48.7′	BX; 246m; *Far*: gray clayey silt		2.0	0.86	1.9	0.49	?B, -T, +O	0.25	0.61
89-02B	Montague Strait	59° 58.6′ 147° 48.6′	BX; 245m; *Far*: gray clayey silt								
89-03A	Knight Island	60° 14.8′ 147° 38.8′	BX; 268m; *Far*: soft slt clay; off Snug Harbor		2.1	1.1	1.7	0.45	-B, -T, +O	0.27	0.69
89-03B	Knight Island	60° 14.9′ 147° 39.1′	BX; 276m; *Far*: soft slt clay; off Snug Harbor								
89-04A	Knight Island	60° 16.4′ 147° 42.1′	BX; 125m; *Far*: gray clayey silt; Snug Harbor		1.9	1.5	1.7	0.50	?B, -T, +O	0.34	0.70
89-05A	Eleanor Island	60° 32.9′ 147° 30.4′	BX;197m; *Far*: gray silty clay		2.2	1.2	1.5	0.51	-B, -T, +O	0.30	0.62
89-05B	Eleanor Island	60° 33.0′ 147° 30.7′	BX; 215m; *Far*: gray silty clay								
89-06	Naked Island	60° 40.0′ 147° 06.1′	BX; 400m; *Far*: gray mud		2.7	0.69	1.6	0.47	-B, -T, +O	0.21	0.63
89-07A	Bligh Reef	60° 47.2′ 146° 57.2′	BX; 395m; *Far*: very soft gray mud								
89-07B	Bligh Reef	60° 47.3′ 146° 57.4′	BX; 398m; *Far*: very soft gray mud								
89-07C	Bligh Reef	60° 47.2′ 146° 57.2′	BX; 394m; *Far*: very soft gray mud		2.0	0.57	1.6	0.50	-B, -T, +O	0.18	0.65
89-08B	Storey Island	60° 46.2′ 147° 26.2′	BX; 480m; *Far*: gray silty clay		2.2	1.2	1.6	0.48	-B, -T, +O	0.25	0.56
89-09A	Lone Island	60° 41.1′ 147° 41.1′	BX; 755m; *Far*: olive-gray mud		2.3	0.82	1.6	0.52	-B, -T, +O	0.24	0.69
89-09B	Lone Island	60° 41.0′ 147° 41.2′	GC; 755m; *Far*: olive-gray mud								
89-10A	Wells Passage	60° 46.2′ 147° 56.5′	GC; 342m; *Far*: gray-silty clay								
89-10B	Wells Passage	60° 46.0′ 147° 56.5′	BX; 338m; *Far*: gray-silty clay								
89-10C	Wells Passage	60° 45.8′ 147° 56.6′	BX; 342m; *Far*: gray-silty clay								

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
89-11A	Port Nellie Juan	60° 36.6´ 148° 07.2´	BX; 400m; *Far*: light gy clay; near entrance		2.0	1.3	1.5	0.45	lo B, -T, +O	0.31	0.74
89-12A	Knight Island	60° 28.8´ 147° 45.6´	BX; 183m; *Far*: soupy gray mud; Herring Bay								
89-12B	Knight Island	60° 28.9´ 147° 45.6´	BX; 205m; *Far*: soupy gray mud; Herring Bay		2.0	0.88	1.9	0.50	lo B, -T, +O	0.24	0.65
89-13A	Knight I. Pass.	60° 21.7´ 147°57.6´	GC; 412m; *Far*: brown-mud on frame								
89-13B	Knight I. Pass.	60° 21.8´ 147°57.4´	BX; 389m; *Far*: brown-ooze, gray mud								
89-13C	Knight I. Pass.	60° 21.7´ 147°57.5´	BX; 420m; *Far*: diamict on frame								
89-14A	Knight I. Pass.	60° 46.2´ 147° 56.5´	BX; 600m; *Far*: brown & gray mud								
89-14B	Knight I. Pass.	60° 46.0´ 147° 56.5´	BX; 572m; *Far*: pebble on frame								
89-15A	Latouche Pass.	60° 05.1´ 147° 53.5´	BX; 240m; *Far*: diamict sand/pebbles		1.7	3.6	1.3	0.53	(+)	0.43	0.78
89-15B	Latouche Pass.	60° 05.1´ 147° 53.6´	BX; 243m; *Far*: diamict sand/pebbles								
89-16A	Resurrec. Bay	59° 51.0´ 149° 27.4´	BX; 276m; *Far*: silty clay								
89-16B	Resurrec. Bay	59° 51.0´ 149° 28.0´	BX; 277m; *Far*: silty clay		2.1	0.99	1.6	0.54	lo B, -T, +O	0.28	0.73
89-17A	Gulf of Alaska	59° 31.2´ 149° 41.2´	BX; 115m; *Far*: muddy crs sd; near Chiswell Is.								
89-17B	Gulf of Alaska	59° 31.2´ 149° 43.9´	BX; 115m; *Far*: muddy crs sd; near Chiswell Is.		2.5	0.83	1.7	0.56	lo B, -T, +O	0.27	0.68
89-18A	Gulf of Alaska	59° 32.2´ 150° 03.9´	BX; 95m; *Far*: muddy coarse sand								
89-19B	Gulf of Alaska	59° 32.2´ 150° 37.2´	BX; 75m; *Far*: shell fragments								
89-20	Gulf of Alaska	59° 13.0´ 150° 54.9´	BX; 65m; *Far*: shell hash and dark sand								
90-01	Latouche I.	60° 04.2´ 147° 50.4´	VV; 25m; *Kar*: gy pebbly muddy sd; Sleepy Bay						(-)		

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
90-02 (~90-50)	Latouche I.	60° 04.1´ 147° 50.3´	VV; 18m; *Kar*: gy muddy fine sand; Sleepy Bay		1.5	1.6	1.5	0.57	(-)	0.53	0.48
90-03	Evans Island	60° 04.1´ 147° 59.9´	AN; 8m; *Kar*: sandy mud with phyllite chips								
90-04	Elrington Island	59° 58.1´ 148° 08.5´	Tar on rock; east end of Tombolo Bay								
90-05	Elrington Island	59° 58.3´ 148° 09.6´	Tar on rock; small island in Tombolo Bay								
90-06	Elrington Island	59° 58.2´ 148° 10.5´	Oiled sand; south end of Tombolo Bay	-29.3	1.4	2.0	1.4	0.60	(-)	0.48	0.67
90-06A	Elrington Island	59° 58.2´ 148° 10.5´	Tar on rock; south end of Tombolo Bay	-23.8	1.7	4.3	1.9	0.56	(+)	0.30	1.0
90-07A	Elrington Island	59° 58.1´ 148° 08.8´	VV; 14m; *Kar*: sandy silt shell hash; Tambolo Bay								
90-07B	Elrington Island	59° 58.1´ 148° 08.8´	VV; 14m; *Kar*: sandy silt shell hash; Tambolo Bay								
90-07C	Elrington Island	59° 58.1´ 148° 08.8´	VV; 14m; *Kar*: sandy silt shell hash; Tambolo Bay								
90-08A	Elrington Island	59° 58.0´ 148° 09.3´	GC; 53m; *Kar*:gy sandy mud; Tombolo Bay		2.2	2.8	1.7	0.57	?B, ?T, +O	0.41	0.83
90-08B	Elrington Island	59° 58.0´ 148° 09.3´	VV; 53m; *Kar*: gy sandy mud; Tambolo Bay								
90-09A	Elrington Island	59° 58.2´ 148° 10.3´	VV; 5m; *Kar*: shelly sd, lg cobble; Tombolo Bay								
90-09B	Elrington Island	59° 58.2´ 148° 10.3´	VV; 5m; *Kar*: silty sand; Tombolo Bay								
90-09C	Elrington Island	59° 58.2´ 148° 10.4´	VV; 5m; *Kar*: sand; Tombolo Bay								
90-10	Elrington Island	59° 58.2´ 148° 10.1´	VV 40m; *Kar*: sd, pebbles, shells; Tombolo Bay								
90-11	Knight Island	60° 25.8´ 147° 44.3´	AN;15m; *Kar*: very bn sandy mud; Herring Bay								
90-12	Knight Island	60° 25.2´ 147° 47.3´	VV; 32m; *Kar*: peaty org. mat.; Herring Bay								
90-13	Knight Island	60° 25.7´ 147° 46.9´	VV; 42m; *Kar*: sdy mud w/ rx frag.; Herring Bay		1.4	1.8	1.3	0.62	(-)	0.50	0.61
90-14A	Knight Island	60° 26.4´ 147° 46.4´	VV; 39m; *Kar*: coarse sand; Herring Bay								

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
90-14B	Knight Island	60° 26.4′ 147° 46.4′	VV; 39m; *Kar*: pebbly muddy sd; Herring Bay								
90-14C	Knight Island	60° 26.4′ 147° 46.4′	VV; 39m; *Kar*: cobbles w/ silt; Herring Bay								
90-15	Knight Island	60° 27.3′ 147° 43.2′	VV; 77m; *Kar*: olive gray mud; Herring Bay		2.6	1.8	1.6	0.59	-B, -T, +O	0.33	0.60
90-16	Knight Island	60° 27.3′ 147° 42.5′	VV; 8m; *Kar*: sdy gravel w/ shells; Herring Bay								
90-17A	Knight Island	60° 27.4′ 147° 42.4′	Solid oil on cobble; beach in Herring Bay	-25.3	1.3	2.0	1.4	0.59	(-)	0.53	0.50
90-17B	Knight Island	60° 27.4′ 147° 42.4′	Solid oil on cobble; small island in Herring Bay								
90-18	Knight Island	60° 27.6′ 147° 43.4′	Oily pebbly loam; Herring Bay	-29.2	1.4	2.0	1.3	0.59	(-)	0.49	0.46
90-19	Smith Island	60° 31.7′ 147° 22.6′	Oiled cobbles; north shore of island	-29.4	1.4	2.2	1.6	0.60	(-)	0.48	0.61
90-20	Smith Island	60° 31.7′ 147° 22.2′	Oiled cobbles; north shore of island								
90-21	Smith Island	60° 31.9′ 147° 22.7′	VV; 25m; *Kar*: pebbles, shells/mud/sand								
90-22	Smith Island	60° 32.2′ 147° 21.8′	VV; 95m; *Kar*: olive gray mud		2.1	1.6	1.6	0.49	-B, -T, +O	0.36	0.56
90-23	Smith Island	60° 32.5′ 147° 21.3′	VV; 125m; *Kar*: olive gray mud		3.0	1.7	1.3	0.50	-B, -T, +O	0.26	0.45
90-24A	Eleanor Island	60° 33.4′ 147° 34.6′	VV; 39m; *Kar*: muddy sandy gravel; NW Bay								
90-24B	Eleanor Island	60° 33.4′ 147° 34.6′	VV; 16m; *Kar*: olive gray sand; NW Bay								
90-25A	Eleanor Island	60° 32.8′ 147° 36.1′	VV; 16m; *Kar*: sandy gravel; NW Bay								
90-25B	Eleanor Island	60° 32.8′ 147° 36.1′	VV; 16m; *Kar*: rocks & shells; NW Bay								
90-26	Eleanor Island	60° 33.0′ 147° 36.1′	VV; 41m; *Kar*: olive gray sandy mud; NW Bay		2.0	1.7	1.7	0.49	-B, -T, +O	0.35	0.65
90-27	Eleanor Island	60° 33.2′ 147° 36.2′	VV 36m; *Kar*: muddy gravel; NW Bay								
90-28	Eleanor Island	60° 33.6′ 147° 34.6′	Brown oiled sediment & orgs.; NW Bay								

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
90-29	Eleanor Island	60° 34.1´ 147° 34.4´	Solid oil on rock; Northwest Bay	-29.1	1.4	2.0	1.4	0.61	(-)	0.45	0.68
90-30	Eleanor Island	60° 34.0´ 147° 36.9´	Brown medium sand; Northwest Bay								
90-31	Eleanor Island	60° 33.9´ 147° 36.0´	GC; 90m; *Kar*: mud & gravel; NW Bay								
90-32A	Eleanor Island	60° 33.9´ 147° 34.4´	GC; 31m; *Kar*: mud & sand; NW Bay								
90-32B	Eleanor Island	60° 33.9´ 147° 34.4´	VV; 36m; *Kar*: muddy sand; NW Bay								
90-33	Glacier Island	60° 53.9´ 147° 07.4´	Black patina on rocks; Growler Bay								
90-34	Glacier Island	60° 53.9´ 147° 07.3´	AN; 12m; *Kar*: gray mud, glacial flour; Growler Bay								
90-35	Storey Island	60° 44.2´ 147° 25.1´	VV; 33m; *Kar*: pebbly muddy sand		2.0	2.0	1.5	0.48	-B, -T, +O	0.39	0.71
90-36	Storey Island	60° 44.5´ 147° 25.3´	VV; 50m; *Kar*: pebbly muddy sand		2.0	1.7	1.7	0.46	?B, ?T, +O	0.32	0.65
90-37A	Storey Island	60° 43.9´ 147° 24.7´	Tar on cobble; beach on north shore of island	-23.9	1.5	5.1	1.8	0.57	(+)	0.32	1.0
90-37B	Storey Island	60° 43.9´ 147° 24.7´	Black patina on rock on beach; north shore of isl.								
90-38A	Naked Island	60° 39.1´ 147° 22.3´	GC; 58m; *Kar*: olive gray sandy mud		2.0	1.7	1.6	0.49	-B, -T, +O	0.34	0.70
90-38B	Naked Island	60° 39.1´ 147° 22.3´	VV; 58m; *Kar*: mud w/ rock fragments								
90-39	Naked Island	60° 39.7´ 147° 22.5´	VV; 48m; *Kar*: sandy mud w/rock frag.		1.8	1.6	1.5	0.44	-B, -T, +O	0.35	0.64
90-40	Naked Island	60° 39.3´ 147° 22.5´	VV; 20m; *Kar*: muddy sand		1.7	1.9	1.5	0.56	+B, ?T, +O	0.37	1.1
90-41	Naked Island	60° 39.4´ 147° 22.9´	Oiled cobbles; beach on McPherson Bay	-29.4	1.5	2.2	1.4	0.62	(-)	0.48	0.61
90-42 (=89-06)	Naked Island	60° 40.3´ 147° 06.0´	BX;316m; *Dav*: gray silty clay		2.4	0.71	1.6	0.50	?B, -T, +O	0.22	0.61
90-43 (=89-05)	Eleanor Island	60° 32.8´ 147° 30.7´	BX; 217m; *Dav*: gray silty clay		2.1	1.3	1.5	0.49	-B, -T, +O	0.32	0.61
90-44	L. Axel Lind I.	60° 48.2´ 147° 36.6´	BX; 498m; *Dav*: gray silty clay		2.4	1.0	1.6	0.50	-B, -T, +O	0.26	0.61

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
90-45 (=89-08)	Storey Island	60° 46.2´ 147° 26.6´	BX; 478m; *Dav* : gray silty clay		2.3	0.86	1.5	0.46	-B, -T, +O	0.26	0.65
90-46 (=89-07)	Bligh Reef	60° 47.2´ 146° 57.5´	BX; 397m; *Dav* : gray silty clay		2.6	0.69	1.7	0.47	-B, -T, +O	0.23	0.65
90-47 (=89-04)	Knight Island	60° 16.5´ 147° 42.1´	BX; 113m; *Dav* : pebbly sandy mud; Snug Harbor		2.0	1.4	1.5	0.49	-B, -T, +O	0.35	0.62
90-48 (=89-03)	Knight Island	60° 14.7´ 147° 38.5´	BX; 260m; *Dav* : gy slty clay; off Snug Harbon		2.4	1.1	1.7	0.49	-B, -T, +O	0.31	0.66
90-49 (=89-02)	Montagne Strait	59° 59.7´ 147° 48.7´	BX; 272m; *Dav* : sandy silty clay		1.6	1.0	1.6	0.50	-B, -T, +O	0.30	0.66
90-50 (~90-02)	Latouche I.	60° 05.1´ 147° 51.0´	BX; 66m; *Dav* : gy grvly mdy sand; Sleepy Bay		1.6	2.6	1.5	0.53	?B, -T, +O	0.43	0.76
90-51 (=89-15)	Latouche Pass.	60° 04.2´ 147° 55.2´	BX; 126m; *Dav* : clayey silty sand		1.8	2.4	1.5	0.55	?B, -T, +O	0.43	0.65
90-52 (=89-16AB)	Ressurec. Bay	59° 52.1´ 149° 28.1´	BX 269m; *Dav* : gy slty clay; near bay mouth		2.3	0.84	1.5	0.53	-B, -T, +O	0.25	0.61
92-01	Whittier	60° 46.3´ 148° 41.2´	Street pavement, >20 yr old; near Hodge Bldg.	-24.8	1.1	2.5	1.5	0.54	(+)	0.41	1.0
92-02	Whittier	60° 46.3´ 148° 41.2´	New pavement tar; near Hodge Building								
92-03	Whittier	60° 46.5´ 148° 40.3´	Asphalt, tar paper; Buckner Building	-24.9							
92-04	Whittier	60° 46.5´ 148° 40.3´	Driveway paved before 1964; Buckner Building	-24.3	1.3	4.2	1.7	0.52	(+)	0.39	1.1
92-05[2]	Valdez Arm	61° 00.0´ 146° 47.7´	Tar on rock; east shore	-23.7	1.7	5.3	1.9	0.55	(+)	0.32	1.2
92-06	Old Valdez	61° 07.0´ 146° 16.5´	Tar mats; site of old asphalt-storage plant	-23.6	1.6	5.0	1.9	0.54	(+)	0.31	1.0
92-07	Valdez	61° 07.9´ 146° 14.5´	Tar from new airport runway	-27.2	1.5	2.1	1.9	0.58	(-)	0.39	0.74
92-08	Valdez	61° 08.3´ 146° 12.5´	Tar from Glacier Road, paved in 1971	-27.7							
92-09 (=89-07)	Bligh Reef	60° 47.2´ 146° 57.4´	SM; 395m; *McA* : olive-gray mud		2.5	0.67	1.5	0.48	-B, -T, +O	0.24	0.78
92-10 (=89-06)	Naked Island	60° 39.9´ 147° 06.9´	SM; 275m; *McA* : olive-gray mud		2.6	0.84	1.5	0.49	-B, -T, +O	0.26	0.71

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	C_{28}/C_{29}
92-11	Olsen Bay	60° 40.3′ 146° 14.5′	Black patina on rock; near mouth of bay								
92-12	Olsen Bay	61° 40.4′ 146° 14.0′	Black patina on cobble; west side of bay								
92-13	Olsen Bay	61° 40.5′ 146° 13.5′	Black patina on rock; north end of bay								
92-14	Olsen Bay	60° 44.0′ 146° 13.1′	SM; 30m; *McA* : olive green mud		1.7	0.79	1.4	0.21	-B, -T, +O	0 no S	0 no C_{28}
92-15	Cordova	60° 33.2′ 145° 45.0′	Tar repair at side of road to ferry terminal								
92-16	Naked Island	60° 40.3′ 147° 19.9′	Tar on rocks; east side, McPherson Bay	-23.7	1.7	5.4	1.7	0.54	(+)	0.32	1.1
92-17	Naked Island	60° 40.1′ 147° 19.7′	Tar on rock; east side of McPherson Bay								
92-18A	Naked Island	60° 40.6′ 147° 20.7′	Tar on rock; NE point of McPherson Bay								
92-18B	Naked Island	60° 40.6′ 147° 20.7′	Lichen-like material on rock; NE point, McP. B.								
92-18C	Naked Island	60° 40.6′ 147° 20.7′	Tar on rocks; NE point of McPherson Bay	-23.8							
92-19	Green Island	60° 18.2′ 147° 21.3′	Oil on rock; northeast shore of island	-26.6	2.5	1.4	1.1	0.59	-B, -T, +O	0.54	0.90
92-20	Green Island	60° 18.2′ 147° 21.3′	Tar on rock; northeast shore of island	-23.8	1.6	5.0	1.8	0.55	(+)	0.34	1.1
92-21	Knight Island	60° 14.2′ 147° 43.8′	Dead oil on rock; south shore, Snug Harbor								
92-22	Knight Island	60° 14.2′ 147° 43.5′	Oily fissile meta-shale; S arm of Snug Harbor	-29.5	1.3	1.9	1.4	0.57	(-)	0.50	0.69
92-23 (=89-04)	Knight Island	60° 16.4′ 147° 42.2′	SM; 114m; *McA* : olive-gray mud		1.7	1.9	1.6	0.56	(-), ?O	0.46	0.62
92-24 (=89-03)	Knight Island	60° 15.0′ 147° 38.6′	SM; 262m; *McA* : olive-gray mud		2.0	1.2	1.7	0.51	-B, -T, +O	0.33	0.61
92-25	Knight Island	60° 15.8′ 147° 46.1′	Tar on rock; north arm of Snug Harbor	-23.8	1.5	5.3	1.7	0.54	(+)	0.33	1.2
92-26	Knight Island	60° 15.7′ 147° 46.2′	Solid oiled mat; north arm of Snug Harbor	-29.4	1.3	2.1	1.4	0.59	(-)	0.50	0.73
92-27	Knight Island	60° 15.7′ 147° 46.2′	Black patina on rock; north arm of Snug Harbor								

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	C_{28}/C_{29}
92-28	Evans Island	60° 06.5′ 147° 58.0′	Solid oiled mat; SW end of Shelter Bay	-29.3	0.83	2.0	1.5	0.61	(-)	0.65	0.43
92-29	Evans Island	60° 06.5′ 147° 57.7′	Tar on rock; SE end of Shelter Bay	-23.7	1.6	5.4	2.0	0.53	(+)	0.34	1.1
92-30	Latouche I.	60° 03.2′ 147° 54.1′	Tar in Blackbird Mine dump on island	-24.8							
92-31	Latouche I.	60° 03.2′ 147° 54.1′	Oil at toe of Blackbird Mine dump on island	-24.3							
92-32	Latouche I.	60° 03.2′ 147° 54.1′	Tar on telephone pole at mine dump	-23.6							
92-33D (=89-15)	Latouche Pass.	60° 04.9′ 147° 53.5′	SM; 240m; *McA* : olive-gray mud w/ rocks		1.7	2.0	1.4	0.54	-B, -T, +O	0.49	0.83
92-34	Seward	60° 07.7′ 149° 27.0′	Tar from new airport runway	-28.1	1.2	1.8	1.8	0.58	(-)	0.46	0.63
92-35[2]	Glacier Island	60° 54.0′ 147° 09.0′	Tar on rock; Eagle Bay	-23.8	1.7	4.9	1.9	0.53	(+)	0.32	1.0
92-36A[2]	Olsen Island	60° 52.2′ 147° 34.0′	Tar on rock; Exxon site 6								
92-36B[2]	Olsen Island	60° 52.2′ 147° 34.0′	Tar on rock; Exxon site 6	-23.8	1.5	5.2	1.8	0.55	(+)	0.33	1.1
92-36C[2]	Olsen Island	60° 52.2′ 147° 34.0′	Tar on rock; Exxon site 6								
92-36D[2]	Olsen Island	60° 52.2′ 147° 34.0′	Tar on rock; Exxon site 6								
92-37[2]	Olsen Cove	60° 52.1′ 147° 35.5′	Tar on rock; Exxon site 7	-23.8							
92-38[2]	Naked Island	60° 39.0′ 147° 23.0′	Tar on meta-shale; NE end of Bass Harbor	-23.9	1.6	5.9	1.9	0.55	(+)	0.34	1.1
92-39[2]	Naked Island	60° 42.0′ 147° 26.5′	Matted tar; north shore of island	-23.9							
92-40	Valdez Harbor	61° 07.6′ 146° 20.1′	Tar on rock; Outer Point	-24.0	1.6	5.4	1.7	0.55	(+)	0.32	1.1
92-41	Valdez Harbor	61° 07.7′ 146° 19.9′	Tar on rock; Dock Point	-23.6	1.9	4.6	1.9	0.54	(+)	0.31	1.1
92-42[3]	Gustavus	58° 29.0′ 135° 42.0′	Old section of airport runway	-23.5							
92-43A[4]	Kodiak	57° 45.0′ 152° 30.7′	Navy terminal parking peninsula								

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	C_{28}/C_{29}
92-43B[4]	Kodiak	57° 45.0´ 152° 30.7´	Navy air terminal parking pad	-27.1							
92-43C[4]	Kodiak	57° 45.0´ 152° 30.7´	Old cement; B taxi way								
92-43D[4]	Kodiak	57° 45.0´ 152° 30.7´	Old cement; hanger pad								
92-43E[4]	Kodiak	57° 45.0´ 152° 30.7´	Old material storage pad								
92-43F[4]	Kodiak	57° 45.0´ 152° 30.7´	Old crash hanger pad								
92-43G[4]	Kodiak	57° 45.0´ 152° 30.7´	Edge of new surface of runway 7, 3 yrs. old								
92-43H[4]	Kodiak	57° 45.0´ 152° 30.7´	Old blacktop from run-way 7/25, ~15 yrs. old								
92-43I[4]	Kodiak	57° 45.0´ 152° 30.7´	Old blacktop from road to waste storage								
92-44A[4]	King Salmon	56° 41.4´ 156° 38.7´	New runway 18/36, paved 2 yrs. ago								
92-44B[4]	King Salmon	56° 41.4´ 156° 38.7´	Old active parking pad in front of tower								
92-44C[4]	King Salmon	56° 41.4´ 156° 38.7´	North apron of airport runway	-29.6							
92-45A[4]	Amchitka	51° 23.4´ 179° 19.8´ E	Active runway B, last surfaced in 1965								
92-45B[4]	Amchitka	51° 23.4´ 179° 19.8´ E	Active runway B, last surfaced in 1965								
92-45C[4]	Amchitka	51° 23.4´ 179° 19.8´ E	World War II airport reactivated runway C	-23.4							
92-45D[4]	Amchitka	51° 23.4´ 179° 19.8´ E	World War II airport deactivated runway C								
92-45E[4]	Amchitka	51° 23.4´ 179° 19.8´ E	World War II abandoned runway F								
92-45F[4]	Amchitka	51° 23.4´ 179° 19.8´ E	World War II abandoned runway F								
92-46A[4]	Attu	52° 49.4´ 173° 10.4´ E	World War II deactivated runway								

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
92-46B[4]	Attu	52° 49.4´ 173° 10.4´ E	World War II deactivated runway								
92-46C[4]	Attu	52° 49.4´ 173° 10.4´ E	World War II deactivated runway	-22.8							
92-46D[4]	Attu	52° 49.4´ 173° 10.4´ E	World War II deactivated runway								
92-46E[4]	Attu	52° 49.4´ 173° 10.4´ E	Active runway, re-surfaced in 1983								
92-46F[4]	Attu	52° 49.4´ 173° 10.4´ E	Active runway, re-surfaced in 1983								
92-47[4]	Dutch Harbor	53° 53.8´ 166° 32.2´	Tar from new airport runway	-29.1	1.5	1.6	1.5	0.56	(-)	0.45	0.62
92-48	Deadhorse	70° 15´ 148° 25´	Tar from airport parking pad								
92-49A[4]	Cold Bay	55° 12.9´ 162° 43.9´	North end of runway, west side								
92-49B[4]	Cold Bay	55° 12.9´ 162° 43.9´	End of oil airport runway	-22.7	2.7	6.1	1.4	0.54	(+)	0.34	1.2
92-49C[4]	Cold Bay	55° 12.9´ 162° 43.9´	Abandoned revetment, chip seal from 1940's								
92-49D[4]	Cold Bay	55° 12.9´ 162° 43.9´	Slurry seal for runways from the end of 1970's								
92-49E[4]	Cold Bay	55° 12.9´ 162° 43.9´	Tar dumped next to WW II maintenance bldg.								
92-49F[4]	Cold Bay	55° 12.9´ 162° 43.9´	Newest tar from resurfacing in 1989								
92-49G[4]	Cold Bay	55° 12.9´ 162° 43.9´	Tar from center keel section of runway								
93-01	Port Valdez	61° 05.3´ 146° 26.2´	Tar mat at Salmon Creek	-23.6	1.6	4.9	2.0	0.55	(+)	0.34	1.1
93-02	Port Valdez	61° 05.3´ 146° 26.2´	Tar at high tide mark at Salmon Creek								
93-03	Port Valdez	61° 05.2´ 146° 26.0´	Tar mat near Salmon Creek	-23.7							
93-04	Port Valdez	61° 04.7´ 146° 33.9´	Tar on rocks; Anderson Bay	-23.7	1.6	5.7	2.0	0.54	(+)	.33	1.0

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
93-05	Valdez Narrows	61° 04.3´ 146° 38.5´	Tar on rock; east shore of narrows	-23.7							
93-06	Valdez Narrows	61° 04.3´ 146° 38.5´	Tar mat cementing rock; east shore of narrows	-23.7	1.7	5.2	2.0	0.55	(+)	0.32	0.96
93-07A	Valdez Arm	60° 59.5´ 146° 41.6´	Tar on rock; east shore of arm	-23.8							
93-07B	Valdez Arm	60° 59.5´ 146° 41.6´	Sticky tar mat; east shore of arm	-23.7	1.7	5.2	2.0	0.52	(+)	0.31	1.0
93-08	Peak Island	60° 42.3´ 147° 23.9´	Soft tar on rock; north shore of island	-23.7	1.7	5.3	1.9	0.50	(+)	0.31	1.0
93-09A	Ingot Island	60° 31.9´ 147° 37.7´	Tar on rock; archeologic site	-24.0	1.3	5.1	2.1	0.55	(+)	0.43	1.1
93-09B	Ingot Island	60° 31.9´ 147° 37.7´	Solid, oiled mat; archeologic site	-29.6	1.2	1.9	1.6	0.60	(-)	0.62	0.46
93-10A	Ingot Island	60° 32.0´ 147° 37.7´	Soft tar on beach; north shore of island	-23.7							
93-10B	Ingot Island	60° 32.0´ 147° 37.7´	Hard tar on beach; north shore of island	-23.8							
93-11	Block Island	60° 31.9´ 147° 36.5´	Sticky tar on cobble beach	-23.7	1.6	5.6	1.8	0.53	(+)	0.33	1.2
93-12A	Knight Island	60° 27.5´ 147° 42.6´	Tar on rocks; Herring Bay	-23.9	1.6	3.8	1.9	0.52	(+)	0.35	1.1
93-12B	Knight Island	60° 27.5´ 147° 42.6´	Solid oiled mat; Herring Bay	-29.4	1.3	1.7	1.5	0.60	(-)	0.62	0.40
93-13A	Chenega Island	60° 22.8´ 148° 00.5´	Sticky tar on rock; north shore of island	-24.3	1.6	4.8	1.9	0.53	(+)	0.35	1.2
93-13B	Chenega Island	60° 22.8´ 148° 00.5´	Sticky tar in cracks of rock; north shore of isl.	-29.3	1.3	1.9	1.5	0.57	(-)	0.44	0.50
93-13C	Chenega Island	60° 22.8´ 148° 00.5´	Semi-sticky tar on rock; north shore of island	-29.3	1.3	2.0	1.6	0.57	(-)	0.47	0.61
93-13D	Chenega Island	60° 22.8´ 148° 00.5´	Black patina next to tar on rock; north shore								
93-14A	Granite Cove	60° 25.1´ 147° 57.7´	Semi-sticky tar on rock and in crack	-29.2	1.3	1.9	1.6	0.58	(-)	0.53	0.47
93-14B	Granite Cove	60° 25.1´ 147° 57.7´	Tar on rock; north shore of cove	-23.7	1.5	5.7	2.0	0.51	(+)	0.33	0.97
93-14C	Granite Cove	60° 25.1´ 147° 57.7´	Sticky tar on rock; north shore of cove	-23.7							

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
93-14D	Granite Cove	60° 25.1′ 147° 57.7′	Sticky tar on rock; north shore of cove								
93-14E	Granite Cove	60° 25.1′ 147° 57.7′	Lustrous tar on rock; north shore of cove	-23.5							
93-15A	Point Nowell	60° 26.5′ 147° 56.2′	Sticky tar on rock on beach facing Sound	-23.8							
93-15B	Point Nowell	60° 26.5′ 147° 56.2′	Oily matted organic debris	-29.4	1.3	2.0	1.6	0.58	(-)	0.48	0.54
93-15C	Point Nowell	60° 26.5′ 147° 56.2′	Oil saturated organic material								
93-15D	Point Nowell	60° 26.5′ 147° 56.2′	Tar that breaks with brittle fracture	-23.7	1.7	4.8	1.9	0.54	(+)	0.31	1.0
93-16A	Eshamy Bay	60° 27.9′ 147° 57.6′	Weathered, tar-cemented barnacles	-29.3							
93-16B	Eshamy Bay	60° 27.9′ 147° 57.6′	Sticky tar on bldr beach, south entrance to bay	-23.7	1.8	4.9	1.9	0.55	(+)	0.35	1.1
93-16C	Eshamy Bay	60° 27.9′ 147° 57.6′	Tar-matted organic debris	-29.3	1.3	1.6	1.6	0.60	(-)	0.52	0.44
93-16D	Eshamy Bay	60° 27.9′ 147° 57.6′	Soft tar on beach; south entrance to bay	-23.7							
93-17A	Crafton Island	60° 30.5′ 147° 56.5′	Tar on rock; west shore of north point of island	-23.7	1.5	5.9	1.9	0.54	(+)	0.36	1.1
93-17B	Crafton Island	60° 30.5′ 147° 56.5′	Tar on rock w/ organic matter; west shore of isl.								
93-18A	Culross Island	60° 38.5′ 148° 07.0′	Sticky tar on cobble beach; SE shore of isl.	-23.8	1.8	5.3	1.9	0.53	(+)	0.33	1.1
93-18B	Culross Island	60° 38.5′ 148° 07.0′	Sticky oil among beach cobbles; SE shore of isl.	-29.3	1.4	1.9	1.6	0.59	(-)	0.48	0.62
93-19	Culross Island	60° 44.9′ 148° 10.7′	Sticky oil on slate; beach on Culross Bay	-27.8	1.0	1.2	1.2	0.60	-B, -T, +O	0.46	0.42
93-20	Perry Island	60° 42.8′ 147° 52.6′	Tar on jointed granite; E shore, Day Care Cove	-23.8	1.4	4.7	1.9	0,53	(+)	0.31	0.99
93-21	Lone Island	60° 41.8′ 147° 44.9′	Sticky tar on rocks; north shore of island	-23.7	1.6	5.4	1.8	0.54	(+)	0.34	1.0
93-22A	Growler Island	60° 54.1′ 147° 06.8′	Tar on cobbles; east shore of island	-23.7	1.7	5.1	1.7	0.55	(+)	0.33	1.1
93-22B	Growler Island	60° 54.1′ 147° 06.8′	Tar-cemented conglom-erate; east shore of isl.	-23.7							

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	Tm/Ts (m/z 191)	Triplet (m/z 191)	C_{30}/C_{29} (m/z 191)	C_{31} $\frac{S}{S+R}$ (m/z 191)	BTO	C_{29} $\frac{S}{S+R}$ (m/z 217)	C_{28}/C_{29} (m/z 217)
93-23A	Glacier Island	60° 54.3´ 147° 08.8´	Tar on rock; west shore of Elder Bay	-23.6	1.8	4.5	1.7	0.55	(+)	0.34	1.1
93-23B (=92-35)	Glacier Island	60° 54.0´ 147° 09.0´	Tar on rock at Eagle Bay	-23.7	1.7	4.7	1.6	0.53	(+)	0.34	1.2
93-24[2]	Disk Island	60° 29.3´ 147° 40.2´	Tar on rock in anchorage	-23.7	1.5	5.0	2.0	0.54	(+)	0.38	0.96
93-25[2]	Ingot Island	60° 30´ 147° 38´	Tar on rock; southwest shore of isl.	-23.7							
93-26A[2]	Green Island	60° 17.6´ 147° 25.8´	Tar on rock;.north shore of island	-23.9							
93-26B[2]	Green Island	60° 17.6´ 147° 24.6´	Tar-like residue on rock	-29.2	0.85	2.0	1.7	0.62	(-)	0.73	0.58
93-27[5]	Katalla	60° 12.0´ 144° 25.0´	Composite oil sample, R165-036		0.77	3.4	1.9	0.56	-B, -T, +O	0.49	1.0
93-28[5]	Samovar Hills	60° 07.5´ 140° 46.0´	Oil sample, R165-037; Sec. 3, T21S, R27E		5.7	0 (no C26)	1.4	0.57	-B, -T, +O	0.47	0.17
93-29[5]	Johnston Creek	60° 01.7´ 141° 53.3´	Oil sample, R165-036; Sec. 7, T22S, R21E		3.9	0 (no C26)	1.7	0.56	-B, -T, +O	0.46	0.18
93-30[6]	Knight Island	60° 09.8´ 147° 45.4´	Oily pebbles; Point Helen	-29.4	1.4	2.1	1.5	0.59	(-)	0.47	0.56
94-1A	Knight Island	60° 15.5´ 147° 45.3´	Mossy covered oil; north arm of Snug Harbor								
94-1B	Knight Island	60° 15.5´ 147° 45.3´	Oil w/ pine needles in rock joints; Snug Harbor								
94-1C	Knight Island	60° 15.5´ 147° 45.3´	Tar w/ pine needles on cobble; Snug Harbor								
94-2A	Latouche I.	60° 03.9´ 147° 50.4´	Live oil on pebble; Sleepy Bay	-29.5	1.4	1.8	1.4	0.58	(-)	0.48	0.63
94-2B	Latouche I.	60° 03.9´ 147° 50.4´	Oil-like patina on cobble; Sleepy Bay	-29.3							
94-2C	Latouche I.	60° 03.9´ 147° 50.4´	Oil mat-like pavement; Sleepy Bay	-29.4	1.3	1.9	1.4	0.61	(-)	0.50	0.59
94-2D	Latouche I.	60° 03.9´ 147° 50.5´	Oil-cemented pebbles; Sleepy Bay	-29.4							
94-2E	Latouche I.	60° 04.0´ 147° 50.6´	Tar caulking on log; Sleepy Bay	-23.6	1.8	4.7	1.8	0.52	(+)	0.32	1.1

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
94-2F	Latouche I.	60° 04.0′ 147° 50.5′	Tar w/pine needles on rock; Sleepy Bay	-24.1	1.6	3.8	1.9	0.55	(+)	0.36	0.99
94-2G	Latouche I.	60° 04.0′ 147° 50.5′	Tar on rock; Sleepy Bay								
94-3A	Evans Island	60° 04.0′ 148° 00.5′	Sticky oil mat in dump; Chenega Bay	-24.3	2.7	2.8	1.4	0.56	(+)	0.37	1.1
94-3B	Evans Island	60° 04.0′ 148° 00.5′	Tar on phyllite; Chenega Bay								
94-4	Evans Island	60° 03.5′ 148° 03.2′	Oil from storage tanks; Port Ashton	-23.4	2.6	4.4	1.6	0.50	(+)	0.34	1.3
94-5A	Evans Island	60° 06.7′ 147° 53.4′	Sticky oil on pebbles near Bishop Rock	-29.4	1.3	2.0	1.4	0.58	(-)	0.50	0.64
94-5B	Evans Island	60° 06.7′ 147° 53.4′	Oil in pocket of rock near Bishop Rock	-29.5	1.6	2.0	1.5	0.57	(-)	0.46	0.60
94-5C	Evans Island	60° 06.7′ 147° 53.4′	Tar on rock near Bishop Rock	-23.8	1.6	5.7	1.6	0.54	(+)	0.33	1.2
94-5D	Evans Island	60° 06.7′ 147° 53.4′	Tar with pine needles on rock near Bishop Rock	-29.3	1.4	2.0	1.4	0.58	(-)	0.49	0.62
94-6A	Squire Island	60° 14.9′ 147° 56.9′	Tar with old pine needles on rock; west shore	-23.7	1.6	5.3	1.6	0,53	(+)	0.36	1.2
94-6B	Squire Island	60° 14.9′ 147° 56.9′	Tar with fresh needles on rock; west shore	-23.7							
94-6C	Squire Island	60° 14.9′ 147° 56.9′	Tar on rocks; west shore	-23.7							
94-6D	Squire Island	60° 14.9′ 147° 56.9′	Tar w/ odor on rocks; west shore								
94-07[2]	Valdez Arm	61° 02.5′ 146° 47.4′	Tar on rock; Sawmill Bay	-23.7	1.6	5.2	1.7	0.52	(+)	0.35	1.2
94-8[2]	Perry Island	60° 43.5′ 147° 58.0′	Scattered tar on rocks; West Twin Bay	-23.8							
94-9[2]	Olsen Island	60° 51.9′ 147° 34.8′	Tar on wood from pilings; old fox farm								
94-10[2]	Glacier Pass.	60° 54.0′ 147° 19.9′	Tar on rock; beach W of Eickelberg Bay	-23.7							
94-11	Glacier Island	60° 52.9′ 147° 18.1′	Tar on rock; Irish Cove	-23.7	1.7	4.9	1.5	0.53	(+)	0.33	1.2
94-12	Columbia Bay	60° 56.6′ 147° 08.2′	Tar on timber on beach north of Flent Point	-23.7							

Appendix 2. (continued)

Fieid No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
94-13[2]	Unakwik Inlet	60° 52.8´ 147° 35.0´	Sticky tar patch; Mueller Cove	-29.4	1.5	2.1	1.5	0.60	(-)	0.47	0.47
94-14[2]	Naked Island	60° 39.3´ 147° 26.4´	Tar on rock; Cabin Bay	-23.6							
94-15	Columbia Bay	60° 56.8´ 147° 03.0´	Tar on large rock; north side of Elf Point	-22.8	1.6	5.6	1.8	0.51	(+)	0.33	1.0
94-16	Unakwik Inlet	61° 00.5´ 147° 31.5´	Tar paper from roof of abandoned cannery	-23.3							
94-17	Unakwik Inlet	61° 00.5´ 147° 31.5´	Tar caulking on beam at abandoned cannery	-23.0	2.3	7.5	1.6	0.53	(+)	0.35	1.4
94-18A	Glacier Pass.	60° 55.2´ 147° 16.7´	Tar on rock west of Buyers Cove	-23.7							
94-18B	Glacier Pass.	60° 55.2´ 147° 16.7´	Tar on rock on beach west of Buyers Cove								
94-19[7]	Bethel	60° 47.5´ 161° 45.0´	Airport asphalt in leaking storage drums	-23.3	1.9	5.0	2.1	0.51	(+)	0.28	1.1
94-20	California	35° 10.6´ 120° 37.0´	Oil seep; near Pismo Beach, Price Canyon Rd	-21.0	3.4	5.1	1.5	0.50	+B, -T, +O	0.28	1.4
94-21 (=89-07)	Bligh Reef	60° 47.2´ 146° 57.2´	SM; 390m; *Rai*: gray-blue mud		2.4	0.82	1.5	0.50	?B, -T, +O	0.27	0.63
94-22 (=89-06)	Naked Island	60° 40.0´ 147° 06.0´	SM; 285m; *Rai*: gray-blue mud		2.2	0.79	1.6	0.49	?B, -T, +O	0.25	0.65
94-23 (=89-08)	Storey Island	60° 46.2´ 147° 26.5´	SM; 477m; *Rai*: gray-blue mud		2.5	1.0	1.5	0.47	?B, -T, +O	0.26	0.46
94-24 (=89-09)	Lone Island	60° 41.1´ 147° 41.0´	SM; 747m; *Rai*: gray-blue mud		2.6	1.2	1.5	0.5	?B, -T, +O	0.33	0.58
95-01	Cordova	60° 33.2´ 145° 44.6´	Tar gravel; end of runway, Fuel Service								
95-02	Katalla	60° 11.2´ 144° 25.3´	Seep in moss below drilling rig	-24.7	0.93	3.1	1.8	0.60	-B, -T, +O	0.44	0.84
95-03	Katalla	60° 11.2´ 144° 25.3´	Oil sheen on water at drilling rig site								
95-04	Chilkat	60° 11.3´ 144° 13.0´	Tar on chimney flashing; Bering River	-22.9							
95-05	Chilkat	60° 11.3´ 144° 13.0´	Tar paper from old house on Bering River	-22.9							

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
95-06A	Cordova	60° 29.6′ 145° 28.4′	Tar on old taxiway at main airport	-29.2							
95-06B	Cordova	60° 29.6′ 145° 28.4′	Tar on active taxiway at main airport	-22.3							
95-06C	Cordova	60° 29.6′ 145° 28.4′	New sealant tar on main airport taxiway								
95-07	Nuchek	60° 20.0′ 146° 38.5′	Tar on timber on beach north of houses	-24.0							
95-08A	Ellamar	60° 53.7′ 146° 42.1′	Tar cobble on beach near abandoned dock	-22.4							
95-08B	Ellamar	60° 53.7′ 146° 42.1′	Tar on piling of abandoned dock	-23.4	3.8	2.4	1.6	0.59	(+)	0.31	1.1
95-09	Ellamar	60° 53.7′ 146° 42.1′	Tar on cable binding on piling of new pier	-23.3							
95-10	Old Valdez	61° 06.9′ 146° 16.2′	Tar at keel of abandoned *Emerald Pacific*	-29.3	1.2	2.5	2.0	0.62	(-)	0.42	0.52
95-11A	Old Valdez	61° 06.8′ 146° 16.0′	Dried tar on buried plank of old dock system								
95-11B	Old Valdez	61° 06.8′ 146° 16.0′	Tar on large cobble at site of tank farm	-23.5	1.8	4.7	2.0	0.60	(+)	0.32	1.0
95-11C	Old Valdez	61° 06.8′ 146° 16.0′	Piece of tar at site of tank farm	-23.4							
95-12	Palmer	61° 35.7′ 149° 06.3′	Tar from parking pad at airport	-29.3	1.6	1.5	1.8	0.59	(-)	0.39	0.49
95-13[6]	Elrington Island	59° 58.5′ 148° 11.0′	Tar cemented sand; ER 11A, 8/94	-29.1							
95-14[6]	Ingot Island	60° 30.0′ 147° 38.7′	Tar cemented cobbles; IN 31A, 7/93	-23.6							
95-15[6]	Eleanor Island	60° 33.8′ 147° 34.5′	Tar splatter scraped off rock; EL 58B, 5/92	-24.1							
95-16	Glacier Bay	58° 52.0′ 136° 49.0′	Tar paper from old cabin; Reid Inlet								
95-17	McClure Bay	60° 32.9′ 148° 09.8′	Tar on piling of abandon-ed West Gable cannery	-23.6	15.	0.37	0.88	0.55	(+)	0.33	0.92
95-18	McClure Bay	60° 32.9′ 148° 09.8′	Tar paper on collapsed building at cannery								
95-19	McClure Bay	60° 32.9′ 148° 09.8′	Grease on rusted equipment at cannery	-23.7							

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
95-20	McClure Bay	60° 32.9′ 148° 09.8′	Tar on roofing of power plant at cannery	-23.8							
95-21	McClure Bay	60° 32.9′ 148° 09.8′	Oil residue in valve of fuel tank at cannery	-23.8	2.2	3.7	1.6	0.58	(+)	0.32	1.1
95-22	McClure Bay	60° 32.9′ 148° 09.8′	Oil residue cascading down rock at cannery	-23.7							
95-23	Port Nellie Juan	60° 35.5′ 148° 06.7′	Tar paper from cabin; so. side of PNJ entrance								
95-23A	Port Nellie Juan	60° 35.5′ 148° 06.7′	Oil inside container in cabin; Chevron SAE 30	-27.7							
95-24	Passage Canal	60° 47.8′ 148° 31.8′	Tar on roof of shipwreck, *St. Elias Ocean Product*	-24.8							
95-25	Passage Canal	60° 47.8′ 148° 31.8′	Tar coating on fabric on roof of shipwreck barge	-22.9	2.5	4.5	1.8	0.60	(+)	0.34	1.2
95-26	Whittier	60° 46.5′ 148° 42.8′	Road tar from newly paved road near dump	-29.4							
95-27	Whittier	60° 46.5′ 148° 43.0′	Tar pieces at end of gravel runway	-29,4							
95-28	Whittier	60° 46.5′ 148° 43.0′	Tar w/ gravel from near end of runway by pilings	-24.2							
95-29	Perry Island	60° 41.1′ 147° 55.2′	Tar on rock at old wharf site at oyster farm	-22.3							
95-30	Perry Island	60° 41.1′ 147° 55.2′	Tar on old chimney flashing at oyster farm	-28.7							
95-31	Perry Island	60° 41.1′ 147° 55.2′	Tar on pole of boat shed at oyster farm	-24.8							
95-32	Port Wells	60° 50.5′ 148° 19.3′	Tar on plank near mining equi.; N shore Pigot Bay	-23.7							
95-33	Port Wells	60° 51.1′ 148° 23.3′	Tar paper from old cabin; west end of Pigot Bay								
95-34	Port Wells	60° 50.4′ 148° 23.2′	Roof tar, Forest Ser. cabin; S side, Pigot Bay	-25.4							
95-35	Port Wells	60° 58.1′ 147° 59.8′	Tar paper from old cabin at Golden								
95-36	Port Wells	60° 57.9′ 148° 12.3′	Tar paper from firewall of old truck; Granite Mine								
95-37	Port Wells	60° 57.9′ 148° 12.3′	Grease from barrel on beach near Granite Mine	-25.4							

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
95-38	Port Wells	60° 58.3´ 148° 11.9´	Tar on metal shed roof; north of Granite Mine	-26.1							
95-39	Ester Island	60° 48,0´ 148° 05.0´	Roofing material from W. Noerenberg Hatchery	-27.3							
95-40 (=89-10)	Wells Passage	60° 46.0´ 147° 56.1´	SH; 325m; *Rai* : gray green silty mud		2.5	1.2	1.9	0.45	lo B, -T, +O	0.29	0.58
95-41 (=89-05)	Eleanor Island	60° 32.9´ 147° 30.6´	SH; 204m; *Rai* : gray green silty mud		2.0	1.4	1.7	0.48	?B, -T, +O	0.30	0.56
95-42 (=89-04)	Knight Island	60° 15.6´ 147° 42.0´	SM; 65m; *Rai* : gy-gr mud w/ gv; Snug Harbor		1.9	1.9	1.8	0.49	lo B, -T, +O	0.38	0.56
95-43 (=89-03)	Knight Island	60° 14.0´ 147° 39.0´	SM; 271m; *Rai* : blue gn mud; off Snug Harbor		1.9	1.7	1.8	0.50	?B, -T, +O	0.32	0.55
95-44 (=89-15)	Latouche Pass.	60° 04.6´ 147° 53.7´	SH; 105m; *Rai* : gray green silt		1.7	3.1	1.8	0.49	-B, -T, +O	0.41	0.73
95-45 (=89-02)	Montague Strait	59° 58.4´ 147° 49.9´	SH; 249m; *Rai* : olive sandy mud		1.7	1.2	1.9	0.50	lo B, -T, +O	0.33	0.48
95-46 (=89-01)	Montague Strait	59° 52.3´ 148° 01.5´	SH; 150m; *Rai* : mudy sdy gvl; SW end of str.		1.5	0.63	1.9	0.53	?B, -T, +O	0.29	0.48
95-47[8]	Kodiak I. Gp.	58° 30.2´ 152° 25.3´	NOAA beach sample; R95-06, 603601								
95-48[8]	Kodiak I. Gp.	58° 33.4´ 152° 22.6´	NOAA beach sample; R95-06, 603602								
95-49[8]	Kodiak I. Gp.	58° 33.4´ 152° 22.6´	NOAA beach sample; R95-06, 603603								
95-50[8]	Kodiak I. Gp.	58° 37.9´ 152° 21.8´	NOAA beach sample; R95-06, 603604								
95-51[8]	Kodiak I. Gp.	58° 37.9´ 152° 21.8´	NOAA beach sample; R95-06, 603605								
95-52[8]	Shuyak Island	58° 38.0´ 152° 21.9´	NOAA beach sample; R95-06, 603606	-29.3							
95-53[8]	Kodiak I. Gp.	58° 37.8´ 152° 21.3´	NOAA beach sample; R95-06, 603607								
95-54[8]	Kodiak I. Gp.	58° 37.8´ 152° 21.3´	NOAA beach sample; R95-06, 603608								
95-55[8]	Kodiak I. Gp.	58° 32.3´ 152° 38.4´	NOAA beach sample; R95-06, 603609								
95-56[8]	Shuyak Island	58° 33.9´ 152° 39.0´	NOAA beach sample; R95-06, 603610	-29.3							

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	Triplet	C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	C_{28}/C_{29}
95-57[8]	Kodiak I. Gp.	58° 30.5′ 152° 37.8′	NOAA beach sample; R95-06, 603611								
95-58[8]	Kodiak Island	57° 42.4′ 153° 54.3′	NOAA beach sample; R95-06, 603612	-29.3							
95-59[8]	Kodiak I. Gp.	57° 42.4′ 153° 54.3′	NOAA beach sample; R95-06, 603613								
95-60[9]	California	40° 34.5′ 124° 21.0′	Tar ball; 400m south of Centerville Beach	-26.7	1.4	0.62	0.96	0.57	-B, -T, +O	0.35	0.58
95-61[9]	California	40° 34.3′ 124° 21.1′	Tar ball; 800m south of Centerville Beach	-26.7							
95-62[4]	Bethel	60° 47.5′ 161° 45.0′	Tar from airport parking pad								
95-63[10]	Knight Island	60° 13.4′ 147° 58.5′	GC; 540m; 63-73cm; SW of Squire Island								
95-64[10]	Knight Island	60° 27.3′ 147° 31.7′	GC; 212m; 90-100cm; NW of Seal Island		2.7	0.30	1.9	0.43	-B, -T, +O	0.21	0.48
95-65[10]	Knight Island	60° 22.5′ 147° 32.1′	GC; 175m; 100-110cm; SE of Bay of Isles								
95-66[10]	Knight Island	60° 18.9′ 147° 27.9′	GC; 217m; 30-40cm; off of Marsha Bay		3.0	0.30	1.8	0.44	-B, -T, +O	0.25	0.49
95-67[10]	Latouche I.	60° 03.5′ 147° 46.5′	GC; 345m; 47-57cm; off no. end, Montague St.								
95-68[10]	Ingot Island	60° 32.3′ 147° 43.5′	GC; 693m; 106-116cm; NW of island		2.9	0.27	1.9	0.43	-B, -T, +O	0.20	0.54
96-01[11]	California	34° 50′ 120° 30′	Crude oil from Santa Maria field; Unocal	-23.2	2.2	4.9	0.91	0.58	(+)	0.33	1.5
96-02[11]	California	34° 50′ 120° 30′	Crude oil from Santa Maria field; Chevron								
96-03[11]	California	39° 20′ 123° 40′	Tar from Mackerricher Beach State Park	-26.5	1.8	1.6	0.92	0.57	(+)	0.39	0.57
96-04[11]	California	35° 00′ 119° 30′	Crude oil from San Joaquin; Benicia, CA	-24.6	1.6	5.0	0.91	0.56	(+)	0.44	1.2
96-05[11]	California	35° 00′ 119° 30′	Bunker fuel oil from Huntway Ref.; Benicia	-24.5	1.8	4.3	0.9	0.58	(+)	0.36	1.0

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
96-06[11]	California	34° 50′ 120° 30′	Gas/oil from Santa Maria field; Rodeo, CA								
96-07[11]	California	34° 50′ 120° 30′	No. 6 fuel oil from Unocal; Rodeo, CA	-22.9	6.0	2.8	1.6	0.55	+B, -T, +O	0.31	1.0
96-08	Yakutat	59° 30.7′ 139° 40.0′	Tar splotches at airport between terminal & lodge								
96-09	Cordova	60° 29.6′ 145° 28.4′	Tar from storm drain in old runway	-28.3							
96-10	Cordova	60° 29.6′ 145° 28.4′	Tar from parking ramp of new (1994) runway	-29.4							
96-11	Hawkins Cutoff	60° 31.8′ 146° 17.11′	VV; 9m; *Auk* : gray silty mud; Middle Gd. Shoal								
96-12	Hawkins Cutoff	60° 31.9′ 146° 16.8′	VV; 12m; *Auk* : gy mud; edge of Middle Gd. Shoal		3.2	0.50	1.7	0.34	-B, -T, +O	0.23	0.47
96-13	Hawkins Cutoff	60° 32.3′ 146° 22.3′	VV; 18m; *Auk* : gy mud; edge of Middle Gd. Shoal		2.6	0.60	1.7	0.45	-B, -T, +O	0.20	0.56
96-14	Hawkins Cutoff	60° 30.3′ 146° 24.1′	VV; 15m; *Auk* : gy mud; edge of Middle Gd. Shoal								
96-15	Hinchinbrook I.	60° 28.4′ 146° 26.3′	VV; 12m; *Auk* : gray green mud; north shore		2.7	0.67	1.2	0.17	-B, -T, +O	0.21	0.48
96-16	Hinchinbrook I.	60° 28.5′ 146° 38.3′	VV; 31m; *Auk* : olive gy mud; off Johnstone Pt.		2.5	0.58	1.7	0.27	-B, -T, +O	0.23	0.56
96-17	Hinchinbrook I.	60° 23.7′ 146° 43.4′	VV; 16m; *Auk* : gy fn sd & mud; off Deer Cove								
96-18	Hinchinbrook I.	60° 20.1′ 146° 41.2′	VV; 34m; *Auk* : gy mud, near Bear Cape		2.5	0.42	1.9	0.47	-B, -T, +O	0.21	0.52
96-19	Hinchinbrook I.	60° 17.6′ 146° 40.8′	VV; 14m; *Auk* : gray sdy mud; English Bay		2.5	0.43	1.8	0.48	-B, -T, +O	0.21	0.49
96-20	Hinchinbrook I.	60° 20.9′ 146° 35.9′	VV; 12m; *Auk* : gray sdy mud; Port Etches								
96-21	Montaque I.	60° 21.0′ 147° 05.4′	VV; 76m; *Auk* : gy mud; inside Rocky Bay		2.0	1.1	1.9	0.45	-B, -T, +O	0.28	0.60
96-22	Montaque I.	60° 20.6′ 147° 02.3′	Tar w/ fresh needles on rock; Rocky Bay	-26.9	1.4	2.2	1.5	0.61	(+) (lo)	0.40	0.54
96-23	Montaque I.	60° 20.5′ 147° 02.6′	Tar on beach cobbles; inlet behind Rocky Bay								
96-24	Knight Island	60° 09.5′ 147° 45.5′	Dead oil on rock at high tide line; Point Helen	-29.2							

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
96-25	Knight Island	60° 13.0′ 147° 48.6′	Tar on rock below fuel tank; Thumb Bay	-22.3							
96-26	Knight Island	60° 12.4′ 147° 49.2′	Tar on rocks below tanks at Pt.Oceanic; Thumb B.								
96-27	Chenega Island	60° 16.8′ 147° 04.7′	Oil cemented fissile shale; Old Chenega	-29.2							
96-28	Knight Island	60° 20.7′ 147° 46.0′	Tar on roof of abd. cannery; head of Drier Bay								
96-29	Knight Island	60° 20.7′ 147° 46.0′	Tar on rock from old fuel tanks, head of Drier Bay	-22.6	2.6	6.2	1.8	0.60	(+)	0.42	1.1
96-30	Knight Island	60° 28.0′ 147° 40.6′	Tar on rock; shore of Louis Bay	-23.7							
96-31	Knight Island	60° 28.0′ 147° 40.6′	Mousse on rock; shore of Louis Bay	-29.3							
96-32A	Knight Island	60° 28.0′ 147° 40.6′	Fresh mousse on rock; shore of Louis Bay								
96-32B	Knight Island	60° 28.0′ 147° 40.6′	Tar w/o needles on rock; shore of Louis Bay								
96-32C	Knight Island	60° 28.0′ 147° 40.6′	Tar w/ needles on rock; shore of Louis Bay								
96-33	Knight Island	60° 28.9′ 147° 38.6′	Tar w/ needles on rock; point on Lower Passage								
96-34A	Gulf of Alaska	58° 13.0′ 137° 25.4′	SH; 134m; *Rai* : olive-gy mud; W, Cape Spencer		1.8	2.9	2.0	0.50	-B, -T, +O	0.44	0.00
96-34B	Gulf of Alaska	58° 13.0′ 137° 25.4′	SH; 132m; *Rai* : olive-gy mud; W, Cape Spencer								
96-35A	Gulf of Alaska	59° 14.0′ 140° 20.9′	SH; 138m; *Rai* : gy mud; south of Yakutat Bay		3.0	1.1	2.2	0.42	-B, -T, +O	0.35	0.00
96-35B	Gulf of Alaska	59° 14.0′ 140° 21.1′	SH; 138m; *Rai* : gy mud; south of Yakutat Bay								
96-36B	Gulf of Alaska	59° 44.8′ 143° 34.1′	SH; 308m; *Rai* : gy mud; Bering Trough		3.0	0.3	1.8	0.50	+B, -T, +O	0.18	0.55
96-37B	Gulf of Alaska	59° 44.0′ 144° 00.5′	SH; 120m; *Rai* : gy mud; Kayak I./Bering Trough		3.2	0.30	1.9	0.50	+B, -T, +O	0.17	0.55
96-38	Gulf of Alaska	59° 55.8′ 145° 04.5′	SH; 159m; *Rai* : gy mud; west of Kayak Island		2.9	0.24	1.8	0.52	+B, -T, +O	0.17	0.56
96-39	Gulf of Alaska	60° 10.8′ 145° 46.8′	SH; 119m; *Rai* : gy mud south of Pt. Whitney		2.8	0.32	1.8	0.51	+B, -T, +O	0.20	0.56

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	m/z 191 C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
96-40	Gulf of Alaska	60° 12.9′ 146° 06.76′	SH; 106m; *Rai*: gy mud; south, Hinchinbrook Is.		2.9	0.35	1.8	0.51	-B, -T, +O	0.19	0.54
96-41	Gulf of Alaska	60° 11.9′ 146° 25.2′	SH; 128m; *Rai*: gy mud ESE, Cape Hinchinbr.		1.8	0.37	1.7	0.52	+B, -T, +O	0.19	0.55
96-42A	Hinchinbr. Ent.	60° 18.2′ 146° 47.8′	SH; 270m; *Rai*: gy mud; west of Pt. Etches		2.7	0.47	1.9	0.50	+B, -T, +O	0.21	0.52
96-42B	Hinchinbr. Ent.	60° 18.5′ 146° 47.9′	SH; 277m; *Rai*: gy mud; west of Pt. Etches								
96-43A (=89-15)	Latouche Pass.	60° 05.7′ 147° 53.5′	SH; 225m; *Rai*: sd mud; north end of passage		1.6	3.7	1.5	0.53	(+)	0.43	0.77
96-43B (=89-15)	Latouche Pass.	60° 05.1′ 147° 53.7′	SH; 236m; *Rai*: sd mud; north end of passage								
96-44	Latouche I.	60° 04.8′ 147° 49.6′	SH; 145m; *Rai*: sd mud; off of Sleepy Bay		2.0	1.8	1.9	0.50	(+) (lo B, T)	0.35	0.59
96-45 (=89-03)	Knight Island	60° 14.7′ 147° 38.9′	SH; 264m; *Rai*: olive-gy mud; off of Snug Harbor		2.3	1.4	1.9	0.50	?B, -T, +O	0.31	0.55
96-46 (=89-04)	Knight Island	60° 16.4′ 147° 42.1′	SH; 120m; *Rai*: olive-gy mud; Snug Harbor		2.5	1.1	1.8	0.47	?B, -T, +O	0.29	0.61
96-47	Knight Island	60° 12.1′ 147° 49.6′	Tar on beach cobble; south side, Mummy Bay	-23.6							
96-48	Squire Island	60° 14.0′ 147° 57.1′	Tar w/ pebbles and granules; SW side of island								
96-49	Squire Island	60° 14.0′ 147° 57.1′	Tar blob on rock; SW side of island	-23.7							
96-50	Squire Island	60° 16,2′ 147° 55.4′	Tar w/ twigs and granules; north end of island	-23.6							
96-51	Knight Island	60° 13.5′ 147° 54.5′	Tar lump w/ pine needles near Italian Bay	-23.5							
96-52	Knight Island	60° 11.6′ 147° 50.2′	Tar patch on rock outcrop; south, Mummy Bay	-29.2							
96-53	Evans Island	60° 07.8′ 147° 56.1′	Tar in among rocks, sd; south of Shelter Bay	-29.2	1.2	2.0	1.7	0.60		0.47	0.54
96-54	Fleming Island	60° 11.0′ 148° 01.5′	Tar on beach cliff w/ br. mousse; north end of isl.	-28.9	1.3	2.3	1.7	0.60		0.44	0.56
96-55[8]	Hinchinbrook I.	60° 21.3′ 146° 39.5′	NOAA sample 601508; Constantine Harbor		7.6	0.75	1.5	0.06	-B, -T, ?O	0 no sterane	0 no sterane

Appendix 2. (continued)

Field No.	Location	N. Latitude W. Longitude	Description	$\delta^{13}C$ (‰)	m/z 191 Tm/Ts	m/z 191 Triplet	m/z 191 C_{30}/C_{29}	C_{31} $\frac{S}{S+R}$	BTO	m/z 217 C_{29} $\frac{S}{S+R}$	m/z 217 C_{28}/C_{29}
97-1[8]	Bering River	60° 10.9′ 144° 12.1′	NOAA 806807; sediment near Chilkat		1.0	0.74	1.6	0.52	-B, -T, +O	0.30	0.47
97-2[8]	Bering Lake	60° 19.0′ 144°20.1′	NOAA 806808; sediment from lake		n.d.	n.d.	? 1.0	0.09	(-)	0.20	0.62
97-3[8]	Shepard Creek	60°18.2′ 144° 14.4′	NOAA 806809; sediment from creek		n.d.	n.d.	n.d.	n.d.	(-)	0.08	0.27
97-4[8]	Kushtaka Lake	60° 23.8′ 144° 07.6′	NOAA 806810; sediment #1 from lake		1.1	1.0	1.2	n.d.	(-)	0.33	0.60
97-5[8]	Kushtaka Lake	60° 24.0′ 144° 07.0′	NOAA 806811; sediment #2 from lake		0.66	? 2.5	1.1	0.59	?B, -T, ?O	0.41	? 0.80
97-6[8]	Berg Lake	60° 34.9′ 143° 52.3′	NOAA 806812; sediment #1 from lake		1.4	0.55	1.2	? 0.48	(-)	0.21	0.58
97-7[8]	Dachtoth River	60° 05.0′ 142° 30.7′	NOAA 806814; sediment from east bank of river		2.2	0.26	2.1	0.57	?B, -T, +O	0.27	0.37
97-8[8]	Cape Yakutaga	60° 04.8′ 142° 30.7′	NOAA 806815; sediment from beach at cape		2.7	0.25	1.9	0.55	+B, -T, +O	0.20	0.42
97-9[8]	Katalla	60° 11.2′ 144° 31.2′	NOAA 806822; coal/ sediment from beach		10.3	0	1.8	0.46	+B, -T, +O	0.12	0.12
97-10[8]	Queen Vein	60° 24′ 144° 10′	NOAA 806827; coal from mine		0.78	1.2	1.3	0.6	?B, ?T, +O	0.38	0.50
97-11[8]	Carbon Ridge	60° 24′ 144° 10′	NOAA 806828; coal from mine		0.78	1.1	1.2	0.57	?B, ?T, +O	0.49	0.85
97-12	Portage Glacier	60° 47.4′ 148° 50.0′	Tar from path behind gift shop		1.5	0.76	1.8	0.6	low +	0.34	0.55
97-13	Glacier Island	60° 53.8′ 147° 05.1′	Tar-like material on piling; east side Finski Bay		3.8	0.68	1.0	0.58	(+)	0.34	0.86
97-14	Glacier Island	60° 53.8′ 147° 05.1′	Tar on lath in debris; east side Finski Bay		1.6	5.4	2.2	0.60	(+)	0.30	0.94
97-15	Glacier Island	60° 53.8′ 147° 05.1′	Tar w/ gravel on pallet; east side Finski Bay		1.6	5.1	2.1	0.59	(+)	0.26	0.95
97-16	Eagle Island	60° 54.7′ 147° 10.0′	Tar on rock of cobble beach; SE side of island		1.6	5.3	2.1	0.59	(+)	0.27	0.91
97-17	Eagle Island	60° 54.7′ 147° 10.0′	Tar-cemented gravel on beach; SE side of island		1.6	5.2	2.0	0.59	(+)	0.28	0.85

Appendix 2. (continued)

$\delta^{13}C$(‰), $[(^{13}C/^{12}C_{(sample)}/^{13}C/^{12}C_{(standard)}) - 1] \times 10^3$.
Tm/Ts, 17α-22,29,30-trisnorhopane/18α-22,29,30-trisnorneohopane.
Triplet, [C_{26}-tricyclic terpane (S?)+C_{26}-tricyclic terpane(R?)]/C_{24}-tetracyclic terpane.
C_{30}/C_{29}, 17α,21β(H)-hopane/17α,21β(H)-30-norhopane.
C_{31} S/(S+R), 17α,21β(H)-homohopane(22S)/17α,21β(H)-homohopane (22S)+(22R).
BTO, Bisnorhopane [17α,18α,21β(H)-28,30-bisnorhopane], Trisnorhopane [17α,18α,21β(H)-25,28,30-trisnorhopane], Oleanane.
C_{29} S/(S+R), 24-ethyl-5α,14α,17α(H)-cholestane (20S)/24-ethyl-5α,14α,17α(H)-cholestane (20S)+(20R).
C_{28}/C_{29}, 24-methyl-5α,14α,17α(H)-cholestane (20R)/24-ethyl-5α,14α,17α(H)-cholestane (20R).

[1]Obtained from D.G. Shaw, Institute of Marine Science, University of Alaska, Fairbanks; [2]obtained from J. and N. Lethcoe, Alaska Wilderness Sailing Safaris; [3]obtained from C. Schroth, National Park Service; [4]obtained from J. Reeve Ogle, Reeve Aleutian Airways, Inc.; [5]obtained from L.B. Magoon, Energy Team, U.S. Geological Survey; [6]obtained from L.J. Evans, Alaska Department of Environmental Conservation; [7]obtained from W. Stokes, Alaska Department of Environmental Conservation; [8]obtained from J.W. Short, NOAA, Auke Bay Laboratory; [9]obtained from J. Lesh, California Department of Fish & Game, Oil Spill Prevention & Response Office; [10]obtained from J.M. Kennedy, Kinnetic Laboratories, Inc; [11]obtained from W.T. Castle, California Department of Fish & Game, Petroleum Chemistry Laboratory.

Sediment Samplers: AN, Anchor grab; BX, Box core; GC, Gravity core; SH, Shipek grab; SM, Smith-McIntyre grab; VV, Van Veen grab.

Vessels: *Auk, Auklet* (USGS charter); *Dav, Davidson* (NOAA); *Far, Farnella* (USGS charter); *Kar, Karluk* (USGS); *McA, McArthur* (NOAA); *Rai, Rainier* (NOAA).