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MARINE RESOURCE DAMAGE ASSESSMENT REPORT

FOR THE ARCO ANCHORAGE OIL SPILL

State of Washington

Ecology

JANUARY 1987

87-4

The Washington State Department of Ecology Marine Resource Damage Assessment Report for The ARCO Anchorage Oil Spill, December 21, 1985 into Port Angeles Harbor and the Strait of Juan de Fuca

by

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January 1987
87-4

ACKNOWLEDGMENTS

As the ARCO Anchorage MRDA project leader, I would like to thank all the members of this team for their time and effort. For the majority, this project was not a part of their regular duties and took a special effort. The team worked to accomplish this task and from my perspective it was genuinely appreciated. The following is a list of the MRDA Team members:

Dick Burge	WDF Shellfish Biologist
Al Scholz	WDF Shellfish Biologist
Earl Finn	WDF Fisheries Biologist (MRDA agency liaison)
Dan Penttila	WDF Fisheries Biologist
Dick Pease	WDF Shellfish Biologist
Lynn Goodwin	WDF Shellfish Biologist
Walt Cook	WDF Shellfish Biologist
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Jim Beam	WDF Fisheries Biologist
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Brian Hauger	WDG MRDA agency liaison
Steve Speich	WDG Wildlife Biologist
Richard Lowell	WDG Wildlife Biologist
Lori LeVander	Ecology Fisheries Biologist
Charles Henry	LSU Environmental Chemist

Dave Kennedy and his NOAA staff
Jim Wilman and his EPA staff and TAT

Thanks again for a job well done.

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0.0 EXECUTIVE SUMMARY

The tanker ARCO Anchorage ran aground in Port Angeles Harbor, Washington on December 21, 1985, releasing about 239,000 gallons of Alaska North Slope crude oil (ANS) into the Strait of Juan de Fuca. The shoreline east and west of Port Angeles Harbor was oiled from Dungeness Spit to Crescent Bay. The shoreline along the south side of Ediz Hook inside Port Angeles Harbor remained oiled until at least June, 1986. Little if any evidence of remaining ANS was found outside Ediz Hook on surveys conducted in April, 1986.

The short-term assessment has been completed and the following conclusions can be made:

a) ANS contaminated the south shoreline of Ediz Hook resulting in stressing the hardshell clams and crabs, and killing starfish, jellyfish, and nudibranchs.

b) Outside of Ediz Hook there is no documented impacts to marine organisms, except waterbirds.

c) An estimated 4,000 waterbirds were oiled and died as a result of the oil spill. Nesting marine bird populations in the spill area appear unaffected by the oil spill.

In summary, the documented short-term impacts of the ARCO Anchorage appear limited to the hardshell clam populations inside Ediz Hook and the waterbirds. Long-term impacts are being studied inside Ediz Hook and are outside the scope of this Marine Resource Damage Assessment (MRDA) document.

Washington State investigators documented damages to 12,468 pounds of hardshell clams, 4,000 waterbirds, and damages to other marine organisms totalling $32,930.03.

1.0 INTRODUCTION

On December 21, 1985 at about 1645 hours, the ARCO Anchorage ran hard aground in Port Angeles Harbor, Clallam County, Washington. The grounding ruptured the bottom of tanks #5 center and #5 port resulting in the discharge of about 239,000 gallons of Alaska North Slope crude oil (ANS) (Greiner, 1986).

At about 1652 hours, Captain Robert Sutherland (master of the ship) reported the incident to the National Response Center (NRC), Washington, DC. The NRC reported the incident to the United States Coast Guard (USCG) Captain of the Port office in Seattle at 1655 hours. At 1900 hours, the oil spill was reported to the Washington State Department of Ecology Southwest Region Office (SWRO) by Ron Westly, Washington Department of Fisheries (WDF). Westly had received report of the incident from a Sequim Bay clam farmer. Lewey Kittle was the SWRO spill duty officer.

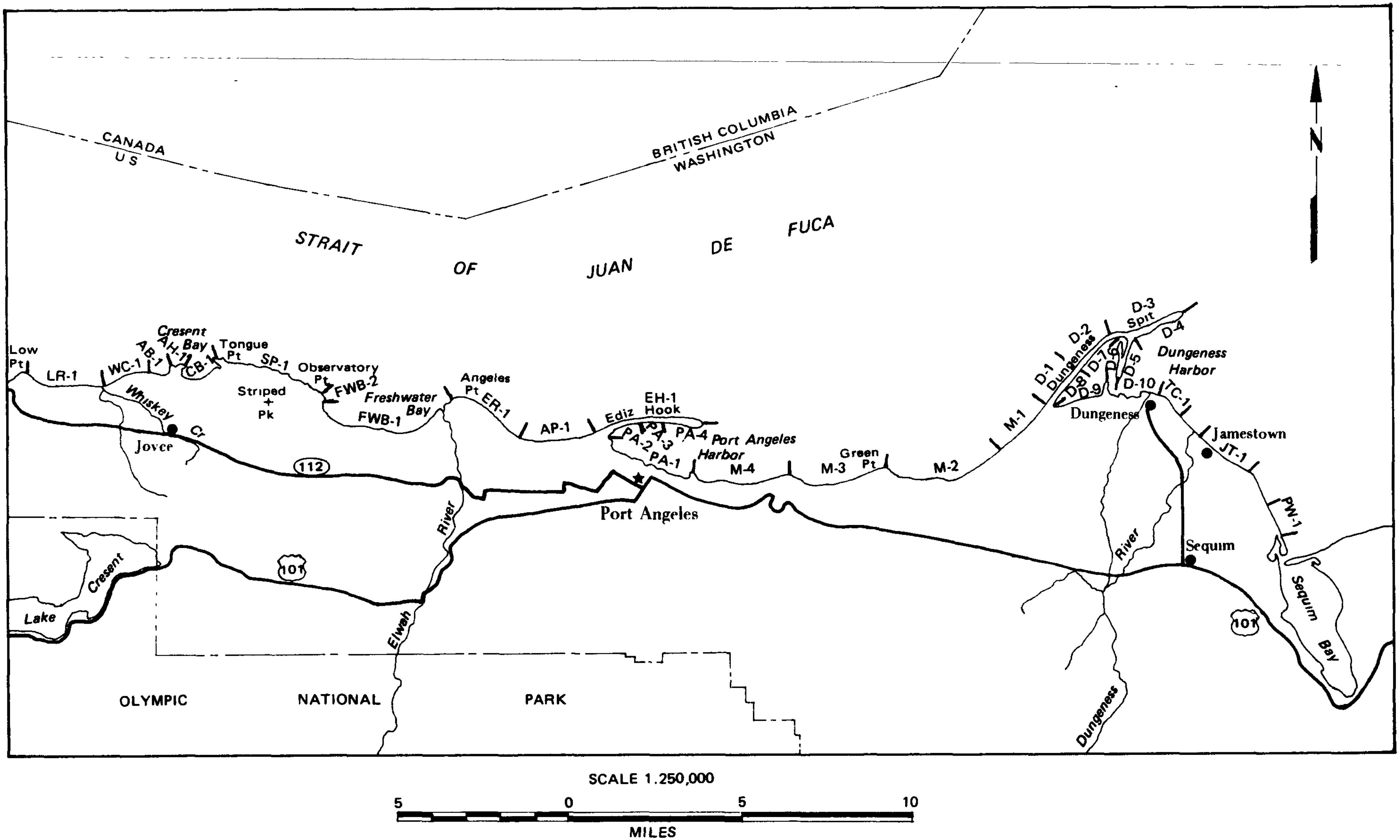

Figure 1. MAP SHOWING SHORELINE SECTORS AND LANDMARKS ASSOCIATED WITH THE BEACH RECONNAISSANCE. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

Kittle reported the incident to Clark Haberman, SWRO manager and the Washington Department of Emergency Management. Tom Eaton was assigned to be the state on-scene coordinator (SOSC) Tom Eaton requested the Operations Management and Support Section to conduct a Marine Resource Damage Assessment (MRDA). Lew Kittle responded.

Kittle started notifying the MRDA Team immediately and by 2100 hours the team was notified. The MRDA Team was made up of representatives from the following state and federal agencies:

Washington State Department of Ecology (Ecology)
Washington State Department of Fisheries (Fisheries)
Washington State Department of Game (WDG)
Washington State Department of Natural Resources (DNR)
Washington State Department of Social and Health Services (DSHS)
Washington State Department of Emergency Management (DEM)
Washington State Parks and Recreation Commission (Parks)
U.S. Department of Interior (DOI)
U.S. Environmental Protection Agency (EPA)
U.S. Coast Guard (USCG)
National Oceanic and Atmospheric Administration (NOAA)

The purpose of the MRDA Team was to document damages to the economically important resources of Washington State resulting from the ARCO Anchorage oil spill. The MRDA Team followed the field and reporting procedures outlined in "Guidelines: Marine Resource Damage Assessment Program (D.O.E. Report 80-15).

2.0 AREA DESCRIPTION

The ARCO Anchorage Oil Spill MRDA study area encompassed the waters and shoreline of the Strait of Juan de Fuca (Strait) from Cape Flattery to Point McCurdy (Figure 1). The Strait is located in the northwest corner of Washington State along the U.S./Canadian border (Figure 1). The Strait is a deep estuary connecting the inland waters of Washington State with the Pacific Ocean. The area has a maritime climate with cool summers and mild winters. The winds are variable and the annual precipitation rate is between 18 and 50 inches. Tidal ranges average between four and ten feet producing strong tidal currents. Currents in the Strait may reach two to four knots, depending on tidal range and prevailing winds (Vagners and Mar, 1972). North- and west-facing shorelines along the Strait are subject to the largest waves and are high energy areas (Gundlach et al., 1980)

The Strait is characterized hydrographically as a two-layer system. The upper 30 meter layer is relatively fresh and the lower layer more saline. The Strait receives a large influx of freshwater from Puget Sound drainages and the Fraser River (Chester et al., 1980). There are two periods of high freshwater runoff. The major runoff occurs during spring snow melt. The smaller secondary runoff occurs during late fall and winter.

The Strait is divided into two subregions: the outer and inner strait. The outer region encompasses everything west of Ediz Hook (Freshwater Bay, Crescent Bay, Agate Bay, Pillar Point to Neah Bay). The inner region encompasses everything east of Ediz Hook (Port Angeles Harbor, Dungeness Spit to the Quimper Peninsula).

The subregions include the following shoreline habitats:

1. Exposed rocky headlands (i.e. Striped Peak Headland)

2. Wave-cut platforms (i.e. the area east of Green Point)

3. Pocket beaches along exposed rocky shores (i.e. Crescent Bay)

4. Sand beaches (i.e. Freshwater Bay)

5. Sand and gravel beaches (mobile sediments) (i.e. Dungeness Spit)

6. Sand and cobble beaches (stable beaches) (i.e. Angeles Point)

7. Exposed tidal flats (i.e. Dungeness Bay)

8. Sheltered rocky shores (i.e. Pillar Point)

9. Sheltered tidal flats (i.e. inner Dungeness Bay)

10. Sheltered marshes (i.e. Pysht River estuary)

The outer region supports significant populations of groundfish, clams, shrimp, sea urchins, and dungeness crab (WDF Report No. 79).

The inner strait is a very productive and species rich area supporting populations of birds, mammals, fish and shellfish, and is one of the major habitats for marine birds on the Pacific Coast of North America.

Two important physical features within the inner strait are Ediz Hook and Dungeness Spit. They are accreted gravel spits protecting embayments. Port Angeles Harbor located inside Ediz Hook is dominated by the logging industry and associated activities. The beach along the inside of Ediz is coarse sand gravel, covered in many areas by log bark debris.

Dungeness Spit and Dungeness Bay are located inside the Dungeness National Wildlife Refuge. Activities in this area are oyster farming and recreation. Dungeness Bay has extensive tidal flats consisting of sand and mud. The sheltered waters and tideflats behind Dungeness Spit support a large and diverse assemblage of marine organisms including harbor seals, river otters, surf smelt, dungeness crabs, oysters, herring, clams,and octopus (WDF Report No. 79). Dungeness Bay also provides important overwintering areas and summer habitats for birds (Wahl et al.,1981).

Fraser River and Puget Sound anadromous salmon and trout pass through the Strait. Gray whale, minke whale, killer whale, harbor porpoise, Dall's porpoise, and several species of pinniped frequent the Strait.

Significant numbers of California, northern, and Pacific sea lions are found in the Strait from December to March . The harbor seal is the most abundant pinniped in the area. Harbor seal pupping areas are Dungeness Spit, Green Point, Low Point, and Deep Creek (Everitt et al., 1979).

3.0 METHODS

3.1 Aerial Reconnaissance

The purpose of the aerial reconnaissance was to document the location of the ANS and update oil trajectories provided by NOAA.

Daily oil spill overflights were conducted by the USCG and NOAA, weather permitting. Overflights were conducted using a helicopter. The oil slick location and description were relayed back to the On Scene Coordinator's command center and the data entered into a computer and plotted.

The aerial reconnaissance data was used by the MRDA Team to locate ANS landfalls and plan the beach reconnaissance.

3.2 Beach Reconnaissance - December 23-30, 1985

The purpose of this beach reconnaissance was to document oiling and resource damages. The reconnaissance data was used to determine where and what type of MRDA studies would be conducted.

To facilitate the beach reconnaissance, the shoreline from Sequim Bay to Pillar Point was divided into sectors. The sectors were selected based on road access and habitat type. A brief description of the sectors is given in Table 1 and shown in Figure 1.

Table 1. Shoreline Sector Descriptions. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Sector	Description
D-1	Outside of Dungeness Spit from the base to first range marker.
D-2	Outside of Dungeness Spit from the first range marker to the second range marker
D-3	Outside of Dungeness Spit from the second range marker to the tip of the spit.
D-4	Inside Dungeness Spit from the tip to Graveyard Spit.
D-5	Base of Graveyard Spit to the tip of the spit.

Table 1. Shoreline Sector Descriptions. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Sector	Description
D-6	Tip of Graveyard Spit to the second range marker inside Dungeness Bay.
D-7	Dungeness Bay from the second range marker to the first range marker.
D-8	Dungeness Bay from the first range marker to the base of Dungeness Spit.
D-9	Dungeness Bay from the base of Dungeness Spit to the tip of Cline Spit.
D-10	Tip of Cline Spit to the Three Crabs Restaurant.
TC-1	Three Crabs Restaurant to the Jamestown Road.
JT-1	Jamestown Road to Kulakala Point.
PW-1	Kulakala Point to Port Williams Road.
M-1	Base of Dungeness Spit to McDonald Creek.
M-2	McDonald Creek to Green Point (Siebert Creek).
M-3	Green Point to Morse Creek.
M-4	Morse Creek to the ITT Rayonier Mill.
PA-1	ITT Rayonier Mill to the Crown Zellerbach Mill.
PA-2	Crown Zellerbech Mill to the A-frame.
PA-3	A-frame to USCG Fence.
PA-4	USCG Fence to Tip of Ediz Hook.
EH-1	North Side of Ediz Hook from Tip to Base.
AP-1	Base of Ediz Hook to Dry Creek (Airport).
ER-1	Dry Creek to Mouth of Elwha.
ER-2	Elwha River Mouth to West End of Place Road.
FWB-1	West End of Place Road to County Park Boat Ramp.
FWB-2	County Park Boat Ramp to Observatory Point.

Table 1. Shoreline Sector Descriptions. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Sector	Description
SP-1	Observatory Point to Tongue Point (Striped Peak Headland)
CB-1	Tongue Point to Agate Bay Headland (Crescent Bay).
AH-1	Agate Bay Headland to Agate Bay.
AB-1	Agate Bay to First Unnamed Creek.
WC-1	Unnamed Creek to Whiskey Creek.
LR-1	Whiskey Creek to Lyre River.
TR-1	Twin River to Silver King Resort.
PP-1	Silver King Resort to Pillar Point.

The beach reconnaissance was conducted on the lowest tide of the day, preferably on a minus tide. During each beach reconnaissance, the intertidal zone from the driftwood line to the water was surveyed for oil and dead or dying organisms. Water, sediment, oil, and tissue samples were collected whenever oil was present. Photographs were taken of oil and oiled organisms.

Surface water and surface sediment samples were collected in bottles provided by the Ecology Environmental Laboratory, Manchester, WA (Manchester Lab). Tissue samples were whole body samples. These samples were double wrapped in aluminum foil. Samples were tagged and sealed with chain-of-custody tape.

The samples were frozen and held under chain-of-custody at the Manchester Lab and shipped under chain-of-custody to the Louisiana State University (LSU) Institute for Environmental Studies, 17 Atkinson Hall, Baton Rouge, LA 70803, for hydrocarbon analysis "fingerprinting".

Charles Henry (LSU, environmental chemist) analyzed the samples and authored the hydrocarbon analysis section of the MRDA. The methods Dr. Henry used to analyze the samples are described in detail in Appendix II.

3.3 Beach Reconnaissance - April 26-28, 1986

The MRDA Team returned to reconnoiter the spill area for a second time from April 26-28, 1986. The reason the MRDA Team returned at this time was that this was the first series of -2 foot tides occurring during the day. This tide series nearly duplicated the minus tide series which took place during the first week of the incident. The purpose of the second reconnaissance was to determine if areas remained oiled and if any latent impacts had occurred.

The methods used in this reconnaissance were the same as described previously.

3.4 Ediz Hook Intertidal Hardshell Clam Studies

The beach reconnaissance data indicated clam populations inside Ediz Hook were impacted by the ANS. Therefore, a series of intertidal clam population estimates were made inside Ediz Hook.

The purpose was to estimate clam populations, clam mortality, and document ANS pollution. The data was used to determine the impacts of the ANS.

These studies were conducted by Al Scholz, Walt Cook, and Randy Butler, WDF shellfish biologists.

During the reconnaissance survey three areas inside Ediz Hook were found to have hardshell clam beds. Two were located on the USCG base and the third was located between the T-bird Marina and the Crown Z Mill. The first hardshell clam bed was located at the bottom of the radar tower east to the old seaplane ramp. The second bed was below Building No. 32 west for 300 feet. The third bed started about 40 feet west of the new boat ramp west of the T-bird Marina and extended west to the Crown Z Mill. For the purposes of this report those areas will be referred to as CGA, CGB, and EHC respectively (Figure 2).

The clam populations in CGA and CGB were estimated by removing the clams from 1 ft^2 sample sites. The sites were selected at random distances along a line through the clam beds. Clams with shell lengths greater than 15 mm were placed in plastic bags, tagged, and taken to the lab where the clams were identified to species and their shell lengths measured. The surface area of the clam bed was estimated and the clam density extrapolated to the clam bed surface area to estimate the clam population. The areas were resampled on April 29, 1986 using the same techniques except that the clams were also weighed. The data from both sampling dates was combined to make the population estimate. The samples were frozen and archived.

The clam population in EHC was estimated by removing the clams from 0.5 m^2 sample sites. Sample sites were located at 269 foot intervals within suitable clam habitat starting 59 feet west of the new boat ramp west of the T-bird Marina. At each site the width of the bed was measured and an area to be dug was selected. The area to be dug was selected along a line perpendicular to the tidal horizon and within the clam bed using a random numbers table. Clams were removed to a depth of 18 inches. Clams with shell lengths greater than 15 mm were placed in plastic bags, tagged, and

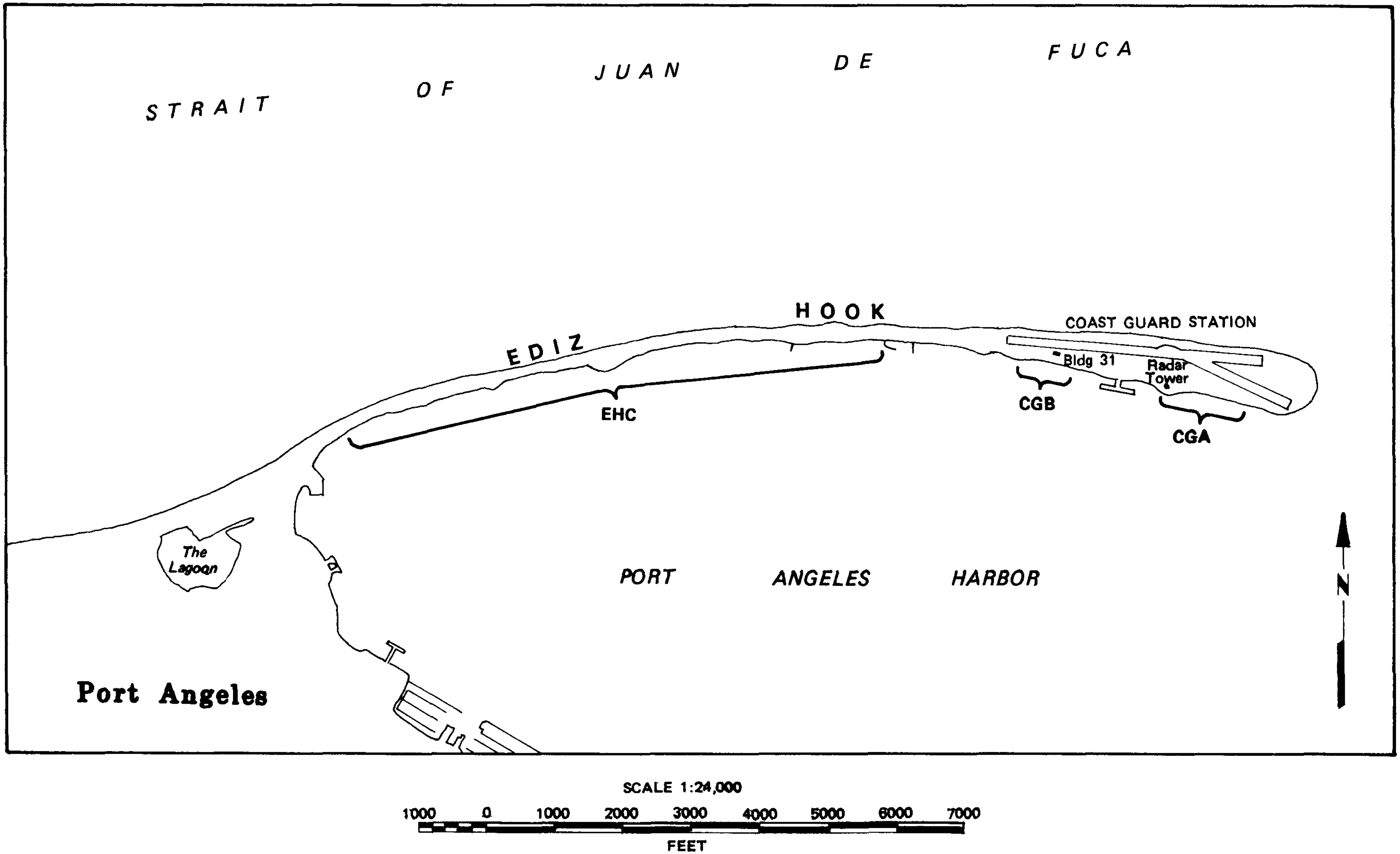

Figure 2. MAP SHOWING SAMPLE SITES AND LANDMARKS ASSOCIATED WITH THE EDIZ HOOK INTERTIDAL CLAM STUDIES. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

taken to the lab where the clams were identified to species and their shell lengths measured. The surface area of the clam bed was estimated and the clam density extrapolated to the clam bed surface area to estimate the clam population. The samples were frozen and archived.

Clams were analyzed for ANS contamination using the methods described previously.

3.5 Tongue Point/Slip Point Intertidal Study

Dr. Jim Walton, Peninsula College, Port Angeles, WA, was the principle investigator and author of this section. He was assisted by his staff and students. Dr. Walton was under contract to conduct this study by WDF.

The purpose of the Tongue Point/Slip Point intertidal studies was to assess the impacts of the ANS on intertidal organisms.

Three transects were examined at each of two locations: Tongue Point, 12 miles west of Port Angeles, and Slip Point, at the east end of Clallam Bay. The area selected at Tongue Point was selected as a study site because it was oiled on December 27, 1985 (James Beam, WDF, personal communication). No oiled areas were observed at Slip Point, therefore, it was chosen as the control for the Tongue Point site.

The three transects at each site were set up as follows:

Site	Description
1	A rectangle one meter by 20 meters reaching from the upper to the lower intertidal zone (transect A & D).
2	A rectangle one meter by 13 meters crossing several tide pools (transects D & E).
3	A rectangle one meter by three meters in an area of small rocks which were raised to examine the marine life on their undersides (transect C & F).

The transects were set up with the help of James Beam (WDF) who had observed the original oiling. The exact location of all transects in relationship to local landmarks was determined so that they could be reexamined at later dates.

The transects were divided into one meter quadrats and in each, the numbers of living or dead individuals of the listed organisms were counted if less than 200, or estimated if more than 200. Evidence of oil was also noted for each quadrat.

3.6 Subtidal Reconnaissance

Lynn Goodwin, WDF shellfish biologist was the principle investigator and author of this section. He was assisted by WDF staff.

3.6.1 Ediz Hook Subtidal Reconnaissance

The purpose of the Ediz Hook subtidal reconnaissance was to document oiling and resource damages. The data was used to determine where and what type of MRDA studies would be conducted in this area.

The Ediz Hook subtidal reconnaissance was conducted by a team of WDF divers who swam a three-leg transect. The first leg started in 55 feet of water south of the Pilot's Station. From the entry point, the divers descended to the bottom and swam directly to the Pilot's Station (+2.0 to +4.0 feet tide level). The second was swam from the Pilot's Station parallel to the beach to a point about 100 yards inside the log rafting area. The third leg was swam from that point under the log rafts, south to a point outside the log rafts (Figure 3). The presence of oil and dead or dying organisms were noted.

Dungeness crab were also collected inside Ediz Hook by Dr. Jim Walton, Peninsula College. The initial collection was with crab pots and later with divers. The crabs were collected, wrapped in aluminum, frozen, and shipped to the LSU Lab for hydrocarbon analysis. The purpose was to determine if those crab were contaminated with ANS.

3.6.2 Green Point, Jamestown, and Middle Ground (Sequim Bay) Subtidal Reconnaissance

The purpose of this subtidal reconnaissance was the same as the previous reconnaissance. The data was used to determine where and what type of MRDA studies were needed.

This reconnaissance was conducted by WDF divers using a WDF boat as a diving platform. In each area, the divers descended to the bottom and surveyed the area for oil and dead or dying organisms and collected clams using a hydraulic lift system.

The sites are shown in Figure 4 and described as follows:

Site	Description
Green Point	West of the base of Dungeness Spit, latitude 48 degrees 09'09", longitude 123 degrees 12'31". Depth: 50 ft. Substrate: sand and pea gravel.
Jamestown	Northeast of Jamestown, latitude 48 degrees 08'08", longitude 123 degrees 03'02". Depth: 42 feet.

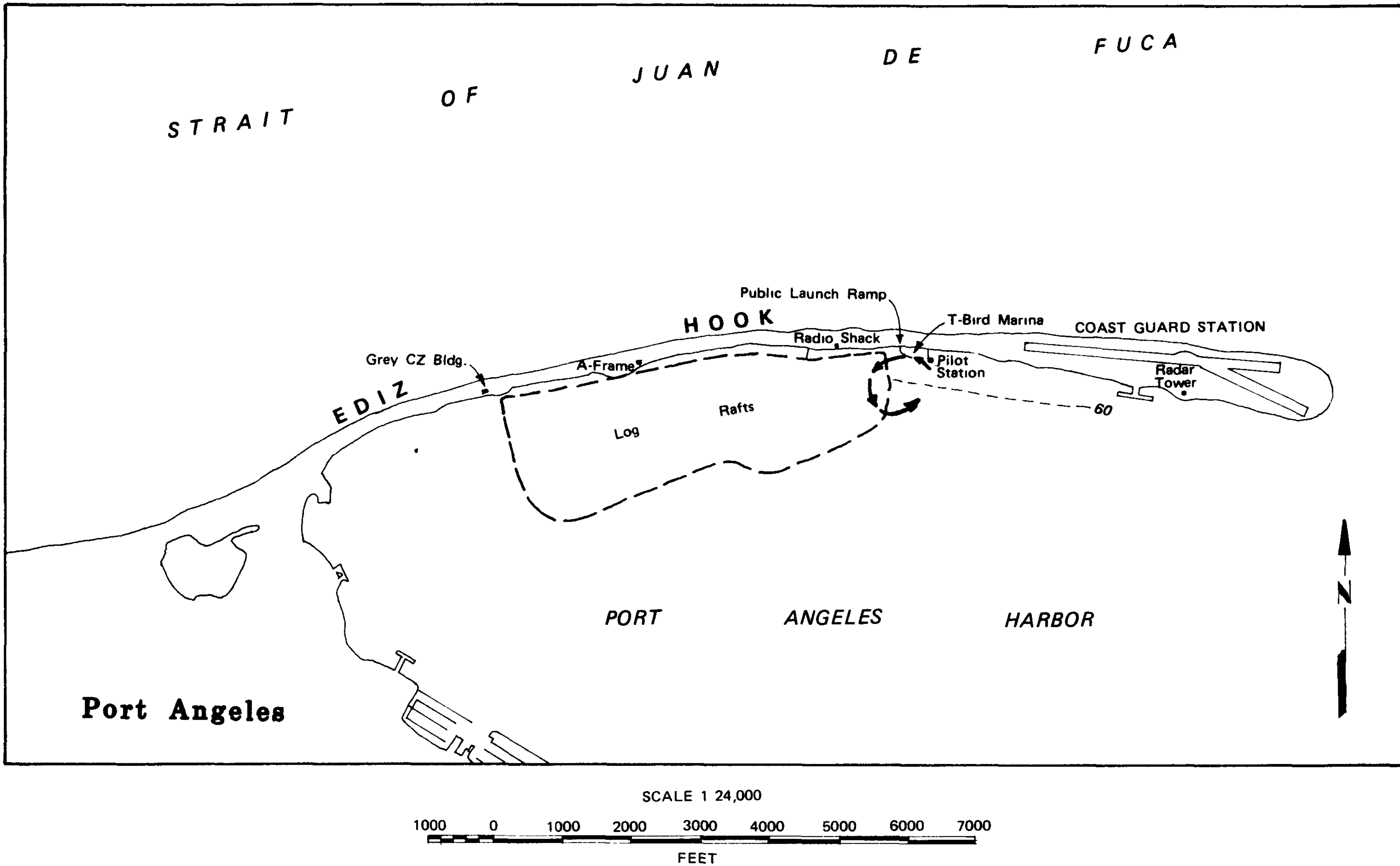

Figure 3. MAP SHOWING TRANSECTS AND LANDMARKS ASSOCIATED WITH THE EDIZ HOOK SUBTIDAL RECONNAISSANCE. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

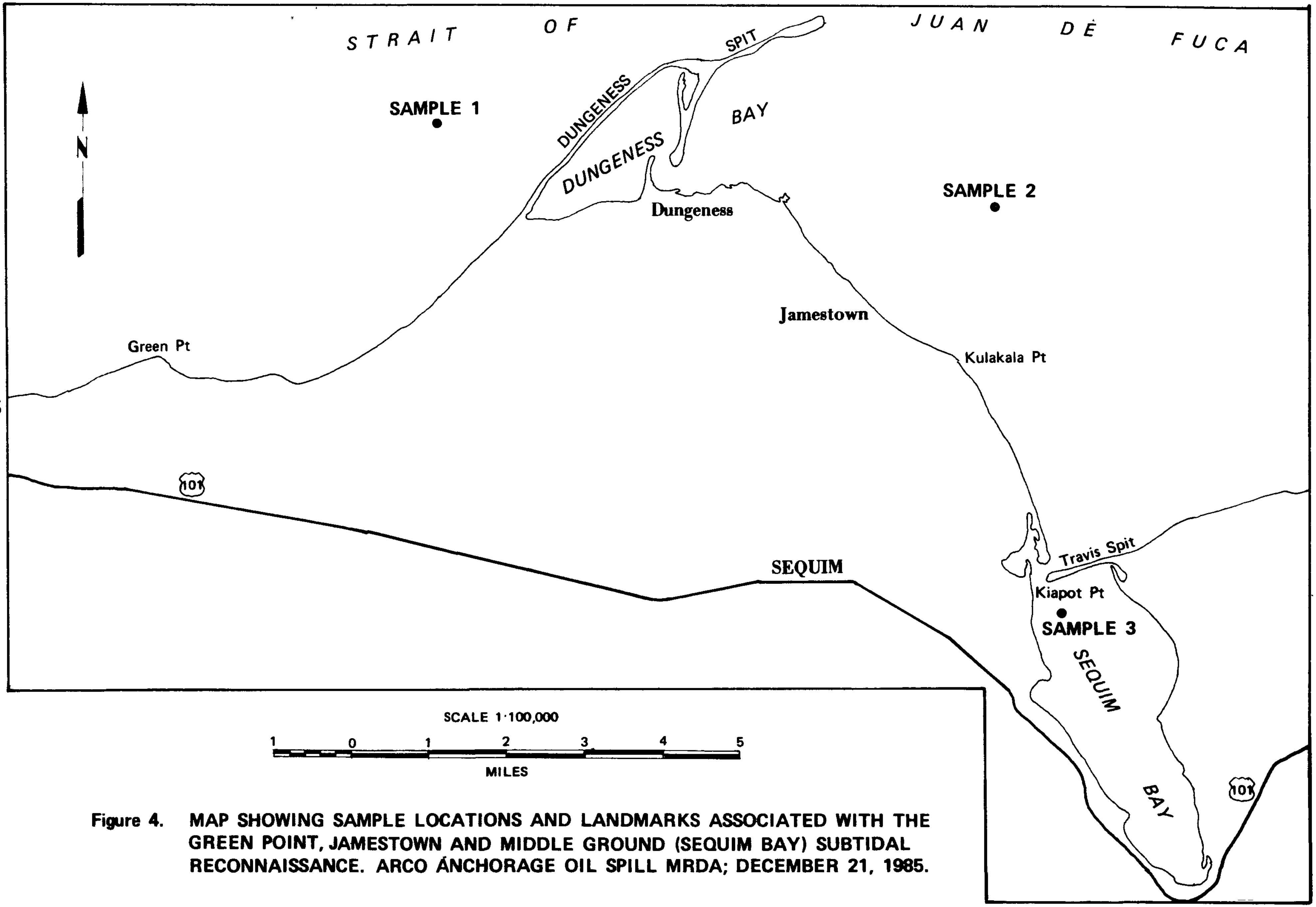

Figure 4. MAP SHOWING SAMPLE LOCATIONS AND LANDMARKS ASSOCIATED WITH THE GREEN POINT, JAMESTOWN AND MIDDLE GROUND (SEQUIM BAY) SUBTIDAL RECONNAISSANCE. ARCO ÁNCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

Middle Ground — North end of Sequim Bay, latitude 48 degrees 04'37", longitude 123 degrees 02'09". Depth: 6 feet. Substrate: sand, pea gravel, and shell.

At least five clams of each species present at each site were collected. The clam samples were double wrapped in aluminum foil, tagged, and frozen. These samples were held under chain-of-custody at the Manchester lab and shipped to the LSU Lab for analysis.

Also, three sediment samples were collected at each site using bottles provided by the Manchester Lab. The sediment samples were collected from the first half inch of the sediments. The bottle was closed and tagged while the diver was on the bottom. Upon arriving at the diving platform the sediment samples were sealed with chain-of-custody tape. The samples were frozen and held under chain-of-custody at the Manchester Lab and shipped to the LSU Lab for analysis.

3.6.3 Striped Peak Headland/Pillar Point Subtidal Reconnaissance

The Striped Peak headland/Pillar Point subtidal reconnaissance was conducted by WDF, Ecology, DNR, and NOAA divers using boats as diving platforms. The divers reconnoitered the kelp beds from Observatory Point to Agate Bay and from Twin Rivers to Pillar Point (Figure 5). The purpose was to select sampling sites and document subtidal oiling. The criteria for a sampling site were: oiled kelp on the surface or at depth and sea urchins being present.

At each sampling site, kelp stipes and sea urchins were collected. Four replicate kelp samples were collected from the shoreward edge to seaward edge of the kelp. The divers descended on the seaward edge of the kelp bed and swam toward the shoreward kelp bed edge. Visual signs of oil and dead or dying organisms were noted. Four sea urchins were collected at each of the following depth ranges: less than 25 feet, 25-40 feet, greater than 40 feet.

Kelp samples were collected in bottles provided by the Manchester Lab. The samples were tagged, sealed with chain-of-custody tape, and frozen.

Sea urchin gonads were taste tested by the WDF and DNR divers. The remaining sea urchin samples were prepared by first removing the spines and then wrapping the sea urchins in aluminum foil. Then the samples were tagged and frozen.

Samples were held at the Manchester Lab under chain-of-custody and shipped to the LSU Lab for analysis.

3.7 Kelp Bed Reconnaissance

Dr. Jim Walton, Peninsula College, Port Angeles, WA, was the principle investigator and author of this section. He was assisted by his staff and students. Dr. Walton was contracted by WDF to conduct the kelp bed reconnaissance from Cape Flattery to Protection Island.

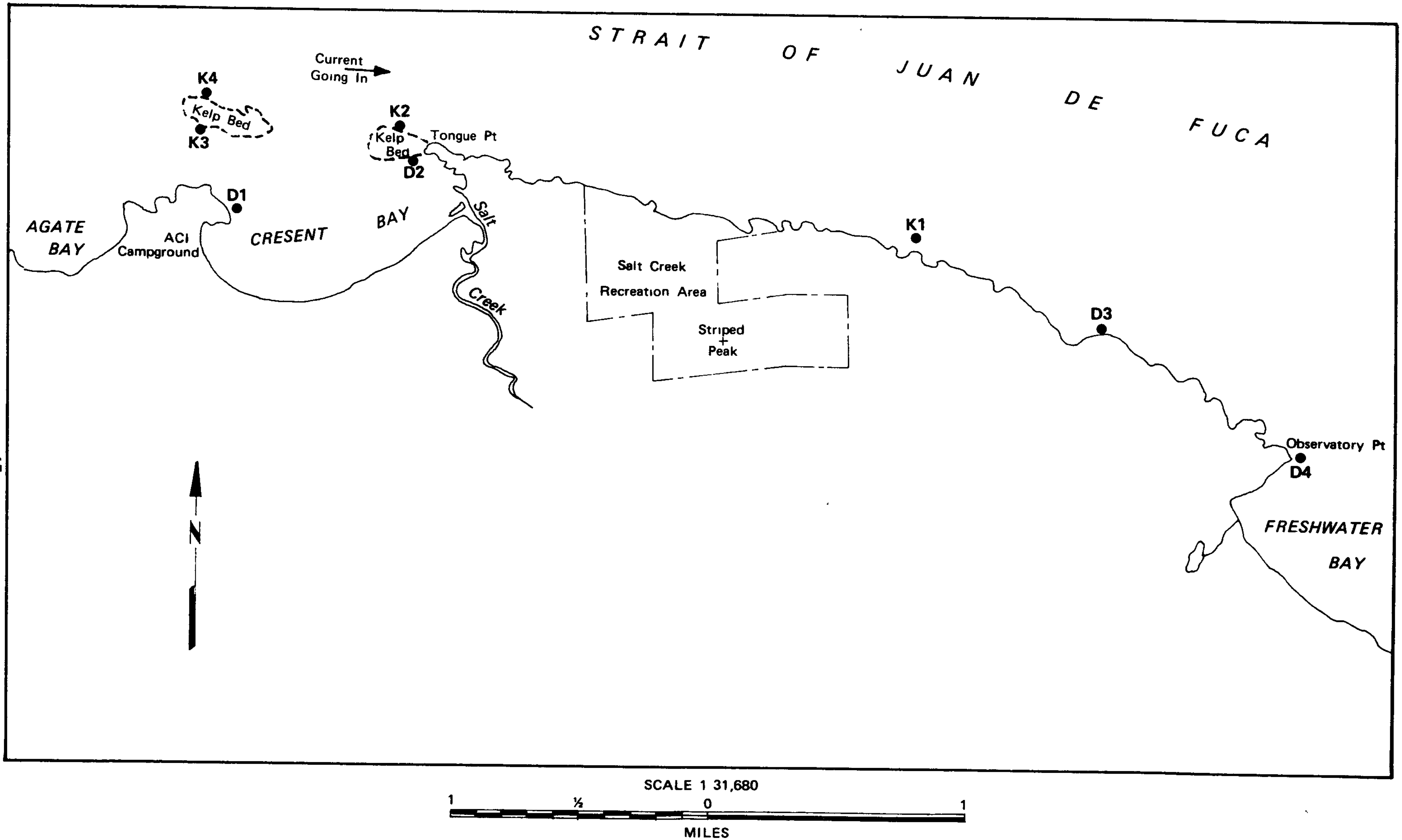

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Figure 5. MAP SHOWING TRANSECTS AND LANDMARKS ASSOCIATED WITH THE STRIPED PEAK HEADLAND/PILLAR POINT SUBTIDAL RECONNAISSANCE. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

The purpose of the kelp bed reconnaissance was to document kelp oiling from Cape Flattery to Protection Island. The data was used to determine the extent and magnitude of kelp oiling.

Boat survey transects were charted on NOAA marine charts, "Strait of Juan de Fuca, Western Part," and "Strait of Juan de Fuca, Eastern Part." Sampling points were marked every 23 mm on the chart corresponding to one nautical mile. In the area of greatest commercial significance, samples were taken every 1/2 mile. The 1/2 mile transects were conducted at Pillar Point and the Striped Peak headland (Figure 6).

Two boat teams were deployed, one for the western portion of the survey, one for the eastern portion. Teams consisted of an operator, an assistant, and an observer. Observers worked the entire survey period to ensure consistency in methods and observations.

Sampling procedure consisted of maneuvering the boat into an area of rafting kelp at the designated sample point and selecting an individual kelp stipe (*Nereocystis*). The stipe was seized about 1/2 meter beneath the pneumatocyst and brought up to the gunwale of the boat. The lower portion of the stipe was severed and released.

The kelp bed and the plants themselves were visually examined for presence of oil and given a numerical value depending on the appearance of oil. Zero was given if no oil was seen; one, if oily sheen was present; two, if patches of emulsified oil ("mousse") were seen; and three, if the plant were covered with emulsified oil. In addition, the plants were sniffed to detect the presence of petroleum aroma. Values of zero and one were recorded for the respective absence or presence of aroma.

Following visual and olfactory observation, a section of stipe 6-10 cm was cut just below the pneumatocyst and placed in bottles provided by the Ecology Manchester Lab. A sample of blade (approx. 10 cm) was also placed in the bottle. Bottles were labeled with sample designation which included date of sample, boat team, and station. Samples were later renumbered to serialize the entire set of samples. Samples were frozen and held at the Manchester Lab under chain-of-custody, and shipped to the LSU Lab for hydrocarbon analysis.

Observation were noted in the observers' log that recorded the sample results, observations of oil in water of kelp bed, extent of kelp beds, and species.

3.8 Subtidal Shellfish Study

Dick Burge, WDF shellfish biologist, was the MRDA team leader for the subtidal shellfish study. Bruce Pease, WDF shellfish biologist, initiated and designed this study. Pease and Michael Kyte coauthored this section.

WDF contracted with Michael Kyte, Ardea Enterprises, to assist with these studies. WDF participated in these studies in site selection, design of the sampling methods and schedule, initial field sampling and establishment of transect

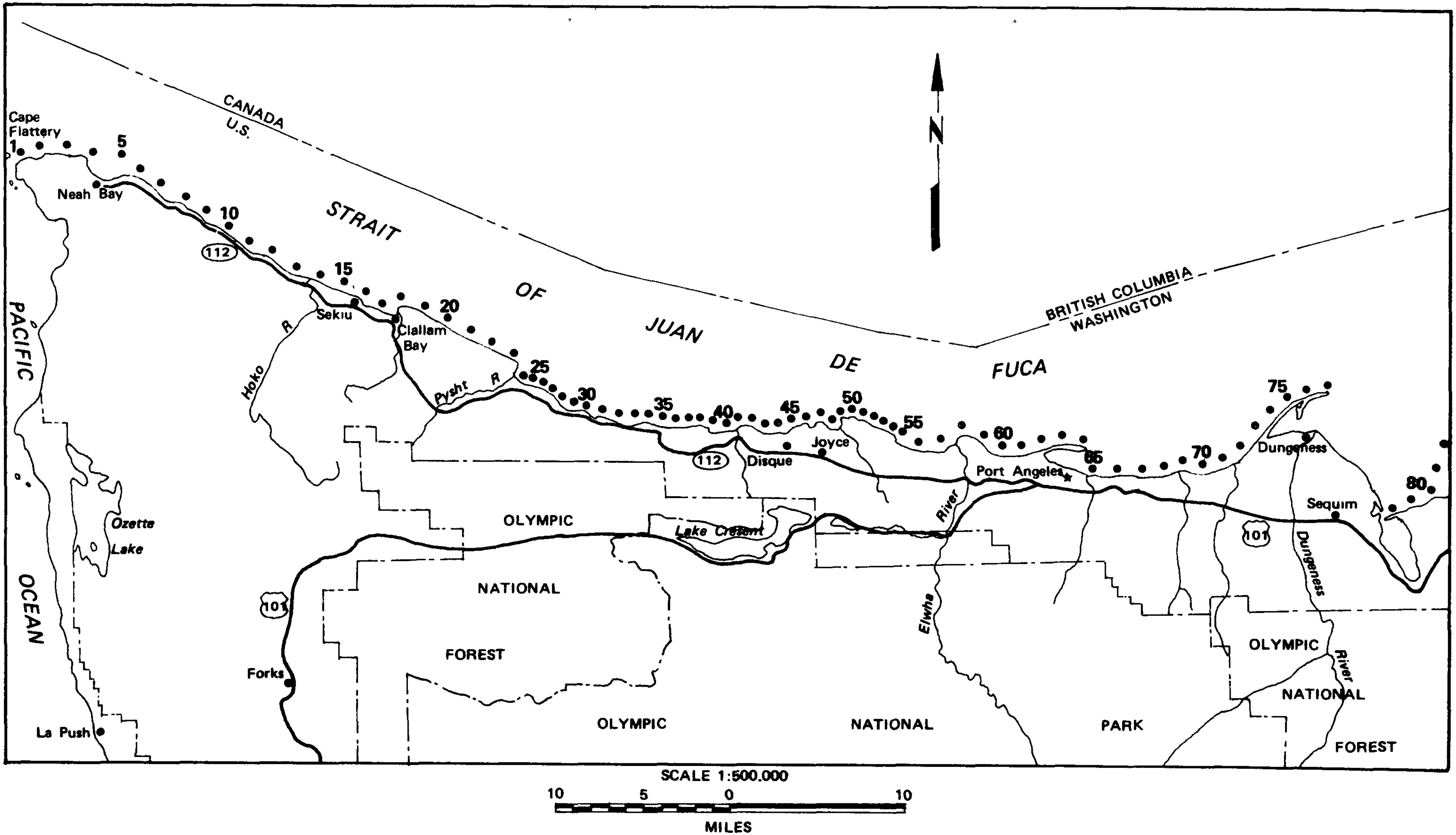

Figure 6. MAP SHOWING TRANSECTS AND LANDMARKS ASSOCIATED WITH THE KELP BED RECONNAISSANCE. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21,1985.

lines, analysis of sea urchin gonad samples, data analysis, and conducted the August sampling. Ardea Enterprises participated in the study design, site selection, initial sampling, and conducted the March sampling.

The purpose of the study was to assess short-term impacts from the ANS on subtidal invertebrates along the shoreline west of Port Angeles. The species included in this study are those that are or may be harvested by commercial fisheries. These include red (*Strongylocentrotus franciscanus*), green (*S. drobachiensis*), and purple (*S. purpuratus*) sea urchins, pinto abalone (*Haliotis kamtschatkana*), rock (*Chlamys giganteus*) and pink (*Chlamys* spp.) scallops, and sea cucumbers (*Stichopus californicus*). In addition, brown algae species *Pterygophora*, *Nereocystis*, and *Laminaria* which are important in Puget Sound marine food chains were also enumerated. The study methods were designed to determine whether short-term mortalities occurred among these species within the selected study areas (Burge, 1986).

Special emphasis was placed on sampling of red sea urchins because most of the red sea urchin harvest in Washington is taken from the Strait of Juan de Fuca west of Port Angeles. Red sea urchins are harvested commercially for their edible roe (gonads). An important aspect of this study was to determine whether the ANS had an effect on red sea urchin gonads.

Two study sites were selected, one in an area that received heavy oiling, and a control in an area that had not received oil from the ARCO Anchorage oil spill (Figure 7). The sites were chosen using the results from the Striped Peak Headland subtidal reconnaissance (section 3.6.3) and the oiled kelp surveys (section 3.7). It was necessary that each study site contain habitat suitable for urchins and kelp and that each site be sufficiently large to establish transects and to place quadrats as described in the following section. Following these criteria, the treatment sites were located about two kilometers (one nautical mile) west of Observatory Point, west of Freshwater Bay and Port Angeles. The control site was established off McCurdy Point east of Discovery Bay.

The Observatory Point site is characterized by solid bedrock sloping steeply (approaching vertical in places) from the upper intertidal to about 15 meters (m) (50 foot) below mean low low water (MLLW). The slope is interrupted by occasional crevices and boulders.

The control site off McCurdy Point is characterized by low ledges of bedrock slightly sloping to the west and north and whose longitudinal axis is oriented north and south. Numerous large boulders lay on the ledges. Aside form these boulders, the area exhibits little vertical relief and the slope from the shoreline is very gradual. Both areas are exposed to winds from the north, west, and east and strong tidal currents flowing west to east.

At each site, two parallel 50 m transects (164 foot) were established by laying gillnet lead line along the bottom. These lines were anchored and marked at each end with white-painted boulders and marked with stainless steel tags at 2 m intervals.

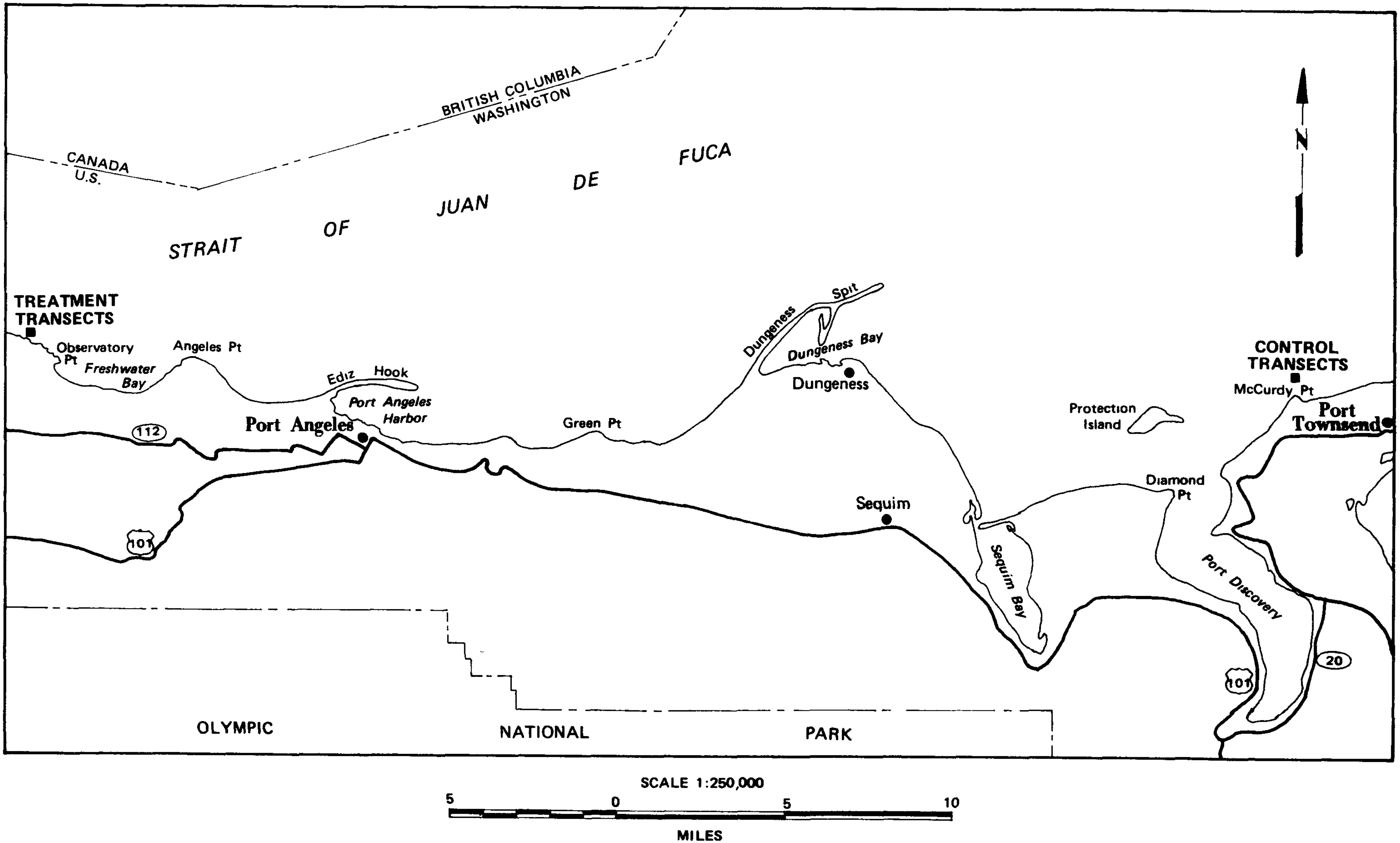

Figure 7. MAP SHOWING STUDY SITES AND LANDMARKS ASSOCIATED WITH THE SUBTIDAL SHELLFISH STUDY. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

In the treatment site, these transects were parallel to depth contours at 6 to 8 m (20 to 25 foot) and 9 to 11 m (30 to 35 foot MLLW depth. Because of the lack of definite slope at the control site, the two transects were placed at the same depth, approximately 11 m (35 foot MLLW, oriented north and south along the ledges, and about 10 m (33 foot apart. Each transect was divided into 5 m intervals. Individuals of the designated invertebrates were counted within one meter of each side of the transects within these intervals.

In addition to the 5 m^2 quadrats, five 1-m^2 quadrats were randomly placed along either side of each transect line using the 2 m interval markers. Odd numbers were arbitrarily placed on the left side and even numbers on the right side of the transect line. Each quadrat location was sampled only once during the study. Individuals of the designated invertebrate species were counted within each quadrat and the test diameter of each red sea urchin was measured. If fewer than 22 red sea urchins were present in all of the quadrats at a transect, individuals were randomly measured along the transect line until at least 22 test measurements were collected.

Fourteen red sea urchins were collected from these quadrats within the commercial size range, 75 to 115 mm (3 to 4.5 inches) in test diameter. If 14 urchins within this size range were not available within the 1 m^2 quadrats, the samples were supplemented with urchins taken randomly from a location at least 5 meters from the transect line. Of these 14 urchins, at least ten were analyzed for gonad condition. For each urchin, sex, gonad color, and percent gonad weight of drained body weight was recorded. A small sample of the gonad from each of the 14 urchins was tasted (by the same biologist during each sampling and in each area) for tainting and a second sample was frozen and archived for hydrocarbon analysis. The urchins were handled and opened with cleaned instruments to prevent contamination with hydrocarbons not originating from the oil spill.

3.9 South Dungeness Bay Surf Smelt Study

The purpose of the study was to assess impacts from the ANS on the surf smelt (*Hypomesus pretiosus*) along the south shoreline of Dungeness Bay.

Dan Penttila, WDF fisheries biologist, was the principle investigator and author of this section. He was assisted by Jim Beam and other WDF staff.

Sampling sites were selected at random inside Dungeness Bay from the base of Dungeness Spit to the base of Cline Spit (Sector D-8). At two sites, a 1 liter substrate core sample was collected. The samples were preserved with Stockard's Solution (4% glacial acetic acid, 6% glycerin, and 5% formalin (38%) in distilled water). The eggs in each sample were counted and a subsample was examined under a dissecting scope for age, fertilization, and mortality rates.

Visual signs of oil were also noted.

3.10 Dungeness Bay Pacific Herring Spawning Ground Survey

The purpose of the study was to assess the impacts of the ANS on the Pacific herring (*Clupea harengus pallasi*)

Dan Penttila, WDF fisheries biologist, was the author of this section. WDF Marine Fish Program staff undertook the spawn survey field work, spawn sample analyses, and biomass estimations. The survey consisted of inspecting marine vegetation samples grappled up from the bottom at 300 yard intervals along the shoreline of the bay. At each sampling station, the vegetation was identified to genus and the overall intensity of herring spawn was estimated, using the field spawn intensity guide shown in Table 2. Each sampling station was located on a field chart, and the water depth recorded. Samples of spawn-laden vegetation were preserved from selected stations. Five-minute plankton tows were conducted at fixed sites northwest of Cline Spit and east Graveyard Spit. The purpose was to monitor the abundance of herring and other baitfish larvae.

In the lab, the preserved spawn samples were inspected under 15x, and spawn deposition date(s) estimated. The embyronic developmental stage present were matched with known times of occurrence during the standard 14-15 day winter herring incubation period.

Spawning escapement tonnage estimates were derived from a knowledge of the lineal extent of the spawn patches along the shoreline and the spawn-deposition intensities within them. Table 2 gives the spawning escapement/spawn intensity relationships presently used by WDF for herring escapement estimates. The estimation technique considers only the length of spawn patches, the widths are assumed to be constant.

This technique correlates, within ten percent, with population biomass estimates derived from hydro-acoustic/midwater trawl sampling surveys in the Gulf of Georgia area (Whatcom county, WA), Where both techniques are used to assess a known discrete herring stock (Trumble, 1983).

Table 2. Herring Spawn Intensity/Spawn Escapement Values Used by WDF. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Field Est. Spawn Intensity	Est. Tons of Spawner Herring to Deposit 1 Statute Mile of Spawn
"Trace"	0 (original location/intensity of spawn unknown)
"Very Light"	43
"Light"	214
"Light-medium"	360
"Medium"	600
"Medium-heavy"	900
"Heavy"	1,286
"Very Heavy"	2,571

3.11 Ichthyoplankton Study

The purpose of the ichthyoplankton study was to assess the impacts of ANS on the icthyoplankton in the study area.

Dan Penttila, WDF fisheries biologist, was the author of this section. The icthyoplankton field studies and initial workup of the samples were conducted Dr. Jim Walton and his students at Peninsula College, with confirming analysis undertaken by WDF.

Four sampling sites were set up between Port Angeles and Dungeness Bay (Figure 8). Two replicate 10- minute tows were made at each site at about 4 m depth, in opposite directions, and the catches pooled and preserved in the field. Net type, water depth, tow time, weather and sea state were noted (Walton, Peninsula College, personal communication). Fish larvae in the plankton tows were sorted into the following categories: herring, smelt, sandlance, and other.

Herring, smelt, and sandlance were tallied and total lengths measured to the nearest millimeter. The macrozooplankton were examined for dominant organism and the presence/absence of 26 classes of organisms, much in the same manner as similar samples from Puget Sound herring spawning ground surveys had been analyzed since 1975 (WDF unpub. Data). Settled volume of the total catch was estimated. Samples were archived by WDF.

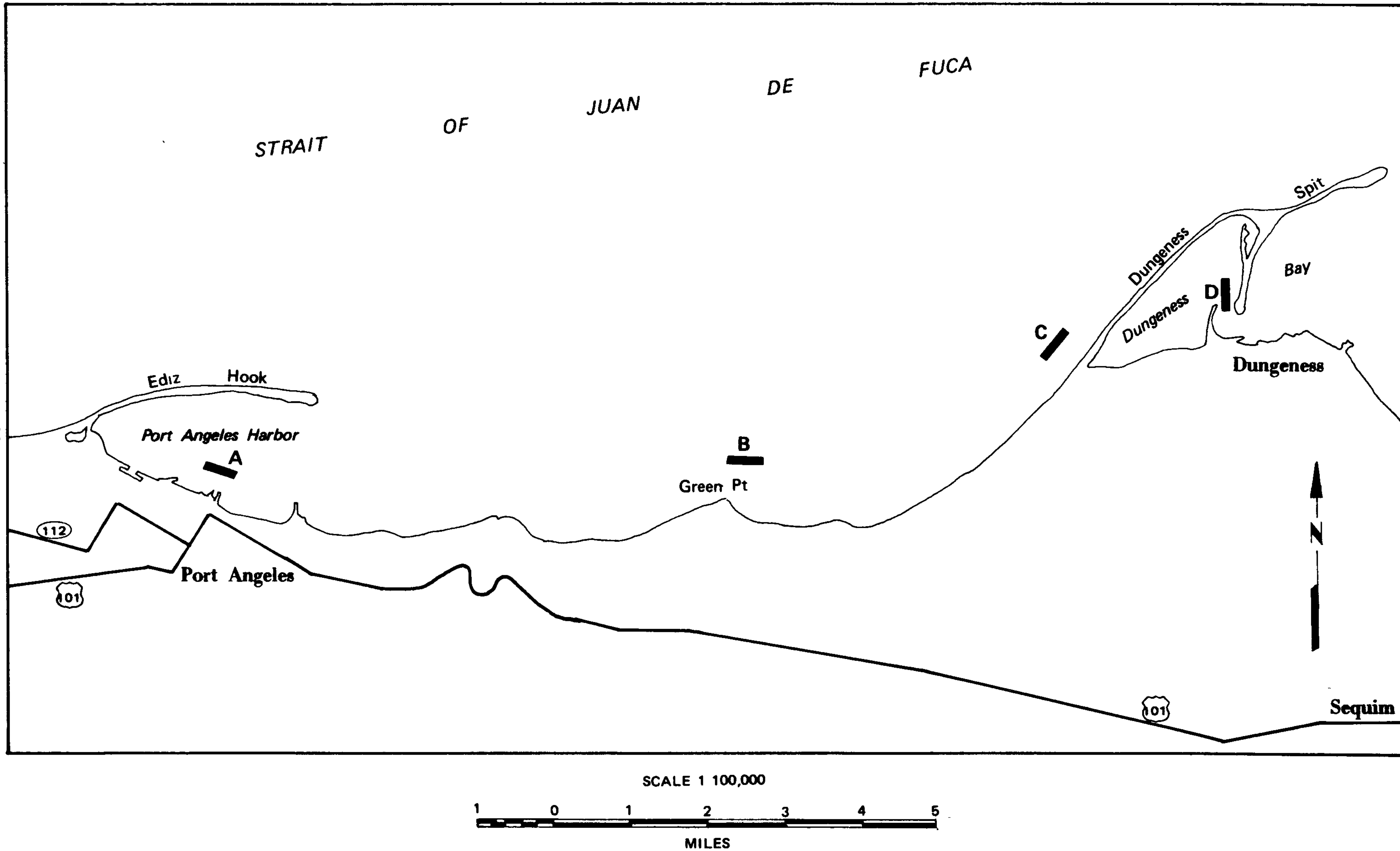

Figure 8. MAP SHOWING LOCATIONS OF DAYTIME NEAR–SURFACE PLANKTON SAMPLING STATIONS IN THE PORT ANGELES – DUNGENESS SPIT REGION, FEBRUARY–MARCH 1986: A. PORT ANGELES HARBOR, B. GREEN POINT, C. WEST DUNGENESS SPIT, D. CLINE SPIT. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

3.12 Juvenile Salmon and Epibenthic Invertebrate Reconnaissance

Kurt Fresh, WDF fisheries biologist, was the principle investigator and author of this section. Gene Sanborn, Mark Carr, Steve Schroder, and Curtis Dahlgren (WDF staff) helped collect the samples. Jeffery Cordell, WDF consultant, will be analyzing the epibenthic samples.

The purpose of this reconnaissance was to determine whether typical juvenile salmonid food organisms were available during the 1986 juvenile salmon outmigration.

Four sites were sampled:

Site No.	Location
1	Base of Dungeness Spit
2	Inside Ediz Hook (In 3 separate areas)
3	Freshwater Bay near Observatory Point
4	West Whidbey Island (≈2km S of Deception Pass)

3.12.1 Juvenile Salmonids

Juvenile salmonids were collected at each site using a 33m long beach seine (fish samples were not collected at Ediz Hook). The seine was set 10 m from shore and parallel to the beach and then hauled into the beach. Salmonids were identified to species, counted and measured (fork length). Catches of other fish species were also enumerated. Water temperatures and salinities at the sites were collected.

3.12.2 Epibenthic Invertebrates

Epibenthic samples were collected using a plankton pump. To collect a sample, the pump was first flushed for 15 seconds with the suction head at mid-depth. Then after turning the pump off, the suction head was lowered to the bottom, restarted and run for 15 seconds. At that point, two nets (505 and 235 micron mesh size) were inserted into the collection port and the engine run for 45 seconds or until sediment was observed in the nets. The nets were removed and organisms rinsed into collection bottles. The samples were preserved with 10% formalin. A sediment sample was collected using an eckman dredge. The sediment samples were analyzed for particle size.

3.13 Oiled Bird Survey

Robert Steelquist, Peninsula College, organized and supervised the oiled bird collection effort. Steve Speich, WDG biologist, provided the mortality estimate. Steelquist and Speich coauthored this section.

The purpose of this study was to assess the number of oiled birds and resulting bird mortality.

The bird collection effort used the beach reconnaissance shoreline sectors to coordinate the two efforts. The sector descriptions are in Table 1 and shown in Figure 1.

Each day, sectors were assigned to one or more recovery teams, depending on the number of birds that could be effectively removed from the sector.

Recovery teams consisted of between two and eight volunteers, accompanied, whenever possible, by a radio operator (usually a member of a search and rescue organization). As volunteers gathered at the deployment site they registered, were issued a tag with their registration number, received a short training briefing, were given necessary equipment, and then sent to their sector.

Training briefing consisted of a description of the area they were being sent into, methods of capture and transport of oiled birds, methods for reporting their capture results, other observation, and general safety and logistical considerations.

After capture, birds were placed in a modified plastic bag to prevent further preening and to retain body heat. Plastic bags were modified by tearing a small hole in one of the bottom corners. The bird's head would be passed through the hole and the bag turned inside out around the body. The bird would then be placed in a large kraft-paper grocery sack and the sack would be closed and rolled, "sack lunch" style. Using this method, volunteers could carry up eight live birds relatively easily.

Following a search along the assigned sector, crews returned to the field command center. Live birds were placed in a heated shelter and were transported to the bird cleaning clinic. Dead birds were transferred to Steve Speich, WDG. Dead birds were frozen and held under chain-of-custody until they could be counted and identified to species.

Crews were debriefed by the command center supervisor. During debriefing a standard set of questions was asked. Answers were recorded on a standardized form. The questions were: a) How many live birds were recovered by the team in the assigned sector? b) How many dead birds were recovered in the assigned sector? c) How many oiled birds were seen or evaded capture in the assigned sector? Other questions were asked pertaining to areas of greatest concentration of birds, approximate percentage of species among captured, seen birds, location, and extent of oil on beach. Any other remarks made by the team members were noted on the form. Sector report forms were gathered daily and used to plan the following days' activities. After January 1, sector reports were tabulated and analyzed. Live and dead bird data were totaled by sector, day and cumulative results.

3.14 Oiled Large Falcons and Bald Eagle Study

Richard Lowell, WDG wildlife biologist, was the principle investigator and author of this section.

The purpose of the study was to determine if wild peregrine falcons (*Falco peregrinus*), gyrfalcons (*Falco rusticolus*), and bald eagles (*Haliaeetus leucocephalus*) were adversely affected by the ARCO Anchorage Oil Spill.

The study was conducted in Clallam and Jefferson Counties, on the northeastern margin of the Olympic Peninsula. It centered around the Sequim-Dungeness area extending east to Protection Island, west to Port Angeles and south to Burnt Mountain in the Olympic National Park. The area consists primarily of a coastal terrace bounded to the north by the Strait of Juan de Fuca and south by the Olympic Mountains (Maximum elevation 7965 feet).

On land, the study area was surveyed for wild falcons and bald eagles by driving the primary and secondary road systems of the Sequim-Port Angeles region. An 18 foot inflatable raft powered by a 25 horsepower outboard motor was used to search for or track falcons and eagles in marine areas. Extreme care was taken not to influence the natural behavior of the radio-tagged falcons.

Observations were made using 10x50 power binoculars and a 15x45 power zoom spotting scope. All observed large falcons were identified by species and the time, location, and behavior of each sighting was recorded in a field note book or on a portable micro-cassette tape recorder.

In the field, each wild falcon seen was examined visually for the presence or absence of oil-contaminated contour feathers. A bird was considered oiled if it had a matted, sticky, "wet" appearance on the abdominal feathers, accompanied by an atypical brownish discoloration. In hand, the smell, texture, and coloration of oil on the feathers of captured flacons was easily detected. In order to determine the effect of the ANS on wild peregrines, no attempt was made to remove oil from contaminated birds.

Both peregrines and gyrafalcons were aged as immature or adult, whenever possible, based on plumage characteristics and color of cere, orbits and feet.

Sexing of peregrines in the field was based on observing the relative size differences between males and females. In-hand, sexing was based on standard wing and tail measurements (mm) and weight (gm) White, 1968).

Individual falcons were recognized by facial patterns, plumage variations, and the presence or absence of radio transmitters.

An attempt was made to capture any peregrine falcons located within the study area. Falcons were captured using a leather pigeon harness (Beebe and Webster, 1985). After capture, the presence or absence of oil contaminated feathers was noted, blood and feather samples were collected, and standard wing, tail, and weight measurements were recorded. The captured falcons were then banded, radio-tagged, photographed, and released at the site of capture.

A radio transmitter package was attached to the ventral surface of each falcon captured using the methods described by Dunstan (1983). An attempt was made to track each captured falcon using a radio receiver and radio telemetry. The purpose of the radio-tagging was to facilitate recapture and determine if the birds were feeding on oiled prey.

While tracking or searching for falcons, bald eagles were encountered and an attempt was made to assess the presence or absence of oiled feathers on these birds, however, eagles were not the primary focus of this study.

Blood and casting samples were sent to Dr. Michael Fry , Department of Avian Sciences, University of California at Davis, California. Methods for analysis of oil residues in blood serum and casting were modified from procedures by Fry and Lowenstein (1985), Gay *et al.* (1980), and Belisle *et al.* (1981). Procedures are explained in detail in "Study of Oil Contaminants in Feathers of oiled Prey Birds, castings, and serum from Falcons Impacted in the "ARCO Anchorage" Oil Spill" by D. Michael Fry (Appendix III).

3.15 Nesting Marine Bird Survey

The purpose of the study was to determine if the marine bird populations in the oil spill area suffered a measurable decline following the ARCO Anchorage oil spill.

Steve Speich, WDG biologist, was the principle investigator and author of this section.

Marine bird surveys were conducted along the shoreline and near shore waters, inclusive of bays and harbors, from McCurdy Point to Agate Bay. Observations were made from a 17 foot Boston whaler while cruising the shoreline along predetermined transects. The transects duplicated those used during the MESA Project (Wahl et al., 1981). Transects were added in areas not covered in the MESA Project. The new transects were established using the MESA Project criteria. During the surveys, marine birds were identified to species, sexed, aged, and tallied. The following activities were also noted: feeding, roosting, and nesting. When nesting was observed, counts of active nests or nesting individuals were noted. At nesting sites, eggs and/or young were counted and abnormalities noted. Detailed breeding marine bird censuses were made on Protection Island and in Port Angeles Harbor.

4.0 RESULTS

4.1 AERIAL RECONNAISSANCE

The NOAA data indicated currents and wind transported the ANS out of Port Angeles Harbor along two pathways. The first and dominant pathway was eastward along the 10 fathom line to the base of Dungeness Spit. From there the ANS was transported along the north side of the spit to the tip. Once the ANS reached the tip of the spit, most of the oil moved to the northeast and collected in a gyre and then down the middle of the Strait (plots are shown in Appendix I).

The reports indicated that on every tidal exchange, less than one percent of the ANS north of Dungeness Spit moved south of the Spit into Dungeness Bay. In Dungeness Bay, the ANS was reported as a silver sheen.

The second pathway was around the end of Ediz Hook (the Hook) and then westward along the north side of the Hook. From the middle of the Hook, the ANS moved northwest in a gyre north of Angeles Point. From the gyre, the ANS moved westward down the Strait.

From December 23 to the 25th, the aerial reconnaissance data indicated the ANS was onshore along the south shoreline of Ediz Hook and the north shoreline of Dungeness Spit. The concentrations were reported as heavy black oil. The oil offshore from Ediz Hook to the gyre northeast of Dungeness Spit was reported as brown streamers mixed with brown oil (emulsified oil) patches. The heaviest ANS concentrations were in the Dungeness Spit "knuckle" and inside Ediz Hook. The ANS in the "knuckle" was reported as brown to black. The ANS inside Ediz Hook was along the south shoreline from the Crown Zellerbach Mill (Crown Z) to the tip of the Hook. The heaviest concentration was in the A-frame area and in the log boom area. This oil was reported as brown to black and 2 to 3 inches thick.

During that same period, offshore oil was reported from Ediz Hook to Twin Rivers. The ANS was reported as brown oil streamers and large brown oil patches indicating the oil was more weathered in the outer Strait than in Port Angeles Harbor. The oil patches were located off Angeles Point, the Striped Peak headland, and Twin Rivers. No onshore ANS was reported in the outer Strait (west of Ediz Hook).

On December 25, gale force winds from the northeast pushed the offshore oil southward toward Sequim Bay and into the kelp beds Freshwater Bay to Agate Bay. On December 26, in the inner Strait, an oil slick was observed within one mile of Sequim Bay between Kulakala Point and Protection Island. This slick was reported as 10 percent sheen, 1 percent brown oil and 89 percent open water. North and east of Dungeness Spit the oil was reported as 85 percent brown oil and 15 percent sheen indicating the gale had weathered the ANS significantly. Sheen was reported as far east as Smith Island.

On December 26, east winds (17 kts) pushed the ANS west as far as Tatoosh Island where it was reported as brown streamers.

On December 30, ANS was observed from Dungeness Spit to Slip Point, Clallam Bay. The oil slick between Kulakala Point and Protection was reported as a sheen. From Dungeness Spit to Agate Bay the offshore oil was reported as gray to silver sheen with some brown oil indicating the ANS concentrations were declining in the offshore areas. ANS was reported onshore from Observatory Point to Tongue Point (Striped Peak headland). Pockets of ANS were reported at the west end of Freshwater Bay and Crescent Bay.

On January 1, gale force east winds (30+ kts) pushed more oil onshore at Observatory Point, the Striped Peak headland, and Tongue Point. Pockets of brown oil were observed at the west end of Freshwater Bay and Crescent Bay.

From January 3 to January 9, the offshore oil concentrations declined steadily along the south shoreline of the Strait. ANS remained along the south shoreline of Ediz Hook.

The data indicate the ANS in the offshore areas had declined significantly by December 30 and by January 3 the ANS was down to a few sheens. The two gale force wind events had dissipated the ANS and transported the remaining ANS onto the Striped Peak headland.

Based on the above information, the MRDA Team initially planned beach reconnaissance from Port Angeles to Sequim Bay. As later data indicated the ANS was onshore west of the Hook, reconnaissance was planned in that area.

4.2 Beach Reconnaissance - December 23-30, 1985

The majority of the beach reconnaissance from December 23-30, 1985 was conducted at night because the low tides were at night. The nighttime low tides afforded the best beach access, but darkness hampered observations.

4.2.1 Ediz Hook Beach Reconnaissance

The south shoreline of Ediz Hook was oiled on December 22, 1985 and remained oiled to at least June 1, 1986. Birds, clams, crabs,starfish, and nudibranchs were impacted by the ANS inside Ediz Hook (Table 3). Based on this data the MRDA Team (WDF) conducted clam population studies inside Ediz Hook.

4.2.2 Beach Reconnaissance East of Ediz Hook (Inner Strait)

East of Ediz Hook, the intertidal zone on the outside of Dungeness Spit and the inside of Dungeness Spit were oiled. No oil was observed in the intertidal zone from the ITT Rayonier Mill to the base of Dungeness Spit or from Graveyard Spit to Sequim Bay (Table 3).

The north shoreline of Dungeness Spit was oiled from December 22, 1985 to January 3, 1986. The heaviest oil concentration was in the "knuckle" area (Figure 9). In this area, kelp crabs and birds were impacted by the ANS.

The north shoreline of Dungeness Spit is a high energy beach and does not provide a stable intertidal clam habitat (Burge, WDF shellfish biologist, personal communication) and clam studies were not recommended in this area.

In areas inside and south of Dungeness Spit, oil was observed in the intertidal zone about half way between Graveyard Spit and the tip of Dungeness Spit. In this area, birds were impacted by the ANS (Table 3).

Based on the above data, the MRDA Team did not recommend conducting intertidal studies from the ITT Rayonier Mill to Graveyard Spit. They did recommend conducting intertidal studies inside Dungeness Bay, subtidal studies inside Sequim Bay, off Jamestown, off Green Point, and intertidal studies inside Ediz Hook.

Table 3. Results of the Beach Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Sector	Date/Time	Observations
D-8	12-23/AM	No oil observed on beach or water. No oiled. Hasselbart/Wray (USFWS).
D-1	12-23/PM	No oil on beach for first 1/4 mile. Oiling increased from sheen to 1-2 in. thick at sector end. 25-30 oiled birds. No dead mammals, clams, or fish. Sample No.s 017182, 017183, & 017184. Cloud/Wagner (Ecology/EPA).
M-2	12-23/PM	No oil on beach. 10-20 oiled birds. Cummins/Anthony (WDG).
M-4	12-23/PM	No oil on beach. Oiled birds present. Burge/Finn (WDF).
PA-3	12-23/PM	Oil 1-2 in. thick on intertidal zone. Clams and crabs narcotized. Sample No. 017188. Anderson/Boden (Ecology/EPA).
PA-4	12-23/PM	Light oiling on tip of Ediz Hook increasing to to heavy near USCG fence. Dead starfish and nudibranchs. Clams narcotized. Sample No.s 017185, 017186, & 017187. Scholz/Stoner (WDF/EPA).

Table 3. Results of the Beach Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Sector	Date/Time	Observations
FWB-2	12-26/AM	No oil on beach. No oiled birds on beach. 30-40 birds on water, 10-15% were oiled. Stoner/Portelle (EPA).
CB-1	12-26/AM	No oil at Salt Creek. 50 birds on water, 40-50% were oiled. Stoner/Portelle (EPA).
AB-1	12-26/AM	No oil on east end of bay. 10-15 birds on water, none oiled. Shellfish appeared normal. Stoner/Portelle (EPA).
D-3	12-26/1230	Intertidal zone heavily oiled. Kelp crabs narcotized and suffering predation. Cloud/Ballou (Ecology/NOAA).
D-4	12-26/1830-2030	Beach oiled from middle of sector for 200 yards, width 24 in., thickness 1/4 in.. Swath at +6 ft. tideline. 11 oiled birds. Shellfish appeared normal. Burge/Beam (WDF).
PW-1	12-26/1845-2030	No oil observed. Two oiled birds. Shellfish appeared normal. Sainsbury/Stoner (EPA).
PA-3	12-26/1850-2000	Oil covered intertidal zone. Shellfish narcotized. Butler (WDF).
PA-4	12-26/1855-2000	Oil covered intertidal zone and penetrated 6 in. into substrate. One oiled bird. Shellfish appeared normal. Scholz/Gromley (WDF).
JT-1	12-26/1900-2130	No oil observed. Three oiled birds. Shellfish appeared normal. Portelle/Stoner (EPA).
EH-1	12-26/2000	No oil on rocks. Oil slick offshore about 50-100 ft. Organisms on rocks appeared normal Three oiled grebes on beach. 2-10 oiled grebes offshore. Shellfish appeared normal. Dorgaw/Koch (NOAA).

Table 3. Results of the Beach Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Sector	Date/Time	Observations
D-2 & 3	12-27/AM	No oil observed below the high tideline. Above high tideline oil was mixed with debris. 15 oiled grebes, 8-10 oiled oldsquaw ducks, and 12 oiled loons were observed. Webb/Portelle (EPA).
PP-1	12-27/PM	Narrow sheen band observed. Webb/Portelle (EPA).
SP-1 & CB-1	12-27/PM	Intertidal zone oiled. Oiled birds present. Sample No.s 0171200, 017202, & 017203. Burge/Beam (WDF).
FWB-1	12-27/PM	High intertidal zone oiled. Oil visible offshore in kelp and in small patches. Gromley (WDF).
PP-1	12-28/AM	No oil at Pysht River. No oiled birds. Cloud/Hurdle (Ecology/NOAA).
D-1	12-31/0900	No oil. No oiled birds. Seiler/Kmet (Ecology).
D-2	12-31/1000	Heavy sheen on beach. Pockets of oil and oily debris at high tideline. No oiled birds. Seiler/Kmet (Ecology).

4.2.3 Beach Reconnaissance West of Ediz Hook (Outer Strait)

West of Ediz Hook, the intertidal zone and kelp beds were oiled from the west end of Freshwater Bay to Pillar Point starting on December 27, 1985. The heaviest oiling occurred along the Striped Peak headland. No dead or dying intertidal organism were observed, but oiled birds were observed (Table 3).

Based on the above data, the MRDA Team recommended kelp bed habitat and intertidal shellfish studies be conducted at Striped Peak Headland, Tongue Point, and Agate Bay Headland.

4.2.4 Beach Reconnaissance Hydrocarbon Analysis

Four reference samples were collected from the ARCO Anchorage on December 22, 1985. The samples were taken from tanks 4 and 5 center. The samples were separated by normal phase liquid chromatography into three fractions: F-1, aliphatics; F-2, slightly polar aromatics (PAH's); F-3, polar compounds. Only the first two fractions were analyzed on GC/FID for oil characterization. Sample no.s 527171 and 527174 were further characterized by GC/MS analysis.

The ANS onboard the vessel was low in polar aromatics (PAH's). Naphthalene and its C-1 through C-4 homologs predominated (Henry, 1986). The ANS matched well with the EPA reference oil for Prudhoe Bay crude oil within the parameters tested. Chromatograms are shown in Appendix II, Figures 1-11.

Sample no.s 017182-184 were collected from sector D-1 on December 23, 1985 two days after the spill. Each sample was heavily contaminated with ANS (Table 4). The ANS had lost most of the lighter aliphatic and aromatic components which is typical of slightly weathered oil. The "fingerprint" matched the F-2 fraction from the reference samples.

Sediment sample no. 017185 collected from sector PA-4 on December 23, 1985 contained low levels of aliphatic hydrocarbons, C-12 through C-29 (Table 4). Only a trace of aromatics was detected. The oil was slightly weathered; the degree of weathering was consistent with that reported above. In general, the analysis of this sample revealed low level contamination of ANS.

Water sample no.s 017186 and 017187 collected from sector PA-4 on December 23, 1985 were heavily contaminated with ANS. The analysis revealed slightly weathered ANS.

Water sample no. 017188 collected from sector PA-2/3 on December 23, 1985 was heavily contaminated with slightly weathered ANS.

Water sample no. 017190 collected from sector FWB-1 on December 30, 1985 was slightly contaminated with weathered ANS.

Water sample no. 017191 collected by Eloise Kailin (Sequim Bay resident) from Sequim Bay on December 23, 1985 was not contaminated with ANS.

Water sample no.s 017200 and 017203 collected on December 27, 1985 from Tongue Point and Observatory Point respectively (sector SP-1) were heavily contaminated with ANS.

Water sample no. 017202 collected near Observatory Point (sector SP-1) was contaminated with low levels of oil, but analysis revealed it did not match ANS.

Water sample no. 017204 collected in sector WC-1 on December 27, 1985 was heavily contaminated with ANS.

The data to this point indicated the oil had contaminated the shoreline from the tip of Dungeness Spit to Whiskey Creek. It took about six days for the ANS to reach and oil this shoreline. As time passed, the oil weathered and lost most of the PAH's leaving the heavier molecular weight components of the ANS, but the ANS could still be "fingerprinted".

Table 4. Hydrocarbon Analysis Results for Beach Reconnaissance December 23-30, 1985. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Sector	Date	Sample no.	Sample Type	ANS Contamination
D-1	12-23-85	017182	Oil/water	Heavy
D-1	12-23-85	017183	Sediment	Heavy
D-1	12-23-85	017184	Oil	ANS
PA-4	12-23-85	017185	Sediment	Low Level
PA-4	12-23-85	017186	Oil/Water	Heavy
PA-4	12-23-85	017187	Oil	Heavy
PA-2 & PA-3	12-23-85	07188	Oil/water	Heavy
FWB-2	12-30-85	017190	Oil/water	Slightly
Sequim Bay*	12-23-85	017191	Water	No
SP-1	12-27-85	017200	Oil/Water	Heavy
SP-1	12-27-85	017202	Oil/Water	No
SP-1	12-27-85	017203	Oil/Water	Heavy
WC-1	12-27-85	017204	Oil/Water	Heavy

* Sample collected by Eloise Kailin in Sequim Bay on 12-23-85

4.3 Beach Reconnaissance April 26-28, 1986

The spill area from the tip of Dungeness Spit to Observatory Point were reconnoitered on April 26-28, 1986. ANS was found only along the south shoreline of Ediz Hook (Tables 5 & 6). Impacts were found only along the south shoreline of Ediz Hook.

Initially it was thought sea urchins in sector FWB-1 had been impacted by the ANS, but analysis did not reveal ANS contamination (Table 6). ANS was also reported in sector D-3 (Table 5), but analysis did not reveal ANS contamination (Table 6).

The substrate along the south shoreline of Ediz Hook from the T-Bird Marina to beyond the A-frame had been disturbed during the oil cleaning operation. Clams inhabiting the cleaned area were killed by the operation. The beach above the 0.0 tideline appeared clean. Below the 0.0 tideline to -2.0 foot line the beach was oiled. Analysis of the sediments revealed ANS contamination (Table 6). Clams removed from this zone were visibly oiled along their siphons and the top of their shells. The substrate around the horse clams was contaminated with oil to depth of about 12 inches. Analysis revealed this oil was ANS (Table 6, sample no.s 187087, 187088, and 187089). This indicated clams in sectors PA-2, PA-3, and PA-4 were being exposed to the ANS daily.

Analysis of mussel, clam, and oyster samples collected along the south shoreline of Ediz Hook, sectors PA-4 and PA-2, revealed they were contaminated with ANS (Table 6; sample no.s 187082, 187086, and 187092). This data confirmed the shellfish inside the Hook were being exposed to ANS daily.

Table 5. Results of the Beach Reconnaissance, April 26-28,1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Sector	Date/Time	Observations
D-4	4-26/0900	Fresh oil near tip of Dungeness Spit (7 yds x 150 yds). Lighter weight oil than ANS. No oil above high tideline Kittle/LeVander (Ecology).
D-3	4-26/1000	Oil sheen noted under large cobble at -2.0 ft in the "knuckle" area. Sparse oil splashes above high tideline. Kittle/LeVander (Ecology)
D-3	4-27/1100	Upper beach: no visible oil. Lower beach: oil sheen observed a 8 locations from lighthouse to west end of "knuckle". Sample No.s 187077, 187078, 187079, & 187080. No dead or stressed organisms observed. Kittle/Levander (Ecology).
ER-1	4-28/1115	Cobble beach (6"-20" diam.). No oil observed Kelp and algae appeared normal. No dead or stressed organisms observed. Finn/Gromley (WDF)
ER-2 & FWB-1	4-28/1100	1st mile cobble beach. Then large boulder, bedrock, gravel, and sand beach. No oil observed. Stressed sea urchins observed. Sample No.s 187073, 187074, 187075, & 187076. Stressed sea urchins less than 5% of population. No other stressed or dead organisms observed. Burge/Kauzloric (WDF).

Table 5. Results of the Beach Reconnaissance, April 26-28,1986.
ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Sector	Date/Time	Observations		
PA-4	4-28/1100	Oil observed at extreme high tideline. Oil sheen observed throughout intertidal zone. No dead or stressed organisms observed. Sample No.s 187082, 187083, 187084, 187085, & 187086. Scholz/Newman/Kittle (WDF/Ecology).		
PA-2 & PA-3	4-28/1110	Upper beach: Large rock (less than 7") with sand fill. Lower beach: sand/mud. Intertidal zone oiled. Heaviest oiling from 0.0 ft. to -2.0 ft. No oil below -2.0 ft. Oil in 0.0 to -2.0 ft zone in substrate about 4 in. No dead or stressed organisms observed. Sample No.s 187087 & 187089. Butler/LeVander (WDF/Ecology).		
FWB-1	04-28-86	187073	Sediment	No
FWB-1	04-28-86	187074	Sediment	No

Table 6. Hydrocarbon Analysis Results for Beach Reconnaissance April 26-28, 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.*

Sector	Date	Sample no.	Sample Type	ANS Contamination
FWB-1	04-28-86	187075	Sea Urchin	No
FWB-1	04-28-86	187076	Sea Urchin	No
D-3	04-27-86	187077	Water	No
D-3	04-27-86	187078	Sediment	No
D-3	04-27-86	187079	Sediment	No
D-3	04-27-86	187080	Sediment	No
PA-4	04-28-86	187082	Mussels	Low Level
PA-4	04-28-86	187083	Sediment	Trace
PA-4	04-28-86	187084	Sediment	Trace

Table 6. Hydrocarbon Analysis Results for Beach Reconnaissance April 26-28, 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.* (Continued)

Sector	Date	Sample no.	Sample Type	ANS Contamination
PA-4	04-28-86	187085	Sediment	No
PA-4	04-28-86	187086	Clams	Yes
PA-3	04-28-86	187087	Sediment	Yes
PA-3	04-28-86	187088	Sediment	Yes
PA-3	04-28-86	187089	Sediment/Sludge	Yes
PA-3	04-28-86	187090	Water	Yes
PA-2	04-28-86	187091	Rocks	Yes
PA-2	04-28-86	187092	Oyster	Yes

* A more detailed report of the individual findings can be found in Appendix II.

Based on the above information, the MRDA Team recommended a long-term impact study be conducted inside Ediz Hook.

4.4 Ediz Hook Intertidal Hardshell Clam Population Studies

4.4.1 CGA Hardshell Clam Population Study

The results of sampling the CGA clam bed on December 27 and April 29 are presented in Table 7.

Table 7. Intertidal Clam Sampling Results from Station CGA, Collected on December 27, 1985 and April 29,1986. ARCO Anchorage Oil Spill MRDA, December 21, 1985.

Sample No.	Native Littleneck No.	Native Littleneck Wgt(gm)	Butter Clams No.	Butter Clams Wgt(gm)	Horse Clams No.	Horse Clams Wgt(gm)
December 27, 1985 Samples						
1	2		2		--	
2	--		--		--	
3	4		1		--	
4	1		--		--	
5	2		--		--	
6	--		1		--	
7	1		--		--	
8	--		--		3	
9	7		1		2	
10	1		2		--	
Totals	18		7		5	
April 29, 1986 Samples						
1	--		--		2	90.7
2	1	15.5	--		--	
3	--		2	155.9	--	
4	--		1	10.3	--	
5	3	57.8	--		2	115.9
6	3	50.9	1	161.9	3	349.9
7	1	4.1	--		2	14.1
8	1	27.3	--		--	
9	--		--		--	
10	--		--		2	164.9
11	1	2.9	--		1	14.1
12	3	94.2	2	17.8	1	37.8
Totals	13	252.7	6	345.9	13	787.4
Combined Samples	31		13		18	
Avg clams/ft^2	1.41		0.59		0.82	
Avg wgt(gm)/clam		19.4		57.7		35.7

The surface area of the CGA clam bed was 5,700 ft^2. Extrapolating the clam density in Table 7 to the clam bed surface area provided a hardshell clam population of:

Species	Number
Native Littleneck Clams (*Protothaca staminea*)	8,037
Butter clam (*Saxidomus giganteus*)	3,363
Horse clam (*Tresus* spp.)	4,674

Applying species average weight per clam to the CGA clam bed species population estimate provided the following weight estimates:

Species	Weight
Native littleneck clam	344 lb
Butter clam	428 lb
Horse clam	368 lb
Total	1,140 lb

4.4.2 CGB Hardshell Clam Population Study

The results of sampling the CGB clam bed on December 27 and April 29 are presented in Table 8.

Table 8. Intertidal Clam Sampling Results from Station CGB, Collected on December 27, 1985 and April 29,1986. ARCO Anchorage Oil Spill MRDA, December 21, 1985.

Sample No.	Native Littleneck No.	Native Littleneck Wgt(gm)	Butter Clams No.	Butter Clams Wgt(gm)	Horse Clams No.	Horse Clams Wgt(gm)
December 27, 1985 Samples						
1	--		--		2	
2	1		2		--	
3	--		1		--	
4	--		1		--	
5	--		1		1	
6	--		--		2	
Totals	1		5		5	
April 29, 1986 Samples						
1	--		--		--	
2	--		--		--	
3	--		--		--	
4	--		2	443.3	--	
5	--		2	440.9	--	
6	--		1	0.9	--	
7	--		2	322.3	--	
8	--		1	210.0	--	
Totals	0		13	1,417.4	0	
Combined Samples	1		18		5	
Avg clams/ft^2	0.07		1.29		0.36	
Avg wgt(gm)/clam		19.4*		109.0		35.7*

* Used weight data from WDF station CGA.

The surface area of the CGB clam bed was 3,690 ft^2. Extrapolating the clam density in Table 8 to the clam bed surface area provided a hardshell clam population of:

Species	Number
Native littleneck clams	258
Butter clams	4,760
Horse clam	1,328

Applying species average weight per clam to the CGB clam bed population estimate provided the following weight estimates:

Species	Weight
Native littleneck clam	11 lb
Butter clam	1,144 lb
Horse clam	105 lb
Totals	1,209 lb

No dead clams were observed at stations CGA or CGB.

4.4.3 EHC Hardshell Clam Population Study

The EHC clam population study was conducted on December 1 and 2, 1986. The results of the sampling are presented in Table 9.

Table 9. Intertidal Clam Sample Results from WDF Station EHC Collected on December 1 and 2, 1986. ARCO Anchorage Oil Spill MRDA; December 21,1985.

Sample Site	Bed Width (ft)	Sample No.	Horse Wgt (gm)	Butter Wgt (gm)	*Macoma* spp. Wgt (gm)	Cockles Wgt(gm)
1	55.2	1	--	--	--	--
		15	--	--	--	--
2	48.4	2	356.0	--	--	--
		16	--	--	--	--
3	69.9	3	--	--	--	--
		17	--	--	2.4	--
4	90.1	4	12.7	--	--	--
		18	--	--	--	--
5	86.1	5	40.7	--	10.6	9.4
			46.9	--	10.9	--
			--	--	9.3	--
			--	--	4.2	--
6	69.9	6	--	--	18.7	--
			--	--	2.6	--
7	45.7	7	197.5	142.3	--	--
8	26.9	8	712.9	--	13.4	--
			--	--	8.1	--
			--	--	5.8	--
9	29.6	9	236.6	--	8.6	--
			190.8	--	--	--
			234.0	--	--	--

Table 9. Intertidal Clam Sample Results from WDF Station EHC Collected on December 1 and 2, 1986. ARCO Anchorage Oil Spill MRDA; December 21,1985. (Continued)

Sample Site	Bed Width (ft)	Sample No.	Horse Wgt (gm)	Butter Wgt (gm)	*Macoma* spp. Wgt (gm)	Cockles Wgt(gm)
10	24.4	10	--	--	--	--
11	29.6	11	--	--	4.2	--
12	26.9	12	--	--	--	--
13	16.1	13	--	--	--	--
14*	5.4	14	--	--	--	--
15*	21.5	19	--	--	--	--
16*	32.3	21	232.3	--	4.3	--
17	21.5	22	--	--	2.4	--
18	16.1	23	--	225.0	--	--
19	29.6	24	153.2	--	--	17.2
20	18.8	25	--	--	--	--
21	21.5	26	--	--	--	--
		Totals	2,413.6	367.3	105.5	26.6
Avg clams/m^2			0.88	0.16	1.12	0.16
Avg wgt(gm)/clam			219.4	183.7	7.5	13.3

*The beach between these sites was not suitable clam habitat due to heavy bark buildup from the log rafting activities in Port Angeles Harbor.

The surface area of the EHC clam bed was 1.96 hectares. Extrapolating the clam density in Table 9 to the clam bed surface area provided a hardshell clam population of:

Species	Number
Horse clams	17,248
Butter clams	3,136
Cockles	3,136
Macoma spp.	21,952

Applying species average weight per clam to the EHC clam bed population estimate provided the following weight estimates:

Species	Weight
Horse Clams	8,343 lb
Butter clam	1,270 lb
Macoma spp.	363 lb
Cockles	92 lb
Total	10,068 lb

ANS was visible in sample sites 7, 8, 9, 12, and 13 indicating the beach along the south side of Ediz Hook is still contaminated with the oil from the ARCO Anchorage oil spill.

4.4.4 Ediz Hook Intertidal Clam - Hydrocarbon Analysis

Data in Table 10 indicate the sediment, water, clams, mussels (*Mytilus edulis*) were contaminated with ANS on December 25, 1985 and were still contaminated on March 28, 1986.

Table 10. Hydrocarbon Analysis Results for the Inside of Ediz Hook, Samples Collected from December 27, 1985 to April 28, 1986. ARCO Anchorage Oil Spill MRDA, December 21, 1985.

Date	Location	Sample Type	ANS Contamination
12/23/85	Inside Ediz Hook on USCG Base: Sector PA-4	Sediment	Low Level
12/23/85	Inside Ediz Hook on USCG Base: Sector PA-4	Oil/Water	Heavy
12/23/85	Inside Ediz Hook on USCG Base: Sector PA-4	Oil	Positive I.D.
12/23/85	Inside Ediz Hook between T-Bird Marina & Crown Z: Sector PA-4	Oil/Water	Heavy
12/27/85	Inside Ediz Hook on USCG Base: Station CGA	Clams	Heavy
12/27/85	Inside Ediz Hook on USCG Base: Station CGB	Butter Clams	Heavy
12/27/85	Inside Ediz Hook on USCG Base: Station CGB	Butter Clams	Heavy
12/27/85	Inside Ediz Hook on USCG Base: Station CGB	Butter Clams	Heavy
12/27/85	Inside Ediz Hook on USCG Base: Station CGB	Butter Clams	Heavy
12/27/85	Inside Ediz Hook on USCG Base: Station CGB	Butter Clams	Heavy
12/27/85	Inside Ediz Hook on USCG Base: Station CGB	Butter Clams	Heavy
04/28/86	Inside Ediz Hook near Radar Tower: Station CGA	Sediment	Trace

Table 10. Hydrocarbon Analysis Results for the Inside of Ediz Hook, Samples Collected from December 27, 1985 to April 28, 1986. ARCO Anchorage Oil Spill MRDA, December 21, 1985. (Continued)

Date	Location	Sample Type	ANS Contamination
04/28/86	Inside Ediz Hook near Radar Tower: Station CGA	Butter Clams	Inconclusive
04/28/86	Inside Ediz Hook near Radar Tower: Station CGA	Mussels	Low Level
04/28/86	Inside Ediz Hook near Radar Tower: Station CGA	Butter Clams	Inconclusive
04/28/86	Inside Ediz Hook near T-Bird Marina: Sector PA-3	Sediment	Yes
04/28/86	Inside Ediz Hook 500 yds E. of A-Frame: Sector PA-3	Sediment	Yes
04/28/86	Inside Ediz Hook near A-Frame: Sector PA-3	Sludge	Yes
04/28/86	Inside Ediz Hook near A-Frame: Sector PA-3	Water	Yes
04/28/86	Inside Ediz Hook 100 yds W. of A-Frame: Sector PA-3	Rocks	Yes
04/28/86	Inside Ediz Hook 200 yds W. of A-Frame: Sector PA-3	Oyster	Yes

The data in Table 10 indicates the clams inside Ediz Hook remained contaminated with ANS through April, 1986 and the levels of ANS were dropping, but remained through the critical clam spawning season.

4.5 Tongue Point/Slip Point Intertidal Study

Tongue Point was studied on February 5 and March, 1986, and Slip Point was studied on February 6 and March 6, 1986.

The tables for this section were placed in Appendix IV because of their bulk. Those tables contain the information gathered at each site. Several observations can be made from the data in those tables: a) There does not appear to have been immediate severe mortality in the intertidal areas examined at Tongue Point. b) Evidence of ANS had rapidly diminished from the first sightings there. c) We did not observe conspicuous differences between the two study sites that could be attributed to the oiling at Tongue Point.

4.6 Subtidal Reconnaissance

4.6.1 Ediz Hook Subtidal Reconnaissance

The Ediz Hook subtidal reconnaissance was conducted by WDF on December 26, 1985. From 55 feet to about the -4.0 feet tide level, the substrate was bark, wood debris, trash, scattered logs, and mud. In this zone, the bottom was covered with unattached algae (*Ulva* spp.). The following marine invertebrates were observed: coon-stripe shrimp (*Pandalus danae*), spotted shrimp (*Crago* spp.), mysids, euphausids, jellyfish (*Aequorea aequorea* and *Cyanea capillata*), red rock crab (*Cancer productus*), and dungeness crab (*C. magister*). The jellyfish were stressed and dying. The other invertebrates were not stressed. Fish observed in this zone were ratfish (*Hydrolagus collici*), kelp greenling (*Hexagrammos decagrammus*), and sculpins (*Cottus* spp.). The fish were not stressed and appeared normal.

In the zone from -2 feet to the waterline, the intertidal area was contaminated with ANS. From -4 feet to -2 feet, no oil was observed on the bottom. In this area the substrate was sand and pea gravel. Eelgrass (*Zostera marina*) was present. Horse clams in this subtidal zone (-2 feet and deeper) responded to touch and did not appear stressed.

Oil droplets were observed under the log rafts in the water column to a depth of about one foot, but no oil was observed below that point or on the bottom.

The dungeness crab samples were collected from April 16 to 29, 1986. The reason for the long collection period was the lack of crab and pilfering of the crab pots. Finally, divers were deployed to collect the crabs. The results of the effort is shown in Table 11.

The analysis did not reveal ANS contamination in the crabs collected.

Table 11. Hydrocarbon Analysis Results for the Ediz Hook Subtidal Reconnaissance, Samples Collected April 16-29, 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1986.

Location	Sample Type	ANS Contamination
Port Angeles Harbor near T-Bird Marina	Dungeness Crab	No
Port Angeles Harbor near Merrill Ring	Dungeness Crab	No
Port Angeles Harbor near Crown Z.	Dungeness Crab	No
Dungeness Spit	Dungeness Crab	No

As a result of this reconnaissance, the MRDA team did not recommend subtidal studies inside Ediz Hook.

4.6.2 Green Point, Jamestown, and Middle Ground (Sequim Bay) Subtidal Reconnaissance

In this area, the subtidal reconnaissance was conducted by Lynn Goodwin, Bruce Pease, and G. Budd on January 27, 1986. No oil was observed on the bottom at the sampling sites.

Chemical analysis revealed 50-100 ppb ANS was present in one of the Green Point sediment samples. No ANS was detected in the remaining sediment samples or the tissue samples (Table 12).

Table 12. Hydrocarbon Analysis for the Green Point, Jamestown, and Middle Ground (Sequim Bay) Subtidal Reconnaissance, Samples Collected January 27, 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1986.

Location	Sample Type	ANS Contamination
Station #5	Geoduck Clam	No
Station #5	Geoduck Clam	No
Station #5	Geoduck Clam	No
Station #5	Geoduck Clam	No

Table 12. Hydrocarbon Analysis for the Green Point, Jamestown, and Middle Ground (Sequim Bay) Subtidal Reconnaissance, Samples Collected January 27, 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1986. (Continued)

Location	Sample Type	ANS Contamination
Station #5	Geoduck Clam	No
Station #5	Sediment	No
Station #5	Sediment	No
Station #5	Sediment	Yes 50-100ppb
Station #6	Sediment	No
Station #6	Sediment	No
Station #6	Sediment	No
Station #7	Littleneck Clams	No
Station #7	Butter Clams	No
Station #7	Horse Clams	No
Station #7	Sediment	No
Station #7	Sediment	No
Station #7	Sediment	No
Station #7	Littleneck Clams	No

Based on this data the MRDA Team did not recommend further studies in this area.

4.6.3 Striped Peak Headland/Pillar Point Subtidal Reconnaissance

4.6.3.1 Striped Peak Headland Subtidal Reconnaissance

Dives were conducted at each of the "D" sites (Figure 5). Only surface observations of the kelp were made at the "K" sites. A summary of the observations of surface kelp at each site are given in Table 13. The kelp (*Nereocystis luetkeana*) was found to be oiled. The oil was grey to creamy brown in color. It had a viscous, sticky consistency and formed a band up to approximately one inch wide and approximately one eighth inch thick extending along the stipe from the pneumatocyst as far as four feet. The oil was attached to the epiphytes growing on this portion of the kelp. In many instances pieces of drift algae and seagrass were incorporated in the oil band. The oil was strongly adherent. Oiled kelp occurred at the surface at all sites except Crescent Rock and inside Tongue Point. The highest incidence of oiled kelp was observed near observatory Pointy and the west side of Crescent Bay. There was a slight oil sheen in all kelp beds.

Table 13. Results of the January 7, 1986 Striped Peak Headland/Pillar Point Subtidal Reconnaissance (Surface Observations of Oiled Kelp). ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Site	Percent of Kelp Stipes with Oil
D1	50-60
D2	0
D3	50-60
D4	50-60
K1	50-60
K2	20-30
K3	0
K4	0

Table 14 summarizes the depth range and observation of oiled kelp during each dive. Red, green, and purple sea urchins as well as sea cucumbers (*Parastichopus* spp.) were observed at all sites. There was no indication of stress or damage to the flora and fauna at any of the sites. Several red urchins were observed with patches of exposed test, but this was considered to be old damage from starfish (*Pycnopodia* spp. or *Fusitriton* spp.) predation.

Table 14. Results of January 7, 1986 Striped Peak Headland/Pillar Point Subtidal Reconnaissance (Subsurface Observations of Oiled Kelp). ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Site	Percent of Kelp Stipe Fragments with Oil	Water Depth (feet)
D1	<10	Shoreline to 25
D2	<10	15-25
D3	<10	15-30
D4	0	15-30

At site D1 WDF divers swam from the intertidal shoreline down to 25 feet, which was the range of rocky sea urchin habitat. Red urchins were abundant between the water depths of 15 and 25 feet. There were numerous small urchins, indicating good recruitment. Abalone were also abundant. Of the 20 or 30 kelp stipe fragments observed on the bottom, two were oiled (<10%). Urchins were observed eating clean kelp fragments, but not oiled kelp fragments. The oiled fragments were fresh and were not immediately adjacent to urchins. Tasting the gonads from several urchins in this area revealed no tainting. No oil was observed on the intertidal rocks.

At sit D2 the urchins were sparsely distributed. Green urchins were more abundant than red urchins. Of the 30 or 40 kelp stipe fragments observed, four were oiled (<10%). Urchins were not eating the oiled fragments.

Red urchins were abundant at sit D3. Many small were observed along with several abalone. Of the 30 or 40 kelp stipe fragments observed three were oiled (10%). At a water depth of 20 feet two red urchins were observed eating the oiled kelp fragments. These urchins and two immediately adjacent to the fragment were collected for hydrocarbon analysis. At a water depth of 30 feet, a second sample of four sea urchins was collected within two or three feet of an oiled stipe fragment. No urchins were observed below 30 feet. At the surface, four kelp samples were collected from plants with oiled stipes and four kelp samples were collected from plants without visible oil. The analysis revealed the oil on the oiled plants was ANS, but no ANS was detected in the urchin samples (Table 15). Taste testing of the gonads from several urchins revealed no tainting.

Table 15. Hydrocarbon Analysis for the Striped Peak Headland/Pillar Point Subtidal Reconnaissance, Samples Collected January 7, 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1986.

Site	Sample Type	Depth (Feet)	ANS Contamination
D3	Kelp	0	Yes
D3	Kelp	0	Yes
D3	Kelp	0	Yes
D3	Kelp	0	Yes
D3	Kelp	0	No
D3	Kelp	0	No
D3	Kelp	0	No
D3	Kelp	0	No
D3	Sea Urchin	20	No

Table 15. Hydrocarbon Analysis for the Striped Peak Headland/Pillar Point Subtidal Reconnaissance, Samples Collected January 7, 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1986.

Site	Sample Type	Depth (Feet)	ANS Contamination
D3	Sea Urchin	20	No
D3	Sea Urchin	20	No
D3	Sea Urchin	20	No
D3	Sea Urchin	30	No
D3	Sea Urchin	30	No
D3	Sea Urchin	30	No
D3	Sea Urchin	30	No

At site D4 red urchins were observed down to 50 feet. A sea urchin sample was collected at a depth of 48 feet. No oiled kelp stipe fragments were observed on the bottom in this area. The intertidal zone on the adjacent rock pinnacle was examined and no oil was observed.

4.6.3.2 Pillar Point Subtidal Reconnaissance

At Pillar Point, the subtidal reconnaissance was conducted near the mouth of Jim Creek where commercial urchin divers indicated the heaviest concentration of oiled kelp was located. Surface observations of oiled kelp were similar to Stripe Peak, except 30-40 percent of the stipes were oiled. No oiled stipe fragments were observed on the bottom. Two sea urchin samples were collected containing four replicates of red urchins. Also, oiled kelp stipe and frond samples were collected. These samples were frozen and archived.

The data in this section indicated kelp was transporting the ANS to the bottom where it was consumed by sea urchins, but analysis of the sea urchins themselves did not reveal ANS contamination. Surely, those urchins observed eating the ANS took in the ANS and metabolized it in some fashion. Since urchins do not have a gall bladder, it was not possible to analyze for bile metabolites. This is an area that could use further research to answer the question of the fate of ANS within urchins and its' effect on them.

Based on the data above, the MRDA team recommended subtidal studies be conducted in the Striped Peak headland area.

4.7 Kelp Bed Reconnaissance

The kelp bed reconnaissance was conducted from January 13-16, 1986.

The results of the kelp bed reconnaissance indicate that visible traces of emulsified oil persisted in kelp bed communities for at 25 days following the December 21 spill (Table 16). Affected kelp bed were located between Low Point (station no. 40) and Ediz Hook (station no. 64), and between McDonald Creek (station no. 72) and the "knuckle" of Dungeness Spit (station no. 76). Areas of highest concentration (based on visual rating of two on a scale of three) were Tongue Point (station no. 49), the area east of Angeles Point and Ediz Hook (station no.s 60 - 62), the tip of Ediz Hook (station no. 64) and the "knuckle" of Dungeness Spit (station no. 76).

Oiled kelp samples were frozen and archived at the Manchester Lab pending future need for analysis.

Table 16. Results of January 13-16, 1986 Kelp Bed Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985. Survey was conducted by Dr. Jim Walton, Peninsula College, Port Angeles, WA

Sample No.	Oil: Visible*	Aroma	Comments
Start a Cape Flattery			
1	0	0	Kelp in line just off rocks.
2	0	0	Large bed.
3	0	0	5 Acre bed in bight.
4	0	0	East-facing beach.
5	0	0	--
6	0	0	Bed between buoy and shore.
7	0	0	Seal Rock.
8	0	0	--
9	0	0	Small bed.
10	0	0	Small bed.
11	0	0	*Macrocystis* present.
12	0	0	--
13	0	0	--

Table 16. Results of January 13-16, 1986 Kelp Bed Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985. Survey was conducted by Dr. Jim Walton, Peninsula College, Port Angeles, WA (Continued).

Sample No.	Oil: Visible*	Aroma	Comments
13a	No kelp present		Hoko River mouth.
14	0	0	--
15	0	0	--
16	0	0	--
17	0	0	--
18	0	0	Very lacey sheen present.
19	0	0	--
20	0	0	--
21	0	0	--
22	0	0	--
22a	No kelp present		Pysht River mouth.
23	0	0	Large bed present.
24	0	0	--
25	0	0	--
26	0	0	*Macrocystis* present.
27	0	0	*Macrocystis* present.
28	0	0	--
29	0	0	--
30	0	0	*Macrocystis* present.
31	0	0	*Macrocystis* present.
32	0	0	*Macrocystis* present.
33	0	0	--
34	0	0	*Nereocystis* present.

Table 16. Results of January 13-16, 1986 Kelp Bed Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985. Survey was conducted by Dr. Jim Walton, Peninsula College, Port Angeles, WA (Continued).

Sample No.	Oil: Visible*	Aroma	Comments
35	0	0	--
36	0	0	*Macrocystis* present.
37	0	0	--
38	0	0	--
39	0	0	--
40	0	0	Dense bed close to shore.
41	0	0	--
42	0	0	--
43	0	0	--
44	0	0	--
45	1	0	Bed continuous.
46	No kelp present		--
47	1		Kelp continuous.
48	1	0	Kelp continuous.
49	2	0	Kelp continuous. Rainbow sheen on water.
50	0	0	--
51	1	0	Sheen on water.
52	1		Rainbow streaks on water.
53	1	0	Kelp continuous, eagle seen.
54	1	0	Rainbow sheen on blades.
55	1	0	Large bed.
56	1	0	Kelp discontinuous.

Table 16. Results of January 13-16, 1986 Kelp Bed Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985. Survey was conducted by Dr. Jim Walton, Peninsula College, Port Angeles, WA (Continued).

Sample No.	Oil: Visible*	Aroma	Comments
57	1	0	Large bed.
58	1	0	Kelp sparse.
59	1	0	Tide rip has rainbow sheen.
60	2	0	Spotty sheen on water.
61	2	0	Continuous kelp, rainbow sheen.
62	2	0	Rainbow sheen.
63	0	0	--
64	2	0	Oil odor in air, kelp thin.
65	0	0	Kelp discontinuous.
66	0	0	Kelp discontinuous.
67	0	0	--
68	0	0	Large bed.
69	0	0	--
70	0	0	Kelp sparse.
71	0	0	--
72	1	0	Kelp discontinuous.
73	1	0	Sheen on kelp.
74	0	0	Kelp sparse.
75	1	0	--
76	2	0	Kelp continuous, sparse.
77	0	0	Seals off spit end.
78	0	0	--
79	0	0	Large kelp bed.

Table 16. Results of January 13-16, 1986 Kelp Bed Reconnaissance. ARCO Anchorage Oil Spill MRDA; December 21, 1985. Survey was conducted by Dr. Jim Walton, Peninsula College, Port Angeles, WA (Continued).

Sample No.	Oil: Visible*	Aroma	Comments
80	0	0	--
81	0	0	7 harbor seals along spit.
82	0	0	Small patches of kelp.
End at Protection Island			

4.8 Subtidal Shellfish Study

The treatment site was sampled on January 30, March 15, and July 31,1986. The control site was sampled on February 4, March 16, and August 13, 1986.

Samples collected in January and February will hereafter be referred to as sample 1, those collected in March will be referred to as sample 2, and the samples collected in July and August will be called sample 3. A t-test was used to determine whether the density, test diameter, and gonad data from the two transects at each site could be pooled for each sampling date. In all cases, it was found that the data could be pooled (means were not significantly different at $p<0.05$). In order to simplify and enhance the statistical analysis, the mean values in the following tables and analyses were calculated using the pooled samples from each site on each date without regard to individual transects.

Observed mean densities of the designated invertebrate species in the 1 and 5 m^2 quadrats are presented in Tables 17 and 18. Red and green sea urchin and sea cucumber densities were analyzed with 2-way analysis of variance (ANOVA) and the results are summarized in Table 19. The density of each of these species was significantly higher at the treatment site than at the control site. Only green sea urchin densities changed significantly over time. One-way ANOVA followed by the Newman-Keuls multiple range test showed that green sea urchin densities increased significantly ($p<0.05$) in sample 3 at the treatment site, but did not change significantly at the control site.

Rock scallop and abalone densities were too low to be analyzed statistically. No pattern of spatial or temporal variation was observed for those species.

Kelp stipe fragments were observed at the treatment and control sites, but no oiled fragments were observed. Very little macroalgae was observed at either site in samples 1 and 2. Regrowth of kelp was extensive at both sites in sample 3.

Table 17. Mean Densities (± 1 standard error) of Invertebrates in 5 m^2 Quadrats (n=40) at the Study Sites in 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

	Treatment Site			Control Site		
Species[a]	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
Urchins						
Red	18.2 ±2.7	20.2 ±2.4	21.7 ±1.6	9.6 ±1.7	9.0 ±1.4	8.8 ±1.7
Green	4.1 ±2.9[b]	NC[c]	25.1 ±6.0[b]	0.8 ±0.3[b]	NC	0[b]
Cucumbers	2.2 ±0.5	3.2 ±0.4	2.6 ±0.3	.05 ±.03	.05 ±.03	.03 ±.03
Scallop[d]	.03 ±.03	.05 ±.03	.05 ±.03	.08 ±.04	.07 ±.04	.03 ±.03
Abalone	0	0	0	.03 ±.03	.13 ±.05	.05 ±.03

a See the text for scientific names.
b Sample size (n) = 20 quadrats.
c Not counted in these quadrats.
d Rock Scallops.

Table 18. Mean Densities (± standard error) of Invertebrates in 1 m^2 Quadrats (n=10) at the Study Sites in 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

	Treatment Site			Control Site		
Species[a]	Sample 1	Sample 2	Sample 3	Sample 1	Sample 2	Sample 3
Urchins						
Red	3.2 ±1.4	5.1 ±1.3	5.3 ±1.9	1.8 ±0.8	5.0 ±2.2	1.0 ±0.6
Green	0.8 ±0.5	1.6 ±0.6	4.9 ±1.7	0.3 ±0.2	0.1 ±0.1	0
Cucumbers	0.2 ±0.1	0.3 ±0.1	0.8 ±0.2	0.1 ±0.1	0.1 ±0.1	0
Scallop[d]	0	0	0	0.1 ±0.1	0	0
Abalone	0	0.1 ±0.1	0	0	0.1 ±0.1	0

a See the text for scientific names.

Analyses of the gonad percent of body weight and sex ratios are presented in Table 19. The color of all examined sea urchin gonads was normal varying from light yellow to darker orange. Also, no tainting was found in the tasted sea urchin gonads from either date or transect (Pease, 1986).

Table 19. Summary of 2-way ANOVA of Invertebrate Density by Site and Sample Date. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Species[a]	1 m^2 Quadrats Site	Date	5 m^2 Quadrats Site	Date
Red Urchin	NS[b]	NS	**	NS
Green Urchin	**[d]	*[c]	**	*
Sea Cucumber	*	NS	**	NS

[a] See the text for scientific names.
[b] No significant difference.
[c] Significantly different at p <0.05
[d] Significantly different at p <0.001 (highly significant)

Mean test diameters of red urchins at the study sites are summarized in Table 20. Two-way ANOVA revealed that test diameters were not significantly different between sites ($p>0.05$), but were significantly different between sampling dates ($p<0.001$). One-way ANOVA followed by the Newman-Keuls multiple range test showed that the difference in test diameters between sampling dates was not significant ($p>0.05$) at the treatment site. However, the mean test diameter at the control site in sample 3 was significantly higher than the previous samples.

Table 20. Mean Test Diameter (± 1 standard error) of Red Urchins (n=44) at Study Sites in 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Sample	Site: Treatment	Site: Control
1	95.7 ±4.4	82.9 ±6.0
2	95.3 ±3.0	76.9 ±6.4
3	106.3 ±3.3	119.7 ±5.8

Mean gonad indices (gonad weight ÷ drained body weight) of the red sea urchins at the study sites are summarized in Table 21. Data from the sites in this study are compared with data collected at Point Wilson in 1977 (Shaul, 1982). Two-way ANOVA revealed that the indices were significantly different ($p<0.001$) among both sites and sample dates. Indices at the control site were consistently lower than indices at the other sites on all sample dates. The highest indices were consistently found at the treatment site. One-way ANOVA followed by the Newman-Keuls multiple range test revealed that within each site, the index on each sampling date was significantly different from the index on every other sampling date. The highest indices were found in sample 1 at the control and Point Wilson sites and in sample 2 at the treatment site.

Table 21. Mean Gonad Index (± standard error) of Red Sea Urchins (n=22) at the Study Sites in 1986 and at Point Wilson in 1977[a]. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Sample	Site: Treatment	Control	Point Wilson
1	25.0 ±1.0	11.0 ±1.1	23.1 ±0.9[b]
2	28.3 ±1.2	7.7 ±0.6	16.5 ±0.7[c]
3	14.5 ±0.6	3.6 ±0.4	12.5 ±0.5[d]

a Shaul, W., 1982. Washington Sea Urchin Survey Data, 1976-1980. WDF Special Shellfish Report No. 1. pp. 123.
b Sample collected January 19, 1977.
c Sample collected March 3, 1977.
d Sample collected July 20, 1977.

Sex ratios of the red sea urchins at the study sites are presented in Table 22. Sex ratios were close to 50 percent. Sex ratios were not determined in samples with a high proportion of spawned out urchin in which the gametes had not regenerated.

Table 22. Sex Ratio (% female) of Red Sea Urchin (n=22) at the Study Sites in 1986 and at Point Wilson in 1977[a]. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Sample	Site: Treatment	Control	Point Wilson
1	50	48	59[b]
2	54	ND[e]	50[c]
3	52	ND	ND[d]

a Shaul, W., 1982. Washington Sea Urchin Survey Data, 1976-1980. WDF Special Shellfish Report No. 1. pp. 123.
b Sample collected January 19, 1977.
c Sample collected March 3, 1977.
d Sample collected July 20, 1977.
e ND = Not determined because many of the gonads did not contain gametes

Despite the similar appearance of the habitat in the two study sites, quantitative comparisons of the red and green sea urchin and sea cucumber densities and red sea urchin gonad development indicate that the sites are fundamentally different. This difference is related to fundamental differences in wave and tidal current exposure, macroalgae distribution and commercial harvest histories. Because of these differences, the most meaningful comparison is between sampling dates. It can be assumed that if the treatment site was severely affected by the oil spill, short-term effects would be evident and distinguishable from normal seasonal variation evident at the control site.

Oil was observed at the treatment site during a kelp survey conducted by Peninsula College (section 4.7), and WDF biologists observed oil on kelp at this location in December. Physical evidence of the December spill in the form of oil on kelp or other objects was not found here during this study. No biological evidence in the form of tainting of sea urchin gonads or obvious mortalities were observed. The density of red sea urchins and sea cucumbers and average size of sea urchins did not change significantly during this study.

Green sea urchin densities increased significantly in the summer sample at the treatment site. This species is known to be mobile and opportunistic and the observed influx was probably related to natural seasonal and temporal variation.

Red sea urchin gonad indices at the treatment site were significantly higher than those at the control site or those previously sampled at Point Wilson in 1977. Because the gonads are used to store energy, the gonad index is related to feeding activity. It appears that more food was available to the red sea urchins at the treatment site than to those at the control site. Food availability is primarily related to macro-algae distribution and tidal current regimes.

Historical data (Shaul 1982) shows that the gonad index starts dropping in March and April, falls to the lowest levels in May-July, then increases again in late August-September. This pattern is a result of spawning in the spring-summer months. Seasonal variation of gonad indices at the control area followed the expected pattern. The observed increase in gonad index at the treatment site in March was anomalous. The increase indicated delayed spawning at this site. However, the low index at the treatment site in July indicated the red sea urchins spawned at this site.

The oil spill tracking conducting by USCG/NOAA found that oil slicks did not extend east of Protection Island. As expected, no evidence of oil contamination was found in the control site off McCurdy Point. Sampled sea urchin gonads showed no evidence of tainting and invertebrate densities remained stable.

No short-term mortalities of subtidal invertebrates were observed in this study. The anomalies observed at the treatment site were an increase in the density of green sea urchins and a delay in red sea urchin spawning. There was no direct evidence that these anomalies are related to the oil spill. Unfortunately, there was no long-term data base from this habitat to define the limits of natural variability. The observed changes did not appear to be detrimental to the subtidal community in the short-term. However, long-term sublethal effects on gamete and larval viability, recruitment, and resistance to disease and predators could become evident a later time. These effects could take the form of anomalous decreases in populations of affected organisms.

4.9 South Dungeness Bay Surf Smelt Study

The South Dungeness Bay surf smelt field sampling surveys were conducted by Jim Beam, WDF, on December 26, 1985, January 3, and January 13, 1986. Lab analysis was conducted by Dan Penttila, WDF.

Table 23. Results of December 1985 - January 1986 WDFisheries Dungeness Bay Surf Smelt Spawn Sample Analysis. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Date	Area	Sample No.	½- 1 coil	1 coil	1½ coils	1½ coils	Dead	No eggs	% Dead	Est. No. of broods	Wt.(g) Substrate sample	eggs/ gram	Remarks
12/26/85	0.4 mi. W. of Cline Spit	1	70	11	2	1	235	319	73.7	2	97.2	3.28	Fine grain fraction (Sample retained)
12/26/85	0.4 mi. W. of Cline Spit	2	67	4	1	1	197	270	73.0	2	125.7	2.15	Medium-fine grain fraction (Sample retained)
1/3/86	0.4 mi. W. of Cline Spit	1	4	23	3		32	62	51.2	1	70.1	0.88	Fine grain fraction (Sample retained)
1/3/86	0.4 mi. W. of Cline Spit	2	5	19			41	65	63.1	1	126.6	0.51	Medium-fine grain fraction (Sample retained)
1/13/86	W. of Cline Spit	1			3	6	2	11	18.2	1	75.1	0.15	Fine fraction
1/13/86	W. of Cline	2			2	3	1	6	16.7	1	125.6	0.05	Medium-fine grain fraction

AV/OP3/86/120510

The smelt eggs found in the samples were attributable to a single light-moderate intensity spawning that occurred 1-2 days before the ARCO Anchorage oil spill. At about one week in age, the intensity of incubating spawn, 2-3 eggs per gram of beach material, was typical of winter-deposited smelt spawn in Puget Sound. It was unusual that no further spawnings were evidenced in the samples. Although the sampling occurred near the end of the Dungeness spawning season, January 15 (Schaefer, 1936), one would have expected further spawnings, judging from recent winter surf smelt spawning data from other Puget Sound beaches. WDF has no baseline surf smelt spawning ecology data for the Dungeness Bay stock, therefore further comment on reasons for the abrupt cessation of spawning would be speculative.

The December 26 and January 3 samples had a high incidence of dead eggs. The December 26 samples had an average of about 73 percent dead eggs (Table 23). For comparison, egg mortality data were pooled from 48 samples of similar aged eggs collected from Fidalgo Bay (1981-1983), Ross Point (1982-1985) and south Hood Canal (1983-1985) (WDF unpub. data). The mean was 9.1% and the standard deviation was ±7.8% for those samples. In the smelt egg mortality data collected from those study areas, only three samples out of 311 were found to have mortalities exceeding 70%.

Likewise, the samples of January 3, 1986 showed an unusually high egg mortality averaging 57%, whereas 21 samples of similar aged winter spawn from Fidalgo Bay, Ross Point, and South Hood Canal, 1981-1985 showed an average egg mortality of 16.5%, standard deviation of ±18.0% (Table 24).

Table 24. Summary of Data on In Situ Mortalities of Winter Surf Smelt Spawn Samples Dominated by Half-Coil and One-Coil Embrylogical Developement Stages in the Puget Sound Area 1981-1985. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

		Half-coil Stage			One-coil Stage		
Area	Season	No. Sample	Mort. Avg.	S.D.	No. Sample	Mort. Avg.	S.D.
Ross Point	1982-1983	5	9.8	2.0	0	-	-
	1983-1984	3	8.9	3.6	1	14.1	-
	1984-1985	9	3.8	4.5	1	5.3	-
Fidalgo Bay	1981-1982	6	15.8	6.8	3	46.9	31.2
	1982-1983	12	5.8	3.4	5	8.1	6.4
S. Hood Canal	1983-1984	0	-	-	3	1.9	1.4
	1984-1985	13	15.8	10.5	8	17.6	7.8
Pooled		48	9.1	7.8	21	16.5	18.0

The sample collected on January 13, 1986 revealed survivors of the brood present in the previous two samples. *In situ* mortalities were in about the normal range for spawn of such an age. During the calm, cold foggy weather that prevailed during the sampling period, an incubation time of 60 days was estimated.

The reason for the high mortalities was not apparent. The samples were not perceptibly contaminated by hydrocarbons. The substrates sampled appeared to be normal looking beach material with moderate amounts of organic detritus. Near-freezing weather was recorded during the survey period. However, observations in other areas indicate that freezing weather alone does not produce mass mortalities in incubating smelt spawn (Penttila, 1985).

Within the Dungeness smelt spawn samples, those eggs that remained alive appeared to be developing normally. Any differences observed could not be attributable to outside effects. Subsamples of the December 26, 1985 and January 3,1986 spawn samples have been archived.

4.10 Dungeness Bay Pacific Herring Spawning Ground Survey

Herring spawning ground surveys were conducted in Dungeness Bay on a weekly basis (9 surveys) from February 5 to April 3, 1986. Five such surveys had been conducted in Dungeness Bay in 1983 and were used for comparison.

Pacific herring were found spawning in small overlapping patches on the south shore of inner Dungeness Bay (Table 25). Spawning occurred in shallow-subtidal depths between the landward end of Dungeness Spit and Cline Spit to the east (Figures 9-10).

The primary spawn deposition substrate was a red algae community comprised of *Gracilariopsis* and/or *Neoagardhiella*. *Zostera* was also present in the area, but is used relatively infrequently by herring spawning in Dungeness bay.

The data indicate the Dungeness Bay 1986 herring spawning season began on January 28 and ended on March 16 (Table 25), as judged from the detection of spawn found *in situ*. Although, the first three surveys found spawn *in situ*, planktonic herring larvae were absent, suggesting that no earlier spawning had gone undetected. No new spawn was found on the March 26 or April 3 surveys indicating the end of the spawning season.

The Dungeness Bay 1986 herring spawning escapement totaled 234 tons (Table 25), compared with 197 tons in 1983. There were no observations of unusually high spawn mortalities in the field nor in the samples of spawn inspected in the lab. All Dungeness Bay herring spawn was deposited at "very light" intensities. It should be noted in Figures 9-10, that although consecutive surveys appeared to find spawn in nearly identical areas from week to week, spawn was commonly from different spawning events, with weekly overlapping of old, eyed-spawn with new spawn.

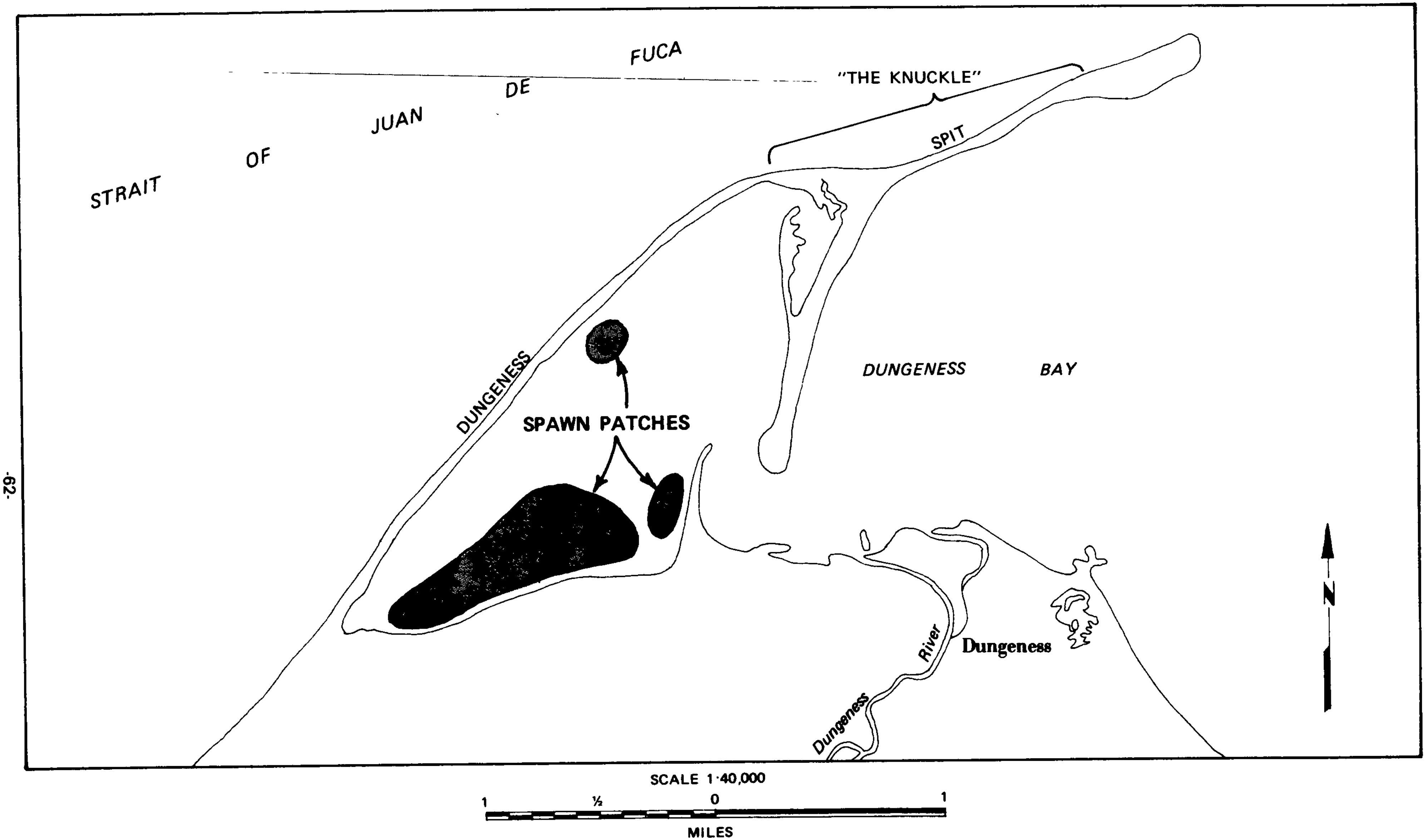

Figure 9. CUMULATIVE DISTRIBUTION OF PACIFIC HERRING SPAWN FROM 5 WDF SURVEYS CONDUCTED IN FEBRUARY AND MARCH, 1983 WITH ESTIMATED SPAWN DATES. ARCO ANCHORAGE OIL SPILL MRDA, DECEMBER 21, 1985.

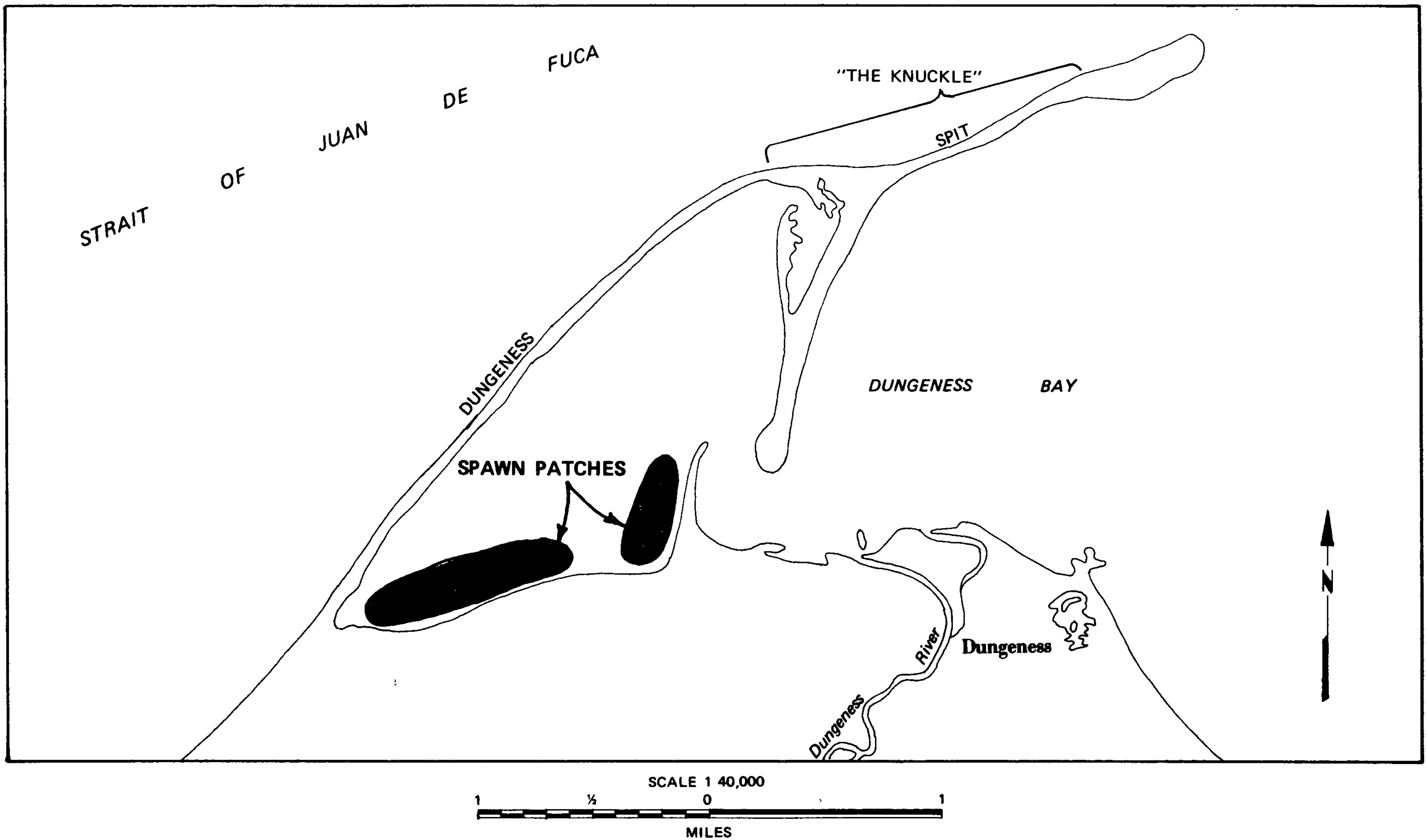

Figure 10. CUMULATIVE DISTRIBUTION OF PACIFIC HERRING SPAWN FROM 3 WDF SURVEYS CONDUCTED IN FEBRUARY AND MARCH, 1986 WITH ESTIMATED SPAWN DATES. ARCO ANCHORAGE OIL SPILL MRDA, DECEMBER 21, 1985.

Table 25. WDF Pacific Herring Spawning Ground Survey Results, Dungeness Bay. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Survey Date	Spawn Dates	Survey Est. Biomass (Tons)	Cumulative Biomass (Tons)
Feb. 5, 1986	Jan. 28, Feb. 1, 3, & 5	35	35
Feb. 12, 1986	Feb. 10 & 12	27	62
Feb. 19, 1986	Feb. 15, 17, & 18	46	108
Feb. 26, 1986	Feb. 24 & 25	61	169
Mar. 6 1986	Mar. 2 & 4	19	188
Mar. 12 1986	Mar. 6, 8, 9, & 11	39	227
Mar. 19, 1986	Mar. 16	7	234
Mar. 26, 1986	--	0	234
Apr. 3, 1986	--	0	234

The 1986 herring spawning activity in Dungeness Bay appeared to be unaffected by the ARCO Anchorage oil spill, at least to the limits of survey technique sensitivity. The 1986 spawning appeared to be similar to that of 1983. The 1983 and 1986 herring had very similar spawning escapements, spawn deposition locations, spawn intensities, overall spawning seasons and the habit of spawning frequently in relatively small, overlapping patches.

4.11 Ichthyoplankton Study

The ichthyoplankton field studies were conducted from February 6 to March 6,1986 by Dr. Walton and his students.

4.11.1 Larval Fish Assemblage

A total of 1,053 larval fishes were present in the samples including 1,003 larval fishes in the pre-sorted larval fish samples and an additional 50 specimens recovered when the macrozooplankton catches were re-inspected by WDF. Examination of all specimens under 15x revealed no physical abnormalities that were not attributable to net-damage during capture. Pelagic fish eggs were uncommon in the samples, being present in Port Angeles Harbor on February 26 and March 6, and at Green Point on February 6 and 26, but never present in great numbers.

The larval fish species composition was 18.6% Pacific sandlance (*Ammodytes* spp.), 16.1% smelt (*Osmerid* spp.), and 65.1% unidentified marine fish larvae (Table 26).

Pooling the Port Angeles area half-meter net catches yielded about seven fish larvae per tow minute. These catches might be roughly compared to those made during February-March 1986 by WDF herring spawning survey crews using similar gear and techniques in other Puget Sound areas. By comparison, the Totten Inlet-Squaxin Pass area in Southern Puget Sound which supports sizable sandlance and smelt spawning populations yielded 6.7 sandlance/smelt per tow minute. The Birch Point - Semiahmoo Bay area in Northern Puget Sound which supports small sandlance and smelt spawning populations yielded 2.2 sandlance/smelt larvae per tow minute. Lastly, the Fidalgo Bay area east of Anacortes which supports sizable sandlance and smelt spawning populations yielded 24.2 sandlance/smelt larvae per tow minute. The data suggest that a "reasonable" variety of marine fishes was successfully reproducing in the Port Angeles - Dungeness Spit area during the survey period. The use of unmetered nets of a variety of sizes, mouth-openings, and net mesh sizes, along with an absence of baseline data for the study area, make quantitative comparisons difficult.

Chester et.al (1980) provided some baseline data for the plankton of the Strait of Juan de Fuca. The MRDA study and Chester's study cannot be compared directly because of the different techniques used and the station placement. Their closest sampling station to our study was located about 3.5 miles north of Green Point. However, Chester also found sandlance and smelt larvae to be common and also more or less evenly distributed in the surface 50 m of the water column. Fish eggs were concentrated very near the surface, to extent that our 4 m sampling depth may not have sampled them adequately. The February-March period was found to be the time of highest icthyoplankton abundance and diversity.

4.11.2 Larval Fish Distribution

Significant differences in the abundances and species composition of larval fish assemblages over short geographical distances are a common feature of protected bays and inlets within Puget Sound. Variation was noted in the abundance of total fish larvae between the four sampling sites compared. The result was that for every fish larva captured at the West Dungeness Spit station, 3.9 larvae were found at Port Angeles Harbor, 7.8 larvae at Cline Spit, and 24.4 at Green Point.

The high abundance of larvae at Green Point was attributed to the single very large catch of a variety of larval species on February 26. On that day, the station yielded 669 larvae, 63.5 % of the total catch for the study. The differences in larval abundance between earlier and later sampling at the same station, and between this station and adjacent stations at the same time were quite striking. If the very high catch of February 26 is disregarded, then the relative abundance of larvae a Green Point fall within the range of the other stations, 6.2 larvae there for every one at West Dungeness Spit.

Table 26. Data Summary from Near-Surface Plankton Samples Collected from February 6 to March 6, 1986. ARCO Anchorage Oil Spill, MRDA; December 21, 1985

Date	Sample Time	Tow Minutes	Net Size	Sandlance		Smelt		Herring		Other Fish Larvae (No.)	Dominant Organism
				No.	Mean Length	No.	Mean Length	No.	Mean Length		
Collected at Port Angeles Harbor											
2/21/86	1519-1531	20	0.50 m	0		2	11.5 mm	0		32	Copepods
2/26/86	1236-1249	20	0.50 m	1	12.0 mm	10	9.2 mm	0		73	Large copepods
3/6/86	1142-1205	20	0.50 m	1	6.0 mm	0		0		11	Copepods, chaetognaths
Collected at Green Point											
2/6/86	1533-1559	30	0.30 m	6	10.5 mm	67	10.1 mm	0		21	Copepods
2/14/86	1514-1523	20	0.30 m	0		1	10.0 mm	0		0	Small copepods
2/26/86	1320-1333	20	0.50 m	119	11.5 mm	88	11.9 mm	0		462	Copepods, Ctenophores
3/6/86	1106-1122	20	0.50 m	6	7.3 mm	0		0		34	Small copepods
Collected at West Dungeness Spit											
2/6/86	1435-1515	30	0.30 m	2	6.5 mm	0		0		2	Small copepods (benthic debris)
2/13/86	1345-1405	20	0.30 m	3	6.0 mm	0		0		3	Small copepods
2/28/86	1018-1041	30	0.25 m	0		0		0		2	Small copepods (benthic debris)
3/6/86	1024-1041	20	0.50 m	7	6.4 mm	0		0		7	Small copepods
Collected at Cline Spit											
2/13/86	1251-1310	20	0.30 m	13	6.5 mm	1	9.0 mm	0		0	Small copepods
2/28/86	0918-1344	25	0.25 m 0.5 m	38	8.2 mm	1	11.0 mm	1	9.0 mm	39	Small copepods (benthic debris)

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This abrupt peak in abundance at the Green Point station was contributed to by a variety of species. Although large numbers of sandlance and smelt were caught, they in no higher proportion of the total larvae present here than for the total study area. It is not uncommon for baitfish spawn-hatching events from large discrete spawnings to result in sudden high abundances of yolk sac larvae appearing in the plankton, numerically dominating the local icthyoplankton for a brief period until they disperse. None of the baitfish larvae or other fish species were at the yolk sac stage, and could have been in the plankton for 2-4 weeks or more.

It is possible that on February 26 the Green Point station plankton tows traversed a micro-hydrographic feature that was, for a small area and/or a short time, promoting the accumulation of macrozooplankton, including fish larvae. The February 26 Green Point station yielded not only the largest number of fish larvae, but also the largest volume of total macrozooplankton of the study.

The low abundance of fish larvae at the West Dungeness Spit station may have been caused by sampling technique. On two of the four visits, the sampling net was allowed to touch bottom while towing, fouling the catch with benthic debris and thus lowering the filtering efficiency of the net.

4.11.3 Larval Sandlance

Pacific sandlance larvae were detected in 10 of the 13 zooplankton collections, and were present in the study area throughout the sampling period. The presence of small yolk-sac stage sandlance throughout the sampling period suggests continuous spawning was occurring in the general region.

The largest sample of sandlance larvae, from Green Point on February 26, contained specimens up to 18mm in length (Figure 11). At this length, the larvae are relatively motile and capable of avoiding the net. Catching them at all suggests that large numbers may have been present. A sandlance larva this size may have been in the plankton for a month or so. If the incubation time was around two weeks, as for herring, then spawn deposition would have occurred in early mid-January. The data suggest that larger, older larvae may also have been present. By this size and age, larvae cannot be attributed to more than just the general regional spawning area. Specific documented spawning sites, evidenced by eggs *in situ*, have not yet been described for Puget Sound or adjacent waters. The Pacific sandlance has been the subject of a number of recent laboratory behavioral and oil impact studies undertaken the researchers a the Battelle Marine Research Laboratory on Sequim Bay (Pearson, et.al,1984 and Pinto, et.al, 1984).

4.11.4 Larval Smelt

Large numbers of smelt-type larvae were found at Green Point on February 6 and 26 (Figure 12). These larvae were identified as longfin smelt (*Spirinchus thaleichtys*), on the basis of ventral gut pigmentation (Garrison and Miller, 1982). This osmerid species is commonly anadromous, but these particular larvae cannot be attributed to any known spawning

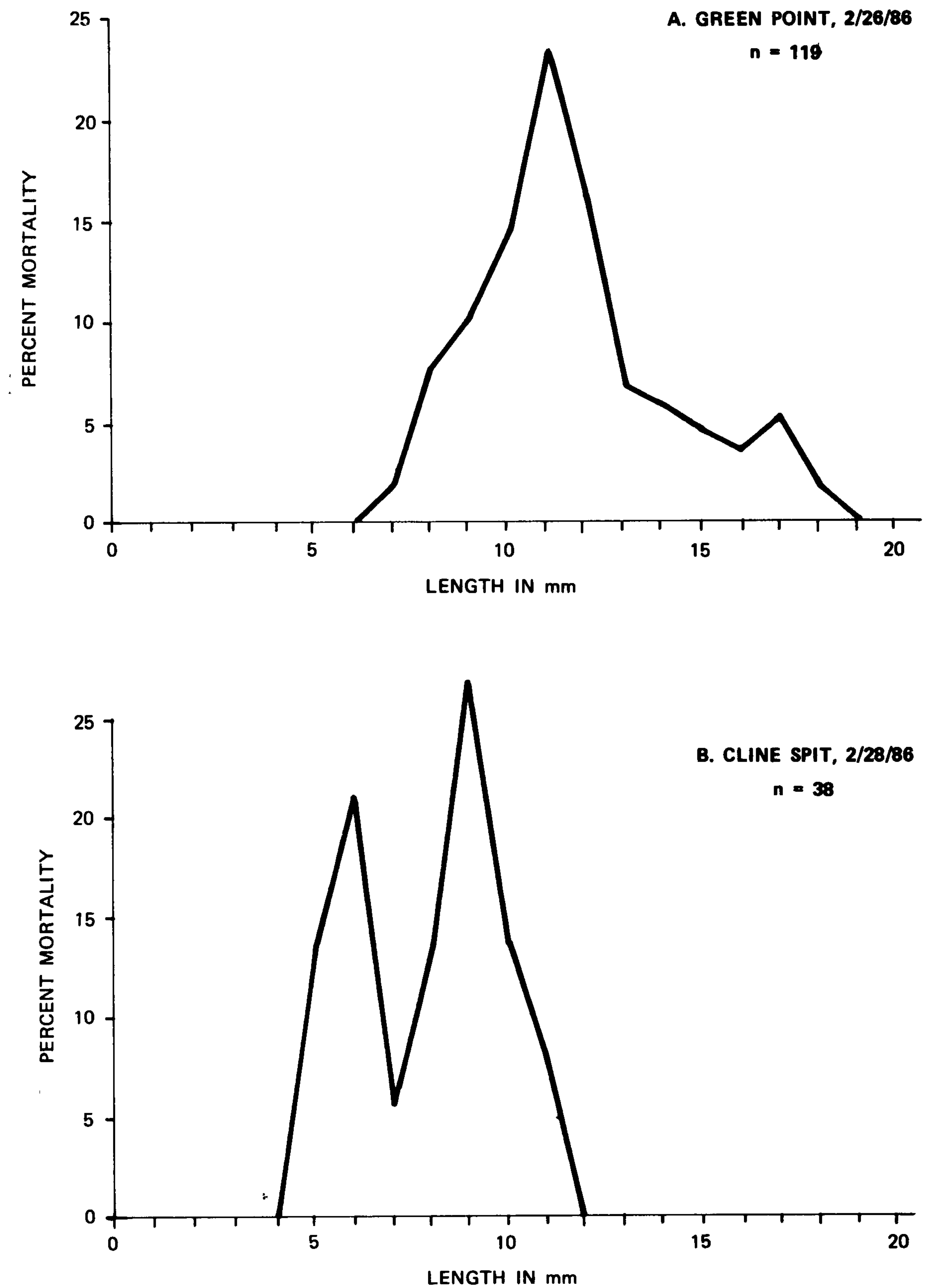

Figure 11. LENGTH FREQUENCIES OF LARVAL PACIFIC SANDLANCE *(AMMODYTES SP.)* FROM THE PORT ANGELES – DUNGENESS SPIT AREA, FEBRUARY 1986. ARCO ANCHAORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

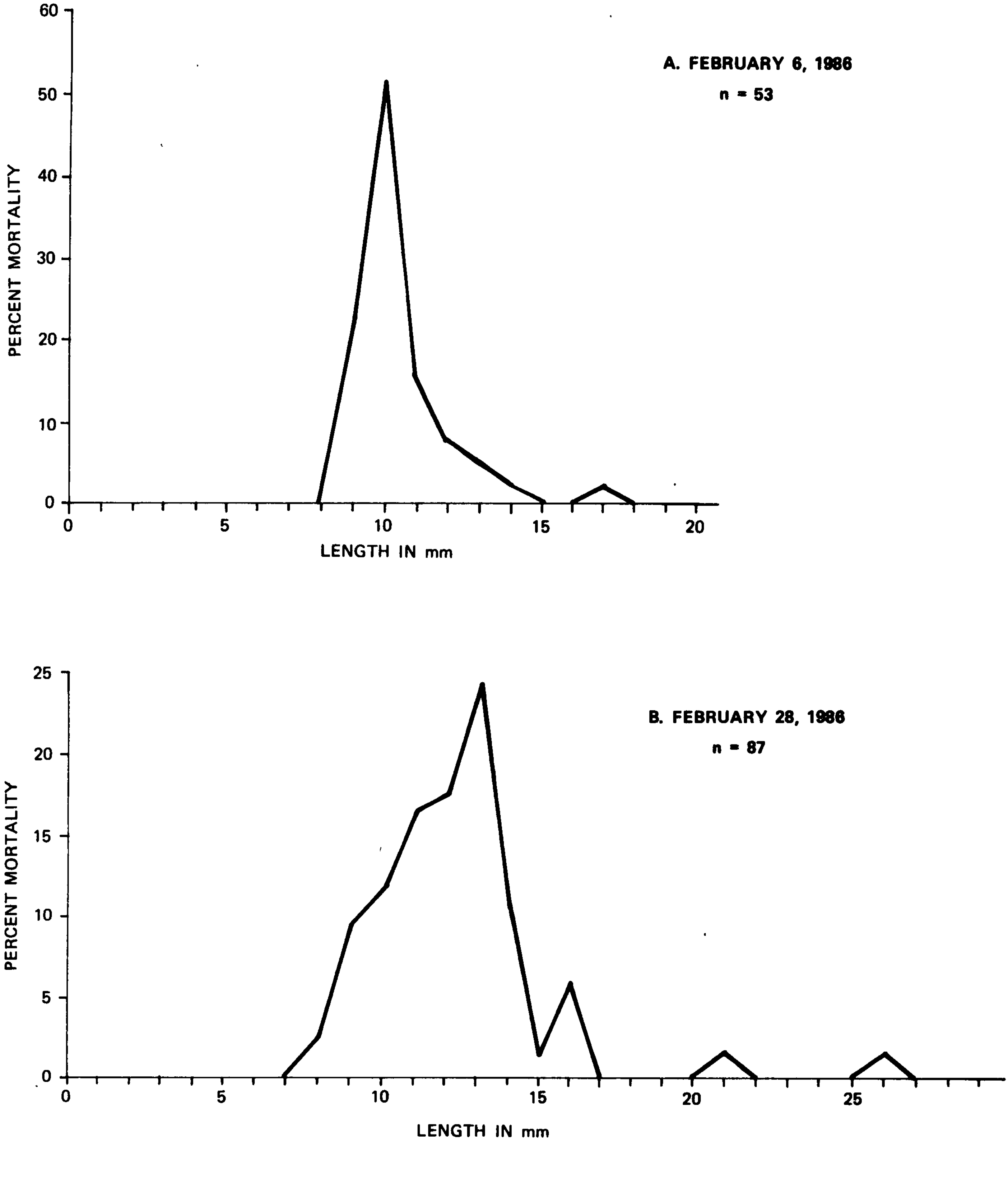

Figure 12. LENGTH FREQUENCIES OF LARVAL LONGFIN SMELT *(SPIRINCHUS SP.)* FROM GREEN POINT, FEBRUARY 1986. ARCO ANCHORAGE OIL SPILL MRDA; DECEMBER 21, 1985.

stream. Miller et.al (1980) reported this species to be second in overall abundance in nearshore surface trawl catches of the 1976-1979 MESA Strait of Juan de Fuca baseline studies.

Of the 170 Osmerid larvae present in the plankton samples from this study, all but two were longfin smelt. The single Osmerid larva caught at the Cline Spit station on February 13 and one larva out of the large catch made a Green Point on February 26 were surf smelt (*Hypomesus pretiosus*).

4.11.5 Invertebrate Plankton Assemblage

The invertebrate plankton collected during this study was dominated by calanoid copepods. Juvenile forms dominated the copepods. Chaetognaths and ctenophores were collected, as were lesser numbers of appendicularians, pelagic amphipods, decapod zoeae, other crustacean zoeae, pteropods, bivalve veligers, pelagic annelids, siphonophores, and hydromedusae. No net clogging phytoplankton blooms were in evidence in any of the samples. Our sampling was conducted prior to the reported high abundance period for phytoplankton (May-August) in the Strait of Juan de Fuca (Chester et. al, 1980).

4.12 Juvenile Salmon and Epibenthic Invertebrate Reconnaissance

Juvenile salmon and epibenthic invertebrates were collected in the Strait of Juan de Fuca and Whidbey Island on May 19 and May 29, 1986.

4.12.1 Juvenile Salmon

Twelve chum salmon fry (*Oncorhynchus keta*), ≈500 sandlance, and ≈500 surf smelt were caught at Dungeness Spit and 25 chum salmon fry, 25 coho salmon (*O. kisutch*) yearlings, and ≈ 1,000 surf smelt were caught at Freshwater Bay. At the West Whidbey Island site, 47 chum salmon fry were caught (Table 27).

4.12.2 Epibenthic Invertebrates

Epibenthic invertebrates were present in samples from all sites. Thus there does not appear to have been a complete (i.e. catastrophic) loss of epibenthic organisms.

Table 27. Juvenile Salmon and Epibenthic Invertebrate Reconnaissance Results. ARCO Anchorage Oil Spill MRDA; December 21,1985.

Site No.	Date	Chum Salmon Fry	Coho Salmon	Sand-lance	Surf Smelt	Epibenthic Invertebrates
1	5/19	12	0	≈500	≈500	Present
2*	5/29	--	--	--	--	Present
3	5/19	25	00	00	≈1,000	Present
4	5/29	47	00	00	00	Present

* No fish samples were collected.

An analysis of the epibenthic samples will follow the main MRDA in February or March, 1987 as an addendum to the MRDA. The purpose of the analysis is to document whether salmonid food organisms were present in the study areas.

4.13 Oiled Bird Survey

4.13.1 Bird Species Affected

One thousand nine hundred and seventeen (1,917) oiled waterfowl representing 38 species (8 families) were collected. Most of those birds were collected along Dungeness Spit starting on December 23 and ending December 28, 1985 (Table 28). Peak collection time was on December 24 when 353 birds were collected. 1,562 were alive and 355 were dead (Table 29).

The number of birds per family and family composition was: 14 loons (<1%), 1,118 grebes (58%), 40 cormorants (2%), 476 ducks/coots (25%), 6 shorebirds (<1%), 36 gulls (2%), and 225 alcids (12%) (Table 29).

Most incapacitated birds sought shelter in the drift line of the beach and would attempt to preen. Birds would hide among beach logs along Dungeness Spit. In rocky intertidal areas birds sought shelter in small niches of the beach or in nearshore kelp.

Also, oiled waterbirds experience an increased vulnerability to predation for a variety of reasons. Those birds most seriously oiled lose buoyancy and beach themselves to prevent sinking and to relieve exhaustion. As a result of beaching themselves, reduced flight capabilities, and in many cases an innate awkwardness on land, vulnerability to predation by avian predators is significantly increased. Weakness resulting from reduced feeding capacity and loss of insulation further contribute to this vulnerability (BLM, 1979). Additionally, a bird which has beached itself early on a falling tide and is weak, flightless, and awkward on land as the result of oiling, can end up a great distance from the safety of the water as the tide ebbs. This is especially true in an area where the distance between the high and low tide marks is extensive.

Table 28. Bird Collection Results. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Date	Sector	Birds Live	Birds Dead	Number Caught	Est. No. Escaped
Dungeness Spit Area					
12-23-85	D-3	25	3	28	15
	D-2	86	2	88	5
	D-2	20	0	20	3
	D-1	25	1	26	30
	M-1	7	0	7	3
	Daily Totals	163	6	169	56
12-24-85	D-1	8	11	19	0
	D-1	10	2	12	10
	D-1	1	0	1	0
	D-2	6	2	8	12
	D-3	19	8	27	6
	D-3	18	1	19	8
	D-3	27	0	27	27
	D-3	40	6	46	18
	D-4	50	1	51	150*
	D-5	9	5	14	20
	D-6	3	1	4	6
	TC-1	2	2	4	5
	TC-1	10	2	12	3
	PW-1	1	1	2	15
	M-1	28	1	29	9
	M-2	29	0	29	40
	M-2	29	20	49	6
	Daily Totals	290	63	353	185*
12-25-85	D-1	6	5	11	8
	D-2	2	2	4	5
	D2 + D-3	1	0	1	0
	D-3	3	2	5	2
	D-3	4	4	8	4
	D-5	3	1	4	9
	TC-1	1	1	2	15
	J-1	2	4	6	24
	M-1	4	0	4	0
	M-1	3	0	3	17
	M-2	17	1	18	10
	M-2	40	0	40	0
	Daily Totals	86	20	106	94

Table 28. Bird Collection Results. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Date	Sector	Birds Live	Birds Dead	Number Caught	Est. No. Escaped
12-26-86	Poor weather. No collection.				
Dungeness Spit Area					
12-27-85	D-2 + D-3	1	0	1	2
	D-3 + D-4	7	5	12	18
	D-4	3	0	3	2
	D-5	4	1	5	7
	D-6	3	1	4	4
	D-7	4	18	22	4
	D-8 + D-1	0	1	1	1
	D-9	1	1	2	15
	D-10	4	3	7	11
	D-10	0	1	1	0
	PW-1	1	1	2	1
	M-1	0	2	2	5
	Daily Totals	28	34	62	70
Beaches West of Ediz Hook					
12-27-85	AP-1 + ER-1	3	4	7	6
	FWB-1	5	0	5	6
	CB-1	2	1	3	75-100*
	CB-1	1	1	2	150-200*
	WC-1	0	3	3	130*
	Daily Totals	11	9	20	12
Dungeness Spit Area					
12-28-85	D-1	1	1	2	1
	D-2	8	12	20	10
	D-3	0	3	3	5
	D-3	5	1	6	2
	D-3	2	6	8	7
	D-4	1	1	2	10
	D-4	3	0	3	2
	D-5	2	2	4	32
	D-5	2	0	2	6
	D-7	0	1	1	5
	D-8	3	3	6	2
	D-8	2	2	4	5
	D-10	1	6	7	2
	PW-1	0	1	1	5
	Daily Totals	30	39	69	106

Table 28. Bird Collection Results. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Date	Sector	Birds Live	Birds Dead	Number Caught	Est. No. Escaped
Beaches West of Ediz Hook					
12-28-85	AP-1	3	3	6	84
	AP-1	0	4	4	12
	AP-1	2	3	5	12
	ER-1	2	0	2	10
	FWB-1	7	2	9	40
	FWB-1	0	2	2	12-15
	CB-1	0	1	1	25
	CB-1	0	2	2	8-10
	WC-1	0	2	2	0
	TR-1	3	0	3	300*
	Daily Totals	17	19	36	203-208
Dungeness Spit Area					
12-29-85	No Area Data				
Beaches West of Ediz Hook					
12-29-85	AP-1	2	0	2	28
	ER-1	9	1	10	18-20
	FWB-1	2	0	2	8
	CB-1	0	3	3	5
	CB-1	1	1	2	54
	WC-1	0	1	1	4
	WC-1	2	0	2	19
	PP-1	2	1	3	12
	Daily Totals	18	7	25	148-150

* Boat Observations - These observations were not used in daily totals.

4.13.2 Bird Cleaning Clinic Mortalities

One thousand two hundred and forty-three (1,243) birds representing 27 species died at the bird cleaning clinic. This represents 80% of the birds brought into the clinic. The majority of the mortalities were grebes (941 birds), 76%; ducks (154 birds), 12%; and alcids (124 birds), 10%. The red-necked grebes accounted for 69 percent of all birds that died at the clinic.

4.13.3 Bird Mortalities (Shorelines)

Three hundred fifty-five (355) dead birds were collected from the shorelines in the spill area representing 29 species (Table 29)., The

Table 29. Numbers and Percentages of Oiled Waterfowl. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Species Name	Found Dead		Died at Cleaning Station		Released Alive		Birds in Captivity	Total Birds Processed		Released Found Dead
	Number	%	Number	%	Number	%	Number	Number	%	Number
LOONS										
Red-throated Loon			1	<1				1	<1	
Arctic Loon	2	<1	5	<1				7	<1	
Common Loon			2	<1	3	1		5	<1	1
Yellow-billed Loon			1	<1				1	<1	
Subtotal	2	1	9	1	3	1	0	14	<1	1
GREBES										
Pied-billed Grebe			1	<1				1	<1	
Horned Grebe	10	3	69	6	30	11		109	6	
Red-necked Grebe	87	25	863	69	18	6	28	996	52	2
Eared Grebe			1	<1	1	<1		2	<1	
Western Grebe	2	<1	7	1	1	<1		10	1	
Subtotal	99	28	941	76	50	18	28	1,118	58	2
CORMORANTS										
Double-crested Cormorant	3	1	1	<1				4	<1	
Brandt's Cormorant	1	<1	1	<1				2	<1	
Pelagic Cormorant	10	3	7	1	12	6		34	2	
Subtotal	14	4	9	1	17	6	0	40	2	0
DUCKS										
Mallard	1	<1			3	1		4	<1	
Northern Pintail	3	1						3	<1	
American Wigeon	12	3			3	1		15	1	
Canvasback	1	<1						1	<1	
Greater Scaup	2	<1	2	<1				4	<1	
Lesser Scaup	2	<1	1	<1	4	1		7	<1	
Harlequin	1	<1	3	<1	3	1		7	<1	
Oldsquaw	31	9	43	3	6	2	9	89	5	
Black Scoter	2	<1	2	<1	4	1		8	<1	
Surf Scoter	14	4	5	<1	14	5		33	2	
White-winged Scoter	70	20	64	5	95	34		229	12	2
Scoter species					1	<1		1	<1	
Common Goldeneye	12	3	14	1	8	3		34	2	

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Table 29. Numbers and Percentages of Oiled Waterfowl. ARCO Anchorage Oil Spill MRDA; December 21, 1985 (Continued)

Species Name	Found Dead		Died at Cleaning Station		Released Alive		Birds in Captivity	Total Birds Processed		Released Found Dead
	Number	%	Number	%	Number	%	Number	Number	%	Number
DUCKS (Continued)										
Goldeneye species	2	<1						2	<1	
Bufflehead	11	3	16	1	2	1	1	30	2	
Hooded Merganser			1	<1				1	<1	
Red-breasted Merganser	1	<1	3	<1	3	1		7	<1	
Subtotal	165	46	154	12	146	52	10	475	25	2
RAILS										
American Coot					1	<1		1	<1	
Subtotal	0	0	0	0	1	<1	0	1	<1	0
SHOREBIRDS										
Black-bellied Plover	2	<1						2	<1	
Plover species					1	<1		1	<1	
Dunlin					3	1		3	<1	
Subtotal	2	<1	0	0	4	1	0	6	<1	0
GULLS										
Mew Gull	5	1			3	1		8	<1	
California Gull	1	<1						1	<1	
Glaucous-winged Gull	16	5	6	<1	5	2		27	1	
Subtotal	22	6	6	<1	8	3	0	36	2	0
ALCIDS										
Common Murre	14	4	35	3	51	18		100	5	2
Pigeon Guillemot	29	8	88	7	1	<1		118	6	
Marbled Murrelet	1	<1						1	<1	
Ancient Murrelet	5	1	1	<1				6	<1	
Subtotal	49	14	124	10	52	19	0	225	12	0
Unknown species	2	<1						2	<1	
Totals	335		1,243		281		38	1,917		7
Percent of Total	19%		65%		15%		2%			

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species composition was: 25% red-necked grebes (87 birds), 20% white-winged scoter (70 birds), 9% oldsquaw (31 birds), and 8% pigeon quillemot (Table 29).

4.13.4 Oiled Bird Mortality Estimate

Although it was documented that 1,917 waterbirds were oiled, more oiled birds undoubtedly died than were accounted for. Several studies show sinking rates from 40 percent to 90 percent for oiled birds (Bibby and Lloyd, 1977; Jones et al., 1970; Dunnet, 1982). Variables such as distance from shore, wave action, currents, and wind affect sinking rates. The majority of birds in the ARCO Anchorage oil spill were estimated to be oiled within 1 to 10 kilometers from shore. The time the oiled birds spent in the water was relatively short, the distance to shore was short, and the calm water reduced the energy drain on the oiled birds reducing the mortality rate of oiled birds in the water. The rate of recovery should therefore have been about 50 percent (Wahl, 1981). Perhaps another 2,083 birds were oiled and died undetected. In total, about 4,000 birds were oiled and killed by oil from the ARCO Anchorage oil spill on December 21, 1985, in Port Angeles Harbor, Washington.

4.13.5 Released Birds

Two hundred eight-one (281) birds representing 24 species were released, as March 13, 1986. This represents 18 percent of the live birds brought into the clinic. The released area was searched for six weeks following the bird release. Out of 281 birds released from the clinic, seven mortalities (2.5%) were recovered.

4.14 Oiled Large Falcons and Bald Eagle Study

4.14.1 Peregrine Falcons

The study began on December 28, 1985 and ended on March 18, 1986, a total of 82 days.

Results of the peregrine falcon aspect of this study were limited due to the limited transmission range of the radio-transmitters (1-2 miles). The transmitter package on falcon PF-2 had an effective range of mile. The poor performance of radio transmitters attached to captured peregrines made tracking difficult and resulted in poor success in recovering prey remains. Immature male peregrine (PF-7) was trapped, radio-tagged, and released and was never seen in the study area again. Apparently the falcon immediately left the area as its' radio signal was later received in the Lummi Flats area of Whatcom County, approximately 85 km northeast of the study area (Dobler, personal communication).

This also indicated that immature males are wide ranging and suggests that the impact of the oil spill could be widespread and not confined solely to those falcons wintering or inhabiting the immediate spill vicinity.

During the study, seven peregrine falcons were observed in the study area,including four adults (three females and one male) and three immature falcons (one female and two males). Oil was detected on three (43%) of the seven peregrines observed during the study (Table 30). Three peregrine falcons (1 immature female; PF-5, 1 immature male; PF-7, and 1 adult female; PF-2) were captured and radio-tagged on December 30, 1985, January 8, 1986, and February 13, 1986 respectively (Table 30). The first oiled falcon (PF-5) was captured on December 30, 1985, nine days after the oil spill.

The three radio-tagged peregrines (PF-5, PF-7, and GF-8) were last observed in the study area in February 12, 1986, January 8, 1986, and February 18, 1986 respectively.

Table 30. Falcon Species, Age, and Sex Data. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

#	Species	Age	Sex	Captured	Oiled
PF-1	Peregrine	Adult	Female		Yes. Visually detected.
PF-2	Peregrine	Adult	Female	X	No
PF-3	Peregrine	Adult	Female		No
PF-4	Peregrine	Adult	Male		**
PF-5	Peregrine	Immat.	Female	X	Yes. Physically confirmed.
PF-6	Peregrine	Immat.	Male		Yes. Visually detected.
PF-7	Peregrine	Immat.	Male	X	No
GF-8	Gyrfalcon	2nd Yr	Female	X	Yes. Physically confirmed.

** Presence or absence of oil could not be determined.

Table 31. Size and Weight Data for Captured Falcons. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

#	Band No.	Age	Sex	Species	Wing	Cord Length (mm)	Tail Length (mm)	Weight (gm)
PF-2	887-63536	Adult	Female	Peregrine	R	356	163	965
					L	356		
PF-5	887-63535	Immature	Female	Peregrine	R	361	182.5	1,185
					L	366		
PF-7	987-37325	Immature	Male	Peregrine	R	328	156	769
					L	330		
GF-8	887-62512	Immature	Female	Gyrfalcon	R	399	225	1,533
					L	399		

Peregrines were observed feeding on four occasions. Prey items included one female green-winged teal (*Anas carolinensis*) and three unidentified ducks (Table 32).

Table 32. Peregrine Falcon Prey Remains. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Date	Falcon	Prey Species
12-26-85	UF[1]	Horned Grebe (oiled)
1-1-86	PF-5	Unidentified waterfowl.
1-7-86	PF-1	Female green-wing teal.
1-14-86	PF-2	Unidentified waterfowl.[2]
2-5-86	PF-5	Unidentified waterfowl.[2]
3-3-86	PF-3[3]	Glaucous-winged gull.

1 Unidentified falcon: probable falcon kill as evidenced by clearly nipped keel bone and severed neck.

2 Could not be confirmed as falcon as bird was not observed on the prey.

3 No remains were recovered, visual identification only.

On December 26, a partially eaten oiled horned grebe (*Podiceps auritus*) carcass was recovered from the tip of Ediz Hook (Table 32). The carcass had a nipped keel bone and a severed neck indicating it had been killed and partially eaten by a large falcon. During the oiled bird collection effort, field crews reported finding evidence that raptors had been eating oiled waterfowl (Wray, USFWS and Speich, WDG, personal communication).

Three peregrine roosting sites were identified in the study area. The sites were located near the top of north facing, vertical bluffs facing the Strait of Juan de Fuca. Two of these sites were on ledges and the other was at the top of a bluff under a heavy salal (*Gaultheria shallon*) overhang. One site, a traditional roost site (Dobler and Lowell unpub data) was used by a single peregrine (PF-5) and the other was used by two different peregrines (PF-5 and PF-4), sometimes simultaneously. Two of these sites were used by a 2nd-year gyrfalcon (GF-8).

The blood sample from falcon PF-7 was lost, but the remaining samples were sent to Dr. Fry for analysis, one was from an oiled peregrine (PF-5).

Analysis of peregrine blood and castings did not reveal the presence of ANS (Fry, 1986, Appendix III).

4.14.2 Gyrfalcon

One gray-morph gyrfalcon (2nd-year female) was observed in the study area. It was captured and radio-tagged on January 21, 1986. This falcon was first observed on December 28, 1985 and last observed in the study area on March 16, 1986. This gyrfalcon was oiled on its ventral surface Table 30.

Three roosting sites were utilized by the gyrfalcon in the study area. Two were the previously described peregrine roosting sites and the third was a vertical rock face with an eastern exposure on the coniferous mountain side of Burnt Mountain located 11 km from Port Angeles in the Olympic Mountains.

A 2cc whole blood sample was taken from the gyrfalcon for analysis. Analysis of the gyrfalcon blood and castings did not reveal the presence of ANS (Fry, 1986, Appendix III).

Of the eight large falcons utilizing the study area, ANS was detected on four (50%), three peregrines and the gyrfalcon. The location of the ANS on the falcons suggests contamination occurred through contact with and ingestion of oiled prey (Table 35). Of the 38 bird species oiled or killed as the result of the ARCO Anchorage oil spill, eleven are known prey species for peregrines and four are known prey species for gyrfalcon (Table 34).

Table 33. Gyrfalcon Prey Remains. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Date	Falcon	Prey Species
1-14-86	GF-8	Scav. White-wing Scoter
1-21-86	GF-8	Robbed, Unid. Passerine
1-31-86	GF-8	Scav. Greenwing Teal
2-08-86	GF-8	Female Widgeon
2-15-86	GF-8	Female Widgeon
2-17-86	GF-8	Hybrid Male Widgeon
2-21-86	GF-8	Male Widgeon
2-23-86	GF-8	Male Mallard
2-27-86	GF-8	Female Bufflehead

Table 34. Comparison of Peregrine Falcon and Gyrfalcon Prey Species and the Bird Species Oiled as a Result of the ARCO Anchorage Oil Spill. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Oiled Bird Species[1]	
LOONS	
Red-throated Loon	
Common Loon	
Arctic Loon	
Yellow-billed Loon	
GREBES	
Pied-billed Grebe	
Horned Grebe	P
Redneck Grebe	
Eared Grebe	
Western Grebe	
CORMORANTS	
Double-crested Cormorant	
Brandt's Cormorant	
Pelagic Cormorant	P

Table 34. Comparison of Peregrine Falcon and Gyrfalcon Prey Species and the Bird Species Oiled as a Result of the ARCO Anchorage Oil Spill. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Oiled Bird Species[1]		
DUCKS		
Mallard	P	G
Northern Pintail		
American Widgeon	P	G
Canvasback		
Greater Scaup		
Lesser Scaup		
Harlequin		
Oldsquaw		
Black Scoter		
Surf Scoter		
White Winged Scoter		G
Common Goldeneye		
Bufflehead	P	G
Hooded Merganser		
Red-breasted Merganser		
RAILS		
American Coot		
SHOREBIRDS		
Black-bellied Plover	P	
Dunlin	P	
GULLS		
Mew Gull	P	
California Gull		
Glaucous-winged Gull	P	
ALCIDS		
Common Murre		
Pigeon Guillemot	P	
Marbled Murrelet		
Ancient Murrelet	P	

[1] Data from Table 29 (Section 4.13)
P Peregrine prey species.
G Gyrfalcon prey species.

The amount of time spent foraging in the oil spill area appeared to influence the likelihood of falcons becoming oiled. The three falcons observed in the study with the greatest frequency (PF-1, PF-5, and GF-8) were oiled. The contaminated birds were oiled on the lower abdomen and on the sides of the lower mandible suggesting they were oiled as the result of feeding on oiled prey and/or preening oiled feathers (Table 39).

Table 35. Location of ANS on Oiled Falcons. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Falcon Description	Oiling Description
Adult female peregrine (PF-1)	Lower abdomen. Visual determination
Immature female peregrine (PF-5)	Lower abdomen, undertail coverts, tail wing primaries, sides of lower mandible. Captured.
Immature male peregrine (PF-6)	Lower abdomen. Visual determination. (Drying posture suggested wings and tail were oiled).
2nd year gyrfalcon (GF-8)	Right shoulder, lower and mid abdomen, legs, under tail coverts, tail, and wing secondaries. Captured.

Age and experience, general condition and sex are all factors which may influence the likelihood of a particular falcon becoming contaminated with crude oil as a result of preying on oil-contaminated prey.

"Sexual dimorphism is very marked in peregrines with the female being as much as 50% larger than the male" (Ratcliffe, 1980). For the Sequim-Dungeness area Dobler (1984) found, "that while prey selection by sex does overlap, there is a strong preference by the male for prey weighing less than 100 grams. Consequently passerines compromise a significant percentage of their diet. Females more often selected from 400 to 800 gram prey." The majority of the most significantly oiled waterbirds in the ARCO Anchorage oil spill area were medium to large in size. Therefore, the female peregrine would appear to be at a greater risk of encountering oiled prey.

Certain individual falcons were seen within the study area with more frequency than others. An adult female peregrine (PF-1) was seen regularly in the study area from December 28, 1985 to March 1, 1986. Of the three falcons seen in the study area with the most frequency (GF-8, PF-5, and PF-1) all were contaminated with oil.

Visual detection of oil on peregrines can be difficult and the accuracy of such determinations can be influenced by a variety of factors. Natural coloration, especially the brown coloration of immature plumage, natural staining, amount of oil contacted, time elapsed since contamination occurred, distance between observer and specimen, natural lighting, and optics can influence the accuracy of visual detection of oiled plumage on falcons.

4.14.3 Bald Eagle

Four adult bald eagles and one immature bald eagle displaying signs of oil-contamination were observed in the study area. The oiled adult bald eagles had oil blackened heads and tails. The oiled immature bald eagle was seen regularly near the mouth of the Dungeness River. Also, Wahl (1986) reported seeing an oiled bald eagle in the study area during his overflight.

Because of the scavenging nature of bald eagles and because waterbirds comprise a significant portion of the diet of bald eagles wintering in the Sequim-Dungeness and surrounding area (Lowell, unpubl. data), they would appear to be more susceptible to oil-contamination than falcons. Wahl (1986) cited one report of an oiled bald eagle and reported eagles were observed feeding on oiled dead birds on December 29, 1985.

Unlike peregrines and to some extent gyrfalcons, bald eagles lack a preference for airborne prey and show no reluctance to feed on waterbirds which are dead or rendered flightless. Because of their large size, eagles are capable of feeding on many of the larger waterbirds that a peregrine would avoid.

No bald eagles were captured to confirm oil contamination, but five visual determinations were made. Detection of oil on adult bald eagle plumage is aided by the eagle's white head and tail feathers, but incomplete head molts can complicate determinations. Four adult bald eagles were observed with dirty oil blackened heads and tail feathers. Additionally, one immature bald eagle was observed displaying signs of oiling, "drying out" posture.

Falcons and eagles alike tend to display certain behavioral characteristics indicating their plumage is oiled. A matted, sticky, and wet appearance of the feather in the abdominal region, accompanied by a brownish coloration is indicative of oiled plumage. Birds perched in a "drying posture", wings drooped at sides and tail fanned, for a period longer than a day and not displaying the vigorous amounts of preening characteristics of a bird which has recently bathed is suspect. Such behavior appears to be intended to "dry out" oiled feathers. Oiled feathers do not "dry out" resulting in prolonged periods of this behavioral activity. Birds with oiled flight feathers appear to labor excessively in flight.

Using the figures in Table 29 (Section 4.13), 1,917 oiled birds, 48% of the estimated 4,000 birds oiled, were collected and transported to the bird cleaning clinic. Removal of these birds resulted in significantly reducing the number of oiled birds available to falcon and eagle predation and scavenging.

Little information is available concerning the effects of oil ingestion by peregrines or other raptors. Pattee and Franson (1981) in a study conducted to determine the hazards of Ixtoc I oil ingestion to peregrine falcons through the use of a surrogate species the American kestrel (*Falco sparverious*) found that:

> *Dietary Ixtoc I crude oil evidently poses little hazard to free-ranging American kestrels. High level continual exposure (equalling 0.5% of the bird's body weight) caused death after two weeks when combined with severe cold stress, but lower level exposure was apparently harmless. Such high level exposure is improbable in nature because of avoidance of the oiled food and the amount of time required for such exposure to occur. Even if such exposure occurs, survival is good (88%) and recovery rapid. It is therefore unlikely that the Ixtoc I oil spill posed any acute toxic hazard to peregrine falcons. However, long-term effects of such exposure were not determined, nor were the effects of other types of oils evaluated.*

Information concerning the effects of oil ingestion by some species of waterfowl does give rise to serious concerns. Ingested sublethal oil concentrations impair liver and kidney physiological functions in waterfowl and may have a similar impact on peregrines (BLM, 1979).

"In an attempt to clean to clean oil off themselves, the birds ingest oil. Several researchers have stated that direct toxic effects of this ingested oil were an important factor in bird mortality. These authors showed ingestion of oil, in quantities comparable to what would be swallowed during preening, caused lipid pneumonia, gastrointestinal irritation, liver malfunction, and adrenal cortical hyperplasis. Consumption of oil contaminated prey also leads to ingestion of oil..." (Hartung, 1967) Egg laying has been temporarily stopped by birds fed small amounts of oil (BLM, 1979).

In conclusion, the study found that peregrines, a gyrfalcon, and bald eagles wintering within the region of the ARCO Anchorage Oil Spill were contaminated with ANS probably as a result of contact with and ingestion of oiled waterbirds. No mortality or short term ill affects resulting from oil contamination were detected amongst falcons or eagles known to have been oiled.

Because oiled adult female peregrine PF-1 eluded capture thereby preventing the desired attempted to radio-tag her and locate her eyrie, long term effects of oil contamination, specifically threats to reproduction and productivity could not be determined.

4.15 Nesting Marine Bird Survey

4.15.1 Protection Island

Protection Island has been identified as the most important marine bird nesting site in the Puget Sound region (Speich and Wahl, in press).

4.15.1.1 Double-crested Cormorant

Double-crested cormorants (*Phalacrocorax auritus*) have nested on Protection Island at different times over the past fifty years (Ibid). In the past four years the number of nesting birds has increased. In the summer of 1986, 100 nests were observed (Table 36), the largest number known for Protection Island.

During this survey, double-crested cormorant reproduction on Protection Island appeared normal. By the last census, August 8, 1986, many nest held large young and the young had fledged from the remainder.

4.15.1.2 Pelagic Cormorant

Pelagic cormorants (*P. pelagicus resplendens*) have occasionally nested on Protection Island over the last fifty years (Ibid). Recent surveys have revealed a steady increase in numbers (Table 36). This survey found 639 active nests on July 2, 1986. On August 8, 1986, only 491 nests were found. The loss was probably due to predation by bald eagles. The majority of the losses were suffered in the vicinity of a bald eagle nest on the north side of the island.

During this survey, pelagic cormorant reproduction appeared normal on Protection Island. Pelagic cormorants were observed incubating young and by the August 8, 1986 survey many nests held young.

Table 36. Protection Island Double-crested and Pelagic Cormorant Census Data from 1973 to 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Year	Number of Nests: Double-crested Cormorant	Number of Nests: Pelagic Cormorant	Source
1973	3	109	Speich and Wahl, in press
1974	-	-	Ibid
1975	0	194	Ibid
1976	0	194	Ibid
1977	-	-	Ibid
1978	0	295	Ibid
1979	0	292	Ibid
1980	8	332	Ibid
1981	-	-	Ibid

Table 36. Protection Island Double-crested and Pelagic Cormorant Census Data from 1973 to 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Year	Number of Nests: Double-crested Cormorant	Number of Nests: Pelagic Cormorant	Source
1982	-	427	Ibid
1983	5	465	Thompson, S. P., unpbl.
1984	24	500	Ibid
1985	41	500	Ibid
1986	100	640	This study

4.15.1.3 Pigeon Guillemot

Pigeon guillemots (*Cepphus columba*) have been observed nesting on Protection Island for over a century (Ibid). In recent years the numbers of pigeon guillemots associated with the island have increased (Table 37). The high count from this survey was 1,235 bird counted on July 2, 1986. The data in Table 31 indicates no significant decline in the pigeon guillemot population at Protection Island following the ARCO Anchorage oil spill.

Table 37. Protection Island and Vicinity Pigeon Guillemot Census Data from 1923 to 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Year	Number of Individuals	Source
1923	60-70	Speich, S. and T. Wahl, in press
1939-1942	Present	Ibid
1954	Present	Ibid
1955	200	Ibid
1956-1960	Present	Ibid
1968	Present	Ibid
1972	Present	Ibid

Table 37. Protection Island and Vicinity Pigeon Guillemot Census Data from 1923 to 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Year	Number of Individuals	Source
1973	50-60	Ibid
1975-76	360	Ibid
1978	526	Ibid
1979	652	Ibid
1980	635	Ibid
1982	1,300	Ibid
1983	1,528	Thompson, S. P., personal communication
1984	1,500	Ibid
1985	1,052	Ibid
1986	1,235	This study

4.15.2 Port Angeles Harbor

Birds in Port Angeles Harbor were censused six times in 1986 (Table 38). These surveys included all docks, log rafts, dolphins, pilings, and shorelines as visible from the boat.

4.15.2.1 Pelagic Cormorant

This species was first recorded nesting in Port Angeles in 1978 (Speich, Ibid). In 1978, 29 to 38 active nests were observed on the pilings near the ITT Rayonier plant. In this study, 98 active nests were observed (Table 38), many observed on the same pilings.

By the last survey, most nests held adults incubating eggs. The data indicate the number of pelagic cormorants nesting in Port Angeles Harbor has increased since 1978.

4.15.2.2 Glaucous-winged Gull

During the MESA bird censuses in 1978 and 1979 (Wahl et al., 1981), glaucous-winged gull (*Larus glaucenscens*) nests were not reported in Port Angeles Harbor. During this survey, at least 30 pairs were attempting to nest in the harbor (Table 38). Eight nests were lost to disturbance: logs turning over and shooting. Nearly all of the remaining nests hatched young and large young were observed at several nests. The eggs and small young appeared normal. Glaucous-winged gull reproduction in Port Angeles Harbor appeared normal. The data indicate the glaucous-winged gull population is increasing in Port Angeles Harbor.

4.15.2.3 Pigeon Guillemot

Pigeon guillemots were found in small numbers during the censuses (Table 32). Counts ranged from 11 to 39 birds. From April 1978 to August 2, 1979, twenty-five counts were made (Ibid). The counts ranged from zero to 22 birds. The numbers of birds observed in this study were higher than the 1978-1979 study. However, the 1978-1979 study counted birds from the shore, underestimating the actual number of birds present.

Several adult pigeon guillemots were observed carrying fish to young under docks indicating the presence of nests and young in Port Angeles Harbor. Because of the inaccessible location of nests, it was not possible to pinpoint nests and observe young in the nests.

The data indicate there were about as many pigeon guillemots in Port Angeles Harbor during this study as there were in the 1978-1979 study.

Table 38. Numbers of Nesting Marine Birds Observed in Port Angles Harbor in 1986. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

	Number of Nests		Number of Birds
Date	Pelagic Cormorant	Glaucous-winged Gull	Pigeon Guillemot
June 11	74	12	35
June 12	--	12	28
June 19	98	30	39
June 27	96	26	11
July 1	--	25	20
July 22	--	22	30

4.15.3 Striped Peak Headland

The Striped Peak Headland is the nearshore area between Observatory Point and Crescent Bay (Figure 1). This area was surveyed five times (Table 34).

4.15.3.1 Pelagic Cormorant

Two small nesting colonies were found along this shoreline. As the season progressed the number of nests increased from 9 to a maximum of 16 and declined to 15. Because these colonies were unknown prior to this study, it was not possible to draw any conclusions about the populations. However, adult birds were observed incubating eggs.

4.15.3.2 Pigeon Guillemot

During this survey, 58 pigeon guillemots were observed in this area (Table 39). Previous counts in this area in 1978-1979 recorded only 27 birds (Speich, unpbl. Data). However, the 1978-1979 study was from aircraft and underestimated the numbers present.

4.15.3.3 Marbled Murrelets

On July 1, 1986, 61 marbled murrelets (*Brachyramphus marmoratus*) were observed in this area (Table 39). During the previous nine surveys conducted from 1978-1978 (Ibid) these birds were not observed in this area. But, the surveys were from aircraft and this small species is easily overlooked during aerial surveys.

Table 39. Numbers of Nesting Marine Birds Observed in the Striped Peak Headland Area. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

	Number of Birds		Number of Nests
Date	Pigeon Guillemot	Marbled Murrelet	Pelagic Cormorants
June 11	58	4	9
June 23	44	7	14
June 27	45	33	16
July 1	50	62	16
July 22	60	31	15

4.15.4 Other Areas

Pigeon guillemots and marbled murrelets were found in nearly all nearshore areas surveyed. Neither species was missing in areas where they were known to occur (Ibid). Previously identified nesting sites were found in use.

There were no indications of a decline in the numbers of pigeon guillemots in the study area, nor a decrease in the numbers of nesting birds. The numbers of marbled murrelets appeared normal and they occurred in areas previously identified. Cormorant, gull, and guillemot reproduction appeared normal in the survey areas.

5.0 COMPILATIONS AND COMPUTATIONS

In this section, resource losses are compiled by species, monetary values are assigned to these organisms, and the final monetary resource damage assessment is computed. The compilations are explained in detail here.

5.1 Clams

The data indicate 67,892 hardshell clams (12,468 pounds) were effected by the ARCO Anchorage Oil Spill: butter clams, native littleneck clams, cockles, horse clams, and *Macoma* spp. clams.

Butter clams, native littleneck clams, and cockles were valued as a recreational resource at $1.18 per pound in 1976 (Stokes,1979). Horse clams and *Macoma* spp. clams were valued at $.71 per pound (Ibid) These values were then multiplied by the consumer price index (CPI) increase from 1976 to 1986 (Bureau of Labor Statistics, 1986). The CPI increase was 196%. Applying the CPI increase to the per pound value provided a recreational values of $2.31 per pound for butter clams, littleneck clams, and cockles and $1.39 per pound for horse clams and *Macoma* spp. clams.

Table 40. Clam Resource Losses by Species. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Species	Pounds	Recreational Value ($/lb)	Resource Losses
Butter clams	2,842	$2.31	$6,565.02
Littleneck clams	355	$2.31	820.05
Cockles	92	$2.31	212.52
Horse clams	8,816	$1.39	12,254.24
Macoma spp. clams	363	$1.39	504.57
Total	12,468	Total	$20,356.40

The clam losses amounted to $20,356.40.

5.2 Waterbirds

The data indicate an estimated 4,000 waterbirds were oiled and died as the result of the ARCO Anchorage Oil Spill: 28 loons, 2,236 grebes, 80 cormorants, 950 ducks, 2 rail, 12 shorebirds, 72 gulls, 450 alcids, 2 unidentified birds, and 168 unaccounted for birds. Birds processed through the bird cleaning station will not be included in this MRDA.

Therefore, 2,083 birds will be included in this MRDA: 14 loons, 1,118 grebes, 40 cormorants, 475 ducks, 1 rail, 6 shorebirds, 36 gulls, 225 alcids, and 168 unaccounted for birds.

5.2.1 Marinefowl

For the purposes of this MRDA marinefowl will include loons, grebes, cormorants, rails, shorebirds, gulls, and alcids. The data indicate 1,608 marinefowl were not processed through the bird cleaning station and therefore will be included in this section.

The marinefowl were valued at $2.82 per bird in 1976 (Stokes,1979) using scoters as a baseline. This value was then multiplied by the consumer price index (CPI) increase from 1976 to 1986 (Bureau of Labor Statistics, 1986). The CPI increase was 196%. Applying the CPI increase to the bird value provided a marinefowl value of $5.53 per bird.

The resource losses for marinefowl amounted to $8,892.24.

5.2.2 Ducks

The data indicate 475 ducks were not processed through the cleaning station and therefore will be included in this section. Duck species oiled in this incident were: 4 mallard, 3 northern pintail, 15 American widgeon, 1 canvasback, 4 greater scaup, 7 lesser scaup, 7 harlequin, 89 oldsquaw, 8 black scoter, 33 surf scoter, 229 white-winged scoter, 1 unidentified scoter, 34 common goldeneye, 2 unidentified goldeneye, 30 bufflehead, 1 hooded merganser, and 7 red-breasted merganser. For the purposes of this MRDA the 168 unaccounted for birds will be included under ducks.

The economic value for ducks was based on Stokes' 1979 report (Ibid). The values were increased as in the marinefowl section. The values are shown in Table 41.

Table 41. Economic Values for Oiled Birds. ARCO Anchorage Oil Spill MRDA; December 21, 1985.

Species	1976 Value	CPI Increase	1986 Value	No. of Birds	Economic Losses
Mallard	$4.82	196%	$9.45	4	$37.80
Northern Pintail	$5.63	196%	$11.03	3	$33.09
American widgeon	$5.63	196%	$11.03	15	$165.60
Canvasback	$5.63	196%	$11.03	1	$11.03
Greater scaup	$2.82	196%	$5.53	4	$27.65

Table 41. Economic Values for Oiled Birds. ARCO Anchorage Oil Spill MRDA; December 21, 1985. (Continued)

Species	1976 Value	CPI Increase	1986 Value	No. of Birds	Economic Losses
Lesser scaup	$2.82	196%	$5.53	7	$38.71
Harlequin	$2.82	196%	$5.53	7	$38.71
Oldsquaw	$2.82	196%	$5.53	89	$492.17
Black scoter	$2.82	196%	$5.53	8	$44.24
Surf scoter	$2.82	196%	$5.53	33	$182.49
White-winged scoter	$2.82	196%	$5.53	229	$1,266.37
Scoter species	$2.82	196%	$5.53	1	$5.53
Common goldeneye	$2.82	196%	$5.53	34	$188.02
Goldeneye species	$2.82	196%	$5.53	2	$11.06
Bufflehead	$2.82	196%	$5.53	30	$165.90
Hooded Merganser	$2.82	196%	$5.53	1	$5.53
Red-breasted Merganser	$2.82	196%	$5.53	7	$38.71
Unaccounted birds	$2.82	196%	$5.53	168	$929.04
				TOTAL	$3,681.39

The duck resource losses amounted to $3,681.39.

5.3 MRDA Grand Total

The ARCO Anchorage Oil Spill MRDA Grand total was $32,930.03.

6.0 DISCUSSION

This MRDA is considered conservative for the following reasons: 1) only sport and commercial species were included, except for marinefowl, 2) forage organisms were not included although they are basic food chain organisms providing resources needed to support life in the Strait of Juan de Fuca.

RCW 90.48.142 states that any person who pollutes the waters of the state in violation of the law and in so doing causes death or injury to state resources "shall be liable to pay the state damages in an amount equal to the sum of money necessary to restock such waters, replenish such resources and otherwise restore the stream, lake, or other water source to its condition prior to injury." This law provides the Department of Ecology with the legal authority to protect these bodies of water.

7.0 RECOMMENDATIONS

It is recommended that the party responsible for the damages to the state's resources pay the $32,930.03 indicated in this ARCO Anchorage Oil Spill Marine Resource Damage Assessment. RCW 90.48.142 stipulates that money collected through resource damage assessments shall be paid to the agency responsible for the resources damaged. In this case, the Department of Fisheries should receive $20,350.40 and the Department of Game should receive $12,573.63.

RCW 90.48.142 further stipulates that half the money received from damage assessments shall be spent in the county where the damage occurred.

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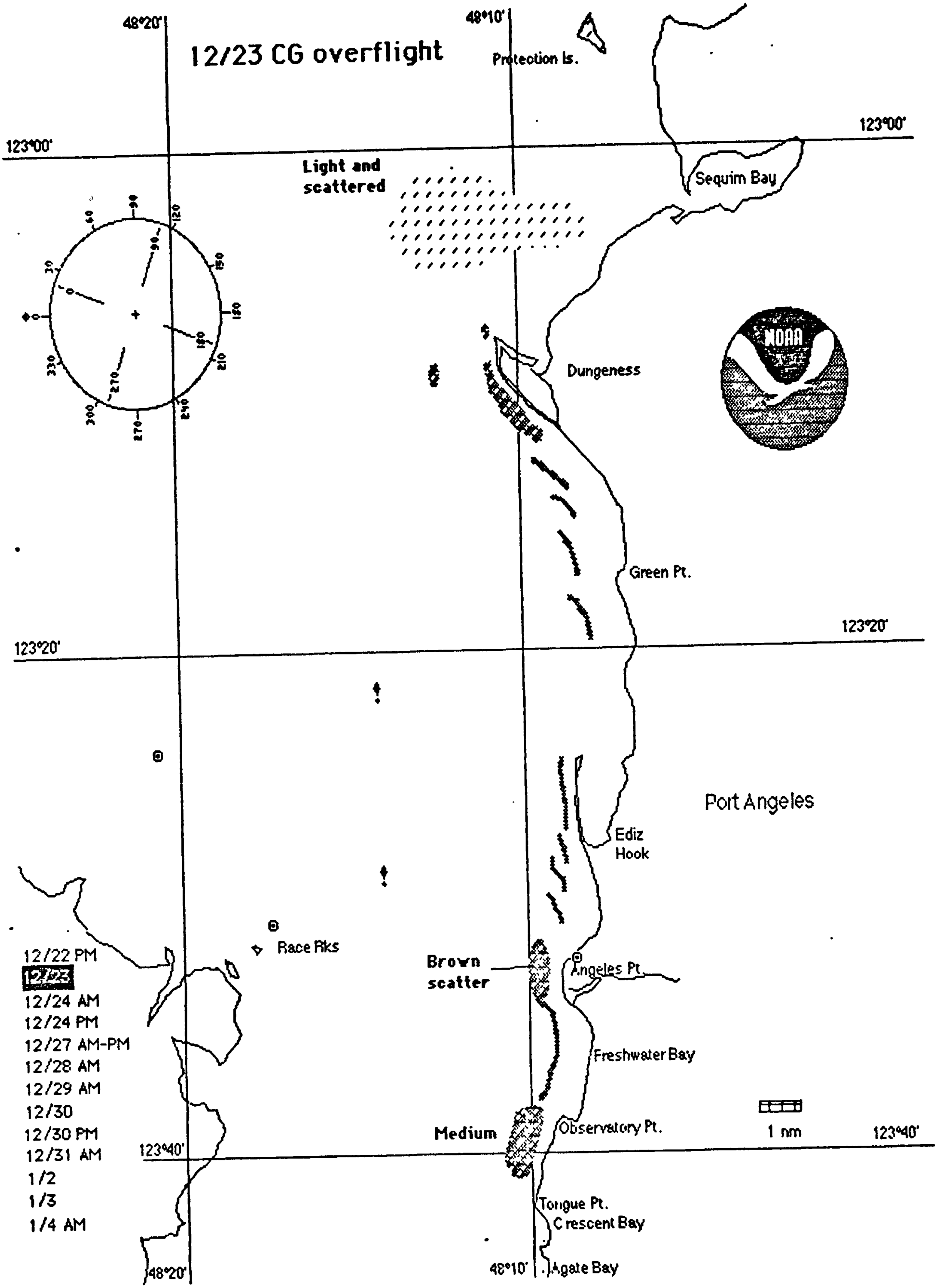
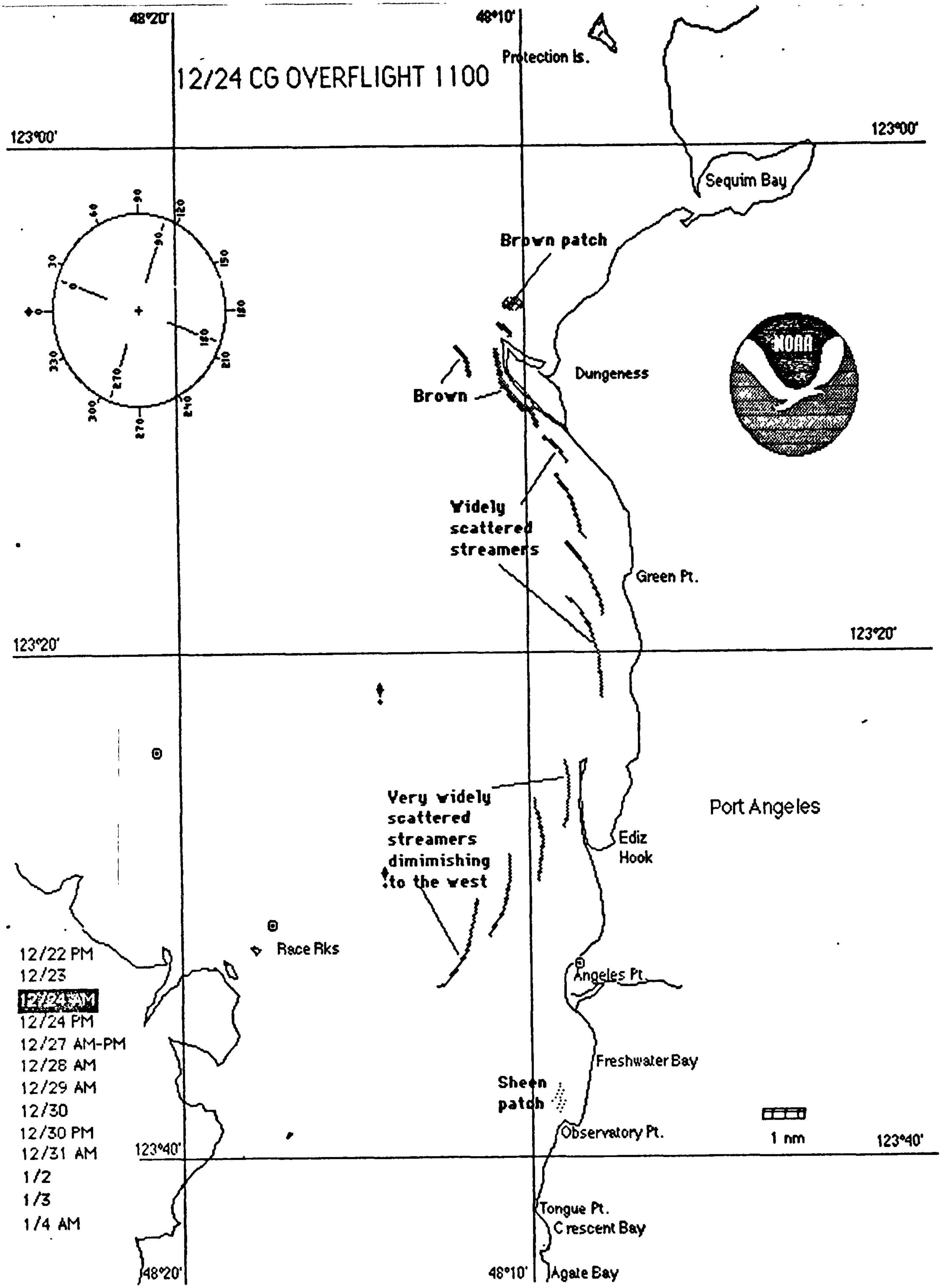
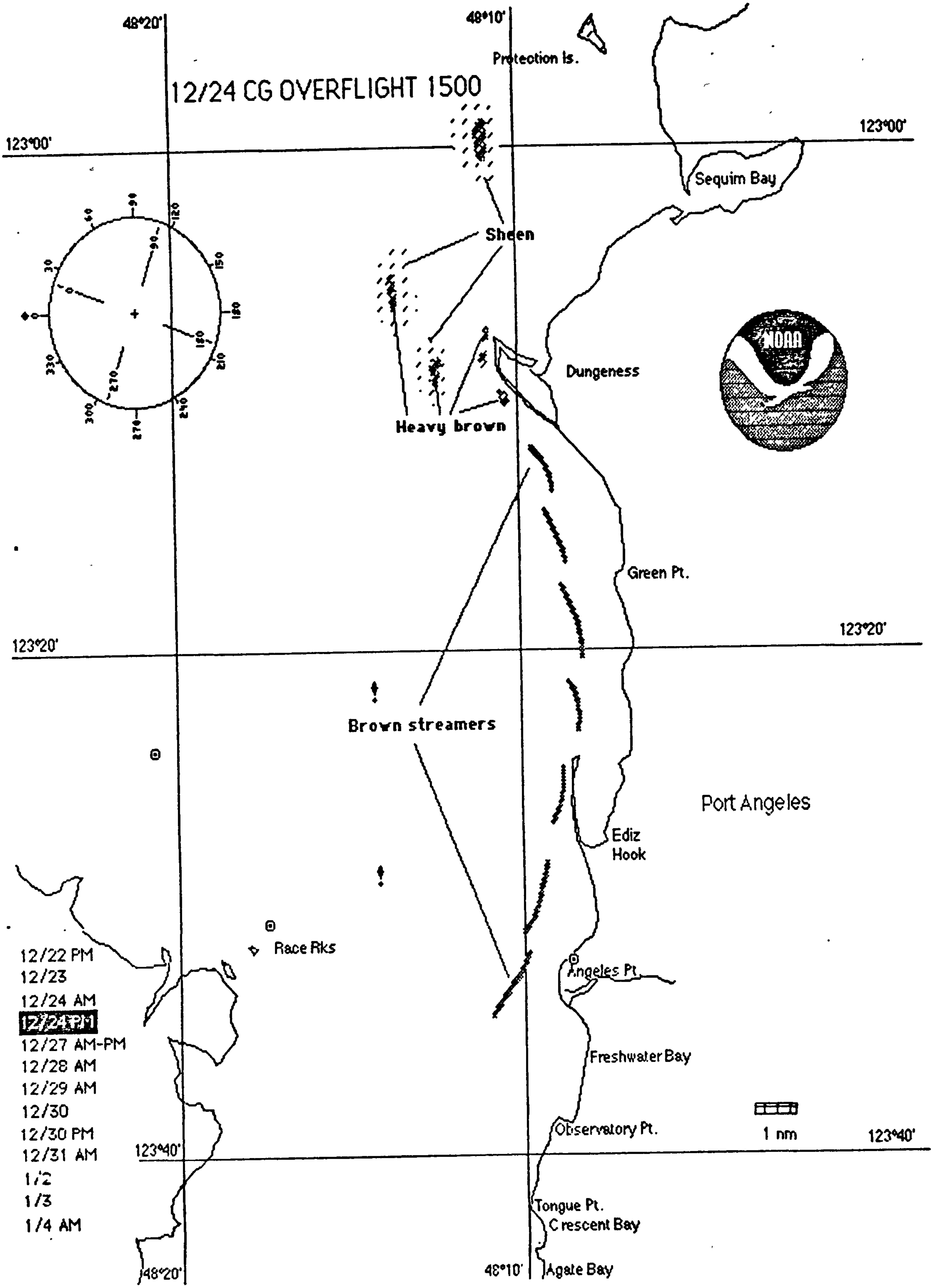
9.0 APPENDIX I

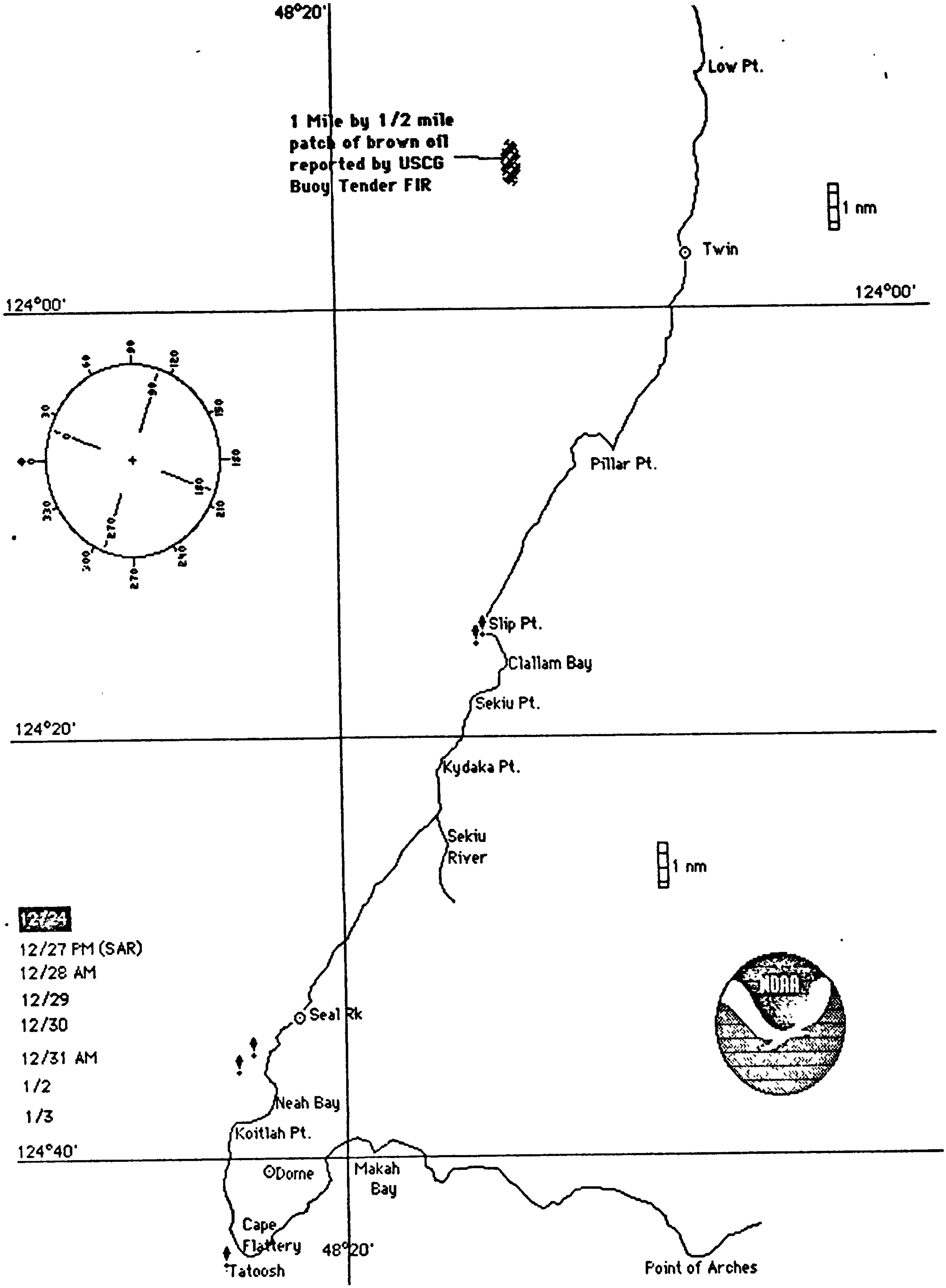
NOAA/USCG OIL SPILL

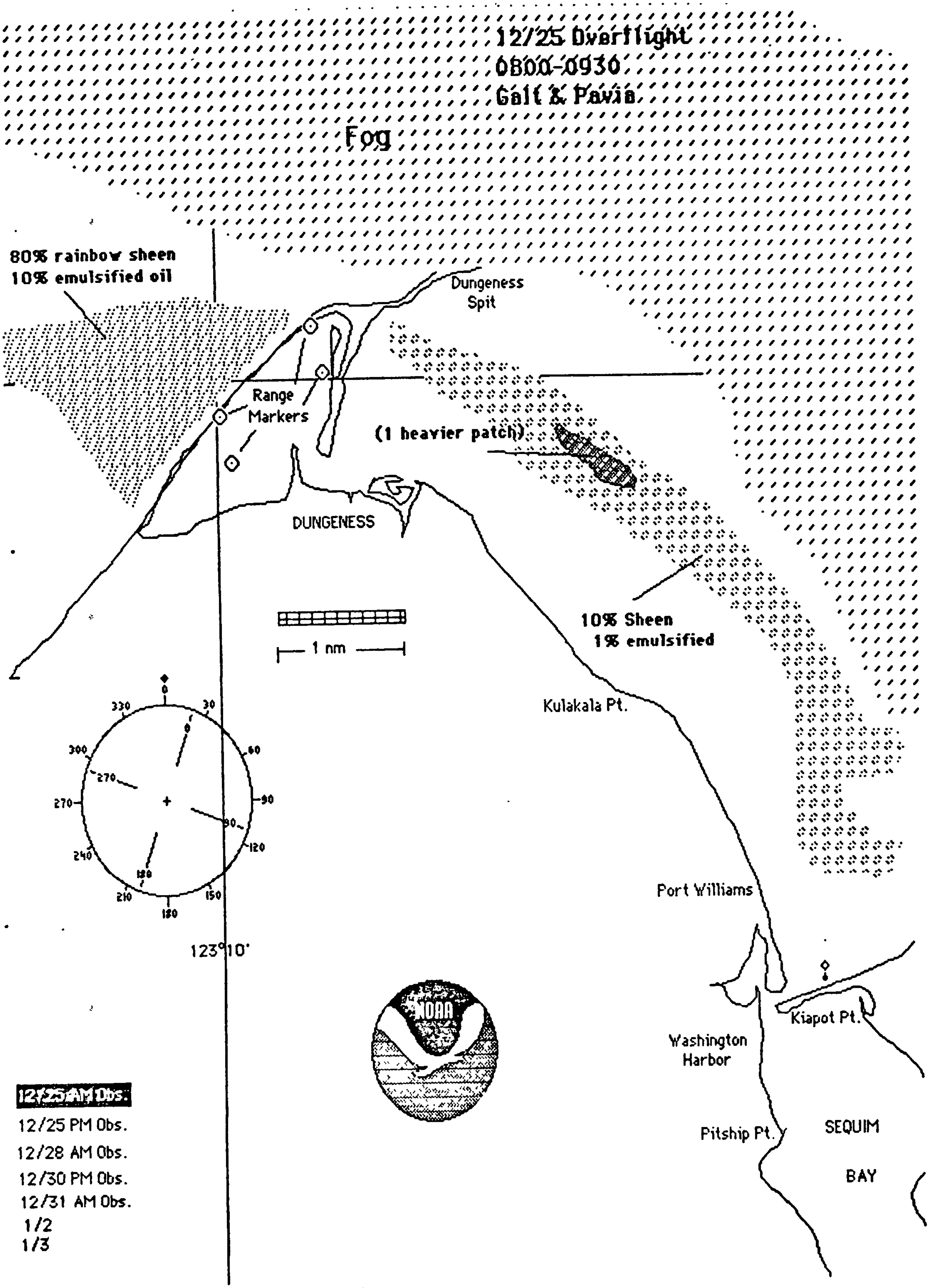
OVERFLIGHT PLOTS

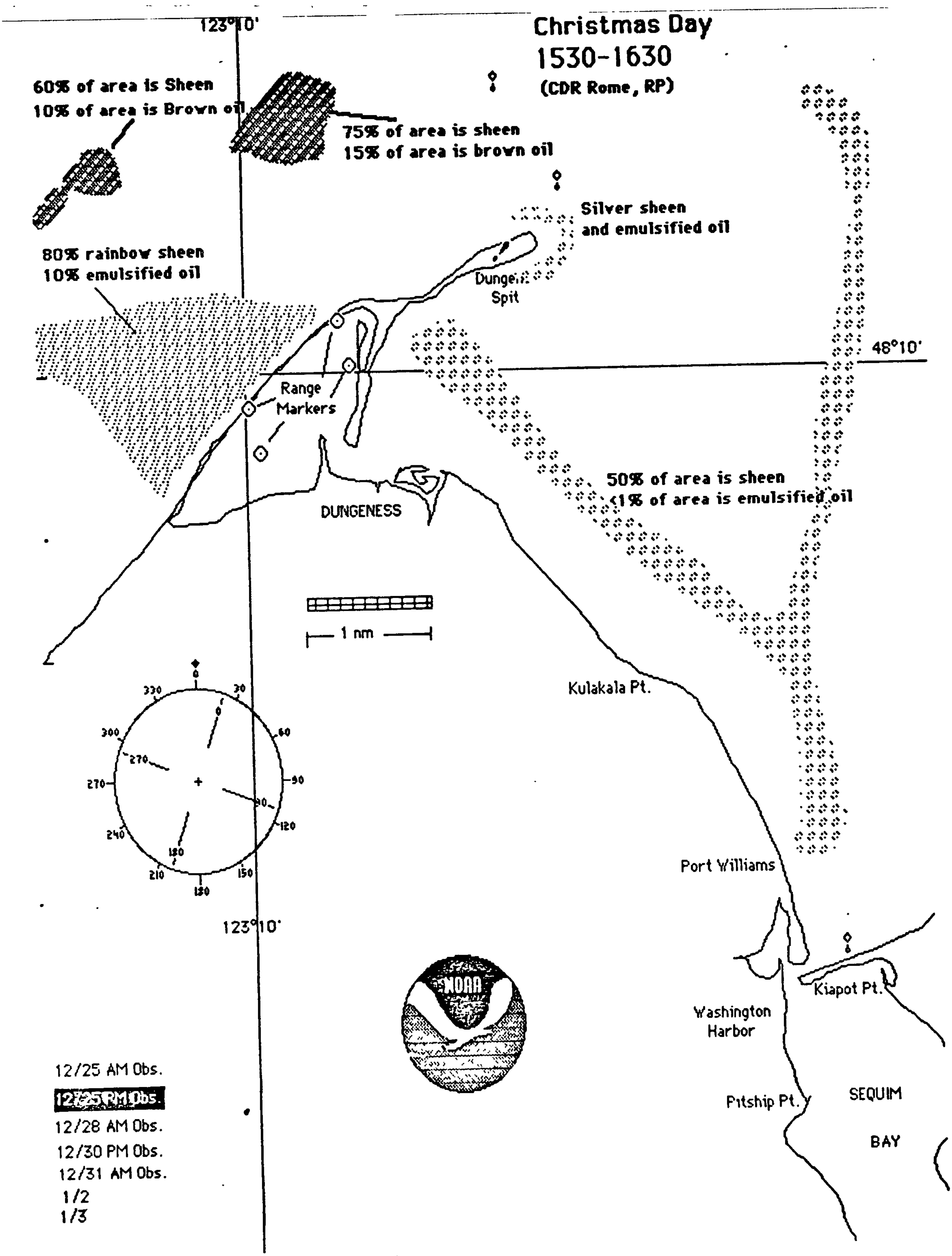

12/23 CG overflight
Protection Is.
Sequim Bay
Light and scattered
Dungeness
Green Pt.
Port Angeles
Ediz Hook
Race Rks
Brown scatter
Angeles Pt.
Freshwater Bay
Medium
Observatory Pt.
Tongue Pt.
Crescent Bay
Agate Bay
1 nm
48°20'
48°10'
123°00'
123°20'
123°40'
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM

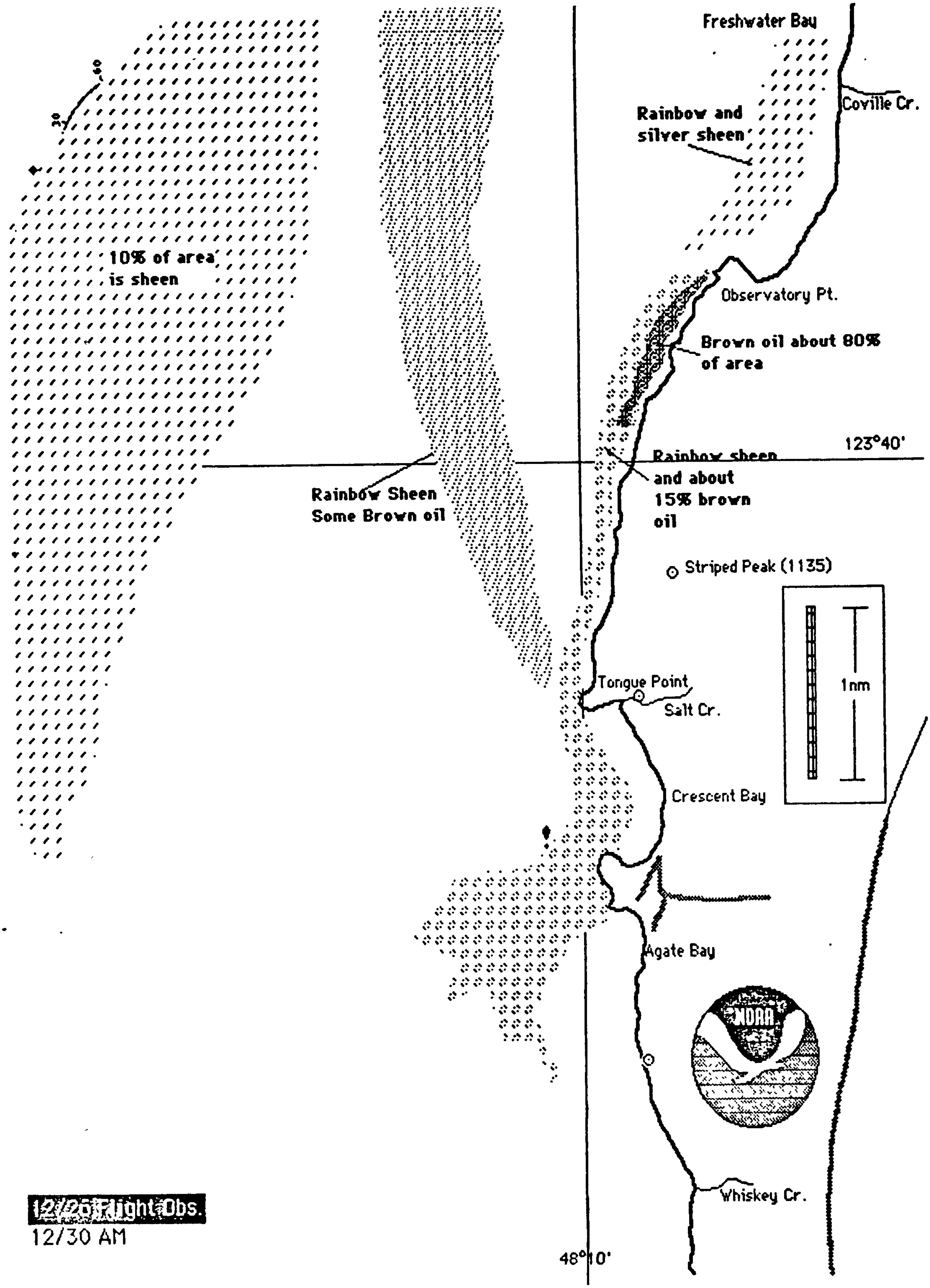

12/24 CG OVERFLIGHT 1100
48°20'
48°10'
123°00'
123°00'
123°20'
123°20'
123°40'
123°40'
48°20'
48°10'
Protection Is.
Sequim Bay
Brown patch
Brown
Dungeness
Widely scattered streamers
Green Pt.
Very widely scattered streamers dimimishing to the west
Port Angeles
Ediz Hook
Race Rks
Angeles Pt.
Freshwater Bay
Sheen patch
Observatory Pt.
1 nm
Tongue Pt.
Crescent Bay
Agate Bay
NOAA
90
60
120
30
150
0
180
330
210
300
240
270
0
90
180
270
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM

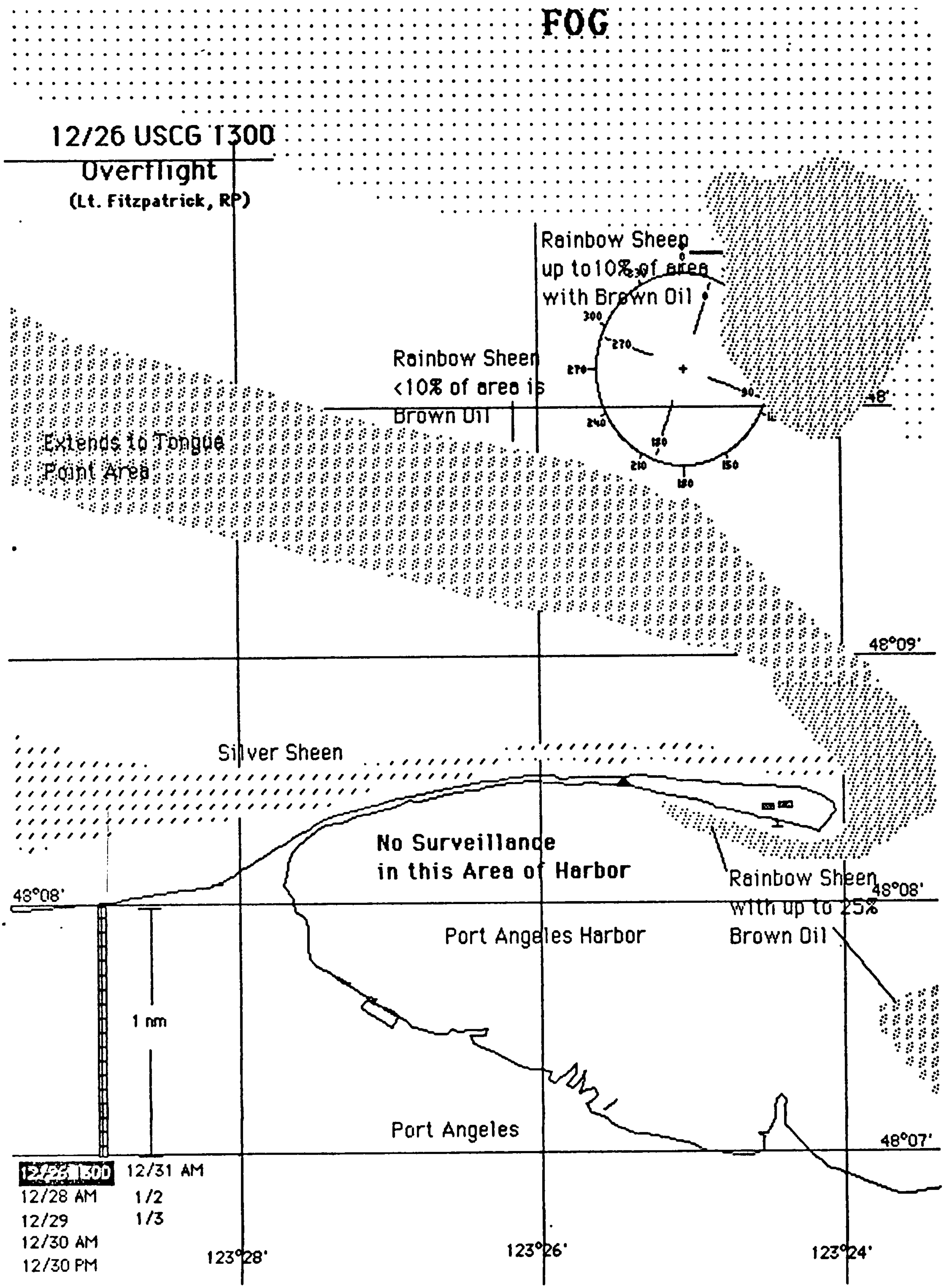

12/24 CG OVERFLIGHT 1500
48°20'
48°10'
123°00'
123°20'
123°40'
Protection Is.
Sequim Bay
Sheen
Dungeness
Heavy brown
NOAA
Green Pt.
Brown streamers
Port Angeles
Ediz Hook
Race Rks
Angeles Pt.
Freshwater Bay
Observatory Pt.
1 nm
Tongue Pt.
Crescent Bay
Agate Bay
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM

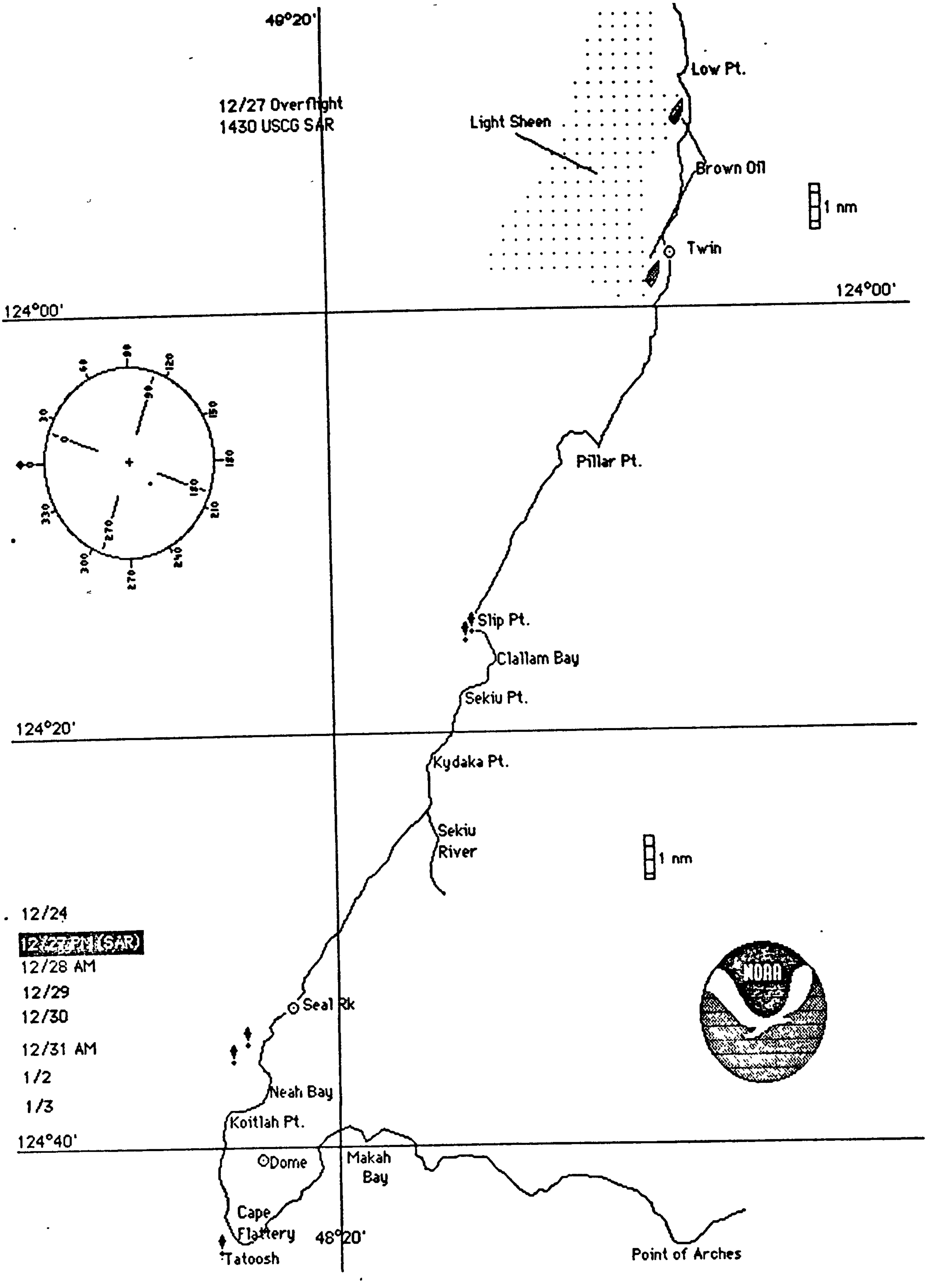

48°20'
Low Pt.
1 Mile by 1/2 mile
patch of brown oil
reported by USCG
Buoy Tender FIR
1 nm
Twin
124°00'
124°00'
Pillar Pt.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu
River
1 nm
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
Neah Bay
Koitlah Pt.
124°40'
Dorne
Makah
Bay
Cape
Flattery
48°20'
Tatoosh
Point of Arches

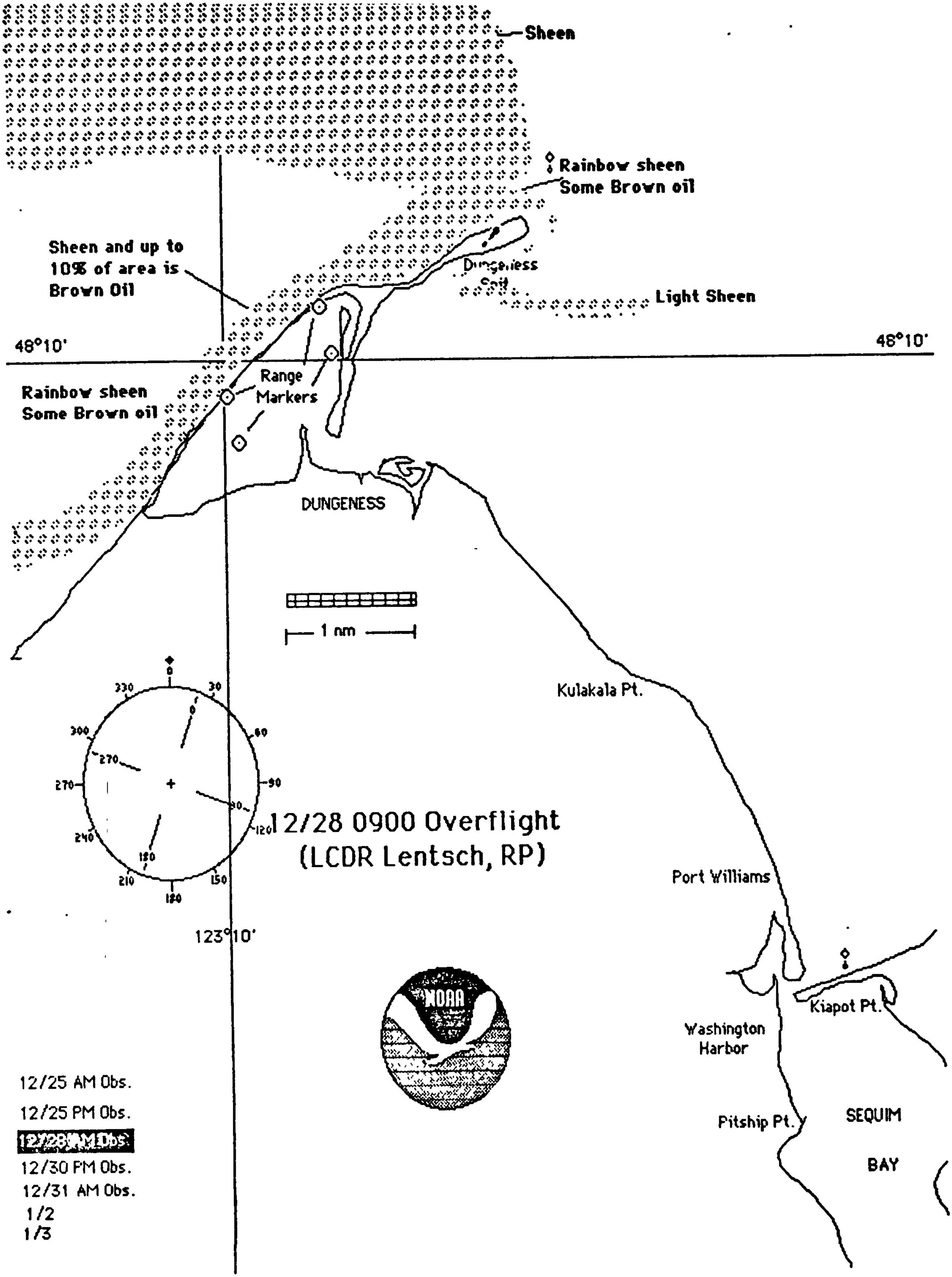

12/25 Overflight
0800-0930
Galt & Pavia
Fog
80% rainbow sheen
10% emulsified oil
Dungeness
Spit
Range
Markers
(1 heavier patch)
DUNGENESS
10% Sheen
1% emulsified
1 nm
Kulakala Pt.
Port Williams
123°10'
Washington
Harbor
Kiapot Pt.
Pitship Pt.
SEQUIM
BAY
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3


Christmas Day
1530-1630
(CDR Rome, RP)
123°10'
60% of area is Sheen
10% of area is Brown oil
75% of area is sheen
15% of area is brown oil
Silver sheen
and emulsified oil
80% rainbow sheen
10% emulsified oil
Dungeness Spit
48°10'
Range Markers
DUNGENESS
50% of area is sheen
<1% of area is emulsified oil
1 nm
Kulakala Pt.
Port Williams
123°10'
Washington Harbor
Kiapot Pt.
Pitship Pt.
SEQUIM BAY
NOAA
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3

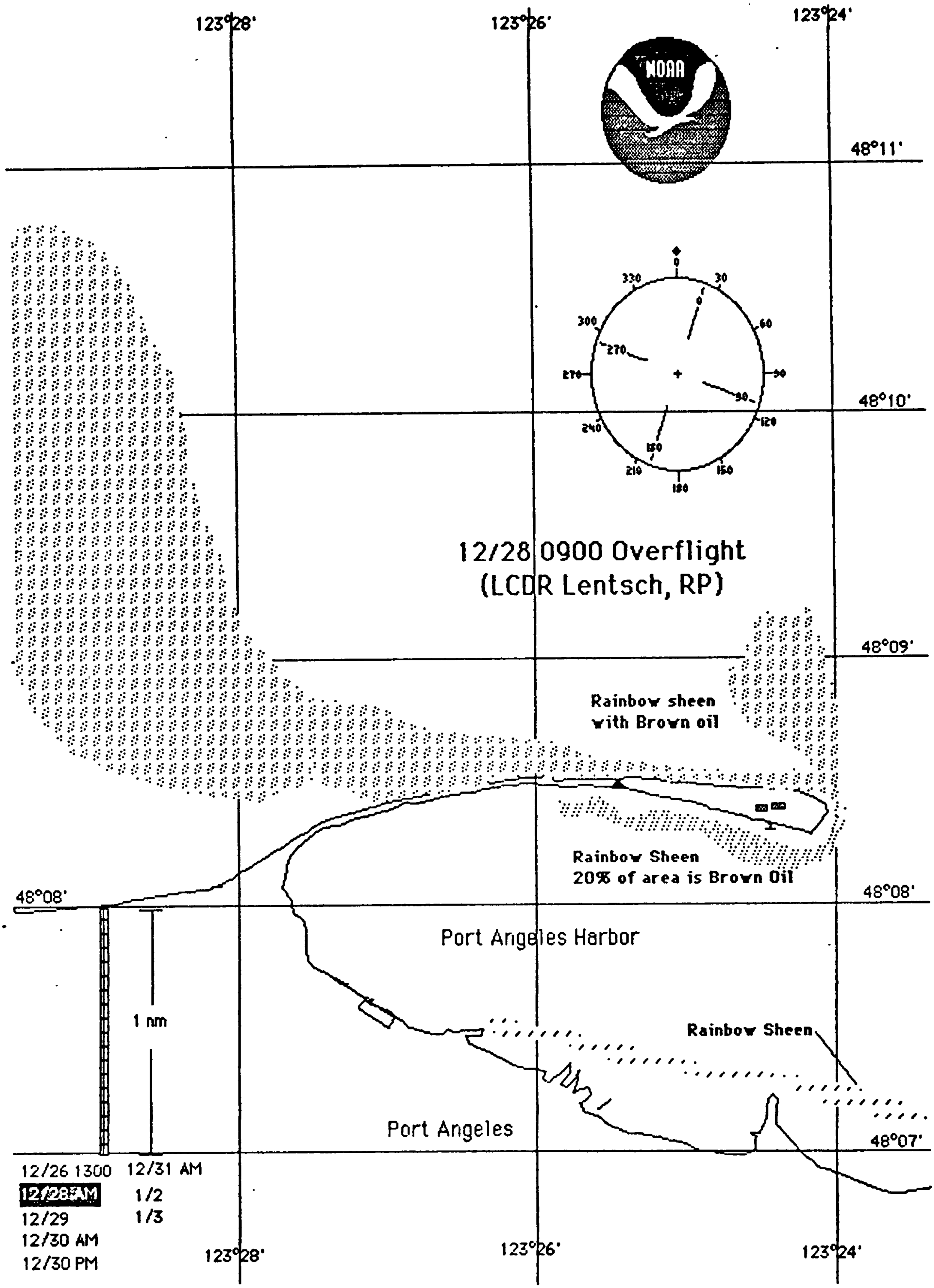

Freshwater Bay
Coville Cr.
Rainbow and silver sheen
10% of area is sheen
Observatory Pt.
Brown oil about 80% of area
123°40'
Rainbow sheen and about 15% brown oil
Rainbow Sheen Some Brown oil
Striped Peak (1135)
1nm
Tongue Point
Salt Cr.
Crescent Bay
Agate Bay
Whiskey Cr.
48°10'
12/25 Flight Obs.
12/30 AM


FOG
12/26 USCG 1300
Overflight
(Lt. Fitzpatrick, RP)
Rainbow Sheen
up to 10% of area
with Brown Oil
Rainbow Sheen
<10% of area is
Brown Oil
48'
Extends to Tongue
Point Area
48°09'
Silver Sheen
No Surveillance
in this Area of Harbor
Rainbow Sheen
with up to 25%
Brown Oil
48°08'
48°08'
Port Angeles Harbor
1 nm
Port Angeles
48°07'
12/26 1300
12/31 AM
12/28 AM
1/2
12/29
1/3
12/30 AM
12/30 PM
123°28'
123°26'
123°24'

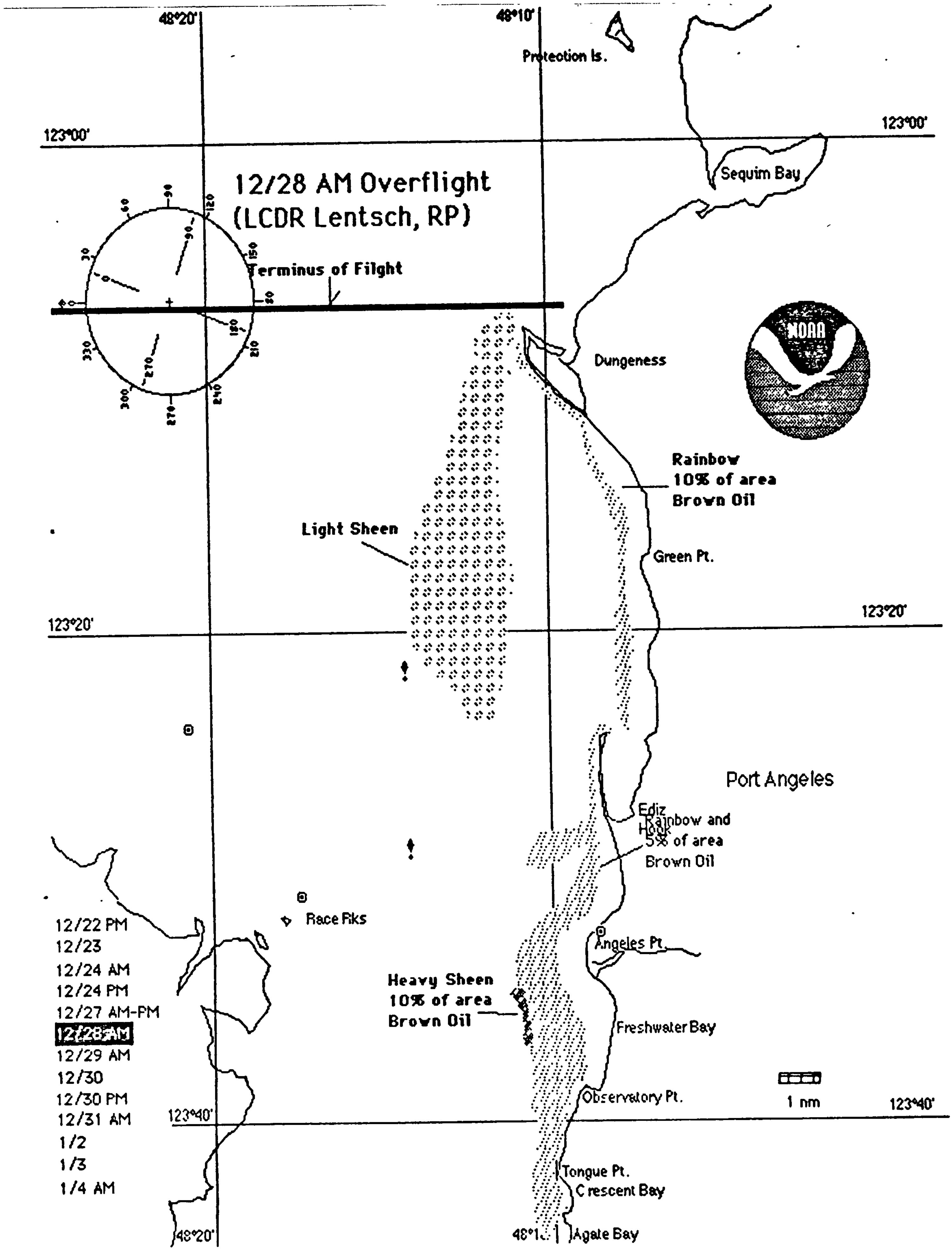

48°20'
12/27 Overflight
1430 USCG SAR
Light Sheen
Low Pt.
Brown Oil
1 nm
Twin
124°00'
124°00'
Pillar Pt.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu
River
1 nm
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
NOAA
Neah Bay
Koitlah Pt.
124°40'
Dome
Makah
Bay
Cape
Flattery
48°20'
Tatoosh
Point of Arches



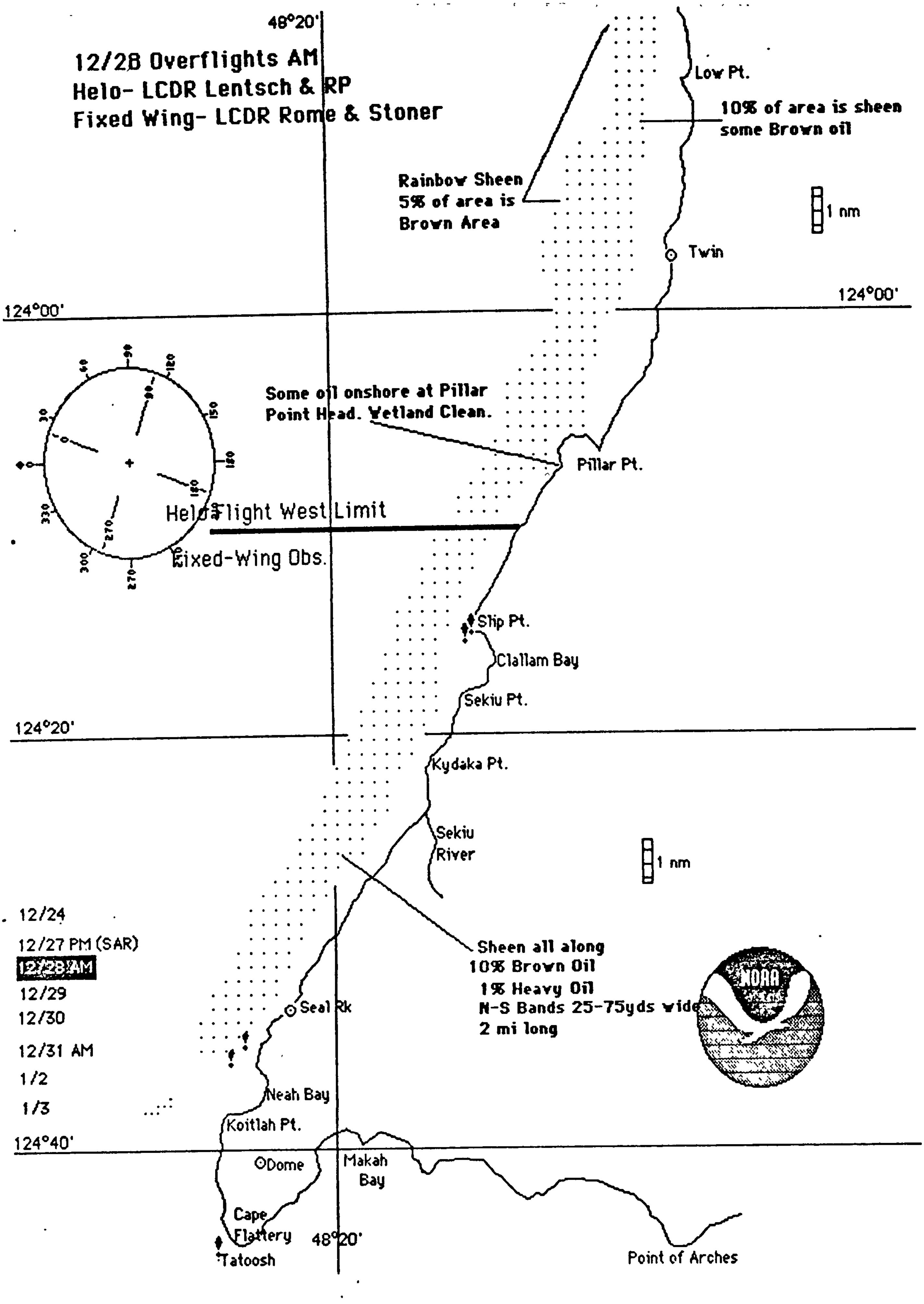
Sheen
Rainbow sheen
Some Brown oil
Sheen and up to
10% of area is
Brown Oil
Dungeness
Spit
Light Sheen
48°10'
48°10'
Rainbow sheen
Some Brown oil
Range
Markers
DUNGENESS
1 nm
Kulakala Pt.
12/28 0900 Overflight
(LCDR Lentsch, RP)
Port Williams
123°10'
Washington
Harbor
Kiapot Pt.
Pitship Pt.
SEQUIM
BAY
NOAA
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3

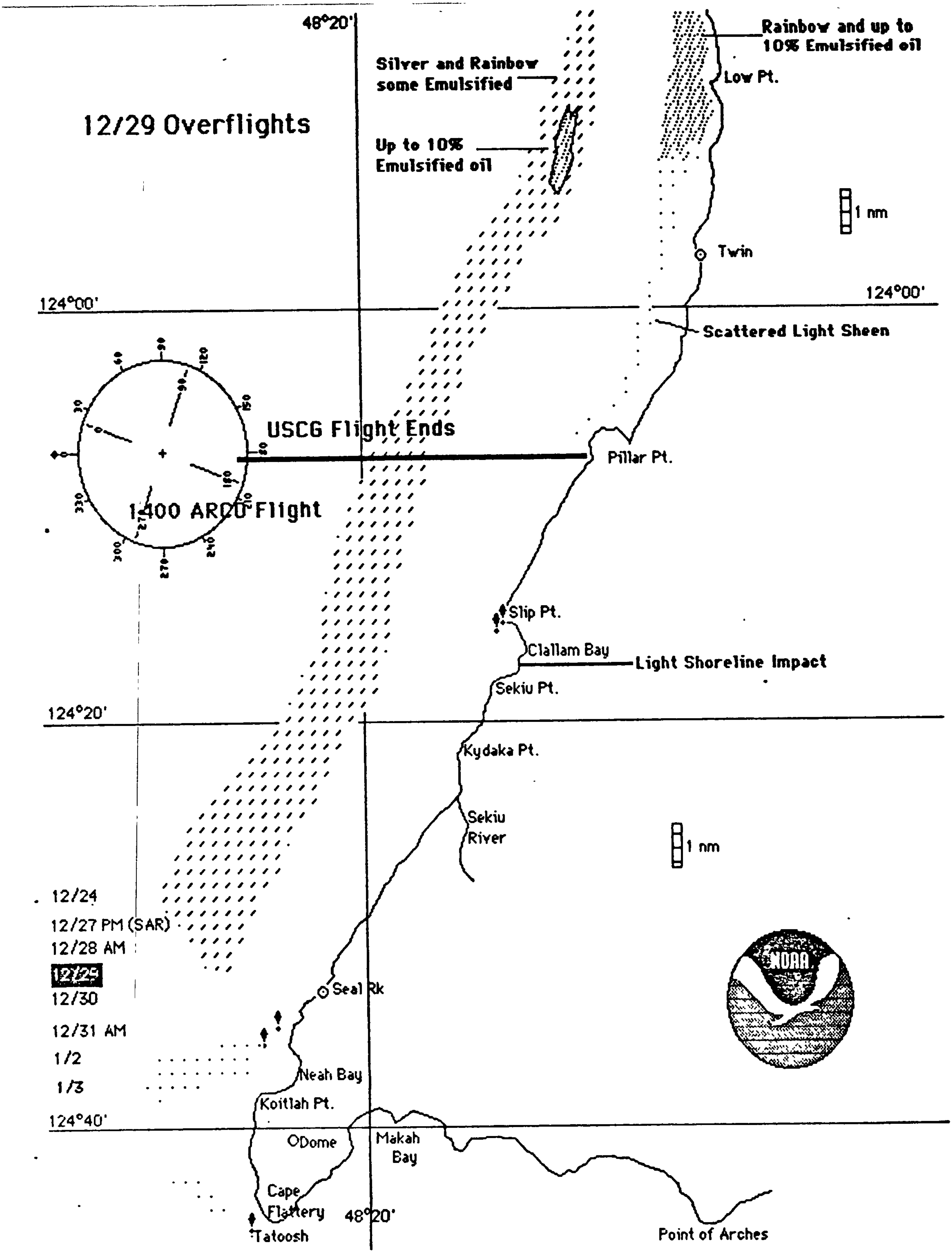


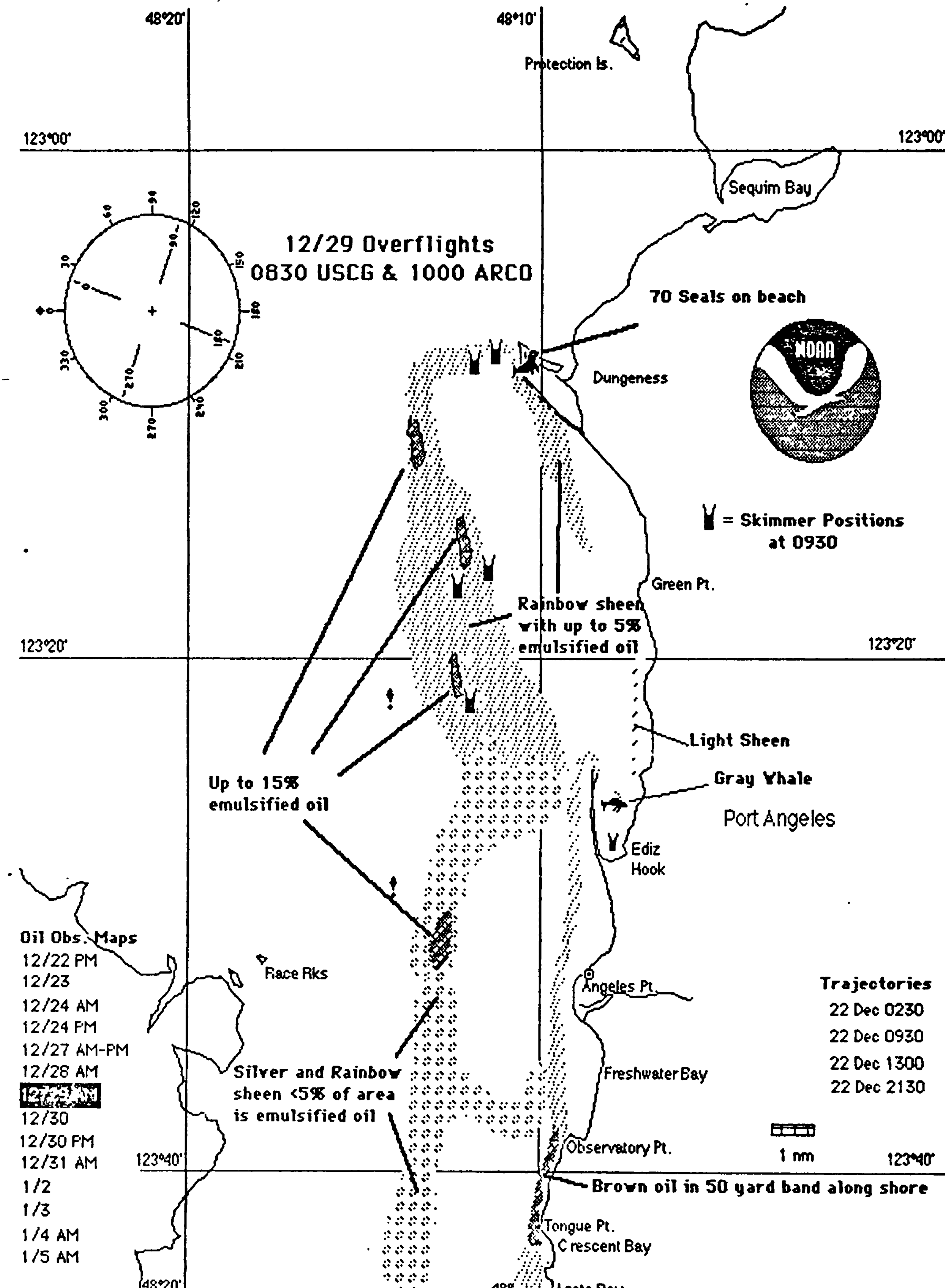
123°28'
123°26'
123°24'
NOAA
48°11'
48°10'
48°09'
48°08'
48°07'
0
30
60
90
120
150
180
210
240
270
300
330
12/28 0900 Overflight
(LCDR Lentsch, RP)
Rainbow sheen
with Brown oil
Rainbow Sheen
20% of area is Brown Oil
Port Angeles Harbor
1 nm
Rainbow Sheen
Port Angeles
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3

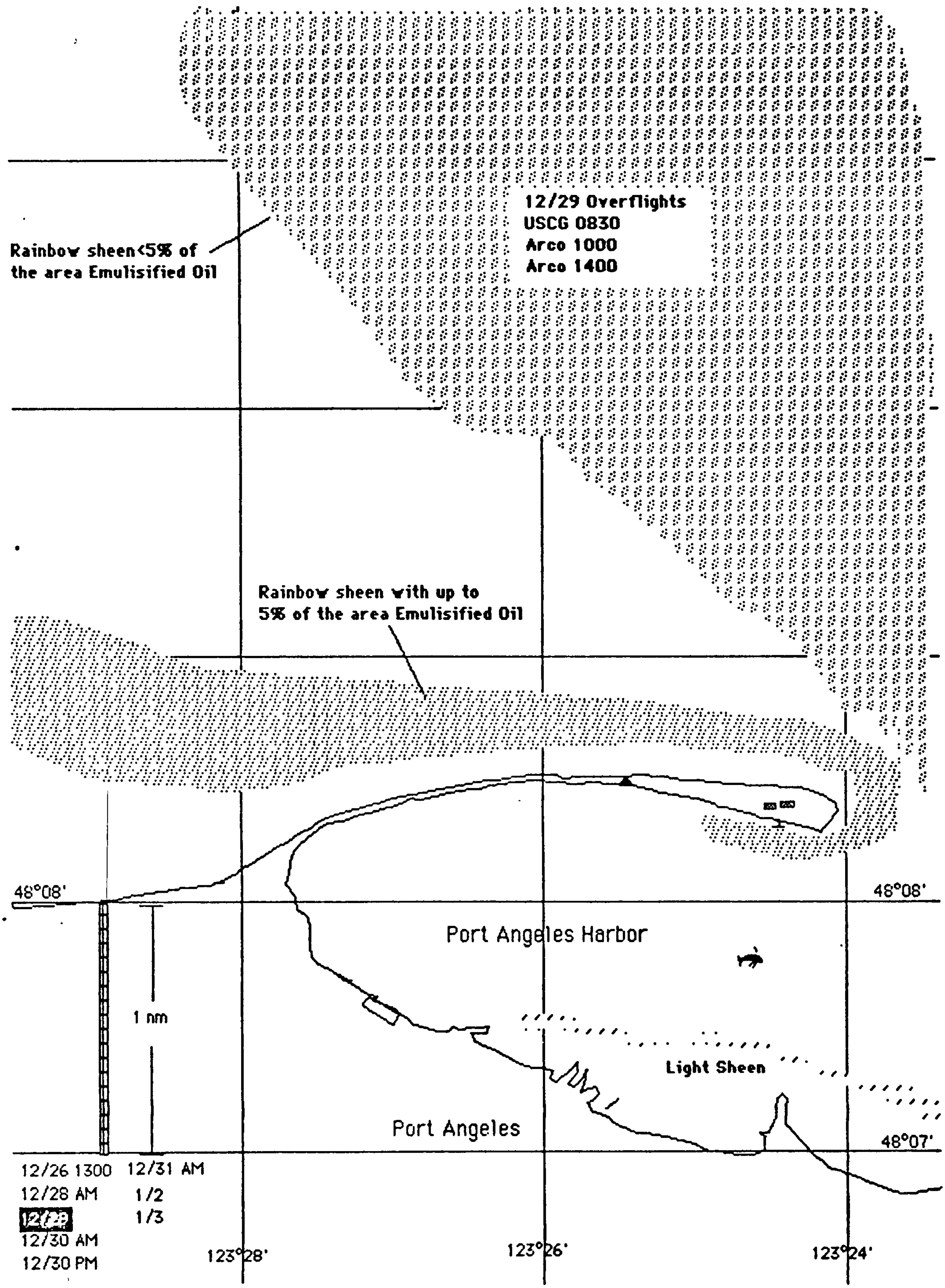


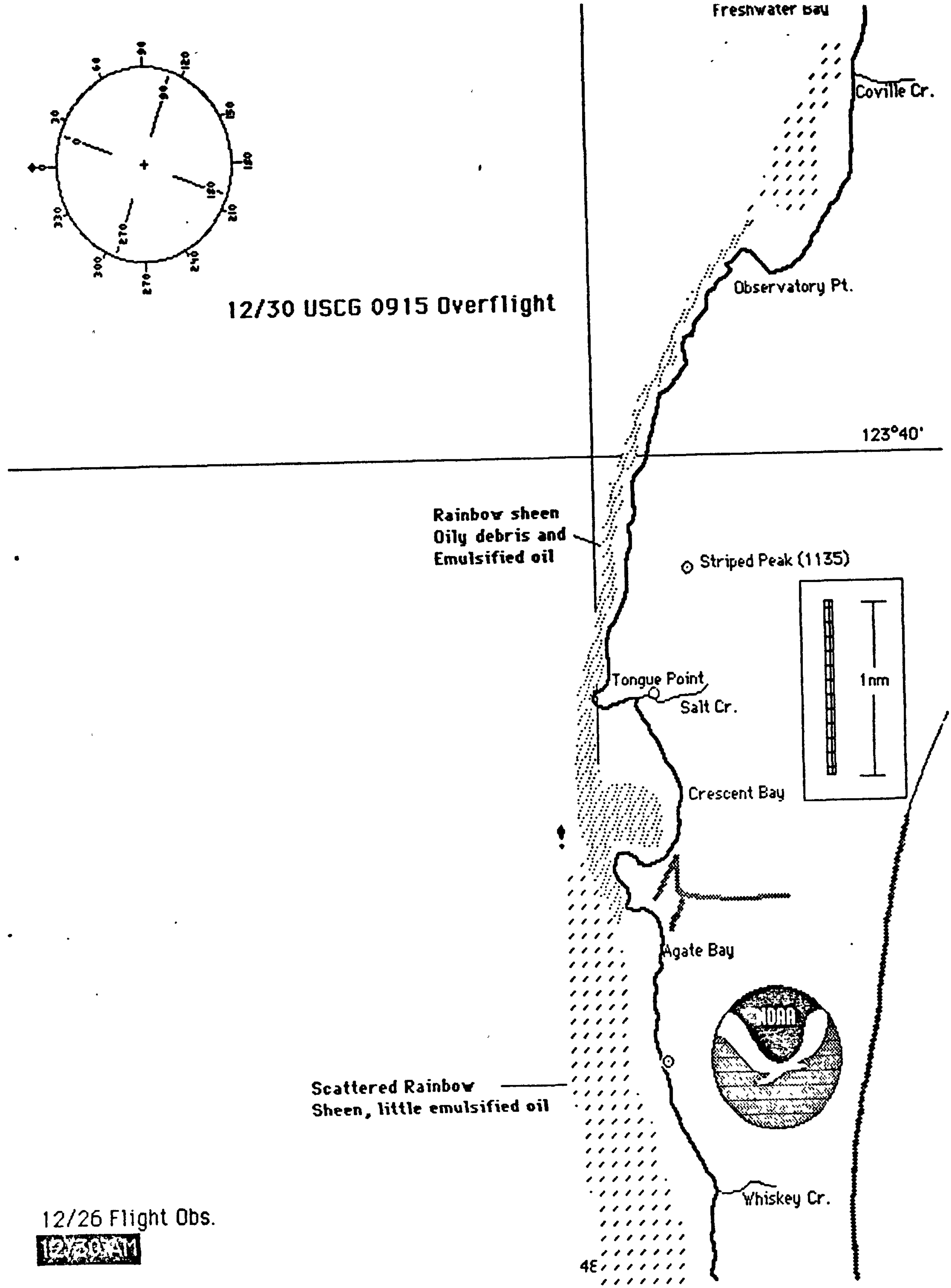
12/28 AM Overflight
(LCDR Lentsch, RP)
48°20'
48°10'
123°00'
123°20'
123°40'
Protection Is.
Sequim Bay
Terminus of Filght
Dungeness
NOAA
Rainbow
10% of area
Brown Oil
Light Sheen
Green Pt.
Port Angeles
Ediz Hook
Rainbow and
5% of area
Brown Oil
Race Rks
Angeles Pt.
Heavy Sheen
10% of area
Brown Oil
Freshwater Bay
Observatory Pt.
1 nm
Tongue Pt.
Crescent Bay
Agate Bay
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM

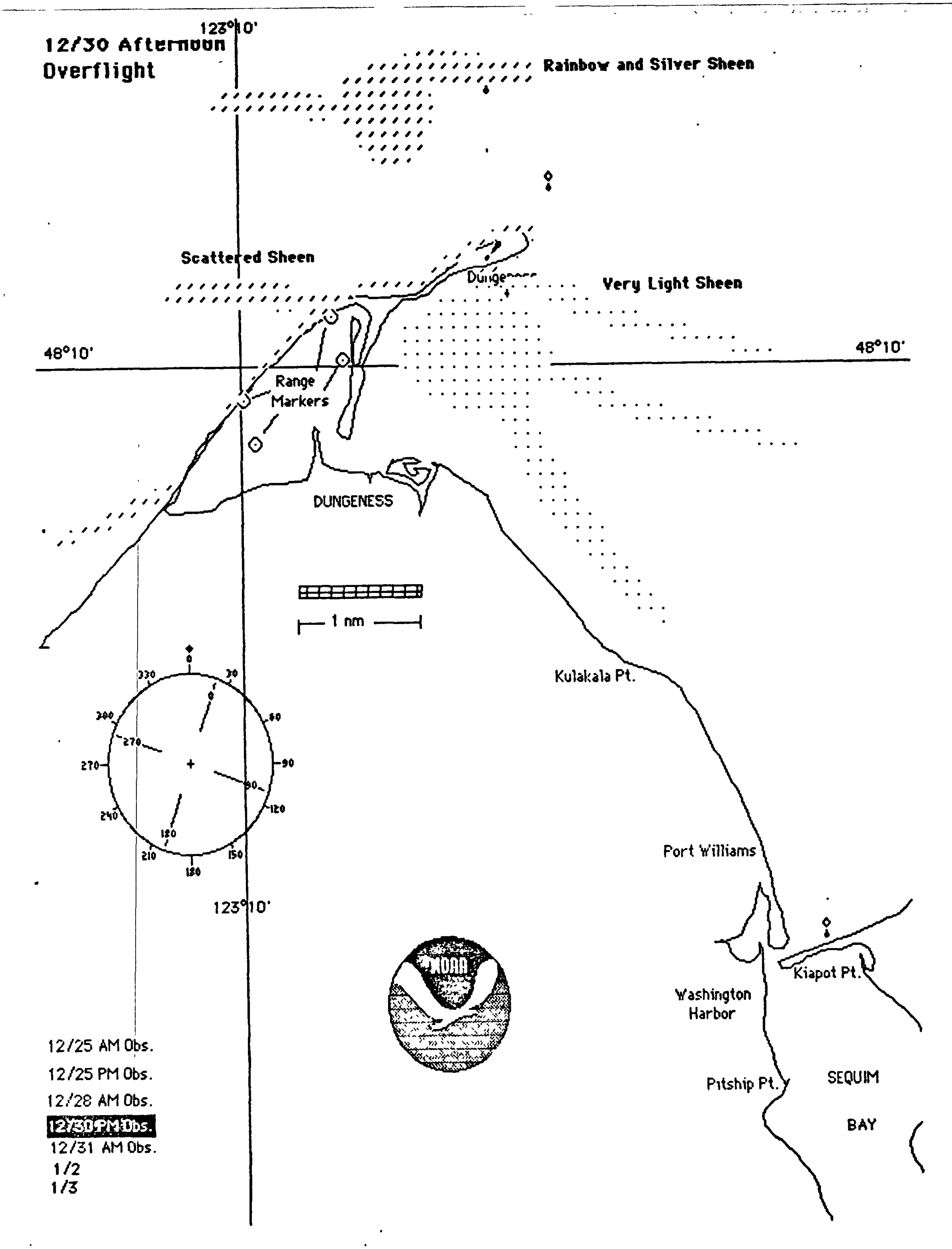

12/28 Overflights AM
Helo- LCDR Lentsch & RP
Fixed Wing- LCDR Rome & Stoner
48°20'
Low Pt.
10% of area is sheen
some Brown oil
Rainbow Sheen
5% of area is
Brown Area
1 nm
Twin
124°00'
124°00'
Some oil onshore at Pillar
Point Head. Wetland Clean.
Pillar Pt.
Helo Flight West Limit
Fixed-Wing Obs.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu
River
1 nm
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Sheen all along
10% Brown Oil
1% Heavy Oil
N-S Bands 25-75yds wide
2 mi long
NOAA
Seal Rk
Neah Bay
Koitlah Pt.
124°40'
Dome
Makah
Bay
Cape
Flattery
48°20'
Tatoosh
Point of Arches


12/29 Overflights
48°20'
Silver and Rainbow some Emulsified
Up to 10% Emulsified oil
Rainbow and up to 10% Emulsified oil
Low Pt.
1 nm
Twin
124°00'
124°00'
Scattered Light Sheen
USCG Flight Ends
Pillar Pt.
1400 ARCO Flight
Slip Pt.
Clallam Bay
Light Shoreline Impact
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu River
1 nm
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
NOAA
Neah Bay
Koitlah Pt.
124°40'
ODome
Makah Bay
Cape Flattery
48°20'
Tatoosh
Point of Arches

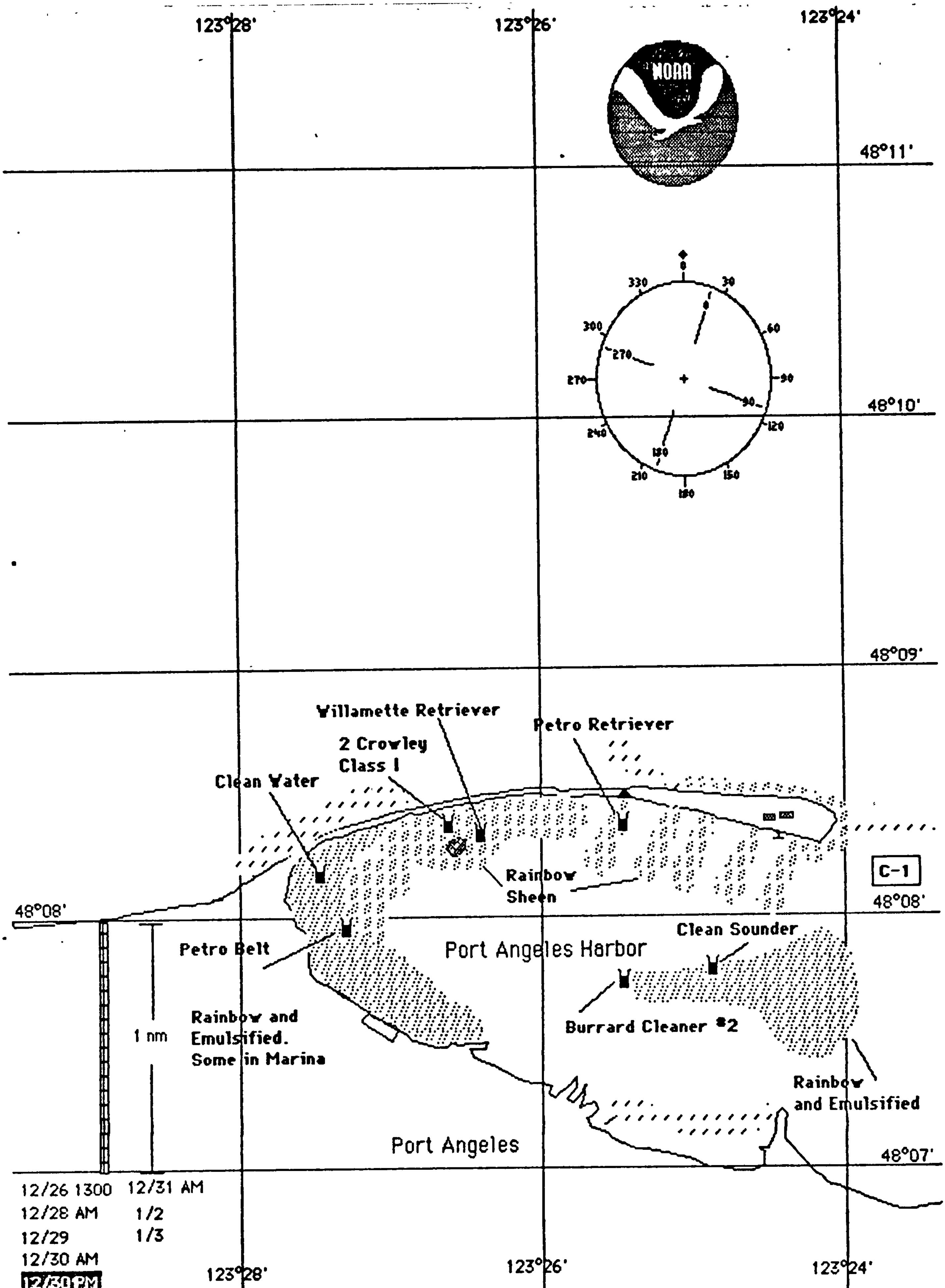

12/29 Overflights
0830 USCG & 1000 ARCO
48°20'
48°10'
Protection Is.
123°00'
123°00'
Sequim Bay
70 Seals on beach
Dungeness
= Skimmer Positions at 0930
Green Pt.
Rainbow sheen with up to 5% emulsified oil
123°20'
123°20'
Light Sheen
Gray Whale
Port Angeles
Ediz Hook
Up to 15% emulsified oil
Oil Obs. Maps
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
Race Rks
Angeles Pt.
Trajectories
22 Dec 0230
22 Dec 0930
22 Dec 1300
22 Dec 2130
Freshwater Bay
Silver and Rainbow sheen <5% of area is emulsified oil
Observatory Pt.
1 nm
123°40'
123°40'
Brown oil in 50 yard band along shore
Tongue Pt.
Crescent Bay
Agate Bay
48°20'
48°

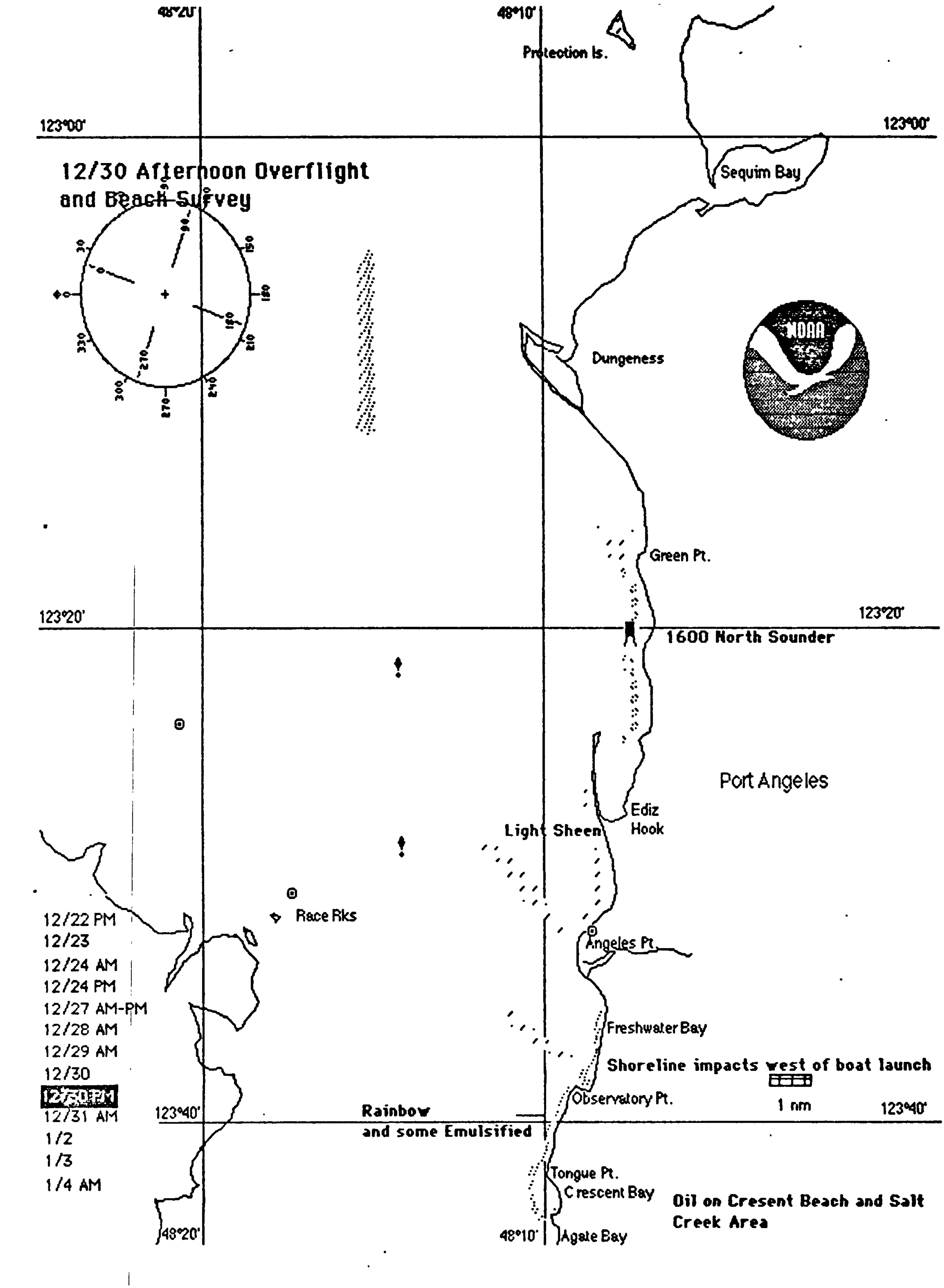

12/29 Overflights
USCG 0830
Arco 1000
Arco 1400
Rainbow sheen<5% of the area Emulisified Oil
Rainbow sheen with up to 5% of the area Emulisified Oil
48°08'
48°08'
Port Angeles Harbor
1 nm
Light Sheen
Port Angeles
48°07'
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
123°28'
123°26'
123°24'

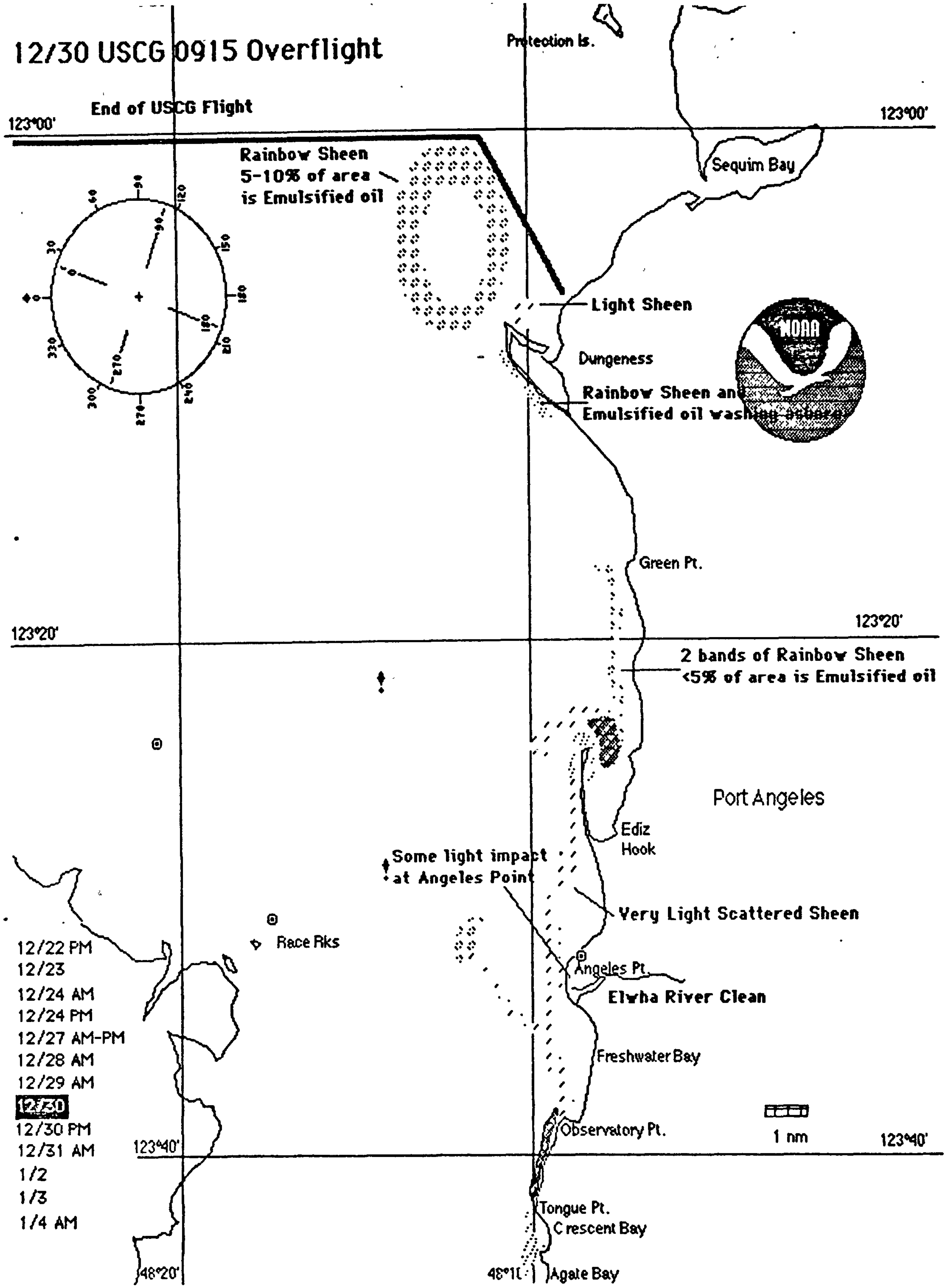

12/30 USCG 0915 Overflight
Freshwater Bay
Coville Cr.
Observatory Pt.
123°40'
Rainbow sheen
Oily debris and
Emulsified oil
Striped Peak (1135)
1nm
Tongue Point
Salt Cr.
Crescent Bay
Agate Bay
NOAA
Scattered Rainbow
Sheen, little emulsified oil
Whiskey Cr.
12/26 Flight Obs.
12/30 AM

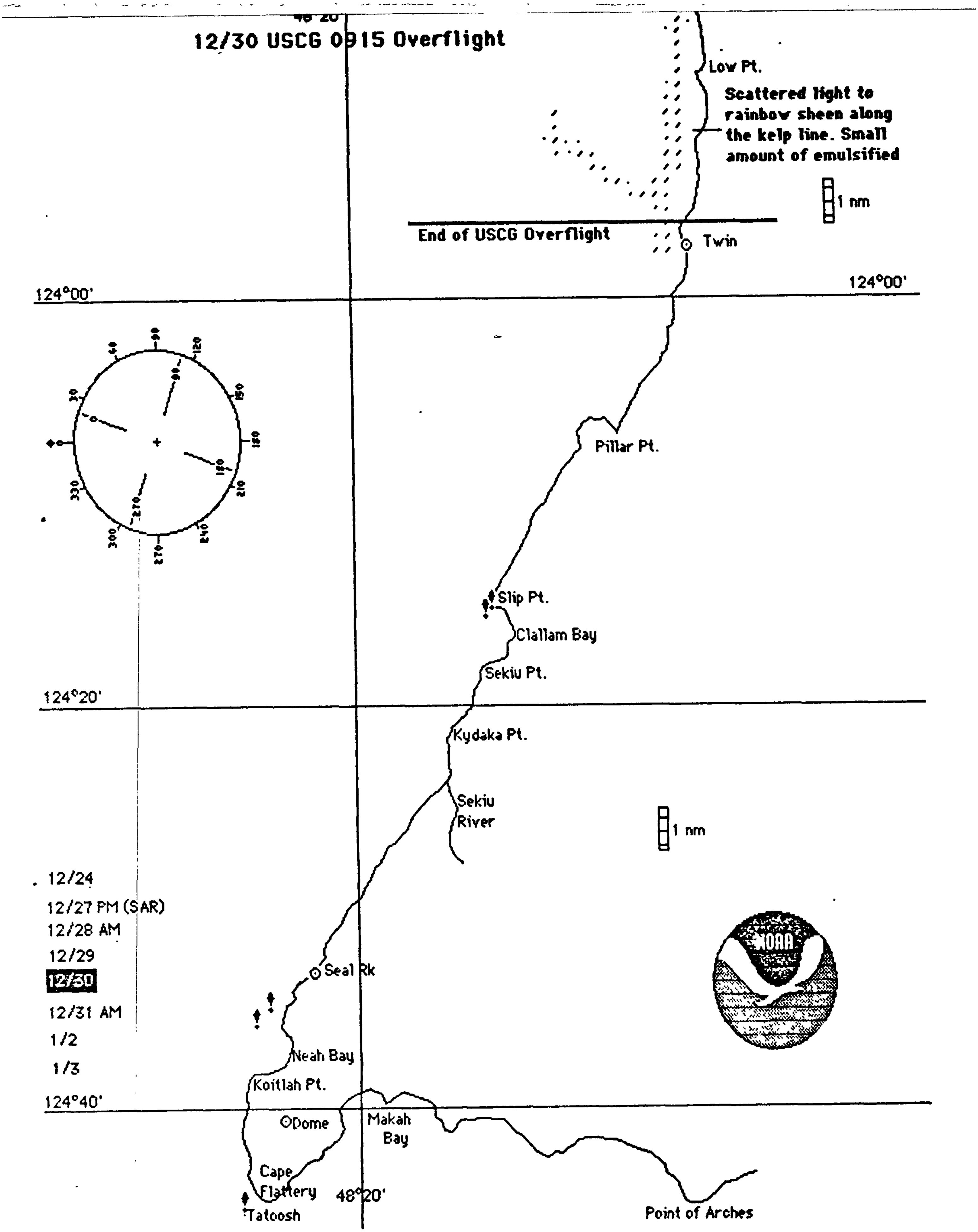


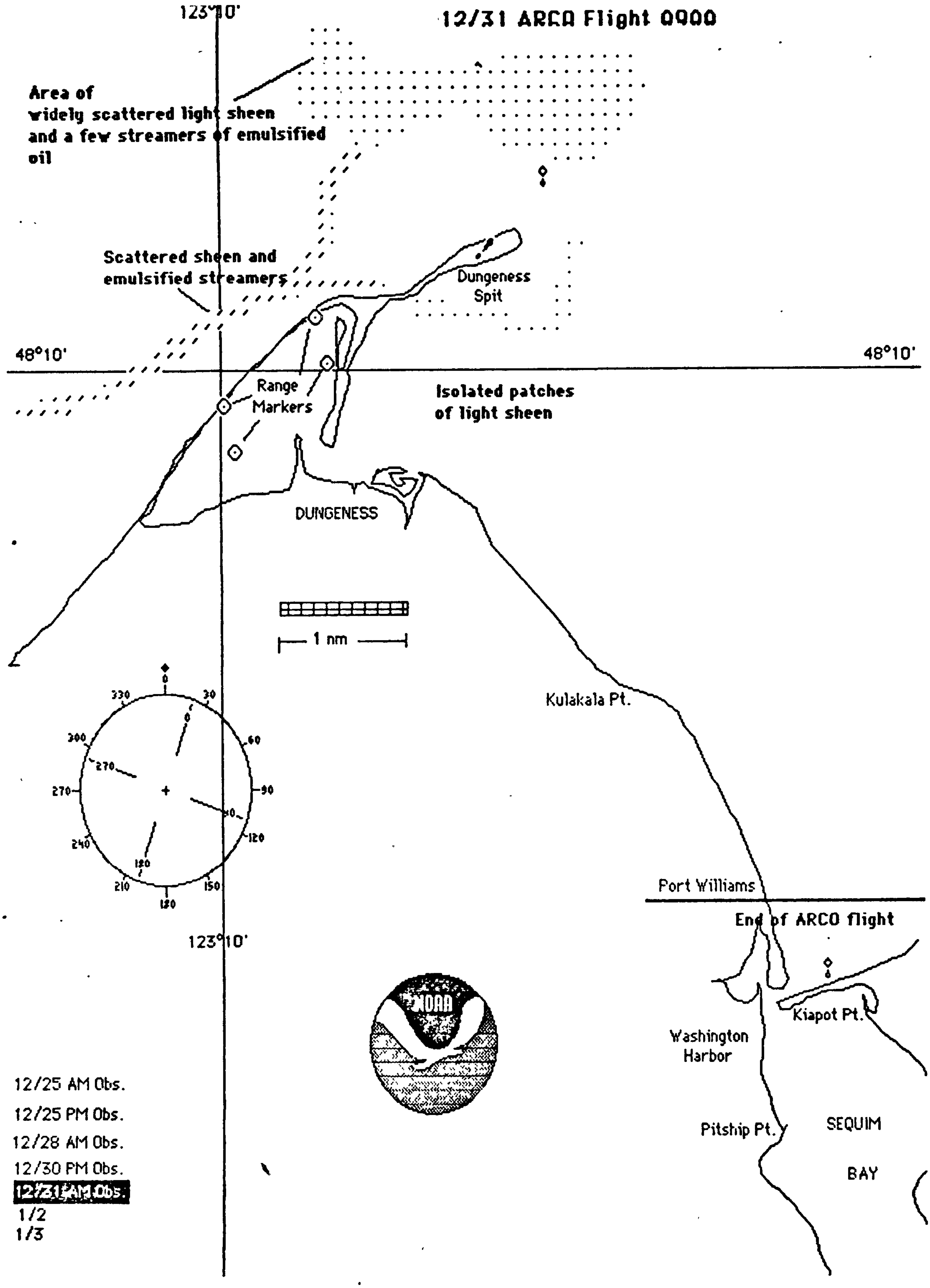
12/30 Afternoon
Overflight
123°10'
Rainbow and Silver Sheen
Scattered Sheen
Very Light Sheen
Dungeness
48°10'
48°10'
Range
Markers
DUNGENESS
1 nm
0
30
60
90
120
150
180
210
240
270
300
330
Kulakala Pt.
Port Williams
123°10'
Washington
Harbor
Kiapot Pt.
Pitship Pt.
SEQUIM
BAY
NOAA
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3


123°28'
123°26'
123°24'
NOAA
48°11'
330
30
300
60
270
90
240
120
210
150
180
0
270
90
180
48°10'
48°09'
Willamette Retriever
Petro Retriever
2 Crowley
Class I
Clean Water
Rainbow
Sheen
C-1
48°08'
Petro Belt
Port Angeles Harbor
Clean Sounder
Burrard Cleaner #2
1 nm
Rainbow and
Emulsified.
Some in Marina
Rainbow
and Emulsified
Port Angeles
48°07'
12/26 1300
12/28 AM
12/29
12/30 AM
12/30PM
12/31 AM
1/2
1/3
123°28'
123°26'
123°24'

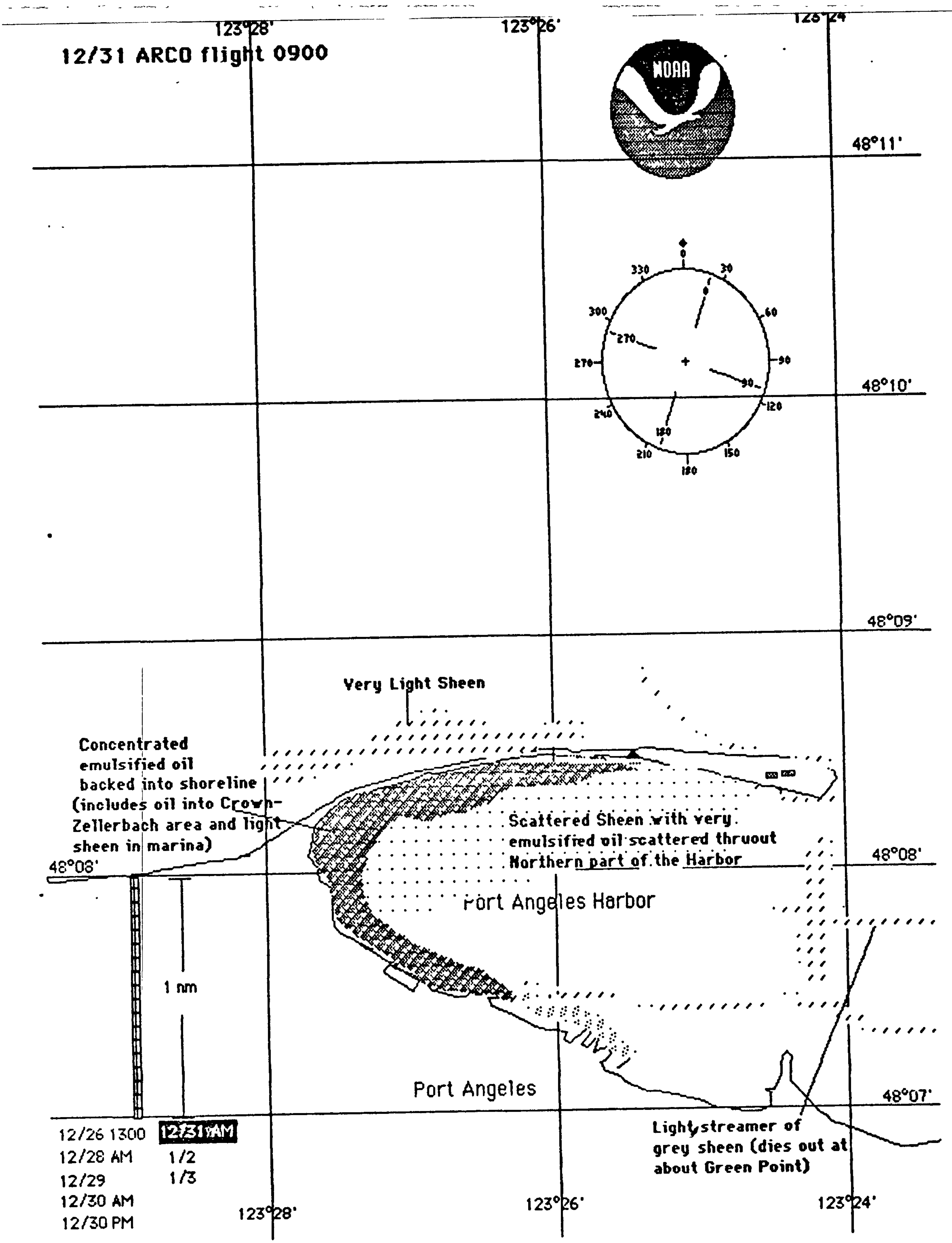

48°20'
48°10'
Protection Is.
123°00'
123°00'
12/30 Afternoon Overflight
and Beach Survey
Sequim Bay
Dungeness
NOAA
Green Pt.
123°20'
123°20'
1600 North Sounder
Port Angeles
Ediz
Hook
Light Sheen
Race Rks
Angeles Pt.
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
Freshwater Bay
Shoreline impacts west of boat launch
Observatory Pt.
1 nm
123°40'
123°40'
Rainbow
and some Emulsified
Tongue Pt.
Crescent Bay
Oil on Cresent Beach and Salt Creek Area
48°20'
48°10'
Agate Bay

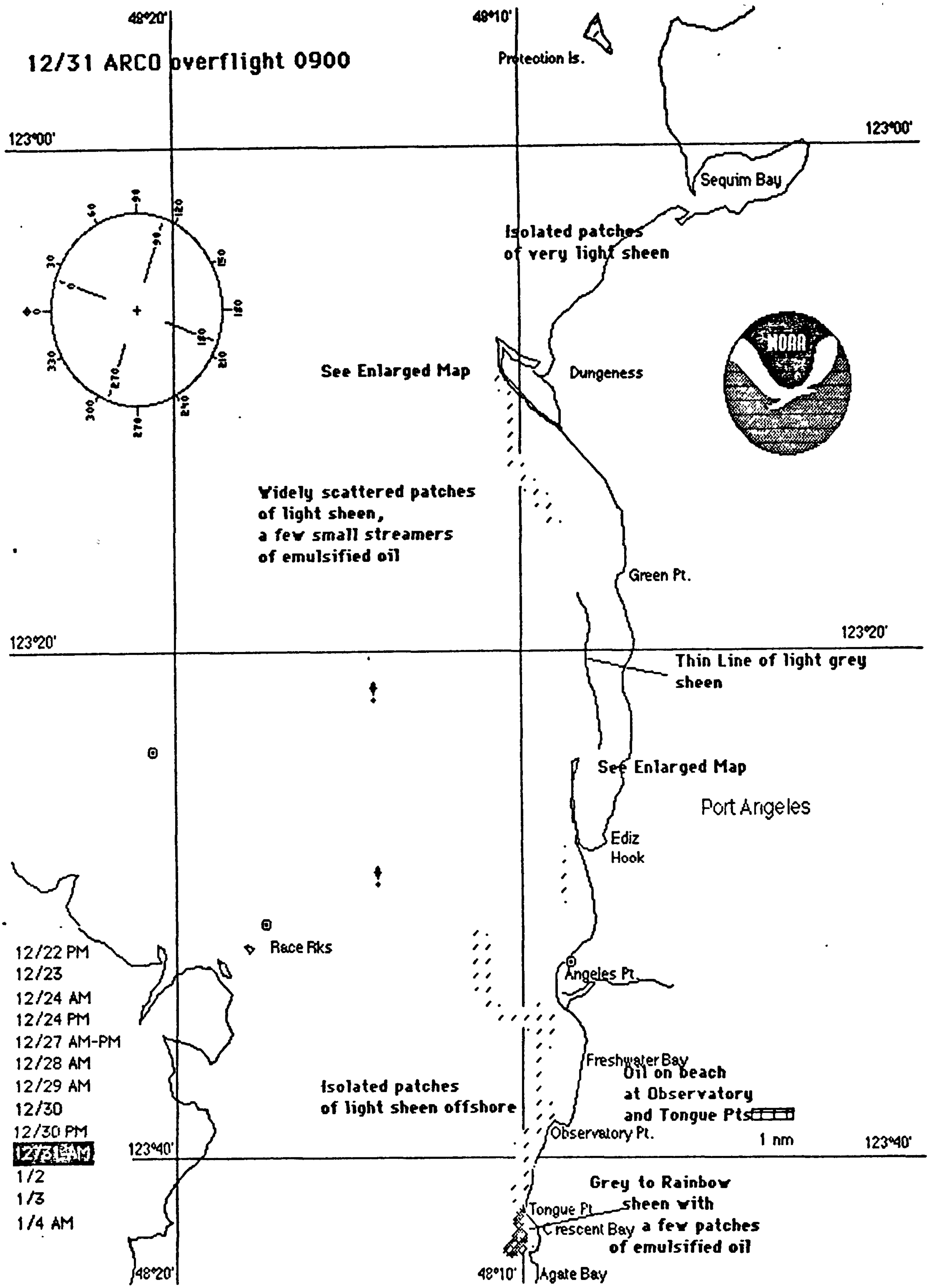

12/30 USCG 0915 Overflight
Protection Is.
End of USCG Flight
123°00'
123°00'
Rainbow Sheen
5-10% of area
is Emulsified oil
Sequim Bay
Light Sheen
Dungeness
Rainbow Sheen and
Emulsified oil washing ashore
NOAA
Green Pt.
123°20'
123°20'
2 bands of Rainbow Sheen
<5% of area is Emulsified oil
Port Angeles
Ediz
Hook
Some light impact
at Angeles Point
Very Light Scattered Sheen
Race Rks
Angeles Pt.
Elwha River Clean
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
Freshwater Bay
Observatory Pt.
1 nm
123°40'
123°40'
Tongue Pt.
Crescent Bay
48°20'
48°10'
Agate Bay

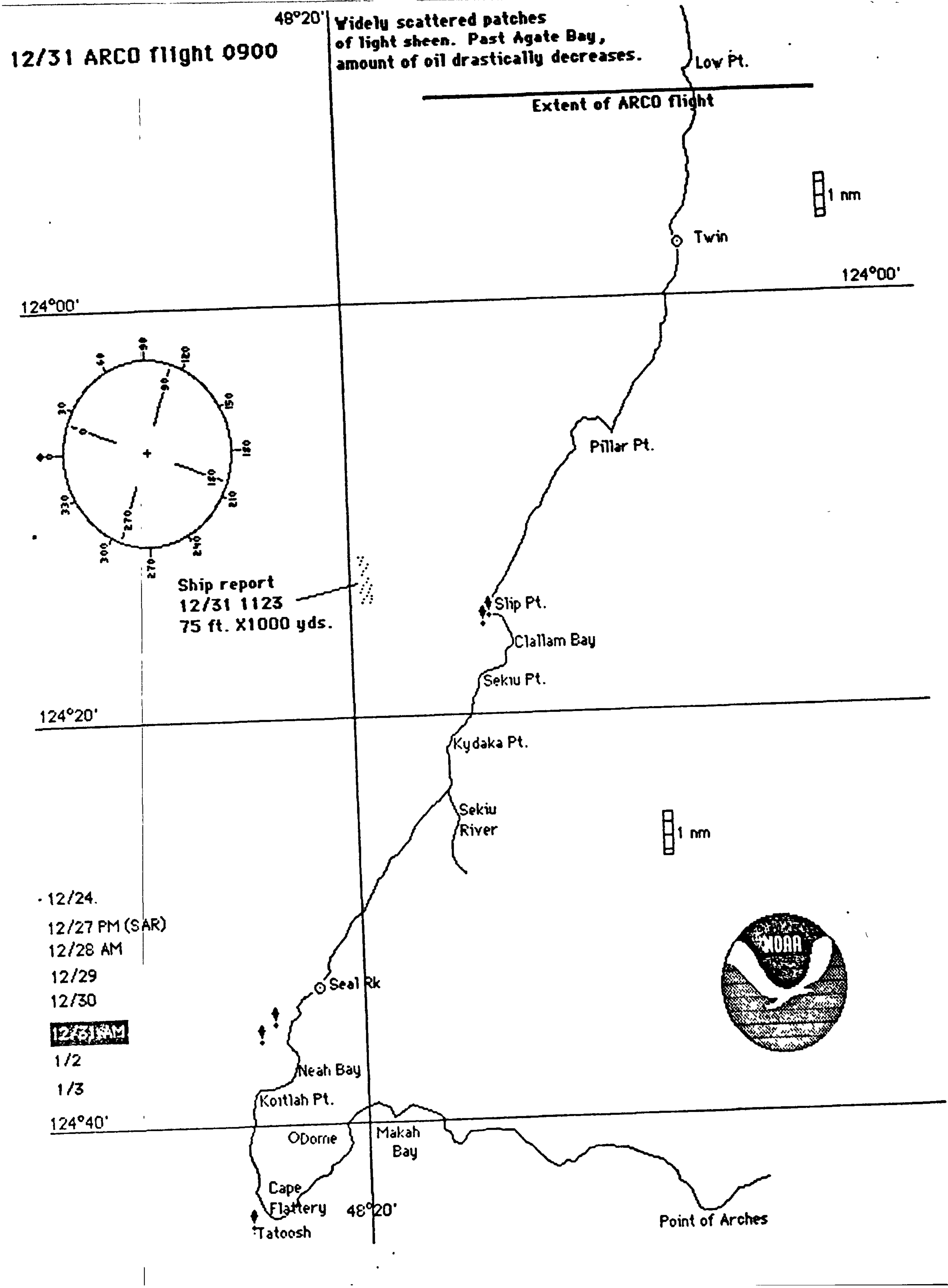

12/30 USCG 0915 Overflight
Low Pt.
Scattered light to rainbow sheen along the kelp line. Small amount of emulsified
1 nm
End of USCG Overflight
Twin
124°00'
124°00'
Pillar Pt.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu River
1 nm
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
Neah Bay
Koitlah Pt.
124°40'
Dome
Makah Bay
Cape Flattery
48°20'
Tatoosh
Point of Arches
NOAA

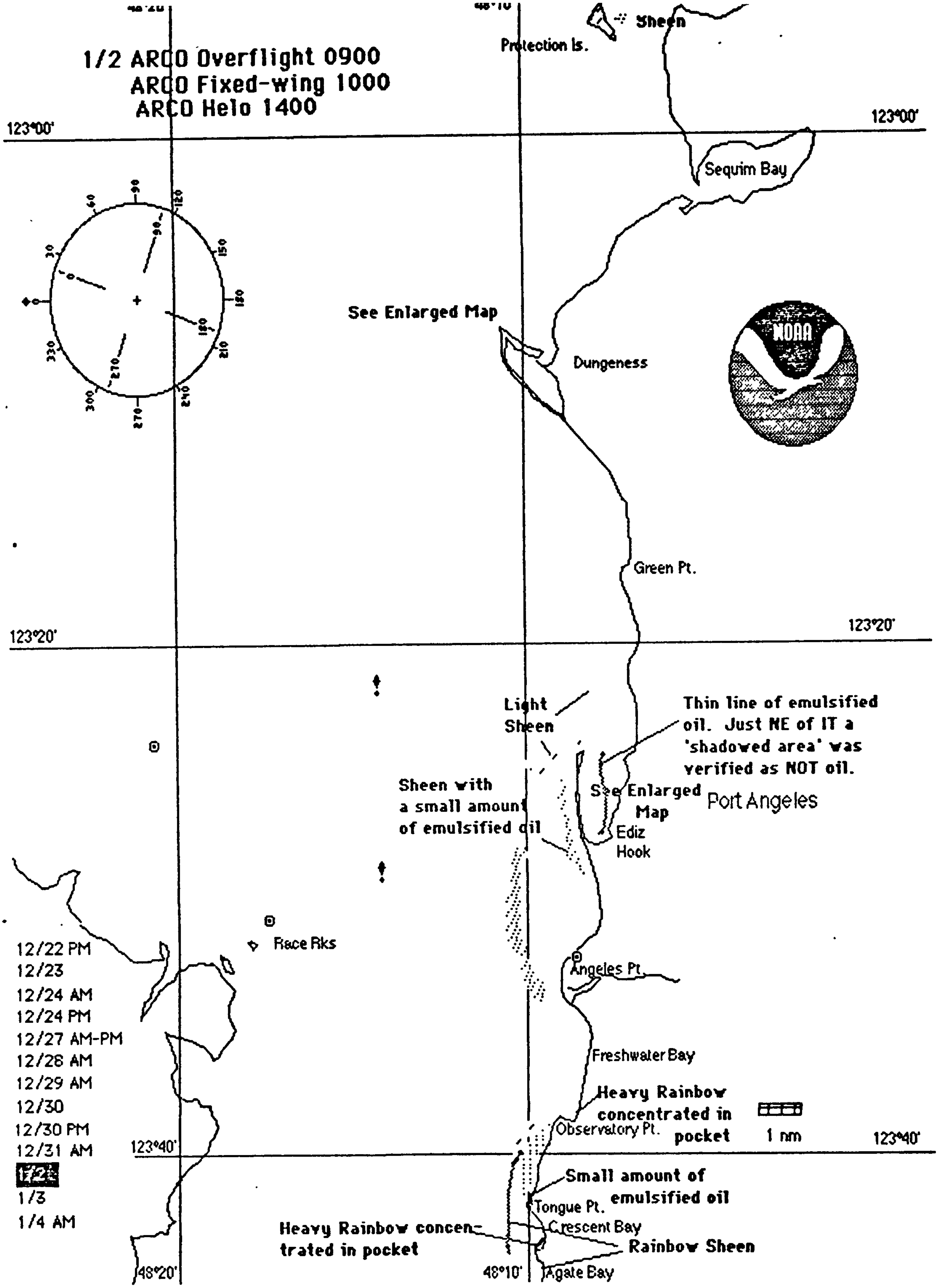


12/31 ARCO Flight 0900
123°10'
Area of widely scattered light sheen and a few streamers of emulsified oil
Scattered sheen and emulsified streamers
Dungeness Spit
48°10'
48°10'
Range Markers
Isolated patches of light sheen
DUNGENESS
1 nm
Kulakala Pt.
330
0
30
300
60
270
90
240
120
210
150
180
123°10'
Port Williams
End of ARCO flight
Kiapot Pt.
Washington Harbor
Pitship Pt.
SEQUIM
BAY
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3

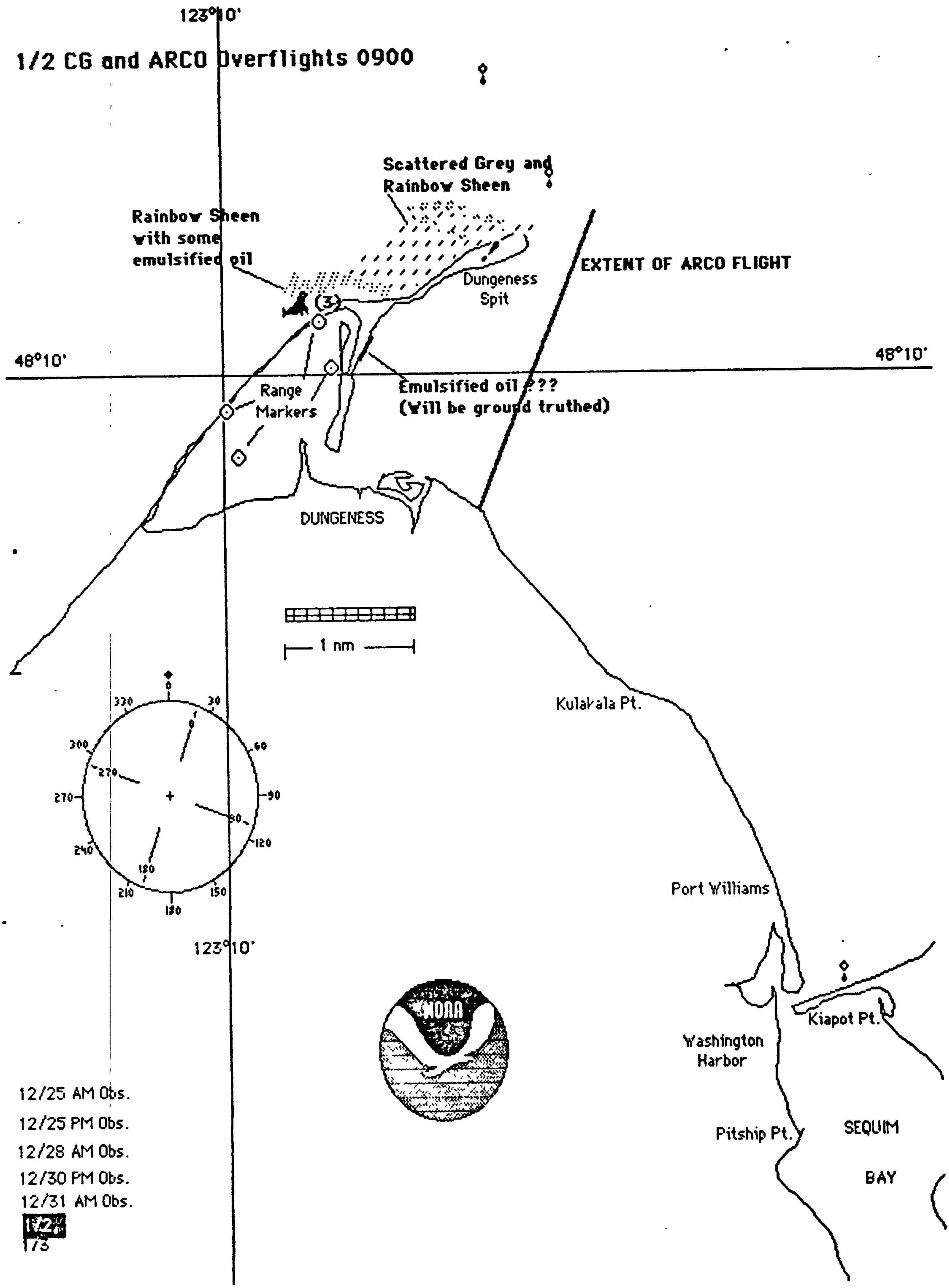

12/31 ARCO flight 0900
123°28'
123°26'
123°24'
NOAA
48°11'
48°10'
48°09'
48°08'
48°07'
0
30
60
90
120
150
180
210
240
270
300
330
Very Light Sheen
Concentrated emulsified oil backed into shoreline (includes oil into Crown-Zellerbach area and light sheen in marina)
Scattered Sheen with very emulsified oil scattered thruout Northern part of the Harbor
Port Angeles Harbor
1 nm
Port Angeles
Light streamer of grey sheen (dies out at about Green Point)
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3

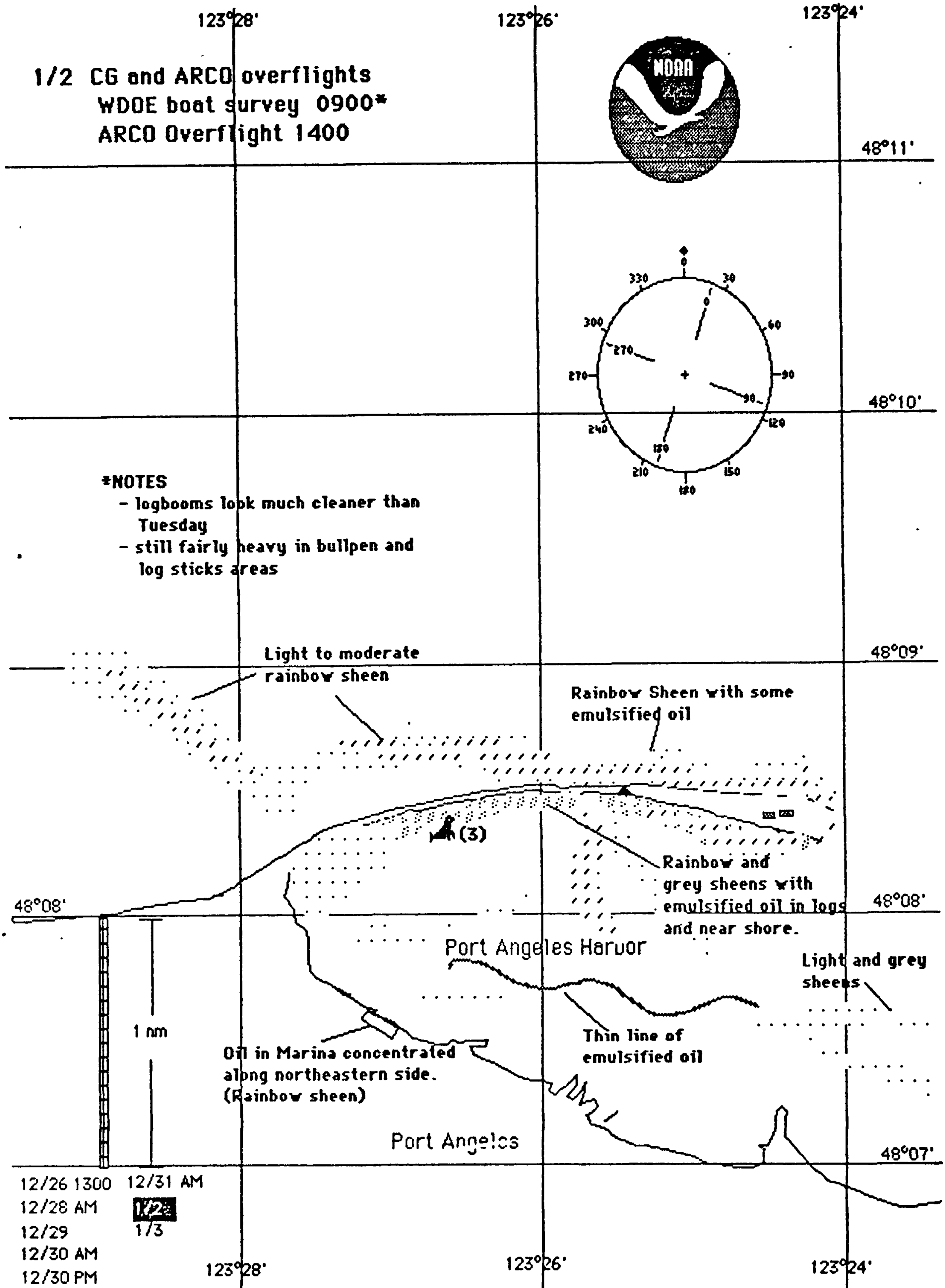

12/31 ARCO overflight 0900
48°20'
48°10'
Protection Is.
123°00'
123°00'
Sequim Bay
Isolated patches
of very light sheen
See Enlarged Map
Dungeness
Widely scattered patches
of light sheen,
a few small streamers
of emulsified oil
Green Pt.
123°20'
123°20'
Thin Line of light grey
sheen
See Enlarged Map
Port Angeles
Ediz
Hook
Race Rks
Angeles Pt.
Freshwater Bay
Oil on beach
at Observatory
and Tongue Pts
Isolated patches
of light sheen offshore
Observatory Pt.
1 nm
123°40'
123°40'
Grey to Rainbow
sheen with
a few patches
of emulsified oil
Tongue Pt
Crescent Bay
Agate Bay
48°20'
48°10'
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM

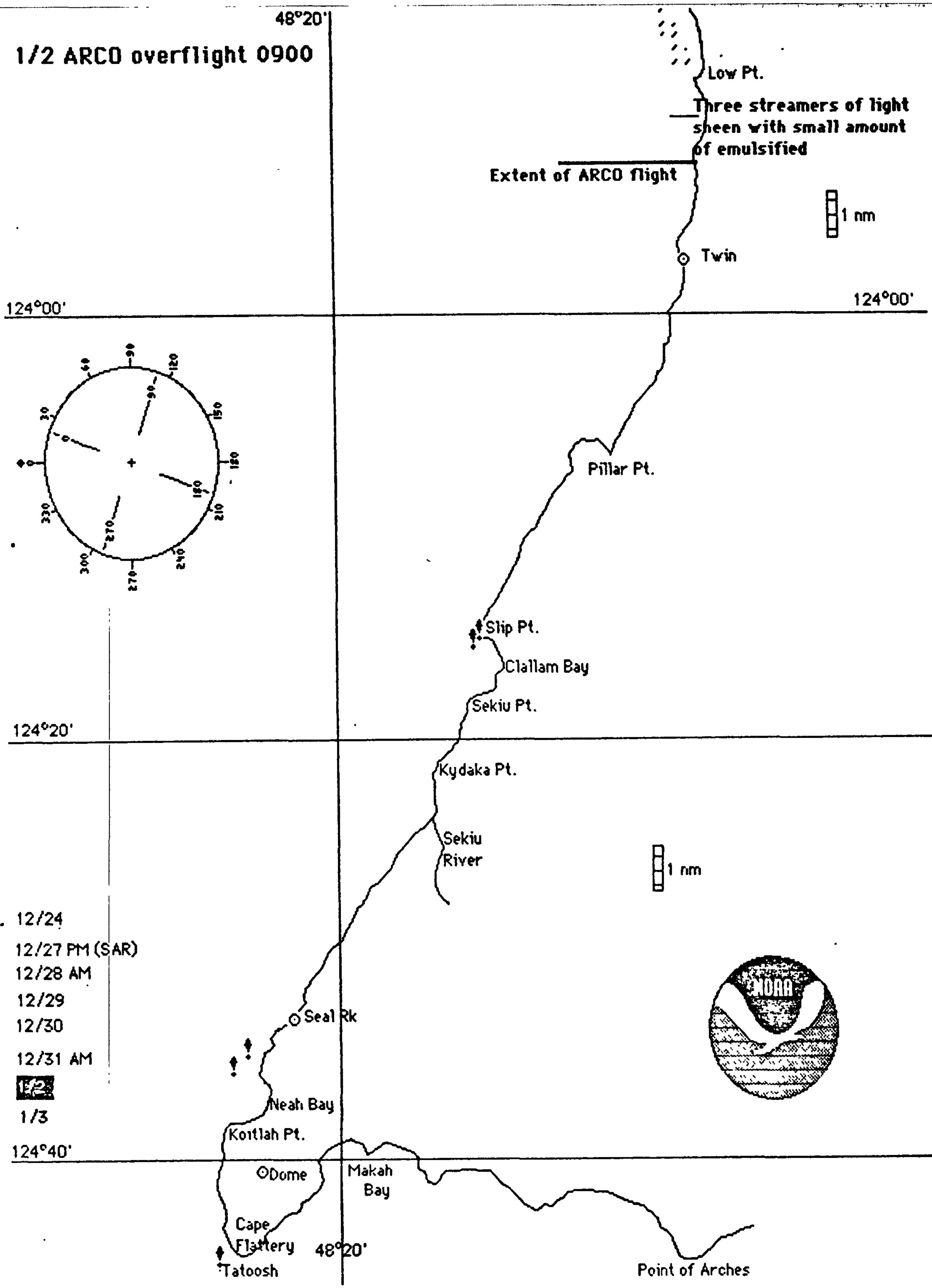

12/31 ARCO flight 0900
48°20'
Widely scattered patches of light sheen. Past Agate Bay, amount of oil drastically decreases.
Low Pt.
Extent of ARCO flight
1 nm
Twin
124°00'
124°00'
Pillar Pt.
Ship report
12/31 1123
75 ft. X1000 yds.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu
River
1 nm
12/24.
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
NOAA
Neah Bay
Koitlah Pt.
124°40'
Makah
Bay
Cape
Flattery
48°20'
Tatoosh
Point of Arches



1/2 ARCO Overflight 0900
ARCO Fixed-wing 1000
ARCO Helo 1400
Sheen
Protection Is.
123°00'
123°00'
Sequim Bay
See Enlarged Map
Dungeness
Green Pt.
123°20'
123°20'
Light Sheen
Thin line of emulsified oil. Just NE of IT a 'shadowed area' was verified as NOT oil.
Sheen with a small amount of emulsified oil
See Enlarged Map
Port Angeles
Ediz Hook
Race Rks
Angeles Pt.
Freshwater Bay
Heavy Rainbow concentrated in pocket
1 nm
Observatory Pt.
123°40'
123°40'
Small amount of emulsified oil
Tongue Pt.
Crescent Bay
Heavy Rainbow concentrated in pocket
Rainbow Sheen
48°20'
48°10'
Agate Bay
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
NOAA

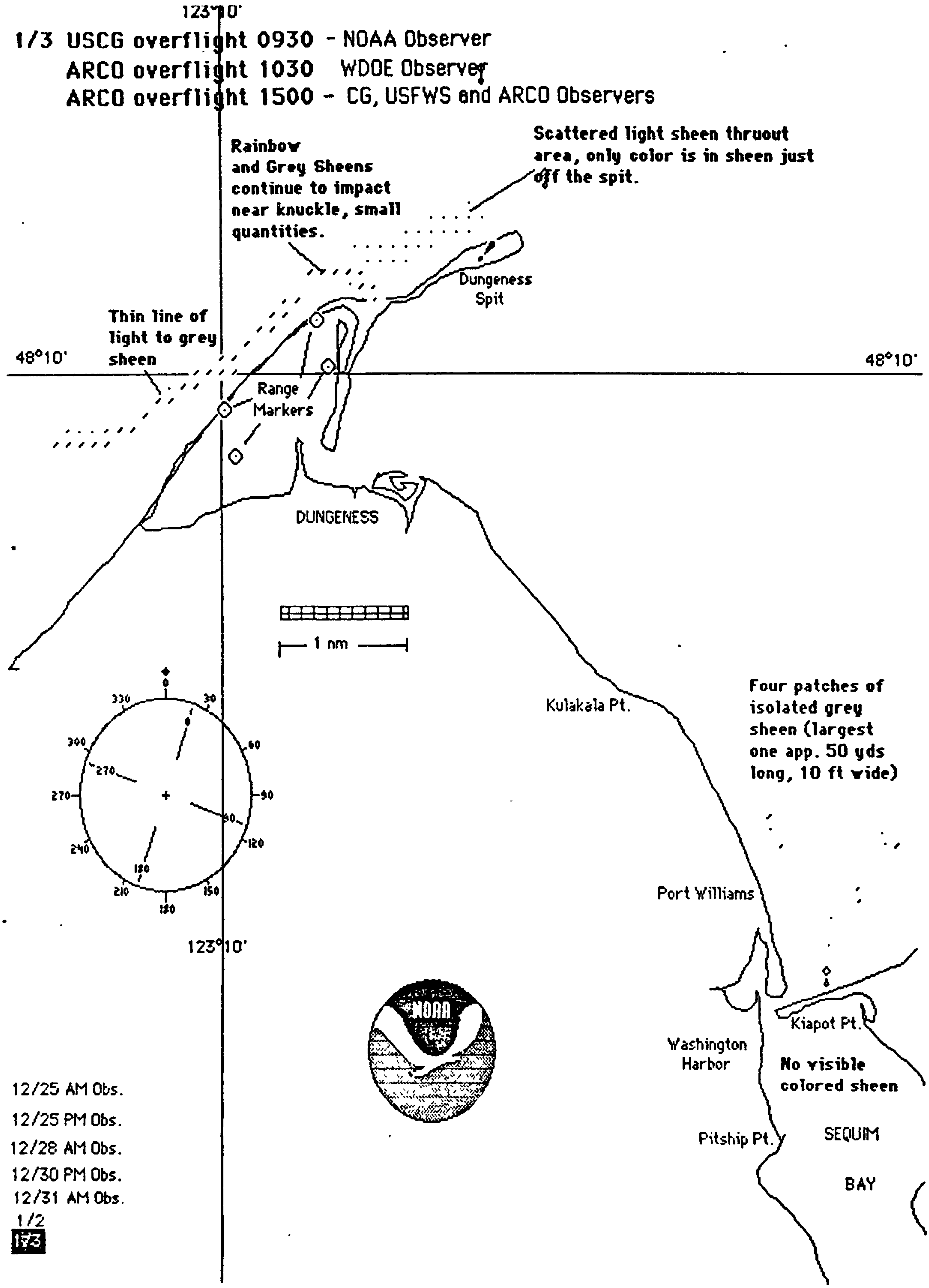

1/2 CG and ARCO Overflights 0900
123°10'
Scattered Grey and Rainbow Sheen
Rainbow Sheen with some emulsified oil
EXTENT OF ARCO FLIGHT
Dungeness Spit
(3)
48°10'
48°10'
Range Markers
Emulsified oil ???
(Will be ground truthed)
DUNGENESS
1 nm
330
0
30
300
60
270
90
240
120
210
180
150
Kulakala Pt.
Port Williams
123°10'
NOAA
Kiapot Pt.
Washington Harbor
Pitship Pt.
SEQUIM
BAY
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3

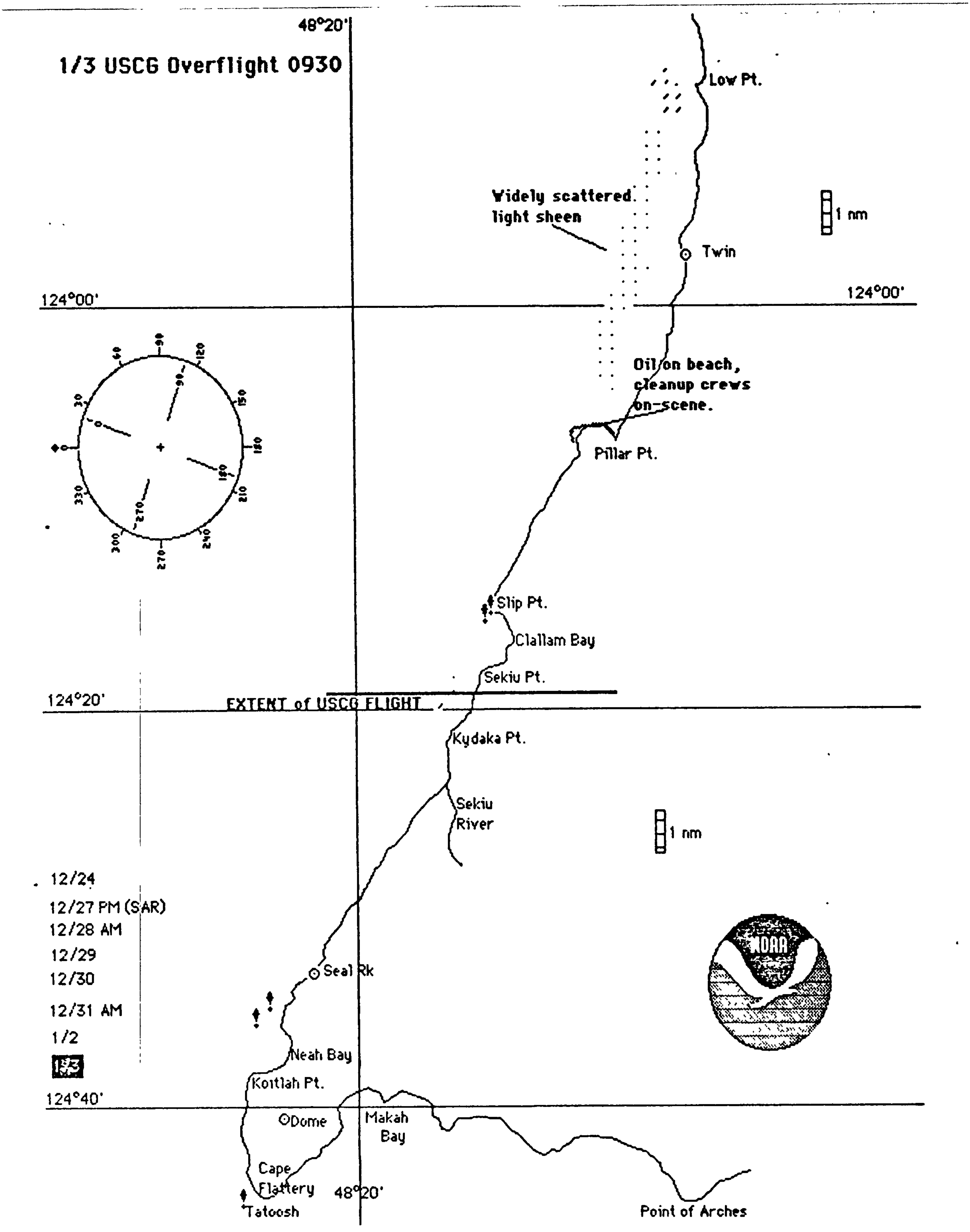

123°28'
123°26'
123°24'
1/2 CG and ARCO overflights
WDOE boat survey 0900*
ARCO Overflight 1400
NOAA
48°11'
0
330
30
0
300
60
270
270
+
90
90
48°10'
240
120
180
210
150
180
*NOTES
- logbooms look much cleaner than Tuesday
- still fairly heavy in bullpen and log sticks areas
Light to moderate rainbow sheen
48°09'
Rainbow Sheen with some emulsified oil
(3)
Rainbow and grey sheens with emulsified oil in logs and near shore.
48°08'
Port Angeles Haruor
Light and grey sheens
1 nm
Thin line of emulsified oil
Oil in Marina concentrated along northeastern side. (Rainbow sheen)
Port Angelcs
48°07'
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
123°28'
123°26'
123°24'



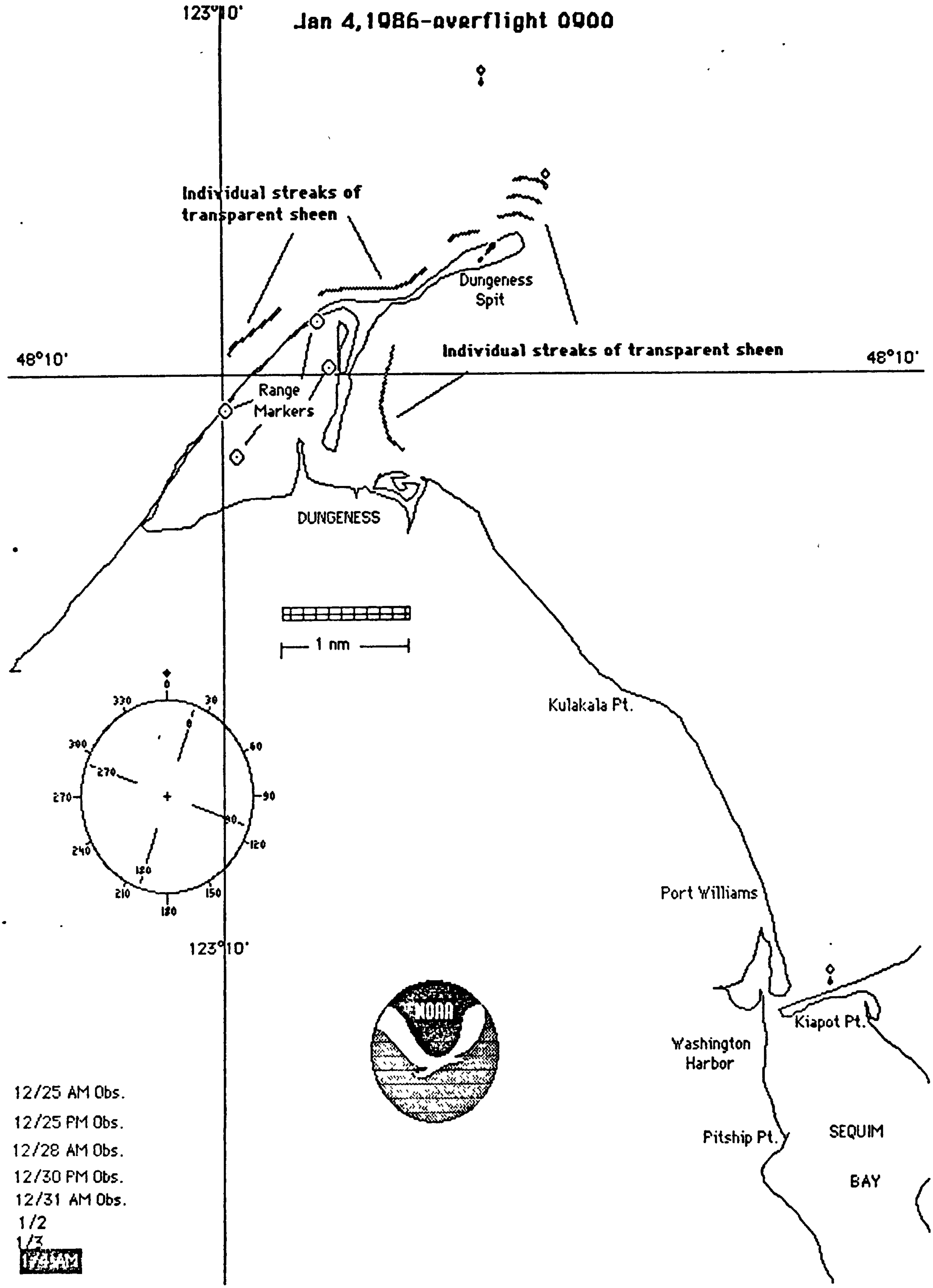
1/2 ARCO overflight 0900
48°20'
Low Pt.
Three streamers of light sheen with small amount of emulsified
Extent of ARCO flight
1 nm
Twin
124°00'
124°00'
Pillar Pt.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu River
1 nm
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
Neah Bay
Koitlah Pt.
124°40'
Dome
Makah Bay
Cape Flattery
48°20'
Tatoosh
Point of Arches
NOAA

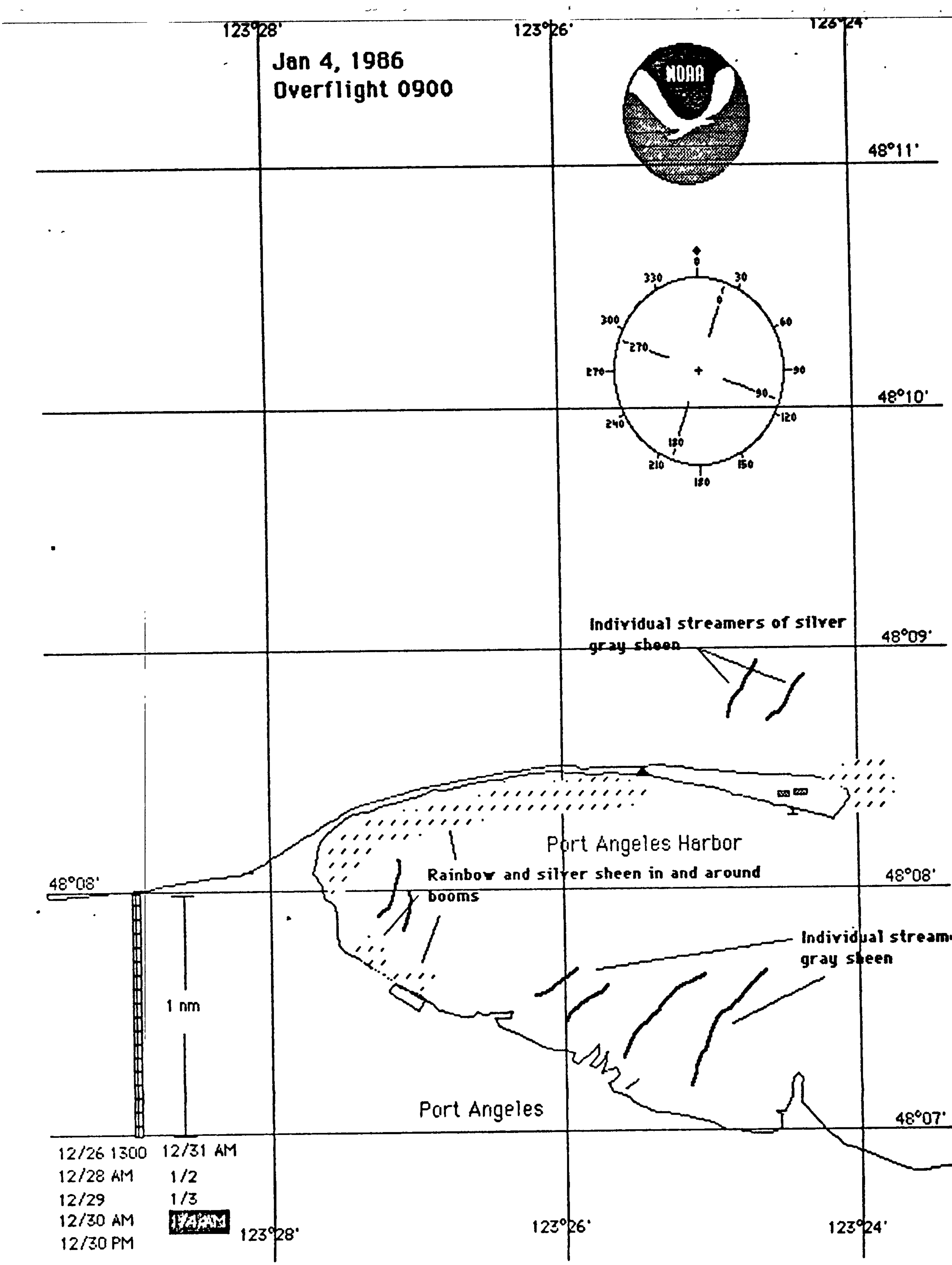
1/3 USCG overflight 0930 - NOAA Observer
ARCO overflight 1030 WDOE Observer
ARCO overflight 1500 - CG, USFWS and ARCO Observers



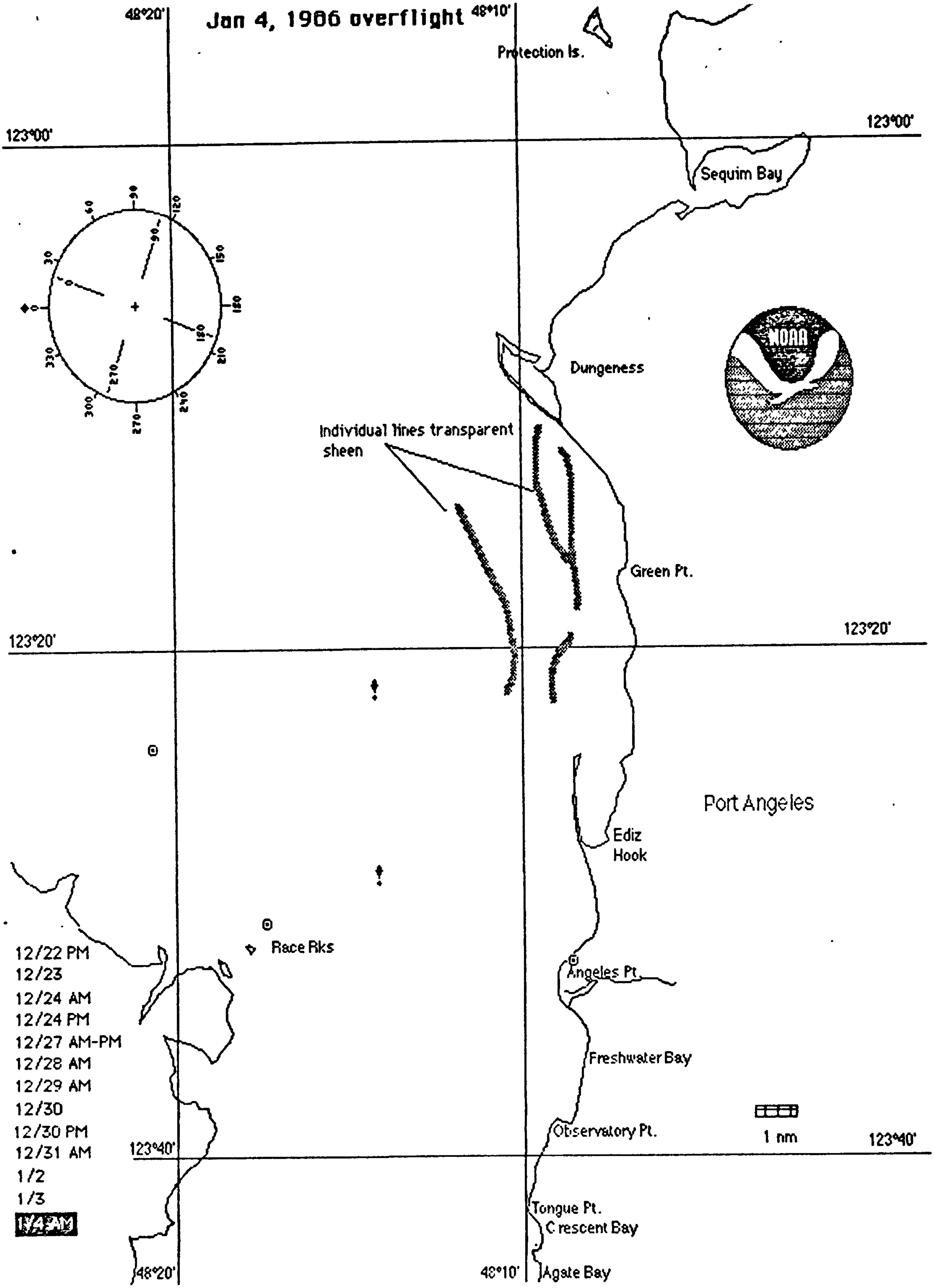

1/3 USCG Overflight 0930
48°20'
Low Pt.
Widely scattered light sheen
1 nm
Twin
124°00'
124°00'
Oil on beach, cleanup crews on-scene.
Pillar Pt.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
EXTENT of USCG FLIGHT
Kydaka Pt.
Sekiu River
1 nm
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
Neah Bay
Koitlah Pt.
124°40'
Dome
Makah Bay
Cape Flattery
48°20'
Tatoosh
Point of Arches

Jan 4,1986-overflight 0900

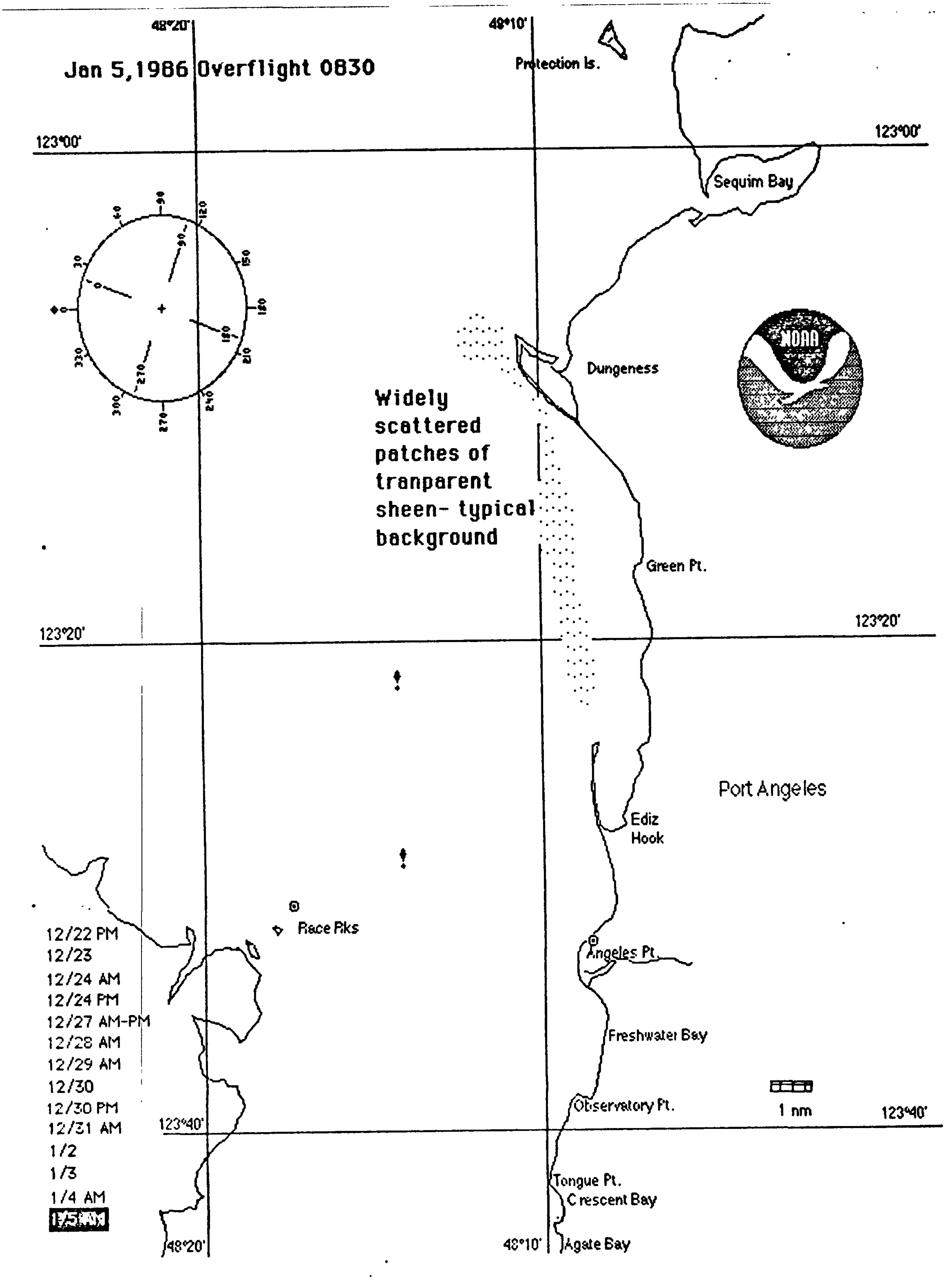




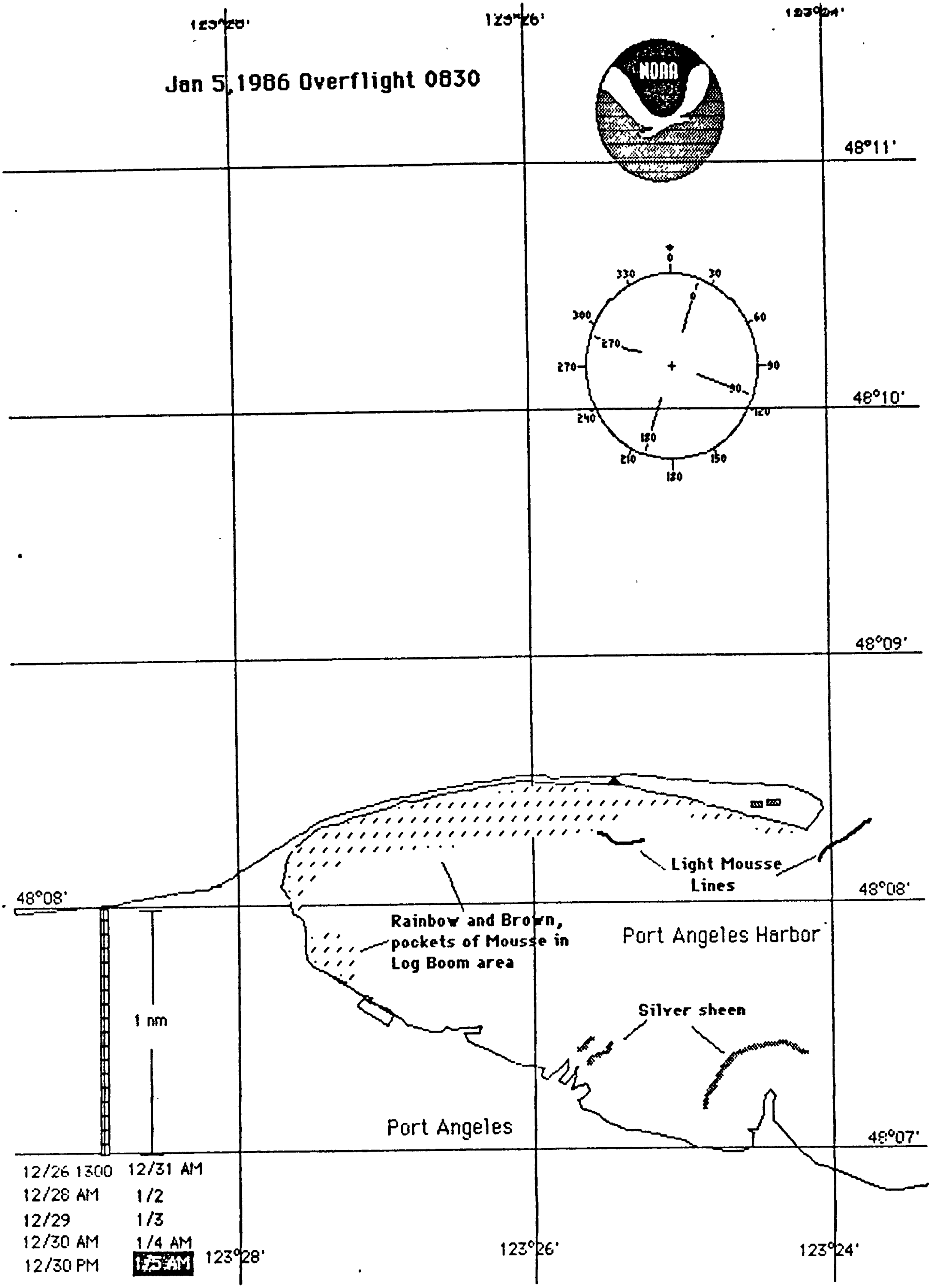
Jan 4, 1986
Overflight 0900
123°28'
123°26'
123°24'
48°11'
48°10'
48°09'
48°08'
48°07'
Individual streamers of silver gray sheen
Port Angeles Harbor
Rainbow and silver sheen in and around booms
Individual stream
gray sheen
1 nm
Port Angeles
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM

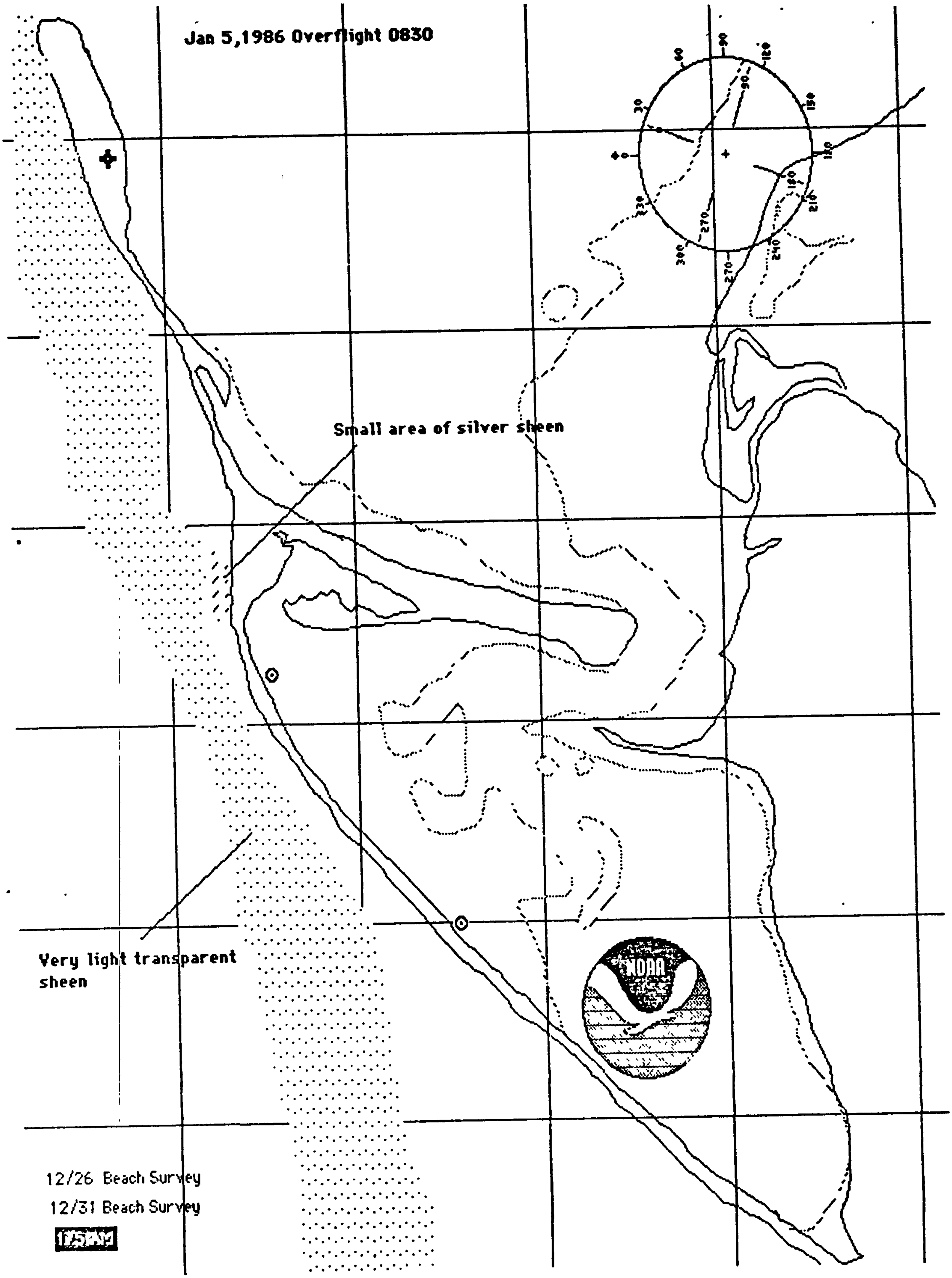


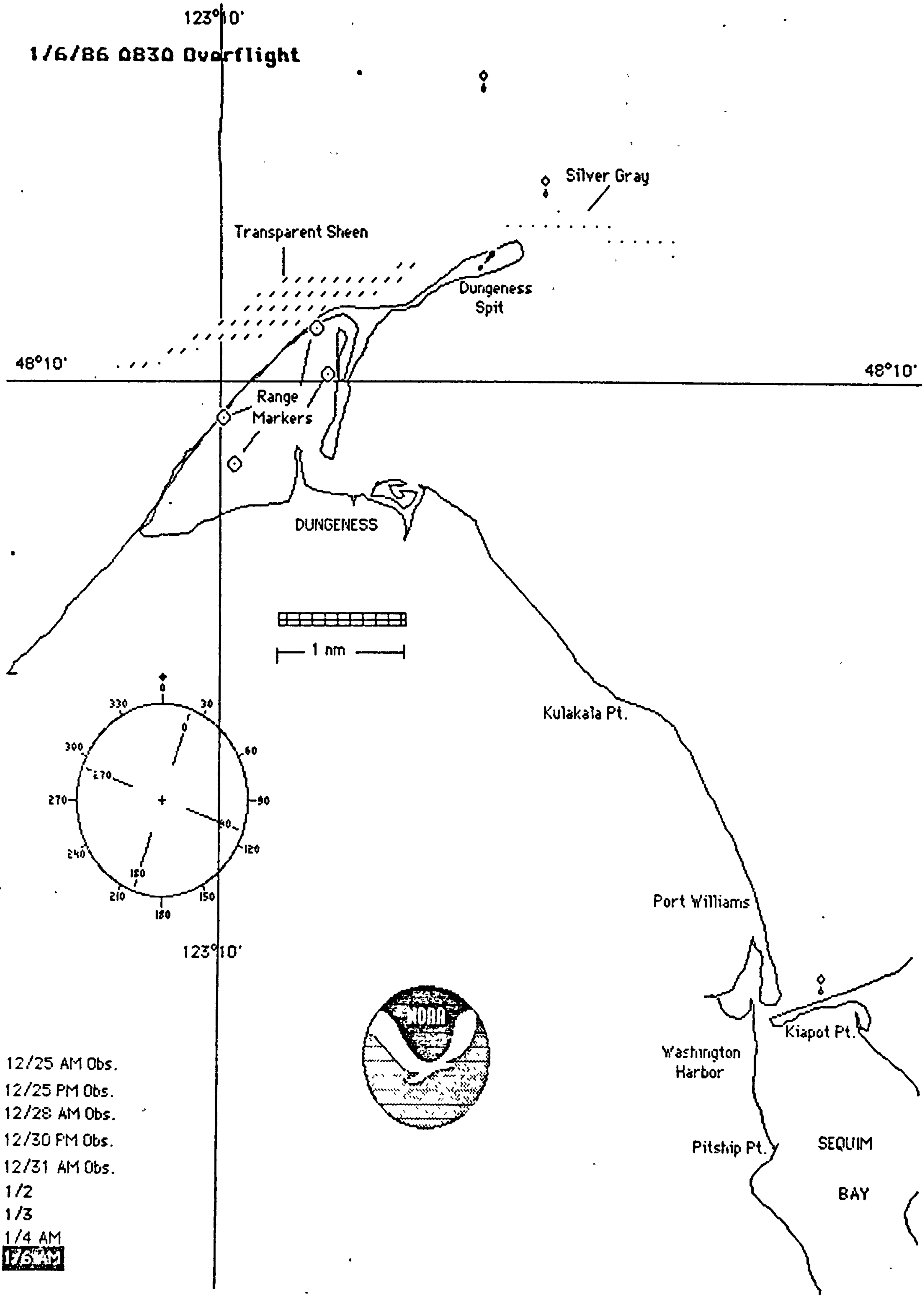
Jan 4, 1986 overflight
48°20'
48°10'
Protection Is.
123°00'
123°00'
Sequim Bay
Dungeness
Individual lines transparent sheen
Green Pt.
123°20'
123°20'
Port Angeles
Ediz Hook
Race Rks
Angeles Pt.
Freshwater Bay
Observatory Pt.
1 nm
123°40'
123°40'
Tongue Pt.
Crescent Bay
Agate Bay
48°20'
48°10'
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM



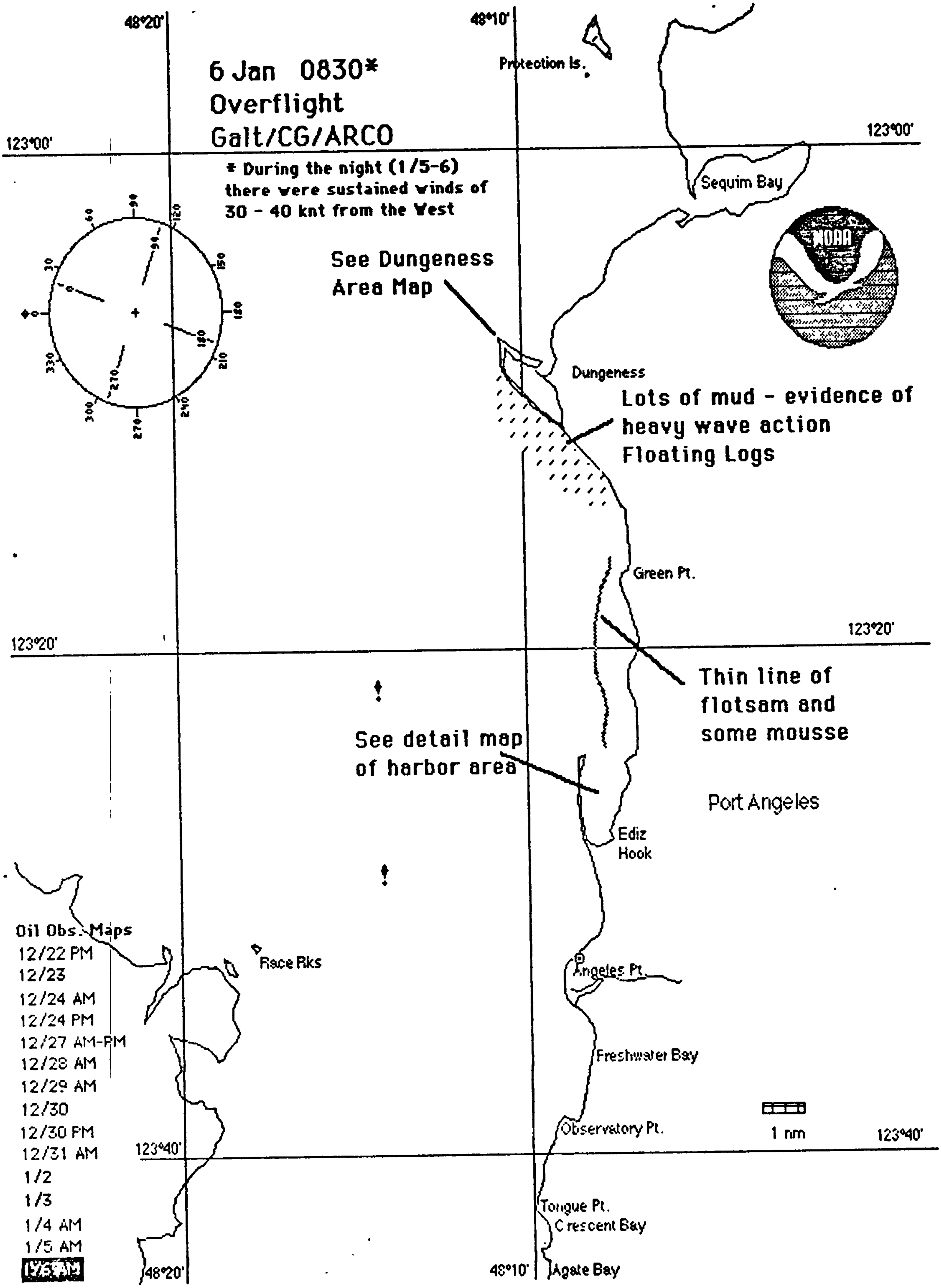
Jan 5,1986 Overflight 0830
48°20'
48°10'
Protection Is.
123°00'
123°00'
Sequim Bay
Dungeness
NOAA
Widely scattered patches of tranparent sheen- typical background
Green Pt.
123°20'
123°20'
Port Angeles
Ediz Hook
Race Rks
Angeles Pt.
Freshwater Bay
Observatory Pt.
1 nm
123°40'
123°40'
Tongue Pt.
Crescent Bay
Agate Bay
48°20'
48°10'
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM

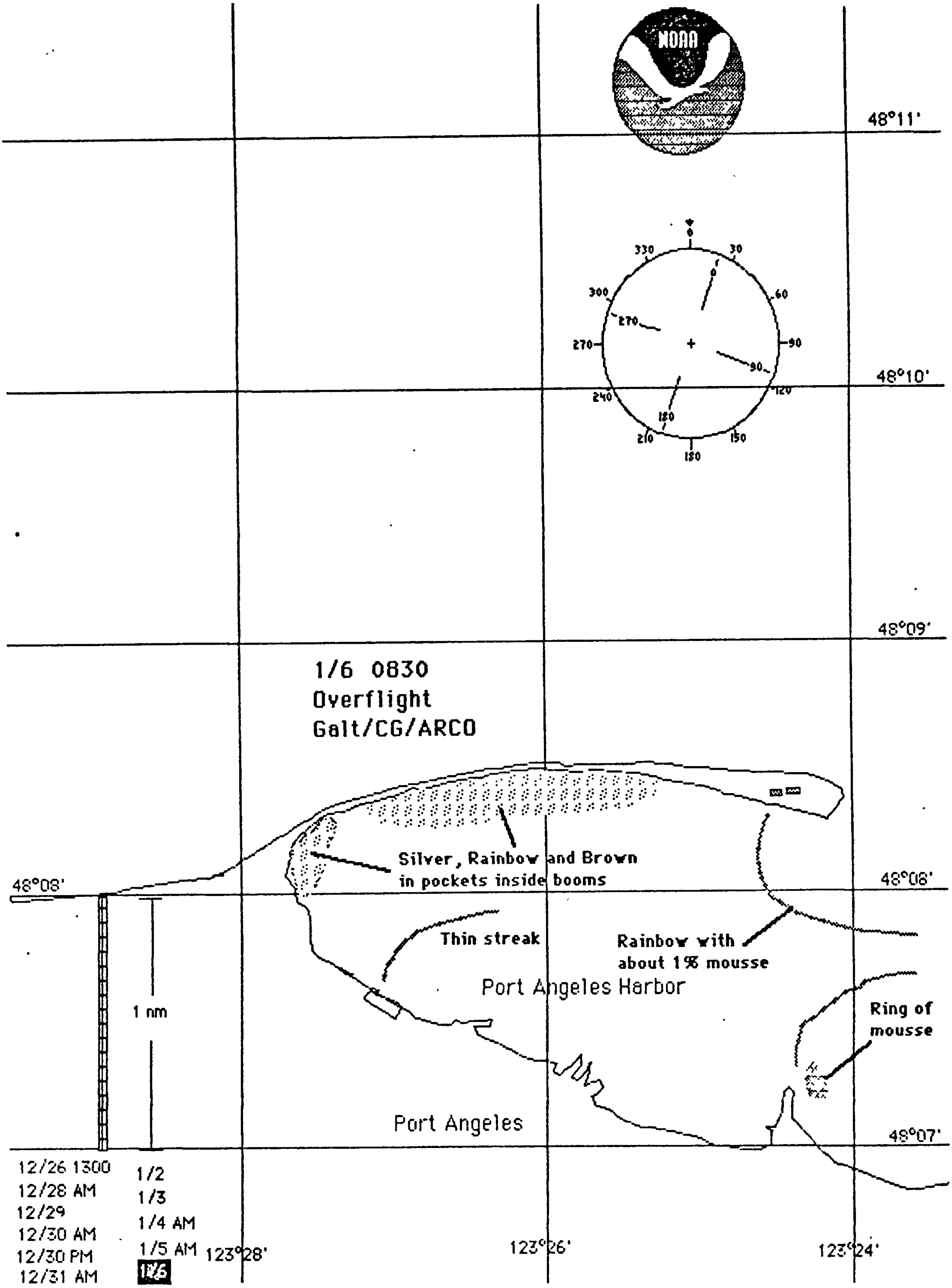

Jan 5, 1986 Overflight 0830
NOAA
123°28'
123°26'
123°24'
48°11'
48°10'
48°09'
48°08'
48°07'
0
30
60
90
120
150
180
210
240
270
300
330
Light Mousse Lines
Rainbow and Brown, pockets of Mousse in Log Boom area
Port Angeles Harbor
Silver sheen
1 nm
Port Angeles
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM

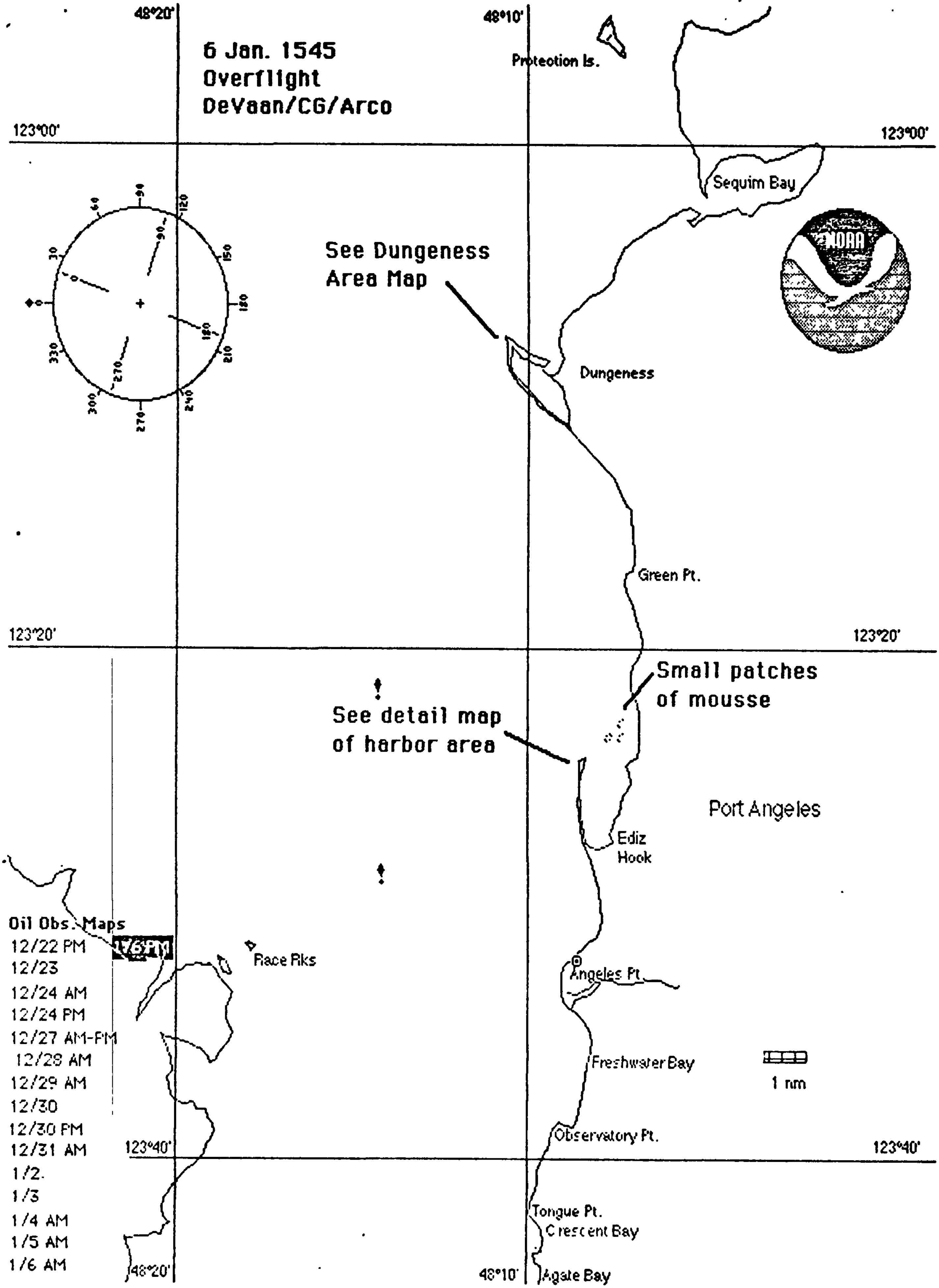

Jan 5,1986 Overflight 0830
Small area of silver sheen
Very light transparent sheen
12/26 Beach Survey
12/31 Beach Survey
1/5 AM
NOAA



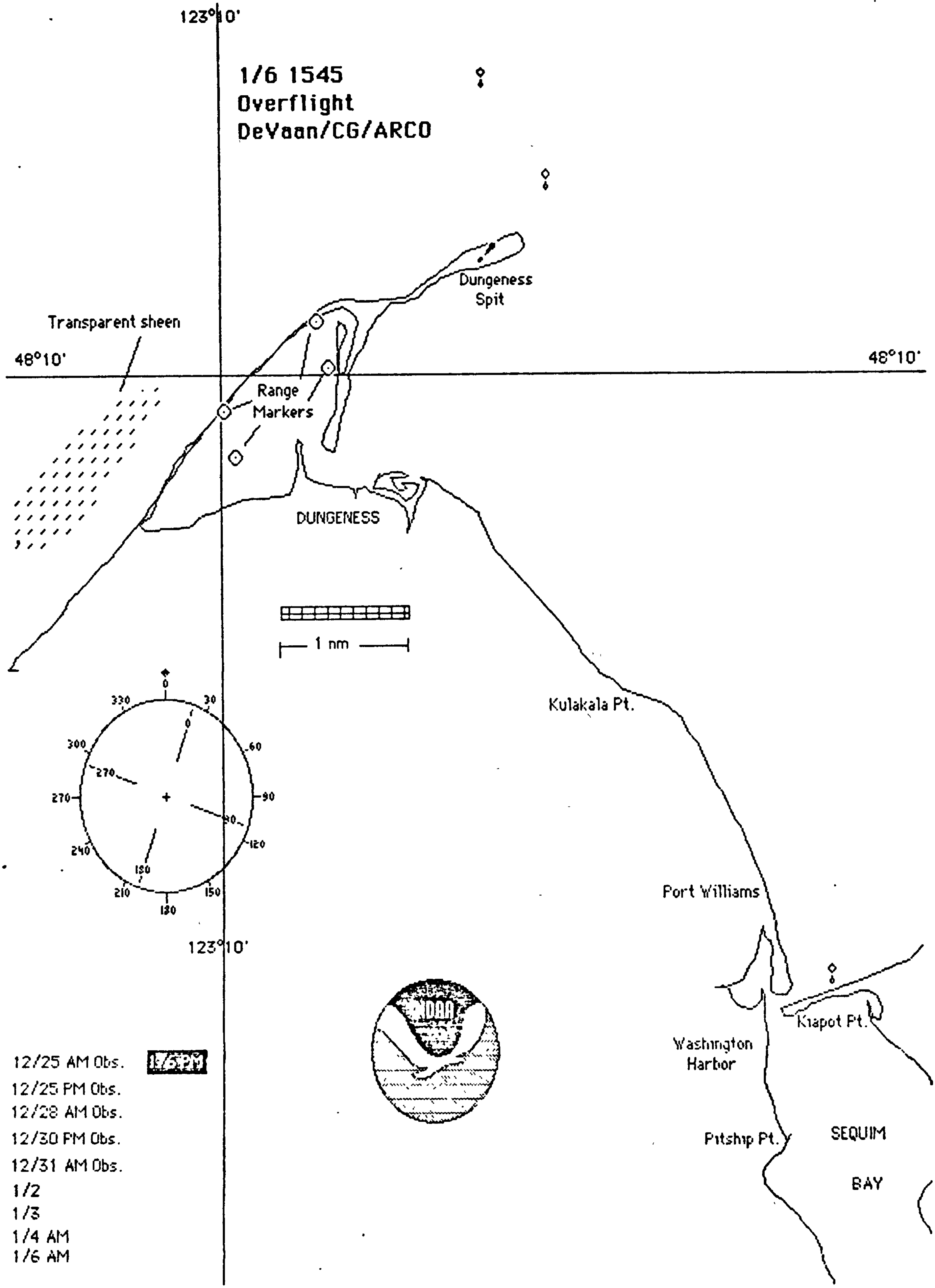
1/6/86 0830 Overflight
123°10'
Silver Gray
Transparent Sheen
Dungeness Spit
48°10'
48°10'
Range Markers
DUNGENESS
1 nm
Kulakala Pt.
330
0
30
300
60
270
90
240
120
210
150
180
123°10'
Port Williams
Washington Harbor
Kiapot Pt.
Pitship Pt.
SEQUIM
BAY
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3
1/4 AM
1/6 AM

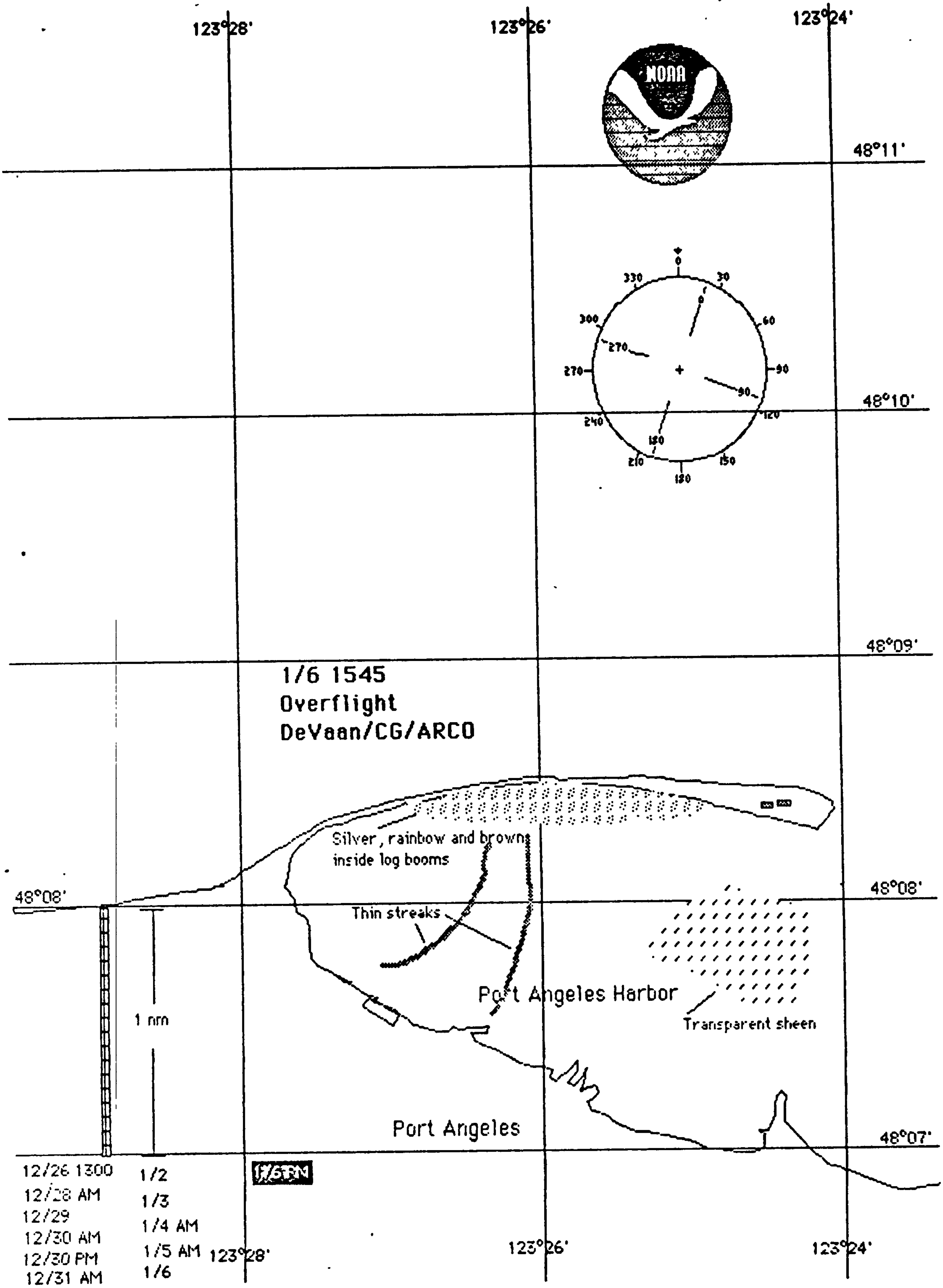

48°20'
48°10'
6 Jan 0830*
Overflight
Galt/CG/ARCO
Protection Is.
123°00'
123°00'
* During the night (1/5-6) there were sustained winds of 30 - 40 knt from the West
Sequim Bay
See Dungeness Area Map
Dungeness
Lots of mud - evidence of heavy wave action
Floating Logs
Green Pt.
123°20'
123°20'
Thin line of flotsam and some mousse
See detail map of harbor area
Port Angeles
Ediz Hook
Oil Obs. Maps
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6 AM
Race Rks
Angeles Pt.
Freshwater Bay
Observatory Pt.
1 nm
123°40'
123°40'
Tongue Pt.
Crescent Bay
48°20'
48°10'
Agate Bay


NOAA
48°11'
48°10'
48°09'
48°08'
48°07'
1/6 0830
Overflight
Galt/CG/ARCO
Silver, Rainbow and Brown
in pockets inside booms
Thin streak
Rainbow with
about 1% mousse
Port Angeles Harbor
Ring of
mousse
Port Angeles
1 nm
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6
123°28'
123°26'
123°24'

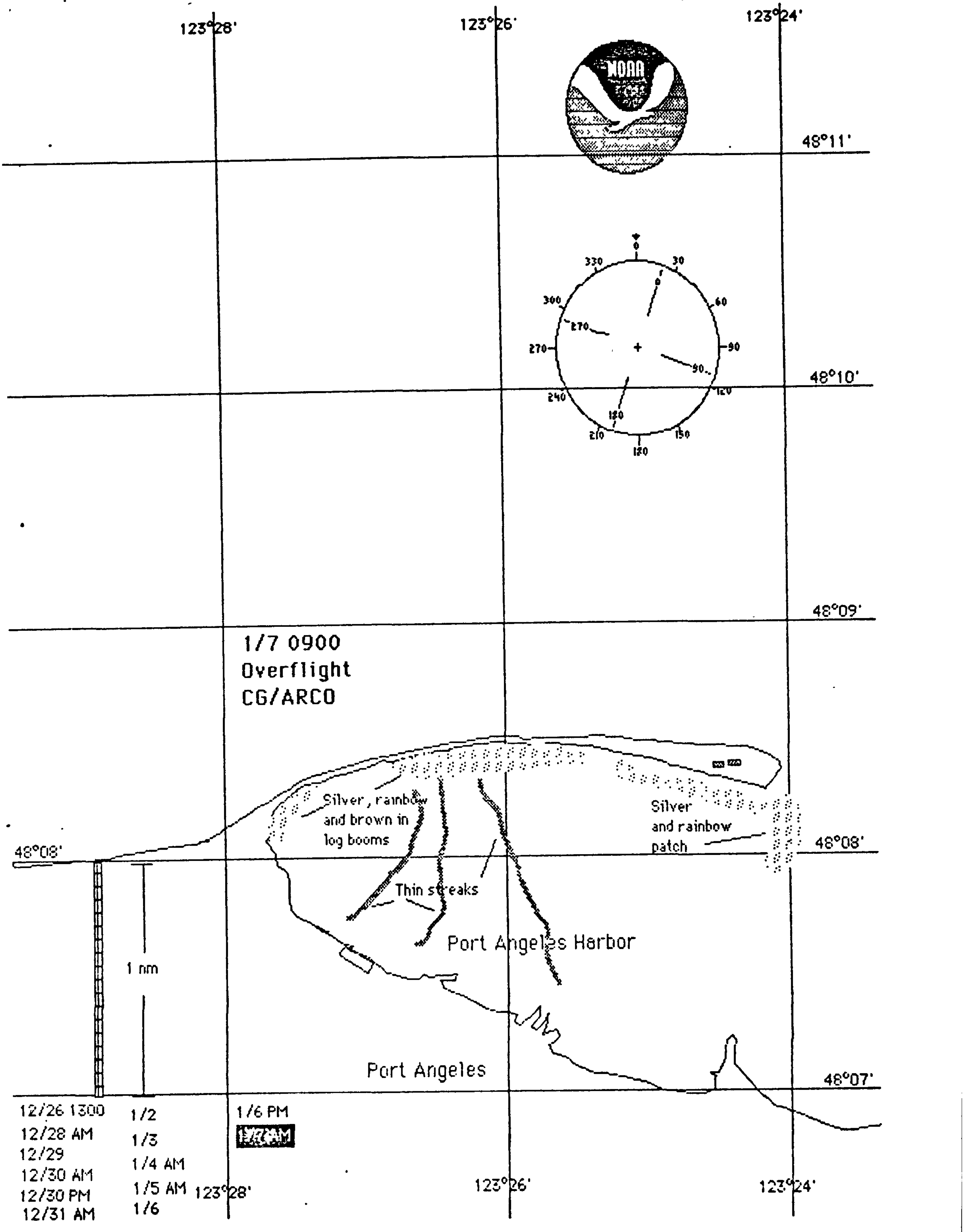


6 Jan. 1545
Overflight
DeVaan/CG/Arco
48°20'
48°10'
Protection Is.
123°00'
123°00'
Sequim Bay
See Dungeness
Area Map
Dungeness
Green Pt.
123°20'
123°20'
Small patches
of mousse
See detail map
of harbor area
Port Angeles
Ediz
Hook
Oil Obs. Maps
12/22 PM
1/6 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6 AM
Race Rks
Angeles Pt.
Freshwater Bay
1 nm
Observatory Pt.
123°40'
123°40'
Tongue Pt.
Crescent Bay
48°20'
48°10'
Agate Bay

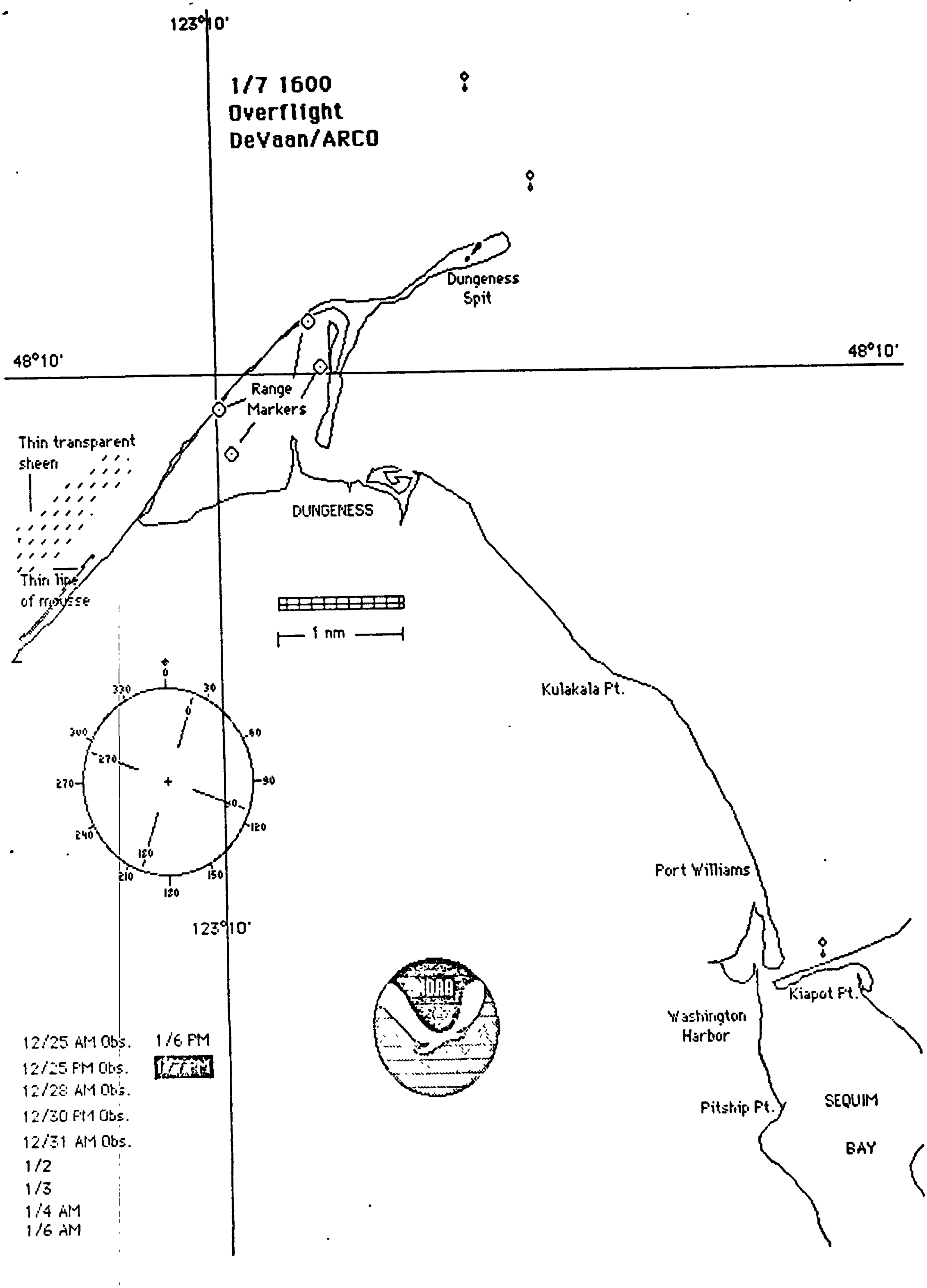

123°10'
1/6 1545
Overflight
DeVaan/CG/ARCO
Dungeness
Spit
Transparent sheen
48°10'
48°10'
Range
Markers
DUNGENESS
1 nm
Kulakala Pt.
0
330
30
300
60
270
90
240
120
210
150
180
0
270
90
150
123°10'
Port Williams
Kiapot Pt.
Washington
Harbor
Pitship Pt.
SEQUIM
BAY
12/25 AM Obs.
1/6 PM
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3
1/4 AM
1/6 AM

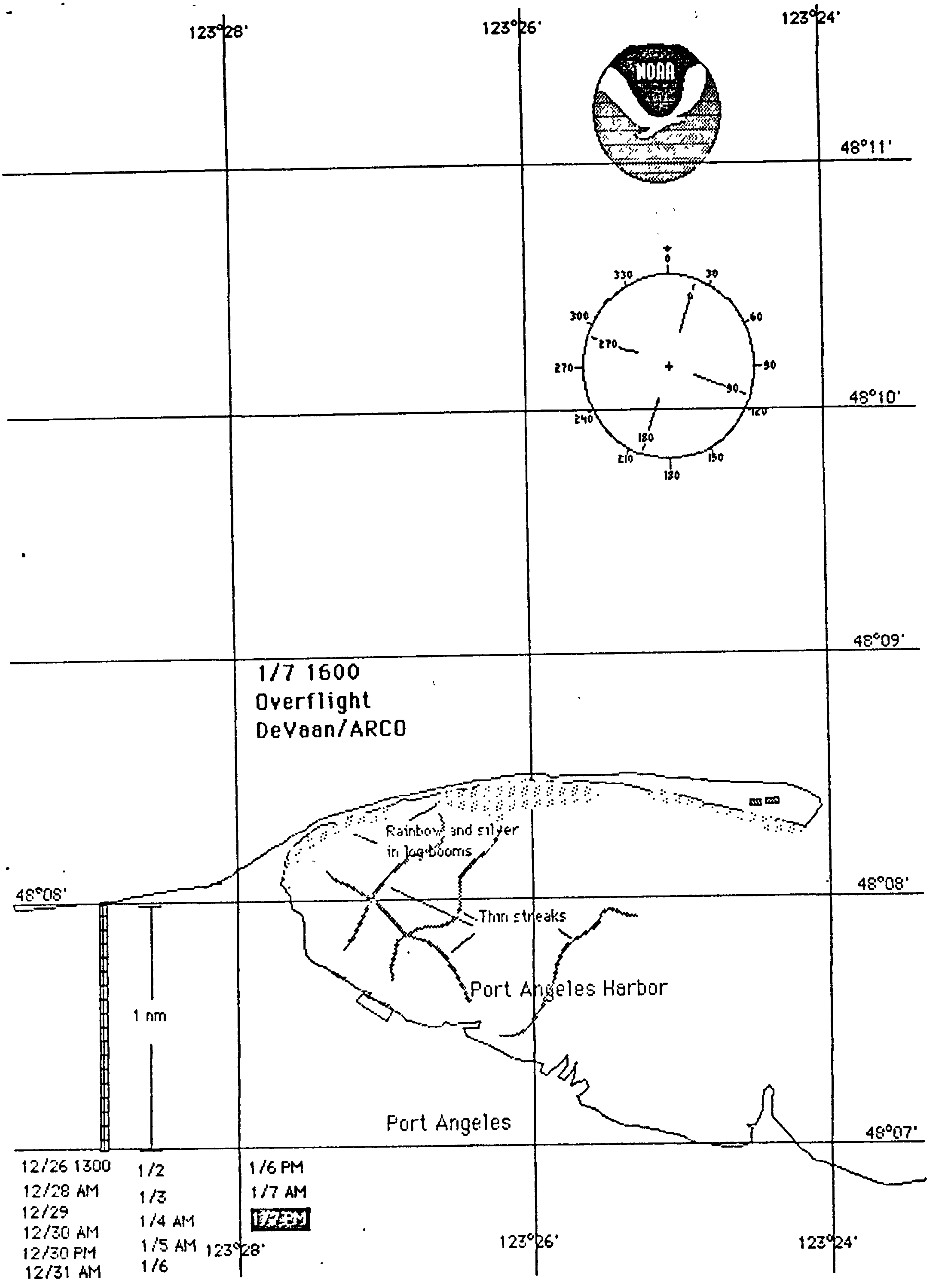


123°28'
123°26'
123°24'
NOAA
48°11'
48°10'
48°09'
1/6 1545
Overflight
DeVaan/CG/ARCO
Silver, rainbow and browns inside log booms
48°08'
Thin streaks
Port Angeles Harbor
Transparent sheen
1 nm
Port Angeles
48°07'
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6
1/6PM

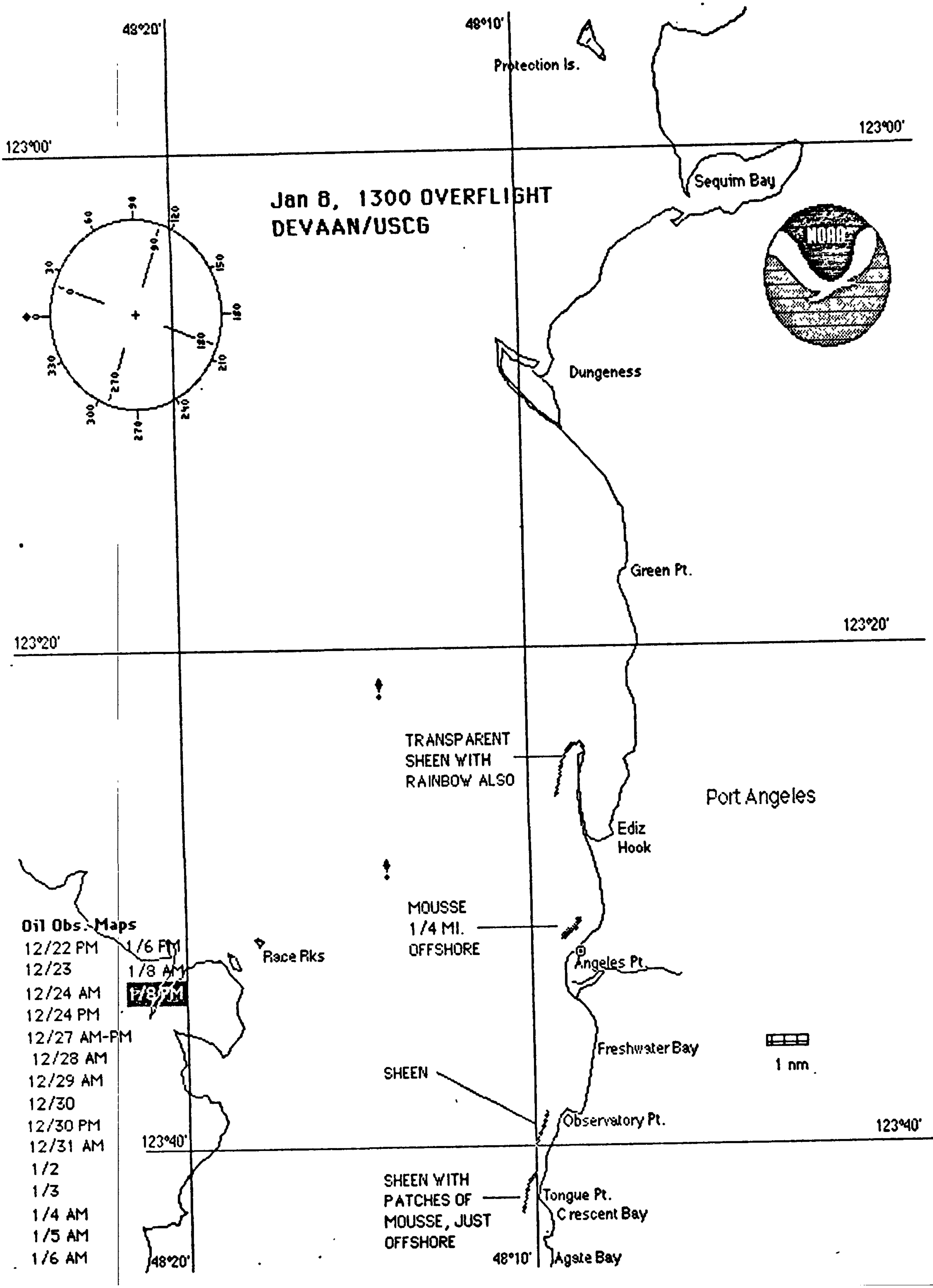


123°28'
123°26'
123°24'
NOAA
48°11'
0
30
60
90
120
150
180
210
240
270
300
330
0
90
120
270
48°10'
48°09'
1/7 0900
Overflight
CG/ARCO
Silver, rainbow and brown in log booms
Silver and rainbow patch
48°08'
48°08'
Thin streaks
1 nm
Port Angeles Harbor
Port Angeles
48°07'
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6
1/6 PM
1/7 AM
123°28'
123°26'
123°24'

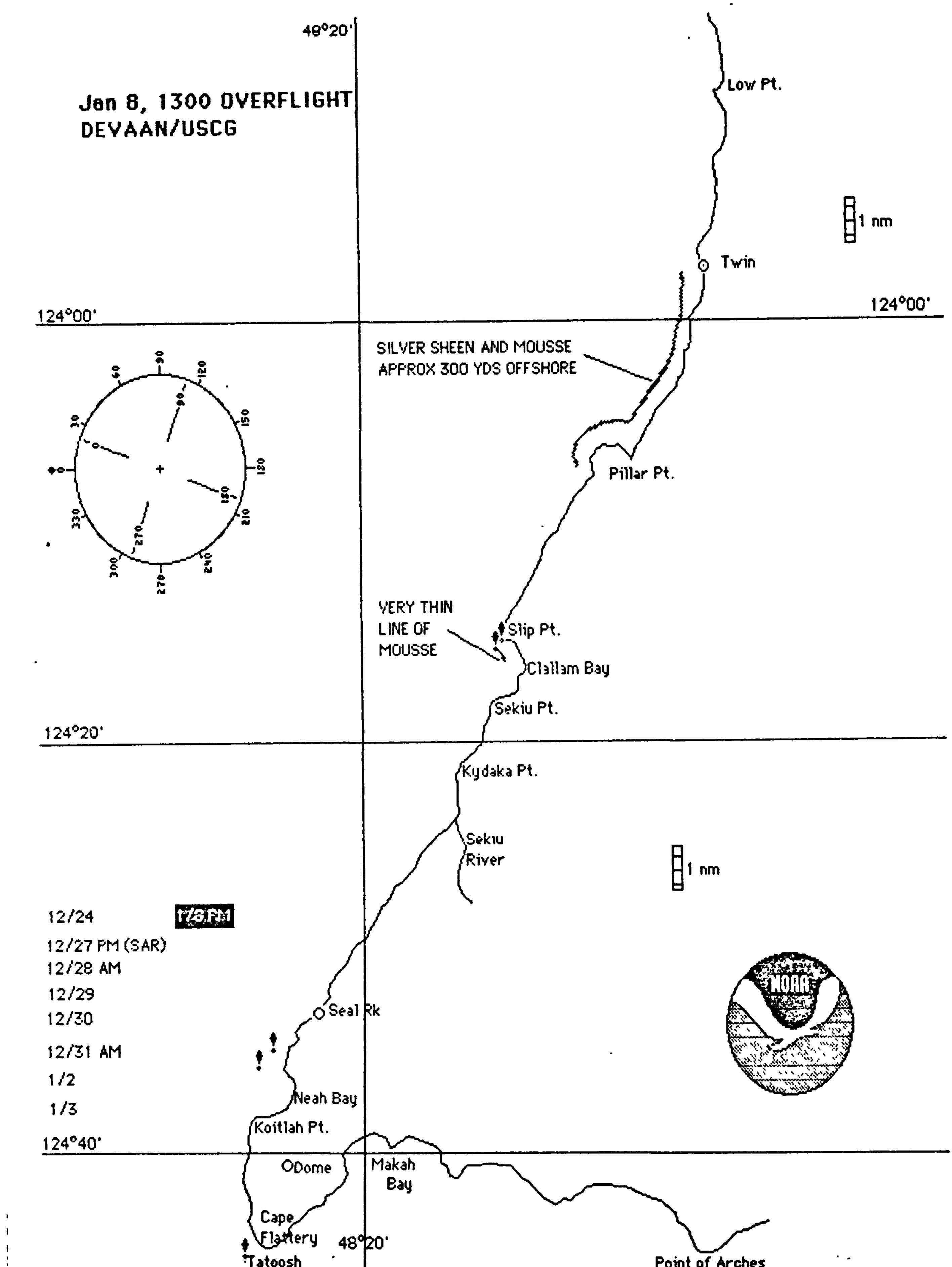

1/7 1600
Overflight
DeVaan/ARCO
123°10'
48°10'
48°10'
Dungeness
Spit
Range
Markers
Thin transparent
sheen
Thin line
of mousse
DUNGENESS
1 nm
Kulakala Pt.
Port Williams
Washington
Harbor
Kiapot Pt.
Pitship Pt.
SEQUIM
BAY
0
30
60
90
120
150
180
210
240
270
300
330
123°10'
12/25 AM Obs.
12/25 PM Obs.
12/28 AM Obs.
12/30 PM Obs.
12/31 AM Obs.
1/2
1/3
1/4 AM
1/6 AM
1/6 PM
1/7 PM

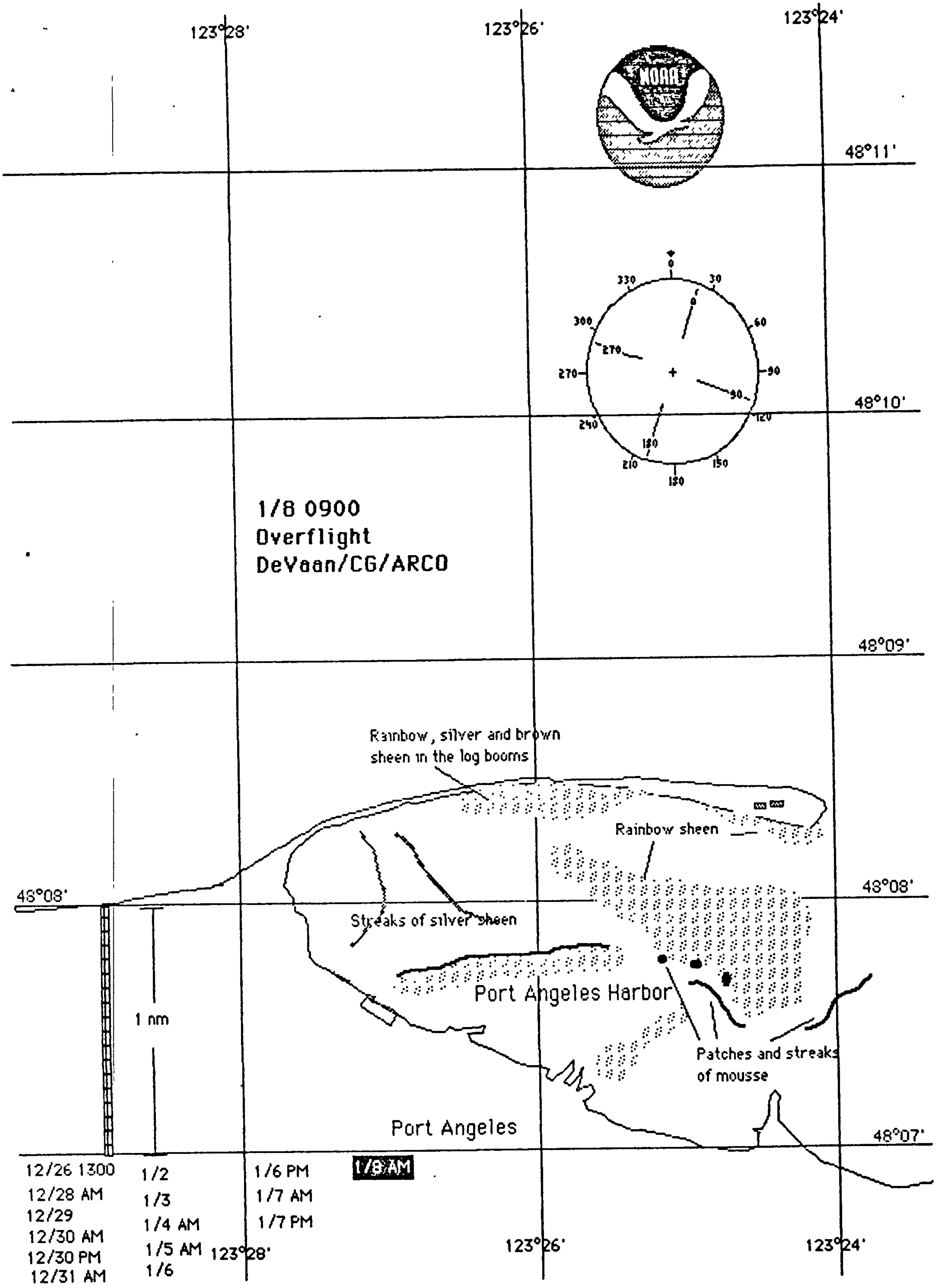


123°28'
123°26'
123°24'
NOAA
48°11'
0
30
60
90
120
150
180
210
240
270
300
330
48°10'
48°09'
1/7 1600
Overflight
DeVaan/ARCO
Rainbow and silver
in log booms
48°08'
Thin streaks
Port Angeles Harbor
1 nm
Port Angeles
48°07'
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6
1/6 PM
1/7 AM
1/7 PM
123°28'
123°26'
123°24'

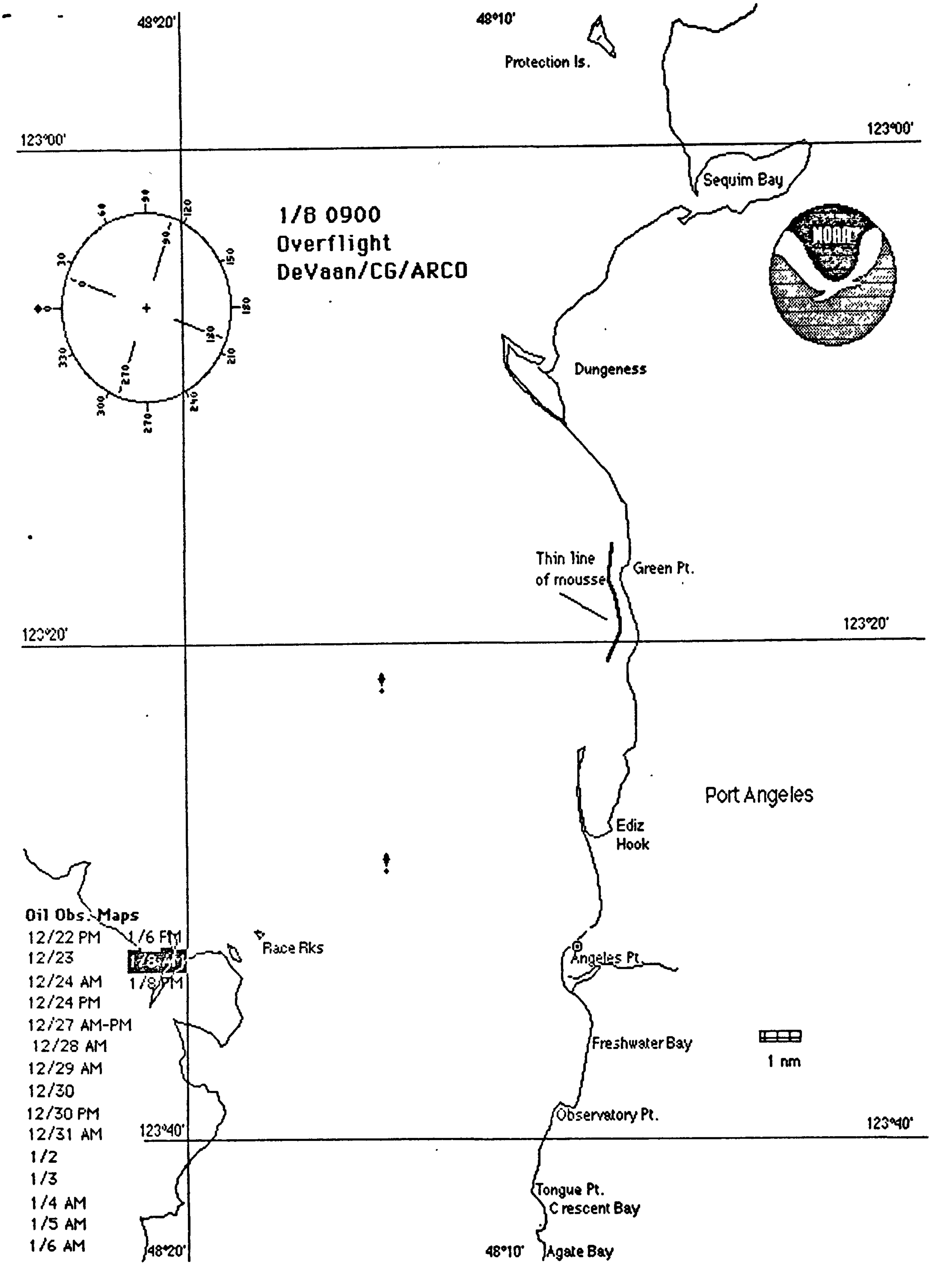


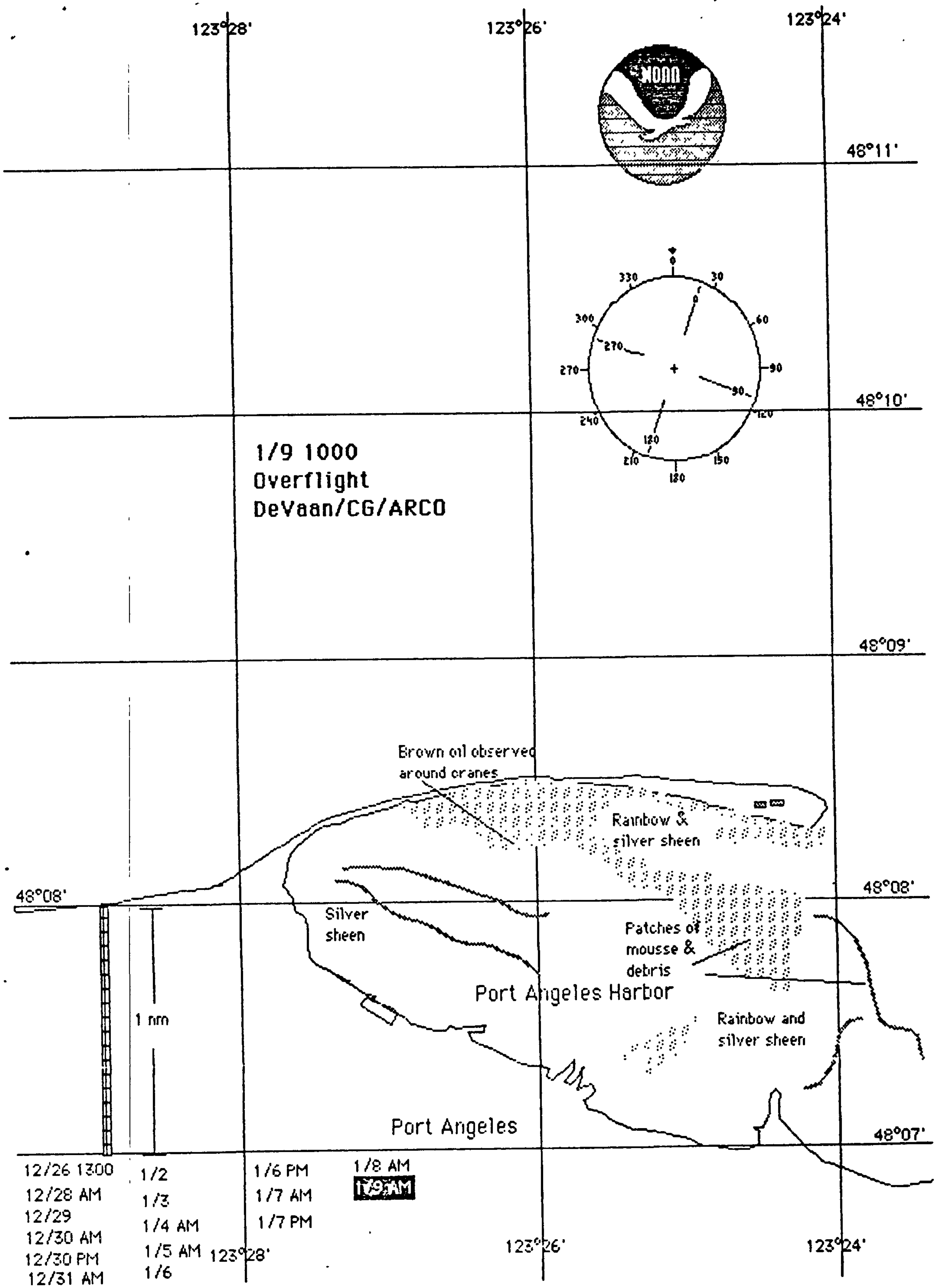
Jan 8, 1300 OVERFLIGHT
DEVAAN/USCG
48°20'
48°10'
Protection Is.
123°00'
Sequim Bay
NOAA
Dungeness
Green Pt.
123°20'
TRANSPARENT SHEEN WITH RAINBOW ALSO
Port Angeles
Ediz Hook
MOUSSE 1/4 MI. OFFSHORE
Angeles Pt.
Race Rks
Freshwater Bay
1 nm
SHEEN
Observatory Pt.
123°40'
SHEEN WITH PATCHES OF MOUSSE, JUST OFFSHORE
Tongue Pt.
Crescent Bay
Agate Bay
Oil Obs. Maps
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6 AM
1/6 PM
1/8 AM
1/8 PM


Jan 8, 1300 OVERFLIGHT
DEVAAN/USCG
48°20'
Low Pt.
1 nm
Twin
124°00'
124°00'
SILVER SHEEN AND MOUSSE
APPROX 300 YDS OFFSHORE
Pillar Pt.
VERY THIN
LINE OF
MOUSSE
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu
River
1 nm
12/24
1/8 PM
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
Seal Rk
Neah Bay
Koitlah Pt.
124°40'
Dome
Makah
Bay
Cape
Flattery
48°20'
Tatoosh
Point of Arches
NOAA

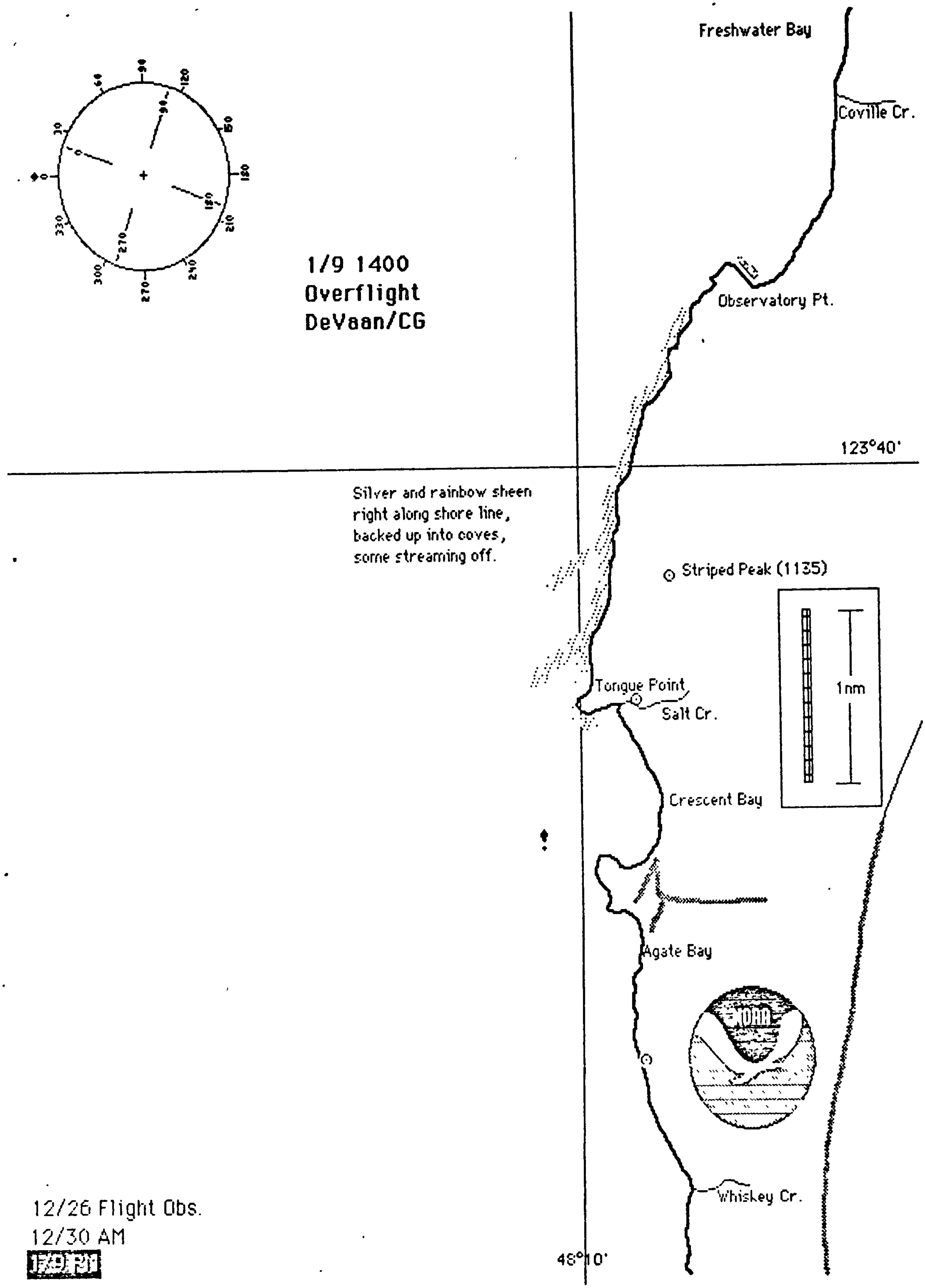


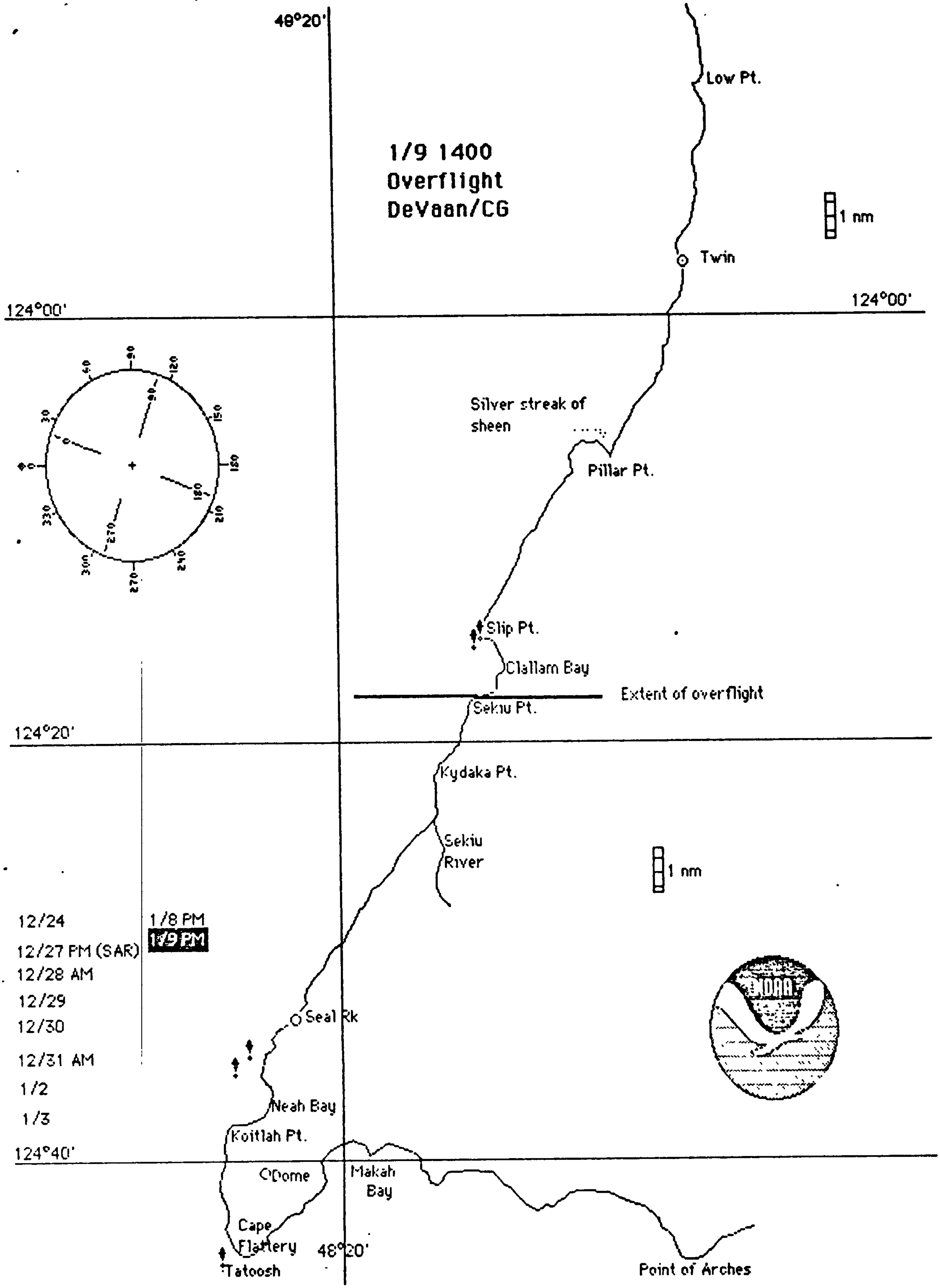
123°28'
123°26'
123°24'
NOAA
48°11'
48°10'
48°09'
48°08'
48°07'
0
30
60
90
120
150
180
210
240
270
300
330
1/8 0900
Overflight
DeVaan/CG/ARCO
Rainbow, silver and brown sheen in the log booms
Rainbow sheen
Streaks of silver sheen
Port Angeles Harbor
Patches and streaks of mousse
Port Angeles
1 nm
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6
1/6 PM
1/7 AM
1/7 PM
1/8 AM

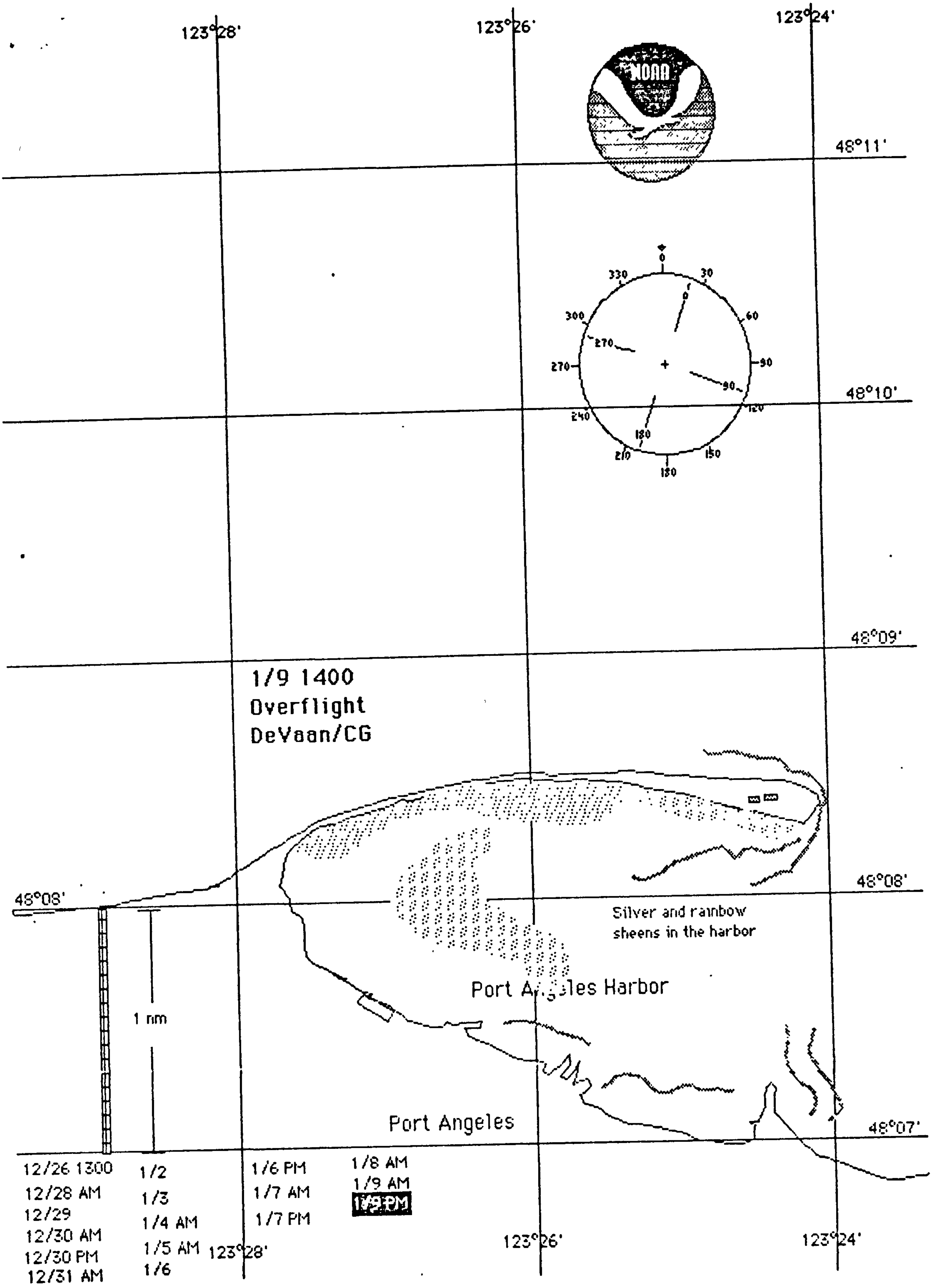

48°20'
48°10'
Protection Is.
123°00'
123°00'
Sequim Bay
1/8 0900
Overflight
DeVaan/CG/ARCO
Dungeness
Thin line
of mousse
Green Pt.
123°20'
123°20'
Port Angeles
Ediz
Hook
Oil Obs. Maps
12/22 PM
12/23
12/24 AM
12/24 PM
12/27 AM-PM
12/28 AM
12/29 AM
12/30
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6 AM
1/6 PM
1/8 AM
1/8 PM
Race Rks
Angeles Pt.
Freshwater Bay
1 nm
Observatory Pt.
123°40'
123°40'
Tongue Pt.
Crescent Bay
48°20'
48°10'
Agate Bay



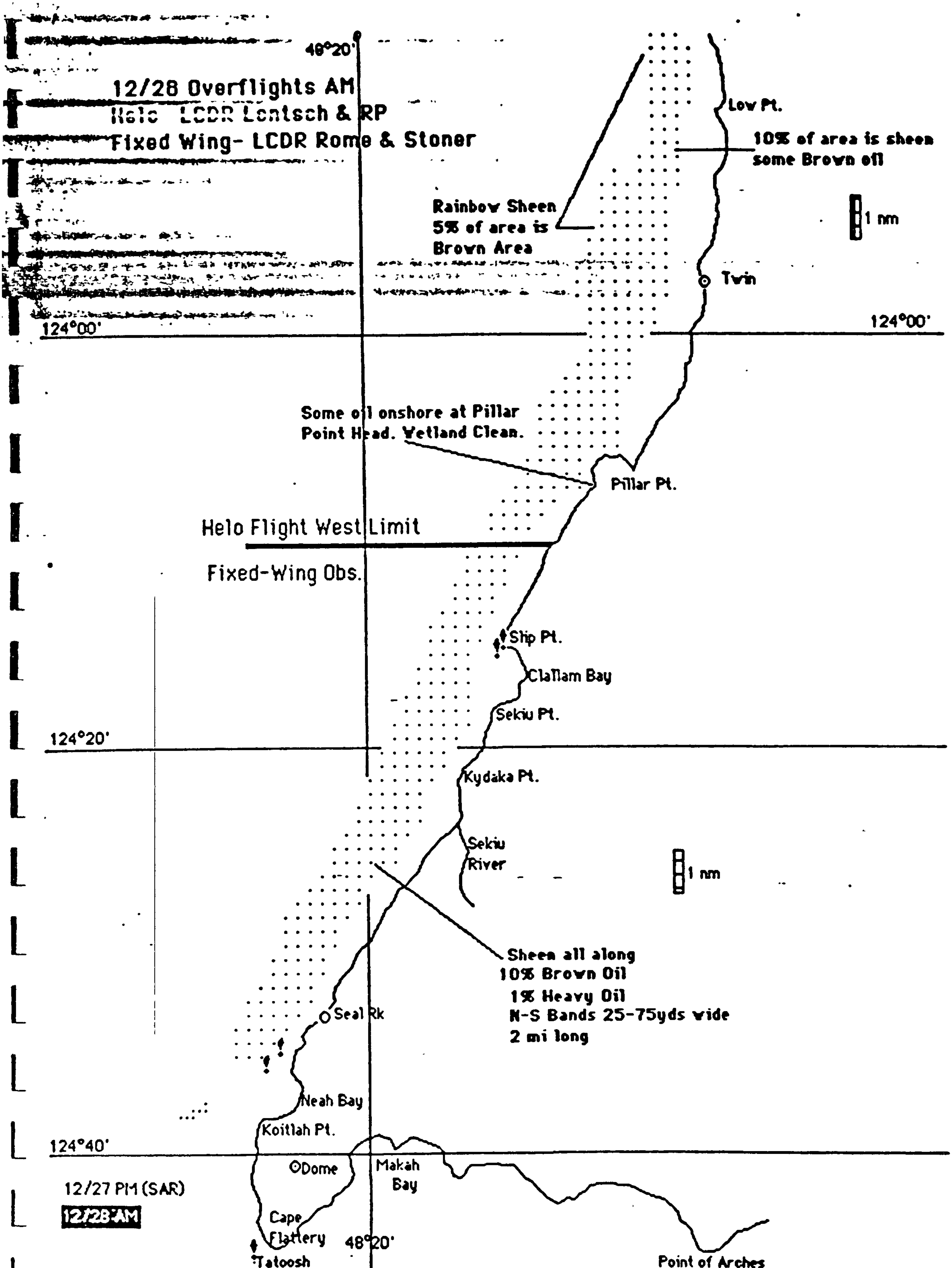
123°28'
123°26'
123°24'
48°11'
48°10'
48°09'
48°08'
48°07'
1/9 1000
Overflight
DeVaan/CG/ARCO
Brown oil observed around cranes
Rainbow & silver sheen
Silver sheen
Patches of mousse & debris
Port Angeles Harbor
Rainbow and silver sheen
Port Angeles
1 nm
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6
1/6 PM
1/7 AM
1/7 PM
1/8 AM
1/9 AM


1/9 1400
Overflight
DeVaan/CG
Freshwater Bay
Coville Cr.
Observatory Pt.
123°40'
Silver and rainbow sheen right along shore line, backed up into coves, some streaming off.
Striped Peak (1135)
1nm
Tongue Point
Salt Cr.
Crescent Bay
Agate Bay
NOAA
Whiskey Cr.
48°10'
12/26 Flight Obs.
12/30 AM
1/9 PM

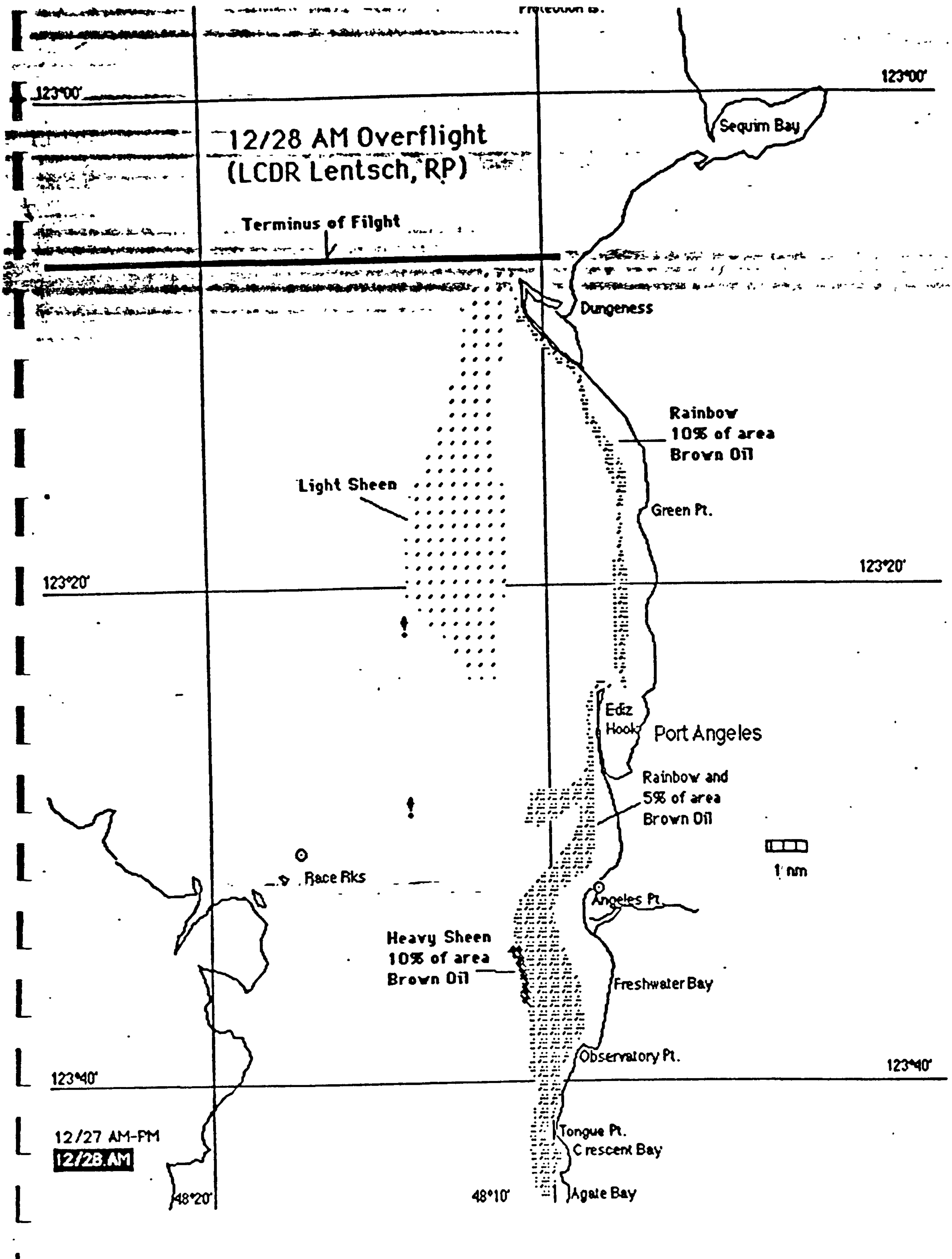

1/9 1400
Overflight
DeVaan/CG
48°20'
124°00'
124°00'
124°20'
124°40'
48°20'
Low Pt.
Twin
1 nm
1 nm
Silver streak of
sheen
Pillar Pt.
Slip Pt.
Clallam Bay
Extent of overflight
Sekiu Pt.
Kydaka Pt.
Sekiu
River
Seal Rk
Neah Bay
Koitlah Pt.
C'Dome
Makah
Bay
Cape
Flattery
Tatoosh
Point of Arches
12/24
12/27 PM (SAR)
12/28 AM
12/29
12/30
12/31 AM
1/2
1/3
1/8 PM
1/9 PM



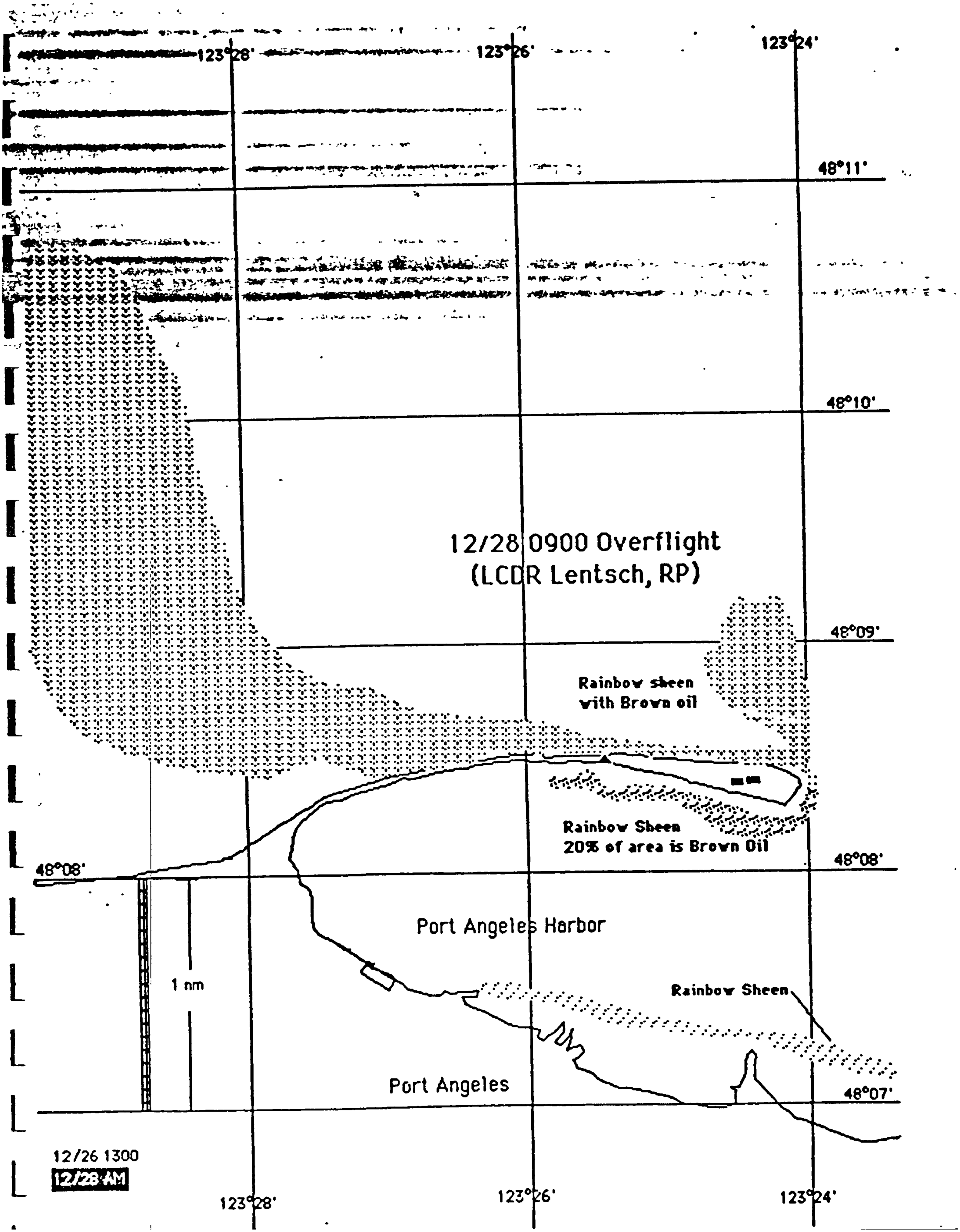
123°28'
123°26'
123°24'
NOAA
48°11'
0
30
60
90
120
150
180
210
240
270
300
330
270
90
180
48°10'
48°09'
1/9 1400
Overflight
DeVaan/CG
48°08'
Silver and rainbow
sheens in the harbor
Port Angeles Harbor
1 nm
Port Angeles
48°07'
12/26 1300
12/28 AM
12/29
12/30 AM
12/30 PM
12/31 AM
1/2
1/3
1/4 AM
1/5 AM
1/6
1/6 PM
1/7 AM
1/7 PM
1/8 AM
1/9 AM
1/9 PM
123°28'
123°26'
123°24'

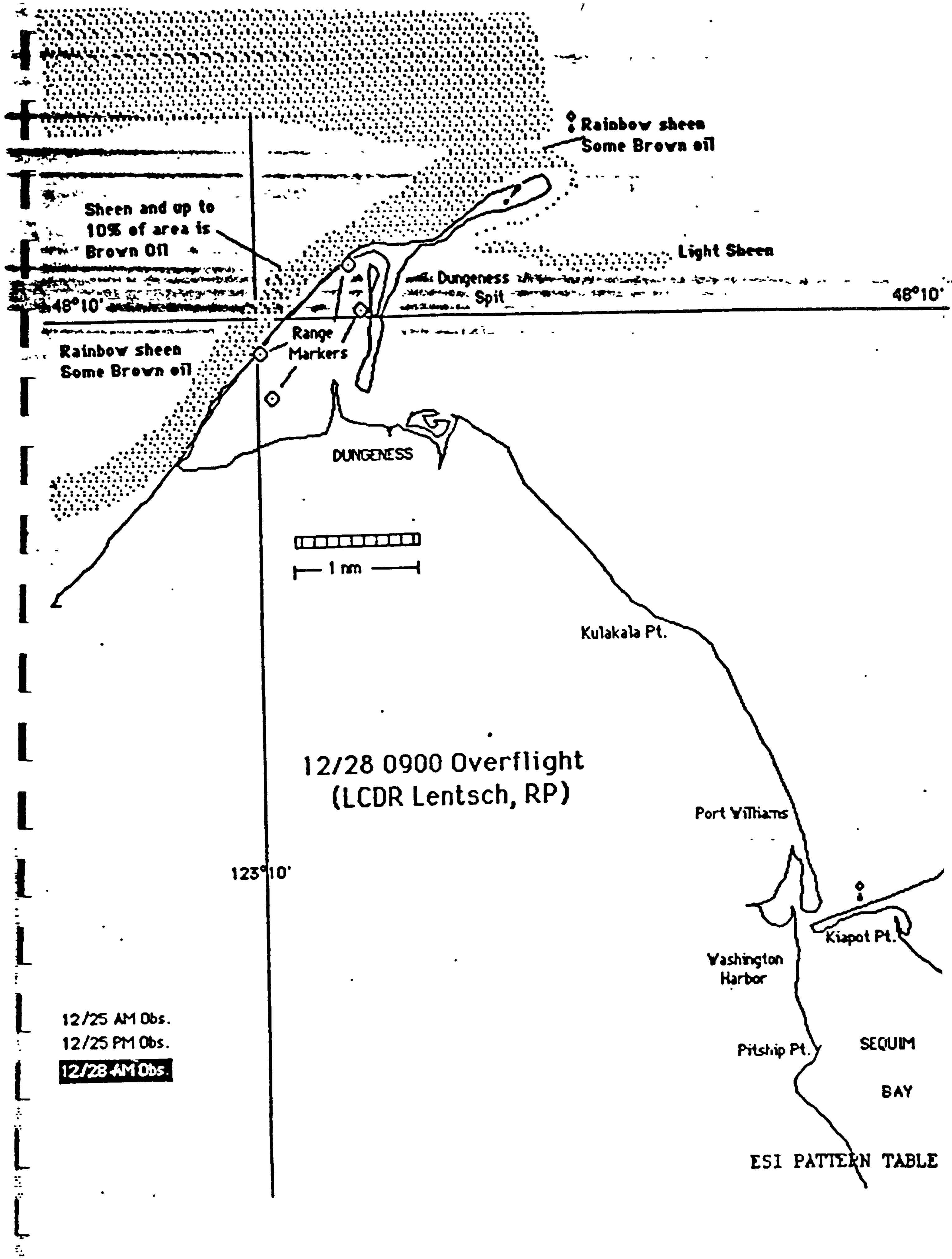


48°20'
12/28 Overflights AM
Helo LCDR Lentsch & RP
Fixed Wing- LCDR Rome & Stoner
Low Pt.
10% of area is sheen
some Brown oil
Rainbow Sheen
5% of area is
Brown Area
1 nm
Twin
124°00'
124°00'
Some oil onshore at Pillar
Point Head. Wetland Clean.
Pillar Pt.
Helo Flight West Limit
Fixed-Wing Obs.
Slip Pt.
Clallam Bay
Sekiu Pt.
124°20'
Kydaka Pt.
Sekiu
River
1 nm
Sheen all along
10% Brown Oil
1% Heavy Oil
N-S Bands 25-75yds wide
2 mi long
Seal Rk
Neah Bay
Koitlah Pt.
124°40'
Dome
Makah
Bay
12/27 PM (SAR)
12/28 AM
Cape
Flattery
48°20'
Tatoosh
Point of Arches



12/28 AM Overflight
(LCDR Lentsch, RP)
Terminus of Filght
Sequim Bay
123°00'
123°00'
Dungeness
Rainbow
10% of area
Brown Oil
Light Sheen
Green Pt.
123°20'
123°20'
Ediz
Hook
Port Angeles
Rainbow and
5% of area
Brown Oil
1 nm
Race Rks
Angeles Pt.
Heavy Sheen
10% of area
Brown Oil
Freshwater Bay
Observatory Pt.
123°40'
123°40'
Tongue Pt.
Crescent Bay
Agate Bay
12/27 AM-PM
12/28 AM
48°20'
48°10'


123°28'
123°26'
123°24'
48°11'
48°10'
12/28 0900 Overflight
(LCDR Lentsch, RP)
48°09'
Rainbow sheen
with Brown oil
Rainbow Sheen
20% of area is Brown Oil
48°08'
48°08'
Port Angeles Harbor
1 nm
Rainbow Sheen
Port Angeles
48°07'
12/26 1300
12/28 AM
123°28'
123°26'
123°24'



ESI PATTERN TABLE

10.0 APPENDIX II

REPORT ON ARCO ANCHORAGE OIL SAMPLES

FROM LSU

September 23, 1986

TO: Lew J. Kittle, Jr.
Dept. of Ecology, Olympia, Washington 98504

FROM: Charles B. Henry, Jr.
Environmental Chemistry, GC/MS

SUBJECT: **REPORT ON ARCO ANCHORAGE OIL SAMPLES**

This report is on the analytical analysis of Port Angeles samples submitted by the Department of Ecology, Washington State. The samples were received in two groups: 11 March, 1986 and 9 April, 1986. All but one of the samples were received in good condition. Sample 86187058 was damaged in transit.

These analysis concentrate on **confirmation of samples as ARCO oil** based on chromatographic profiles compared to reference oils. High resolution gas chromatography augmented with mass spectroscopy was used.

Please call me with any questions.

Key definitions:

Heavily contaminated -- Contains visible oil. Quantitations by the analytical methods used would be semiquantitative at best because of the large dilutions required.

Fingerprint -- Chromatographic profile of the unfractioned or fractioned oil sample by high resolution gas chromatography.

Sample #527171-527174 Referance Oils:

Each of the oils were diluted in hexane. The fraction that went into solution (primarily the aliphatics and aromatics) were further separated by normal phase liquid chromatography into three fractions: F-1, aliphatics; F-2, slightly polar aromatics (PAH's); F-3, polar compounds. This step is necessary because of the complexity of crude oil. Only the first two fractions were analyzed on GC/FID for oil characterization. Two of the reference oils (#527171 and #527174) were analyzed by GC/MS for further characterization of the PAH's and their homologs. Also, FT-IR comparisons were made.

In general, the ARCO reference oils were low in PAH's. Naphthalene and its C-1 thru C-4 homologs predominated (Benzene and most of the alkyl substituted benzenes are not applicable to this analytical method and were not considered when these relative determinations are made). In addition, Phenanthrene and dibenzothiophene and their related homologs were present. The reference oils provided matched well with the EPA reference oil for Prudhoe Bay within the parameters tested. See attached chromatograms Fig. 1-11.

Sample #017182-17184 D-1

These samples were prepared as above. Each was heavily contaminated. When the F-1 and F-2 fraction analyses were compared to the reference samples the following differences were noted: the lighter aliphatic (those less than C-12 were not detected at the dilution level required) and aromatic components (the heavily substituted benzenes and naphthalenes) were greatly reduced in relation to the heavier molecular weight components. This is typical of slightly weathered oil. These changes in profile are normally attributed to evaporation. The "fingerprint" obtained from the F-2 fraction matched that of the ARCO oil reference samples analyzed above.

Sample #017185-017187 PA-4

Sediment #017185 contained low levels of aliphatic hydrocarbons, C-12 thru C-29 (see the aliphatic report attached). Only a trace of aromatics were detected. The oil was slightly weathered; the degree of weathering was consistent with that reported above. In general, the analysis of this sample revealed low level contamination of ARCO oil.

Samples #017186 and #017187 were heavily contaminated. The analysis revealed slightly weathered ARCO oil.

Sample #017188 PA-3

Heavily contaminated with slightly weathered ARCO oil.

Sample #017190 Freshwater Bay

Slightly contaminated water sample. Some heavy aromatics were present. Probably due to particulate deposition: the sample contained a large amount of "trash" in the bottom.

Sample #017191

Doesn't appear to be ARCO oil.

***** Sample #017193-017199 Clams (HP-1 & CG-B-1 thru 6)

These biota samples contained visible oil. Heavily contaminated with ARCO oil.

Sample #017200 Tongue Point

Heavily contaminated ARCO oil.

Sample #017202 Observation Point

Low levels of weathered oil can not confirm as ARCO oil.

Sample #017203 Observation Point

Heavily contaminated ARCO oil.

***** NOT INVOICED

<u>Sample #017204 Whiskey Creek</u>

Heavily contaminated ARCO oil. In addition to GC/FID analysis of the F-1 and F-2 fractions, this sample was analyzed by GC/MS for confirmation. The GC/MS analysis revealed slightly weathered low aromatic oil. The degree of weathering was slightly more evident than the other samples of the same date: the naphthalenes were noticably reduced. The fingerprint was that of ARCO oil.

<u>*****Samples #027229-027336 Kelp Samples</u>

Some of these samples contained visible oil, their chromatographic fingerprint matched the ARCO oil reference. Most of the samples contained no visible oil; they showed no contamination after anlaysis by GC.

<u>Sample #027237-027244 Observatory Pt. (Sea Urchin)</u>

These samples do not indicate any contamination by ARCO oil within the method detection limits (20 ppm). This was verified by GC/MS.

<u>Samples #067319-067326 Station #5</u>

The Geoduck samples were extracted and analyzed. Results indicate some high molecular weight aliphatics (C-23 thru C-30) but no aromatics related to the ARCO oil. This was verified by MS on sample #067322. The mass spec analysis did indicate the presence of PCB's and other chlorinated hydrocarbons at low levels (this is reported only to support the methods's validity).

Sediment samples #067324 and #067325 showed only traces of hydrocarbons, and they were below the min. detection limit set for quantitations at 20 ppb. Sample #067326 showed evidence of contamination; aliphatics ranged from 50ppb to 100ppb. The profile was the same as that of the reference oil.

<u>Samples #067332-067334 Station #6</u>

Only trace levels of hydrocarbons were found (less than 10ppb). These indicated a degree of weathering not consistent with the other ARCO oil spill samples.

<u>Sample #067335-067340 Station #7</u>

In samples 067338 through 340 only trace levels of hydrocarbons were detected, less than 10ppb (normal background). No ARCO oil detected. All three samples were confirmed by running duplicates on GC/MS.

Analysis of little neck clam sample #067035 by mass spec indicated no ARCO oil contamination.

<u>Sample #187066 Near Crown Z.</u>

No aliphatics or aromatics detected. Detection limit 20ppb.

Sample #187067-070 Crabs

The crab samples were split into two fractions for analysis: The leg meat was removed and analyzed seperatly from the hepatopancreas. The samples were analyzed by GC/MS. No contamination by ARCO oil was detected in either fraction.

Sample #187072-187076 Freshwater Bay

Samples 187061 thru 187063 demonstrated slight contamination of aliphatic and aromatic hydrocarbons. The low levels found were weathered to the point that verification as ARCO oil is not possible. Other aromatic hydrocarbons, probably resulting from particulate deposition, were present.

Sediment sample #187072 was contaminated with low levels of aliphatic and aromatic hydrocarbons. This sample is also inconclusive because of the low levels present and the degree of weathering.

Urchin samples #187075 and #187076 at first seemed to show visible oil contamination, but after analysis by GC this was not confirmed. The film was probably due to decaying vegetation. The urchins were then extracted and analyzed by GC. These samples were also analyzed by GC/MS. Trace levels of contamination were present. Couldn't confirm as ARCO oil.

In general, all the samples from Freshwater Bay contained a "hint" of contamination, but it was too low to positivily confirm as ARCO oil. The degree of weathering could be consistent with the spill date.

Sample #187077-080 Dungeness Spit

Traces of polynuclear aromatic hydrocarbons were found in these samples. Their presence is probably attributed to combustion particulate matter.

Water sample 187077 was first reported as positive for very low concentrations of aromatics consistent with that in ARCO oil based on GC/FID analysis of a highly concentrated extract. The levels noted were less than 1 ppb. It would be **premature** to conclude this significant and a positive sample. The methodology employed to see such a low level was not in the routine scheme of analysis; therefore, its validity is at best questionable. Within the normal paramters **this sample is negative: not detected above 10ppb.**

Samples #187081 and 187082

Sample 187082 shows slight contamination of ARCO oil. Sample 187081 inconclusive.

Samples #187083 and 187084

Analysis indicates only trace levels aromatics similar to ARCO oil and fluoranthrene and pyrene (probably combustion related deposition).

Samples #187085-090 Ediz Hook

Sample #187085 indicates only trace contamination: cannot confirm as ARCO oil.

Samples #187087-089 indicate contamination by ARCO oil. The weathering effects are pronounced: pristane and phytane are at a greater concentration than the aliphatics C-17 and C-18. Also present are the heavier aromatics related to combustion deposition.

Oyster sample #187092 shows evidence of contamination by ARCO oil.

Sample #187097

Does not seem to be contaminated.

Samples #147853-147855

Only sample #147854 can be confirmed as ARCO oil. The other two samples are too weathered for confirmation.

Sample #147856

Could find no evidence of ARCO oil contamination.

STANDARD METHODS EMPLOYED

Preparation of samples containing oil

Samples containing visible oil were treated as the reference oils. Visible oil samples were only fingerprinted. Quantitative treatment was not applicable due to the large dilutions made.

Sediment extractions

Fifty grams of sediment excluding larger rocks and shells weighed out into a clean solvent rinsed 250 ml beaker. A surrogate standard, Hexamethylbenzene, was added. An equal amount of sodium sulfate was added and mxied well with a stainless steel spatula. 50-75 mls of DCM, dichloromethane, was added and stirred into the sample. Then the sample was sonicated in a bath type sonicator for 12 min. Afterwards, the DCM was decanted off into a round-bottom flask. This was repeated twice more: 3 extractions total. The combined extracts were rotovaped down to approximately 2 ml. A pasteur pipette was used to transfer the extract to a 4 ml glass vial with a teflon lined cap. The round-bottom flask was rinsed with 1 ml of DCM which was added to the vial. The extract was then blowndown to a final volume of 0.5 ml under a gentle stream of nitrogen gas. The sample is now ready for fractionation and analysis.

Water sample preparation

500 mls of water was extracted by liquid--liquid extraction utilizing separatory funnels. Hexamethylbenzene was added as a surrogate standard. Three extractions of 50 mls each were combined and rotovaped to concentrate the extract to a final volume of 0.5 ml. The sample is now ready for analysis.

Tissue sample preparation

100 grams of tissue, or what ever was available, was placed in a stainless steel blender and shredded. 50 grams was subsmpled into a 250 ml beaker. Surrogate standard, Hexamethylbenzene, was added. The sample was then saponified with sodium hydroxide. 50 grams of sodium sulfate was added and mixed well. The rest of the method is identical to that for sediments above.

References

Birkimer, D.L.; (USCG); Oil Spill Identification System. Report #CG-D-52-77. June 1977.

Overton, E.B.; Farrington, J.W.; "Detailed Chemical Analysis of IXTOC-I Crude Oil and Selected Environmental Samples From the Researcher and Pierce Cruises." Preliminary Results From the September 1979 Researcher/Pierce IXTOC-I Cruise; NOAA Publication; p.439-495.

MacLeod, W.D.; Brown, D.W.; Standard Analytical Procedures of the NOAA National Analytical Facility 1985--1986. NOAA Technical Memorandum NMFS F/NWC-92.

COMPOUND	conc. in PPM wet wt.		
	187088	187087	86187092
C-12	1.1	0.6	
C-13	2.1	0.92	
C-14	2.0	1.0	
C-15	2.4	0.94	
C-16	2.0	1.1	
C-17	1.5	0.67	
PRISTANE	2.3	1.75	
C-18	1.4	0.76	
PHYTANE	1.6	1.31	
C-19	1.3	0.40	
C-20	1.4	0.74	
C-21	1.2	0.53	
C-22	1.0	0.40	
C-23	TRACE	TRACE	
C-24	TRACE	TRACE	
C-25	TRACE	TRACE	
NAPHTHALENE	ND	ND	ND
" C-1 HOMOLOGS		ND	ND
" C-2 HOMOLOGS		ND	ND
" C-3 HOMOLOGS		ND	ND
PHENANTHRENE		0.10	TRACE
"C-1 HOMOLOGS		PNQ	0.013
"C-2 HOMOLOGS		PNQ	0.075
"C-3 HOMOLOGS		PNQ	0.11
ANTHRACENE		0.05	ND
DIBENZOTHIOPHENE		TRACE	ND
"C-1 HOMOLOGS		PNQ	ND
"C-2 HOMOLOGS		PNQ	0.020
"C-3 HOMOLOGS		PNQ	TRACE
FLUORANT		TRACE	0.010
PYRENE		0.17	0.011
BENZO(A)ANTHRACENE		0.26	0.010
CHRYSENE		0.16	0.010
BENZO(B)FLUORANT		TRACE	TRACE
BENZO(K)FLUORANT		TRACE	TRACE
BENZO(A)PYRENE		TRACE	TRACE

* Homologs are semiquantitative

PNQ Present not quantitative.

COMPOUND	conc. in PPM wet wt.		
	017185	**067326**	**187089**
C-12......................................	ND	TRACE	55
C-13......................................	TRACE	TRACE	82
C-14......................................	.013	.052	75
C-15......................................	.017	.057	79
C-16......................................	.029	.093	06.0
C-17......................................	.020	.076	61
PRISTANE............................	.011	.054	72
C-18......................................	.016	.0100	61
PHYTANE.............................	.010	.040	52
C-19......................................	.018	.080	54
C-20.....................................	.020	.058	60
C-21.....................................	.016	.057	100
C-22......................................	.08	.049	90
C-23.....................................	.017	.051	TRACE
C-24.....................................	.017	TRACE	TRACE
C-25.....................................	.015	TRACE	TRACE
NAPHTHALENE..................			ND
" C-1 HOMOLOGS..............			TRACE
*" C-2 HOMOLOGS..............			10
*" C-3 HOMOLOGS..............			26
PHENANTHRENE................			0.73
"C-1 HOMOLOGS................			19
"C-2 HOMOLOGS................			24
"C-2 HOMOLOGS................			28
ANTHRACENE....................			0.4
DIBENZOTHIOPHENE.........			TRACE
"C-1 HOMOLOGS................			15
"C-2 HOMOLOGS................			25
"C-3 HOMOLOGS................			31
FLUORENE.........................			0.07
PYRENE...............................			0.22
BENZ(A)ANTHRACENE.....			0.51
CHRYSENE..........................			0.32
BENZO(B)FLUORANT.........			0.26
BENZO(K)FLUORANT.........			0.09
BENZO(A)PYRENE..............			ND

Ecology Lab No.	Location	Sample Type	Collection Date
*527171	AA-1-5C	Oil (reference)	12/22/85
*527172	AA-2-5C	Oil (reference)	12/22/85
*527173	AA-5-4P	Oil (reference)	12/22/85
*527174	AA-6-4P	Oil (reference)	12/22/85
017182	D-1	H_2O/Oil	12/23/85
017183	D-1	Sediment	12/23/85
017184	D-1	Oil	12/23/85
017185	PA-4	Sediment	12/23/85
017186	PA-4	H_2O/Oil	12/23/85
017187	PA-4	Oil	12/23/85
017188	PA-3 (T-Bird)	H_2O/Oil	12/23/85
017190	Freshwater Bay	H_2O/Oil	12/30/85
017191	Sequim Bay	H_2O/Oil	12/30/85
017192	Dungeness Spit	Tissue	12/31/85
017193	HP-1	Tissue (clam composite)	12/27/85
017194	CG-B-1	Tissue (Butter clams)	12/27/85
017195	CG-B-2	Tissue (Butter clams)	12/27/85
017196	CG-B-3	Tissue (Butter clams)	12/27/85
017197	CG-B-4	Tissue (Butter clams)	12/27/85
017198	CG-B-5	Tissue (Butter clams)	12/27/85
017199	CG-B-6	Tissue (Butter clams)	12/27/85
017200	Tongue Point	H_2O/Oil	12/26/85
017202	Observatory Point	H_2O/Oil	12/27/85
017203	Observatory Point	H_2O/Oil	12/27/85
017204	Whiskey Creek	H_2O/Oil	12/27/85
017205	CGA-1	Clams (composite)	12/27/85
017206	CGA-2	Clams (composite)	12/27/85
017207	CGA-3	Clams (composite)	12/27/85
017208	CGA-4	Clams (composite)	12/27/85
017209	CGA-5	Clams (composite)	12/27/85
017210	CGA-6	Clams (composite)	12/27/85
017211	CGA-7	Clams (composite)	12/27/85
017212	CGA-8	Clams (composite)	12/27/85
017213	CGA-9	Clams (composite)	12/27/85
017214	CGA-10	Clams (composite)	12/27/85
027219	Dungeness Spit #1	Sediment	1/3/86
027220	Dungeness Spit #2	H_2O/Oil	1/3/86
027221	Dungeness Spit #3	Sediment	1/3/86
027222	Dungeness Spit #4	H_2O/Oil	1/3/86
027223	Dungeness Spit #5	Sediment	1/3/86
027224	Dungeness Spit #6	Sediment	1/3/86
027229	1-A	Tissue (Kelp Stipe)	1/7/86
027230	2-A	Tissue (Kelp Stipe)	1/7/86
027231	3-A	Tissue (Kelp Stipe)	1/7/86
027232	4-A	Tissue (Kelp Stipe)	1/7/86
027233	1-B	Tissue (Kelp Stipe)	1/7/86
027234	2-B	Tissue (Kelp Stipe)	1/7/86
027235	3-B	Tissue (Kelp Stipe)	1/7/86
027236	4-B	Tissue (Kelp Stipe)	1/7/86

Ecology Lab No.	Location	Sample Type	Collection Date
027237	0.7 W. Observatory Pt. 1	Tissue (Sea Urchin)	1/7/86
027238	0.7 W. Observatory Pt. 1a	Tissue (Sea Urchin)	1/7/86
027239	0.7 W. Observatory Pt. 2	Tissue (Sea Urchin)	1/7/86
027240	0.7 W. Observatory Pt. 2a	Tissue (Sea Urchin)	1/7/86
027241	0.7 W. Observatory Pt. 3	Tissue (Sea Urchin)	1/7/86
027242	0.7 W. Observatory Pt. 3a	Tissue (Sea Urchin)	1/7/86
027243	0.7 W. Observatory Pt. 4	Tissue (Sea Urchin)	1/7/86
027244	0.7 W. Observatory Pt. 4a	Tissue (Sea Urchin)	1/7/86
027245	ACI Campground	Tissue (Abalone)	1/7/86
027246	ACI Campground	Tissue (Kelp)	1/7/86
027247	ACI Campground	Tissue (Kelp)	1/7/86
027248	Observatory Pt. 01	Tissue (Sea Urchin)	1/7/86
027249	Observatory Pt. 02	Tissue (Sea Urchin)	1/7/86
027250	Observatory Pt. 03	Tissue (Sea Urchin)	1/7/86
027251	Observatory Pt. 04	Tissue (Sea Urchin)	1/7/86
027252	0.7 W. Observatory Pt. 05	Tissue (Sea Urchin)	1/7/86
027253	0.7 W. Observatory Pt. 06	Tissue (Sea Urchin)	1/7/86
027254	0.7 W. Observatory Pt. 07	Tissue (Sea Urchin)	1/7/86
027255	0.7 W. Observatory Pt. 08	Tissue (Sea Urchin)	1/7/86
027256	Deep Creek 1N	Tissue (?)	1/7/86
027257	Deep Creek 2N	Tissue (?)	1/7/86
027258	Deep Creek 3N	Tissue (?)	1/7/86
027259	Deep Creek 4N	Tissue (?)	1/7/86
*027260	Deep Creek 1S	Tissue (?)	1/7/86
027261	Deep Creek 2S	Tissue (?)	1/7/86
027262	Deep Creek 3S	Tissue (?)	1/7/86
027263	Deep Creek 4S	Tissue (?)	1/7/86
*067319	Station #5	Tissue (Geoduck)	1/27/86
067320	Station #5	Tissue (Geoduck)	1/27/86
067321	Station #5	Tissue (Geoduck)	1/27/86
067322	Station #5	Tissue (Geoduck)	1/27/86
067323	Station #5	Tissue (Geoduck)	1/27/86
**067324	Station #5	Sediment	1/27/86
067325	Station #5	Sediment	1/27/86
067326	Station #5	Sediment	1/27/86
067327	Station #6	Tissue (Geoduck)	1/27/86
067328	Station #6	Tissue (Geoduck)	1/27/86
067329	Station #6	Tissue (Geoduck)	1/27/86
067330	Station #6	Tissue (Geoduck)	1/27/86
067331	Station #6	Tissue (Geoduck)	1/27/86
*067332	Station #6	Sediment	1/27/86
067333	Station #6	Sediment	1/27/86
067334	Station #6	Sediment	1/27/86
*067335	Station #7	Tissue (Little Neck Clams)	1/27/86
067326	Station #7	Tissue (Butter Clams)	1/27/86
067337	Station #7	Tissue (Horse Clams)	1/27/86
*067338	Station #7	Sediement	1/27/86
067339	Station #7	Sediment	1/27/86
067340	Station #7	Sediment	1/27/86

Ecology Lab No.	Location	Sample Type	Collection Date
067341	Control CW	Tissue (Sea Urchin)	2/4/86
067342	Control CW	Tissue (Sea Urchin)	2/4/86
067343	Control CW	Tissue (Sea Urchin)	2/4/86
067344	Control CE	Tissue (Sea Urchin)	2/4/86
067345	Control CE	Tissue (Sea Urchin)	2/4/86
067346	Control CE	Tissue (Sea Urchin)	2/4/86
067347	Control TS	Tissue (Sea Urchin)	1/30/86
067348	Control TS	Tissue (Sea Urchin)	1/30/86
067349	Control TS	Tissue (Sea Urchin)	1/30/86
067350	Control TD	Tissue (Sea Urchin)	1/30/86
067351	Control TD	Tissue (Sea Urchin)	1/30/86
067352	Control TD	Tissue (Sea Urchin)	1/30/86

STUDY OF OIL CONTAMINANTS IN FEATHERS OF OILED PREY BIRDS, CASTINGS, AND SERUM FROM FALCONS IMPACTED IN THE "ARCO ANCHORAGE" OIL SPILL

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October 1, 1986

Introduction

The "Arco-Anchorage" oil spill in Port Angeles, WA. harbor December 21, 1985 resulted in the beaching of hundreds of oiled grebes, loons, sea ducks and other birds, many of which were not immediately recovered by State personnel or volunteers and taken to cleaning centers. Some oiled birds were observed being fed upon by birds of prey which were either residents or winter migrants in the Port Angeles area.

This study is an attempt to determine whether falcons which had been observed feeding upon oiled birds had injested detectable amounts of hydrocarbons.

Regurgitated castings composed primarily of feathers were collected from beneath perches of a Peregrine Falcon and a Gyrfalcon during January and February, 1986, while these birds were actively chasing, catching and eating oiled birds as prey. Several falcons which were captured had traces of oil on their tails or lower body plumage indicating that they had come in contact with oiled prey.

Two falcon castings and feathers from an oiled Horned Grebe which appeared to be a falcon kill were provided by Richard Lowell, of Port Angeles, WA. The castings were moist, tightly compressed massess of feathers with a distinct mercaptan stench. The sample of oiled feathers was a loose collection of individual feathers pulled from the body of the dead Horned Grebe. Each sample was packaged in saran-wrap in a zip-lock bag.

One regurgitated casting analyzed was from Gyrfalcon #5069, recovered 1/21/86 as a fresh casting. The Gyrfalcon was trapped and found to have oil on the lower breast, tail feathers, right shoulder and secondary feathers. The second casting was from an adult female Peregrine Falcon designated "Dungeness" and was recovered on 2/1/86, approximately six weeks after the oil spill. This falcon eluded capture and therefore the presence of oil on its plumage could not be confirmed.

Several falcons were captured during the field study after the oil spill. Blood samples were taken from each bird, centifuged, and divided into three fractions: 1) blood cells to be used for DNA hybridization analysis; 2) serum samples provided to this study for detection of hydrocarbons; and 3) serum samples for routine clinical chemistry panels to assess the health of these falcons.

Material and Methods:

Methods for analysis of oil residues in serum and castings were modified from procedures by Fry and Lowenstine (7), Gay _et al_. (8) and Belisle _et al._ (5).

Preparation of serum samples:

Two serum samples were provided for analysis:

1) Gyrfalcon, female, Jan. 21, 1986 (Canadian?), 0.5 ml.
2) Peregrine Falcon,immature female #1,Dec.30, 1985, Sequim, WA, 0.5ml

Each sample was mixed with 10 ml 4N KOH, vortexed and placed in an 80°C water bath for 2 hrs to saponify neutral lipids. The aliphatic hydrocarbon fraction was extracted from the saponified emulsion and partitioned against 10 ml "Spectra" grade hexanes, vortexed for 30 sec, and allowed to stand to separate. The hexane extract was removed with a pasteur pipet and the volume was reduced to 0.1 ml prior to gas chromatography/mass spectrometry (GC/MS) analysis.

Preparation of Castings and Oiled Feathers:

Castings and feathers were pulled apart and extracted with 12 ml "Spectra" grade dichloromethane (CH_2Cl_2) for 30 minutes at room temperature. Samples were centrifuged at 800 x g and 10 ml of the solvent was recovered. Solvent volume was reduced to 1.0 ml for subsequent column chromatography.

Sample cleanup was performed on a 15 x 1 cm column packed with partially deactivated silica gel (deactivated with 3% water by weight) and was rinsed with hexane prior to use. Samples were eluted from the columns with 50 ml hexane and 50 ml benzene. Eluted samples were reduced to 0.5 ml prior to injection onto the gas chromatograph.

Analysis of extracts of feathers, castings and serum samples was performed on a Finnegan Model 3200 gas chromatograph/mass spectrometer maintained by the Facility for Advanced Instrumentation, University of California, Davis for recharge use by Departments and outside projects. One microliter samples were injected onto a 20 m DB-5 glass capillary column (J. and W. Scientific, Inc.) with an injection split ratio of 1:10. Samples were separated using a temperature program of 6°C per minute from 70 to 270°C. Data was stored on disk and analyzed using the Finnegan Incos data system. Reconstructed ion chromatograms were produced for selected ion masses to identify persistent aromatic and aliphatic hydrocarbons. Mass spectrometers used as GC detectors are not particularly sensitive, but offer the advantage of the ability to identify peaks. The detection sensitivity for hydrocarbons in this study was approximately 0.1 ng, giving an ability to detect hydrocarbons in samples at approximately 0.01 ug per ml serum or 0.01 ug per g of casting.

Results:

Analysis of oil extracted from feathers and castings:

Dichloromethane extracts of castings and oiled feathers from the Horned Grebe were brown in color. Most of the color remained on the silica gel cleanup column after elution with hexanes and benzene. The 1 ml of dichloromethane introduced on the column with all samples caused both the aliphatic and aromatic fractions of the petroleum to elute together. The benzene elution contained no additional identifable petroleum peaks.

The reconstructed ion chromatogram (RIC) of the hexane fraction of the extract of oiled feathers from the Horned Grebe is shown in Figure 1. The chromatogram is typical of GC/MS profiles of heavily weathered petroleum, containing several sharp peaks and a large "envelope" of unresolved peaks with longer retention times. Weathered petroleum looses many of the volatile components through atmospheric loss prior to being recovered, and as a result the sharply resolved aliphatic peaks are reduced in size and number. The large envelope of unresolved components is a mixture of many hundreds of aliphatic and aromatic compounds not resolvable by gas chromatography of the entire mixture.

Identification of individual compounds and classes of compounds was accomplished by reconstructing selected ion chromatograms of the molecular ions or component ions of aromatic and aliphatic hydrocarbons. The bottom of Figure 2 is a reconstruction of the first half of the total chromatogram shown in Figure 1. The top of Figure 2 is the selected ion chromatgram for mass 71, the molecular weight of a five carbon chain with 11 hydrogen atoms, which is an ionized fragment of straight-chain aliphatic hydrocarbons. The resolved peaks represent the series of aliphatic hydrocarbons present in the weathered oil. The two prominent peaks had retention times consistent with c-18 and c-20 hydrocarbons. The weathering resulted in the loss of most of the smaller molecular weight aliphatics, and the relatively short glass capillary column and 6^{o} per minute temperature program resulted in incomplete separation and broadening of the peaks of larger molecular weight species. Small broad peaks are present for several of the hydrocarbons with more than twenty carbon atoms.

Identification of several polynuclear aromatic hydrocarbons with the mass spectrometer was possible by selectively monitoring for molecular ions (the intact molecule with the loss of single electron). Figures 3 through 5 show the reconstructed ion chromatograms and the retention times and distribution of selected ions. Figure 3 gives the chromatographic pattern for ions of mass 178, representing phenanthrene or anthracene (MW=178), and the methyl-, dimethyl-, and trimethyl- substitutions at the successively higher molecular weights of masses 192, 206 and 220. See Figure 6 for diagrams of aromatic hydrocarbon molecules. Figure 4 represents a similar series for the four-ring aromatics: fluoranthene and pyrene (MW=202), methyl-fluoranthene, methyl-pyrene, or benzofluorene (MW=216), and the dimethyl- (MW=230), trimethyl- (MW=244), and tetramethyl- (MW=258) substituted species. The increased noise in this series is due to the very low concentrations of these compounds. Figure 5 gives the chromatograms of the 5 ring series comprised of chrysene, benzanthracene, benzphenanthrene, napthacene, and triphenylene (all MW=222), and the methyl, dimethyl, and trimethyl substitutions (MWs=236, 250, and 264 respectively). Identification of the "parent" unsubstituted compounds was based on confirmation of the mass spectra and retention times of standard and examples presented in the literature (9). The peaks of the methyl-substituted compounds, each of which followed with a successively longer GC retention time, were verified with mass spectra and by their relative retention times when concentrations were too low for mass spectral confirmation.

The reconstructed ion chromatograms of the Gyrfalcon and Peregrine castings are given as Figures 7 and 10. Only a very minor "envelope" of compounds of long retention time was detected in the Gyrfalcon casting. The highly expanded RIC and selected ion fragment pattern of MW=71 are given in Figure 8 and indicate unresolved aliphatic hydrocarbons slightly above background levels. Figure 9 gives the selected ion patterns of phenanthrene/anthracene (MW=178) and fluoranthene/pyrene (MW=202) which show no detectable peaks of these aromatics in the casting. Only unresolvable traces of hydrocarbons were detected in this sample.

Figure 10 represents the Peregrine casting, which has several small individual peaks. The peak at scan #457 has the retention time and spectrum of 2,6,10,14-tetramethyl-pentadecane (pristane), a methyl substituted aliphatic hydrocarbon present in crude petroleum. The presence of this compound alone, without other aliphatics or aromatics is highly unlikely, and must represent a contaminant from the glassware or solvents. The second small peak at scan # 407 is an unidentified compound containing a disulfide and several carbon atoms and is probably a substituted thiol of bacterial origin which was partly responsible for the intense odor of the castings. Other mercaptans would have been water soluble and not extracted from the silica gel column. No petroleum hydrocarbons from the "Arco Anchorage" were detected in this sample.

Figures 11 and 12 give the reconstructed chromatograms of the extracts of Gyrfalcon and Peregrine serum samples. Both profiles are at background with only minor peaks at scans #387 and #391, which represent the same compound, benzenedicarboxylic acid (phthalic acid), a ubiquitious plasticizer found in almost every sample, whose source could be glassware. plastic bags, GC column contaminants, syringes, or even prey items of the birds. No petroleum hydrocarbons were detected in sera of either of the falcons.

Discussion:

Prudhoe Bay crude oil is an aromatic based crude containing moderate levels of many polynuclear aromatics including several cancer suspect agents. The toxicity of Prudhoe Bay crude has been evaluated in several field trials, captive experiments and laboratory studies on seabirds, particularly by the Canadian Wildlife Service (12, 13, 14, 15, 16, 17, 18, 19, 20, 22) and by the U. S. Fish and Wildlife Service Patuxent Laboratory at Laurel, Maryland (1, 2, 3, 4, 10, 11, 21). The physiological toxicity of crude oil is due largely to the polyaromatic hydrocarbons (6, 9, 10, 11, 18, 19, 20). This was one reason for selectively monitoring for the presence of these persistent compounds in the weathered oil on feathers and in the castings and sera of falcons at risk.

No components of oil were detected in the castings or sera of falcons indicating that, although the birds were feeding on oiled prey, the levels of oil ingested and retained by the birds was probably very low. Analysis of fat was not performed, as birds were not sacrificed. Fat samples would be the tissue likely to have the highest concnetrations of oil contaminants because the hydrocarbon fraction is lipid soluble. Serum has little circultaing lipid, except in female birds during egg formation, and resultingly, the concentrations of oil components would be expected to be lower in serum than for many other tissues. Our ability to concnetrate the samples and monitor for low concnetrations of specific ions, however, should have been able to detect the presence of contaminants if they were recently eaten and present in physiologically significant concentrations.

In summary, feathers from an oiled Horned Grebe contained heavily weathered crude oil with a high polyaromatic content siminalr to the spilled Prudhoe Bay crude oil from the "Arco Anchorage". Samples of feathers from castings of a Peregrine Falcon and a Gyrfalcon did not contain detectable amounts of hydrocarbons. Serum samples from one Peregrine Falcon and one Gyrfalcon did not contain detectable hydrocarbon residues from consumption of oiled prey.

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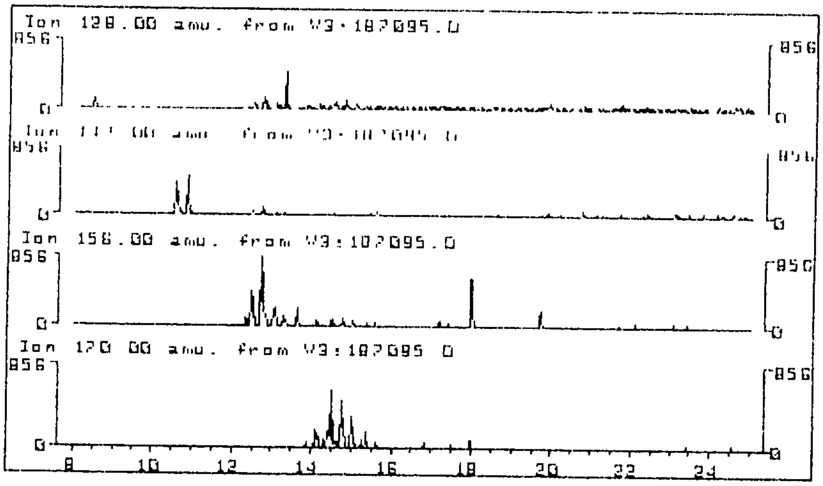
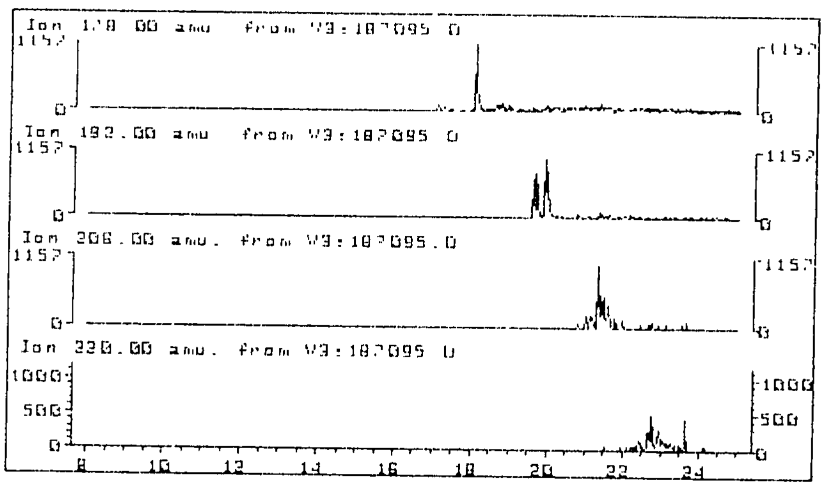
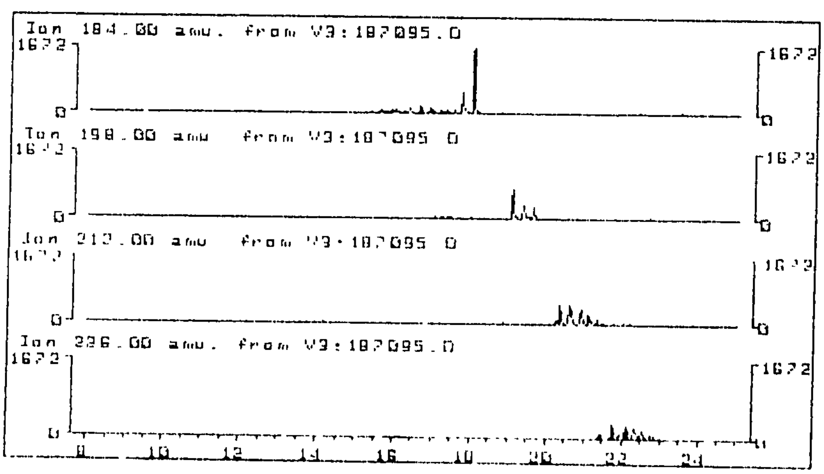
11.0 APPENDIX III

STUDY OF OIL IN FEATHERS OF OILED PREY BIRDS, CASTINGS, AND SERUM FROM FALCONS IMPACTED IN THE "ARCO ANCHORAGE" OIL SPILL

MAJOR HOMOLOG GROUPS







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Operator : CB

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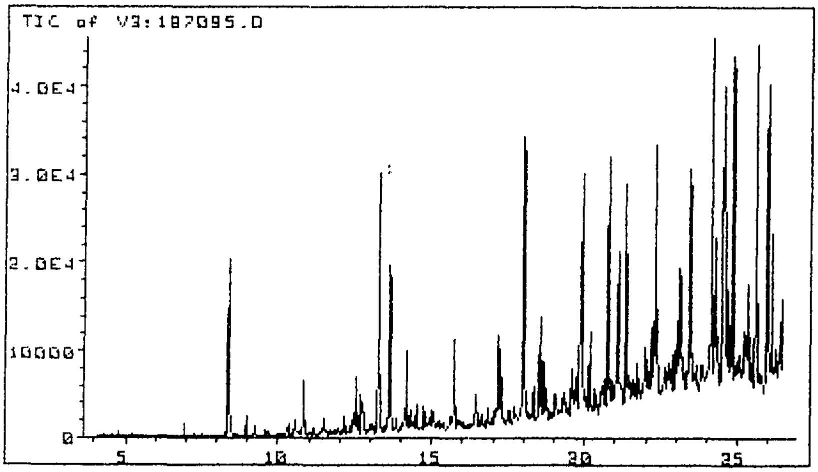
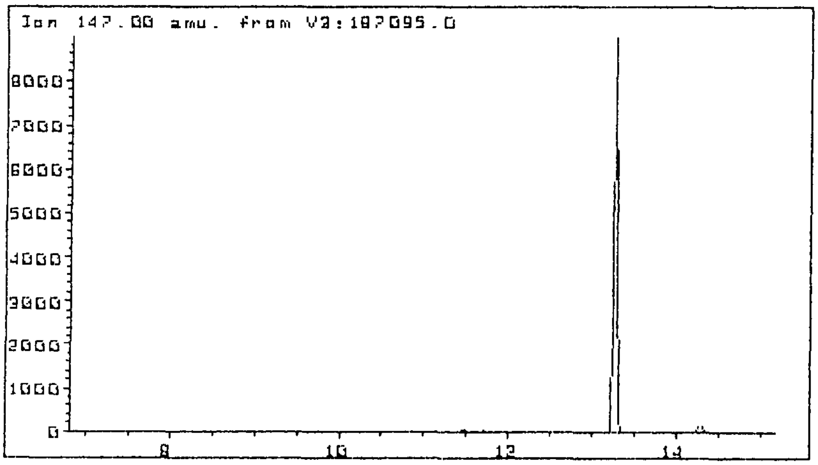
Replicate num :   0



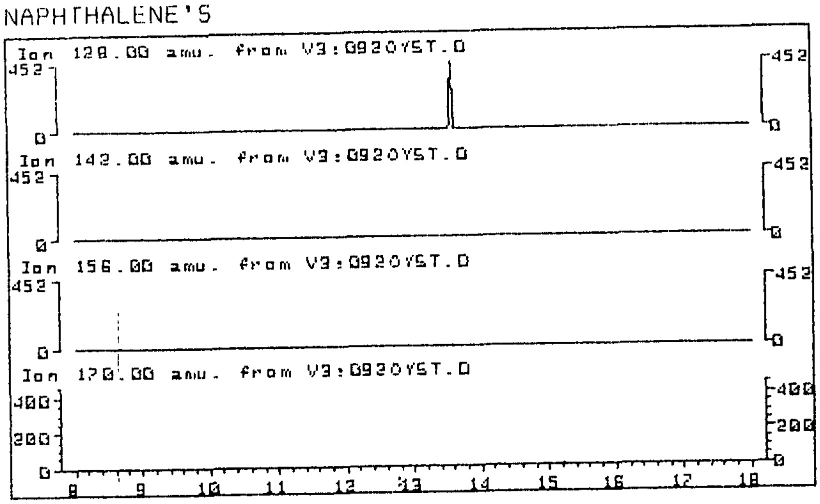
.......................MACRO ACRO ARCOX
I.S.



INST. FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY

187092

MAJOR HOMOLOG GROUPS
NAPHTHALENE'S



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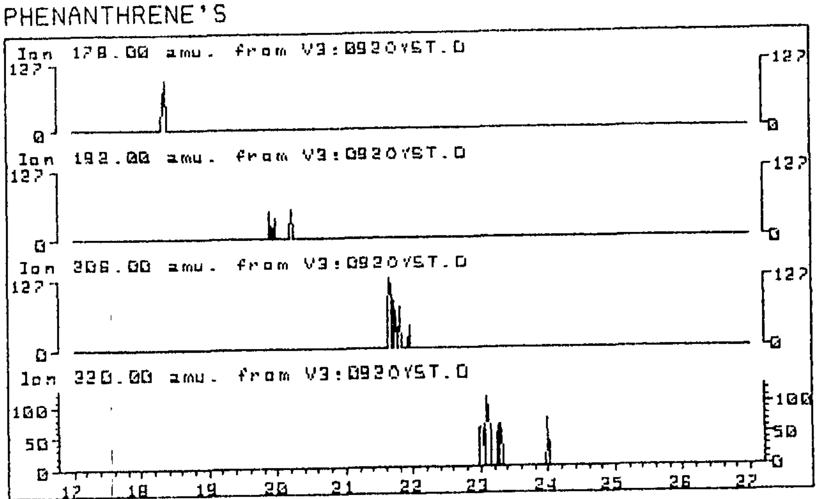

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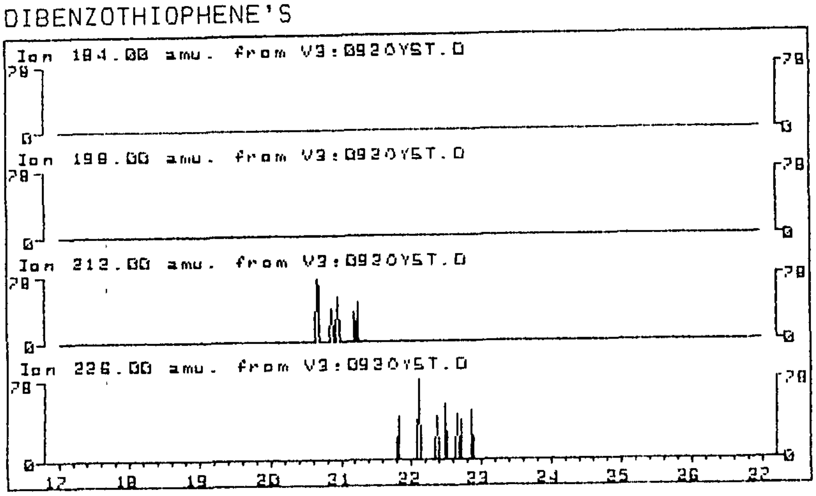
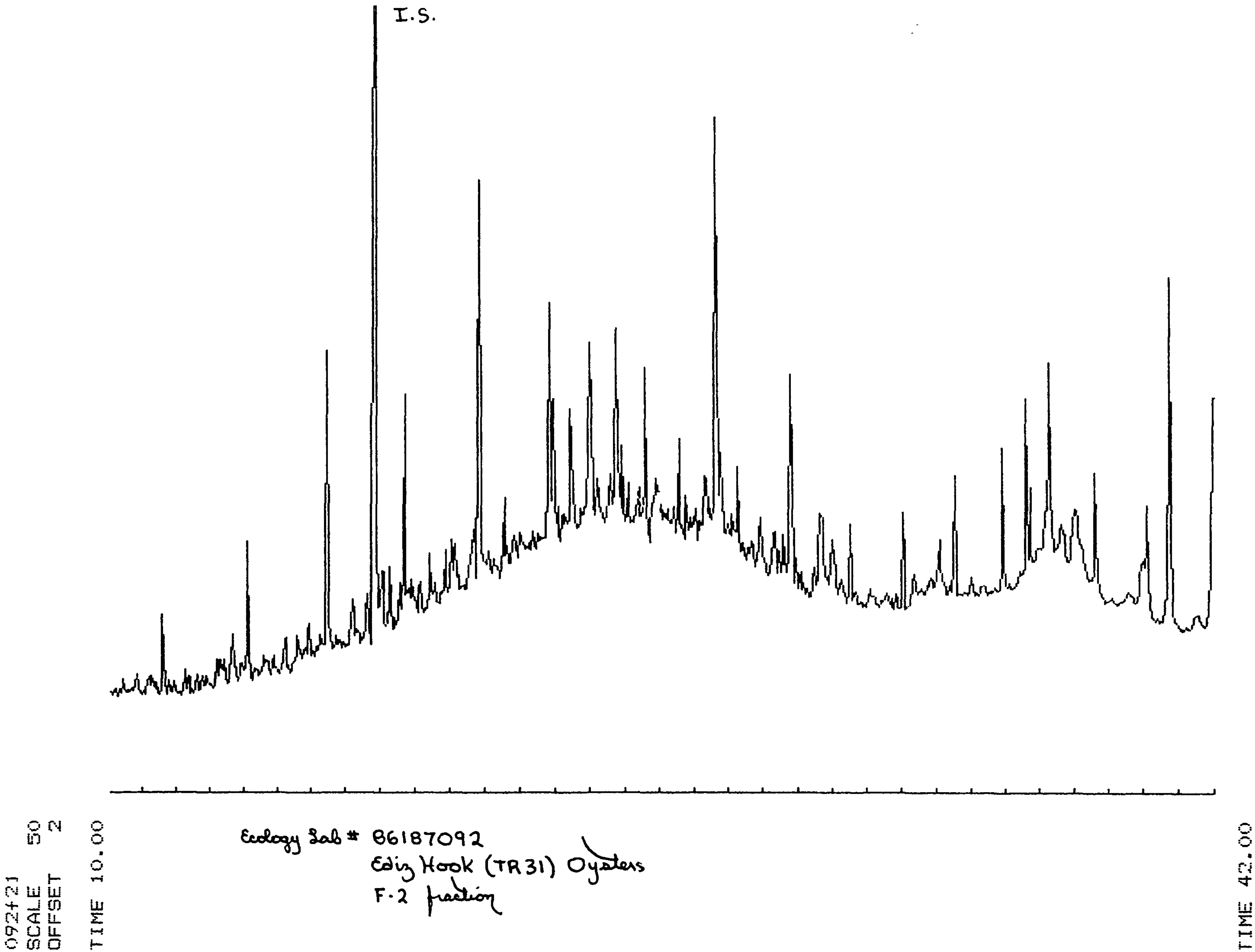


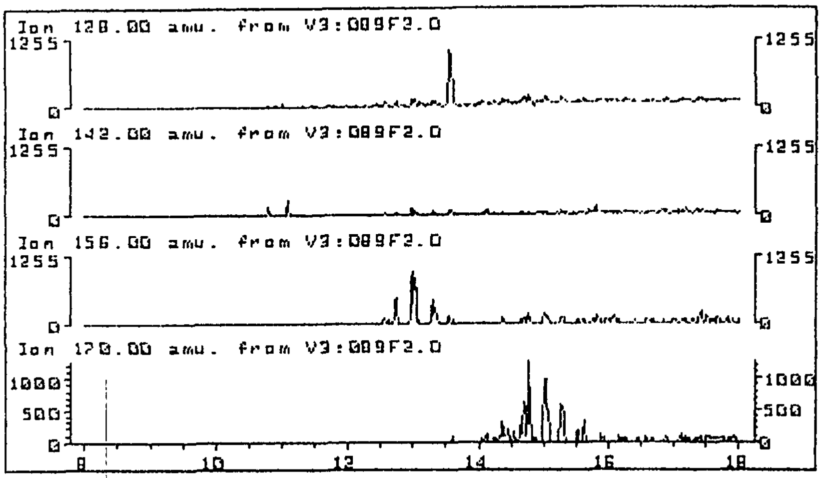


Ecology Lab # 86187092
Ediz Hook (TR31) Oysters
F-2 fraction

MAJOR HOMOLOG GROUPS

Ecology Lab # 187089

NAPHTHALENE'S



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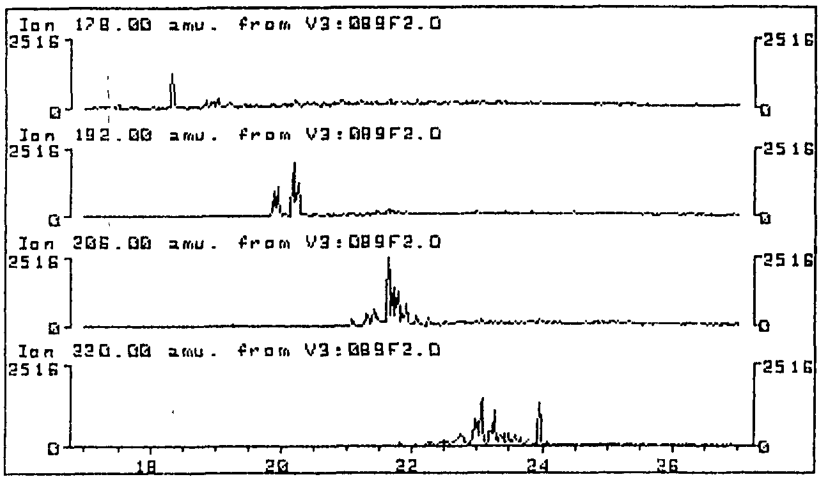
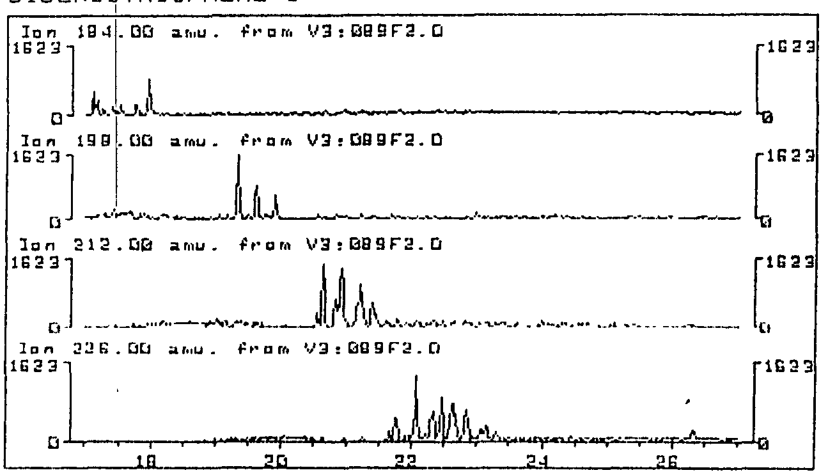
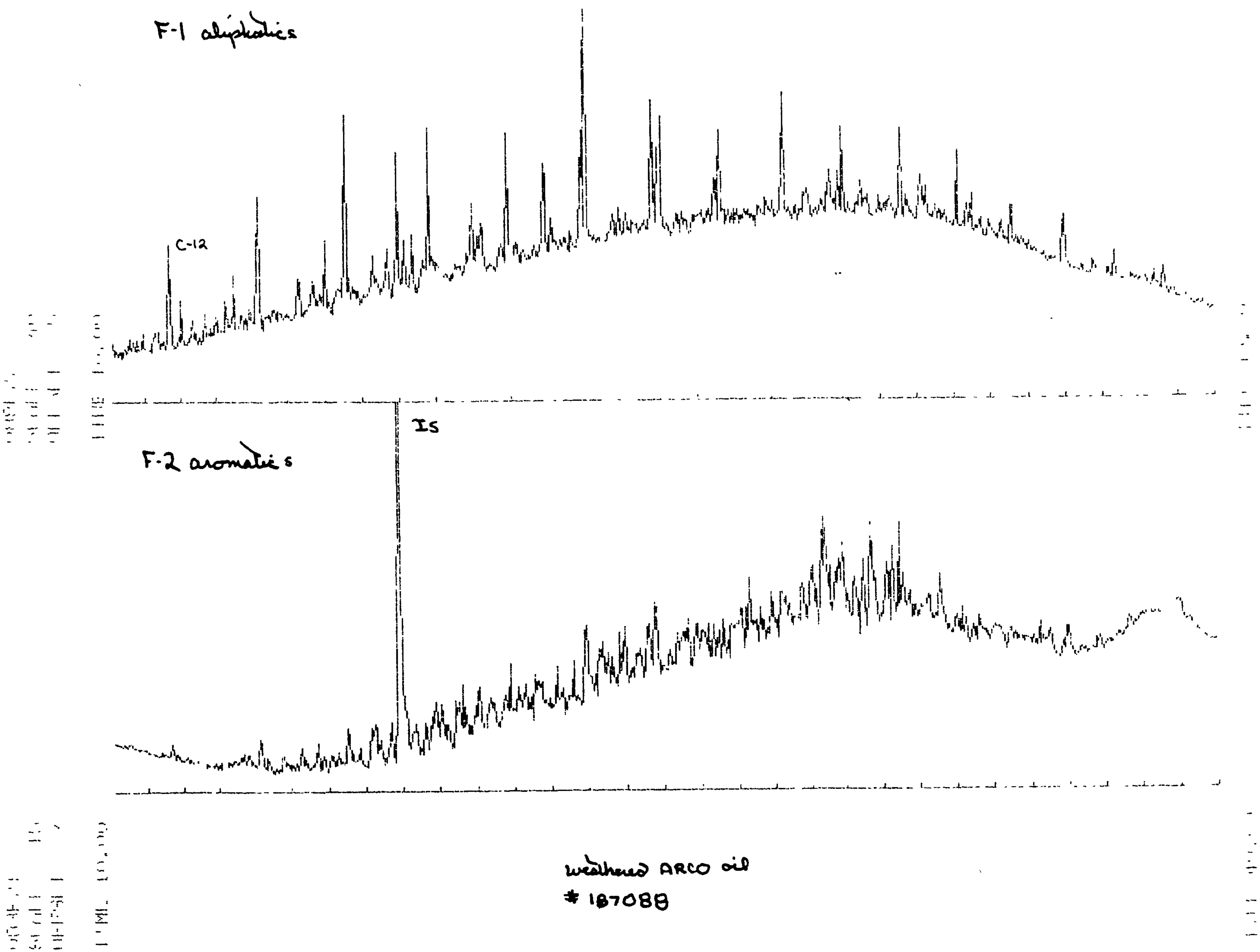


DIBENZOTHIOPHENE'S




F-1 aliphatics
C-12
IS
F-2 aromatics
weathered ARCO oil
187088

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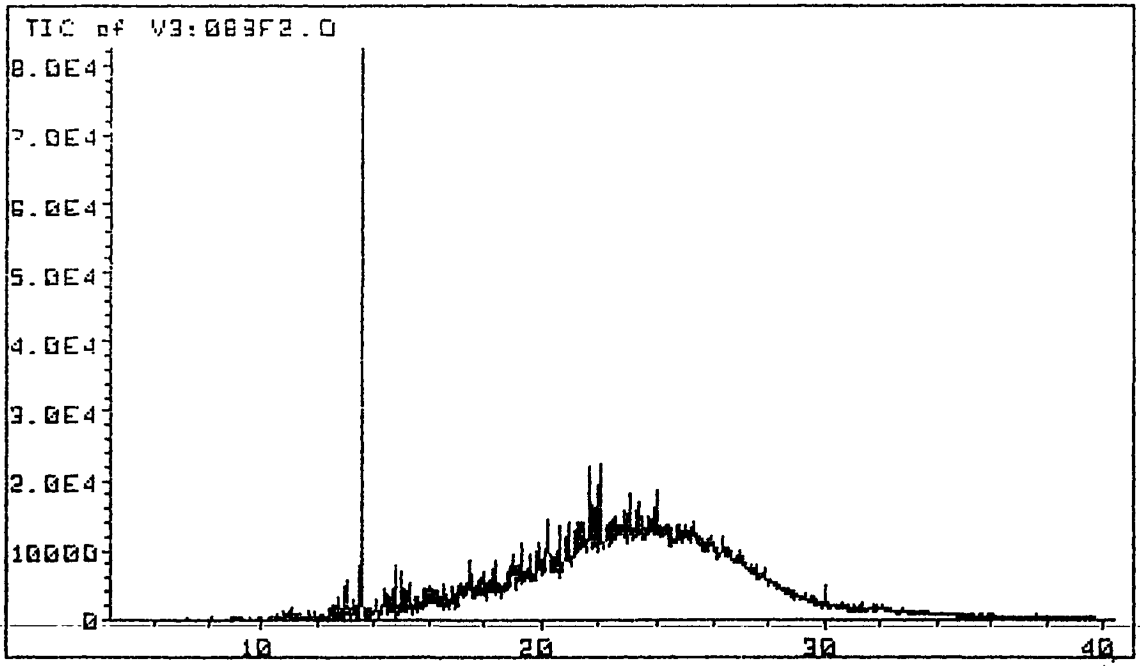

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Lewey J. Kittle, Jr.
Dept. of Ecology
State of Washington
Mail Stop PV 11
Olympia, Washington 98504-8711

22, Nov. 1986

Dear Dr. Kittle:

Enclosed is the information you requested by phone on 14, Nov. 1986.

I limited the compound list to the major aromatic componets in slightly weathered crude oil, those usally associated with particulate deposition, and those of intrest because of there potential carcinogenicity.

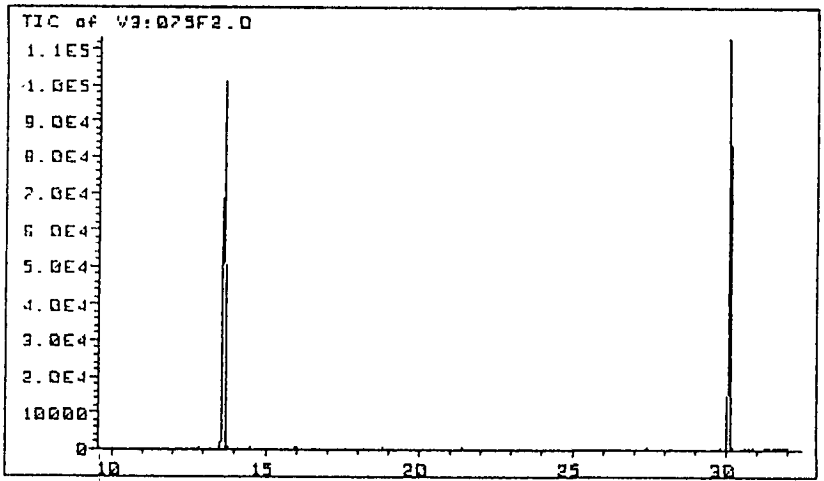
All of the weights listed are in PPM wet weight. The clams are calculated by weight less their shell. Please contact me with any questions.

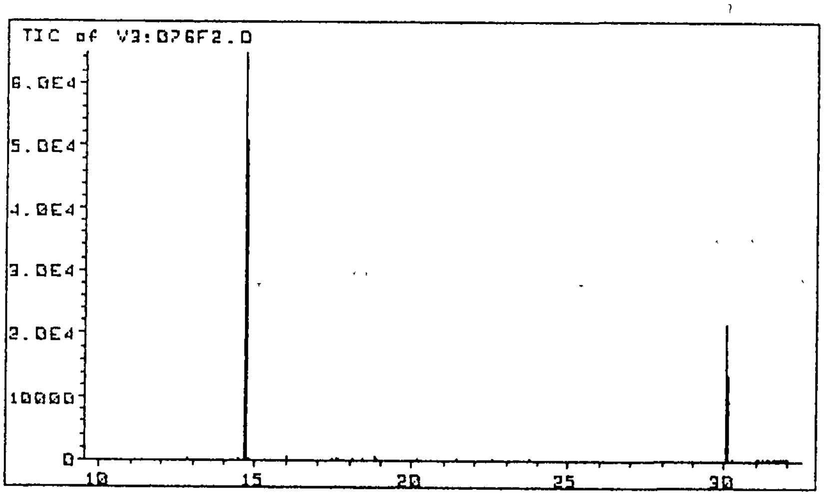
Sincerely,

Charlie Henry

enclosures

xc: Tom McKinney

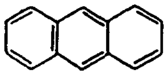
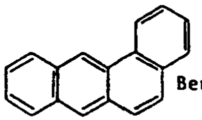
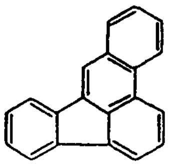
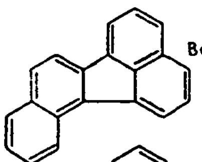
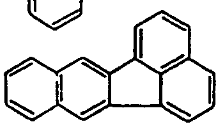
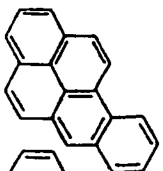
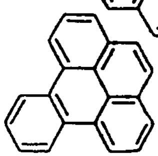

TIC of V3:075F2.D
1.1E5
1.0E5
9.0E4
8.0E4
7.0E4
6.0E4
5.0E4
4.0E4
3.0E4
2.0E4
10000
0
10
15
20
25
30


TIC of V3:076F2.D
6.0E4
5.0E4
4.0E4
3.0E4
2.0E4
10000
0
10
15
20
25
30

HPLC for the measurement of PNA's in water
from a reprint of a presentation at the Water Quality Technology Conference, Kansas City, Missouri Dec, 1977

Table 1a

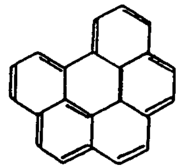
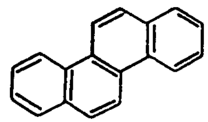
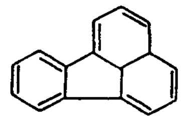
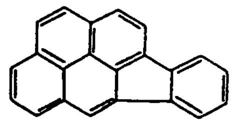
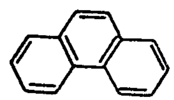
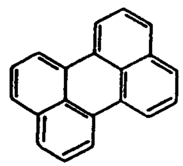
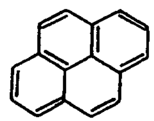
PAHs Commonly Found in Water

Structure	I.U.P.A.C. name	Mol. Wt.	Relative Carcinogenicity	Abbreviatio
	Anthracene	178	?	An
	Benzo(a)anthracene	228	+	B(a)A
	Benzo(b)fluorathene	252	++	B(b)F
	Benzo(j)fluorathene	252	++	B(j)F
	Benzo(k)fluorathene	252	-	B(k)F
	Benzo(a)pyrene	252	+++	B(a)P
	Benzo(e)pyrene	252	+	B(e)P

+++, active; ++, moderate; +, weak; ?, unknown; -, inactive

Table 1b

PAHs Commonly Found in Water

Structure	I.U.P.A.C. name	Mol. wt.	Relative Carcinogenicity	Abbreviation
	Benzo(ghi)perylene	276	-	B(ghi)P
	Chrysene	228	-	Ch
	Fluoranthene	202	-	Fl
	Indeno(1,2,3-cd)pyrene	276	+	IP
	Phenanthrene	178	?	Ph
	Perylene	252	-	Per
	Pyrene	202	-	Pyr

(Harrison et al., 1975)

Table 1. Concentrations of the major PAHs found in ARCO samples

conc. in ppm wet weight

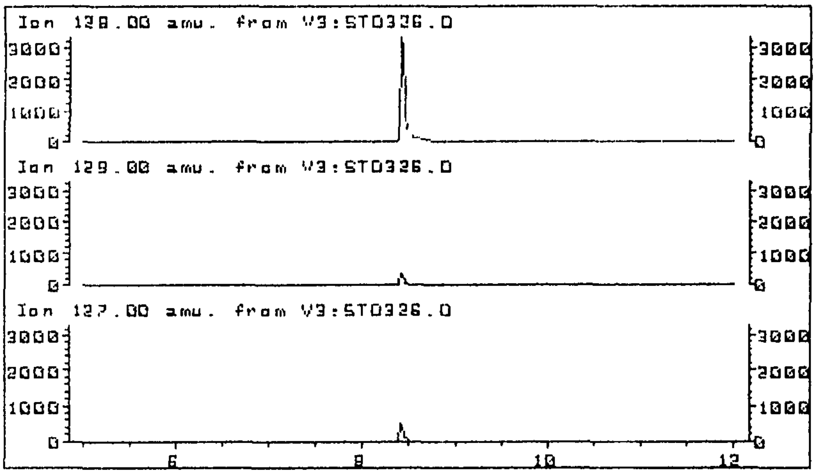
COMPOUND	187086	187087[4]	187088	187089
NAPHTHALENE	ND	ND	ND	ND
TOTAL NAPTHALENES[1]	T	ND	T	36
PHENANTHRENE	0.13	0.10	T	00.73
TOTAL PHENANTRENES[1]	2.1	----	T	71
DIBENZOTHIOPHENE[2]	T	T	ND	00.13
TOTAL DIBENZOTHIOPHENES[1]	2.8	----	T	71
FLUORANTHRENE	0.15	T	0.70	00.07
PYRENE	0.08	0.17	4.30	00.22
BENZO(a)ANTHRACENE	ND	0.26	ND	00.51
CHYRSENE	T	0.16	T	00.32
BENZO(b)FLOURANTHRENE[3]	ND	T	T	00.35
BENZO(a)PYRENE	ND	T	ND	ND

COMPOUND	187092	187093[5]	187095[5]	147854[6]
NAPHTHALENE	ND	ND	T	T
TOTAL NAPTHALENES[1]	ND	ND	0.57	166
PHENANTHRENE	T	ND	0.32	30
TOTAL PHENANTRENES[1]	0.20	ND	1.3	50
DIBENZOTHIOPHENE[2]	ND	ND	0.18	11
TOTAL DIBENZOTHIOPHENES[1]	0.02	ND	0.50	22
FLUORANTHRENE	0.01	T	T	00.46
PYRENE	0.01	T	T	01.0
BENZO(a)ANTHRACENE	0.01	T	ND	----
CHYRSENE	0.01	T	ND	----
BENZO(b)FLUORANTHRENE[3]	T	ND	ND	----
BENZO(a)PYRENE	T	ND	ND	----

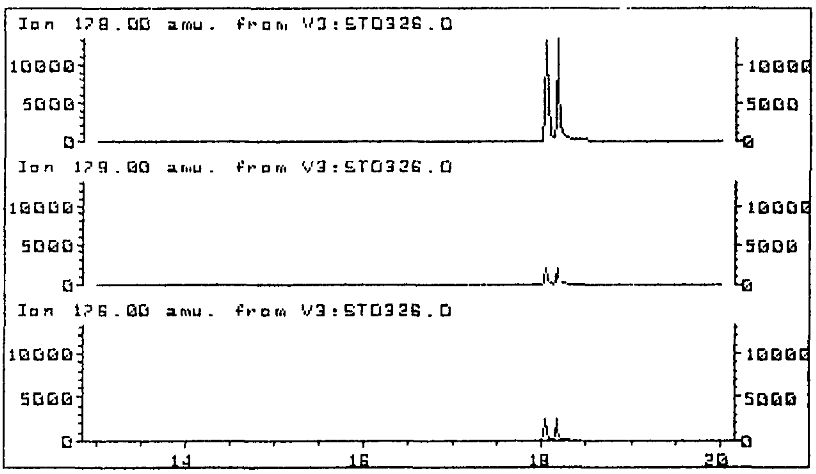
ND- NOT DETECTED. Unless stated otherwise, the detection limit is 0.02 ppm wet weight.
T-TRACE (COMPOUND PRESENT BUT BELOW INTEGRATION PARIMETERS)
---- -UNABLE TO QUANTITATE OR VARIFY.

1. The total concentration of the C-1 through C-3 homolog groups. SEMIQUANTITATIVE
2. SEMIQUANTITATIVE Calculations based on the response factor of phenantrene.
3. Benz0(b)fluorantrene and benzo(k)fluoranthrene are reported as one since they tend to coelute on the GC.
4. Sample 187087 was quantitated on a GC/FID. The FID does not have the selectivity to resolve the homolog groups for accurate quantitations.
5. Detection limit 0.1 ppm
6. Semiquantitative.

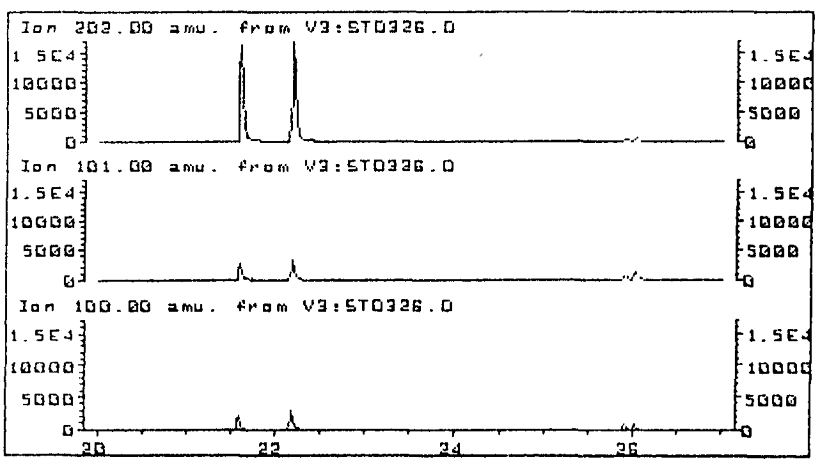
NAPH.



PHEN.



FLUORANT. AND PYRENE

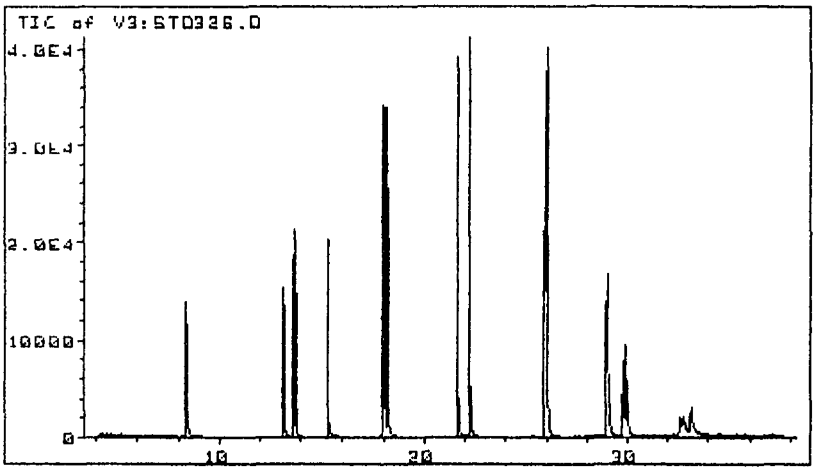


Data file: V3:STD326.D
File type: GC / MS DATA FILE

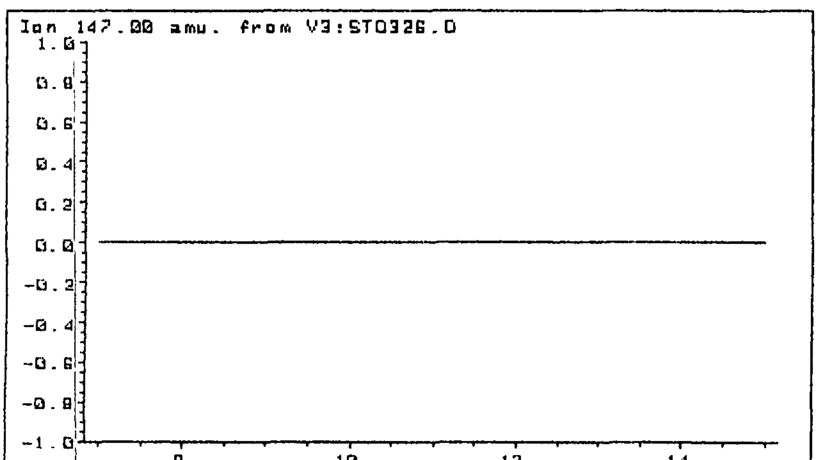
Name Info: 50 NG 007 PLUS IS
Misc Info: BNA METH
Operator : CB

Date : 21 Nov 86 12:24 pm
Instrment: MS_5970
Inlet : GC

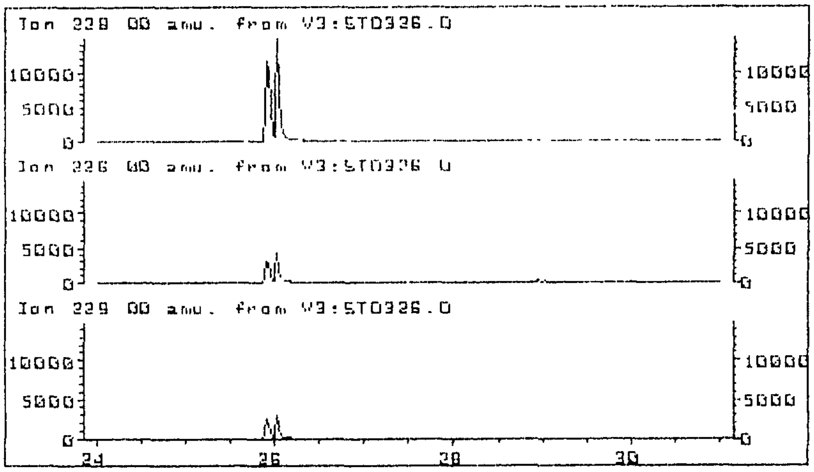
Sequence index : 0
Als bottle num : 0
Replicate num : 0



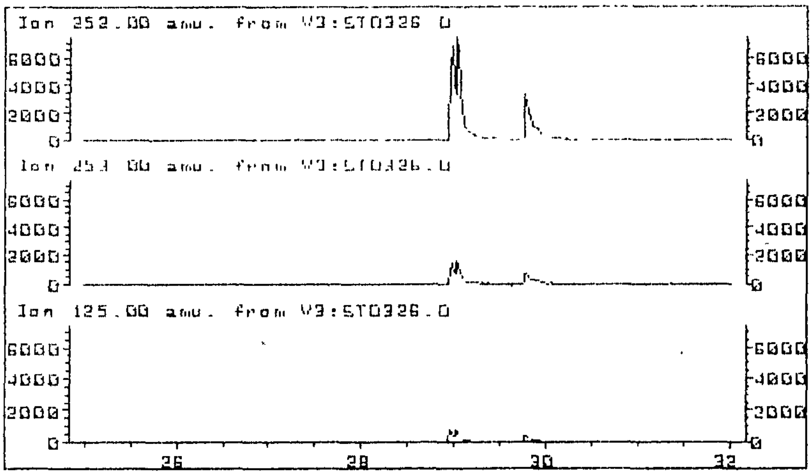
........................MACRO ACRO ARCOX
I.S.



B(A)ANT. AND CHRYSENE



B(A)P.

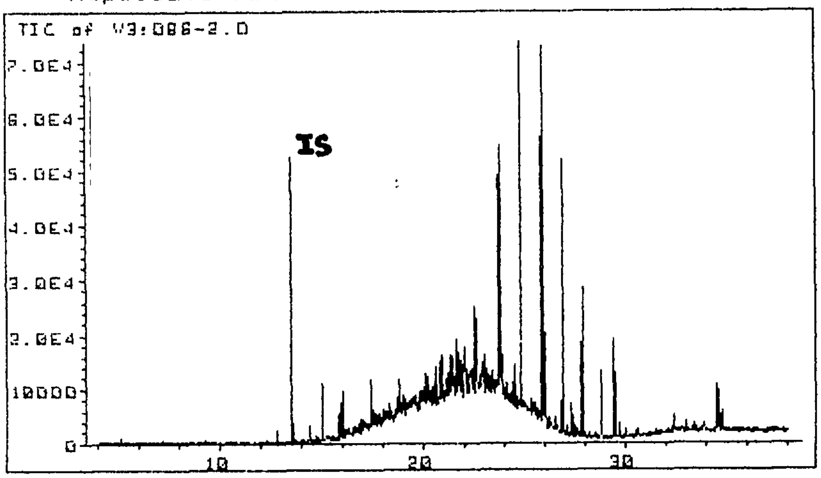


Data file: V3:086-2.D
File type: GC / MS DATA FILE

Name Info: 187086-2-F2 2UL INJ ARCO OIL SPILL
Misc Info: BNA METH EMV=1800
Operator : CB

Date : 5 Sep 86 3:40 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



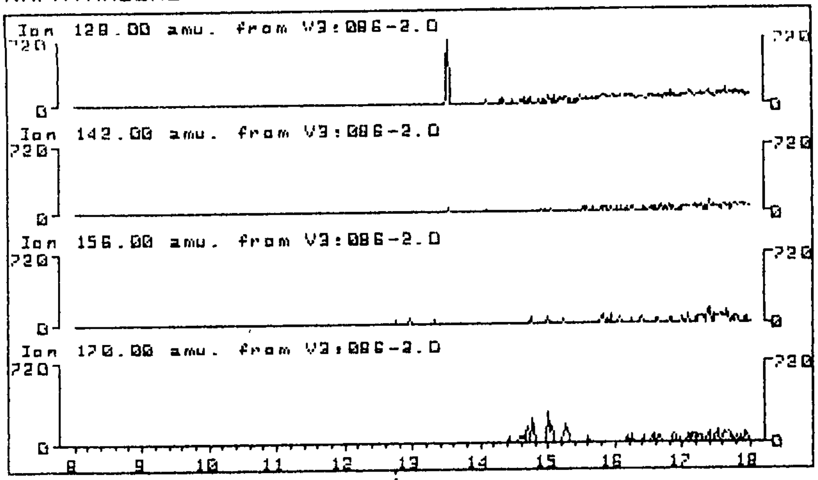
F-2 fraction ext of a medium size clam

total wt 231 grams
net wt 27.8 grams (weight less the shell)

INST. FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY

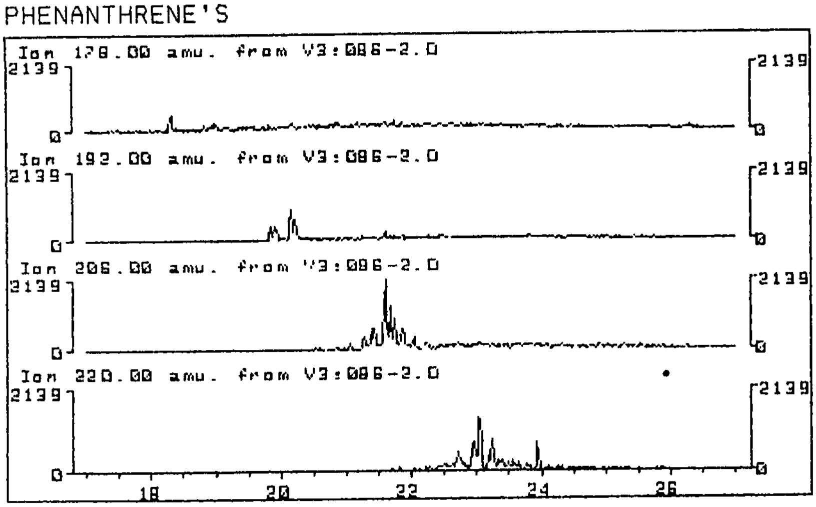
MAJOR HOMOLOG GROUPS

NAPHTHALENE'S

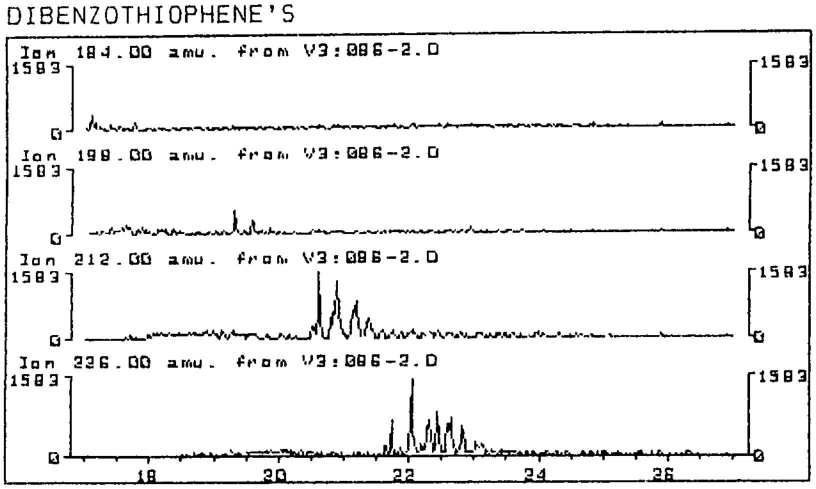


Sample 187086

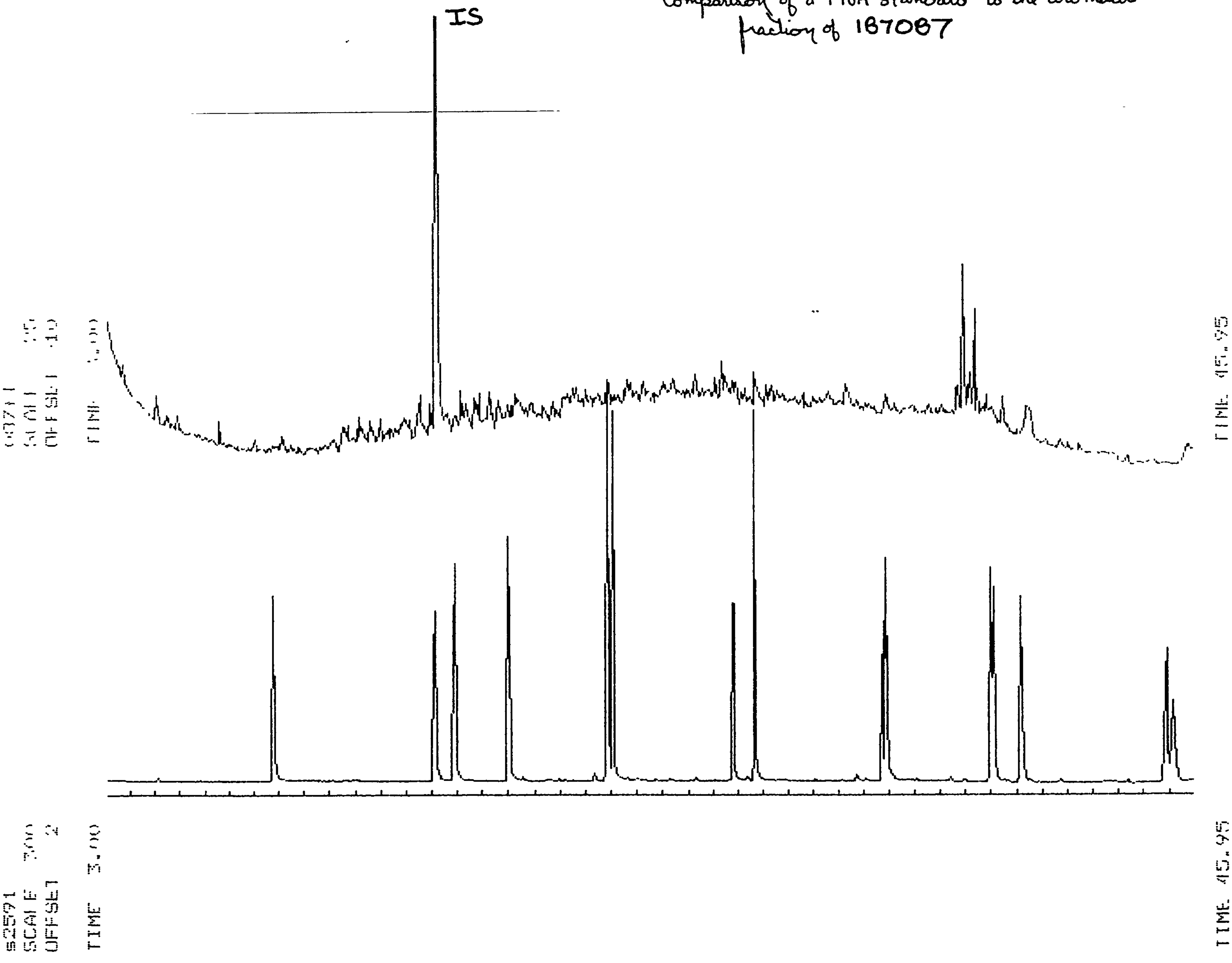
PHENANTHRENE'S



DIBENZOTHIOPHENE'S



Comparison of a PNA standard to the aromatic fraction of 187087



LIBRARY SEARCH RESULTS

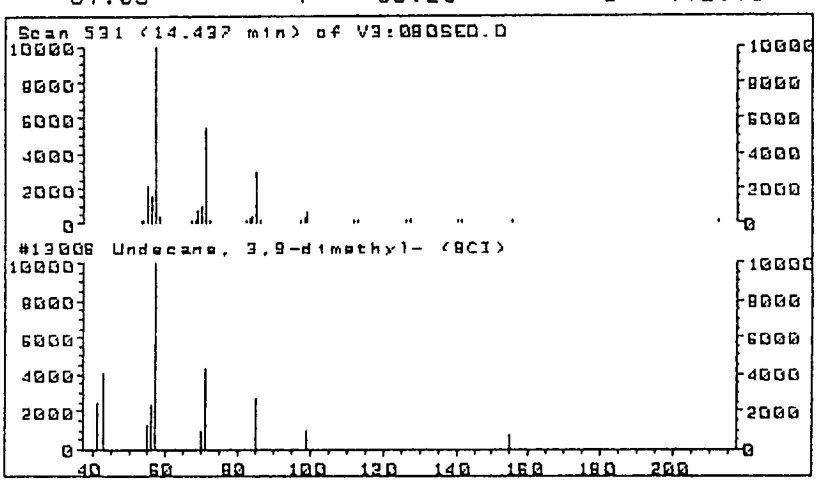
Scan 531 (14.437 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Undecane, 3,9-dimethyl- (8CI)	17301314	13006	9120
2: Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9110
3: Tritetracontane (8CI9CI)	7098217	37877	9090
4: Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9022
5: Undecane, 3,6-dimethyl- (8CI)	17301289	13003	8984
6: Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8945
7: Undecane, 5,5-dimethyl- (8CI)	17312731	13019	8916
8: Octatriacontane, 3,5,23-trimethyl- (8CI)	13897160	37638	8912
9: Undecane, 3,5-dimethyl- (8CI)	17312811	13027	8904
10: Hexadecane, 2,6,10-trimethyl- (9CI)	55000527	23956	8860

Scan 531 (14.437 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
53.15	2	68.15	1	84.20	4	113.20	2
54.15	2	69.15	7	85.20	29	126.20	1
55.15	21	70.15	10	86.20	2	127.20	1
56.15	16	71.15	55	97.20	2	140.25	1
57.15	100	72.15	2	98.20	3	141.25	1
58.15	4	82.10	1	99.20	6	155.25	1
67.05	1	83.20	3	112.10	2	212.30	1



LIBRARY SEARCH RESULTS

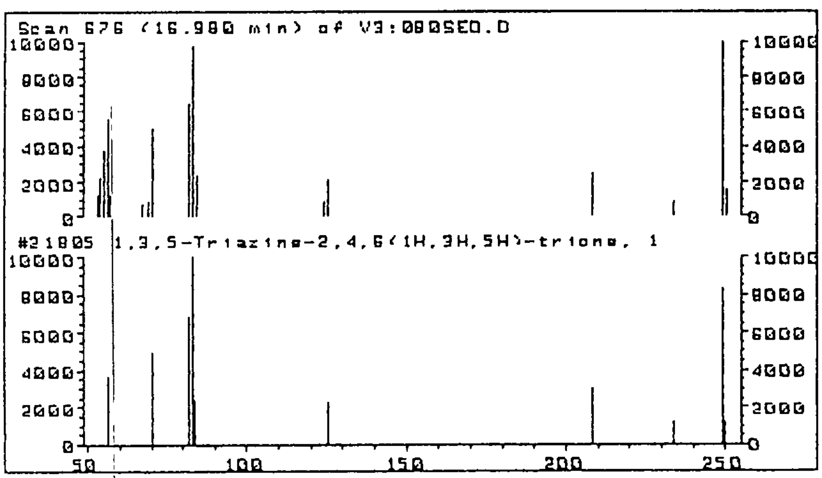
Scan 676 (16.980 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: 1,3,5-Triazine-2,4,6(1H,3H,5H)-trione, 1	1025156	21805	9588
2: 1H-1,2,4-Triazole, 1-butyl- (8CI9CI)	6086222	3367	7388
3: Cyclohexane, pentyl- (8CI9CI)	4292926	7859	6819
4: Cyclohexane, butyl- (8CI9CI)	1678939	5403	6774
5: Cyclohexane, (4-methylpentyl)- (9CI)	61142209	10378	6722
6: 1H-Pyrrolizine-1-carboxylic acid, hexahy	54514964	10627	6705
7: Cyclohexane, octyl- (9CI)	1795159	14874	6642
8: Cyclohexane, 1,1'-(1,3-propanediyl)bis-	3178243	16670	6625
9: Glycine, N-(3-methyl-1-oxo-2-butenyl)-,	56009348	10958	6621
10: Cyclohexane, decyl- (9CI)	1795160	18898	6603

Scan 676 (16.980 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
52.95	12	67.25	7	83.10	98	208.10	25
53.95	22	69.05	9	84.10	23	234.10	9
55.15	37	70.05	50	124.00	9	249.15	100
56.05	56	82.10	65	125.10	21	250.25	16
57.05	12						



LIBRARY SEARCH RESULTS

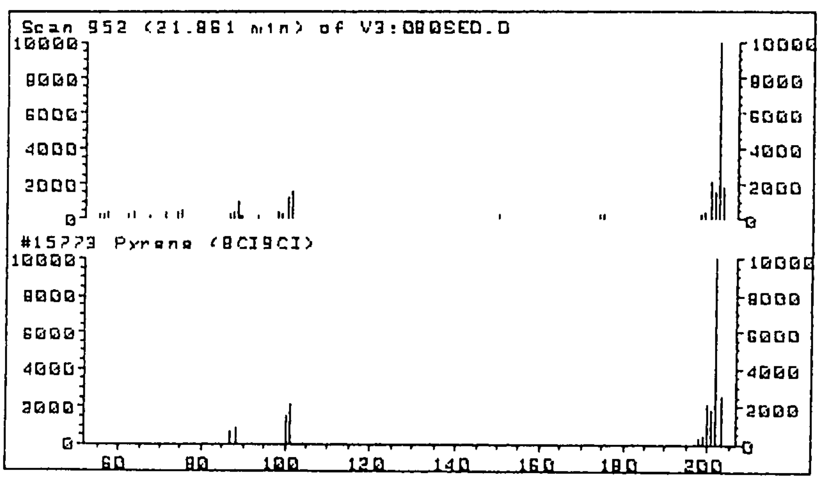
Scan 952 (21.861 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Pyrene (8CI9CI)	129000	15773	9942
2:	Fluoranthene (8CI9CI)	206440	15774	9899
3:	Benzene, 1,1'-(1,3-butadiyne-1,4-diyl)bi	886668	15775	9825
4:	L-Tryptophan, N-(trifluoroacetyl)-1-(tri	52558119	35317	9387
5:	1H-Indole-3-propanoic acid, 1-(trimethyl	55319910	34487	9081
6:	7H-Furo[3,2-g][1]benzopyran-7-one, 9-[(4	65853147	25690	9060
7:	7H-Furo[3,2-g][1]benzopyran-7-one, 9-[[5	68725644	35158	8992
8:	Glycine, N,N'-1,2-ethanediylbis[N-(2-eth	3626004	33784	8941
9:	Pyrene, 10b,10c-dihydro-10b,10c-dipropyl	28816946	25964	8865
10:	7H-Furo[3,2-g][1]benzopyran-7-one, 9-hyd	2009247	15687	8825

Scan 952 (21.861 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
55.05	3	74.05	4	93.10	2	175.05	3
55.95	3	74.95	5	98.00	4	198.10	3
56.25	3	86.20	3	98.70	3	199.10	4
57.15	4	87.30	4	100.10	12	200.10	21
62.05	3	88.10	10	101.10	16	201.20	16
63.15	4	88.90	2	150.15	3	202.10	100
67.25	2	89.10	2	174.05	3	203.10	18
70.85	4						



LIBRARY SEARCH RESULTS

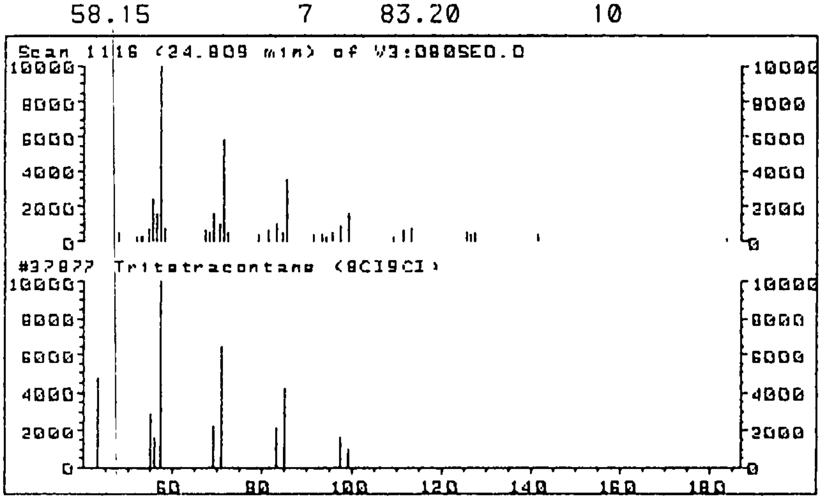
Scan 1116 (24.809 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Tritetracontane (8CI9CI)	7098217	37877	9344
2: Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9176
3: Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9094
4: Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8985
5: Undecane, 3,9-dimethyl- (8CI)	17301314	13006	8920
6: Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	8915
7: Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8913
8: Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8838
9: Heneicosane (8CI9CI)	629947	26682	8828
10: Nonahexacontanoic acid, 18-oxo- (9CI)	40710289	38734	8819

Scan 1116 (24.809 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
47.45	5	66.95	6	84.30	5	109.10	3
51.55	3	68.15	5	85.20	35	111.10	6
52.85	3	69.05	16	91.20	4	113.20	7
53.05	3	70.15	10	92.90	4	125.20	5
54.25	7	71.05	58	94.20	3	126.20	4
55.15	23	72.15	5	95.20	5	127.20	5
56.15	16	78.95	4	97.10	9	141.15	4
57.15	100	81.10	6	99.20	15	183.45	2
58.15	7	83.20	10				



LIBRARY SEARCH RESULTS

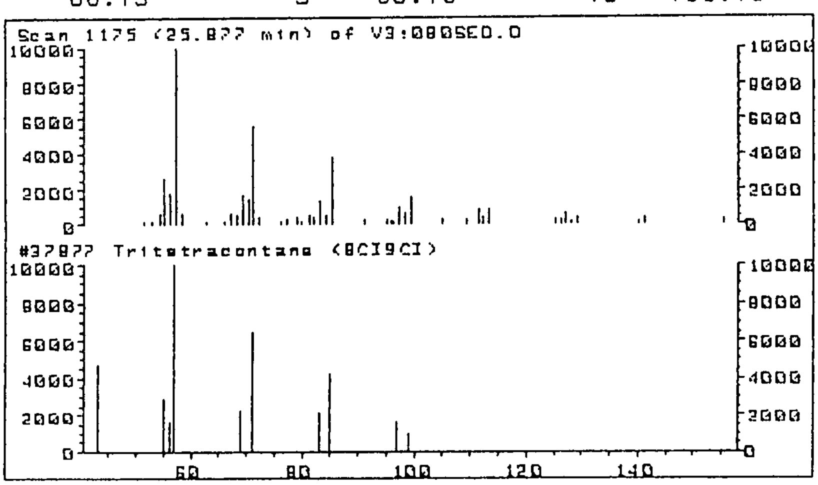
Scan 1175 (25.877 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Tritetracontane (8CI9CI)	7098217	37877	9351
2: Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9083
3: Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9005
4: Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8949
5: Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8911
6: Undecane, 3,9-dimethyl- (8CI)	17301314	13006	8870
7: Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	8821
8: Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8766
9: Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8755
10: Nonahexacontanoic acid, 18-oxo- (9CI)	40710289	38734	8742

Scan 1175 (25.877 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
51.55	2	69.15	17	84.10	5	111.30	8
52.95	2	70.15	14	85.20	37	112.00	4
54.15	6	71.15	56	91.20	3	113.20	9
55.15	26	72.15	4	95.20	3	125.20	3
56.15	18	76.25	2	95.90	2	126.40	3
57.15	100	77.15	3	96.20	2	127.10	6
58.15	6	79.15	4	97.10	10	128.10	2
62.75	2	79.85	2	98.30	6	129.00	4
65.85	2	81.20	5	99.20	15	140.15	2
67.15	6	82.10	4	105.00	3	141.25	4
68.15	5	83.10	13	109.10	3	155.25	3



LIBRARY SEARCH RESULTS

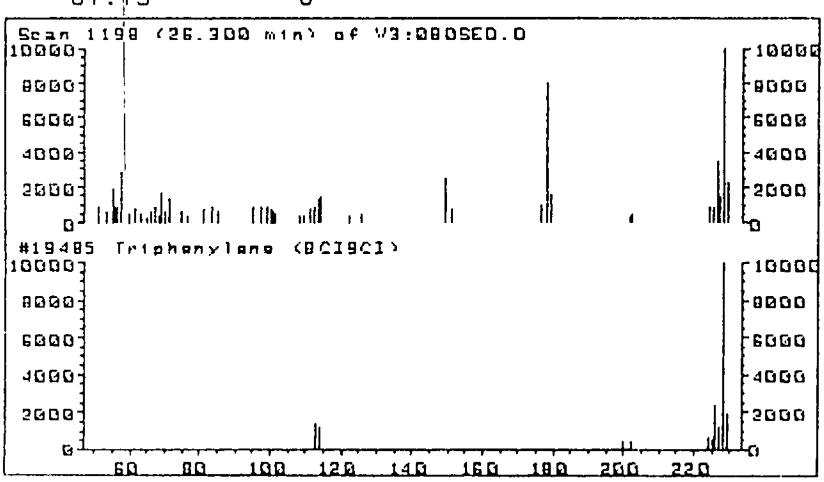
Scan 1198 (26.300 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Triphenylene (8CI9CI)	217594	19485	7703
2:	Chrysene (8CI9CI)	218019	19486	7601
3:	Naphthacene (8CI9CI)	92240	19483	7462
4:	Benzo[c]phenanthrene (8CI9CI)	195197	19484	7427
5:	3,6-Phenanthrenedicarbonitrile (8CI)	18930784	19478	7405
6:	Thiazolo[4,5-f]quinoline, 2,7,9-trimethy	38463397	19392	7292
7:	Thiazolo[5,4-f]quinoline, 2,7,9-trimethy	38463477	19393	7276
8:	Benzo[1,2-b:5,4-b']difuran-4,8-dione, 2-	26962425	19409	7213
9:	Purine-6(1H)-thione, 3,7-dimethylseleno-	23663583	19505	7203
10:	Naphtho[2,3-b]furan-2(3H)-one, 4,8-bis(a	16822143	30757	6719

Scan 1198 (26.300 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
50.95	8	68.35	4	100.10	7	151.05	7
53.45	6	69.15	17	100.50	6	176.05	10
55.05	19	70.15	6	101.10	5	178.05	80
55.95	8	71.05	13	108.40	4	179.15	15
56.25	8	74.95	6	109.30	4	201.40	4
57.15	28	76.25	4	111.30	7	202.00	5
59.75	5	81.20	7	112.10	8	224.00	8
61.15	7	83.10	8	113.30	13	225.20	9
61.65	5	85.20	6	113.90	14	226.10	35
63.25	5	95.10	9	122.20	4	227.10	14
65.15	3	97.20	9	125.30	5	228.10	100
66.15	6	99.10	9	149.05	25	229.10	22
67.15	8						



LIBRARY SEARCH RESULTS

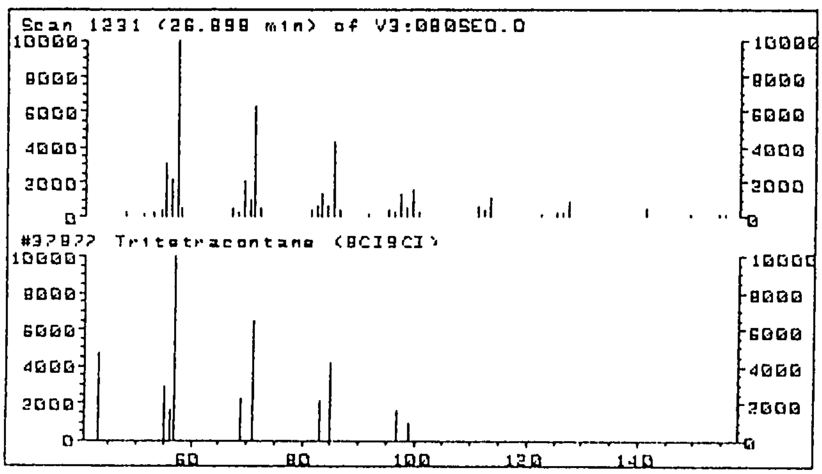
Scan 1231 (26.898 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Tritetracontane (8CI9CI)	7098217	37877	9353
2:	Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9055
3:	Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	8991
4:	Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8976
5:	Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	8863
6:	Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8851
7:	Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8763
8:	Undecane, 3,9-dimethyl- (8CI)	17301314	13006	8743
9:	Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8741
10:	Heneicosane (8CI9CI)	629947	26682	8717

Scan 1231 (26.898 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
47.85	3	69.15	20	91.30	2	122.20	2
51.05	2	70.25	10	95.20	4	125.10	3
53.05	3	71.15	63	96.10	3	126.20	3
54.15	4	72.15	5	97.20	13	127.20	8
55.15	31	81.20	4	98.20	5	141.25	5
56.15	21	82.20	6	99.20	16	149.15	2
57.15	100	83.20	13	100.30	3	154.15	2
58.05	5	84.20	6	111.10	6	154.35	2
67.15	5	85.20	43	112.20	4	155.25	2
68.15	3	86.20	4	113.20	11		



LIBRARY SEARCH RESULTS

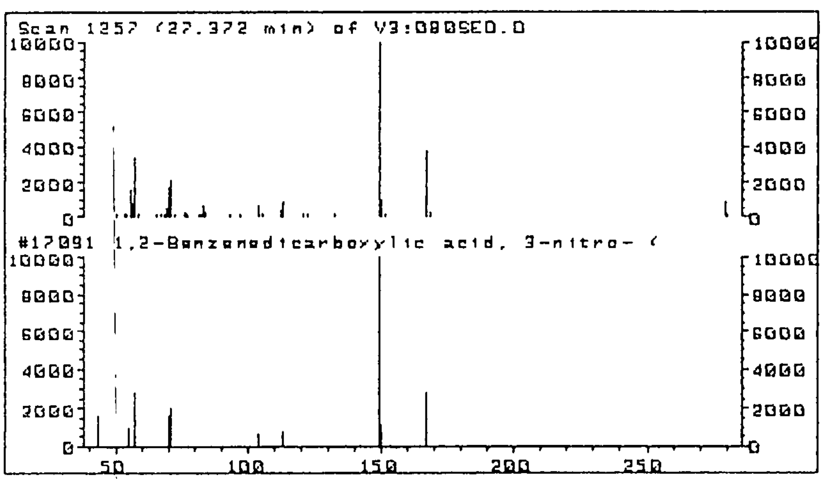
Scan 1257 (27.372 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	1,2-Benzenedicarboxylic acid, 3-nitro- (	603112	17091	9830
2:	1,2-Benzenedicarboxylic acid, diisooctyl	27554263	33129	9614
3:	1,2-Benzenedicarboxylic acid, diisodecyl	26761400	35426	9063
4:	Aspidofractinine-3-methanol, (2.alpha.,3	2656442	27893	8965
5:	1,2-Benzenedicarboxylic acid, diheptyl e	3648213	31658	8843
6:	1,2-Benzenedicarboxylic acid, bis(1-meth	131157	33127	8742
7:	1,2-Benzenedicarboxylic acid, decyl octy	119073	34392	8709
8:	1,2-Benzenedicarboxylic acid, butyl 2-me	17851535	24887	8640
9:	1,2-Benzenedicarboxylic acid, bis(2-ethy	117817	33125	8551
10:	1,2-Benzenedicarboxylic acid, bis(1-meth	605458	21931	8534

Scan 1257 (27.372 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
50.05	1	68.15	1	83.20	6	122.10	1
53.15	1	69.15	5	84.20	3	132.00	2
54.25	1	70.15	17	93.10	2	149.05	100
55.15	15	71.15	21	97.20	1	150.05	10
56.15	7	72.05	1	104.10	6	151.05	1
57.15	34	76.05	3	105.10	2	167.05	37
58.15	1	77.05	1	112.10	4	168.05	3
65.15	2	81.20	1	113.20	8	279.25	8
67.15	1	82.20	1	121.00	2	280.15	1



LIBRARY SEARCH RESULTS

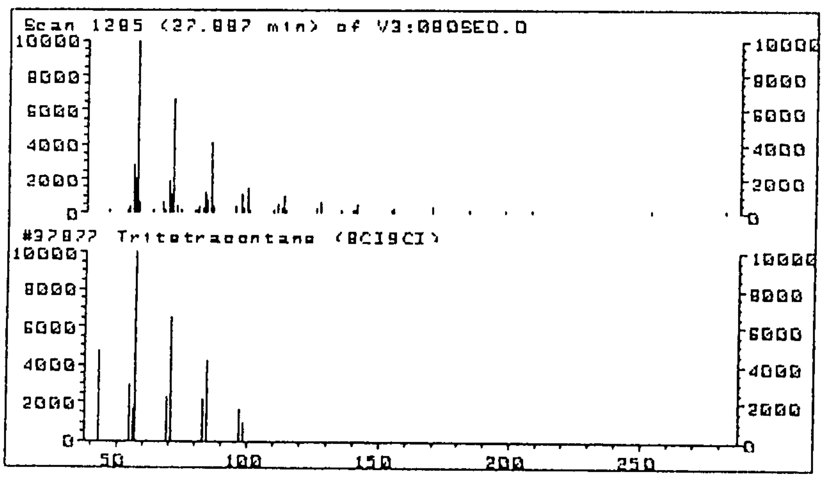
Scan 1285 (27.887 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Tritetracontane (8CI9CI)	7098217	37877	9362
2:	Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9129
3:	Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9064
4:	Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	9014
5:	Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	8940
6:	Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8834
7:	Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8827
8:	Heneicosane (8CI9CI)	629947	26682	8791
9:	Undecane, 3,9-dimethyl- (8CI)	17301314	13006	8781
10:	Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8761

Scan 1285 (27.887 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
46.35	1	71.15	66	97.20	11	139.25	2
53.05	2	72.15	4	98.20	3	140.15	2
54.15	4	73.65	1	99.20	14	141.25	5
55.15	28	79.05	2	100.00	2	154.35	2
56.15	20	80.10	2	109.10	2	155.25	3
57.15	100	81.10	4	111.20	5	169.25	4
58.15	6	82.10	3	112.30	3	183.25	2
62.95	2	83.20	12	113.20	10	197.30	2
67.05	6	84.20	7	114.20	2	207.10	2
68.15	2	85.20	41	125.30	3	253.25	2
69.15	19	86.10	4	127.20	6	281.25	2
70.15	11	95.10	4	135.25	2		



LIBRARY SEARCH RESULTS

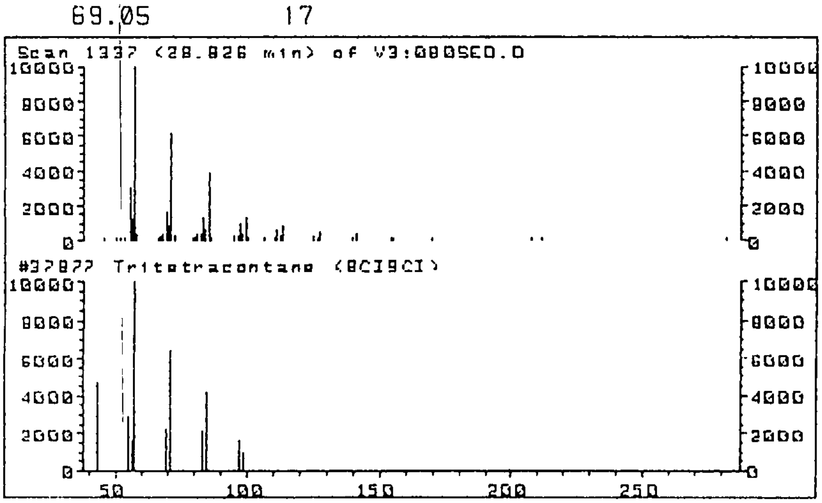
Scan 1337 (28.826 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Tritetracontane (8CI9CI)	7098217	37877	9291
2:	Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9173
3:	Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9103
4:	Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8958
5:	Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	8951
6:	Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8903
7:	Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8902
8:	Heneicosane (8CI9CI)	629947	26682	8837
9:	Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8823
10:	Octatetracontane, 1-iodo- (9CI)	40710701	38604	8790

Scan 1337 (28.826 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
45.55	2	70.15	9	95.10	3	125.10	3
50.05	2	71.15	62	96.20	3	126.20	2
51.65	1	72.05	3	97.20	10	127.20	5
53.25	2	79.15	1	98.20	4	139.25	1
55.15	30	80.20	1	99.20	13	141.25	4
56.15	12	81.20	4	100.30	2	154.35	2
57.15	100	82.10	4	106.20	1	155.15	2
58.15	4	83.20	13	110.20	2	169.25	2
66.05	1	84.20	6	111.10	6	207.00	2
66.95	3	85.20	39	112.20	3	211.40	1
68.15	4	86.20	2	113.20	9	281.15	1
69.05	17						



LIBRARY SEARCH RESULTS

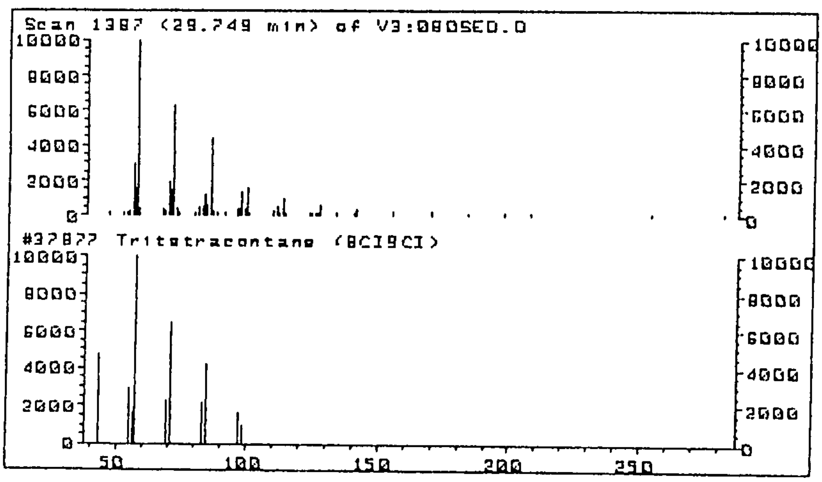
Scan 1387 (29.749 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Tritetracontane (8CI9CI)	7098217	37877	9242
2: Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9159
3: Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9099
4: Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	8970
5: Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8903
6: Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8848
7: Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8845
8: Heneicosane (8CI9CI)	629947	26682	8833
9: Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8821
10: Octatetracontane, 1-iodo- (9CI)	40710701	38604	8728

Scan 1387 (29.749 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
46.55	2	72.15	4	97.20	13	126.10	2
51.75	1	73.05	2	98.30	4	127.20	6
52.95	1	79.15	2	99.20	16	133.05	1
54.15	3	81.20	5	100.20	2	140.35	2
55.15	29	82.10	5	109.30	3	141.25	4
56.15	15	83.10	12	111.20	5	155.25	3
57.15	100	84.20	6	112.10	2	169.25	3
58.15	4	85.20	44	113.10	10	183.25	2
67.15	4	86.30	3	114.20	1	197.20	2
68.15	3	88.00	1	123.00	2	207.20	2
69.15	19	91.10	1	124.20	1	253.25	2
70.15	14	95.30	4	125.30	2	281.15	2
71.15	63	96.10	4				



LIBRARY SEARCH RESULTS

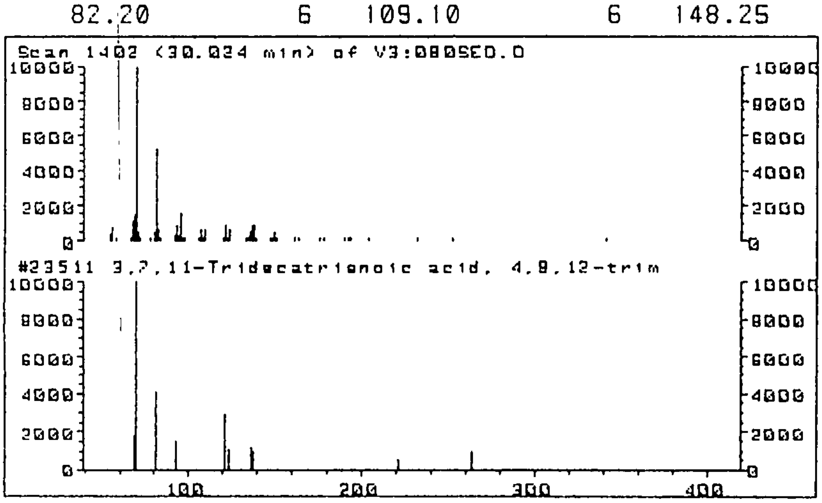
Scan 1402 (30.024 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	3,7,11-Tridecatrienoic acid, 4,8,12-trim	36237704	23511	9638
2:	3,7,11-Tridecatrienenitrile, 4,8,12-trim	6006015	19801	9181
3:	2,6,10,14,18,22,26,30-Dotriacontaoctaen-	33569798	37513	9146
4:	3,7,11-Tridecatrienoic acid, 4,8,12-trim	36237691	23510	9085
5:	.psi.,.psi.-Carotene, 7,7',8,8',11,12-he	540056	37290	9080
6:	2,6,10,14,18,22-Tetracosahexaene, 2,6,10	111024	34022	9010
7:	2,6,10-Dodecatrienoic acid, 3,7,11-trime	10485708	21976	8900
8:	Bicyclo[2.2.1]heptan-2-one, 4,7,7-trimet	10292985	7398	8737
9:	2,6,10-Nonadecatriene, 2,6,10,14-tetrame	31147350	28684	8714
10:	6,10,14-Hexadecatrienoic acid, 3,7,11,15	36237726	28826	8706

Scan 1402 (30.024 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
53.15	4	83.20	2	119.10	2	149.15	5
55.15	7	91.10	3	120.20	1	150.15	1
57.15	2	92.20	1	121.10	9	161.15	1
65.05	1	93.10	9	122.10	2	163.15	1
67.15	11	94.10	3	123.10	6	175.15	2
68.15	14	95.10	15	133.15	1	177.15	1
69.15	100	96.20	1	134.25	1	189.30	1
70.15	5	97.20	1	135.15	5	191.30	1
71.15	1	105.10	2	136.15	8	192.20	1
77.05	2	106.10	1	137.25	8	203.30	1
79.15	5	107.10	6	138.15	1	231.30	1
81.20	52	108.10	2	147.25	2	252.15	1
82.20	6	109.10	6	148.25	1	341.40	1



LIBRARY SEARCH RESULTS

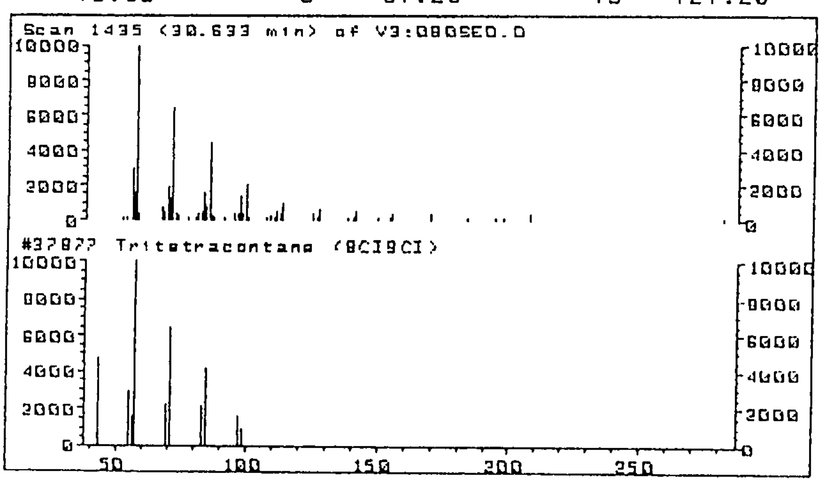
Scan 1435 (30.633 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Tritetracontane (8CI9CI)	7098217	37877	9281
2: Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9194
3: Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9131
4: Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	9017
5: Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8963
6: Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8869
7: Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8861
8: Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8861
9: Heneicosane (8CI9CI)	629947	26682	8852
10: Octatetracontane, 1-iodo- (9CI)	40710701	38604	8756

Scan 1435 (30.633 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
51.95	2	76.85	2	98.20	4	138.25	2
53.25	2	80.20	2	99.20	20	140.35	2
55.15	29	81.20	4	100.20	2	141.15	5
56.05	15	82.20	5	100.40	2	149.25	1
57.15	100	83.20	15	107.00	1	154.15	2
58.05	4	84.30	7	108.90	3	155.25	4
67.05	7	85.20	44	110.20	2	169.25	4
68.05	5	86.30	3	111.10	5	183.25	2
69.15	19	87.00	1	112.30	4	194.20	1
70.15	12	91.00	2	113.20	10	197.20	2
71.15	64	95.10	4	125.10	4	207.00	4
72.15	4	96.30	4	126.10	2	281.15	2
73.05	3	97.20	13	127.20	6		



LIBRARY SEARCH RESULTS

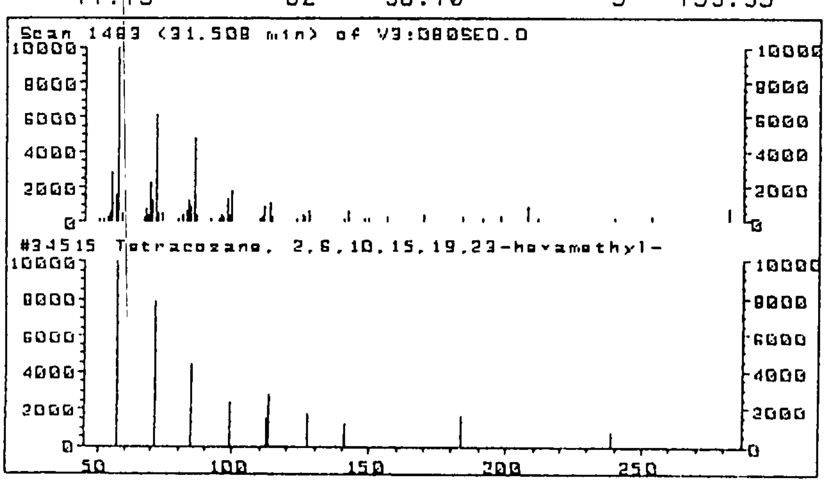
Scan 1483 (31.508 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9198
2: Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9144
3: Tritetracontane (8CI9CI)	7098217	37877	9138
4: Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	9019
5: Heneicosane (8CI9CI)	629947	26682	8877
6: Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8876
7: Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8854
8: Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8812
9: Nonahexacontanoic acid, propyl ester (9C	40710416	38742	8666
10: Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8632

Scan 1483 (31.508 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
50.15	2	72.05	5	97.10	13	140.35	2
52.05	2	73.15	5	98.20	4	141.15	6
53.35	3	79.15	2	99.20	18	147.25	2
54.05	5	81.30	4	109.20	2	149.15	1
55.05	28	82.20	6	110.20	3	155.35	3
56.15	16	83.20	12	111.10	9	169.15	4
57.15	100	84.30	8	113.20	11	183.25	3
58.25	5	85.20	48	114.20	3	191.20	1
66.55	3	86.10	4	123.00	2	197.30	3
67.15	7	91.10	2	125.20	4	207.10	9
68.15	4	91.40	2	126.10	3	211.30	2
69.05	22	94.10	2	127.20	6	239.35	2
70.05	12	95.20	4	139.65	2	253.15	3
71.15	62	96.10	3	139.95	1	281.15	7



LIBRARY SEARCH RESULTS

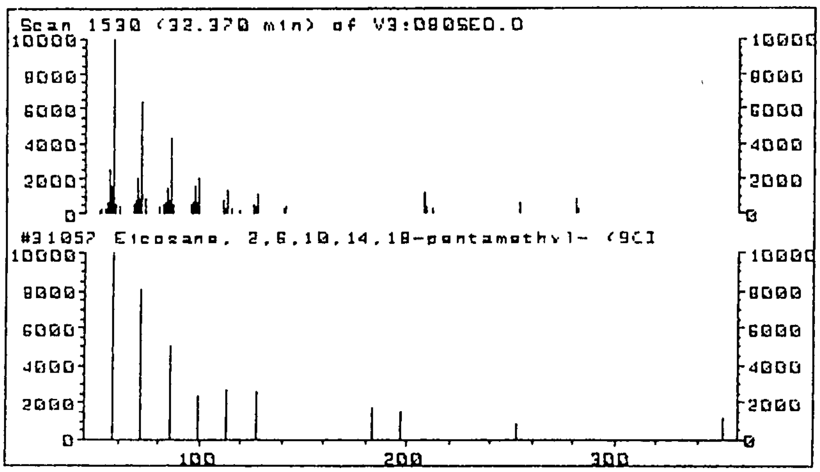
Scan 1530 (32.370 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	9584
2: Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	9581
3: Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	9292
4: Heneicosane (8CI9CI)	629947	26682	9166
5: Nonahexacontanoic acid, propyl ester (9C	40710416	38742	8924
6: Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8836
7: Tritetracontane (8CI9CI)	7098217	37877	8707
8: Undecane, 5,5-dimethyl- (8CI)	17312731	13019	8680
9: Nonahexacontanoic acid, 18-oxo- (9CI)	40710289	38734	8650
10: Octatriacontane, 3,5-dimethyl- (8CI)	13897206	37514	8648

Scan 1530 (32.370 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
50.05	2	69.15	20	86.20	5	125.20	5
51.35	3	70.15	9	95.20	5	126.10	4
53.15	3	71.15	64	96.30	6	127.20	11
54.35	6	72.25	7	97.20	16	140.35	3
55.05	25	73.15	8	98.30	6	141.25	4
56.25	16	79.15	4	99.20	20	207.10	12
57.15	100	81.20	5	111.20	7	208.10	4
58.15	5	82.10	6	112.00	3	211.30	3
60.25	4	83.20	14	113.10	13	253.15	6
67.05	5	84.30	7	114.30	3	281.05	9
68.05	7	85.20	43	119.10	2	282.05	3



LIBRARY SEARCH RESULTS

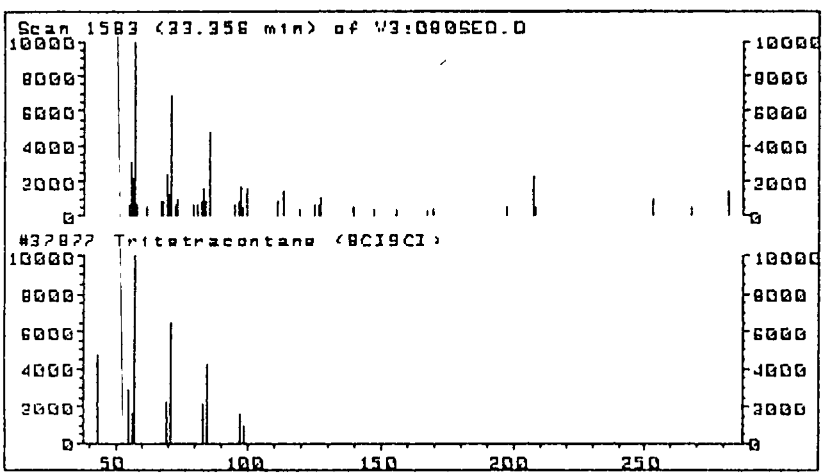
Scan 1583 (33.356 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Tritetracontane (8CI9CI)	7098217	37877	9022
2:	Eicosane, 2,6,10,14,18-pentamethyl- (9CI	51794162	31057	8867
3:	Tetracosane, 2,6,10,15,19,23-hexamethyl-	111013	34515	8862
4:	Nonadecane, 2,6,10,14-tetramethyl- (9CI)	55124806	29120	8709
5:	Heptadecane, 2,6,10,15-tetramethyl- (9CI	54833486	26688	8697
6:	Tetracontane, 3,5,24-trimethyl- (9CI)	55162613	37878	8668
7:	Heneicosane (8CI9CI)	629947	26682	8637
8:	Hexadecane, 2,6,10,14-tetramethyl- (8CI9	638368	25305	8618
9:	Nonahexacontanoic acid, methyl ester (9C	40710369	38735	8582
10:	Nonahexacontanoic acid, propyl ester (9C	40710416	38742	8566

Scan 1583 (33.356 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
54.45	6	72.55	6	97.20	17	147.15	4
55.15	30	73.15	10	98.20	5	155.25	4
56.25	21	79.25	6	99.20	16	166.95	3
57.15	100	81.20	6	111.10	9	169.15	4
57.95	6	82.20	8	113.20	14	197.20	5
61.25	5	83.20	16	119.30	4	207.10	22
67.05	8	84.30	8	125.10	6	208.00	5
68.15	8	85.20	48	126.20	6	253.05	10
69.15	23	85.90	6	127.20	11	267.15	5
70.15	12	95.10	6	139.15	5	281.05	14
71.15	68	96.10	9				



LIBRARY SEARCH RESULTS

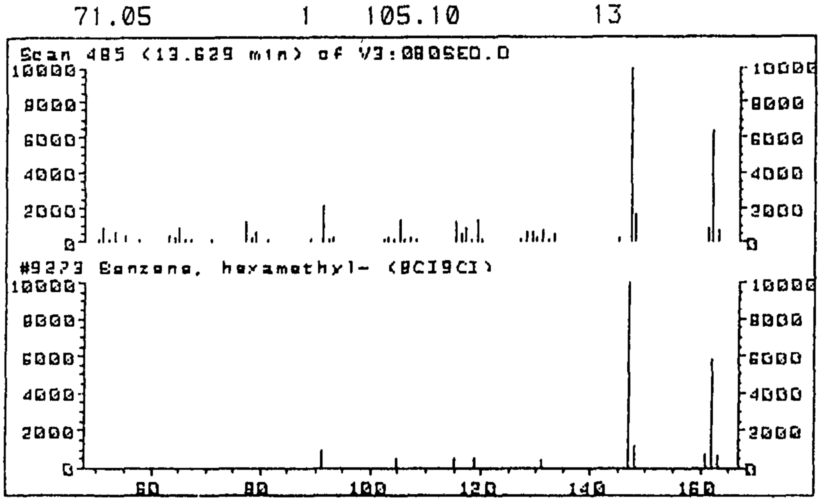
Scan 485 (13.629 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Benzene, hexamethyl- (8CI9CI)	87854	9273	9838
2:	1H-Inden-1-one, 2,3-dihydro-7-hydroxy-3-	40513506	9216	9528
3:	Benzo[b]thiophene, 7-ethyl- (8CI9CI)	16587421	9226	9487
4:	Bicyclo[2.2.0]hexa-2,5-diene, 1,2,3,4,5,	7641772	9294	9485
5:	Benzo[b]thiophene, ethyl- (9CI)	54385636	9229	9473
6:	Benzene, 1,2-diethyl-3,4-dimethyl- (9CI)	54410752	9320	9421
7:	3H-Indazol-3-one, 1-ethyl-1,2-dihydro- (	54385625	9426	9389
8:	Ethanone, 1-(2,4,5-trimethylphenyl)- (9C	2040075	9256	9377
9:	Tricyclo[3.2.1.02,7]oct-3-ene, 2,3,4,5-t	62338447	9330	9331
10:	Benzene, 1,4-bis(1-methylethyl)- (9CI)	100185	9276	9276

Scan 485 (13.629 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
50.15	2	77.05	12	106.10	1	129.10	6
51.05	8	78.15	3	107.10	3	130.10	3
52.15	2	79.05	6	108.10	1	131.10	7
53.15	6	81.20	1	115.10	12	132.10	2
55.15	4	89.10	1	116.10	5	133.15	5
57.75	1	91.10	21	117.10	8	145.15	3
63.05	4	92.10	2	118.20	1	147.15	100
64.15	3	93.20	3	119.10	13	148.15	17
65.05	8	102.10	1	120.10	1	161.25	9
66.05	1	103.10	3	127.10	2	162.15	64
67.05	1	104.20	1	128.10	6	163.15	7
71.05	1	105.10	13				



LIBRARY SEARCH RESULTS

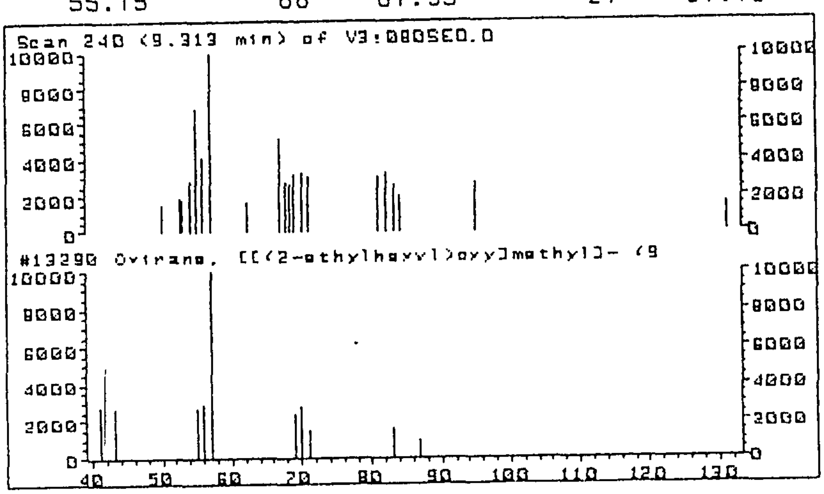
Scan 240 (9.313 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Oxirane, [[(2-ethylhexyl)oxy]methyl]- (9	2461156	13290	7847
2: 2-Hexene, 1-butoxy-, (E)- (9CI)	54340679	8214	7757
3: Cyclopropane, 1-(2-methylbutyl)-1-(1-met	64723360	10388	7748
4: 2-Undecene, 6-methyl-, (Z)- (9CI)	74630436	10396	7687
5: 1-Hexanol, 3,5,5-trimethyl- (8CI9CI)	3452979	6293	7636
6: 2-Octen-1-ol (8CI9CI)	22104785	3921	7594
7: 1-Hexene, 2,5,5-trimethyl- (9CI)	62185562	3642	7592
8: 1-Dotriacontanol (8CI9CI)	6624799	36005	7566
9: Cyclopropanemethanol, .alpha.,2-bis(1-me	56259166	8218	7515
10: 1-Dodecanol, 2-methyl-, (S)- (9CI)	57289266	15474	7514

Scan 240 (9.313 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
50.05	15	56.05	41	68.45	26	82.30	33
52.75	19	57.05	100	69.05	32	83.30	26
53.15	18	62.45	17	70.25	33	84.20	20
54.05	28	67.05	51	71.15	31	95.10	27
55.15	68	67.95	27	81.10	31	131.20	16



LIBRARY SEARCH RESULTS

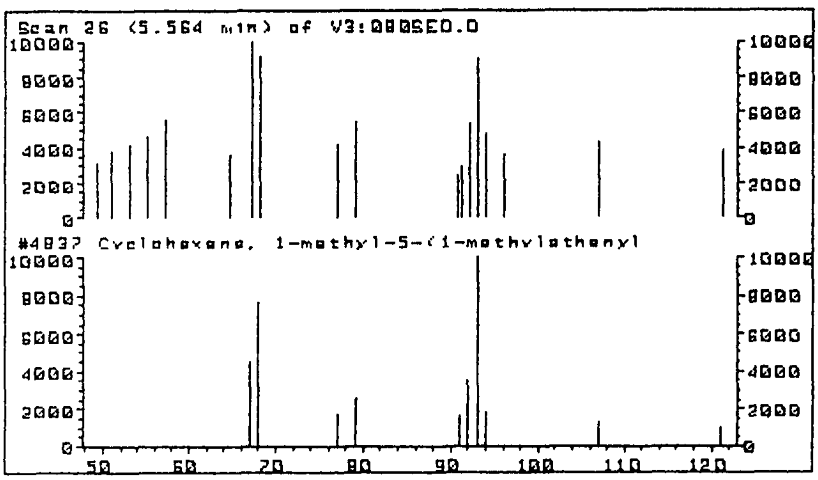
Scan 26 (5.564 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Cyclohexene, 1-methyl-5-(1-methylethenyl	13898732	4837	8984
2: Cyclohexanol, 1-methyl-4-(1-methyletheny	10198239	14797	8724
3: Bicyclo[2.2.1]hept-2-ene, 1,7,7-trimethy	464175	4790	8605
4: Cyclohexene, 1-methyl-5-(1-methylethenyl	1461274	4811	8599
5: Cyclohexene, 1-methyl-4-(1-methylethenyl	5989275	4828	8564
6: Cyclohexene, 4-ethenyl-1,4-dimethyl- (9C	1743619	4812	8412
7: 1,5,9-Cyclododecatriene, 1,5,9-trimethyl	21064197	16065	8411
8: Cyclohexene, 1-methyl-4-(1-methylethenyl	5989548	4829	8200
9: 1,5-Cyclooctadiene, 1,5-dimethyl- (8CI9C	3760143	4821	8151
10: 3-Cyclohexene-1-ethanol, .beta.,4-dimeth	18479680	7793	7895

Scan 26 (5.564 min) of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
49.25	32	64.55	36	90.80	25	94.10	48
50.85	39	67.15	100	91.20	29	96.00	36
52.95	42	68.15	92	92.20	53	107.00	43
55.15	47	77.05	42	93.00	91	121.20	39
57.15	56	79.05	55				



TIC of V3:080SED.D
187080 F2 25G/FV=0.5/ 3UL INJ

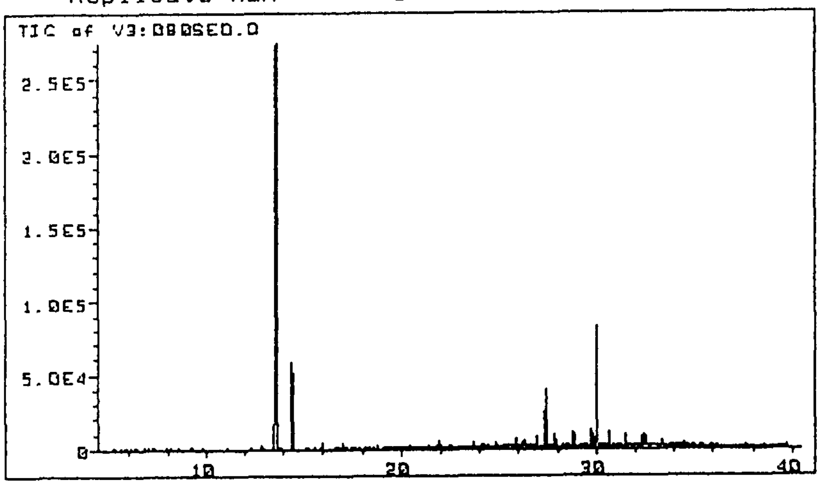
peak#	ret time	area	start time	end time
1	5.562	21145	5.479	5.621
2	9.315	28340	9.269	9.439
3	13.620	15120591	13.404	13.777
4	14.441	1324662	14.349	14.510
5	16.975	77486	16.923	17.049
6	21.864	97187	21.817	21.939
7	24.810	65987	24.735	24.854
8	25.877	118625	25.825	25.919
9	26.296	135069	26.240	26.344
10	26.898	149564	26.845	26.953
11	27.374	911112	27.315	27.484
12	27.883	192329	27.843	27.931
13	28.833	245196	28.732	28.988
14	29.753	256104	29.604	29.839
15	30.019	1984517	29.949	30.119
16	30.641	241337	30.581	30.727
17	31.503	209265	31.434	31.618
18	32.366	140917	32.310	32.407
19	32.463	339065	32.407	32.704
20	33.354	142363	33.223	33.448

Data file: V3:080SED.D
File type: GC / MS DATA FILE

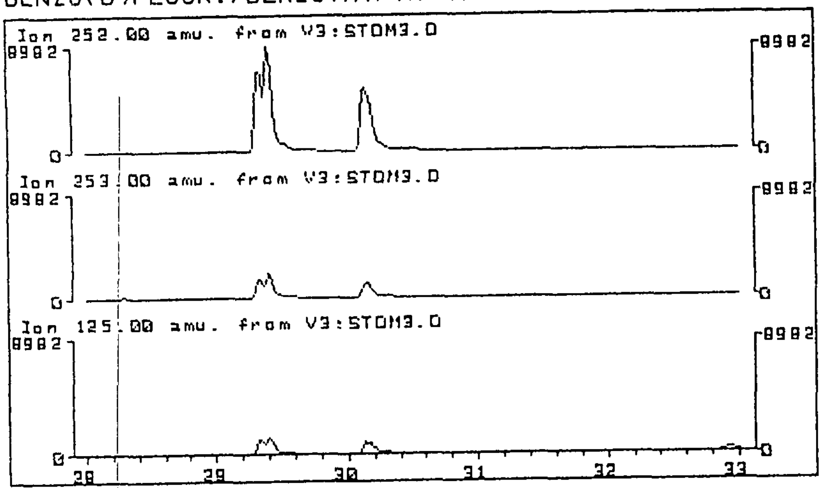
Name Info: 187080 F2 25G/FV=0.5/ 3UL INJ
Misc Info: BNA METH EMV=1800
Operator : CB HENRY EIS--LSU

Date : 20 May 86 2:46 am
Instrment: MS_5970
Inlet : GC

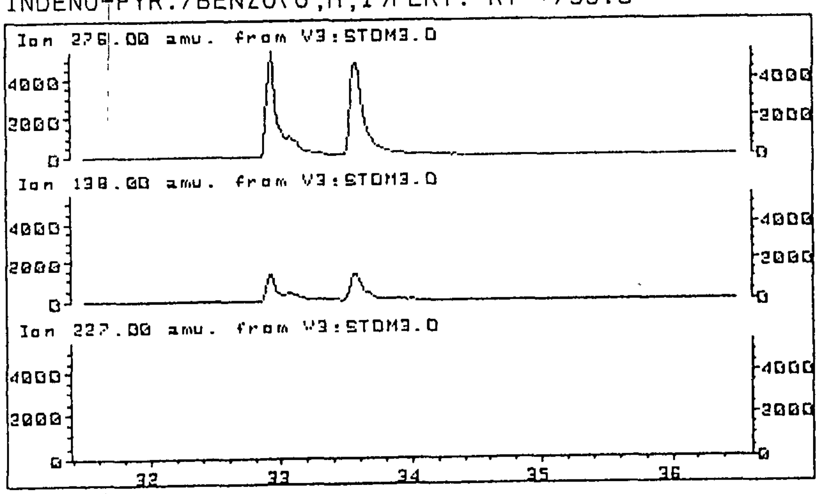
Sequence index : 0
Als bottle num : 0
Replicate num : 0



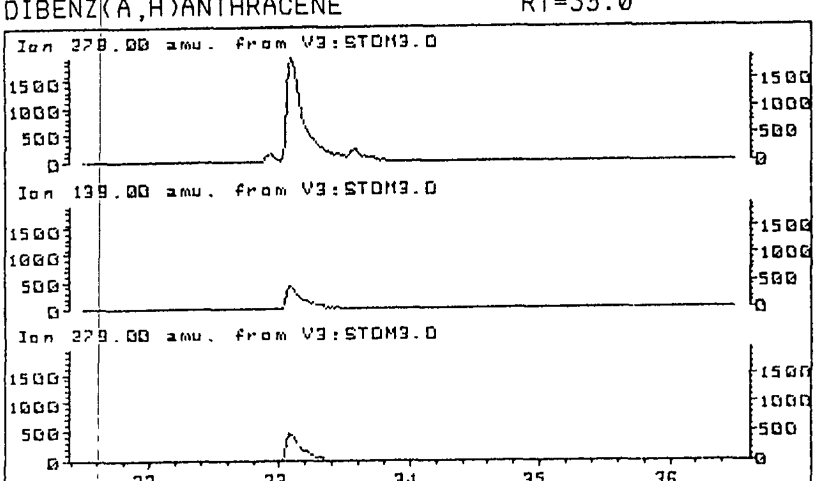
BENZO(B)FLUOR./BENZO(A)PYR RT=29.3/30.1



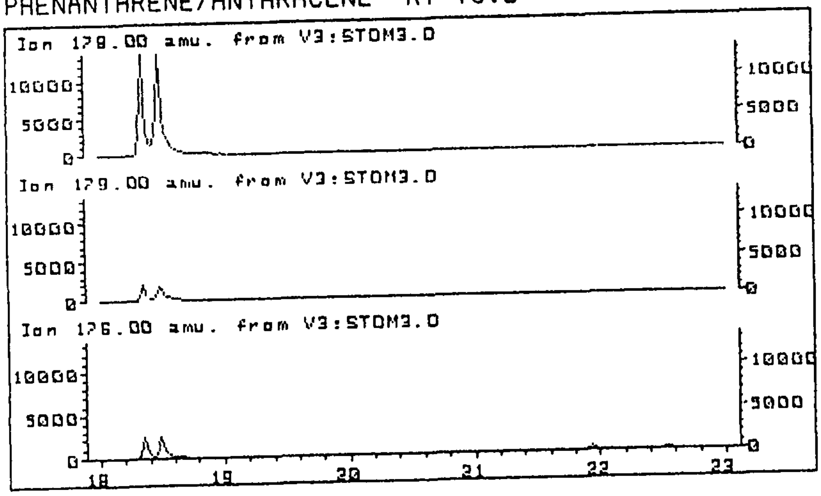
INDENO-PYR./BENZO(G,H,I)PERY. RT=?/33.5



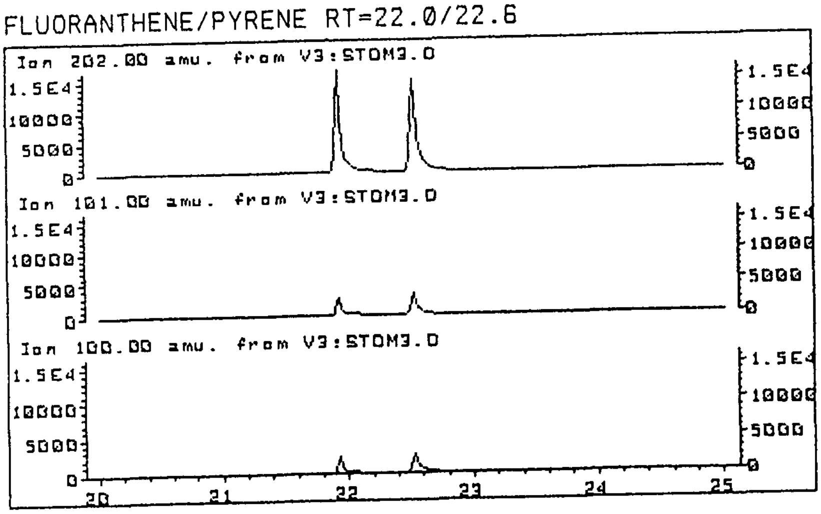
DIBENZ(A,H)ANTHRACENE RT=33.0



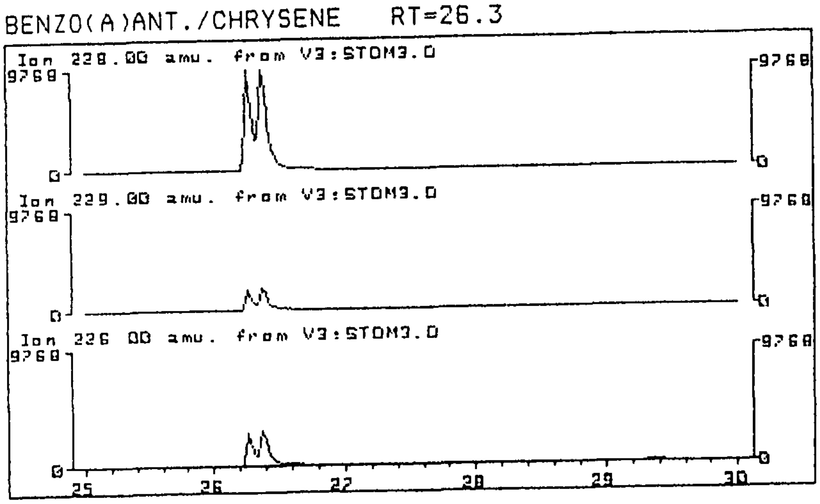
PHENANTHRENE/ANTHRACENE RT=18.5



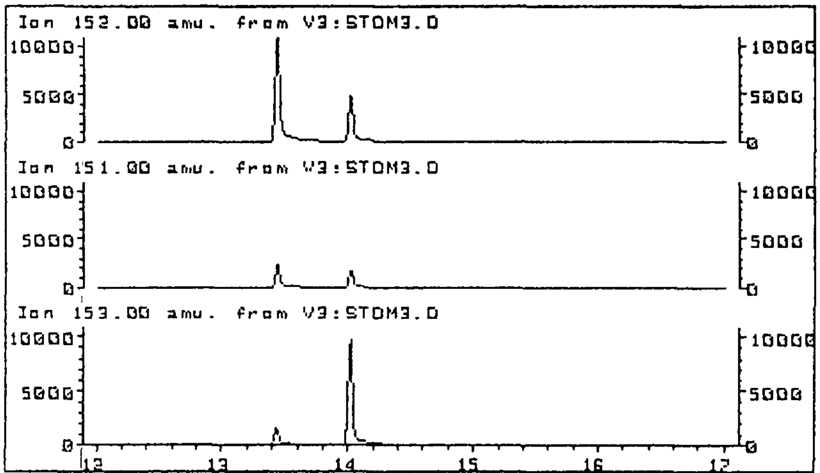
FLUORANTHENE/PYRENE RT=22.0/22.6



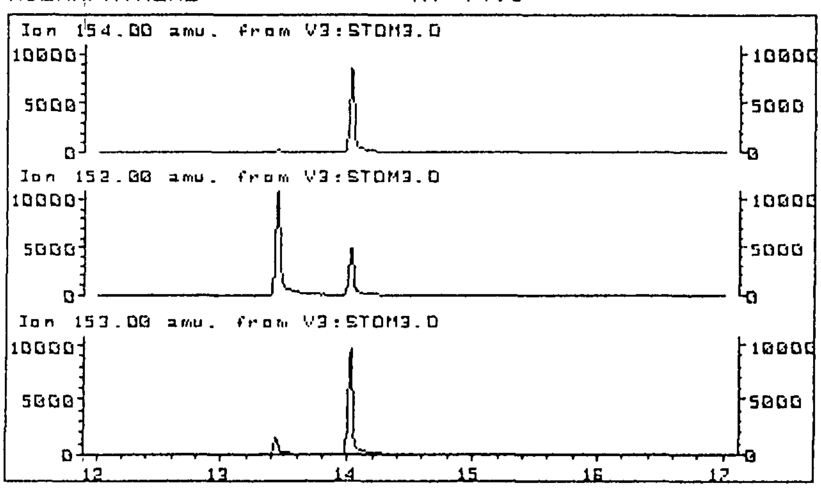
BENZO(A)ANT./CHRYSENE RT=26.3



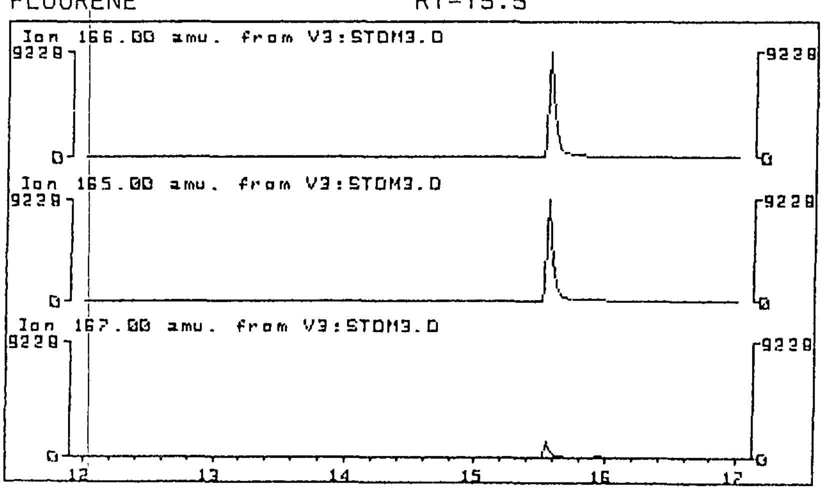
ACENAPHTHYLENE RT=13.4



ACENAPHTHENE RT=14.0



FLUORENE RT=15.5



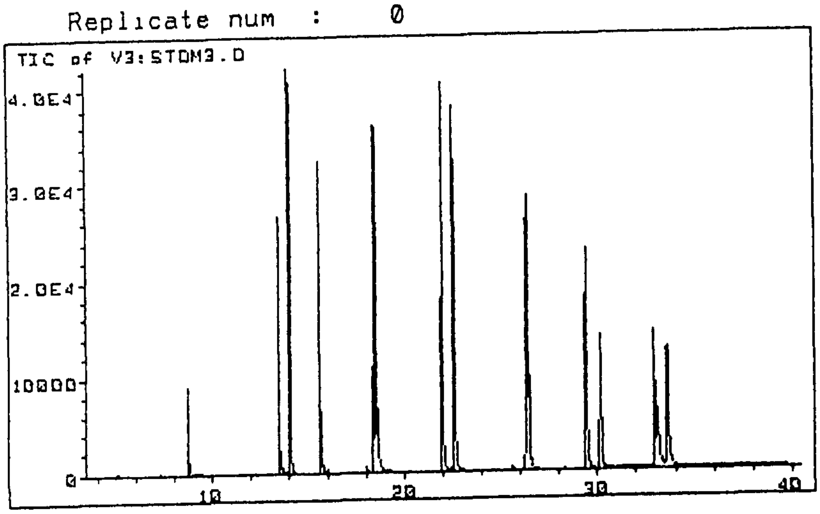
Data file: V3:STDM3.D
File type: GC / MS DATA FILE

Name Info: PNA MIX 100NG
Misc Info: BNA EMV=1600
Operator : CA HENRY

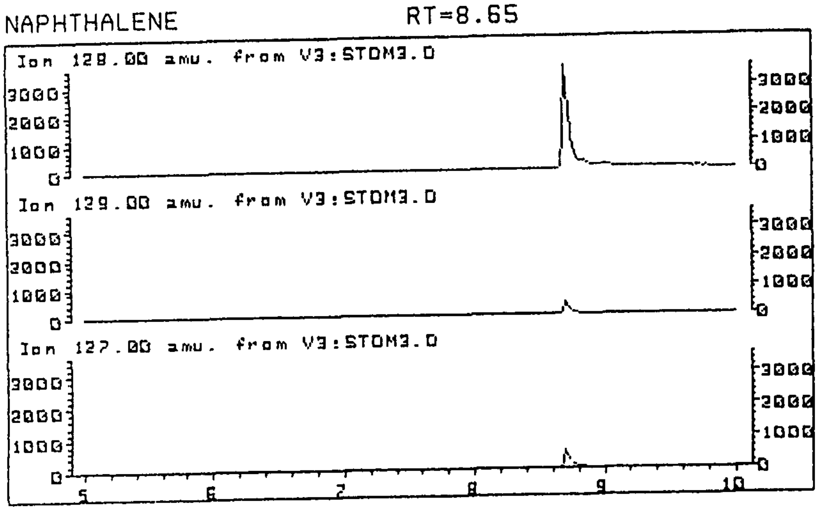
Date : 21 Jun 86 2:17 pm
Instrment: MS_5970
Inlet : GC

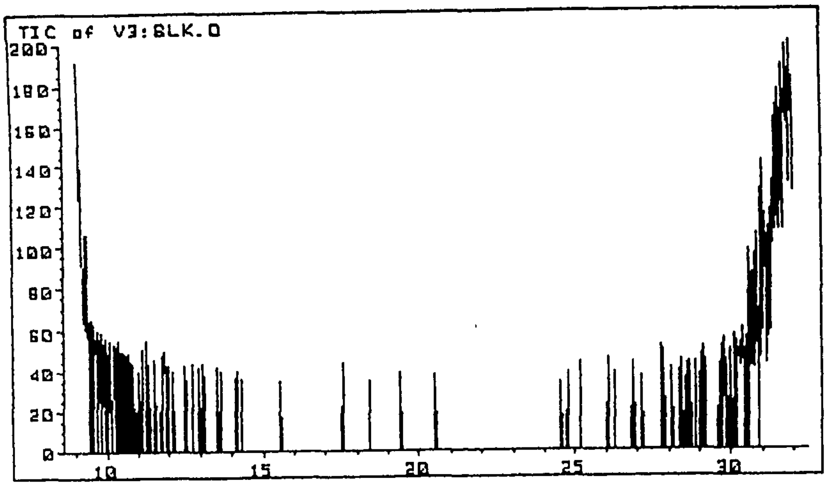
PNA STD ANALYSIS

Sequence index : 0
Als bottle num : 0
Replicate num : 0



NAPHTHALENE RT=8.65





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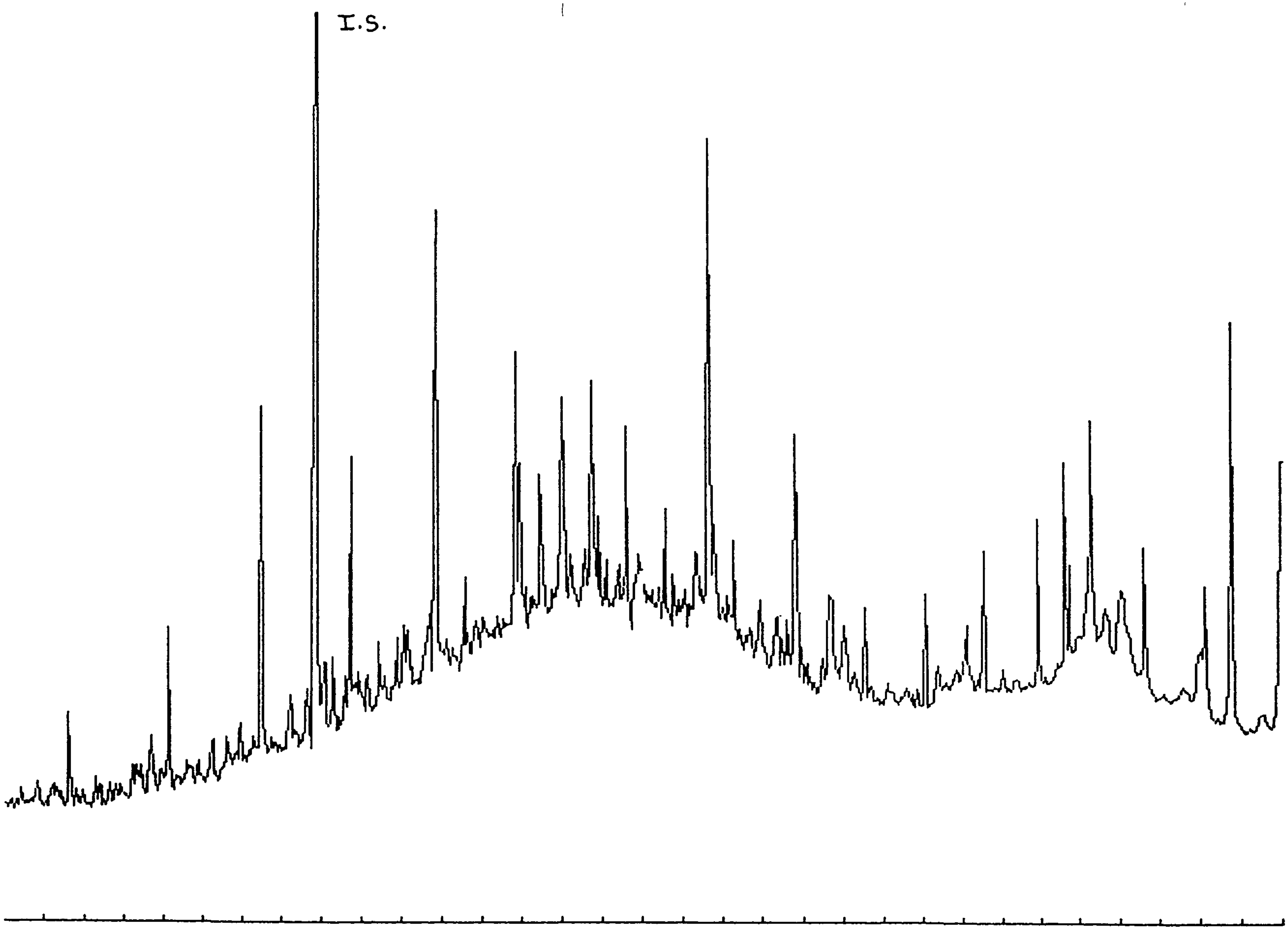
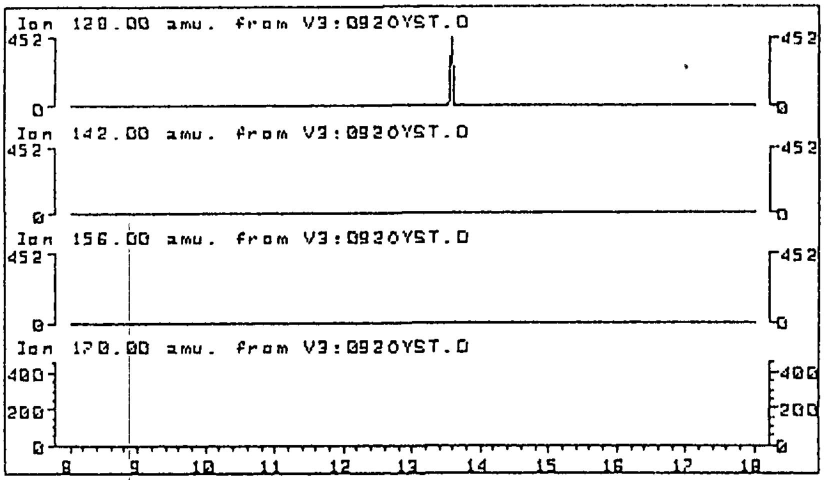


Ecology Lab # 86187092
Ediz Hook (TR31) Oysters
F-2 fraction

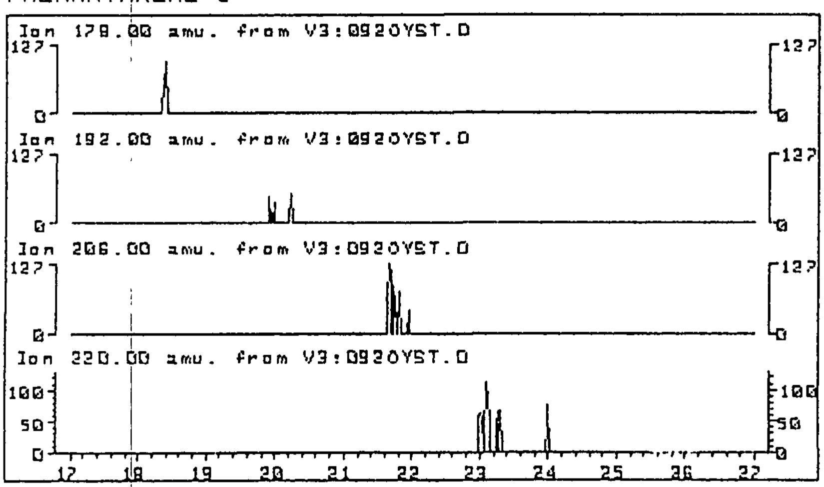
INST. FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY

Ecology Sub # 86187092

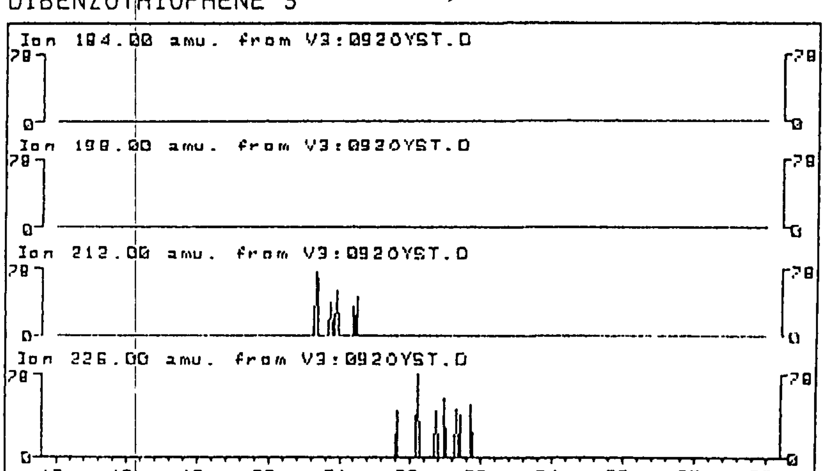
MAJOR HOMOLOG GROUPS
NAPHTHALENE'S



PHENANTHRENE'S



DIBENZOTHIOPHENE'S

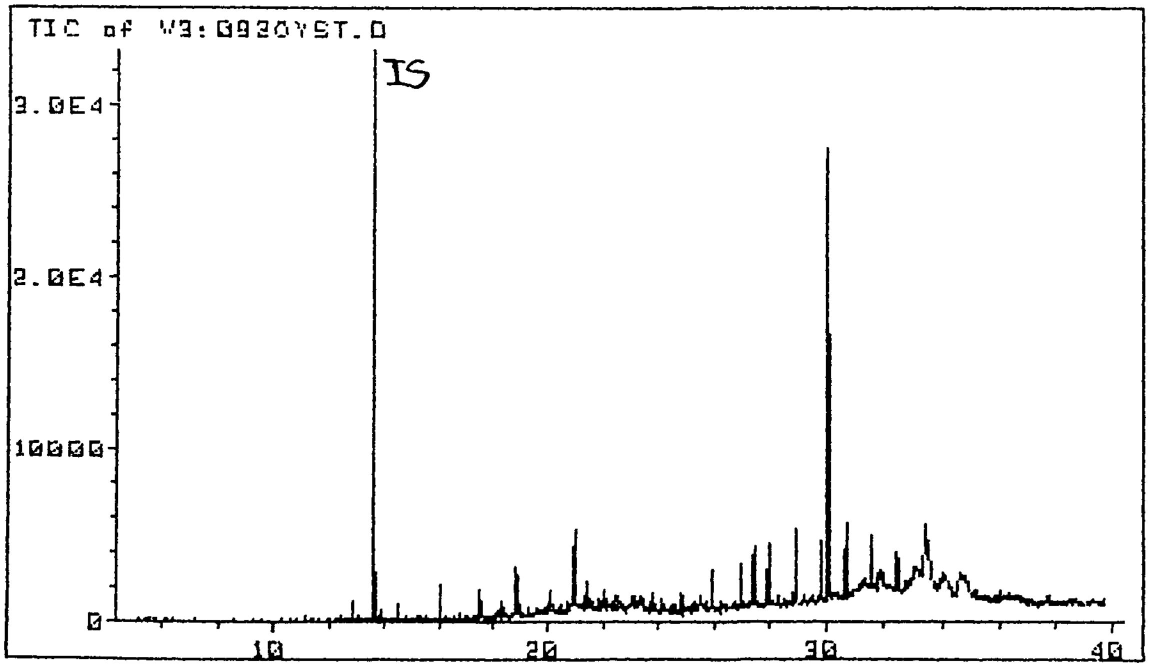


Data file: V3:092OYST.D
File type: GC / MS DATA FILE

Name Info: 86187092 OYSTERS F-2 FRACTION
Misc Info: METH EMV=1600
Operator : CB.

Date   : 2 Jun 86   8:06 am
Instrment: MS_5970
Inlet   : GC

Sequence index :   0
Als bottle num :   0
Replicate num :   0

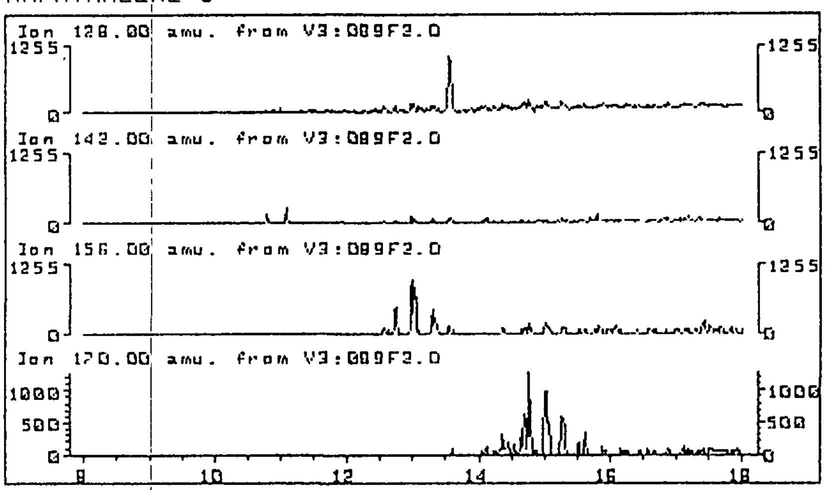


INST. FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY

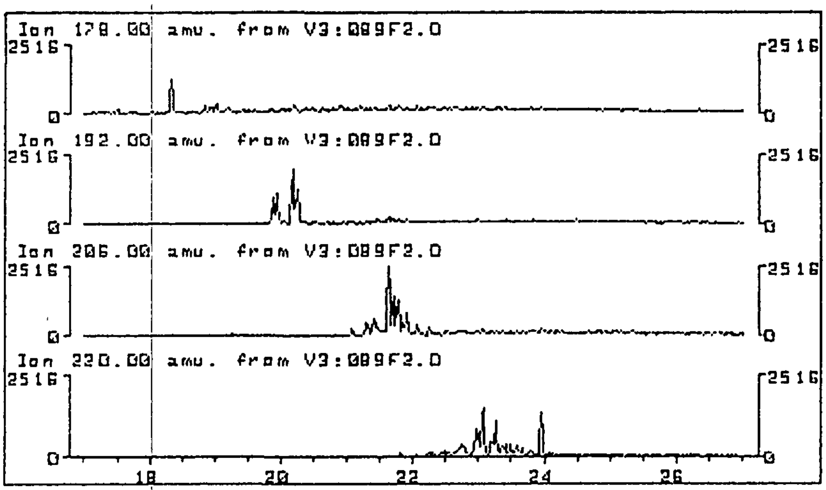
Ecology Lab # 187089

MAJOR HOMOLOG GROUPS

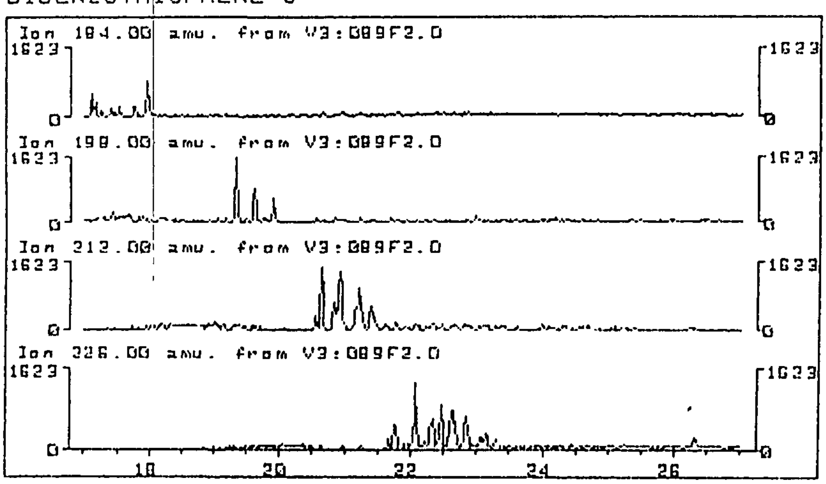
NAPHTHALENE'S



PHENANTHRENE'S



DIBENZOTHIOPHENE'S

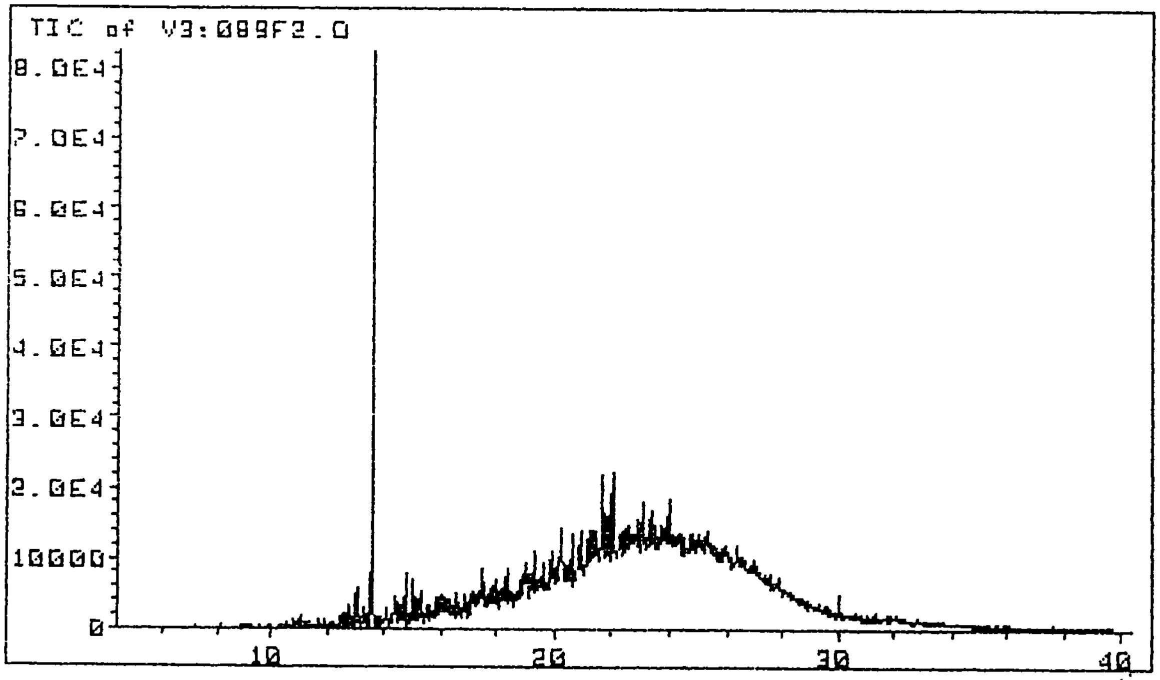


Data file: V3:089F2.D
File type: GC / MS DATA FILE

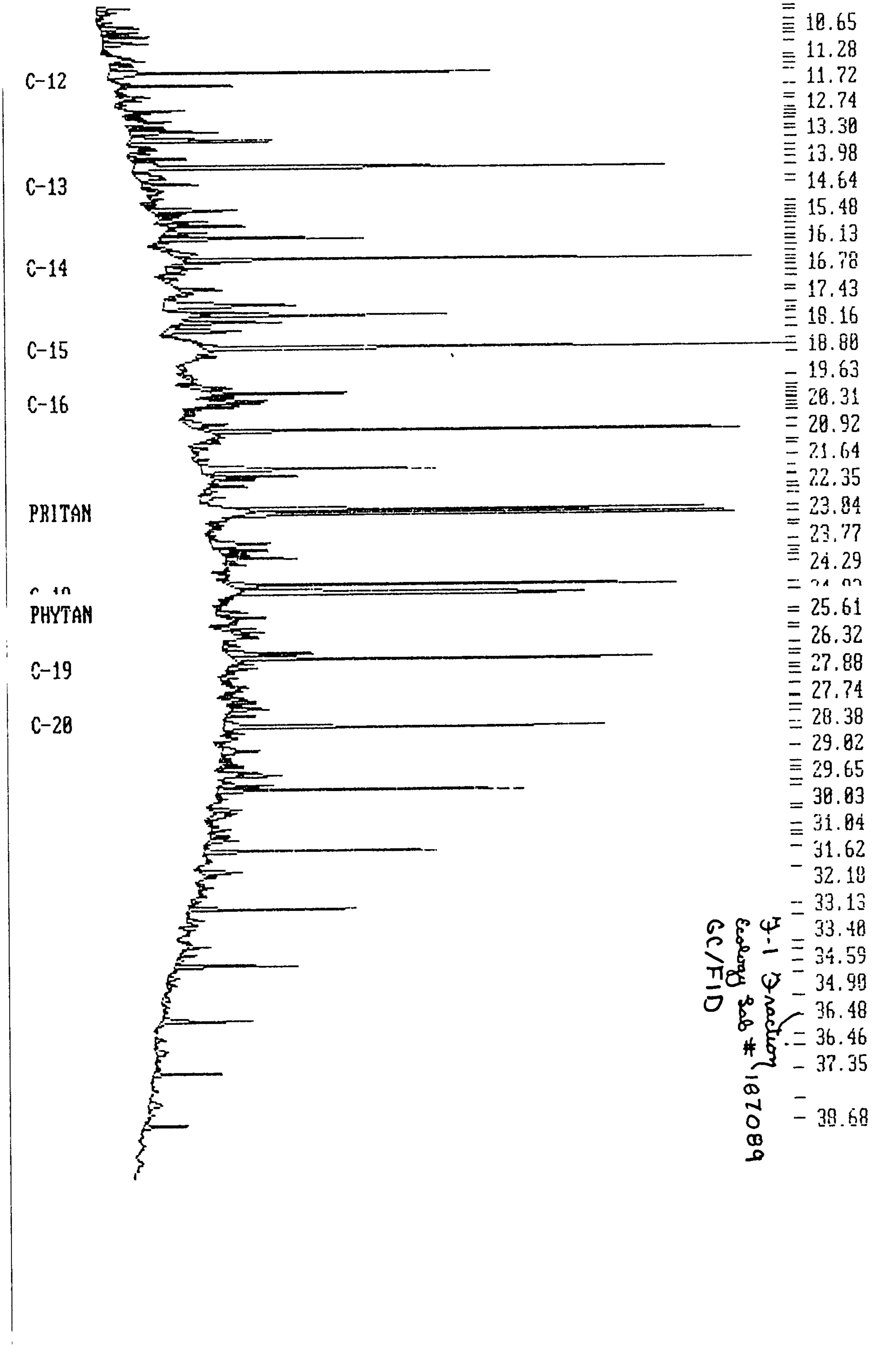
Name Info: 187089 SED EXT 05G/.5 MLS 2UL INJ(50G/.5ML SUB .05)
Misc Info: BNA METH EMV=1600
Operator : CB HENRY

Date : 20 May 86 4:35 pm
Instrment: MS_5970
Inlet : GC

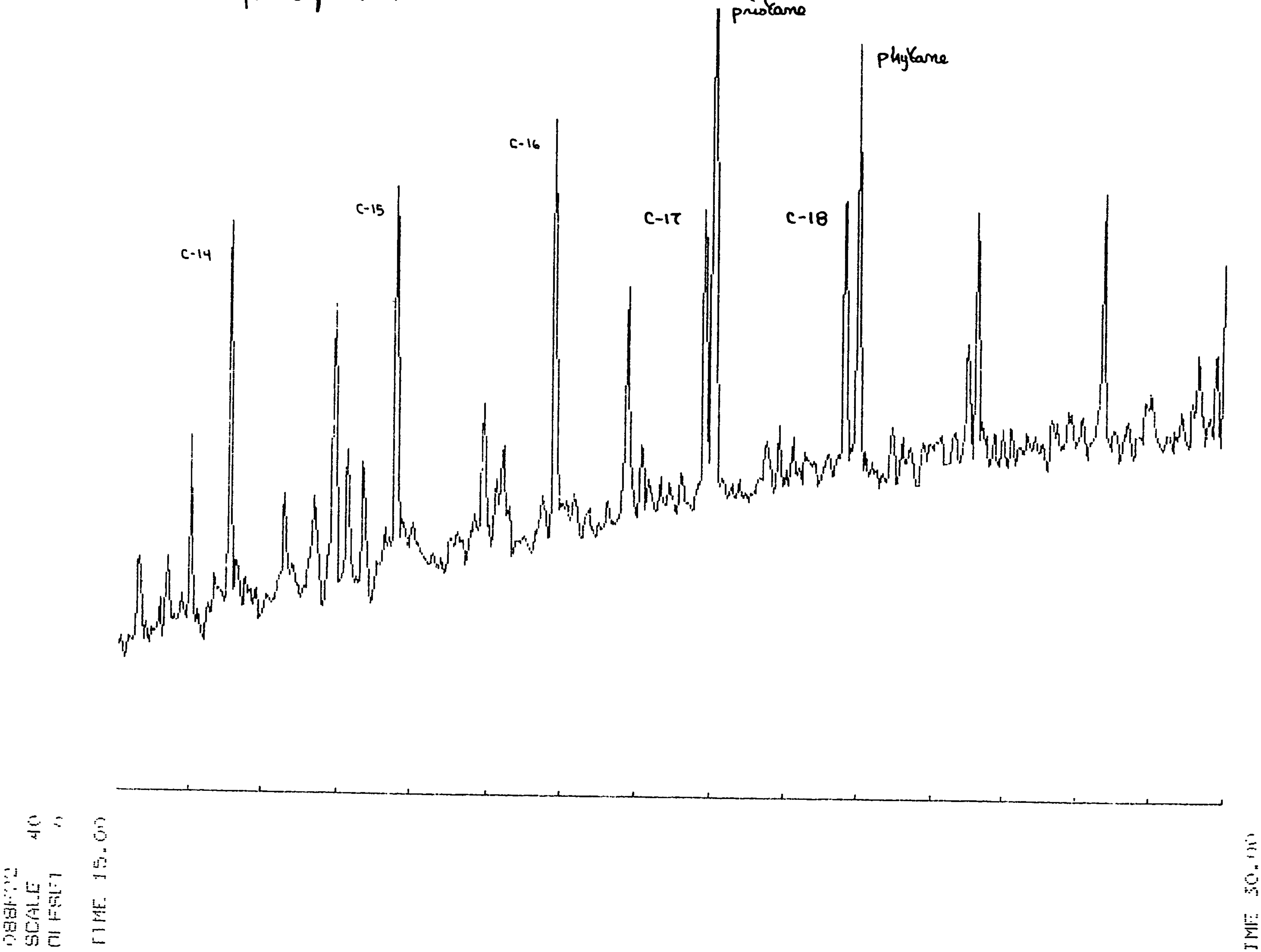
Sequence index : 0
Als bottle num : 0
Replicate num : 0

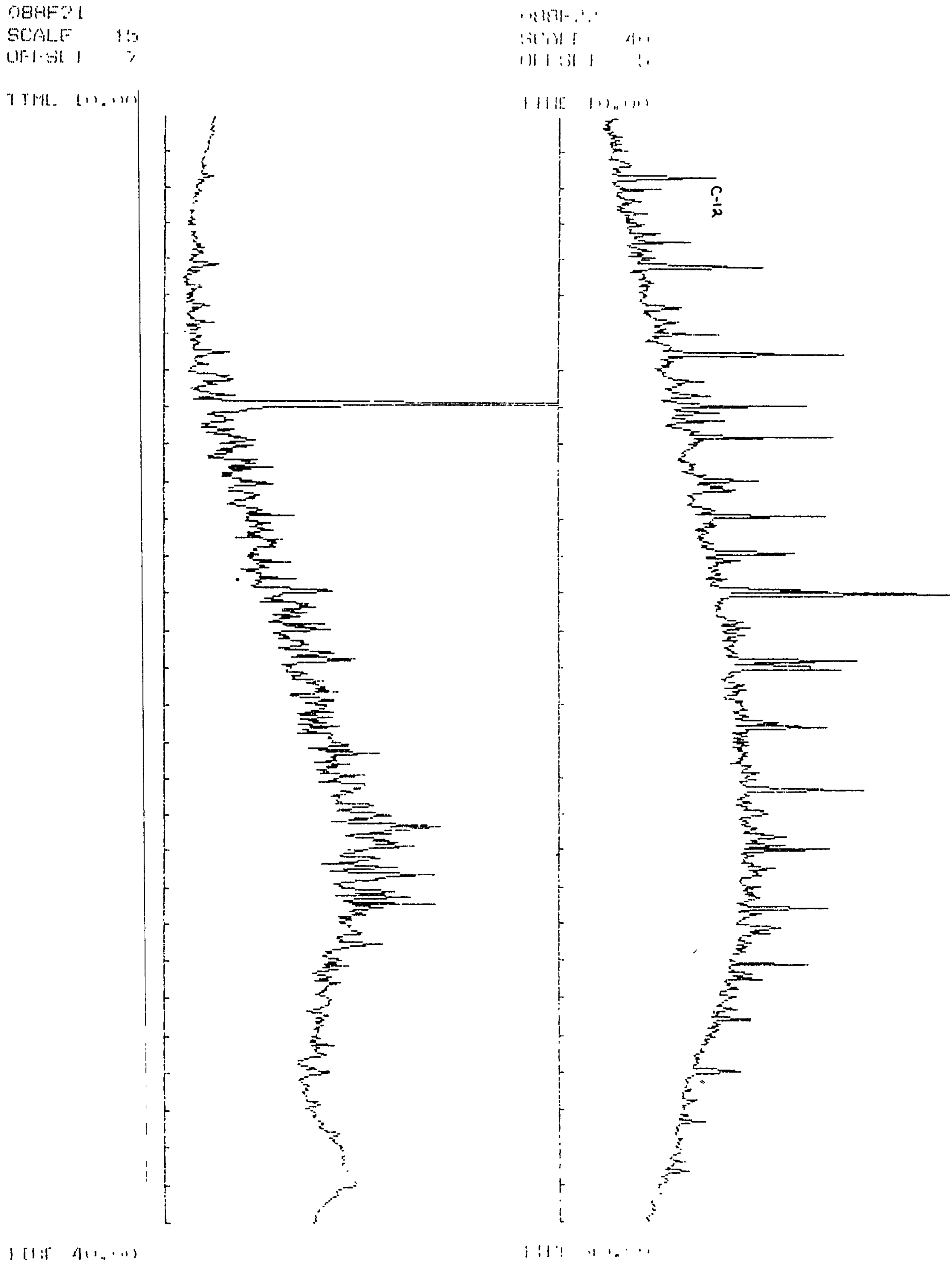


Start Time: 10.00 Stop Time: 40.00 Offset: 0
Low Value: 1166? High Value: 1e3.e4 Scale Factor: 1



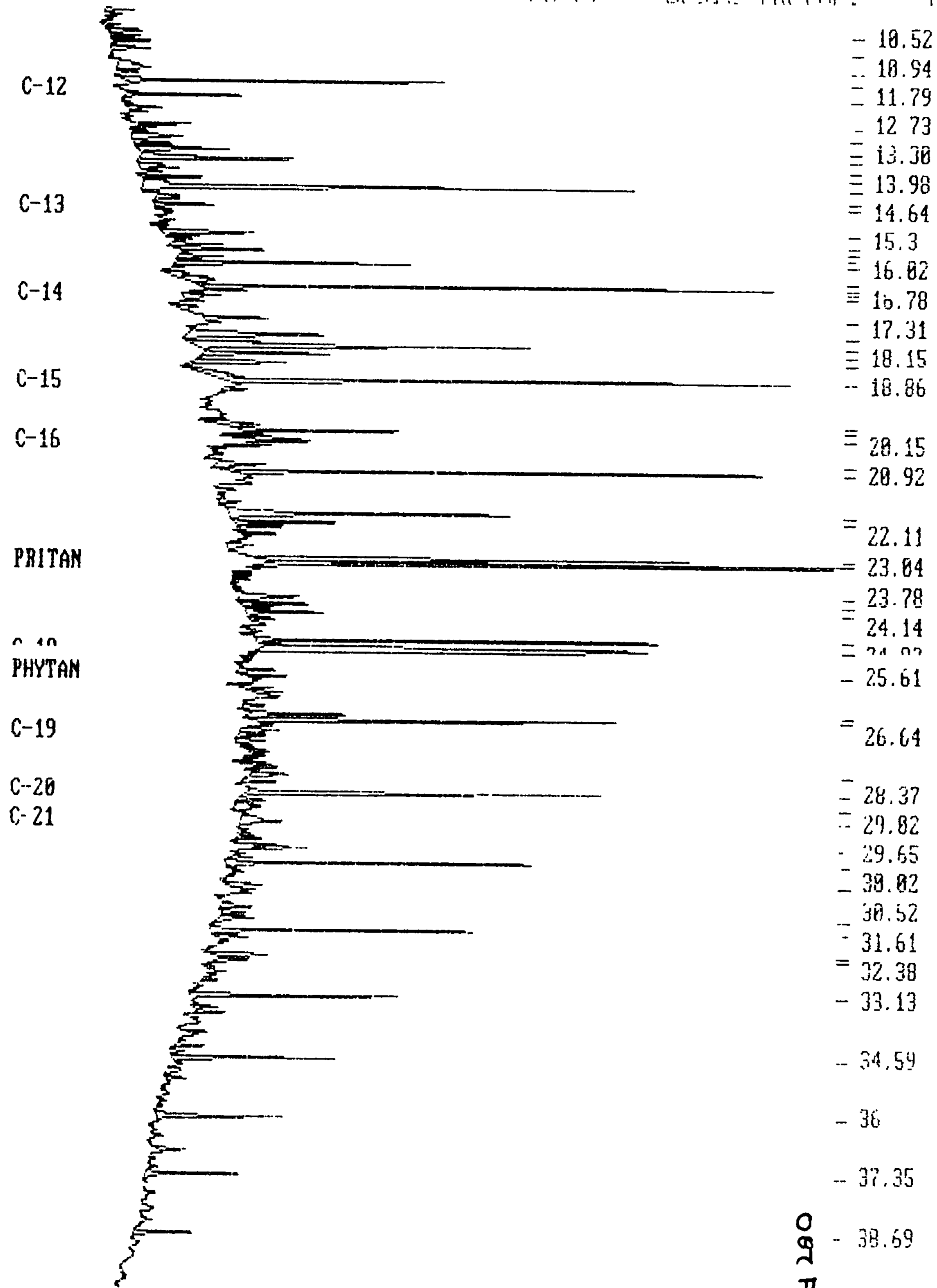
Ecology Lab # 86187088
Aliphatic fraction F.1





08AF21
SCALE 15
OFFSET 7
TIME 10.00
TIME 40.00
TIME 10.00
C-12

Start time: 10.00 Stop time: 40.00 Offset: 0
Low Value: 9423 High Value: [illegible] Scale Factor: 1



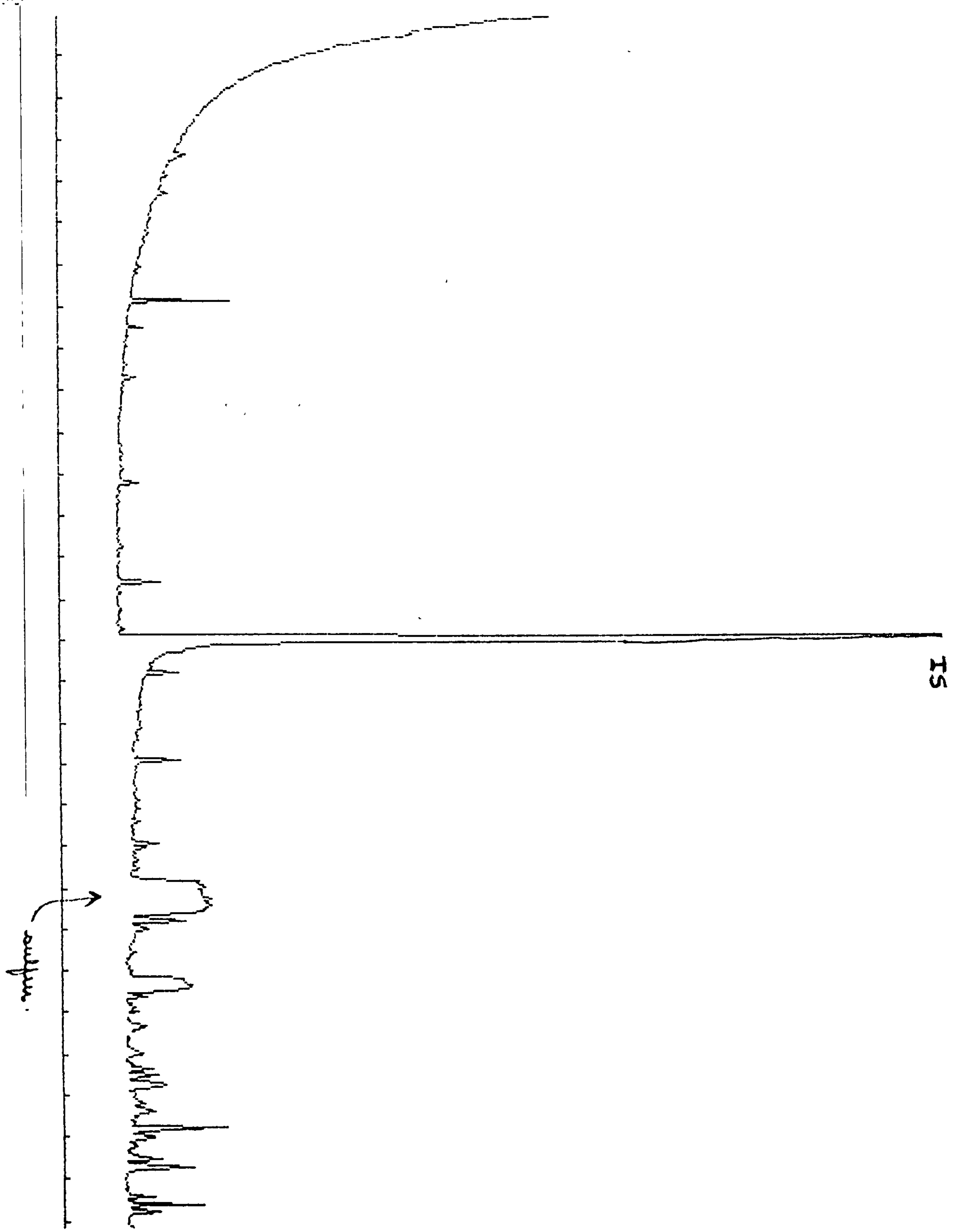
[illegible]
SCALE 25
OFFSET [illegible]

TIME 7.00

0851:21
SCALE 50
OFFSET 4

TIME 3.00

Ecology Lab
* 86187085
F-2 fraction



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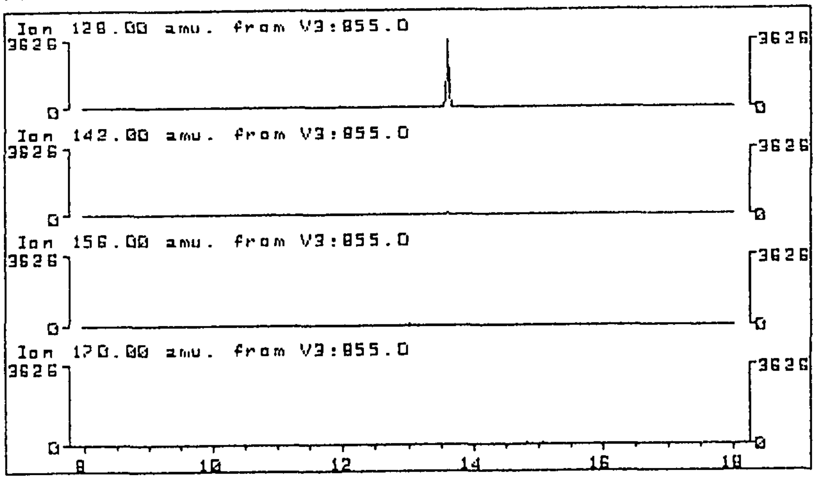
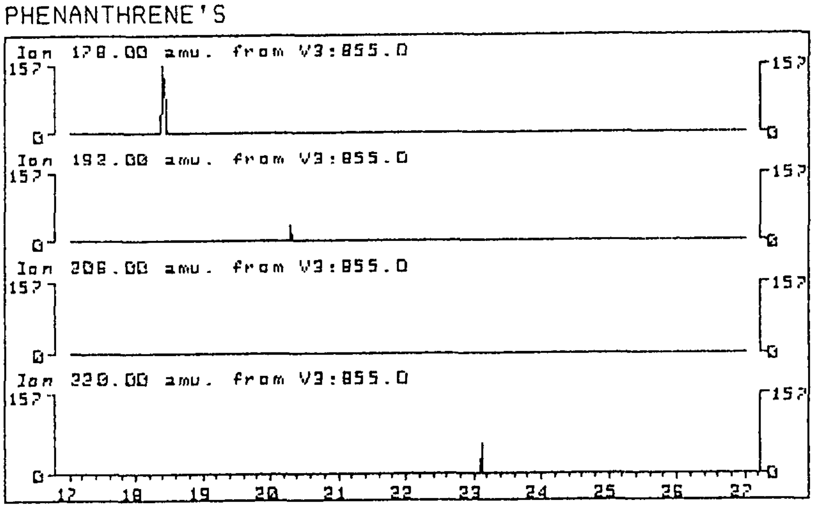
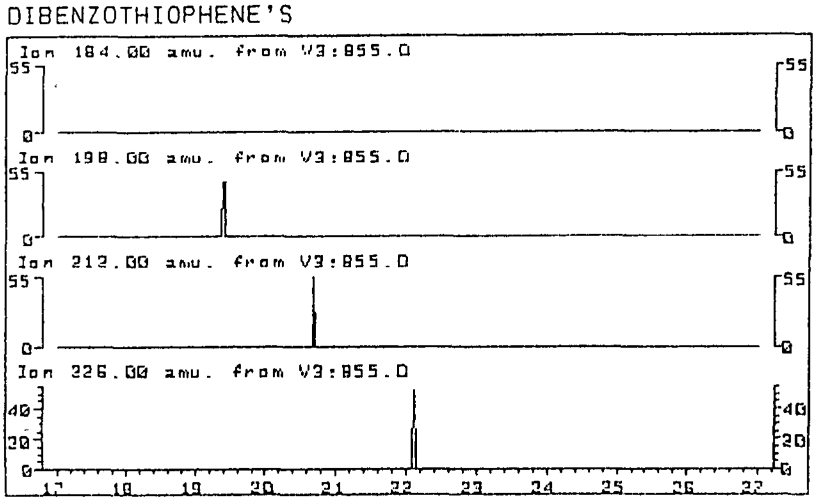
MAJOR HOMOLOG GROUPS
NAPHTHALENE'S

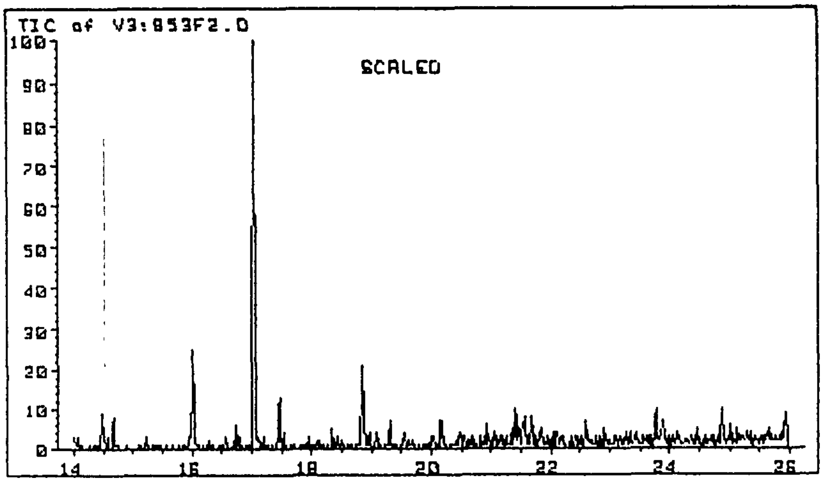


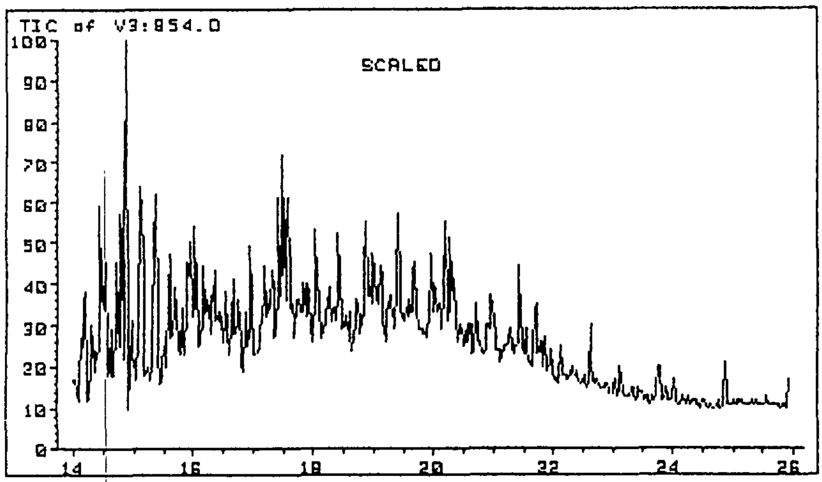
PHENANTHRENE'S

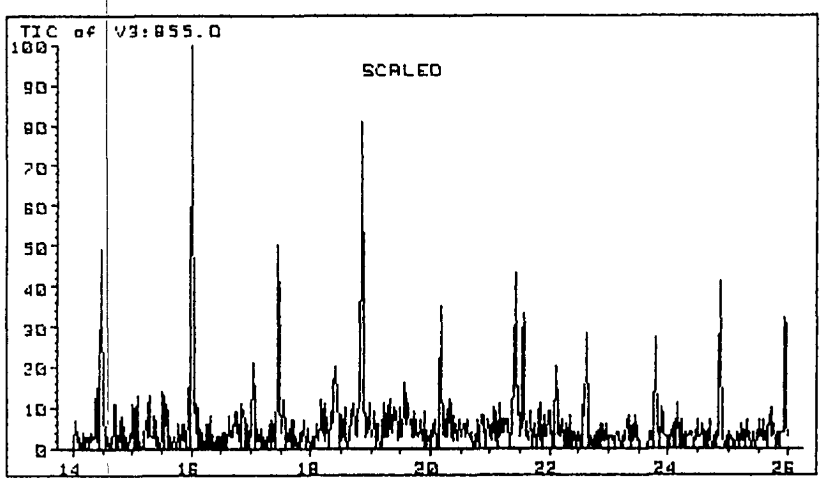


DIBENZOTHIOPHENE'S




TIC of V3:853F2.D
SCALED


TIC of V3:854.D
SCALED


TIC of V3:855.D
SCALED

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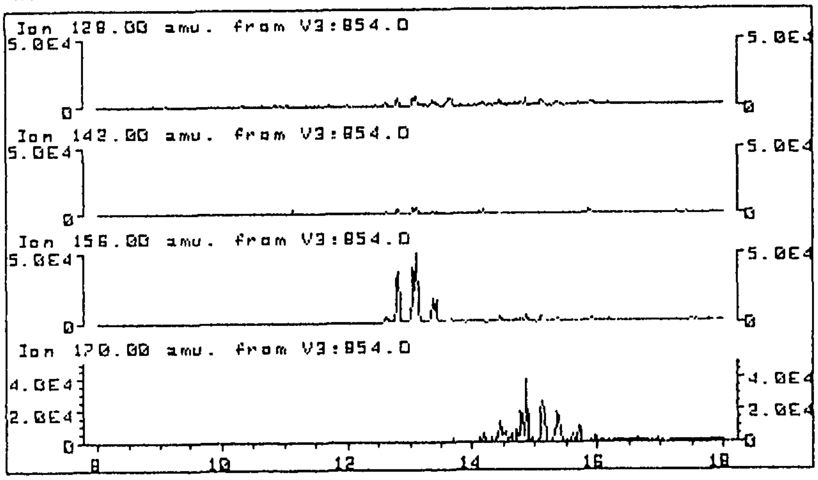
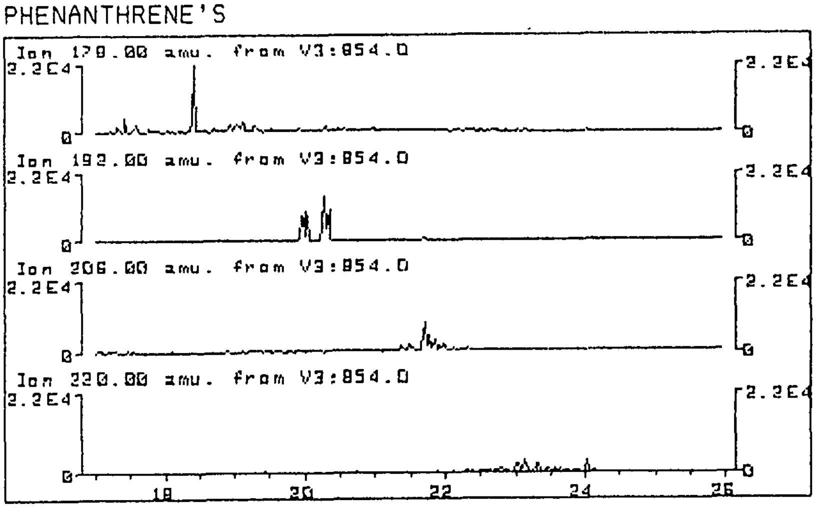
MAJOR HOMOLOG GROUPS

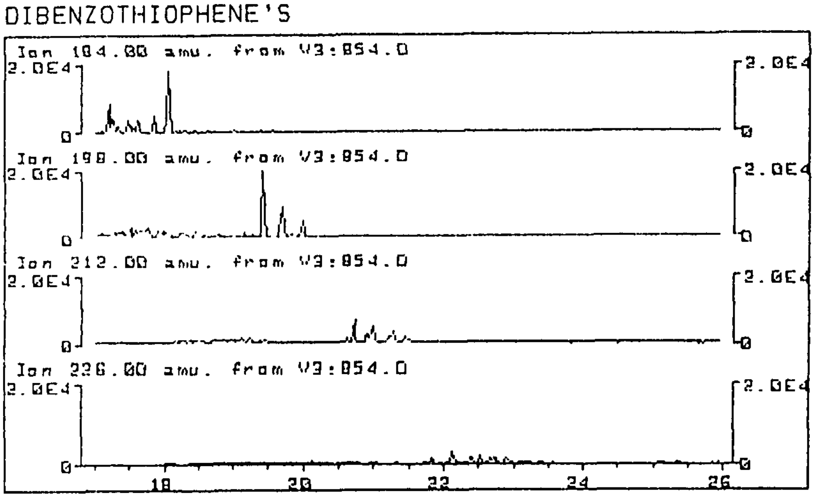
NAPHTHALENE'S



PHENANTHRENE'S



DIBENZOTHIOPHENE'S

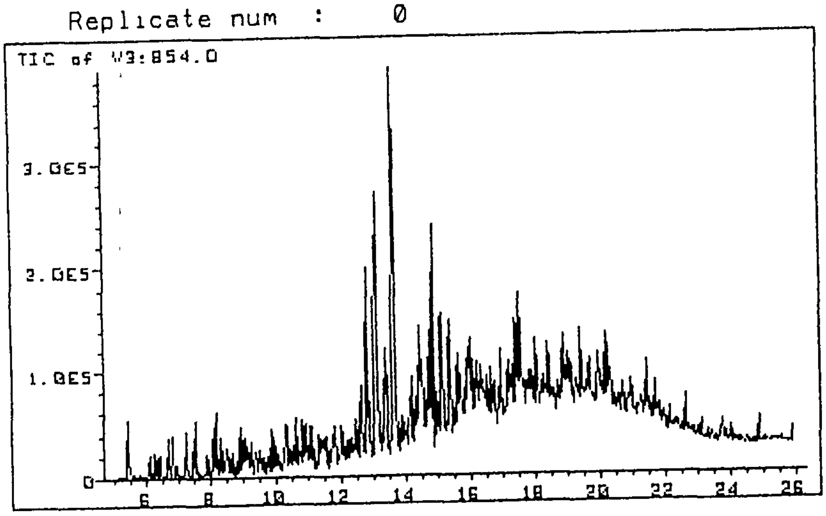


Data file: V3:854.D
File type: GC / MS DATA FILE

Name Info: SAMPLE 147854 1UL INJ
Misc Info:
Operator : CB HENRY IES--LSU

Date : 2 Jun 86 9:42 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



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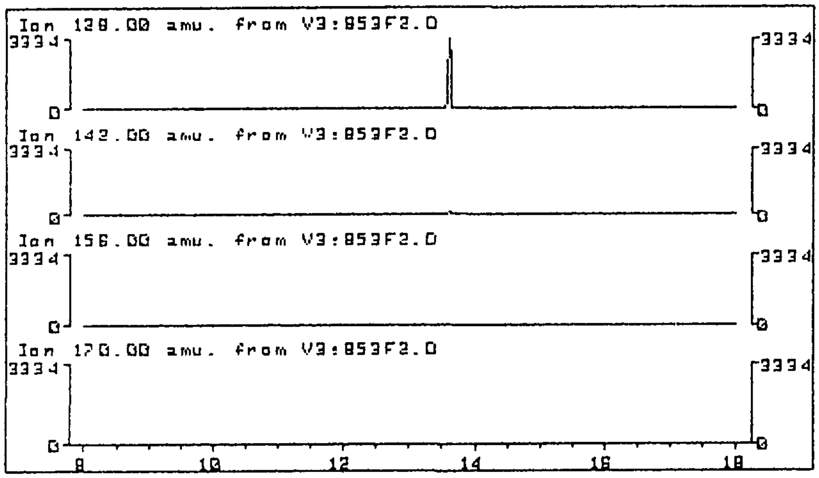
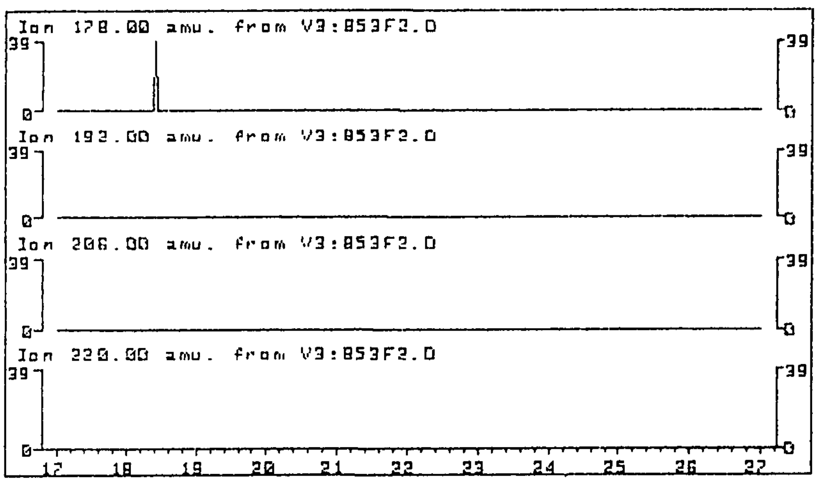
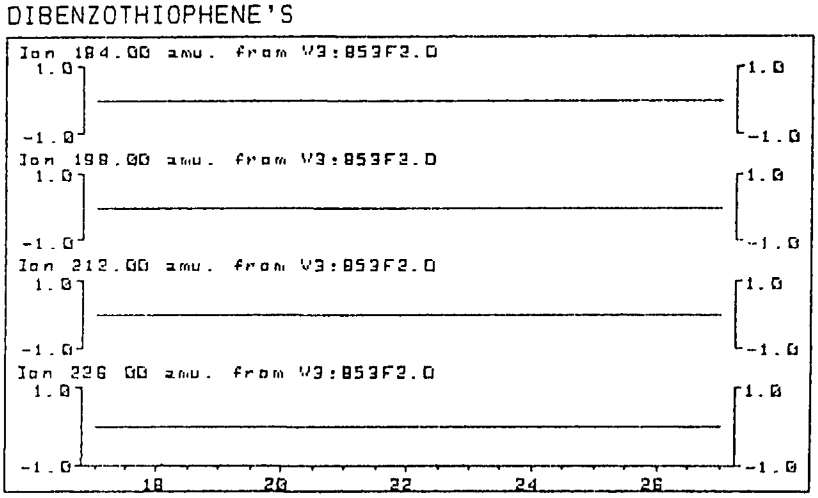
MAJOR HOMOLOG GROUPS
NAPHTHALENE'S

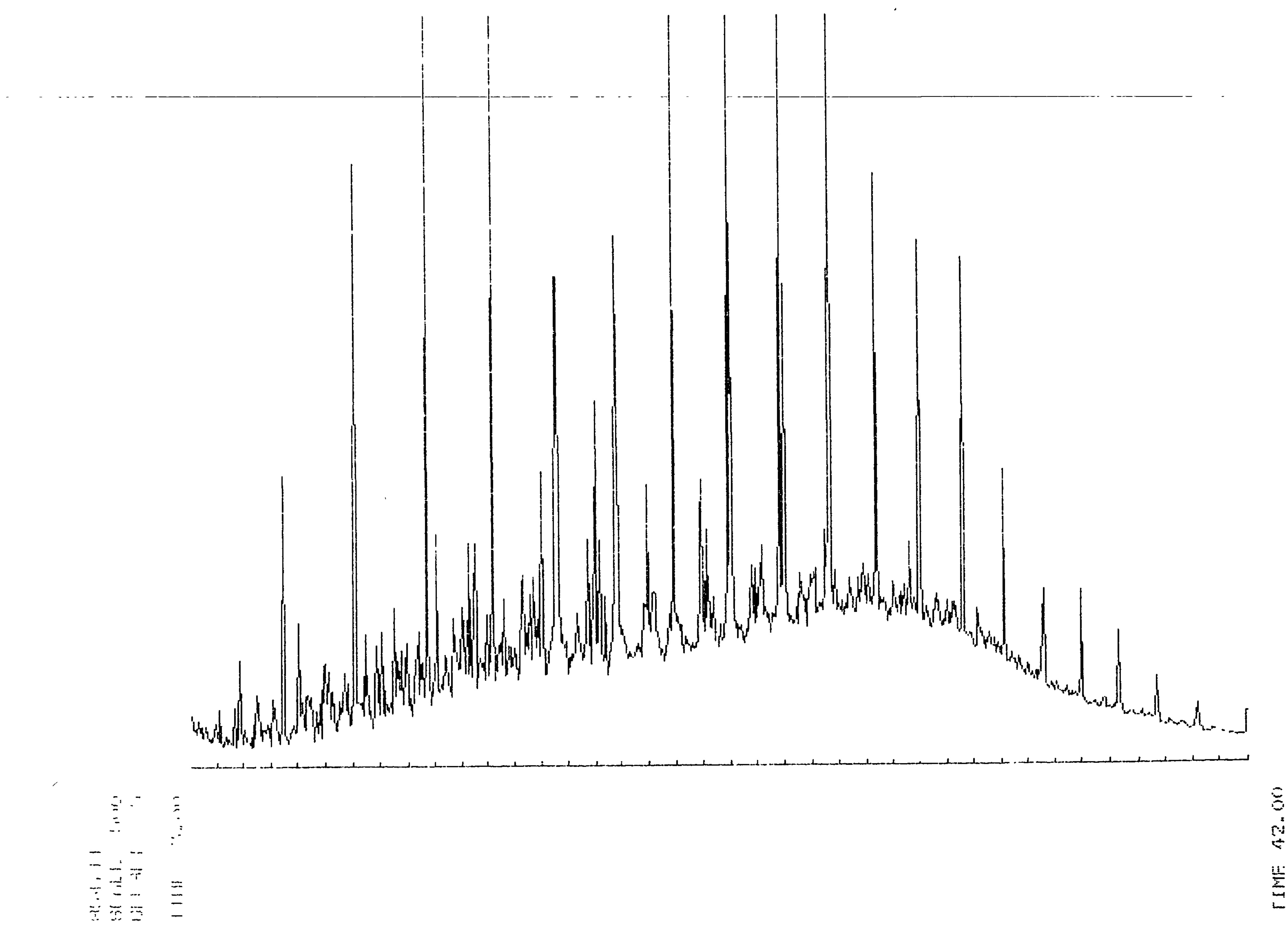


PHENANTHRENE'S



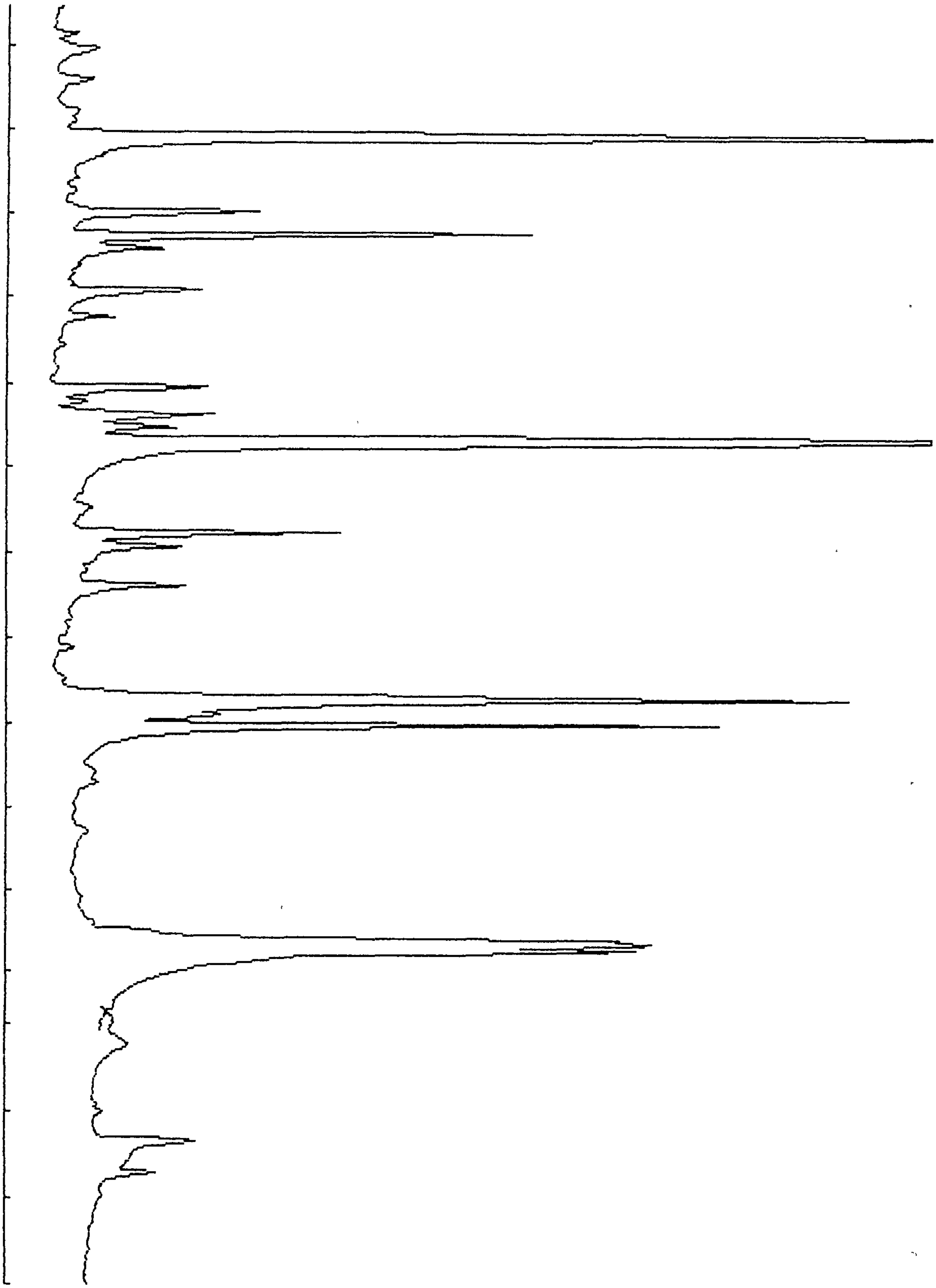
DIBENZOTHIOPHENE'S



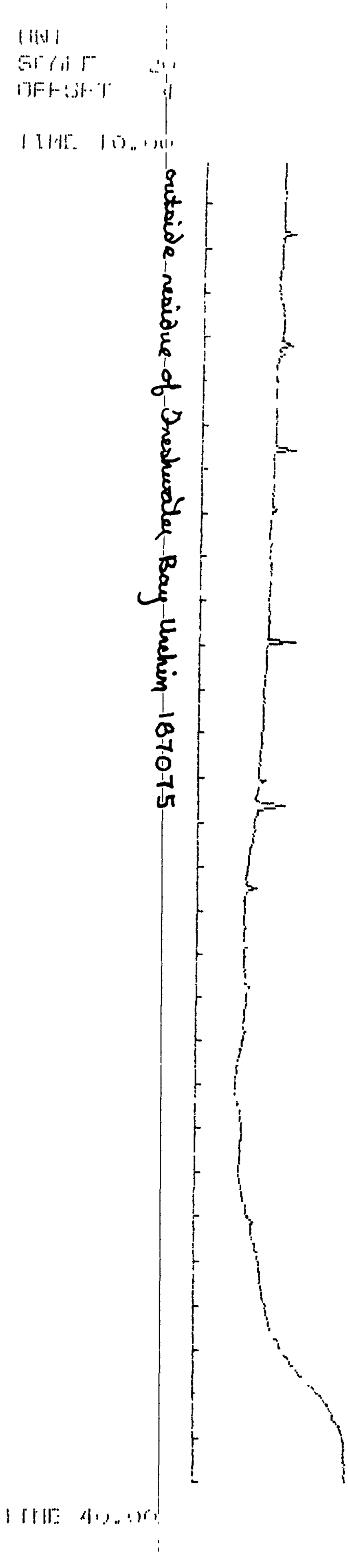

TIME 42.00

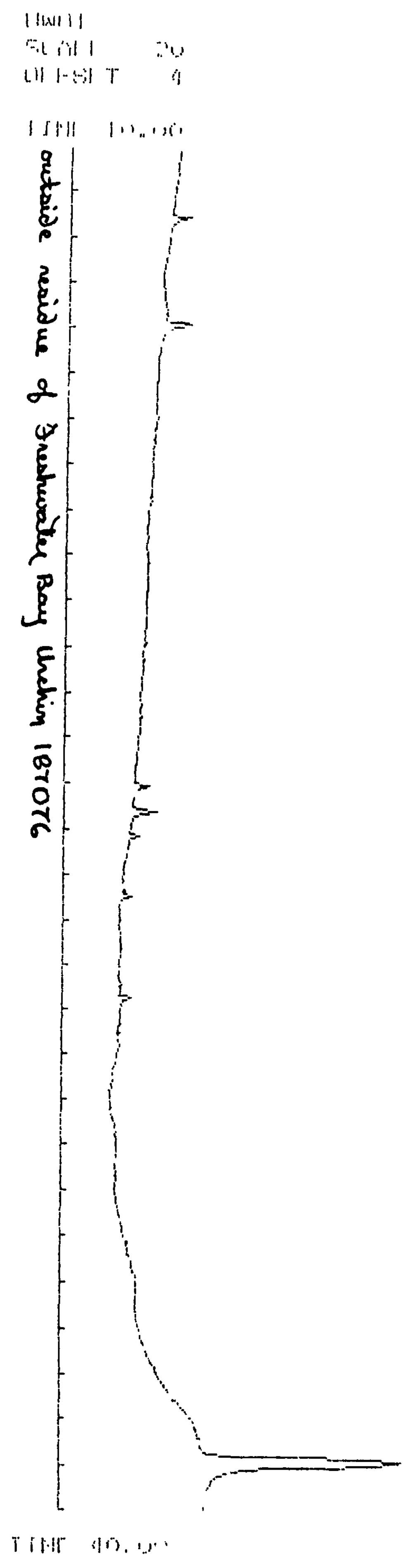
072N1
SCALE 125
OFFSET 0

TIME 22.50



TIME 38.00


UNIT
SCALE 20
OFFSET 4
TIME 10.00
outside residue of Freshwater Bay Urchin 187075
TIME 40.00

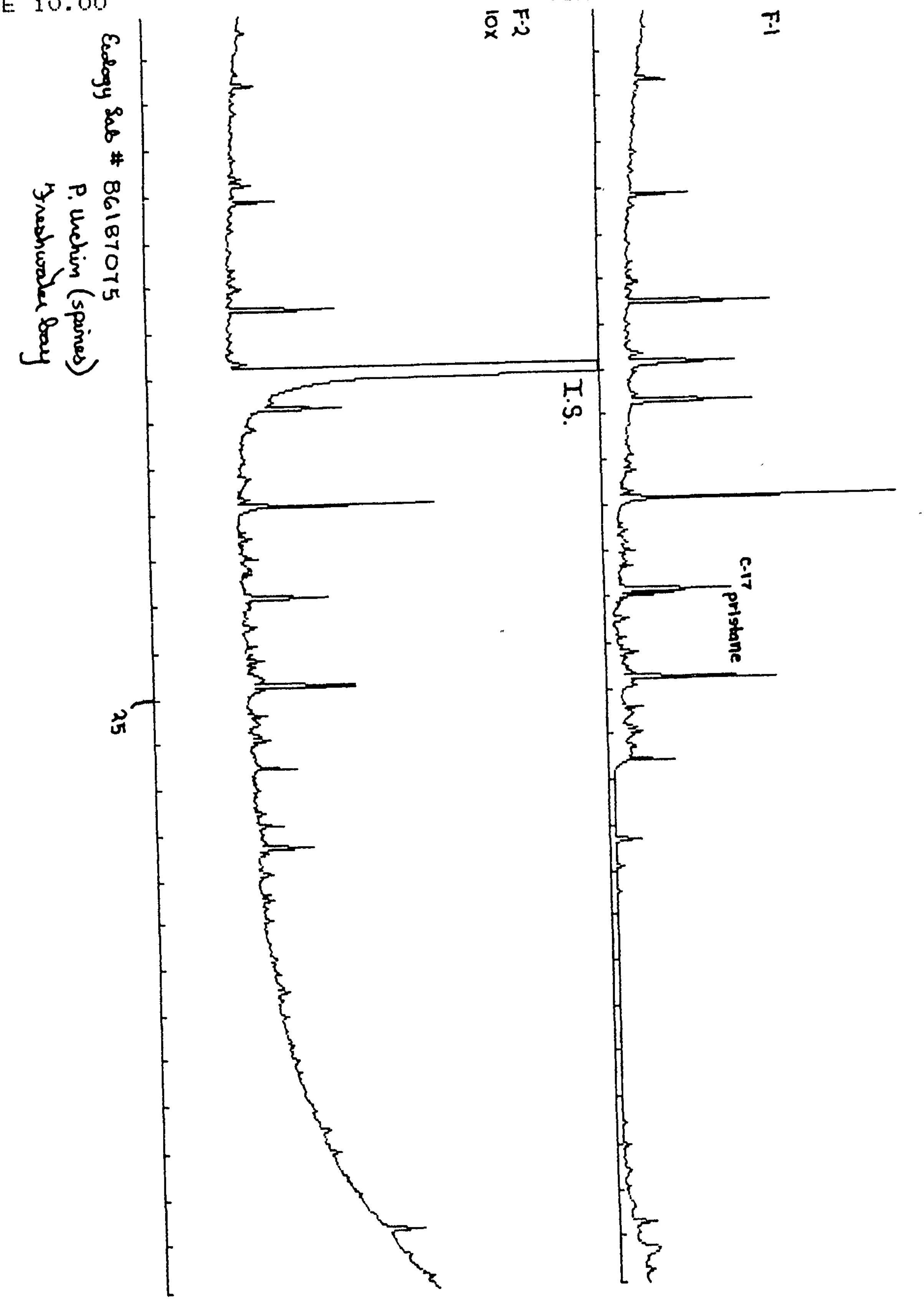

UNIT
SCALE 20
OFFSET 4
TIME 10.00
outside residue of Freshwater Bay Urchin 187076
TIME 40.00

075F13
SCALE 25
OFFSET 2

TIME 10.00

075F11
SCALE 25
OFFSET 4

TIME 10.00



TIME 38.00

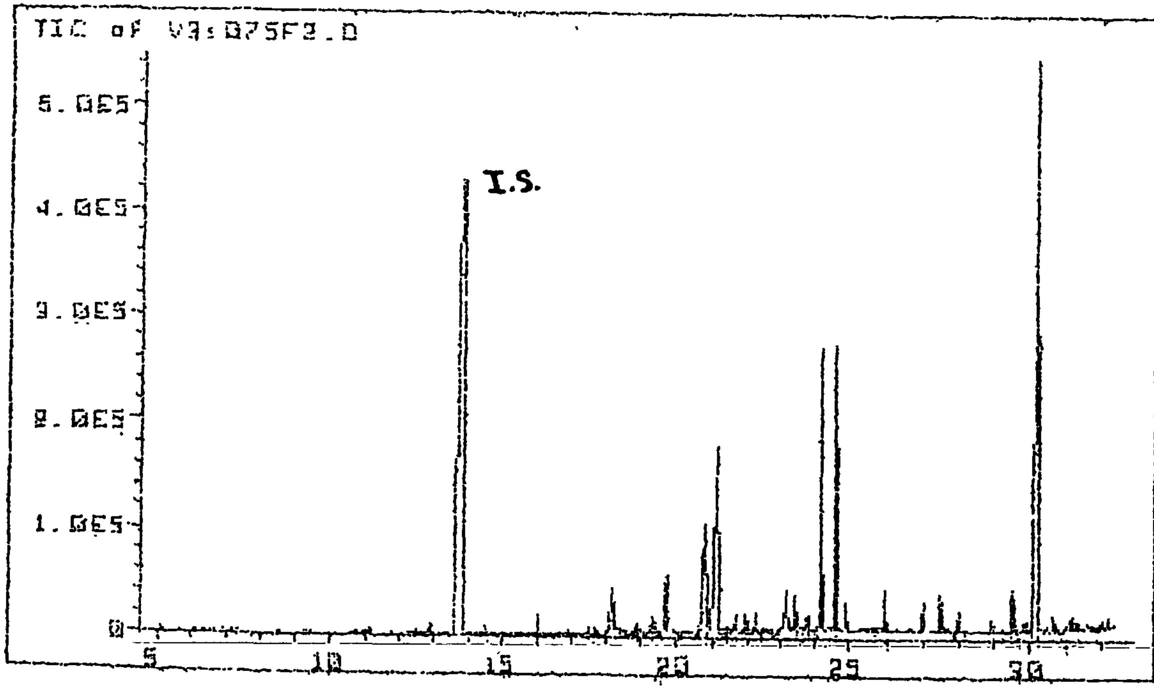
TIME 38.00

Data file: V3:075F2.D
File type: GC / MS DATA FILE

Name Info: Ecology Lab # 187075
Misc Info:
Operator :

Date : 8 Jun 86 7:37 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



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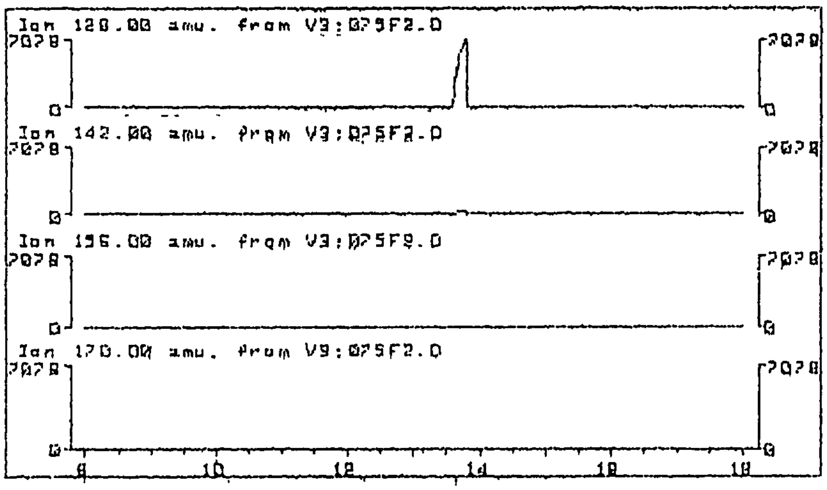
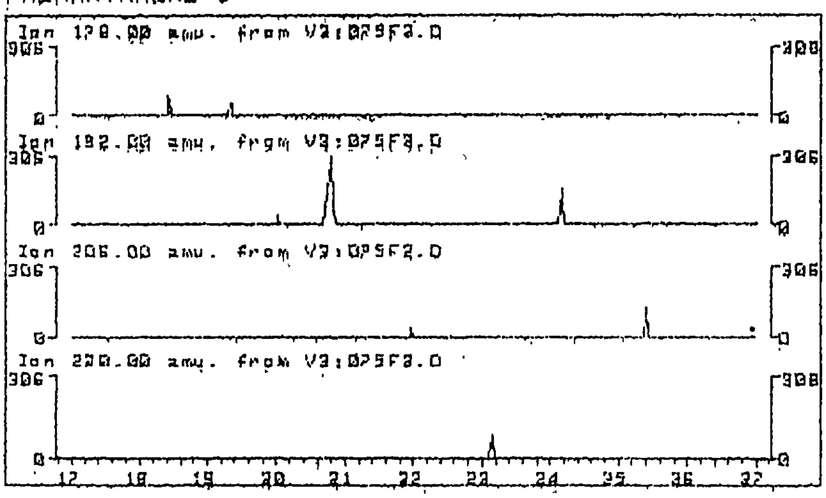
187075 Freshwater Bay P. Urchin (spines)

MAJOR HOMOLOG GROUPS

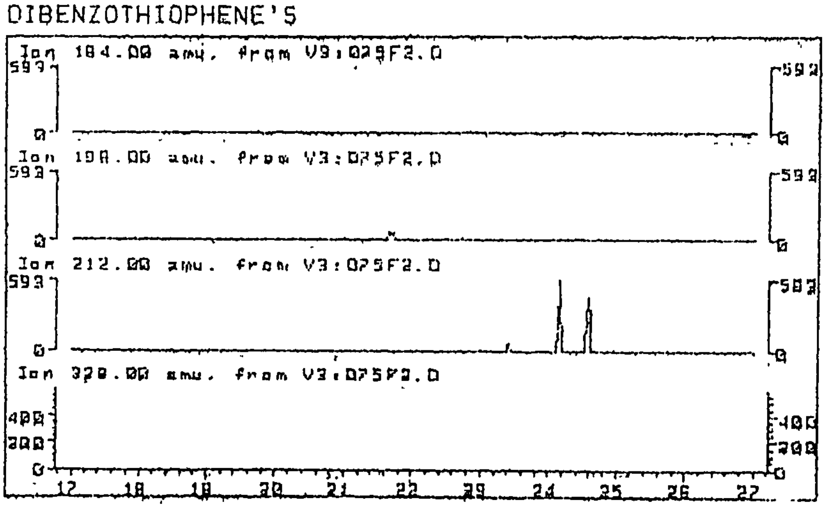
NAPHTHALENE'S



PHENANTHRENE'S

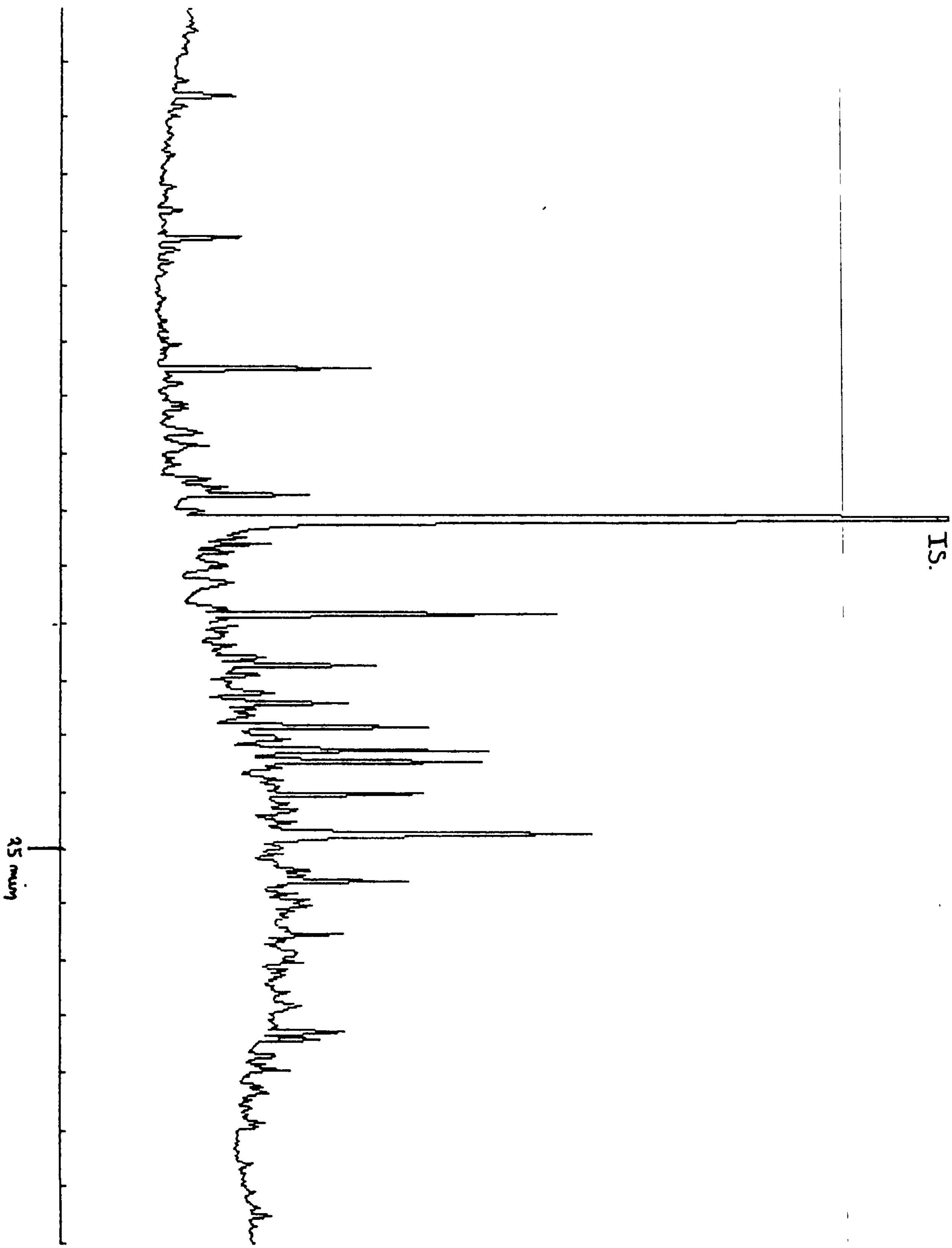


DIBENZOTHIOPHENE'S



076f21
SCALE 25
OFFSET 4

TIME 10.00



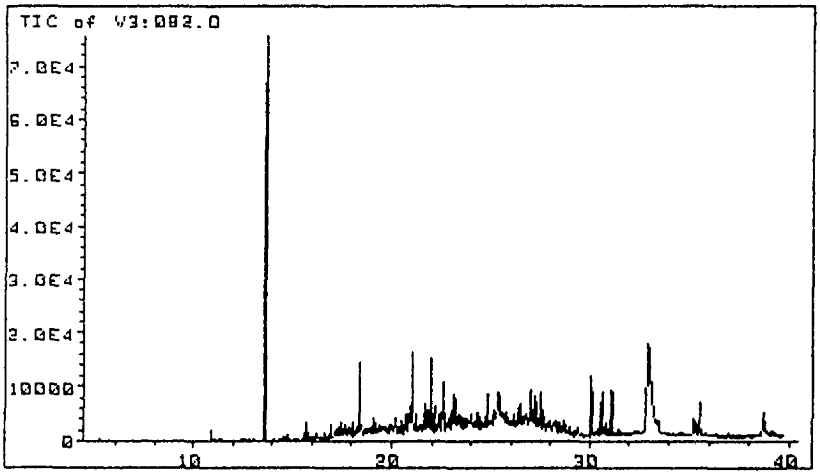
TIME 32.00

Data file: V3:082.D
File type: GC / MS DATA FILE

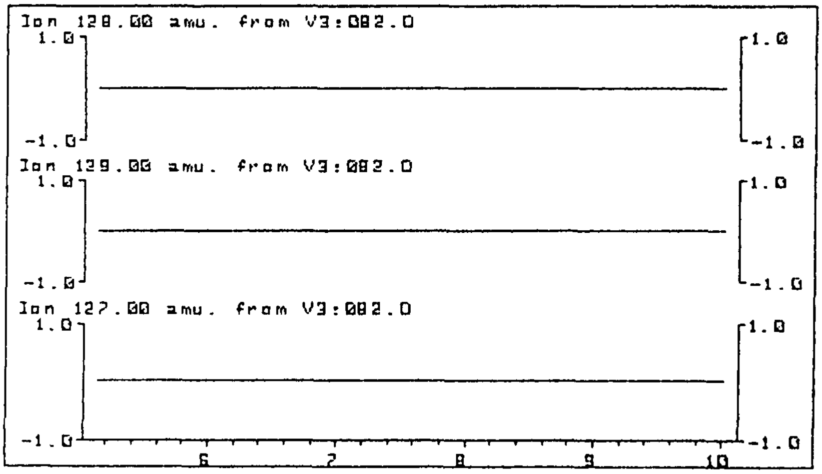
Name Info: 187082 WASH SPILL 4 UL INJ
Misc Info: METH EMV=1600
Operator : CB

Date : 2 Jun 86 10:38 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



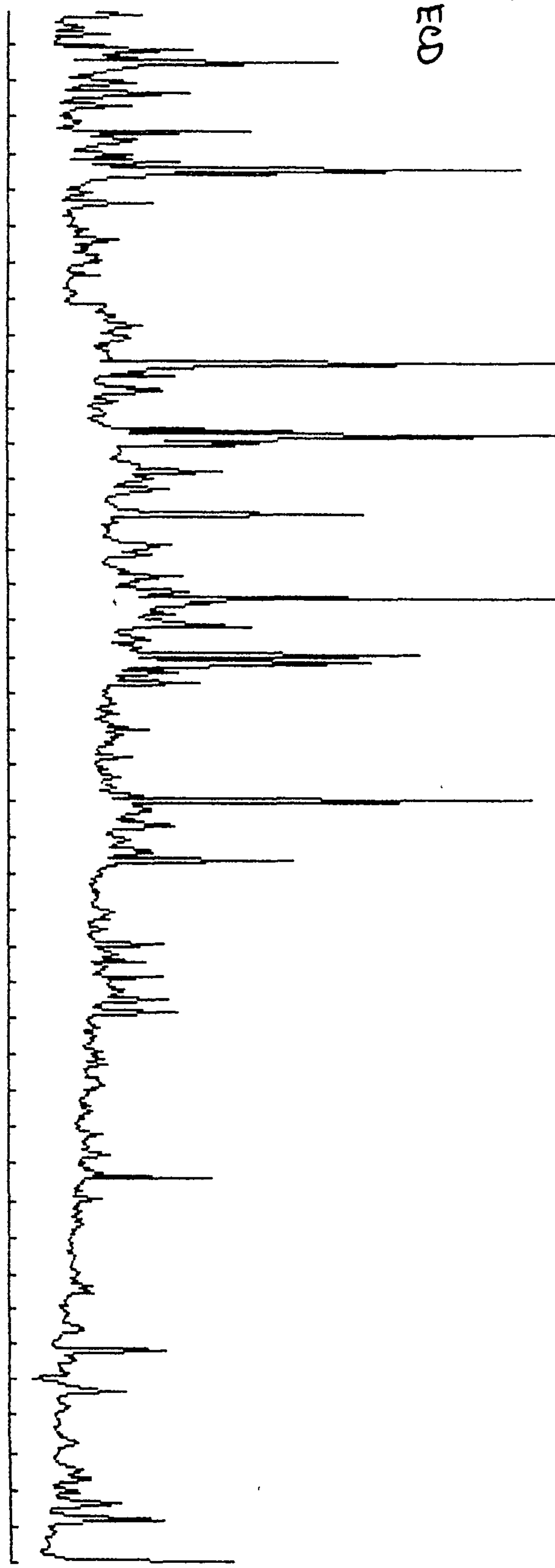
NAPHTHALENE RT=8.65



8242e1
SCALE 100
OFFSET 2

TIME 3.00

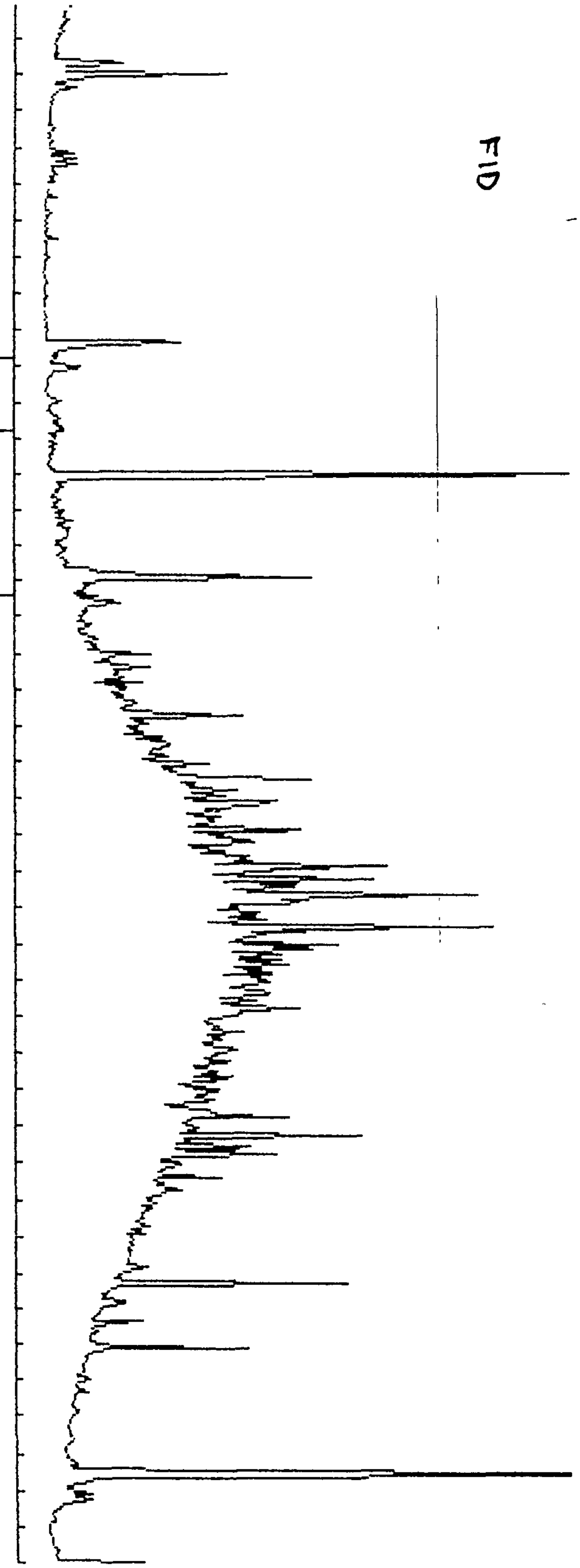
Eaglehawk oysters



TIME 46.00

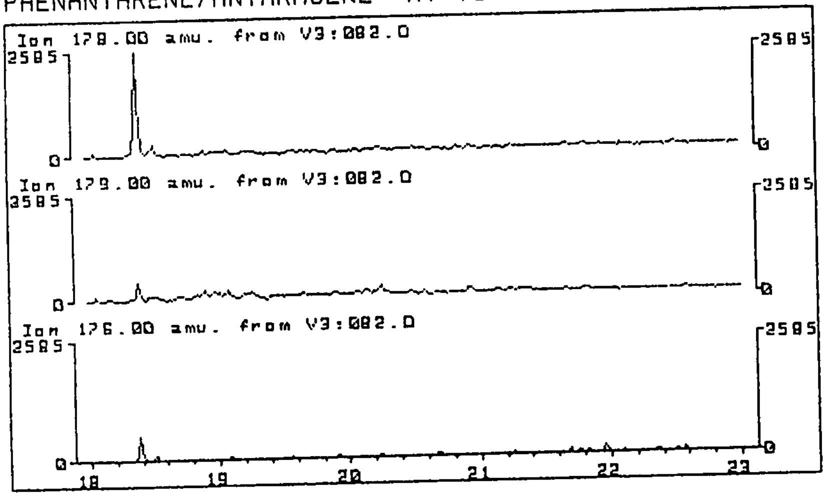
8242f1
SCALE 100
OFFSET 2

TIME 3.00

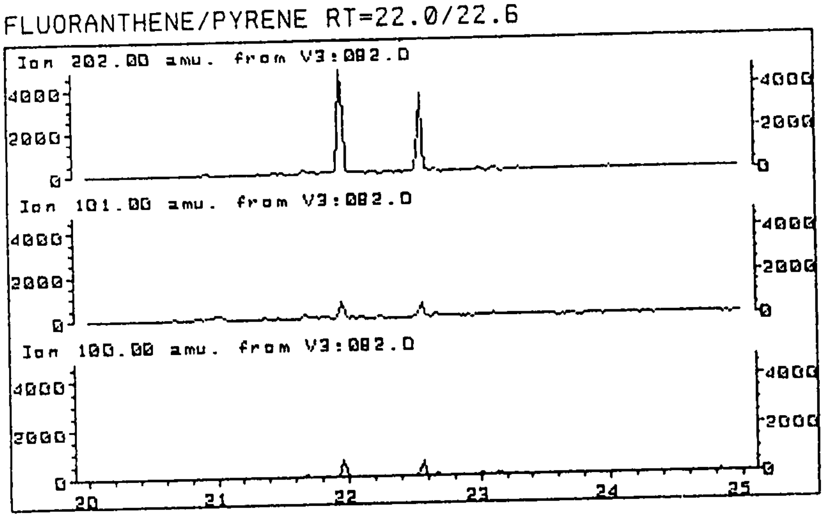


TIME 46.00

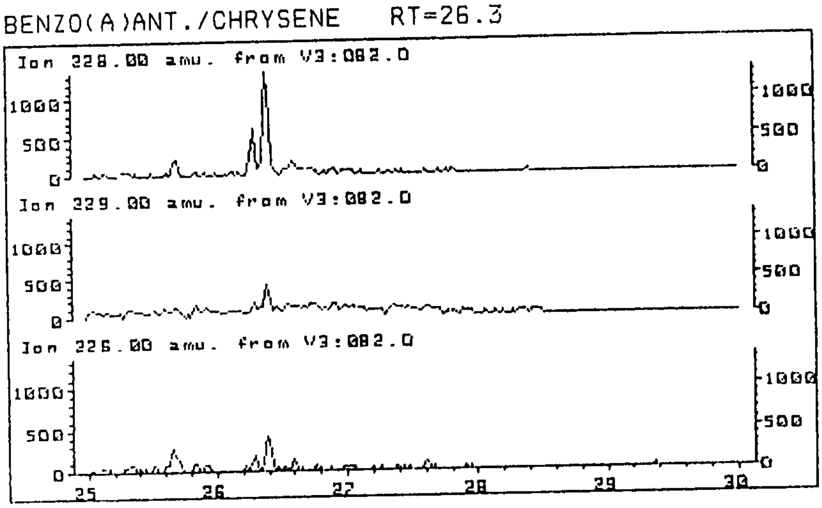
PHENANTHRENE/ANTHRACENE RT=18.5



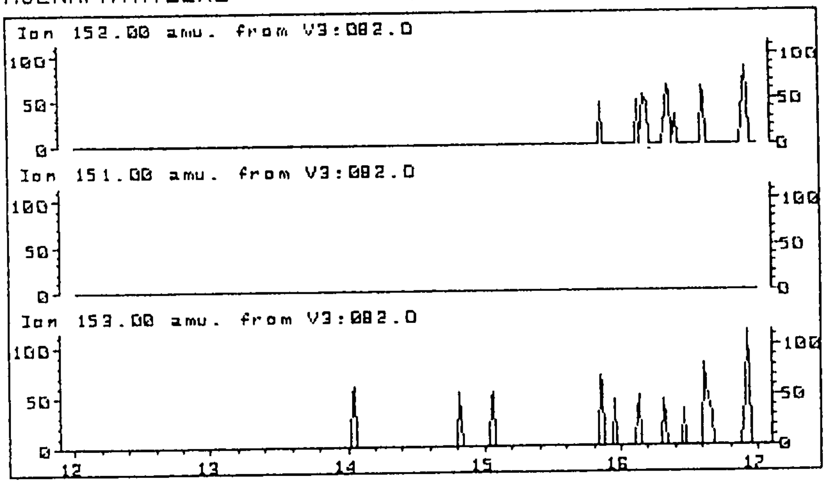
FLUORANTHENE/PYRENE RT=22.0/22.6



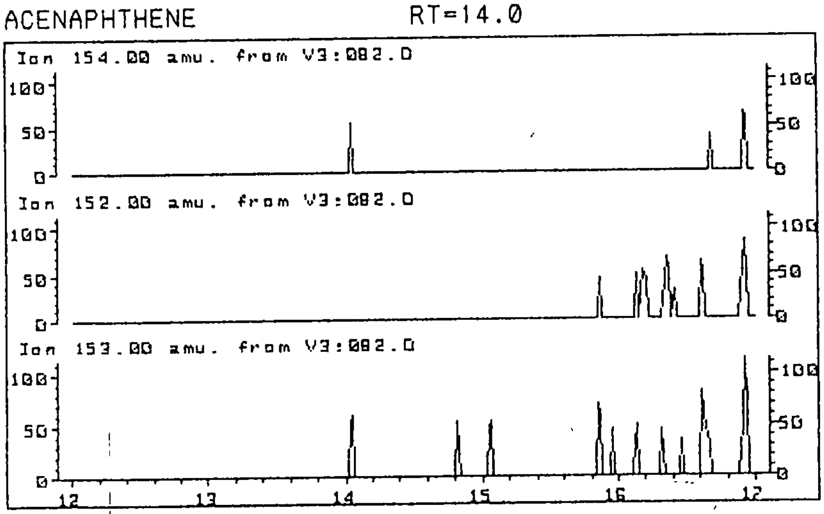
BENZO(A)ANT./CHRYSENE RT=26.3



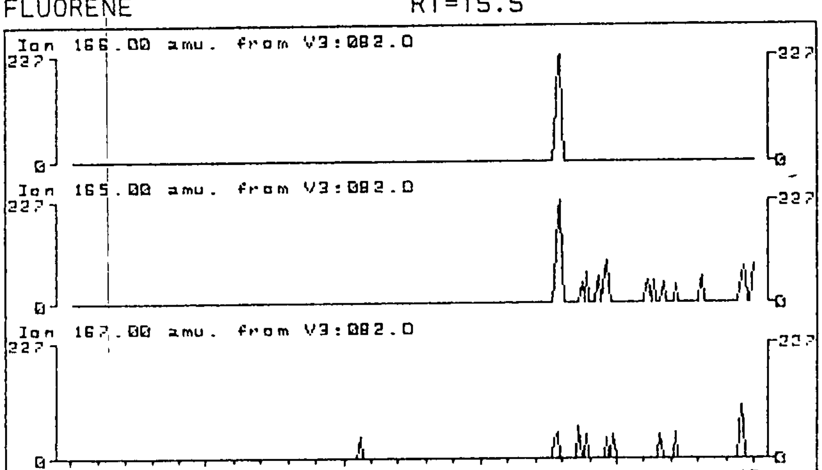
ACENAPHTHYLENE RT=13.4



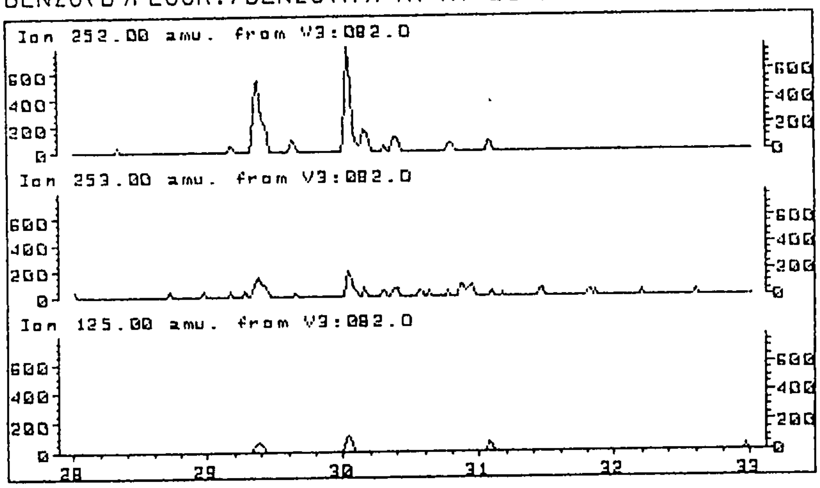
ACENAPHTHENE RT=14.0



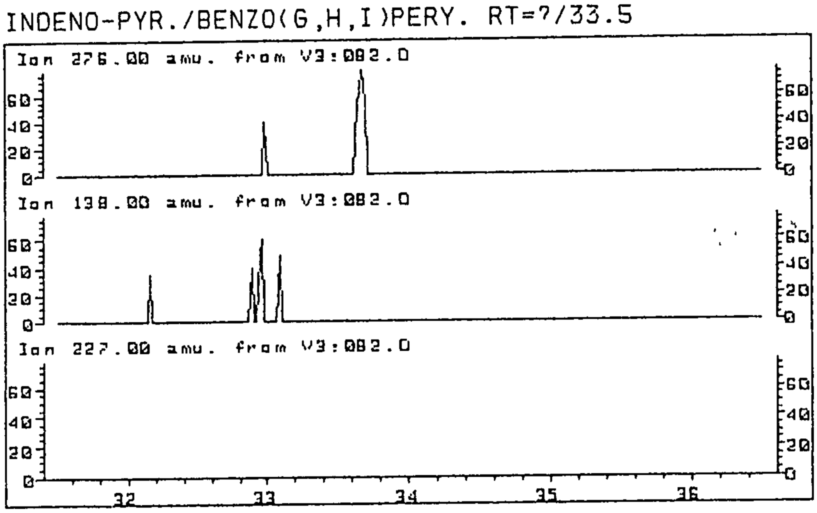
FLUORENE RT=15.5



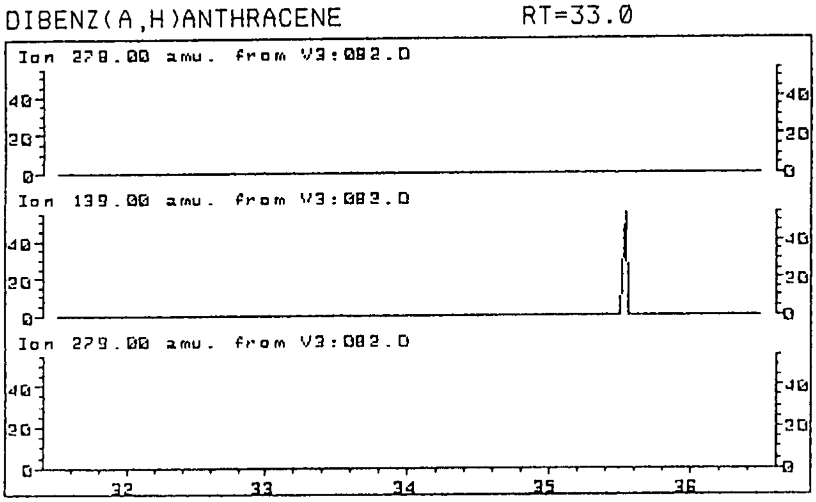
BENZO(B)FLUOR./BENZO(A)PYR RT=29.3/30.1



INDENO-PYR./BENZO(G,H,I)PERY. RT=?/33.5



DIBENZ(A,H)ANTHRACENE RT=33.0

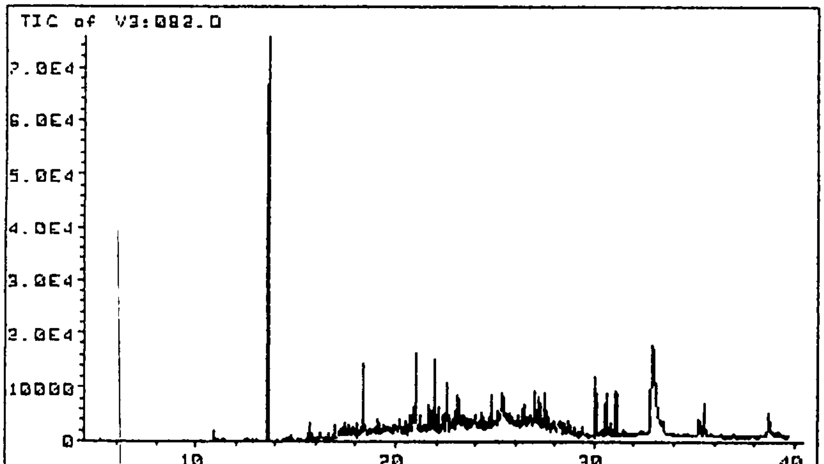


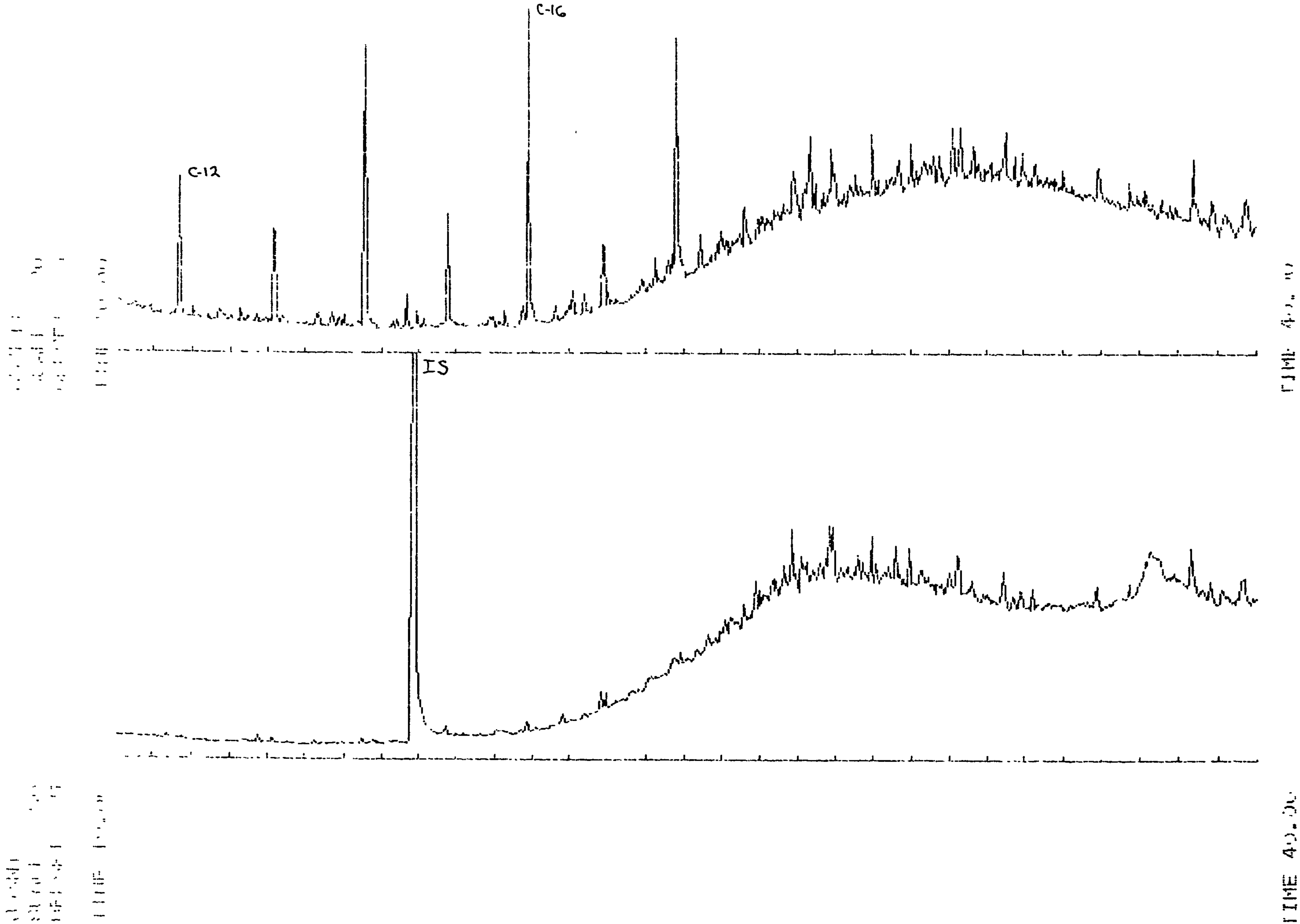
Data file: V3:082.D
File type: GC / MS DATA FILE

Name Info: 187082 WASH SPILL 4 UL INJ
Misc Info: METH EMV=1600
Operator : CB

Date : 2 Jun 86 10:38 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0




C-12
C-16
IS
TIME 40.00

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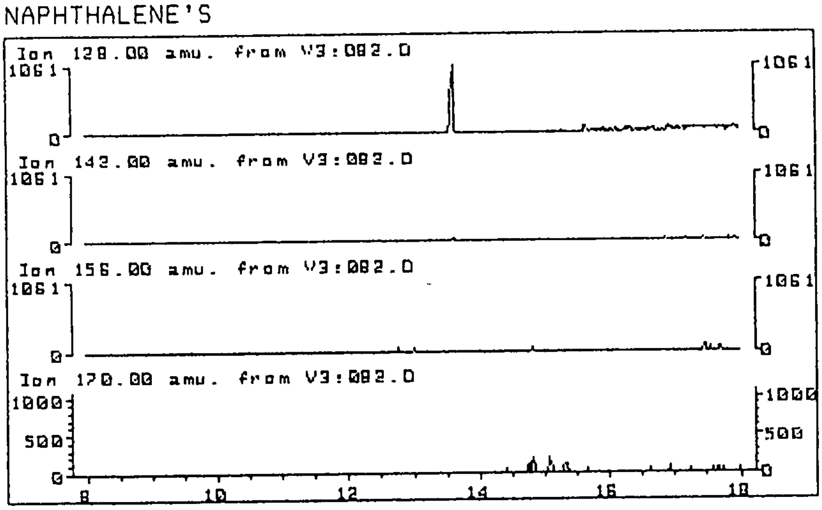
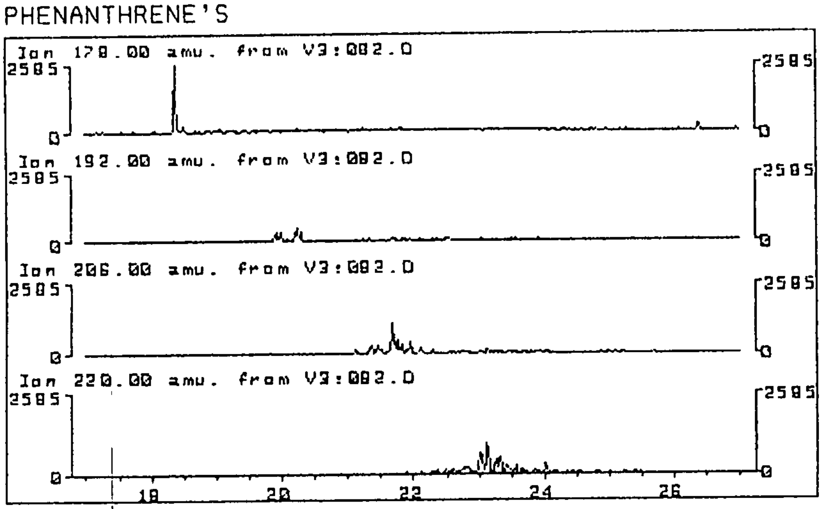
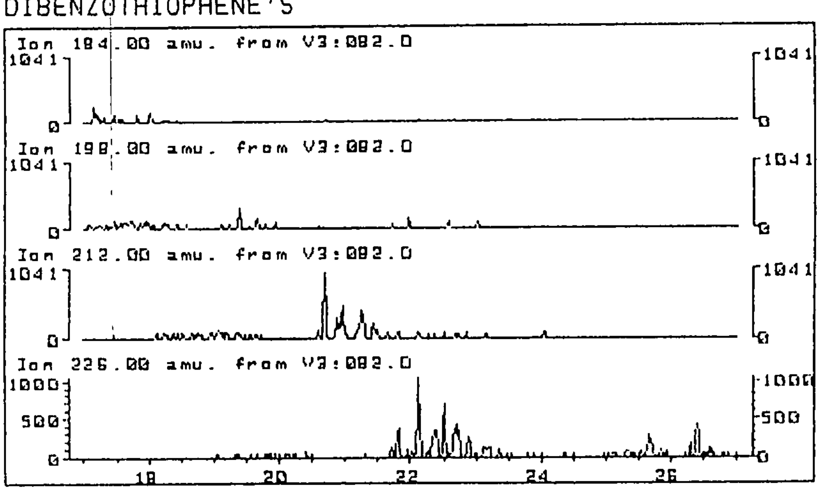
MAJOR HOMOLOG GROUPS
NAPHTHALENE'S



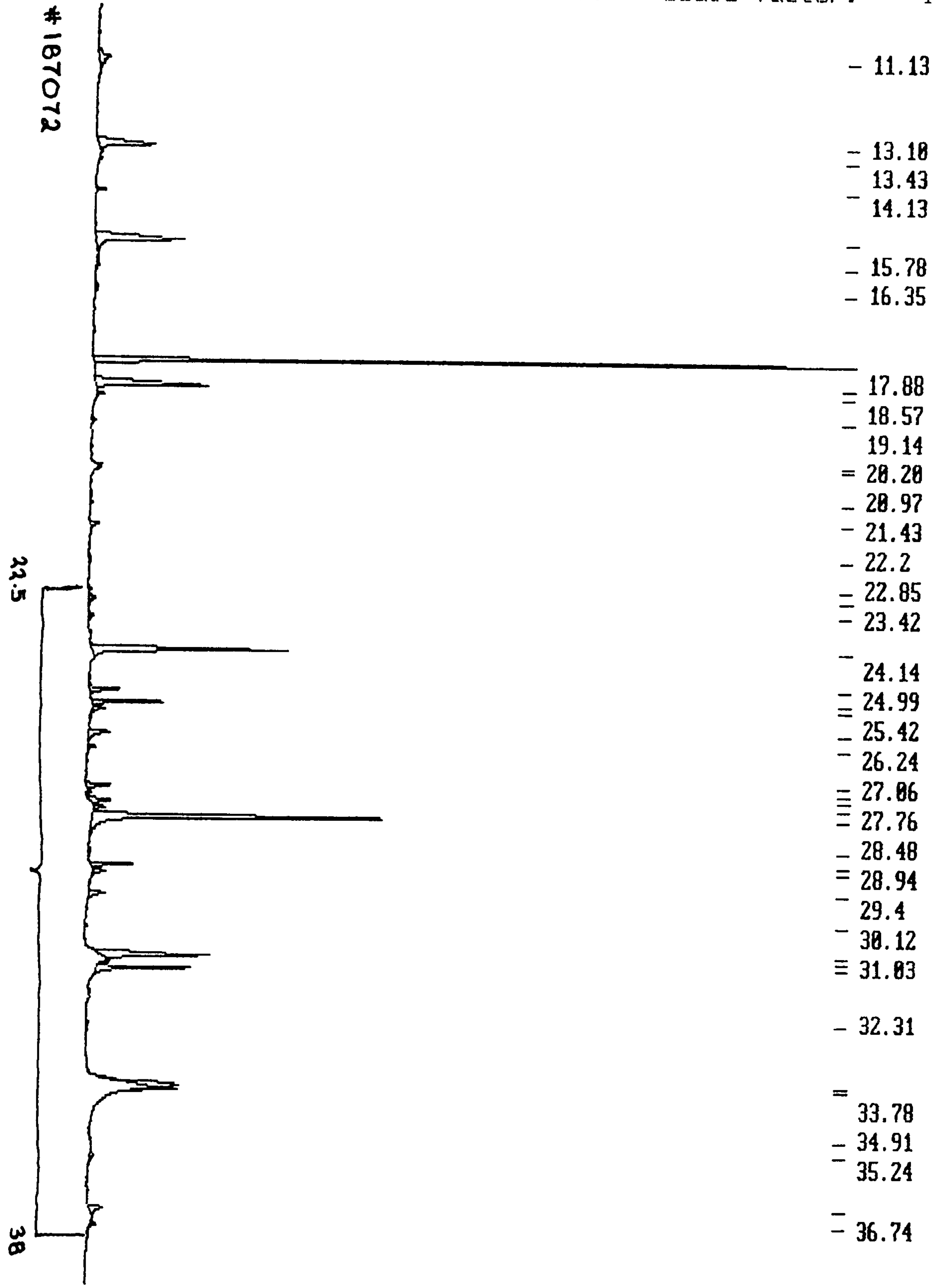
PHENANTHRENE'S



DIBENZOTHIOPHENE'S

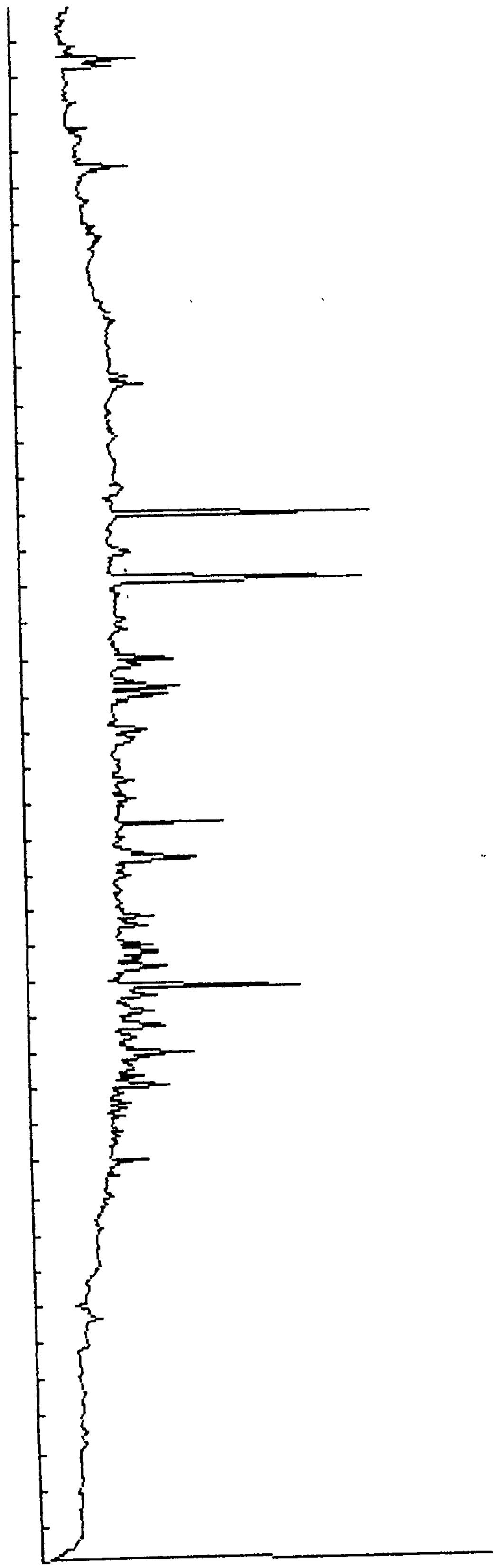


Start time: 10.00 Stop time: 38.00 Offset: 0
Low Value: 5080 High Value: 662048 Scale factor: 1



68f2e1
SCALE 45
OFFSET 4

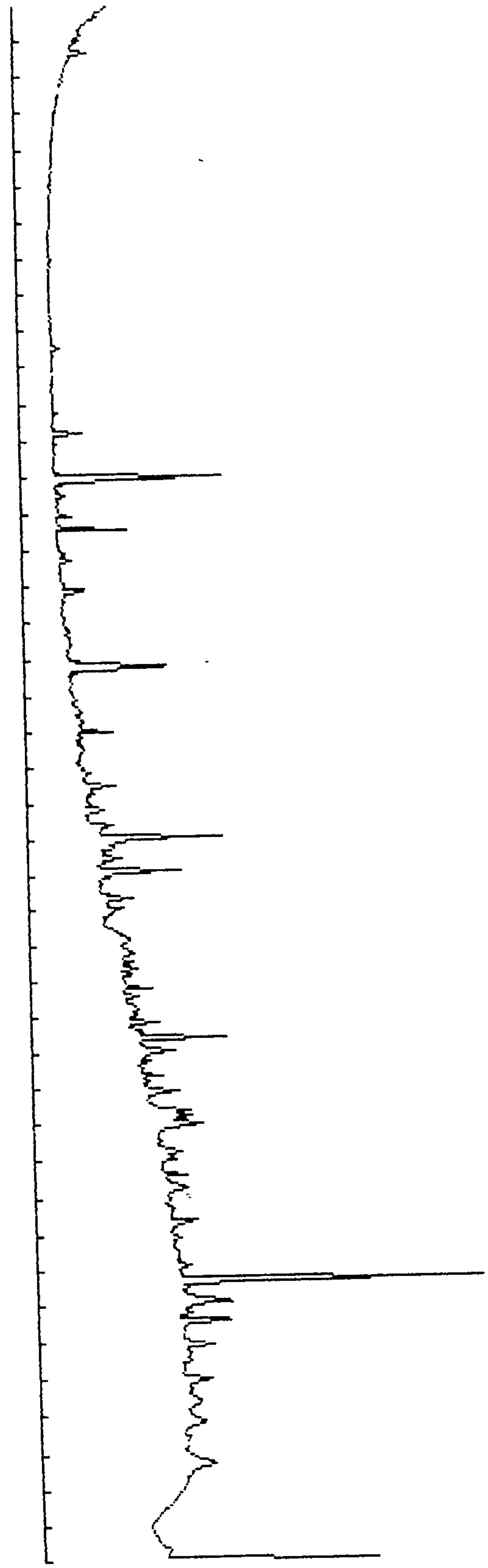
TIME 3.00



TIME 46.00

68f2f1
SCALE 45
OFFSET 4

TIME 3.00

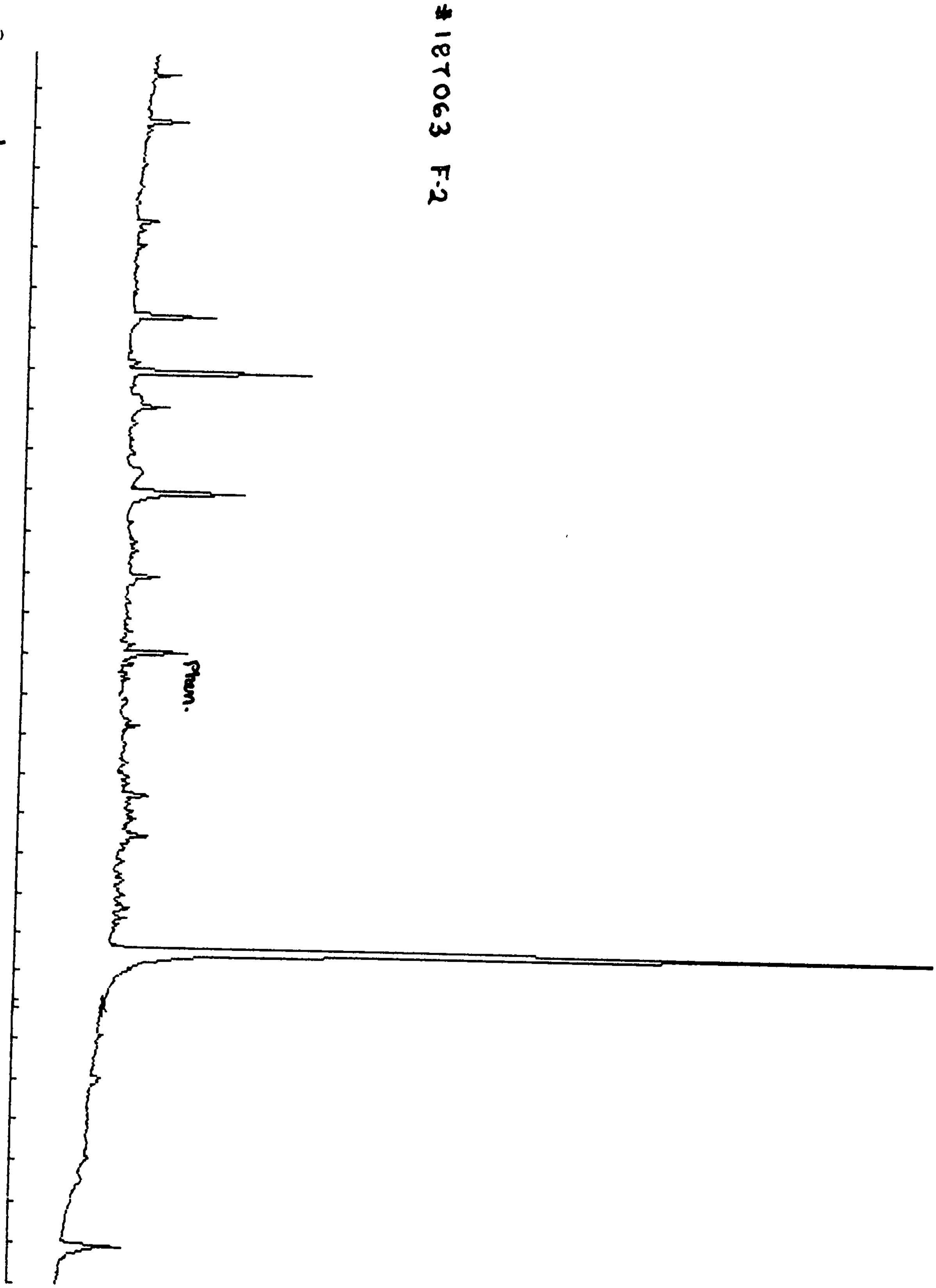


TIME 46.00

063F2
SCALE 20
OFFSET 4

TIME 10.00

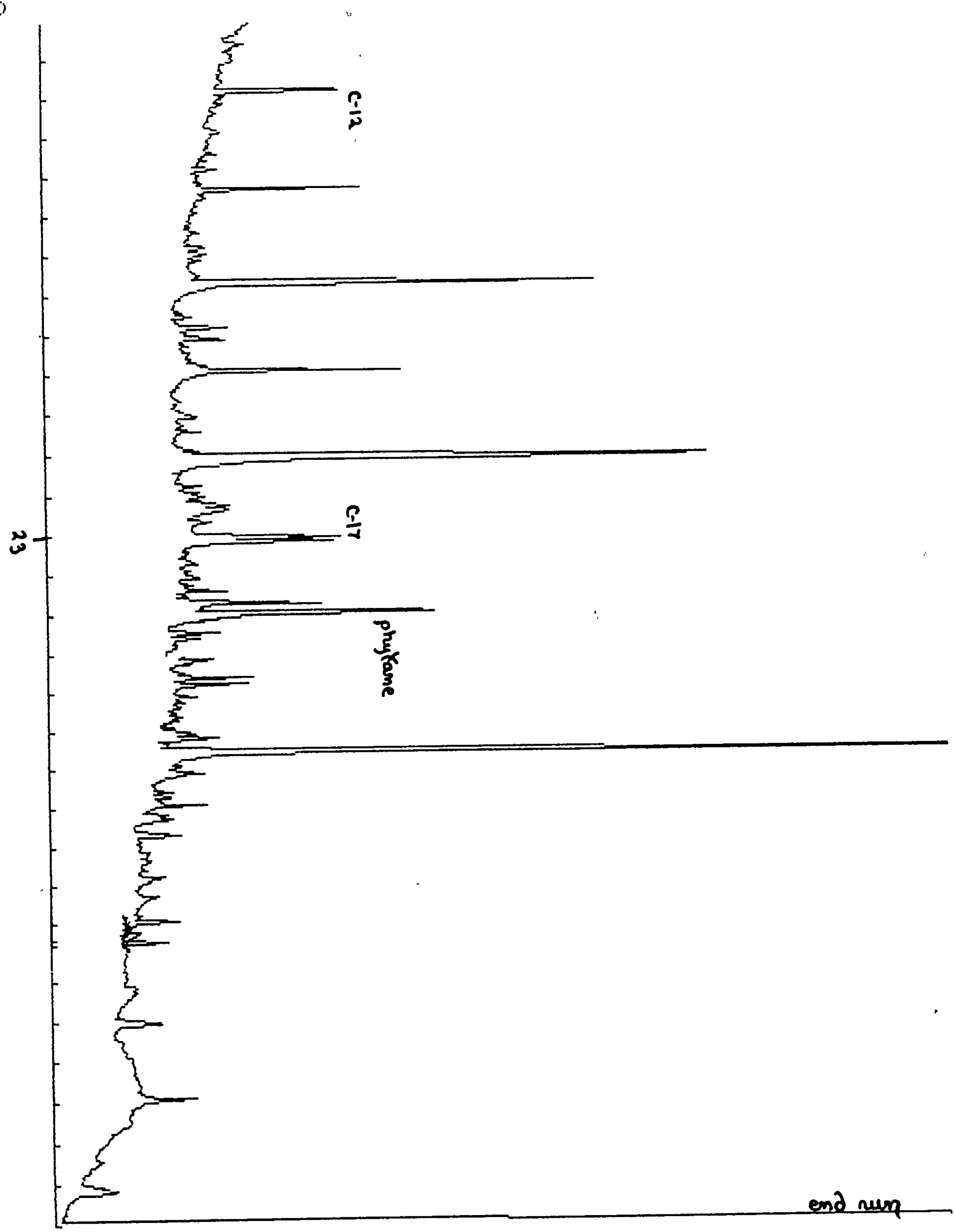
horse clams
Freshwater Bay



TIME 42.00

063F1
SCALE 10
OFFSET 5

TIME 10.00

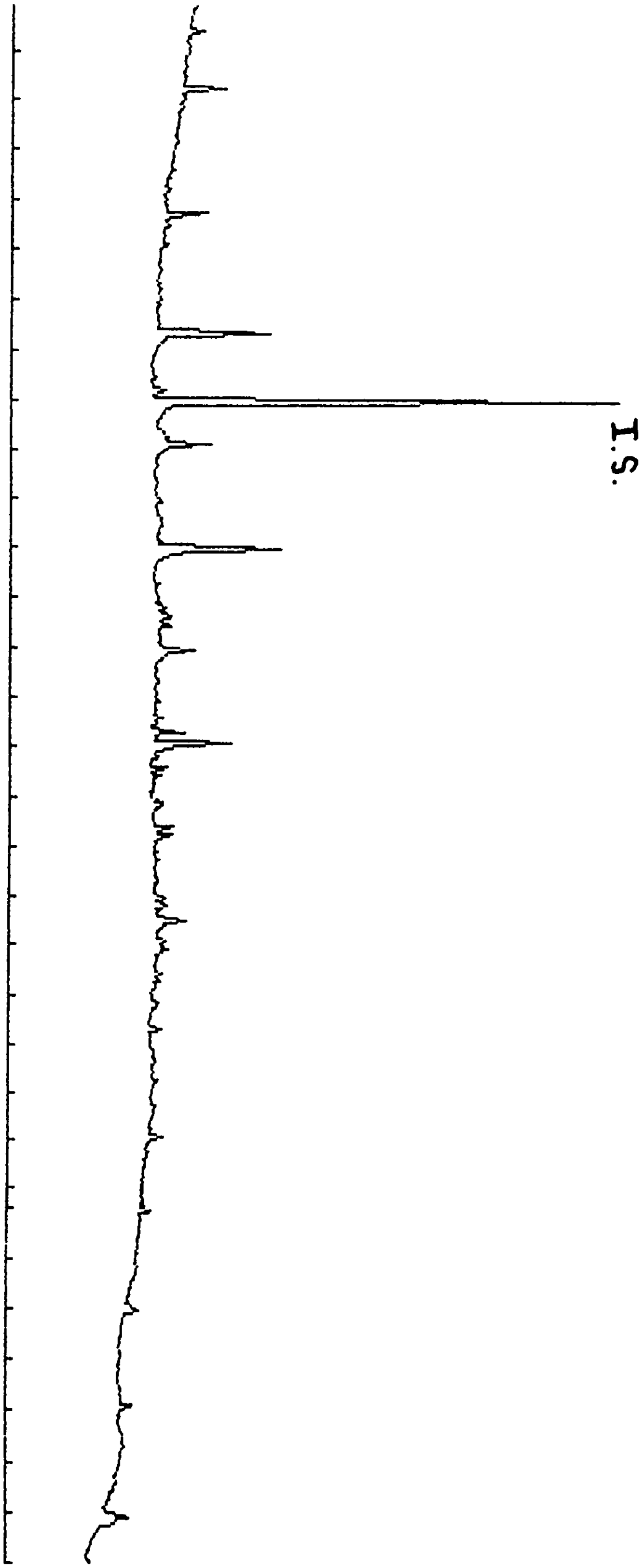


TIME 42.00

062F2
SCALE 20
OFFSET 4

TIME 10.00

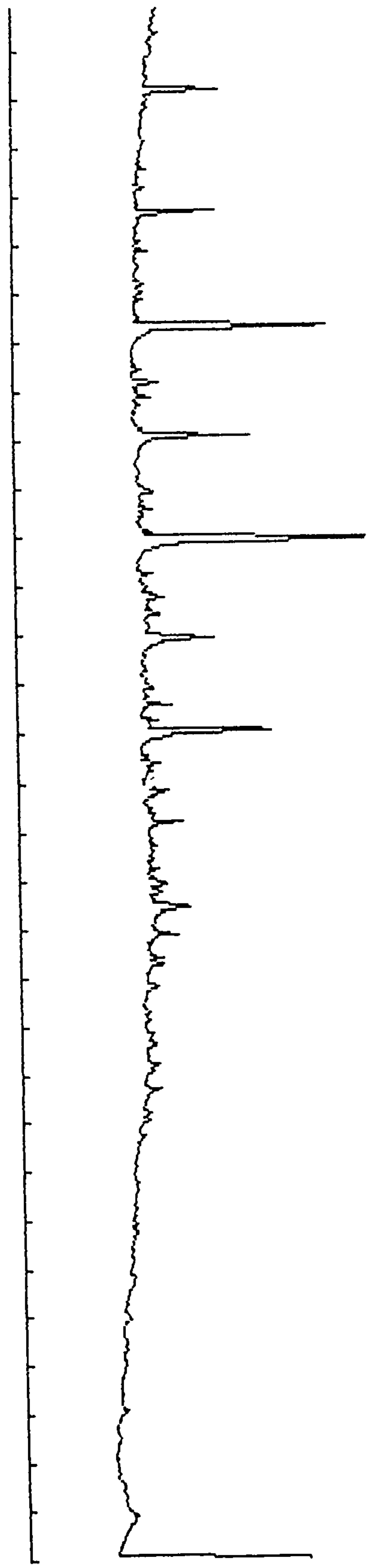
#187062 F-2
Freshwater Bay Rock Crab



TIME 42.00

062F1
SCALE 20
OFFSET 4

TIME 10.00

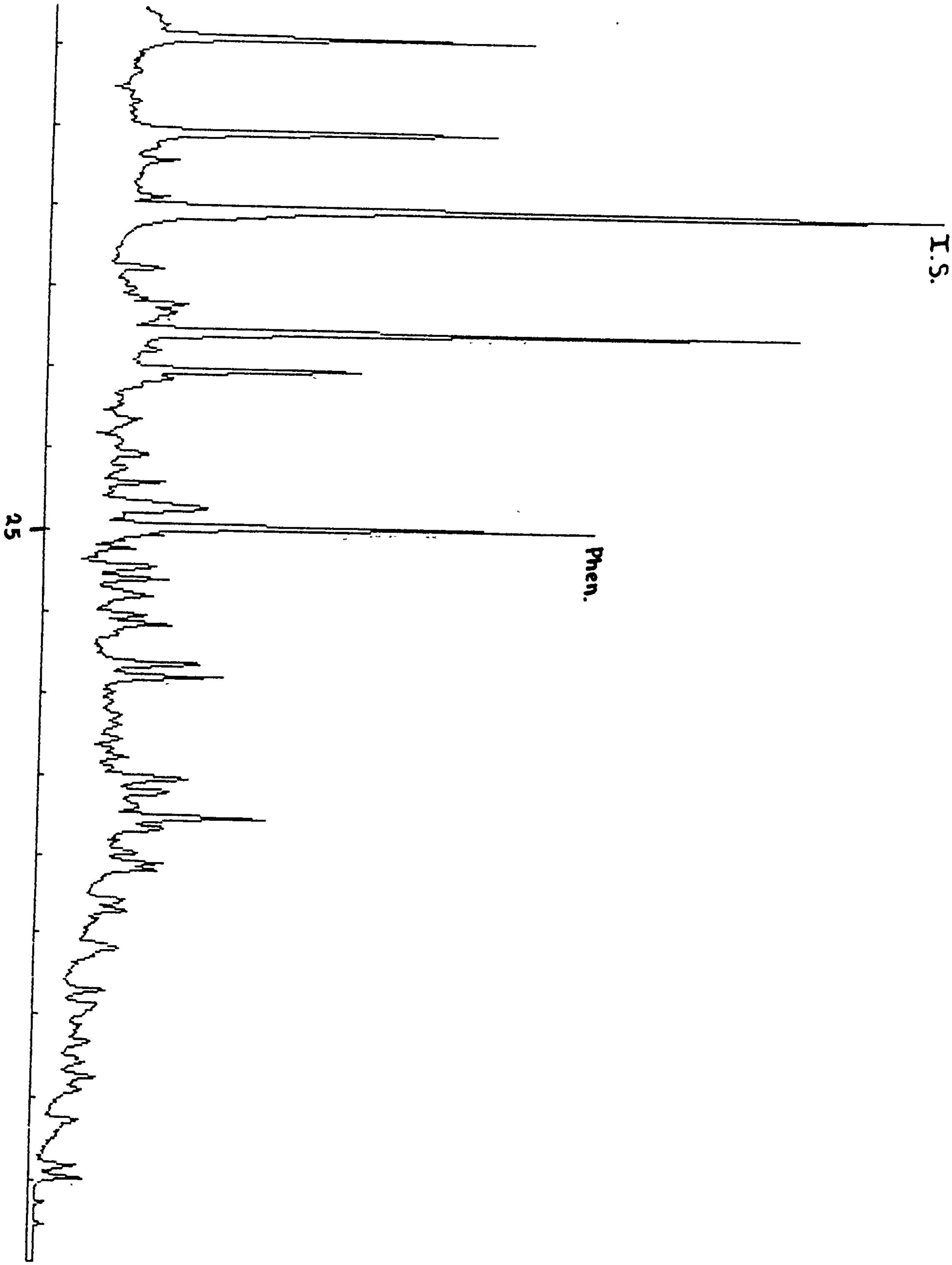


TIME 42.00

#18T062
Freshwater Bay
Rock Crab

061F2
SCALE 10
OFFSET 6

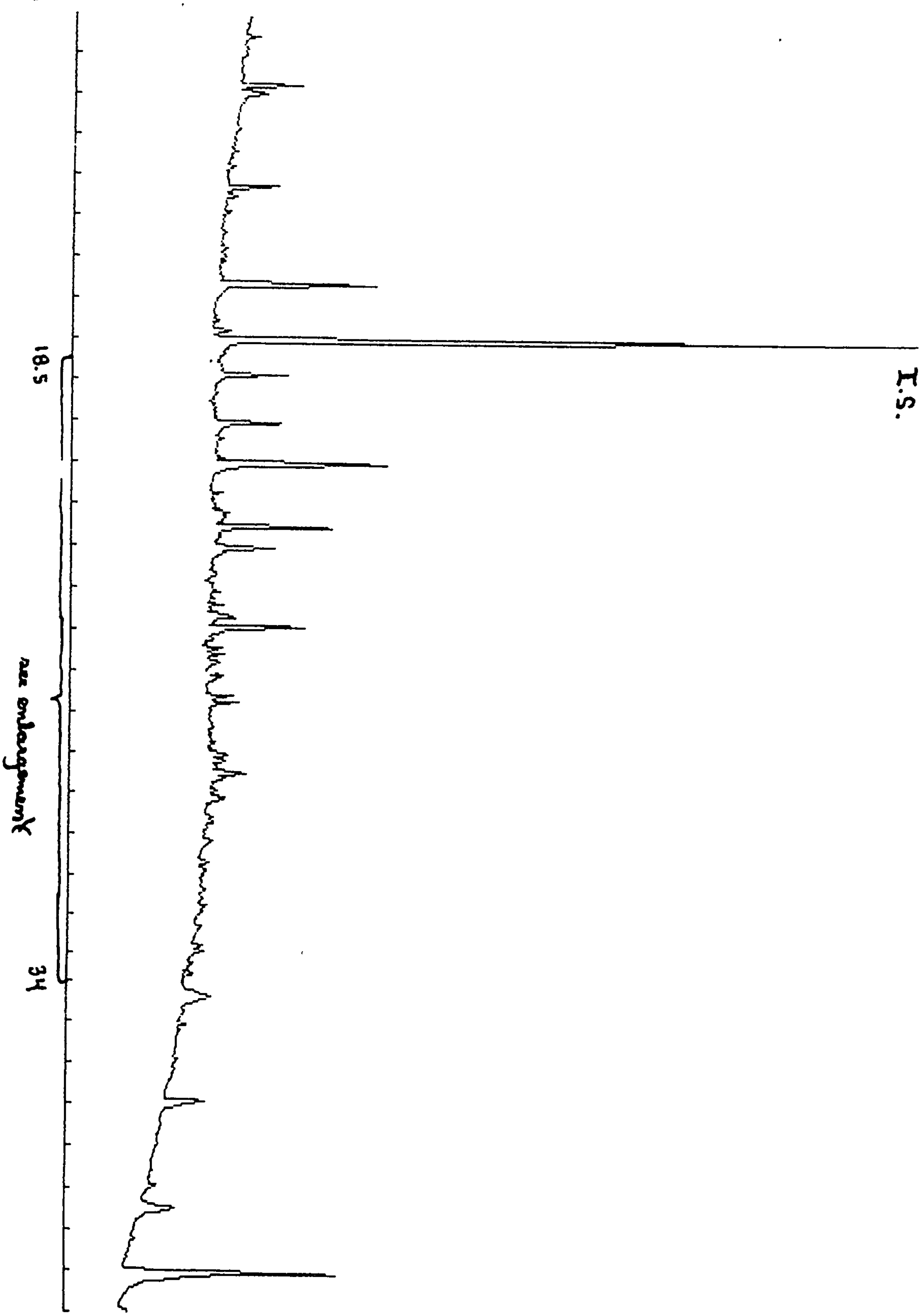
TIME 18.50



TIME 34.00

061F2
SCALE 20
OFFSET 4

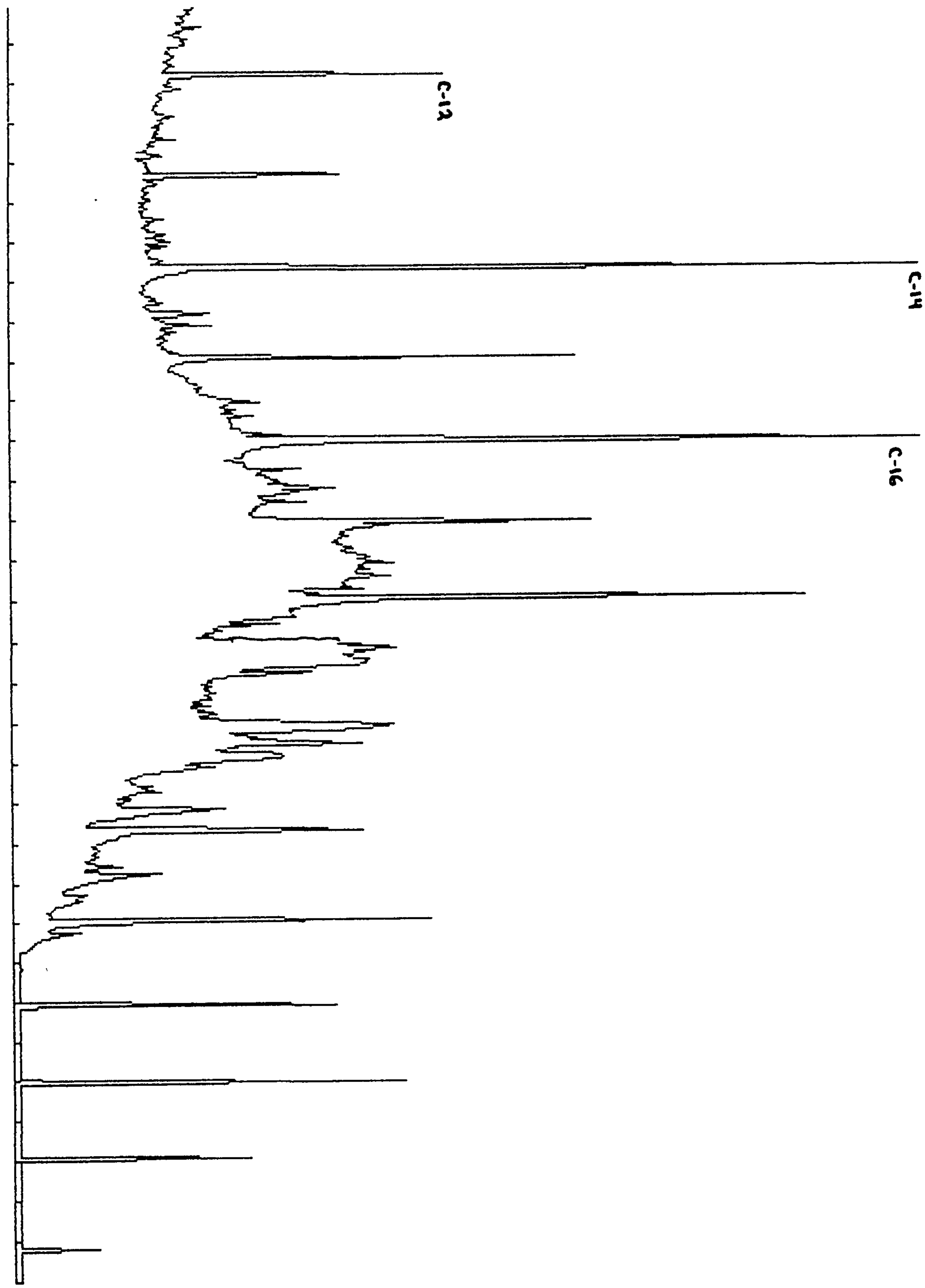
TIME 10.00



TIME 42.00

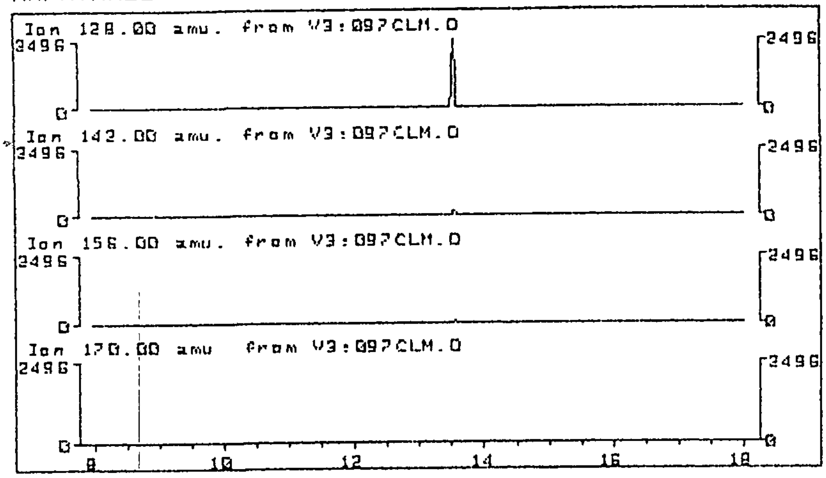
061F1
SCALE 10
OFFSET 6

TIME 10.00

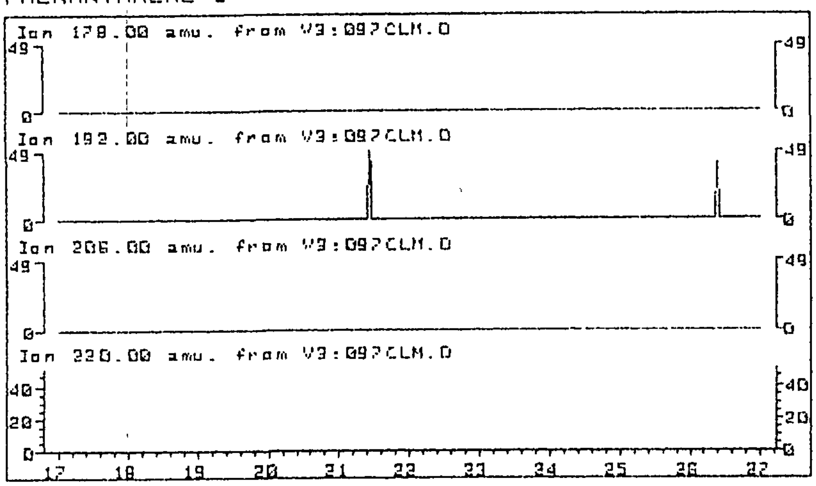


TIME 42.00

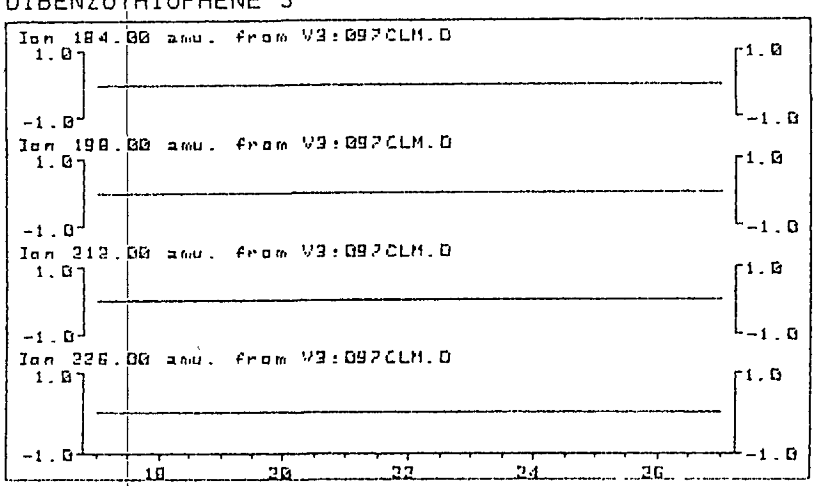
NAPHTHALENE'S



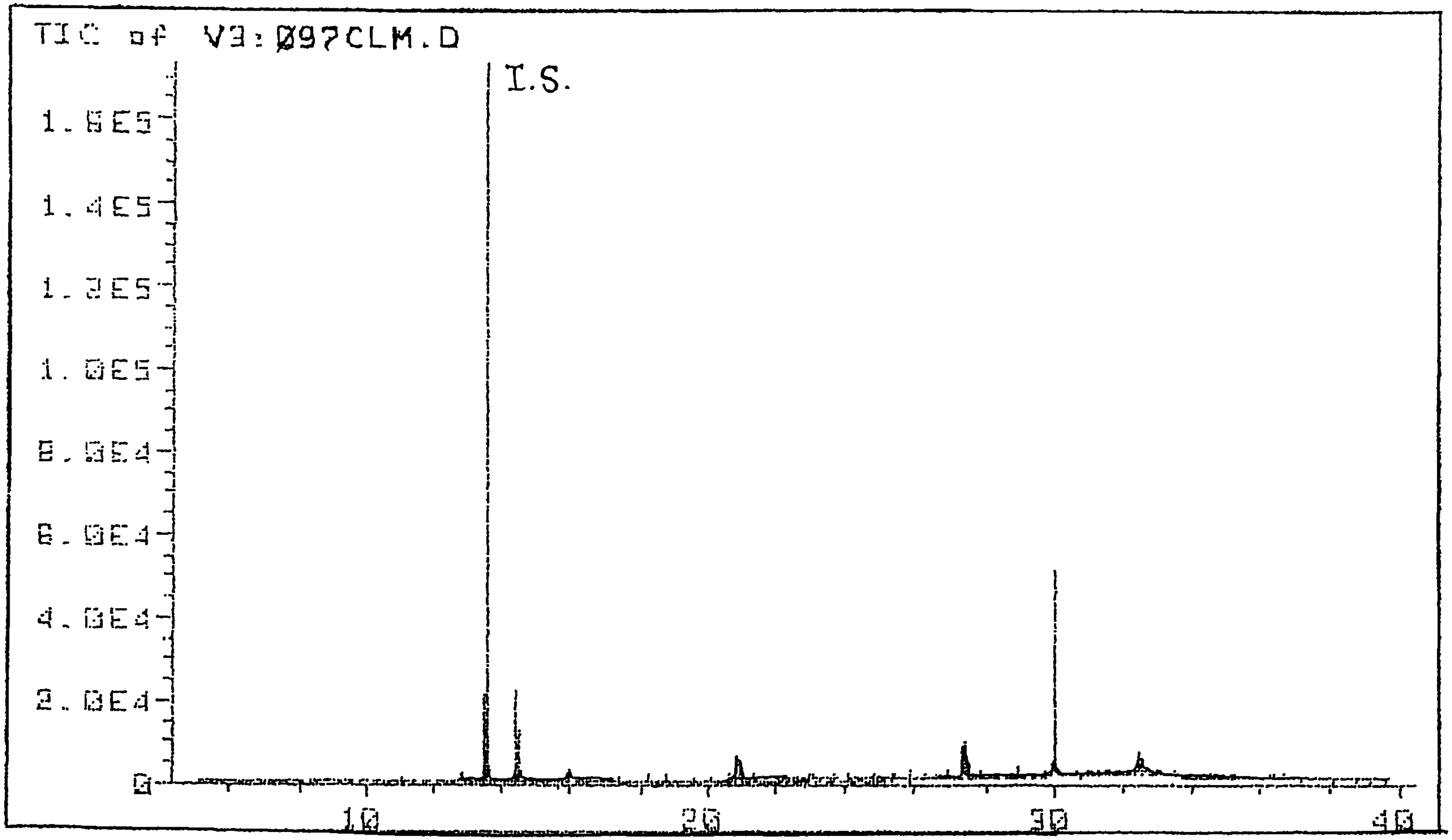
PHENANTHRENE'S



DIBENZOTHIOPHENE'S



Ecology Lab # 8G187Ø97 GC/MS



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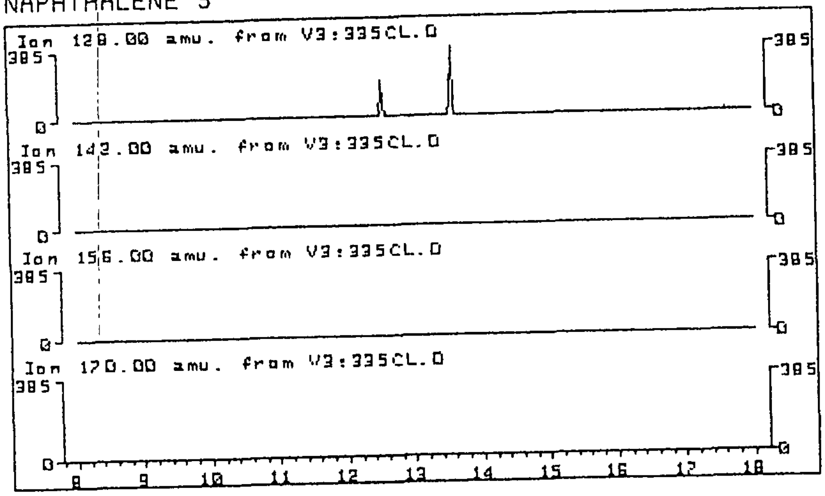
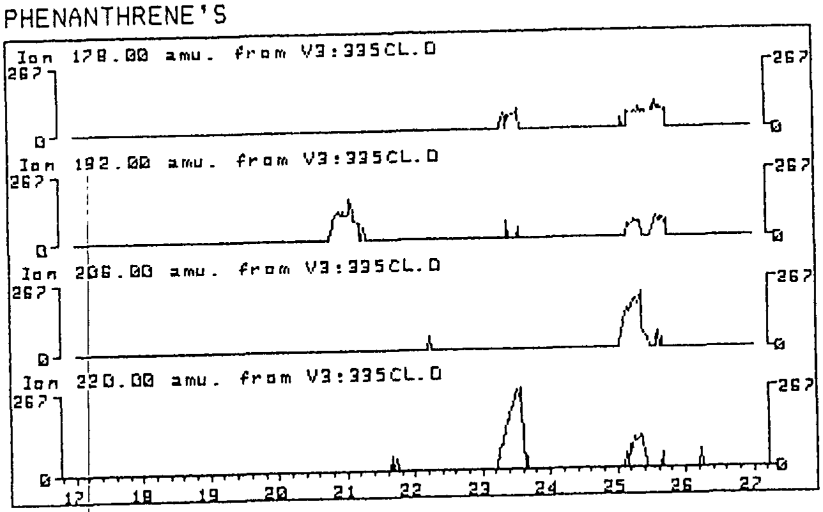
MAJOR HOMOLOG GROUPS

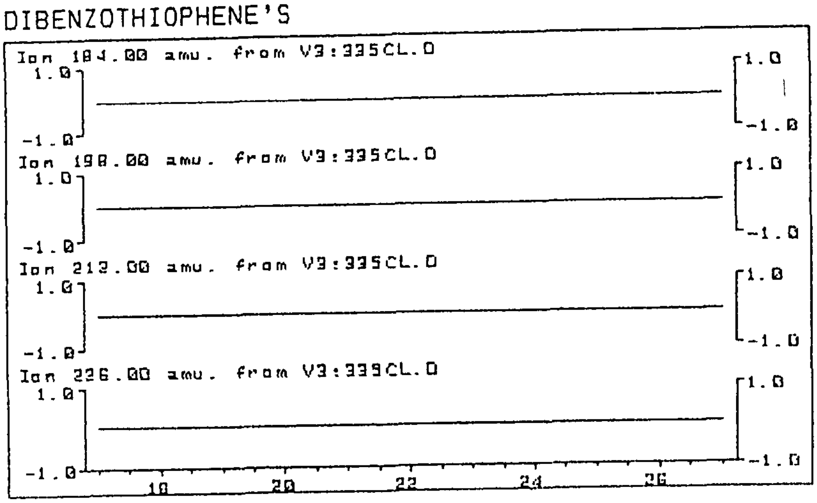
NAPHTHALENE'S



PHENANTHRENE'S



DIBENZOTHIOPHENE'S

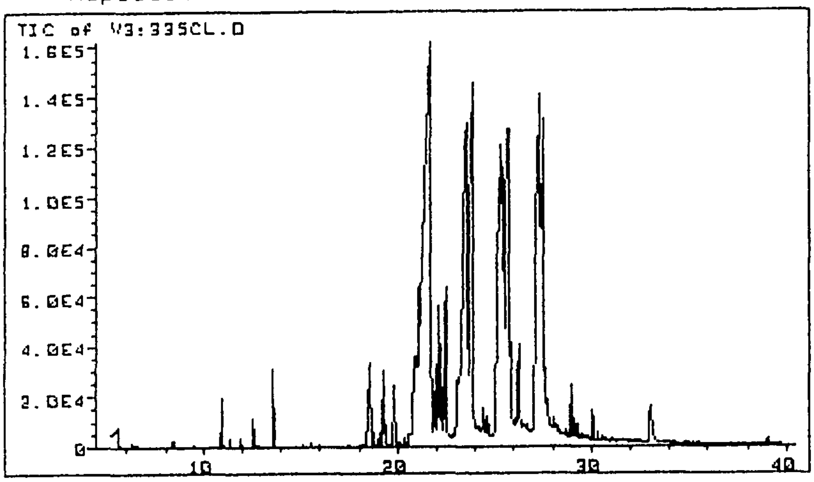


Data file: V3:335CL.D
File type: GC / MS DATA FILE

Name Info: 335 CLAM WASH SPILL 2 UL INJ
Misc Info: METH EMV=1600
Operator : CB

Date : 2 Jun 86 12:13 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



LIBRARY SEARCH RESULTS

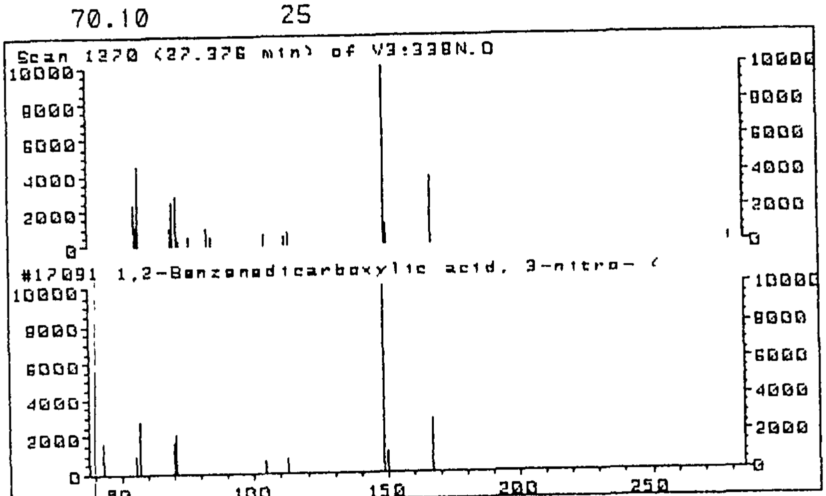
Scan 1270 (27.376 min) of V3:338N.D
067338 SED EXT 50G/.5 MLS 2UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: 1,2-Benzenedicarboxylic acid, 3-nitro- (	603112	17091	9644
2: 1,2-Benzenedicarboxylic acid, diisooctyl	27554263	33129	9417
3: 1,2-Benzenedicarboxylic acid, diisodecyl	26761400	35426	8936
4: 1,2-Benzenedicarboxylic acid, bis(2-ethy	117817	33125	8633
5: Aspidofractinine-3-methanol, (2.alpha.,3	2656442	27893	8500
6: 1,2-Benzenedicarboxylic acid, diheptyl e	3648213	31658	8369
7: 1,2-Benzenedicarboxylic acid, bis(1-meth	131157	33127	8291
8: 1,2-Benzenedicarboxylic acid, decyl octy	119073	34392	8266
9: 1,2-Benzenedicarboxylic acid, diundecyl	3648202	36218	8191
10: 1,2-Benzenedicarboxylic acid, butyl 2-me	17851535	24887	8093

Scan 1270 (27.376 min) of V3:338N.D
067338 SED EXT 50G/.5 MLS 2UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
55.10	24	71.10	28	84.10	5	149.05	100
56.10	11	72.20	3	104.00	6	149.95	12
57.10	45	76.10	5	112.25	5	167.05	38
69.10	10	83.10	10	113.15	7	279.25	4
70.10	25						



LIBRARY SEARCH RESULTS

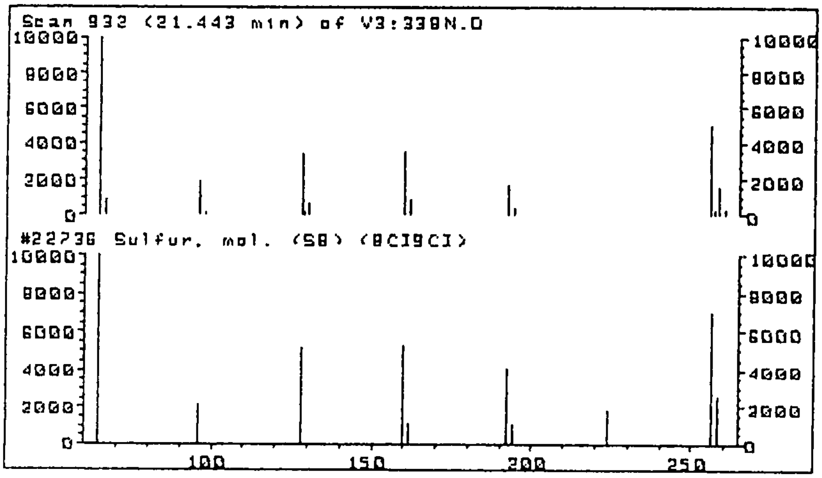
Scan 932 (21.443 min) of V3:338N.D
067338 SED EXT 50G/.5 MLS 2UL INJ

Library file: NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Sulfur, mol. (S8) (8CI9CI)	10544500	22736	9656
2: Manganese, [[1,2-ethanediylbis[carbamodi	12427382	23607	8895
3: Cyclobutane, 1,1'-(1,1,2,2-tetrafluoro-1	35207944	31105	7535
4: Tetrazolo[1,5-b]pyridazine, 6-chloro- (8	21413150	8087	7263
5: Sulfur dioxide(DOT) (8CI9CI)	7446095	146	7033
6: Ethene, 1,2-difluoro- (9CI)	1691130	143	6599
7: 2H-1,2,3-Thiadiazine, 2-(2,4-dinitrophen	57954515	35072	6326
8: Ethanol, 2-[[4-[(7-chloro-4-quinolinyl)a	118423	29961	6129
9: Cyclobutane, 1,1'-(1,1,2,2-tetrafluoro-1	35208027	32853	5927
10: 5.alpha.-Cholestan-6-one, 3.beta.-methox	5837398	34309	5922

Scan 932 (21.443 min) of V3:338N.D
067338 SED EXT 50G/.5 MLS 2UL INJ

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
64.00	100	127.95	34	161.85	8	256.85	3
66.00	8	128.95	1	191.90	17	257.85	16
95.90	19	129.95	6	193.90	4	259.75	3
97.90	2	159.85	35	255.75	50		



TIC of V3:338N.D
067338 SED EXT 50G/.5 MLS 2UL INJ

peak#	ret time	area	start time	end time
1	21.435	205732	21.374	21.602
2	27.380	105226	27.321	27.539

Data file: V3:338N.D
File type: GC / MS DATA FILE

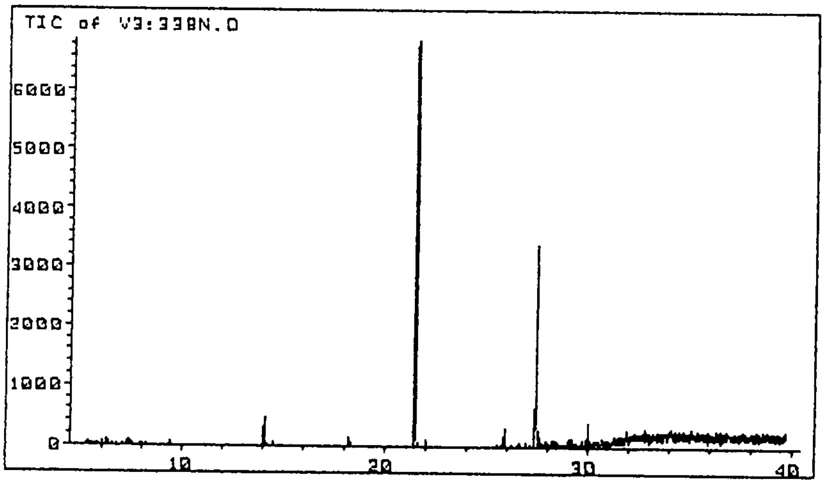
Name Info: 067338 SED EXT 50G/.5 MLS 2UL INJ
Misc Info: BNA METH

EMV=1600

Operator : CB HENRY

Date : 20 May 86 1:06 pm
Instrment: MS_5970
Inlet : GC

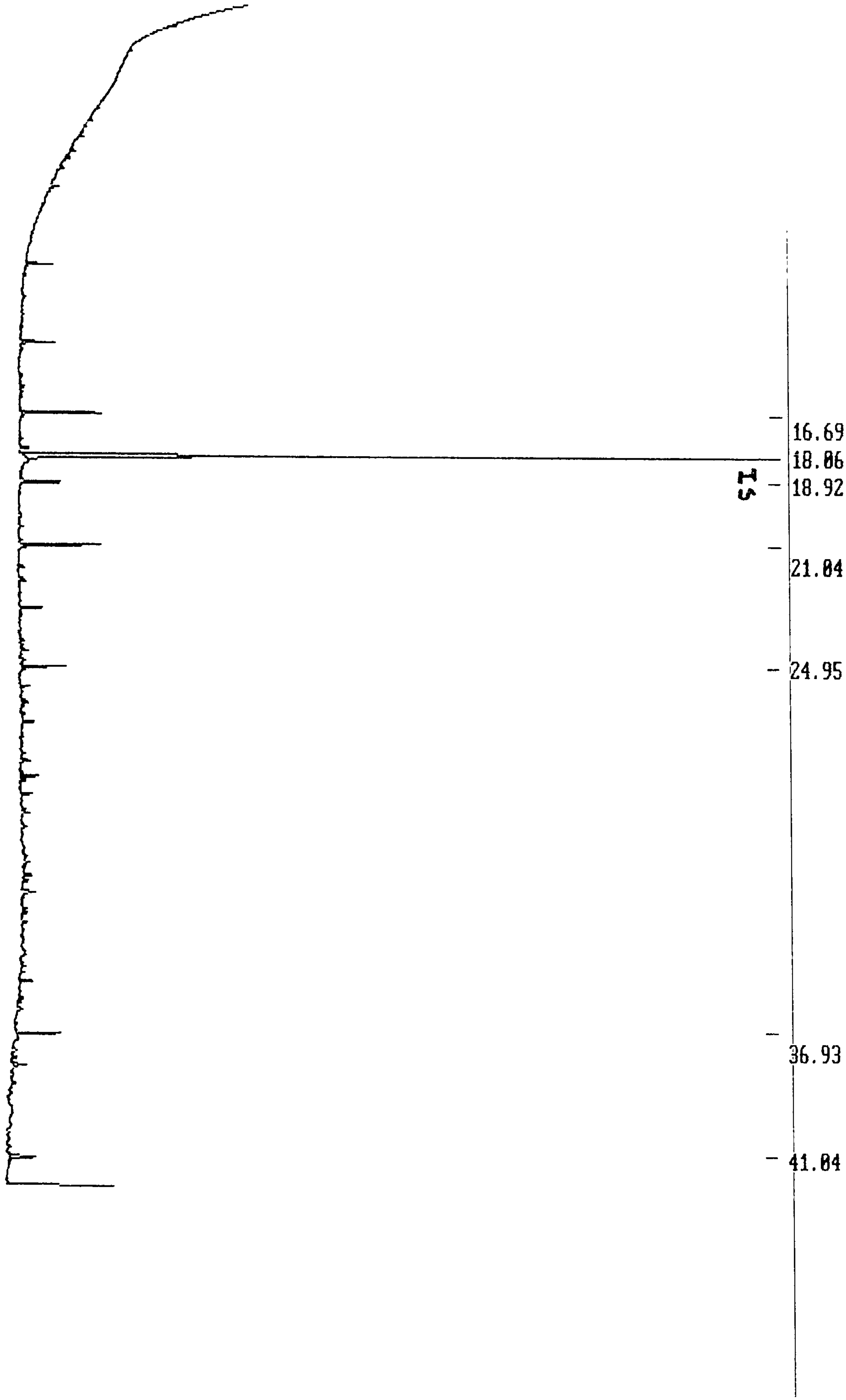
Sequence index : 0
Als bottle num : 0
Replicate num : 0



338

tart time:	3.00	Stop time:	42.00	Offset:	0
ow Value:	5033	High Value:	61562	Scale factor:	1

#067338

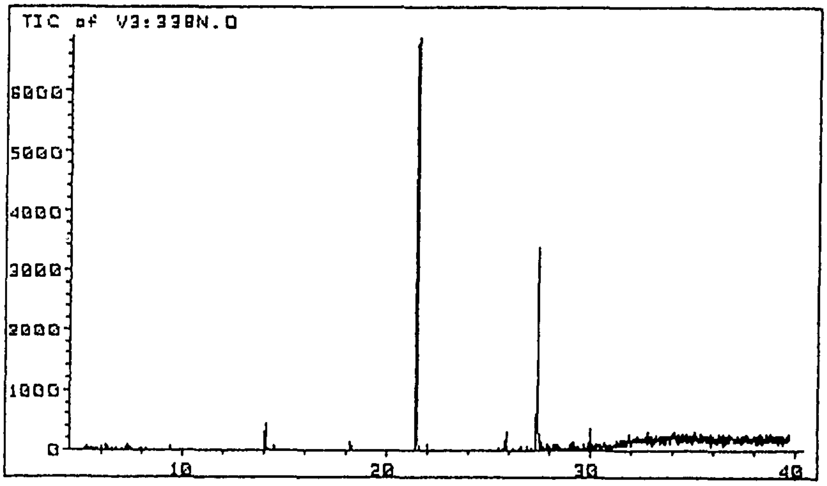


Data file: V3:338N.D
File type: GC / MS DATA FILE

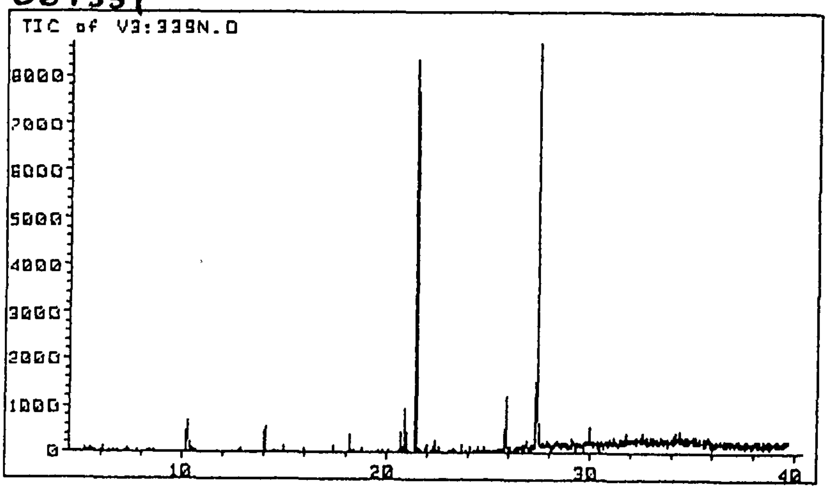
Name Info: 067338 SED EXT 50G/.5 MLS 2UL INJ
Misc Info: BNA METH EMV=1600
Operator : CB HENRY

Date : 20 May 86 1:06 pm
Instrment: MS_5970
Inlet : GC

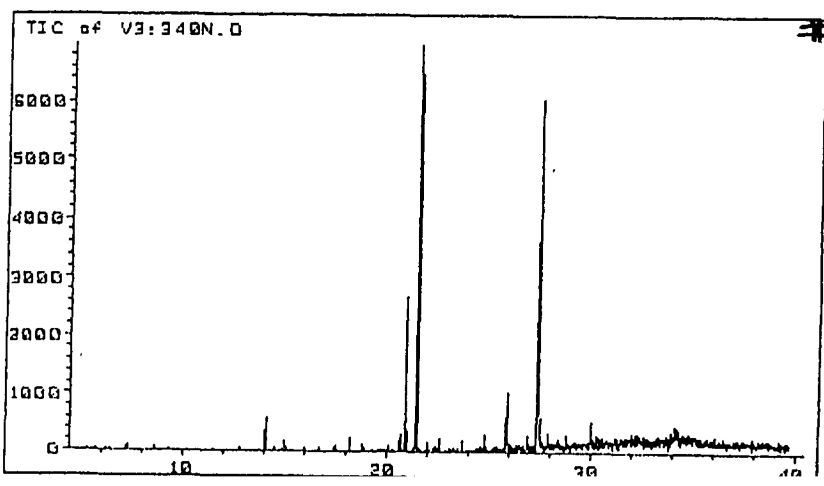
Sequence index : 0
Als bottle num : 0
Replicate num : 0



#067339



#067340

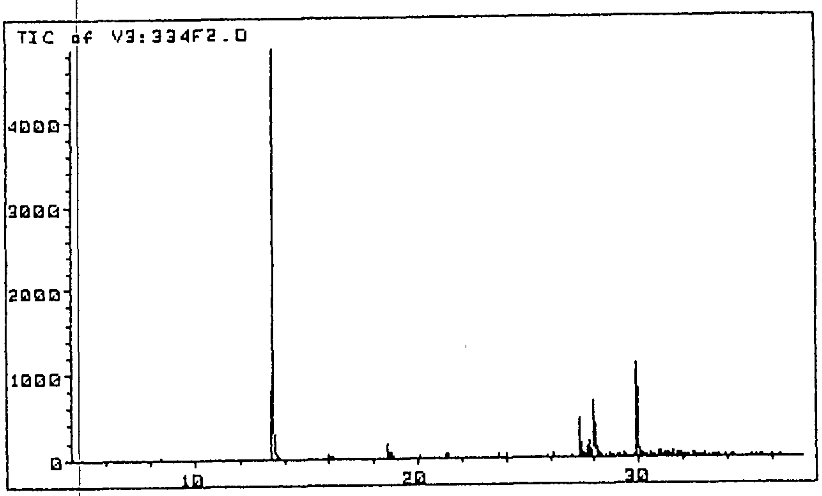


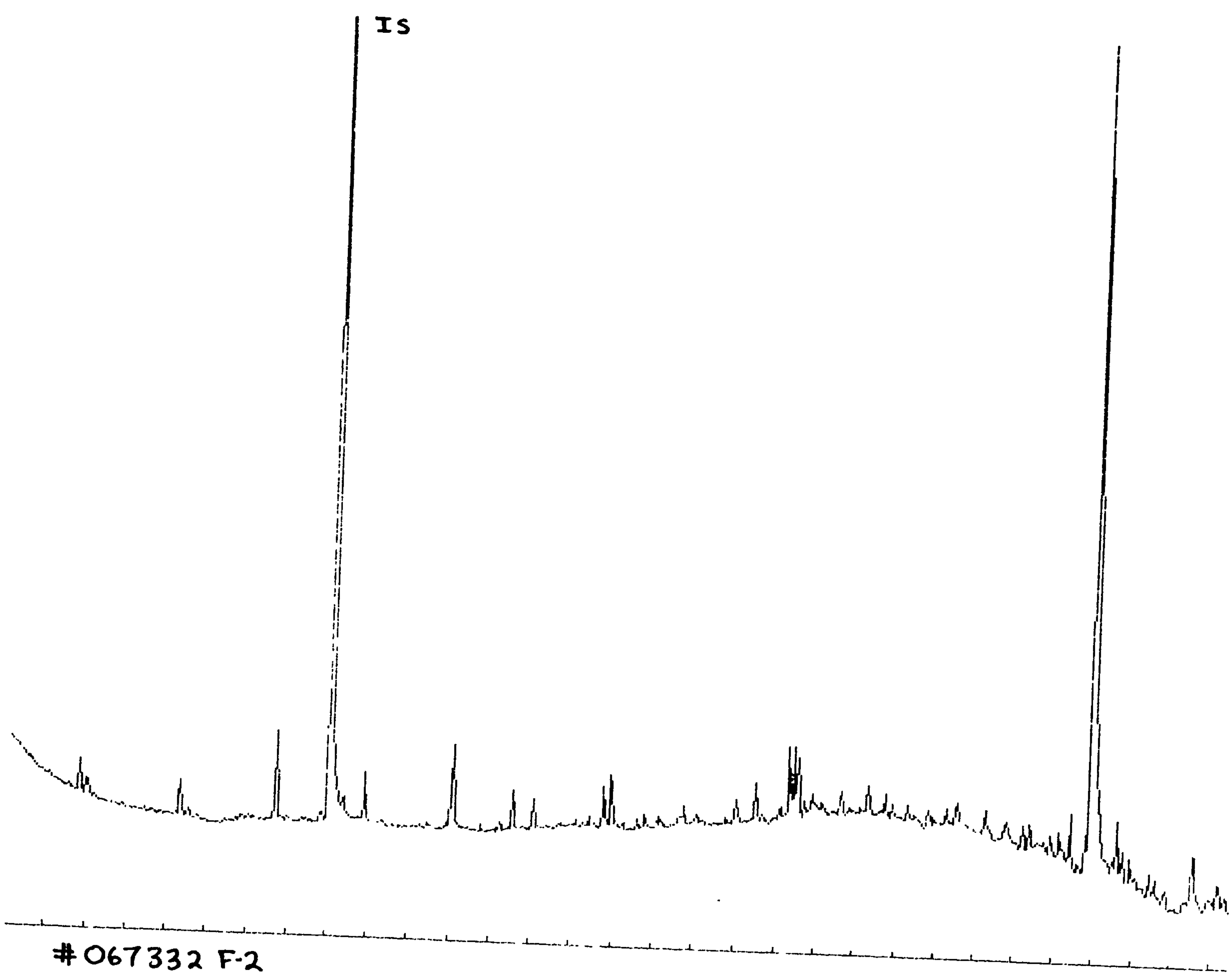
Data file: V3:334F2.D
File type: GC / MS DATA FILE

Name Info: 067334 F2 4 UL INJ
Misc Info: BNA METH EMV=1600
Operator : CB HENRY

Date : 14 Apr 86 10:30 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0





#067332 F-2

Ecology Lab # 067334 (sediment)
F-1 fraction

Operator CB	Date 13 Apr 86
Stationary Phase Sou Phenyl Milk S	Instrument HP-5890 Detector FID
Film Thickness 0.56 um	Range - Attenuation -
Column No - Type Cap	Flow Rates, cc/min
Length 25 M OD ___ ID 0.32 mm	Make up 30 Type N_2
Carrier Gas He	Hydrogen 40 Air 450
ū ___ Flow 2 mls/min	On Column ☐ Split ☐ Splitless Injection ☑
Chart Speed -	Ratio - Hold Time -
Sample 067334 F-1	Temperature – Det. 300 Inj 250
Size 4ul Solvent Hex	Column Initial 70 Time 3
Concentrations 1:100 conc.	Rate 6 Final 280 Time 4

067334 F-1

LIBRARY SEARCH RESULTS

Scan 1183 (25.906 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

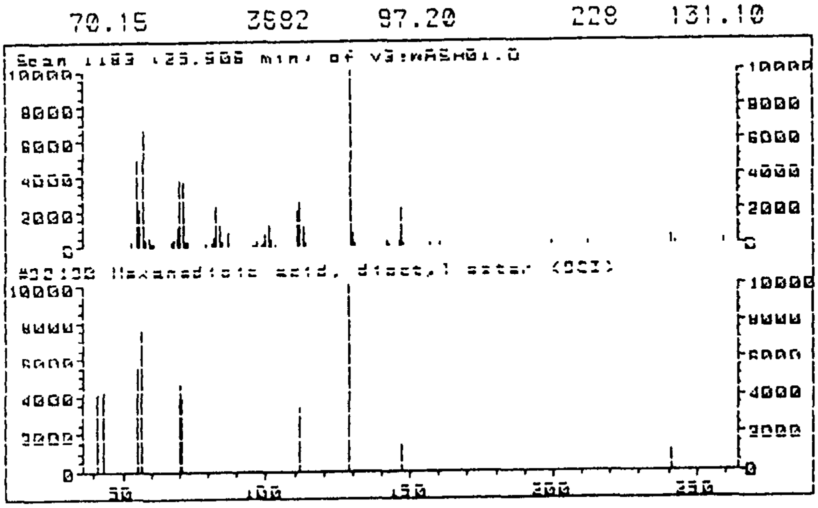
Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Hexanedioic acid, dioctyl ester (9CI)	123795	32130	9061
2: Hexanedioic acid, dicyclohexyl ester (9C	849990	27879	7625
3: Pentanedioic acid, 2-methyl-, bis(1-meth	57983490	22872	7599
4: Cyclohexanecarboxylic acid, 2-(1,1-dimet	27392161	12917	7596
5: Cyclohexanecarboxylic acid, 2-(1,1-dimet	27392150	12916	7526
6: Butanedioic acid, 2,3-dimethyl-, bis(1-m	57983296	22870	7471
7: Cyclohexanecarboxylic acid, 4-(1,1-dimet	943292	12904	7418
8: Cyclohexanecarboxylic acid, 3-(1,1-dimet	27392172	12918	7412
9: 2,5-Piperazinedione, monooxime (9CI)	56700845	3993	7377
10: Naphthalene, dibutyldihydro- (9CI)	74646439	21104	7309

RETRIEVE
Which match (1 to 10):
Scan 1183 (25.906 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

Y: Set of 4 MS
X: Scan 1183 (25.906 min) of

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
51.05	94	71.15	3593	98.10	89	142.00	225
53.05	253	72.25	250	99.20	126	143.10	71
55.05	4893	72.95	258	100.10	607	146.20	315
56.15	2079	79.05	116	101.10	1173	147.10	2131
57.15	6590	81.05	186	102.00	347	148.10	133
58.15	367	82.05	501	103.10	79	157.15	126
59.15	456	83.05	2200	111.10	2052	160.15	121
60.15	151	84.05	1418	112.10	2426	199.15	146
61.15	200	85.15	295	113.20	1094	212.15	124
67.15	259	87.05	707	114.10	131	241.20	538
68.05	367	95.20	96	129.10	10000	242.20	124
69.05	1032	96.40	76	130.00	692	259.20	297
70.15	3692	97.20	228	131.10	124		



LIBRARY SEARCH RESULTS

Scan 1271 (27.481 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

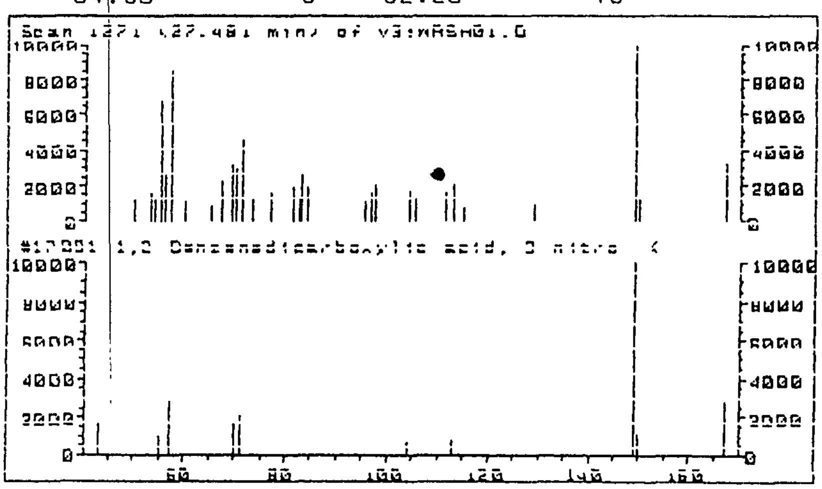
Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	1,2-Benzenedicarboxylic acid, 3-nitro- (	603112	17091	8239
2:	1,2-Benzenedicarboxylic acid, diisodecyl	26761400	35426	7925
3:	1,2-Benzenedicarboxylic acid, diisooctyl	27554263	33129	7916
4:	1,2-Benzenedicarboxylic acid, dinonyl es	84764	34391	7834
5:	1,2-Benzenedicarboxylic acid, bis(2-ethy	117817	33125	7729
6:	4H-1-Benzopyran-4-one, 2-(3,4-dihydroxyp	29428589	37911	7569
7:	5,9-Methano-5H-[1,4,2,3]dioxadiazolo[2,3	56909149	21570	7347
8:	Naphthalene, 1,2,3,4,4a,5,6,8a-octahydro	55976095	9636	7044
9:	Aspidofractinine-3-methanol, (2.alpha.,3	2656442	27893	6936
10:	Naphtho[2,3-b]furan-4,9-dione, 2,3-dihyd	75093419	23435	6999

RETRIEVE
Which match (1 to 10):
Scan 1271 (27.481 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

Y: Set of 4 MS
X: Scan 1271 (27.481 min) of

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
49.95	11	67.15	22	82.95	27	111.20	15
53.05	15	69.15	32	84.15	18	113.10	20
54.05	12	70.05	29	95.20	10	115.10	7
55.15	69	71.15	45	96.30	15	129.10	8
55.95	27	73.05	12	97.20	19	149.10	100
57.05	84	76.95	15	104.00	16	150.00	13
60.05	10	81.05	18	105.10	13	166.95	33
64.95	8	82.25	13				



LIBRARY SEARCH RESULTS

Scan 938 (21.538 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

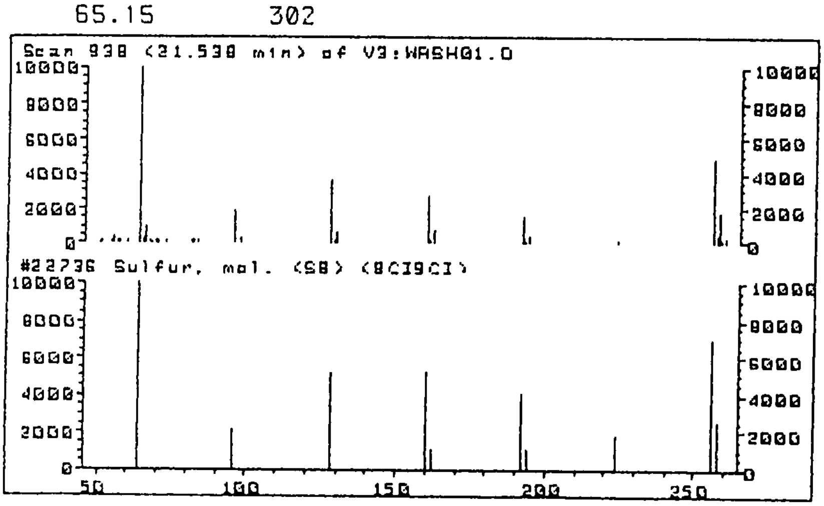
Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

	CAS #	Library Index #	Match Quality
1: Sulfur, mol. (S8) (8CI9CI)	10544500	22736	9590
2: Manganese, [[1,2-ethanediylbis[carbamodi	12427382	23607	8861
3: Cyclobutane, 1,1'-(1,1,2,2-tetrafluoro-1	35207944	31105	7663
4: Tetrazolo[1,5-b]pyridazine, 6-chloro- (8	21413150	8087	7386
5: Sulfur dioxide(DOT) (8CI9CI)	7446095	146	7153
6: Ethene, 1,2-difluoro- (9CI)	1691130	143	6711
7: 2H-1,2,3-Thiadiazine, 2-(2,4-dinitrophen	57954515	35072	6433
8: Ethanol, 2-[[4-[(7-chloro-4-quinolinyl)a	118423	29961	6233
9: 5.alpha.-Cholestan-6-one, 3.beta.-methox	5837398	34309	6022
10: 1,3-Dioxane, 5,5-difluoro- (9CI)	36301447	3228	5978

RETRIEVE
Which match (1 to 10):
Scan 938 (21.538 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

Y: Set of 4 MS
X: Scan 938 (21.538 min) of V

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
50.15	86	65.95	947	83.25	125	191.85	1553
50.75	107	67.15	176	96.00	1928	192.85	95
54.15	116	67.85	92	98.00	302	193.85	407
55.15	410	68.05	89	127.90	3671	223.80	167
56.05	116	68.95	209	129.00	155	255.80	4892
57.15	191	69.95	113	129.90	605	256.80	422
59.95	122	72.95	143	159.85	2741	257.80	1781
61.35	71	81.15	104	160.85	155	258.80	146
63.95	10000	82.05	104	161.85	698	259.70	272
65.15	302						



LIBRARY SEARCH RESULTS

Scan 605 (15.673 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

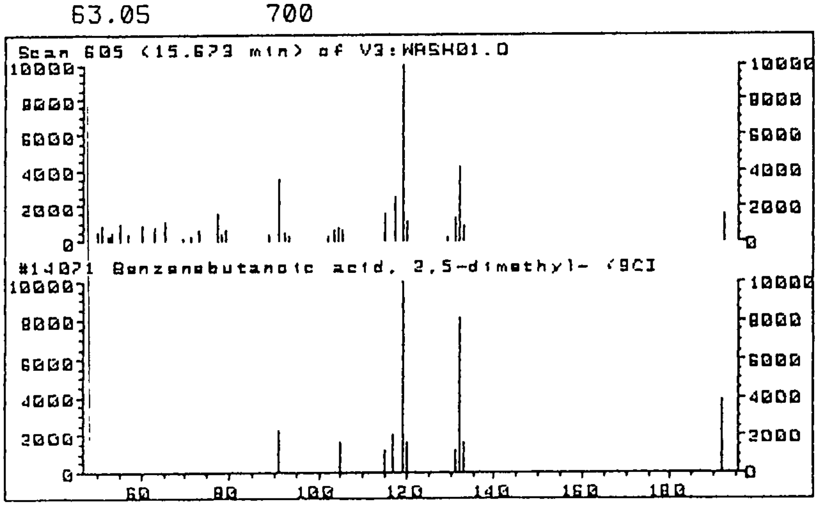
Library file: DATA:NBS_REVE.L
Library name: NBS MASS SPECTRAL DATABASE

		CAS #	Library Index #	Match Quality
1:	Benzenebutanoic acid, 2,5-dimethyl- (9CI	1453061	14071	9313
2:	Benzenepropanoic acid, .alpha.,.alpha.-d	54932886	15983	8749
3:	Benzene, 1,1'-(1,1,2,2-tetramethyl-1,2-e	1889674	20617	8742
4:	Benzene, 4-(chloromethyl)-1,2-dimethyl-	102465	7992	8651
5:	Benzenepropanoic acid, .beta.,.beta.-dim	1010486	11903	8649
6:	Benzene, methyl(1-methylethyl)- (9CI)	25155151	4581	8645
7:	Benzene, (1,1-dimethylnonyl)- (9CI)	55191258	19911	8624
8:	Benzene, (1-chloroethyl)methyl- (9CI)	72403157	8001	8615
9:	Benzene, 1-methyl-3-(1-methylethyl)- (9C	535773	4569	8551
10:	Benzene, 1-(1,5-dimethyl-4-hexenyl)-4-me	644304	15762	8532

RETRIEVE
Which match (1 to 10):
Scan 605 (15.673 min) of V3:WASH01.D
067324 EXT FINAL VOL .1 ML; 2UL INJ

Y: #14071 Benzenebutanoic aci
X: Scan 605 (15.673 min) of V

m/z	abund.	m/z	abund.	m/z	abund.	m/z	abund.
49.95	500	65.05	1100	91.05	3500	117.10	2500
51.05	800	69.15	200	92.15	500	119.10	10000
52.35	300	71.25	300	93.15	300	120.10	1100
52.65	300	73.15	600	102.00	300	129.20	300
53.15	500	77.05	1500	103.20	600	131.10	1300
55.05	1000	78.05	400	104.20	700	132.10	4200
57.15	400	79.15	600	105.20	600	133.00	900
59.95	800	88.85	400	115.10	1500	192.15	1600
63.05	700						

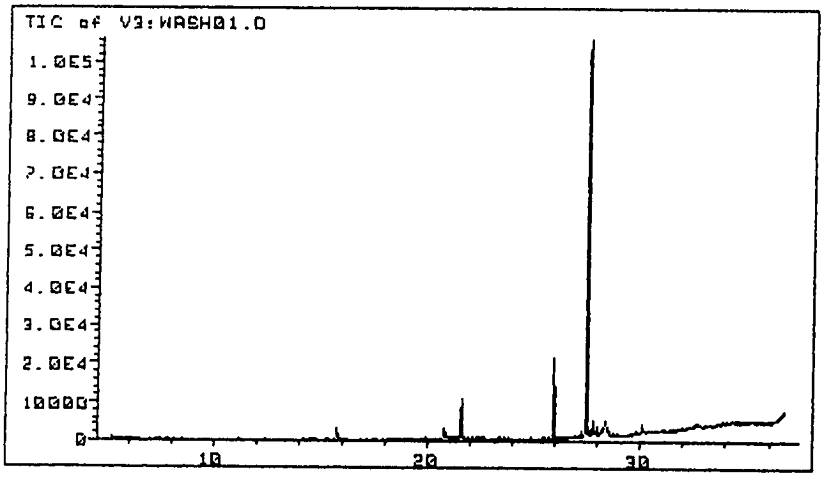


Data file: V3:WASH01.D
File type: GC / MS DATA FILE

Name Info: 067324 EXT FINAL VOL .1 ML; 2UL INJ
Misc Info: BNA METH EMV=1600 50(3)-280(8) T2=4 INJ TEMP=225
Operator : CB HENRY---------------LSU

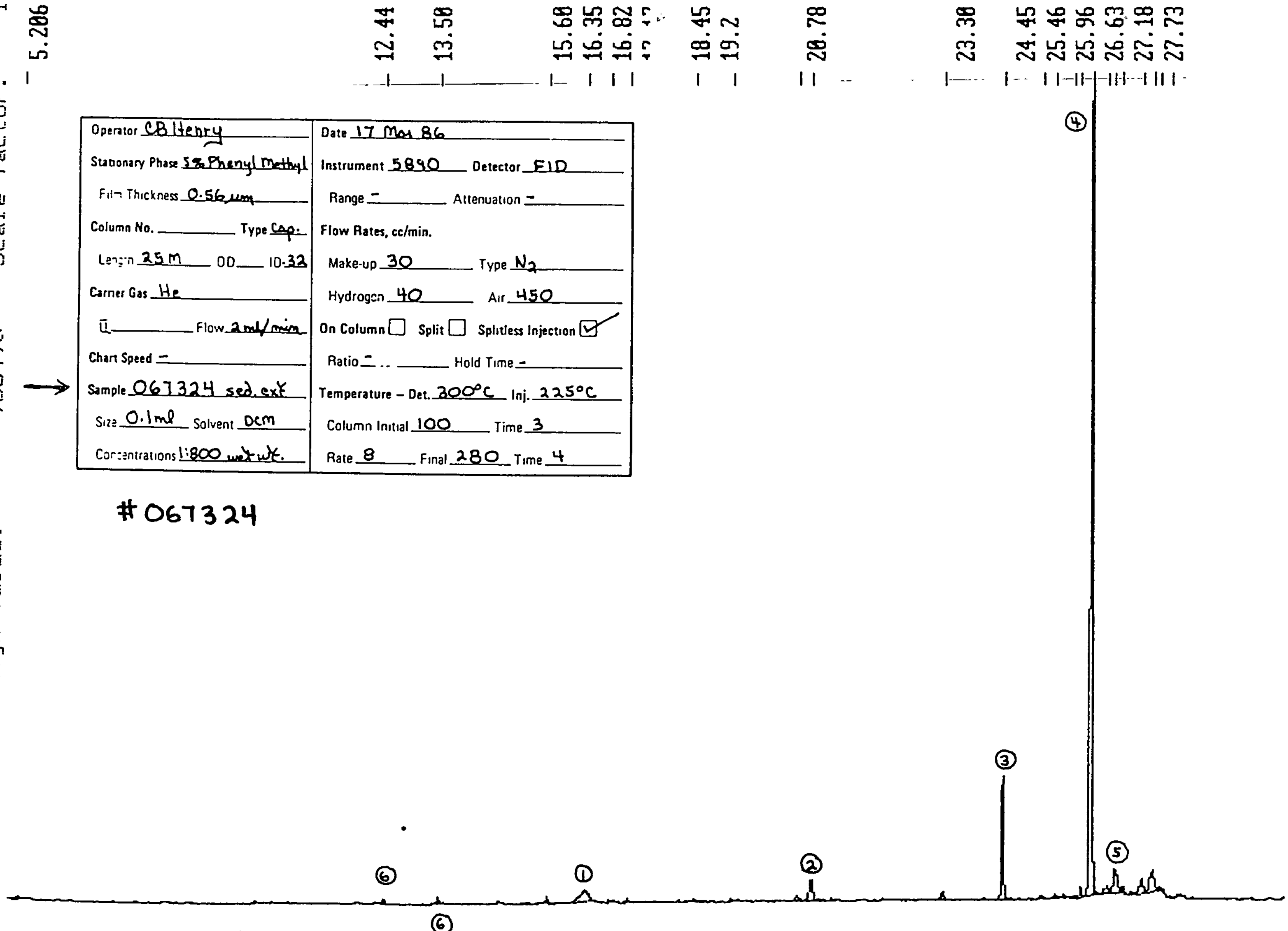
Date : 17 Mar 86 2:40 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



Data file A: W-511

Start time: 5.00 Stop time: 30.00 Offset: 0
Low Value: 5957 High Value: 958493 Scale factor: 1



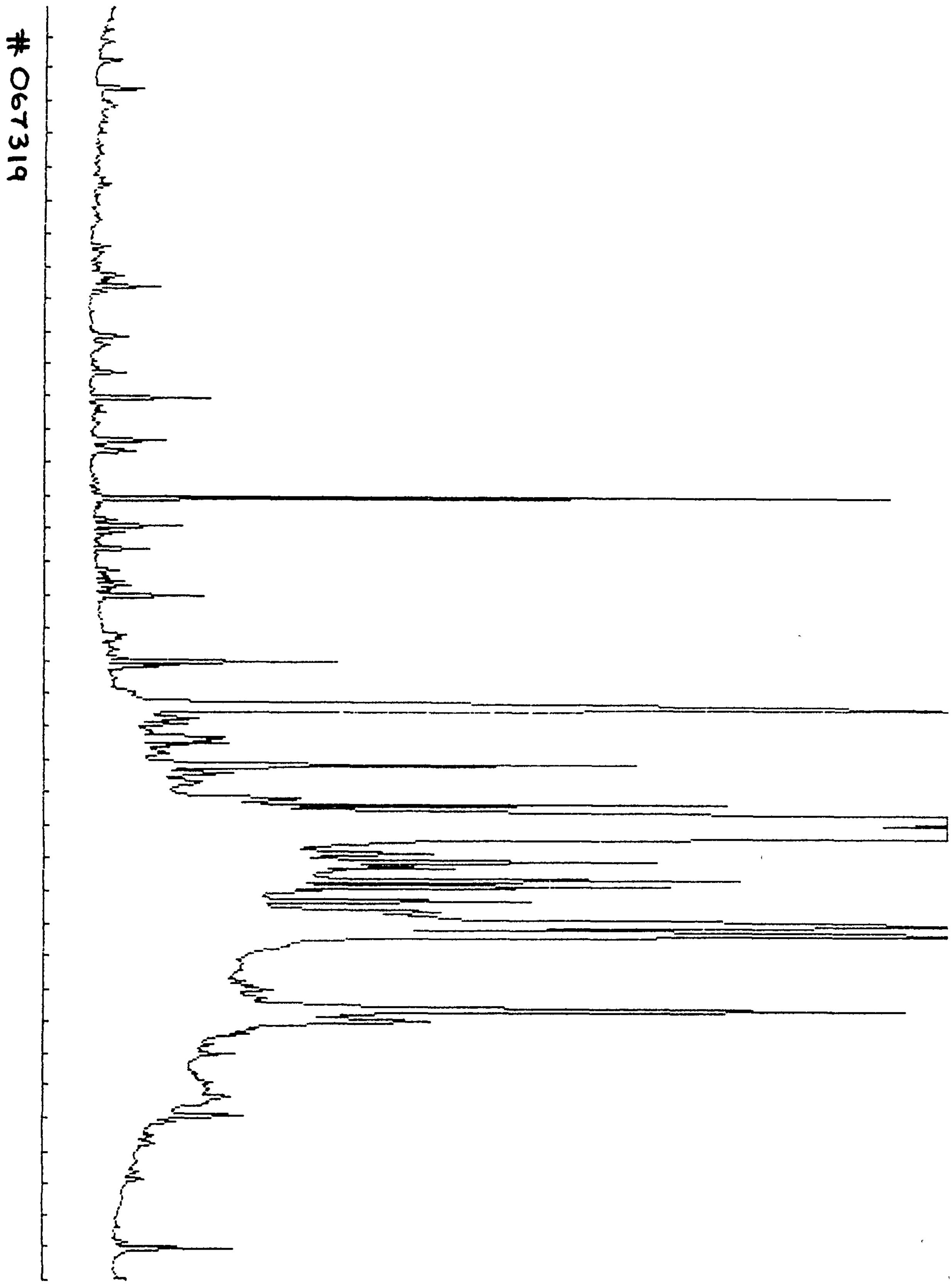
Operator CB Henry	Date 17 Mar 86
Stationary Phase 5% Phenyl Methyl	Instrument 5890 Detector FID
Film Thickness 0.56 um	Range - Attenuation -
Column No. ____ Type Cap.	Flow Rates, cc/min.
Length 25 M OD ____ ID .32	Make-up 30 Type N_2
Carrier Gas He	Hydrogen 40 Air 450
____ Flow 2 ml/min	On Column ☐ Split ☐ Splitless Injection ☑
Chart Speed -	Ratio - ____ Hold Time -
Sample 067324 sed. ext	Temperature – Det. 300°C Inj. 225°C
Size 0.1 ml Solvent DCM	Column Initial 100 Time 3
Concentrations 1:800 wet wt.	Rate 8 Final 280 Time 4

#067324

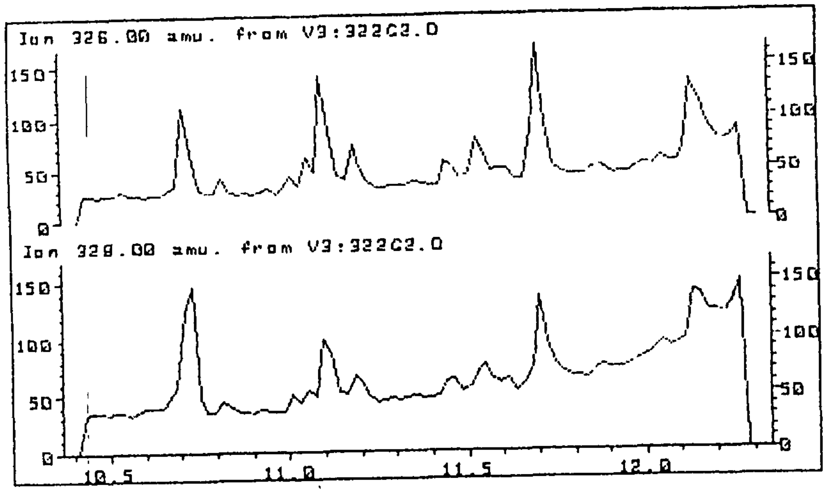
1 2,5 dimethylbenzenebutanoic acid
2 molecular sulfur
3 unidentified organic acid
4 phthalate
5 phthalate
6 [illegible]

419G1
SCALE 350
OFFSET 2

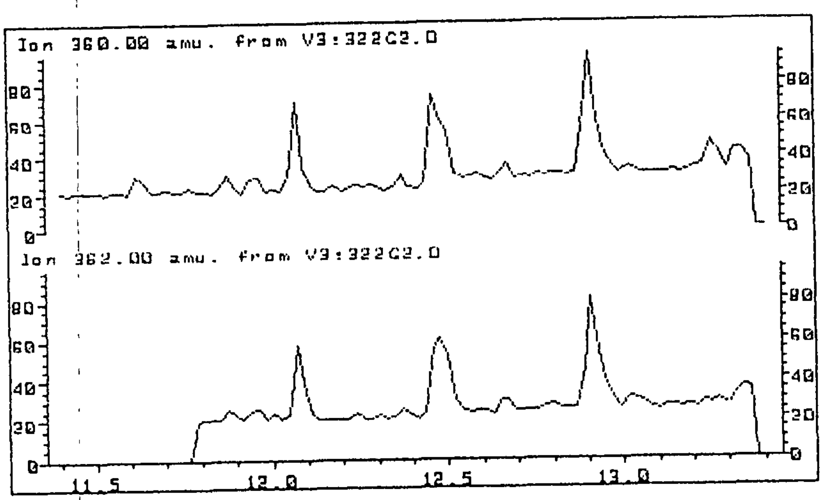
TIME 3.00



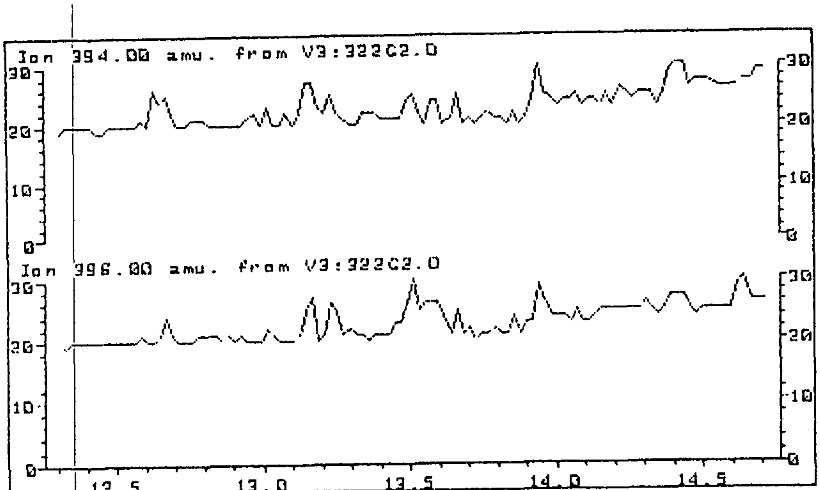
TIME 42.00



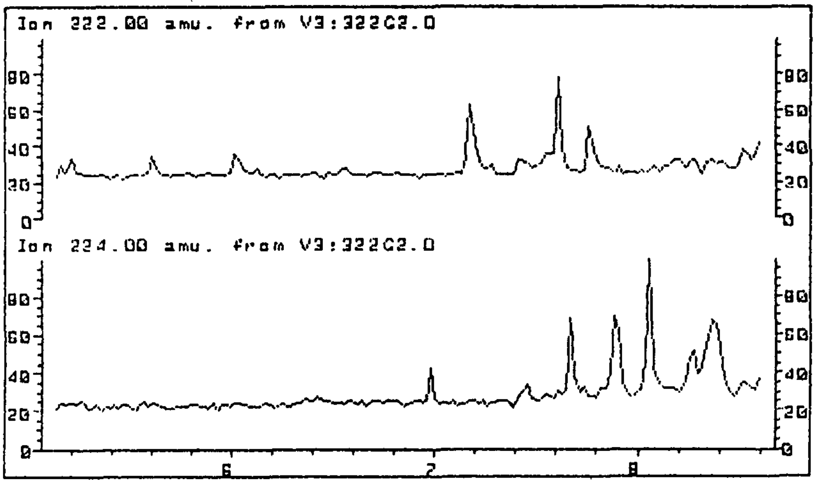
Ion 326.00 amu. from V3:322C2.D
Ion 328.00 amu. from V3:322C2.D
10.5
11.0
11.5
12.0

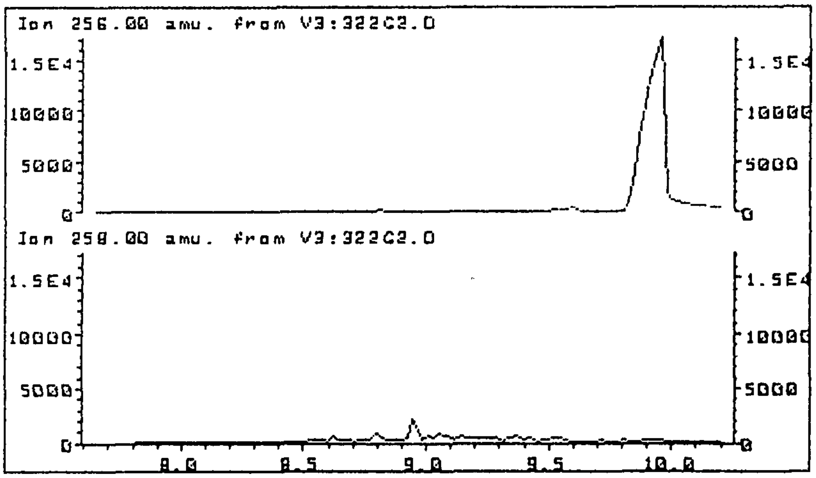


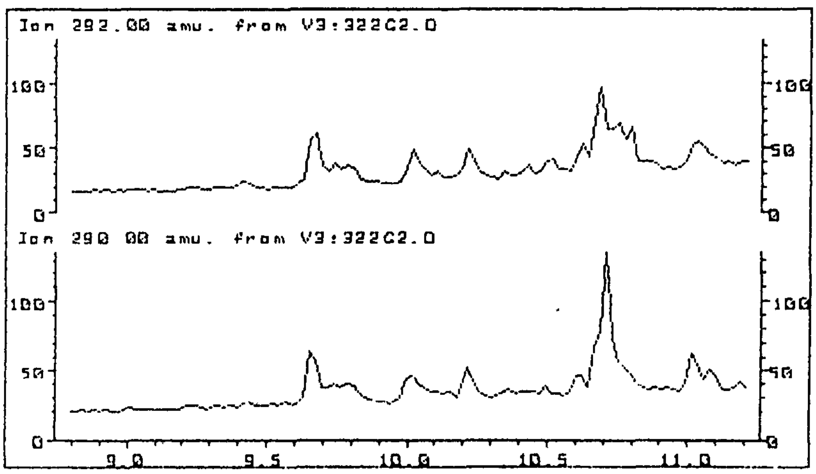
Ion 360.00 amu. from V3:322C2.D
Ion 362.00 amu. from V3:322C2.D
11.5
12.0
12.5
13.0



Ion 394.00 amu. from V3:322C2.D
Ion 396.00 amu. from V3:322C2.D
12.5
13.0
13.5
14.0
14.5


Ion 222.00 amu. from V3:322C2.D
Ion 224.00 amu. from V3:322C2.D
0
20
40
60
80
6
7
8


Ion 256.00 amu. from V3:322C2.D
Ion 258.00 amu. from V3:322C2.D
0
5000
10000
1.5E4
8.0
8.5
9.0
9.5
10.0

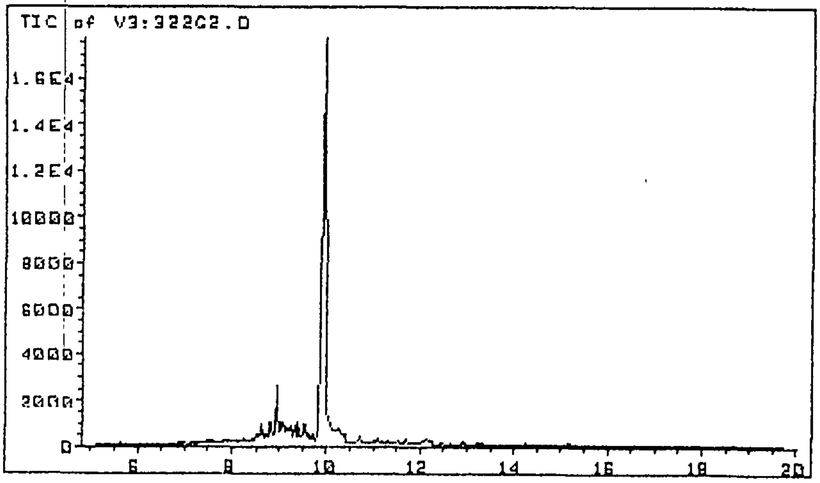

Ion 292.00 amu. from V3:322C2.D
Ion 290 00 amu. from V3:322C2.D
0
50
100
9.0
9.5
10.0
10.5
11.0

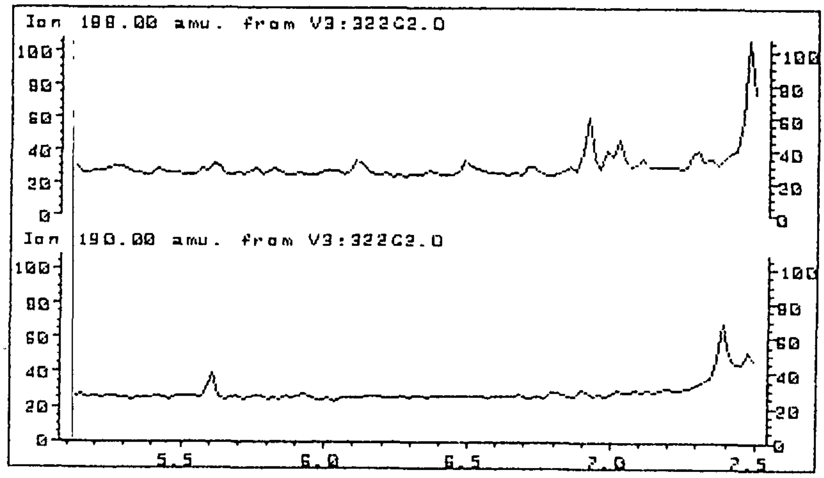
Data file: V3:322G2.D
File type: GC / MS DATA FILE

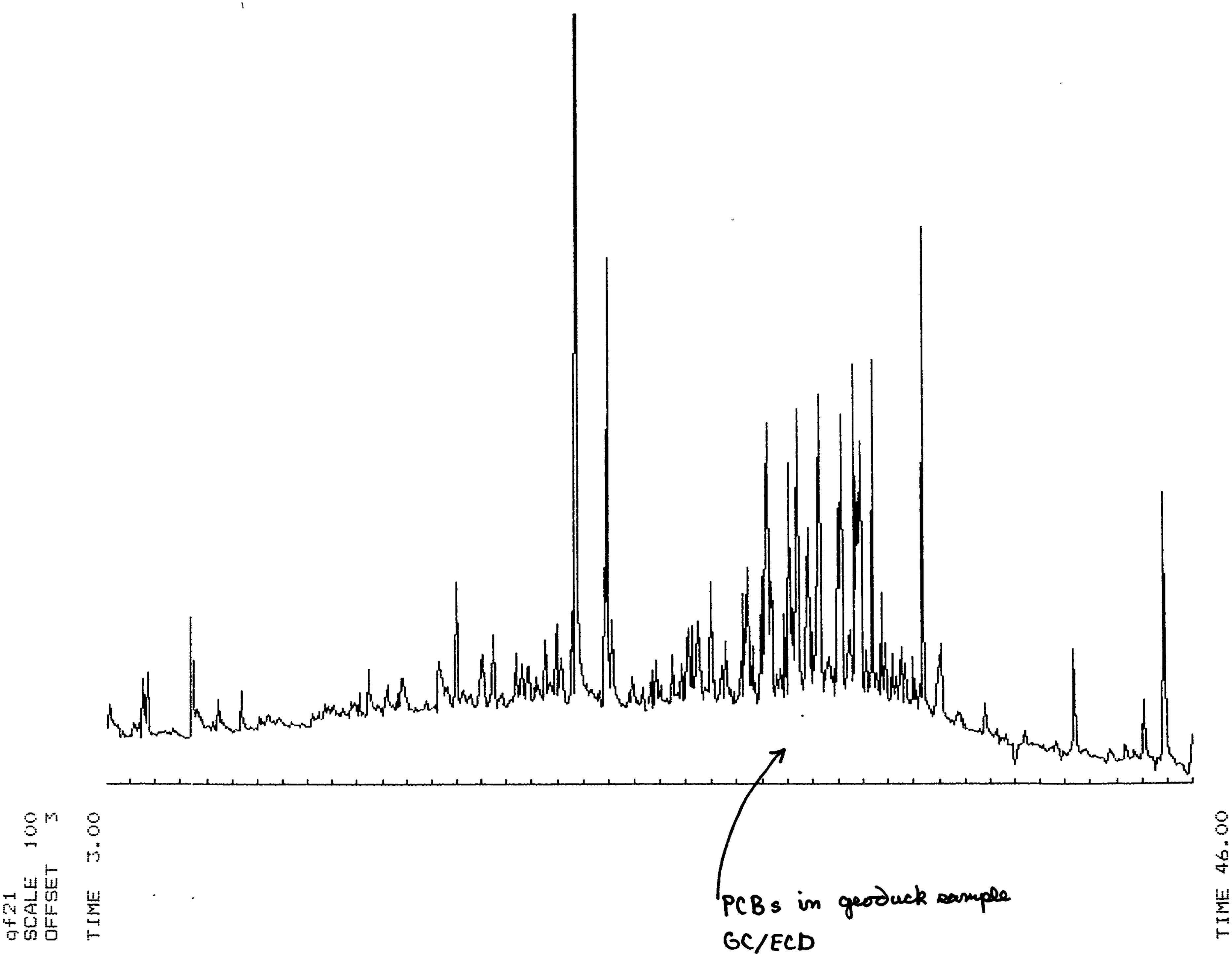
Name Info:
Misc Info:
Operator :

Date : 30 Apr 86 8:44 am
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



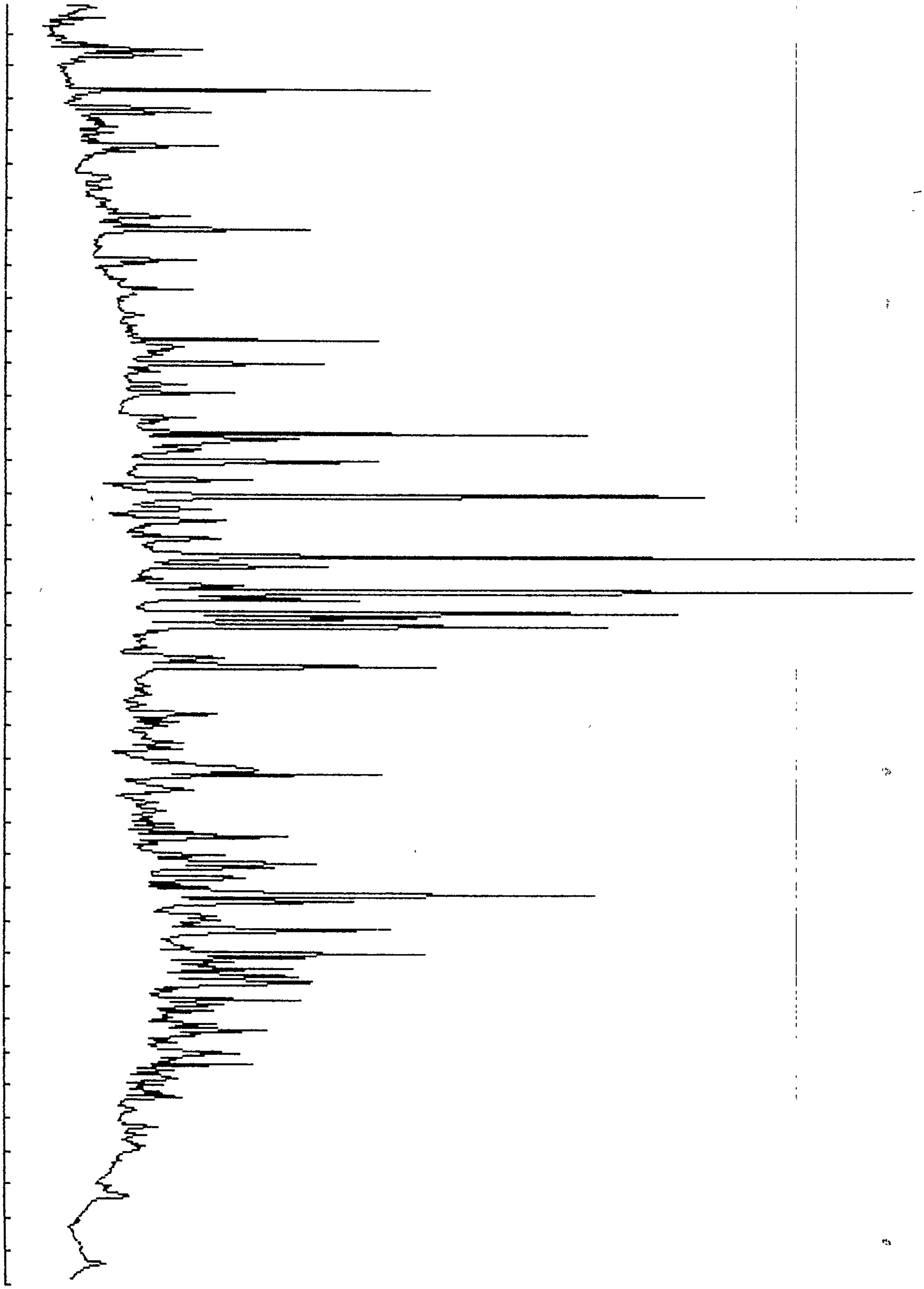




PCBs in geoduck sample
GC/ECD

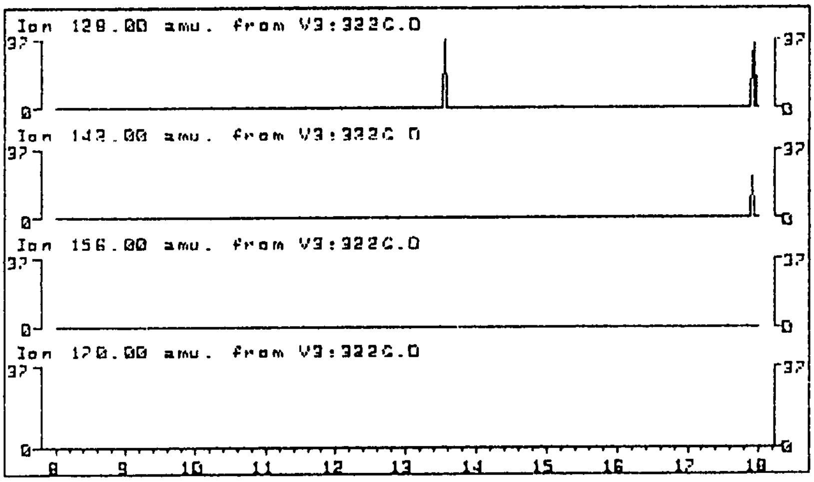
319xe1
SCALE 50
OFFSET 6

TIME 3.00

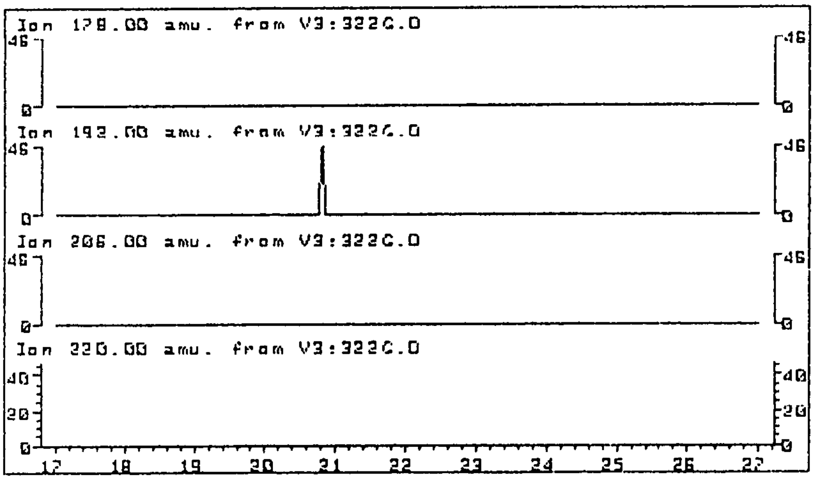


TIME 42.00

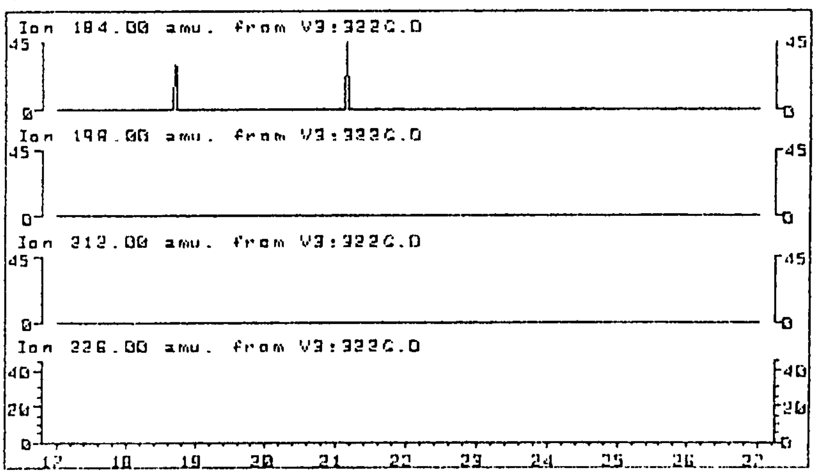
NAPHTHALENE'S



PHENANTHRENE'S



DIBENZOTHIOPHENE'S

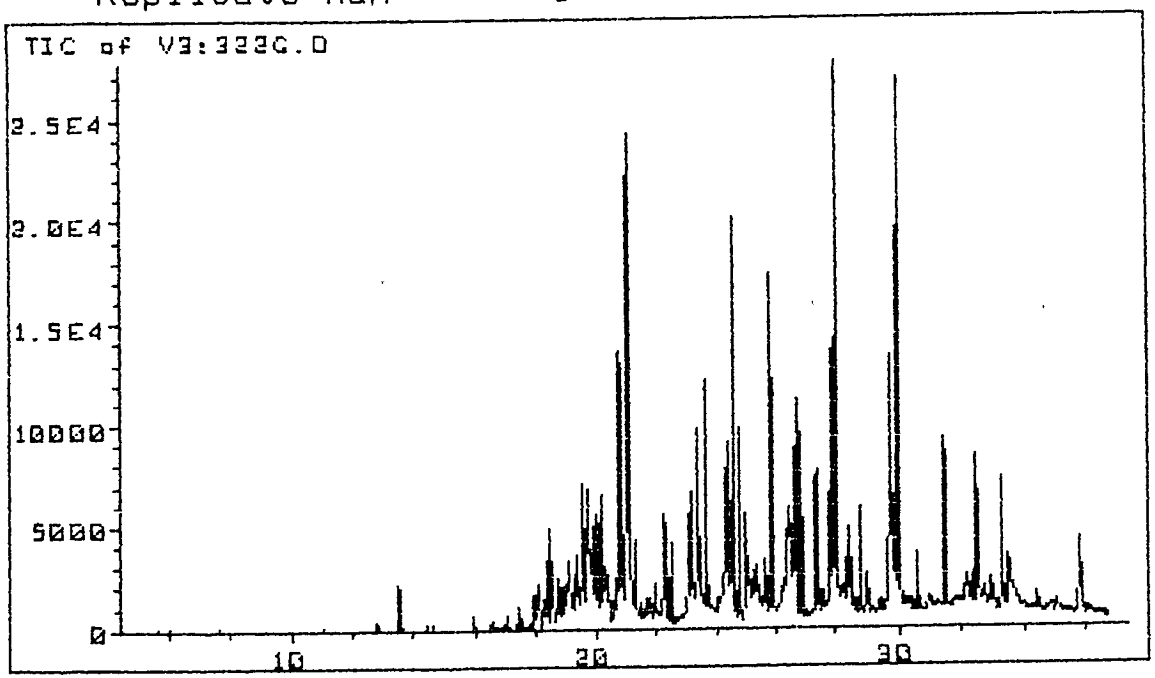


Data file: V3:322G.D
File type: GC / MS DATA FILE

Name Info:
Misc Info:
Operator :

Date : 30 Apr 86 7:46 am
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



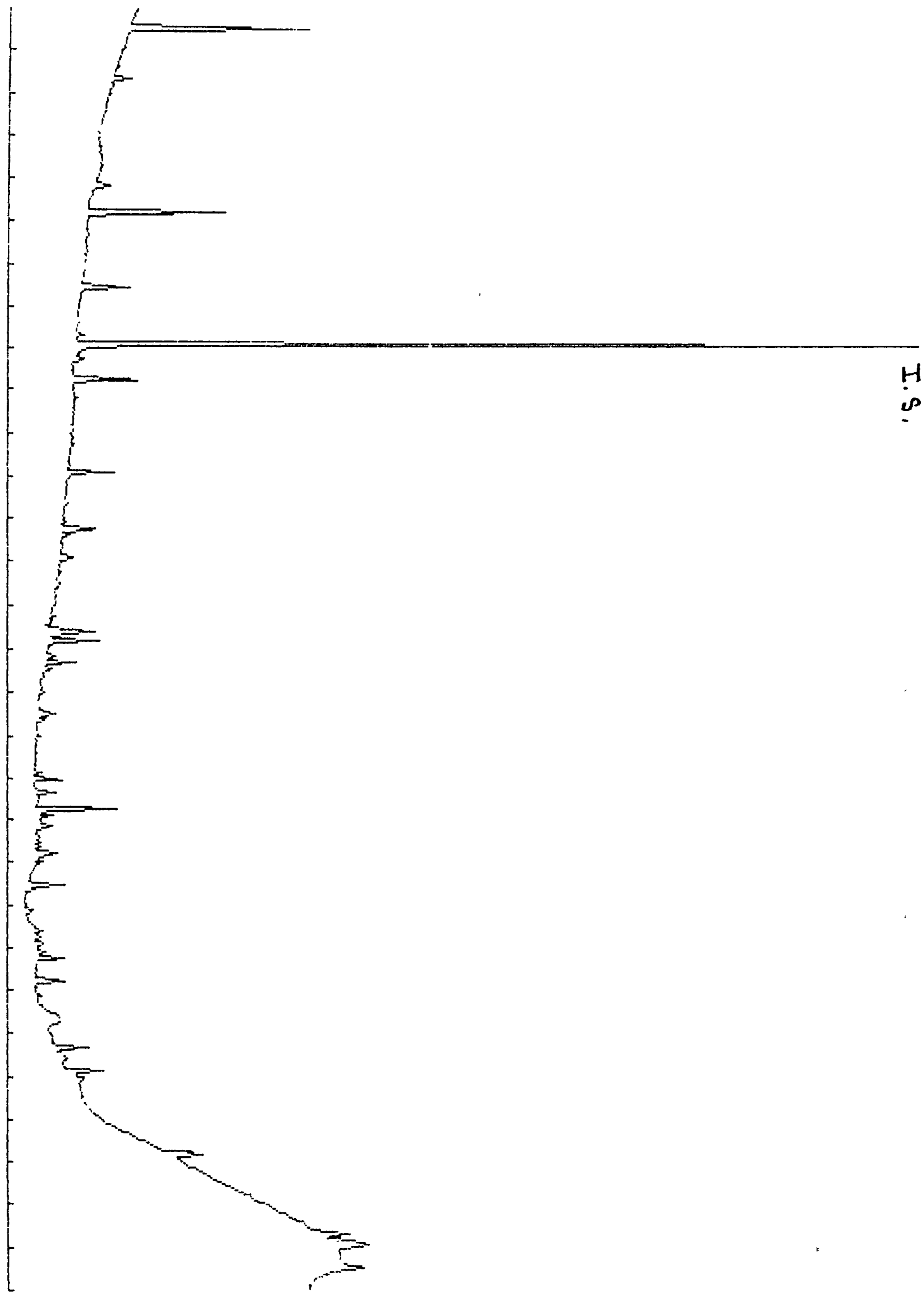
239 duplicate

238F27

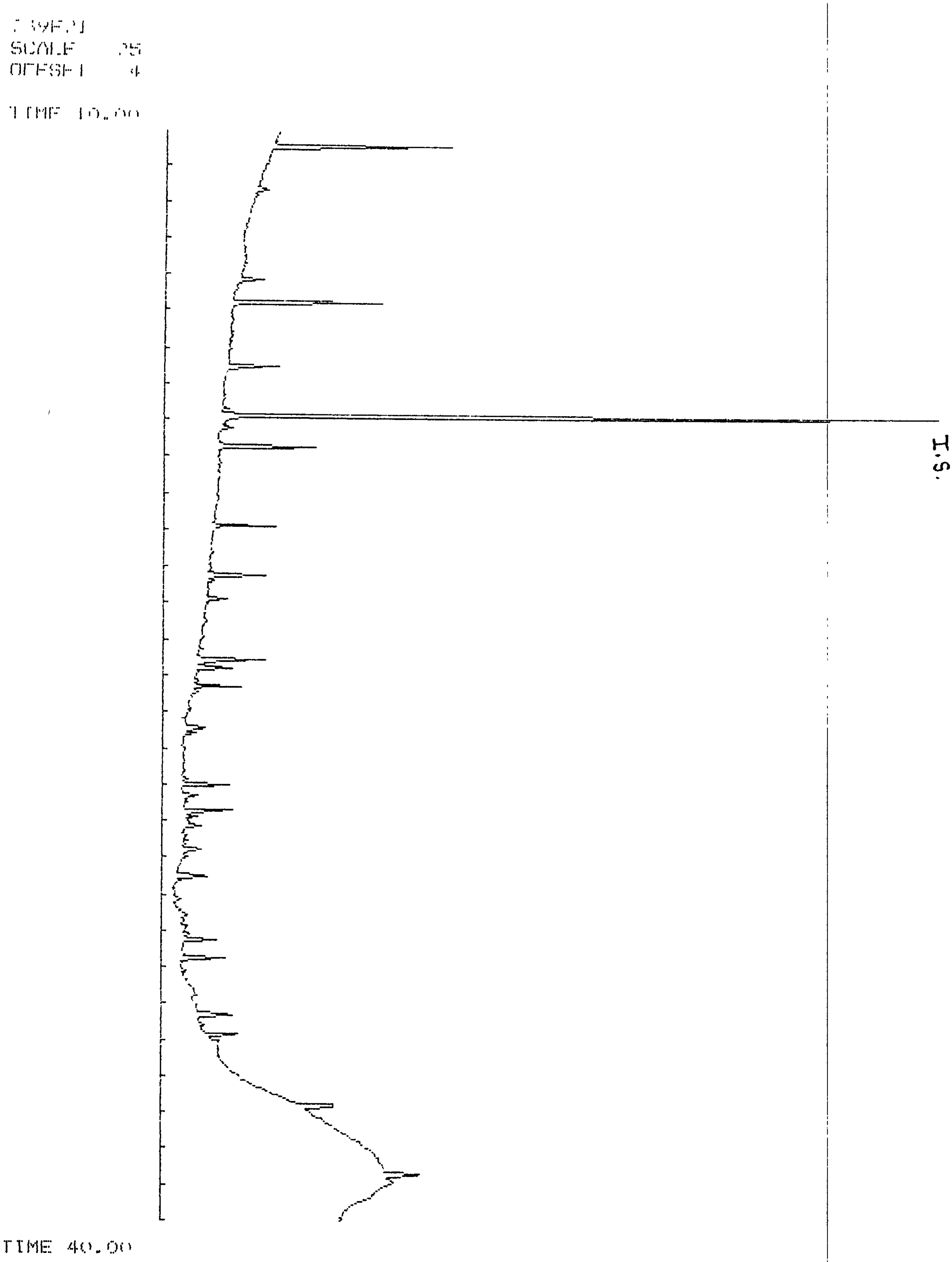
SCALE 25

OFFSET 4

TIME 10.00

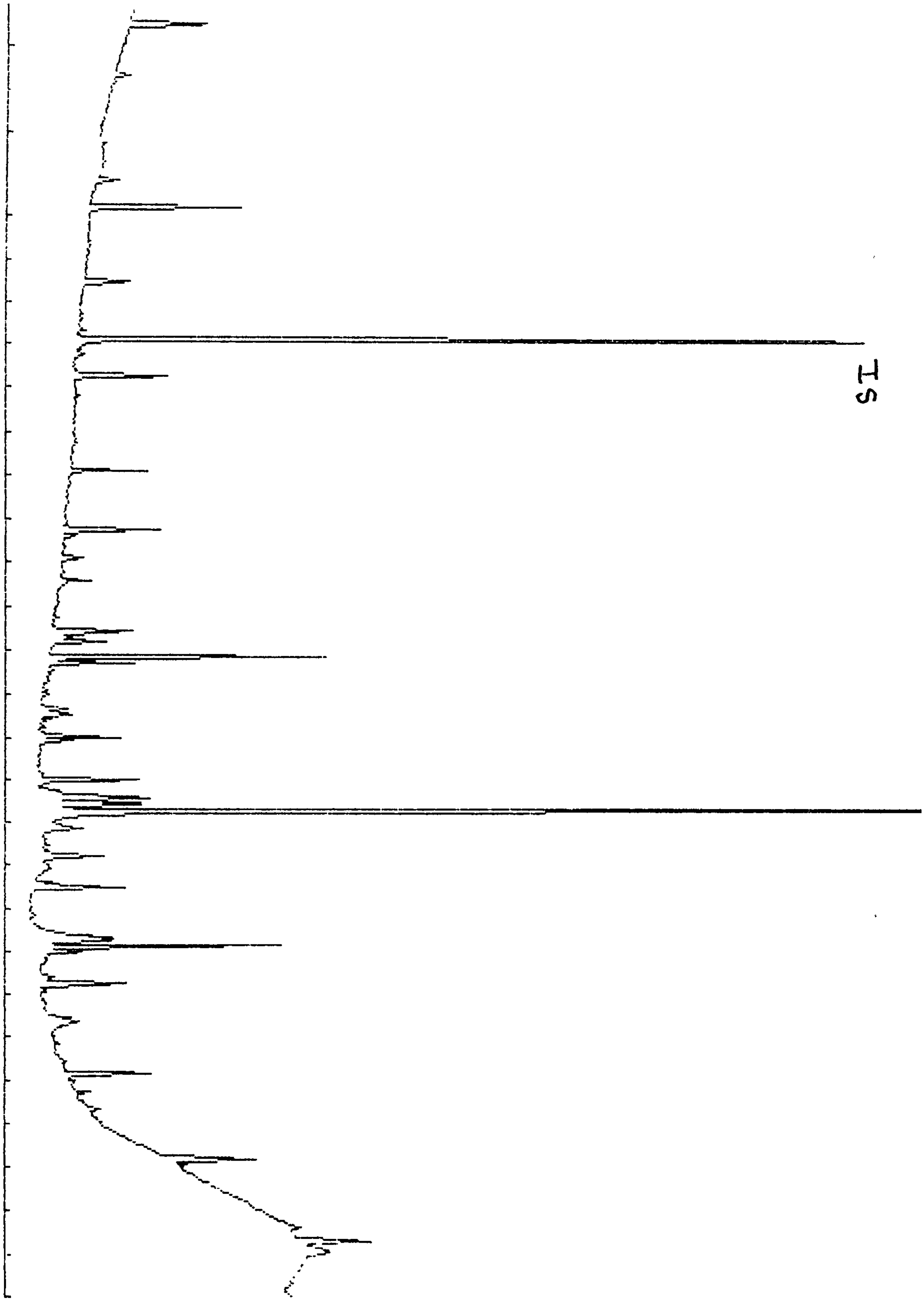


TIME 40.00


SCALE .25
OFFSET 4
TIME 10.00
I.S.
TIME 40.00

J38F21
SCALE 25
OFFSET 4

TIME 10.00



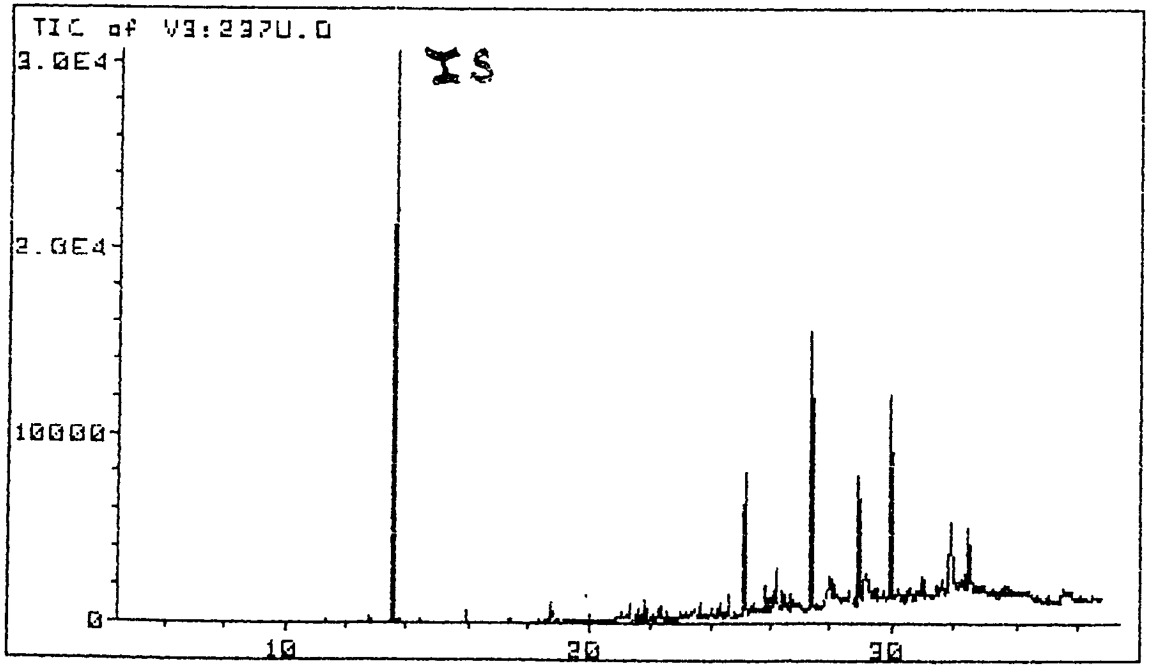
TIME 40.00

Data file: V3:237U.D
File type: GC / MS DATA FILE

Name Info:
Misc Info:
Operator :

Date   : 30 Apr 86 10:17 am
Instrment: MS_5970
Inlet   : GC

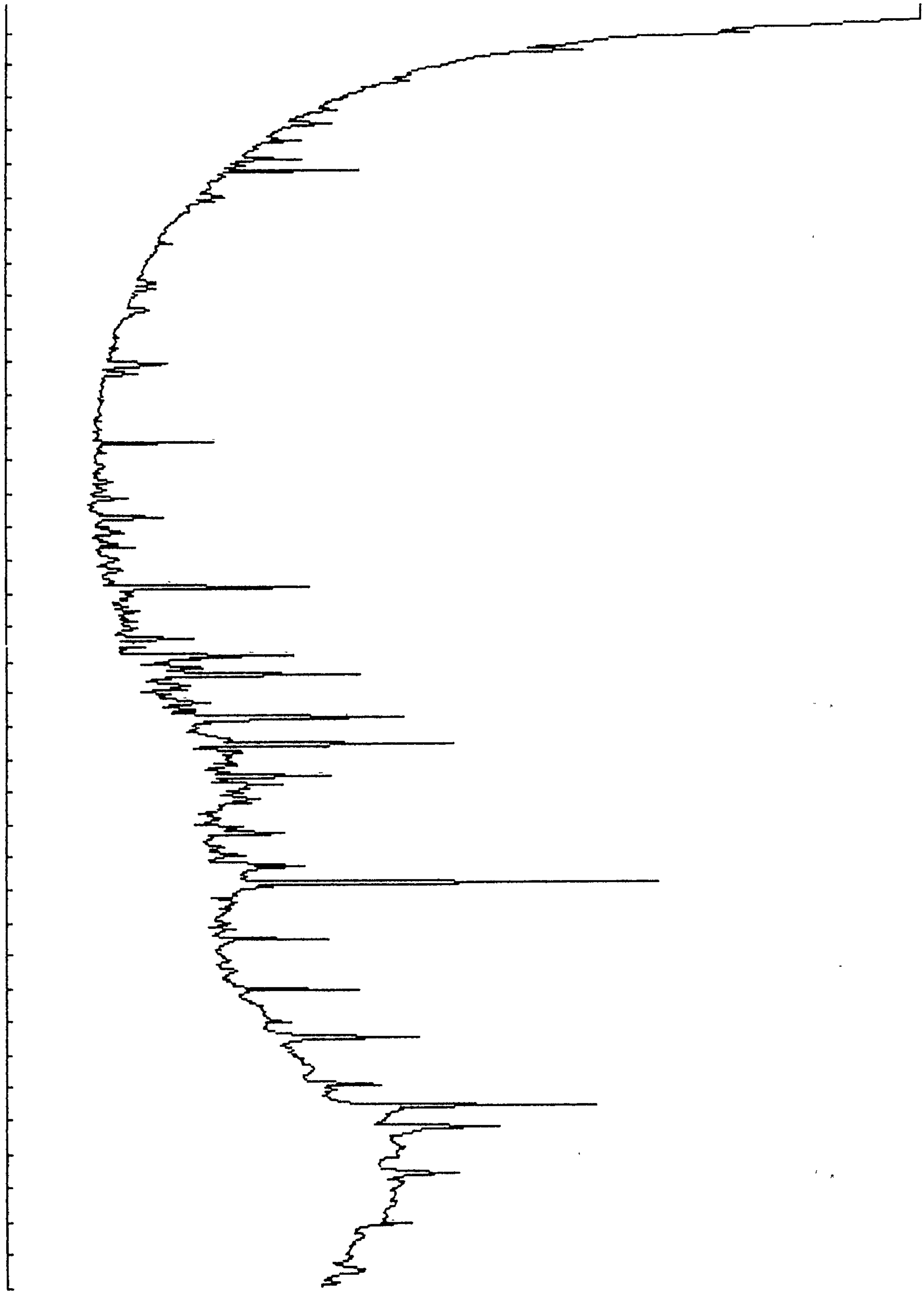
Sequence index :   0
Als bottle num :   0
Replicate num :   0



246f21
SCALE 15
OFFSET 4

TIME 3.00

027246 F-2



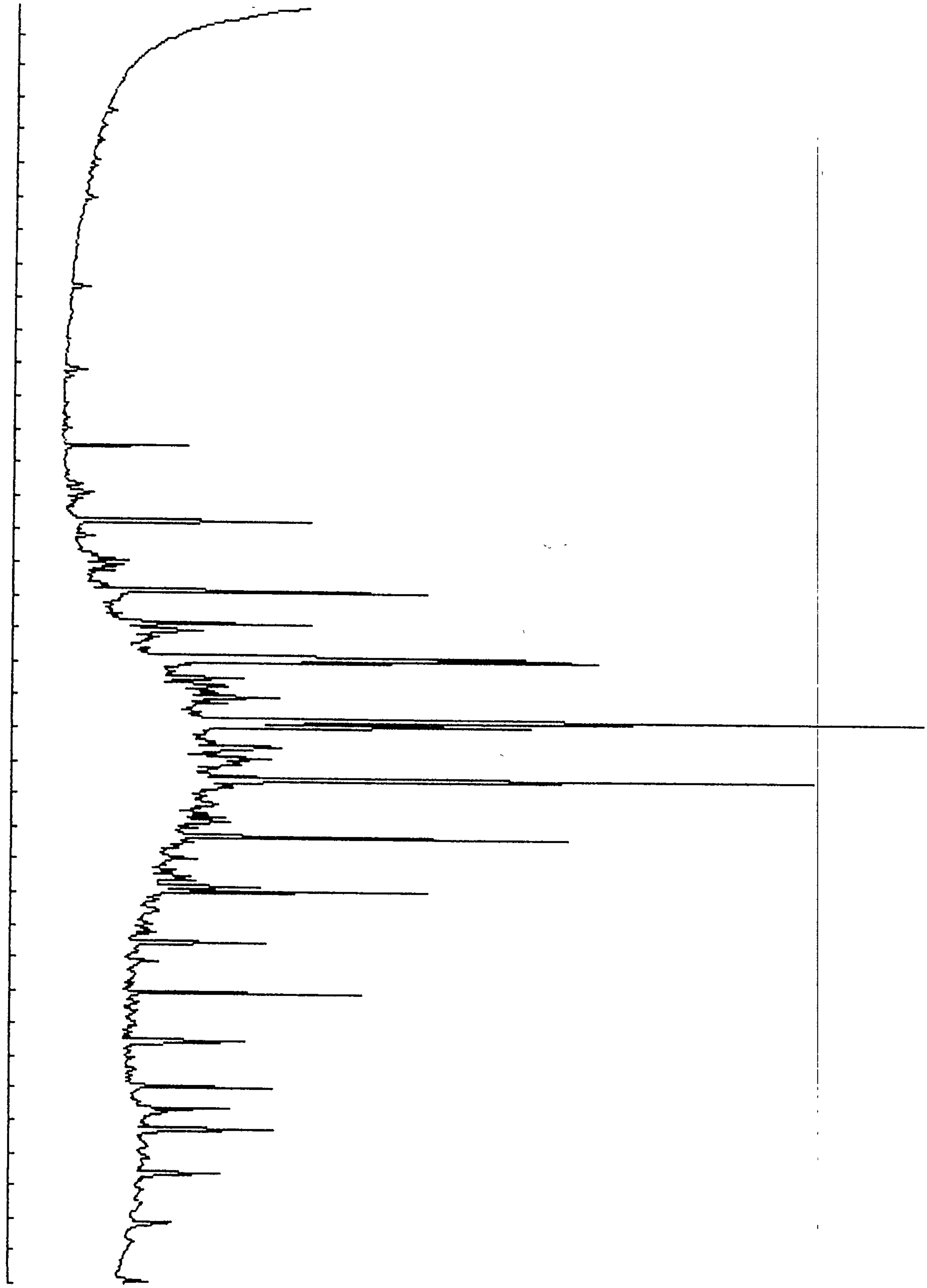
TIME 42.00

246f11
SCALE 75
OFFSET 2

This kelp had visible oil.

TIME 3.00

#027246 F-1

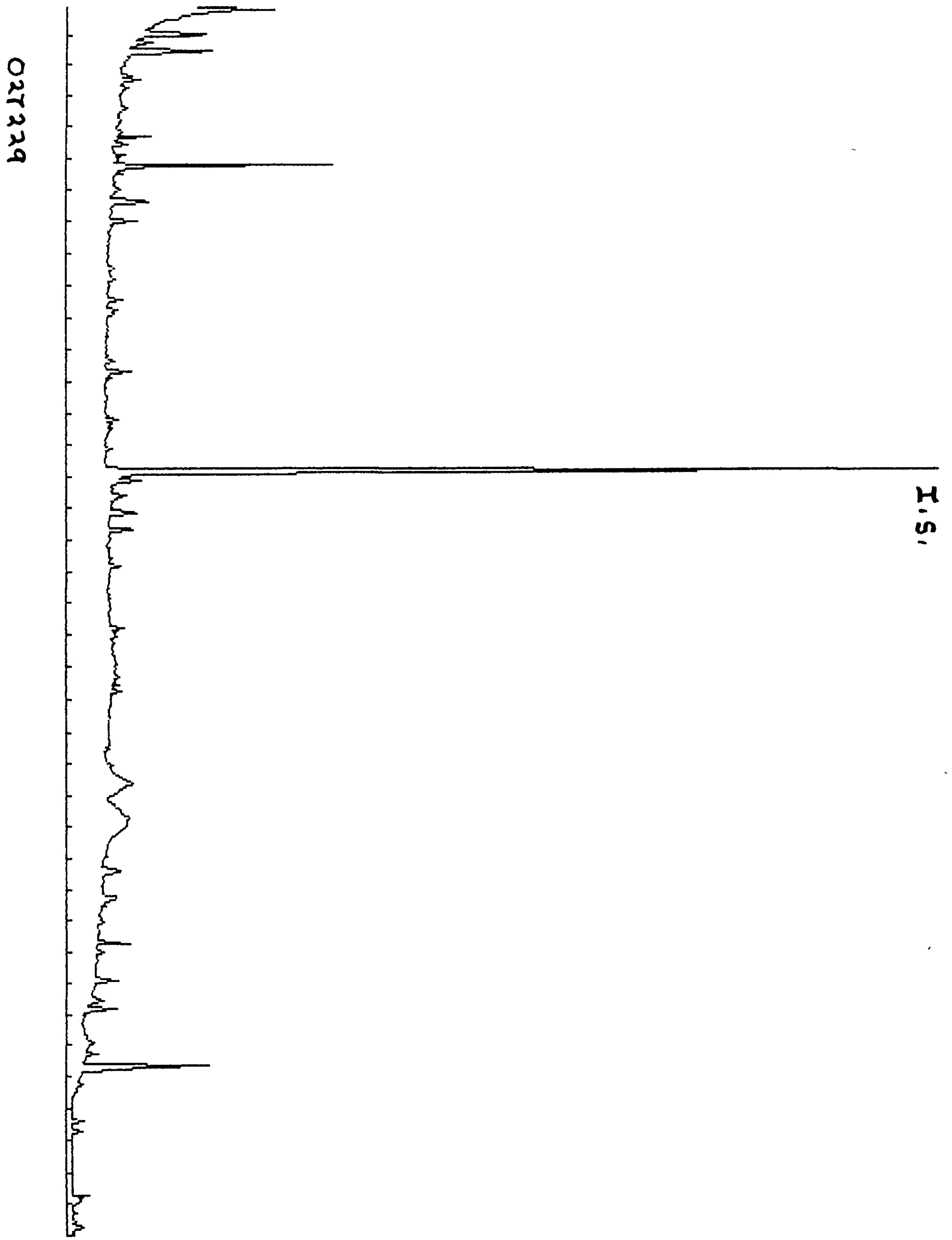


TIME 42.00

Kelp 6/19/86 Port Angeles

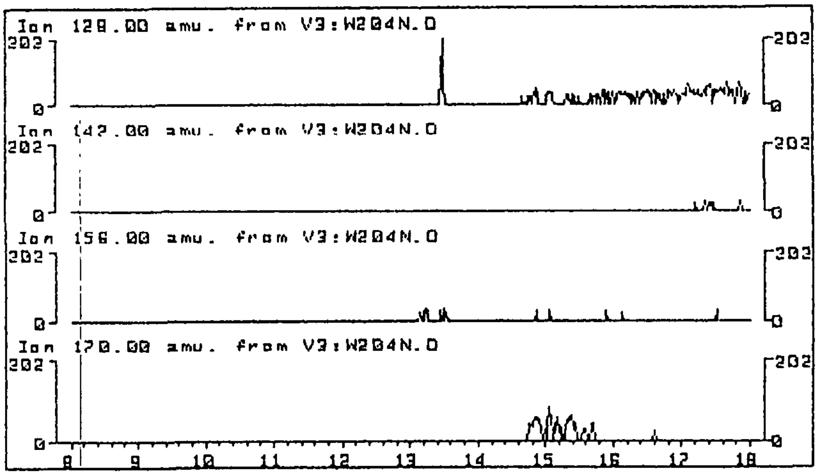
272291
SCALE 50
OFFSET 0

TIME 3.00

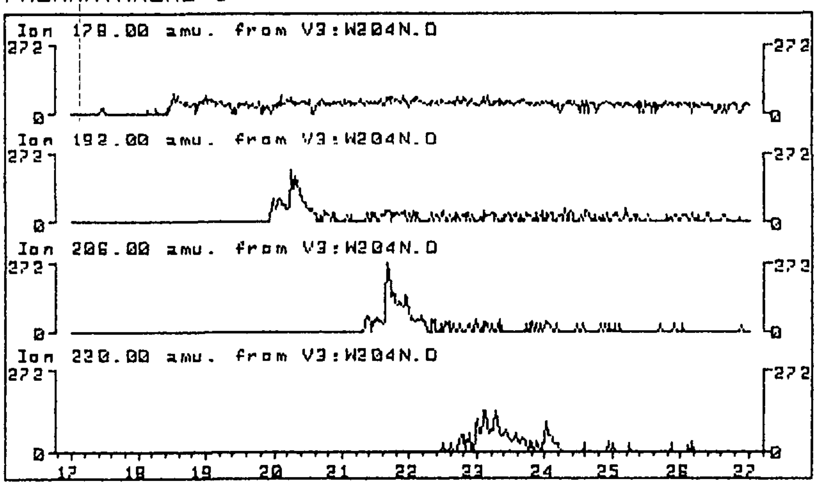


TIME 42.00

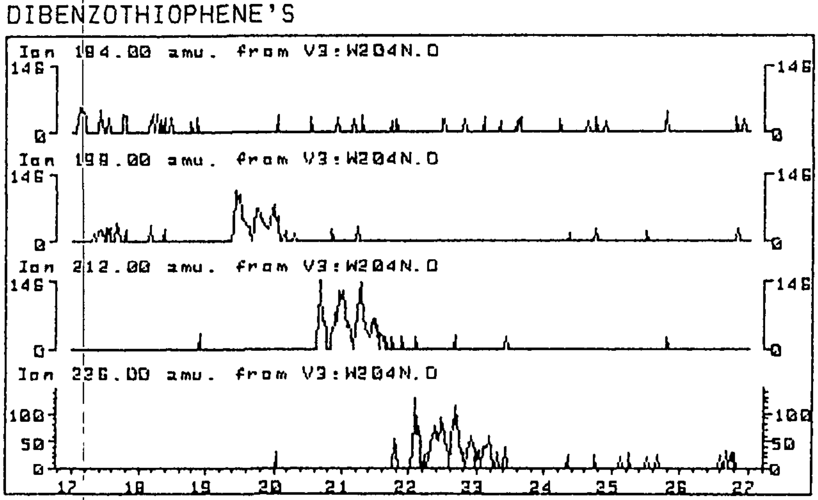
NAPHTHALENE'S



PHENANTHRENE'S



DIBENZOTHIOPHENE'S

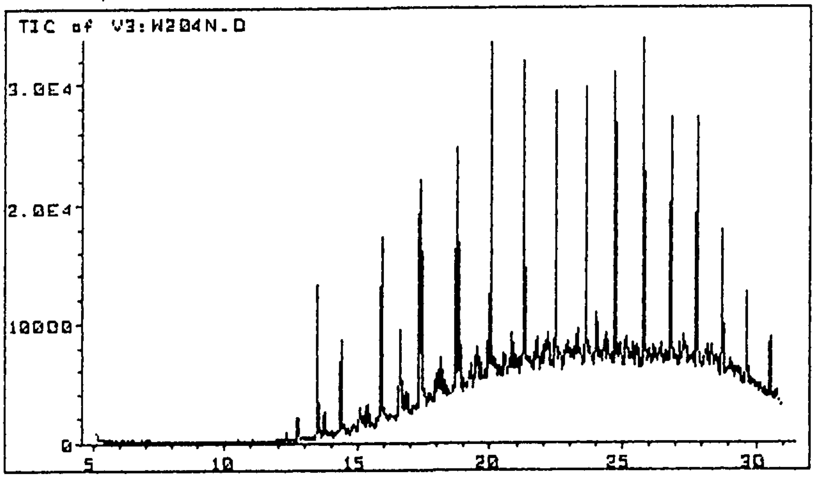


Data file: V3:W204N.D
File type: GC / MS DATA FILE

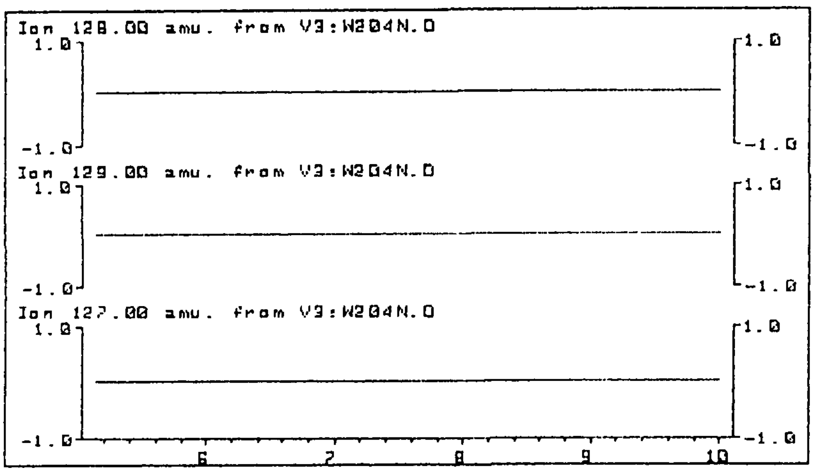
Name Info: 017204 WHISKEY BAY 2 UL INJ
Misc Info: BNA METH EMV=1600
Operator : CB HENRY

Date : 14 Apr 86 7:16 pm
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0



NAPHTHALENE RT=8.6



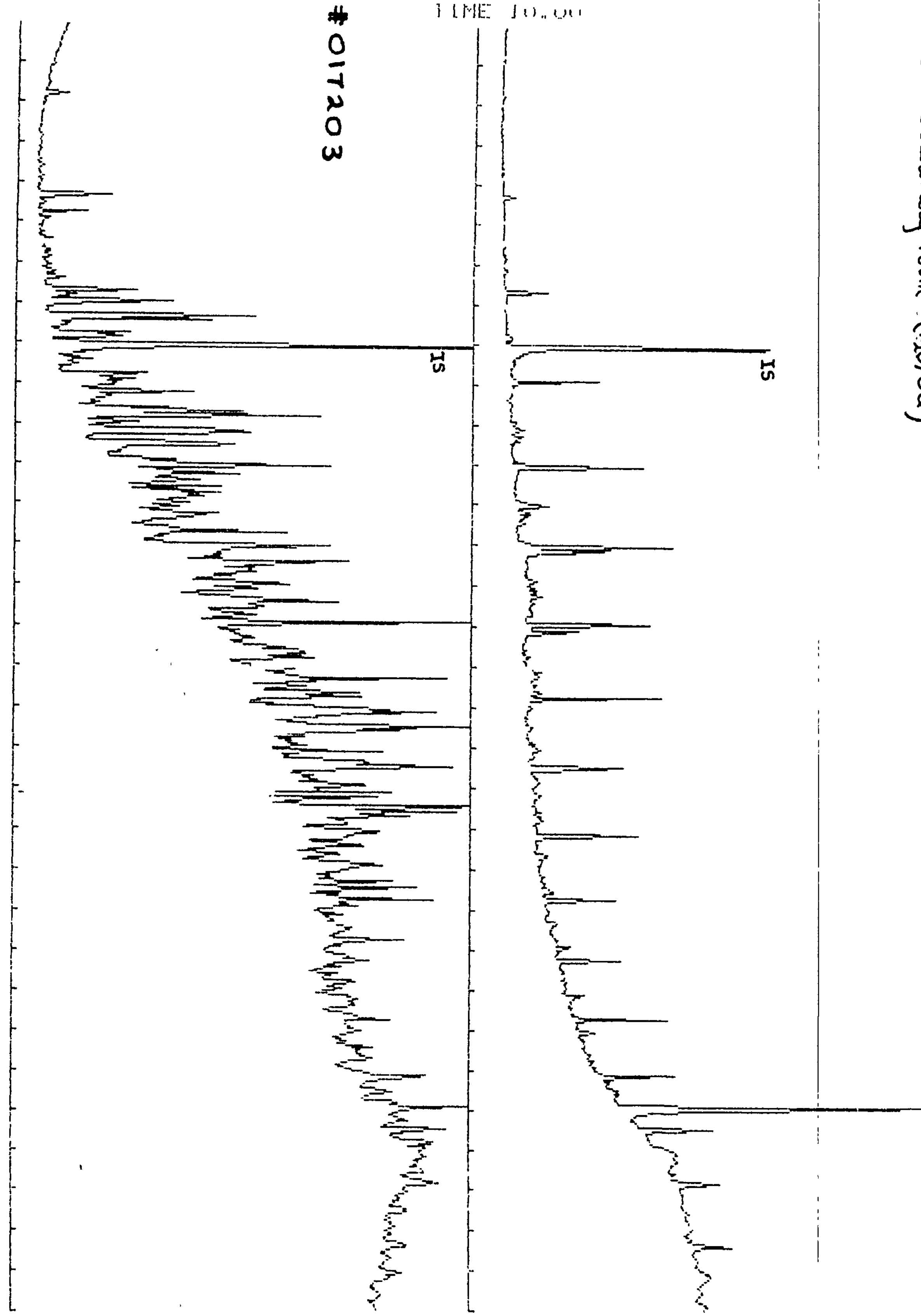
Ecology Lab # 01T203 Observatory Point (H2O/Oil)

203F21
SCALE 25
OFFSET 5

TIME 10.00

203F11
SCALE 20
OFFSET 0

TIME 10.00

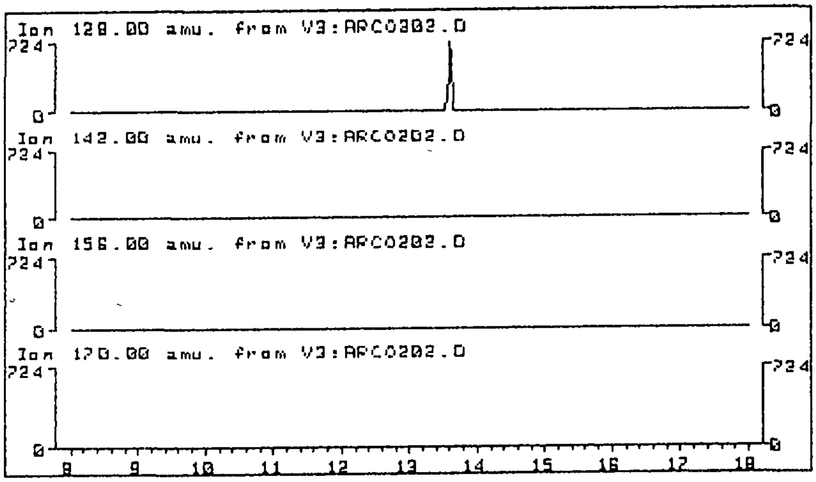


TIME 42.00

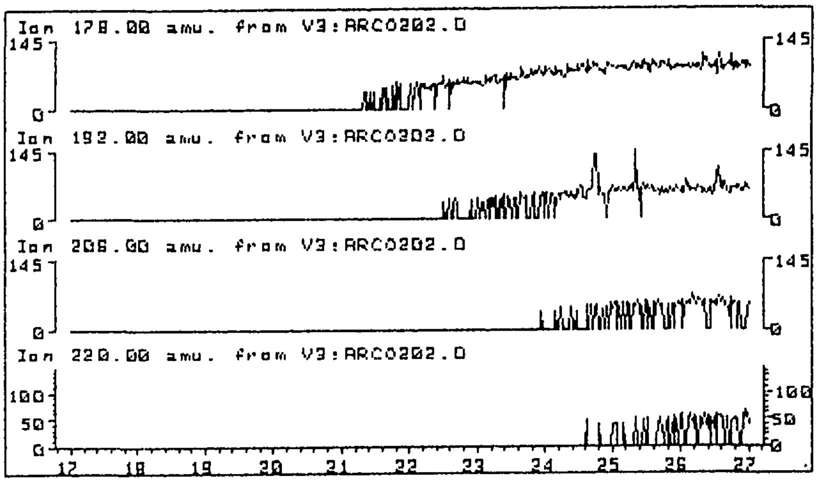
TIME 42.00

INST. FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY

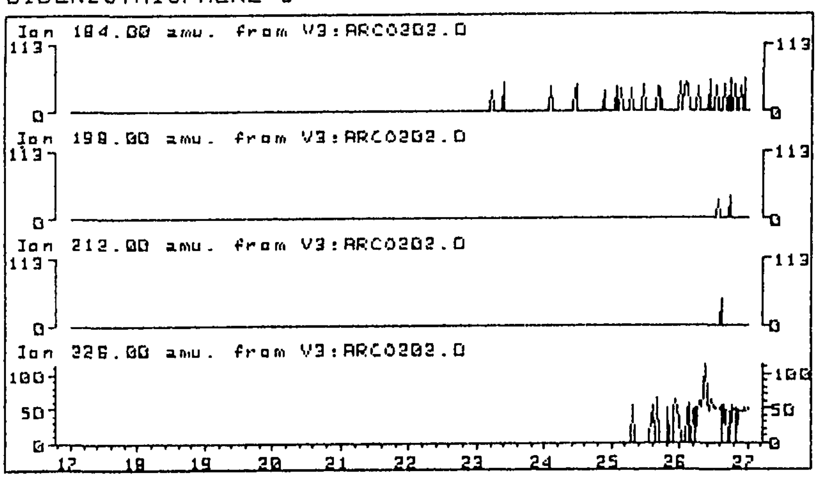
MAJOR HOMOLOG GROUPS
NAPHTHALENE'S

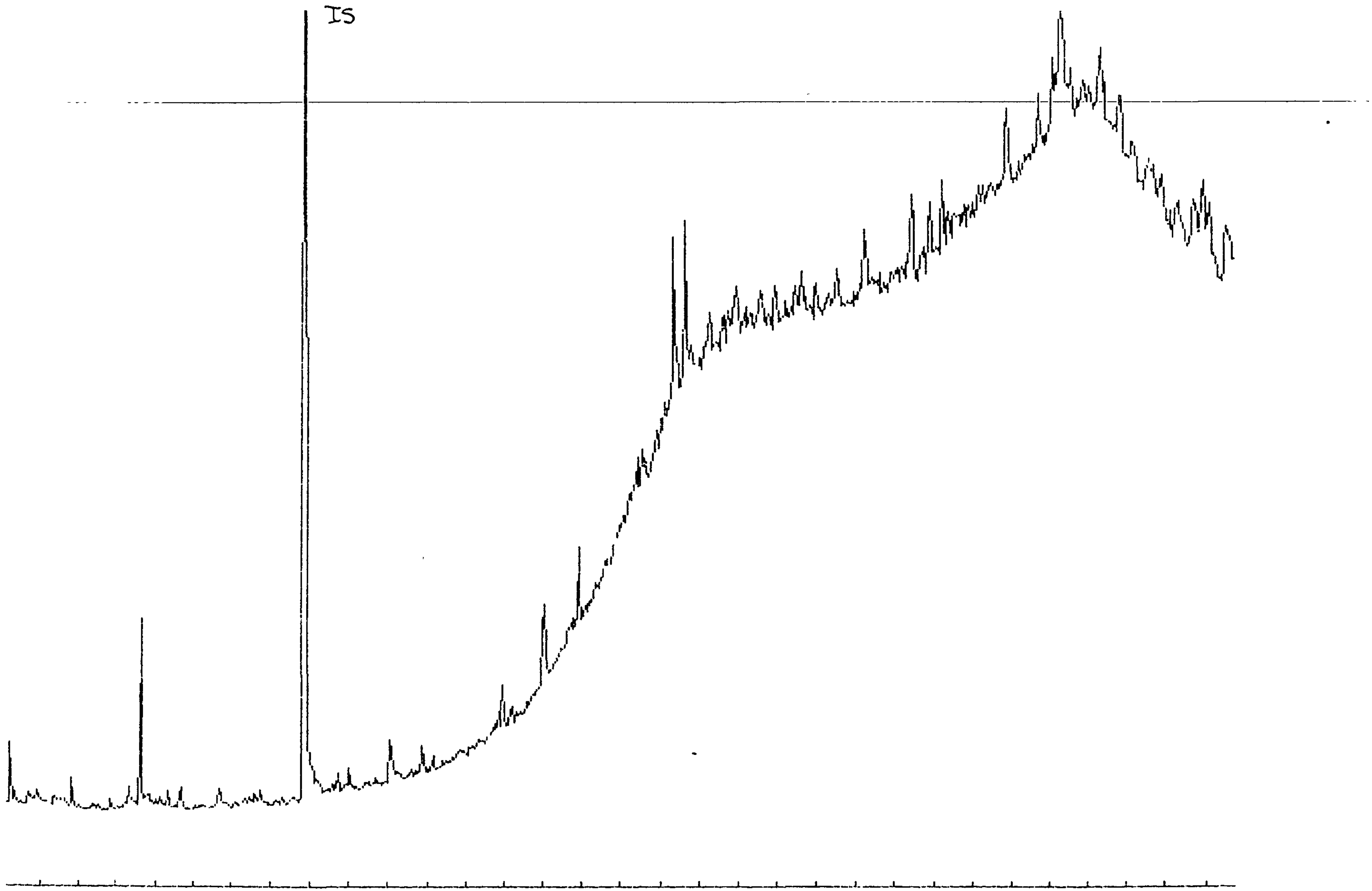


PHENANTHRENE'S



DIBENZOTHIOPHENE'S





#017202

SCALE 50
OFFSET 5

TIME 16.00

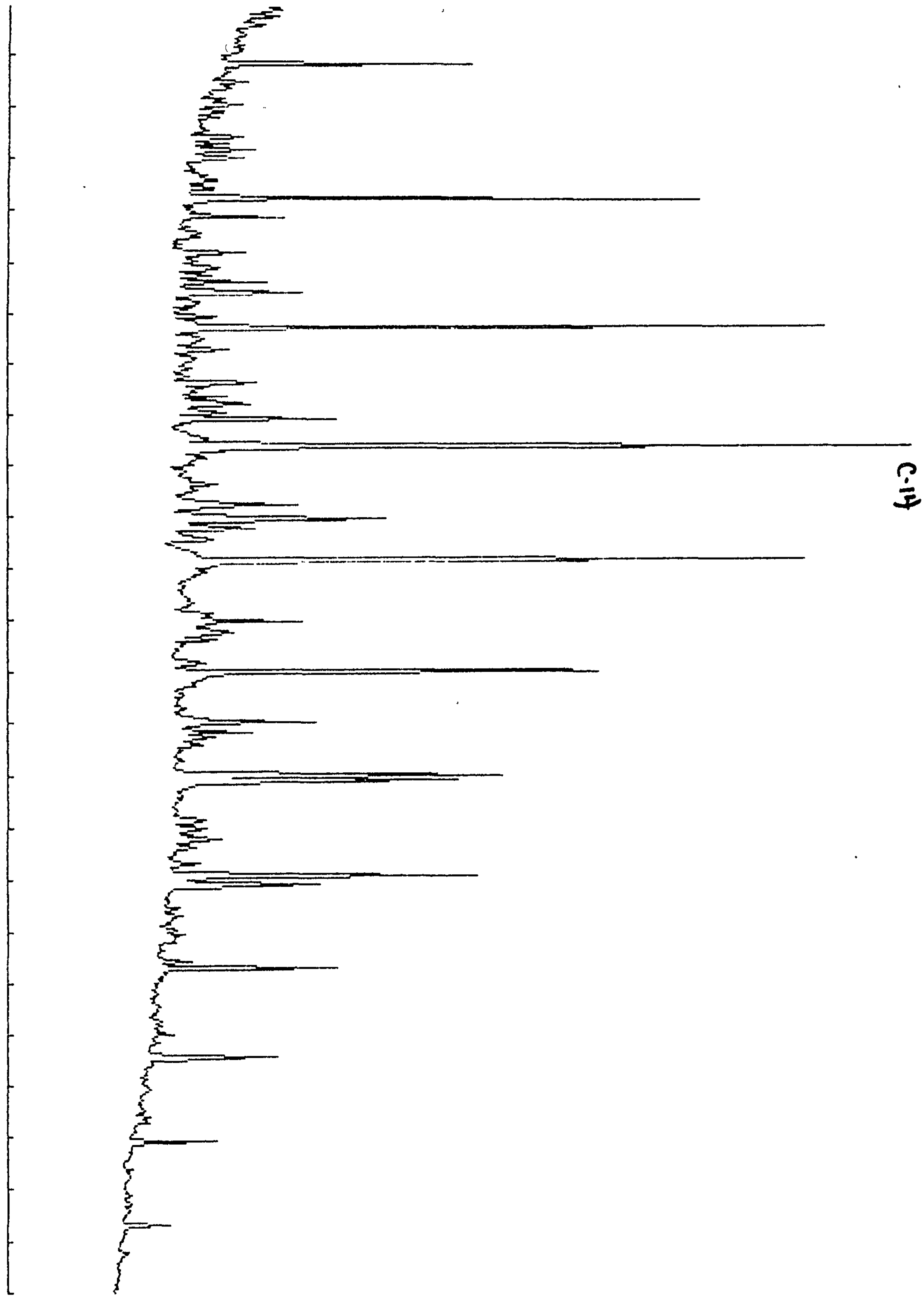
TIME 41.75

fig. 30

J88F#1
SCALE 20
OFFSET 4

TIME 7.00

F-1 aliphatic fraction
017188
PA-3 (T-Bird)



TIME 32.00

fig. 14

Data file: V3:188F2.D
File type: GC / MS DATA FILE

Name Info: 017188 PORT ANG. WASH SPILL 2 UL INJ
Misc Info: METH EMV=1600
Operator : CB

Date   : 2 Jun 86   9:36 am
Instrment: MS_5970
Inlet   : GC

Sequence index :   0
Als bottle num :   0
Replicate num :   0

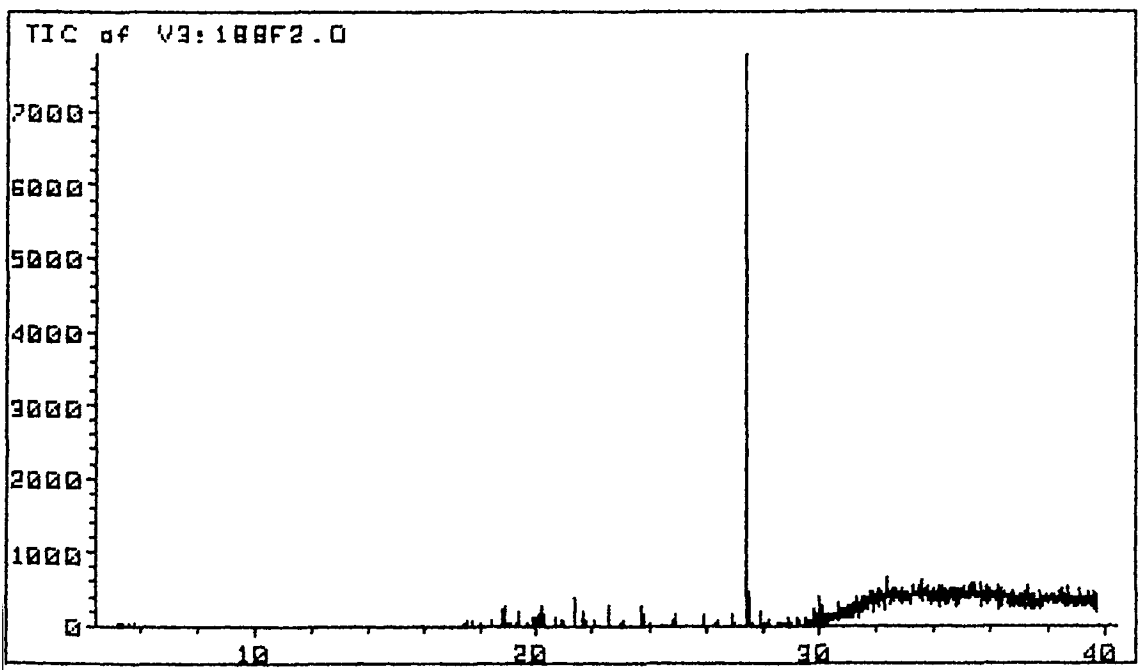


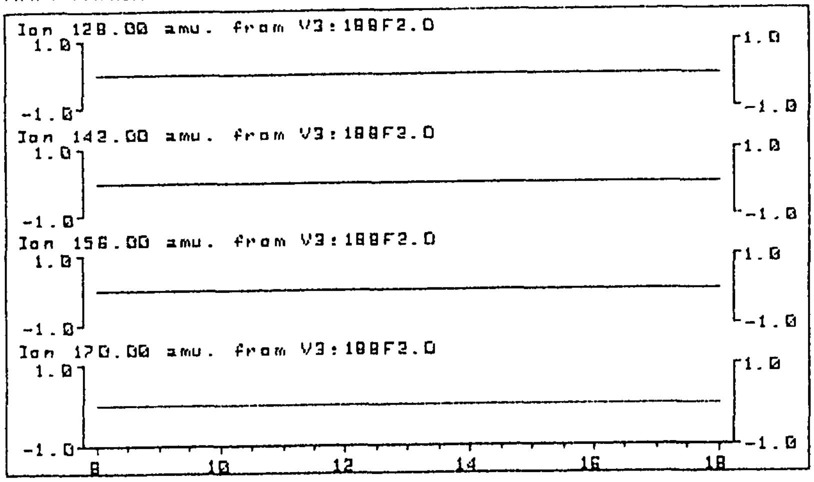
fig. 15

fig. 16

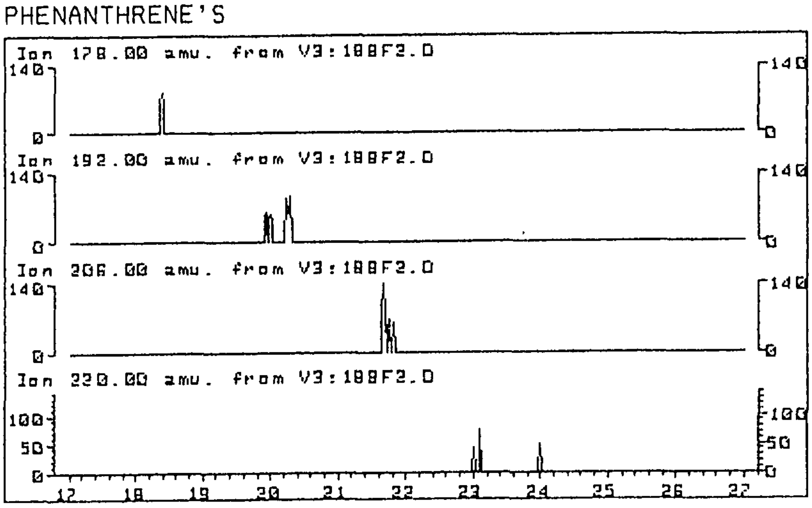
INST. FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY

MAJOR HOMOLOG GROUPS

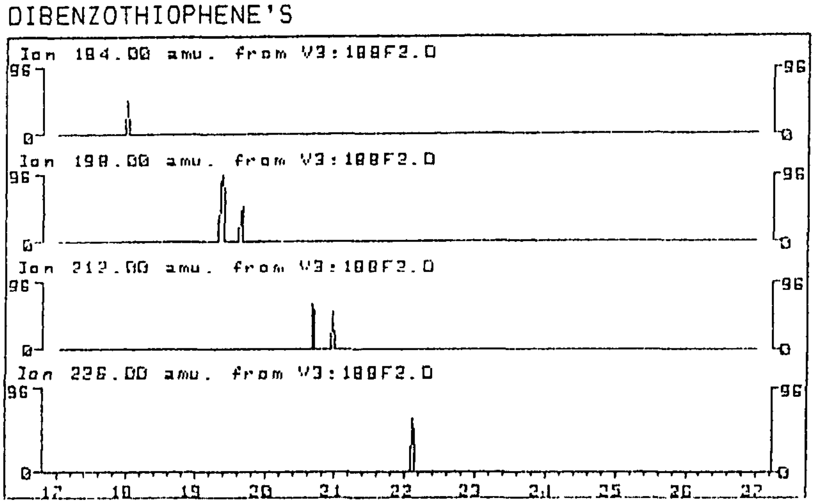
NAPHTHALENE'S



PHENANTHRENE'S



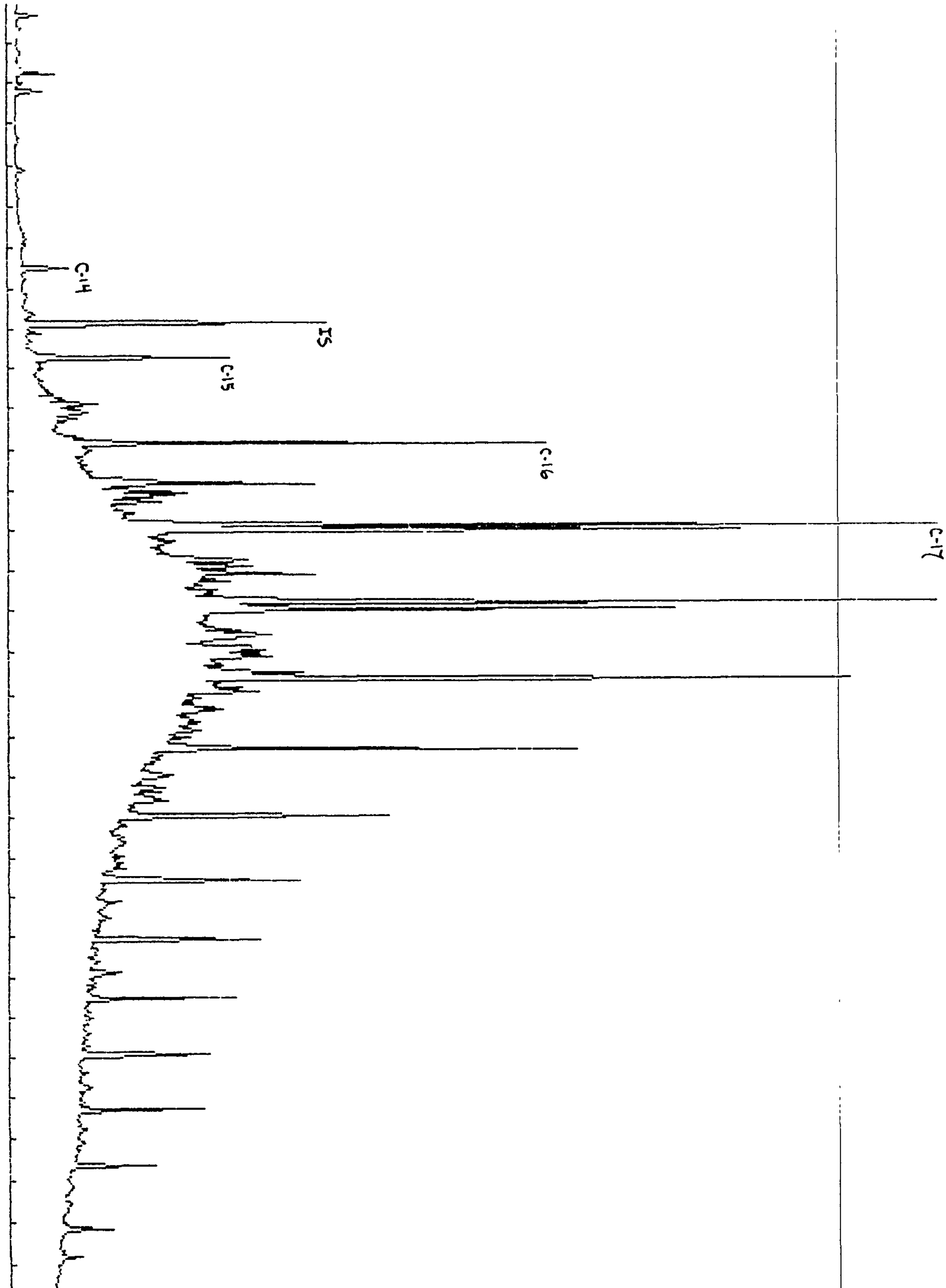
DIBENZOTHIOPHENE'S



190M1
SCALE 750
OFFSET 5

TIME 10.00

#017190 Freshwater Bay
water/oil ext.



TIME 41.75

fig.17

fig. 18

Data file: V3:190.D
File type: GC / MS DATA FILE

Name Info: 85017190 ARCO OIL SPILL SAMPLE   FINAL VOL.=1.0 ML
Misc Info: BNA METH EMV=1600
Operator : CB

Date : 2 Jun 86   5:21 am
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0

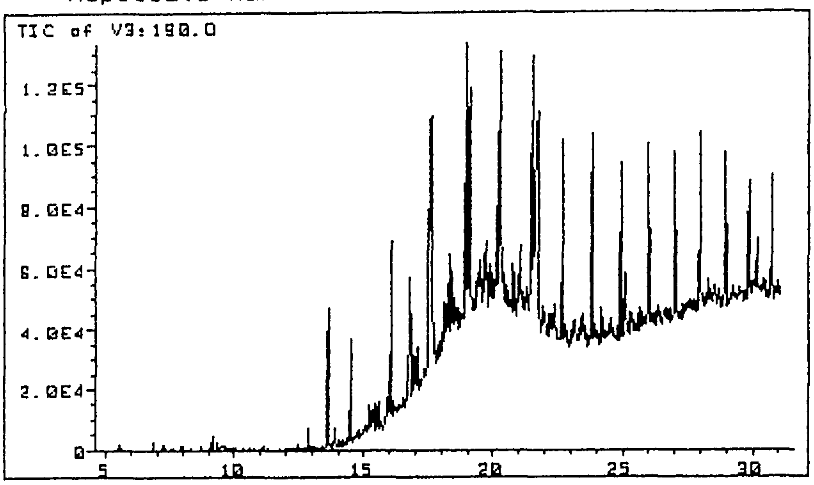
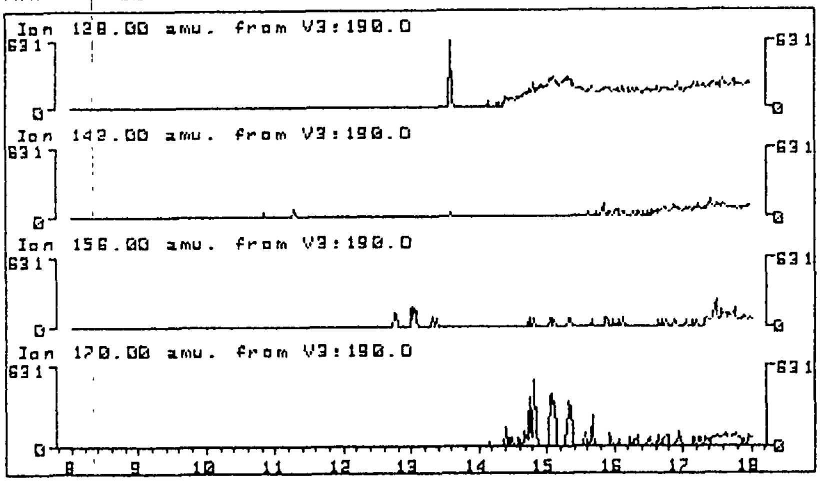


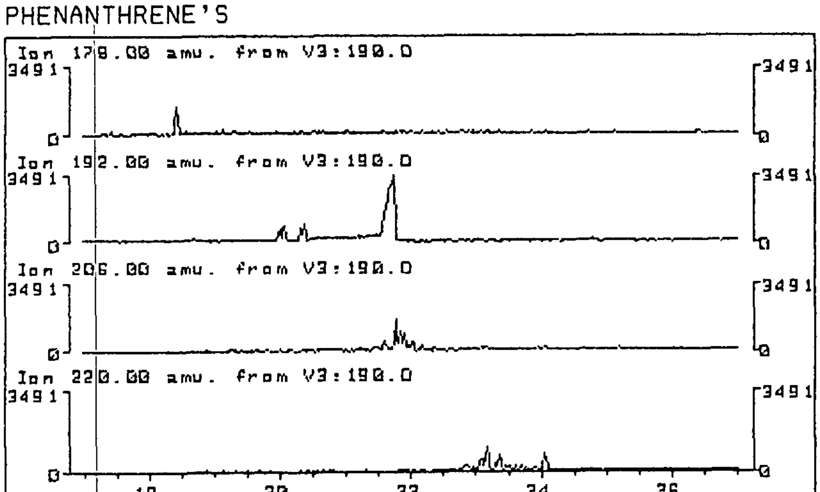
fig. 19

INST. FOR ENVIRONMENTAL STUDIES
LOUISIANA STATE UNIVERSITY

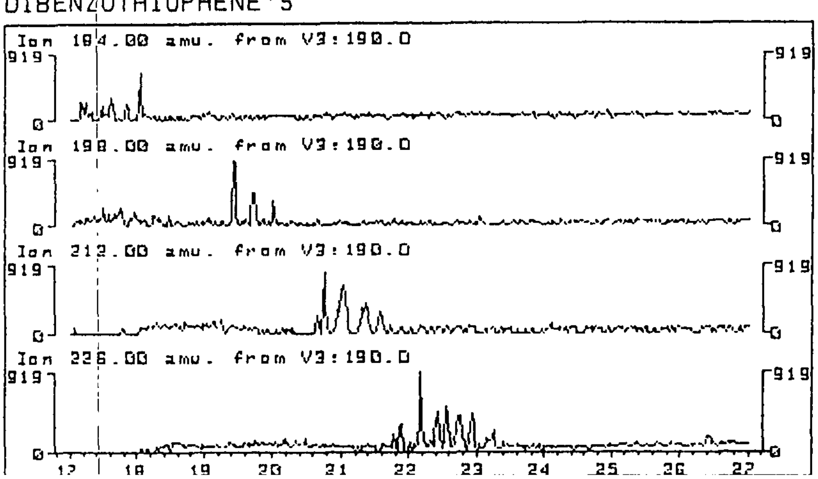
MAJOR HOMOLOG GROUPS
NAPHTHALENE'S



PHENANTHRENE'S

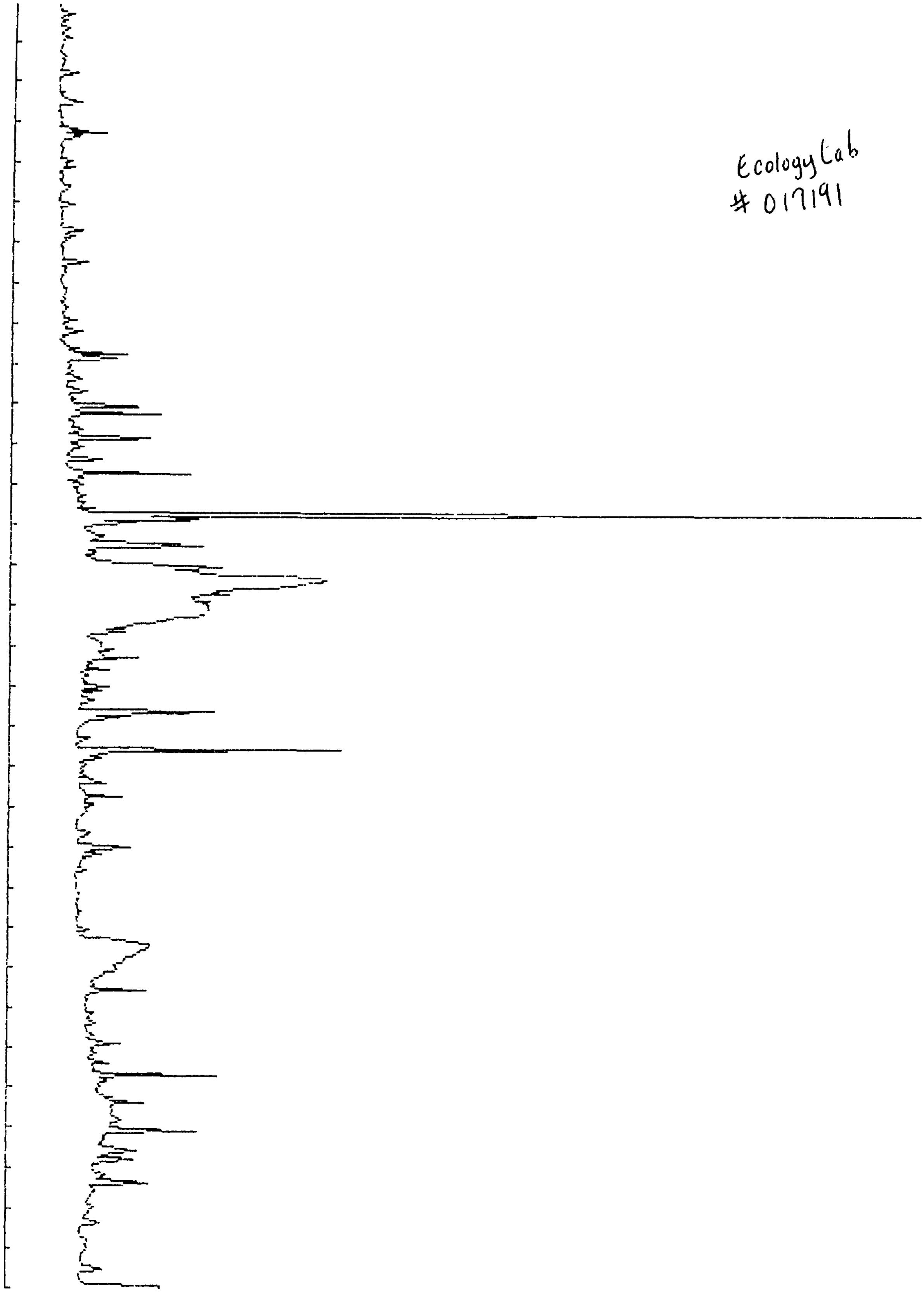


DIBENZOTHIOPHENE'S



PRINT
SCALE 150
OFFSET 0

TIME 10.00



TIME 4[illegible].00

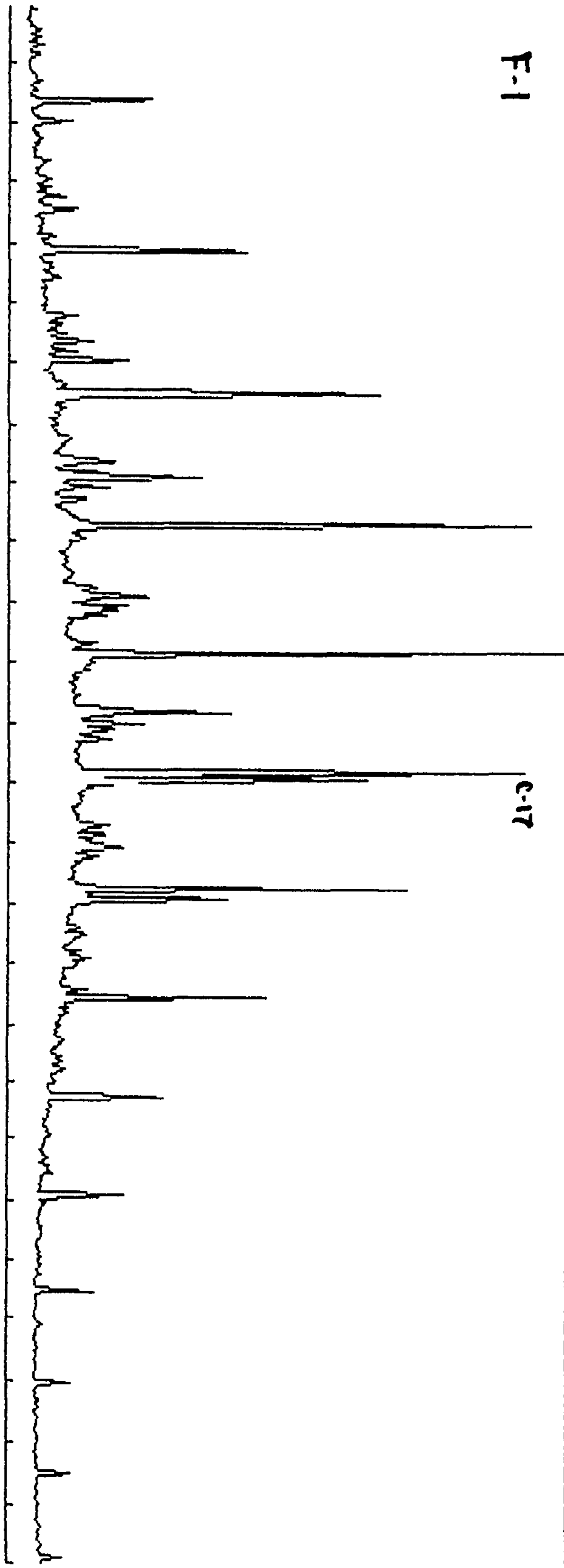
fig. 20

Ecology Lab
017191

193F11
SCALE 225
OFFSET 4

TIME 10.00

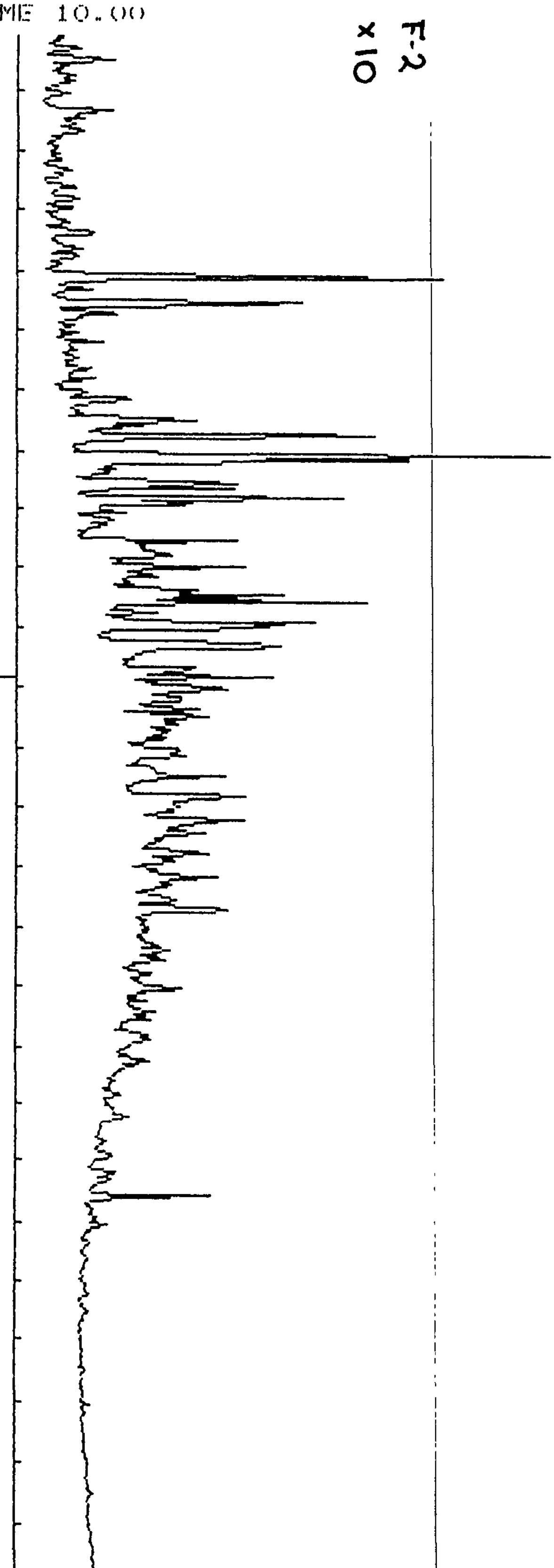
#017193
HP-1
clam



TIME 36.00

193F21
SCALE 65
OFFSET 4

TIME 10.00



TIME 36.00

fig. 21

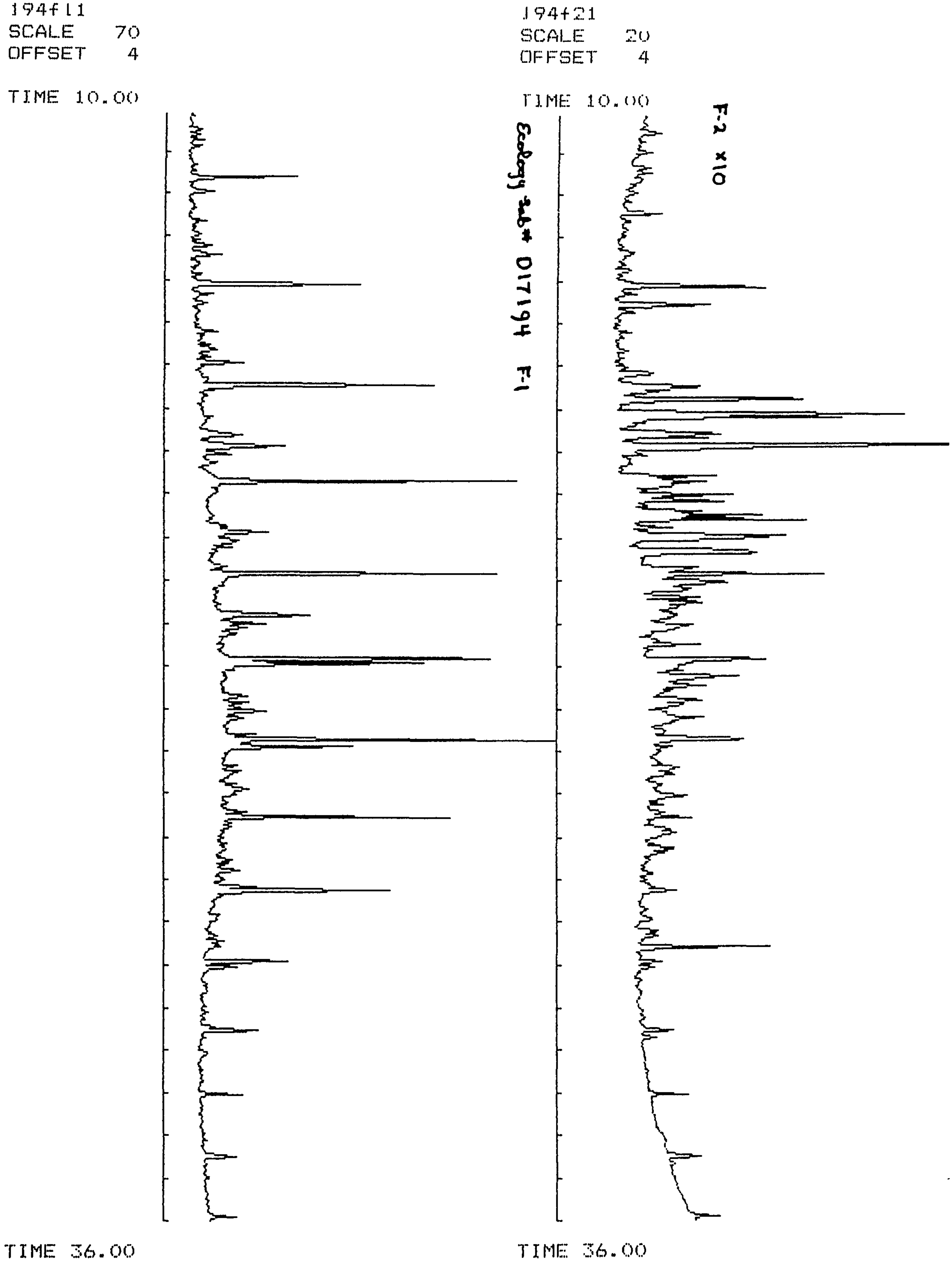

194f11
SCALE 70
OFFSET 4
TIME 10.00
TIME 36.00
194f21
SCALE 20
OFFSET 4
TIME 10.00
TIME 36.00
Ecology Lab# D17194 F-1
F-2 x10

fig 22

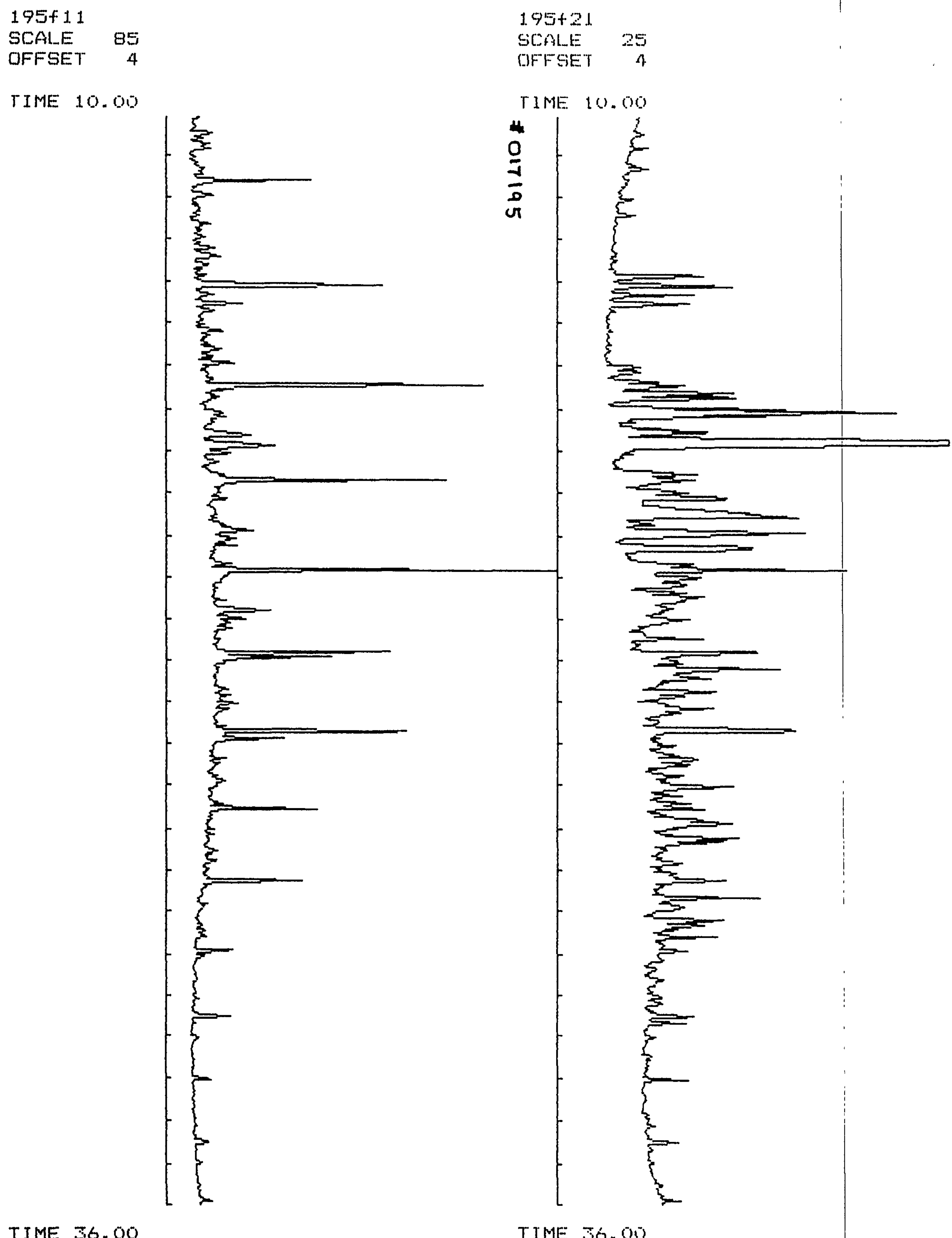
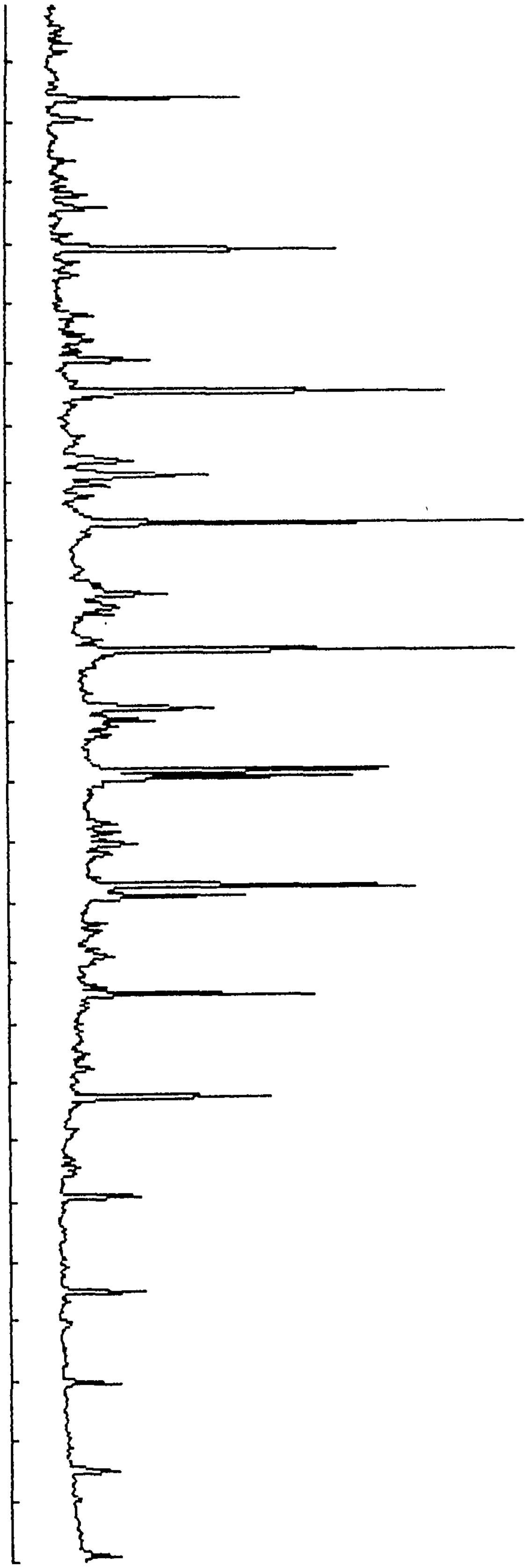

195f11
SCALE 85
OFFSET 4
TIME 10.00
TIME 36.00
195f21
SCALE 25
OFFSET 4
TIME 10.00
TIME 36.00
#017195

fig. 23

196f11
SCALE 50
OFFSET 4

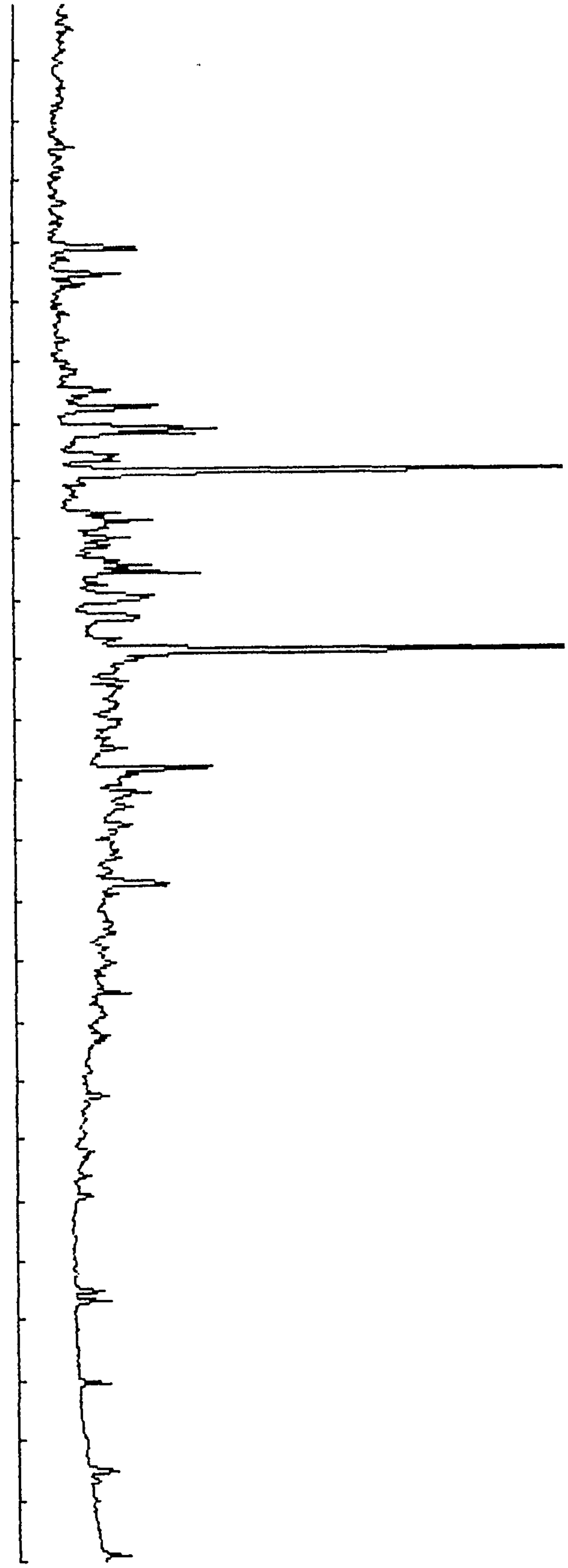
TIME 10.00



TIME 36.00

196f21
SCALE 40
OFFSET 4

TIME 10.00



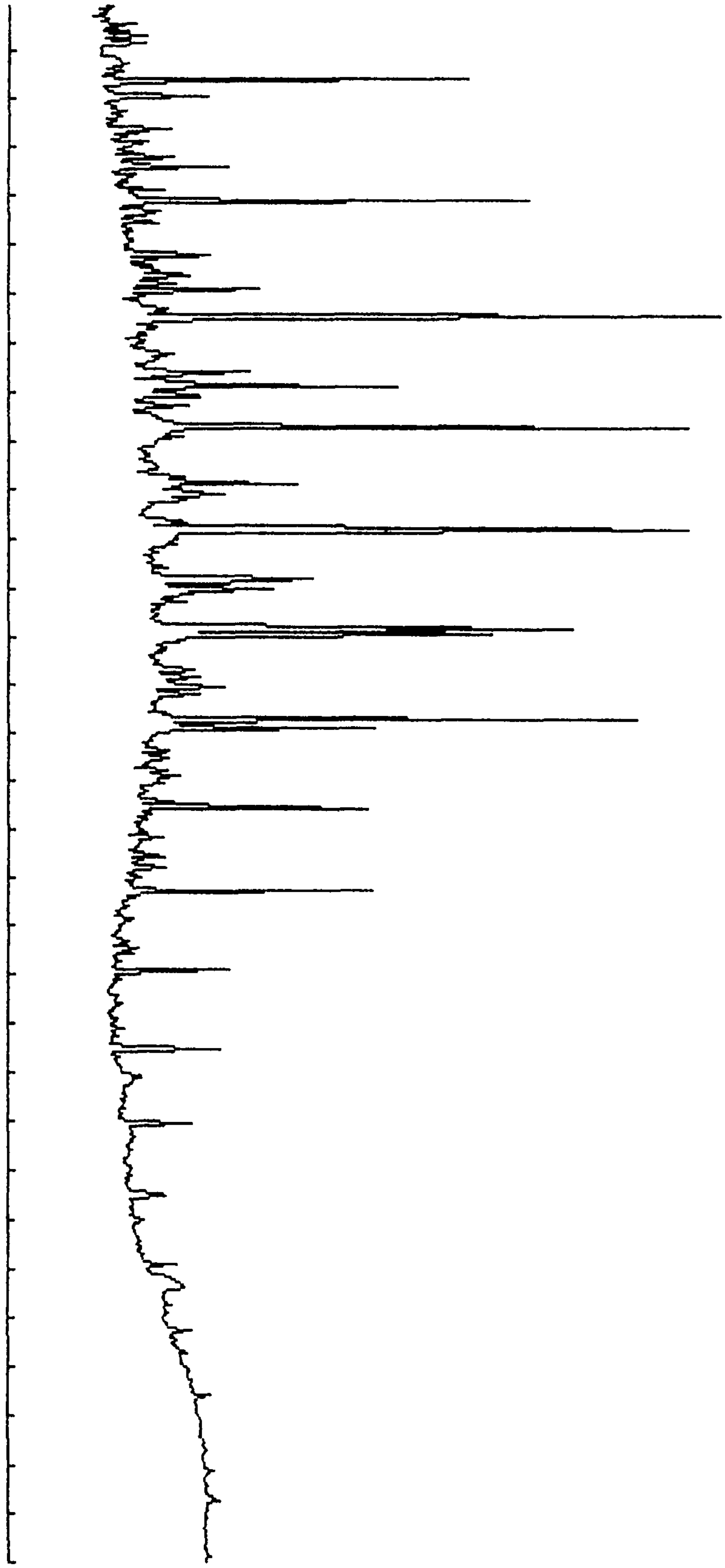
TIME 36.00

fig. 24

197F11
SCALE 75
OFFSET 2

TIME 10.00

#017197 F-1



TIME 42.00

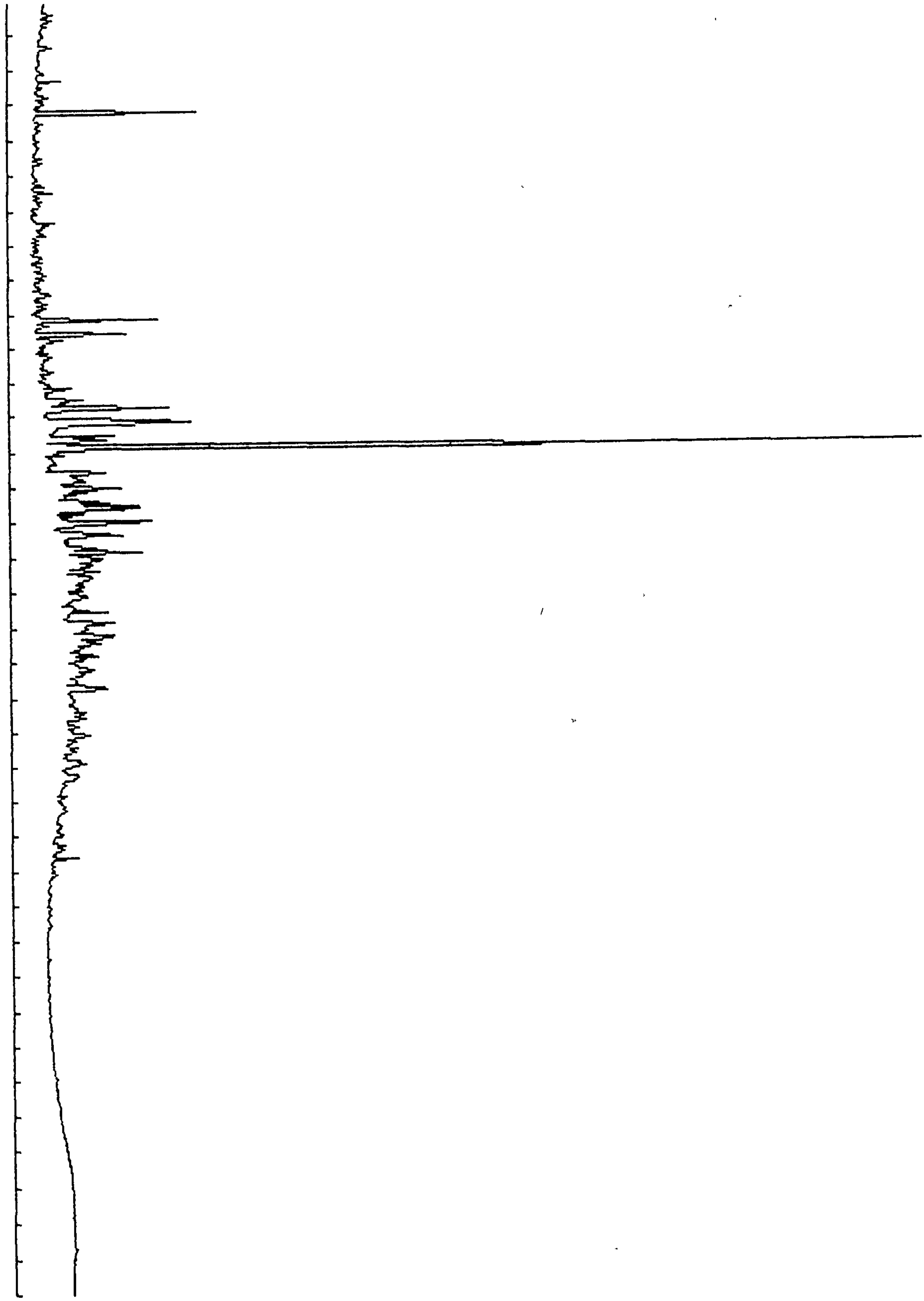
METHOD: PORT ANGELES RECORDED IN FILE: A:bna .MET

pg. 25

197F23
SCALE 200
OFFSET 2

TIME 5.00

Ecology Lab # 017197 F-2



TIME 42.00

fig. 26

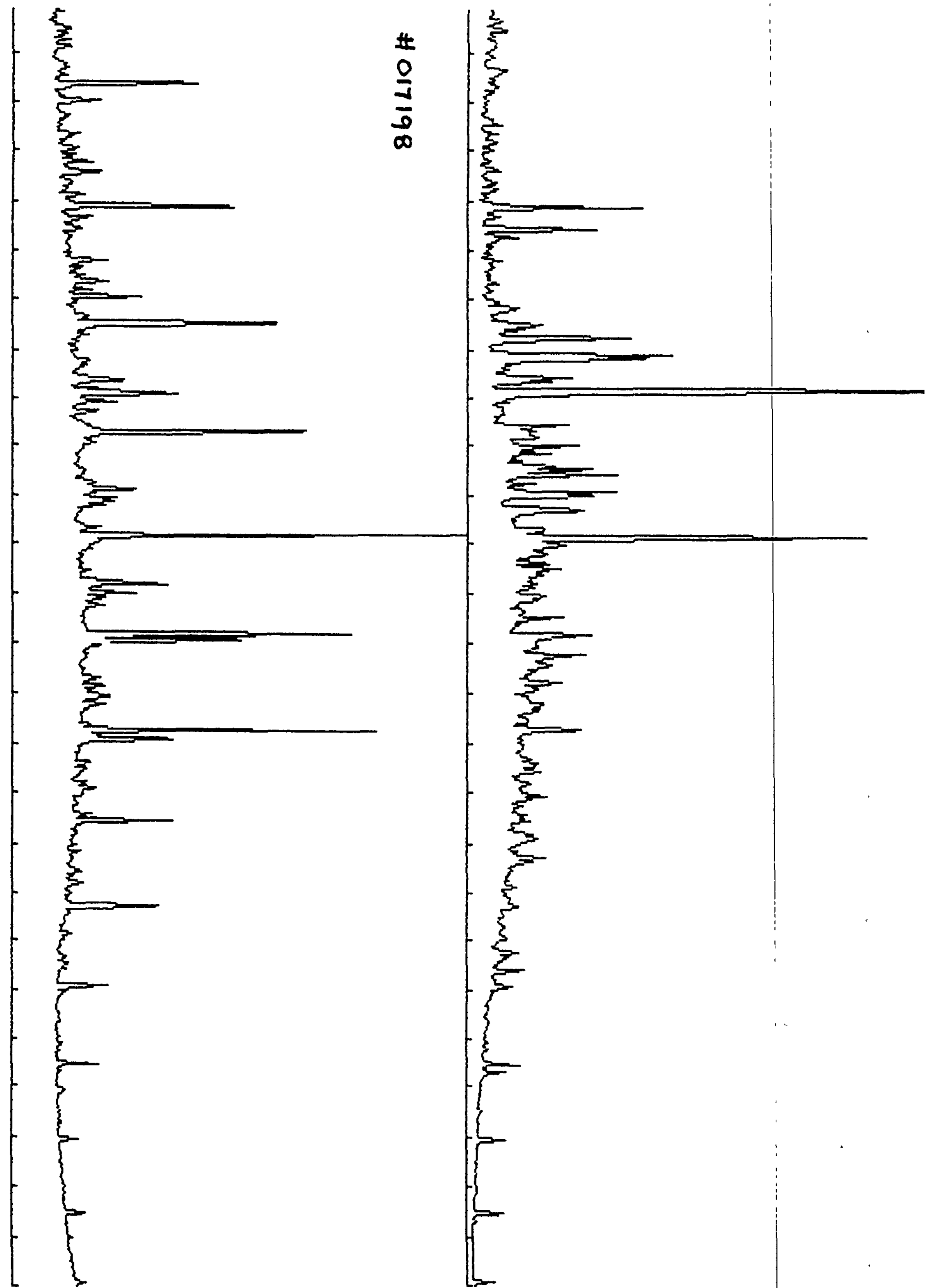

198f11
SCALE 50
OFFSET 3
TIME 10.00
TIME 36.00
198f21
SCALE 30
OFFSET 1
TIME 10.00
TIME 36.00
#017198

fig. 27

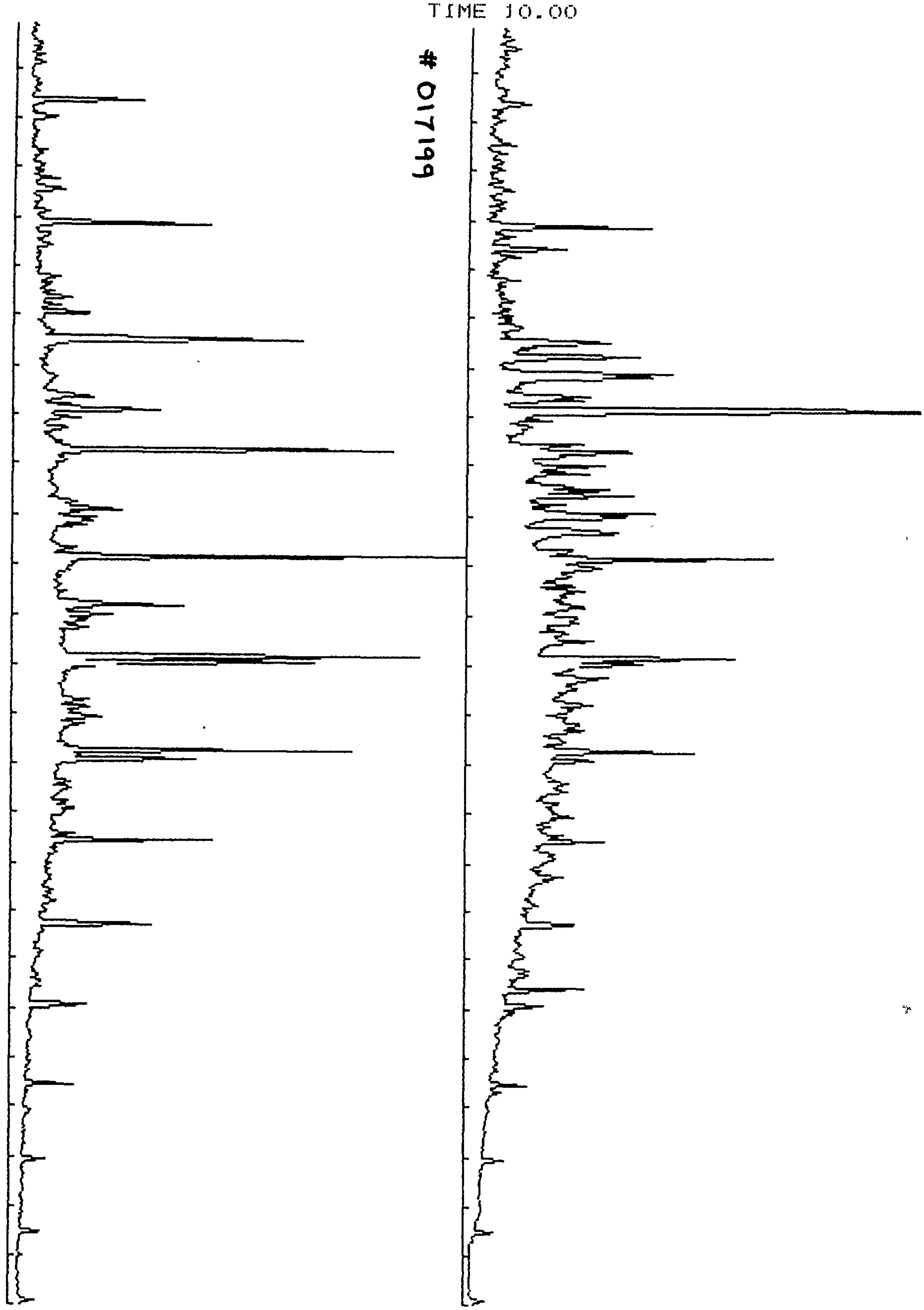
199f11
SCALE 75
OFFSET 1

TIME 10.00

199f21
SCALE 20
OFFSET 1

TIME 10.00

017199



TIME 36.00

TIME 36.00

fig 28

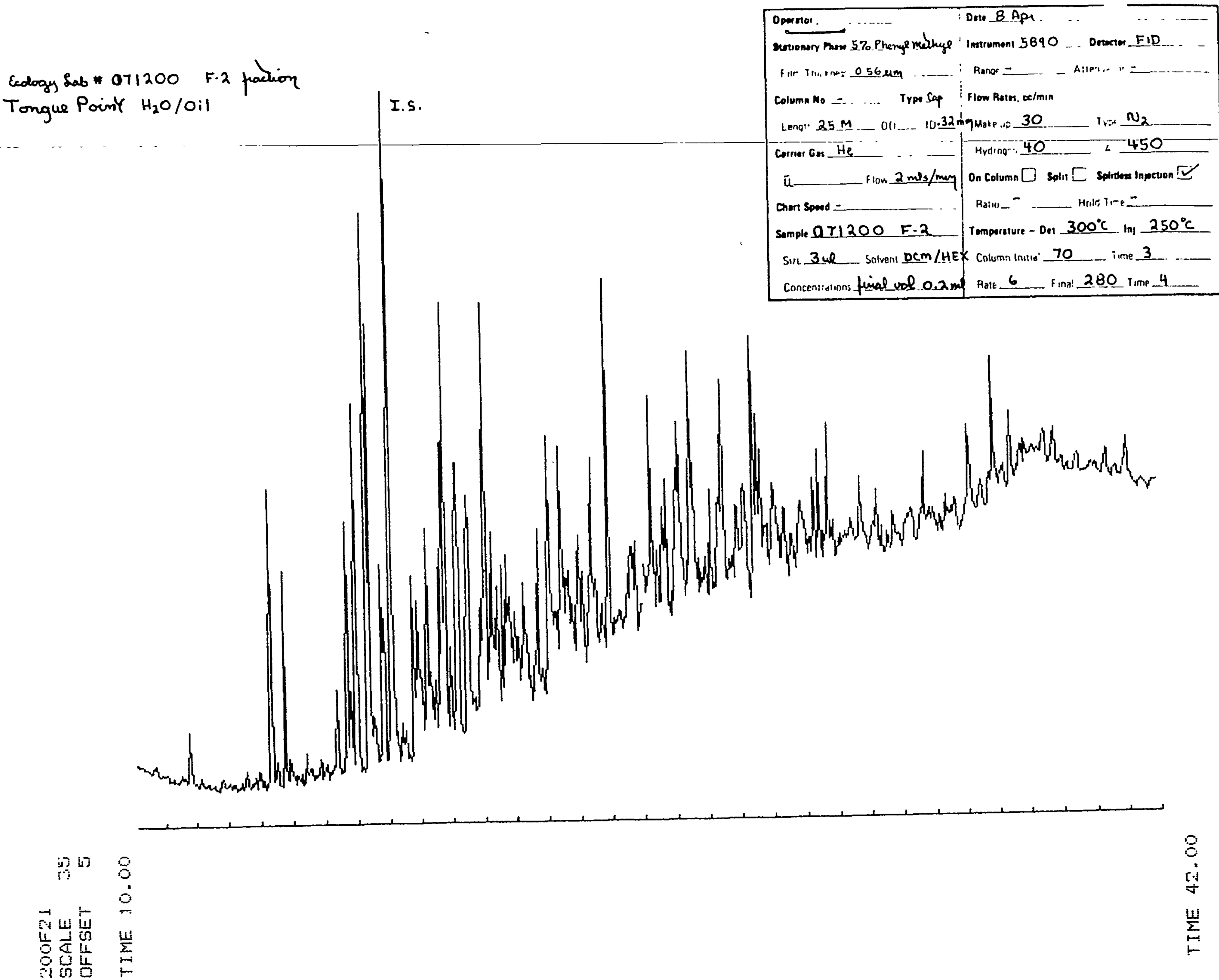

Ecology Lab # 071200 F-2 fraction
Tongue Point H_2O/Oil
I.S.
Operator
Date 8 Apr
Stationary Phase 5% Phenyl Methyl
Instrument 5890
Detector FID
Film Thickness 0.56 um
Range -
Column No -
Type Cap
Flow Rates, cc/min
Length 25 M
ID .32 mm
Make up 30
Type N_2
Carrier Gas He
Hydrogen 40
450
Flow 2 mls/min
On Column
Split
Splitless Injection ✓
Chart Speed -
Ratio -
Hold Time -
Sample 071200 F-2
Temperature – Det 300°C
Inj 250°C
Size 3 ul
Solvent DCM/HEX
Column Initial 70
Time 3
Concentrations final vol 0.2 ml
Rate 6
Final 280
Time 4
200F21
SCALE 35
OFFSET 5
TIME 10.00
TIME 42.00

fig 29

#017187

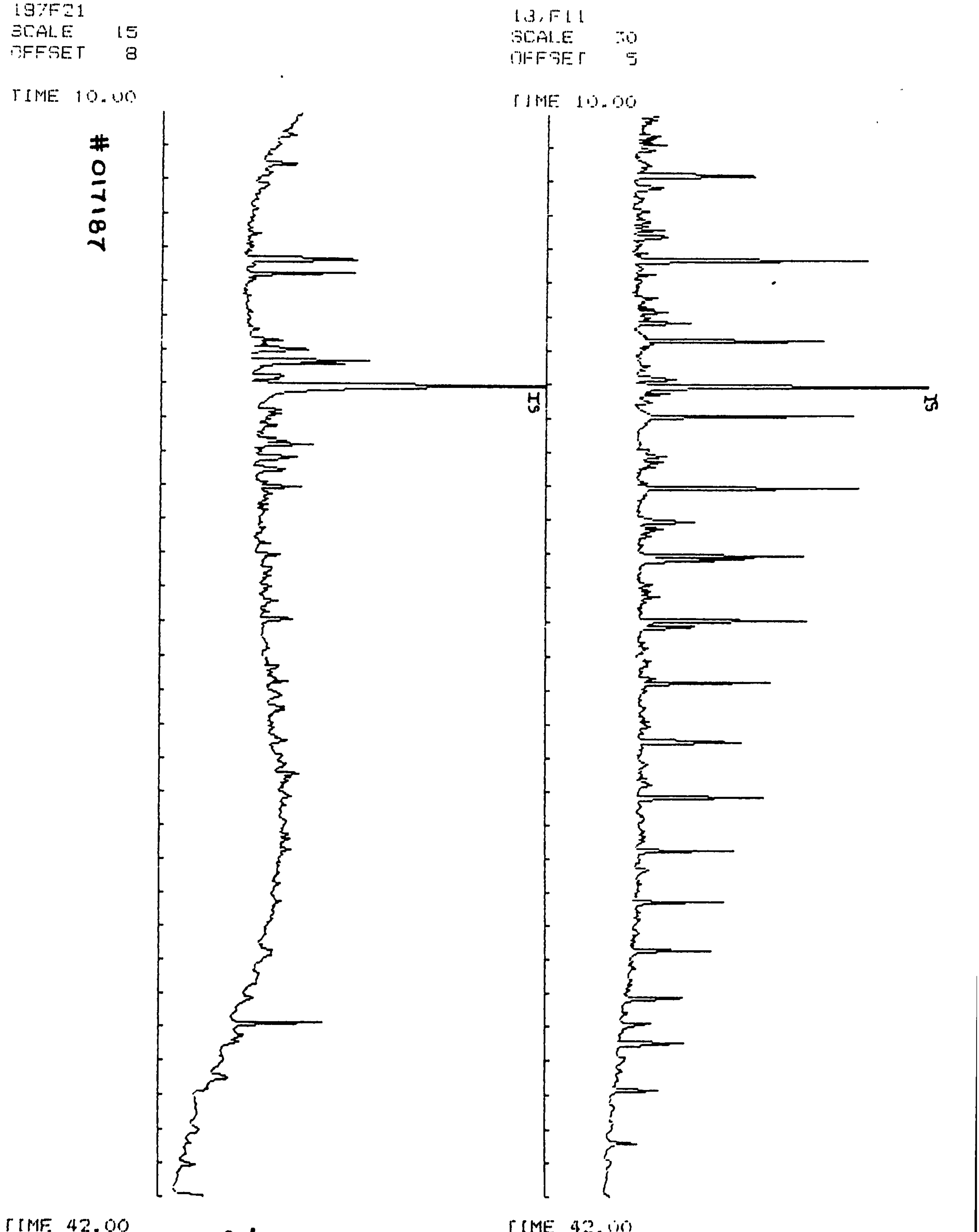
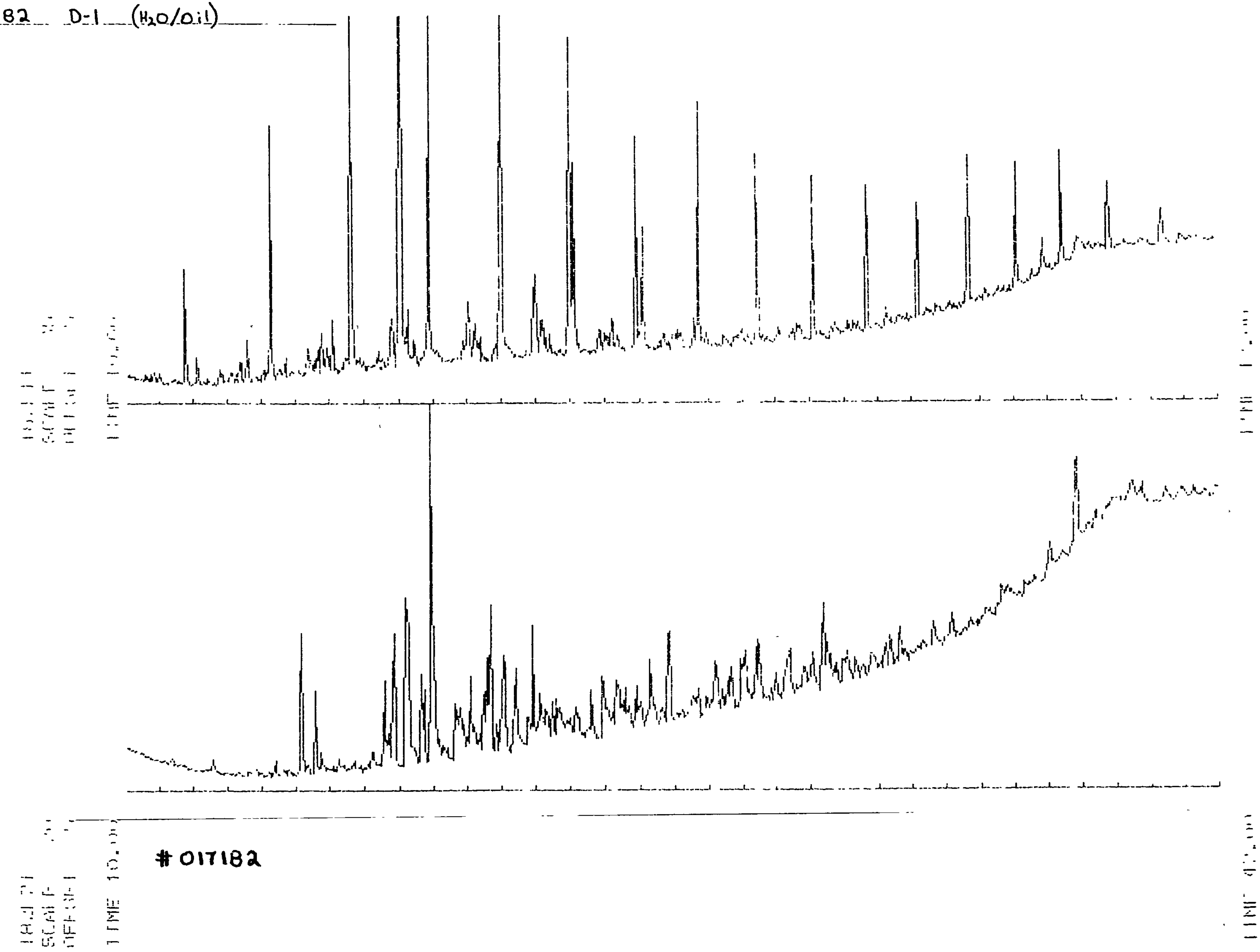


fig. 13

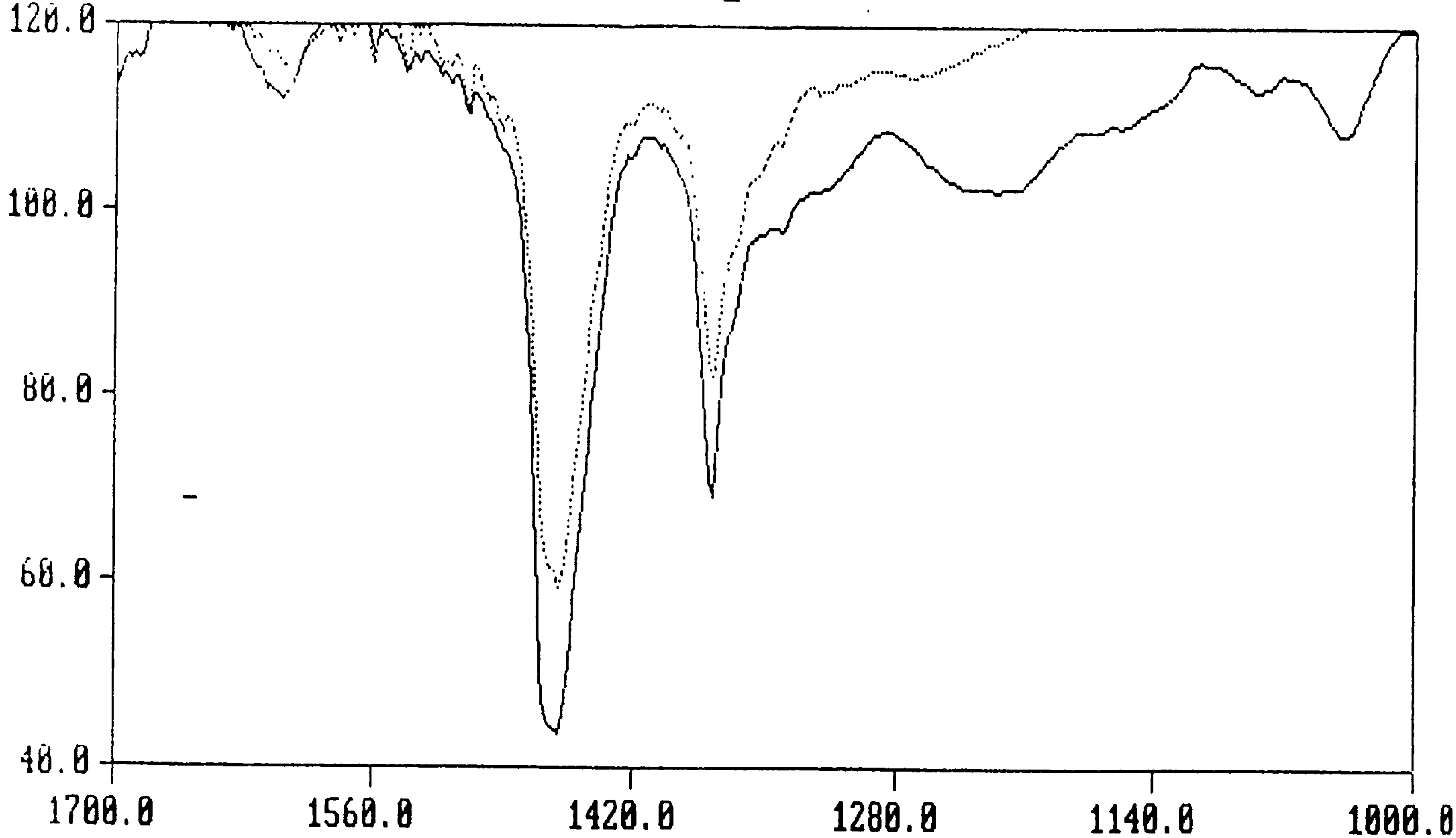
017182 D-1 (H_2O/Oil)



#017182

fig. 12

Sample



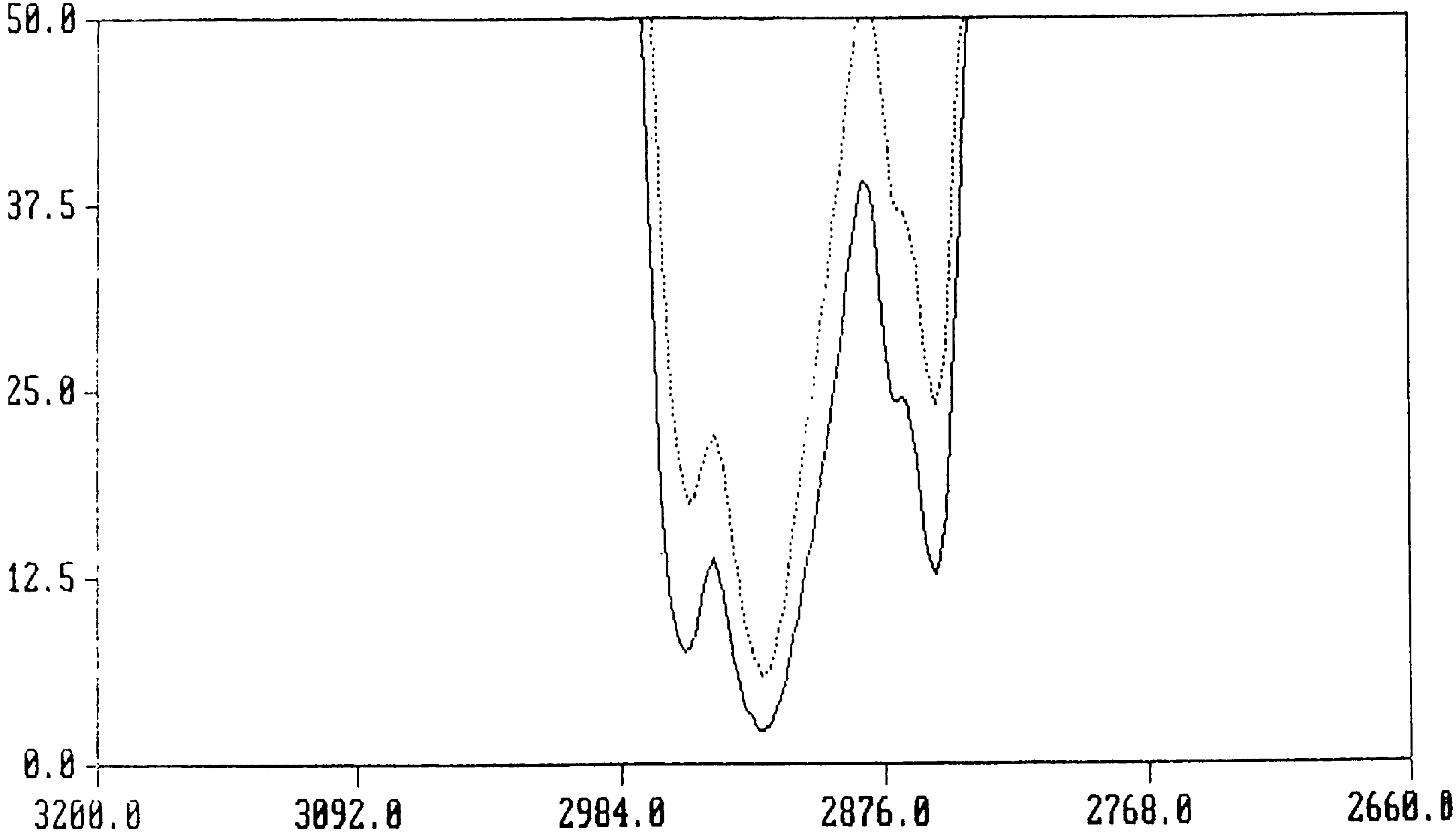
OPERATOR: MISSIE

SAMPLE: ARABIAN LIGHT/REF PRUDHOE BAY

FORM: PLOTS OVERLAY_

SCANS: 32 RESOLUTION: 4 cm -1 DATE: 6/04/86

Sample



OPERATOR: MISSIE

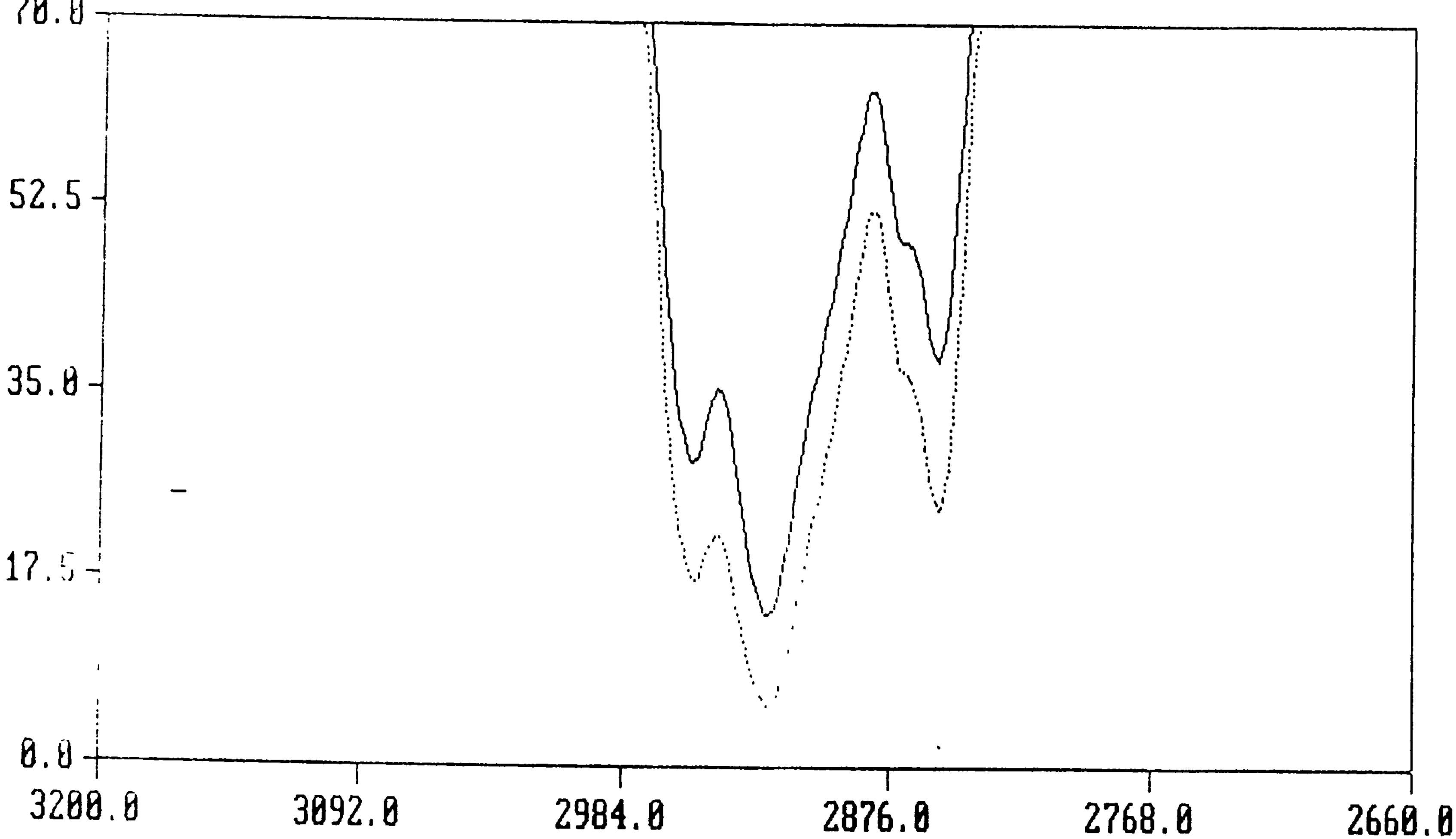
SAMPLE: ARABIAN LIGHT/REF PRUDHOE BAY

FORM: ~~PLOTS OVERLAY~~_

SCANS: 32 RESOLUTION: 4 cm -1 DATE: 6/04/86

Fig. 10

Sample



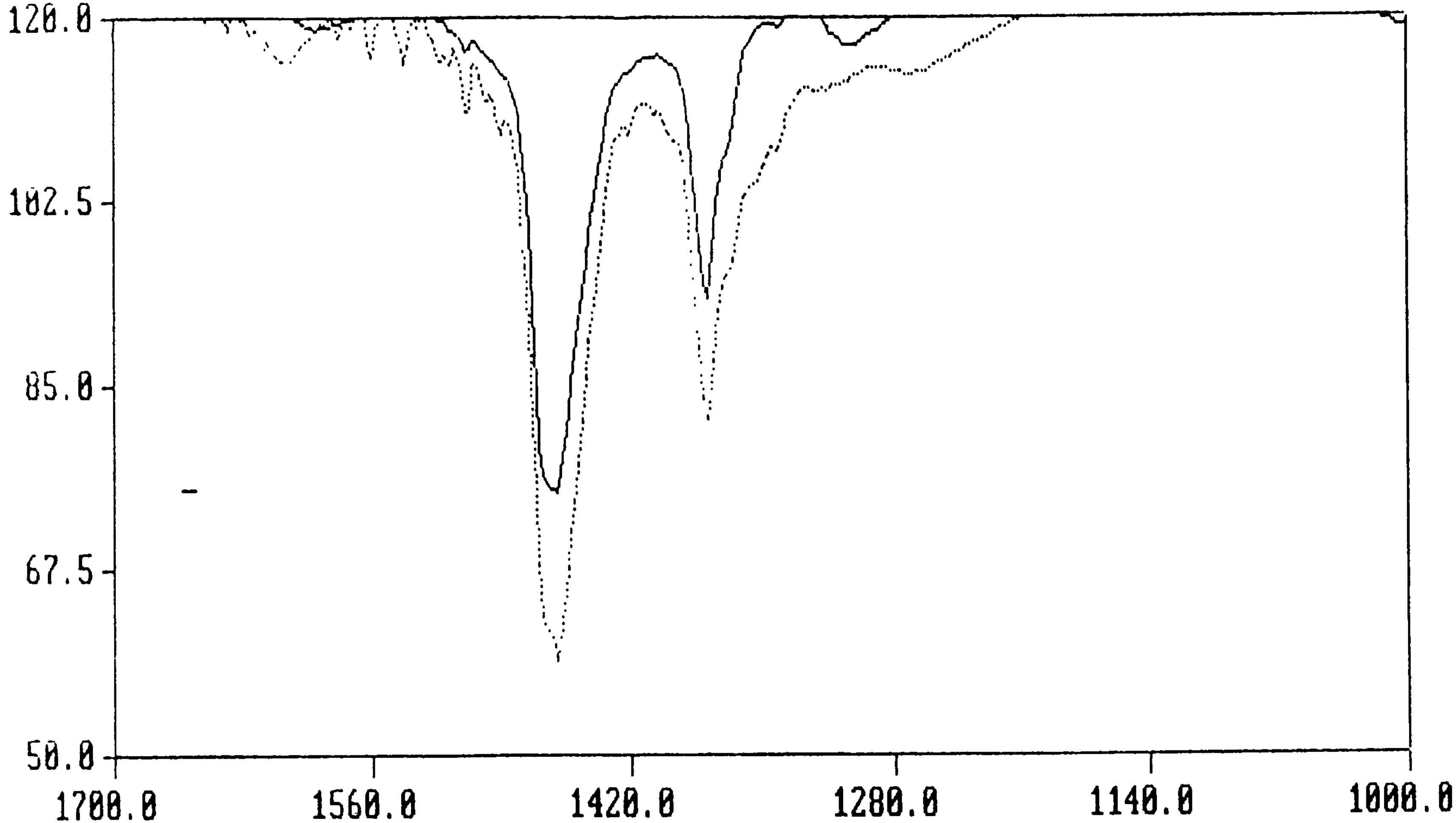
OPERATOR: MISSIE

SAMPLE: SO LA CRUDE OIL/REF PRUDHOE BAY

FORM: PLOTS OVERLAY_

SCANS: 32 RESOLUTION: 4 cm -1 DATE: 6/04/86

Sample



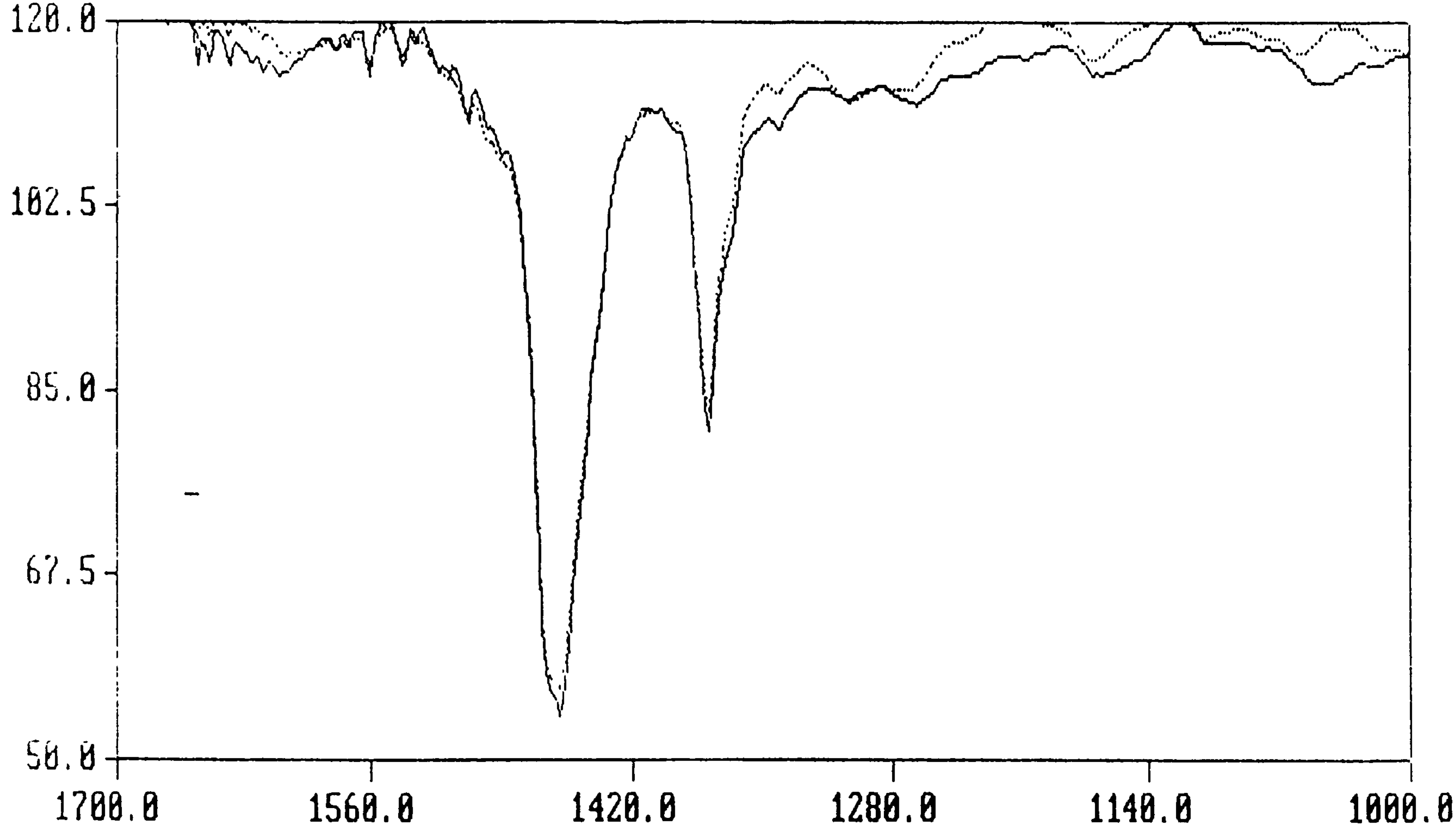
OPERATOR: MISSIE

SAMPLE: SO LA CRUDE OIL/REF PRUDHOE BAY

FORM: PLOTS OVERLAY_

SCANS: 32 RESOLUTION: 4 cm -1 DATE: 6/04/86

Sample



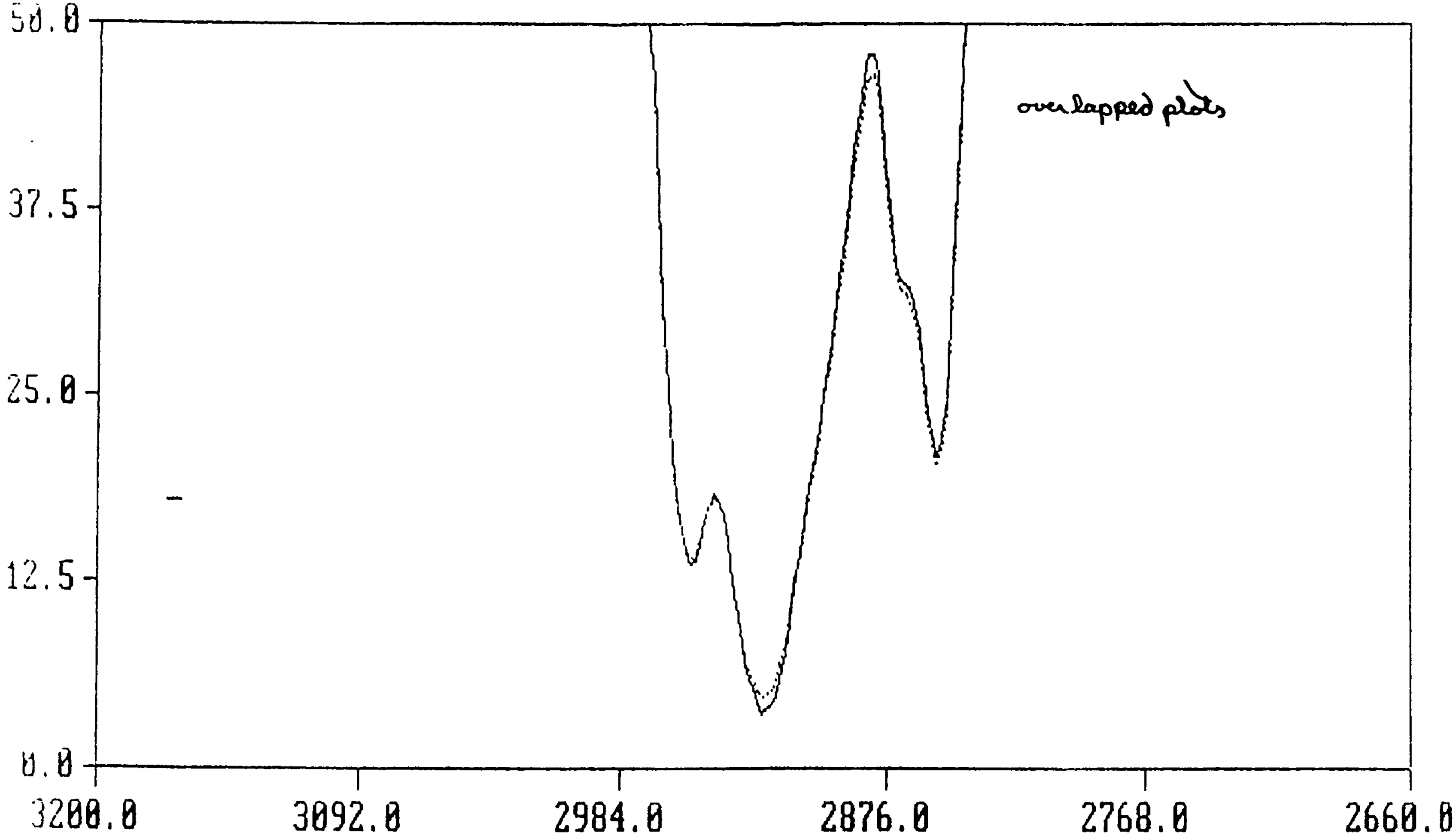
OPERATOR: MISSIE

SAMPLE: ARCO OIL/REF PRUDHOE BAY

FORM: PLOTS OVERLAYED

SCANS: 32 RESOLUTION: 4 cm -1 DATE: 6/04/86

Sample



OPERATOR: MISSIE

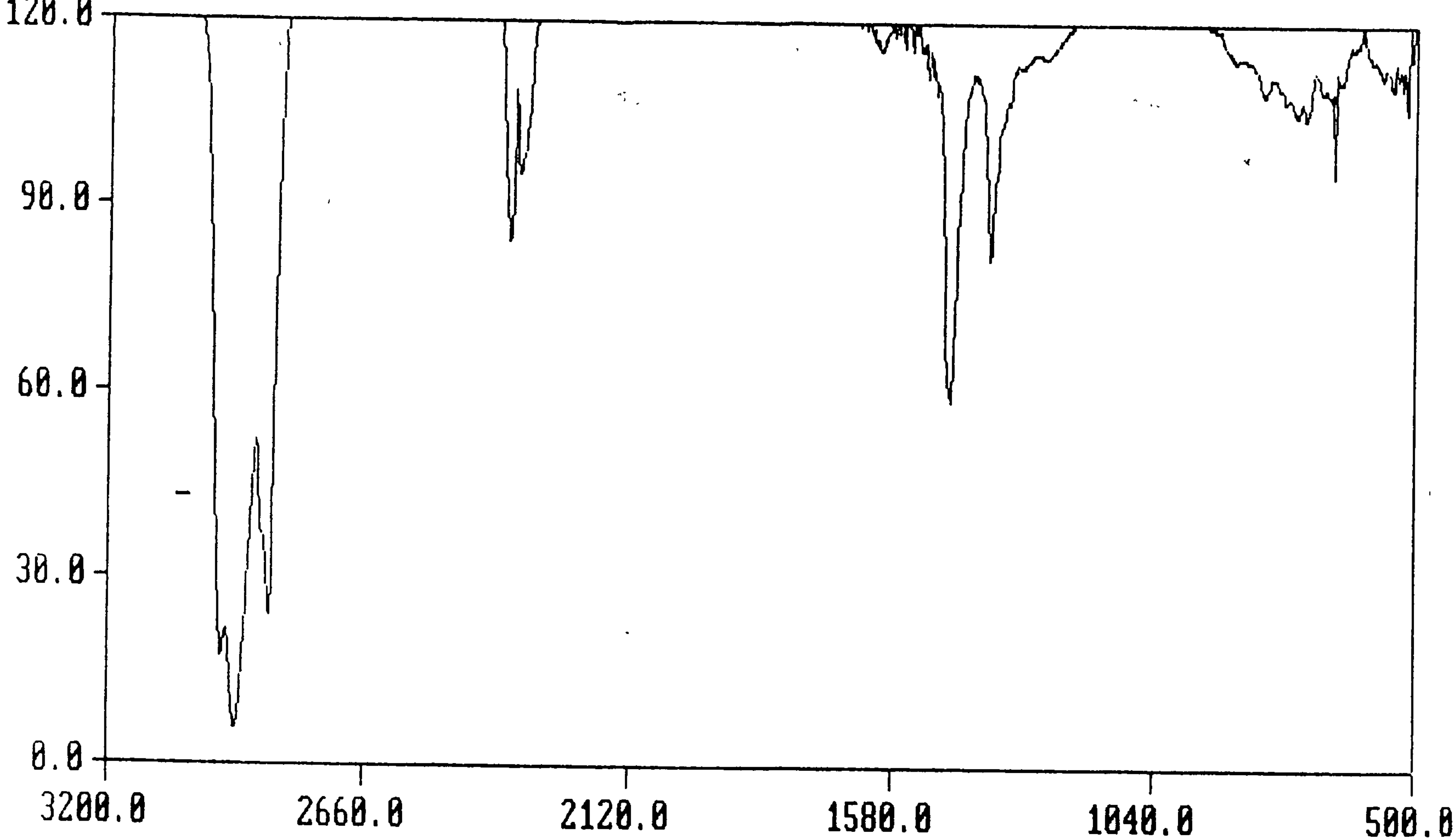
SAMPLE: ARCO OIL/REF PRUDHOE BAY

~~FORM: PLOTS OVERLAYED~~

SCANS: 32 RESOLUTION: 4 cm -1 DATE: 6/04/86

JS 6

Sample



OPERATOR: MISSIE

SAMPLE: PRUDHOE BAY OIL

FORM: _

SCANS: 32

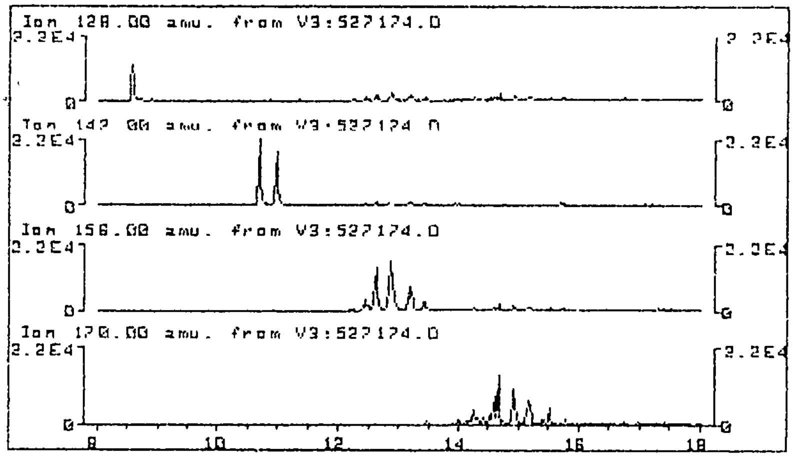
RESOLUTION: 4 cm -1

DATE: 6/04/86

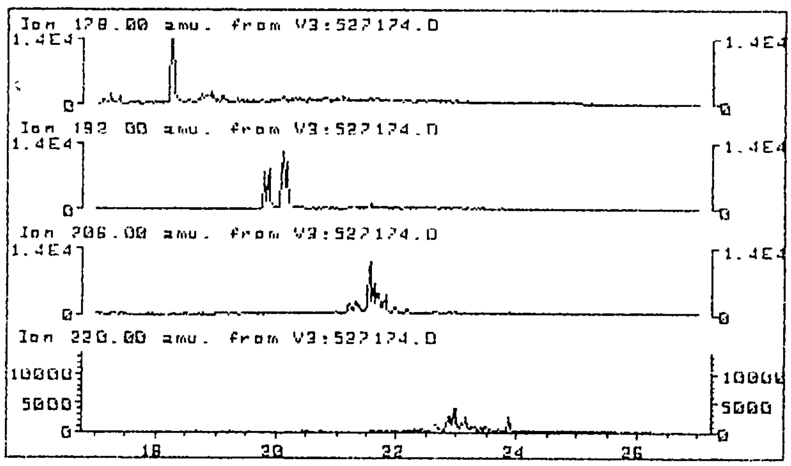
Fig. 5

fig 4

NAPHTHALENE'S



PHENANTHRENE'S



DIBENZOTHIOPHENE'S

area = 378456

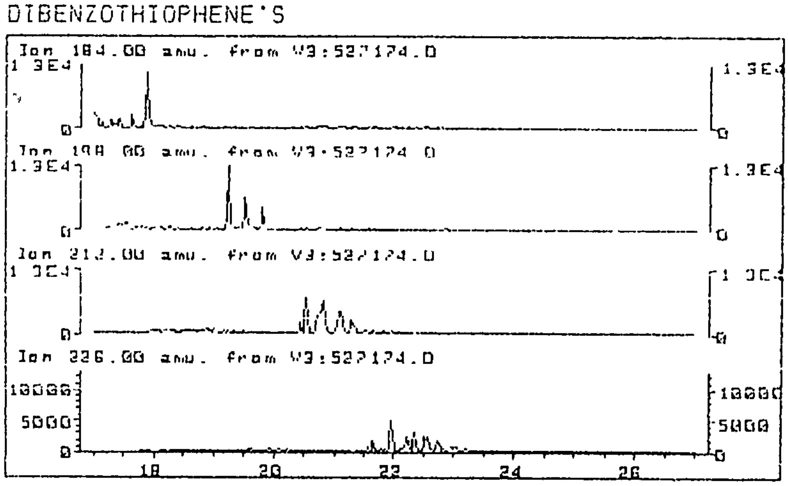


fig 3

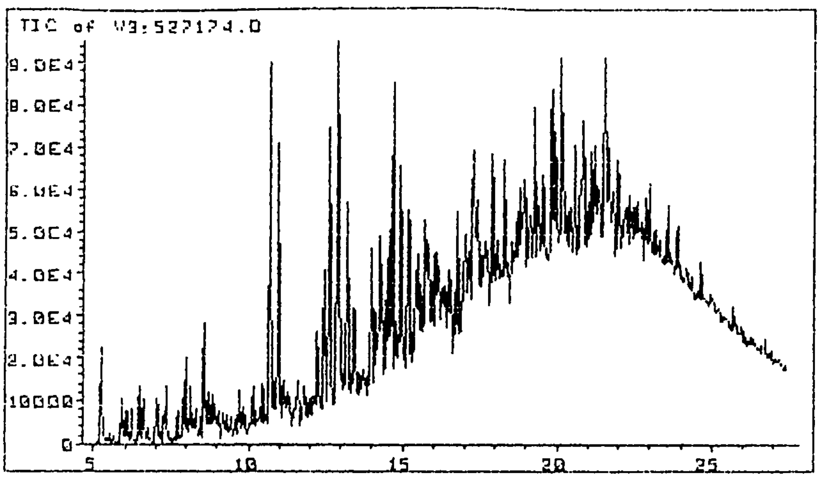
Characterization of ARCO ref. oil by high resolution GC/MS

Data file: V3:527174.D
File type: GC / MS DATA FILE

Name Info: * 527174 F-2 FRACTION
Misc Info:
Operator : CB HENRY

Date : 21 Mar 86 6:15 am
Instrment: MS_5970
Inlet : GC

Sequence index : 0
Als bottle num : 0
Replicate num : 0

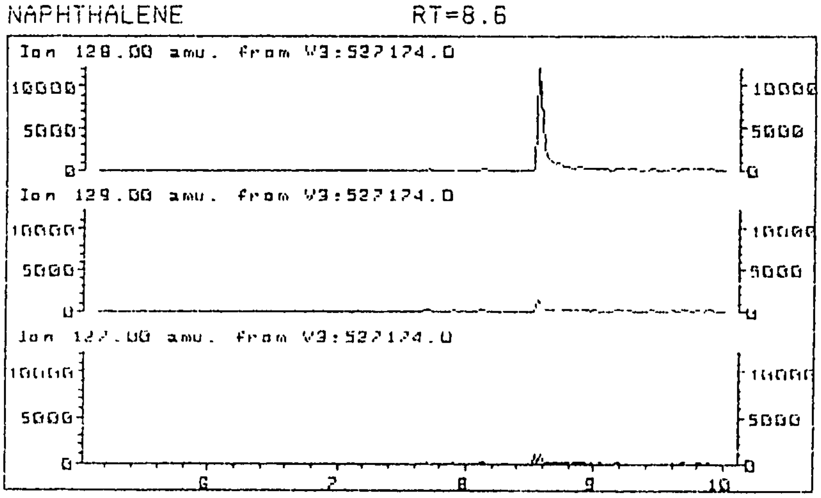


Extracted Ion Profiles

NAPHTHALENE RT=8.6

A- 373210

abundance



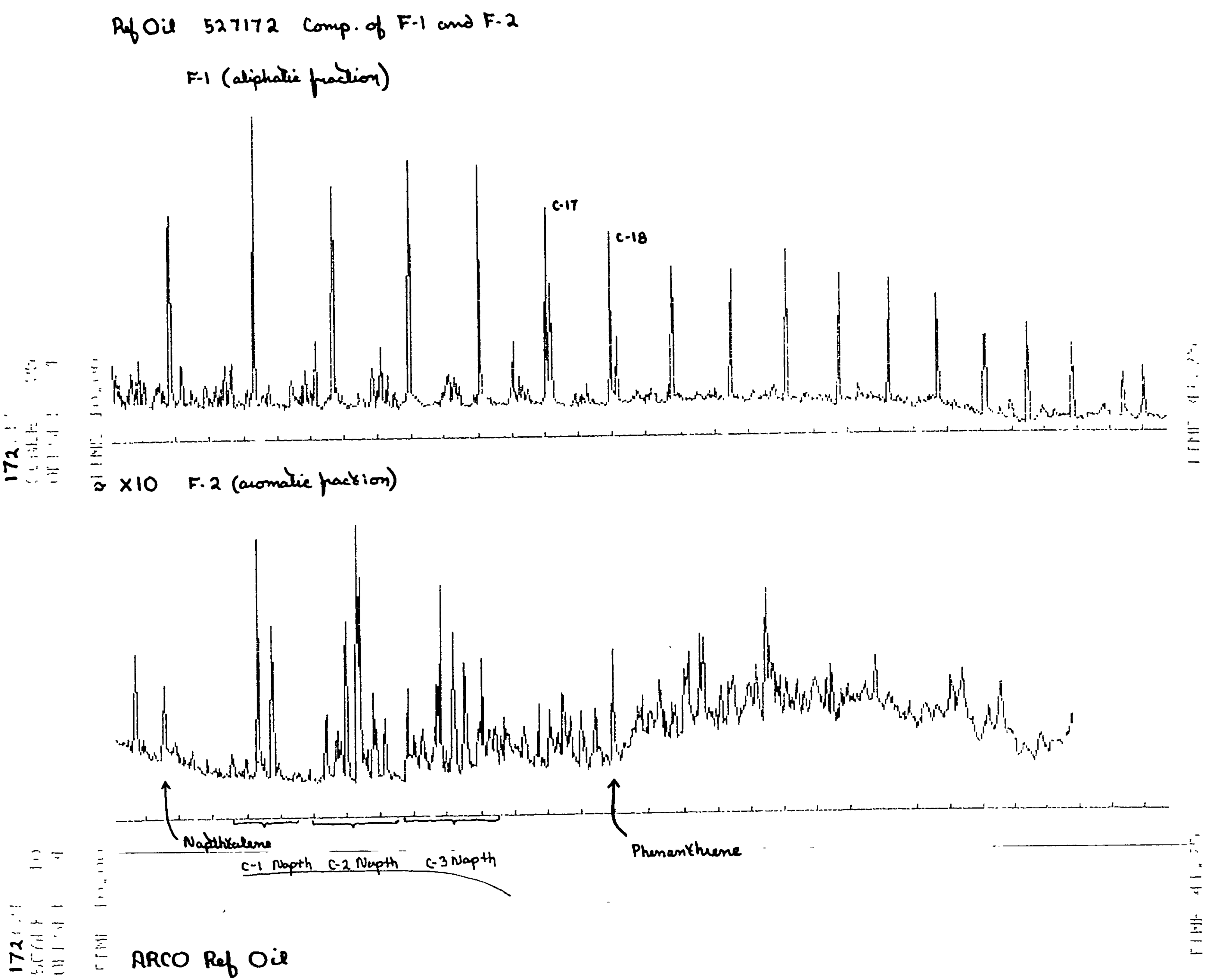

Ref Oil 527172 Comp. of F-1 and F-2
F-1 (aliphatic fraction)
C-17
C-18
X10 F-2 (aromatic fraction)
Napthalene
C-1 Napth
C-2 Napth
C-3 Napth
Phenanthrene
ARCO Ref Oil

fig. 2

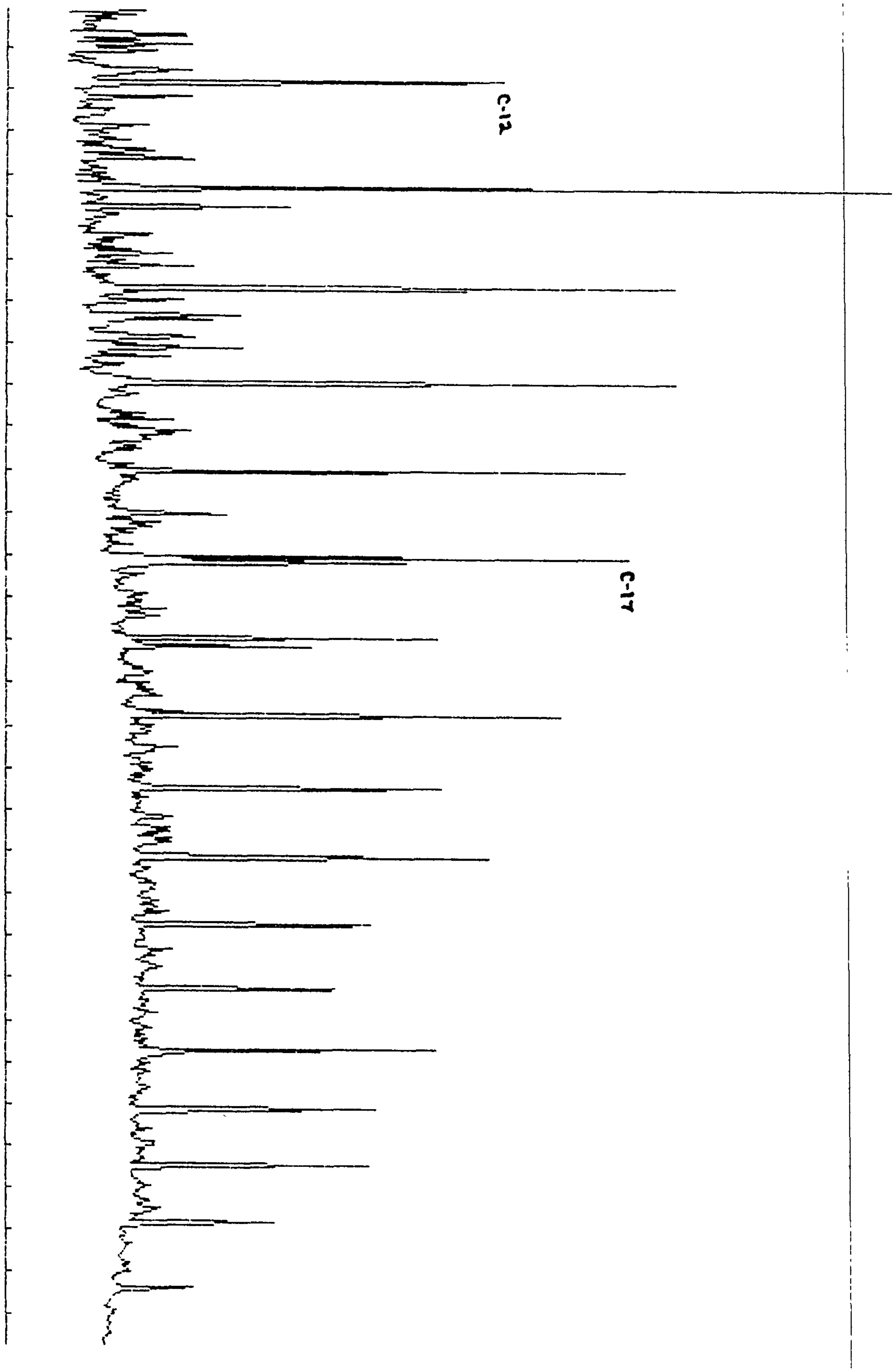
Ecology Lab No.	Location	Sample Type	Collection Date
86187056	Elwha River E.	Sediment	4/28/86
86187057	Elwha River E.	Sediment	4/28/86
86187058	Elwha River E.	Sediment	4/28/86
86187059	Elwha River E.	Moon Snail	4/28/86
86187060	Freshwater Bay	Sediment	4/28/86
86187061	Freshwater Bay	Bentnose Clams	4/28/86
86187062	Freshwater Bay	Rock Crab	4/28/86
86187063	Freshwater Bay	Horse Clams	4/28/86
86187064	Observatory Point	Sediment	4/28/86
86187065	Ediz Hook (Old Dock)	Mussels (2)	4/28/86
**86187066	Near Crown Z.	H_2O	4/28/86
**86187067	Near Crown Z.	Dungeness Crabs (5)	4/29/86
**86187068	Near T-Bird	Dungeness Crabs (5)	4/29/86
**86187069	Near Merrill Ring	Dungeness Crabs (5)	4/23/86
**86187070	Dungeness Spit	Dungeness Crabs (5)	4/16/86
86187071	Ediz Hook (TR1)	Clams	4/28/86
*86187072	Freshwater Bay	Sediment	4/28/86
86187073	Freshwater Bay	Sediment	4/28/86
86187074	Freshwater Bay	Sediment	4/28/86
**86187075	Freshwater Bay	Purple Urchin (spines)	4/28/86
**86187076	Freshwater Bay	Purple Urchin (no spines)	4/28/86
**86187077	Dungeness Spit (3B)	H_2O	4/27/86
**86187078	Dungeness Spit (3B)	Sediment	4/27/86
*86187079	Dungeness Spit (19B)	Sediment	4/27/86
**86187080	Dungeness Spit (32T)	Sediment	4/27/86
*86187081	Near Radar Tower	Butter Clams	4/28/86
*86187082	Near Radar Tower	Mussels	4/28/86
*86187083	USCG Dock	Sediment	4/28/86
*86187084	Radar Tower	Sediment	4/28/86
*86187085	Ediz Hook	Sediment	4/28/86
*86187086	Ediz Hook (USCG Dock)	Clams	4/28/86
*86187087	Ediz Hook (TR1)	Sediment	4/28/86
*86187088	Ediz Hook (TR8)	Sediment	4/28/86
*86187089	Ediz Hook (TR11)	Sludge	4/28/86
*86187090	Ediz Hook (TR13)	H_2O	4/28/86
86187091	Ediz Hook (TR30)	Rocks	4/28/86
*86187092	Ediz Hook (TR31)	Oysters	4/28/86
86187093	Ediz Hook (TR31)	Horse and Butter Clams	4/28/86
86187094	Ediz Hook (TR5)	Healthy Sand Lance	4/28/86
86187095	Ediz Hook (TR1)	Clam	4/28/86
86187096	Ediz Hook (TR8)	Clam, Crab	4/28/86
**86187097	Angeles Point	Butter Clams	4/09/86

SCALE 115
OFFSET 0

TIME 10.00

Ref Oil 527171
neat (diluted)

Ref ARCO Oil
Ecology Lab # 527171
hexane soluble fraction



TIME 41.75

Fig. 1

12.0 APPENDIX IV

MISCELLANEOUS REPORTS AND DATA

FOR THE ARCO ANCHORAGE OIL SPILL MRDA

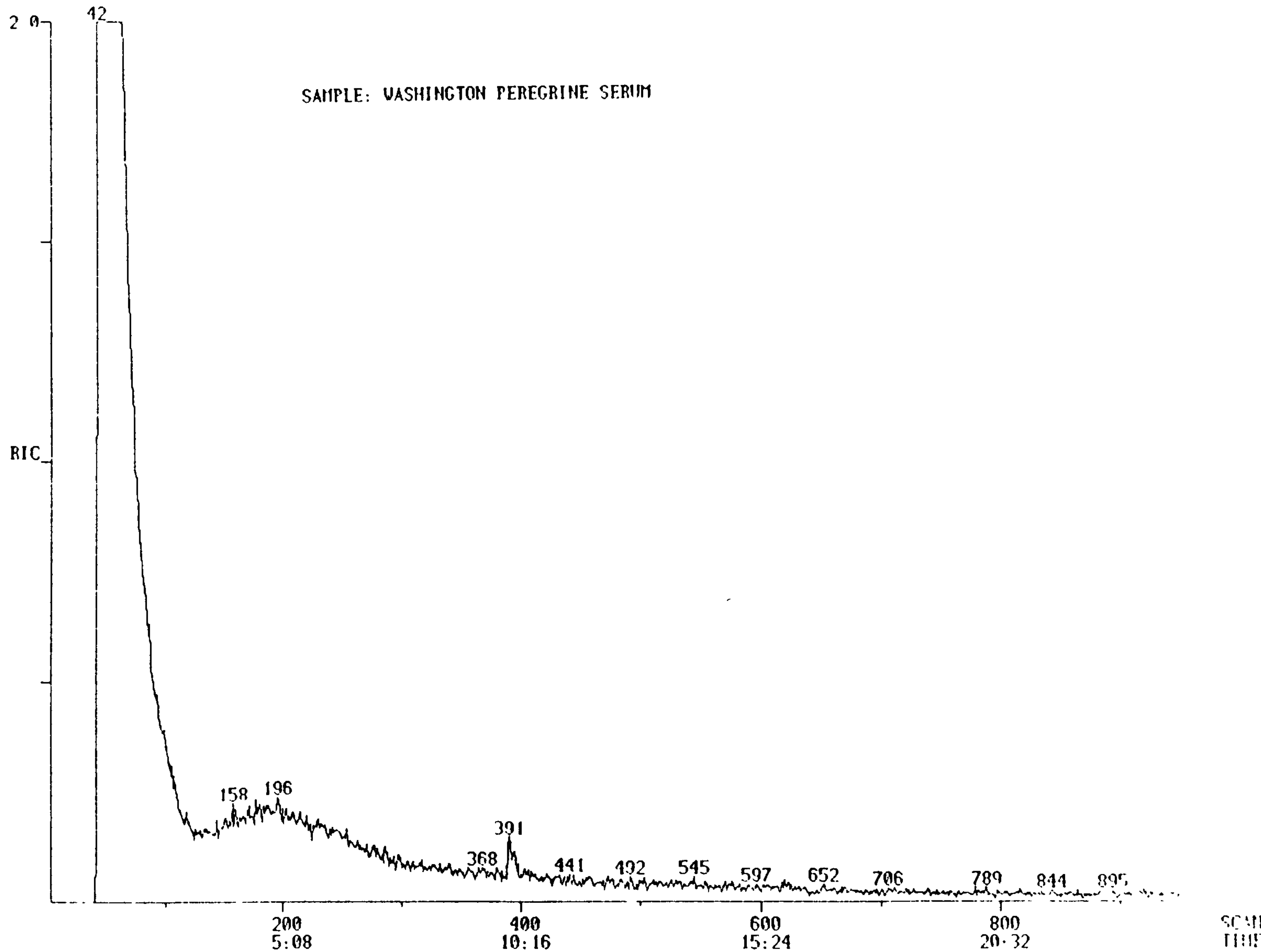


Figure 12. Reconstructed ion chromatogram (RIC) of the hexane/dichloromethane extract of a serum sample from a Peregrine Falcon, immature female #1, Dec. 30, 1985.

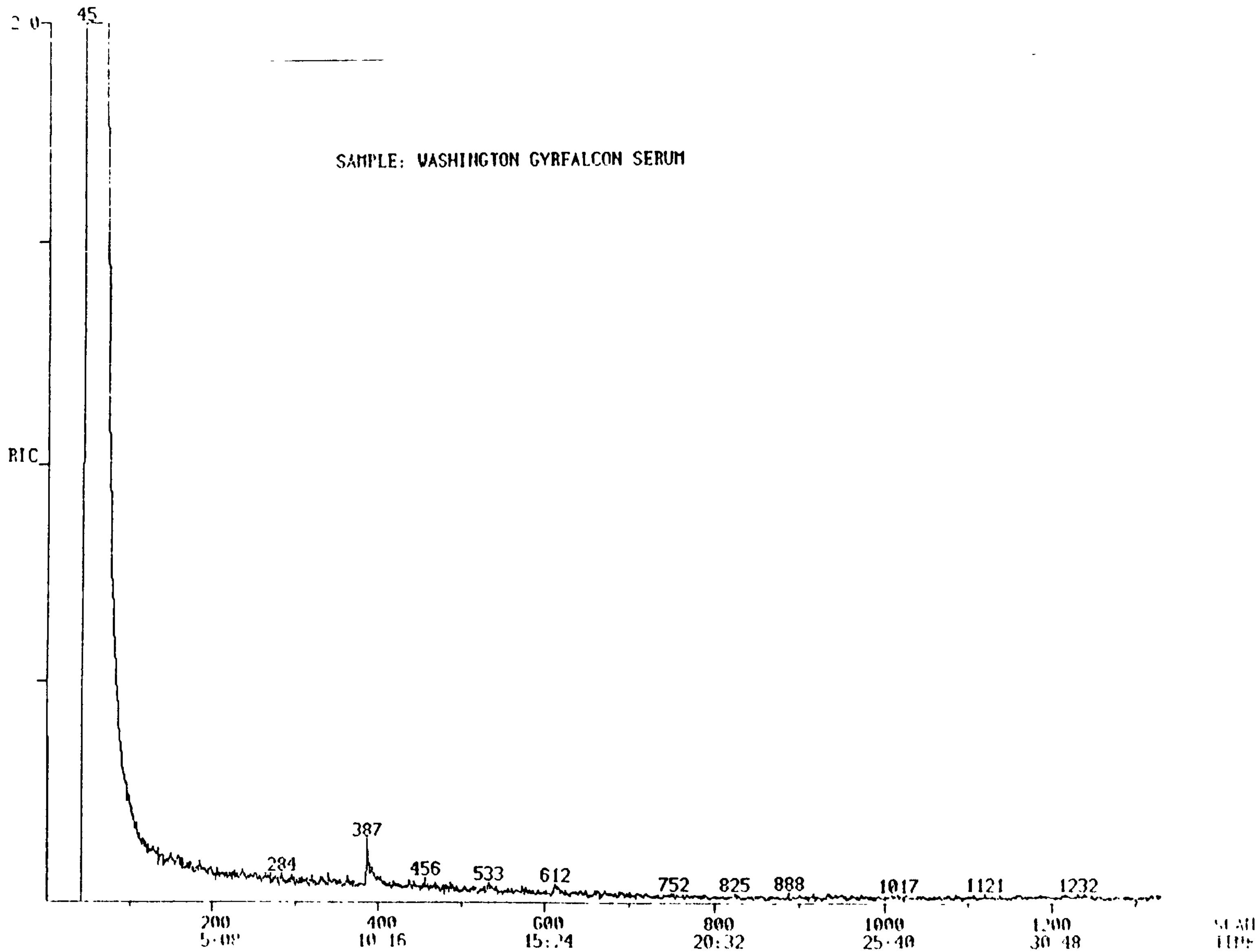


Figure 11. Reconstructed ion chromatogram (RIC) of the hexane/dichloromethane extract of a serum sample from a Gyrfalcon, female, Jan. 21, 1986.

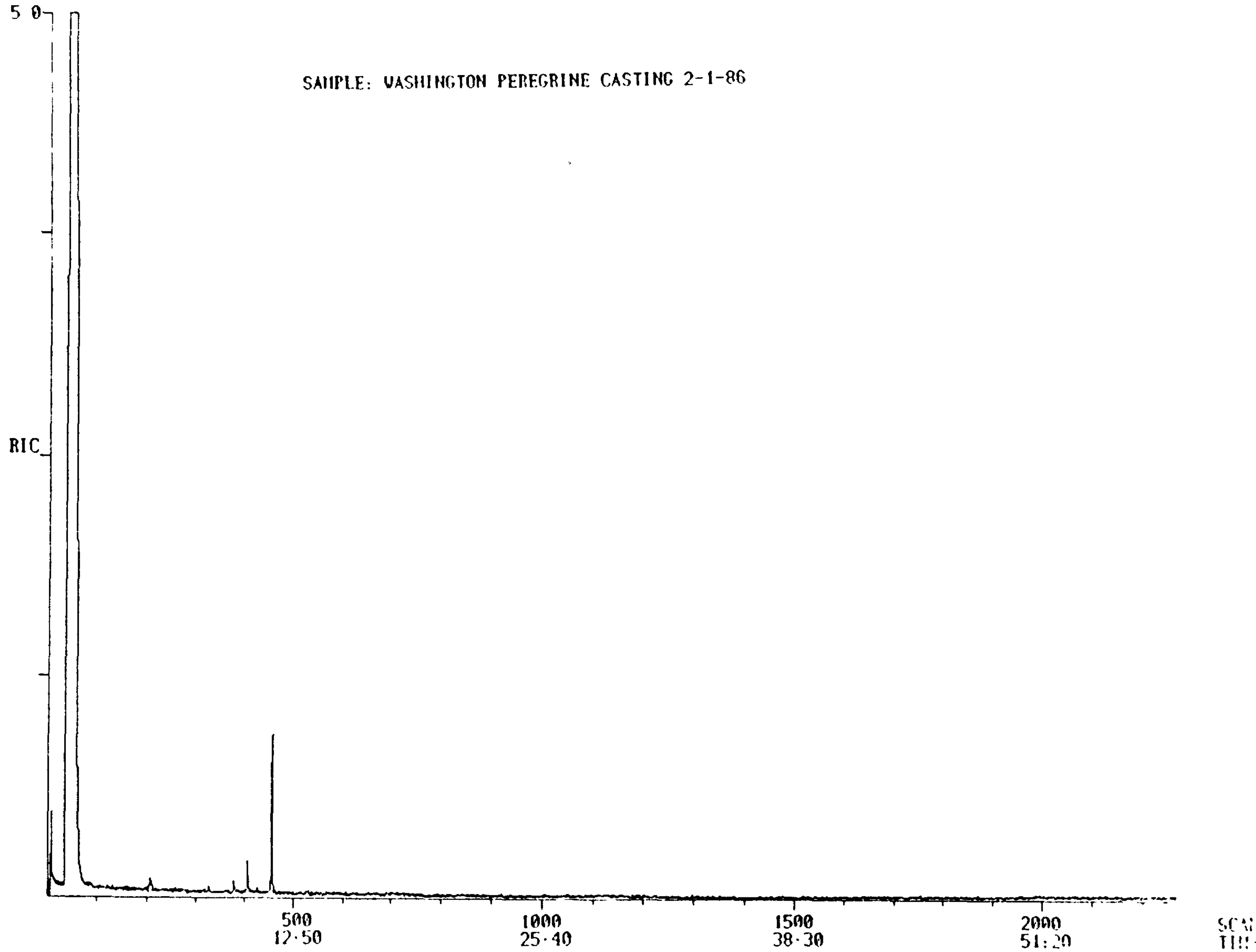


Figure 10. Reconstructed ion chromatogram (RIC) of the hexane/dichloromethane extract of a casting of adult female "Dungeness" Peregrine Falcon from 2/1/86.

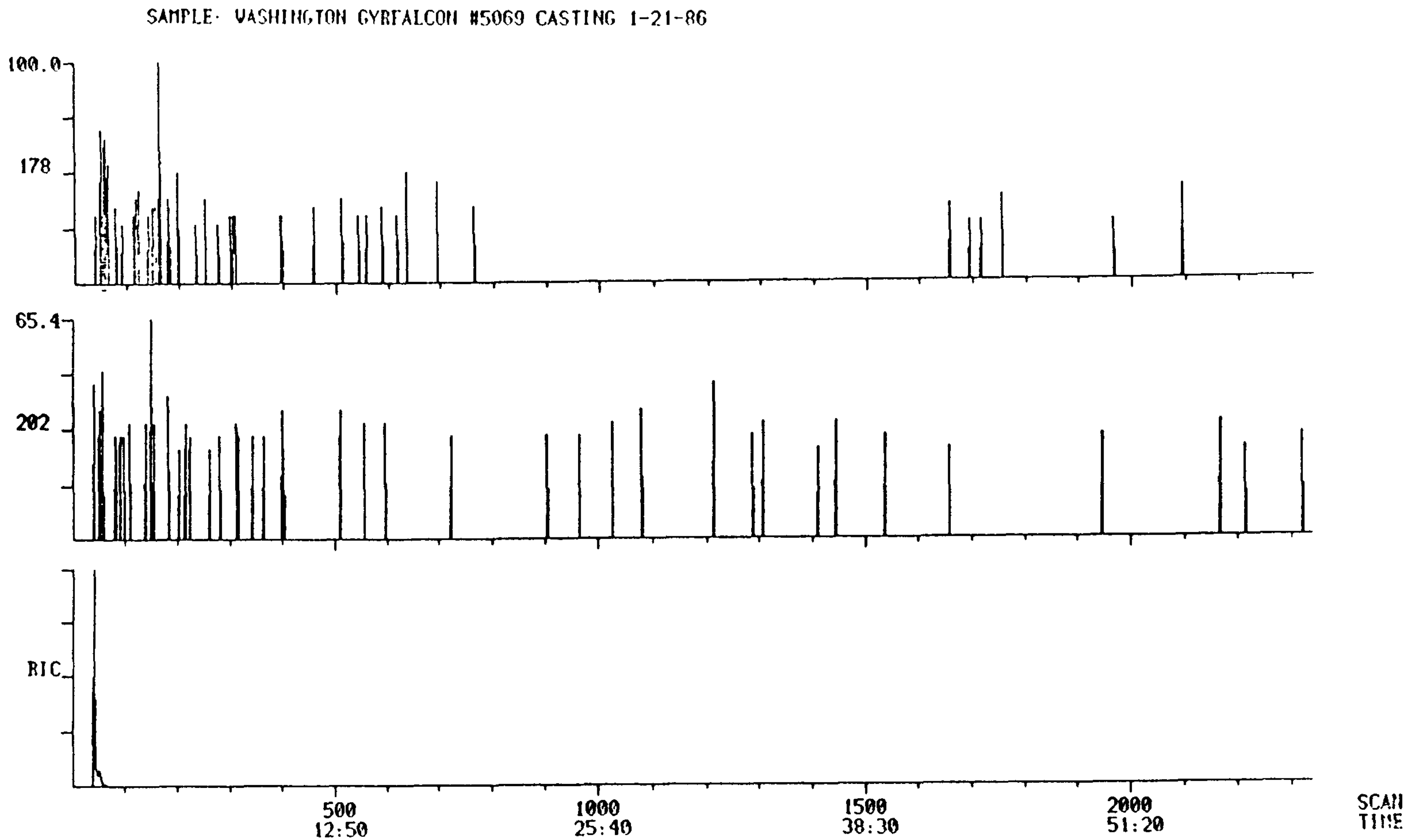


Figure 9. Unexpanded RIC and mass chromatograms of the hexane/dichloromethane extract of a casting of Gyrfalcon 5069 from 1/21/86. Chromatograms of masses 178 and 202 plus RIC.

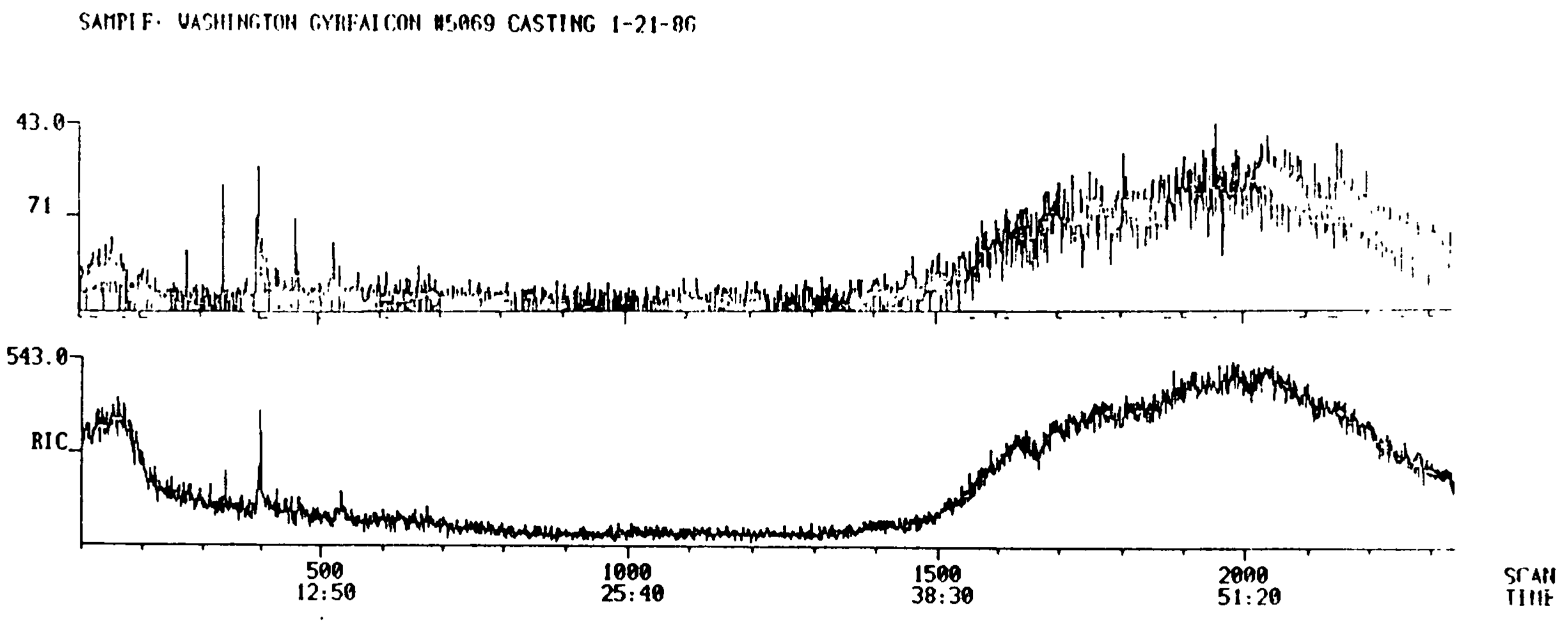


Figure 8. 20X expanded RIC and mass 71 chromatogram of the hexane/dichloromethane extract of a casting of Gyrfalcon 5069 from 1/21/86.

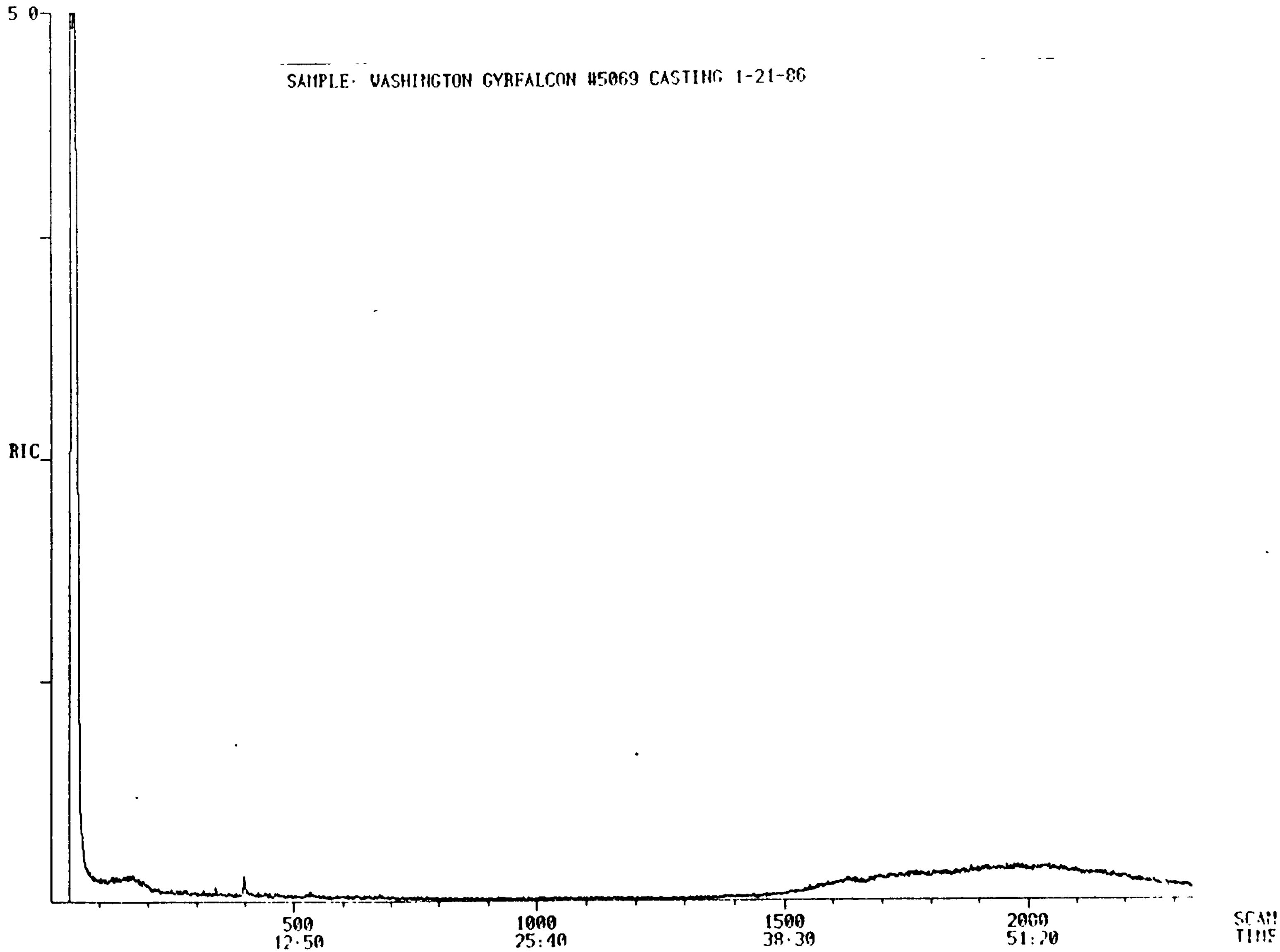
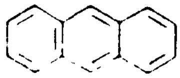
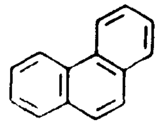


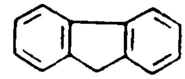
Figure 7. Reconstructed ion chromatogram (RIC), expanded 20X, of the hexane/dichloromethane extract of a casting of Gyrfalcon 5069 from 1/21/86.



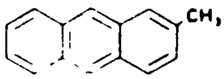
Anthracene



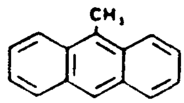
Phenanthrene



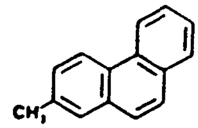
Fluorene



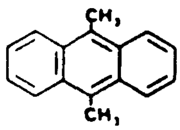
2-Methylanthracene



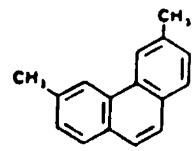
9-Methylanthracene



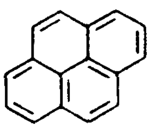
2-Methylphenanthrene



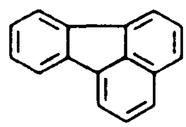
9,10-Dimethylanthracene



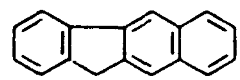
3,6-Dimethylphenanthrene



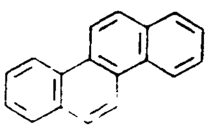
Pyrene



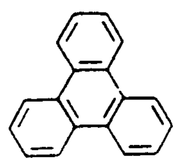
Fluoranthene



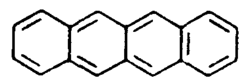
2,3-Benzofluorene



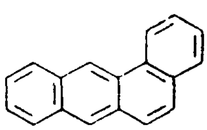
Chrysene



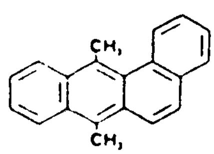
Triphenylene



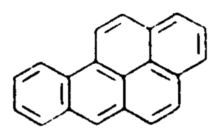
Naphthacene



2,3-Benzanthracene



7,12-Dimethylbenz(a)anthracene



Benzo(a)pyrene

Figure 6. Chemical structures of some polynuclear aromatic hydrocarbons present in crude oil.

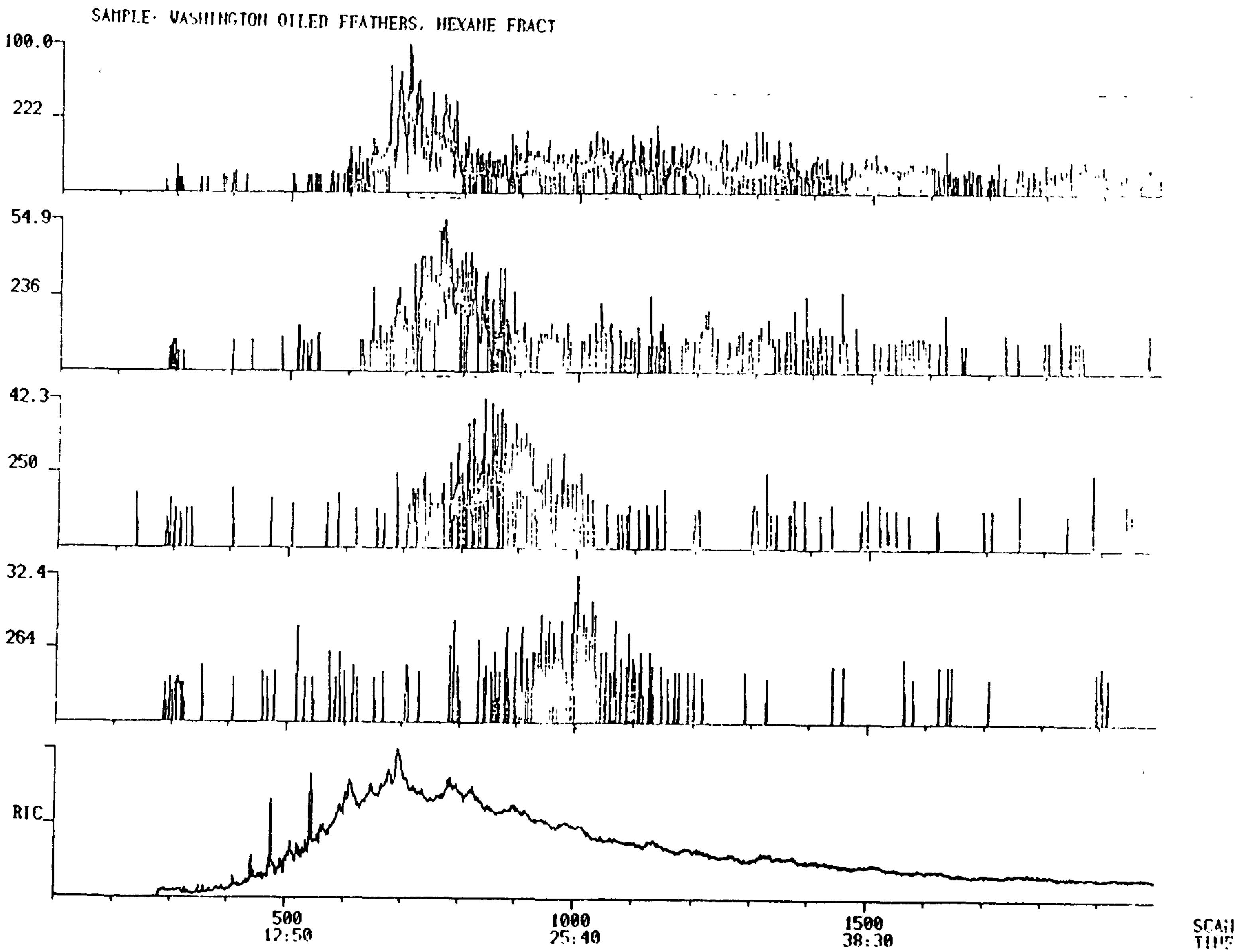


Figure 5. RIC and mass chromatograms of the hexane/dichloromethane extract of feathers from an oiled Horned Grebe. Chromatograms of masses 222, 236, 250, 264, plus RIC.

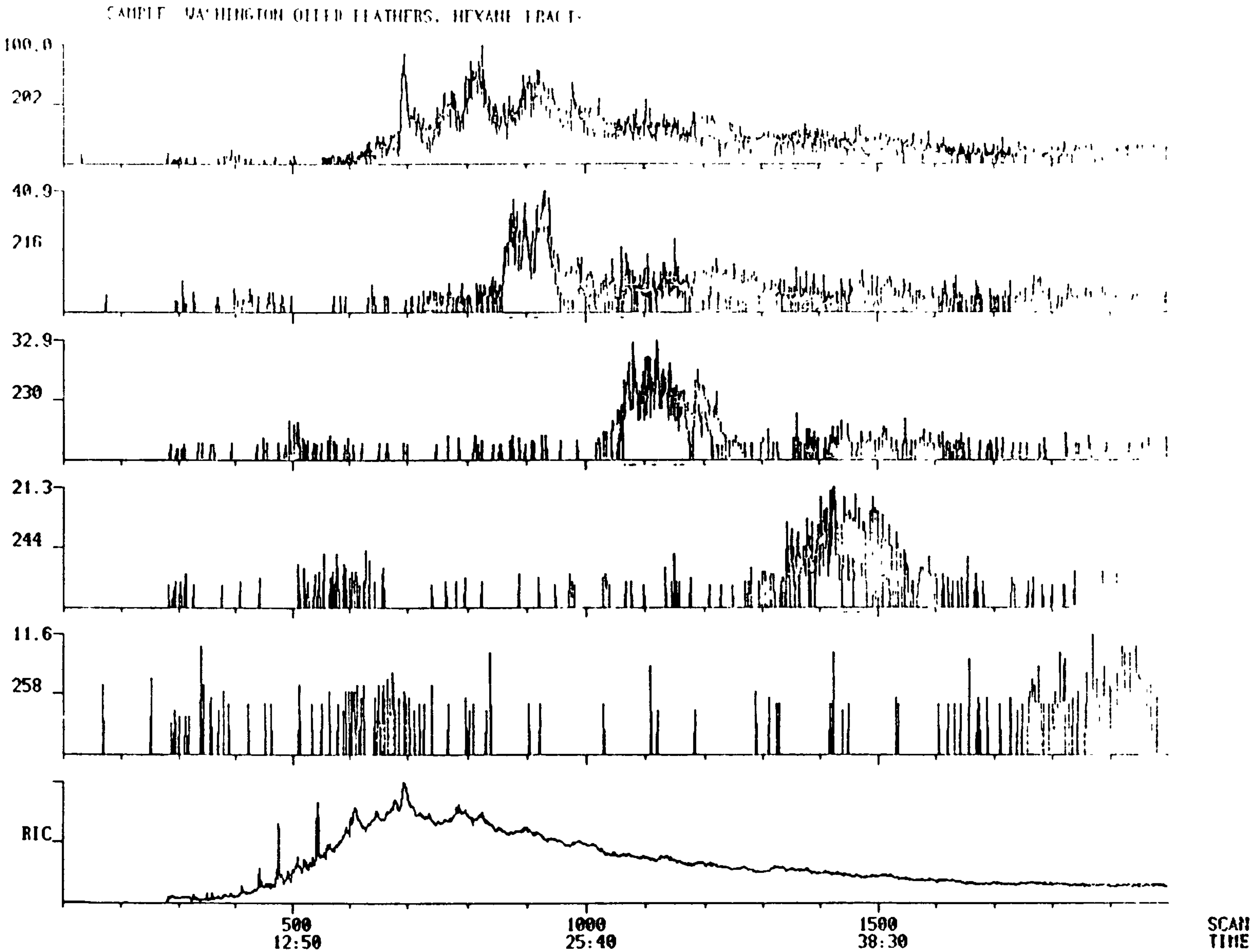


Figure 4. RIC and mass chromatograms of the hexane/dichloromethane extract of feathers from an oiled Horned Grebe. Chromatograms of masses 202, 216, 230, 244, 258, plus RIC.

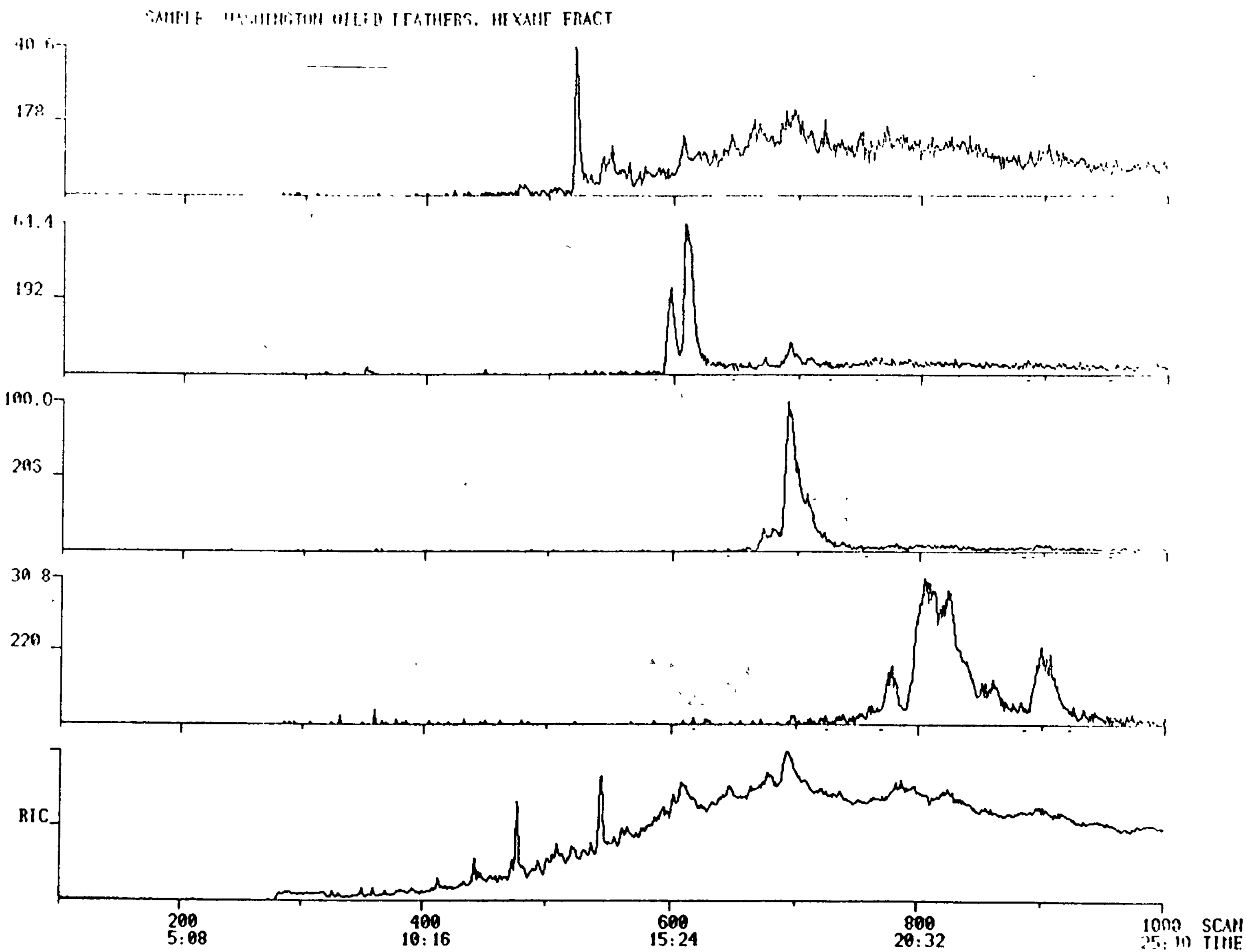


Figure 3. RIC and mass chromatograms of the hexane/dichloromethane extract of feathers from an oiled Horned Grebe. Chromatograms of masses 178, 192, 206, 220, plus RIC.

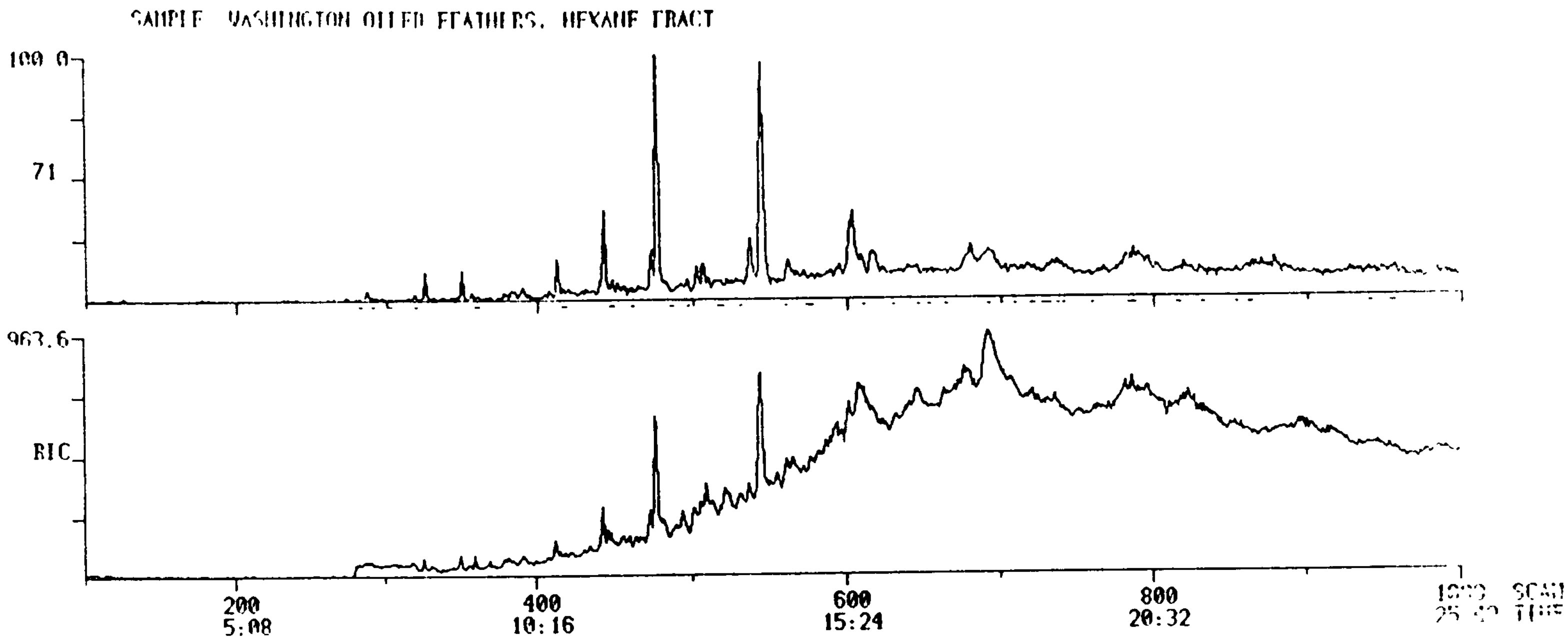


Figure 2. RIC and mass 71 chromatogram of the hexane/dichloromethane extract of feathers from an oiled Horned Grebe.
Top: Mass 71 chromatogram, Bottom: RIC.

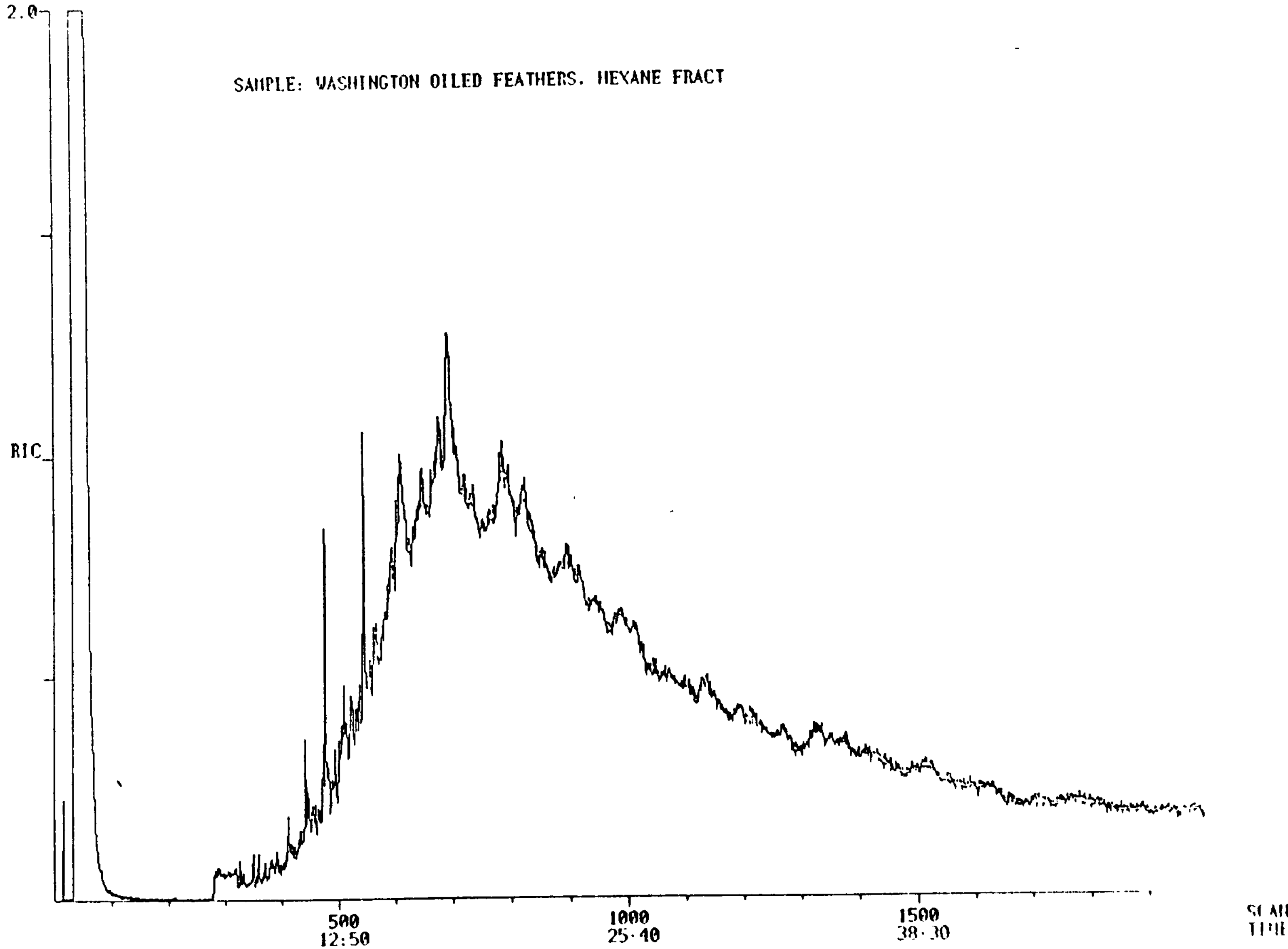
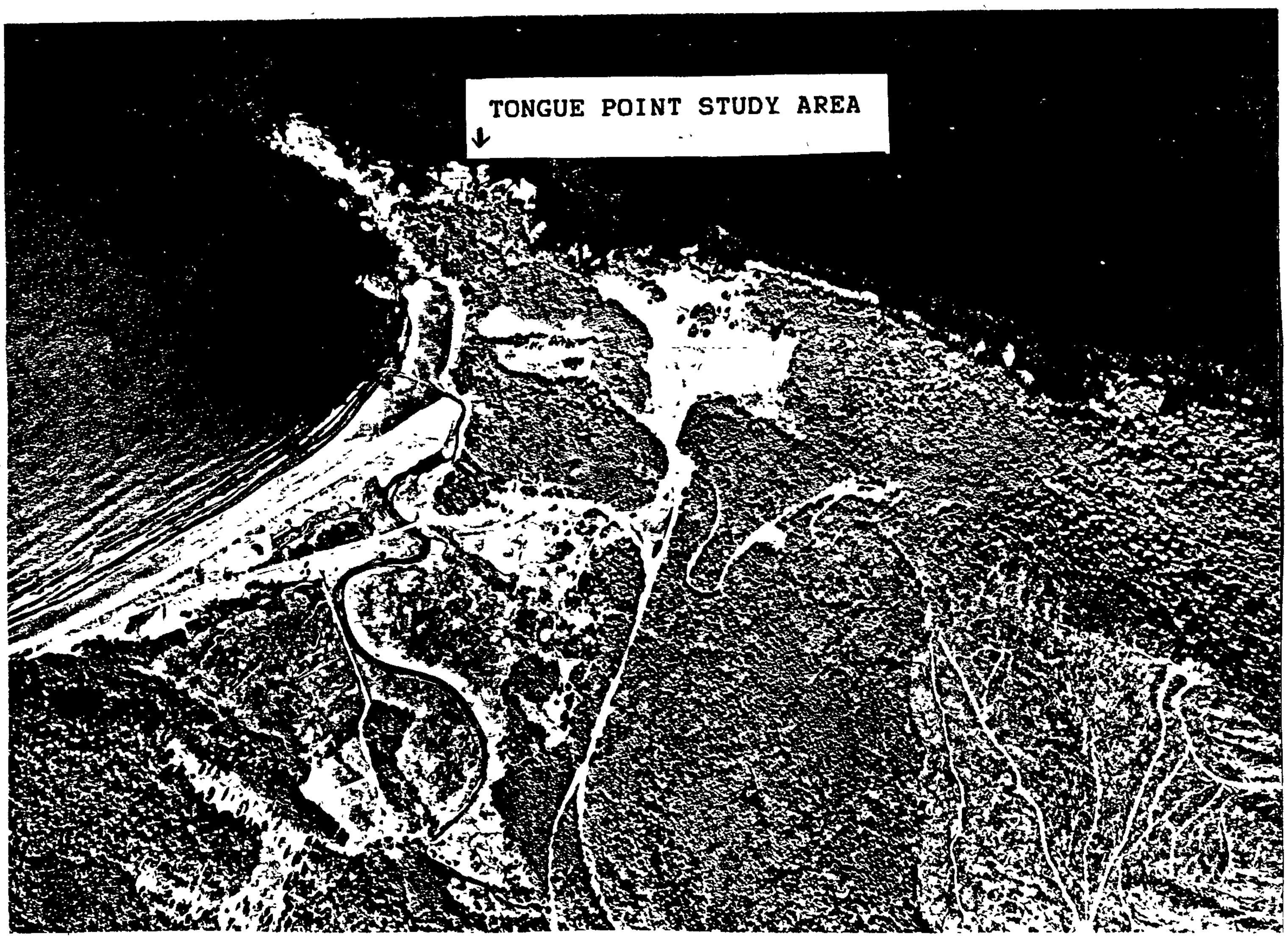


Figure 1. Reconstructed ion chromatogram (RIC) of the hexane/dichloromethane extract of feathers from an oiled Horned Grebe.


TONGUE POINT STUDY AREA

INTERTIDAL SURVEY BY THE PENINSULA COLLEGE
FISHERIES TECHNOLOGY PROGRAM

Three transects were examined at each of two locations, Tongue Point, 12 miles west of Port Angeles, and Slip Point, at the east end of Clallam Bay. Tongue Point was studied on February 5 and March 5, 1986 and Slip Point was studied on February 6 and March 6, 1986. The area selected at Tongue Point had been observed by Albert Sholz, Richard Burge, Wayne Gormley and James Beam of the Department of Fisheries to have been coated with a layer of oil on December 27, 1985. No oiled areas have been observed at Slip Point and it was chosen on this basis for comparison with Tongue Point.

The three transects were set up as follows at each location:

1- A rectangle one meter by 20 meters reaching from the upper to the lower intertidal region (transects A and D)

2- A rectangle one meter by 13 meters crossing several tide pools (transects B and E)

3- A rectangle one meter by three meters in an area of small rocks which were raised to examine the marine life on their undersides (transects C and F)

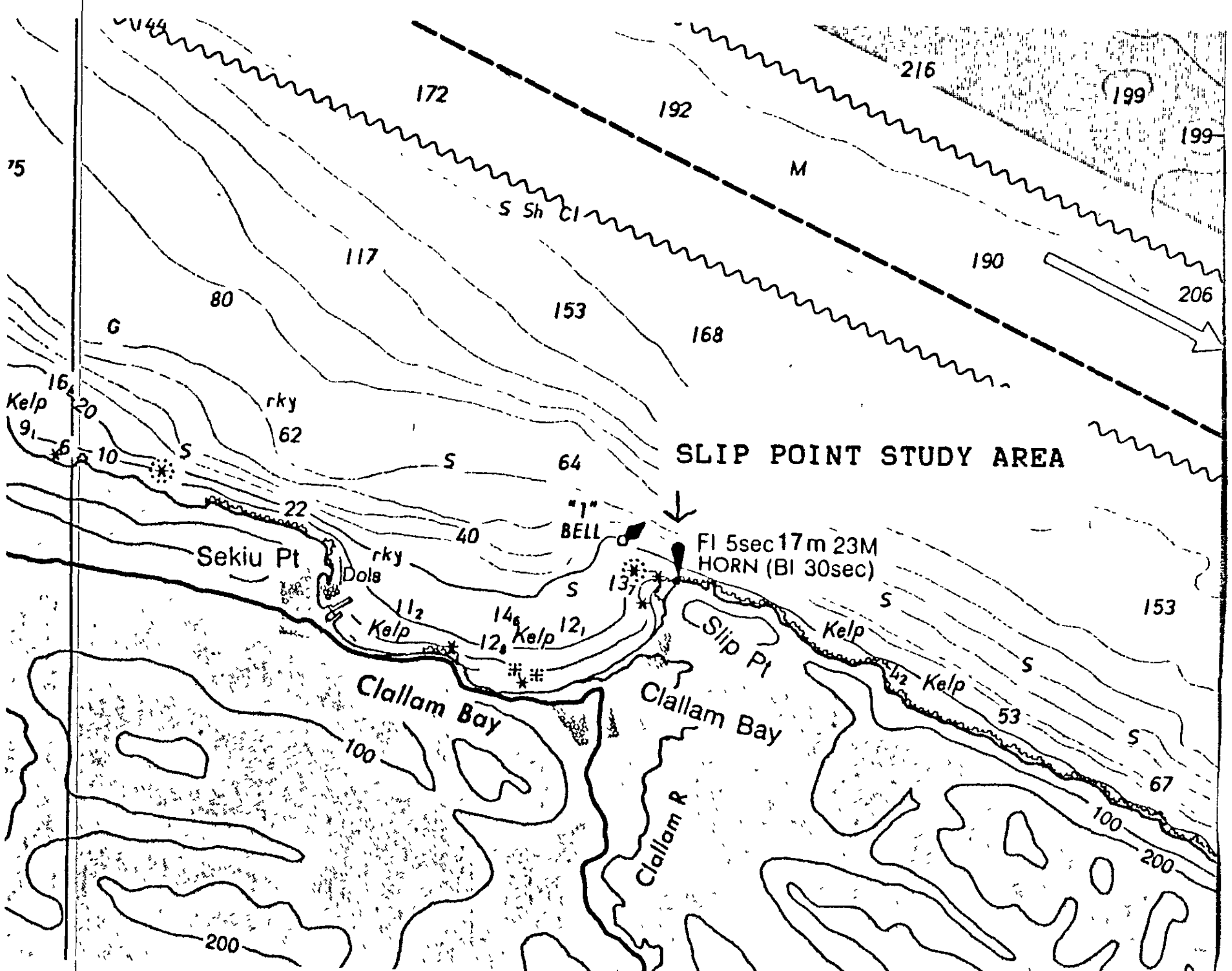
The transects at Tongue Point were set up with the help of James Beam of the Department of Fisheries who had observed the original oiling. The exact location of all transects in relationship to local landmarks was determined so that they could be reexamined at later dates.

The transects were divided into one meter quadrats and in each the numbers of living or dead individuals of the listed organisms were counted if less than 200 or estimated if greater than 200. Evidence of oil was also noted for each quadrat.

The following charts contain the information gathered at each location. Several general observations can be made. There does not appear to have been immediate severe mortality in the intertidal areas examined at Tongue Point. Evidence of oil has rapidly diminished there. We did not observe conspicuous differences between the two locations that could be attributed to the oiling at Tongue Point.

TRANSECT A

TRANSECT E



SLIP POINT STUDY AREA
"1" BELL
Fl 5sec 17m 23M
HORN (Bl 30sec)
Sekiu Pt
Dols
Kelp
rky
Clallam Bay
Slip Pt
Clallam Bay
Clallam R
172
192
216
199
M
S Sh Cl
117
153
168
190
206
80
62
64
40
22
153
53
67
100
200

Date 02/05/86

General Location Tongue Point

Transect Number Sec A

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Red Sea Urchin <u>Strongylocentrotus franciscanus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin <u>Strongylocentrotus droebachiensis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin <u>Strongylocentrotus purpuratus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Pinto Abalone <u>Haliotis kamtschatkana</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop <u>Hinnites giganteus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel <u>Mytilus californianus</u>	0:0	12:0	8:0	0:0	2:0	0:0	5:0	6:0	6:0	1:0	2:0	3:0	2:0	1:0	5:0	14:0	11:0	0:0	0:0	2:0
Gooseneck Barnacle <u>Pollicipes polymerus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton <u>Katharina tunicata</u>	0:0	0:0	0:0	0:0	0:0	0:0	2:0	0:0	13:0	9:0	4:0	6:0	13:0	12:0	120:0	15:0	30:0	10:0	4:0	3:0
Finger Limpet <u>Collisella digitalis</u>	148:0	200:0	24:0	10:0	19:0	0:0	17:0	12:0	42:0	28:0	19:0	16:0	16:0	11:0	13:0	16:0	9:0	0:0	0:0	11:00

General Location Tongue Point Date: 02/05/86

Transect Number Sec A Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Purple Shore Crab <u>Hemigrapsus nudus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Aggregating Anemone <u>Anthopleura elegantissima</u>	0:0	6:0	46:0	94:0	0:0	100:0	151:0	102	375:0	312:0	148:0	105:0	219:0	103:0	85:0	26:0	14:0	0:0	0:0	0:0
Large Green Anemone <u>Anthopleura xanthogrammica</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	72:0	0:0	1:0	0:0	0:0	0:0	2:0	2:0	0:0
Barnacles <u>Balanus sp.</u>	2000:0	16000:0	400:0	300:0	80:0	115:0	112:0	1200:0	1280:0	5000:0	1100:0	1300:0	1100:0	1300:0	500:0	500:0	1700:0	500:	0:0	37:0
Sea Cabbage <u>Hedophyllum sessile</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Alaria <u>Alaria marginata</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Feather Boa Kelp <u>Egregia menziesii</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 02/05/86

General Location Tongue Point

Transect Number Sec B

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Red Sea Urchin <u>Strongylocentrotus franciscanus</u>	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin <u>Strongylocentrotus droebachiensis</u>	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin <u>Strongylocentrotus purpuratus</u>	0:0	13:0	36:0	29:0	85:0	152:0	120:0	30:0	0:0	2:0	0:0	3:0	20:0
Pinto Abalone <u>Haliotis kamtschatkana</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop <u>Hinnites giganteus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel <u>Mytilus californianus</u>	60:0	37:0	48:0	200:0	12:0	0:0	1:0	40:0	300:0	300:0	40:0	0:0	0:0
Gooseneck Barnacle <u>Pollicipes polymerus</u>	60:0	55:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton <u>Katharina tunicata</u>	0:0	1:0	6:0	6:0	6:0	3:0	0:0	6:0	0:0	15:0	30:0	2:0	1:0
Finger Limpet <u>Collisella digitalis</u>	300:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Shore Crab <u>Hemigrapsus nudus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 02/05/86

General Location Tongue Point

Transect Number Sec B

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Aggregating Anemone <u>Anthopleura elegantissima</u>	24:0	50:0	21:0	42:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Large Green Anemone <u>Anthopleura xanthogrammica</u>	0:0	6:0	2:0	2:0	3:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Barnacles <u>Balanus sp.</u>	1400:0	248:0	225:0	240:0	300:0	20:0	50:10	200:25	1000:100	2000:100	10:3	90:5	4:4
Sea Cabbage <u>Hedophyllum sessile</u>	0:0	0:0	6:0	3:0	2:0	0:0	0:0	0:0	0:0	12:0	10:0	1:0	9:0
Alaria <u>Alaria marginata</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	1:0
Feather Boa Kelp <u>Egregia menziesii</u>	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 02/05/86

General Location Tongue Point

Transect Number Sec C

Quadrat Number	1	2	3
Red Sea Urchin _Strongylocentrotus franciscanus_	0:0	0:0	0:0
Green Sea Urchin _Strongylocentrotus droebachiensis_	0:0	0:0	0:0
Purple Sea Urchin _Strongylocentrotus purpuratus_	0:0	0:0	1:0
Pinto Abalone _Haliotis kamtschatkana_	0:0	0:0	0:0
Purple-Hinged Rock Scallop _Hinnites giganteus_	0:0	0:0	0:0
California Mussel _Mytilus californianus_	2:0	3:0	1:0
Gooseneck Barnacle _Pollicipes polymerus_	0:0	0:0	0:0
Black Chiton _Katharina tunicata_	0:0	0:0	1:0
Finger Limpet _Collisella digitalis_	0:0	6:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 02/05/86

General Location Tongue Point

Transect Number Sec C

Quadrat Number	1	2	3
Purple Shore Crab Hemigrapsus nudus	3:0	6:0	18:0
Six-Armed Seastar Leptasterias hexactis	1:0	1:0	0:0
Aggregating Anemone Anthopleura elegantissima	1:0	13:0	9:0
Large Green Anemone Anthopleura xanthogrammica	0:0	0:0	0:0
Barnacles Balanus sp.	0:0	350:0	600:0
Sea Cabbage Hedophyllum sessile	0:0	0:0	0:0
Alaria Alaria marginata	0:0	0:0	0:0
Feather Boa Kelp Egregia menziesii	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Slip Point

Date: 02/06/86

Transect Number Sec D

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Red Sea Urchin <u>Strongylocentrotus franciscanus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin <u>Strongylocentrotus droebachiensis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin <u>Strongylocentrotus purpuratus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0
Pinto Abalone <u>Haliotis kamtschatkana</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop <u>Hinnites giganteus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel <u>Mytilus californianus</u>	0:0	11:3	193:5	84:0	18:0	7:0	0:0	0:0	4:0	0:0	0:0	0:0	0:0	0:0	0:1	1:0	0:0	0:0	0:0	0:0
Gooseneck Barnacle <u>Pollicipes polymerus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton <u>Katharina tunicata</u>	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	2:0	6:0	6:0	1:0	2:0	0:0	0:0	0:0
Finger Limpet <u>Collisella digitalis</u>	17:0	18:0	0:0	0:0	0:0	0:0	6:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Shore Crab <u>Hemigrapsus nudus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	6:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Aggregating Anemone <u>Anthopleura elegantissima</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	3:0	33:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 02/06/86

General Location Slip Point

Transect Number Sec D

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Large Green Anemone Anthopleura xanthogrammica	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Barnacles Balanus sp.	11:7	453:27	135:17	132:0	102:0	16:0	111:0	53:0	8:0	22000:0	2:0	87:0	120:0	400:0	470:0	141:0	200:0	713:5	353:4	0:0
Sea Cabbage Hedophyllum sessile	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	6:	5:0	27:0	3:0
Alaria Alaria marginata	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	1:0
Feather Boa Kelp Egregia menziesii	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Slip Point   Date: 02/06/86

Transect Number Sec E

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Red Sea Urchin <u>Strongylocentrotus franciscanus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin <u>Strongylocentrotus droebachiensis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin <u>Strongylocentrotus purpuratus</u>	11:0	6:0	7:0	4:0	44:0	20:0	72:0	77:0	6:0	20:0	42:0	67:0	19:0
Pinto Abalone <u>Haliotis kamtschatkana</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop <u>Hinnites giganteus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel <u>Mytilus californianus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Gooseneck Barnacle <u>Pollicipes polymerus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton <u>Katharina tunicata</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	2:0	1:0	0:0	2:0	2:0	0:0
Finger Limpet <u>Collisella digitalis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Shore Crab <u>Hemigrapsus nudus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Aggregating Anemone <u>Anthopleura elegantissima</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	2:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Slip Point Date: 02/06/86

Transect Number Sec E

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Large Green Anemone *Anthopleura xanthogrammica*	0:0	1:0	0:0	1:0	0:0	1:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0
Barnacles *Balanus sp.*	50:0	0:0	6:0	0:0	66:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Sea Cabbage *Hedophyllum sessile*	0:0	0:0	0:0	0:0	0:0	6:0	5:0	3:0	1:0	0:0	18:0	2:0	15:0
Alaria *Alaria marginata*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Feather Boa Kelp *Egregia menziesii*	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 02/06/86

General Location Slip Point

Transect Number Sec F

Quadrat Number	1	2	3
Red Sea Urchin _Strongylocentrotus franciscanus_	0:0	0:0	0:0
Green Sea Urchin _Strongylocentrotus droebachiensis_	0:0	0:0	0:0
Purple Sea Urchin _Strongylocentrotus purpuratus_	0:0	0:0	0:0
Pinto Abalone _Haliotis kamtschatkana_	0:0	0:0	0:0
Purple-Hinged Rock Scallop _Hinnites giganteus_	0:0	0:0	0:0
California Mussel _Mytilus californianus_	0:0	1:0	0:0
Gooseneck Barnacle _Pollicipes polymerus_	0:0	0:0	0:0
Black Chiton _Katharina tunicata_	1:0	1:0	0:0
Finger Limpet _Collisella digitalis_	1:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 02/06/86

General Location Slip Point

Transect Number Sec F

Quadrat Number	1	2	3
Purple Shore Crab Hemigrapsus nudus	14:0	0:0	3:0
Six-Armed Seastar Leptasterias hexactis	0:0	0:0	0:0
Aggregating Anemone Anthopleura elegantissima	0:0	43:0	18:0
Large Green Anemone Anthopleura xanthogrammica	0:0	0:0	0:0
Barnacles Balanus sp.	390:0	414:C	258:61
Sea Cabbage Hedophyllum sessile	0:0	0:0	0:0
Alaria Alaria marginata	0:0	0:0	0:0
Feather Boa Kelp Egregia menziesii	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 03/05/86

General Location Tongue Point

Transect Number Sec A

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Red Sea Urchin <u>Strongylocentrotus franciscanus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin <u>Strongylocentrotus droebachiensis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin <u>Strongylocentrotus purpuratus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	2:0	0:0	0:0	0:0	0:0	5:0	18:0	144:0	65:0	44:0	28:0
Pinto Abalone <u>Haliotis kamtschatkana</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop <u>Hinnites giganteus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel <u>Mytilus californianus</u>	0:0	16:0	15:0	1:0	3:0	0:1	2:1	11:0	2:0	3:0	2:0	2:0	2:0	19:0	28:0	17:0	7:0	2:0	9:0	2:0
Gooseneck Barnacle <u>Pollicipes polymerus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton <u>Katha-ina tunicata</u>	0:0	0:0	0:0	1:0	0:0	0:0	0:0	1:0	2:0	1:0	4:0	10:0	6:0	15:0	24:0	15:0	31:0	21:0	9:0	1:0
Finger Limpet <u>Collisella digitalis</u>	0:0	18:0	8:0	8:0	2:0	14:0	18:0	14:0	18:0	0:0	0:0	0:0	20:0	2:0	2:0	0:0	0:0	0:0	0:0	0:0
Purple Shore Crab <u>Hemigrapsus nudus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0
Aggregating Anemone <u>Anthopleura elegantissima</u>	3:0	37:0	64:0	92:0	82:0	70:0	93:0	205:0	172:0	106:0	101:0	72:0	107:0	340:0	43:0	177:0	191:0	71:0	25:0	1:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Tongue Point

Date: 07/05/86

Transect Number Sec A

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Large Green Anemone <u>Anthopleura xanthogrammica</u>	0:0	0:0	0:0	0:0	120:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	2:0	1:0	0:0
Barnacles <u>Balanus sp.</u>	2000:0	16000:0	239:0	42:0	430:0	260:0	500:0	900:0	3600:0	1700:0	1000:0	900:0	600:0	500:0	200:0	900:0	175:0	650:35	31:0	127:13
Sea Cabbage <u>Hedophyllum sessile</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0
Alaria <u>Alaria marginata</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Feather Boa Kelp <u>Egregia menziesii</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	29:0	22:	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 03/05/86

General Location Tongue Point

Transect Number Sec B

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Red Sea Urchin <u>Strongylocentrotus franciscanus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin <u>Strongylocentrotus droebachiensis</u>	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin <u>Strongylocentrotus purpuratus</u>	0:0	13:0	33:0	0:0	39:0	101:0	93:0	53:0	4:0	21:0	0:0	21:0	24:0
Pinto Abalone <u>Haliotis kamtschatkana</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop <u>Hinnites giganteus</u>	0:0	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel <u>Mytilus californianus</u>	57:0	79:2	45:3	450:0	15:0	2:0	3:0	27:1	21:0	13:0	15:0	0:0	0:0
Gooseneck Barnacle <u>Pollicipes polymerus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton <u>Katharina tunicata</u>	81:2	57:0	1:0	3:0	12:0	7:0	1:0	1:0	7:0	3:0	7:0	5:0	0:0
Finger Limpet <u>Collisella digitalis</u>	650:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Shore Crab <u>Hemigrapsus nudus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	45:0	56:0	13:0	81:0	3:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 03/05/86

General Location Tongue Point

Transect Number Sec B

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Aggregating Anemone <u>Anthopleura elegantissima</u>	0:0	0:0	1:0	1:0	3:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Large Green Anemone <u>Anthopleura xanthogrammica</u>	0:0	0:0	2:0	7:0	5:0	1:0	0:0	6:0	9:0	19:0	18:0	15:0	5:0
Barnacles <u>Balanus sp.</u>	1500:40	653:57	231:46	6400:640	241:27	13:0	25:5	57:15	3020:17	35:11	37:13	36:3	45:6
Sea Cabbage <u>Hedophyllum sessile</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Alaria <u>Alaria marginata</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Feather Boa Kelp <u>Egregia menziesii</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Tongue Point   Date: 03/05/86

Transect Number Sec C

Quadrat Number	1	2	3
Red Sea Urchin *Strongylocentrotus franciscanus*	0:0	0:0	0:0
Green Sea Urchin *Strongylocentrotus droebachiensis*	0:0	0:0	0:0
Purple Sea Urchin *Strongylocentrotus purpuratus*	0:0	0:0	1:0
Pinto Abalone *Haliotis kamtschatkana*	0:0	0:0	0:0
Purple-Hinged Rock Scallop *Hinnites giganteus*	0:0	0:0	0:0
California Mussel *Mytilus californianus*	2:0	3:0	1:0
Gooseneck Barnacle *Pollicipes polymerus*	0:0	0:0	0:0
Black Chiton *Katharina tunicata*	0:0	0:0	1:0
Finger Limpet *Collisella digitalis*	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Tongue Point   Date: 03/05/86

Transect Number Sec C

Quadrat Number	1	2	3
Purple Shore Crab <u>Hemigrapsus nudus</u>	3:0	6:0	18:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	1:0	1:0	0:0
Aggregating Anemone <u>Anthopleura elegantissima</u>	1:0	13:0	9:0
Large Green Anemone <u>Anthopleura xanthogrammica</u>	0:0	0:0	0:0
Barnacles <u>Balanus sp.</u>	0:0	350:0	600:0
Sea Cabbage <u>Hedophyllum sessile</u>	0:0	0:0	0:0
Alaria <u>Alaria marginata</u>	0:0	0:0	0:0
Feather Boa Kelp <u>Egregia menziesii</u>	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 03/06/86

General Location Slip Point

Transect Number Sec D

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Red Sea Urchin <u>Strongylocentrotus franciscanus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin <u>Strongylocentrotus droebachiensis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin <u>Strongylocentrotus purpuratus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Pinto Abalone <u>Haliotis kamtschatkana</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop <u>Hinnites giganteus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel <u>Mytilus californianus</u>	0:0	0:0	41:0	199:0	0:0	19:0	19:0	1:0	0:0	3:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Gooseneck Barnacle <u>Pollicipes polymerus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton <u>Katharina tunicata</u>	0:0	0:0	0:0	0:0	0:0	1:0	0:0	0:0	1:0	0:0	3:0	1:0	3:0	8:0	2:0	2:0	5:0	1:0	0:0	0:0
Finger Limpet <u>Collisella digitalis</u>	7:0	7:0	5:0	0:0	0:0	13:0	22:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Shore Crab <u>Hemigrapsus nudus</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar <u>Leptasterias hexactis</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Aggregating Anemone <u>Anthopleura elegantissima</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	12:0	7:0	0:0	4:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

Date: 03/06/86

General Location Slip Point

Transect Number Sec D

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Large Green Anemone <u>Anthopleura xanthogrammica</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Barnacles <u>Balanus sp.</u>	955:200	810:300	293:80	221:35	184:8	164:0	65:3	144:0	87:0	5200:	6050:0	52:0	500:0	3100:0	8000:0	3000:0	7:0	1000:0	1000	56:0
Sea Cabbage <u>Hedophyllum sessile</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	5:0	0:0	5:0	13:0	18:0	3:0	16:0
Alaria <u>Alaria marginata</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	1:0	14:0	16:0
Feather Boa Kelp <u>Egregia menziesii</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Slip Point   Date: 03/06/86

Transect Number Sec F

Quadrat Number	1	2	3
Red Sea Urchin _Strongylocentrotus franciscanus_	0:0	0:0	0:0
Green Sea Urchin _Strongylocentrotus droebachiensis_	0:0	0:0	0:0
Purple Sea Urchin _Strongylocentrotus purpuratus_	0:0	0:0	0:0
Pinto Abalone _Haliotis kamtschatkana_	0:0	0:0	0:0
Purple-Hinged Rock Scallop _Hinnites giganteus_	0:0	0:0	0:0
California Mussel _Mytilus californianus_	1:0	0:0	0:0
Gooseneck Barnacle _Pollicipes polymerus_	0:0	0:0	0:0
Black Chiton _Katharina tunicata_	2:0	0:0	0:0
Finger Limpet _Collisella digitalis_	0:0	0:0	0:0
Purple Shore Crab _Hemigrapsus nudus_	42:0	9:0	13:0
Six-Armed Seastar _Leptasterias hexactis_	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individuals.

General Location Slip Point　　　　Date: 03/06/86

Transect Number　Sec F

Quadrat Number	1	2	3
Aggregating Anemone Anthopleura elegantissima	3:0	49:0	87:0
Large Green Anemone Anthopleura xanthogrammica	0:0	0:0	0:0
Barnacles Balanus sp.	3000:0	3000:600	1300:260
Sea Cabbage Hedophyllum sessile	0:0	0:0	0:0
Alaria Alaria marginata	0:0	0:0	0:0
Feather Boa Kelp Egregia menziesii	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individual.

General Location Slip Point Date: 03/06/86

Transect Number Sec E

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Red Sea Urchin *Strongylocentrotus franciscanus*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Green Sea Urchin *Strongylocentrotus droebachiensis*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Sea Urchin *Strongylocentrotus purpuratus*	35:0	0:0	21:0	10:0	43:1	17:0	13:0	83:0	60	107:0	101	20:0	31:1
Pinto Abalone *Haliotis kamtschatkana*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple-Hinged Rock Scallop *Hinnites giganteus*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
California Mussel *Mytilus californianus*	2:2	2:0	0:1	1:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Gooseneck Barnacle *Pollicipes polymerus*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Black Chiton *Katharina tunicata*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Finger Limpet *Collisella digitalis*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Purple Shore Crab *Hemigrapsus nudus*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Six-Armed Seastar *Leptasterias hexactis*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0
Aggregating Anemone *Anthopleura elegantissima*	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0

Numbers before the colons indicate the number of living individuals, numbers after the colons indicate the number of dead individual.

General Location Slip Point Date: 03/06/86

Transect Number Sec E

Quadrat Number	1	2	3	4	5	6	7	8	9	10	11	12	13
Large Green Anemone <u>Anthopleura xanthogrammica</u>	2:0	0:0	1:0	0:0	0:0	0:0	1:0	0:0	0:0	0:0	0:0	0:0	0:0
Barnacles <u>Balanus sp.</u>	0:0	21:0	211:0	105:0	0:0	11:0	400:21	53:0	0:0	0:0	0:0	0:0	0:0
Sea Cabbage <u>Hedophyllum sessile</u>	0:0	1:0	4:0	1:0	1:0	0:0	10:0	8:0	2:0	4:0	5:0	15:0	8:0
Alaria <u>Alaria marginata</u>	0:0	0:0	0:0	0:0	0:0	0:0	11:0	8:0	0:0	1:0	0:0	0:0	0:0
Feather Boa Kelp <u>Egregia menziesii</u>	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0	0:0