ENVIRONMENTAL PROTECTION
CONSERVATION AND PROTECTION
ENVIRONMENT CANADA

THE NESTUCCA OIL SPILL: FATE AND EFFECTS TO MAY 31, 1989

Regional Program Report 89-01

by

L. E. Harding
J. R. Englar

June, 1989

Abstract

Approximately 875,000 litres of Bunker C fuel were spilled off the Washington coast during the early morning of December 23, 1988. The oil was first reported on the British Columbia coast near Carmanah Point on December 31, 1989, and progressed north, arriving as small patches at Cape Scott on about January 14. Oiling was reported as far south as Victoria, and traces of Nestucca oil landed on islands off the northern mainland near Bella Bella.

Within this area, a total of 150 km of coastline were affected, mostly with light to moderate stranding of oil dispersed along high tide lines. At least two km were heavily oiled. Most oiling in B.C. was confined to outer islands and headlands. Oiled locations were characterized by light to moderate distribution of patches of oil scattered along the high tide zones in discrete areas of accumulation. Subtidal accumulations occurred in two locations.

Significant accumulations of oil (i.e., numerous locations of Class 4-5, moderate to heavy oiling; see text for definitions) occurred in Barkley Sound, Long Beach, the mouth of Clayoquot Sound, Estevan Point, Nootka Island, Kyuquot Sound and Brooks Peninsula. These areas contained important seabird, fish, shellfish and marine mammal habitats. Shorelines of six provincial Ecological Reserves were lightly (scattered patches) oiled. Approximately 3,500 dead seabirds were found in B.C. and 9,000 in Washington. The Canadian Wildlife Service (CWS) is analyzing data to estimate the number of birds that actually died, and studies are continuing to determine if any B.C. breeding populations were affected.

Some seals, sea lions and river otters were found dead and others were observed to be oiled, but no deaths attributable to oil were confirmed in these species. One sea otter is known to have died from oil. Studies by the Department of Fisheries and Oceans (DFO) will determine if there has been any impact on the populations. The grey whales migrated through the area without incident during March-April.

Crabs were contaminated with oil in and near the entrances to Clayoquot Sound, resulting in an extended (until June 26) closure of crab fishing in some important crab fishery areas.

Barkley Sound was closed to all commercial bivalve harvesting for several weeks following the spill and the area of the coast between Amphitrite Point and Estevan Point was closed for a similar period for gooseneck barnacle and mussel commercial harvesting. These closures were precautionary to prevent contaminated products from entering the market and were lifted

after extensive laboratory testing of shellfish samples. Salmon habitat and most salmon and shellfish farms were located in protected bays and inlets, away from the exposed outer coastline where most of the oiling occurred. Some wild shellfish stocks were slightly contaminated.

Herring altered their historically documented spawning locations in Barkley Sound and studies are continuing to determine if this change was oil-related. However, the commercial catch quotas were met and there was no evidence of tainting of herring products.

RÉSUMÉ

A l'aube du 23 décembre 1988, un déversement de quelque 875 000 litres de mazout C s'est produit au large de la côte de l'État de Washington. En Colombie-Britannique, l'apparition de mazout sur la côte a d'abord été observée près de Carmanah Point, le 31 décembre 1989, tandis que le déversement s'avançait vers le nord, atteignant par petites nappes Cape Scott vers le 14 janvier. On a signalé la présence de mazout jusqu'à Victoria, au sud, et trouvé des traces de pétrole sur les îles au large de la partie nord du territoire continental, près de Bella Bella.

A l'intérieur de cette zone, un secteur côtier de 150 milles a été touché, surtout par des déversements légers et moyens de mazout répartis le long de la ligne de marée haute. Au moins deux kilomètres de côte ont été fortement contaminés. En Colombie-Britannique, la contamination a été limitée en grande partie aux caps et aux îles extérieures. Dans les zones contaminées, le mazout était réparti en flaques distinctes de petits et moyenne densité le long de la ligne de marée haute. Nous avons relevé des accumulations infralittorales à deux endroits.

D'importantes accumulations de mazout (i.e., plusieurs endroits de Classe 4-5, contamination de pétrole moyenne à sévère; voir le texte pour les définitions) ont été observées dans la baie Barkley, à Long Beach, à l'embouchure de la baie Clayoquot, à Estevan Point, à l'île Nootka, dans la baie Kyuquot et dans la péninsule de Brooks. Ces régions renferment d'importants habitats d'oiseaux marins, de poisson, de crustacés et coquillages, et de mammifères marins. Le littoral de six réserves écologiques provinciales a été légèrement souillé (flaques éparpillées). Environ 3 500 oiseaux marins morts ont été trouvés en Colombie-Britannique tandis qu'on en a trouvé 9 000 dans l'État de Washington. Le Service canadien de la faune analyse présentement les données en vue d'évaluer le nombre réel d'oiseaux qui sont morts et les analyses se poursuivent pour déterminer l'incidence du déversement sue les populations qui nichent en Columbie-Britannique.

Un certain nombre de phoques, d'otaries et de loutres communes ont été trouvés morts tandis que certains autres étaient tachés d'huile. Cependant, aucun décès attribuable au mazout n'a été confirmé en ce qui touche ces espèces. Le décès d'une loutre de mer a été attribué au déversement. Des études menées par Pêches et Océans Canada permettront de déterminer s'il y a eu un impact sur les populations de poissons. Les baleines grises ont franchi le secteur sans incident durant leur migration en mars et avril.

Les crabes à l'embouchure et près de l'embouchure de la baie Clayoquot ont été contaminés, ce qui a entraîné la fermeture prolongée (jusqu'au 26 juin) de certaines importantes zones de pêche au crabe.

La baie Barkley a été fermée à toute pêche commerciale des bivalves pendant quelques semaines après le déversement et le secteur côtier compris entre Amphitrite Point et Estevan Point a été fermé, pour le même durés, à la pêche commerciale des anatifes et des moules. Il s'agissait dans ces cas de fermetures préventives destinées à empêcher l'apparition de produits contaminés sur le marché, la pêche a repris après des analyses exhaustives d'échantillons en laboratoire. La plupart des piscifactures de saumon et des parcs de coquillages étaient situées dans des baies et des bras de mer protégés, à l'écart de la côte extérieure, que a été la plus affectée par le déversement.

Les harengs ont déménagé de leurs secteurs de frai traditionnels et des études sont menées en vue de déterminer si ce déménagement est lié au déversement. Cependant, les pêcheurs ont atteint leurs quotas de pêche au hareng et on n'a trouvé aucune trace de souillure dans les produits de hareng.

TABLE OF CONTENTS

LIST OF APPENDICES

FORWARD

BACKGROUND

Following arrival of oil from the stricken barge, Nestucca, on the west coast of Vancouver Island, the BC provincial and federal Ministers of Environment, Bruce Strachan and Lucien Bouchard, asked for a full assessment of the impact of the spill. Colin Wykes, Director of Environmental Services of Environment Canada's Pacific & Yukon Regional Office, was assigned to coordinate this assessment. This report has been prepared in partial fulfilment of this responsibility. This report documents the distribution and movements of oil along the Vancouver Island coastline as a basis for further studies of the longer term impact. It also summarizes those environmental impacts that occurred, and could be documented, during this initial period.

DISCLAIMER

Tentative conclusions drawn herein are based on preliminary analysis of data and may change with additional analysis and new data. This report is without prejudice to any legal actions.

ACKNOWLEDGEMENTS

Many people contributed to this assessment, including scientists, fisheries officers, technical support staff and people with essential local knowledge of the environment and conditions on the west coast of Canada. Colin Wykes directed the environmental assessment and the preparation of this report. John Davis led the fisheries assessment and provided valuble comments on an earlier draft. We especially wish to acknowledge the contributions of Bob Langford, B.C. Ministry of Environment; Steve Wetmore, Rick McKelvey, Moira Lemon, Gary Kaiser and Jean-Pierre Savard of the Canadian Wildlife Service; Mike Rodway, seabird specialist; John Davis, Colin Levings, Carey McAllister, Walter Cretney and Mike Flynn for Department of Fisheries and Oceans; Ken Langelier, Island Veterinary Hospital, Nanaimo; Louise Goulet, Director of the B.C. Ecological Reserve Program; Larry Baird, Chief of the Uclulet Indian Band; Bill Green, Fisheries Policy Advisor for the Nuu Chah Nulth Tribal Council, Norman Dale, environmental coordinator for the Kwakiutl Territorial Fisheries Commission; and Karl Sturmanis, band planner for the Kwakiutl District Council.

1.0. INTRODUCTION

On December 23, 1989 an estimated 875,000 litres of Bunker C oil were spilled off Grays Harbor, Washington, arriving at Vancouver Island on December 31. This report presents preliminary results of studies on the fate of the oil and summarizes effects that were known to the end of May, 1989.

Place names on the west coast of Vancouver Island are shown in Figure 1 and for Barkley Sound in Figure 2.

1.1. Physical Setting

Vancouver Island is entirely on the America tectonic plate. The Pacific Plate, just offshore, is being subducted under it; hence, there is a high earthquake frequency for the region. Geothermal vents, supporting unique, recently discovered life forms, also occur along the plate margins.

Two peninsulas break the otherwise northwest-southeast trending shoreline: Hesquiat Peninsula (Estevan Point) and Brooks Peninsula.

The mountains of Vancouver Island are relatively old (Mesozoic), geologically, compared to the mainland coast ranges. Hence, their rounded aspect.

Vancouver Island was entirely glaciated during the last ice age which ended some 12,000 years ago. South of Tofino the continental glacier extended some distance offshore (about halfway across the continental shelf), cutting deep seaward trenches off Clayoquot and Barkley Sounds. North of Tofino the ice edge remained close to shore; hence, the absence of deep trenches and the occurrence of terminal moraines of glacial till at the mouths of inlets. This feature has implications for the movement of sunken oil entrained in near-bottom waters.

The inlets include four sounds (Barkley, Clayoquot, Nootka and Kyuquot) and numerous fjords. Sounds are characterized by numerous islands, some of fair size (e.g., Meares and Nootka). Fjords are typically long and narrow, with deep central troughs and shallow sills at their mouths. Estuarine circulation in these inlets is driven by fresh surface runoff water entraining seawater and flowing seaward over denser bottom waters (Thomson, 1981). Bottom waters are drawn into the inlets to replace the volume entrained in surface runoff. The high rainfall of the region ensures vigorous estuarine circulation, driven by numerous short rivers entering at the heads of the inlets.

1.2. Native Communities

The Nuu-Chah-Nulth Tribal Council represents 14 Native Indian bands on the west coast of Vancouver Island (Table 1). Other member bands are in the Port Alberni Area (Opetchesaht) and the Olympic Peninsula of Washington State (Makah). Their territory covers the coast from the Port Renfrew area to the

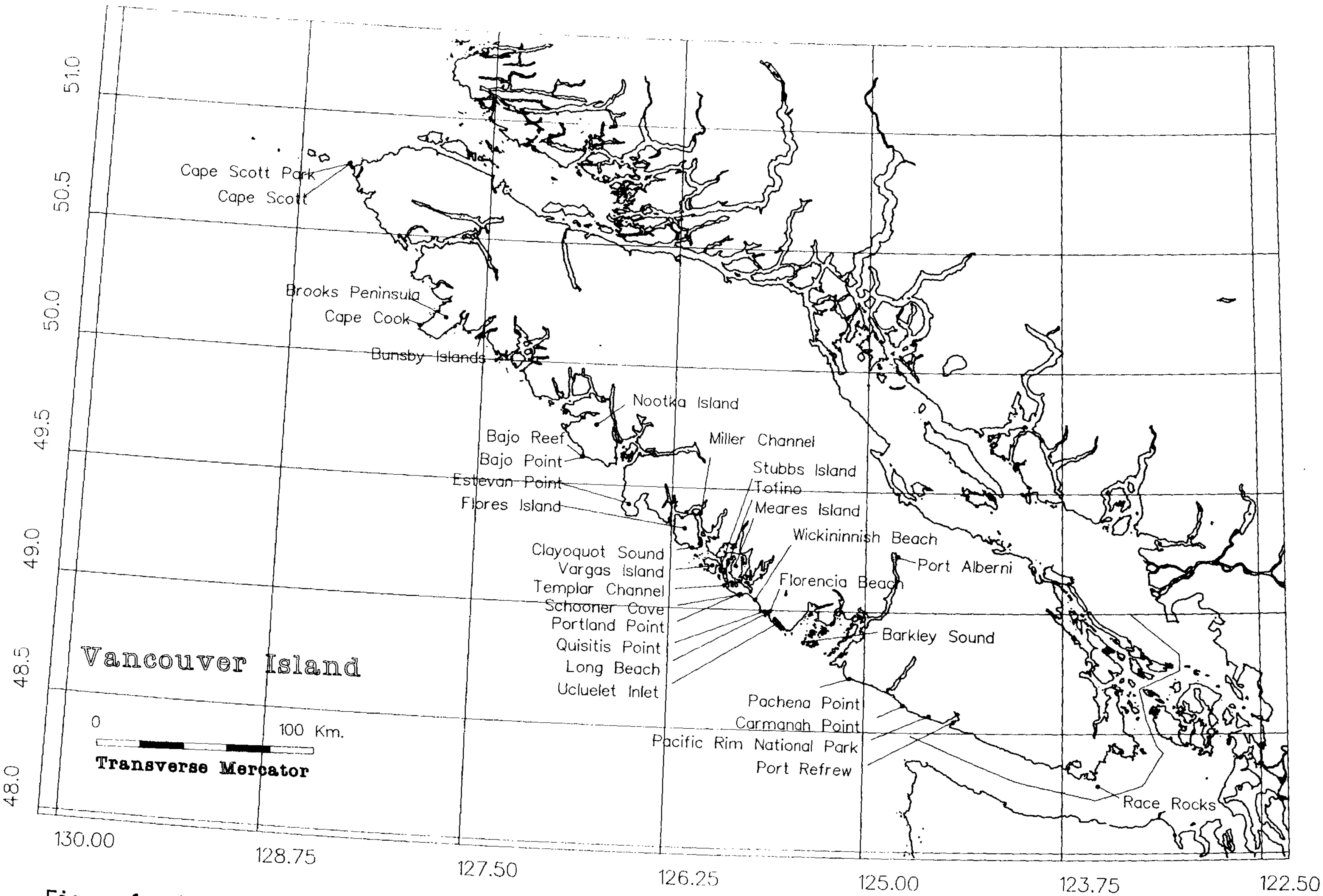


Figure 1. Vancouver Island location map.

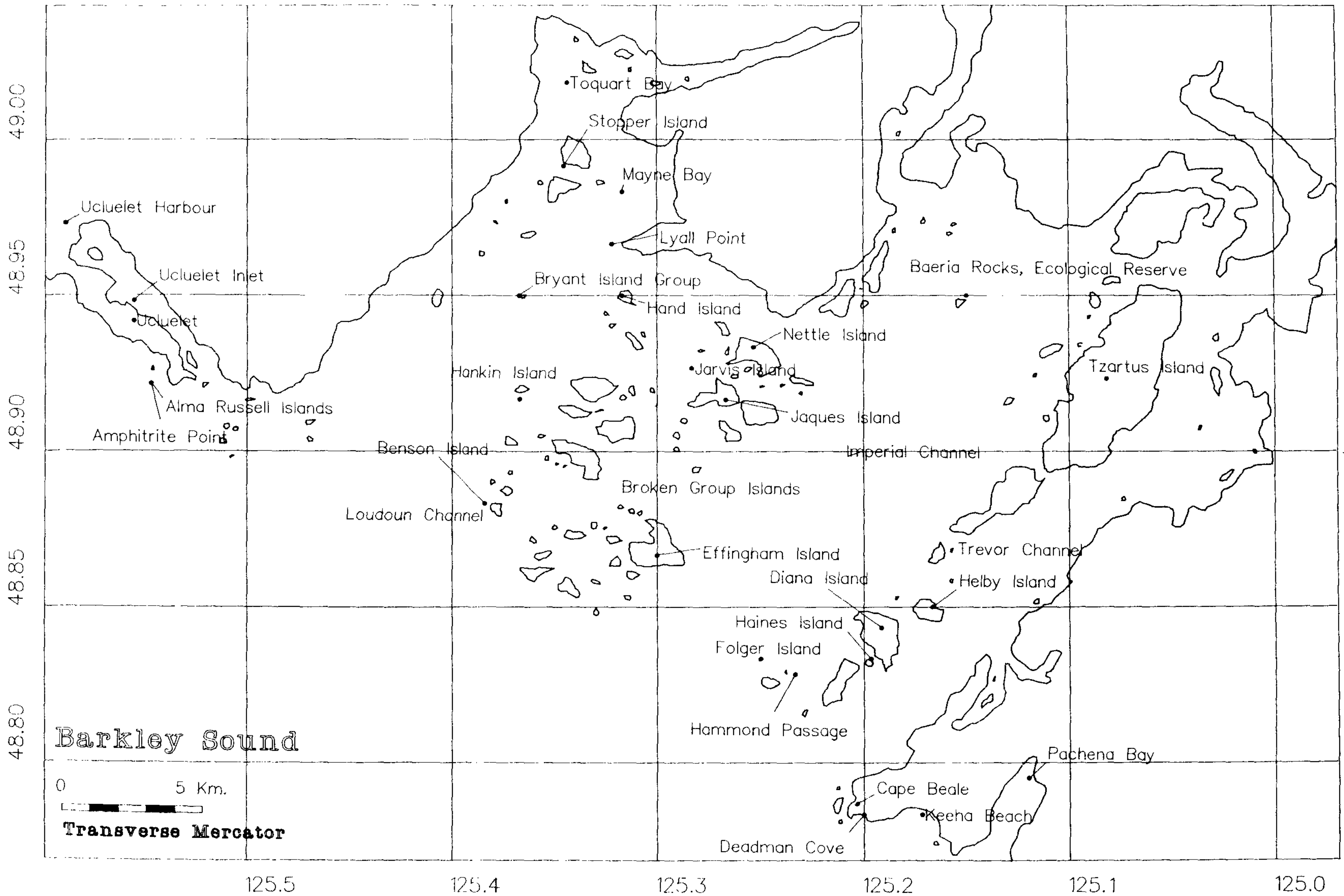


Figure 2. Barkley Sound location map.

Brooks Peninsula. There are about 7,000 Nuu-Chah-Nulth people in B.C. and about 1,000 more in Washington State (Nuu-Chah- Nulth Tribal Council, 1985).

North of the Brooks Peninsula to Cape Scott is the land of the Kuakiutl District Council. There are two bands (Table 1) and 19 reserves from Cape Scott to Brooks Peninsula. The main population centres that use west coast resources are in the Quatsino Sound area. There are about 300 people in both bands (Carl Sturmanus, pers. comm.).

Table 1. Indian Bands of the area affected by oil as a result of the Nestucca spill on the west coast of Vancouver Island.

1.	Kyuquot	Nuu-Chah-Nulth Tribal Council
2.	Ehattesaht	Nuu-Chah-Nulth Tribal Council
3.	Nuchatlaht	Nuu-Chah-Nulth Tribal Council
4.	Mowachaht	Nuu-Chah-Nulth Tribal Council
5.	Hesquiaht	Nuu-Chah-Nulth Tribal Council
6.	Ahousaht	Nuu-Chah-Nulth Tribal Council
7.	Clayoquot	Nuu-Chah-Nulth Tribal Council
8.	Ucluelet	Nuu-Chah-Nulth Tribal Council
9.	Toquaht	Nuu-Chah-Nulth Tribal Council
10	Sheshaht	Nuu-Chah-Nulth Tribal Council
11.	Uchucklesaht	Nuu-Chah-Nulth Tribal Council
12.	Ohiaht	Nuu-Chah-Nulth Tribal Council
13.	Ditidaht	Nuu-Chah-Nulth Tribal Council
14.	Pacheenaht	Nuu-Chah-Nulth Tribal Council
15.	Nawhitti	Kwakiutl District Council
16	Quatsino	Kwakiutl District Council

Native people continue to use marine resources throughout their tribal territories. These include traditional foods, craft materials and medicines as well as commercial fisheries. More than 80 species of plants and animals are involved (Nuu-Chah-Nulth Tribal Council, 1985). These renewable resources make the single most important contribution to the economy of the coastal communities, in some cases constituting the entire economic base (Nuu-Chah-Nulth Tribal Council, 1985).

The importance of marine resources to Nuu-Chah-Nulth people goes far beyond their economic value. They are considered their heritage, their present and future (Nuu-Chah- Nulth Tribal Council, 1985).

1.3 Tourism

Pacific Rim National Park consists of three units: Long Beach Unit, Broken Group Unit and West Coast Trail Unit. Currently over 500,000 tourists visit the Park annually. The Park is known worldwide for its scenic splendour, abundant natural resources, unique life forms and geology, and relatively pristine environmental quality.

Visitors also support a vigorous tourism industry outside the Park. The centres of Tofino and Ucluelet host guests in accommodations ranging from bed and breakfast to luxury resorts. The area's beaches are a major attraction, as are whale watching, fishing, sea kayaking, bird and marine mammal watching and SCUBA diving and coastal hiking.

The natural values that support the tourism industry often conflict with resource use activities of another industry: logging. Tofino, in particular, has been the centre of controversy between logging companies and coalitions of native people, environmentalists, and tourism facility operators. The major concerns centre around the highly visible scars on the landscape, the terrain damage and stream siltation that inevitably accompanies logging on steep slopes in high rainfall areas. For example, logging on Meares Island in Clayoquot Sound is currently under court injunction pending progress on native land claims.

1.4 Environmental Impact Assessment

A federal-provincial team was assembled on January 5, 1989 to participate in establishing clean-up priorities and to assess the short- and long-term environmental impacts of the spill. This team, the composition of which evolved during the scientific spill response, included representatives of DOE (Environmental Protection, Canadian Wildlife Service, Canadian Parks Service), Fisheries Oceans Canada (DFO), Energy, Mines and Resources (Geological Survey of Canada), B.C. Ministry of Agriculture and Fisheries (MAF), B.C. Ministry of Environment, Planning and Assessment (MOE), and the Nuu-Chah-Nulth Tribal Council. This team established headquarters at the Canadian Coast Guard base at Amphitrite Point in Ucluelet, B.C. Daily meetings between field staff and coordinators were held at this location from January 7 to February 12, 1989, to plan and implement the environmental impact studies.

An environmental consultant, ESL Environmental Services Limited, was contracted by Environment Canada and the B.C. Ministry of Environment, to assist in assembling data on the impacts that were observed during the initial response, on behalf of these agencies.

Several studies were initiated to determine the immediate or short-term impacts of the Nestucca oil spill on the biophysical environment of the west coast of Vancouver Island. A preliminary evaluation was provided by Duval (1989). This report provides interim results of continuing studies. Longer-term research programmes will focus on the fate of Bunker C oil in key environmental compartments and the effects of the

Nestucca oil on valued ecosystem components. The overall objective of these investigations will be to assess the impact of the Nestucca spill on the Canadian marine environment. Some of the longer-term studies have already been initiated.

In addition to assessing the environmental impact, the environmental impact assessment team advised the Regional Environmental Emergencies Team (REET) on environmental sensitivities during the spill response.

1.5 Cleanup Methods

1.5.1 Containment and Recovery

No attempts at containment or recovery of oil at sea were possible, given the nature and location of the spill.

1.5.2 Shoreline Protection

Protection of threatened habitat and wildlife populations were considered in three cases.

First, as spill trajectories and aerial observations showed slicks or pans of oil to be drifting towards the Bunsby Islands, both CWS and DFO recommended that this area, an Ecological Reserve important for marine mammals and seabirds, be protected from oil if possible. REET considered possible protection measures, including application of dispersants or sinkants, and booming. Oil spill response experts advised that both dispersants and sinkants have to be applied quickly on fresh oil to be effective, and would be completely ineffective on the oil en route to Canada some three weeks after the initial spill. Dispersants are generally ineffective against Bunker C oils (NRC, 1989). Similarly, booms were rejected on the basis that the rough seas at the time would prevent even deployment, and thus effectiveness. On this basis, REET subcommittee decided not to request either of these techniques.

Second, after oil was observed in the Cape Scott area, CWS recommended placement of booms across the mouth of Hansen's Lagoon to protect wintering waterfowl. Again, REET decided against this on the basis that booms would be ineffective while heavy swells, driven by southwest gales, were breaking in the narrow mouth of the inlet.

Third, when the phenomenon of re-oiling was predicted on January 11, and observed on January 12, REET considered leaving oil on the shorelines until the re-oiling events ended, to save the cost of repeated cleanup. However, on advice of the Environmental Assessment Team, REET asked for shorelines to be cleaned as often as they were oiled, to remove as much oil volume as possible, and to minimize lifting of oil by high tides and storms and consequent redistribution of oil from contaminated to uncontaminated beaches. This was felt by on-scene staff to be an effective, though costly, strategy that minimized environmental damage in several areas.

1.5.3 Cleanup Techniques

Most of the oil was picked up manually by raking or shovelling oil and oiled debris and scraping oil from rocks and depositing it into plastic bags, which were collected and taken to temporary storage. Eventual disposal was by incineration in approved municipal incinerators. Some power equipment (e.g., a backhoe) was used to collect oil on accessible beaches near Tofino.

In several locations, Petromesh - an absorbent, commercial material - was used to scrape/absorb oil from rocks and cobbles.

In a heavily contaminated eelgrass bed in Stuart Bay near Ucluelet, Petromesh was anchored with rocks and oil-absorbing pom poms were deployed in sand and later recovered. This procedure was repeated until absorbent material began to appear clean.

Several other techniques were tested for applicability in the west coast winter environment:

1. Test burning of oiled rocks using gasoline gel.

Burning was assessed experimentally at the CCG Base at Amphitrite Point using a gasoline gel product to initiate combustion. Residue was submitted to the Conservation and Protection (C&P) lab for GC/MS analysis, and results forwarded to on-site staff. On the basis of these results, (see Sect. 3.1.10) and the general ineffectiveness of the technique, this product was not used operationally.

2. Test burning of oiled rocks with tiger torches.

Propane-powered Tiger torches were used on a trial basis in situ on a heavily oiled, cobble beach of considerable environmental sensitivity (Bajo Point). On the basis of general ineffectiveness and the increased mobilization of oil into gravel and as slick onto the water, this technique was not used operationally.

3. Burning of oiled logs.

Heavily oiled logs were burned at several locations including important tourist beaches in Pacific Rim National Park (PRNP), and on a number of islands in the Broken Island Group of PRNP. The latter included an important sea lion haul- out and tide pools important to tourists.

At some of the log burning locations - including Estevan Point, George Fraser Island and the Brooks Peninsula - bags of oil and oiled debris were also disposed of by burning, although this was not an officially approved waste disposal procedure.

4. Cropping of oiled eelgrass.
Eelgrass is a major contributor to detritus-based food webs supporting secondary production in marine ecosystems including Dungeness crab habitat and grey whale feeding habitat. Eelgrass beds in the Stubbs Island area are the primary food supply for migrating Brant (a small, coastal goose). When considerable oiling was found in these eelgrass beds at the start of Brant migration (early February) cleanup crews were sent to crop exposed, contaminated eelgrass at a low (1 m) tide to prevent ingestion by brant.

5. At Bajo Point, a heavily oiled cobble beach near a sea otter colony and adjacent to an archaeological site and existing Indian reserve, a reciprocating kiln was used to burn oiled cobbles and gravel. It was constructed in Ucluelet from plans provided by CCG, based on one built for the Arrow spill (1970). However, the burning was inefficient, apparently because of the small amount of oil remaining on the material or the limitations of the design throughput volume. Some of the most contaminated material was removed from the beach and transported to an abandoned log deck inland from the coast where it was burned.

2.0 METHODS

2.1 Areas of Special Concern

Information on areas of special concern during the spill response derived primarily from three sources: (1) published information such as reports and sensitivity/resource atlases available to on-site response staff, (2) knowledge of experts located on-site or consulted by phone/fax, and (3) data generated during the response by on-site specialists. This section describes those information resources available to, and used by, the environmental impact assessment team to identify environmentally sensitive areas during the spill response, January 7 to February 12, 1989. Locations of all environmentally sensitive areas identified, as well as oil stranding locations that threatened them, were entered into a geographic information system, "QUIKMap", by ESL Environmental Services Ltd. for production of the base maps and data overlays. Sample colour maps covering key resource areas are contained in the report by Duval et al, 1989.

2.1.1 Biologically Sensitive Habitats

Establishment of cleanup priorities on the basis of environmental values requires the knowledge of both important resources in an area, and sensitivity of those resources to oil pollution. Sensitive areas were identified with reference to a variety of sensitivity and resource atlases (LGL Limited and ESL Environmental Sciences Limited 1980; Guide to Ecological Reserves in British Columbia, 1983; Nassichuk and Millen, 1982; Harper and Sawyer, 1983; Department of Fisheries and Oceans 1985; Department of Fisheries and Environment 1978; Environmental Protection Service, 1978; Environmental Protection, 1975).

Supplementary information of fate and effects of oil in temperate and arctic marine environments was also available (Hodgson et al, 1987; Fingas, 1988 and 1987; Percy and Wells, 1984; ESL Environmental Sciences Limited et al 1986; Duval and Vonk, 1987; Duval et al, 1981; NRC, 1985).

Experts consulted on fate and biological effects of oil in marine environments included Dr. Peter Wells, Dr. John Vandermuelen, Gary Sergy and Dr. Wayne Duval.

2.1.2 Ecological Reserves and Marine Parks

Concerns related to oiling of Ecological Reserves were identified for on-site staff by Louise Goulet, Ecological Reserves Coordinator, B.C. Ministry of Parks. The reference document Guide to Ecological Reserves in British Columbia (1987) was the source of detailed maps of the six oiled ecological reserves provided to on-site cleanup personnel

(Harding, 1989). Locations of B.C. provincial marine parks were provided by the Ministry of Environment and Parks (1987).

Ministry of Parks staff conducted surveys of ecological reserves and provincial marine parks on several occasions from January 3 to January 21, 1989 and advised on-site staff of concerns (summarized by D. Fraser, memo to L. Harding, 31 Jan. 1989).

2.1.3 Seabirds

Oil affects birds by physical contact from loss of buoyancy and thermal regulation, and toxicity from ingestion. Concern for seabirds and waterfowl fall into three categories: wintering concentrations immediately at risk to oil, nesting colonies and individuals at risk if residual oil remains during breeding season, and birds at risk through ingestion of oil via contaminated prey or other food sources.

Literature available to on-site staff included sensitivity atlases noted above, seabird colony location maps, maps of seasonal distribution and densities of marine birds on the west coast (Vermeer et al, 1983), a draft inventory of seabird colonies of British Columbia with up-to-date (1988) data on nesting populations at the 93 known colonies (Rodway et al, 1989) and various reports on effects, or potential effects, of oil on seabirds (Vermeer and Vermeer, 1975; Hooper et al, 1987).

On-site seabird specialists included CWS biologists Moira Lemmon, Rick McKelvey, Gary Kaiser and Jean-Paul Savard and consultants Dr. Alan Burger and Michael Rodway.

CWS began survey of bird habitat on January 11 with two primary objectives: (1) identify wintering concentrations and (2) to identify which breeding colonies were sufficiently contaminated with oil to warrant cleanup. Winter bird concentration surveys were necessary because the information available (primarily Vermeer et al, 1983) was not specific to mid-winter and was of insufficient detail to locate specific bird concentrations threatened by oil. CWS survey data were summarized for REET daily, and mapped on hydrographic charts. Data from these charts were copied to digital computer files for use by "QuikMap". A preliminary report with full data tabulations was completed on February 10 (Rodway et al, 1989).

Several private veterinarians also advised on treatment of oiled birds.

2.1.4 Fisheries and Marine Mammals

Data from published resource map atlases noted above were transferred to hydrographic charts, updated and annotated by DFO fisheries officers,management biologists and scientists for shellfish, fish and marine mammals, and by Dr. Jim Darling of the

Whale Research Foundation for grey whales. This additional information was based on unpublished data and personal knowledge of resource distribution. Data from these charts were copied to digital computer files for use by "QuikMap". Economic value of shellfish resources affected by closures in Barkley and Clayoquot Sounds were provided by Harding and Langford (1989), supplemented by DFO specialists (e.g., current herring spawn harvest values).

Information on effects of oil on sea otters was derived from Davis et al (1988) and Williams et al (1988).

In addition to those noted above, experts consulted on effects of oil on marine mammals included Dr. John Ford of the Vancouver Aquarium and Dr. Tim Riley of RPI International, Inc. Private veterinary pathologists also examined dead marine mammals to determine causes of death.

DFO conducted extensive on-site surveys of threatened fisheries and marine mammal resources during the spill response.

1.5 Aquaculture

Finfish, shellfish and marine plant farm leases (including those for which applications were pending, but facilities not yet constructed) were available as plotted maps at 1:40,000 scale for digital files and base maps previously prepared by ESL Environmental Sciences Ltd. under contract to Environment Canada. On-site staff also had atlases showing biophysical suitability for net cage rearing of salmon (ESL Environmental Sciences Ltd., 1988). These data were also available on small scale hydrographic charts and data listings provided by Ministry of Agriculture and Fisheries.

Experts consulted included Bruce Kay (Environment Canada), Rudy Chiang (Fisheries and Oceans Canada) and Bob Cox and Baron Carswell (B.C. Ministry of Agriculture and Fisheries).

Ministry of Agriculture and Fisheries staff also conducted surveys of wild and cultured shellfish stocks in the affected area.

2.2 Physical and Chemical Studies

2.2.1 Oil Distribution

From January 4 to January 11 locations of oil observations were recorded on Canadian Hydrographic Service (CHS) charts at the environmental assessment team headquarters at Amphitrite Point. On January 11 a more formal record-keeping system was established. An oil spill classification rating system and an oil observation report form were prepared (Appendix 1) and distributed to field personnel. These forms were completed for all oil observations and reports received by environmental assessment personnel until February 22, 1989.

The cumulative lengths of affected coastline up to January 11 were estimated by field personnel. These observations were also recorded on CHS charts.

Later most records were entered into a dBASE III computer database; however, several of the map annotations up to January 11 were found, by examination of other records, to be overestimations of the area actually affected, and hence were deleted from the database or modified to reflect the more conservative estimates. These records were used to create oil location data files read by a Georeferenced Information System (GIS) as overlays on base maps. The base maps were digitized from CHS charts at the smallest scale available (usually 1:40,000 but also 1:77,000 and 1:150,000 for some areas of the coast).

2.2.2 Subtidal Oil Examinations

Private SCUBA divers were contracted by DOE to examine subtidal sediments during January and again in April to note changes in oil distribution, characteristics and concentration. Samples of subtidal and neutrally buoyant oil were collected during the January dives and forwarded to laboratories for density analysis.

DOE dives were completed as shown in Table 2. Numerous subtidal inspections were also made by DFO and Nuu-Chah-Nulth Tribal Council dive teams.

Table 2. DOE SCUBA dive locations and dates.

Date	Location	Depth (m)
January 11	Templar Channel near Stubbs Island	4.5
January 11	Ahous Bay near Vargas Island	11.0
January 11	LaCroix Group Rocks near Vargas Isl.	8.0
January 11	Rasser Pt. near Vargas Isl.	26.0
January 11	NW corner of Wickanninish Isl.	9.0
April 12	Ahous Bay near Vargas Island	10.0
April 12	LaCroix Group Rocks near Vargas Isl.	10.0
April 12	NW corner of Wickanninish Island	5.0
April 12	NW corner of Wickanninish Island	20.0

Subtidal sediment samples were collected from the research vessel, C.S.S. John P. Tully, during January 23-February 1, 1989. This was a joint DFO/DOE cruise, with DOE staff participating during January 23-28 and a DOE contractor during January 28-February 1. Objectives of the sediment sampling program were to (1) determine if subtidal oil deposits were occurring at the mouths of the northern inlets (Kyuquot Sound, Esperanza Inlet and Nootka Sound), as they were at the mouth of Clayoquot Sound (based on SCUBA dive observations and the occurrence of oiled crabs in commercial crab traps); and (2) to more fully determine (based on SCUBA dive observations and the occurrence of oiled crabs in commercial crab traps); and (2) to more fully determine the distribution of subtidal oil in the area of Clayoquot Sound and Long Beach.

The ship followed a zig-zag pattern within 40 km of the coast from Brooks Peninsula to Cape Beale, stopping for sediment grabs at inshore stations where the depth was between 100 and 25 metres. A total of 81 grabs were obtained with a Smith-MacIntyre grab. Samples were examined visually for presence of oil and eight were sub-sampled and frozen for chemical analysis. Water, neuston and plankton samples were also taken. A Remotely Operated Vehicle (ROV) was deployed to search for oil deposits in the Long Beach area, but was unable to operate because of the high sea state. The program and results are more fully described by Levings (1989).

2.2.3 Water Sampling

During the *Tully* cruise, water samples were pumped from stations at the inshore ends of transects and from Barkley Sound. Sample size was 25-30 litres, pumped through filters of mesh size 3.0 to 0.4 microns(Levings, 1989). At stations off Tofino and in Barkley Sound, vertical profiles were obtained at 2, 5, 15, and 25 metres. Filters were examined visually during the cruise for presence of oil and preserved for later chemical analysis.

Water samples were collected from surf and tide pools in heat treated, aluminum foil sealed glass jars on February 10 at three locations along Quisitis Point. They were submitted to the C&P laboratory for hydrocarbon quantification by Infra Red (IR) analysis.

Water column samples were again collected during March 23-27 at 11 stations in the Long Beach-Stubbs Island area at surface, 1 metre and near bottom depths. Methods and station locations are described by Waters (1989), included as Appendix 2. Samples were analyzed by Seakem Ltd. as described previously.

2.2.4 Beach Sand - Surface

Canadian Parks Service staff began walking beaches daily in the Long Beach Unit of Pacific Rim National Park on January 4 to note presence and amount of oil, and formalized oil observations on January 9 with the oil classification system referred to above (Appendix 1). Daily records were kept of oil amounts at six beaches: Florencia, Schooner, Long, Wickanninish, Combers and South. After January 30 oil "blobs" (i.e., oil lumps or patches which were usually between 1 and 10 cm diameter) were counted in 100 square metre transects along the high tide berm line, the only location where oil was consistently observed (Wilson, 1989). As well, the oil classification system (Appendix 1) was further refined to take into account the fact that oil was coming ashore follows:

Class 1:	No oil observed
Class 2 Light:	1-10 blobs/100 square metres
Class 2 Moderate:	10-50 blobs/100 square metres
Class 2 Heavy:	50-75 blobs/100 square metres
Class 3 Light:	75-100 blobs/100 square metres
Class 3 Moderate:	100-125 blobs/100 square metres
Class 3 Heavy:	125+ blobs/100 square metres

The number of blobs associated with each class type was determined by several 100 m * 1 m transects in each area.

2.2.5 Beach Sand - Subsurface

Beach sand samples were collected during January 14-16 at duplicate transects from high, medium and low tide zones, 0, 15 and 30 cm deep at 10 stations from Brooks Peninsula to Barkley Sound. The transects were at Brooks Peninsula, Ahous Bay (Vargas Island), Bajo Point, Combers Beach, Wickanninish Beach, Florencia Bay, Dicebox Island (Broken Islands), Wouwer Island (Broken Islands), Mayne Bay and Pachena Bay. Samples were collected in Whirlpac bags and analyzed by Seakem Ltd. using IR (quantitated against hexadecane) to quantify total hydrocarbons. Selected samples were analyzed at the Institute of Ocean Sciences by GC/MS to identify the hydrocarbons present and verify concentration of total hydrocarbons.

2.3 Chemical Analysis

2.3.1 Chemical Identification of Oil

Selected oil samples collected January 4 to March 7, from Keeha Bay on Vancouver Island to Flamingo Bay on Morseby Island (Queen Charlotte Islands) were matched against oil from the barge, Nestucca, by a variety of analyses. These included trace metal analysis by Inductively Coupled Argon Plasma Emission Spectrophotometer (ICAP), organic analysis by Flame Ionization Detection Capillary Gas Chromatography (GC-FID), oil and grease and total hydrocarbons by InfraRed Spectrophotometry (IR) and ratioing by Ultraviolet/Visible Spectrophometry (UV-VIS).

Identity was confirmed by noting the similarity of trace GC peaks, metal content, etc., compared to the Nestucca standard, taking into account weathering which may have reduced lower molecular weight fractions.

Oil samples were also analyzed by GC to determine the amount of weathering, by noting the similarity of chromatograms in the low molecular weight fractions, and to determine the effectiveness of cleanup technique tests.

2.3.2 Water and Beach Sand Samples

Extracted water and beach sand samples were analyzed by IR quantitated against a "standard" oil mixture of isooctane, benzene and hexadecane to determine the level of hydrocarbons, including non-petroleum hydrocarbons.

2.3.3 GC/MS Analysis by DFO

Samples of the January 14-16 beach sand survey were selected for further analysis by GC/MS on the basis of high IR results. These were from Brooks Peninsula, Wickanninish Beach, Combers Beach and Mayne Bay. The alkanes were quantified (using the M/Z 57 ion) were the n-alkanes from undecane (nC_{11}) to hexatriacontane (nC_{36}) inclusive and the branched alkanes norpristane, pristane and phytane. PAH were quantified in the range naphthalene to dibenzanthracene with emphasis on aromatics still left in the *Nestucca* oil.

3.0 RESULTS

3.1 Fate

3.1.1 Amount of Oil

Approximately 450 tonnes of oil and oily debris were recovered in B.C. (Rod Nelson, CCG, pers. comm. 2 May 1989) of which approximately 10% would have been oil (Ed Owens, pers. comm., Jan. 1989). More than 500 short tons, or 454 tonnes, were collected in Washington (Wash. Dep. of Ecology). If 10% of the total amount of oil and oily debris was oil, this would amount to about 11% of the approximately 850 tonnes spilled. Roughly 89%, or 757 tonnes, would therefore have been lost to the environment. If one assumes that most, or at least half, of the oil that came ashore was collected (the cleanup policy was to be as thorough as possible), then a rough estimate of the amount of oil that arrived on Canada's shorelines would have been about 50-100 tonnes.

3.1.2 Distribution in British Columbia

Oil observations locations are listed in Appendix 3. The broad distribution of Nestucca oil in B.C. is shown in Figure 3. Oil locations by time series are shown in Figure 4. More detailed time series for Barkley Sound, Nootka Sound, Checkleset Bay and Cape Scott are shown in the map folio, Appendix 4.

Oil generally was confined to outer islands and headlands. After initial strandings, oil was continually re-distributed, trending north with prevailing wind and currents. The first observation in Canada was on December 31, 1988 at Carmanah Point. It reached Barkley Sound on January 4, 1989, Nootka Island on January 7, Brooks Peninsula on January 13, Quatsino Sound on January 14 and Cape Scott on January 15. Nestucca oil (confirmed by chemical analysis) found on three islands off the northern Mainland near Bella Bella on January 27 was judged to have been deposited several days earlier. Oil was also reported at Sooke on January 14 and at Victoria on January 15.

Most records are of stranded oil on shorelines; however, incoming slicks or pans of oil were observed on the water off Barkley Sound, within Barkley Sound as far as Mayne Bay, off Long Beach, near Estevan and Escalante Point, in Checkleset Bay south of the Brooks Peninsula, and on the incoming tide at Triangle Island. Many light sheens were also reported throughout the area both during the initial strandings and for several weeks thereafter.

Oil was deposited subtidally as observed by SCUBA divers (see below) and inferred by the presence of oil on Dungeness crabs (Cancer magister) off Long Beach and the mouth of Clayoquot Sound. At some locations in this area nearly 100% of crabs caught in commercial traps were oiled in mid-January, declining to only a few percent by the end of March and remaining

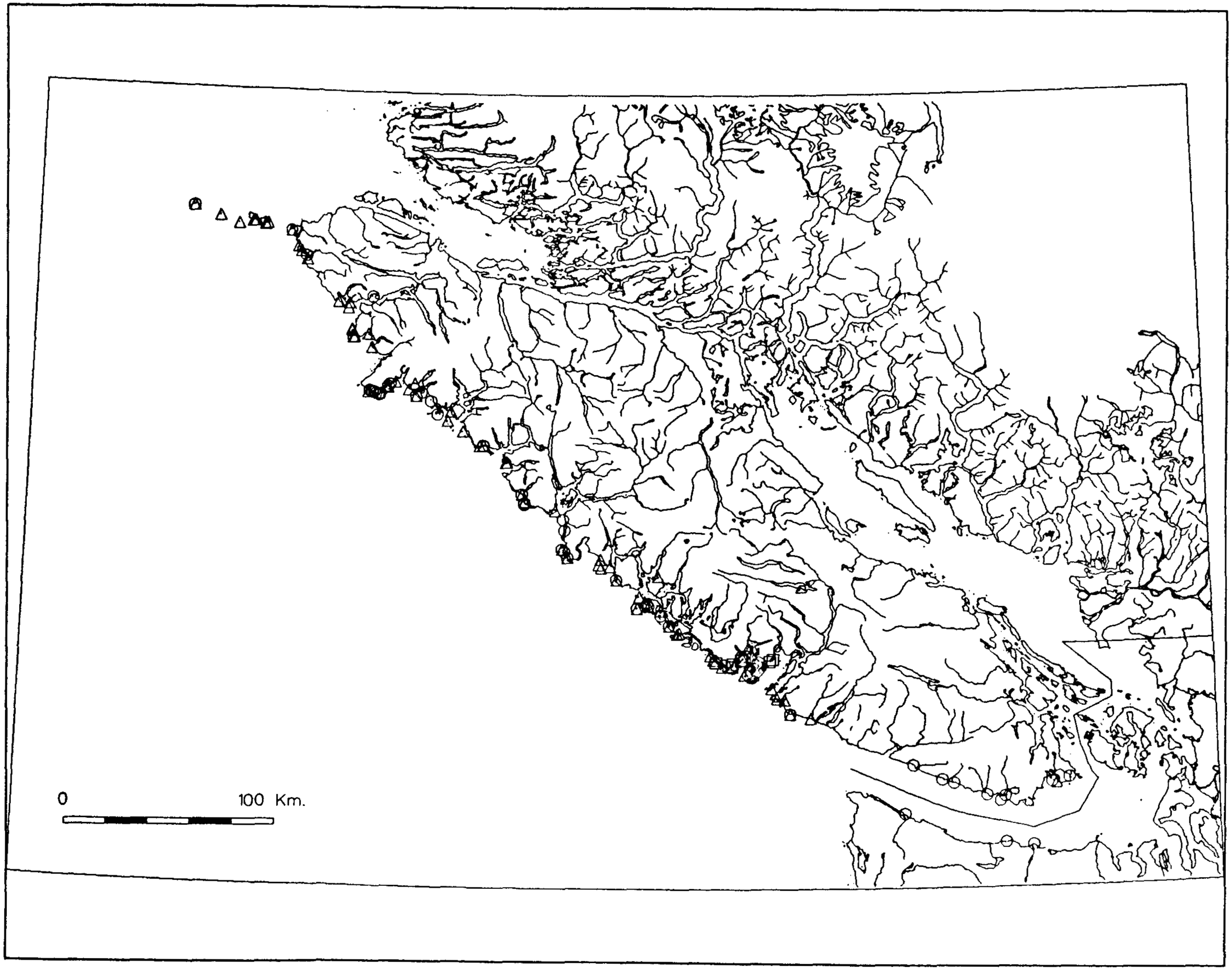
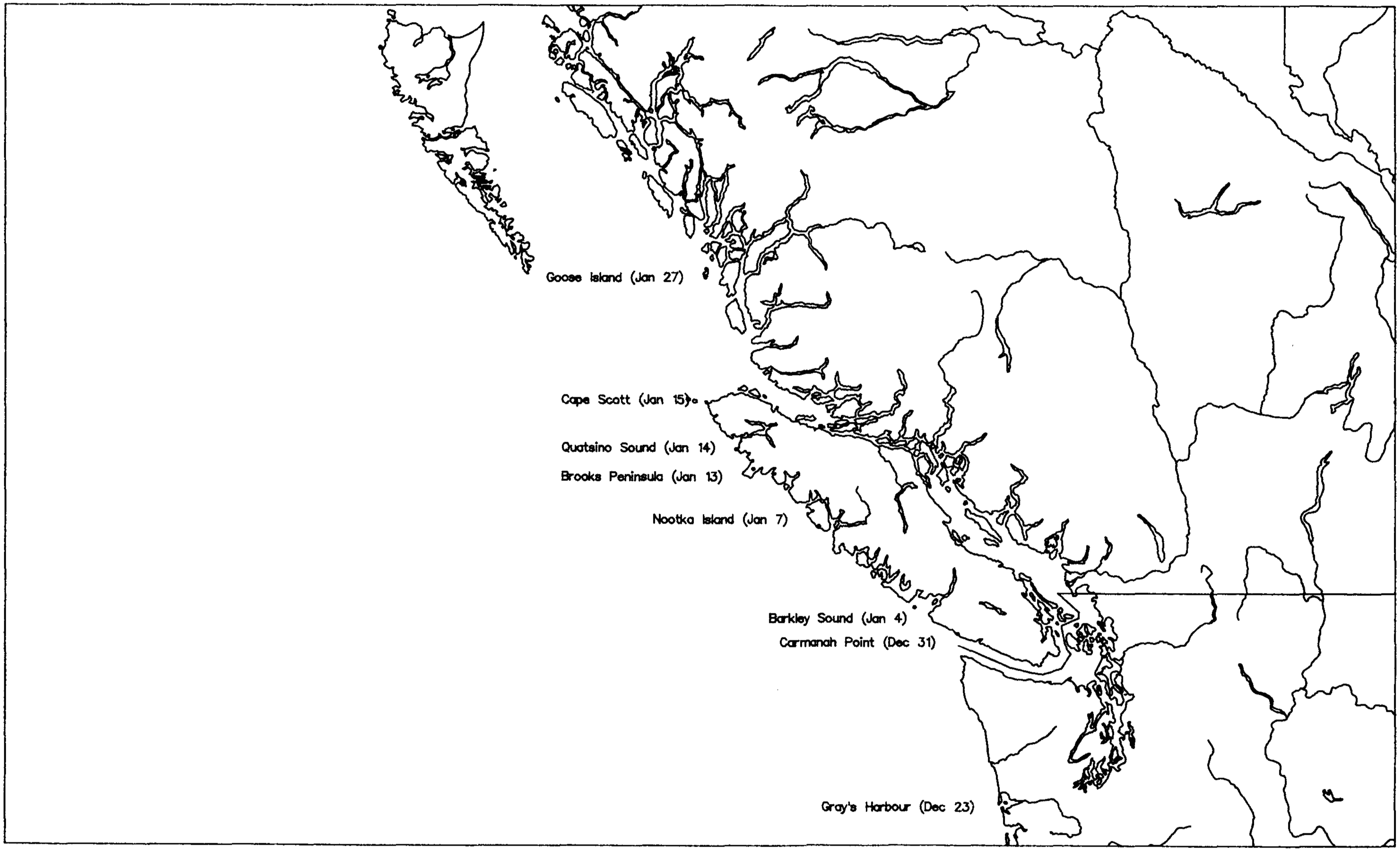


Figure 3. Distribution of oil observations along the west coast of Vancouver Island. Squares indicate observation from 31 December to 6 January; circles, January 7-15; and triangles January 16 through February.

Figure 4. Dates of first observation of oil at selected locations.



relatively constant since then (C. Levings, DFO, pers. comm.). However, extensive crab trapping by DFO off the mouths of inlets north of Clayoquot Sound to the Brooks Peninsula has not demonstrated the presence of subtidal oil in these areas (C. Levings. pers. comm.).

Multiple observations of stranded oil at one location on successive dates often included different estimates of length of shoreline affected, either because oil was removed by successive high tides, or because more was deposited. Taking the maximum length estimated for each location, and ignoring 43 locations were observers failed to record the length, a total of 152 km were affected. Of this, 2.0 km were heavily oiled, i.e., rated as Class 5. These estimates are subject to change as reports from other agencies and groups are assembled and analyzed.

3.1.3 Subtidal Oil Deposits

Subtidal oil was observed during two of the five SCUBA dives in the Stubbs Island-Wickanninish Island area in January. Divers reported a few 2-5 cm spheres of oil on the sea bottom at depths less than 7.9 m, and neutrally buoyant oil in the water column at this depth. A neutrally buoyant sphere of oil was collect and confirmed by GC-FID to be Nestucca oil, and submitted for density analysis (see below). The sinking rate of oil spheres released at 4.5 m was 5 cm/s. At one of the two sites, oil was also seen stuck to a commercial crab trap and on eelgrass. Divers also noted that oil drops placed on vegetation stuck to eelgrass, but not to algae.

During the four dives in April, no oil contamination was observed. Again, invertebrates and fish observed were visually uncontaminated and appeared healthy.

3.1.4 Density Analysis

Samples of neutrally buoyant oil collected by SCUBA divers in January were sent to the national environmental emergencies technology laboratory in Ottawa for density analysis by Fingas (1989). When the samples arrived, the neutrally buoyant oil had separated into a sunken blob and a much larger floating blob. The seawater was still clean and could also be analyzed for density. Two samples averaged 1.02295 and 1.0229 at 53C. Sunken oil was much heavier (1.0455 at 53C, mean of three runs) than water and the floating oil (1.0186 at 53C, mean of two runs). The heavy blob was examined in detail and found to contain small angular gravel, such as that derived from a beach. The oil extracted from the blob had a similar density to that of the floating oil. The beach material was therefore the source of the higher density.

The analyst concluded, based on these results, that:

"The neutrally-buoyant oil found during the dives was rendered such by the incorporation of beach material. This material was course (1 to 3 mm) and angular. The oil adhesion is temporary and resurfacing of some oil material would occur. The remaining oil would sink." (Fingas, 1989: in Duval et al., 1989)

The C&P laboratory also analyzed the neutrally buoyant oil sample by GC-FID and compared chromatograms to those of the Nestucca standard to confirm its identity.

3.1.5 Sediment Sampling

Of the 81 sediment samples collected during the Tully cruise between Brooks Peninsula and Cape Beale, none had definite oil contamination and two had traces of blackish material that may have been oil (Levings, 1989). Results are not yet available for the eight samples retained for chemical analysis.

3.1.6 Water Sampling

Of 49 water samples pumped from various depths during the Tully cruise between Brooks Peninsula and Barkley Sound, none showed definite oil on the filters (Levings, 1989). On two filters, traces of blackish material that may have been oil were noted. The samples currently await chemical analysis by DFO.

Three water samples were collected along Quisitis Point, where a high percentage of Dungeness crabs were oiled and shorelines were repeatedly oiled, on February 10 when oil contamination was still visible on rocks and eelgrass. The samples contained 0.6, 2.5 and 0.4 mg/l total hydrocarbons by IR analysis. It is not known what proportion, if any, are petroleum hydrocarbons.

Based on these preliminary results, more extensive water sampling was undertaken under contract to DOE during March 23- 26 in the Tofino-Stubbs Island area (Waters, 1989; Appendix 2). Fifty-one samples were analyzed by Seakem Ltd. for hydrocarbons by IR analysis. Results were negative: no hydrocarbons were detected at detection limits of 0.13-0.15 mg/l.

3.1.7 Oil in Beach Sand - Surface

Bunker C from the Nestucca was at sea from 1-3 weeks before stranding in coastal areas of Vancouver Island and would have undergone substantial "weathering" during this period, despite the low air and water temperatures in January (ref Sect. 3.1.9). Loss of some low molecular weight fractions in all samples was confirmed by GC analysis with comparison to the Nestucca standard.

After initial oiling, some shorelines experienced repeated re-oiling, as tides, wind and ocean currents redistributed oil throughout the region, or uncovered oil that had been buried in beach sands or subtidal sediments. Most significant re-oiling had tapered off by the end of January, although a general re-oiling about March 7 affected shorelines on Long Beach and the Brooks Peninsula. Chemical analysis confirmed this as Nestucca oil (ref Sect. 3.1.9).

Continuous monitoring in the Long Beach unit of Pacific Rim National Park shows trends that were probably representative of other relatively heavily oiled areas (Wilson, 1989).

Though not formally classified, some of the beaches cleaned by volunteers during January 3-9 were probably of Class 5 Heavy at least for some portion of the high tide zone. Oil contamination on beaches in the Long Beach Unit of Pacific Rim National Park declined from Class 4 Medium to Heavy during January 9-12, to Class 2 Light on all six beaches monitored by January 30. Elevations in classification (e.g., from 3 to 4 or from Light to Moderate) occurred repeatedly during January 14-28, indicating re-oiling. These beaches were cleaned repeatedly by volunteers.

Light Class 2 (using the modified classification system) persisting through March on all six Park beaches indicates continued, low-level contamination. A general re-oiling event occurred during March 6-7 when Long Beach and Combers Beach were elevated to Class 3 Light to Moderate. The incoming oil was in the form of shot-sized pellets and 1-10 cm blobs. Re- oiling at this time also occurred on the south coast of the Brooks Peninsula and on islands south of Amphitrite Point in sufficient amounts to warrant cleanup (K. Hebron, pers. comm.). Parks data shows that small (1-10 cm) blobs of oil were still being deposited through April, and oil deposits large enough to warrant cleanup were still being discovered, or uncovered at that time.

Many observers noted that even when oil was not visible on the sand, shoes and boots still accumulated a considerable amount of oil after a short walk (known as the "white boot test"). Oil in this case probably occurred either adsorbed to sand grains, or as droplets in interstitial water, in addition to the visible blobs.

3.1.8 Oil in Beach Sand - Subsurface

Samples from duplicate transects at high, medium and low tide at 10 beaches from Brooks Peninsula to Barkley Sound were submitted to a private laboratory (Seakem Ltd.) for analysis. Results for January and March are given in Appendix 4 and summarized in Table 3. In January and March the Brooks Peninsula samples contained no IR detectable hydrocarbons (the station was about 2 km north of the known oiled beaches). The Pachena Bay station had only one of 18 samples with detectable hydrocarbons (2.6 ug/g) and was not resampled in March. Of the other beaches, Mayne Bay had the most widely (evenly) distributed hydrocarbons, up to 45 ug/g in January, while Florencia and Wickanninish Beaches had the highest levels (250 ug/g and 542 ug/g, respectively) in January. By March most hydrocarbon levels had dropped to less than 35 ug/g, although a high of 117 ug/g was recorded at Mayne Bay. In March, 4 of the original 10 beaches had no IR detectable hydrocarbons and these were not scheduled for re-sampling in June.

Table 3. Range of total hydrocarbons (ug/g) by IR in 18 samples from each of 10 beaches sampled in January and March, 1989 (duplicate transects at high, medium and low tide, 0, 15 and 30 cm depth; n.d. means not detected at a detection limit of 1.0 ug/g; n.s. means not sampled).

Beach	January	March
Brooks	n.d.	n.d.
Bajo	n.d.-7.0	2.0-3.5
Dicebox	3.0-5.0	n.d.
Mayne	n.d.-45	10-118
Wouwer	n.d.-12	4.0-35
Florencia	n.d.-250	n.d.-2.5
Wickanninish*	n.d.-542	n.d.-8.0
Combers	n.d.-25	n.d.
Pachena	n.d.-2.6	n.s.

*Nestucca verified.

Preliminary analysis by GC/MS of four samples from the above set was provided by Walter Cretney, I.O.S. (Table 4). Only the Wickanninish Beach sample contained PAH that could be attributable to the Nestucca oil. The PAH in this sample were about 10% of the quantified alkanes in amount. The PAH in the rest were about 1-4% of these alkanes. The area of the MS reconstructed ion chromatogram (RIC) less the area of internal standards was divided by the area of the quantified compounds to give a multiplication factor for estimating the total organics in the samples in the nC_{11} to nC_{36} range. Only the Mayne Bay sample contained an unresolved complex mixture (UCM). This sample also contained some sulfur. The UCM was not included in the multiplication factor determination. Gravimetric concentrations by Seakem Ltd. were in line with those determined by GC/MS. Quantitation results are given in Table 4.

Table 4. Preliminary quantitation by GC/MS of petroleum hydrocarbons in beach sand (ug/g). T1 or T2 refer to Transect 1 or 2 of duplicate transects; HT, LT and MT are High Tide, Low Tide and Medium Tide; 0, 15 and 30 cm are depths in the beach from which samples were taken.

	Wick. Beach	Combers Beach	Mayne Bay	Brooks
	T1,HT,0cm	T2,LT,15cm	T1,MT,0cm	T2,HT,15cm
Alkane/PAH	0.033	0.0056	0.031	0.05
Total organics	2.2	1.8	8.2	0.65

3.1.9 Chemical Identification of Nestucca Oil

Twenty-four samples were submitted for chemical "fingerprinting" against the *Nestucca* product. These included samples collected on beaches during January 4 - March 7, from Keeha Bay to Moore Island near Bella Bella on the northern mainland. Table 5 gives the dates and locations of oil samples analyzed for comparison with the *Nestucca* barge standard.

GC-FID analysis of the *Nestucca* barge product provided a chromatogram consistent with the sample being a petroleum oil falling within the range of a "Bunker C" type fuel. The hydrocarbon range is primarily in the C_{12} to C_{26} range with traces between the C_{10} to C_{12} and C_{26} to C_{38} ranges. The ratio of the *Nestucca* sample UV-Visible absorbances at 228 nm and 256 nm is also consistent with that obtained from a laboratory standard of Bunker C (1.64 vs 1.78 respectively).

RESULTS: FATE

Table 5. Sample dates and locations for oil identification

Date	Location	Positive Match
25 Dec	Portland, OR (Nestucca)	-
9 Jan	Nootka Sound	yes
11 Jan	Keeha Bay	yes
11 Jan	Keeha Bay	yes
12 Jan	Cleland Island	yes
15 Jan	Guise Bay	yes
16 Jan	Quisitis Point	yes
16 Jan	Wickanninish Beach	yes
21 Jan	Side Bay	yes
24 Jan	Gilbert Island	yes
27 Jan	Tatcho Point	yes
27 Jan	Moore Island	yes
27 Jan	Goose Island	yes
1 Feb	Gilbert Island	yes
2 Feb	Brooks Peninsula	yes
10 Feb	Quisitis Point	no
23 Feb	Keeha Bay	yes
23 Feb	George Fraser Isl.	yes
23 Feb	Brabant Isl.	yes
24 Feb	Flamingo Bay (QCI)	no
24 Feb	Flamingo Bay (QCI)	no
24 Feb	Flamingo Bay (QCI)	yes
9 Mar	Friendly Cove	yes
9 Mar	Clerke Point	yes
10 Mar	Black River	yes

The 24 samples from the B.C. coast each contained petroleum hydrocarbons. Of these, 21 samples provided GC-FID patterns characteristic of weathered Bunker C type fuels. Varying degrees of weathering were exhibited in each sample, primarily in the C10 to C15 range. The samples also provided a good GC-FID match, weathering considered, to the Nestucca barge source sample. The ratios of the samples' UV-Visible absorbances at 228 nm and 256 nm were consistent with a single source for the samples and yielded an average value of 1.38 (S.D. = 0.04). A subsample of the Nestucca barge sample artificially weathered in the laboratory provided a ratio of 1.47 (a decrease from 1.64 in the unweathered sample), consistent with other data from this lab showing that this ratio decreases as sample weathering increases.

Figures 5 and 6 compare the chromatogram of a typical sample from the B.C. coast (9 January, Nootka Sound) with that from the Nestucca barge sample.

Metal analysis provided an average Nickel/Vanadium ratio of 0.40 (S.D. = 0.11) for the samples from the B.C. coast, compared to 0.42 for the Nestucca Barge sample.

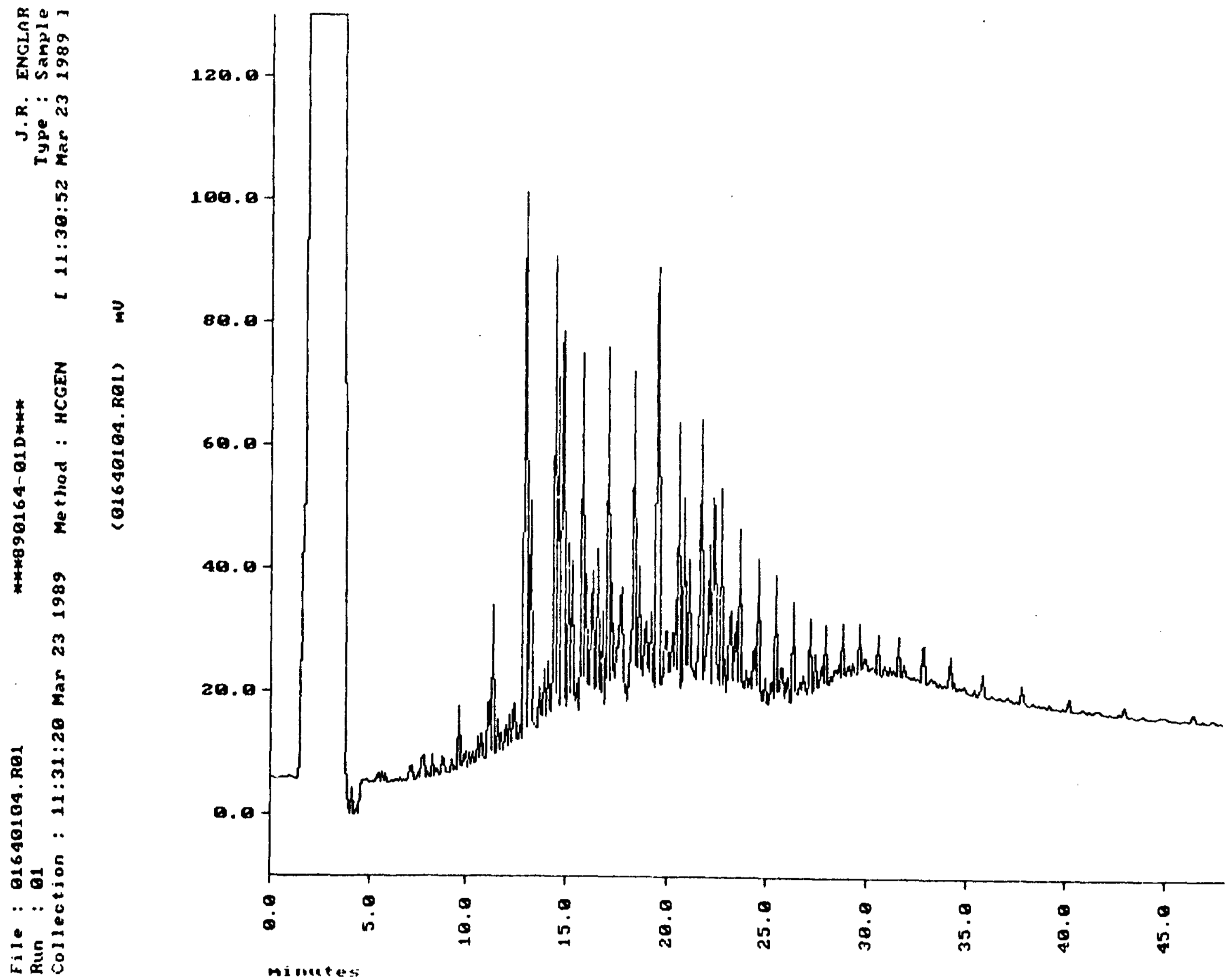


Figure 5. Nestucca oil gas chromatogram. Sample taken at Portland, Oregon, December 25, 1988.

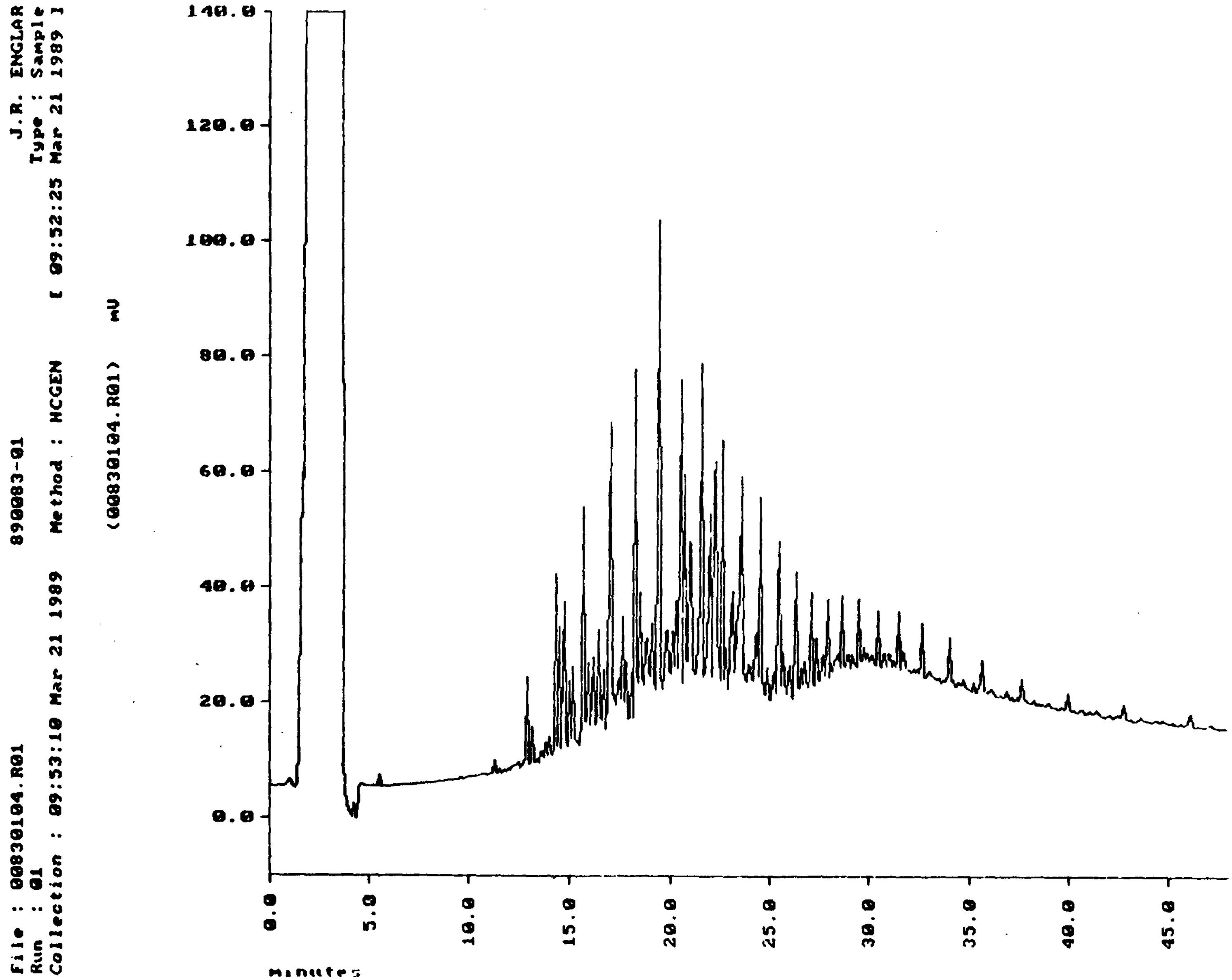


Figure 6. Gas chromatogram of oil from beach at Nootka Sound, January 9, 1989. Note similarity to Figure 5, except for loss of low molecular weight fractions.

Of three samples of oil from Flamingo Bay (Queen Charlotte Islands) two were Bunker C petroleum hydrocarbons, but did not match the Nestucca sample. The third, also Bunker C, provided a reasonable match (considering the strong weathering evident in this sample).

A sample from Quisitis Point collected on February 10 also did not match the Nestucca sample. It was a 6.0 cm "tar ball", clearly different in form, texture and colour than the bulk of the oil contaminating the beaches. The GC-FID chromatograms indicated that it was probably a mixture of two types of petroleum hydrocarbons (a diesel and another higher boiling point HC) that were much more highly refined than the standard marine fuel oils. It could not be matched with any of the laboratory standard petroleum hydrocarbons. Only two such tar balls were observed by environmental assessment personnel during the spill response. These plus the two Queen Charlotte Island samples that did not match the Nestucca standard, demonstrate a low level of background oil contamination in the northeast Pacific Ocean, undoubtedly from tanker traffic. It should be noted that all other samples from Quisitis Point and surrounding areas proved to be Nestucca oil.

3.1.10 Burning Trials

Figure 7 shows a chromatogram of residue derived from test burning of oiled rocks with Napalm, overlaid with a chromatogram from the Nestucca barge sample (dotted line). The more volatile fractions of the Bunker C from the barge (on the left side of the "envelope") were reduced significantly by the test burn. However, the heavier, less volatile components introduced by the Napalm are very evident. These two features indicate that only low temperature combustion occurred.

3.2. Biological Effects

This section is based on Duval et al (1989) except where noted.

3.2.1 Plant Communities

The Nestucca spill resulted in some mortality and damage to plants within the intertidal zone. Much of the oil-contaminated debris removed by clean-up crews during shoreline restoration programs was eelgrass and intertidal algae. Oil adhered to eelgrass more than to algae, and limited contamination of eelgrass beds in low intertidal and shallow subtidal zones was observed.

The salt-marsh habitat within Friendly Cove on Nootka Island was extensively contaminated with Bunker C and required an intensive clean-up effort. Despite efforts to remove most of the oil-contaminated marsh vegetation from Friendly Cove, some oil

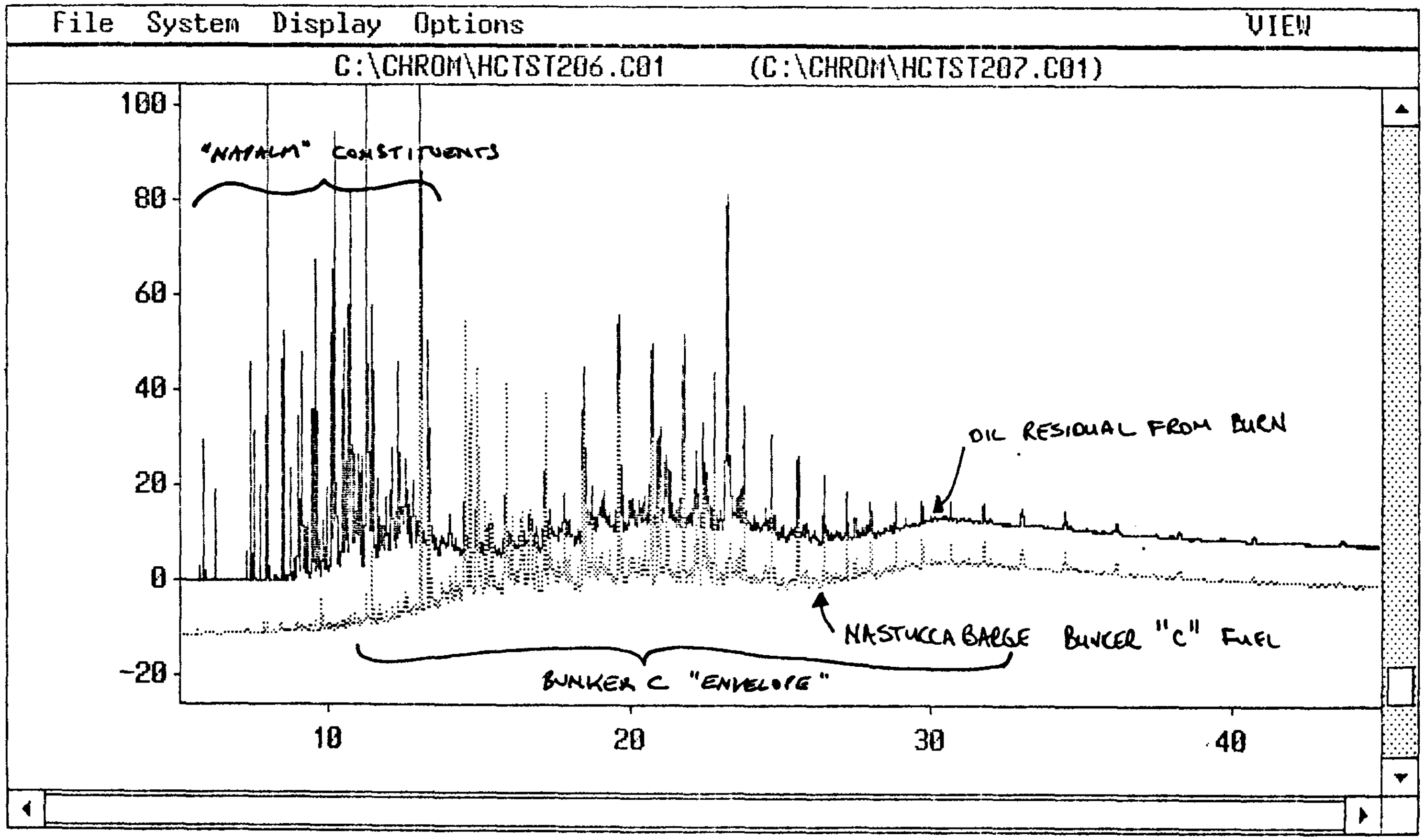


FIGURE 7: COMPARISON OF NESTUCCA OIL CHROMATOGRAM WITH CHROMATOGRAM OF RESIDUE AFTER BURNING OIL OFF INTERTIDAL SUBSTRATES USING A GASOLINE GEL PRODUCT (NAPALM)

NOTE: RETENTION OF HIGHER MOLECULAR WEIGHT NESTUCCA OIL CONSTITUENTS AND ADDITION OF LIGHTER FRACTIONS IN RESIDUE.

penetrated the sediments. Marsh grasses can be severely affected by oil contamination and can require many years to recover. This is because of the tendency of oil to penetrate and persist in the sediments, thereby resulting in long-term toxic effects due to the uptake of petroleum hydrocarbons through the root systems of these plants.

3.2.2 Benthic fauna

SCUBA divers contracted by DOE examined benthic fauna at five locations where oiled crabs were reported in the Long Beach-Stubbs Island area (see Sec. 2.2.2). A variety of invertebrates (olive shell snails, sea cucumbers, sea pens, Anthopleura sp. and Tealea sp. anenomes, rock scallops, abalone, white cap limpets, Callistoma sp. snails, California mussels, horse clams, orange cup coral), as well as juvenile flounders, kelp greenling and spiney lumpsuckers, were visually uncontaminated and appeared healthy. During the four dives in April, invertebrates and fish observed were also visually uncontaminated and appeared healthy.

Some mortality could have occurred in subtidal habitats adjacent to extensively oiled shoreline areas, although these areas are expected to be relatively limited in spacial extent (e.g., sporadically along the few beaches that experienced heavy oiling). Mortality of infauna has been documented infrequently following bunker fuel spills (Duval, 1985; NRC, 1985).

Large numbers of dead Dungeness and other crabs, as well as shed exoskeletons (normal during the moult), were observed from time to time during the spill response period. On one occasion large numbers of dead urchins were reported on a beach near Pachena Bay (Doug Swanston, pers. comm). It is not known whether these represent unusual or natural mortality. Crustaceans (e.g., crabs) and echinoderms (e.g., sea urchins) are the predominant taxonomic groups comprising the epifauna, with the former suffering greatest losses following oil spills (Duval, 1985; NRC, 1985). Echinoderms are also very sensitive to hydrocarbons as shown at many other marine oil spills. The fact that oiled Dungeness crabs were recovered from traps in the Long Beach-Stubbs Island areas indicated that exposure occurred in at least some habitats. Oiled crabs were still being reported at the end of March, 1989.

3.2.3 Intertidal Invertebrates

Observations of dead gammarid amphipods on oil mats indicate that some losses of intertidal fauna occurred in most areas where oil stranded, but the size of extensively-oiled areas was small in comparison to the amount of immediately adjacent uncontaminated habitat along all parts of the coast. Intertidal invertebrates have often been one of the most visibly affected biological resources following oil spills (Duval, 1985; NRC, 1985). The dominant taxonomic groups in rocky areas are gastropods, (e.g., limpets, snails), sessile crustaceans (e.g., barnacles) and some bivalve molluscs (e.g., mussels), while other bivalves (e.g., clams and oysters) and highly mobile crustaceans (e.g., amphipods) tend to predominate in sandy habitats. The most common cause of mortality among intertidal species is smothering by thick layers of stranded oil. There is often complete elimination of intertidal fauna in heavily-oiled areas, and this likely occurred in heavily oiled sections of shoreline.

Opportunities exist for recolonization of affected areas through recruitment once oil begins to naturally disperse from these habitats. In addition, most intertidal fauna reproduce during the spring and summer, and the associated larval settlement will greatly accelerate the recovery process through recolonization by natural dispersal of individuals from uncontaminated areas, providing that the habitat is amenable to recolonization, i.e., no substantial amount of oil remains.

3.2.4 Fish

One of the concerns related to this spill was the potential impacts of Bunker C in shallow subtidal habitats in important herring spawning areas such as the northern shoreline of Barkley Sound. Herring adults, eggs, larvae and juveniles occupy certain nearshore habitats and are highly vulnerable to oil pollution. Eggs and larvae at certain stages are very sensitive to hydrocarbons (NRC, 1985). With the exception of oil along the western shore of Barkley Sound between Toquart Bay and Ucluelet, there was no extensive oiling of herring spawning sites.

Even in this areas, where light oiling stranded at the high tideline along certain beaches, extensive SCUBA diving showed no contamination of either the sea floor or the plants that herring use as substrates for spawning. An exception was a heavily oiled herring spawning area in Stuart Bay at the mouth of Ucluelet Inlet, which required intensive clean-up. DFO investigators noted, however, that most herring did not spawn in areas of Barkley Sound that they had used historically, and instead spawned among the Broken Islands Group and near Mayne Bay (Mike Flynn, pers. comm.). As these areas were also oiled and historical spawning records indicate occasional changes of this type from time to time, it is not clear if the change was a response to oil contamination.

Organoleptic test results for herring and herring spawn were negative.

There are numerous salmon spawning steams, estuarine habitats and nearshore salmon rearing areas along the west coast of Vancouver Island. Generally these are located along sheltered portions of the coast and were not directly affected by oil from the Nestucca. No impacts on salmonids were identified in DFO's preliminary analysis dated February 22, 1989 (Duval et al, 1989).

The impact of this oil spill on other fish species such as Pacific cod, rockfish and lingcod is largely unknown. Bottom-dwelling fish in the few areas where oil was expected to reach the seafloor may be affected if their habitat or prey were contaminated by oil. Although some reports of oiled rockfish and lingcod were received, DFO has been unable to obtain any samples of oiled fish to verify this problem (J. Davis, pers. comm.).

3.3.5 Birds

The most apparent initial impact of the Nestucca spill was the death of at least 12,877 seabirds in British Columbia and Washington. A total of 3,568 birds were found on the west coast of Vancouver Island. The vast majority of these were found dead, although a handful died at treatment centres. These figures do not include those that recovered and were released from treatment centres. A preliminary tally of 9,309 birds were found dead on Washington beaches or did not respond to treatment (Don Kane, U.S. Fish and Wildlife Service pers. comm, cited by Rodway et al, 1989). Preliminary analysis of dead bird data from Washington and British Columbia, considering the number of birds that sank before landing and those that landed but were not found, suggests that at least 16,000 and perhaps as many as 20,000-30,000 seabirds died as a result of the Nestucca spill (Burger, 1989).

Dead birds were found over the entire length of Vancouver Island from Sooke to Cape Scott, although most birds were recovered from beaches within Pacific Rim National Park and the Tofino/Clayoquot Sound area. This is at least in part because of the intensity of the cleanup efforts in these areas.

In B.C. investigators counted 31 species. Common Murres were the major victims in Washington (about 80%) and Common Murres and Cassin's Auklets (42% and 32% respectively) were most affected in B.C. World populations of those species are not threatened, but local populations are possibly at risk. Only 5,620 Common Murres are estimated to breed in B.C., with the majority nesting on Triangle Island off the north tip of Vancouver Island (Rodway et al, in prep). Where those birds winter is unknown. Over 2.3 million Cassin's Auklets breed in the province (Rodway et al, in prep), but where local populations winter is again unknown. The overall impact of this spill on Canadian populations of these and other bird species will not be known until summer breeding ecology surveys have been completed.

3.3.6 Marine Mammals

During the response to the Nestucca spill, top priority was given to assessment of two sea otter colonies where significant amounts of oil were observed. Sea otters are an endangered species in Canada and, at present, the only two colonies known in Canada are at Checkleset Bay and Bajo Reef on Nootka Island. In addition, sea otters are known to be both highly vulnerable and sensitive to oil exposure. The otter colonies were monitored on a regular basis by DFO with assistance from Vancouver Aquarium staff. Aerial surveys showed lower sea otter population counts than in previous years (Ford, 1989); however, the counts during the spill were conducted under winter conditions when observation was difficult and are not comparable to a proper, summer population census. One oiled, dead animal was collected and the cause of death was confirmed to be related to oil. Almost certainly more than one otter was killed by the oil, but the accurate estimate will not be available until proper surveys can be conducted during the summer (Ford, 1989).

Although some oil-contaminated seals and sea lions were reported, significant impacts of the Nestucca spill on these populations are considered very unlikely. In all cases, the animals appeared healthy and exhibited normal behaviour. Totals of eight seals, 18 sea lions and two elephant seals and two river otters (K. Langelier, pers. comm.) were either found dead or were reported to be oiled (Olesiuk, 1989). In cases where mammal specialists were able to examine the carcasses, causes of death appeared not related to oiling (J. Davis, pers. comm.; K. Langelier. pers. comm.).

Grey whales migrated normally during February-April, with no unusual behaviour or deaths reported (J. Darling. pers. comm.). DFO is currently conducting surveys of grey whale feeding habitats to ascertain if benthic areas are contaminated.

3.2.7 Crabs and Shellfish

On January 6 DFO closed Statistical Area 23 (Barkley Sound) to commercial bivalve harvesting as a precautionary measure, pending results of organoleptic testing (i.e., smell, taste and visual examination for presence of oil). Similarly, a precautionary closure for commercial mussel and gooseneck barnacle harvesting was put in place for all of area 24 (from Amphitrite Point to Estevan Point, including Clayoquot Sound). Local people were advised not to eat shellfish from contaminated beaches during these closures. The area of shellfish closures was 750 km of coastline (56,000 ha) in Area 23 and 960 km of shoreline (49,000 ha) in Area 24.

Samples were collected from Statistical Areas 20 through 27, covering the entire west coast of Vancouver Island (DFO

Organoleptic Test Database dated 20 March 1989). The samples included bay mussels, California mussels, Pacific oysters, Olympia oysters, gooseneck barnacles, chitons, Dungeness crabs, a variety of clam species including manilla, littleneck, geoduck and horseclams, red and purple sea urchins and sea cucumbers.

Following testing, the precautionary closure of harvesting from shellfish leases in Area 23 was lifted for oysters on January 18, and for all species on January 20. The closure was lifted January 25 in Area 24.

Three statistical sub-areas (124-1, 124-3 and 124-8 near Tofino), where crabs and crab traps were oiled, were closed to crab harvest on January 18. The frequency of oiled crabs in test samples declined gradually and by the end of April only a few individuals in both locations were still oiled (C. Levings. pers. comm.). This closure remained in effect through May due to persistent oiling of crabs and concerns about the possibility of such crabs entering the market. The commercial crab fishing areas affected are among the most important in the area.

In northern areas, although isolated samples of sea mussels failed inspection tests (at Grants Bay, Morpheus Island and Maquinna Point), closure was not warranted.

Shellfish from these areas are important in the diet of many local families, especially native people. These areas are normally open for commercial bivalve shellfish harvesting during November-March and closed during the remainder of the year due to PSP contamination. Area 23 is generally open for the full 4-5 months.

Non-commercial harvest areas on the outer coast were also oiled, and local people were advised not to eat these shellfish.

3.2.8 Fish and Shellfish Farms

Fish farms on the west coast of Vancouver Island are located in protected areas away from the exposed headlands and islands that received most of the oil following the Nestucca spill. As a result, the event had little effect on the salmon farming industry in this region. Traces of oil were seen at four salmon farms, although no damage or loss of sales were reported.

Shellfish leases and wild stocks of shellfish are generally located in sheltered bays and along protected areas of the shoreline. Because most of the oil from the Nestucca affected exposed outer coast areas, there was little impact on shellfish resources. No cultured oyster stocks were reported to be contaminated as a result of this spill, and only one area of wild stock harvest (Mayne Bay) was contaminated. Commercial clam diggers in the Barkley Sound area had to forego potential clam harvests from 21 tides during January due to both the shellfish closure and the possibility that the harvest could not be marketed.

3.2.9 Parks and Natural Areas

All three units of Pacific Rim National Park (PRNP) and six B.C. Ecological Reserves, (Anne Valle Island, Sartine Island, Beresford Island, Solander Island, Checkleset Bay and Beria Rocks) were oiled to some extent. Within the Broken Islands Group and the Long Beach units of PRNP and within Checkleset Bay, oiling was heavier and more extensive and required cleanup in many locations. Along the West Coast Trail unit and at the other Ecological Reserves, oiling was spotty and required occasional clean-up.

Local people were concerned that the widespread, low-level contamination of recreational beaches may cause a significant decline in tourism during 1989. Potential visitors to the west coast may be concerned that their personal enjoyment will be reduced due to the presence of oil on the beaches, particularly if they perceive that environmental quality, wildlife and park beach resources have deteriorated as a result. If this is the case, the direct and indirect economic impact, in terms of local employment, future investment and expansions to tourist facilities could be significant. From a tourism and recreation perspective, the park is internationally recognized as an accessible, protected, and natural coastal environment. Half a million tourists visit the park annually to view and experience a variety of unique and ecologically sensitive environments. The impact, if any, of the Nestucca spill on tourism to this area will become evident later in the year.

Ecological Reserves contain unique biophysical features that make them essential in the life cycles of certain species, and for ecological research. The effect of even light oiling on their use for continuing and future research is as yet not known.

3.2.10 Sensitive Areas

A total of 854 environmentally sensitive areas were identified. These included 93 migratory bird nesting colonies, 13 winter seabird concentrations, 230 native resource harvest areas and 443 fisheries and marine mammal habitats. Locations are shown on colour maps included in the perliminary evaluation by Duval et al (1989). Detailed information on seabird numbers and species breeding at each colony is given by Rodway et al. (1989), a draft of which was provided to on-site personnel by the senior author. Tables 6 and 7 give the number of locations identified for each resource and the code used in the maps referred to above. Bird concentration areas are indicated on the maps by a standing seabird symbol for nesting colonies and a floating seabird symbol for winter concentrations.

RESULTS: BIOLOGICAL EFFECTS

Comparison with the oil location maps shows the areas of potential impact on biological resources and native harvest areas.

Table 6. Numbers of Fish and Marine Mammal Habitats identified.

RESOURCE	CODE	NUMBER OF LOCATIONS
WHALE FEEDING AREA	W	23
CRABS/PRAWNS/SHRIMP	C P S	11
GEODUCK	G	64
FINFISH FARM	FF	16
HATCHERY/GROWOUT SITE	HGS	1
CLAMS/OYSTERS	CO	175
HERRING SPAWNING	H	80
GOOSENECK BARNACLES	GB	21
ABALONE	A	14
SEA URCHIN	U	14
SEALS	S	31
SEA LIONS	SL	9
SEA OTTERS	SO	7

Table 7. Numbers of Native Resource Harvest areas identified.

RESOURCE	CODE	NUMBER OF LOCATIONS
ABALONE	A	13
GOOSENECK BARNACLES	B	5
CLAMS	C	71
CHITONS	Ch	14
CRABS	Cr	14
SEABIRD EGGS	E	2
FISH	F	6
GEESE AND DUCKS	G	21
HALIBUT	H	15
HERRING	He	5
HERRING ROE	Hr	11
HARBOUR SEAL	Hs	11
LING COD	L	18
MUSSELS	M	19
OYSTERS	O	23
ROCK COD	R	18
SALMON	S	33
SCALLOPS	Sc	5
SEA LION	Sl	5
TROUT	T	2
SEA URCHINS	U	25
WEAVING GRASS	W	1

*Code refers to map codes in Duval et al, 1989

4.0 COMPARISON WITH OTHER BUNKER C SPILLS

This section reviews the fate of oil and effects observed in some other Bunker C spills: the Arrow spill of 9,400 tons into Chedabucto Bay, N.S. in February, 1970 and the Argo Merchant spill of 223,000 tons off NE U.S. in December, 1976. Some information on fate of Bunker C is also available from a spill into San Francisco Bay in 1981.

4.1 Fate

4.1.1 Water

After the Arrow spill, small oil droplets (5 um to 2 mm size) formed by surf and wave action were found in the water column down to 80 m (Forrester, 1971; in NRC, 1985). Zooplankton (copepods) ingested small particles and their feces contained up to 7% Bunker C; 10% of the oil in the water column was associated with zooplankton (Conover, 1971; in NRC, 1985). The total HC concentrations in the water 3 months after the spill were up to 100 ug/L (Levy, 1971; in NRC, 1985), compared to a background of about 1.0 ug/L (Gordon & Mickalik, 1971; in NRC, 1985).

In the San Francisco Bay spill, oil (increased in density by evaporation of lighter fractions and solution of low molecular weight fractions) was mixed in the water column by tidal currents and wind. Some was transported landward by near-bottom currents and eventually beached (Conomos, 1975; in NRC, 1985).

Under oil slicks spilled from the Argo Merchant, oil droplets greater than 100 um were found in 5 of 42 samples. Water taken from 6 m above the bottom had oil-coated particles of size 100 to 500 um. Total HC concentrations in water ranged up to 340 ug/L, down to 20 m depth (Cornillan, 1978; in NRC, 1985).

After the Nestucca spill, limited sampling in February of surf and tide pool water and analysis by IR gave results of 400-2500 ug/L total hydrocarbons. It is not known what proportion, if any, represents petroleum hydrocarbons (see discussion under Sediments). Water column samples collected in March had no detectable hydrocarbons.

4.1.2 Beaches

The Arrow spill virtually coated 300 km of shoreline, concentrated primarily in the upper 2/3 of the intertidal zone along much of the coastline. By contrast, in the Nestucca spill less than 1/100th of this length of coastline was heavily oiled.

The Arrow oil was most persistent when stranded along the mean high tide line. It mixed with sand, rocks and gravel and formed a pavement of tar. By 1976 only a few "hot spots" had visible surface oil, but subsurface chemical analysis showed high concentrations within beaches:

Depth	concentration
surface	106 ug/g
7-11 cm	1,280 ug/g
12-15 cm	27 ug/g

In sheltered lagoons, the oil was still visible 10 years later (Keizer et al, 1978). In the Nestucca spill, one sheltered lagoon near Friendly Cove was oiled, but cleaned up.

The Argo Merchant oil was blown offshore by strong winds and did not become beached. The San Francisco Bay spill resulted in some oiled beaches, which were cleaned up.

In general, rocky shores "self-clean" in months; lagoons and marshes take years or decades to clean. In cobble beaches, oil sinks deep into gravel; pools collects in hollows, form a "skin" and remain unchanged for a long time (NRC 1985). This is the situation at Bajo Point in the Nestucca incident, a sensitive area because of the sea otter colony.

Tidal pumping is the force causing penetration, which is greater in coarser sediments. In beaches, buried oil may have a long residence time (e.g., greater than 3 years after the Amoco Cadiz spill in France). However, there is considerable transport and re-burial of oil in beach sands; the tendency is for oil to work downward to the water table in thick sand layers (NRC, 1985) and laterally along bedding planes to outcrops, in thinner sand layers.

Some oil was buried in beach sands after the Nestucca spill; however, on rocky shorelines considerable self-cleaning was very evident during the spill response period. Residual hydrocarbons were detected in sands of 9 of 10 beaches sampled along the west coast in mid January, when up to 540 ug/g HC were detected in beach sands. The maximum at the same 10 beaches in March was 118 ug/g. Four of the 10 beaches had no detectable hydrocarbons in March, and these were not scheduled for resampling in June.

Oil continued to strand, however, at least through March 30 along high tide lines as less than 1-10 cm blobs in the Long Beach Unit of Pacific Rim National Park, and probably elsewhere from Barkley Sound to the Brooks Peninsula. This probably derives from oil separating from subtidal deposits and refloating; from uncovering of blobs which had been buried; or from redistribution of stranded oil missed during cleanup operations.

4.1.3 Sediment

After the Arrow spill, some subtidal sediments were almost completely covered with oil. Six years later, sediments contained 10 to 25,000 ug/g hydrocarbons (by florescence; Keizer et al, 1978).

In the Argo Merchant case, small tar oil particles were found in a 10-15 square km area around the site. Concentrations were 0.1 to 327 ug/g HC (Hoffman & Quinn, 1980; in NRC, 1985). After 7 months, only a trace remained at one station.

The BIOS studies of an experimental crude oil spill on Baffin Island documented migration, over 1-3 years, of intertidal oil into subtidal sediments (Boehm et al, 1987). In these studies, biodegradation was restricted to the beached oil, with no significant degradation apparently occurring subtidally.

In the Nestucca spill, traces of subtidally deposited oil were observed by divers near Stubbs Island, and fairly wide distribution in the Long Beach-Stubbs Island area is inferred from the amount of oiling on crabs and crab traps. Sediment samples taken during the Tully cruise showed, however, that there is no broad-scale subtidal oil contamination, based on visual examination. Chemical analysis is needed to confirm the absence of oil in these samples.

Recurrent slicks in several areas (e.g., Dicebox Island, Clark Island, Stubbs Island, Escalante Point) after about mid- January probably resulted from oil separating from blobs that sank after incorporating beach sediment, as described in the lab by Fingas (1989).

4.1.4. Degradation Processes

The following degradation process are expected to act on the remaining oil (summarized from NRC, 1985):

Evaporation generally accounts for a loss of 1/3 to 2/3 of the spilled product, primarily of the light ends.

Dissolution accounts for a negligible mass, but is important toxicologically because only the light fractions (the most soluble and volatile) readily dissolve, and these account for most of the acute toxicity (see Abernathy et al 1986).

Emulsification is dependant on the content of asphaltenes; the rate is increased by the presence of products of photochemical and microbial degradation.

Photooxidation degrades evaporated oil in the gaseous state, and to a lesser extent, of slicks. Visual evidence of photooxidation of slicks is of darkening colour. It increases emulsification, increases formulation of soluble organics and increases toxicity. An effect in the water column is to decrease primary productivity.

Sedimentation is greater in fine-grained sediments (silt and clay) and less in sand. Formation of oil-clay colloids leads to flocculation, thence to sedimentation. Another route is through zooplankton (especially copepods) via fecal pellets. There is also direct partitioning of low-solubility hydrocarbons onto particles of high organic content in the water column.

Fractionation of the original mixture results in the alkylated benzenes and naphthalenes entering the water phase, while the higher molecular weight aliphatic hydrocarbons and PAH's are adsorbed by suspended clay particles and eventually deposited.

Bioturbation moves deposited oil into deeper sediment horizons. It also keeps the oiled layer oxidized and subject to microbial degradation where sediments are continually exposed to pore-water and surface waters.

Biological metabolism (e.g., by oleoclastic bacteria, ciliate protozoa) can degrade chemically and physically weathered oil into constituent components, which can be used as nutrient/carbon sources.

4.2 Chemical tests of Cleanup Techniques

4.2.1 Test Burning with a Gasoline Gel Product

Analysis of burn residue showed that while some low molecular weight fractions were reduced, combustion was incomplete and, in fact, added low molecular weight, diesel- like constituents. At low combustion temperatures the potential for retention of PAH and other toxic organics is increased. Therefore, the test burn was not successful in destroying the oil - particularly not the higher molecular weight fractions - and may in fact have increased the concentration of toxic organics in the residual material.

4.2.2 Burning of Oil and Oiled Debris

Evans et al (1988) studied production of PAH during test burning of Alberta crude oil as a means of removing an environmental threat from spilled oil. They found that burning produced marginally less total PAH (the sum of the residue plus smoke/vapor) than was present in the original oil; however, the concentration of PAH with 5 or more rings, which includes benzo[a]pyrene (a mammalian carcinogen), was 10 to 20 times greater in the smoke compared to the fuel. The crude oil and the residue had the same relative concentrations of the various classes of PAH, and the reduction in the overall amount arose from the fraction of the oil burned. While about 90% of the PAH for the oil and residue had three rings, the PAH content of the smoke/vapor was equally divided among three rings, four rings and five or more rings.

Therefore, burning Nestucca oil and oiled debris would have distributed high molecular weight PAH in the environment near the beach fires.

4.3 Biological Effects

4.3.1 Toxicity

Acute LC 50 values generally range from 2 to 30 ppm for the monocyclic (lighter) components and 1 to 6 ppm for polycyclic (heavier) aromatic hydrocarbons to a variety of invertebrates and vertebrates. Experts agree that LC 50 values for total hydrocarbons of a single oil are poor measures of toxicity because (a) many of the hydrocarbons are not readily miscible or soluble in water, hence test organisms in aqueous media are not exposed to easily described or constant concentrations, and (b) the effects are often at the cellular level, hence may require longer term (chronic) tests to express them (NRC, 1985). The latter is especially true of Bunker C because of its higher proportion of high molecular weight compounds and residual hydrocarbons and non-hydrocarbons relative to other refined and crude oils (NRC, 1985), resulting in many potential sources of toxicity.

Most metabolites are no more toxic than parent compounds, but the PAH's give rise to mutagenic intermediates and to metabolites capable of binding with nucleic acids (Varanasi and Gmur, 1980; Varanasi et al., 1980, 1982; in NRC, 1985). For example, English sole injected with benzo(a)pyrene had altered sister chromatid exchange rates (Stromberg et al., 1982; in NRC, 1985), fertilized eggs of English sole exposed to 0.1 - 4.2 ug/L benzo(a)pyrene had increased chromosome abnormalities of the yolk-sac membranes (Hose et al., 1981; in NRC, 1985) and purple sea urchins exposed for 15-30 minutes with 1.0 - 50 ug/L benzo(a)pyrene yielded embryos with increased mitotic abnormalities (Hose et al., 1985; in NRC, 1985).

Although the Nestucca oil was not acutely toxic to rainbow trout at 100 and 1000 ppm in static 96 hr. bioassays by the Washington Department of Ecology (Steve Hunter, in lit. to Fred Beech, 11 Jan. 1989) it did contain a relatively high proportion of PAH's. These included naphthalene, acenaphthene, dibenzofuran, fluorene, phenanthrene, pyrene, chrysene, benzo(b)fluoranthene, and benzo(a)pyrene at 10's to 100's of ppm. Benzo(a)pyrene was present at 130 ppm.

Based on these characteristics, the Nestucca oil would be expected to have little or no acute toxicity to juvenile or adult fish but significant chronic toxicity possibly involving chromosomal and cell division abberations leading to mutations, or induction of carcinomas; effects would differ greatly with exposure concentrations and time, types of organisms exposed and tissues concentrations attained (NRC, 1985; Peter Wells, pers. comm., February, 1989).

4.3.2 Littoral Communities

The 1970 Arrow bunker C spill in Chedabucto Bay, N.S., was well documented and studied for approximately 10 years afterwards. It reduced the density of rockweed, Fucus vesiculosus, for about five years after the spill. There was complete elimination of F. spiralis, a species confined to the high tide line where the oil was concentrated. Marsh grass, Spartina alternifolia, declined for one year and recovered in two years. In 1976 marsh grass had 15,000 ug/g HC compared to less than 70 ug/g in controls (Thomas, 1978; in NRC, 1985). Barnacles and periwinkles were not immediately affected (e.g., barnacle, Balanus balanoides), larvae settled and grew normally but were reduced in numbers where rockweed was reduced, a secondary ecosystem effect (Thomas, 1979; in NRC, 1985).

Bivalve larval recruitment was reduced for six years after the Arrow spill (Gilfillan and Vandermuelan, 1978; in NRC, 1985).

Species diversity was lower at oiled sites six years after the Arrow spill. Macrofaunal biomass was 1/4 that of the control site (1,400 wet g per square meter versus 4,400 wet g per square meter). Oil in living clams averaged 150-350 ug/g in 1979 compared to 650 ug/g in recently dead bivalves in 1979. Periwinkles still had 12-18 ug/g HC in 1976 (Vandermuelen, 1977; in NRC, 1985).

Softshell clam populations were still stressed nine years after the Arrow spill (fewer mature adults, lags in soft tissue and shell growth, etc.) (McDonald and Thomas, 1982; in NRC, 1985).

The Lugworm, Arenicola sp., increased in oiled areas (Gordon et al, 1978; in NRC, 1985) as observed after other spills (NRC, 1985).

Overall, seaweeds and bivalves were affected, while polychete populations generally were not negatively affected. Studies of littoral species in the area of the Nestucca spill are not planned.

4.3.3 Pelagic Communities

The Argo Merchant bunker spill had very little impact on marine fauna or phytoplankton (NRC, 1985). Copepods within 10 km had oil in their intestines and on their mandibles as has often been observed at spills. In the area of the spill, most cod and pollock eggs were dead or inviable and sandlance larvae were low in numbers (NRC, 1985).

Based on studies at a number of spills worldwide, oil has short term effects on zooplankton (e.g., lethality, lowered feeding and reproduction, tissue contamination, abnormal development of embryos, community changes) but populations probably recover and maintain themselves due largely to their wide distribution and rapid regeneration rates (NRC, 1985, p. 405). Mesocosm studies with zooplankters have addressed this point, but population effects on most zooplankters are very difficult to quantitatively study in the field.

4.4 Predictions on the Long Term Fate of Nestucca Oil

Predictions of effects, based on the above review and early observations of the behaviour of the oil from the *Nestucca* spill, are given as hypotheses which can be tested with appropriately designed studies.

The extent of long term environmental impact of the *Nestucca* spill on the scale of major spills worldwide will be relatively modest. For example, heavily oiled shorelines (defined by nearly complete coverage of some portion of the intertidal zone) totalled about 2.0 km of the 152 or so km in total that received some oil, and this is less than 1% of the 300 km of shoreline that the *Arrow* spill coated in Nova Scotia. The foregoing lead to a few predictions of the *Nestucca* spill on littoral and pelagic communities:

4.4.1 Sand Beaches

On heavily oiled sand beaches oil "pancakes" up to a meter or more in diameter were probably buried during periods of sand accumulations in calm weather (Ed Owens, pers. comm. January, 1989). These will persist for many months or longer, and may be exposed during storms accompanied by erosion of beach sands. Very small, exposed oil pancakes and droplets will be degraded by photooxidation and, if washed back into the ocean, by microbial action. Larger patties will form a "crust" highly resistant for further weathering, and may persist for decades.

4.4.2 Cobble/rock Beaches

On cobble/rock beaches (e.g., Bajo Point) where the oil was allowed to penetrate into the gravels, the oil will become a tarry "pavement" and persist for many years. This has been observed at many spills, large or small, crude, fuel or bunker (NRC, 1985; Jordan and Payne, 1989).

4.4.3 Subtidal Deposits

Oil has been deposited subtidally in the Long Beach-Stubbs Island area, and probably in other areas that experienced significant oiling of beaches. Subtidal deposits incorporated into sediments will persist for many months or longer and may be a source of continued minor re-oiling of beaches and low contamination of biota. Surficial deposits will eventually be degraded by microbial action; deposits worked below the level of bioturbation or covered by clean sediments will become a permanent feature of the sediment horizon. As low molecular weight fractions continue to dissolve and degrade, these deposits will become semi-solid.

4.4.4 Sheltered Lagoons

In sheltered lagoons (e.g., Friendly Cove) any oil remaining after clean-up will become a long-term feature of the sediments, gradually decomposing into harmless constituents. This process will be most rapid near the surface under aerobic decomposition. EFFECTS

4.4.5 High Intertidal Meadows

Oil stranded in high intertidal "meadows" of marsh grass, will eventually be degraded by photooxidation, evaporation and microbial degradation as well as by physical weathering during storms and high tides, and will disappear. Although infrequent and very small in the Nestucca spill area, these habitats are biologically productive; many are critical habitat for aquatic species and wildlife.

4.4.6 Exposed Rocky Shorelines

On exposed rocky shorelines (including recreationally important tide pools in Pacific Rim National Park), most oil will already have been lifted off and removed by high tides, broken up by wave action, and chemically degraded by photooxidation, evaporation and dissolution. At the rare locations where low intertidal zones were heavily contaminated and oil was worked into the gravel substrate (e.g., Stuart Bay near Ucluelet) oil will persist for many months or longer.

Oil droplets washed back into the sea will be mostly degraded microbiologically; some will become incorporated into pockets of sediments, where they will persist for months or longer.

4.4.7 Above High Tide

Oil stranded at and above the normal high tide line (the supra-littoral zone) of all beach types will become transformed into a tarry "pavement" or coating on rocks and logs, and will persist in that form for many months or longer. This is a microbiologically important beach zone.

4.5 Predictions on Biological Effects

4.5.1 Sand Beaches

Dissolved oil fractions would have been distributed widely within heavily oiled beach sands by tidal pumping. A continued source of these compounds will derive from any buried oil and reoiling that may occur from subtidal deposits as noted above. The amount of these fractions in Bunker C amenable to dissolution is low, however. Bivalves molluscs in heavily contaminated beaches (e.g., Florencia) may be tainted, and may have suffered mortality. Observations of oil sheens issuing from clam siphon holes on Long Beach on January 7 (ref. L. Harding field notes) suggest that these organisms were exposed to hydrocarbons as was observed following the Arrow spill (Thomas, 1973, 1977, 1978; in NRC, 1985 p. 542). As long as oil persists within beach sands and gravels, bivalve molluscs may be tainted and may suffer reduced shell and soft body growth and recruitment. The total effects may not exceed those of natural events, such as the freezing of high intertidal mussels that apparently occurred during the unusually cold weather of early February (ref. L. Harding field notes of February 10). Other littoral fauna, such as sandlance, amphipods, etc., may also be affected. Crustaceans are, in general, especially sensitive to low molecular weight fractions; many invertebrates are slow metabolizers, compared to fish, of the high molecular weight compounds (NRC, 1985; Wells and Percy, 1985; Rice, 1985).

4.5.2 Zooplankton

Pelagic zooplankton populations, although low during the spill period, may have been affected while that fresh oil was coming in and being physically weathered and redistributed by wave action. Some groups, such as calanoid copepods, actively graze on oil particles of the appropriate size that they ingest (Conover, 1971 and Davenport, 1982 reviewed by Wells and Percy, 1985). By spring their populations would probably have recovered, assuming the water column is essentially free of hydrocarbons. Settling larvae might be affected in areas of highest sediment contamination but this has only been noted experimentally in heavily oiled trays of sediment (Vanderhorst et al.).

4.5.3 Epibenthos

Contamination of crabs and other epibenthos will continue as long as oil occurs as surficial deposits to which they are exposed. As these deposits become covered by sediment and detritus and incorporated into the bioturbation zone, the effects on epibenthos will diminish, but bioaccumulation and effects on infauna may continue. Continual decreases in the percentage of crabs and crab traps oiled (nearly 100% in early January compared to approximately 50% in early February and 6 to 38 % at the end of March; Colin Levings, pers. comm.) suggests that this process is well underway. Essentially complete incorporation of oil into bottom sediments may be inferred when crabs and crab traps are 100% free of oil, although other mechanisms for loss might also be present (e.g., petroleum hydrocarbons washed out and diluted in the system; Jordan and Payne, 1980; NRC, 1985). Lethal and sublethal effects on infauna may gradually diminish over a longer time frame, as has been shown for some groups such as amphipods (Sanders et al, 1980 in NRC, 1985 p. 536).

4.5.4 Tide Pool Life

In recreationally important tide pools, little visual impact is expected because (a) in most cases heavy oil deposits only remained in these environments until the next high tide, and residues were quickly physically degraded and removed by wave action, etc., and (b) the visual elements - adult anemones, starfish, snails, barnacles, crabs, limpets, etc. - are not particularly susceptible to the small amounts of oil that may have been present as particulates (droplets) or dissolved fractions, and (c) any dead or moribund animals would be quickly removed by predators/scavengers, and replaced by immigration when oil concentrations in the water diminish.

4.5.5 Seabirds and Marine Mammals

No continued effect of floating oil on seabirds or mammals is predicted, since the fate of oil is towards degradation in the water column and on surficial subtidal deposits, and towards stability in littoral and subtidal sediments and at the high tide line.

5.0 PROPOSED STUDIES FOR FISCAL YEAR 1989-90

This section outlines the DOE studies currently planned.

5.1 Fate

5.1.1 Persistence in Beach Sand and Gravel

A long term study has been initiated by EP with contractor support, involving duplicate transects on ten beaches in the affected area, to quantify the occurrence of residual oil in beach sands and gravels. Persistence is being assessed by chemical and physical analysis of oil collected from beaches and subtidal deposits over time during the spill, to document oil distribution and the oil aging process. EP is collecting samples and undertaking quantitative hydrocarbon analysis by IR, while DFO is analyzing selected samples by GC/MS to identify petroleum and other hydrocarbons present. The study design calls for sampling every two months as long as significant oil of Nestucca origin remains detectable in the samples. The first two samplings (January and March) showed modest (up to 100's ppm) levels of residual oil in beach sediments; the second sampling (June) is awaiting analysis.

Pending results of the June sampling, subsequent sampling is planned for September, continuing periodically until no hydrocarbons of Nestucca origin are found.

A complementary monitoring program is also in place by Canadian Parks Service to systematically walk major beaches in Pacific Rim National Park and note the occurrence of "tar balls" and oil droplets that may have been washed in or uncovered. It consists of periodic beach walks, to continue at least through the tourist season. To date, small oil droplets (dime-nickel size and smaller) still occur at a relatively high frequency (up to several per square meter) in PRNP beaches, with some larger concentrations also observed. A general incidence of re-oiling occurred with winter storms in early March.

5.1.2 Persistence in Subtidal Habitats

EP is participating in a DFO study of effects of subtidally deposited oil on crab and whale habitat by analyzing water and sediments to document the persistence, composition and concentrations of oil constituents in these environments. Water samples were collected by an EP contractor in March, 1989 and sediments were collected by DFO in April, 1989.

5.1.3 Post Spill Collection and Data Analysis

Continuing reports of oil on beaches within and outside of the Parks, require inspections by Parks or EP staff. Small amounts are cleaned up immediately if possible; larger amounts are referred to CCG for action.

5.2 Effects

5.2.1 Seabird Breeding Colonies

British Columbia is home to 27% of the world's population of Rhinoceros Auklets, 71% of the world's population of Cassin's Auklets, 42% of the world's population of Ancient Murrelets and 78% of the Canadian population of Tufted Puffins. Substantial numbers of these and other species were killed during the *Nestucca* spill. In addition, oil contaminated some nesting islands used by Alcids, Gulls and Cormorants.

CWS will contract surveys and augment existing research on the west coast of Vancouver Island to determine the impact of the spill on species suffering high mortality from the spill and on nesting islands where significant quantities of oil were present.

Colonies to be surveyed are:

-Solander Island for Cassin's Auklets
-Triangle Island for Cassin's Auklets
-Triangle Island for Common Murres
-Cleland Island, Seabird Rocks, Starlight Reef for nesting species on oiled islands.

5.2.2 Eelgrass and Algal/herring Spawning/seabird Communities

Herring spawning habitats support both the commercial herring roe fishery and seabirds that feed on the herring and roe. CWS began monitoring birds at Stuart Bay as an adjunct to the brant surveys completed during March-April and will continue during FY 89-90.

5.2.3 Environmental Assessment Decisions

Environmental information supporting environmental assessment and protection decisions came primarily from three sources: (1) published literature and sensitivity/resource atlases, (2) advice of experts given on site and contacted by telephone/fax, and (3) new data, such as on wintering seabird concentrations, generated by the Environmental Impact Assessment Team. Environment Canada will review, analyze and document the environmental information sources and supporting rationale for daily and ongoing assessment and cleanup priorities.

5.2.4 Interim Impact Assessment

An interim impact assessment will be completed in early 1990 either by hosting a workshop and inviting papers to be presented on all aspects of the *Nestucca* impact assessment, or by contracting to prepare an assessment with agency input.

6.0 CONCLUSIONS

Significant impacts were identified in the following areas:

1. Seabirds: 12,877 dead seabirds were collected in Washington and B.C., or did not respond to treatment. Preliminary data analysis suggests that this represents at least 16,000 that actually died, and possibly as many as 20- 30,000. Effects on world populations are unlikely; effects on B.C. breeding populations are currently unknown.

2. Tainting or occurrence of oil on shells and carapaces caused some crab and mussel samples to fail organoleptic tests. Commercial, recreational and domestic harvesting of crabs and other shellfish were restricted temporarily in some areas; crab fishery remained closed through April in areas near Tofino.

3. Important tourist beaches were oiled both inside of Pacific Rim National Park and in areas served by private resort operators. Effects of the public's perception of the widely reported spill, or of actual experiences of tourists with residual oil on the beaches, will not be known until after at least one tourist season.

4. At least one sea otter died from oiling; effects on the population will be known after summer surveys following spring whelping.

These conclusions are preliminary and may very well be modified as a result of continuing studies.

7.0 REFERENCES

Boehm, P.D., M.S. Steinhauer, D.R. Green, B. Fowler, B. Humphry, D.L. Fiest and W.J. Cretney 1987. Comparative fate of Chemically Dispersed and Beached Crude Oil in Subtidal Sediments of the Arctic Nearshore. Arctic 40(Supp): 133-140.

Burger, Alan, 1989. Effects of the 'Nestucca' oil spill (January 1989) on seabirds along the southwest coast of Vancouver Island. Report to Environment Canada (draft dated 8 May 1989).

Davis, R.W., T.M. Williams, J.A. Thomas, R.A. Kastelein and L.H. Cornell 1988. The effects of oil contamination and cleaning on sea otters (Enhydra lutris). II. Metabolism, thermoregulation and behaviour. Can. J. Zool. 66:2782-2790.

Department of Ecology 1989. Summary of events and news coverage 1988/1989 Grays Harbor Oil Spill. News Release, Department of Ecology, Olympia, Washington, March 14, 1989.

Duval, Wayne S., Linda C. Martin and Ron P. Fink 1981. A prospectus on the biological effects of oil spills in marine environments. Report by ESL Environmental Sciences Limited for Dome Petroleum Ltd., Calgary. 92 pp.

Duval, Wayne S. (ed.) 1985. A Review of the biological fate and effects of oil in cold marine environments. Manuscript Report EE-74. January, 1976. River Road Environmental Technology Centre, Environment Canada, Ottawa K1A 1C8. 242 pp. Environmental Protection Service 1975. Oil and Chemical Spill Counter Measures Series.

Duval, W., S. Hopkinson, R. Olmsted, and R. Kashino, 1989. The Nestucca oil spill: Preliminary evaluation of impacts on the west coast of Vancouver Island. Report by Environmental Sciences Ltd. for Environment Canada and B.C. Ministry of Environment

Environmental Protection Service 1978. West coast offshore environment.

ESL Environmental Sciences Limited, S.L. Ross Environmental Research Limited and Arctic Laboratories Limited 1986. A review of the biological fate and effects of oil in cold marine environments. Environment Canada (unpub.)

ESL Environmental Sciences Limited 1988. Biophysical suitability of net cage rearing of salmonids. Report for Ministry of

REFERENCES

Agriculture and Fisheries.

Evans, D., G. Mulholland, D. Gross and H. Baum. Burning, smoke production and smoke dispersion from oil spill combustion. Proc. 11th Arctic and Marine Oil Spill Program Technical Seminar, Vancouver, B.C. June 7-9, 1988. pp. 41-88.

Fingas, Merv, 1989. Report on the "Sunken" oil found during the Nestucca incident. Environment Canada unpubl. manuscript, 5 pp.

Fingas, Merv (Ed.) 1988. Proc. of the eleventh Arctic and Marine Oil Spill Program and Technical Seminar. Vancouver, June 7-9, 1988. Environment Canada. 514 pp.

Fingas, Merv (Ed.) 1987. Proc. of the tenth Arctic and Marine Oil Spill Program and Technical Seminar. Edmonton, June 9-11, 1987. Environment Canada. 467 pp.

Fisheries and Environment Canada 1978. Potential Pacific coast oil ports: A comparative environmental risk analysis. Vol. II Supplementary Appendices.

Ford, John, 1989. Aquarium staff stand by to rescue sea otters. Sea Pen 33(2): 11-12.

Guide to Ecological Reserves in British Columbia. Ministry of Environment and Parks, Victoria, B.C. 1987.

Harding, L.E. and R. Langford 1989. Short term environmental impact of the Nestucca oil spill in Canada: January 6 to January 20, 1989. Greater Ucluelet Marine Biology and Oceanography Institute/Environment Canada File Report 89-01.

Harding, L.E. 1989. Short term environmental impact of the Nestucca oil spill in Canada: January 6 to January 29, 1989. Environment Canada File Report.

Harper, J.R. and B. Sawyer 1983. Coastal analysis of the Long Beach segment and Broken Islands Group, Pacific Rim National Park. Report by Woodward-Clyde Consultants for Parks Canada.

Hodgson, Gordon W., Ona M. Stonkus and Gary A. Sergy (Editors) 1987. Arctic 40(Supplement 1 on the BIOS Project): 279 pp.

Hooper, Tracy D., Kees Vermeer and Ildy Szabo 1987. Oil pollution of birds. CWS Tech. Rep. Series No. 34. 180 pp.

Levings, C., 1989. Final cruise Report, C.S.S. John P. Tully,

REFERENCES

January 23 - February 1, 1989 (unpubl. manuscript).

LGL Limited and ESL Environmental Sciences Limited 1980. Map Folio Volume XVII Biological resources of coastal and offshore British Columbia. Inventory and analysis of sensitivity to oil spills. Report for Transmountain Pipeline Company Ltd.

Ministry of Environment and Parks 1987. Coastal Marine Parks of British Columbia (map).

National Research Council, 1985. Oil in the Sea: Inputs, Fates and Effects. National Academy Press, Washington, D.C.

Nassichuk, M. and J. Millen 1982. List of Environmental Resource concerns for offshore drilling the permit blocks and environmental sensitivity map. Department of Environment and Department of Fisheries and Oceans (Unpubl.)

National Research Council, 1985. Oil in the sea: Inputs, fates, and effects. National Academy Press, Wash. DC. 601 pp.

Nuu-Chah-Nulth Tribal Council, 1985. Presentation to the West Coast Offshore Exploration Environmental Assessment Panel. Port Alberni, B.C., October, 1985. 56 pp.

Olesiuk, Peter, 1989. Summary of seal/sea lion incidents recorded during the oil spill. (unpublished). Department of Fisheries and Oceans, Nanaimo. 3 pp.

Percy, Jon A. and Peter C. Wells 1984. Effects of petroleum in polar marine environments. MTS Journal 18(3): 51-61 pp.

Rodway, Michael S., R. Wayne Campbell, Gary W. Kaiser and Moira J.F. Lemon (In Prep.) Seabird colonies of British Columbia. 307 pp.

Rodway, Michael S., Moira J.F. Lemon, Jean-Pierre L. Savard and Richard McKelvey 1989. Nestucca Oil Spill: Impact assessment of avian populations and habitat. Technical Report Series No. 68. Canadian Wildlife Service. 7 pp. + Appendices.

Rodway, M.S., R.W. Campbell, G.W. Kaiser, and M.J.F. Lemon (in prep) Seabird colonies of British Columbia.

Samson, A.L., J.H. Vandermuelen, P.G. Wells and C. Moyse 1980. A selected bibliography on the fate and effects of oil pollution relevant to the Canadian Marine Environment, 2nd Edition. Environment Canada report No. EPS-3-EC-80-5.

REFERENCES

Shoreline protection and cleanup manual: Bamfield to Esquimalt, Vancouver Island. Department of Environment Regional Program Report 83-4. 1983.

Thompson, Richard E. 1981. Oceanography of the British Columbia Coast. Canadian Special Publication of Fisheries and Aquatic Sciences 56. Depart of Fisheries and Oceans. 284 pp.

Vermeer, Kees, Ian Robertson, R.Wayne Campbell, Gary Kaiser and Moira Lemmon 1983. Distribution and Densities of marine birds on the Canadian west coast. CWS. 73 pp.

Vermeer, Kees and Rebecca Vermeer 1975. Oil threat to birds on the Canadian West Coast. Canadian Field-Naturalist 89(3):278-298.

Washington Department of Ecology 1989. Summary of events and news coverage: 1988/1989 Grays Harbor Oil Spill. Unpubl. ms.

Waters, R. 1989. A water sampling program to document the level of hydrocarbons in seawater following the Nestucca oil spill. Report to Environment Canada, (unpub. manuscript). 10 pp.

Waters, R., H. Herunter and D. Swanston, 1989. Subtidal oil search, Ucluelet-Tofino April survey. Unpubl. report to C. Levings, Department of Fisheries and Oceans, May 4, 1989. 8 pp.

Williams, T.M., R.A. Kasetlein, R.W. Davis and J.A. Thomas 1988. The effects of oil contamination and cleaning on sea otters (Enhydra lutris). I. Thermoregulatory implications based on pelt studies. Can. J. Zool. 66: 2776-2781.

Wilson, E. 1989. Long Beach Unit oil monitoring results from January 30 to April 30, 1989. Pacific Rim National Park unpubl. manuscript, 4 pp.

Appendix 1. Oil Classification System

SHORELINE CONTAMINATION

CLASS 1

- no visible oil on surface of rock or beach
- no visible oil in subsurface sediments
- no visible oil in or on logs

CLASS 2

- sheen ("rainbow oil") on surface of rock or beach
- no visible black oil on rock or beach
- thin (less than 1 inch or 2 centimetres) cover of oil on logs or on rocks

CLASS 3

- sheen ("rainbow oils") on surface and brown or black oil
- size of brown or black oil i dime/nickel size or less with occasional hand size blobs

CLASS 4

- surface oil cover on rocks and/or beach is thick (more than 1 inch)
- size of blobs is plate or cow-patty and larger
- logs have blobs or oil cover greater than 1 inch thick

CLASS 5

- continuous oil cover, not blobs, greater than 3 inches thick

OIL COVERS ON SHORE

LIGHT

- 5 to 10% of the shore covered with sheen ("rainbow oil")
- brown/black blobs no greater than nickel/dime size
- no more than 10 blobs per square meter

MODERATE

- brown/black oil blobs of plate or cow-patty size
- more than 1 blob per square meter
- greater than 10 meters of shore contaminated

HEAVY

- brown/black blobs of plate size or larger over more than 10 meters of shore but not continuous oil cover

COMPLETE CONTAMINATION

- brown/black oil on surface covers more than 25% of the shore
- more than 25 meters length of shore contaminated

Appendix 2. Report of Rob Waters on Water Column Sampling Program, March 23-27, 1989

A REPORT

TO

ENVIRONMENT CANADA
Conservation and Protection

A WATER SAMPLING PROGRAM TO DOCUMENT THE LEVEL OF HYDROCARBONS IN SEAWATER FOLLOWING THE NESTUCCA OIL SPILL

by

Rob Waters
Environmental Consultant

March 31, 1989

Introduction

At the request of Environment Protection, Marine Programs, a water sampling program was undertaken to obtain discreet water samples from the surface, near surface and bottom waters to document hydrocarbon levels in seawater as a part of the monitoring effort associated with the Nestucca oil spill. The program included an evaluation of immediately available water sampling techniques, and associated discussions with Fisheries and Oceans and Environment Canada staff. The following report includes: a discussion of the methodology including equipment evaluation, selection and application in the field; sampling program development; and a discussion on field observations. A figure showing the equipment is provided along with a figure on sample station locations. A tabulation of sample stations and sample identification is also presented.

Water Sampling Program

The water sampling program was established in consultation with Environment Canada with input from Fisheries and Oceans. The focus was on those areas where oiling of crabs had been recorded in the Tofino area as well as oiling observations in Ucluelet Inlet and area. Based on this information sampling sites around Tofino in areas of crab oiling and areas with no record of oiling were selected as shown in Figure 2. Sampling sites were selected around Ucluelet based on information where intertidal oiling had occurred and had recurred.

At each site the objective was to obtain near surface and bottom water samples in duplicate along with surface grab samples. In total nine sites in the Tofino area and two sites in the Ucluelet area were selected for sampling. As a matter of record, samples were named with the prefix NOS (Nestucca Oil Spill) and numbered sequentially.

The 'VARGAS ISLAND' was used for the a sampling platform in the Tofino area and a charter from Island West was used in Ucluelet. Sample locations are shown on Figure 2 and described in Table 2.

Methodology

Sampling Equipment Review

As a part of the project a review of water sampling methodologies was undertaken to assess the various options available within the time frame to undertake the proposed water sampling program. Consideration was given to standard water collection techniques such as bottle casts and insitu pumping. Current sampling techniques applied by government regulators and researchers were discussed with field staff and scientists. For collection of water samples for organic analyses the main method which appears to be used is grab sampling which essentailly restricts one to the surface water. Bottle casts using Van Dorn type bottles are another option but also have associated contamination problems because they pass through the water column open. One method used by the Institute of Ocean Sciences is insitu sampling with a submersible pump through a teflon and stainless steel braided tube. This technique was applied on the CSS Tully during the Cruise in January 1989 assessing the Nestucca oil spill. Preference was indicated for teflon tubing to avoid the effects from plastic tubing and associated by-products. Review of this approach of sampling at depth was carried out and a modified system adapted for application on this project.

Sampling Equipment

Description

Based on the review and the limited time frame for action a modified water sampling system was applied in this project in the hopes of obtaining the best water samples. Essentially the system minimized the use of plastics and used a metal tubing with an air pressure released stopper, a hand operated vacuum pump and vacuum flask. The main components of the water sampling system are shown in Figure 1. While the teflon tubing is preferred its function under vacuum was questionable and it is expensive. Where needed to interconnect the metal tubing to the pump or flask tygon tubing was used with a minimal amount of high quality vinyl tubing as adaptors. The 1m and bottom water sampling probe was .5 inch treated copper tubing with threaded unions. The copper was dipped and treated in an acid bath at a metal finishing plant. All tubing and the vacuum flasks were rinsed with hexane. Samples were collected in treated 1 liter glass sample jars supplied by Environment Canada as well as two aqualungs for air pressure supply.

Water Sampling Technique
The following outlines the procedure in taking a water sample using the equipment described above. Upon reaching a sampling point the depth was checked and the cleaned and rinsed probe with tethered bottom stopper in place was passed through the water column. When contact with the bottom was made the probe was lifted approximately .5 meter and tied off. The air line was then attached and sufficient pressure applied to force the stopper out of the bottom end of the pipe allowing the water at that depth to enter the sampling system. The tubing at this time was connected to the pump and 3 to 4 liters water were pumped through the system. The tubing system was changed so that the pump was now attached to the vacuum flask outlet and the stoppered inlet was connected to the sampling probe top. Three aliquots were then taken to rinse the flask and then water samples were collected in the flask and transfered to the marked sample bottles. A field blank was taken midway through the sampling program using the bottom water sampling system.

Upon retrieval the tubes were detached and contact sampling equipment was in dilute soap, rinsed in distilled water, allowed to drain, then rinsed with methanol, hexane and finally distilled water. When not in use the tube ends were covered or stoppered.

Field Observations

During the conduct of the field program in the Tofino area weather conditions were ideal allowing easy access to near shore waters in exposed areas. However during the Ucluelet portion of the program poor weather limited sampling to the protected waters of Stuart Bay in Ucluelet Inlet. All sampling was carried out on the flood tide.

The following outlines the field observations made on sample collection. In general no direct observations of oil were seen in water either in samples or during system flushing except for two locations in the Tofino sampling area. The two locations were NOS-2 off Quisitis Point and in the vicinity of NOS-4 where supplementary sampling investigation was carried out between Stubbs and Wickinninish Islands. At the former, oil droplets were observed to occur from the pump discharge during the flushing process while sampling bottom water. At the latter several attempts at sampling bottom water and surface sediment fines did not reveal any oil on the water discharge, however a small slick of oil some 1 meter by .5 meter was observed during this investigation. The slick was observed several meters down current from the sample site and it is suggested it occurred as a result of the sample probes disturbance of the bottom sediments. On completion of the water sampling program 10 sample stations had been sampled at three depths for a total of five liters per station. Fifty samples and one field blank were delivered to the Seakem laboratory in Sidney, B.C.

Table 1
West Coast-Nestucca Oil Spill
Water Sample Identification

Station	Surface Grab	1 meter	At Depth		Depth(m)
NOS-1	#5	3 & 4	1 & 2		12
NOS-2	10	8 & 9	6 & 7		12
NOS-3	15	13 & 14	11 & 12		8
NOS-4	20	18 & 19	16 & 17		7
NOS-5	25	23 & 24	21 & 22		4
NOS-6	30	28 & 29	26 & 27		10
NOS-6A	31			Field Blank	
NOS-7	36	34 & 35	32 & 33		10
NOS-8	41	39 & 40	37 & 38		10
NOS-9	46	44 & 45	42 & 43		9
NOS-10	No	Samples			
NOS-11	53	51 & 52	49 & 50		7

Note: NOS=Nestucca Oil Spill
Depths in meters are approximate.

TABLE 2
WEST COAST--NESTUCCA OIL SPILL
WATER SAMPLE STATION LOCATIONS

Station	Location	Loran Coordinates
NOS-1	Quisitis Point	29225.4/41629.3
NOS-2	Quisitis Point	29230.2/41628.9
NOS-3	Templar Channel	See Figure 2
NOS-4	Stubbs Island	See Figure 2
NOS-5	Maurus Channel	See Figure 2
NOS-6	Father Charles Channel	See Figure 2
NOS-7	Browning Passage	See Figure 2
NOS-8	Lemmens Inlet	See Figure 2
NOS-9	Heynen Channel	See Figure 2
NOS-11	Stuart Bay-Ucluelet	See Figure 2

Note: NOS=Nestucca Oil Spill
There are no samples marked NOS-10

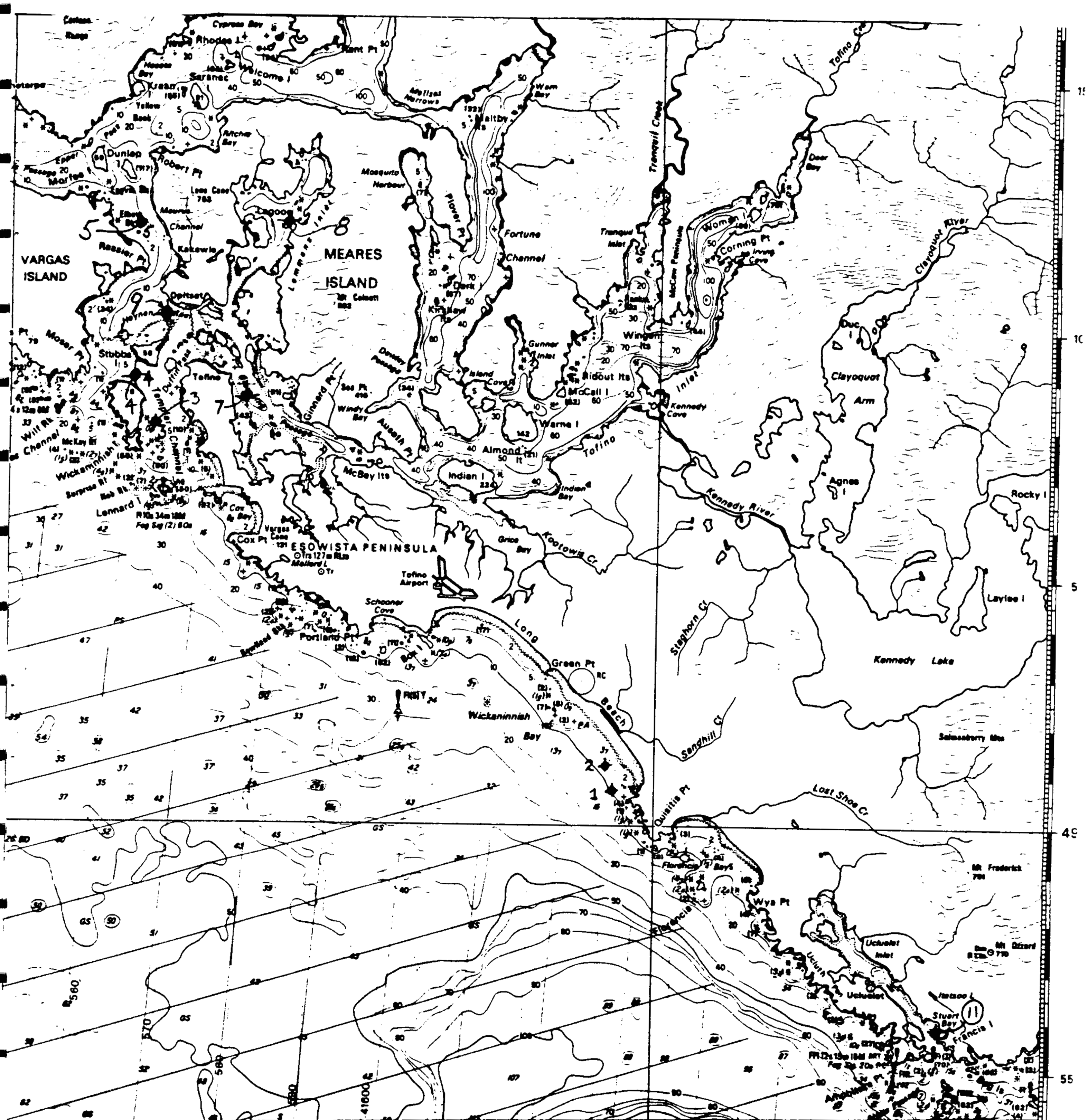


FIGURE 2. Water Sampling Stations 1-9 and 11, Nestucca Oil Spill Monitoring March 23-27, 1989.

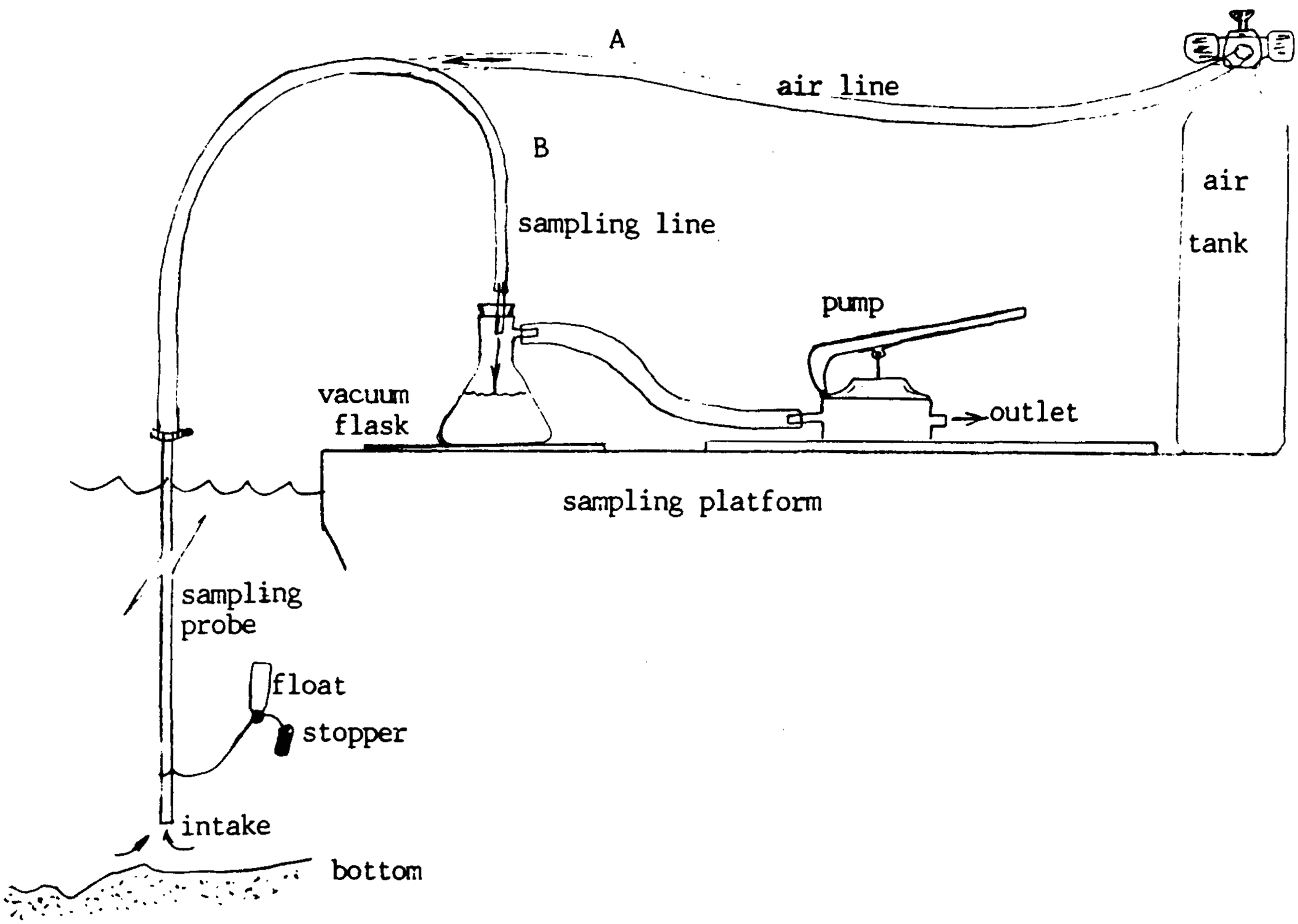


FIGURE 1. Water Sampling Equipment Schematic

A-Initial operation to remove stopper at desired depth by supplying high pressure air.

B-Connection for water sampling operation.

Appendix 3. Oil Classification Database

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
** AREA ACOUS						
ACOUS PENINSULA ALONG EAST SIDE OF BYERS CONE			5 BAGS COLLECTED	0.0	02/06/89	G. ELLIS - CWS
BATTLE BAY	3L	5-20CM PATTIES	BLACK OIL/SHEEN, 6 DEAD BIRDS	0.0	01/16/89	C.O.GRP DFO
BATTLE BAY			47 BAGS	0.0	02/06/89	G. ELLIS
BATTLE BAY - W END OF BAY, E OF RIVER MOUTH	3M		SEA OTTERS IN AREA, CLASS 3-4 OIL CONTAMINATION	0.0	01/23/89	PETER OLESIUK - DFO
BYERS CONE - SOUTH END			SLICK	0.0	01/17/89	REP. TO HARDING
CUTTLE ISLETS - SOUTH BEACH			5 BAGS	0.0	01/24/89	PETER OLESIUK G. ELLIS
UNNAMED IS. BTW. CUTTLE IS/ACOUS PEN. - N BEACH	4			0.0	01/14/89	REET
** AREA ANGELES						
ANGELES POINT, CRESENT BAY AND KYDAKA POINT	3	2M X 300 M SHEEN	SHEEN SUSPECTED TO BE FROM BILGE	0.0	01/15/89	USCG
JUAN DE FUCA - W OF NEAH BAY AND EAST FOR 15KM		15 KM	OFFSHORE SLICK	15000.0	01/13/89	J.DAVIS
USA		50 M X 25 KM SLICK	SLICK MOVING AWAY FROM SHORE	25000.0	12/23/89	USCCG
** AREA BAJO						
BAJO CREEK		20-50CM X >2.5CM PATCHES	BROWN OIL MIXED WITH EELGRASS/KELP, 4 DEAD BIRDS	0.0	01/21/89	K. HEISE, L. BARRETT-LENNARD
BAJO POINT			OIL ON BEACH, AERIAL SURVEY	0.0	01/07/89	OSC, M. GREEN
BAJO POINT	3H	300 M BEACH	HEAVY OIL DEPOSITS, MORE CREW REQUIRED?	300.0	01/10/89	CCG304 BEECH HARDING
BAJO POINT		250 M3 ON BEACH, 100 M2 SLICK OFFSHORE	OIL ENTRENCHED IN ROCK, SLICK OFFSHORE	250.0	01/24/89	MCALLISTER HEBRON
BAJO POINT - 3.2 KM SOUTH OF	2M		SMALL PATCHES OF OIL, 20 TONS OIL REMOVED TO DATE	0.0	01/10/89	FV EASTWARD SWANSTON
BAJO POINT - N SHORE	3M	30MX20M PATCHES ALONG 200M BEACH, 10CM PENETRATION	BLACK SLICK, OILED EELGRASS/KELP/LOGS, ROCKY B.	200.0	01/14/89	BEV BLUETT, JOHN FORD - DFO
BAJO POINT - NORTH FOR 4 KM	4H	EXTENDS ALONG BEACH 2.4 KM	BLACK OIL MIXED W/ SEAWEED, CLASS 4 H-L	2400.0	02/08/89	KEITH HEBRON
BAJO POINT - NORTH OF	4H	100X50M SOLID COVER, 10CM THICK	BLACK SLICK/SHEEN WITH SEAWEED/LOGS, ROCKY BEACH	100.0	01/17/89	BEV BLUETT - DFO
BAJO POINT AND BAJO REEF (OFFSHORE)		1.6 KM X 0.8 KM SHEEN	SHEEN TRAILING SE FROM BAJO 01/10/89	1600.0	01/08/89	SIR JAMES DOUGLAS SHERWOOD
BEANO CREEK - NORTH OF	4	300 M BEACH		300.0	01/13/89	
CALVIN CREEK - S OF	3M	20-40CM PATCHES	SLICK MIXED WITH SEAWEED/LOGS, ROCKY BEACH	0.0	01/15/89	JOHN FORD, BEV BLUETT - DFO
CALVIN CREEK - SOUTH TO UNNAMED CREEK	3	2-5CM PATCHES, THIN	BLACK OIL AT HIGH TIDE, SANDY BEACH, NO PENETRAT.	0.0	01/25/89	KATHY HEISE

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
** AREA BARKLEY						
AUSTIN ISLAND			OILED DEBRIS, 2 BAGS, 1 DEAD DUCK	0.0	01/22/89	LARRY BAIRD
BARKLEY SOUND (OFFSHORE SLICKS)	H		HEAVY OIL SLICKS ON WATER/BEACH BROKEN ISL.	0.0	01/04/89	REP. BY MAZEROLLEP - NEEC
BARKLEY SOUND - 24 KM OFFSHORE		61 X 30 M SHEEN	VISUALLY OBSERVED/IR DOCUMENTED	30.0	01/11/89	B. SHERWOOD
BEG ISLAND			SLICK	0.0	01/10/89	REP.TO HARDING
BEG ISLAND	2		SHEEN	0.0	01/15/89	OWENS
BEG ISLAND (HIGH INTERTIDAL)		LESS THAN 6" DIAMETER GLOBS	BLACK TAR/SHEEN, OILED KELP, ROCKY BEACH	0.0	01/08/89	BARRY LAWLEY
BEG ISLAND - ON MAINLAND NR ISLAND	2		OILED BEACH	0.0	01/08/89	MCINTYRE
BENSON IS. - NE BEACHES		UP TO 3M WIDE, 15CM THICK, 18-190M, 15CM PENETR.	BLACK SLICK IN LOGS/SEAWEED, 10 DEAD BIRDS	190.0	01/08/89	CCG HELO D.CULVER TO B.BLUETT
BRABANT ISLAND - WEST BAY	4	75-100M X 10M BEACH	BLACK OIL MIXED IN COBBLE/ROCKS	100.0	02/17/89	RICHARD LUCAS - NTS
BROKEN ISLAND GROUP - BEACHES	4	10 KM	CL4-5 CUMULATIVE TO JAN. 11 BY PLANIMETER	10000.0	01/11/89	OLMSTED
CAPE BEALE - 2 BAYS, SOUTH END	3	2.5CM BLOBS, .6CM THICK	BROWN OIL, 14 DEAD BIRDS, GRAVEL/ROCK BEACH	0.0	01/19/89	
CAPSTAN ISLAND - SOUTH OF (PEACOCK CHANNEL)			OFFSHORE SHEEN	0.0	01/13/89	REP.TO HARDING
CREE TO SOUTH OF AUSTIN ISLAND			SHEEN/SLICK OFFSHORE	0.0	01/16/89	REP.TO HARDING
DEMSTER ISLAND - NORTH OF			SLICK ON BEACH	0.0	01/11/89	REP.TO HARDING
DICE BOX ISLAND (LOWER BEACH)	4	PATCHY, 15 CM DEEP	BLACK SLICK ON EELGRASS/SEAWEED/LOGS, 4 DEAD BIRDS	0.0	01/13/89	BEV BLUETT REET
DICEBOX ISLAND	3		SHEEN, OIL 23CM DEEP INTO GRAVEL	0.0	01/22/89	LARRY BAIRD
DICEBOX ISLAND - SOUTH COAST, WEST END	3H	1-5CM PATCHES, 1-2CM THICK OVER 40X1M AREA	BLACK OIL ON PEBBLE BEACH, 1 BAG NEW OIL	40.0	02/15/89	HEBRON, LUCAS, STEVENSON
EAST HOWELL TO DICEBOX ISLAND			SHEEN/SLICK OFFSHORE	0.0	01/16/89	REP.TO HARDING
EFFINGHAM ISLAND - INSIDE BAY			SLICK IN BAY	0.0	01/06/89	CCG HELO
EFFINGHAM ISLAND - SOUTH SIDE		200 X 100 M SLICK	OILED SEAWEED, 2 OILED EAGLES, 4 BAGS	200.0	01/21/89	ED OWENS L. BAIRD
GIBRALTER ISLAND - EAST BAY			SLICK ON BEACH	0.0	01/11/89	REP.TO HARDING
GILBERT ISLAND - EAST COAST			SLICK ON BEACH	0.0	01/11/89	REP.TO HARDING
GLEN ISLET			SLICK ON BEACH	0.0	01/17/89	REP.TO HARDING
HANKIN ISLAND - E OF DODD ISLAND - W OF		2 SLICKS	SLICKS	0.0	01/05/89	
HOWELL ISLAND - 2 BAYS ON EAST SIDE			SLICK INSIDE BAY 01/08/89	0.0	01/06/89	CCG HELO
HOWELL ISLAND - EAST POINT			OIL PATTIES, 10 BAGS, OILED KELP/LOGS, 1 DEAD BIRD	0.0	01/22/89	LARRY BAIRD

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
JAQUES ISLAND - NORTH END			SLICK ON BEACH	0.0	01/17/89	REP.TO HARDING
KEITH ISLAND - SE BAY			OIL INSIDE BAY	0.0	01/08/89	CCG HELO
LOUDOUN CHANNEL - OFFSHORE		3 X 31 M SHEEN	RAINBOW SHEEN	0.0	01/08/89	SIR JAMES DOUGLAS
LOUDOUN CHANNEL - OFFSHORE		182 M X 46 M SHEEN	VISUAL SURVEY/IR DOCUMENTED, STREAMING INTO CHAN.	0.0	01/11/89	B. SHERWOOD
LOVETT AND TRICKETT ISLANDS - N OF			SLICK	0.0	01/05/89	
LOVETT ISLAND - WEST SIDE	4	70-105CM PATCHES, 2-5CM THICK OVER 50M BEACH	BLACK OIL MIXED W/ SEAWEED/LOGS, ROCKY SHORE	50.0	02/17/89	RICHARD LUCAS
MULLINS ISLAND - NE COAST			SLICK ON BEACH	0.0	01/11/89	REP.TO HARDING
OUTER BROKEN ISLANDS - LEEWARD SHORES		LESS THAN REP. ON JAN 4 AND 5	OIL WIDESPREAD, SHEEN THROUGHOUT AREA	0.0	01/07/89	REP.BY MAZEROLLE - NEEC
PIGOT ISLAND			POINT OBSERVATION	0.0	01/16/89	REP.TO DAVIS
TOPOLTAT BEACH - SOUTH OF BAMFIELD		GLOBS AND MIXED DEBRIS ALONG TIDE LINE	12 DEAD BIRDS PICKED UP, GRAVEL BEACH	1000.0	01/11/89	JACKIE LEE
TRICKETT ISLAND - OFFSHORE			SHEEN	0.0	01/13/89	REP.TO HARDING
TURRET ISLAND			OIL STRINGERS WEST - SHEEN	0.0	01/08/89	CCG HELO
TURTLE ISLAND			OIL PATTIES IN SEAWEED, 3 BAGS, 1 DEAD BIRD	0.0	01/22/89	LARRY BAIRD
WOUWER ISLAND			OIL IN INTERTIDAL ZONE, SOUTH SIDE HEAVILY OILED	0.0	01/08/89	MCINTYRE
WOUWER ISLAND			SHEEN AND OIL BLOBS, WILL CLEAN	0.0	01/11/89	BAMFIELD I TO CCG
WOUWER ISLAND - EAST SIDE			HEAVILY OILED	0.0	01/11/89	BAMFIELD I TO CCG
WOUWER ISLAND - NARROW PART OF IS. (2 BEACHES)	2M	200M (CLASS 2M) AND 100M (CLASS 3L)	INSIDE BEACH - 3L BLOBS, OUTSIDE BEACH - 2M ON LOG	300.0	01/14/89	PETER OLESIUK, LARRY BAIRD
WOUWER ISLAND - NE OF			SHEEN	0.0	01/21/89	ED OWENS
WOUWER TO CREE ISLAND - OFFSHORE	H	200-300M X 5M SLICK	POSS. CONTAMIN. 1972 VAN LEEN HEAVY 01/11/89	300.0	01/20/89	DOUG SWANSTON
WOUWER TO HOWELL IS. AND DICEBOX IS.			SLICK	0.0	01/04/89	
** AREA BARTLETT						
BARTLETT ISLAND - EAST COAST			POINT OBSERVATION	0.0	01/19/89	REP.TO J.DAVIS
BARTLETT ISLAND - SOUTH COAST	4	1.6 KM	CUMULATIVE TO JAN. 11 BY PLANIMETER	1600.0	01/11/89	OLMSTED
BARTLETT ISLAND - WEST COAST	2		SHEEN	0.0	01/14/89	SWANSTON
** AREA BROOKS						
BROOKS PENINSULA - NR BANKS REEF		2 - 1X10M PATCHES (INCOMPLETE OBSERVATIONS)	BLACK SLICK MIXED WITH SEAWEED/LOGS, ROCKY BEACH	20.0	01/17/89	KEITH HEBRON
BROOKS PENINSULA - SOUTH COAST	4	75 M, 300M AND 3000M PATCHES, 5-20 CM THICK	BLACK SLICK/SHEEN, ROCKY SHORELINE	3375.0	01/13/89	K. HEBRON, M. RODWAY
BROOKS PENINSULA - SOUTH SHORE	4M	20-50+CM PATCHES, 2.5-5CM THICK OVER 4.7 KMS	BLACK OIL MIXED W/ SEAWEED, 6 DEAD BIRDS	4700.0	01/22/89	C. HAND, L. CONVEY

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
CLERKE POINT - 2.4 KM NW	4	300 M	75 M CL 5, 300 M AT BASE OF LOGS	300.0	01/13/89	REET
CLERKE POINT TO 1.5 KM EAST	4M	3-100CM DIAM. PATCHES, 1-30CM THICK, 1.5KMX200M B.	BROWN OIL IN LOGS/SEAWEED, 2 DEAD BIRDS, 30 BAGS	1500.0	01/22/89	D. SWANSTON, NTC CREW REET
JACKOBSON POINT - BEACH TO THE SW OF	4	1.5 KM, 300 M PATCHES	50 BAGS 01/16/89	1500.0	01/14/89	REET ED OWENS - CCG PEARKES
JACKOBSON POINT AND WEST 2.8KM	4M	3-100 CM DIAM, 1-30 CM THICK, 2.8KMX200M BEACH	BROWN OIL/SHEEN, 4 DEAD BIRDS, 30CM PENETR. 30 BAG	2800.0	01/22/89	D. SWANSTON P. OLESIUK
ORCHARD POINT - BEACH SOUTH OF	2L	1-10CM PATCHES, 1-2CM THICK OVER 200X50M BEACH	BROWN OIL/SHEEN IN SEAWEED/LOGS, 0.5 BAGS	200.0	01/24/89	DOUG SWANSTON
UNNAMED BAY - NR BANKS REEF	5	35-40M OF BEACH	BLACK OIL IN SAND, OILED LOGS	40.0	02/06/89	L GAULET REP.TO R.LAMPART
UNNAMED IS. (2) EAST OF FEREY ROCK - EAST SHORE				0.0	/ /	CWS
UNNAMED ISLET (180) TO MAINLAND - CHECLESET BAY	4	1 M DIAM. PATTIES	PATTIES ON SHORE/KELP/ROCK/WATER	1.0	01/14/89	CWS
** AREA BUNSBYS						
BUNSBY ISLAND - INNER IS., EAST SHORE			BLOBS ON ROCKS	0.0	01/19/89	GRAEME ELLIS REP. TO B.BLUETT
BUNSBY ISLANDS			HEAVY OILING, SEA OTTER HABITAT	0.0	01/23/89	PETER OLESIUK - DFO
GULL ISLET	4	300 M	23 BAGS	300.0	01/27/89	DOUG SWANSTON
GULL ISLET - SW CORNER	4	300 M BEACH OILED	DEAD SEA OTTER, 5 DEAD BIRDS, 40 BAGS, 01/24/89	300.0	01/22/89	M. RODWAY P. OLESIUK
SOUTH BUNSBY ISLAND	4	20M PATCHES	BLACK SLICK/SHEEN, OILED KELP, OTTERS WITHIN 300M	20.0	01/15/89	RANDY KASHINO - ESL
** AREA CAPE SCOTT						
CAPE PALMERSTON - EAST SIDE	4L	10-20CM PATCHES, 1-2CM THICK OVER 300X20M AREA	BROWN OIL/SHEEN W/SEAWEED/LOGS, 10 BAGS, CL 4L-3M	300.0	01/24/89	DOUG SWANSTON
CAPE SCOTT - N OF GUISE BAY	3L	1-75CM PATCHES, .1-30CM THICK OVER 1.5KMX100M AREA	BROWN OIL/SHEEN ON SEAWEED/LOGS, 3 DEAD BIRDS	1500.0	01/24/89	D. SWANSTON, K. STURMANIS
GUISE BAY	3		CLASS 3 TO 4, 15 BAGS	0.0	01/25/89	DOUG SWANSTON
GUISE BAY - UNNAMED BAY TO THE WEST	3	12 - 50-100CM PATTIES, 0.5-1MM THICK, OVER 400M	OILED EELGRASS	400.0	01/15/89	RODWAY - CWS
HANSENS LAGOON - WEST SIDE NR SOUTH END	2	10-25CM PATCHES	FRESH OIL AT HIGH TIDELINE W/ SEAWEED, 1/4 BAG	0.0	01/24/89	RODWAY, LEMON - CWS
LOWRIE BAY - NORTH END	3L	10-40CM PATCHES, .01-.05CM THICK OVER 300M BEACH	BROWN OIL/SHEEN IN SEAWEED/ LOGS, 5 BAGS, CL 3-4	300.0	01/24/89	D. SWANSTON
LOWRIE BAY - S. END, FIRST BEACHES TO THE NORTH		25-50CM PATCHES	FRESH OIL ON HIGH TIDE W/ SEAWEED/LOGS, 5-10 BAGS	0.0	01/24/89	RODWAY, LEMON - CWS

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
** AREA CARMANAH						
AGATE BEACH - CARMANAH TO BONILLA PT.		1.8M PATCHES, 7.5-10CM THICK	BLACK OIL, 50 DEAD BIRDS	2.0	01/21/89	CARL EDGAR SR. - NTC
BONILLA POINT	4H		RE-OILED 01/19/89	0.0	01/16/89	REET
BOTANICAL BEACH TO CARMANAH POINT		2.5 CM TAR BALLS, SCATTERED	OIL IN KELP AND ON ROCKS IN HIGH ENERGY AREA	0.0	01/01/89	CCGE
CARMANAH LIGHT - 2M NORTH	3L	5-7CM PATCHES, .1-1CM THICK, 2000M ALONG BEACH	SHEEN MIXED WITH LOGS/SEAWEED, 5 DEAD BIRDS	2000.0	01/16/89	DOUG SWANSTON
CARMANAH POINT			NUMEROUS OIL SLICKS IN AREA	0.0	01/07/89	REPORTED TO HARDING
CARMANAH POINT LIGHT STATION - BEACH			FEW SMALL TAR BALLS, 2 DEAD OILED BIRDS	0.0	12/31/88	LIGHT STATION TO FMG
CLO-OOSE	4	3 - 1X1M PATCHES, UP TO 18CM THICK		3.0	01/10/89	EPS TO CCG BEECH
OWEN POINT - SURGE CHANNELS		1-20CM PATCHES, <1CM THICK, 100X10M OF SHORELINE	BROWN SLICK/SHEEN, ROCKY SHORE	100.0	01/16/89	DAN VEDOVA - DOE, L. MITCHELL
SAN JUAN POINT		600M ALONG SHORE	BLACK SLICK MIXED WITH SEAWEED/LOGS, ROCKY BEACH	600.0	01/16/89	LARRY MITCHELL
** AREA CLAYOQOT						
BROWN'S BEACH			10 BAGS +, OILED LOGS, RE-OILED JAN 30 - 2 BAGS	0.0	01/29/89	CCG
** AREA CLAYOQUOT						
CHESTERMAN AND MCKENZIE BEACH	4L		ALSO REPORTED 01/17/89	0.0	01/03/89	CCG TOFINO TRAFFIC D.LEBLANC
CHESTERMAN BEACH		3CM PATCHES ALONG ENTIRE BEACH	SHEEN/SLICK MIXED WITH SEAWEED, 1 DEAD SEAL	0.0	01/12/89	TOM CURLEY, BILL GREEN
COX BEACH		20 X 280 M STRAND & PATCHES	OFFSHORE/BEACH	280.0	01/15/89	DFO HARDING
COX POINT AND COX BAY	3	10.1 KM	CUMULATIVE TO JAN. 11 BY PLANIMETER	10100.0	01/07/89	R. OLMSTED REP. TO HARDING
ECHACHIS ISLAND - WEST COAST		5-140CM PATCHES, 2.5-15CM THICK	BLACK OIL MIXED W/ SEAWEED, 9 DEAD BIRDS 01/15/89	0.0	01/12/89	REET V.HUSBAND
STUBBS ISLAND - EAST COAST	2		10% EELGRASS OILED, SHEEN	0.0	02/01/89	CWS
STUBBS ISLAND - NORTH COAST	3			0.0	01/16/89	CWS
STUBBS ISLAND - SUBMERGED		5 CM - 60 CM PATCHES	BUNKER AT 1-2 FATHOMS, OILED CRAB TRAPS AT 15 M	0.0	01/08/89	EP DIVE CONTRACTOR
STUBBS ISLAND - WEST COAST	4	1.6 KM	CUMULATIVE TO JAN. 11 BY PLANIMETER	1600.0	01/11/89	OLMSTED REET
SURPRISE REEF		140M SLICKS OVER 175 X 52.5 M AREA	2 SLICKS, AIR OBSERVATION, OFFSHORE?	0.0	01/21/89	HEISE, BARRETT-LENNARD
TEMPLAR CHANNEL - N OF TONQUIN IS. NR THORN REEF		3 X 45 M SLICK	BLUE SLICK	0.0	01/20/89	REET
TOFINO TO 32KM SOUTH/8KM NORTH - PARALLEL TO SHORE		SLICKS 8 KM LONG, 50 M WIDE	8 KM OFFSHORE, SOME SHEEN, SOME DARK OIL	40000.0	01/06/89	CCG HELO
WICKANINNISH ISLAND	3	4.8 KM	CUMULATIVE BY PLANIMETER	4800.0	01/05/89	OLMSTED

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
WICKANINNISH ISLAND		1-2CM PATTIES OVER 20M BEACH	BLACK OIL ON LOGS	20.0	02/11/89	RICHARD LUCAS - NTC
** AREA CLELAND						
BLUNDEN ISLAND - EAST SIDE			OILED DEBRIS AT HIGH TIDE, 1-2 BAGS	10.0	01/18/89	MIKE RODWAY - CWS
CLELAND ISLAND	4L	150 M OILED DEBRIS, NUMEROUS 1 M PATCHES	OILED DEBRIS, CWS: EST 20 BAGS - CLASS 4	150.0	01/11/89	HARDING, MCKELVEY, RODWAY
CLELAND ISLAND	3L		LARGE PATCHES COAT ROCKS, 25 BAGS	0.0	01/18/89	SWANSTON RODWAY
CLELAND ISLAND			15 BAGS	0.0	01/20/89	CWS
CLELAND ISLAND - OFFSHORE		2 - 1X2 M SURFACE SLICKS	SURFACE SLICKS	4.0	01/05/89	CWS
CLELAND ISLAND - SE BEACH AND WEST SIDE OF ISLAND		10CM BLOBS OVER 35M BEACH (WEST SIDE)	OIL IN ROCKS ABOVE BEACH, 2 BAGS (SE), 6 BAGS (W)	35.0	01/22/89	MIKE RODWAY
** AREA CLUTUS						
CLUTUS POINT - EAST SIDE	4	200X1M AREA	BLACK OIL MIXED WITH SEAWEED/LOGS	200.0	02/12/89	LUCAS, HEBRON, STEVENSON
CLUTUS POINT - WEST SIDE (BEACH AND OFFSHORE)	0	1-3X2CM PATCHES 50X1M, 900X30M SLICK OFFSHORE	BROWN OIL/SHEEN, 4 DEAD BIRDS, SAND-GRAVEL BEACH	50.0	01/20/89	DAN VEDOVA
** AREA CULLITE						
CULLITE	2	2.5-5CM PATCHES, 15CM THICK	BLACK SLICK MIXED WITH SEAWEED	0.0	01/16/89	BOB JONES
CULLITE CREEK - NORTHSIDE	4H	20-50+CM PATCHES, 3-4CM THICK, 1800X8M ON BEACH	BLACK SLICK/SHEEN IN LOGS/SEAWEED, 12 DEAD MURRES	1800.0	01/16/89	DAN VEDOVA AND L. MITCHELL
** AREA DARLING						
KLANAWA RIVER NORTH TO DARLING CREEK	0	3-50CM DIAM. ALONG 1.5KM BEACH	BROWN OIL MIXED W/ SEAWEED, >30 DEAD BIRDS, 30 BAG	1500.0	01/20/89	ALAN BURGER, DOUG SWANSTON
** AREA DAVID						
DAVID AND FORBES ISLAND - BTW			OFFSHORE SLICK	0.0	01/07/89	MCINTYRE
DAVID ISLAND - EAST OF			POINT OBSERVATION	0.0	01/04/89	HEBRON
** AREA DEER						
EDWARD KING ISLAND - WEST COAST			1.73 BAGS COLLECTED, ROCK/COBBLE BEACH	0.0	01/21/89	ED OWENS
HAINES ISLAND			OILED BEACH	0.0	01/16/89	REP.TO HARDING
HELBY ISLAND - NW CORNER (INDIAN RESERVE)		1-10 CM X 1 CM THICK PATCHES	BROWN OIL/SHEEN, 2 DEAD BIRDS, 6 BAGS REMOVED	0.0	01/20/89	DOUGLAS JOHNSON,WILFRED DENNIS
KIRBY POINT	4M			0.0	01/20/89	SWANSTON
KIRBY POINT - SW BAY (TOP OF BEACH)		3-10CM PATCHES, 1CM THICK OVER 200M OF BEACH	BROWN OIL/SHEEN MIXED W/ SEAWEED/LOGS, 6-7 BAGS	200.0	01/20/89	WILFRED DENNIS - OHIAT BAND
LEACH ISLET - NR FOLGER ISLAND			SLICK	0.0	01/04/89	HEBRON

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
** AREA DUNSMUIR						
LONETREE PT - 30M S. DUNSMUIR POINT - 650M S.		2 - 30.5 M2 SHEENS	LIGHT SHEEN CONFIRMED BY BAMFIELD SAR	0.0	01/14/89	MV HAIDA BRAVE
** AREA ELBOW						
ELBOW BANK - OFFSHORE			SURFACE SLICK	0.0	01/19/89	
** AREA ESCALANTE						
ESCALANTE				0.0	01/23/89	REET
ESCALANTE BEACH		50X50CM PATCHES, 7.5CM THICK, 100-1000M APART	BLACK OIL, 7 DEAD BIRDS, SEAL AND WHALE CARCASS	0.0	01/17/89	DARRELL WILLIAMS
ESCALANTE POINT		183M DIAM. PATCH		183.0	01/12/89	REET CGS GRP
ESCALANTE POINT	5	200 X 100 M SLICK	OIL IN ROCKY INTERTIDAL AREA, MNT.EQUIP.C. CLEANUP	200.0	01/21/89	MNT. EQUIP. COOP REET
ESCALANTE POINT TO SPLIT CAPE			DISCONTINUOUS SLICK ALONG COAST	0.0	01/15/89	REP. TO HARDING
** AREA ESPERANZA						
CATALA ISLAND - SW COAST	4	2.5-5CM THICK	BLACK OIL	0.0	02/10/89	KEITH HEBRON
CATALA ISLAND - WEST COAST			BIRD HABITAT OILED CLEANED 01/19/89	0.0	01/17/89	SWANSTON
YELLOW BLUFF	3L		CLASS 3 AND 4	0.0	01/18/89	SWANSTON
YELLOW BLUFF - BAY EAST OF	2			0.0	01/13/89	REP. TO HARDING
YELLOW BLUFF - BAY WEST OF				0.0	01/25/89	REP. TO HARDING
** AREA ESTEVAN						
ESTEVAN - SE OF			PATCHES OF OIL 01/15/89	0.0	01/12/89	REET DFO
ESTEVAN POINT - 1.6 KM NORTH AND 2.4 KM SOUTH	4	5-8CM PATCHES OVER 4 KM SHORE	OILED BEACH/LOGS, HEAVY AT LIGHTHOUSE 01/12/89	4000.0	01/09/89	LIGHTKEEPER REET
** AREA FLORES						
COW CREEK - 2.5 KM EAST OF	2L			0.0	01/14/89	SWANSTON
COW CREEK - EAST	4	15.5 KM (EXAGERATED?)	CUMULATIVE TO JAN. 07 BY PLANIMETER	15500.0	01/05/89	OLMSTED REP. TO HARDING
DAGGER POINT	3M	1.6 KM	CUMULATIVE TO JAN. 11 BY PLANIMETER 01/25/89	1600.0	01/11/89	OLMSTED
RAFAEL POINT	3M	10-75 CM PATCHES, 0.1-10CM THICK, >300X150M OF B	BROWN SLICK/SHEEN, MIXED WITH SEAWEED/LOGS	300.0	01/14/89	SWANSTON J.FORD, B.BLUETT
** AREA GIBSON PARK						
WHITE SAND COVE BEACH	0			0.0	01/10/89	BARRY LAWLEY
** AREA GRANT						
GRANT BAY - NW CORNER	4L	1-30CM PATCHES, 1-2CM THICK, OVER 400X50M AREA	BROWN OIL/SHEEN IN DEBRIS, 3 DEAD BIRDS, 15 BAGS	400.0	01/24/89	DOUG SWANSTON

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
** AREA GRASSY						
GRASSY ISLAND - HIGH ROCKS (SE SIDE)	3	20CM BLOBS, 1CM THICK	BROWN OIL/SHEEN MIXED W/ SEAWEED, 5 BAGS	0.0	01/17/89	MARK MICHAEL
GRASSY ISLAND - WEST AND SOUTH BEACH AND N ROCKS	3L	1-3CM PATCHES, 1 CM THICK OVER 500M	BROWN OIL/SHEEN, 2 BAGS	500.0	01/26/89	DOUG SWANSTON
** AREA GREGOIRE						
GREGOIRE POINT - SOUTH OF	4M	8X40CM PATCHES OVER 1.6-3KM OF BEACH	BROWN OIL MIXED WITH SEAWEED, ROCK-PEBBLE BEACH	3000.0	01/18/89	VICTORIA SMITH
** AREA HEATER						
HEATER POINT - SOUTHEAST OF	3L	1.5 KM	AREAS RATED CLASS 2	1500.0	01/24/89	SWANSTON
** AREA HESQUIAT						
BOAT BASIN TO MATLAHAW HESQUIAT HARBOUR	3L	30 CM PATCHES, 3 CM THICK OVER 300 M SHORE	10 BAGS BLACK OIL MIXED W/SEAWEED, SANDY	300.0	01/17/89	D.IGNACE, S.MICKEY HARDING
HESQUIAT POINT	4	200 M, 4 SLICKS	THICK COATING OF OIL ON ROCKS 10 BAGS	200.0	01/10/89	HARDING
HESQUIAT POINT - SOUTH OF	3		POINT OBSERVATION 01/25/89	0.0	01/17/89	
HOMAIS COVE			OILED	0.0	01/15/89	REP.TO J. DAVIS
HOMAIS COVE	5L	1.5M PATCHES, 12CM THICK, OVER 91M BEACH	BLACK OIL/SHEEN ON SEAWEED/LOGS, 1 DEAD BIRD	91.0	01/17/89	DAN SAVEY
HOMAIS COVE - N OF	5L	1.5 M DIAM. PATCHES, 5 CM THICK, 20X10M OF BEACH	BROWN SLICK IN SAND AND KELP, EST. 30 BAGS	20.0	01/15/89	DAVE IGNACE - NTC
PEREZ ROCKS	4	61 CM PATCHES OVER 130 M	NOT RECORDED IN OIL SIGHTINGS LOG	130.0	01/15/89	NTC
** AREA HOTSPRING						
HOT SPRINGS COVE			SLICK	0.0	01/25/89	
** AREA IMPERIAL						
ALMA RUSSEL ISLAND - NW NR MAHK ROCK			POINT OBSERVATION - MAP	0.0	01/04/89	HEBRON
EFFINGHAM INLET (SUBTIDAL)		7.5 KM SUBMERGED OIL?	OIL ON HAGFISH/CRAB TRAPS, THICK STICKY TAR	0.0	01/16/89	OCEAN BARON VIA TOFINO RADIO
KYEN POINT			POINT OBSERVATION - MAP	0.0	01/04/89	HEBRON
** AREA KUTCOUS						
UNNAMED POINT - WEST OF KUTCOUS PT.		10 - 3-5CM PATCHES, 1 CM THICK, OVER 10M OF SHORE	BROWN OIL/SOME SHEEN, OILED LOGS/SEAWEED, 5 BAGS	10.0	01/19/89	DOUG SWANSTON
** AREA KWAKIUTL						
KWAKIUTL POINT	2L	10-30CM PATCHES, 1CM THICK OVER 200X50M BEACH	BROWN OIL/SHEEN MIXED W/ SEAWEED, 1 BAG	200.0	01/24/89	DOUG SWANSTON

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
UNNAMED ISLET - NW OF KWAKIUTT POINT	2L	10-50CM PATCHES, 15CM THICK OVER 300X50M BEACH	BROWN OIL/SHEEN ON SEAWEED/LOGS, 2-3 BAGS	300.0	01/24/89	DOUG SWANSTON
UNNAMED ISLETS - SE OF KWAKIUTL POINT	2	10-50CM PATCHES, 10CM THICK OVER 500X50M BEACH	BROWN OIL/SHEEN W/ SEAWEED/LOGS, 2 BAGS	500.0	01/24/89	DOUG SWANSTON
** AREA KYUQUOT						
KYUOQUOT CHANNEL - SW OF ENTRANCE ROCKS		50M X 300M SHEEN	TO BE CHECKED BY CCG HELO	0.0	01/13/89	
KYUQUOT (OFFSHORE)		1500 X 50M SHEEN	SHEEN	1500.0	01/13/89	HELO MP1
RUGGED PT (S SIDE) TO GROSS PT (N SIDE)	4	3-30CM X 10CM PATCHES OVER 800X40M B., 10 CM PENET	BROWN OIL/SHEEN MIXED W/ SEAWEED/LOGS, 10 BAGS	800.0	01/22/89	ALEX SHORT
** AREA LAWN						
LAWN POINT	3	1 M PATCHES, SEVERAL CM THICK, 2 BLOBS	BLACK SLICK,	2.0	01/14/89	MIKE RODWAY - CWS
LAWN POINT - SE SIDE	4L	10-75CM PATCHES OVER 500X50M AREA	BROWN OIL/SHEEN ON SEAWEED/LOGS, 30 BAGS, CL3M-4L	500.0	01/24/89	SWANSTON J. DAVIS
** AREA LONG						
COMBERS BEACH	4	25.4CM DIAM. PATCHES ABOUT 3M APART	ON BEACH AT HIGH AND LOW TIDE LINES	0.0	01/12/89	CCG REET
FLORENCIA BEACH	4M	5.5 KM	CUMULATIVE TO JAN. 11 BY PLANIMETER	5500.0	01/11/89	OLMSTED
FLORENCIA BEACH	4	7-10 CM BLOBS EVERY 7-15 M OVER 250 M BEACH	SANDY BEACH, OILED LOGS	250.0	01/13/89	MAC ELDER LES DAWES
FLORENCIA BEACH	3	1-25CM PATCHES OVER 100-200M BEACH	BROWN SLICK/SHEEN W/SEAWEED REOILED 01/25/89	200.0	01/16/89	RANDY KASHINO - ESL
FLORENCIA BEACH - MID			OIL PATCHES - TAR BALLS AND PADS	0.0	01/03/89	MAC ELDER TO CCG TOF. TRAF.
GREEN POINT	4H	30 CM PATCHES X 15 M, 1.6 KM	OIL COVERAGE 0-15%, AVER. 5%, HIGH TIDE	1600.0	01/04/89	CCGE MAC ELDER
GREEN POINT ROCK	4		SMALL QUANTITIES OF HEAVY OIL	0.0	01/09/89	DAN VEDOVA - PARKS CANADA
LONG BEACH			LIGHT OIL ON 300+ CRAB TRAPS, CLEANED NATUR./VOL.	0.0	01/07/89	REP. TO HARDING
LONG BEACH	4M		BLACK OIL MIXED W/ SEAWEED, 40-50 DEAD BIRDS	0.0	01/16/89	D.LEBLANC M.ELDER
LONG BEACH - AT AIRPORT	H	8.05 KM	INTENSIVE OIL COVERAGE, SPORADIC AREAS	8050.0	01/03/89	M.ELDER TO CCG TOFINO TRAFFIC
LONG BEACH - OFFSHORE SLICKS				0.0	01/13/89	REET
LONG BEACH AT WICKINNINISH INN	4H	3CM - 3M DIAM. PATCHES, 350 - 450 M AREA	OIL SUBSURFACE PRIOR TO IMPACT, 25 DEAD BIRDS	450.0	01/03/89	MAC ELDER TO TOFINO TRAFFIC
PEBBLES BEACH - EAST OF WICKININNISH CENTER		LESS THAN 20CM DIAM. PATCHES	ESTIMATES CLEANUP - 10 MEN/2 DAYS	0.0	01/09/89	DAN VEDOVA - PARKS CANADA
PORTLAND POINT	5	3.6X4.6 M PATCHES. 10 CM THICK	BROWN SLICK ON ROCKS, 12 DEAD BIRDS, 41 BAGS	5.0	01/13/89	LISA TREMBLAY - VOL.
PORTLAND POINT - OFFSHORE			SLICK	0.0	01/13/89	

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
SANDHILL CREEK			OILED LOGS, THREAT TO SWANS & SALMON	0.0	01/08/89	MCINTYRE?
SCHOONER BEACH	L		SLIGHT OIL CONTAMINATION	0.0	01/03/89	CCG TOFINO TRAFFIC
SCHOONER BEACH (OFFSHORE)			SLICK	0.0	01/12/89	SPILL COORD. CENTER
SCHOONER BEACH - 1 BAY NW	2	200 X 2 M SHEEN	BLUE SHEEN, AIR OBSERVATION	200.0	01/19/89	BEV BLUETT - DFO
SCHOONER COVE			CLEANED BY VOLUNTEERS	0.0	01/07/89	REP. TO HARDING
SCHOONER COVE AND GREEN POINT	4		GREEN POINT RATED CLASS 3	0.0	01/17/89	D.LEBLANC REET
SCHOONER COVE TO LONG BEACH	3L	2CM TAR BALLS OVER SEVERAL 100M BEACH, NARROW BAND	NUMEROUS TAR BALLS MIXED W/ SEAWEED	500.0	01/23/89	PARKS VOL.TO MORRISON
WICKANINNISH BAY	4	16.4 KM (EXAGERATED?)	CUMULATIVE TO JAN. 11 BY PLANIMETER	16400.0	01/11/89	OLMSTED
WICKANINNISH BAY - OFFSHORE SLICKS			8 SLICKS/SHEEN IN BAY	0.0	01/05/89	
WICKANINNISH BEACH	4	2-25 CM PATCHES, 4 KM X 3M OF BEACH	BROWN OIL, 15% COVERAGE/METER SANDY BEACH	4000.0	01/16/89	DAN VEDOVA KASHINO ELDER
WICKANINNISH BEACH TO COMBERS BEACH	3	<1-2.5 CM PATCHES EVERY 1-45 M	NORTH END OF BEACH - CLASS 3-4, SOUTH END - CL. 3	0.0	01/18/89	ED OWENS
WYA POINT - S OF			OIL WELL WEATHERED, SAMPLED FOR RESEARCH	0.0	01/20/89	ED OWENS
** AREA LOOKOUT						
LOOKOUT ISLAND	3	3-15CM PATCHES, 3-30CM THICK, 1.5KM X 10-200M	BROWN OIL/SHEEN W/ SEAWEED/LOGS, 20 BAGS, 10CM PEN	1500.0	01/22/89	DOUG SWANSTON G. ELLIS
LOOKOUT ISLAND - REEF WEST OF	3L		CLASS 3 TO 4 LIGHT	0.0	01/21/89	CWS
** AREA MAYNE						
LYALL POINT TO LOGGERS LANDING			SCATTERED OIL MIXED W/ SEAWEED, SLICK OBS.01/07/89	0.0	01/09/89	CG731
MAYNE BAY	4	8.6 KM, 15 CM PATTIES	REMOVED 2,270 KG OIL RE-OILED 01/12/89	8600.0	01/11/89	CGE731 OLMSTED LAWLEY
MAYNE BAY - OFFSHORE		3 SLICKS	SLICKS	0.0	01/05/89	
** AREA MCLEAN						
CLANNINICK COVE			18 BAGS	0.0	01/22/89	CCG
CLANNINICK COVE - BEACH	3		4 BAGS FOR PICK-UP 2HRS FOR 2 PEOPLE 01/30/89	0.0	01/27/89	D.SWANSTON G.ELLIS
CLANNINICK COVE - NORTH END			5 BAGS COLLECTED	0.0	02/06/89	CWS
CLANNINICK INLET - HEAD OF (OFFSHORE?)	4M	180M WIDE	LIGHT TO MODERATE CONTAMINATION	180.0	01/19/89	PETER OLESIUK REET
COLE ROCK	3L			0.0	01/21/89	SWANSTON

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
MCLEAN AND VANCOUVER ISLAND - BETWEEN	4L	7M DIAM. PATCHES, 12.5CM THICK OVER 1.8 KM	BLOBS OF OIL, SEA OTTER IN AREA	1800.0	01/23/89	PETER OLESIUK
** AREA MCQUARRIE						
MCQUARRIE ISLETS	3L		SHEEN ON WATER TO SE	0.0	01/19/89	SWANSTON
** AREA MILLAR						
MILLAR CHANNEL		0.8 KM SLICK	SLICK, OIL ASHORE AT VARGAS/FLORES	800.0	01/05/89	DFO
** AREA MISSION						
AKTIS & SPRING ISL. - CHANNEL BTW TO FAV. ENTR.			OFFSHORE SLICK/SHEEN	0.0	01/21/89	REP. TO HARDING
AKTIS - EAST SIDE	0	15 CM PATCHES ALONG 500 M BEACH	BLACK SLICK, SAND BEACH, MIXED WITH LOGS/SEAWEED	500.0	01/12/89	MIKE OSCAR REP. TO J.VINCENT
AKTIS ISLAND (OFFSHORE)		20-30CM PATTIES	SLICK	0.0	01/13/89	B. GREEN - NTC
AKTIS ISLAND - SE SIDE		30-90 CM PATCHES, 5-15 CM THICK, 500 M	BLACK SLICK IN LOGS/SEAWEED/KELP, 10 DEAD BIRDS	500.0	01/12/89	DICK LEO S.KAYRA
ATKIS ISLAND - EAST SIDE			5 BAGS COLLECTED	0.0	02/07/89	CWS
CHANNEL BETWEEN AKTIS AND SPRING IS. (SUBTIDAL)		20 CM PATCHES, 10 CM THICK	MIXED WITH SEAWEED, SUBTIDAL, BLACK GLOBS	0.0	01/12/89	DICK LEO TO BILL GREEN
KAMILS ISLAND - SE BEACHES, IN BAY		100, 70CM BLOBS, 5CM THICK	BROWN OIL/LIGHT SHEEN, GRAVEL BEACH, OFFSHORE?	70.0	01/18/89	
KAMILS TO SORBY ISLAND - OFFSHORE			SLICK EXTENDS BTW ISLANDS	0.0	01/18/89	G. ELLIS - CWS
MISSION GROUP				0.0	01/20/89	REET CWS
SPRING ISLAND - SE SIDE		5-50CM PATCHES, 2 CABLES LONG	BLACK SLICK/SHEEN, ROCKY BAYS, 3 DEAD BIRDS, ROCKY	60.0	01/15/89	G. ELLIS TO JOHN DAVIS
SPRING ISLAND - SE SIDE OF SOUTH END		15-30 CM PATCHES, 7-10 CM THICK, 1/3 IS.SHORELINE	BLACK SLICK/SHEEN, MIXED WITH SEAWEED, 2 DEAD BIRD	800.0	01/12/89	JOHN VINCENT
SPRING ISLAND - SS/E	4	45 CM PATCHES, 4 CM THICK OVER 800 M	BROWN SLICK/SHEEN MIXED WITH LOGS/SEAWEED,	800.0	01/12/89	LEONARD JOHN - KYUQUOT BAND
SPRING ISLAND - SSW	3L		NUMEROUS BAGS ON BEACH	0.0	01/19/89	PETER OLESIUK
SPRING ISLAND - WEST AND SOUTH SIDE		32CM PATCHES, 4CM THICK	BROWN OIL MIXED W/ SEAWEED, ROCK/GRAVEL SHORE	0.0	01/12/89	JOHN VINCENT - NTC
SPRING ISLAND TO UNNAMED ISLAND TO SOUTH			SLICK	0.0	01/12/89	G. ELLIS - CWS
UNNAMED ISLAND AT FAVORITE ENTRANCE			OILED	0.0	02/07/89	CWS
** AREA NEWCOMBE						
ALLEY RK - HUMPHRIES REEF - FRANCIS IS. - FOOD IS.			OFFSHORE SLICK	0.0	01/04/89	HEBRON
BEACH FROM MAGGIE R. TO FORBES ISLAND			OIL PRESENT, EST. 4 CLEAN-UP CREW FOR 1 DAY	0.0	01/14/89	FISHERIES OFFICER
FOOD ISLET			OILED SECOND OBSERV. 01/11/89	0.0	01/05/89	MCINTYRE ALDERMAN (UCLUELET)

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
FOOD ISLET ALONG COAST TO WEST OF N. STOPPER ISL.		SCATTERED	SCATTERED OIL CONTAMIN. ALONG ENTIRE AREA, JAN 23	0.0	01/14/89	REP.TO HARDING
FOOD ISLET ALONG COAST TO WEST OF N. STOPPER ISL.			RESIDUAL BENCHMARKS, CLEANUP	0.0	02/11/89	BAIRD
FORBES ISLAND			OFFSHORE SLICK	0.0	01/04/89	HEBRON MCINTYRE
SARGISON BANK - NW OF			SLICK	0.0	01/04/89	HEBRON
UNNAMED POINT - NEWCOMBE CH. S OF TWIN R. I.R.			BLACK OIL IN SCATTERED PATTIES	0.0	01/22/89	AF GRAVON TO COMOX POST
** AREA NITINAT						
CHEEWAHT RIVER MOUTH	3L	10-20 CM PATCHES, 2-4 CM THICK, 200M ON BEACH	BLACK SLICK/SHEEN ON WATER/SAND BEACH	200.0	01/12/89	ROBERT KNIGHTON TO BILL GREEN
DEER BEACH - S OF DARE POINT		23-35CM PATCHES SPREAD OVER 1.6KM	OIL PATCHES	1600.0	02/13/89	CLEANUP CREW REP.TO CARL EDGAN
NITINAT AREA	2	TRACES OF OIL IN VARIOUS LOCATIONS	CUMULATIVE TO JAN 11	0.0	01/07/89	REP. TO HARDING
NITINAT/TSUSIAT		3.96 KM		3960.0	01/22/89	REET
** AREA NOOTKA						
FRIENDLY COVE	H	9M X 1.5M SEVERAL CM THICK	HEAVY OILING, 10-12 PERSONS ON CLEAN-UP	9.0	01/08/89	LIGHTKEEPER CCGS
FRIENDLY COVE			10% OF OIL REMAINS, TO BE CLEANED NATURALLY	0.0	01/12/89	CCG DOUGLAS HEBRON
FRIENDLY COVE		305 X 91 M, 200 M OFFSHORE	SLICK	0.0	01/17/89	CG 304 REET
FRIENDLY COVE			CG REMOVED OIL BAGS ON JAN 28	0.0	01/22/89	SIMMONS, PHILLIPS, LUCAS
MAQUINNA POINT (OFFSHORE)	4L		SLICK	0.0	01/08/89	SIR JAMES DOUGLAS
MAQUINNA POINT - NW OF	4L			0.0	01/15/89	SWANSTON
NOOTKA ISLAND - SOUTH TIP, LIGHT STATION	5	1.5 KM	CUMULATIVE BY PLANIMETER	1500.0	01/07/89	OLMSTED REP.TO HARDING GREEN
NOOTKA SOUND - 16 KM SOUTHWEST (OFFSHORE)		2 SLICKS	DETECTED BY THERMAL IR IMAGERY	0.0	01/10/89	SHERWOOD, DUNN
SAN MIGUEL ISLAND		152M X 15M, 15-30CM PENETRATION	OIL IN GRAVEL, CLEAN-UP IN PROGRESS	152.0	01/09/89	CCGS SIR JAMES DOUGLAS
SKUNA BAY	4M	2 KM	OILED KELP, 50 BAGS, L/H CONTAM., 02/08/89	2000.0	01/28/89	D.SWANSTON REET
YUQUOT POINT			OILED BEACH	0.0	01/09/89	NOOTKA LIGHTKEEPER
YUQUOT TO MAQUINNA POINT	L		SLICK	0.0	01/13/89	REP. TO HARDING
YUQUOT TO MAQUINNA POINT		10 X 10 M	AERIAL OBSERVATION	10.0	01/17/89	
** AREA NUCHATLITZ						
COLWOOD ROCKS			SHEEN	0.0	01/21/89	REP.TO J.DAVIS/L.HARDIN G

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
FERRER POINT - 4.5 KM SOUTHEAST OF	4	1.2 M TAR MATS	AERIAL SURVEY, REMOTE SENSING, OILED BEACH	1.2	01/10/89	SHERWOOD, DUNN
NUCHATLITZ - SEAWARD SIDE OF PORT LANGFORD	4		REEFS AND SANDBARS, EST. 160 BAGS, 1 DEAD OTTER	0.0	01/28/89	DOUG SWANSTON
NUCHATLITZ AREA	3		CLASS 3 SOME 4, 25 BAGS COLLECTED	0.0	01/18/89	SWANSTON TULLEY E.OWENS
NUCHATLITZ AREA				0.0	02/01/89	CCG
** AREA PACHENA						
BLACK RIVER - NORTH OF			OILED	0.0	01/23/89	REP. TO J. DAVIS
KEEHA BAY	3H	1-10CM PATCHES OVER 200M (CL3H) AND 1000M (CL3L)	BROWN OIL/SHEEN MIXED W/ DEBRIS, 5 DEAD BIRDS	1200.0	01/20/89	DAN VEDOVA
KEEHA BAY		70-100CM PATCHES OVER 2-300M	SANDY BEACH	300.0	02/22/89	CARL EDGAR SR. - NTC
KEEHA BAY - OFFSHORE	4	2.3 KM	CUMULATIVE TO 04 JAN. BY PLANIMETER	2300.0	01/04/89	OLMSTED, HEBRON
KEEHA BEACH - DEADMAN COVE	3M	5-30CM PATCHES OVER 500M BEACH	CLASS 3-4, M TO L CONTAMIN.	500.0	01/16/89	D. SWANSTON D. HAGSTROM
PACHENA BAY (WEST SIDE) AND KEEHA BAY			BLOBS SCATTERED ON BEACH, 30 DEAD BIRDS	0.0	01/21/89	OHIAHT BAND REP. TO S. PETERS
PACHENA BAY - MOUTH			HEAVY OIL MIXED W/ LOGS	0.0	01/20/89	SWANSTON
PACHENA BAY - MOUTH OF PACHENA RIVER	3	SMALL PATCHES SCATTERED OVER 200M BEACH	OIL ON LOGS AT TOP OF BEACH, AIR OBSERVATION	200.0	01/21/89	DARRELL ROSS - NTC
PACHENA BAY - OFFSHORE	3	3.1 KM BEACH AND 2 SLICKS	CUMULATIVE BY PLANIMETER	3100.0	01/05/89	OLMSTED, MCINTYRE
PACHENA LIGHT TO DARLING RIVER	2		20 BAGS PICKED UP, 40 DEAD BIRDS	0.0	01/15/89	DAVE HERITAGE J.DAVIS
PACHENA POINT		600LBS BAGGED OIL OVER 6 KM AREA	400LBS (13 BAGS) FROM 3KM N 200LBS FROM 3KM SOUTH	6000.0	01/09/89	LIGHTHOUSE
PACHENA POINT AREA				0.0	02/01/89	CCG
SAND STONE FLATS - S. OF PACHENA BAY			NUMEROUS OIL PATCHES, SEA LION AND SEAL AREAS	0.0	01/07/89	REP. TO HARDING
SEABIRD ROCKS			9 BAGS OFF SOUTH BEACH, BLOBS ON NE BEACH	0.0	01/11/89	CWS
SEABIRD ROCKS - BEACH S OF PACHENA	2		BROWN OIL, 2 DEAD BIRDS 5 BAGS, 01/20/89	0.0	01/11/89	REET DAN VEDOVA
UNNAMED BAY - SOUTH OF BLACK RIVER		3CM - 1M PATCHES, 1-10CM THICK OVER 1000X200M B.	BROWN OIL/SHEEN, 4 DEAD BIRDS, 25 BAGS, 20CM PENET	1000.0	01/20/89	DOUG SWANSTON
** AREA QCS						
GOOSE GROUP OF ISLANDS (QUEEN CHARLOTTE SOUND)		3, 10-30 CM PATTIES	OILED EELGRASS, SAMPLE COLLECTED	1.0	01/27/89	M. RODWAY - CWS
** AREA QUATSINO						
CAPRINO RIVER ESTUARY		12X1M PATCHES, 29CM THICK AND 8KM SHEEN	BLACK SLICK/SHEEN, AIR OBSERVATION	8000.0	01/14/89	BILL OAK TO DON RODDEN
MONTGOMERY POINT, ROBSON AND SOUTH DANGER ROCK			POINT OBSERVATION	0.0	01/20/89	REP. TO HARDING

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
QUATSINO SOUND		3 PATCHES, 0.8 KM APART	OFFSHORE SLICKS, AERIAL SURVEY	25.0	01/14/89	CCG
** AREA RACOON						
RACOON POINT - POINT 2.8 KM NW OF				0.0	01/18/89	REP. TO J. DAVIS
** AREA RAFT						
RAFT COVE			40 BAGS	0.0	01/21/89	CCG EP
RAFT COVE - EAST BEACH	2L	1-10CM PATCHES OVER 200X50M BEACH	BROWN SHEEN SEAWEED/LOGS, 1 BAG, CL2-3VL 01/24/89	200.0	01/24/89	DOUG SWANSTON J.DAVIS
RAFT COVE AND 3.2 KM NORTH	3M	EST. 100 BLOBS, 2-22 CM THICK OVER 1-2 KM BEACH	OIL MIXED WITH EELGRASS, 15 BAGS	2000.0	01/14/89	JOHN MARTINELLO, HOLBERG
** AREA SAN JOSEF						
HANNA POINT - EAST SIDE	4L	10-50CM PATCHES, 1-2CM THICK OVER >300MX30M BEACH	BROWN OIL/SHEEN ON LOGS/SEAWEED,1 DEAD BIRD,15 BAG	300.0	01/24/89	DOUG SWANSTON
SAN JOSEF BAY		1 - 1X1.5 M PATCH	IMPORTANT ESTUARY CLEANED 01/19/89	1.5	01/12/89	MIKE RODWAY
SAN JOSEF BAY			OIL HAULED UP ON NETS	0.0	01/20/89	FISHING BOATS
** AREA SCOTT						
BERESFORD AND SARTINE ISLAND			POINT OBSERVATIONS	0.0	01/18/89	REP. TO HARDING
COX ISLAND - 2 BAYS ON SOUTH SIDE	L	2-50 CM BLOBS	L OIL IN BIRD FEEDING AREAS 2-3 BAGS, 01/24/89	0.0	01/17/89	CWS
LANZ ISLAND - BAY MIDDLE OF SOUTH SIDE		10 CM PATCHES	EST. 1 BAG NOT WORTH CLEANING	0.0	01/24/89	RODWAY, LEMON - CWS
TRIANGLE ISLAND		1-10 CM BLOB, 1 M THICK AND 8 M LONG		8.0	01/24/89	MIKE RODWAY - CWS
TRIANGLE ISLAND - SOUTH BAY	3	10-20 CM BLOBS	OIL ON ROCKS	1.0	01/15/89	RODWAY - CWS
** AREA SEA OTTER						
SEA OTTER COVE		20-50CM PATCHES OVER 400 M BEACH	SCATTERED BLOBS, EST. 5 LBS, SANDY BEACH	400.0	01/15/89	FISHERMAN REP. TO J CHAMBERS
SEA OTTER COVE - SMALL BAY ON N BEACH	4	25-50CM PATCHES OVER 400M AREA	20-25 BAGS AT HIGH TIDE LEVEL, NATIVE HARVEST AREA	400.0	01/24/89	RODWAY, LEMON - CWS
WINIFRED ISLAND			1 BAG. NATIVE HARVEST AREA	0.0	01/24/89	RODWAY, LEMON - CWS
** AREA SIDE						
MAYDAY ISLAND - NORTH OF			POINT OBSERVATION	0.0	01/19/89	REP TO J. DAVIS
SIDE BAY				0.0	01/22/89	CCG HELO REET
SIDE BAY - NORTH SHORE	3	35x70CM PATCHES, 2.5-5CM THICK, OVER 810M	BLACK OIL/SHEEN MIXED W/ SEAWEED/LOGS, 25 DEAD BDS	810.0	01/17/89	BRUCE WHITZEL

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
** AREA SIDNEY						
SIDNEY INLET		220 M LONG SLICK	SMALL SLICK, SHEEN WITH BLOBS	220.0	01/11/89	ATLIN POST TO CCG
** AREA SOOKE						
CHINA BEACH			1 BAG OIL REMOVED	0.0	01/12/89	ROBIN SAULE - PROV. PARKS
GORDON'S BEACH - 6 KM WEST OF SOOKE		19 L OIL EVERY 0.8 KM	ESTIMATE	1000.0	01/09/89	BILL BELL TO CCG
JORDAN RIVER, CHINA AND SOMBRIO BEACHES			SHEEN AND SMALL BLOBS	0.0	01/11/89	LEAHE CHATAN - CITIZEN
SOMBRIO, FRENCH AND BOTANICAL BEACHES	0		CLEANED BY PARKS	0.0	01/16/89	KEL HICKIE
SOOKE BASIN (OFFSHORE?)	2	40 X 400 M SHEEN	RAINBOW SHEEN, OFFSHORE?	400.0	01/15/89	RCMP
SOOKE BASIN - E OF WHIFFEN SPIT	0		FEW PATCHES	0.0	01/14/89	DENNIS LANGOIS REP. TO PEP VIC
** AREA STOPPER						
STOPPER ISLAND - WEST AND NORTH OF			OIL STRINGERS WEST IN MID-CHANNEL SLICK	0.0	01/04/89	HEBRON CCG HELO
** AREA TATCHU						
SANDSTONE POINT TO JURASSIC POINT	3L	1-30CM PATCHES, 1-10CM THICK OVER 500M	BROWN OIL/SHEEN W/ SEAWEED/LOGS, 2 BAGS	500.0	01/25/89	DOUG SWANSTON
TATCHU POINT	5	3X100M PATCHES, >30CM THICK OVER 300X5M AREA	BROWN OIL, 30 BAGS CL3, 100 BAGS CL5, OILED KELP	300.0	01/25/89	DOUG SWANSTON CCG
TATCHU POINT	4		CREW CLEANING CL 4, CL 5 REPORTED JAN 25 - NOT OIL	0.0	01/27/89	
TATCHU POINT - EAST OF			POINT OBSERVATION	0.0	02/10/89	
TATCHU POINT - NORTH OF	4M	3.5M SHEEN, 10CM PATCHES OVER 9.7M	BLACK OIL MIXED WITH DEBRIS/SEAWEED, 3 DEAD BIRDS	9700.0	01/18/89	SIMON JOHN
** AREA THOMAS						
UNNAMED ISLAND - ESE OF THOMAS ISLAND	4	1M UP TO 300M PATCHES COVERING 1 KM BEACH	SLICK, OILED KELP, CLEANED BY CCG	1000.0	01/14/89	CWS
UNNAMED ISLAND EAST OF THOMAS ISLAND	4	1 KM BEACH OILED		1000.0	01/14/89	CWS
UNNAMED ISLETS SE OF THOMAS ISLAND			OILED	0.0	01/14/89	CWS
** AREA THORNTON						
THORNTON - ISLANDS 1.4KM SE OF			SLICK	0.0	01/14/89	REP. TO HARDING
THORNTON ISLAND			BAGS SET ON LOGS MELTED, LOGS NEED BURNING	0.0	01/22/89	MIKE RODWAY - CWS
THORNTON ISLAND	3	1-10CM PATCHES, 1CM THICK OVER 500X100M AREA	BROWN OIL/SHEEN W/ SEAWEED/LOGS, 2 BAGS +	500.0	01/25/89	DOUG SWANSTON
THORNTON ISLAND - N END	4	6-20 CM BLOBS COVERING 200M BEACH	40 TO 50 BAGS COLLECTED	200.0	01/14/89	CWS

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
THORNTON ISLANDS - N ISLET		70CM PATCHES, 5-8CM THICK	BROWN OIL, EST. 25-30 BAGS, SANDY BEACH	0.0	01/18/89	WAYNE STEVENSON, K. HEBRON
** AREA UCLUELET						
AMPHITRITE POINT - WEST SIDE (TOP OF BEACH)	3M	7.5-16CM PATTIES, INTERMITTENT	OIL MIXED WITH SEAWEED, CLASS 3 AND 4, SANDY BEACH	0.0	01/18/89	PETER TIMMERMANS - CITIZEN
FLETCHER BEACH	L		LIGHT OIL ON EELGRASS	0.0	02/02/89	
FRANCIS ISLAND - NR LIGHT	4	10-105CM PATCHES OVER A 7-10M AREA	THIN COATING OF OIL ON LOGS, INTERTIDAL, 10 BAGS	10.0	01/26/89	CITIZEN
FRANCIS POINT			SMALL AREA OILED BEACH, 36 BAGS	0.0	01/29/89	CCG CREW
GEORGE FRASER ISLAND - EAST SIDE (4 BEACHES)	4H	1M DIAM.X 5-7CM PATCHES OVER TOTAL OF 325M	BLACK OIL PATTIES W/ SEAWEED/LOGS, 1 DEAD BIRD	325.0	02/15/89	RICHARD LUCAS
GEORGE FRASER ISLAND - WEST SIDE		1M DIAM. PATCHES, 10-15CM THICK OVER 60M AREA	OILED LOGS AT TOP OF BEACH	60.0	02/21/89	LARRY BAIRD
SPRING COVE AND FLETCHER BEACH		50 - 100 M ALONG SHORE	SMALL OIL DEPOSIT	100.0	01/10/89	MAYOR OF UCLUELET
STUART BAY - S PENINSULA	4	23 X 61 M, 15 CM THICK OVER 105 M BEACH	OILED EELGRASS/KELP/ROCKS, 4 DEAD BIRDS, 50 BAGS	105.0	01/18/89	RAY HAIPEE L.BAIRD
STUART BAY - UCLUELET HARBOUR (ITATTSOO RESERVE)		3-30 CM PATCHES, 1 CM THICK, 600M ALONG BEACH	BLACK SLICK/SHEEN, 3 DEAD BIRDS CLEAN 01/13/89	600.0	01/12/89	RAY HAIPEE CGE731
UCLUELET HARBOUR AT GOVERN. WHARF		2-10 CM DIAM. PATCHES	BLACK TAR/SHEEN, OILED EELGRASS, ROCKY BEACH	0.0	01/09/89	BARRY LAWLEY
UCLUELET PENINSULA			POINT OBSERVATION FROM MAP	0.0	01/05/89	MCINTYRE?
UCLUTH PENINSULA			POINT OBSERVATION	0.0	01/17/89	REP. TO DAVIS
UNNAMED BAYS (2) - E ENTRANCE TO UCLUELET HARBOUR			BLACK TAR IN SMALL PATCHES	0.0	01/08/89	BARRY LAWLEY
** AREA VARGAS						
AHOUS BAY - NORTH END	3L	1-75CM BLOBS, FILM TO 3MM THICK, 15X155M OF BEACH	BLACK SLICK/SHEEN MIXED WITH SEAWEED AND LOGS	155.0	01/14/89	ROD SAM OHIAHT - NTC
AHOUS BAY - NORTH END		20-50CM PATCHES SCATTERED	SCATTERED PATTIES, EST. 25 BAGS 01/19/89	0.0	01/18/89	RODWAY SWANSTON
AHOUS POINT	2L	100 M AREA	POOLS AND PATCHES ON ROCK, ROCK SHORELINE	100.0	01/11/89	LAURIE SOLSBERG
VARGAS ISLAND			MANY BAGS TO BE REMOVED	0.0	01/11/89	REET
VARGAS ISLAND - NW CORNER NR HOBBS IT.		2-3CM PATCHES, 1CM THICK	OIL IN SAND, MIDDLE INTERTIDAL ZONE, 15 BAGS	0.0	01/22/89	ED OWENS
VARGAS ISLAND - WEST COAST	2	9.6 KM	CUMULATIVE TO JAN. 07 BY PLANIMETER	9600.0	01/05/89	DFO OLMSTED REP.TO HARDING
VARGAS ISLAND - WEST OF MOSER POINT	2L		CLASS 2 TO 3, LIGHT CONTAMINATION	0.0	01/19/89	

NESTUCCA OIL RECORD DATABASE
SORTED BY AREA

LOCATION	CLASS	AMOUNT OF OIL	REMARKS	LENGTH(M)	DATE	OBSERVER
** AREA VICTORIA						
BREAKWATER AT DALLAS RD. MONTREAL RD. VICTORIA		10CM PATTIES: 1 PER 15M FOR 805M	BLACK TAR/SHEEN ON SEAWEED/LOGS, 7 DEAD BIRDS,	805.0	01/16/89	LARA MCMAMEE REP. TO FATHER
UNNAMED COVE WEST OF MACLAUGHLIN PT.	4	15X46CM PATCHES OVER 9.2M SHORE (200-300LBS)	BLACK OIL, ADJACENT COVES FOULED, 1 DEAD SEAL	9.2	01/17/89	MR. CAPEN REP. TO R.KEHL - DFO
WILLOWS BEACH - OAK BAY	4	12 - 10-20CM BLOBS, 10CM THICK, OVER .5KM BEACH	BLACK TAR, 1 DEAD BIRD, NOT CONFIRMED	500.0	01/15/89	CHEK TV
** AREA WALTERS						
WALTERS ISLAND - SOUTH BAY			OILED	0.0	01/21/89	G. ELLIS - CWS
** AREA WHITEPINE						
WHITEPINE COVE			OIL IN CLAM BEDS	0.0	01/17/89	REP.TO J.DAVIS REET

Appendix 4. Map Folio.

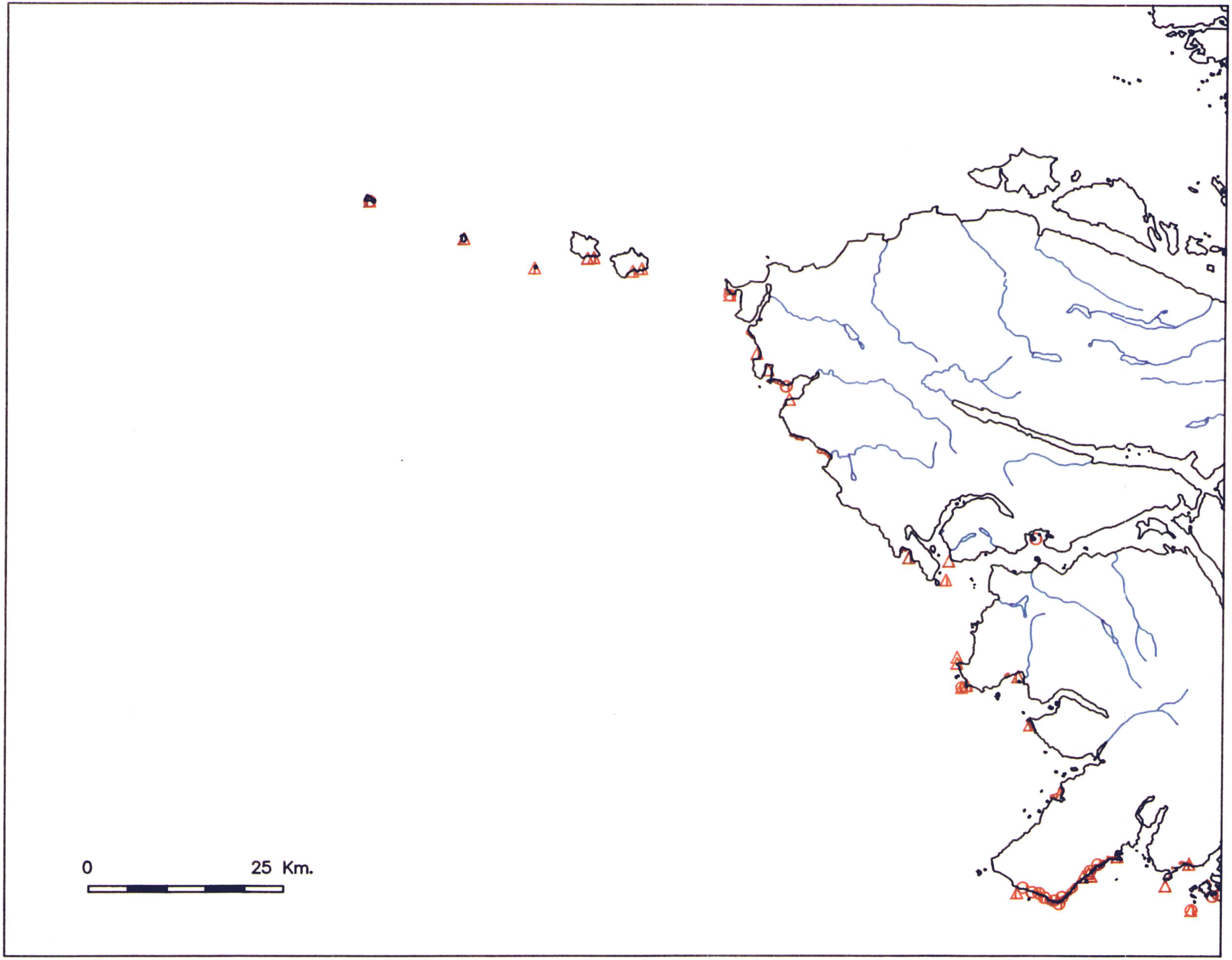
1. Oil locations along west coast of Vancouver Island
2. Oil Locations: Juan de Fuca Strait
3. Oil Locations: Barkley Sound to Clayoquot Sound
4. Oil Locations: Flores Island to Nootka Sound
5. Oil Locations: Kyuquot Sound to Brooks Peninsula
6. Oil Locations: Brooks Peninsula to Cape Scott

Offshore slicks and areas of numerous or continuous oil accumulations along shorelines are shown with vertical hatching. Symbols indicate observations too small to map: Squares indicate observations from 31 December to 6 January; circles, January 7-15; and triangles January 16 through February.

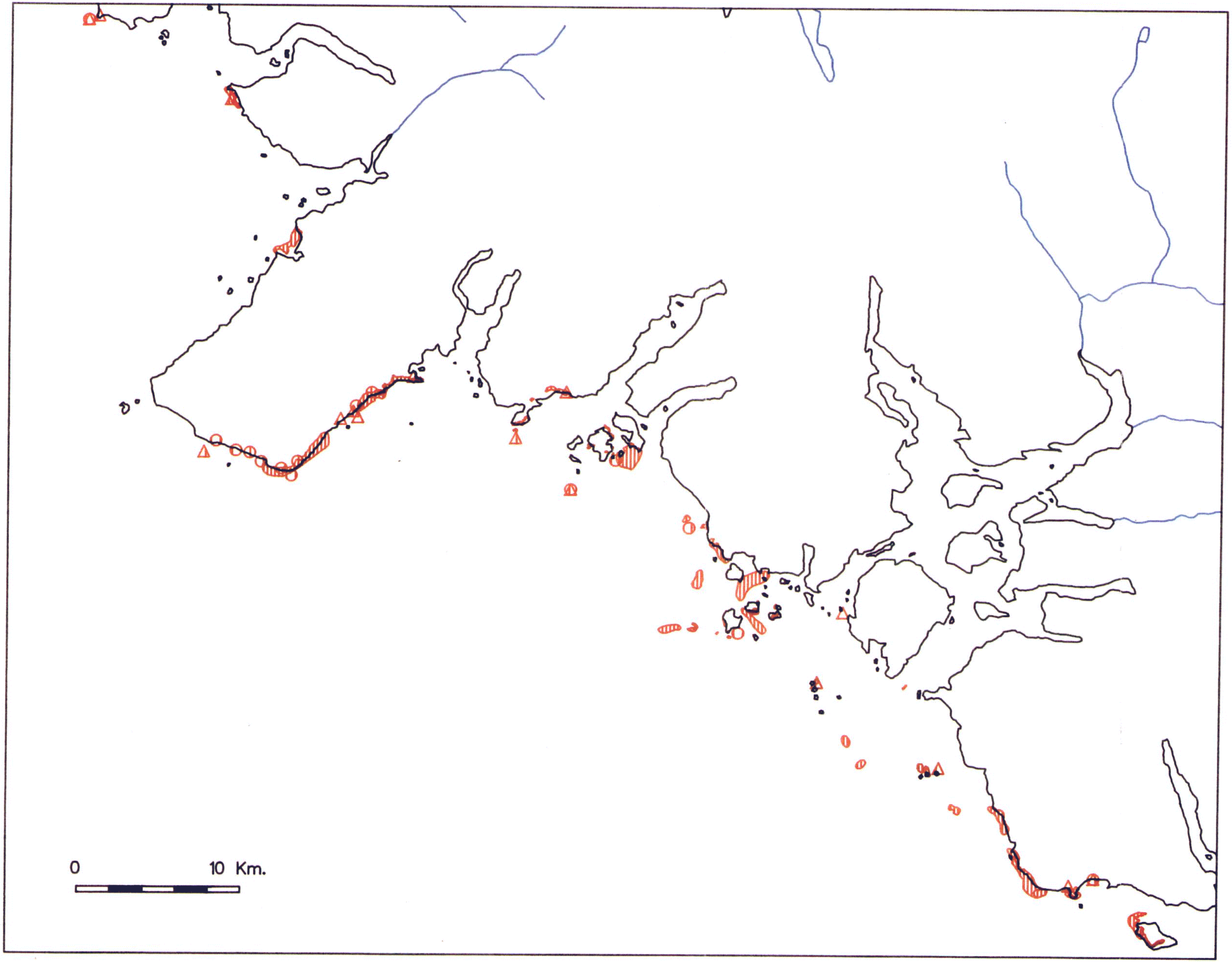
Appendix 4. Map Folio.

1. Oil locations along west coast of Vancouver Island
2. Oil Locations: Juan de Fuca Strait
3. Oil Locations: Barkley Sound to Clayoquot Sound
4. Oil Locations: Flores Island to Nootka Sound
5. Oil Locations: Kyuquot Sound to Brooks Peninsula
6. Oil Locations: Brooks Peninsula to Cape Scott

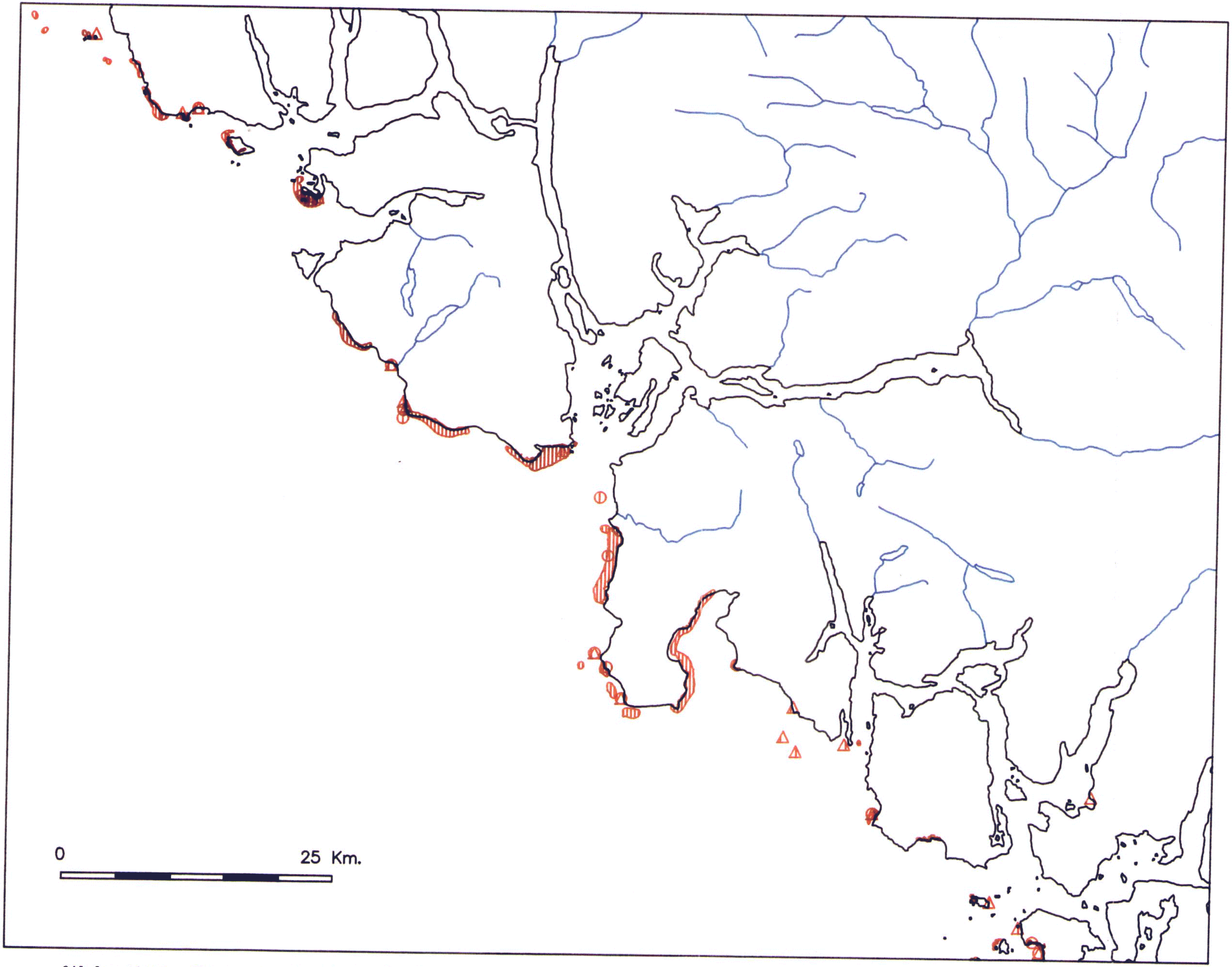
Offshore slicks and areas of numerous or continuous oil accumulations along shorelines are shown with vertical hatching. Symbols indicate observations too small to map: Squares indicate observations from 31 December to 6 January; circles, January 7-15; and triangles January 16 through February.



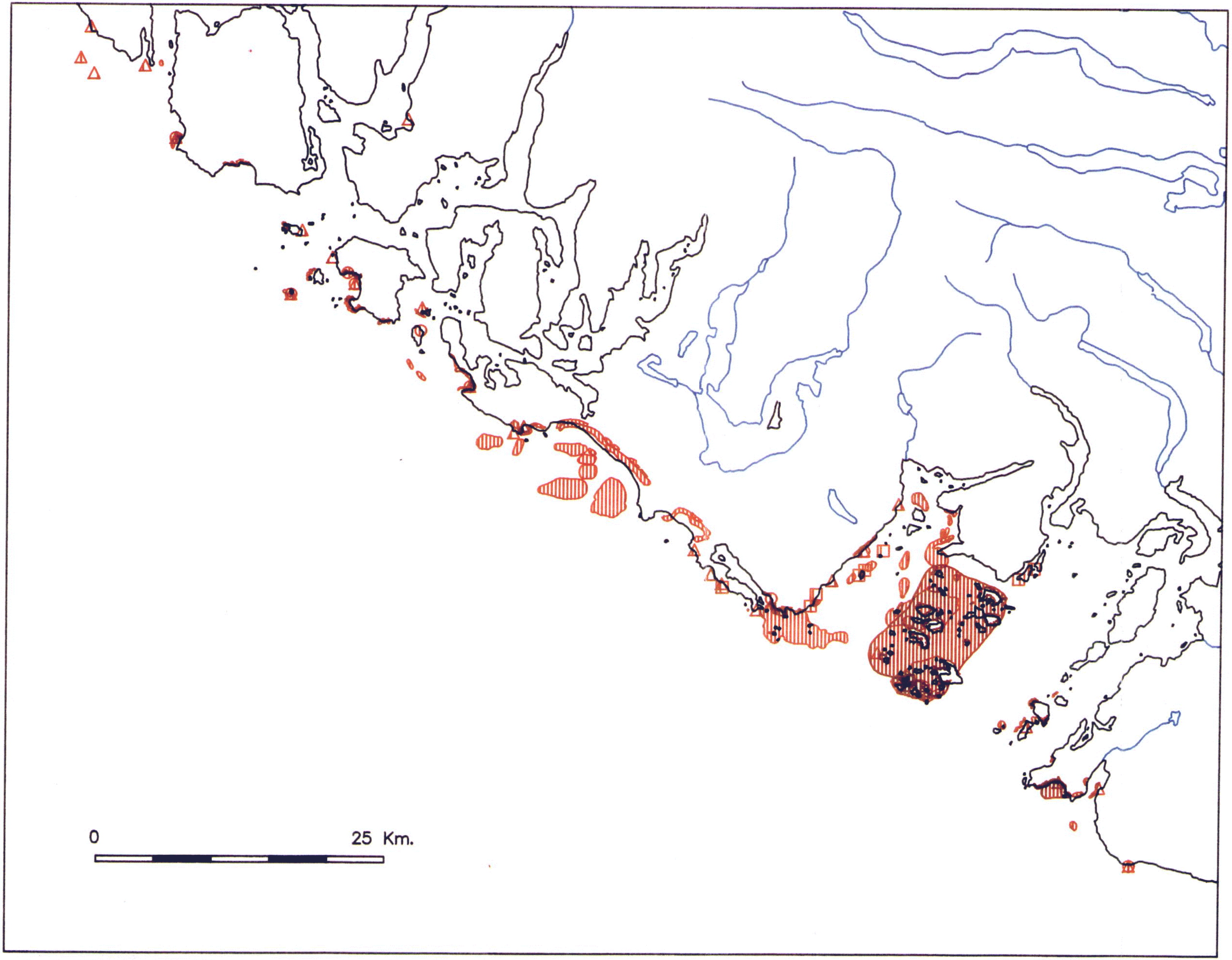
Oil locations: Brooks Peninsula to Cape Scott



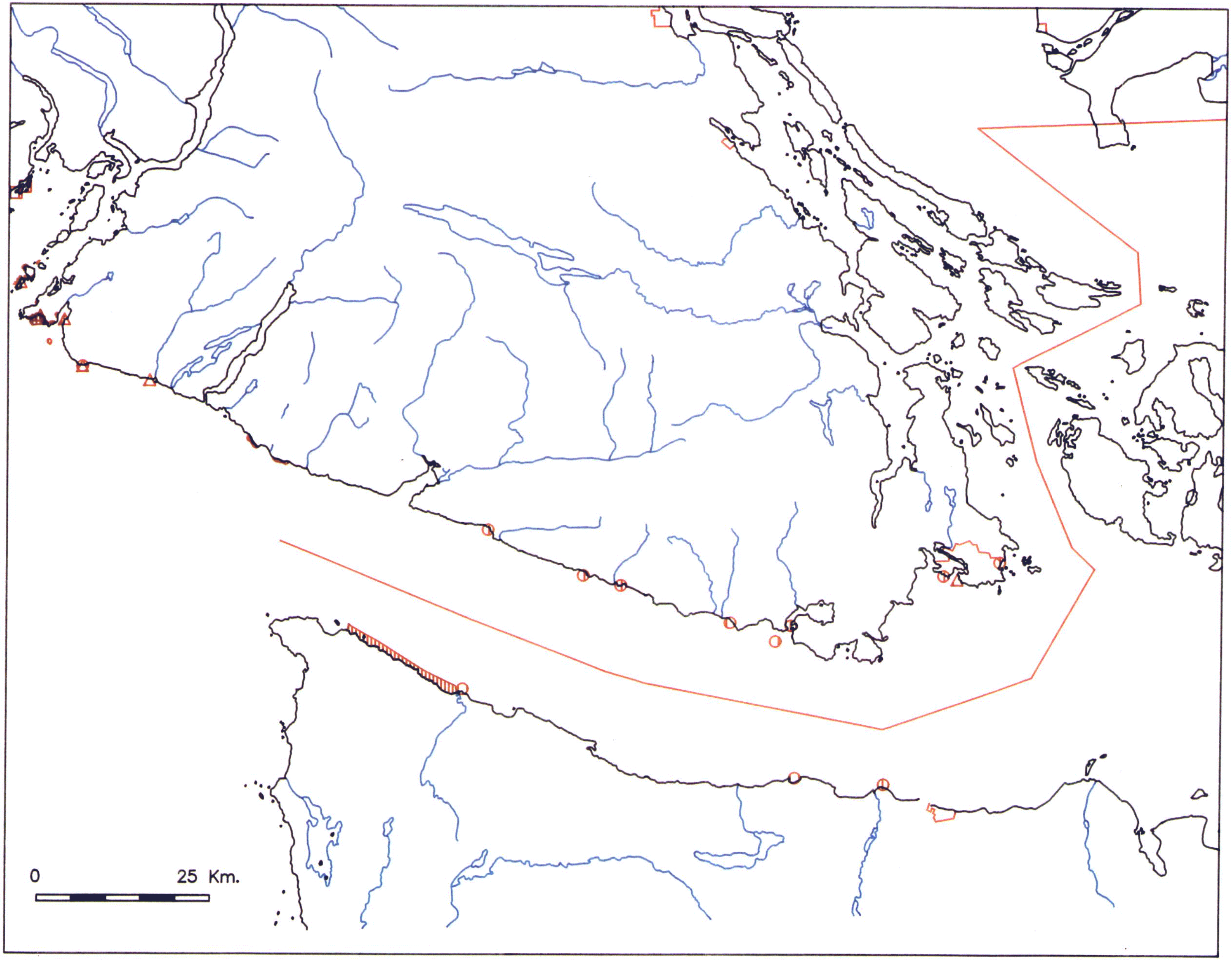
Oil locations: Kyuquot Sound to Brooks Peninsula



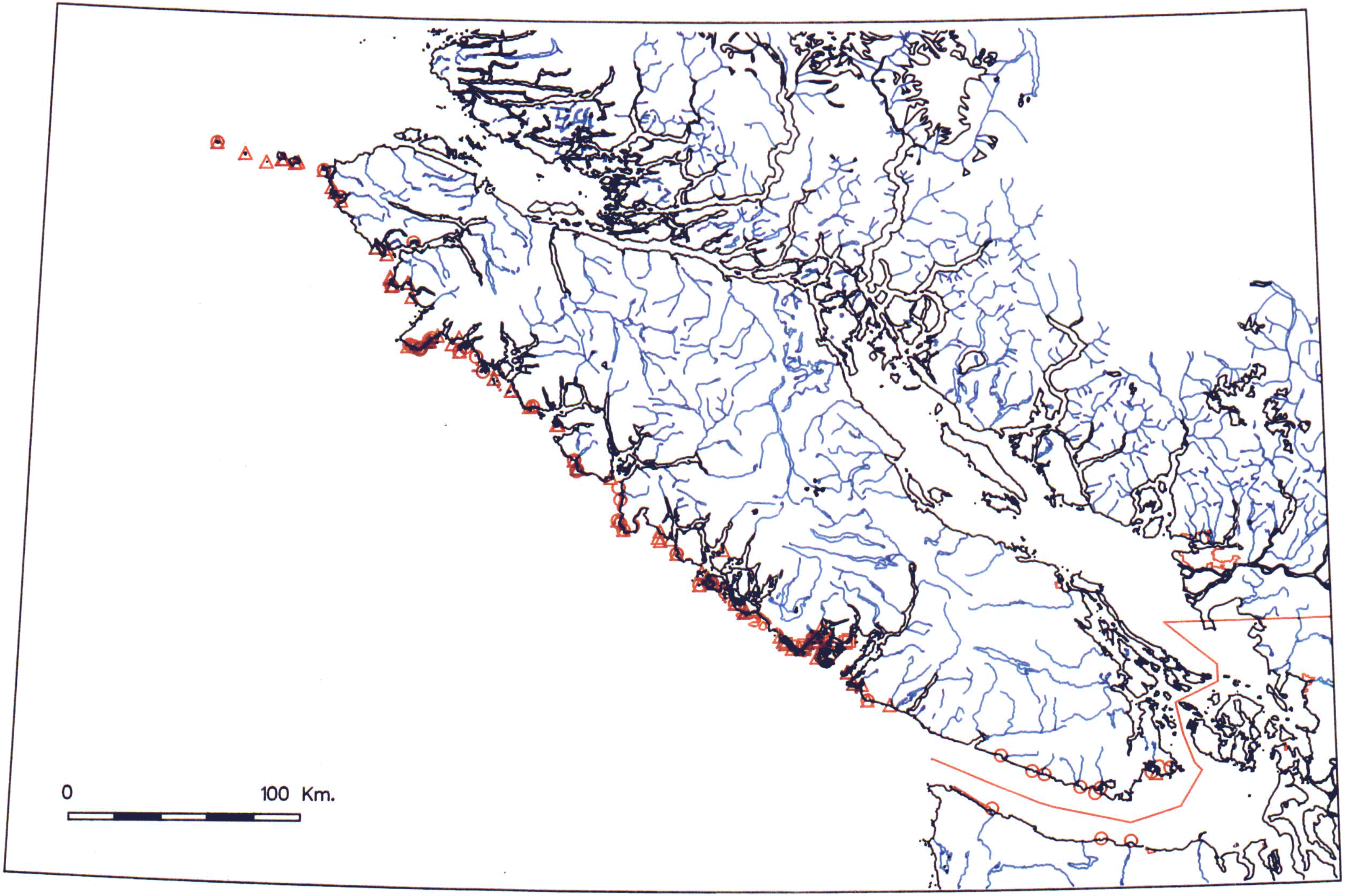
Oil locations: Flores Island to Nootka Sound



Oil locations: Barkley Sound to Clayoquot Sound



Oil locations: Juan de Fuca Strait



Oil locations along west coast of Vancouver Island.