Tar and Particulate Pollutants on the Beaufort Sea Coast

C.S. WONG, D. MacDONALD
and W.J. CRETNEY

Beaufort Sea Technical Report No. 13

Beaufort Sea Project

DISTRIBUTION OF TAR AND OTHER PARTICULATE POLLUTANTS ALONG THE BEAUFORT SEA COAST

C.S. Wong*, D. Macdonald** and W.J. Cretney *

*Ocean Chemistry Division
Ocean & Aquatic Sciences, Pacific Region
Department of the Environment
211 Harbour Road
Victoria, B.C.

**Thalassic Data Ltd.
3445 West 31st Avenue
Vancouver, B.C.

2. Beaufort Sea Technical Report No. 13

1 Beaufort Sea Project.
512 Federal Building
1230 Government Street
Victoria, B.C.
V8W 1Y4

March, 1976

TABLE OF CONTENTS

List of Figures

1. SUMMARY

This report summarizes the objectives of the project, the study area, methods, sources of data and field and laboratory results of the investigation during the summers of 1974 and 1975 along the Beaufort Sea Coast. The objectives of the study are: (1) to establish the baseline distribution of particulate pollutants, especially for tar and plastics, in the present-day Beaufort Sea marine environment, (2) to establish areas with natural seepage of crude oil and (3) to establish the chemical characteristics of hydrocarbons in the present-day beach sediment, nearshore sediment and marine organisms, including fish. The study area in 1974 covered the SW coast of Mackenzie Bay and portions of the western coast of Tuktoyaktuk Peninsula. In 1975 the area was expanded to include not only the Yukon Coast, but also some of the offshore islands of the Mackenzie River Delta and a larger portion of Tuktoyaktuk Peninsula. No extensive tar pollution was found and no natural seepage was evident, although some isolated occurrences of asphalt near Drift Point and grease near Shingle Point and around Tuft Point and Warren Point were encountered. However, plastic wastes, in particular explosive cannister fragments originating from marine seismic activities, were prevalent and were found to have re-inundated beaches that had been cleaned up during the 1974 survey. Beach sediment, nearshore sediment and fish samples were collected to establish their hydrocarbon characteristics.

2. INTRODUCTION

2.1 General Nature and Scope of Study

This report intends to present information on the distribution of tar and other particulate pollutants along the Beaufort Sea Coast surveyed by Ocean Chemistry Division, Ocean and Aquatic Sciences, Pacific Region during the summer season of 1974. This study was planned and co-ordinated by Dr. C.S. Wong. The requirements in logistics were worked out by Mr. R.D. Bellegay of Ocean Chemistry Division during the early stage of the proposal and the laboratory analysis was supervised by Dr. W.J. Cretney. The survey along stretches of the Beaufort Sea Coast was carried out by Mr. D. Macdonald on contract from Ocean Chemistry Division to C.E.L.L. and under DSS File Ref. No. 01SX KF832-4-0095 and to Thalassic Data Ltd. under contract DSS File Ref. No. KF-832-4-2107 in cooperation with the field parties of the Geological Survey of Canada under Mr. C.P. Lewis and of the Arctic Biological Station under Dr. J.G. Hunter.

The occurrence of particulate pollutants, in particular plastics and petroleum residues, often referred to as "tar lumps or tar balls", is a useful indicator of human input into the environment. Their high resistance to biodegradation results in their ubiquitous and persistent distribution in regions with human activities.

Plastic is a modern form of material which is definitely an indicator of man's pollution in the environment. The most common plastic compounds are polyethylene, polystyrene, polyvinyl chloride, polypropylene and acrylonitrile butadiene styrene (Cundell, 1974). Polyethylene (specific gravity 0.91-0.96) as well as polystyrene foam (specific gravity 0.8) will be seaborne pollutants of a persistent nature due to oxidation-resistant and ultraviolet stablizing properties incorporated into the commercial plastics. In recent years, seaborne plastics appear in oceanic waters (Heyerdahl, 1971, Vernick et. al., 1974) and plastic products were accumulated in foreshores of densely populated areas (Cundell, 1974).

Tar lumps occur on ocean waters as ubiquitous as living organisms collected in mass, in some cases (Wong et al, 1974). The occurrence of pelagic tar was summarized by Butler, et al (1973). Beach tar can be the result of natural seepage (Wilson et al, 1974) or of human activities in the production and utilization of petroleum, as is evident in the buildup of beach tar since World War II on rocks and beaches of the Mediterranean, N. Sea coasts and Bermuda (Morris et al, 1973).

2.2 Specific Objectives

This study hopes to achieve the following objectives: (1) To establish the baseline distribution of particulate pollutants, especially tar and plastics, in the present-day Beaufort Sea marine environment. (2) To establish areas with natural seepage of crude oil, if any, in the present-day Beaufort Sea marine environment. (3) To establish the chemical characteristics of hydrocarbons in present-day beach sediment samples, nearshore sediment samples and organisms in the nearshore environment.

2.3 General Relationship to Concerns of Offshore Exploratory Drilling

The Arctic environment is a unique ecosystem. Due to extremely low temperature and a very short summer, weathering is a much slower process in the Arctic than in a warmer area. Our field party sighted along the Beaufort Sea Coast carcasses of whales known to have beached over a year ago. Particulate pollutants of plastics and tar will be expected to stay in the cold environment for a very long period of time due to their high resistance to biodegradation. Although the effects of such pollutants, other than aesthetic, are unknown at present, the longevity of their presence is of deep concern to those who wish to preserve the Arctic in the present state of beauty and natural ecology. Increased human activities in connection with exploratory drilling can lead to introduction of large amounts of non-biodegradable plastic wastes in the form of housewares, packaging materials, blow-moulded containers and polyethylene sheets. As discussed later in this same report, the exploratory process using explosives in plastic containers introduces unexpected large quantities of plastics into the Beaufort Sea environment. It is also important to know before any large-scale drilling, the state of pollution of the beaches along the Beaufort Sea coast with respect to tar and to ascertain if such tar occurrence is of a natural-seepage origin or introduced by humans. The characterestics of natural hydrocarbons should also be established so that future changes resulting from drilling activities can be monitored by referring to present-day baseline data. In short, we would like to put in quantitative terms a description of our Beaufort Sea coastal environment with respect to known sources of particulate pollutants. If it is very clean now, we want to know how clean it is.

3. RESUME OF CURRENT STATE OF KNOWLEDGE

No quantitative work or systematic survey exists to describe the current environmental conditions in the Arctic, with respect to particulate pollutants. Four onshore seep areas were shown in a world map of reported seeps (Wilson et al, 1974) for the

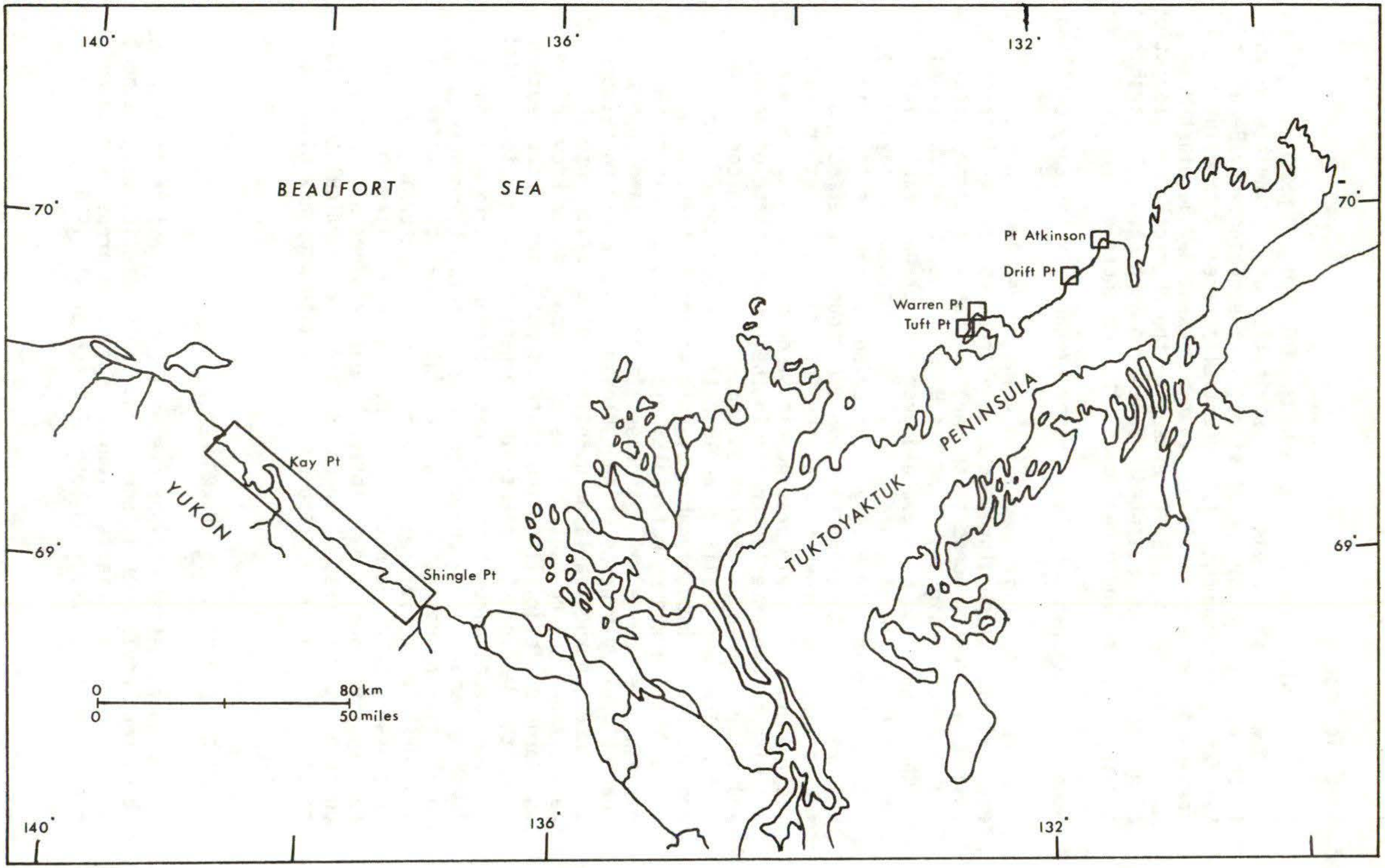

Fig. 1A, Study Areas, 1974

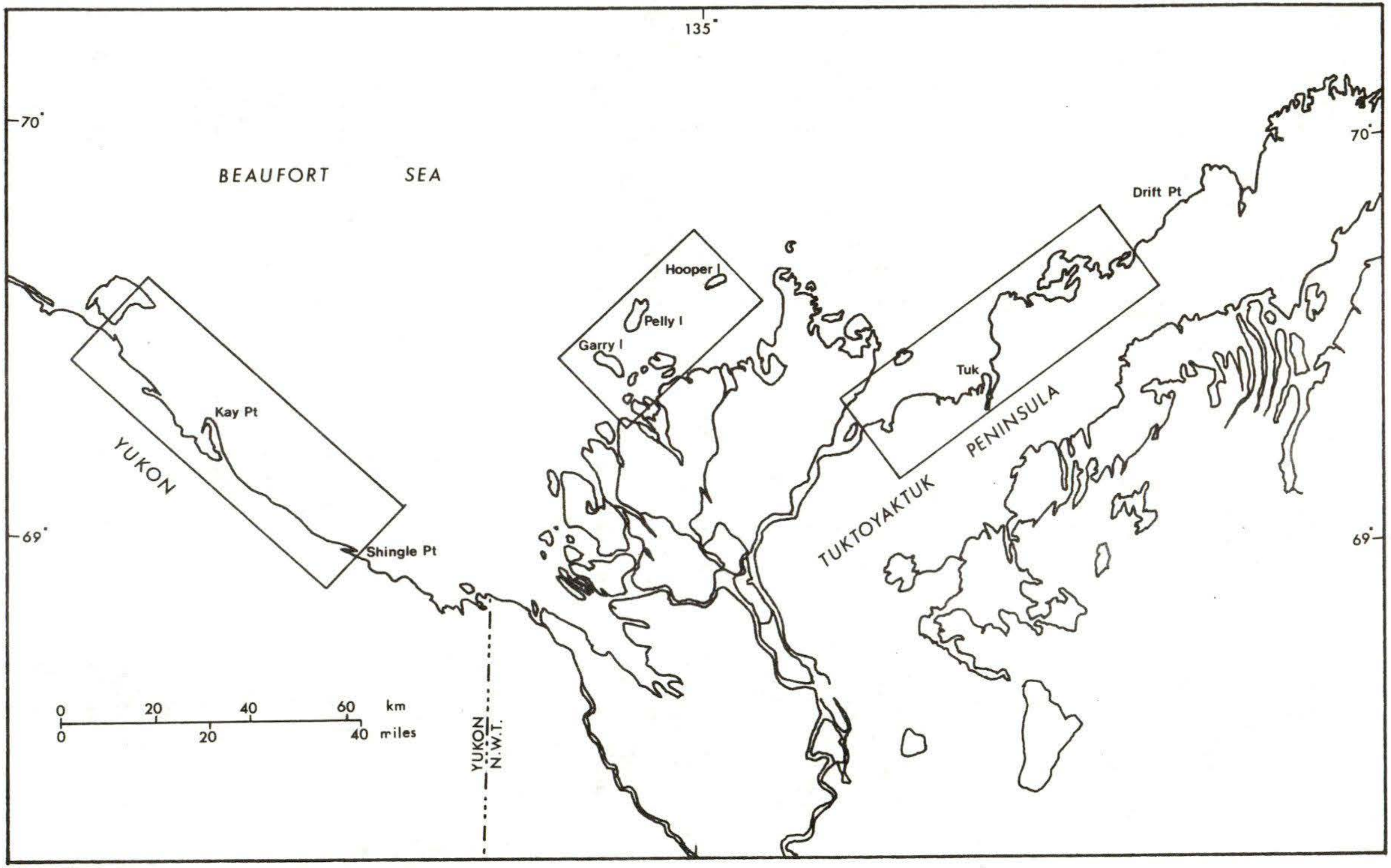

Figure 1B, Study Areas, 1975

Beaufort Sea Coast in the Mackenzie Bay area. No offshore seepage was shown in the Arctic. In general, the seepage potential of the continental margins in Beaufort Sea does not appear to be high. In Wilson et al, 1974 discussion, the seepage-prone areas in the Arctic Ocean and the seepage rates estimated were only moderate to low compared to other oceanic areas. Tar, introduced by river drainage from areas such as Athabasca and Mackenzie eroding tar sand formation, can be a possible source. Regarding plastics, reports of pollution were mainly subjective, as newspaper or magazine articles. No quantitative recording was made.

4. STUDY AREA

4.1 Geographic Location

In 1974 the study areas covered two major stretches of the coastline: (1) the SW coast of Mackenzie Bay from the Blow River Delta (68° 55'N, 137° 10'W) to Stokes Point (69° 20'N, 138° 45'W), and (2) portions of the western coast of Tuktoyaktuk Peninsula from Tuft Point (29° 42'N, 132° 38'W) to Atkinson Point (69° 57'N, 132° 23'W). A map outlining the study areas is shown in Figure 1A, while more detailed maps of sampling locations are found in Appendix 12.1

In 1975 three major areas were investigated: (1) the Yukon coast from Shingle Point Spit to Herschel Island, (2) the front of the Mackenzie River Delta, including Garry, Pelly, Hooper and Kendall Islands, and (3) Tuktoyaktuk Peninsula, down Kittigazuit to Drift Point. The 1975 study areas are outlined in Figure 1B, while more detailed maps of sampling areas are found in Appendix 12.2

4.2 Physiography

(a) Yukon Coast

The Yukon Coastal Plain borders the Beaufort Sea from the Mackenzie Delta to the Alaska border. It exhibits little relief (Figure 2), and may terminate abruptly in cliffs or slope gently down to the sea.

The coast undergoes constant change, aided by thermal erosion of the cliffs and redistribution of these sediments by the action of waves and longshore currents. Coarser sediments have formed numerous beaches and spits, while finer sediment loads are transported to such sediment sinks as Phillips Bay and Shoalwater Bay. Substantial driftwood accumulations are found along the coast, their principal source thought to be the Liard River (Mackay, 1963).

The Blow River and Running River have deeply incised

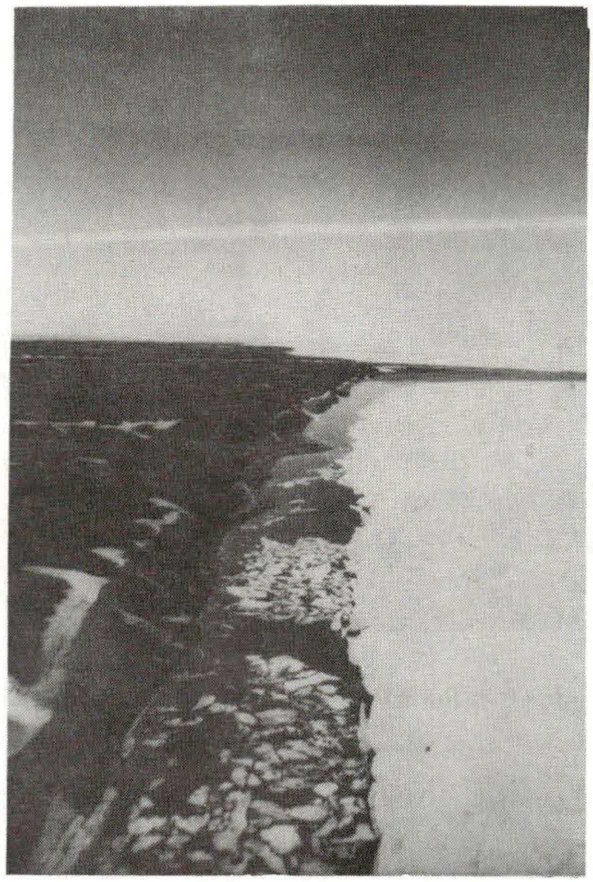

Figure 2. Yukon Coastal Plain. Running River Delta visible in background.

Figure 3. Western Edge of Blow River Delta

Figure 4. Western edge of Running River Delta. Blow River Delta in left background.

Figure 5. Coast about 1 Km west of Blow River Delata. Sampling box 40 cm high.

Figure 6. Shingle Point Spit viewed to the N.E. Driftwood marks major berm. Pack ice and Pressure Ridge on Seaward Edge.

Figure 7. Several Km west of Shingle Point Spit (visible in left background.

Figure 8. Rapid erosion of cliffs to the west of Sabine Point.

Figure 9. Bay-Mouth Bar at King Point.

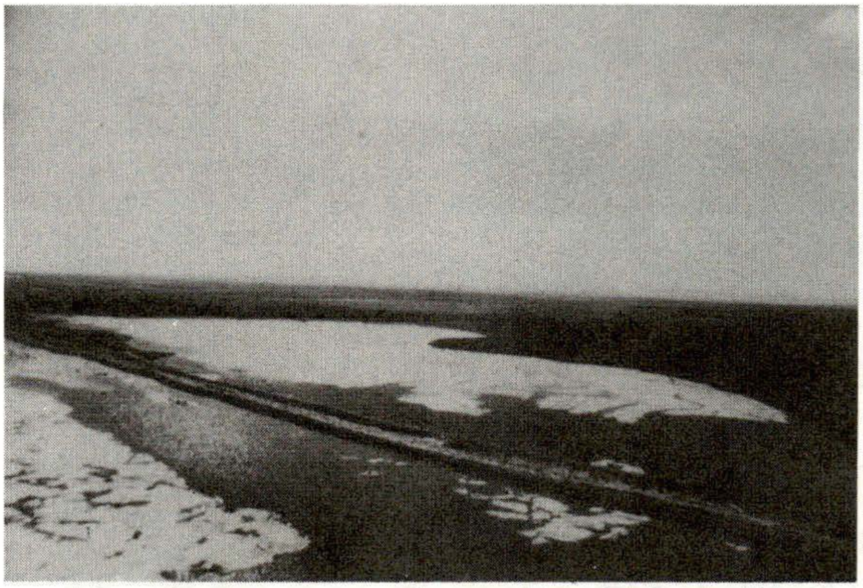

Figure 10. Bay-Mouth Bar enclosing former small boat harbour at King Point.

Figure 11. Cliffs of Babbage Bight; King Point to left.

Figure 12. Along Babbage Bight, about half way between King Point and Kay Point.

Figure 13. Kay Point Spit viewed to S.W. Pack ice on seaward edge.

Figure 14. Niakolik Point (Boat 12' long).

Figure 15. Spit at Tuft Point, viewed to south adjoining Figure 16.

Figure 16. Bay at Tuft Point. Eastern edge of Spit (Fig. 15) visible to right.

Figure 17. Looking south onto Drift Point.

Figure 18. Looking north onto Drift Point. Sample container 40 cm high.

Figure 19. Sampling location just north of Atkinson Point, viewed to north.

the coastal plain and built large low-lying deltas at their mouths. Large driftwood accumulations are found at the western edges of each (Figures 3 and 4). The delta of the Blow River is essentially contiguous with that of the Mackenzie River.

The coastal beaches between Blow River and Shingle Point Spit are quite narrow, generally between 5 and 10 meters wide. The cliffs are fairly stable with some slumping evident (Figure 5).

Shingle Point Spit protrudes from the coast in a northeasterly direction for about 5 km. It is actively increasing both in length and breadth, its sediment source being from the cliffs to the west. Large amounts of driftwood have accumulated at or near the berm of the seaward beach (Figure 6). Outwash fans of nearly constant elevation have formed behind this berm.

The coastal beaches to the west of the spit, and almost as far as Sabine Point, are somewhat wider than those to the east and have larger and more frequent driftwood accumulations (Figure 7). The area from Sabine Point to several miles east of King Point is undergoing rapid erosion. Block slumping and mudflows obliterate the beach and make passage on foot impossible (Figure 8).

Slightly to the east of King Point the cliffs become lower and more gently sloping; the beaches wide and driftwood littered. A wide bay-mouth bar has formed SE from King Point and now completely encloses what was once a small boat harbour and settlement (Figure 9 and 10).

Babbage Bight extends from King Point to Kay Point. Generally fronted by steep cliffs (Figure 11), it is undergoing rapid erosion. Its western limit, at Kay Point, exhibits the highest rate of retreat of any area along the entire Yukon coast. In several areas, however, the plain dips gently to the sea and wide beaches result (Figure 12).

Kay Point Spit trends in a southwesterly direction from the tip of the peninsula, with a length of over 5 km (Figure 13). Fed by the cliffs of Babbage Bight, it is increasing in length, and probably in breadth. Forced to accommodate the rapid recession of the landform it adjoins, it is shifting in a southeasterly direction (McDonald and Lewis, 1973).

The coast from Kay Point to Stokes Point is generally low-lying. Reconnaissance to Niakolik Point (Figure 14), the mouth of the Spring River, and Stokes Point revealed driftwood-laden beaches similar to those already mentioned.

(b) Tuktoyaktuk Peninsula

The areas investigated along Tuk Peninsula all lie in a region of glaciofluvial sand and gravel plains(Rampton,1974) Relief is low, particularly to the north. Marine activity has tended to smooth off the coastline. Blowouts and sand dunes are prevalent features as winds act on the fine to medium grained sandy sediments.

At Tuft Point hills are generally less than 20 m high. Small to medium sized lakes account for about 30% of the land area. Many lakes lie at or near sea level, and are separated from the sea by broad, flat beaches. Storm tides have easy access to these lakes as evidenced by driftwood accumulations along their inland shores, many hundreds of meters from the coast.

The spit at Tuft Point is very wide and flat; devoid of driftwood(Figure 15). The bay which it fronts (Figure 16) is bordered on the north and south by cliffs 5 to 10 m in height which gradually decrease in height towards the center of the bay. Here much driftwood has accumulated near the berm, and several major storm-induced driftwood lines are to be found further inland.

Drift Point (Figures 17 and 18) and Atkinson Point exhibit even less relief. Cliffs of approximately 5 m height at the tip of both points are the most prominent features in the area. Lakes are smaller but more numerous; marshes abound. The surrounding waters are very shoal, and extensive offshore bars lie between the two points. A spit has formed off Drift Point to the NW, in line with these bars, as has a spit to the north and south of Atkinson Point (Figure 19).

5. METHODS AND SOURCES OF DATA

5.1 Preparation of Sampling Apparatus

To minimize contamination it was decided that only glass or teflon surfaces should come in contact with samples to be analyzed for trace amounts of hydrocarbons. Sixteen ounce glass jars were chosen to hold coarse-grained beach sediments, nearshore bottom sediments, and marine organisms. Thirty-eight by three hundred millimeter glass test tubes were selected to contain cores collected in fine-grained beach sediments.

All glassware was given a preliminary wash in water and detergent, followed by a wash in methanol, and finally a wash in dichloromethane. To seal the glass jars, teflon discs were cut out, cleansed of contaminants by Soxhlet extraction with dichloromethane, and placed atop the jar mouth. Aluminum foil was then wrapped over the top of the jar, and the plastic cap screwed in place. Cork stoppers were utilized to seal the glass test tubes. These were wrapped with aluminum foil and then with several layers of teflon tape. Cleansing was accomplished as with the glassware.

A more strigent cleaning procedure was adopted in 1975: (i) wash with detergent and water. (ii) wash with chromic acid (iii) three washes distilled water (iv) wash with methanol three times distilled (v) wash with n-pentane twice distilled.

The recommended procedure for the preservation of samples for hydrocarbon analysis is to quick-freeze the samples over dry ice or in a low temperature freezer, and to maintain them in their frozen state pending analysis. Given the remoteness of the sampling location and the difficulties of logistics support, this was clearly impossible. It was decided to add a preservative to the samples upon collection, and that this procedure, along with the relatively low temperatures in the Arctic, would effectively suspend biodegradation until the samples could be returned to Victoria and frozen. Sodium azide was chosen to be used on sediment samples, in the amount of 100 mg dry weight per 300 ml of sample. Formaldehyde was used to preserve marine organisms in 1974; ethanol in 1975.

A quantity of methanol and of pentane was taken into the field. Any instruments employed in sample collection, such as spatulas, tweezers, and trowels were regularly washed in water and detergent, methanol and pentane and then carried wrapped in aluminum foil.

5.2 Field Techniques

5.2.1 Collection of Plastics

It was soon discovered that plastics tended to accumulate in the same places as driftwood. Because of the large number of small plastic fragments (principally from explosive cartridges), it was necessary to search selected stretches of beach. In most cases, with the exception of Kay Point and the area surrounding Drift Point, distances were paced off. Repeated checks against distances surveyed in with rod and level proved this method to be accurate within 5%. In the two above exceptions, distances were taken from air photos.

All explosive cannister fragments were collected and returned to Victoria. Miscellaneous plastics were collected, recorded and then incinerated.

5.2.2 Grease Samples

When deposits of grease were found, the grease was placed in a plastic bag, with no preservative added.

5.2.3 Beach Sediment Samples

Along the Yukon Coast the beach sediment contained coarse fractions which rendered coring impossible. The procedure thus followed was to dig a hole about one foot deep and to scrape sediment off the wall of the hole, from bottom to top, with a glass jar.

In 1974, along the Tuktoyaktuk Peninsula, the sandy sediment was collected as an undisturbed core in glass test tubes. While a plunger-type corer was available, it was found that the easiest method of sampling was simply to push the inverted tube into the sediment. In this manner cores ranging in length from 12 to 25 cm were collected. Following the addition of sodium azide, the stopper-tube junction was wrapped firstly with teflon tape and then with electrician's tape. At all sampling locations a minimum of three core samples were taken.

At Tuft Point an intensive sampling regime was established. A profile line was surveyed in from the berm crest to the water's edge at low tide down the center of the bay. Sampling was carried out at eight locations along the line. This line was further extended seaward to cross the spit which fronts the bay. Ten sampling locations were established across the spit. To determine the effectiveness of sodium azide as a preservative, 14 samples were taken at one location in the bay, only 8 of which were preserved.

In 1975, the collection procedure was modified slightly. All sediment samples except those collected along Tuktoyaktuk Peninsula north of Topkak Point were stored in 16 ounce glass jars. Sediment was scooped from the beach into the jar using a stainless steel trowel. The trowel was regularly cleaned with detergent and water, methanol, and n-pentane. Sediment samples taken north of Topkak Point were collected as cores in 38 mm x 300 mm glass test tubes. A stainless steel coring barrel with teflon piston was used to extract the core and deposit it into the test tube. At each sediment sampling location three samples were collected. Samples were preserved with an aqueous solution of sodium azide injected by syringe onto the surface of the sediment.

5.2.4 Nearshore Bottom Sediment Samples

In 1974, G.S.C. personnel ran offshore profiles between the Blow River Delta and Shingle Point Spit employing both a depth sounder and side-scan sonar. Surveyors manned three theodolites on shore to affix the boat's position. The records were then examined and sampling locations chosen. A small Petersen's grab sampler was used, lowered by unlubricated eight-inch stainless steel cable. Where samples were taken for hydrocarbon analysis, the outboard motor was raised and the boat anchored. A sample was then taken from the center of the sediment retrieved in the sampler.

In 1975, a small pipe dredge was used to collect nearshore sediment samples. The dredge was towed from the boat using polyethylene rope. Before retrieving the dredge, the outboard motor was raised and the boat allowed to drift for several minutes. Dredge and rope were at all times handled with disposable plastic gloves. Sodium azide was again used as a preservative.

Two samples were collected at each dredging location. Positions were determined by following a compass bearing from a known landmark and timing the boat's travel from shore to that position.

5.2.5 Fish Samples

In 1974, a two-man team conducting fisheries studies ran three beach seines (two at Tuft Point, one at Drift Point) for the purpose of collecting fish for hydrocarbon analysis. At Tuft Point deep water necessitated using a boat to drag one end of the net. The net was attached to the box of the boat, and care was taken to keep the boat headed into the wind. Seawater samples were also collected at both locations.

In 1975, four fish samples were collected at Stokes Point and four at Garry and Pelly Islands. Fish were handled with clean tongs, given an initial rinse in ethanol and the preserved in ethanol.

5.3 Laboratory Techniques

5.3.1 Plastics

Most of the explosive cartridge fragments were returned to Victoria. These were weighed and photographed, and their specific gravity was determined.

5.3.2 Analysis of Grease and Asphalt Samples

Grease and asphalt samples were analyzed by infrared spectrophotometry and gas chromatography. Samples were applied neat to a Perkin-Elmer Model 457 grating infrared spectrophotometer, and by solid sampler or in CS_2 solution to a Varian Aerograph Series 1400 gas chromatograph. Column packing was 3% Dexsil on Chromosorb W, 100/120 mesh. Detector injector temperatures were 400° C; the program was run from 70°C to 400°C at 6 C/min.

5.3.3 Analysis of Sediment Samples

The method being used to analyze sediment samples is that recently published by Giger and Blumer (1974). The sediment is Soxhlet-extracted with methanol for 24 hours, and then with methanol-benzene for a further 24 hours. The hydrocarbons are partitioned from the wet methanol-benzene extract into n-pentane, the latter then being concentrated by evaporation. Elemental sulphur is removed by percolation through a copper column. Isolation of the PAHs is accomplished by gel permeation/adsorption chromatography on Sephadex LH-20, followed by chromatography on alumina/silica gel, and finally by charge transfer complexation with 2,4,7-trinitro-9-fluorenone and subsequent splitting of the complex over an ion exchange resin column.

The PAHs (in methylene chloride-pentane) are applied to an alumina column and eluted with pentane containing an increasing percentage of methylene chloride (4,15,20, 30, 100% v/v). This results in fractionation of the PAHs into eight ring-type concentrates which are then analyzed using ultraviolet spectrophotometry.

5.3.4 Analysis of Fish Samples

A procedure based on the method of Howard, et al (1966) was used to analyze these samples. About 30 grams of fish tissue was digested and saponified in a mixture of ethanol and potassium hydroxide, heated under reflux for 15 hours. Also, included in this mixture was an aliquot of one or more deuterated hydrocarbons to act as internal standards. The hydrocarbon fraction was extracted with iso-octane, and the extract passed through a column containing Florisil covered with sodium sulphate. After further elution with iso-octane, the washing would contain the alkanes, alkenes, and one and two ring aromatic hydrocarbons. These were stored in glass ampoules for future analysis.

The polycyclic aromatic hydrocarbons still remained on the column and were removed with a benzene wash. The benzene was then almost totally evaporated, and replaced as the solvent by hexane. The sample would then be subjected to analysis using a combined gas chromatograph-quadrupole mass spectrometer. The use of isotopically labelled compounds should permit a quantitative measurement of the polyaromatic hydrocarbons present.

It is felt that the PAH fraction should be examined in preference to the paraffinic fraction both because polyaromatics are longer-lived in the environment and because many are carcinogenic.

6. RESULTS

In Appendix 13.1 an inventory is given of all samples collected curing the 1974 field season. Not included are twelve sediment samples collected along the Yukon Coast and broken in transit to Victoria. No analyses have been completed for trace hydrocarbons. Quantitative results are, therefore, restricted to macro-pollutants. Appendix 13.2 gives the inventory of all 1975 samples.

6.1 Plastics

Photographs have been made of those explosive cartridge fragments returned to Victoria and kept in Ocean Chemistry; all other plastics encountered are tabulated in Appendix 14.1 for this 1974 work. Similar data for 1975 are listed in Appendix 14.2.

In the 1974 survey, 2.3 kg of "Geogel" and "Velogel" shell fragments were collected along the Yukon Coast over a search path of approximately 16.4 km. At sampling locations PL-1, PL-2, PL-3 and PL-4 the beaches were at least 50% snow and ice covered; actual plastics concentrations were probably twice that determined. About 1.2 kg of shell fragments were found along selected areas of Tuktoyaktuk Peninsula, over a search path approximately 10 km long*. The specific gravity of these fragments was determined to be 0.91 ± 0.02.

In the 1975 season, approximately 11.9 kg of "Geogel" and "Velogel" fragments were collected along the Yukon Coast over a cumulative research path of 61.1 km, with an average

*Samples PL-24, -25 and -26 were all collected along the same stretch at Tuft Point Bay (Figure 16); PL-24 from water's edge to the high water mark, PL-25 from the high water mark to a minor driftwood line (from a recent storm), and PL-26 from this driftwood line to the berm crest.

linear density of 0.19 g/m. 9.8 g of cannister fragments were collected along Tuktoyaktuk Peninsula over a search path of 77.0 km. (Average linear density: 0.13 g/m and 1.6 kg of fragments on Garry and Pelly Islands over a distance of 9.3 km. (Average linear density: 0.18 g/m). A large quantity of styrofoam fragments was observed on the western shores of Garry Island. The styrofoam was dense and pink in colour, about two inches thick, and sandwiched between two faces of cardboard. Probably tens of thousands of these pieces have washed ashore. Their absence from neighbouring Pelly and Kendall Islands would indicate they originated from one of the nearby Adgo or Netserk sites.

6.2 Grease, Tarballs, Oil Spills, Oil Seeps

In 1974, pieces of grease weighing a total of 380 g were found in a fairly localized area of the Yukon Coast several km west of the Blow River Delta. Smaller but more numberous pieces weighing 425 g in total were found in the vicinity of Tuft Point and Warren Point. These samples were found by chemical analysis to contain predominantly petroleum-type hydrocarbons with a small fatty acid portion (2-3%). The fatty acid portion could be either natural or man-made. Data on the identification by gas chromatography and infrared spectra are in Appendix 15.1.

In 1974, no tarballs, oil spills or oil seeps were discovered by the field party. A thin layer of "crusty" oil was observed in early September on the tidal flats just north of Drift Point. A sample was collected.

In 1975, one tar-like object weighing 156.9 g was found about 2 km south of Drift Point. Oil films were frequently observed on tidal pools and marshes, as in 1974. Samples of the films were collected both years. However, it is felt certain that the oil is exuded from surrounding vegetation and is not the result of a spill. A questionnaire was forwarded to all investigaotrs who might have knowledge of oil spills or natural seepages in the Beaufort Sea Coastal Region. Responses indicated the absence of such knowledge. A literature search has not produced any evidence of natural seepages in the area. Chemical data on the identification of the tar-like object is listed in Appendix 15.1.

6.3 Sediments

Work is still in progress and the data will be presented in 1976 as a supplement report.

Fig. 20. Miscellaneous plastics collected from site PL-74-11 (180 m).

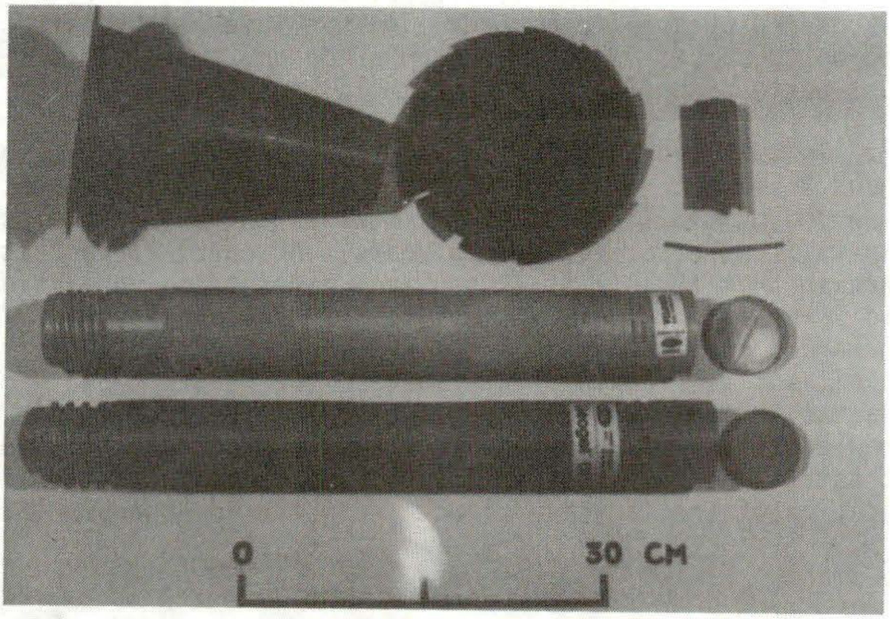

Fig. 21. Geogel and Velogel cartridges; drill hole plugs and blasting cap protector.

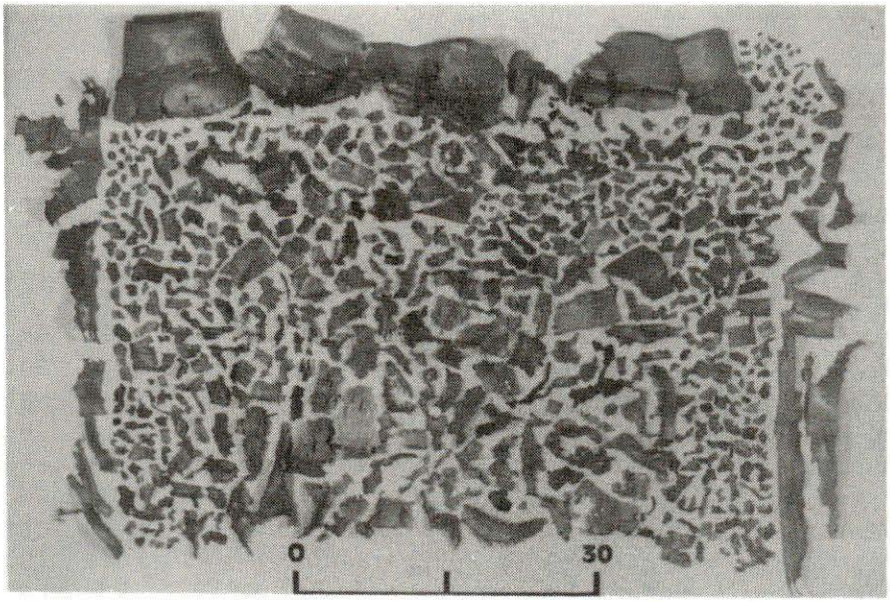

Fig. 22. PL-74-6; 900 m stretch; scale 0-30 cm.

6.4 Fish

Results of analyses of fish for trace hydrocarbons will also be included in the supplemental report.

7. DISCUSSION

7.1 Plastics

Many of the plastics collected are common contaminants of all of Canada's coastal beaches. These include detergent bottles, styrofoam cups and fragments, polyethylene sheeting, and outboard oil containers, as shown in Fig. 20. Other plastics result from activities more specific to the Beaufort Sea area. Surveying flagging was often encountered; an estimated 63 m over a search path of 26.4 km. Plastics relating to marine seismic activities (explosive cartridges, drill hole plugs, blasting cap protectors) as shown in Fig. 21 and 22 were even more prevalent. "Geogel" seismic explosives are manufactured by Canadian Industries Limited. A brochure (Information Report No. 139) describing this product states:

> "Bright orange shell can be easily seen and identified all year round. Made of all-weather plastic that resists water, oil and abrasion. Cartridges will not soften or deteriorate no matter how long the exposure".

"Velogel" seismic explosives were manufactured by Dupont of Canada, Ltd., production having ceased over the last year. The shells are bright yellow.

Storm tides carry driftwood well inland of delta fronts along the Yukon coast, and well inland of coastal beaches along Tuktoyaktuk Peninsula. In 1974, Sample PL-30 indicates that considerable amounts of plastics are carried along with the driftwood. In 1975, Samples PL-75-54 (Pelly Island), PL-75-60 (Tuft Point) and PL-75-62 (Warren Point) were all collected inland from the sea. Each location is protected by a wide spit or bay-mouth bar. The bars at Pelly Island and Tuft Point were observed to be awash during moderate storm tides of approximately four foot height. Driftwood and plastics (and therefore other floating pollutants such as oil) can inundate very large areas of the coast under the action of storm surges.

To find out if there is any renewed buildup of the plastic contamination, the field party revisited in 1975 most locations where explosive cannister fragments were removed in 1974. Table 1 compares some stretches of beach surveyed in 1974 with stretches of beach surveyed in 1975 that are identical to or including the 1974 sampling locations. The linear densities of the plastics of the seven locations average to 0.24 g/m in 1975. Thus, within one year, the plastic contamination level is built up to the same value. Lower but rather constant level of 0.1 g/m occurred in both years for Niakolik Point, Kay Point Spit, Babbage Bight and Drift Point. Maximum linear density recurred for both years in the same areas at King Point and Shingle Point with values between 0.3 to 1.3 g/m. These observations indicate that the plastics should be rather ubiquitous and uniformly distributed in the marine environment. Moreover, from the limited coverage, King Point and Shingle Point may be more susceptible than other surveyed beaches to particulate pollutants. Some of the accumulation might be attributed to longshore transport of plastics from areas that had not been cleared of plastics by the field party. However, plastics accumulating on Kay Point Spit and Niakolik Point are not adjacent to such "source" beaches, and it can, therefore, be inferred that the plastics were reintroduced predominantly from the open sea.

Low plastic and driftwood accumulation between Warren Point and Atkinson Point can be attributed to protection by an almost continuous chain of offshore bars and shoals in that area of the Tuktoyaktuk Penninsula.

7.2 Grease and Asphalt Identification

All grease-like samples collected along the coast of Southern Beaufort Sea have been shown by chemical identification using infrared spectra and gas chromatography to be petroleum-based. The chemical characteristics of the samples were matched with those of known compounds or material, such as industrial grease, asphalt or animal lipids. These greases cannot be of animal origin as shown by infrared spectral characteristics. The infrared spectra of the samples all showed nearly identical adsorption bands in the regions 2900-3000 cm^{-1} and 1350-1500 cm^{-1}. (Figure 41, 42, 43, 47 and 48). These bands, characteristic of alkane hydrocarbons, correspond to carbon-hydrogen stretching and deformation frequencies. Also, clearly discernable in most of the infrared spectra is an absorption band at 720 cm^{-1}, which is the characteristic of hydrocarbon chains longer than four carbons in length. Animal lipids (e.g. triglycerides) would be expected to have these bands in addition to a very strong absorption band in the region 1700-1750 cm^{-1}. The absence of the 1700-1750 cm^{-1} band rules out the possibility of the biogenic origin of the grease samples.

TABLE 1

Comparison of Plastic Contaminations in 1974 & 1975
on Some Stretches of Beaches Along
Southern Beaufort Sea

LOCATION	SAMPLE DESIGNATION	LENGTH OF BEACH SEARCHED (m)	LINEAR DENSITY (g/m)	
			1974	1975
Niakolik Pt.	PL-74-19	1100	0.23	
	PL-75-24	1400		0.11
Kay Pt. Spit	PL-74-18	3375	0.11	
	PL-75-23	3400		0.10
Babbage Bight	PL-74-16	400	0.08	
	PL-74-15	450	0.12	
	PL-75-47	2500		0.07
King Pt.	PL-74-14	550	0.30	
	PL-74-13	70	1.25	
	PL-75-37	2500		0.53
Shingle Pt. Spit	PL-74-5	1300	0.08	
	PL-75-42	1450		0.41
Shingle Pt. Spit	PL-74-6	900	0.30	
	PL-75-36	1350		0.47
Drift Pt.	PL-74-31	2800	0.07	
	PL-75-56	2500		0.13
Average Values			0.24	0.26

The infrared spectrum (Figure 41) of the sample obtained near the Dew Line site on the Yukon Coast shows, in addition to the alkane hydrocarbon absorptions, a strong absorption band near 1600 cm^{-1}. This absorption is characteristic of the carboxylate anion and indicates the presence of soaps (mettalic salts of long-chain fatty acids). Analysis of the samples confirmed the presence of fatty acids (2.4%). The presence of the soap material is strong evidence for the anthropogenic source of the grease. Soaps are common additives used in commerical greases. In fact, over 90% of commercial greases contain soaps as additives (Dawtrey, 1973). The gas chromatogram of the Yukon Coast sample is given in Figure 44 and shows the grease to have a relatively low-boiling point. The envelope is quite smooth although resolved peaks are discernable. This chromatographic behaviour is in marked contrast to that obtained for pelagic tar ("tar balls") found floating in parts of the Atlantic and Pacific Oceans (Butler et al., 1973). In the case of tar balls, which are believed to come from tanker washings, a homologous series of n-paraffin hydrocarbons is almost always present in a substantial amount. The chromatograms, therefore, show a succession of well-resolved peaks rising well above any envelope of unresolved components which may be present. The virtual absence of n-paraffins in lubricating oils and greases is intentional as they are removed in dewaxing processes. The infrared spectra (Figures 42 and 43) and gas chromatograms (Figures 45 and 46) of two commerical greases are shown here for comparison.

The infrared spectra (Figure 47) of the samples obtained along the Tuktoyaktuk Peninsula show the absorption bands present in the Yukon Coast sample. It too would appear to be a soap grease (1.8% fatty acid, absorption at 1600 cm^{-1}). The infrared spectrum also shows additional bands in the region 1000-1100 cm^{-1}. Many oxidation inhibitors, which are added as preservatives in lubricating oils and greases, show absorption bands in this region. For comparison purposes, the infrared spectra of Valvoline X-All grease is shown in Figure 48. The Valvoline grease contains an oxidation inhibitor, though it is unspecified, as an additive. The similarity of the band shapes of the absorptions in the 1000-1100 cm^{-1} region of the two greases indicates that they have the same additive or ones which are very similar. The gas chromatograms of the Tuktoyaktuk grease (Figure 50) and the Valvoline grease (Figure 51) are unquestionably different, however, despite the similarity of their infrared spectra. The Tuktoyaktuk grease appears to be composed of a much higher boiling petroleum fraction.

In contrast to the grease samples which were found in the summer of 1974 and were light brown or yellow in colour, the tar-like sample found at Drift Point in 1975 was almost black in colour. Whereas the light colour of the 1974 greases was immediately suggestive of refined products, the consistency and

and blackness of the Drift Point sample was reminiscent of residual fuel oils, tar balls and tar seep oils. The infrared spectrum (Figure 52) tends to support this observation since there are no absorption bands which can be attributed to the more common additives. The gas chromatogram (Figure 49) of the Drift Point sample showed a smooth broad envelope reaching a maximum between 300 and 400°C. The high boiling range of the sample would make it unlikely to be a residual fuel oil. The lack of prominent n-paraffin peaks would indicate that the origin of the sample was not tanker washing or oil seeps. The apparent lack of additive would indicate that the sample was not a commercial grease. One important characteristic of the sample not previously discussed is its complete solubility in carbon disulfide. Solubility in carbon disulfide is an important and definitive characteristic of asphalts or bitumens. Those materials are non-volatile, viscous liquids or solids which consist mainly of hydrocarbons and are black or brown in colour. For comparison purposes a commerical asphalt sample was obtained by extracting roofing paper with carbon disulfide. The infrared spectrum and gas chromatogram of the commercial sample are reproduced in Figures 53 and 54 respectively. The infrared spectrum of the commercial asphalt is typical of asphalts in general. Kawahara (1974) has made an extensive study of the infrared spectra of 19 authentic industrial asphalts, 21 authentic petroleum No. 6 fuel oils and two lubricant oils. His results established that there were two key ratios, i.e., the ratio of the absorbance at 810 cm^{-1} to that at 720 cm^{-1} and the ratio of the absorbance at 810 cm^{-1} to that at 1375 cm^{-1}, which could be used to classify unknown samples. His results are summarized graphically in Figure 55. Box C contains the loci of the ratios for the No. 6 fuel oils, Box B, the ratios for the asphalts and Box A, the ratios for the lubricating oils. The ratios for the Drift Point sample and the commercial roofing paper sample both lie within Box B and, what is more, outside Box A. Using the infrared data as a classification criterion, together with the solubility characteristics and colour, the Drift Point sample is tentatively identified as an asphalt. It is impossible to ascertain whether this asphalt is natural or anthropogenic since both would have the same chemical characteristics. Natural asphalts are wide-spread (Broome, 1973), as asphalt asphaltites, lake asphalts and natural rock asphalts. These natural deposits can be mined as viscous fluids, pitch tar or a mixture with rocks; asphalts can also be obtained as petroleum refinery products which form the largest supply of present commercial asphalts. Blending of natural tar pitch and petroleum refinery asphalts and wide spread usage of asphalts in human activities such as road building, soil stabilization and roofing, make it difficult to identify the source positively.

8. CONCLUSION

The coastline along the Southern Beaufort Sea studied in the summers of 1974 and 1975 appears to be very clean with respect to oil and tar accumulation. A tar-like object was collected near Drift Point and grease occurrence was found near Shingle Point, Tuft Point and Warren Point. The grease contamination was identified to be man-made by gas chromatographic and infrared techniques. The tar-like object at Drift Point was identified as an asphalt, which can be either anthropogenic or natural.

Plastics contamination of the beach areas, in particular explosive cannister fragments originated from marine seismic activities, was prevalent. Some long stretches of beach that had been cleaned up during the 1974 survey were found to have been re-inundated with the same contaminant level in 1975. The baseline level appears to be around 0.1-0.2 g/m usually lower along protected coastline and much higher in certain areas such as Shingle Point and King Point. Areas of recurring high plastic accumulation after cleanup in previous survey may be more susceptible to oil pollution in case of offshore oil spills.

No natural seepage of crude oil was found in the areas surveyed in 1974 and 1975. Oil films found in tidal pools and ponds appear to be of plant origin from surrounding vegetation

9. RECOMMENDATIONS

The follwoing recommendations are offered with intent to reduce the input of plastics to the Beaufort Sea coastal environment:

(1) Large vessels in the Arctic should be equipped with means for the proper elimination of garbage hitherto simply thrown over-board. This would apply to ships owned or chartered by the Federal Government, and to the drill-ships which Dome Petroleum will bring into Arctic waters in 1976.

(2) Agencies using surveying flagging should be required to retrieve this flagging once their surveys are completed.

(3) Spiral-wound glued paper cartridges should be used for marine seismic work. There appears to be no advantage offered by plastic cartridges. Both can be rapidly coupled to form a column charge, and both will withstand high hydrostatic pressures and long periods of immersion.

(4) Large numbers of styrofoam fragments on Garry Island should be collected while they are still in a localized area.

Due to their low biodegradability in the cold Arctic environment, grease and/or lubricants accidentally introduced into the environment should be removed immediately while still localized.

10. NEED FOR FURTHER STUDY

It seems to be highly desirable to continue similar beach survey studies along the front of the Mackenzie Delta and its offshore islands, particularly in the vicinity of recent or on-going drilling from artificial islands. Tuktoyaktuk Harbour will continue to support increasing ship and barge traffic; baseline data from this area would be valuable. Consideration might also be given to similar studies along the northern coast of Tuktoyaktuk Peninsula. This would be one of the areas most affected by a mishap during proposed offshore drilling operations in 1976.

The technique of observing areas with recurring high plastic accumulation may help to pin-point sections of the coastline mostly likely to be affected by surface pollutants such as floating oil from a spill or blow out, and their likely circulation pattern in the coastal waters. The concept is very similar to the use of drift bottles in the study of coastal circulation, and can be refined to yield useful results without complex instrumentation.

Future visits to the site at Drift Point should be made to ascertain whether natural asphalts do occur, and to establish the magnitude of such natural inputs into the marine environment. Oil films on tidal pools in the Arctic, suspected to be of plant origin, should be studied to establish their natural occurence and hydrocarbon characteristics. By establishing their natural characteristics, future petroleum inputs into the marine environment can be estimated with much better certainity.

11. REFERENCES

Broome, D.E. (1973) Bitumen, In: "Modern Petroleum Technology, Ed. by G.D. Hobson and W.Pohl, John Wiley & Sons, Pub., New York, N.Y., pp. 804-15.

Butler, J.N., Morris, B.F. and Sass, J. (1973), Pelagic Tar from Bermuda and the Sargasso Sea, Bermuda Biol. Stn., Sp. Pub. No. 10, 346 pages.

Cundell, A.M. (1974) Plastics in the Marine Environment, Environ. Conservation, 1, (1) pp. 63-8.

Dawtrey, S. (1973) Modern Lubricating Greases. In: "Modern Petroleum Technology", Ed. G.D. Hobson and W. Pohl, John Wiley & Sons, Pub., New York, N.Y., pp. 762-81.

Giger, W. and M. Blumer (1974) Polycyclic Aromatic Hydrocarbons in the Environment, Anal. Chem., 46, (12) pp. 1663-71.

Heyerdahl, T. (1971) Atlantic Ocean Pollution and Biota Observed by the 'Ra' Expeditions, Biological Conservation, 3, (3) pp. 164-67.

Howard, J.W., Teague, Jr., R.T., White, R.H. and Fry, Jr., B.E., J. Assoc. Offic. Anal. Chem., 49, pp. 595-611 (1966); Howard, J.W., White, R.W., Fry, Jr., B.E. and Turicchi, E.W., ibid., pp. 611-16 (1966).

Kawahara, F.K. (1974) Recent developments in the identification of asphalts and other petroleum products. In: "NBS Spec. Pub. 409, Marine Pollution Monitoring (Petroleum), Proceedings of a Symposium and Workshop held at NBS, Gaithersburg, Maryland, May 13-17, pp. 145-48.

Mackay, J.R. (1963) The Mackenzie Delta Area, N.W.T., Can. Dept. Mines Tech. Surv., Geograph. Br., Mem., 8, 202 pages.

McDonald, B.C. and C.P. Lewis (1973) Geomorphic and Sedimentologic Processes of Rivers and Coast - Yukon Coastal Plain, Report No. 73-39, prepared for Environmental-Social Program, Northern Pipelines.

Rampton, V.N. (1974) Terrain Evaluation with Respect to Pipeline Construction, Mackenzie Transportation Corridor, Report No. 73-47, prepared for Environmental-Social Program, Northern Pipelines.

Venrick, E.L., Backman, T.W., Bartram, W.C., Plah, C.J., Thornhill, M.S. and Yates, R.E. (1973). Man-made objects on the surface of the central North Pacific Ocean, Nature, 241, p. 271.

Wilson, R.D., P.H. Monaghan, A. Osanik, L.C. Price and M.A. Rogers (1974) Natural Marine Oil Seepage, Science, 184, 857-65.

Wong, C.S., D.R. Green and W.J. Cretney (1974) Quantitative Tar and Plastic Waste Distributions in the Pacific Ocean, Nature, 247, pp. 30-2.

Appendix 12.1 Detailed Maps of Sampling Locations, 1974

The following prefix notation has been used:

PL: plastics

G: grease

SW: seawater

S: sediment

B: offshore bottom sediment

F: fish

CS: sediment core

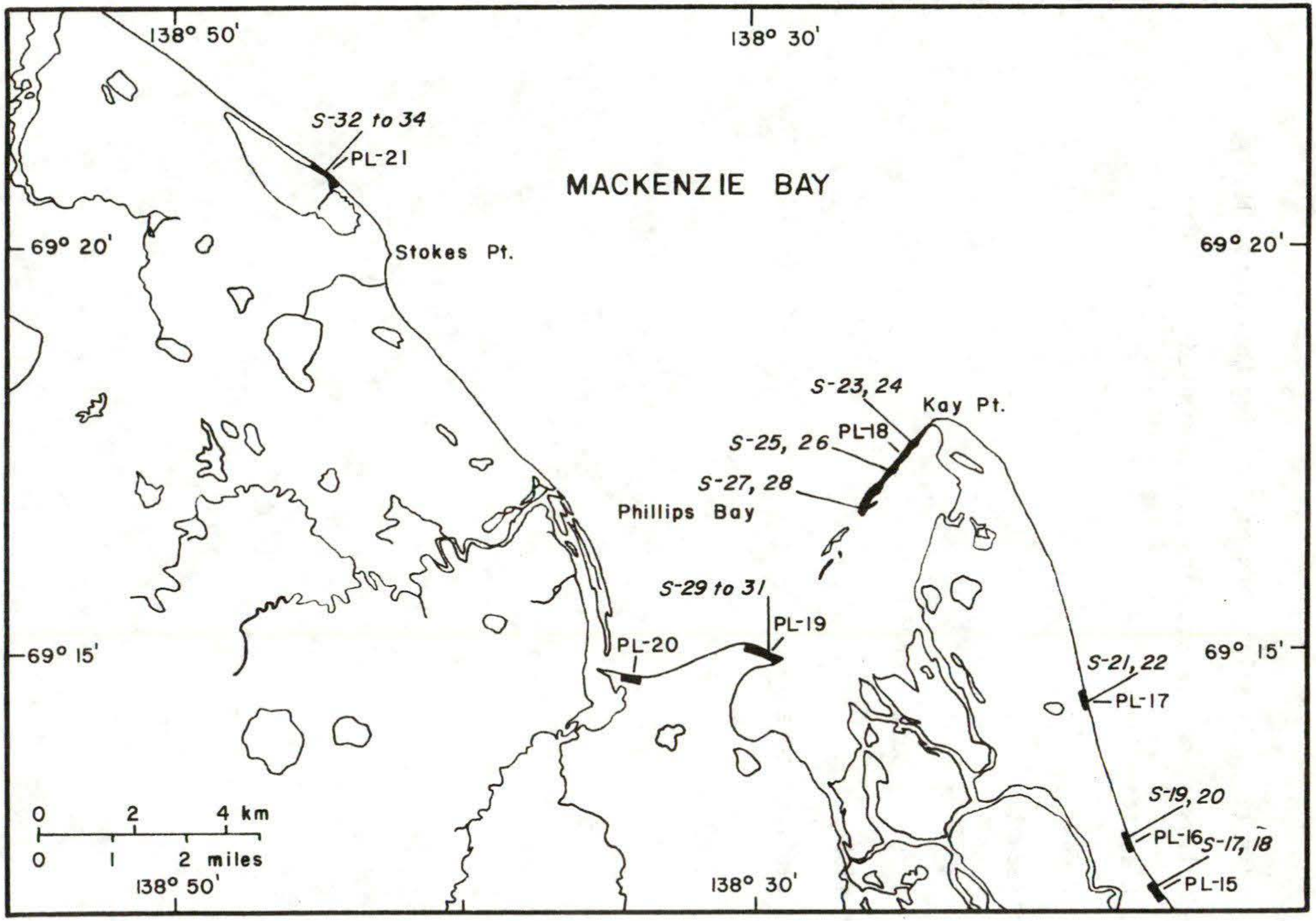

Fig. 23. Sampling locations, Yukon Coast

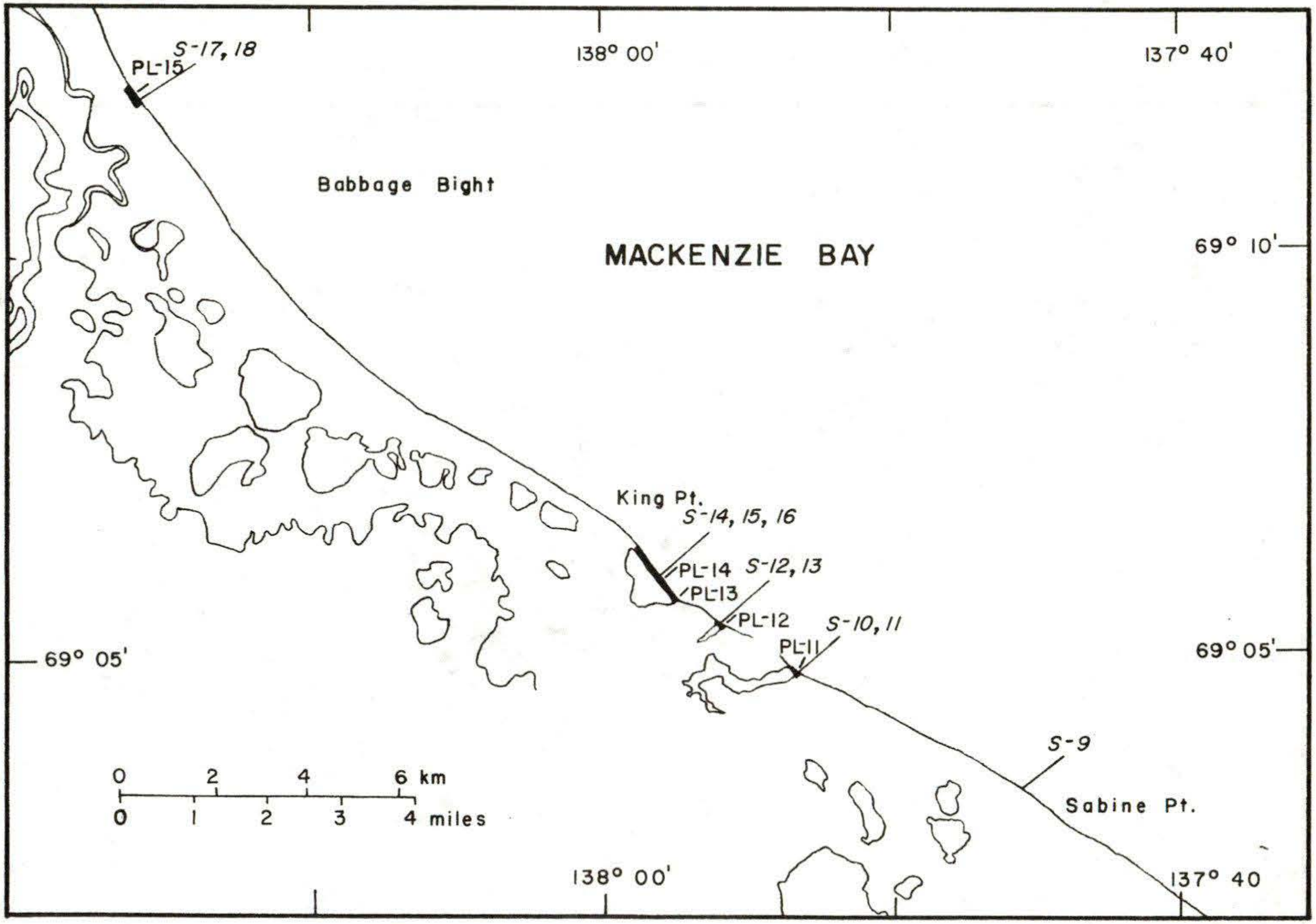

Fig. 24. Sampling locations, Yukon Coast

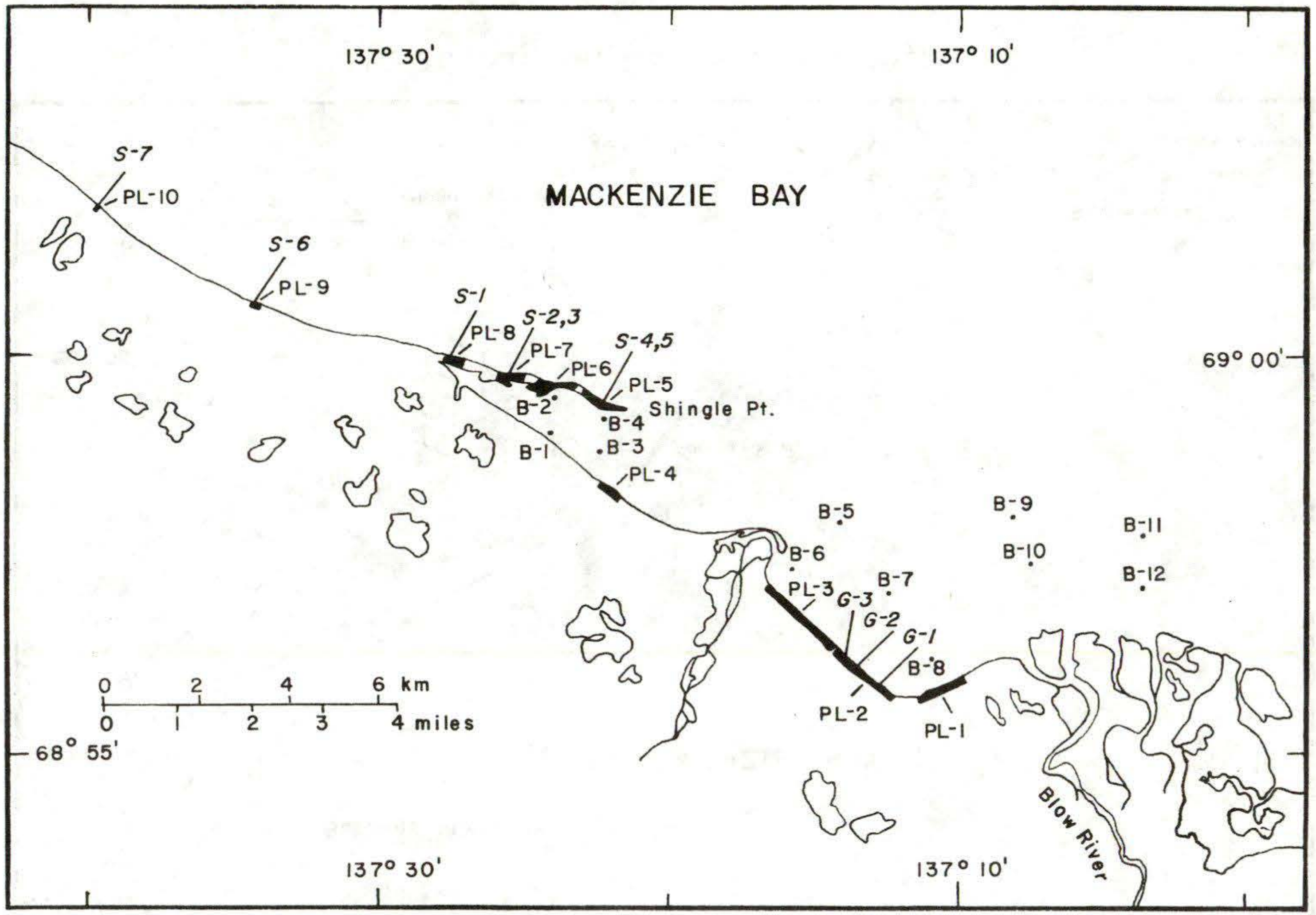

Fig. 25. Sampling locations, Yukon Coast

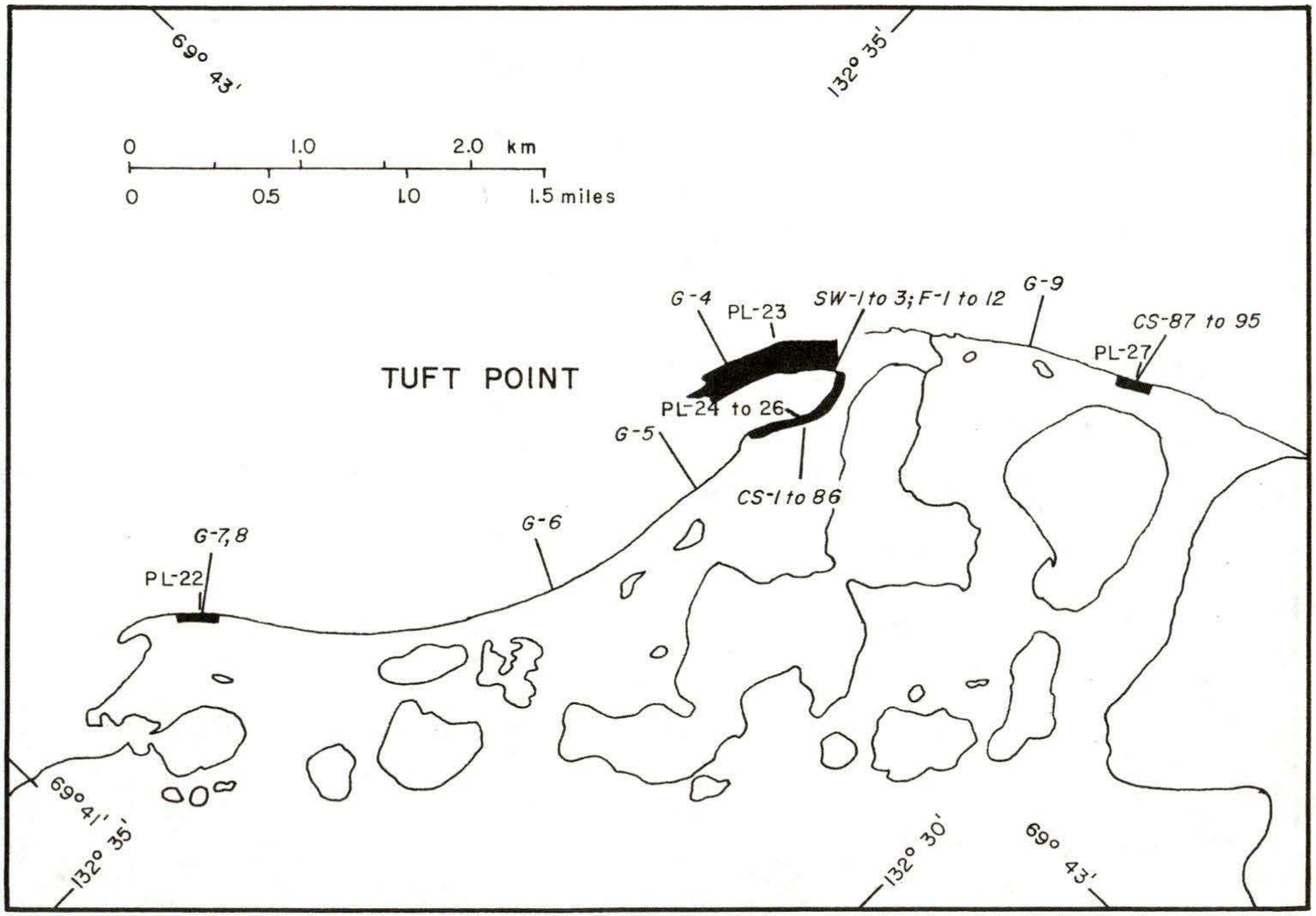

Fig. 26. Sampling locations, Tuktoyaktuk Peninsula

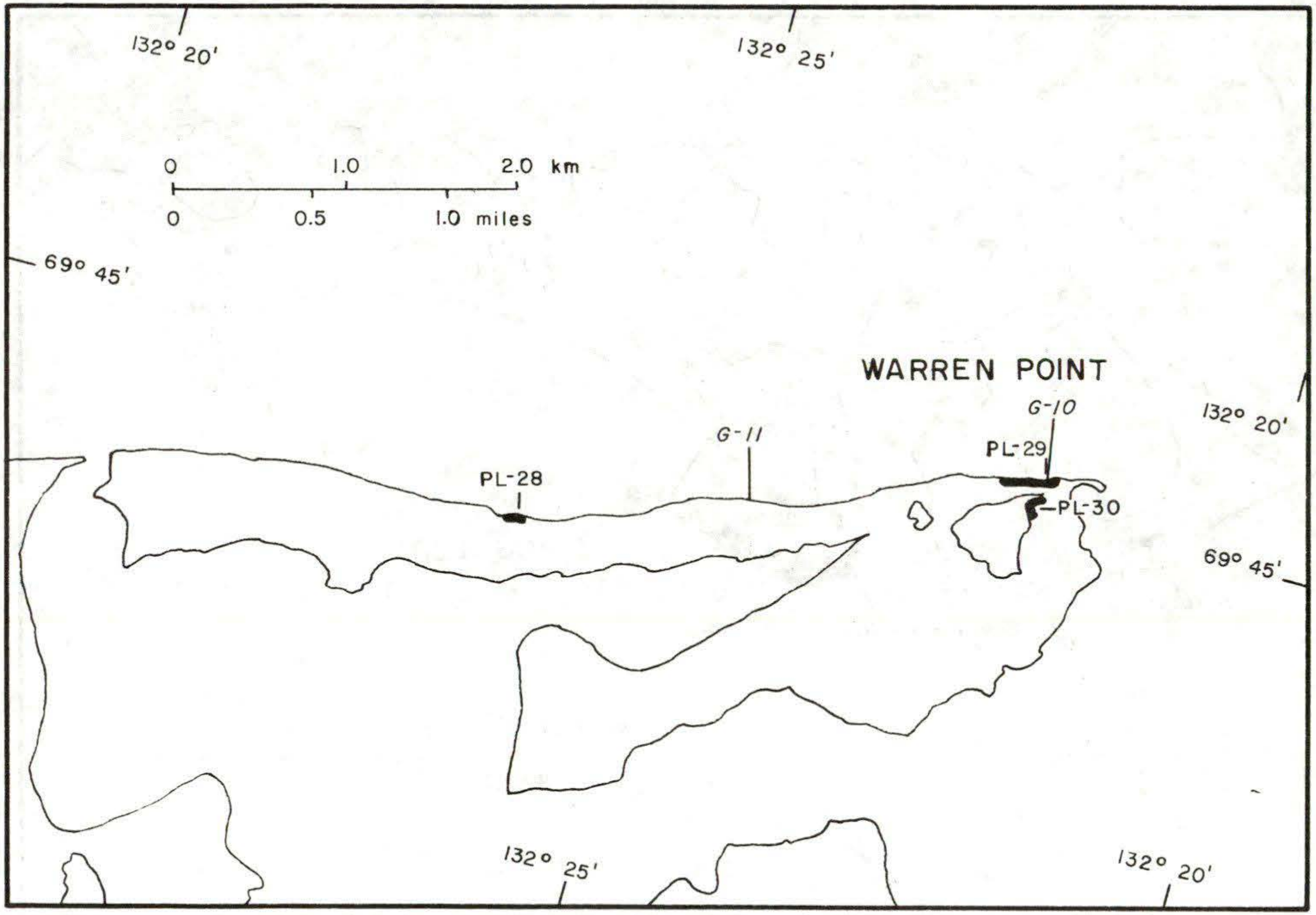

Fig. 27. Sampling locations, Tuktoyaktuk Peninsula

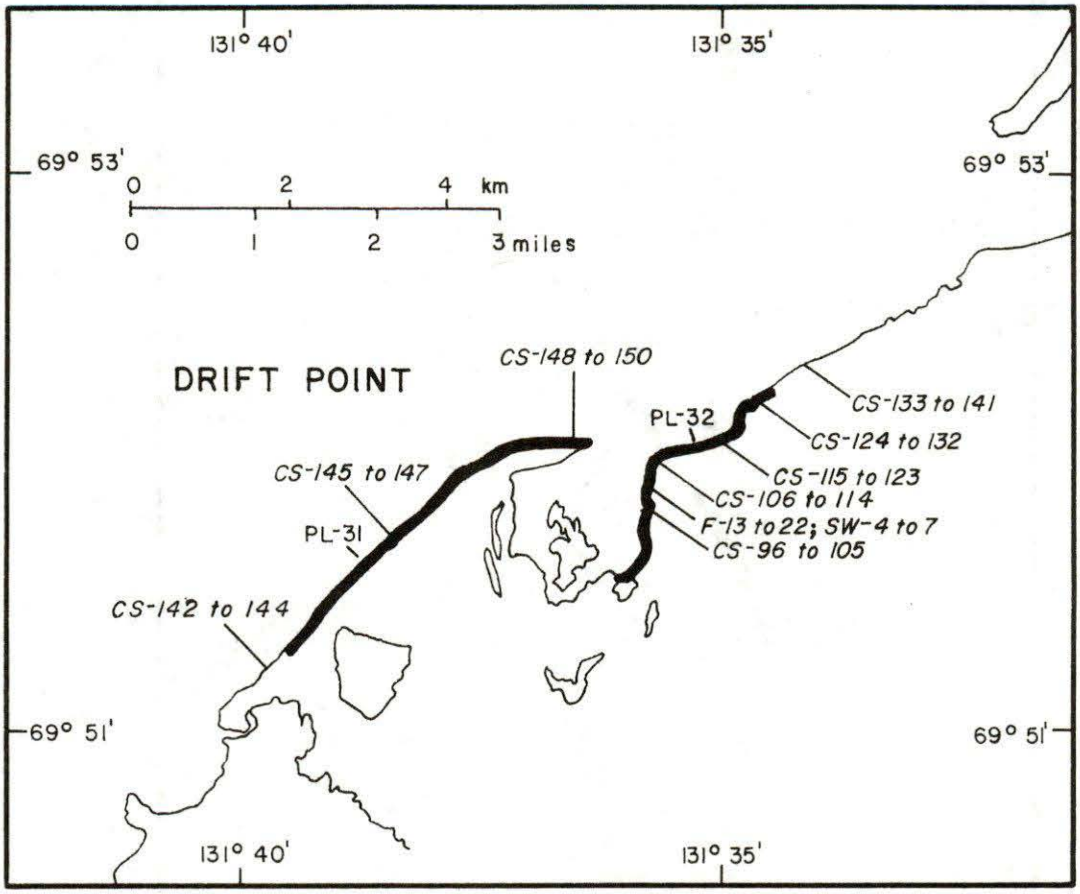

Fig. 28. Sampling locations, Tuktoyaktuk Peninsula

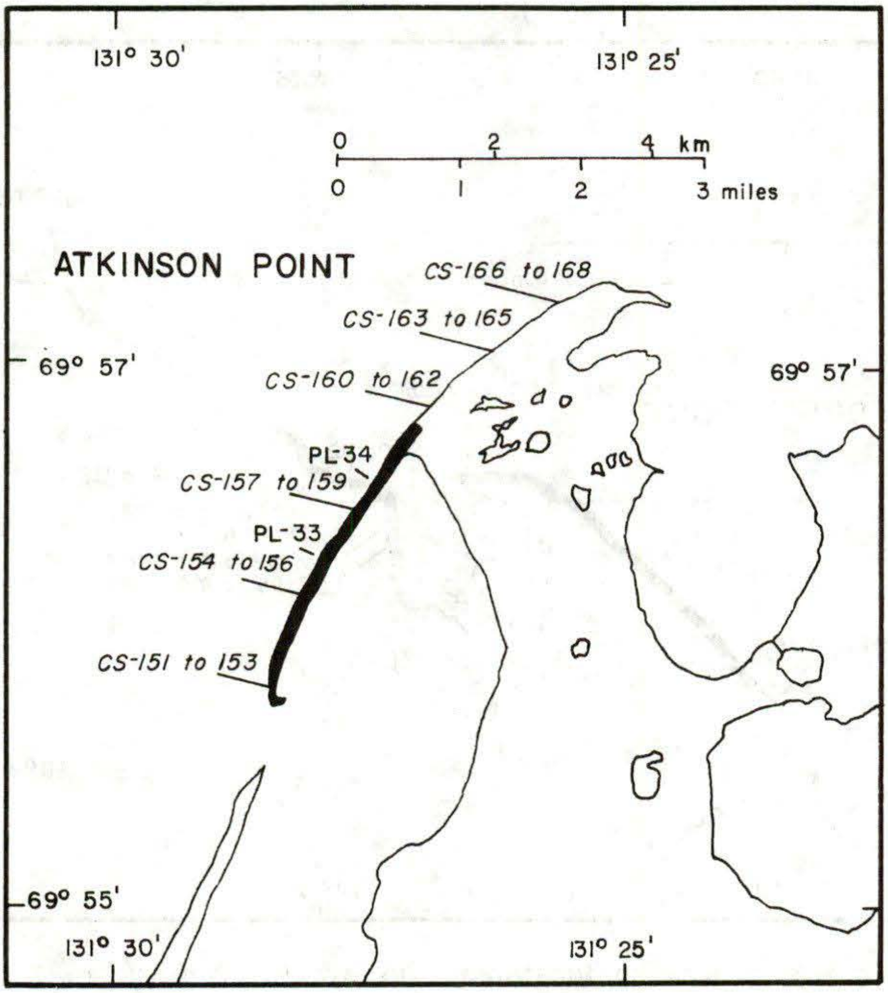

Fig. 29. Sampling locations, Tuktoyaktuk Peninsula

Appendix 12.2 Detailed Maps of Sampling Locations, 1975

The following prefix notation has been used:

PL: plastics

S: sediment

B: offshore bottom sediment

CS: sediment core

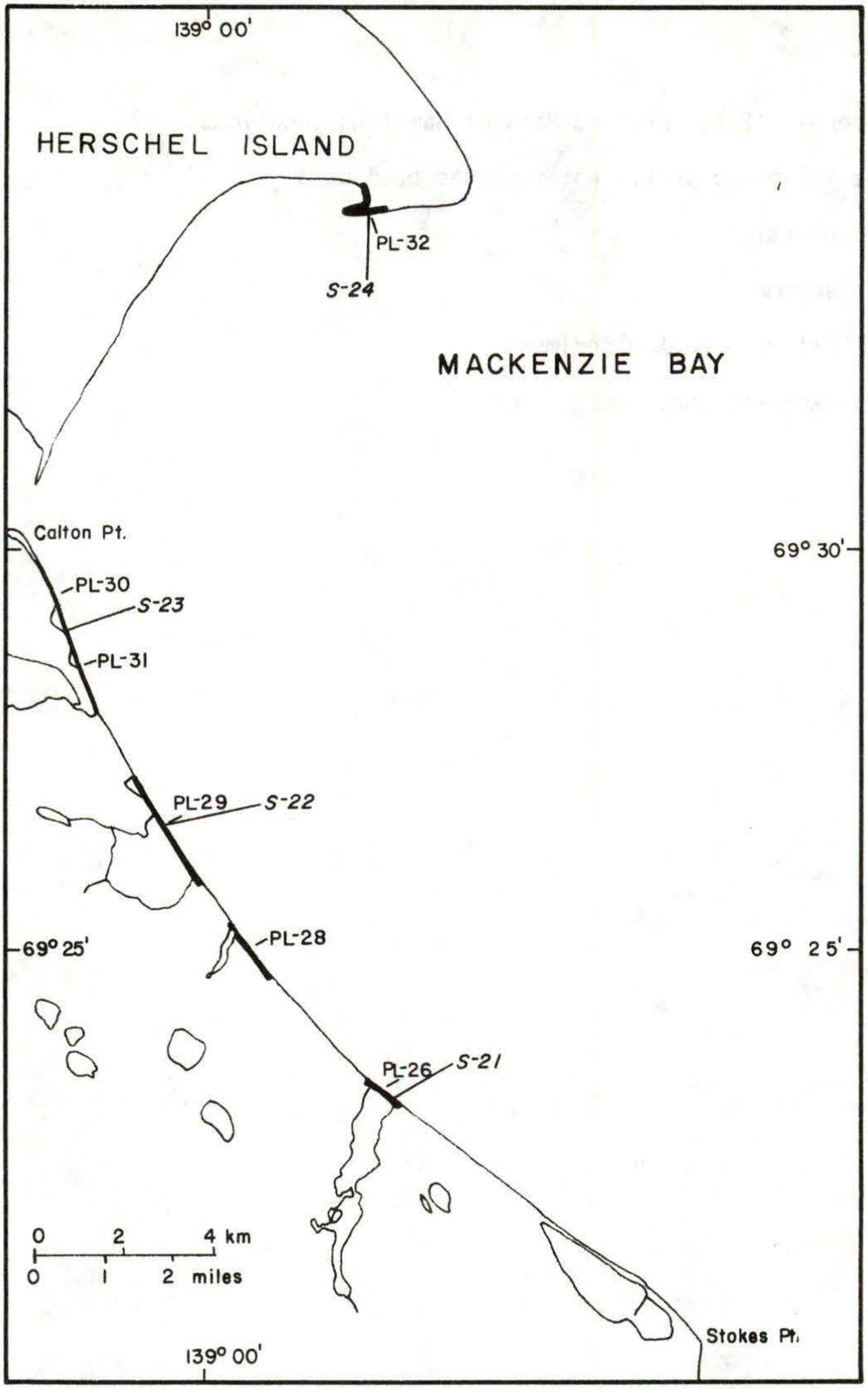

Fig. 30. Sampling Locations, Yukon Coast

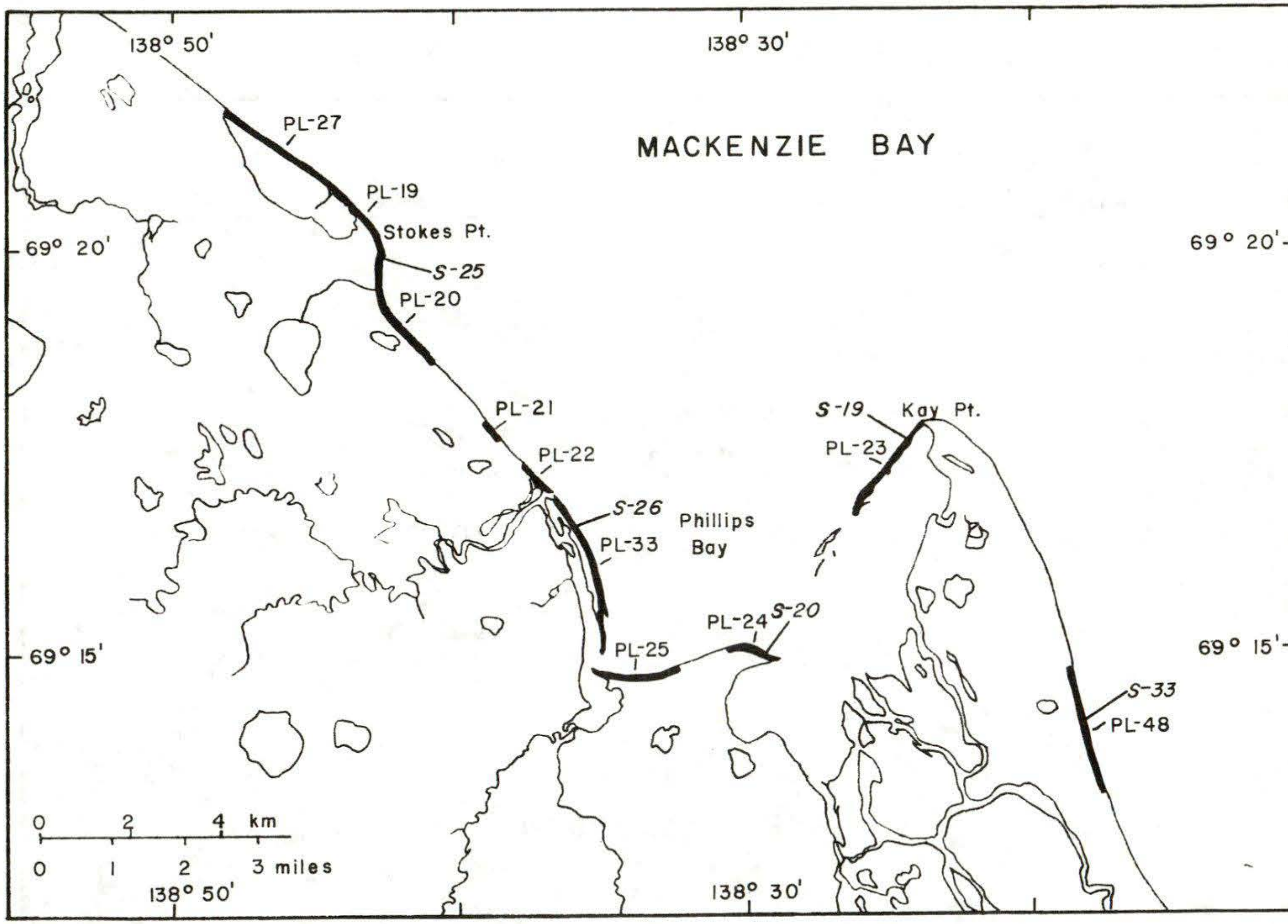

Fig. 31. Sampling locations, Yukon Coast

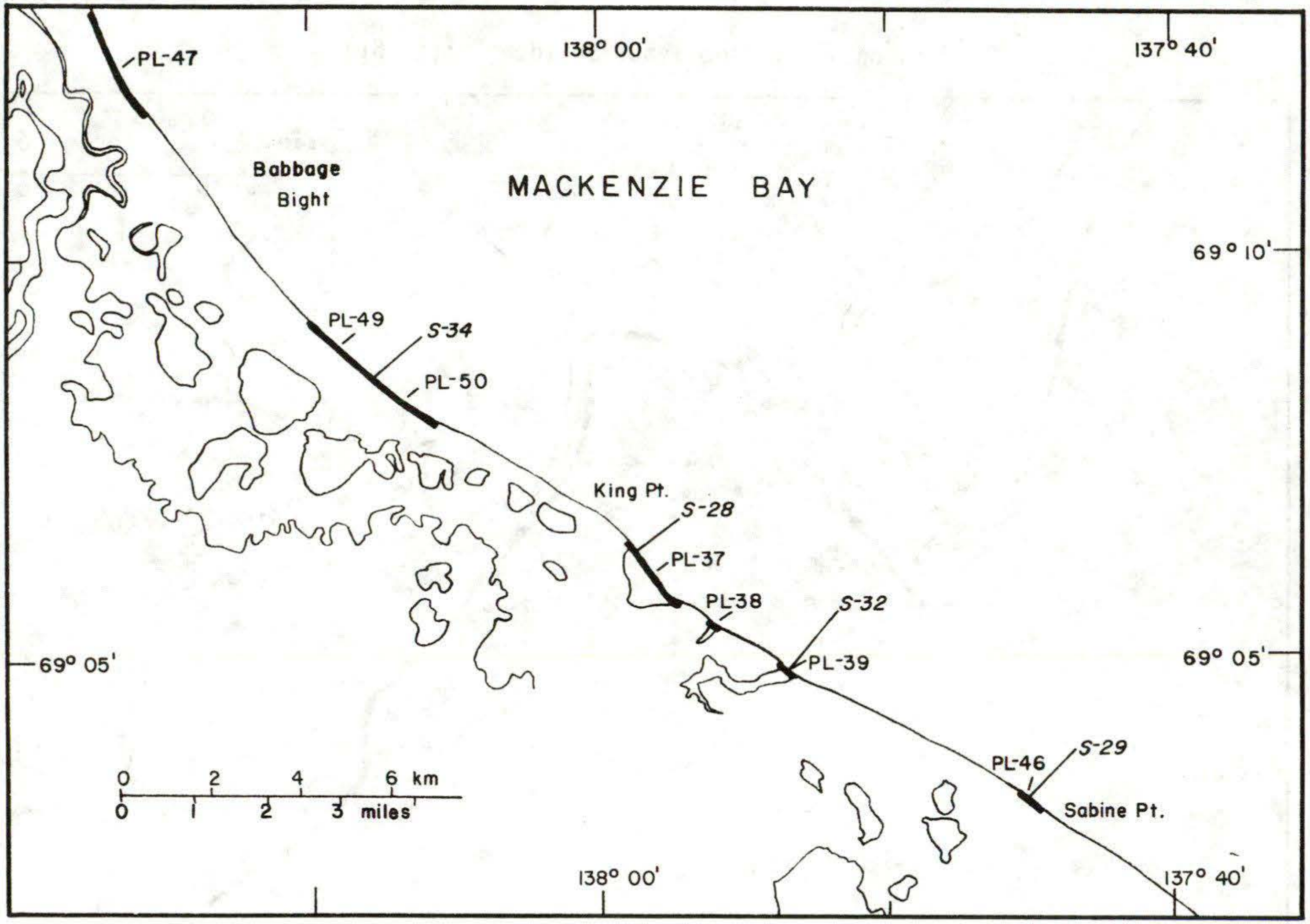

Fig. 32 Sampling locations, Yukon Coast

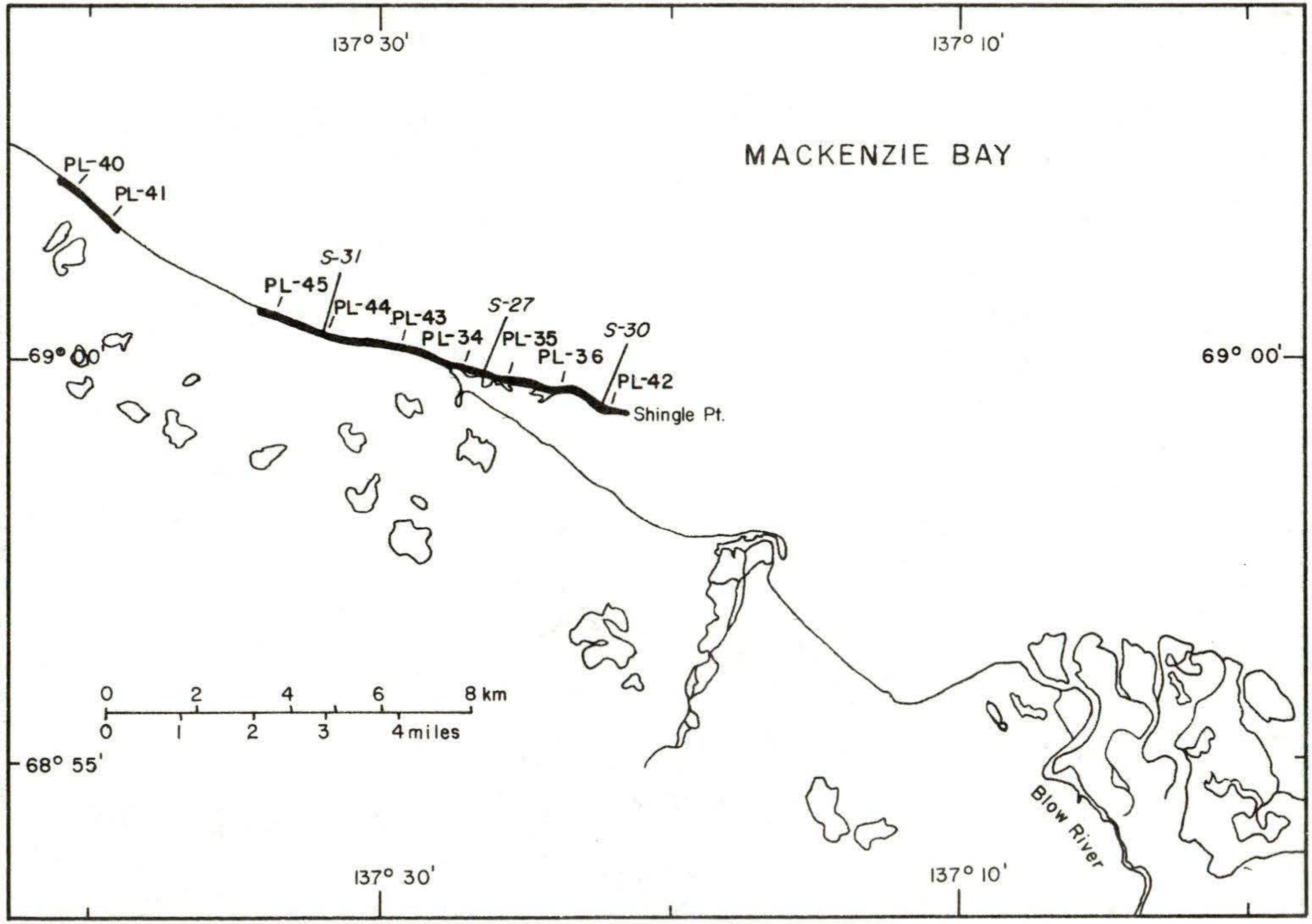

Fig. 33 Sampling locations, Yukon Coast

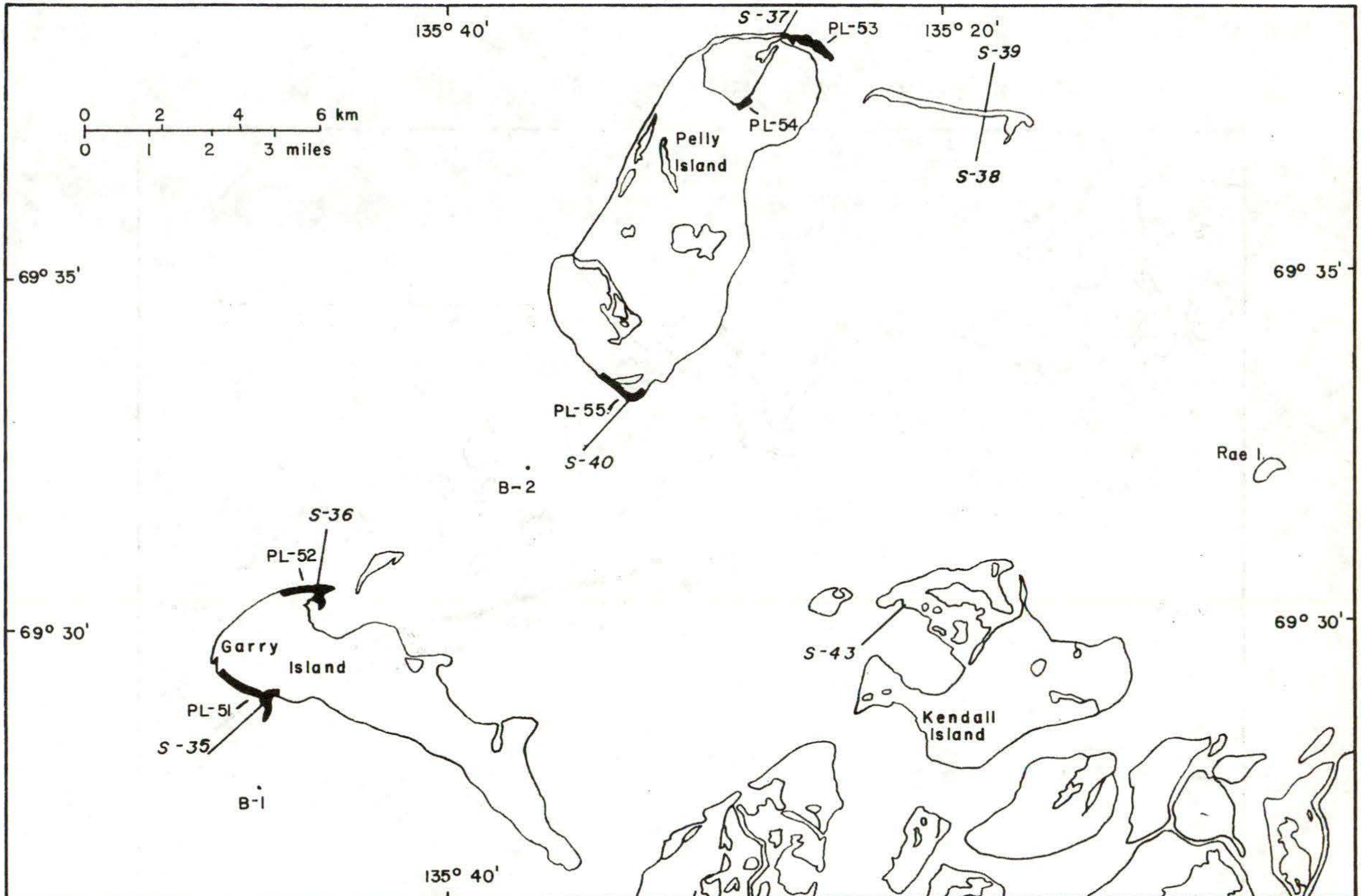

Fig. 34 Sampling locations, Mackenzie River Delta

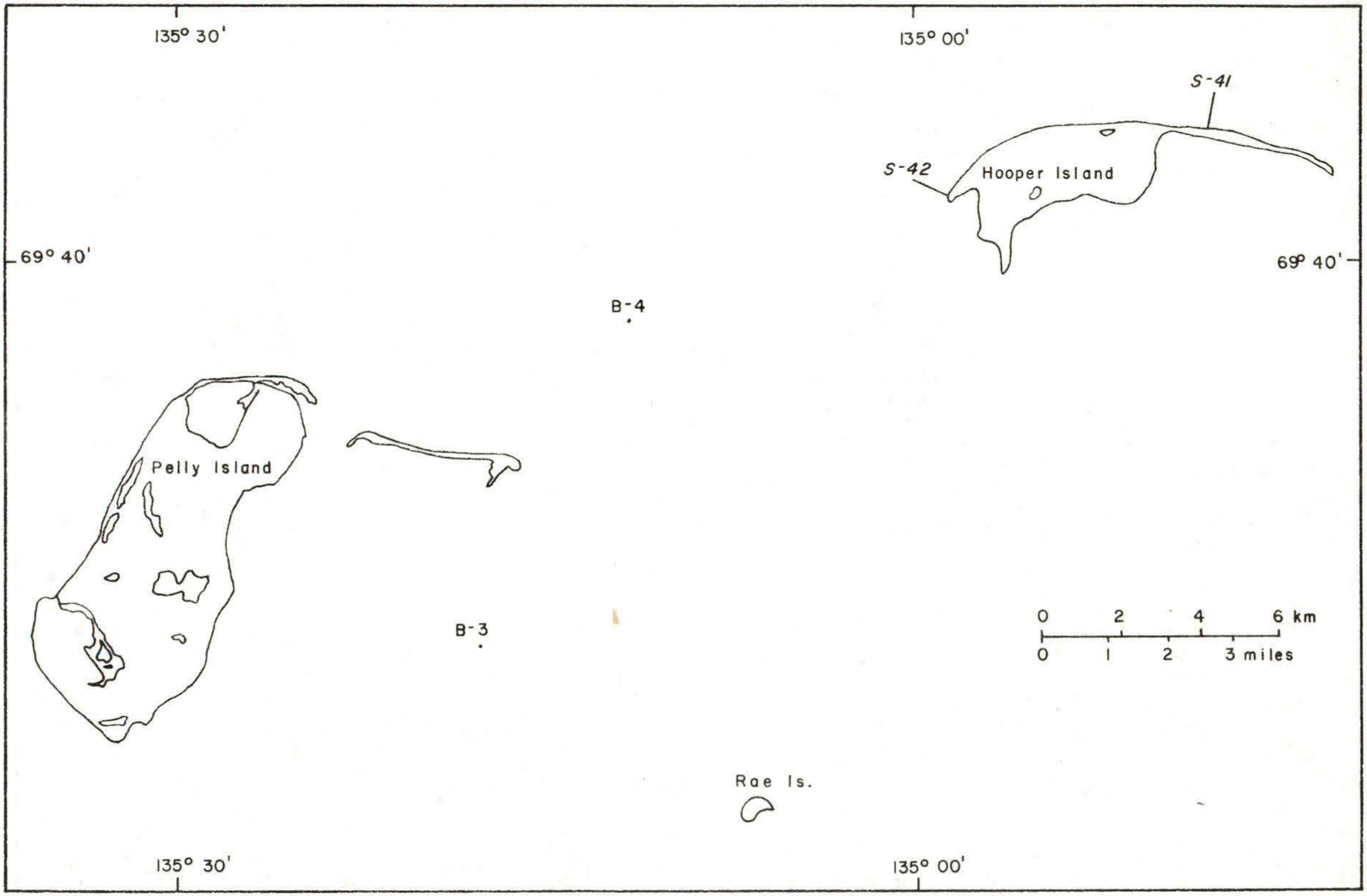

Fig. 35. Sampling locations, Mackenzie River Delta

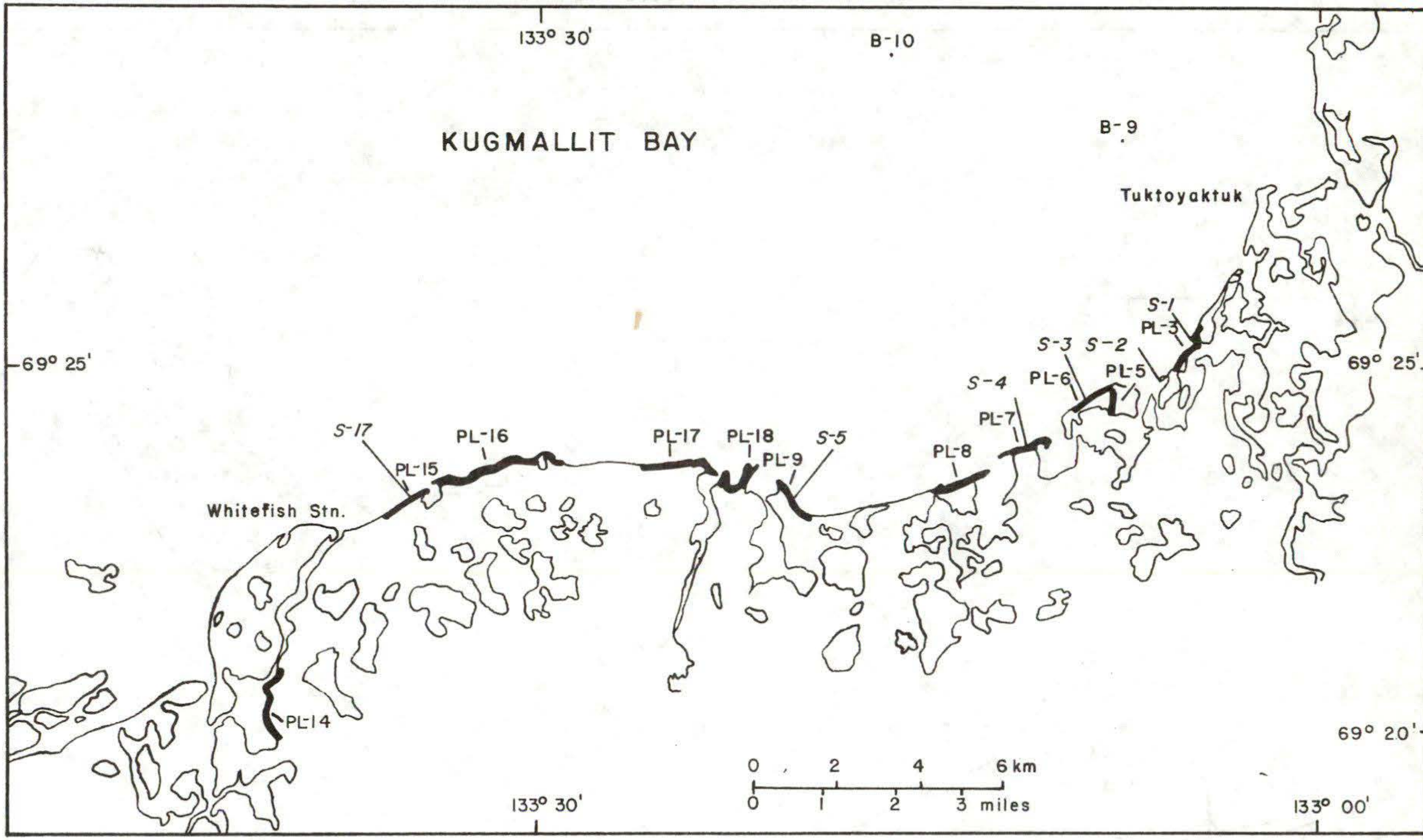

Fig. 36. Sampling locations, Tuktoyaktuk Peninsula

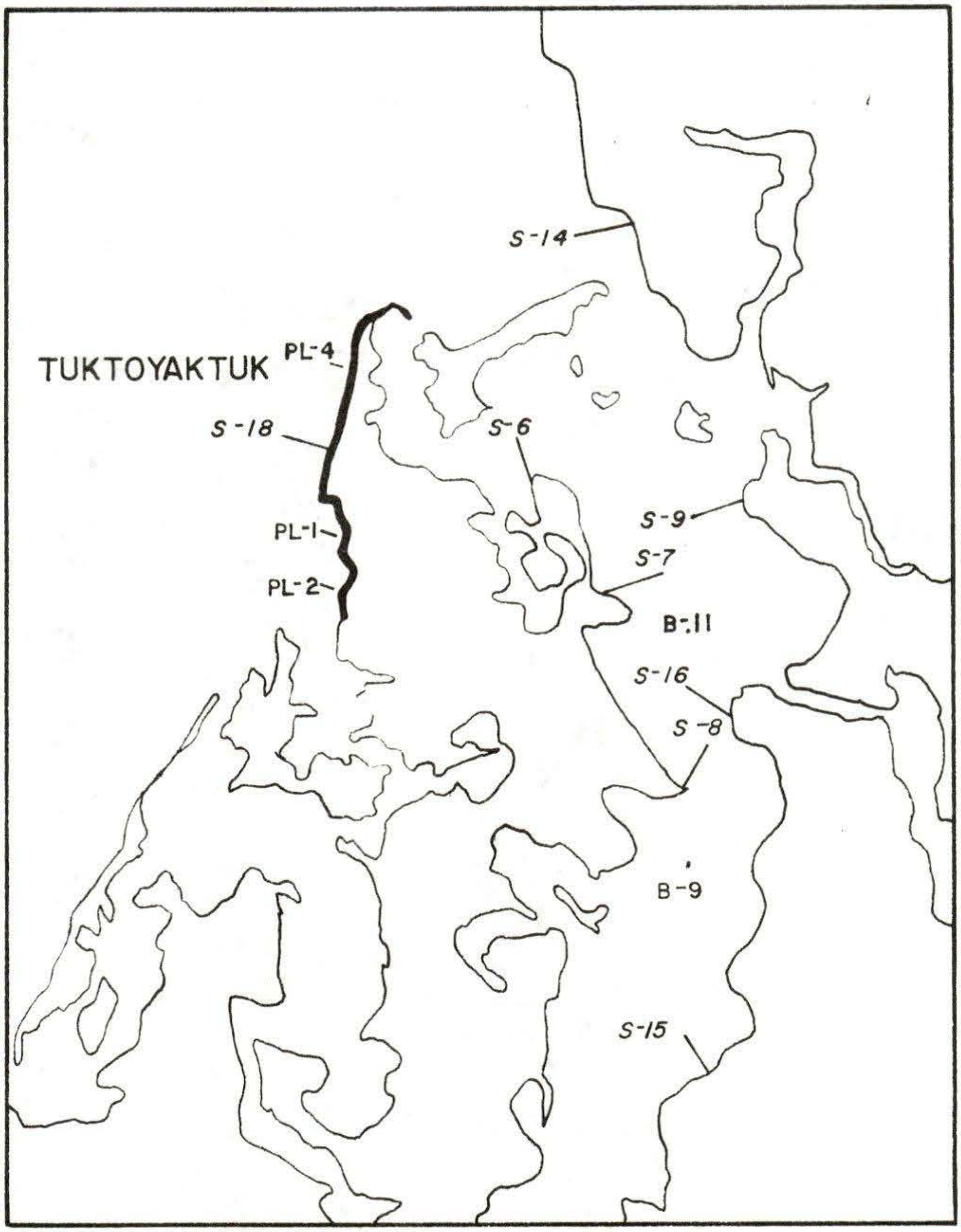

Fig. 37. Sampling locations, Tuktoyaktuk and environs.

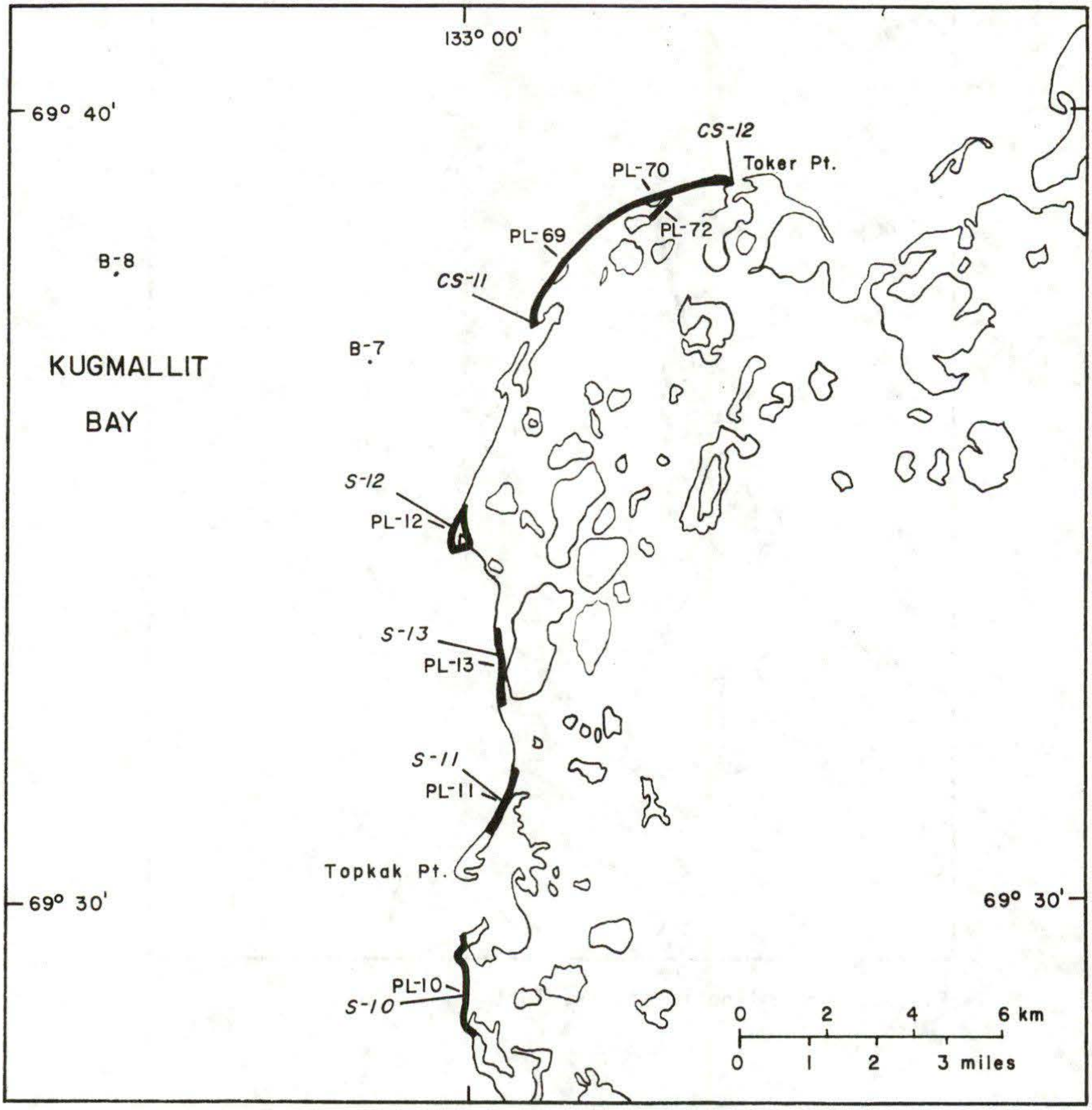

Fig. 38. Sampling locations, Tuktoyaktuk Peninsula

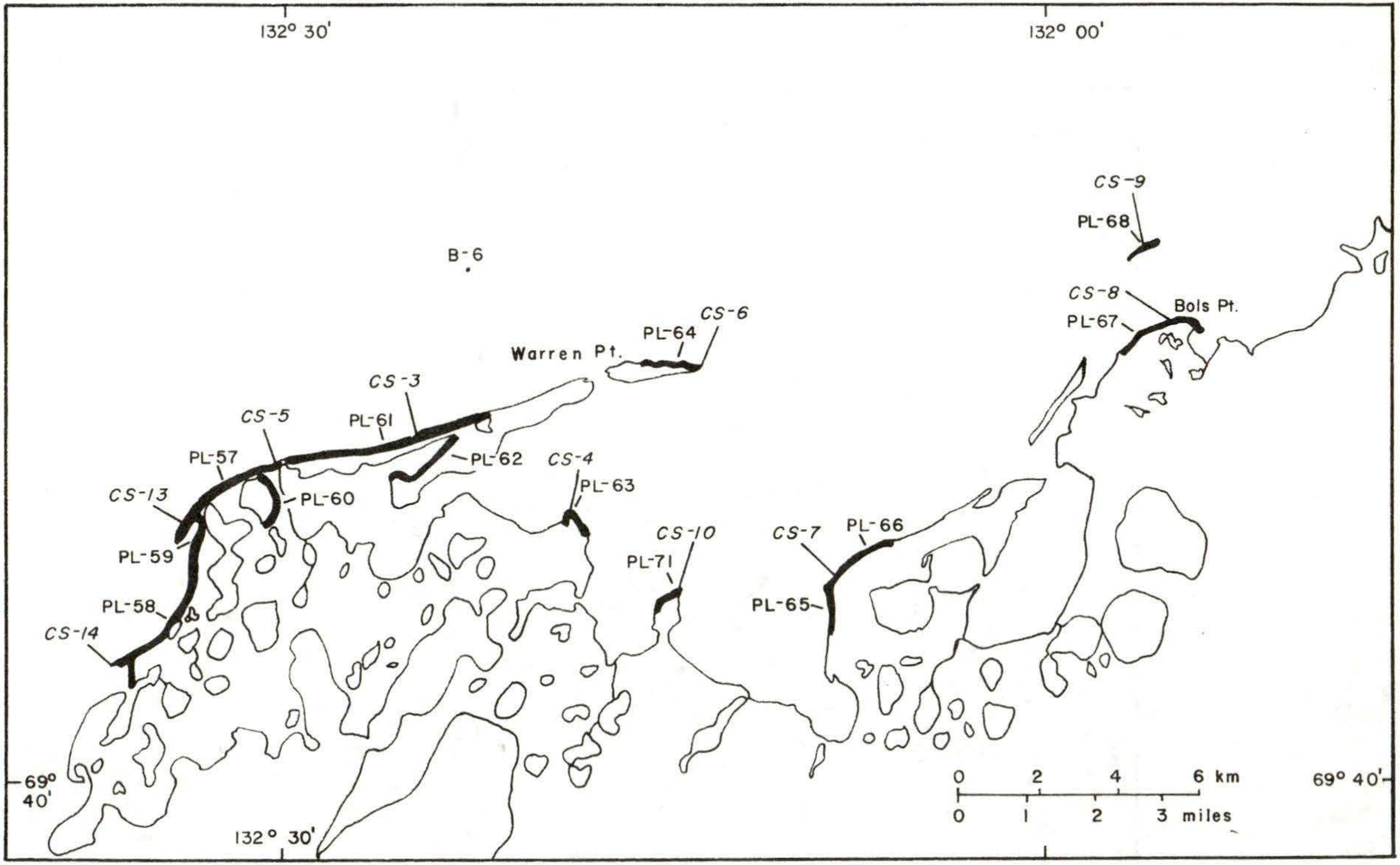

Fig. 39. Sampling locations, Tuktoyaktuk Peninsula

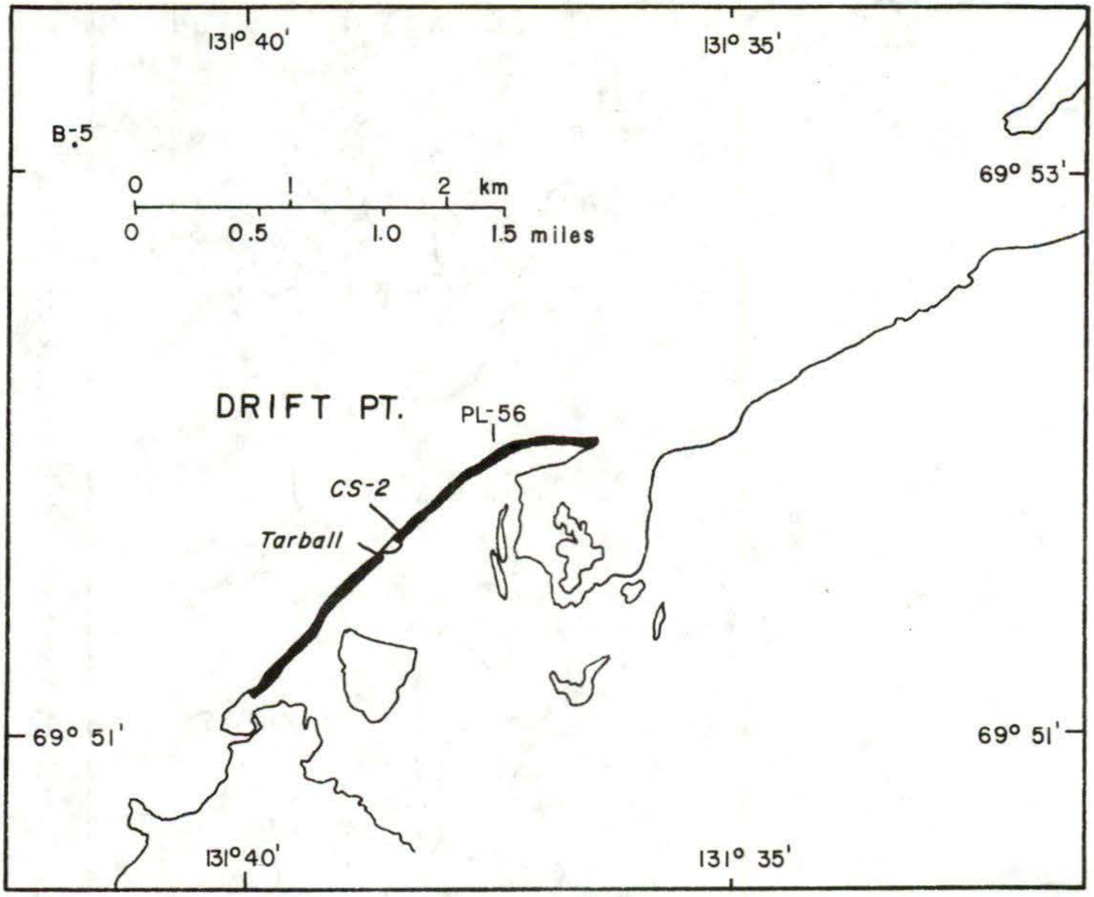

Fig. 40. Sampling locations, Tuktoyaktuk Peninsula

Appendix 13.1 Inventory of Samples (1974)

NUMBER OF SAMPLES COLLECTED

	Yukon Coast	Tuk. Penninsula
S	34	--
PL	21	13
B	12	--
G	3	8
F	--	22
SW	--	7
CS	--	168

SAMPLE NO.	DATE	LOCATION		DISTANCE (M)	WT. CARTRIDGE FRAGMENTS (g/m)
		Latitude	Longitude		
PL-1	June 25/74	68°55.8'	137°11.0'	900	43.4
PL-2	June 24-5/74	68°56.0'	137°13.0'	1500	100.5
PL-3	June 25/74	68°56.8'	137°16.0'	2000	
PL-4	June 27/74	68°58.4'	137°22.2'	675	13.7
PL-5	June 26/74	68°59.0'	137°22.0'	1300	106.2
PL-6	June 29/74	68°59.9'	137°23.7'	900	270.4
PL-7	July 1/74	69°00.0'	137°25.5'	450	72.4
PL-8	July 1/74	69°00.0'	137°27.0'	450	97.5
PL-9	July 3/74	69°00.5'	137°34.0'	180	154.7
PL-10	July 3/74	69°02.0'	137°40.0'	90	25.8
PL-11	July 4/74	69°04.8'	137°53.5'	180	71.0
PL-12	July 13/74	69°05.3'	137°56.0'	350	112.9
PL-13	July 13/74	69°05.7'	137°57.0'	70	87.6
PL-14	July 28/74	69°06.2'	137°58.5'	550	162.3
PL-15	July 28/74	69°12.2'	138°16.4'	450	55.5
PL-16	July 25/74	69°12.7'	138°17.2'	400	30.8
PL-17	July 25/74	69°14.4'	138°18.5'	350	12.6
PL-18	July 29/74	69°17.2'	138°25.3'	3375	360.6
PL-19	July 31/74	69°15.0'	138°29.0'	1100	255.1
PL-20	Aug. 3/74	69°14.7'	138°34.8'	600	135.2
PL-21	Aug. 5/74	69°20.9'	138°44.8'	675	145.0
					WEIGHT (g)
G-1	June 24/74	68°55.9'	137°12.8'		211.0
G-2	June 24/74	68°56.2'	137°13.3'		87.0
G-3	June 25/74	68°56.2'	137°13.6'		82.5

SAMPLE NO.	DATE	LOCATION	
		Latitude	Longitude
S-1	July 1/74	69°00.0'	137°27.0'
S-2	July 1/74	69°00.0'	137°25.5'
S-3	July 1/74	69°00.0'	137°25.5'
S-4	July 7/74	68°59.0'	137°22.0'
S-5	July 7/74	68°59.0'	137°22.0'
S-6	July 3/74	69°00.5'	137°34.0'
S-7	July 3/74	69°02.0'	137°40.0'
S-8	July 3/74	69°02.0'	137°40.0'
S-9	July 4/74	69°03.5'	137°45.5'
S-10	July 4/74	69°04.8'	137°53.5'
S-11	July 4/74	69°04.8'	137°53.5'
S-12	July 13/74	69°05.3'	137°56.0'
S-13	July 13/74	69°05.3'	137°56.0'
S-14	July 28/74	69°06.2'	137°58.5'
S-15	July 28/74	69°06.2'	137°58.5'
S-16	July 28/74	69°06.2'	137°58.5'
S-17	July 28/74	69°12.2'	138°16.4'
S-18	July 28/74	69°12.2'	138°16.4'

SAMPLE NO.	DATE	LOCATION	
		Latitude	Longitude
S-19	July 25/74	69°12.7'	138°17.2'
S-20	July 25/74	69°12.7'	138°17.2'
S-21	July 25/74	69°14.4'	138°18.5'
S-22	July 25/74	69°14.4'	138°18.5'
S-23	July 29/74	69°17.5'	138°24.5'
S-24	July 29/74	69°17.5'	138°24.5'
S-25	July 29/74	69°17.2'	138°25.3'
S-26	July 29/74	69°17.2'	138°25.3'
S-27	July 29/74	69°16.8'	138°26.2'
S-28	July 29/74	69°16.8'	138°26.2'
S-29	July 31/74	69°15.0'	138°29.0'
S-30	July 31/74	69°15.0'	138°29.0'
S-31	July 31/74	69°15.0'	138°29.0'
S-32	Aug. 5/74	69°20.9'	138°44.8'
S-33	Aug. 5/74	69°20.9'	138°44.8'
S-34	Aug. 5/74	69°20.9'	138°44.8'

SAMPLE NO.	DATE	LOCATION		DISTANCE OFFSHORE (M)	BRUNTON AZIMUTH	DEPTH (M)
		Latitude	Longitude			
B-1	July 14/74	68°59.9'	137°23.7'	1100	200°	1.73
B-2	July 14/74	68°59.9'	137°23.7'	100	200°	1.37
B-3	July 14/74	68°59.0'	137°22.0'	1040	195°	1.98
B-4	July 14/74	68°59.0'	137°22.0'	160	195°	1.93
B-5	July 20/74	68°57.0'	137°16.3'	1990	39°	2.36
B-6	July 20/74	68°57.0'	137°16.3'	550	39°	0.61-0.69
B-7	July 16/74	68°55.8'	137°11.0'	2310	334°	2.06
B-8	July 16/74	68°55.8'	137°11.0'	590	334°	1.52
B-9	July 21/74	Blow River Delta		2500	339°	2.21
B-10	July 21/74	"		1380	339°	2.13
B-11	July 20/74	"		2315	0°	2.64-2.79
B-12	July 20/74	"		1226	0°	1.22

SAMPLE NO.	DATE	LOCATION Latitude	Longitude	DISTANCE (M)	WT. CARTRIDGE FRAGMENTS (g/m)
PL-22	Aug. 16/74	69°41.8'	132°36.0'	270	119.1
PL-23	Aug. 15/74	69°43.5'	132°34.0'	1000	45.5
PL-24	Aug. 14/74	69°43.4'	132°33.4'		
PL-25	Aug. 14/74	69°43.4'	132°33.4'	750	301.7
PL-26	Aug. 15/74	69°43.4'	132°33.4'		
PL-27	Aug. 20/74	69°44.3'	132°31.3'	225	39.5
PL-28	Aug. 21/74	69°44.5'	132°28.0'	135	114.1
PL-29	Aug. 21/74	69°45.5'	132°18.6'	330	31.0
PL-30	Aug. 21/74	69°45.5'	132°18.6'	100	51.3
PL-31	Aug. 27/74	69°51.5'	131°39.0'	2800	189.0
PL-32	Aug. 30/74	69°52.1'	131°36.0'	2000	170.9
PL-33	Aug. 26/74	69°56.2'	131°28.2'	2100	55.5
PL-34	Aug. 28/74	69°56.7'	131°27.8'	600	63.0

SAMPLE NO.	DATE	LOCATION	
		Latitude	Longitude
CS-1 to -42	Aug. 15-20/74	69°43.4'	132°34.1'
CS-43 to -86	Aug. 15-20/74	69°43.3'	132°33.5'
CS-87 to -95	Aug. 15-20/74	69°44.2'	132°31.6'
CS-96 to -105	Aug. 26-31/74	69°51.8'	131°36.0'
CS-106 to -114	Aug. 26-31/74	69°52.1'	131°36.1'
CS-115 to -123	Aug. 26-31/74	69°52.2'	131°35.2'
CS-124 to -132	Aug. 26-31/74	69°52.3'	131°34.5'
CS-133 to -141	Aug. 26-31/74	69°52.5'	131°33.4'
CS-142 to -144	Aug. 26-31/74	69°51.2'	131°40.6'
CS-145 to -147	Aug. 26-31/74	69°51.5'	131°39.0'
CS-148 to -150	Aug. 26-31/74	69°52.0'	131°37.0'
CS-151 to -153	Aug. 26-31/74	69°55.8'	131°28.7'
CS-154 to -156	Aug. 26-31/74	69°56.2'	131°28.5'
CS-157 to -159	Aug. 26-31/74	69°56.5'	131°28.0'
CS-160 to -162	Aug. 26-31/74	69°57.2'	131°25.8'
CS-163 to -165	Aug. 26-31/74	69°57.5'	131°24.5'
CS-166 to -168	Aug. 26-31/74	69°57.8'	131°23.3'

SAMPLE NO.	DATE	LOCATION		WEIGHT (g/m)
		Latitude	Longitude	
G-4	Aug. 15/74	69 43.5'	132 34.0'	85.6
G-5	Aug. 16/74			35.2
		69 43.7'	132 33.4'	
G-6	Aug. 16/74	to		91.3
G-7	Aug. 16/74	69 41.7'	132 36.8'	62.2
G-8	Aug. 16/74			81.4
G-9	Aug. 17/74	69 30.0'	132 44.4'	27.2
		to		
		69 33.7'	132 43.6'	
G-10	Aug. 21/74	69 45.5'	132 18.6'	24.0
		to		
G-11	Aug. 21/74	69 44.5'	132 28.0'	18.1

SAMPLE NO.	DATE	NUMBER AND SPECIES	LOCATION		
F-1	Aug. 18/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-2	Aug. 18/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-3	Aug. 18/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-4	Aug. 18/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-5	Aug. 21/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-6	Aug. 21/74	1 Arctic Cisco	Tuft Point	69°43.6'	132°33.5'
F-7	Aug. 21/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-8	Aug. 21/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-9	Aug. 21/74	1 Arctic Cisco	Tuft Point	69°43.6'	132°33.5'
F-10	Aug. 21/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-11	Aug. 21/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-12	Aug. 21/74	1 Least Cisco	Tuft Point	69°43.6'	132°33.5'
F-13	Aug. 31/74	30+ Small Cisco	Drift Point	69°51.8'	131°36.0'
F-14	Aug. 31/74	2 Arctic Cisco	Drift Point	69°51.8'	131°36.0'
F-15	Aug. 31/74	2 Arctic Cisco	Drift Point	69°51.8'	131°36.0'
F-16	Aug. 31/74	1 Broad Whitefish	Drift Point	69°51.8'	131°36.0'
F-17	Aug. 31/74	2 Arctic Cisco	Drift Point	69°51.8'	131°36.0'

SAMPLE NO.	DATE	NUMBER AND SPECIES	LOCATION		
F-18	Aug. 31/74	2 Arctic Cisco	Drift Point	69°51.8'	131°36.0'
F-19	Aug. 31/74	30+ Small Cisco	Drift Point	69°51.8'	131°36.0'
F-20	Aug. 31/74	Small Flounder Small Sculpins	Drift Point	69°51.8'	131°36.0'
F-21	Aug. 31/74	3 Least Cisco	Drift Point	69°51.8'	131°36.0'
F-22	Aug. 31/74	1 Arctic Flounder	Drift Point	69°51.8'	131°36.0'

SAMPLE NO.	DATE	LOCATION
SW-1	Aug. 15/74	Tuft Point
SW-2	Aug. 18/74	Tuft Point
SW-3	Aug. 18/74	Tuft Point
Sw-4	Aug. 31/74	Drift Point
SW-5	Aug. 31/74	Drift Point
SW-6	Aug. 31/74	Drift Point
SW-7	Aug. 31/74	Drift Point

Appendix 13.2 Inventory of Samples (1975)

NUMBER OF SAMPLING LOCATIONS

	Yukon Coast	Tuk. Peninsula	Mackenzie Delta
PL	32	35	5
S	16	18	9
CS	--	14	-
B	--	8	4

TUKTOYAKTUK PENINSULA

SAMPLE NO.	DATE	LENGTH OF BEACH (M)	WT. CARTRIDGE FRAGMENTS (M)	LINEAR DENSITY (g/m)
PL-75-1	June 25	1800	765.8	.43
PL-75-2	June 26	800	148.6	.19
PL-75-3	June 26	2000	359.6	.18
PL-75-4	June 27	1950	123.8	.06
PL-75-5	June 28	450	61.5	.14
PL-75-6	June 28	900*	328.5	.37
PL-75-7	June 29	1900	183.4	.10
PL-75-8	June 29	2000	429.0	.22
PL-75-9	June 29	1400*	181.6	.13
PL-75-10	July 1	2200	199.6	.09
PL-75-11	July 1	1800*	618.4	.34
PL-75-12	July 3	3100*	353.6	.11
PL-75-13	July 3	1800	274.4	.15
PL-75-14	July 8	2000	none	
PL-75-15	July 8	1400	9.1	.01
PL-75-16	July 8	4400*	78.4	.02
PL-75-17	July 9	2300*	415.2	.18
PL-75-18	July 10	2000	268.7	.13
PL-75-56	Aug. 16	2500*	324.9	.13
PL-75-57	Aug. 17	3150*	152.2	.05
PL-75-58	Aug. 18	5000*	1612.8	.32
PL-75-59	Aug. 19	1550*	141.3	.09
PL-75-60	Aug. 22	1900*	64.1	.03
PL-75-61	Aug. 23	6600*	131.0	.02
PL-75-62	Aug. 23	2950*	751.8	.26
PL-75-63	Aug. 23	1650	8.9	.01
PL-75-64	Aug. 24	1100	14.2	.01
PL-75-65	Aug. 24	2000	156.9	.08
PL-75-66	Aug. 24	2000	223.2	.11
PL-75-67	Aug. 24	3100	24.1	.01
PL-75-68	Aug. 24	900	24.1	.03
PL-75-69	Aug. 25	3150*	545.1	.17
PL-75-70	Aug. 25	3850*	555.5	.14
PL-75-71	Aug. 25	500	none	
PL-75-72	Aug. 25	900*	228.1	.25

* Distances estimated from aerial photographs.

TUKTOYAKTUK PENINSULA

SAMPLE NO.	DATE	LOCATION Latitude	Longitude
S-75-1	June 26	69° 26.2'	133° 5.1'
S-75-2	June 26	69° 24.8'	133° 6.0'
S-75-3	June 28	69° 24.5'	133° 8.7'
S-75-4	June 29	69° 23.8'	133° 11.2'
S-75-5	June 29	69° 23.1'	133° 20.2'
S-75-6	June 30	69° 26.1'	133° 0.7'
S-75-7	June 30	69° 25.7'	132° 59.7'
S-75-8	June 30	69° 24.9'	132° 59.0'
S-75-9	June 30	69° 26.0'	132° 58.3'
S-75-10	July 1	69° 29.1'	133° 0.2'
S-75-11	July 1	69° 31.0'	133° 58.7'
S-75-12	July 3	69° 34.7'	133° 0.5'
S-75-13	July 3	69° 32.9'	132° 58.7'
S-75-14	July 6	69° 27.6'	132° 59.1'
S-75-15	July 6	69° 23.8'	132° 58.6'
S-75-16	July 6	69° 25.1'	132° 58.4'
S-75-17	July 8	69° 23.0'	133° 35.5'
S-75-18	July 10	69° 26.8'	133° 2.8'
CS-75-1	Aug. 16	69° 48.8'	131° 46.0'
CS-75-2	Aug. 16	69° 51.6'	131° 38.7'
CS-75-3	Aug. 23	69° 44.7'	132° 24.7'
CS-75-4	Aug. 23	69° 43.8'	132° 18.5'
CS-75-5	Aug. 23	69° 44.4'	132° 30.2'
CS-75-6	Aug. 24	69° 45.7'	132° 13.7'
CS-75-7	Aug. 24	69° 42.8'	132° 8.2'
CS-75-8	Aug. 24	69° 46.3'	131° 55.4'
CS-75-9	Aug. 24	69° 47.2'	131° 57.3'
CS-75-10	Aug. 24	69° 42.8'	132° 14.2'
CS-75-11	Aug. 25	69° 37.4'	132° 57.8'
CS-75-12	Aug. 25	69° 39.2'	132° 50.4'
CS-75-13	Aug. 26	69° 43.5'	132° 34.0'
CS-75-14	Aug. 26	69° 41.7'	132° 36.3'
B-75-5	Aug. 16	69° 53.3'	131° 42.3'
B-75-6	Aug. 24	69° 47.0'	132° 23.0'
B-75-7	Aug. 25	69° 36.8'	133° 03.8'
B-75-8	Aug. 25	69° 38.0'	133° 13.2'
B-75-9	Aug. 30	69° 28.0'	133° 07.4'
B-75-10	Aug. 30	69° 29.2'	133° 11.8'
B-75-11	Aug. 30	69° 24.6'	132° 58.9'
B-75-12	Aug. 30	69° 25.5'	132° 58.8'

MACKENZIE RIVER DELTA

SAMPLE NO.	DATE	LENGTH OF BEACH (M)	WT. CARTRIDGE FRAGMENTS (M)	LINEAR DENSITY (g/m)
PL-75-51	Aug. 7	3000	451.2	.15
PL-75-52	Aug. 8	2200*	426.2	.19
PL-75-53	Aug. 10	2300*	252.9	.11
PL-75-54	Aug. 10	300	381.2	1.27
PL-75-55	Aug. 10	1400	105.4	.08

SAMPLE NO.	DATE	LOCATION	
		Latitude	Longitude
S-75-35	Aug. 7	69°28.9'	135°47.6'
S-75-36	Aug. 8	69°30.6'	135°45.7'
S-75-37	Aug. 10	69°38.4'	135°26.1'
S-75-38	Aug. 10	69°37.2'	135°17.8'
S-75-39	Aug. 10	69°37.3'	135°17.8'
S-75-40	Aug. 10	69°33.5'	135°33.8'
S-75-41	Aug. 11	69°41.9'	134°48.1'
S-75-42	Aug. 11	69°41.0'	134°58.5'
S-75-43	Aug. 11	69°30.3'	135°21.5'
B-75-1	Aug. 4	69°27.5'	135°47.6'
B-75-2	Aug. 8	69°32.1'	135°36.8'
B-75-3	Aug. 8	69°34.6'	135°17.5'
B-75-4	Aug. 11	69°39.2'	135°11.7'

YUKON COAST

SAMPLE NO.	DATE	LENGTH OF BEACH (M)	WT. CARTRIDGE FRAGMENTS (M)	LINEAR DENSITY (g/m)
PL-75-19	July 15	3700*	140.6	.04
PL-75-20	July 15	2300	222.0	.10
PL-75-21	July 15	450	49.3	.11
PL-75-22	July 15	900	54.9	.06
PL-75-23	July 16	3400*	327.8	.10
PL-75-24	July 16	1400*	160.1	.11
PL-75-25	July 17	2400	507.3	.21
PL-75-26	July 18	950*	sample lost	
PL-75-27	July 18	2800*	261.2	.10
PL-75-28	July 20	2000	84.6	.04
PL-75-29	July 20	3000	347.6	.12
PL-75-30	July 20	1800*	333.9	.19
PL-75-31	July 20	2100	543.3	.26
PL-75-32	July 21	2900*	117.6	.04
PL-75-33	July 23	4000*	419.3	.11
PL-75-34	July 25	1650*	501.3	.30
PL-75-35	July 25	1650*	947.1	.57
PL-75-36	July 25	1350*	633.7	.47
PL-75-37	July 27	2500*	1329.3	.53
PL-75-38	July 28	450	674.5	1.50
PL-75-39	July 28	1200	sample lost	
PL-75-40	July 30	1500*	446.8	.30
PL-75-41	July 30	1500*	454.9	.30
PL-75-42	July 30	1450*	593.3	.41
PL-75-43	July 30	2000	493.9	.25
PL-75-44	July 30	1750	356.1	.20
PL-75-45	July 30	1050*	299.0	.29
PL-75-46	July 30	900	340.1	.38
PL-75-47	Aug. 1	2500	185.7	.07
PL-75-48	Aug. 1	3700	396.7	.11
PL-75-49	Aug. 1	2000	302.6	.15
PL-75-50	Aug. 1	2000	347.8	.17

YUKON COAST

SAMPLE NO.	DATE	LOCATION	
		Latitude	Longitude
S-75-19	July 16	69°17.5'	138°24.7'
S-75-20	July 16	69°15.0'	138°29.5'
S-75-21	July 18	69°23.2'	138°53.1'
S-75-22	July 20	69°26.5'	139° 1.2'
S-75-23	July 20	69°28.9'	139° 4.8'
S-75-24	July 21	69°34.2'	138°53.2'
S-75-25	July 22	69°20.1'	138°42.6'
S-75-26	July 23	69°16.4'	138°35.6'
S-75-27	July 25	68°59.9'	137°27.2'
S-75-28	July 28	69° 6.3'	137°59.0'
S-75-29	July 30	69° 3.4'	137°45.3'
S-75-30	July 30	68°59.7'	137°23.5'
S-75-31	July 30	69° 0.4'	137°32.7'
S-75-32	July 28	69° 4.8'	137°53.5'
S-75-33	Aug. 1	69°13.9'	138°18.1'
S-75-34	Aug. 1	69° 9.2'	138°10.5'

Appendix 14.1 Miscellaneous Plastics Wastes, 1974

PL-1	2 outboard oil containers 1 drill hole plub 1 fragment, styrofoam cup surveying flagging (2 m) 1 top, aerosol can 1 plastic float geogel & velogel fragments
PL-2	2 detergent bottles 1 bleach bottle 17 styrofoam cups 3 garbage bags 1 outboard oil container 1 bread bag surveying flagging (3m) geolgel & velogel fragments
PL-3	2" dia. poly. rope (3 m) geogel & velogel fragments
PL-4	3 outboard oil containers 1 detergent bottle 1 small plastic bag 1 sheet clear plastic (1 m^2) 1 fragment, geogel container
PL-5	1 orange plastic tube (1.5 m) 2 floats 2 shotgun shells (plastic casing) 1 "Off" can, plastic top 1 detergent bottle surveying flagging (.2 m) geogel & velogel fragments
PL-6	
PL-7	3 outboard oil containers 1 garbage bag 1 styrofoam cup surveying flagging (2 m) geogel & velogel fragments
PL-7	3 outboard oil containers 1 garbage bag 1 styrofoam cup surveying flagging (1.5 m) geogel & velogel fragments

PL-8		
PL-9	2	outboard oil containers
	5	blasting cap protectors
	1	orange plastic pipe (12 cm)
	1	fragment, detergent bottle
		surveying flagging (1 m)
		geogel & velogel fragments
PL-10	1	bleach bottle
	2	detergent bottles
	20	styrofoam cups (stacked & wrapped in plastic)
	1	drill hole plug
	1	orange plastic pipe (1.5 m)
	1	blasting cap protector
		surveying flagging (9 m)
		large geogel & velogel fragments
PL-11	1	drill hole plug (half)
	3	blasting cap protectors
		surveying flagging (2.5 m)
PL-12	1	garbage bag
	1	fragment, styrofoam
	4	blasting cap protectors
		surveying flagging (3 m)
		large geogel & velogel fragments
PL-13	3	outboard oil containers
	5	blasting cap protectors
	1	fragment, orange pipe (10 cm)
	1	drill hole plug (half)
		surveying flagging (7 m)
		fish net of poly. line (1 x 3 m)
PL-14	1	orange plastic pipe (1.5 m) plus smaller fragment (15 cm)
	3	outboard oil containers
	2	clear plastic bags
	1	fragmented garbage bag
	17	blasting cap protectors
	1	"Tang plastic bag
	1	fragment, drill hole plug
		surveying flagging (6 m)

PL-15	1 detergent bottle 1 drill hole plug 2 garbage bags 1 styrofoam cup plus fragments 1 blasting cap protector surveying flagging (3.5 m)
PL-16	1 outboard oil container 1 fragment, styrofoam 1 fragment, drill hole plug surveying flagging (10 cm)
PL-17	1 detergent bottle 1 "Off can, plastic top 7 segments, styrofoam life ring 1/8" poly. rope (1.5 m) surveying flagging (2 m)
PL-18	1 float 1 outboard oil container plus fragment thereof 2 drill hole plugs 3 fragments, styrofoam 3 blasting cap protectors banding material (2 m) 1" dia. poly. rope (3 m) plus mass of unravelled strands 3/8" poly. rop (10 m) fragments, garbage bag surveying flagging (1.5 m) large geogel & velogel fragments
PL-19	1 garbage bag 5 blasting cap protectors 3 fragments, styrofoam 1 sheet clear plastic (1 m^2) 1/8" poly. rope (6 m) surveying flagging (4 m)
PL-20	1 outboard oil container 5 fragments, styrofoam 2 blasting cap protectors sheet clear plastic (1 m^2) fragment, orange plastic pipe (10 cm) 1 styrofoam cup lid surveying flagging (2 m) geogel & velogel fragments

PL-21	6 fragments, garbage bags 1 top, "Off" can 1 blasting cap protector surveying flagging (5 m) 4 outboard oil containers 1 large sheet clear plastic
PL-22	1 blasting cap protector 1 shotgun shell, plastic casing surveying flagging (1.5 m)
PL-23	
PL-24-26	10 garbage bags 13 outboard oil containers 1 styrofoam cup 2 bread bags 1 sheet clear plastic (3 m^2) 3 shotgun shells, plastic casing 1 fragment, styrofoam surveying flagging (0.5 m)
PL-27	
PL-28	
PL-29	1 blasting cap protector 1 shotgun shell, plastic casing surveying flagging (1 m)
PL-30	
PL-31	2 outboard oil containers 1 sheet clear plastic (1 m^2) 2 garbage bags 1 fragment, drill hole plug 3 fragments, clear sheet plastic 1/4" poly. rope (1 m) surveying flagging (1.5 m)
PL-32	1 bread bag 3 fragments, clear plastic sheeting (1 m^2total) 1 drill hole plug 3 garbage bags 1 quart size vinegar jug (half) 1/2" poly. rope (0.5 m) 1/4" poly. rope (0.2 m) surveying flagging (1.5 m)
PL-33	1/8" poly. rope (1.5 m) surveying flagging (1 m)
PL-34	-

Appendix 14.2 Miscellaneous Plastics Wastes, 1975

PL-1	not collected
PL-2	not collected
PL-3	15 outboard oil containers styrofoam (.03m^3) 4 large garbage bags 3 styrofoam cups surveying flagging (8m) 70 shotgun shell casings 1 gallon size bleach bottle 1 quart size detergent bottle
PL-4	not collected
PL-5	70 shotgun shell casings 4 outboard oil containers 1 quart size bleach bottle surveying flagging (2m) 1 22 shell container 2 small pieces stryofoam
PL-6	4 outboard oil containers 1 gallon size detergent bottle stryofoam (.06m^3) 75 shotgun shell casings 1 float 2 22 shell boxes surveying flagging (4m) 1 drill hole plug 2 stryofoam cups
PL-7	4 outboard oil containers 1 frisbee 1 quart size detergent bottle 1 quart size bleach bottle 4 stryofoam cups 1/8" poly rope (6m) 2 large garbage bags styrofoam (.06m^3) surveying flagging (4m) 4 shotgun shell casings
PL-8	10 outboard oil containers surveying flagging (12m) 2 detergent bottles 5 styrofoam cups 20 shotgun shell casings 1 large garbage bag styrofoam (.06m3)

PL-9	5	outboard oil containers
	1	detergent bottle
	1	hair shampoo bottle
	1	funnel
	1	stryofoam cup
	2	large garbage bags
		surveying flagging (6m)
		styrofoam (.01m^3)
PL-10	7	outboard oil containers
	1	detergent bottle
	1	honey container
	2	floats
	25	shotgun shell casings
	2	large garbage bags
	1	styrofoam cup
		surveying flagging (8m)
		1/4'' poly rope (1m)
		clear plastic sheet (1m x 2m)
PL-11	35	outboard oil containers
	39	shotgun shell casings
	8	large garbage bags
	1	drill hole plug
	1	detergent bottle
	1	styrofoam cup
	1	Tang package
	1	Melmac cup
		styrofoam (.03m^3)
		surveying flagging (5m)
		1/8'' poly rope (4m)
PL-12	96	shotgun shell casings
	5	outboard oil containers
	6	22 shell boxes
	4	stryofoam cups
	8	large garbage bags
	1	2 gallon size plastic container
		clear plastic (1m x 2m)
		surveying flagging (1m)
		1/8'' poly rope (2m)
PL-13	2	quart size bleach bottles
	1	gallon size bleach bottle
	2	outboard oil containers
	6	styrofoam cups
	2	large garbage bags
	6	shotgun shell casings
	1	Off bottle
	2	bread bags
		surveying flagging (2m)
		1/16'' yellow plastic sheet (2m x 3m)

PL-14	1	outboard oil container
	1	food container lid
	1	Viva towel package (plastic only)
PL-15	10	outboard oil containers
	19	shotgun shell casings
	3	garbage bags
	2	22 shell boxes
	1	flashlight casing
	2	detergent bottles (quart size)
	1	detergent bottle (3 quart size)
	1	toffee bag
	2	styrofoam chips
		surveying flagging (3m)
		1/4" poly rope (15 cm)
PL-16	131	shotgun shell casings
	23	outboard oil containers
	1	22 shell casing
	1	detergent bottle
	8	garbage bags
	2	drill hole plugs
	1	plastic cup
	1	toffee wrapper
		styrofoam (.09m^3)
		surveying flagging (8m)
PL-17	29	outboard oil containers
	91	shotgun shell casings
	8	garbage bags
	3	22 shell boxes
	1	water pistol
	1	gallon bucket
	1	"Windex" bottle
	1	"Off" can top
	2	plastic cups
	2	styrofoam cups
	1	plastic shovel (child size)
		styrofoam (.09m^3)
		surveying flagging (.09m^3)
		1/8: poly rope (5m)
PL-18	42	shotgun shell casings
	6	outboard oil containers
	1	bleach bottle
	1	float
		surveying flagging (50m)
		styrofoam (.01m^3)

PL-19	3 large garbage bags 3 outboard oil containers 2 drill hole plugs 1 bread bag 1/8" poly rope (15m) surveying flagging (5m) clear plastic sheet (.6m x 1.2m)
PL-20	3 millipore filter containers 7 outboard oil containers 3 CSK standard NaCl solution bottles 1 antifreeze container 1 styrofoam cup 1 sheet clear plastic 1 flash cube surveying flagging (5m)
PL-21	1 outboard oil container 4 styrofoam cups surveying flagging (4m) styrofoam (.03m^3)
PL-22	1 gallon size plastic container 1 quart size plastic container 1 outboard oil container 1 portion drill hole plug styrofoam (.01m^3) surveying flagging (2m) 1/8" poly rope strands (4m)
PL-23	1 float 1 out board oil container top 1 1/2 styrofoam cup orange pipe (1.5m long) 1/8" poly rope strands (20m) surveying flagging (4m) 2 clear plastic sheets (.6m^2)
PL-24	1 garbage bag 4 foam chips 1 styrofoam cup 2 detergent bottles surveying flagging (7m) 1/8"poly rope strands (1m)

PL-25	2 garbage bags 6 outboard oil containers 1 gallon plastic container 1 quart plastic container 1 float 2 drill hole plugs surveying flagging (4m) styrofoam (.02m^3)
PL-26	1 float 1 garbage bag sheet plastic (.06m^2) surveying flagging (2m)
PL-27	3 outboard oil containers 11 floats 4 styrofoam cups 1 bread bag styrofoam (.01m^3) surveying flagging (15m)
PL-28	2 styrofoam cups 2 halves of drill hole plugs 1 float surveying flagging (4m)
PL-29	4 outboard oil containers 1 garbage bag 1 quart size plastic bottle section of orange tube (.03m)
PL-30	1 section orange pipe (.06m) 4 styrofoam cups 2 quart size containers 4 outboard oil containers 3 shotgun shell casings 1 22 shell box 2 floats 1 drill hole plug surveying flagging (8m) styrofoam (.01m^3) 1/8" poly rope strands (10m)

PL-31	4 outboard oil containers 3 garbage bags 5 styrofoam cups 1 orange section plastic tube 1 quart size bleach bottle 1 quart size detergent bottle surveying flagging (8m) 1" poly rope (2m) 1/8" poly rope strands (2m) clear plastic sheet (.6m x 1.2m)
PL-32	9 outboard oil containers 3 garbage bags 8 quart size bleach bottles 2 shotgun shell casings 2 drill hole plug pieces 1/8" poly rope strands (10m) 1" poly rope strands (2m) surveying flagging (7m) clear plastic sheet (1m x 2m)
PL-33	3 outboard oil containers 1 drill hole plug 1 plastic box 1 hose connection 1 plastic thermos cap 4 garbage bags 1 plastic Sunkist lemon detonating wire (40m) clear plastic cheet (15cm x 25cm) surveying flagging (2m) 2" poly braided rope (4m) clear plastic sheet (1.8m x 3m)
PL-34	1 drill hole plug 2 garbage bags 4 styrofoam cups 5 outboard oil containers 1 float 2 foam chips 1 thermos lid 1/2" poly rope surveying flagging (12m) 1/8" poly rope pieces (6m)

PL-35	2 drill hole plugs 2 outboard oil containers 3 styrofoam cups 1 small bowl 1 vinegar bottle 2 1 quart bleach bottles 1 float 2 garbage bags clear plastic (5cm x 10 cm) surveying flagging (8m) foam chips (.01m^3)
PL-36	6 outboard oil containers 1 styrofoam cup 1 float clear plastic (1.2m x 1.8m) surveying flagging (3m)
PL-37	20 outboard oil containers 1 doll's leg 1 rubber boot 3 floats 2 styrofoam cups 1 drill hole plug 1 1 quart detergent bottle 1 1/2 gallon detergent bottle 2 garbage bags 1 bread bag 1 orange plastic tube (.9m) 1 orange plastic tube (1.5m) 6 white plastic cones clear plastic (.03m x 3.6m) surveying flagging (9m) 1/2'' poly rope (10m) 2 foam chips (10cm x 15cm)
PL-38	1 rubber ball 2 outboard oil containers 6 styrofoam cups 1 Listerine bottle 1 misc. plastic bottle surveying flagging (3m) 1/8'' poly rope (1m)

PL-39	4	outboard oil containers
	1	drill hole plug
	1	car visor
	1	garbage bag
	1	1/2 gallon plastic bottle
	3	styrofoam cups
	4	styrofoam chips (10cm x 10cm)
		surveying flagging (5m)
		1/8" poly rope (1m)
PL-40	6	outboard oil containers
	3	quart size jugs
	1	gallon size jug
	1	Ajax container
	1	float
	5	styrofoam cups
		surveying flagging (20m)
		portion garbage can lid
		styrofoam (.02m^3)
PL-41	9	outboard oil containers
	1	sheet fiberglass (.6m x .6m)
	1	portion orange tube
	2	orange tubes
	1	quart size container
	2	drill hole plugs
	2	garbage bags
	3	styrofoam cups
	1	float
		surveying flagging (10m)
		styrofoam (.02m^3)
PL-42	8	outboard oil containers
	3	quart size containers
	1	drill hole plug
	1	garbage bag
	1	22 shell box
	5	styrofoam cups
		clear plastic sheet (1.2m x 1.2m)
		surveying flagging (5m)
PL-43	13	outboard oil containers
	6	styrofoam cups
	2	floats
	1	quart size container
	1	pint size container
	1/2	drill hole plug
		surveying flagging (8m)
		styrofoam (.02m^3)

PL-44	1 quart size container 2 outboard oil containers 1 garbage bag 2 floats 1 yellow tube (like orange ones) 2 intact Geogel cannisters clear plastic sheet (.9m x .9m) surveying flagging (4m) poly twine (5m)
PL-45	5 outboard oil containers 1 quart size container 1 styrofoam cup 1 float surveying flagging (3m) styrofoam (.02m^3) portion plastic bowl
PL-46	1 outboard oil container 4 styrofoam cups 2 small pieces styrofoam 1 quart size container 1/8" poly rope strands (20m) surveying flagging (10m) clear plastic sheet (1.2m x 2.4m) fragment, drill hole plug
PL-47	9 outboard oil containers 1 gallon size container 2 quart size containers 1 pint size container 5 styrofoam cups 2 peanut can lids 1 gear oil tube 1 garbage bag 1 bowl clear plastic sheet (1.2m x 2.4m) styrofoam (.03m^3) 1/8" poly rope strands (100m) surveying flagging (5m) black fibre cloth (.6m x .4m)
PL-48	3 styrofoam cups 1 egg carton 1 drill hole plug
PL-49	2 quart size containers 2 gallon size containers 4 fragments styrofoam 1 top gallon ice cream container surveying flagging (8m) 1/8" poly rope strands (2m)

PL-50	2 chips styrofoam
	1 quart size container
	3 styrofoam cups
	1 bread bag
	1 garbage bag
	1/2 garbage pail
	surveying flagging (3m)
	1/2" poly braided rope (1m)
	1/16" poly rope strands (5m)
	clear plastic sheet (.6m x 1.5m)
PL-51	1 float
	4 outboard oil containers
	1 quart size container
	1 aerosol top
	thousands of pieces of styrofoam
	styrofoam (.06m^3)
	surveying flagging (15m)
	3/4" poly rope (2m)
	black fibre fabric (.6m x .6m)
	portion inner tube
	3" black poly rope (4m)
PL-52	5 outboard oil containers
	1 gallon bleach container
	2 drill hole plugs
	14 styrofoam cups
	1 funnel
	1 garbage bag
	detonating wire (200m)
	surveying flagging (250m)
	1/16" poly rope strands (100m)
	black fibre fabric (.6m x 1.2m)
	clear plastic sheet (.6m x 1.2m)
	section (.03m) orange tube
	2" styrofoam (.6m x .6m)
PL-53	2 large plastic floats
	1 hard hat
	1 bucket
	4 styrofoam cups
	1 5 gallon water container
	1 glass ball float, plastic case
	surveying flagging (35m)
	poly rope (5m x 1")
	black fibre fabric (.6m x 1.2m)
PL-54	no plastic collected

PL-55	1	outboard oil container
	2	styrofoam cups
	2	floats
	1	22 shell box
	1	garbage bag
		clear plastic sheet (.6m x .6m)
		styrofoam (.06m^3)
		surveying flagging (25m)
		1/8'' poly rope strands (5m)
PL-56	1	garbage bag
	1	outboard oil container
	1	Ajax container
	1	float
		surveying flagging (3m)
		1/8'' poly rope strands (4m)
		white plastic sheet (1m x 4m)
		white plastic sheet (2m x 4m)
PL-57	1	22 shell casing
	1	quart size detergent bottle
	5	shtogun shell casings
	4	styrofoam cups
	1	aerosol can lid
	2	plastic jars
	1	plastic toy dagger
		poly rope strands (1m)
		surveying flagging (2m)
PL-58	13	outboard oil containers
	11	garbage bags
	8	styrofoam cups
	1	drill hole plug
	2	22 shell boxes
	2	floats
	1	hard hat
	3	bread bags
	1	plastic cup
	1	pint size container
	45	shotgun shell casings
		1/4'' poly braided ripe (10m)
		surveying flaggine (5m)
		1/2'' plastic tubing (2m)
		1/8'' poly rope strands (10m)
		1/4'' poly braided rope (10m)
		clear plastic sheet (.6m x 1.2m)
		3/8'' neoprene (.03m x .03m)
		styrofoam (.03m^3)
		black fibre fabric
		fiberglass cloth (.6m x .6m)

PL-59	12	plastic garbage bags
	11	outboard oil containers
	3	styrofoam cups
	3	small plastic wrappers
	2	shotgun shell casings
	2	quart size bleach bottles
	1	plate
		surveying flagging (1m)
		clear plastic sheet (1.5m x 15m)
		1" poly rope (3m)
PL-60	1	bleach bottle quart size
	1	outboard oil container
	14	shotgun shell casings
PL-61	1	shotgun shell casing
	1/2	lunch bucket
		surveying flagging (1m)
		electrical tape (1m)
PL-62	3	outboard oil containers
	26	styrofoam cups
	1	float
	1	top aerosol can
	1	drill hole plug
	14	shotgun shell casings
	1	cup size container
	1	pint size container
		1/32" red plastic sheet (.6m x 1.5m)
		clear plastic sheet (.6m x 1.2m)
		surveying flagging (5m)
		5/16" poly rope (3m)
		black fibre fabric (.3m x .6m)
PL-63	1	styrofoam cup
	1	bottom gallon size Ajax
	1	bread bag
	1/8"	poly rope strand (1m)
	1	white cone
PL-64	1"	poly rope (1m)
PL-65	1	float
	3	shotgun shell casings
	1	piece styrofoam
		surveying flagging (.5m)

PL-66	3 outboard oil containers 2 styrofoam cups 1 hair shampoo container 2 pieces styrofoam 3/16" poly rope (3m) portion garbage bag surveying flagging (7m)
PL-67	2 outboard oil containers 3 styrofoam cups 2 garbage bags 1 clear plastic bag surveying flagging (1m) clear plastic sheet (.6m x .9m)
PL-68	3/4" poly rope (1m)
PL-69	6 outboard oil containers 22 shotgun shell casings 1 garbage can 1 garbage bag 1 Dutch Cleanser bottle 1 quart size detergent bottle 1 22 shell box 2 pieces orange plastic tube (1.5m each) surveying flagging (7m) 1/8" poly rope (10m)
PL-70 PL	5 outboard oil containers 2 garbage bags 2 aerosol can lids 1 pint size detergent bottle 13 shotgun shell casings 2 styrofoam cups surveying flagging (5m) clear plastic sheet (.9m x 1.2m) 1/8" poly rope strands (12m)
PL-71	no plastic collected
PL-72	1 pint size bleach bottle 6 outboard oil containers 1 bowl 73 shotgun shell casings 1 white cone 1 plastic boat surveying flagging (1m) 1/2" poly rope (.5m)

Appendix 15.1 Chemical Data on Identification of Grease and Tar-like Object.

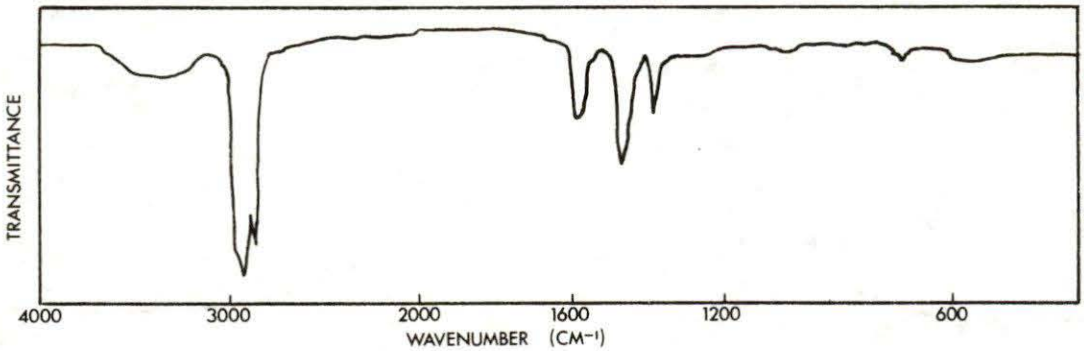

Fig. 41. Infrared spectrum of grease sample G-1 from Yukon Coast.

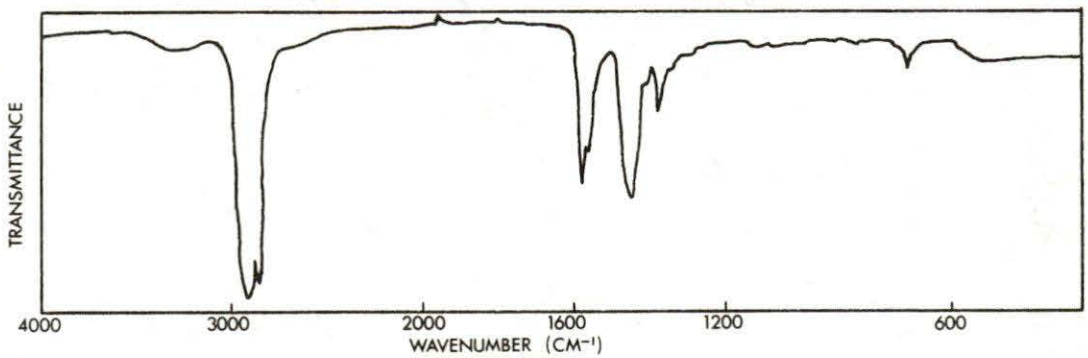

Fig. 42. Infrared spectrum of Gulf Crown EP2 grease.

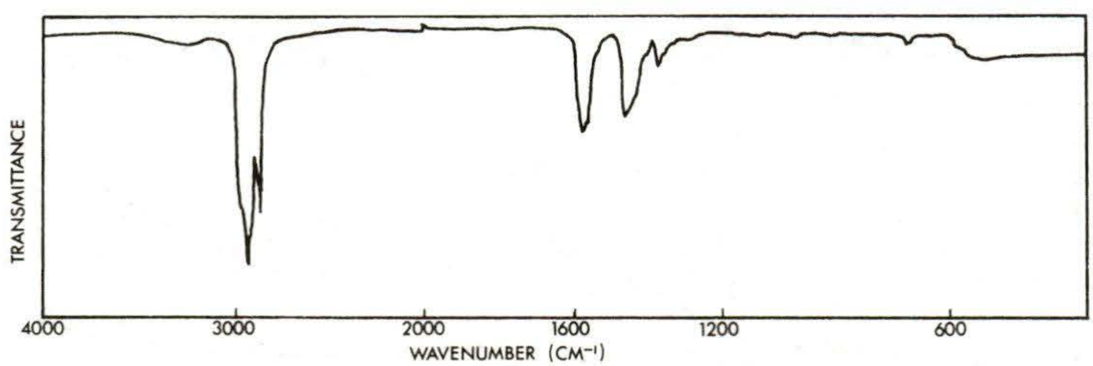

Fig. 43. Infrared spectrum of ESSO mp grease H.

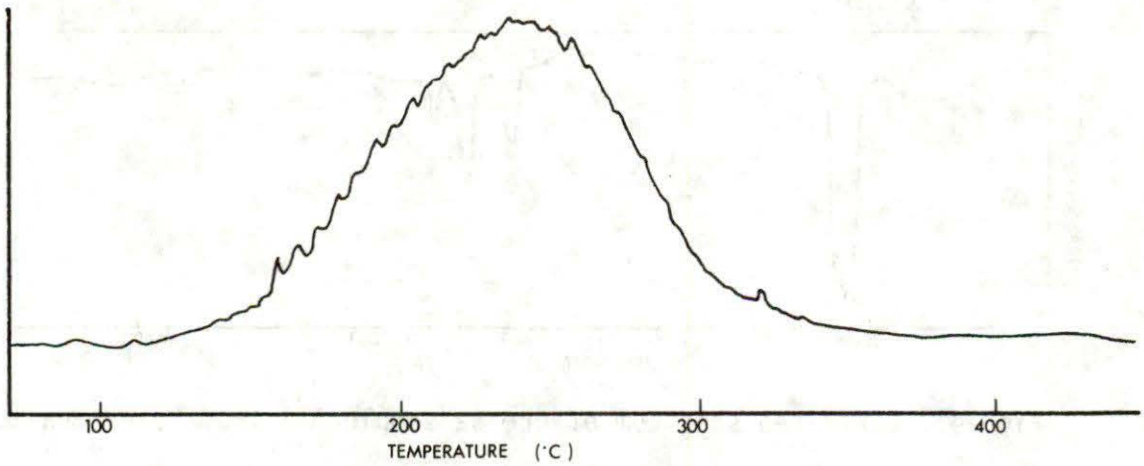

Fig. 44. Gas chromatogram of grease sample G-11 from Yukon Coast; Attenuation 256 x 10^{-10}; Temperature Program: 70 C to 400 C at 6 /min and hold; quantity injected: ca 1 mg.

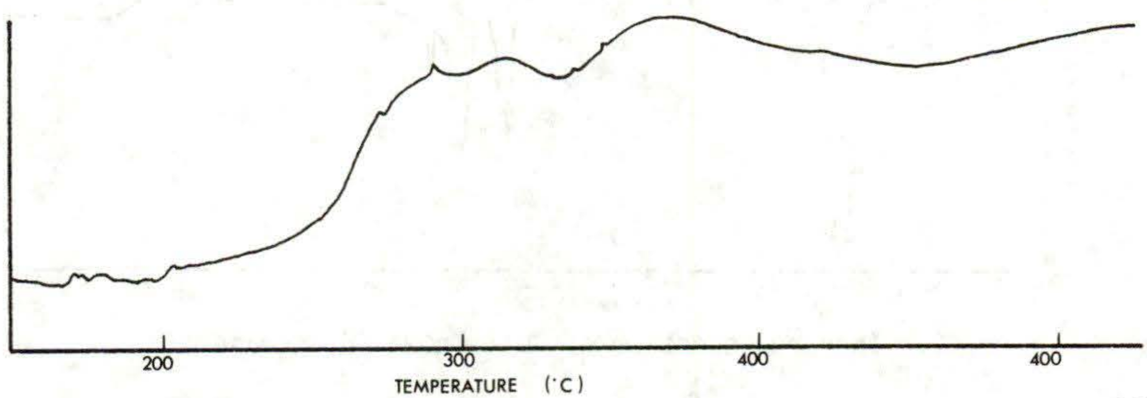

Fig. 45. Gas chromatogram of ESSO mp grease H; Attenuation 64 x 10^{-11}, other conditions as in Fig. 44.

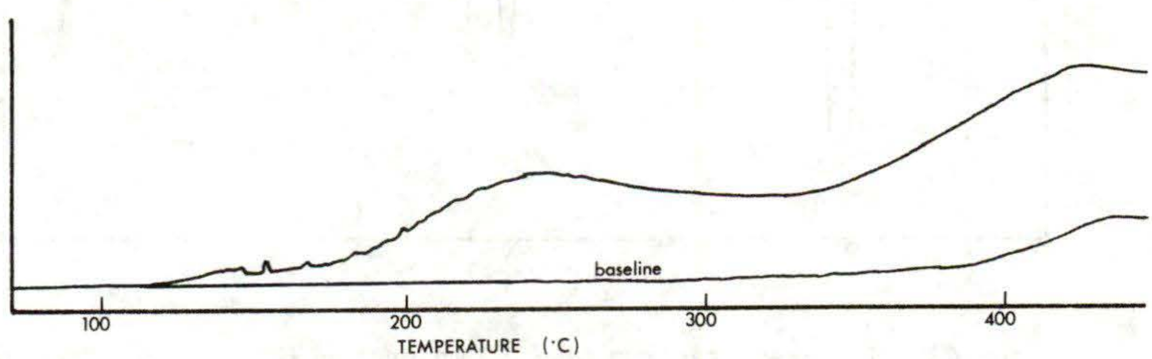

Fig. 46. Gas chromatogram of Gulf Crown EP 2 grease; Attenuation 32 x 10^{-11}; other conditions as in Fig. 44.

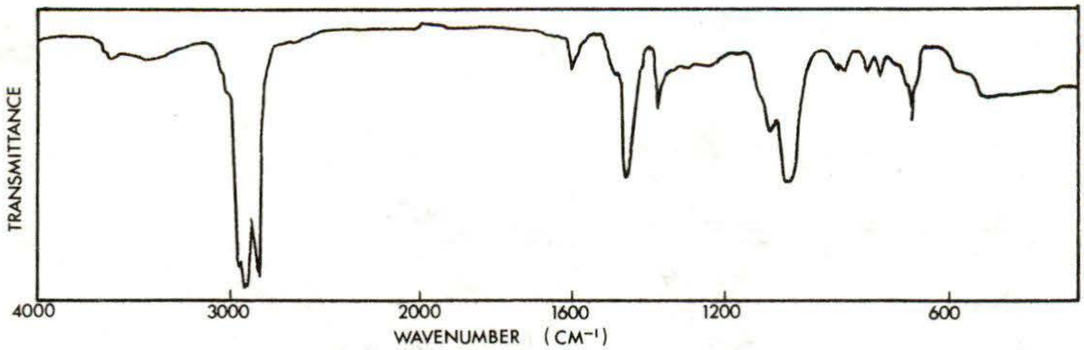

Fig. 47. Infrared spectrum of grease sample G-7 from Tuktoyaktuk Peninsula.

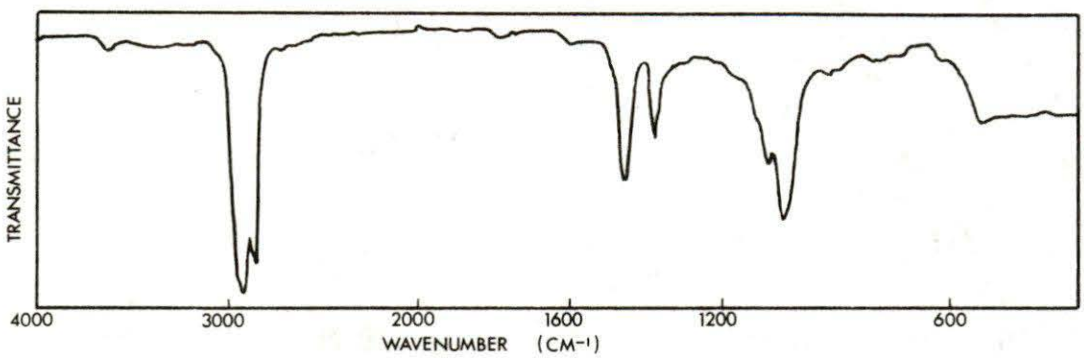

Fig. 48. Infrared spectrum of Valvoline X-All grease.

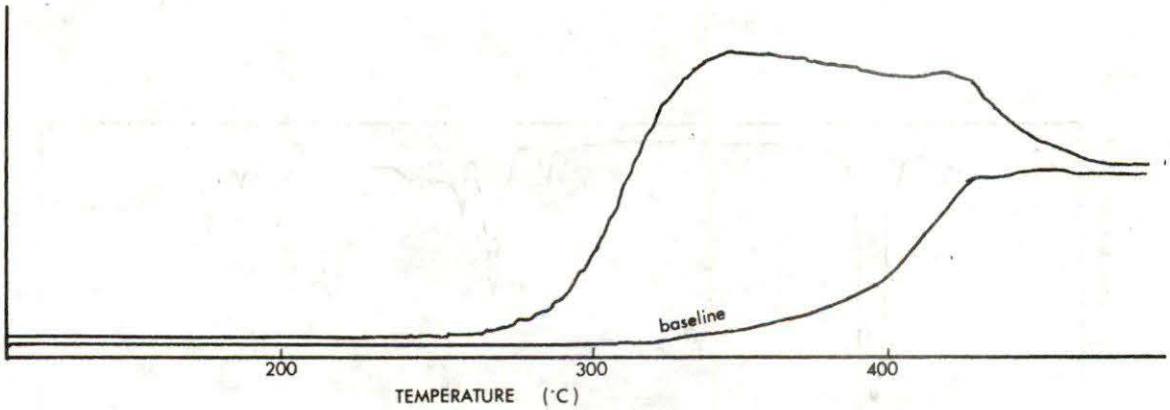

Fig. 49. Gas chromatogram of tar-like object from Drift Point; Attentuation 32 x 10^{-10}, other conditions as in Fig. 44.

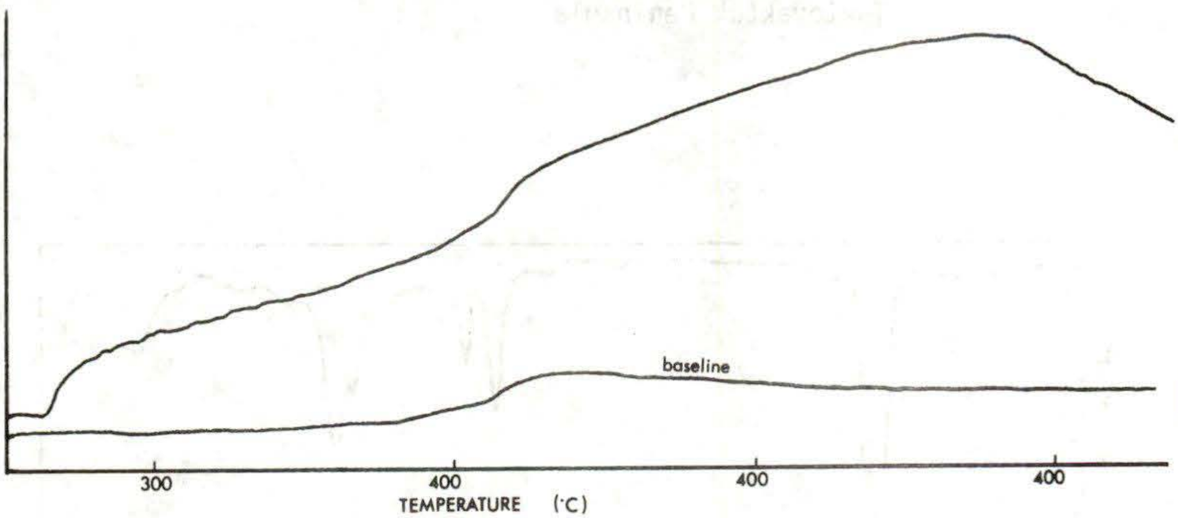

Fig. 50. Gas chromatogram of grease sample G-5 from Tuktoyaktuk Peninsula. Attenuation 32 x 10^{-11}, other conditions as in Fig. 44.

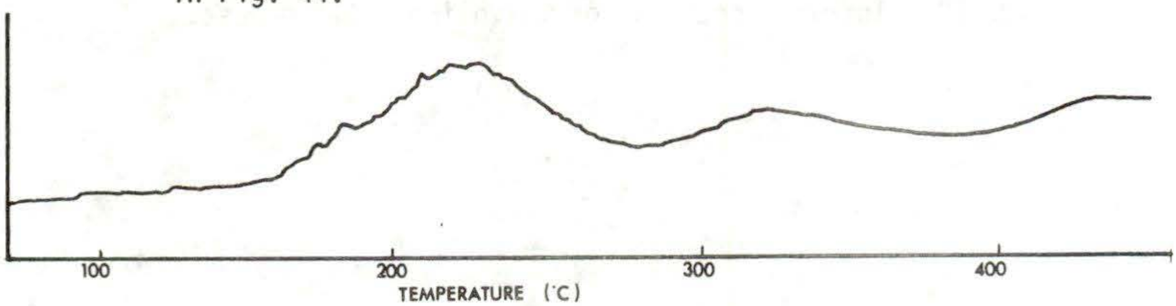

Fig. 51. Gas chromatogram of Valvoline X-All grease; Attenuation 32 x 10^{-10}, other conditions as in Fig. 44.

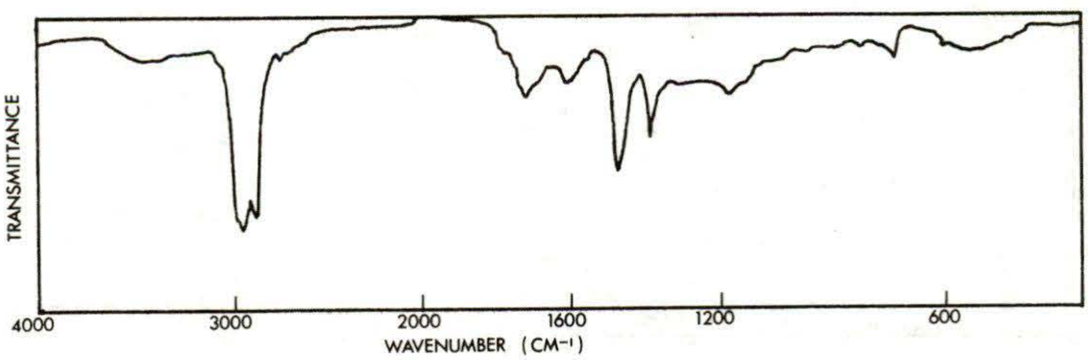

Fig. 52. Infrared spectrum of tar-like object from Drift Point.

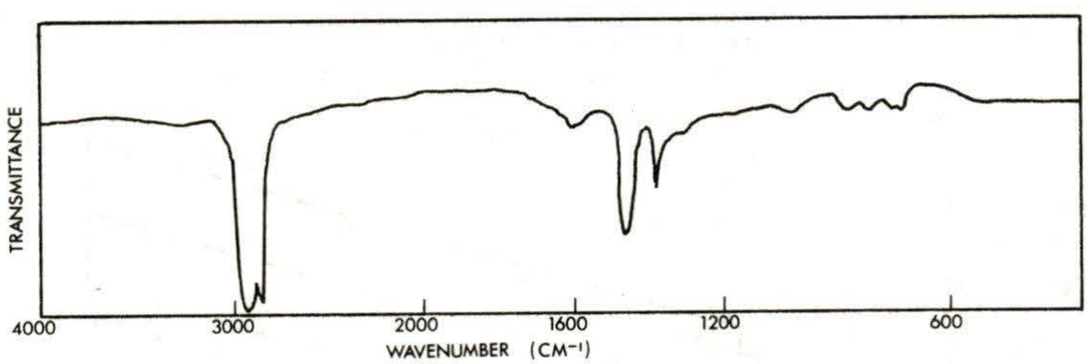

Fig. 53. Infrared spectrum of asphalt sample extracted from roofing paper.

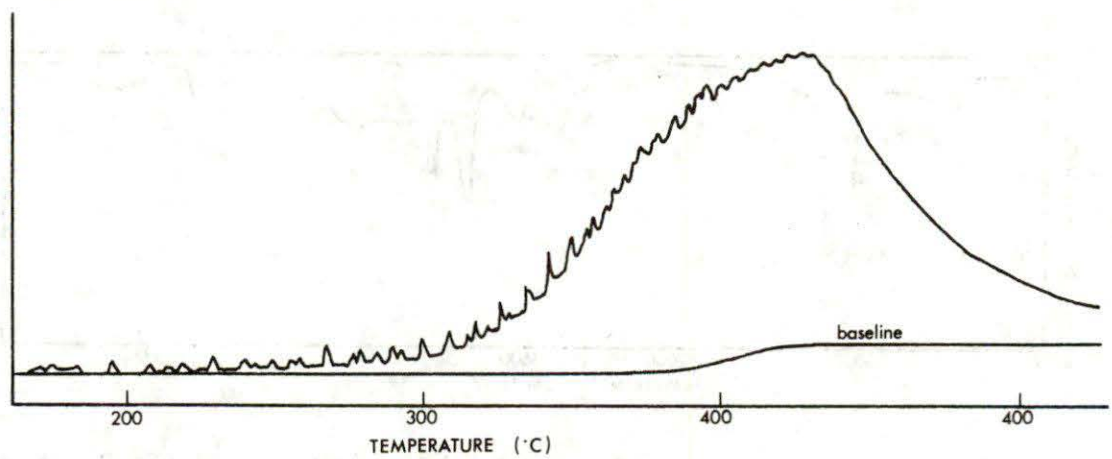

Fig. 54. Gas chromatogram of asphalt sample extracted from roofing paper; Attenuation 64 x 10^{-10}, other conditions as in Fig. 44.

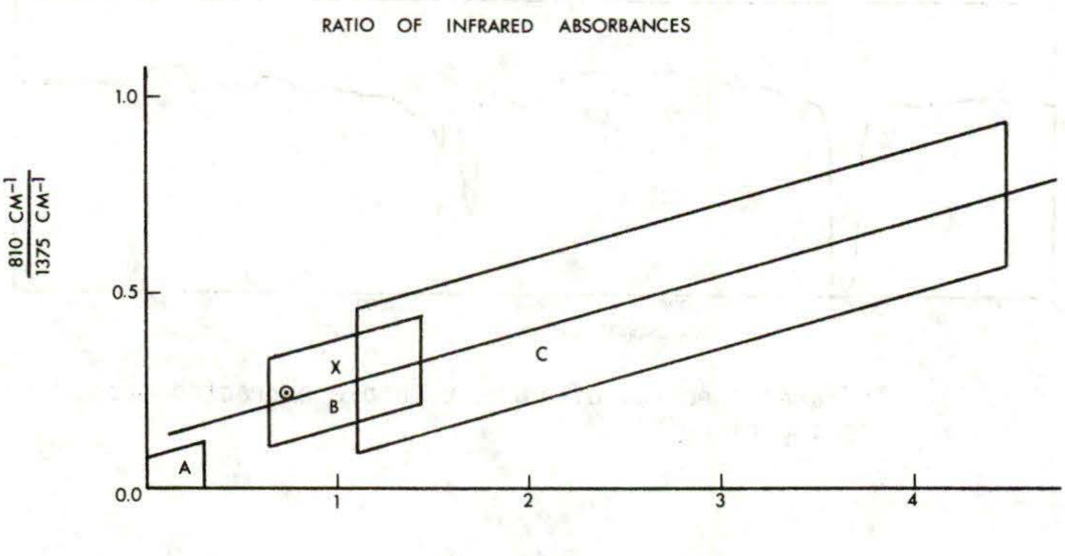

Fig. 55. Relationship of Drift Point tar-like object (⊙) and roofing paper asphalt (X) to other asphalts (Box B) fuel oils (Box C) and lubricant oils (Box A).