THE ARGO MERCHANT OIL SPILL AND THE FISHERY RESOURCES OF NANTUCKET SHOALS AND GEORGES BANK: A SUMMARY OF ASSESSMENT ACTIVITIES AND PRELIMINARY RESULTS

Northeast Fisheries Center
Woods Hole, Massachusetts

Narragansett Laboratory
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The *Argo Merchant* Oil Spill and the Fishery Resources of Nantucket Shoals and Georges Bank: A Summary of Assessment Activities and Preliminary Results

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Summary of Initial Findings

There is evidence of oil contamination in fish, shellfish, ichthyoplankton, and zooplankton populations in the area of the spill. Mortalities of developing cod and pollock embryos in eggs contaminated with oil were observed. No. 6 fuel oil caused significant mortalities of cod embryos in laboratory experiments conducted by NMFS and collaborating scientists of EPA and the University of Kiel. In addition to the mortalities of fish eggs, relatively low abundances of sand launce larvae were observed in the spill zone that may have been caused by oil. The dominant zooplankton species in the area of the spill was the copepod *Centropages typicus*, which is an important food of larval and adult fish. Large numbers of this species were contaminated with petroleum hydrocarbons similar to No. 6 fuel oil, indicating that an important pathway in the food web of the Nantucket Shoals-Georges Bank ecosystems was impacted. The extent of this impact is under investigation. Much of the oil in the copepods was in the form of fecal pellets. These pellets are excreted into the water column, settle to the bottom, and may be concentrated in benthic filter-feeders (mussels, scallops, quahogs). Adverse physiological effects were also observed in reduced respiration of scallops, mussels, and in an ionic imbalance of blood serum of blackback and yellowtail flounders.

The implications of the above results for long-term effects are unclear. Additional extensive surveys and laboratory tests will be required to clarify preliminary findings.

1. INTRODUCTIONON

The impact of the Argo Merchant oil spill on the fish and shellfish stocks of Nantucket Shoals and southern Georges Bank is difficult to assess in the short term of two months. The National Marine Fisheries Service has been conducting semi-annual surveys of groundfish from the Gulf of Maine to Cape Hatteras for the past fifteen years. The surveys are conducted to assess and predict the changes in abundance of the principal fish stocks in the area. Major changes in the abundance of the stocks prior to the Argo Merchant spill were the result of the interaction between intensive fishing and naturally occurring environmental fluctuations. In combination, these events have reduced the fish biomass substantially from former abundance levels in the 1950's and early 1960's.

To date no comprehensive study has been carried out on the effects of oil on the productivity of fish populations on the northeast continental shelf. In fact, most studies concerning the effects of oil on fish and shellfish have been concerned with the onshore or near shore impacts on littoral organisms. Definitive results on the effects on populations of fish are rare. Laboratory studies have shown that crude oil can damage developing fish eggs and cause large-scale mortalities in cod and herring embryos (Kühnhold 1969, 1974). Also, the zooplankton food of fish larvae suffer high mortalities from exposures to crude oil in laboratory experiments (Mironov 1969a, b). In contrast, recent observations from collections made at sea have shown that zooplankters, particularly copepods, can ingest particles of oil and pass them through the gut without any observable effects. Some species of adult fish have been observed to avoid areas contaminated with oil. However, the more sensitive egg and larval stages are carried by the tides and currents and lack the ability to avoid oil spill areas. Bivalve shellfish (quahogs, scallops, mussels) are sedentary and have only limited capability to remove large amounts of petroleum hydrocarbons. They suffer significant mortalities in areas contaminated with oil (Jeffries and Johnson 1975). Proper assessments of the impact of a major spill on the continental shelf require the combined effort of extensive sea sampling and laboratory support studies.

The National Marine Fisheries Service is now initiating both an extensive sampling program and laboratory studies of fish, shellfish, and plankton populations that may have been damaged by the Argo Merchant spill. Twelve to eighteen months will be required to complete the study and sort out the complex interactions among the levels of fishing mortality, natural mortality, oil mortality, and the sublethal effects of oil on the reproductive potential of the fish resources. A short-term study based on the analysis of the results of two surveys of the

Argo Merchant spill area, laboratory observations, and a summary of interviews with fishermen is presently underway. The following investigations are among the first attempts to determine how oil spilled on the continental shelf affects the productivity of fishery resources. Only by conducting integrated studies concerning physiological, genetic, and pathological effects on metabolism and reproduction through surveys of changes in the abundances of populations can we begin to define the real extent of damage caused by the oil. A brief summary of activities and preliminary results is given below.

2. PORT AGENT REPORT

Argo Merchant Oil Spill--F. Riley, Northeast Regional Office, Gloucester:

In the Northeast Region, the National Marine Fisheries Service instructed personnel who are in daily contact with the commercial fishing industry to assess and document the impact of the Argo Merchant oil spill on the day to day activities of the commercial fishermen through a series of weekly reports to the regional director.

In New England approximately 900 direct interviews were made from a total of 4000 fishing trips between December 21 and January 30, at the ports of Portland, Rockland, Gloucester, Boston, and New Bedford, Massachusetts; and Newport, and Pt. Judith, Rhode Island. Of 26 interviews conducted where evidence of the oil spill was noted during that period 5 (20%) indicated direct loss of catch or fouling or loss of gear. The other 21 (80%) reported "oily" birds. All of these incidents occurred in the area to the southeast of the site of the Argo Merchant; the locations were associated with fishing operations as shown in Figure 1.

Specific problems were loss of gear, fouling or loss of catch as follows:

1. A scalloper fishing very near the wreck area had his catch and gear fouled by an oil slick; the catch from that tow was discarded as unmarketable.

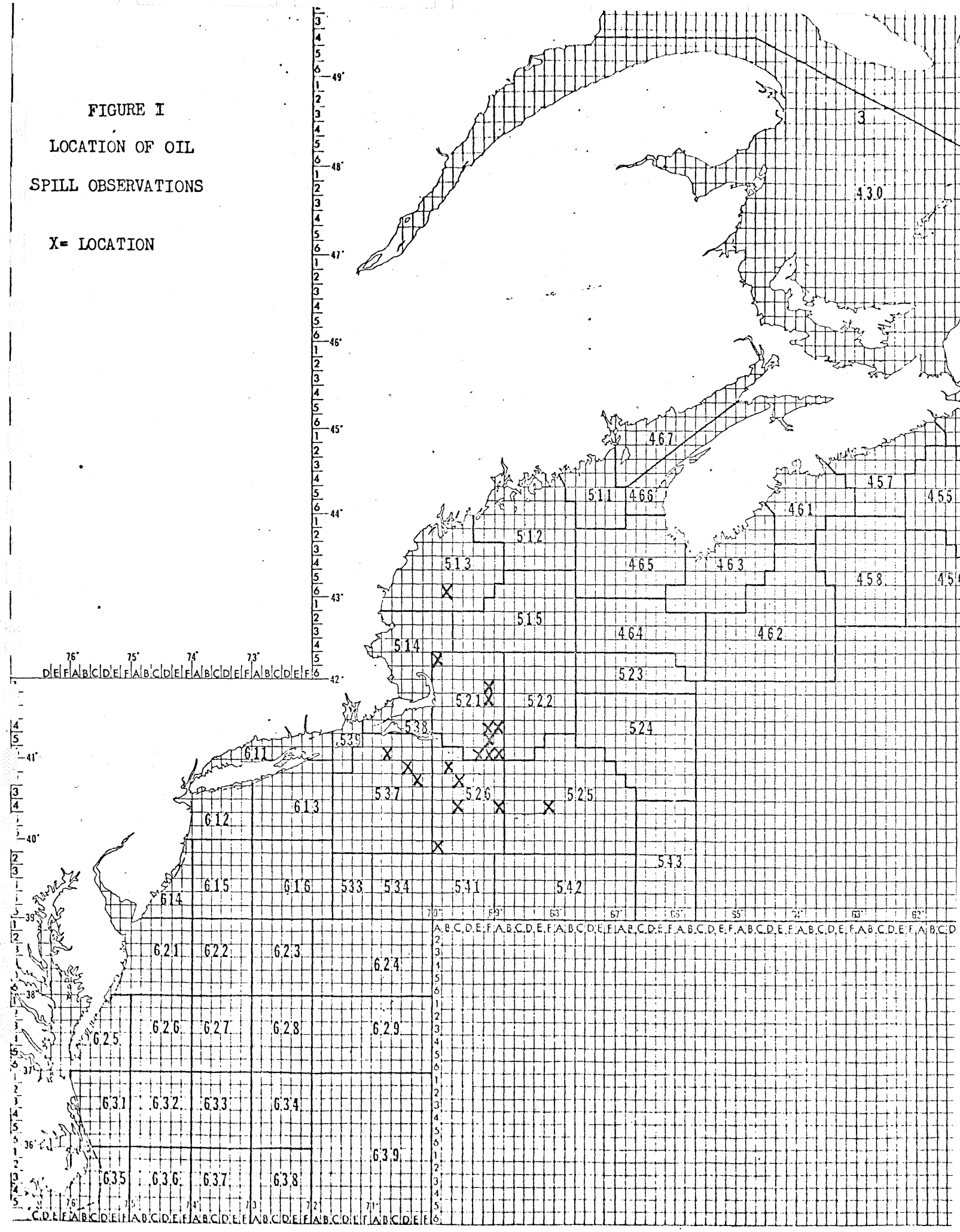
2. Captains of two vessels, fishing American lobster on the edge of the continental shelf, believe that oil fouling of inflatable buoys caused a deterioration of air valves resulting in a loss of these buoys and consequently the gear they marked. The crew's clothing became fouled during handling the gear. One lobster fishing vessel had its gear net in the immediate area of the oil drift and as a result, had to change over the water circulation system from a continuous to a closed one, i.e., instead of taking in water from the area of the oil drift and contaminating the catch, water from a clean area was used and circulated within the vessel's holding system.

FIGURE I

LOCATION OF OIL

SPILL OBSERVATIONS

X= LOCATION



3. Captains of two vessels fishing lobster reported fouled pots, gear and clothing. Caution had to be used in removing lobsters from the contaminated gear.

NOTE: These specific problems were encountered in area 526.

Other Northeast Regional Divisions concerned with monitoring foreign vessels filed negative reports.

The collection of data on the oil spill and its effects is, and will be, an ongoing program for all NMFS field employees in the region.

3. SHORT-TERM ASSESSMENT

3.1. Response to the Spill, G. Kelly, Northeast Fisheries Center, Woods Hole:

On December 15, 1976 when the oil tanker Argo Merchant went aground on Nantucket Shoals, the National Marine Fisheries Service RV Delaware II was engaged in otter trawling off the coast of New Jersey and the RV Albatross IV was in the shipyard undergoing overhaul. On December 17, after a meeting of scientists from the Woods Hole institutions to discuss plans for research in the event of the breakup of the Argo Merchant, Cmdr. Charles Nixon, Port Captain at the Northeast Fisheries Center, contacted the Delaware II to alert Capt. Landsvik to the possibility that the ship might be diverted to the scene of the spill to conduct research. On December 20, following the breakup of the tanker during the gale winds and heavy seas of the weekend, Deputy Center Director Richard Hennemuth ordered the Delaware II to terminate its trawl survey operations and steam to Woods Hole to prepare for a short cruise to survey the fish stocks, ichthyoplankton, and benthic organisms around the oil spill.

The ship arrived in Woods Hole on Dec. 21 and a group of NMFS scientists from Woods Hole and Narragansett, under the direction of Henry Jensen, prepared to sail as soon as possible. The cruise plan was to sample near the edge of the oil slick without contaminating the sampling gear or the ship, and to obtain as many samples of water, fish, benthic organisms and plankton as time would permit. The ship sailed from Woods Hole the afternoon of December 22, began fishing that night, and after occupying 11 stations (Figure 1), returned to Sandy Hook on December 24.

Planning for the second cruise of the Delaware II was done more deliberately than the first, but still in an atmosphere of emergency. The Argo Merchant had broken up and the oil had spread more than 150 miles to the southeast, crossing part of the South Channel and the southwest part of Georges Bank. Maps of the oil slick, plotted day by day from U.S. Coast Guard overflight aerial observations were used as a guide in the selection of sampling stations.

Since no one knew if the oil had mixed downward in the water column or had reached the bottom, it was impossible to define the contaminated

area with any certainty. Three categories of stations were identified and selected for sampling: (1) control stations well away from the site of the spill and outside the influence of the spill overrun, (2) possibly contaminated stations outside the immediate area of the wreck but under the overrun of the drifting oil spill, and (3) probably contaminated stations within about 20 miles of the wreck and under the overrun of the heaviest and most persistent concentrations of the drifting oil spill.

Approximately 65 sampling stations were designated based on random selection of stations within each numbered series of depth strata, normally used on NMFS groundfish trawl surveys. These stations were scattered throughout much of Georges Bank south of 41°45'N latitude and east of 70°00'W longitude. Several control stations were selected east of Cape Cod near Wellfleet, and the plan was for Delaware II to go out through the Cape Cod Canal and sample the control stations first. Initially, the ship would stay north of the potentially contaminated area, work eastward across Georges Bank in the uncontaminated area, then work south across the path of the slick overrun, and finally return westward into the area that held the greatest prospect of contamination.

This plan was followed on Cruise DE 77-01 through the first 28 stations when the cruise was disrupted by stormy weather and the ship sought shelter near Martha's Vineyard. She returned to the vicinity of the spill when the weather improved and successfully completed an additional 11 stations before being forced to return to Woods Hole by a severe storm. A description of the observations and collections made on both cruises is given in the following cruise reports:

3.2. Argo Merchant Oil Spill - Delaware II DE 76-13 22-24 December 1976 - Cruise Results

CRUISE PERIOD AND AREA

The NOAA ship Delaware II sailed from Woods Hole, Massachusetts, on 22 December 1976 to the vicinity of the oil spill from the Argo Merchant, aground on Fishing Rip, and returned to Sandy Hook, New Jersey on 24 December 1976.

OBJECTIVES

The objectives of the cruise were to sample the fish and associated invertebrate and plankton populations in the vicinity of the oil spill and to obtain samples of fish from outside the area of the oil slick to be used as controls for fish to be caught later in the same area. Additional objectives were to obtain oil, water and sediment samples and to observe any obvious effects of oil on birds and mammals in the area.

The cruise was conducted as scheduled. Eleven stations were completed (Figure 1); six were occupied with miscellaneous gear and four with bathythermograph drops and surface water samples only. Station positions were occupied at the boundary of the slick as reported by the Coast Guard who made aerial observations on the day of departure. Three gear stations were occupied on each side of the southern border of the slick. The surface of the water at station nine (one of three stations located within the slick) was not covered with oil at the time it was occupied. Plankton, hydrographic, XBT and sediment samples were obtained from both inside and outside the slick. Two trawl stations were made outside of the slick to obtain fish without contamination from floating oil for miscellaneous studies. All data was recorded in Eastern Standard Time unless otherwise noted. The general information on the various gear, samples and observations is listed in the attached sampling addendum. A breakdown of the type of samples, data disposition, etc. appears in the second Delaware II oil cruise report.

RESULTS

Preliminary on-ship observations regarding the impact, if any, of the oil are included in the addendum.

SCIENTIFIC PERSONNEL

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Gary Carter
Joe Kane
Kevin McCarthy

Delaware II--Cruise DE 76-13 (Argo Merchant Oil Spill); Sampling Addendum

Water Temperature Profile--Stations sampled, 1 - 11--Disposition of samples, Woods Hole

XBT probes were dropped at each station prior to other sampling. Temperatures were nearly isothermal between 5°C in the shoals and 7°C in deeper waters.

Meteorological Observations--Stations sampled, 1 - 11--Disposition of samples, Woods Hole

Observations (wind speed, barometric pressure, temperature, wave height, etc.) were taken at all stations. Wind speed ranged from 12 to 27 knots, wave height between three and six feet.

Surface Water Samples--Stations sampled, 1 - 11--Disposition of samples, Woods Hole

Samples were taken at every station. There was noticeable oil on the surface at stations 7 and 8, although oil was not apparent in samples. A surface oil sample was taken at station 7, where the oil contained sand.

Oil Slick Observations--Stations sampled, 1 - 11--Disposition of data, Woods Hole

Oil was found at station 7 through 8, and half-way to station 9 in 5 to 20-foot wide patches occurring in rows from northwest to southeast. The oil resembled floating black cloth, wrinkled from wave action. Other and more general observations (95 to 99% of this area) were the thin, greasy sheen with characteristic prismatic phenomena and the odor which was noticeable but not outstanding.

Fish Samples--Stations sampled, 4 and 6--Disposition of samples, Woods Hole

A 15-minute tow at 3.5 knots using a Yankee #36 trawl without rollers and with a 1/2-inch liner was made at both stations. All species were sorted, identified and measured (fork length) where applicable. Approximately 20 species of fish and 10 vertebrates were taken. An oil streak 1 x 2 inches was noticed on a winter flounder at station 4. All other specimens appeared oil free.

Hydrocarbon Samples--Stations sampled, 4 and 6--Disposition of samples, Woods Hole

Approximately 20 species of fish and 10 species of invertebrates were frozen in foil-lined bags for hydrocarbon analysis.

Stomach Analysis--Stations sampled, 4 and 6--Disposition of samples, Woods Hole

Stomachs from little skate, big skate, spiny dogfish, cod, windowpane and ocean pout were preserved in 10% formalin for food chain contamination studies.

Maturation--Stations sampled, 4 and 6--Disposition of data, Woods Hole

Gonad development was observed and logged on standard maturation forms; no fish were spawning. Various stages of ripening were observed in cod, long-horned sculpin and ocean pout.

Sonar Traces--Stations sampled, 4 and 6--Disposition of traces, Woods Hole

The 20-25 foot sand humps shown on the bottom trace of station 4 were typical of the bottom on Nantucket shoals at a depth of 30 fathoms or less; the relatively flat though rough bottom trace of station 6 is typical of the channel area at 30 fathoms and greater.

Water Column Samples--Stations sampled, 4, 5, 7, 8--Disposition of samples, Sandy Hook

The water bag sampler was used to collect water at 5 meters below surface and 5 meters above bottom at stations 4, 5 and 7. At station 8, the samples were collected at 5 and 15 meters below surface. Oil was not observed in any of these samples.

Water Column Plankton Samples--Stations sampled, 4 - 9--Disposition of samples, Narragansett

Bottom to surface bongo tows were made (20 cm and 61 cm bongos) with 0.165, 0.253, 0.333 and 0.505 mm mesh nets. No oil particles were noticed but there was probably surface oil contamination in samples 8 and 9 from stations 7 and 8.

Surface Plankton Samples--Stations sampled, 4 - 9--Disposition of samples, Narragansett

Neuston samples (using 0.505 mm mesh) showed specks of tar at stations 4, 5, 6 and 9; station 9 was possibly contaminated. Stations 7 and 8 were made in the oil slick and the net soaked with oil was saved in a can. Larval sand launce and hake were observed in the samples, and *Sagitta* (arrow worms) comprised a large portion of the sample. Also eggs were observed in the station 9 sample.

Bottom Biological Samples--Stations sampled, 4 and 6--Disposition of samples, Woods Hole

A 25 cm ring net (mesh approx. 1 mm) attached to the trawl headrope was used at trawl stations to sample smaller organisms that escape the trawl. Catch was largely small crustacea which were preserved in 10% formalin.

Bottom Sediment Samples--Stations sampled, 4 - 9--Disposition of samples, Woods Hole

Sediments which were obtained: at station 4 by 4-inch pipe dredge were found to be clean; at station 5 by bongos hitting bottom, were discarded, but noted to be clean; at station 6 by pipe dredge were clean; at station 7 by bongos were clean; at station 8 in small amounts, by Dietz Lafond grab were clean; and at station 9 using a Digby dredge contained shell fragments and were also found to be clean. All sediments were stored dry.

Live Samples--Station sampled, 9--Disposition of samples, Milford

Approximately 20 hermit crabs, clams, and miscellaneous bivalves were secured using a Digby dredge (small 2-ft. wide dredge with ring bag and 1/2 inch liner). A tow was made for 5 minutes at approximately 2 1/2 knots. Live samples were maintained in running water. Specimens reached Sandy Hook in viable condition.

Vessels

No fishing vessels were sighted, probably due to the holiday season. The *Argo Merchant* was observed at approximately 6 miles distance. There were two Coast Guard vessels in the area along with two helicopters.

Oil on Gulls--All Station Area--Disposition of records, Woods Hole and Manomet Bird Observatory

Bird observations showed significant amount of fouling of feathers by oil; up to 100% of birds in some areas. Much detail was recorded.

Mammal Watch--All Station Area--Disposition of records, Woods Hole

Whale watch was kept including observations from crow's nest; none were sighted.

Photographs--All Station Area--Disposition of photos, Woods Hole and Narragansett

Photographs of sampling, oil slick and fouled birds were taken by Woods hole and Narragansett team.

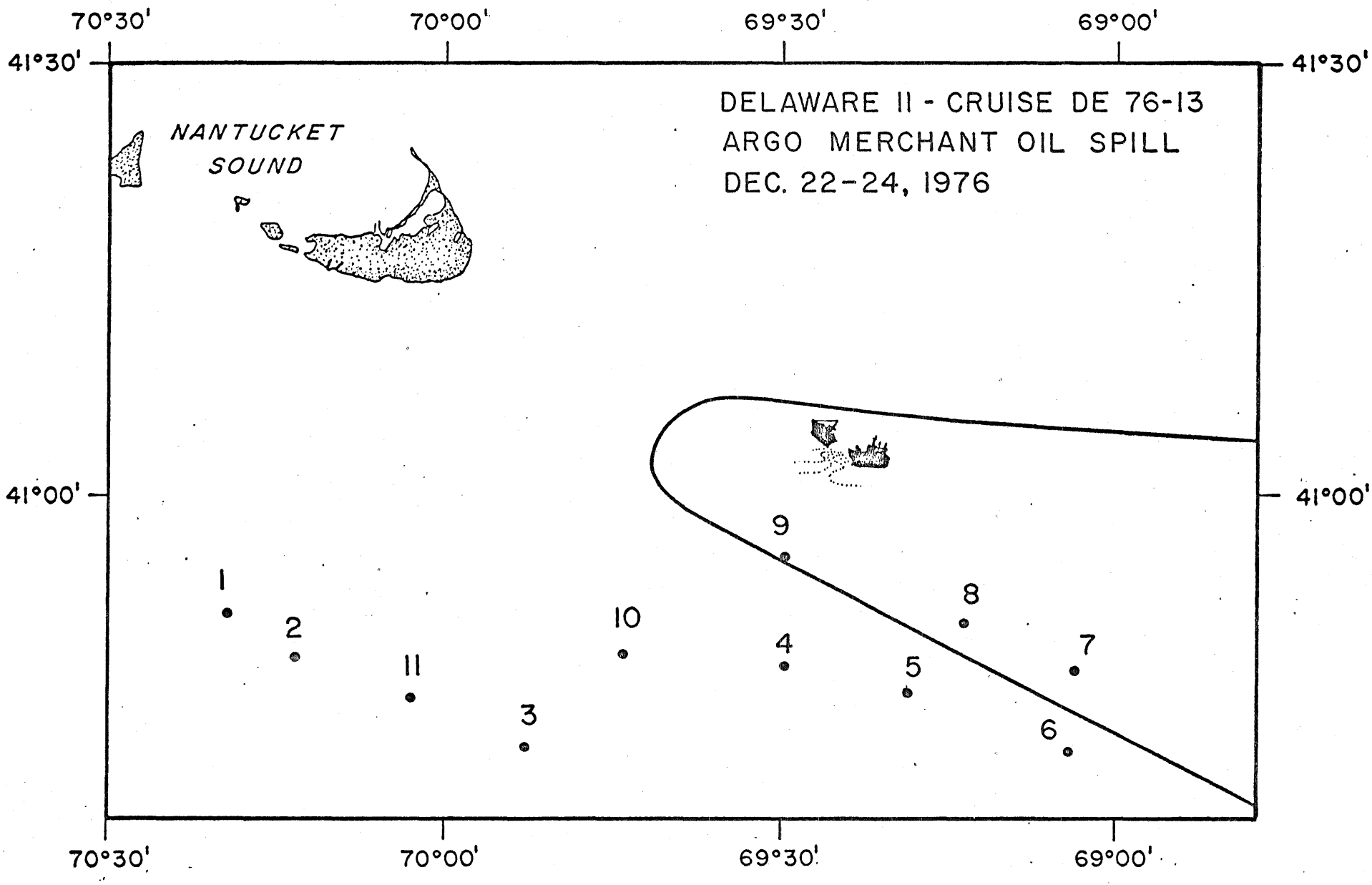

Fig. 1. Station locations.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Northeast Fisheries Center
Woods Hole, Massachusetts 02543

31 January 1977

CRUISE RESULTS
Cruise No. DE 77-01
NOAA R/V DELAWARE II
ARGO MERCHANT Oil Spill

CRUISE PERIOD AND AREA

The NOAA R/V DELAWARE II sailed from Woods Hole, Massachusetts, on 4 January 1977 and returned to Woods Hole on 10 January 1977. The area of investigation was bounded on the north and west by latitude 41°30' N and longitude 70°00'W; and extended to the 150 fathom depth contour on the south and east. This area was chosen so as to include clean zones for control stations on all sides of the estimated oil slick's route. The oil slick was determined by extending the boundary route of the available oil sightings as of 3 January. Additional stations were made east of Cape Cod and south of Nantucket shoals for the release of seabed drifters and additional control stations.

OBJECTIVES

The purpose of the cruise was to assess the condition of the fish stocks and associated populations of invertebrates and plankton on the portions of Nantucket shoals and Georges Bank through which the oil from the tanker ARGO MERCHANT had drifted. An additional objective was to obtail oil, water and sediment samples, along with observations of the oil's effect on birds and mammals of the area.

OPERATIONS

The cruise, originally scheduled for ten days was reduced by storms to four working days. All stations were pre-selected randomly. The stations on the northern side of the slick boundary were given priority for their use as controls and also for establishing the present limits of any contamination. The stations on the eastern limits of the bank and the stations of the area of initial impact around Nantucket shoals were also completed. The southern and mid-sections of the sampling area were omitted.

Forty-three stations were completed using the following gear: XBT and surface bucket thermometer for temperature and salinity samples at every station. Five seabed drifters were released at each station except stations 27 and 39. The #36 Yankee Trawl, with a Ring net and Pipe dredge attached, was used at twenty-four stations. The Digby dredge was used at nine stations. At six of

the trawl stations and at all of the Digby stations, a Hydro cast was made. Neuston plankton gear was used through station 38. The 61 cm bongos were used through station 39 while the 20 cm bongos were used only on the western part of the study area (stations 1-11 and 29-39).

The general statistics on these samplers, their use, and the information on the samples taken, are listed on the attached sampling addendum. This addendum gives the information on the samples taken during both DELAWARE II oil cruises - 77-01, 4-10 January, and 76-13, 22-23 December. Also provided is information concerning the types of samples, station plots, data disposition, etc.

Bird, mammal, and oil slick observations were made by an observer from the Manomet Bird Observatory and other scientists aboard the DELAWARE II. Oil samples from engine fuel, winch hydraulic system, side of vessel, and from the oil slick were taken (disposition Woods Hole). All data were recorded in Eastern Standard Time unless otherwise mentioned.

RESULTS

Preliminary on-ship observations showed clean fish, sediment, and water throughout the area surveyed, except at stations 37-39 which were in the vicinity of the wreck and showed some oil (estimated less than 1/10 of 1%) on the surface. All observations and samples await detailed examination.

SCIENTIFIC PERSONNEL

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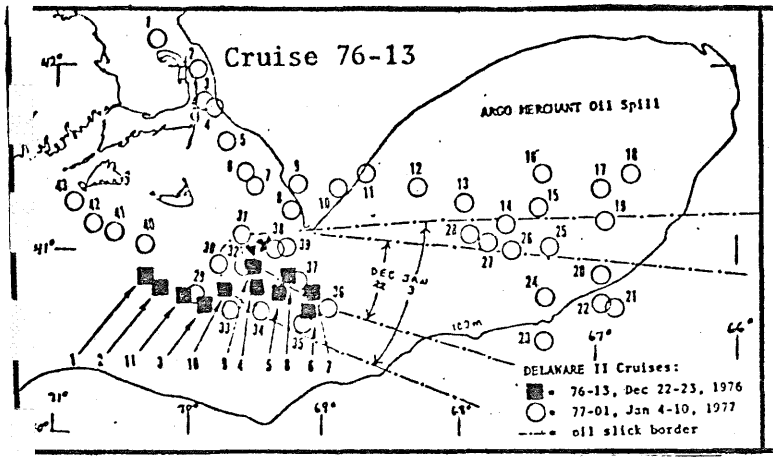
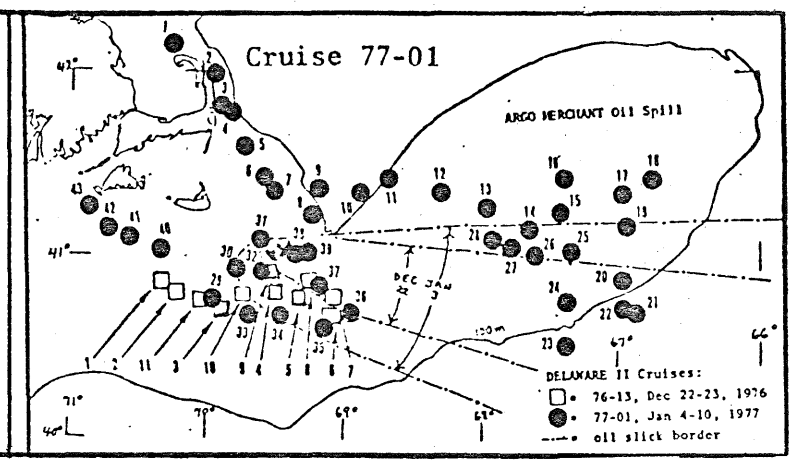
SAMPLE	TYPE OF SAMPLE	SAMPLER	SHIP'S SPEED	TIME	AREA SAMPLED	NO. STA	NO. SAMP	CONTAINER	METHOD PRESERV	INITIAL SPES DISPOSITION	PAGE
ST TOL DATA											
Water temp	Temp/depth	XBT	Stopped	-	Water col	54	54	-	XBT trace	Woods Hole	4
BO OM CURRENT											
urifters	Current	Seabed drifter	-	-	Bottom	43	41	-	-	Woods Hole	5
PLANKTON											
urf plankton	Plankton	.5x1m Neuston	2-4 knots	10 min	Surface	44	44	Qt jar	Formalin	Narragansett	6
Water col plankton	Plankton	61 cm .505 Bongo	2-3 knots	5-12 min	≤110 fm	39	36	"	"	"	6
		61 cm .333 Bongo	"	"	"	39	36	"	"	"	6
		20 cm .253 Bongo	"	"	"	22	22	"	"	"	6
		20 cm .165 Bongo	"	"	"	22	20	"	"	"	6
enthic plankton		30 cm 1.0 Ring net	3.5 knots	15 min	Bottom	26	21	"	"	Woods Hole	6
HY O SAMPLES											
Hydro (surface)	Chlorophyll	5.0 liter Nisken bottle	3.5 knots	-	1 m below	15	11	Milli filter	Frozen	Narragansett	7
"	Nutrients	"	"	-	"	15	13	125 ml	"	"	7
(mid)	Chlorophyll	"	"	-	Mid-depth	15	13	Milli filter	"	"	7
"	Nutrients	"	"	-	"	15	15	125 ml	"	"	7
(botton)	Chlorophyll	"	"	-	1 m above	2	1	Milli filter	"	"	7
"	Nutrients	"	"	-	"	2	2	125 ml	"	"	7
sterile Hydro (surface)	Hydrocarbon	2.0 liter Nisken bag	Stopped	-	5 m below	4	4	Sterile Plastic bag	"	Woods Hole	8
(bottom)	"		"	-	5 m above	4	4	"	"	"	8
urface water	Salinity	Bucket	Variable	-	Surface	54	54	125 ml	-	"	8
SEDIMENT SAMPLES											
enthic sediments	(Unsorted) Sediment	9 cm Pipe dredge	3.5 knots	15 min	Bottom	23	17	Qt jar	Air dry	Woods Hole	8
	(Sorted) Sediment	Digby dredge	2.0 knots	10 min	"	10	9	"	"	"	8
BI OGICAL SAMPLES											
Trawl[1/]	*Flesh	#36 Yankee	3.5 knots	15 min	Bottom	26	86	Foil	Frozen	Woods Hole	9,10-14
ish	Pathology	"	"	"	"	26	21	Glass jar	Formalin	Oxford	9,10-14
	Biochemistry	"	"	"	"	26	14	Plastic bag	Frozen	Milford	9,10-14
[1/] 25m sweep 5 mm liner	Stomachs	"	"	"	"	26	40	Qt jar	Formalin	Woods Hole	9,10-14
	Maturity	"	"	"	"	26	39	-	Mat. log	"	9,10-14
	Behavior	"	"	"	"	26	1	Live tank	Live	"	9,10-14
rawl	Benthic	#36 Yankee	3.5 knots	15 min	Bottom	26	3	Qt jar	Formalin	Woods Hole	8,9,15-18
nvertebrates	*Flesh	"	"	"	"	26	26	Foil	Frozen	"	8,9,15-18
	Pathology	"	"	"	"	26	28	Glass jar	Formalin	Oxford	8,9,15-18
	Biochemistry	"	"	"	"	26	18	Plastic bag	Frozen	Milford	8,9,15-18
	Behavior	"	"	"	"	26	3	Live tank	Live	Woods Hole & Milford	8,9,15-18
redge[2/]	Benthic	Digby dredge	2.0 knots	10 min	Bottom	10	9	Qt jar	Formalin	Woods Hole	8,9,15-18
Invertebrates	*Flesh	"	"	"	"	10	7	Foil	Frozen	"	8,9,15-18
	Pathology	"	"	"	"	10	13	Glass jar	Formalin	Oxford	8,9,15-18
[2/] x22 cm mm liner	Biochemistry	"	"	"	"	10	2	Plastic bag	Frozen	Milford	8,9,15-18
	Behavior	"	"	"	"	10	3	Live tank	Live	Woods Hole & Milford	8,9,15-18
Miscellaneous	Benthic	9 cm Pipe dredge	3.5 knots	15 min	Bottom	26	1	Qt jar	Formalin	Woods Hole	8
Invertebrates	"	0.5 liter grab Dieta-Lafond	Stopped	-	"	1	1	"	"	"	8
	"	Plankton	Variable	(hit bottom)	"	1	1	"	"	"	8

*Whole specimens to be used primarily for hydrocarbon analysis





STATION DATA

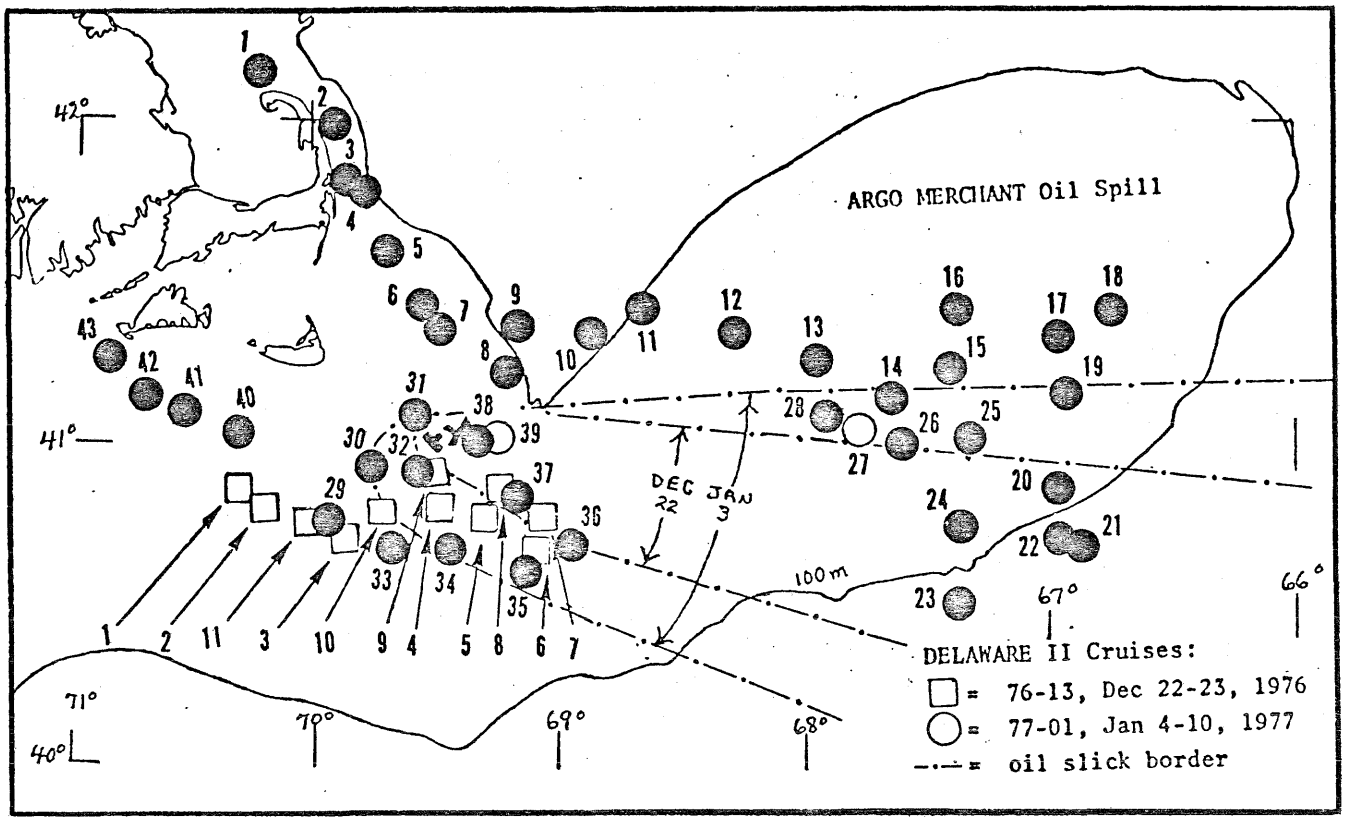
Delaware II - 76-13

Station	Day	Date Month	Year	Time (EST)	Latitude	Longitude	Depth 1/ (M)	Wind Dir	Wind Sp	Wave Hgt (FT)	Air Temp (°C)	Surf 1/ Temp (°C)	Bot 1/ Temp (°C)
1	22	12	76	1930	40°52'	70°20'	43	27	14	6	2.2	6.6	6.6
2	22	12	76	2000	40°49'	70°13'	41	27	14	6	2.2	6.5	6.8
3	22	12	76	2130	40°43'	69°53'	44	23	14	6	3.3	4.7	4.8
4	22	12	76	2380	40°49'	69°30'	44	24	18	6	4.4	5.7	5.7
5	23	12	76	0209	40°47'	69°18'	50	23	14	4	5.6	6.3	6.3
6	23	12	76	0317	40°43'	69°05'	84	24	15	4	6.7	6.7	6.8
7	23	12	76	0651	40°48'	69°04'	79	12	8	2	6.7	7.0	7.9
8	23	12	76	0904	40°52'	69°14'	61	12	2	3	7.2	7.0	-
9	23	12	76	1219	40°56'	69°30'	44	18	6	3	8.3	6.1	6.1
10	23	12	76	1415	40°50'	69°44'	31	27	8	4	6.1	5.0	5.0
11	23	12	76	1520	40°46'	70°03'	39	27	5	4	6.1	5.0	5.6

Delaware II - 77-01

Station	Day	Date Month	Year	Time (EST)	Latitude	Longitude	Depth 1/ (M)	Wind Dir	Wind Sp	Wave Hgt (FT)	Air Temp (°C)	Surf 1/ Temp (°C)	Bot 1/ Temp (°C)
1	4	01	77	1958	42°07'	70°13'	59	32	25	2	2.2	3.2	3.8
2	4	01	77	2143	42°00'	69°57'	40	32	24	3	3.3	3.9	4.0
3	4	01	77	2345	41°49'	69°52'	46	32	25	4	3.3	4.0	4.7
4	5	01	77	0135	41°48'	69°50'	75	34	25	4	2.8	4.2	5.3
5	5	01	77	0415	41°37'	69°43'	40	36	26	4	3.9	4.6	4.7
6	5	01	77	0610	41°27'	69°34'	30	34	25	5	3.3	4.7	5.2
7	5	01	77	0835	41°22'	69°30'	32	36	24	5	2.8	4.7	4.7
8	5	01	77	1115	41°14'	69°13'	84	34	20	4	3.3	6.5	6.5
9	5	01	77	1330	41°23'	69°10'	144	36	15	5	3.9	6.6	7.1
10	5	01	77	1608	41°22'	68°51'	126	36	14	4	4.4	6.7	7.1
11	5	01	77	1800	41°27'	68°39'	96	33	8	4	3.3	6.6	6.8
12	5	01	77	2112	41°22'	68°15'	50	32	15	2	3.3	5.4	5.8
13	5	01	77	2340	41°17'	67°57'	35	32	10	2	2.8	5.5	6.1
14	6	01	77	0105	41°10'	67°38'	51	34	10	3	4.4	5.4	6.4
15	6	01	77	0250	41°15'	67°24'	49	35	16	3	3.9	5.7	5.8
16	6	01	77	0450	41°26'	67°22'	44	36	14	4	4.4	6.0	6.1
17	6	01	77	0737	41°21'	66°57'	66	03	20	4	3.9	5.9	5.9
18	6	01	77	0945	41°27'	66°42'	66	01	20	3	2.8	6.3	6.5
19	6	01	77	1215	41°10'	66°55'	70	03	17	4	3.9	6.1	5.8
20	6	01	77	1420	40°53'	66°58'	89	03	16	4	4.4	7.7	6.7
21	6	01	77	1610	40°42'	66°51'	220	03	12	4	2.8	7.1	8.7
22	6	01	77	1742	40°43'	66°57'	143	05	10	4	2.2	8.4	9.1
23	6	01	77	2100	40°31'	67°21'	143	05	8	1	2.2	6.8	10.3
24	6	01	77	2333	40°45'	67°21'	97	36	-	2	2.2	6.7	6.9
25	7	01	77	0150	41°02'	67°19'	68	13	5	2	2.8	6.2	5.9
26	7	01	77	0335	41°01'	67°35'	64	11	12	2	2.8	5.3	5.7
27	7	01	77	0505	41°04'	67°45'	54	10	8	2	3.9	5.3	6.1
28	7	01	77	0623	41°06'	67°53'	49	10	20	3	5.0	5.1	5.2
29	8	01	77	2037	40°46'	69°57'	26	32	18	4	0.6	4.1	4.1
30	8	01	77	2233	40°56'	69°46'	35	32	16	4	-2.2	4.1	4.5
31	8	01	77	2353	41°06'	69°36'	31	31	18	4	-2.2	5.4	5.4
32	9	01	77	0153	40°56'	69°34'	39	31	20	4	-1.7	4.7	4.9
33	9	01	77	0405	40°41'	69°41'	52	30	18	4	-2.2	5.4	5.4
34	9	01	77	0618	40°40'	69°26'	53	29	20	4	1.7	5.7	5.7
35	9	01	77	0833	40°37'	69°08'	72	32	16	4	0.0	6.5	6.5
36	9	01	77	1030	40°42'	68°56'	67	29	20	4	0.0	5.9	5.9
37	9	01	77	1300	40°51'	69°10'	63	31	16	4	-1.1	5.4	5.5
38	9	01	77	1415	41°01'	69°19'	58	32	12	4	-1.1	5.7	5.8
39	9	01	77	1530	41°02'	69°15'	56	32	6	4	-1.1	6.3	6.3
40	9	01	77	2000	41°03'	70°20'	27	29	9	4	-2.2	1.6	2.0
41	9	01	77	2100	41°06'	70°33'	42	27	8	1	-2.2	4.0	4.0
42	9	01	77	2200	41°09'	70°43'	37	90	8	1	-1.1	4.0	4.0
43	9	01	77	2300	41°16'	70°52'	24	07	16	1	-1.7	2.1	2.1

1/Depth, surface and bottom temperature as recorded from XBT Trace



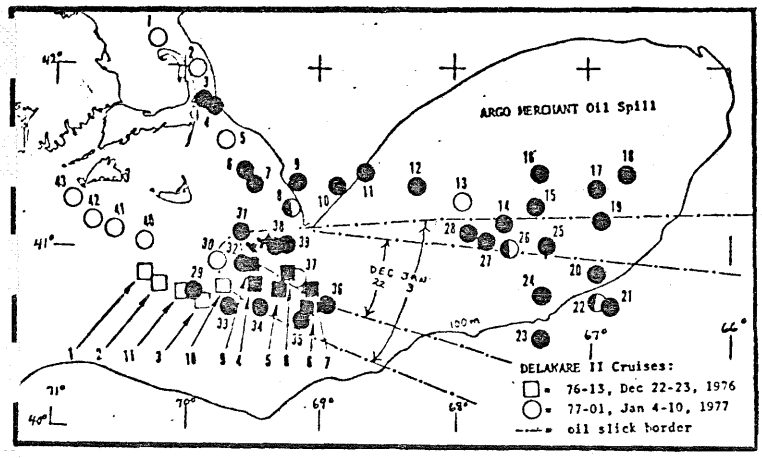
RELEASE OF SEABED DRIFTERS

Station	Identification No.	Station	Identification No.	Station	Identification No.
1	3071-3075	16	3046-3050	31	3161-3165
2	3076-3080	17	3026-3030	32	3111-3115
3	3091-3095	18	3016-3020	33	3126-3130
4	3056-3060	19	3041-3045	34	3146-3150
5	3096-3100	20	3031-3035	35	3106-3110
6	3086-3090	21	3186-3190	36	3101-3105
7	3061-3065	22	3176-3180	37	3131-3135
8	3081-3085	23	3171-3175	38	3166-3170
9	3036-3040	24	3181-3185	39	None
10	3021-3025	25	3196-3200	40	3121-3125
11	3066-3070	26	3151-3155	41	3141-3145
12	3006-3010	27	None	42	3116-3120
13	3051-3055	28	3156-3160	43	3251-3255
14	3011-3015	29	3136-3140		
1/ 15	3000-3005	30	3191-3195		

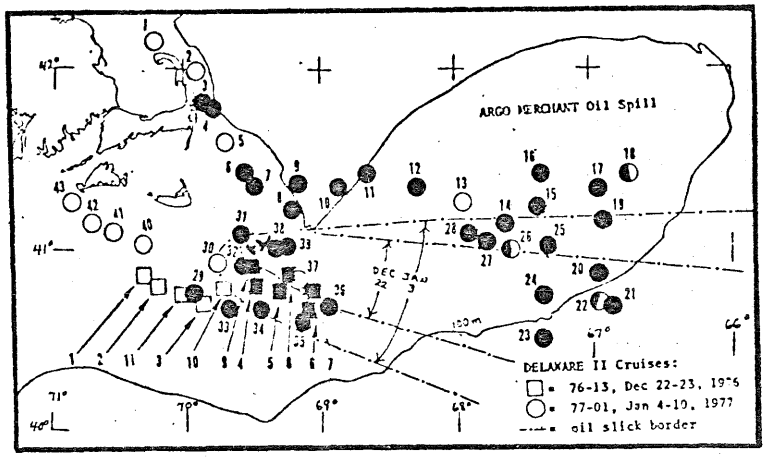
1/ Six drifters

PLANKTON SAMPLES

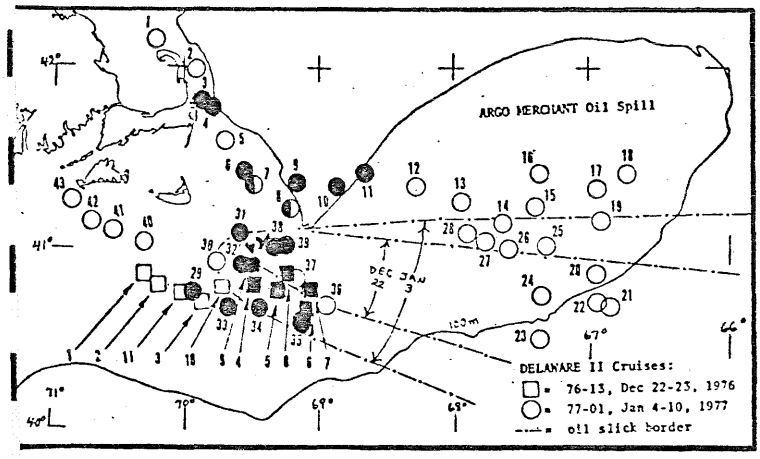
61 cm Bongo .333 mesh



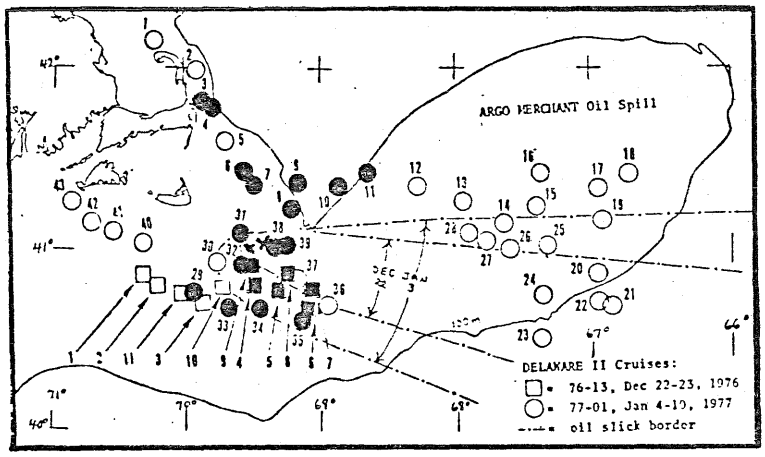
61 cm Bongo .505 mesh



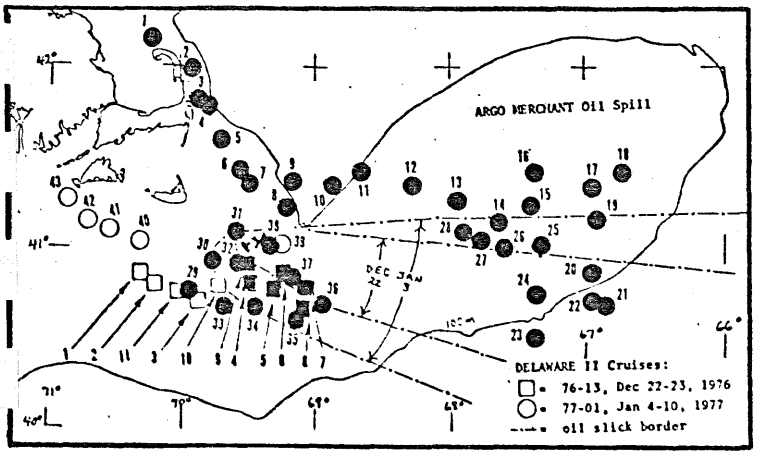
20 cm Bongo .165 mesh



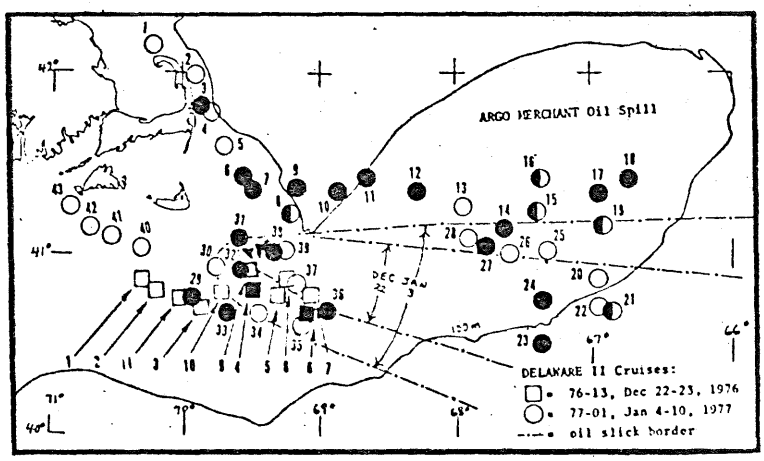
20 cm Bongo .253 mesh



50 cm x 100 cm Neuston .505 mesh



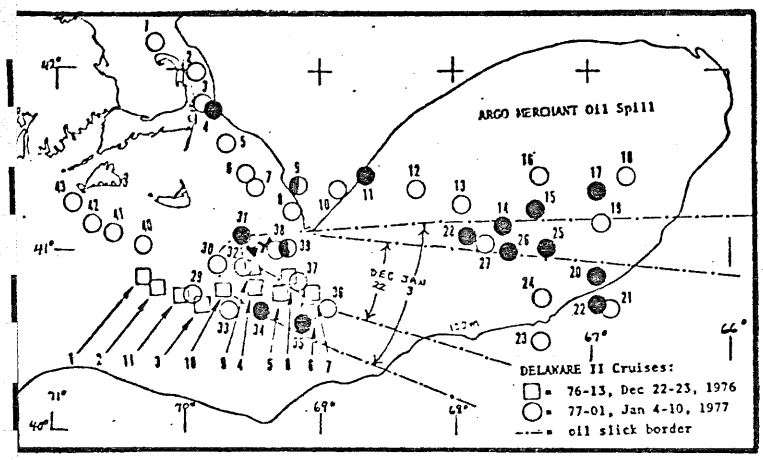
30 cm Ring Net 1.00 mm mesh



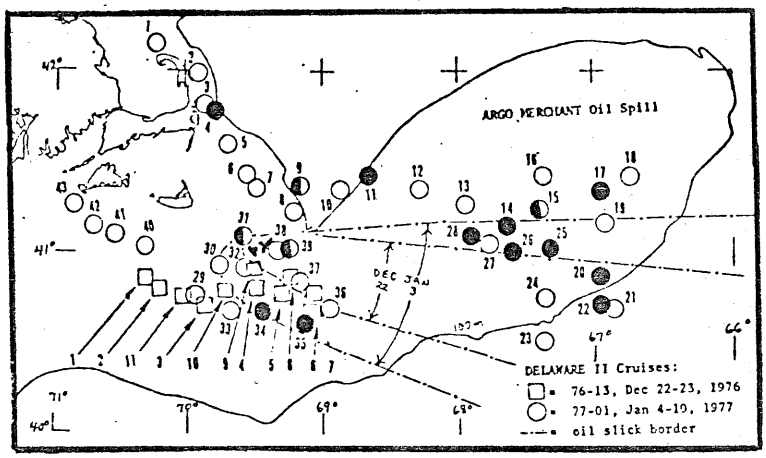
◐ = equipment used, but no sample

HYDRO SAMPLES (5 Liter Nisken Bottle)

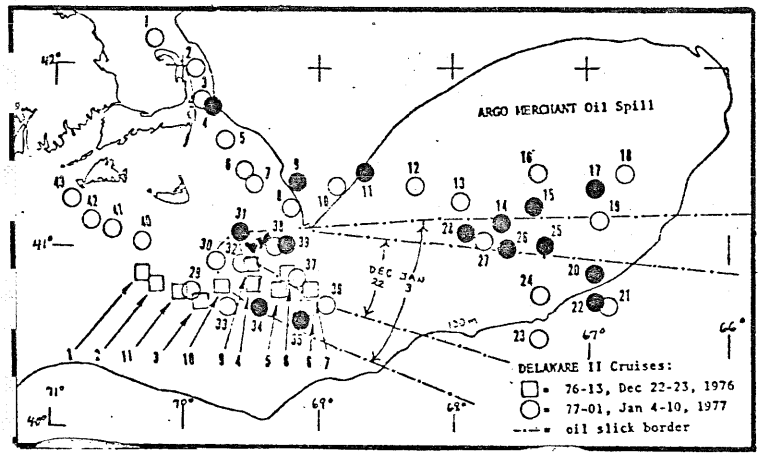
Surface Nutrients



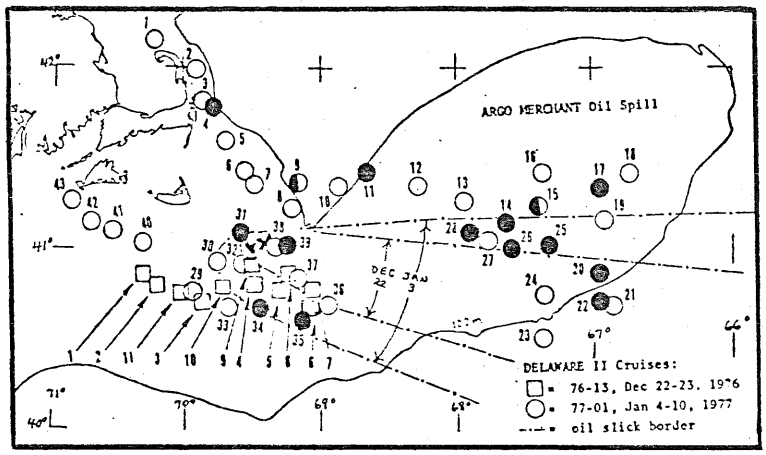
Surface Chlorophyll



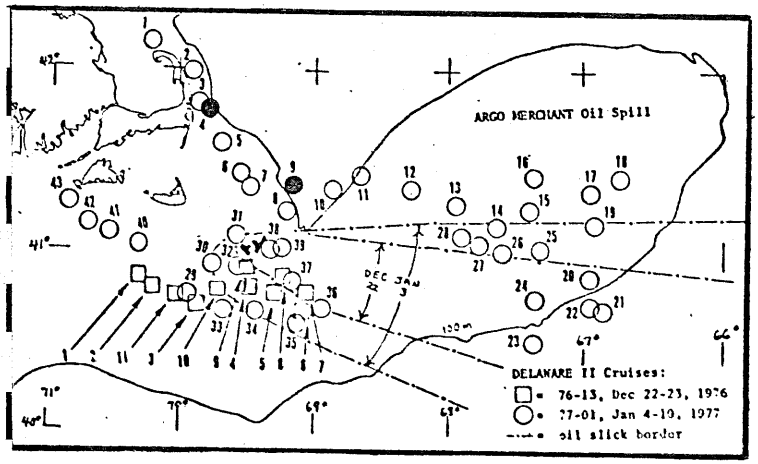
Mid-depth Nutrients



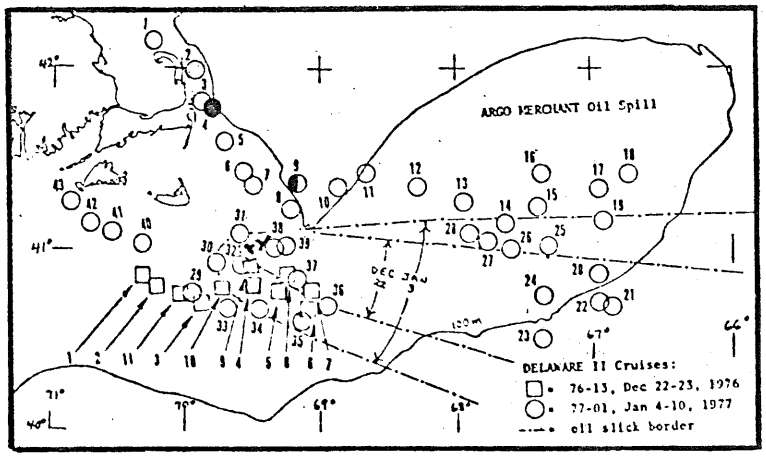
Mid-depth Chlorophyll



Bottom Nutrients



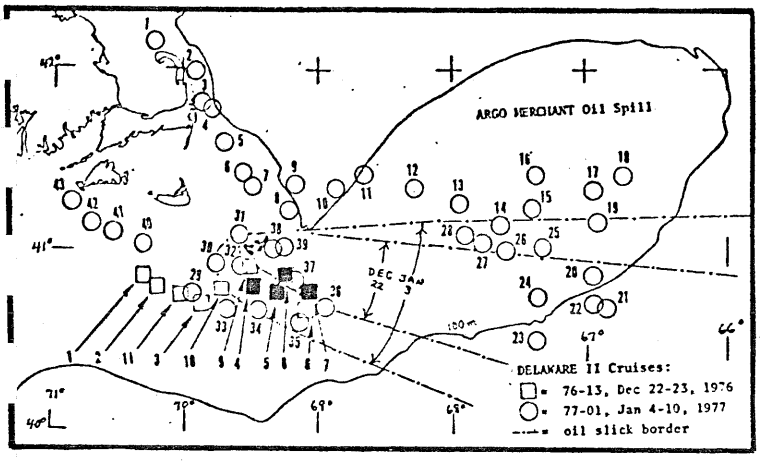
Bottom Chlorophyll



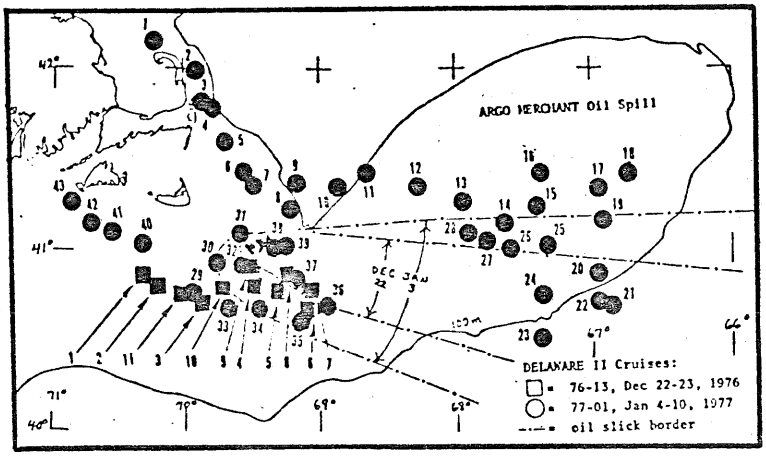
◐ = equipment used, but no sample

HYDRO SAMPLES

2 liter sterile Nisken bags
surface and bottom



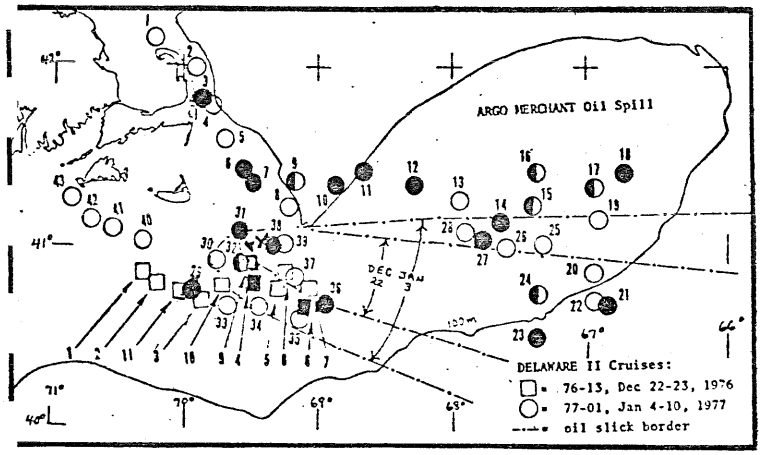
Surface water (125 ml sample)
and XBT casts



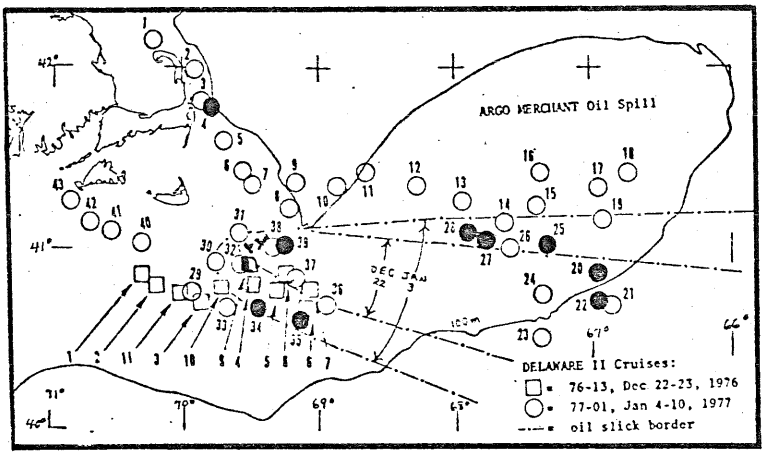
at 15 m

SEDIMENT SAMPLES

Unsorted sample - Pipe dredge



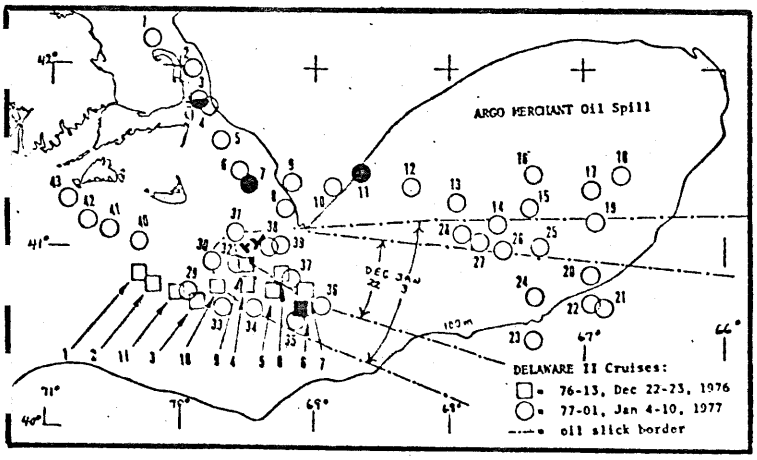
Sorted sample - Digby dredge

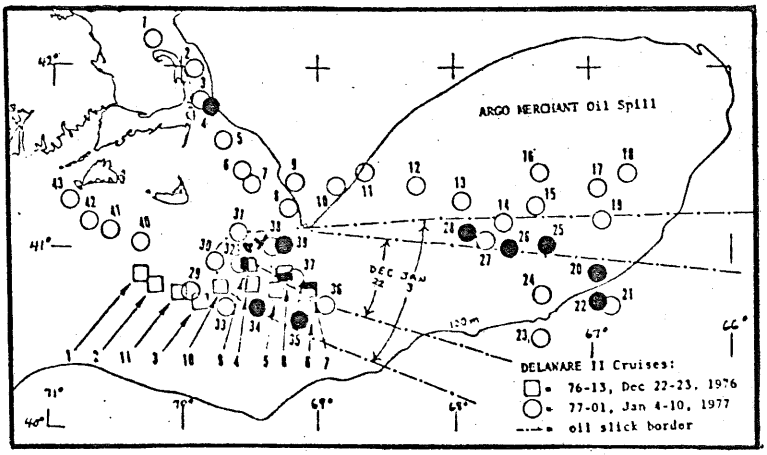


◐ = pipe dredge used, but no sample

BENTHIC SAMPLES[1/]

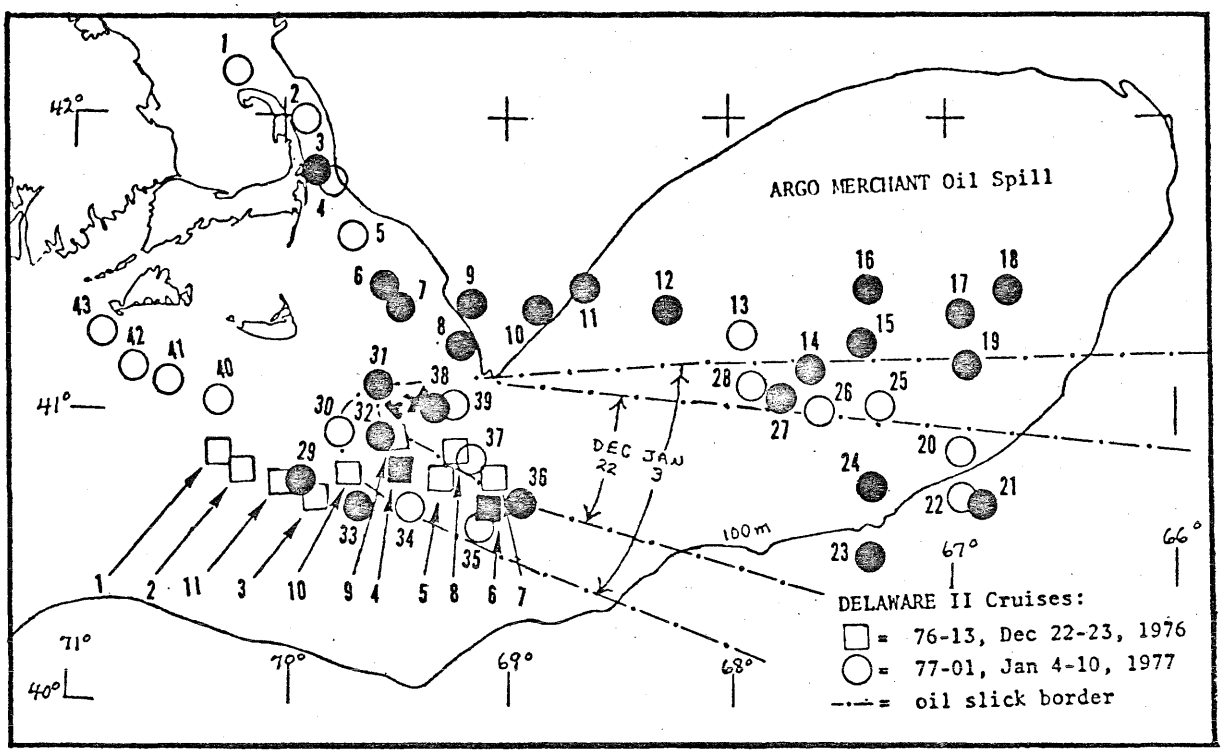
Trawl ● ■ Pipe ◒ Digby ● Dietz-Lafond ■ Plankton ■



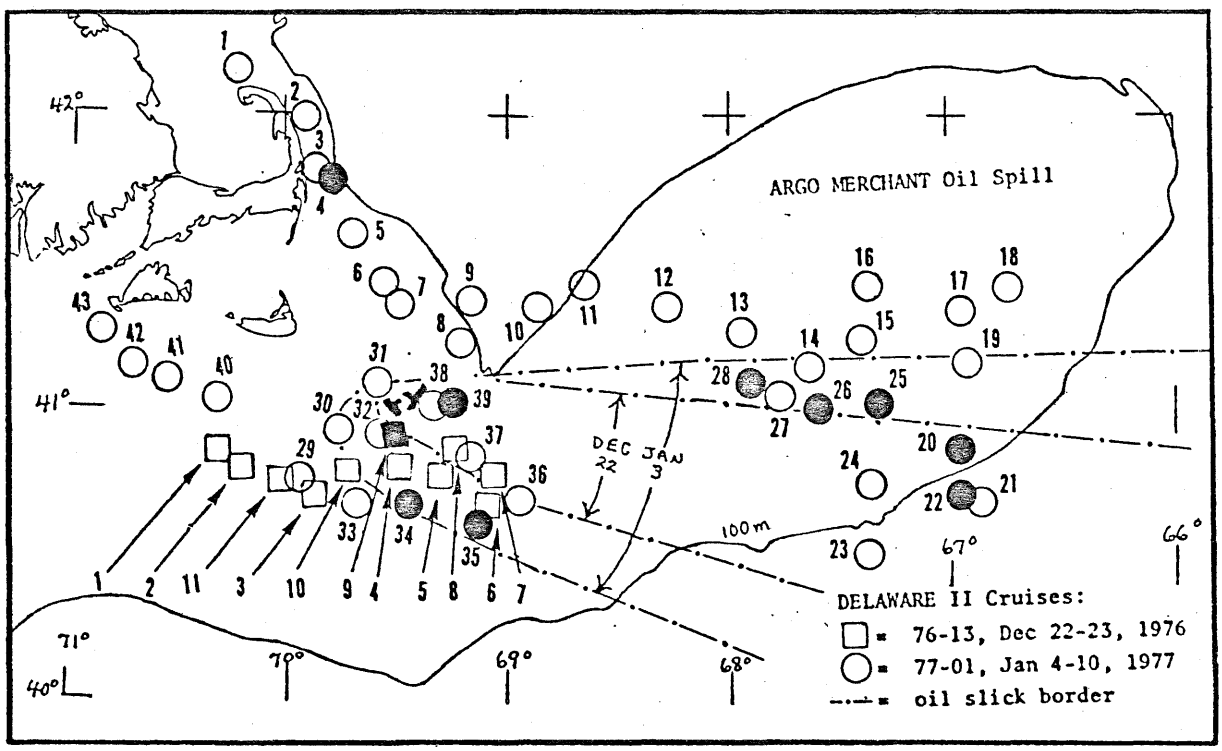


[1/] Samples preserved in formalin and saved for miscellaneous uses. The larger invertebrates are listed under the "Benthic" column of the Invertebrate Sample section.

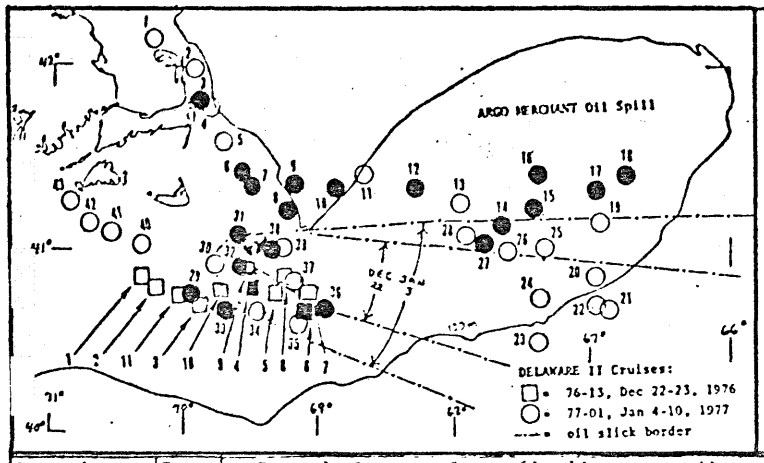
TRAWL LOCATIONS



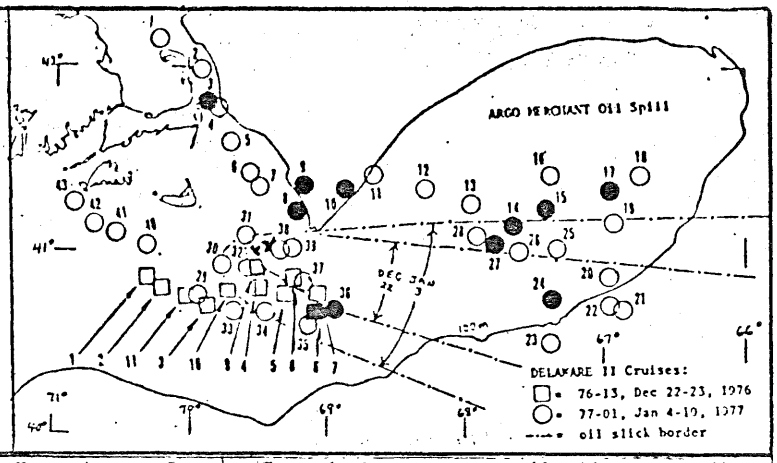
DIGBY DREDGE LOCATIONS



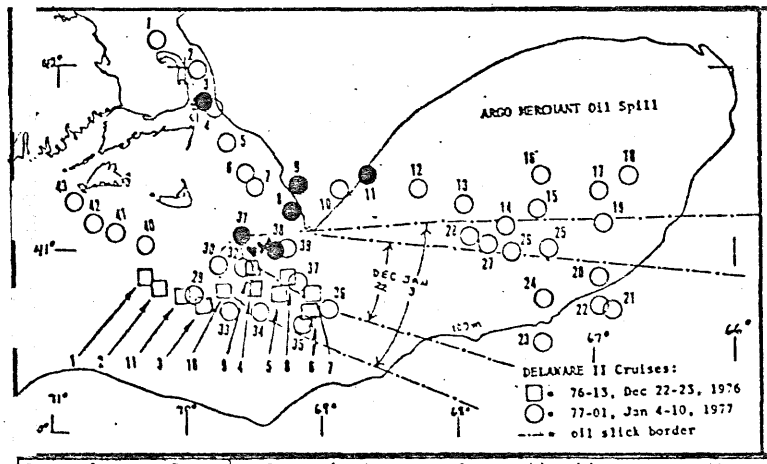
In the following pages of fish and invertebrate samples; stations where species occurred are plotted but only listed when a sample was saved.



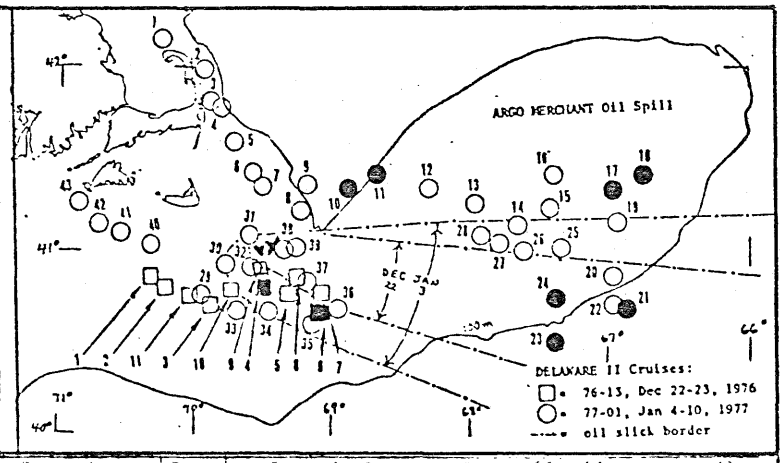
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
COD	3	5				
●	8			6		11
	9				5	5
	14				3	3
	17				1	1
	27				2	2
	29				20	20
	31	1				
	36				6	6
	38	2		1		
	4	5			26	26
■	6	1				



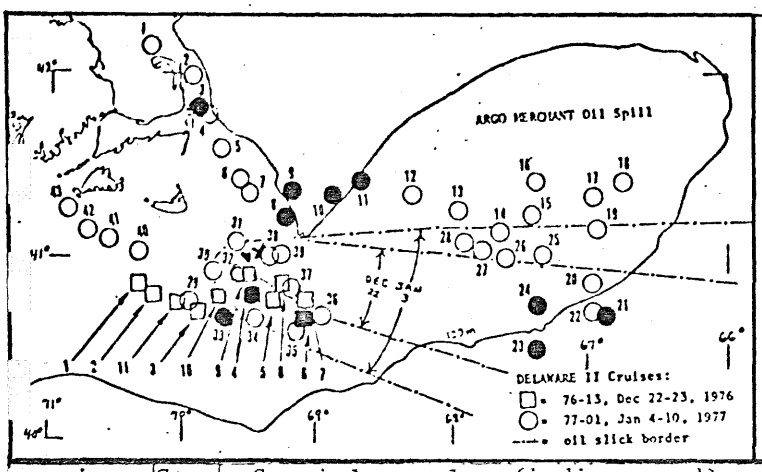
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
HADDOCK	3	7				
●	8	6				
	9			2	5	5
	15				10	10
	27	3			6	6
	36			2		
■	6	1				



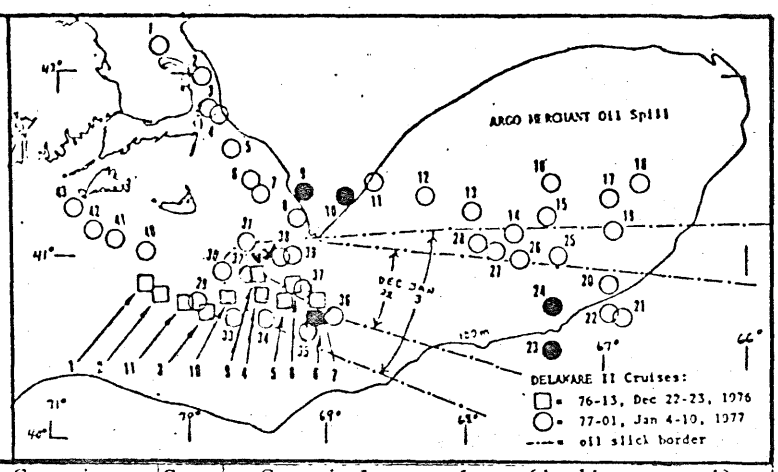
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
POLLOCK	3	2				
●	8	1				
	9				2	2
	11	1			4	4
	31	1			4	4
	38	1				



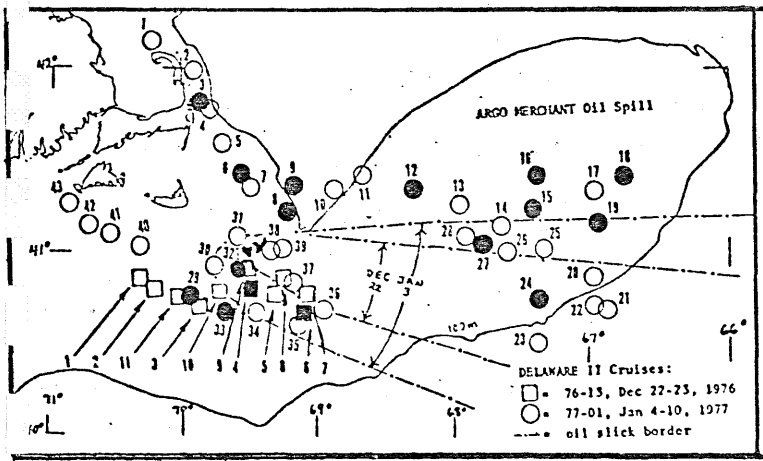
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
SPINY DOGFISH	17	1				
	21	3				
●	23	6			10	
	4	1				
■	6	3			9	



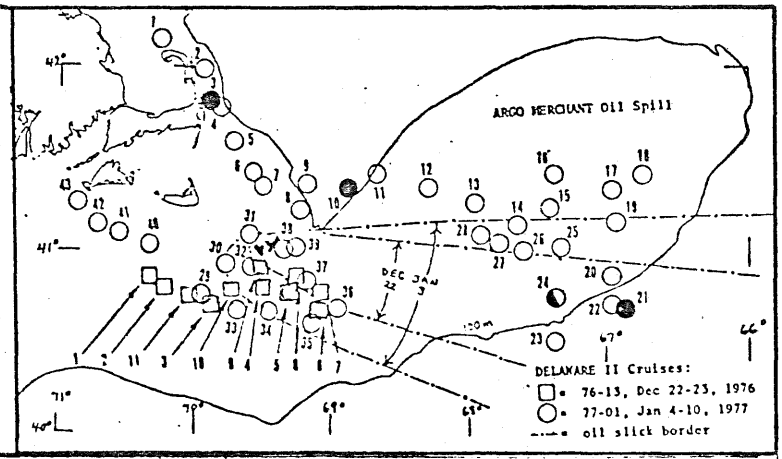
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
SILVER HAKE	3	3				
	8	1				
●	10	5	1			
	11		2			
	23		4			
	24	2				
	33	1				
■	4	1				
	6	4				



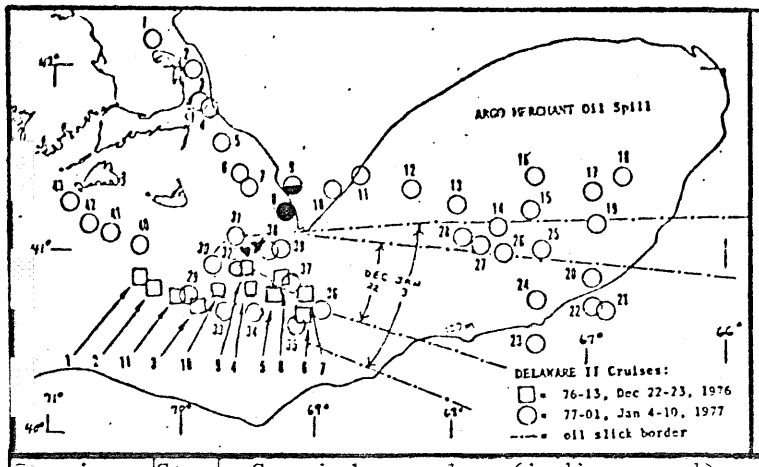
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
RED HAKE	10	5				
	23		3			
●	24	4			6	6
■	6	6				

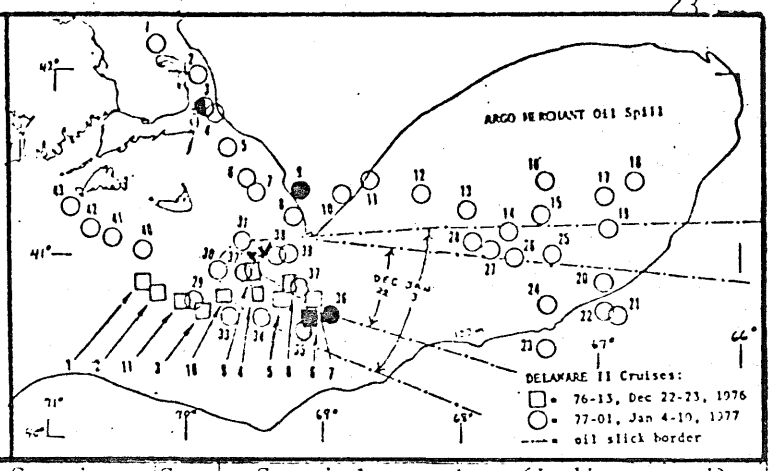


Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
OCEAN POUT	3	15				
	8	1				
●	18				2	2
	19				2	2
	29				5	5
	33				5	5
■	4	1				
	6	4			4	4



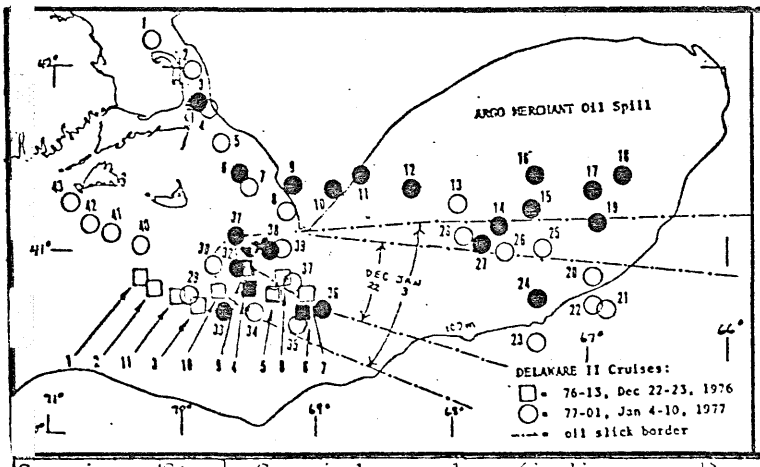
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
WHITE HAKE	3	4				
	10	6	7			
●						
GULF-STREAM FLDR	24	1				
◐						

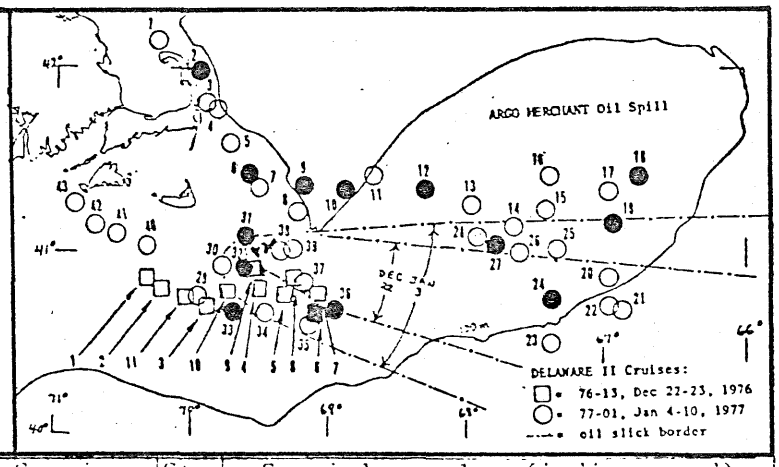




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
MACKEREL ●	8			1		
BLUEBACK ◒	9			1		

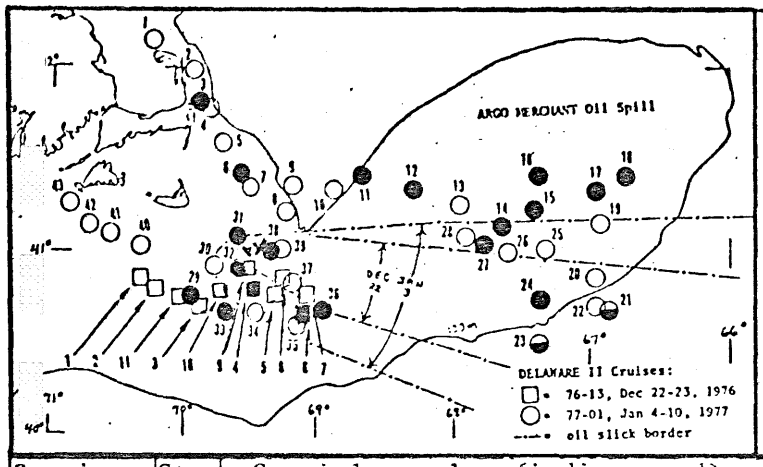
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
HERRING ◐	3		1			
ALEWIFE ●	9			3		
	36	4	6	6	10	10
■	6	1				

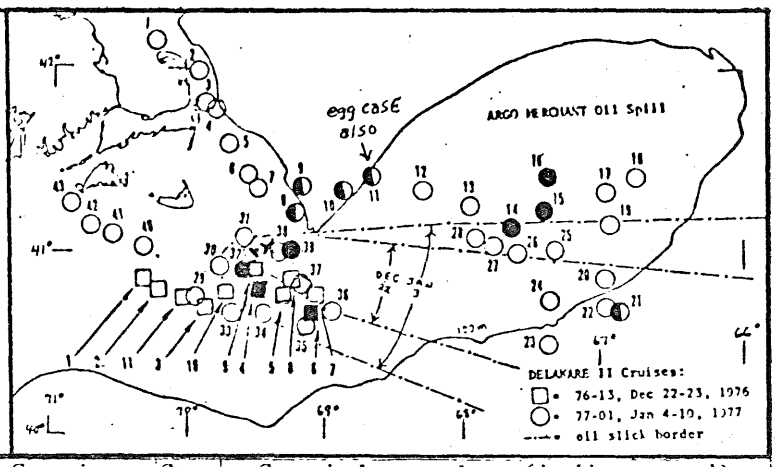




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
LH SCULPIN ●	3	2				20
	11				13	
	18					6
	36	3				
	38		1 live			
■	4	9				
	6	26				24

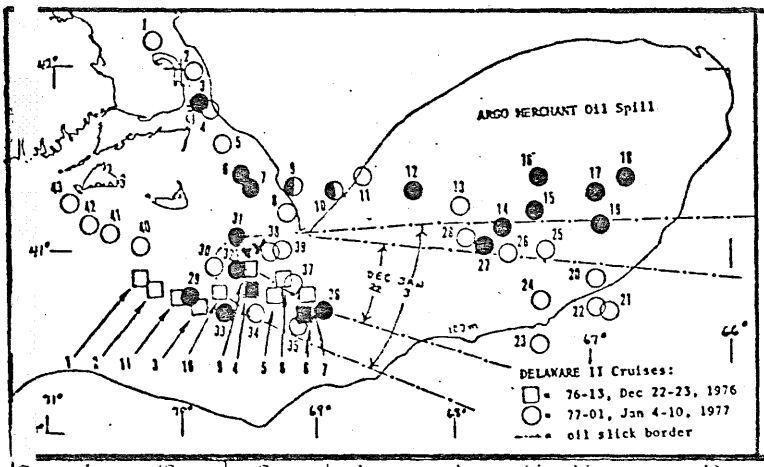
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
SEA RAVEN ●	10	2				
	18				5	5
	24	2				
	32	1				
■	6	4				

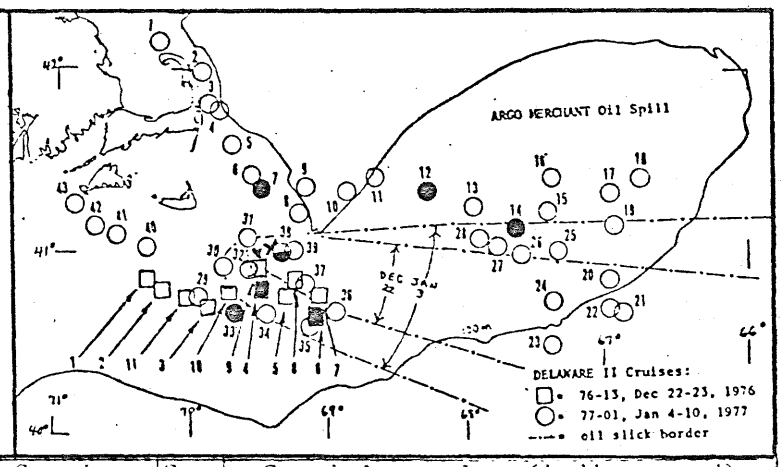




Species Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
LITTLE SKATE	3	3	1			
	12				11	
	14				7	
	36	2			6	
	4	6			40	
	6	6				
LKBELLY OSEFISH	21	4				

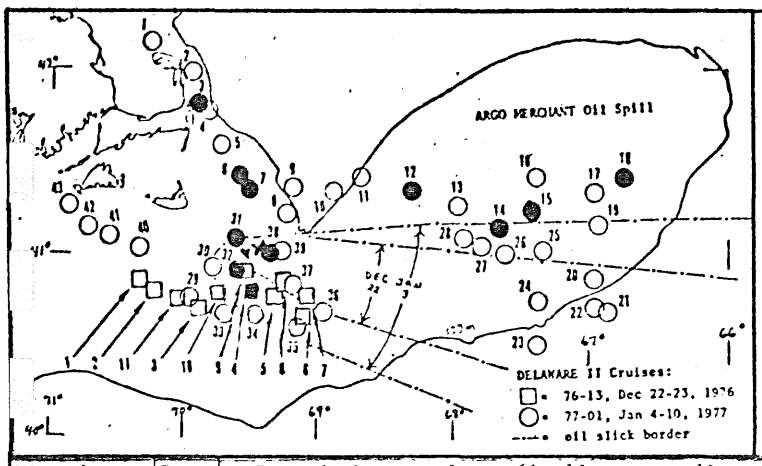
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
SKATE EGG CASE	11	1				
	14	1				
	15	3				
	16	2				
	32	1				
	39	3				
	4	8				
	6	1				
THORNY SKATE	11	7			4	
	21	1				

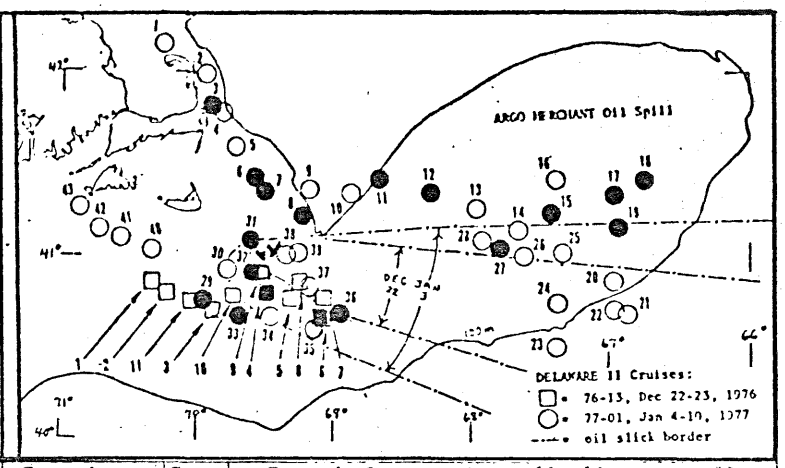




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
WINTER SKATE	7		1			
	27	2				
	36				2	
	4	3			7	
	6	3				
REDFISH	9	5				

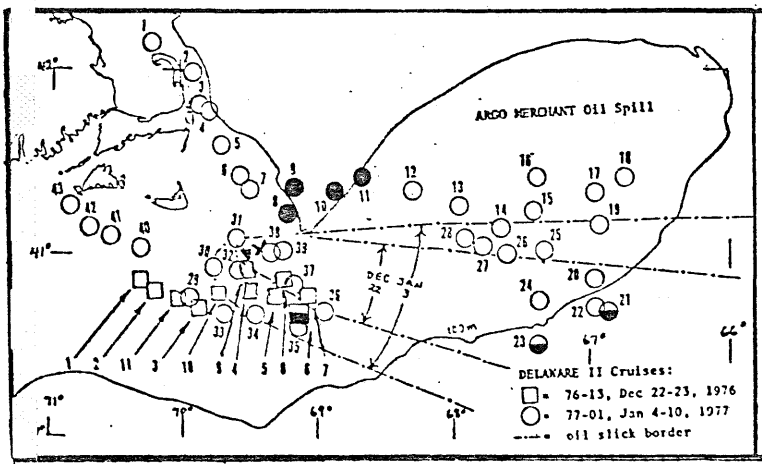
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
SAND LANCE	33	1				
	4	8				
	6	3				
CUNNER	38	2	3	live		

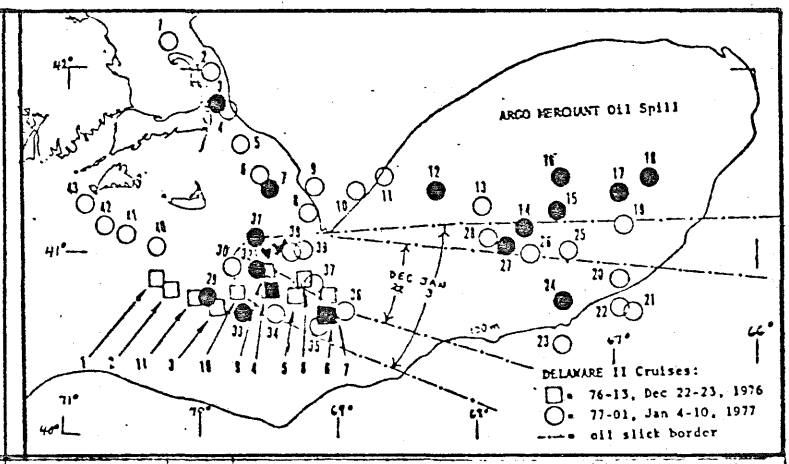




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
BLACK-BACK ●	3	1				
	6		5			5
	7		4		3	3
	12		9	1		
	15			3		
	18		1			
	31	6	7	2		14
	32	1			2	2
	38		5	5		
■	4	1				

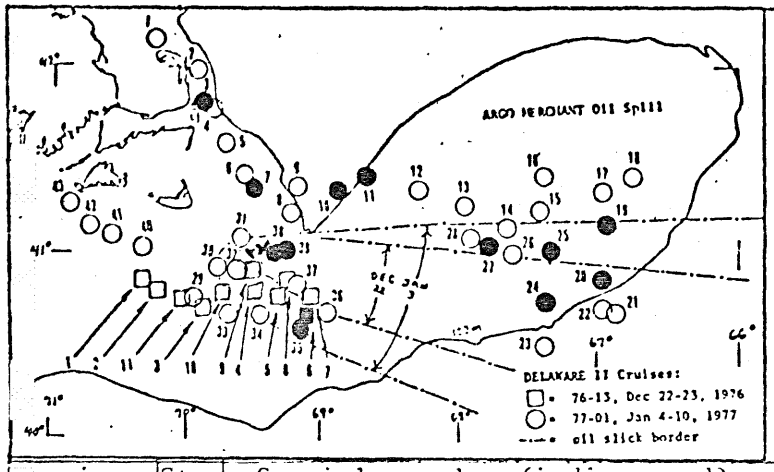
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
YELLOW-TAIL FLDR ●	3	6	11	6		
	6		1			1
	7		7		8	8
	8	2				
	11		10			
	15				3	3
	19					5
	27		3			
	31	3				
	32			7		
	33	1			9	9
	36		4			
■	4	3				
	6	18				

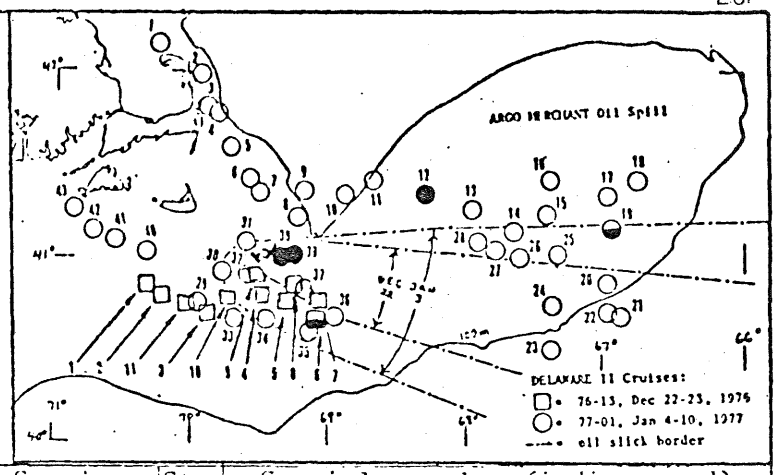




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
AM DAB ●	8	1				
	10				3	3
4-SPOT FLDR ◒	21	1				
⬓	6	2				

Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Stom	Mat
WINDOW-PANE ●	3	3			13	13
	12					
	14	1				
	27				16	16
	31					15
■	4	6			5	5
	6	1				

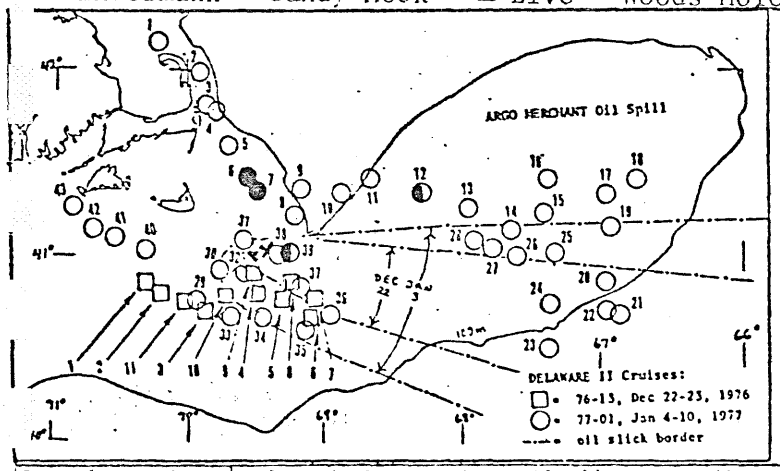


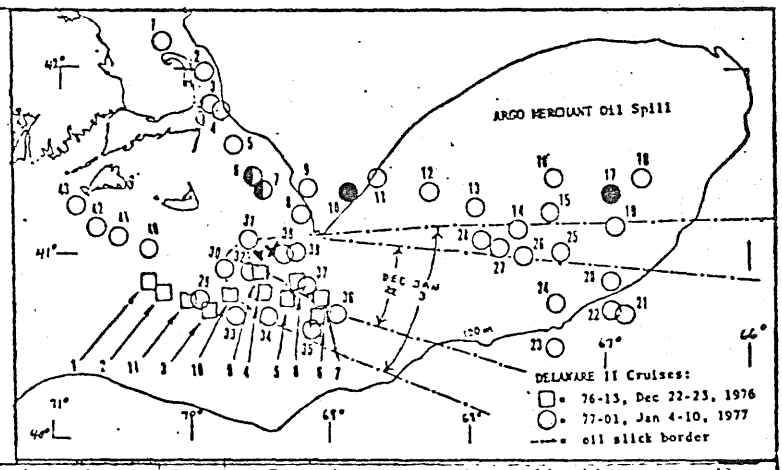


Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
SCALLOPS ●	3	10	6	6	6 1/
	7		4		
	11		5		
	19			2 live	
	20		7	6	
	24		6		
	25				1
	27		2		
	35		3		
	38		1		12 2/
	39	6	6	11 + 7 live	6 1/ + 18 2/
■	6	9			

Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
MYTILUS CLAM ●	12			2	
	38		1		
	39				4
SPONGE ◒	19	1			
◒	6				several

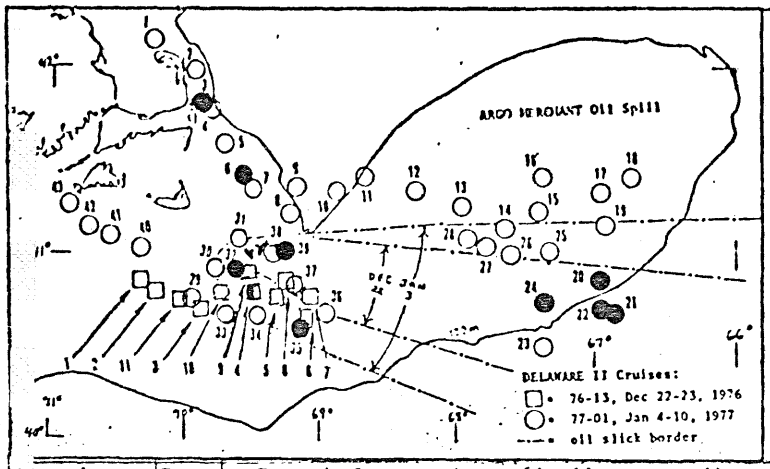
1/ Sindermann - Sandy Hook 2/ Live - Woods Hole

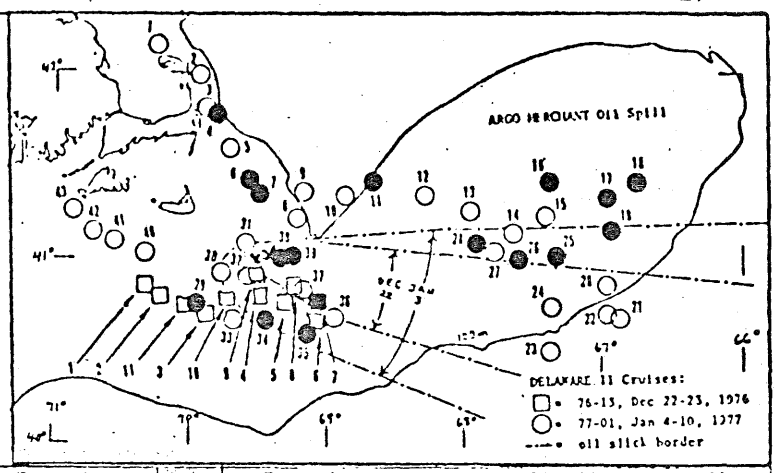




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
HORSE MUSSEL ●	6		7	10	
	7			6 live	
BLUE MUSSEL ◐	12		2		
	39			1 live	

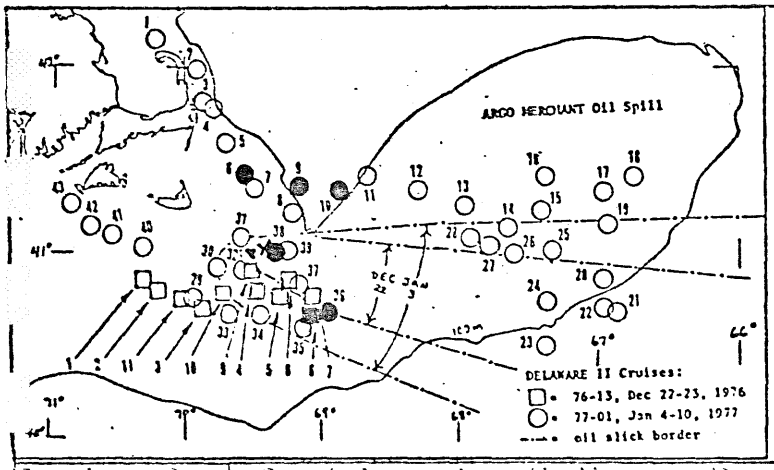
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
SEA ANEMONE ●	10	several			
	17		2		
SEA SQUIRTS ◐	7				several

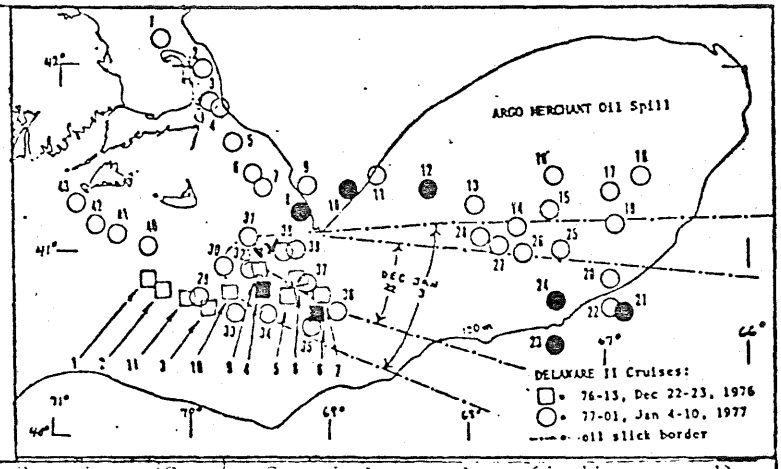




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
CANCER CRAB ●	3		10		
	20				2
	22		2		
	24			1	
	32	2			
	35		4		
	39	several			3
LADY CRAB ■	4	1			

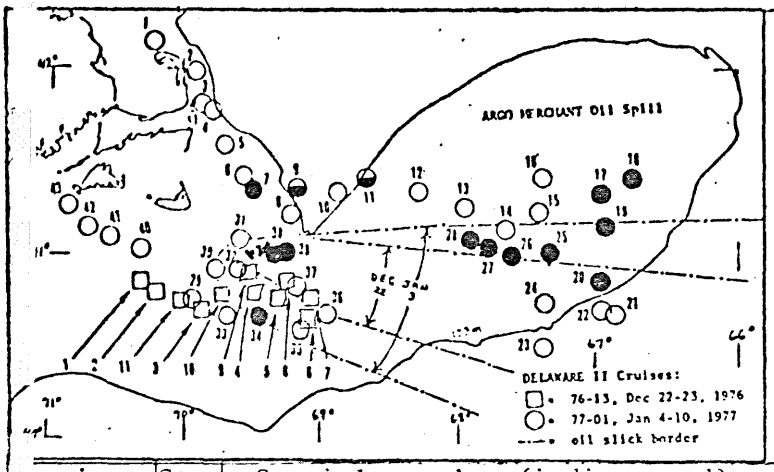
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
HERMIT CRAB ●	4				5
	7				several
	16	several			
	17		3		
	18		6		
	19			6 live	
	25				6
	26				6
	28		6		
	29		2		
	34		4		8
	35		3		
	38		1		
	39	several	9		
■	6				several

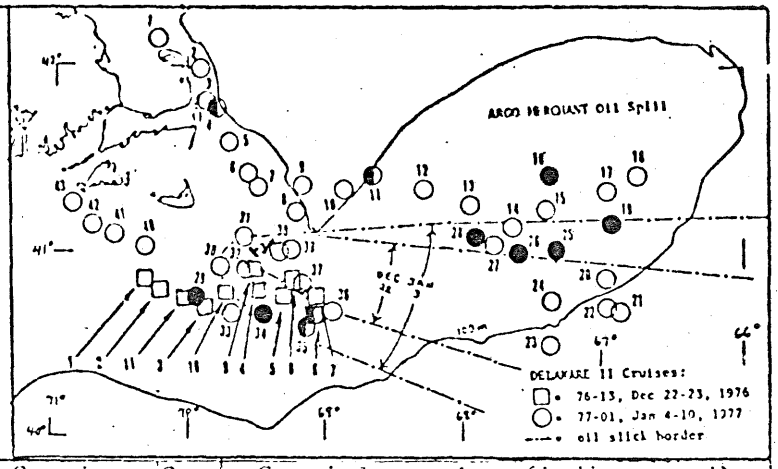




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
LOBSTER ●	6	1			
	9			2	
	10		1		
	36		1	1	
	38		1	1	
■	6	1			

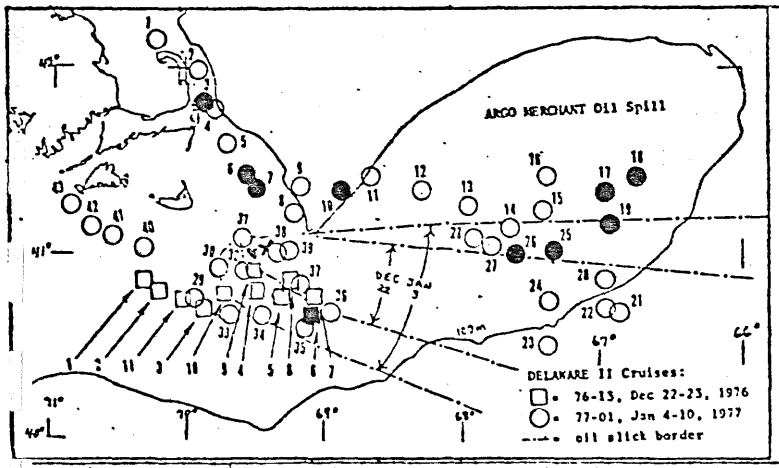
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
LOLIGO ●	12		1		
	21		4		
	23	20	4	14	
■	4	1			
	6	7			

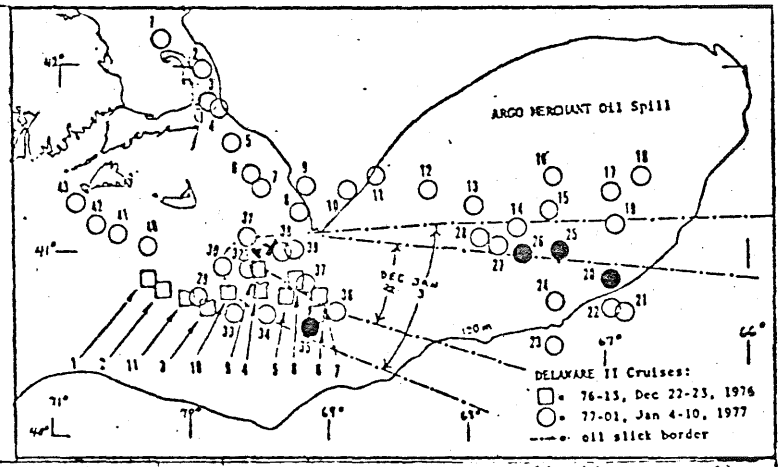




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
WHELKS ●	7				several
	17		4		
	18		15		
	19				
	20				4
	25				6
	26				3
	27				
	28				3
	34				8
	38		3		
	39	several	1		
ILLEX ◒	11	1			

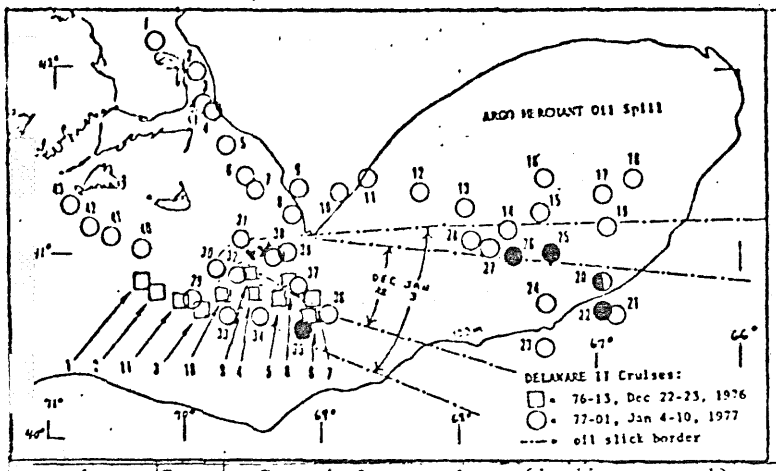
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
SAND DOLLARS ●	25				4
	26				4
	28				24
	34	24	3		12
SHRIMP ◐	4				several
	11	several			several
	35				several
◧	6				several

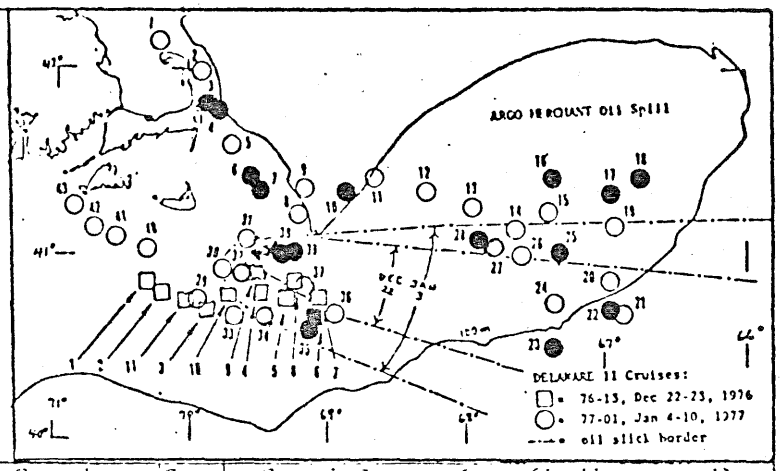




Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
SEA URCHINS ●	3	several			
	6	24			
	7				several
	10	several			
	17		2		
	18		20		
	19	several			
	25				4
	26				2
■	6				several

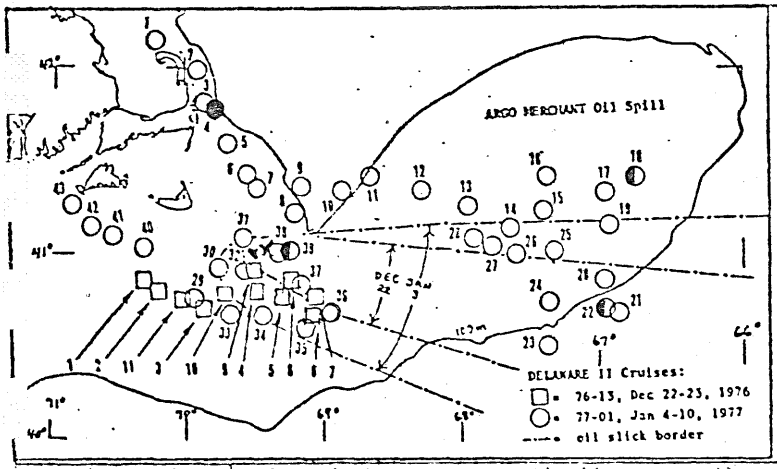
Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
SMALL MISC FISH ●	20				5
	25				2
	26				6
	35				1

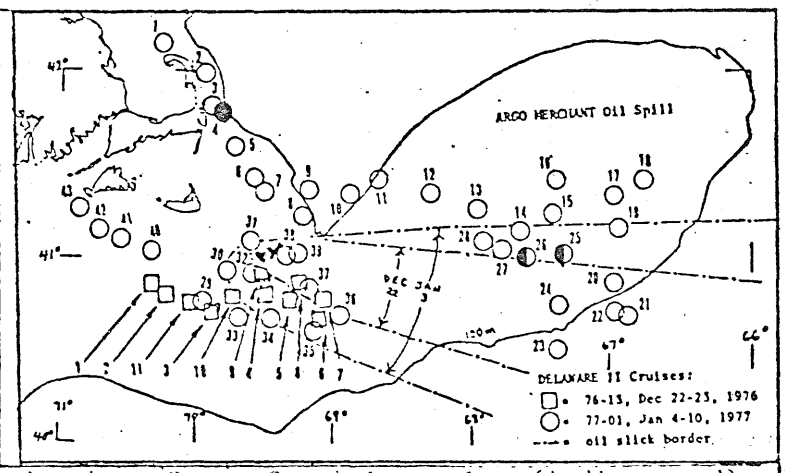




pecies & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
MAHOGANY QUAHOG ●	22				4
	25				1
	26				1
	35	1			10
NUDI-BRANCH ◐	20				1

Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
STARFISH ●	3	several			3
	4				1
	7				several
	10	several			
	16	several			
	17		5		
	22				10
	25				3
	28				1
	35		5		
	38		1		
	39		3		
■	6				several





Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
SEA MOUSE ●	4				4
SEA CUCUMBER ◐	18	1			
	22	1			1
	39	1			1

Species & Cr	Sta No	Special samples (indiv saved) Flesh	Path	Biochem	Benthic
TUBE WORMS ●	4				several
BARNACLE ◐	25				1
	26				3

3.2.1. Fish and Invertebrate Samples for Hydrocarbon Analysis

The first of two groups of samples were sent to the NOAA Analytical Facility, in Seattle, Washington, for detailed hydrocarbon analysis. The fish and invertebrate species selected for analyses are listed in Table 1. In addition, the stomach contents of one cod suspected of containing oil were sent.

Table 1.

Type of Sample	Group I Cruise No.	Group I Station No.	Group II Cruise No.	Group II Station No.
Fish:				
Cod	DE 77-01	3	DE 77-01	38
Haddock	"	8	"	27
Silver hake	"	3	"	24
Red hake	"	10	"	24
Yellowtail flounder	"	3	"	31
Winter flounder	"	3	"	31
Windowpane flounder	"	3	DE 76-13	4
Invertebrates:				
Sea scallops	"	3	DE 77-01	39
Lobster	"	6	DE 76-13	6
Sand dollar	"	19	DE 77-01	34
Special samples:				
Contents of cod stomach containing oil	"	29		
Winter flounder with external smudge of oil	DE 76-13	4		

3.3. Initial Results

3.3.1. Preliminary Report on Plankton Collections made in the Vicinity of Argo Merchant, Delaware II Cruise 76-13, R. Maurer, Northeast Fisheries Center, Narragansett.

Shortly following the Argo Merchant grounding and resultant oil spill, the NMFS vessel R/V Delaware II was dispatched on a sampling reconnaissance to assess any immediate or catastrophic effects related to the fishery resource. A full array of plankton samples was collected at stations 4-9, three outside, two inside and one on the boundary of the slick area (Figure 1). Standard oblique tows were made concurrently with large 61 cm bongos (.505 mm and .333 mm mesh nets) and small 20 cm bongos (.253 mm and .165 mm mesh nets), quantitatively integrating the water column from near the bottom to surface. In addition, 10 minute surface tows were made with a 1 x 1/2 m neuston net (.505 mm mesh net). Samples from the oblique tows, (.333 mm mesh net) were analyzed by the Plankton Sorting Center (NEFC, Narragansett) to provide information on plankton biomass, abundance and diversity. Results from this analysis are presented in Tables 1 and 2.

The dominant copepod species from each station were cleared with lactic acid and examined under a dissecting scope for the presence of oil. On the basis of a preliminary examination the contamination was classified as: (1) external-smudges on the exoskeleton; (2) mandibular-particles adhering to feeding appendages or tar stains on mandibles (Figure 2A, B); and (3) oil particles which have been ingested and either stored or present in the gut, and/or incorporated in feces (Figure 2C,D).

Zooplankton Biomass and Numbers in Relation to Oil Slick Observations

Biomass ranged from 2.0 to 16.4 cc/100 m^3 (Table 1). The lowest biomass measured was within the oil slick area at Station 7, while the highest values were recorded at inshore Stations 4 and 9. Zooplankton numbers follow trends in biomass. Extremely high numbers and biomass occurred at Station 9 which was located on the boundary of the visible slick. Zooplankton species abundance is shown in Table 3.

Considerable differences in biomass, total numbers and species composition as well as individual species abundance occurred within relatively short distances (10 to 25 miles) from Nantucket Shoals to Great South Channel, Tables 1 and 2. These differences can be used to define the communities and pair the stations as follows:

1. Stations 4 and 9--Shoal Community. Nantucket Shoals is characterized by a shallow (<40 m), well-mixed physical environment, extremely turbulent during winter months. Zooplankton numbers are strongly dominated by small calanoid copepods of the genera Pseudocalanus and Paracalanus, with medium size developmental stages, comprising 73% (Sta. 4) and 50% (Sta. 9) of their numbers. These have been combined and will be referred to as Pseudo-paracalanus. The turbulent nature of this shoal environment is demonstrated by the large number of gammarid amphipods, especially

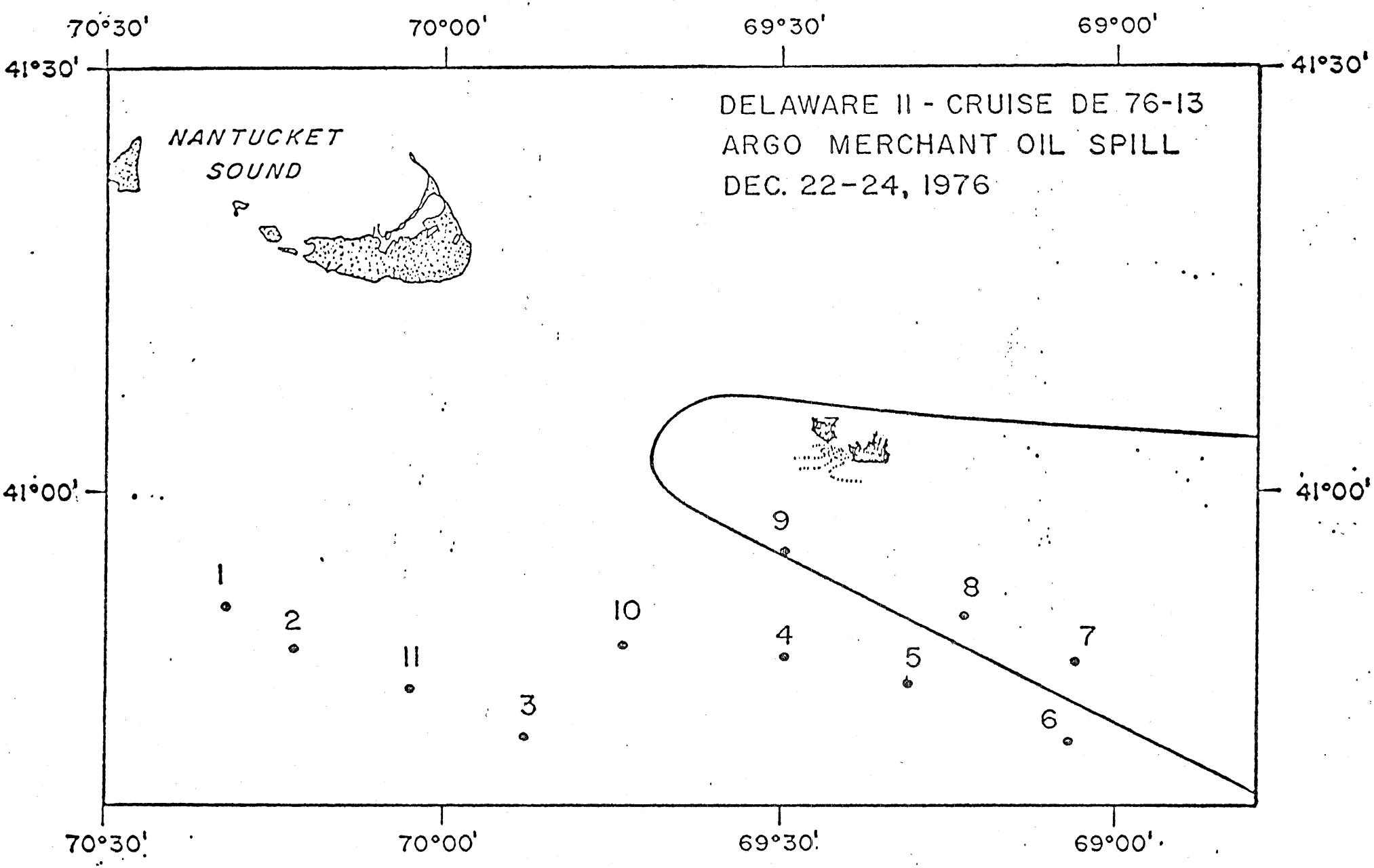


Figure 1. ARGO MERCHANT oil spill area. Plankton collections were made at Stations 4-9.

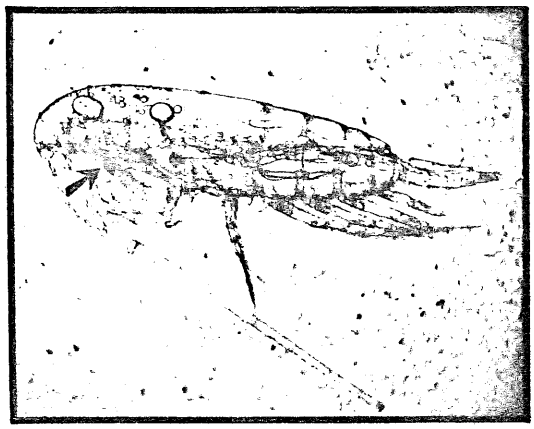
MANDIBULAR CONTAMINATION, OIL PARTICLES ADHERING TO FEEDING APPENDAGES	INGESTED CONTAMINATION, OIL PRESENT IN GUT & NATURAL OIL STORAGE AREAS
(A) CENTROPAGES TYPICUS - VENTRAL VIEW	(C) CENTROPAGES TYPICUS; NOTE ROUNDED STORED PARTICLES
(B.) CALANUS FINMARCHICUS - LATERAL VIEW 	(D.) PSEUDOCALANUS MINUTUS; OIL PRESENT ONLY IN ALIMENTARY TRACT

Figure 2. Mandibular and ingested contamination.

Table 1. Visual observations on oil and associated plankton biomass and numbers.

Stations	Observations	Displacement Vol. cc/100 m^3	Total Zooplankton Numbers/100 m^3
4	No oil noticed at surface; Bongo samples clean; Neuston with specks of tar.	12.1	51,358
5	No oil noticed at surface; Bongo samples clean; Neuston with specks of tar.	3.5	12,488
6	No oil noticed at surface; Bongo samples clean; Neuston with specks of tar.	4.2	2,259
7	Surface oil slick present; Neuston nets fouled with oil.	2.0	2,352
8	Surface oil slick present; Neuston nets fouled with oil.	6.8	28,240
9	Surface oil present in small amounts.	16.4	225,974

Table 2. Zooplankton species abundance from Del. II cruise 76-13. Stations located in vicinity of *Argo Merchant* (see chart). Numbers per 100M^3.

Species	Life Stage *	Stations → 4	5	6	7	8	9
Calanus finmarchicus	000	106	348	175	973	584	1097
	054			9	21		
	052					255	
Centropages typicus	000	5072	4018	753	342	584	5119
	054	740	52	94	32		
	052					218	4388
Centropages hamatus	000	1162	70	27	35	36	2560
Pseudo-paracalanus	000	21874	3809	94	317	23134	126519
	054	16274	470				63625
Metridia lucens	000		313	36	56	36	
	052			58	78	730	365
Temora longicornis	000	106	52	4	14		
Rhincalanus coronutus	000				4		
Oithona sp.	000					328	731
Acartia sp.	000	106					
Calanus minor	000						365
Tortanus discaudatus	000				4		
Alteutha depressa	000	317	104			36	
Sagitta elegans	000		52	395	102	73	
Sagitta serratodentata	000			45	95		
Sagitta spp.	000				4		
Parathemisto sp.	000			112			
	052	106					
	054				35		
Monoculodes sp.	054						731
Gammaridae	054	2959	52				
Gammaridea	000			103			
	054				4		
Crangon septemspinosa	000			4			
Cumacea	054	106					
Cirripedia	013	106					
Asteroidaa	054						365
Gastropoda	000				7		1462
Pteropoda	000				7		
Foraminifera	000	528	209			1314	365
Molts		4650	70				
Fish eggs	054	211	17		14	292	365
Ammodytes americanus	054	1585	2922	350	222	620	18648
Total Zooplankton Numbers		51358	12488	2259	2352	28240	225974

*Life Stage

000 - Adult (large)
054 - Copepodite Stages I-III (medium)
052 - Copepodite Stages IV and V (small)
013 - Nauplius

Table 3. Occurrence of oil contamination on dominant copepod species.

Species	# Examined	# Contaminated	% Contaminated	Type of Contamination E	M	I
Station 4						
Centropages typicus	55	1	1.8	-	-	1
C. hamatus	10	2	20.0	-	-	2
Pseudo-Paracalanus	163	8	4.9	5	-	5
Station 5						
Calanus finmarchicus	20	11	55.0	2	3	6
Centropages typicus	100	61	61.0	1	1	59
Pseudo-Paracalanus	100	25	25.0	-	18	7
Station 6						
Calanus finmarchicus	41	1	2.4	-	1	-
Centropages typicus	100	16	16.0	-	2	14
Pseudo-Paracalanus	21	0	0.0	-	-	-
Station 7						
Calanus finmarchicus	100	14	14.0	2	7	0
Centropages typicus	104	30	28.8	0	1	29
Pseudo-paracalanus	105	35	34.3	2	11	10
Station 8						
Calanus finmarchicus	76	12	15.8	-	10	2
Pseudo-Paracalanus	50	5	10.0	-	4	-
Metridia lucens	32	3	9.4	-	1	2
Station 9						
Centropages typicus	45	13	28.8	2	9	6
C. hamatus	8	3	37.5	1	2	-
Pseudo-Paracalanus	60	3	5.0	1	1	1

Types of contamination E = external
M = mandibular
I = ingested

Monoculodes sp., in the collections. These specimens were apparently lifted into the water column by the vertical turbulence.

The incidence of contamination at Station 4 (Table 3) was quite low for Centropages typicus and Pseudo-paracalanus. A somewhat higher value was recorded for C. hamatus of which only 10 specimens were examined. C. typicus samples along the slick boundary (Sta. 9) were found to have a relatively high incidence of apparently contaminated mandibular and ingested particles.

2. Stations 5 and 8--Transitional Community. These stations taken at about 55 meters, exhibit characteristics of both the shoal and channel communities. Numbers again are dominated by Pseudo-paracalanus, especially at Station 8. A larger calanoid, Centropages typicus, appears as a codominant form. Total zooplankton numbers are 5 to 10 times less than those recorded at the adjacent shoal stations. Contamination appeared greatest at Station 5, taken outside the slick. Over 50% of the C. finmarchicus and C. typicus were affected; most contained ingested particles.

3. Stations 6 and 7--Channel Community. This is a distinctly different community characterized by low biomass, low total numbers and dominated by larger copepods, C. finmarchicus (Station 7), and C. typicus (Station 6). This assemblage is similar in part to the "Calanus community" of the Gulf of Maine (including Calanus finmarchicus, Pseudocalanus minutus, Metridia lucens, Sagitta elegans and Parathemisto) and unlike the Georges Bank winter community which Clarke et al. (1943) showed to be Pseudocalanus dominated. Contamination at Station 6, outside the slick is low, while inside the slick at Station 7, a high number of ingested particles were recorded for C. typicus and Pseudo-paracalanus.

Significant contamination was found in copepods in all three communities, and the occurrence was not restricted to the visible slick area (Table 1), indicating that oil contamination occurred in a major component of the food web. Oil droplets removed from the alimentary tracts of the predominant copepod species, Centropages typicus, were examined for petroleum hydrocarbon content using gas chromatography. The resulting chromatograms were compared by W. W. Kühnhold (University of Kiel, FRG) and R. Lapan (EPA) with chromatograms of oil from the Argo Merchant and were found to be similar.

When oil is incorporated into the feces of zooplankton the specific gravity of the combined pellet (oil and feces) is greater than the oil before ingestion, therefore, it sinks in the water column (Parker et al. 1970). Ingestion by planktonic animals acts as a precipitation mechanism for otherwise buoyant oil particles. The contaminated fecal pellets may then either become covered by sediment, or ingested by detritus feeders.

The impact of oil on zooplankton populations is not clear. The oil contamination observed could affect feeding and reproduction. Sensitive chemoreceptive pores are located along the dorsal exoskeleton of copepods. The pores are used for positioning during reproduction. If they were to become impacted with oil, the individual probably would not be able to reproduce successfully.

Mandibular contamination shown in copepods in Figure 2 may interfere with the handling and ingestion of desired food particles. The toxicity of ingested oil is poorly understood. The degree of toxicity depends on the presence of volatile, aromatic compounds which are released through time as the oil "ages." Additional studies are planned by NMFS to assess the effects of petroleum hydrocarbons on zooplankton.

3.3.2. Impact of Argo Merchant on Ichthyoplankton, W. Smith, D. Busch, L. Sullivan, and K. Sherman, Northeast Fisheries Center, Sandy Hook and Narragansett.

Fish eggs and larvae were collected on the first cruise of the Delaware II (DE 76-13) using paired bongo samplers and a surface neuston net at Stations 4-9 according to standard MARMAP sampling procedures (Figure 1). Stations 7 and 8 were within the area of oil pancakes; Station 9 was at the boundary between "clean" and oil contaminated surface water, while Stations 4, 5, and 6 were along the southern periphery of the spill. The neuston nets towed on Stations 7 and 8 were saturated with oil (Figure 2).

Larvae

Six species of fish larvae were in the collections: sand launce, cod, pollock, rockling, hake and herring. Of these species, only sand launce was abundant. Other larvae were rare (Table 1). The abundance of sand launce decreased sharply at the two sampling stations within the spill area. The reasons for the decrease are not clear, but we assume the decrease in population may be associated with the negative impact of the oil on the viability of larvae. Samples collected from this area during the second cruise of Delaware II (4-10 January) will be examined to corroborate this assumption. The sand launce, while not important in the commercial fishery is a key species in the ecosystem. It is the basic food of predatory fish including cod, haddock, silver hake, as well as marine mammals including porpoises and whales.

Little can be said about the other species as they occurred in very low numbers (<15/station) over the entire survey area.

Eggs

Only two species of eggs were in the samples: cod and pollock. Pollock eggs were most numerous within (Stations 7, 8) and adjacent to (Station 9) the spill zone, while cod eggs were concentrated about the periphery of the spill (Figure 3).

At Station 9 adjacent to the spill area, oil globules were found adhering to the surface membrane (chorion) of 93% of the pollock eggs. Of these eggs later examined by Dr. Longwell at the NMFS Milford Laboratory, 98% were dead or moribund as determined through cytogenetic examination.

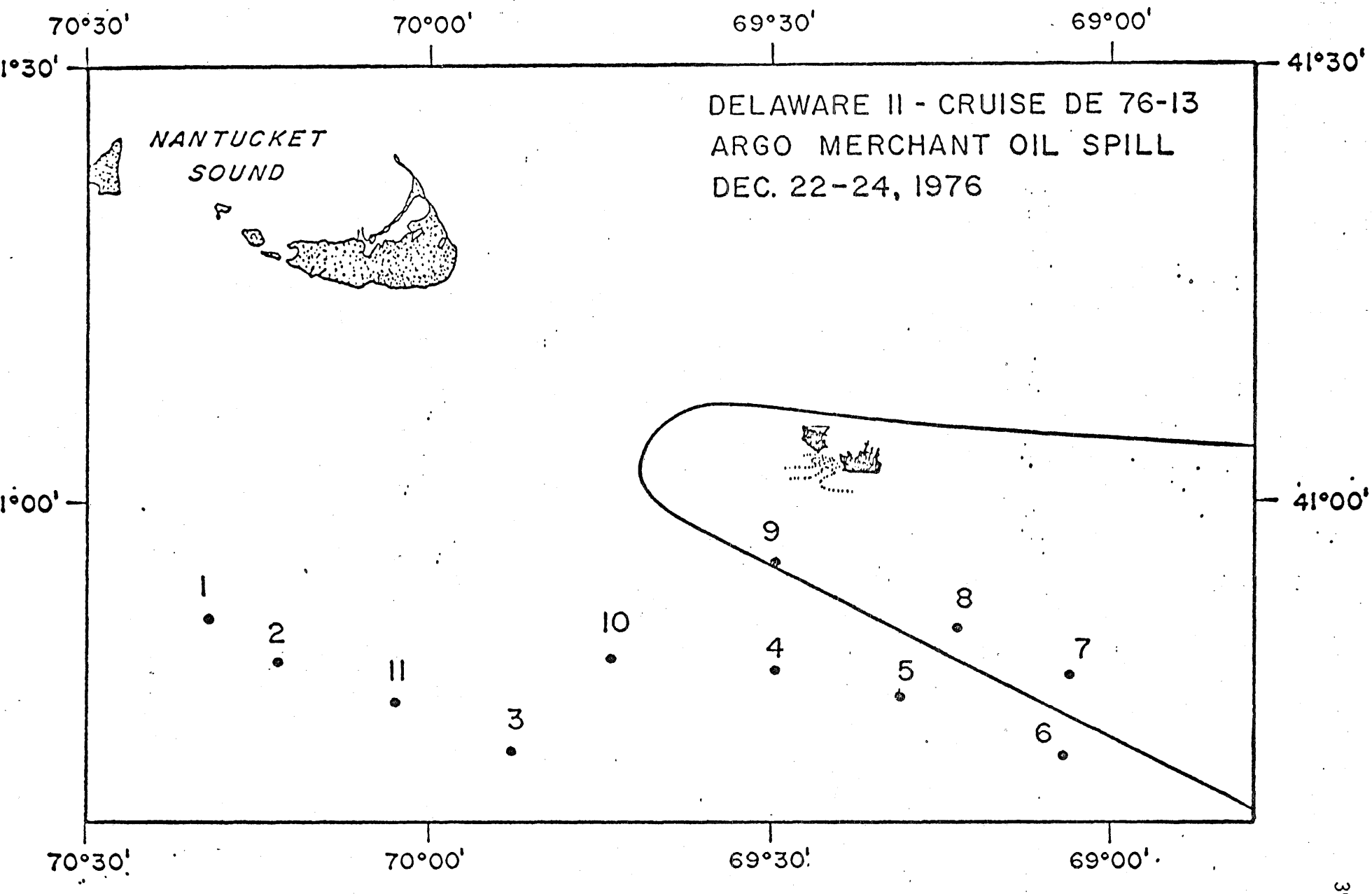


Figure 1. ARGO MERCHANT oil spill area. Plankton collections were made at Stations 4-9.

Figure 2. Biologist Gary Carter with neuston net saturated with oil from Station 8 in area of Argo Merchant oil spill. (Photo by Ron Boisvert, NEFC/NMFS, Narragansett.)

Table 1. Numbers of fish eggs and larvae per sample collected in the area of the ARGO MERCHANT oil spill.

a. Fish eggs

Species	Station 4	5	6	7*	8	9
Cod (*Gadus morhua*)	277	53	17	5	25	310
Pollock (*Pollachius virens*)	5	59	13	32	1139	115
Total	282	112	30	37	1164	425

b. Larvae

Species	Station 4	5	6	7*	8	9
Cod (*Gadus morhua*)	0	1	0	3	0	0
Pollock (*Pollachius virens*)	0	0	15	0	0	0
Sand launce (*Ammodytes americanus*)	5890	10641	5950	1313	1361	5953
Herring (*Clupea harengus*)	2	0	2	0	0	0
Rockling (*Enchelyopus cimbrius*)	0	1	0	0	0	0
Hake (*Urophycis sp.*)	0	0	1	0	0	1
Total	5892	10643	5968	1316	1361	5954

Values in Table 1 represent combined totals of eggs from surface and water column samples. They are not standardized for volume of water strained.

*No surface sample was taken. Numbers are for the water column sample only.

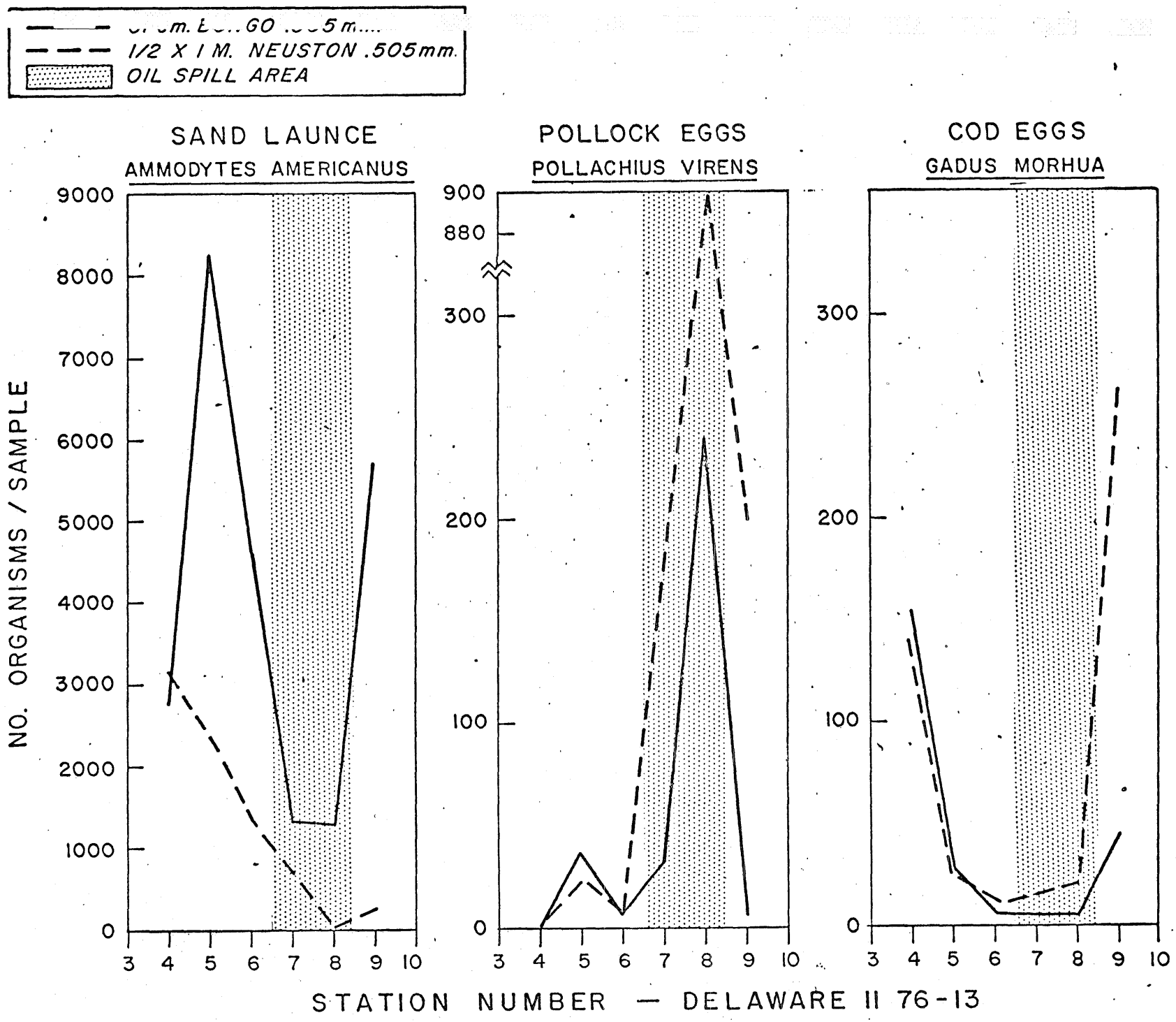


Figure 3. Numbers of fish eggs and larvae from the Argo Merchant oil spill area.

In contrast, only 64% of the cod eggs showed evidence of oil contamination. At Stations 4, 5, and 6 outside of the spill area, more of the eggs were viable.

The most notable change was in the decrease of sand launce larvae at Stations 7 and 8 within the spill zone. This decline in abundance may have been related to Argo Merchant oil contamination. Additional sampling of the area will be conducted to assess sand launce stocks in an effort to estimate the range of "normal" variation in population distribution and abundance. Also, mortality among pollock eggs was increased significantly in the area of the spill, as evidenced by the large numbers of moribund embryos in eggs contaminated with oil. Cod mortality occurred but was lower. Studies are underway to obtain estimates of the extent of mortality inflicted on the populations of both cod and pollock stocks by the Argo Merchant oil.

3.3.3. Genetic Effects, Arlene Longwell, Northeast Fisheries Center, Milford.

It has been demonstrated in the laboratory that compounds extracted from oil films are toxic to fish larvae and to the early developmental stages of planktonic fish eggs. Failure in the past to establish detrimental effects of oil spills in the field is likely attributable to the lack of sufficient, appropriate field tests that might be conducted quickly and cheaply enough when the need arises, as well as to the fortunate resiliency of the ecosystem. However, extrapolation of laboratory data to the field though without adequate field testing can be done only with the utmost caution.

Toxicity of oil components will, of course, vary according to the developmental stage of the eggs at exposure. That there are sublethal effects which lead to later mortality of the fish egg is evident from the published literature on the experimental studies. Teratogenic effects (deformities) are common in oil toxicity tests.

Aromatic hydrocarbons are highly soluble in lipid material as present in the yolky contents of fish eggs. Polynuclear aromatic hydrocarbons can act both as carcinogens and mutagens. Benzene, the largest aromatic compound in crude oil, has been proved mutagenic in a number of published genetic tests on organisms other than fish. Concentration of such hydrocarbons in the fatty material of spawned eggs may accordingly well provoke both cytotoxicity and mutagenicity to the chromosome apparatus in critical early development stages of planktonic or demersal fish eggs. Their absorption through the membranes of planktonic fish eggs spawned in the vicinity of oil spills could similarly provoke these effects which would almost invariably be lethal to the egg. Cytotoxicity, mutagenicity and less direct physiological effects on the chromosomes and nuclei of the early-stage eggs ought to depress the rate of their cell and chromosome divisions.

In light of these findings and in response to the oil spill an effort was undertaken to determine the cytogenetic effects of oil on fish eggs.

Microscopic examinations were made of the dissected embryos of 79 cod eggs and 153 pollock eggs sampled in the vicinity of the Argo Merchant oil spill. This was done using a new application of cytogenetic methodology to fixed fish eggs from field plankton samples (Longwell 1976). Similarly examined were 75 cod embryos from eggs spawned in an aquarium by a small number of females captured in the field.

Sample size and station numbers are drastically limiting, and pollock eggs were not represented in the sub-sample from Station 4. Even so a higher mortality of pollock over cod eggs is obvious. Totaled over all stations, about 20% of the cod eggs were dead or moribund cytologically as compared with 46% of the pollock eggs: For comparison, only 4% of the sample of laboratory spawned cod eggs were dead or moribund (Table 1). The earlier developmental stages of the cod eggs studied should have been more sensitive than the pollock eggs because natural mortality rates are highest in younger embryos. Thus, any real difference between the viability of cod and pollock eggs may be even greater than the numbers alone indicate.

At Station 8 the pollock embryos were malformed in 18% of the eggs; at Station 9 in 9% of the eggs. Pollock eggs at Station 9 carry the strongest implications for an adverse effect of the oil. Here mortality and moribundity were 98% for a reasonable size sample (43 eggs). About 60% of these eggs had strikingly abnormal cell patterns. The large size of the cells of these embryos can be interpreted as indicating that the influencing factor acted much earlier in embryo development than the tail-bud and tail-free stages at which the abnormal pattern was observed. In these embryos, chromosome and cell division had almost entirely ceased or was blocked at the prometaphase division of mitosis (a common action of chemicals adversely affecting the chromosome apparatus). Almost all of the rest of the pollock embryos at this station were merely degenerating examples of this type of abnormal embryo (Table 2).

Oil adhered to almost all the pollock eggs from Station 9 (Figure 1), and the amount of oil on individual eggs was also greater than at the other stations. At this same station, fewer cod eggs were contaminated and the individual eggs were not as heavily contaminated as the pollock eggs. The reasons for the differential contamination are unclear. The pollock eggs were at a later developmental stage than the cod eggs and may have been sampled higher in the water column than the earlier stage cod, thus increasing their chance of being contaminated with oil particles. The fixation of the eggs may affect the adherence of oil to the egg membranes. The membrane contamination observed in the fixed eggs is certainly real, however, suggesting the possibility of species differences in membrane fouling. Normal levels of mortalities during egg production in the natural environment are high. It is difficult to assess the effect of additional mortalities caused by oil on the cod and pollock in the area of the spill. More observations will be required to properly evaluate the population impact.

Table 1. Cytological assays of mortality and moribundity of cod and pollock eggs from the vicinity of the *Argo Merchant* oil spill.

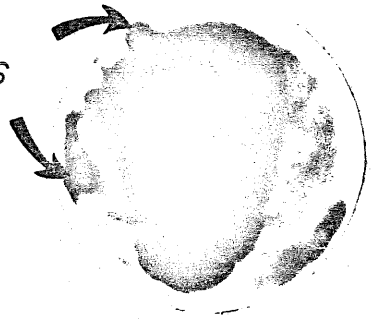
	Total No. Eggs	No. eggs viable	No. eggs dead or moribund	% eggs dead or moribund	% eggs malformed
Station 4					
Cod	14	13	1	7.14	-
Pollock	-	-	-	-	-
Station 5					
Cod	6	3	3	50.00	-
Pollock	11	0	11	100	-
Station 6					
Cod	3	3	0	0	-
Pollock	3	0	3	100	-
Station 8					
Cod	1	1	0	0	-
Pollock	105	86	19	17.92	17.92
Station 9					
Cod	55	43	12	21.82	-
Pollock	43	1	42	97.67	9.30
Laboratory Spawning Cod	75	72	3	4.00	-

Table 2. Number of mitotic telophases of cell division in pollock embryos at Stations 8 and 9.

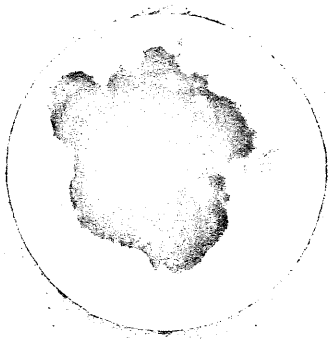
	Telophases (actual number or estimate)					
Pollock eggs	0	3-14	15-25	±50	±75	-100-+200
Station 8	6	7	8	27	8	28
Station 9	35	6	0	0	0	0

POLLOCK EGGS

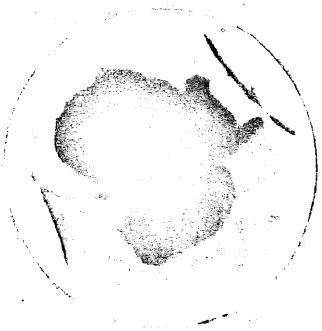
TAIL-FREE EMBRYO



ABNORMAL EMBRYO, PROBABLY ABOUT TAIL-BUD STAGE



ABNORMAL EMBRYO, PROBABLY ABOUT TAIL-BUD STAGE; WITH COLLAPSED MEMBRANE



TAIL-BUD EMBRYO

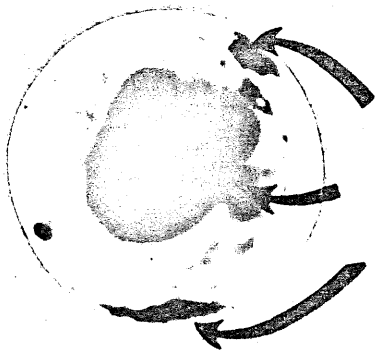


Figure 1. Oil droplets adhering to pollock eggs and abnormal pollock embryos collected in the area of the *Argo Merchant* oil spill. (Photograph by Dean Perry, NEFC, Milford.)

3.3.4. Effects of No. 6 Fuel Oil on Developing Embryos.

W. Kühnhold,* University of Kiel.

Laboratory experiments on the effects of No. 6 fuel oil on pelagic eggs are being conducted at the NMFS and EPA laboratories in Narragansett. These experiments deal with the direct effects of an oil film on floating eggs and also with the effects of the water soluble fraction of No. 6 oil on developing embryos.

Effects of Oil on Floating Eggs

At Station 9 which was located at the periphery of the oil-contaminated area, it appeared that oil was adhering in significantly greater quantities to pollock eggs than to cod eggs in neuston samples. To determine whether there were differences in surface membrane characteristics of the eggs which could result in differential adherence to the oil, experiments involving the exposure of pelagic eggs to an oil film were initiated jointly at the Northeast Fisheries Center Laboratory, Narragansett, and the EPA Laboratory, Narragansett (E. Jackim, R. Pruell).

In these experiments, cod eggs were kept floating under an oil film (Figures 1 and 2) which was stirred both gently and vigorously to mix the eggs with the oil (Figure 3). In no case was there any sign of oil adhering to the living eggs. The same results have been reported for cod eggs by James (1925) and Kühnhold (1972) in tests with crude oil of a similar viscosity. So far, only cod eggs have been available for this test.

The NMFS Narragansett Laboratory plans to expand this study to include pelagic eggs of several species, especially pollock, in order to determine whether there are differences in surface responses of fish egg membranes to oil among important fish species.

Effect of the Water Soluble Fraction of the Oil

The experiments to determine the effect of the water-soluble fraction (WSF) of No. 6 oil conducted in cooperation with EPA (D. Everich) have not been completed and only preliminary results are available.

The experiments are carried out as static tests (Figure 4) to approximate conditions of an acute spill situation where a water body may be covered with an oil slick for a short period only. The dissolved compounds are then subject to evaporation. The extraction of No. 6 fuel oil was prepared according to Hyland (1973) to provide concentrations of WSF comparable to earlier studies.

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*Visiting scientist at the Northeast Fisheries Center, Narragansett, R. I.

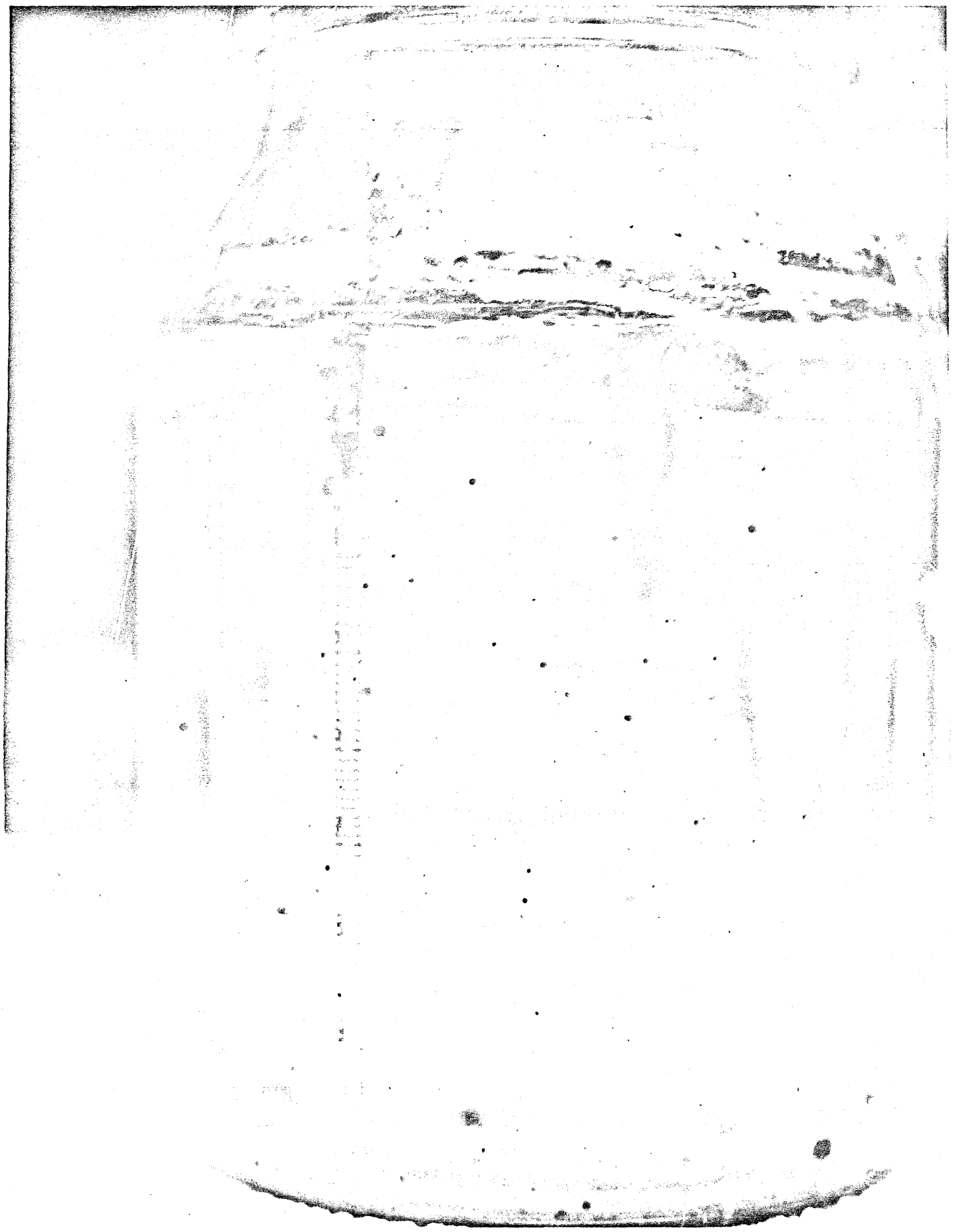

Figure 1. 4-liter jar with a floating film of No. 6 fuel oil (= bunker C oil) for oil-egg-adherence test, ⇨ cod eggs ➡ oil droplets. Cod eggs are floating but not adhering to the oil film. (Photograph by W. Kühnhold)

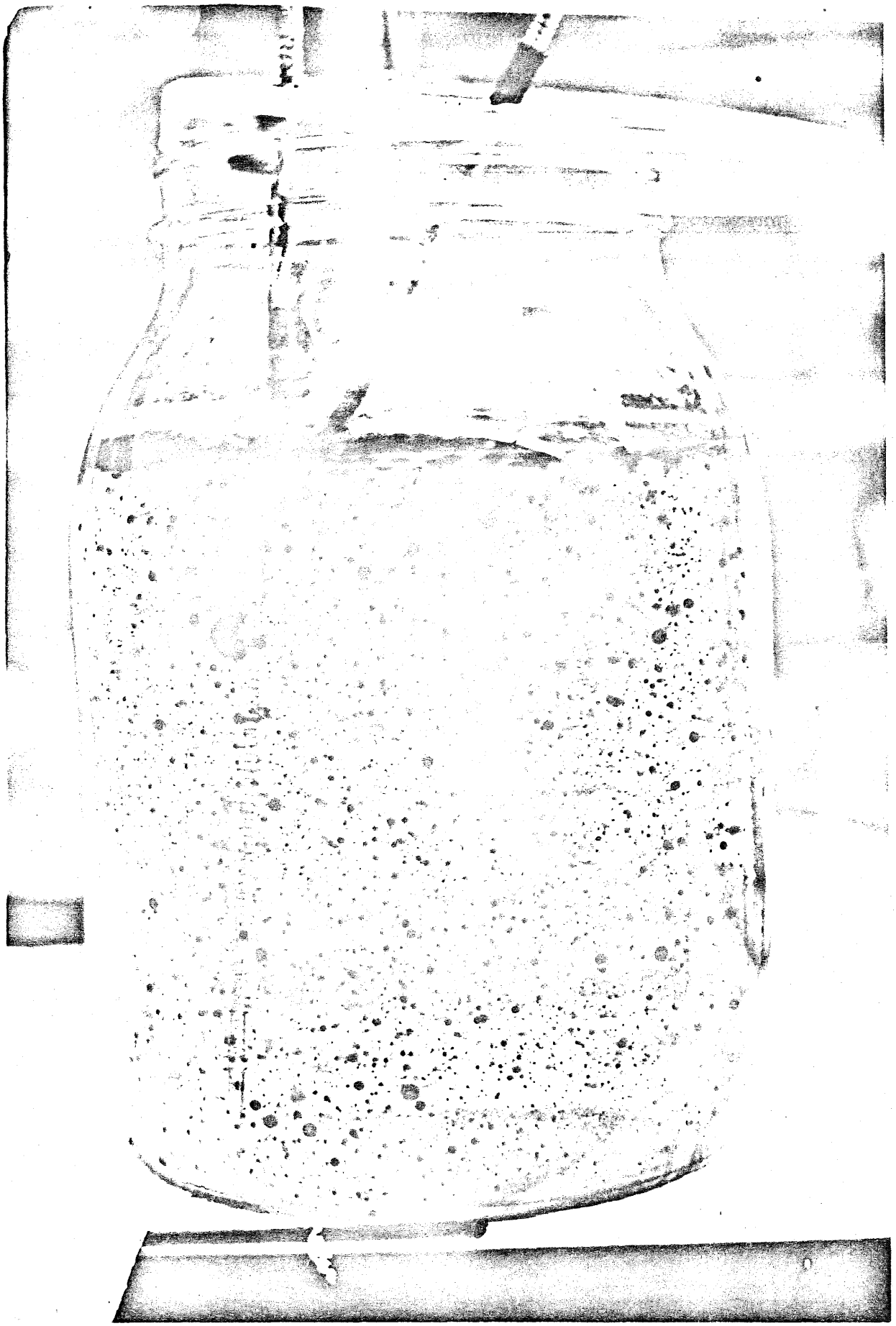

Figure 2. Oil dispersion achieved by vigorous stirring. None of these droplets adhered to the eggs (not visible on the photo). (Photograph by W. Kühnhold)

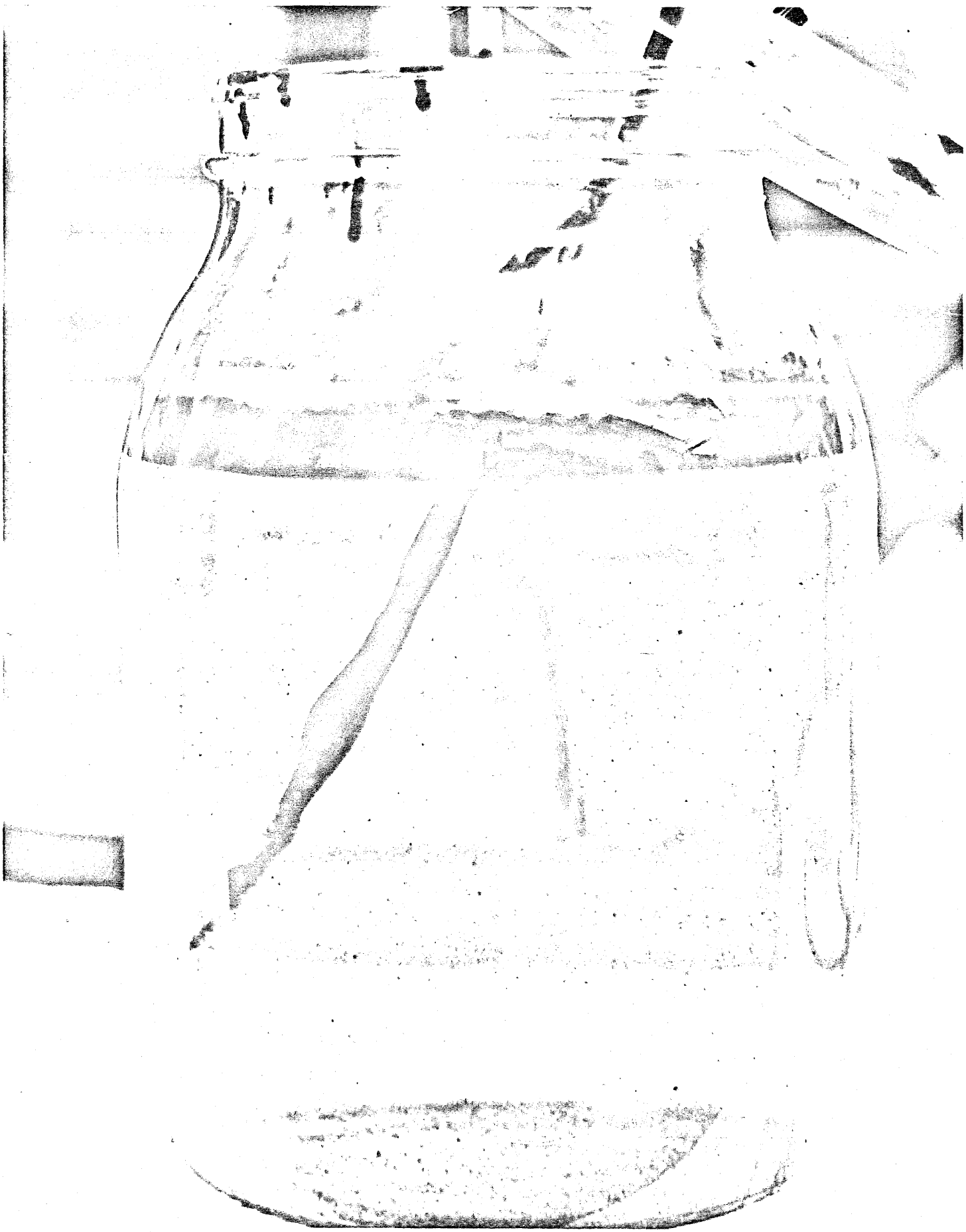

Figure 3. Same oil dispersion 1 hour after stirring. (Photograph by W. Kühnhold)

Figure 4. Series of 1-liter jars for static exposure test of WSF of No. 6 fuel oil. Ca. 100 eggs kept per jar. Eggs were treated with antibiotics in main incubation aquaria before being transferred to exposure tests. (Photograph by W. Kühnhold)

Since no data were available about actual concentrations of the WSF of the Argo Merchant oil at the spill site, initial concentrations of 500, 100, and 10 parts per billion (ppb) of total extractable hydrocarbons (WSF) were used. The loss of hydrocarbons during the course of the tests seems to be low, less than 50% in 10 days. One hundred cod eggs were exposed at different embryonic stages; 4-6 hours (2 cell stage), and 3 and 7 day old embryos.

High mortality was very evident in the youngest embryo group at the highest concentration (500 ppb) after 24 hours. It was observed that the eggs held at 500 ppb sink to the bottom of the test jars prior to dying. This phenomenon is due to loss of osmoregulation in the embryonic organism. Some eggs may actually sink to the bottom several days prior to dying. It was observed that the development was greatly delayed in the higher concentrations, and that the heart beat rate was greatly reduced. From the beginning of regular heart muscle contractions to hatching, the frequency normally increases from ca 30 to 70 beats/min in untreated eggs, whereas the treated eggs showed a decrease in frequency of heart beat to less than 20 beats/min with very irregular muscle contractions. Excess utilization of yolk observed in such affected eggs results from increased metabolism due to stress on the embryo (Kühnhold 1974). Anderson et al. (1976) has indicated that the heart beat rate can also serve as a sensitive indicator for sublethal effects. This was evident in the eggs exposed to the intermediate concentration (100 ppb) which in some cases showed no sign of developmental delay or abnormalities, but did have reduced heart beats. Ten ppb does not appear to increase embryo mortality or alter hatching rates.

Further evaluation of the data should clarify the relationship between hatching and survival rates of larvae and embryonic heart beat frequency.

3.3.5. Preliminary Report--Physiological Effects of Pollutant Stress Investigation, D. Gould, F. Thurberg, Northeast Fisheries Center, Milford.

Two sets of samples of shellfish and fish collected from the Argo Merchant oil spill area and an adjacent clean area (Delaware II cruise 77-01) were examined in the laboratory for physiological disruption. Gill-tissue oxygen consumption rates were measured on ocean scallops (Placopecten magellanicus) and horse mussels (Modiolus modiolus) from both impacted and control areas. Blood samples from six different species of finfish from both impacted and clean areas were also taken on board the research vessel and returned to the laboratory for hematological analysis. Although the sample numbers in both studies were too small for adequate statistical analysis, the results did indicate that both ionic balance in blood serum and respiration rates were altered in those samples taken from the contaminated areas. Hematological measures showed disruption of the ionic balance in blood serum and depression of respiration rates (O_2 consumption). The ionic balance of blood serum from winter and yellowtail flounder caught within the oil spill area was disrupted, and the physiological condition of these fish was poorer than those examined from the control area outside of the spill zone. Both

measures are useful indicators of disruption of physiological activity possibly caused by the oil spill, and this line of study will be pursued.

Samples taken during the same cruise for biochemical examination included brain, kidney, and gonads from 26 teleosts (6 species), and mantle or hepatopancreas, gills, and gonads from 28 bivalves or crustaceans, all from clean areas. Similar tissues were taken from 24 teleosts and 43 bivalves or crustaceans from oil-impacted areas. To perform exploratory biochemistry on this number of samples of different tissues from different species will take several months. Attempts will be made to look for a possible shift from aerobic to anaerobic metabolism, as well as for induction or repression of enzymes, to serve as metabolic yardsticks that will be both analytically feasible and environmentally significant.

3.3.6. The Food Habits of Sixteen Species of Fish Collected in the Region of the Argo Merchant Oil Spill, Richard W. Langton and Ray E. Bowman, Northeast Fisheries Center, Woods Hole.

Stomachs were collected from fish caught with an otter trawl during the *Delaware II* cruises 76-13 and 77-01 (Figure 1, Tables 1 and 2). The fish stomachs were excised aboard the ship, labeled according to species, length, and station, and preserved in 10% formalin. A total of 305 stomachs were collected from 16 different species of fish.

At the laboratory of the Northeast Fisheries Center, NMFS, Woods Hole, the preserved stomachs were opened and the contents washed onto a 0.25 mm mesh screen. The various food organisms were manually sorted, identified to the lowest taxa possible (using a dissecting microscope when necessary) and damp dried on bibulous paper. Each taxonomically distinct group was weighed to the nearest 0.01 g on a Mettler balance immediately after being dried. Parasites in the stomach were included as part of the stomach contents. Food items of little dietary significance or which were unidentifiable because of the degree of digestion were classified as miscellaneous.

For the purpose of analysis all information was pooled by species, regardless of size, for comparison with existing food habits data. Data for each predator are presented as a percentage of the total stomach contents weight and as a mean weight per stomach. The mean weight per stomach was calculated by dividing the total stomach contents weight by the total number of stomachs examined.

Comparison of Food Habits between Cruises

The food habits of six species of fish were investigated following the *Delaware II* cruise 76-13 (Table 3). The same six species plus an additional 10 species were sampled during the second, *Delaware II* 77-01, cruise (Table 4). The food habits of the six co-occurring species were

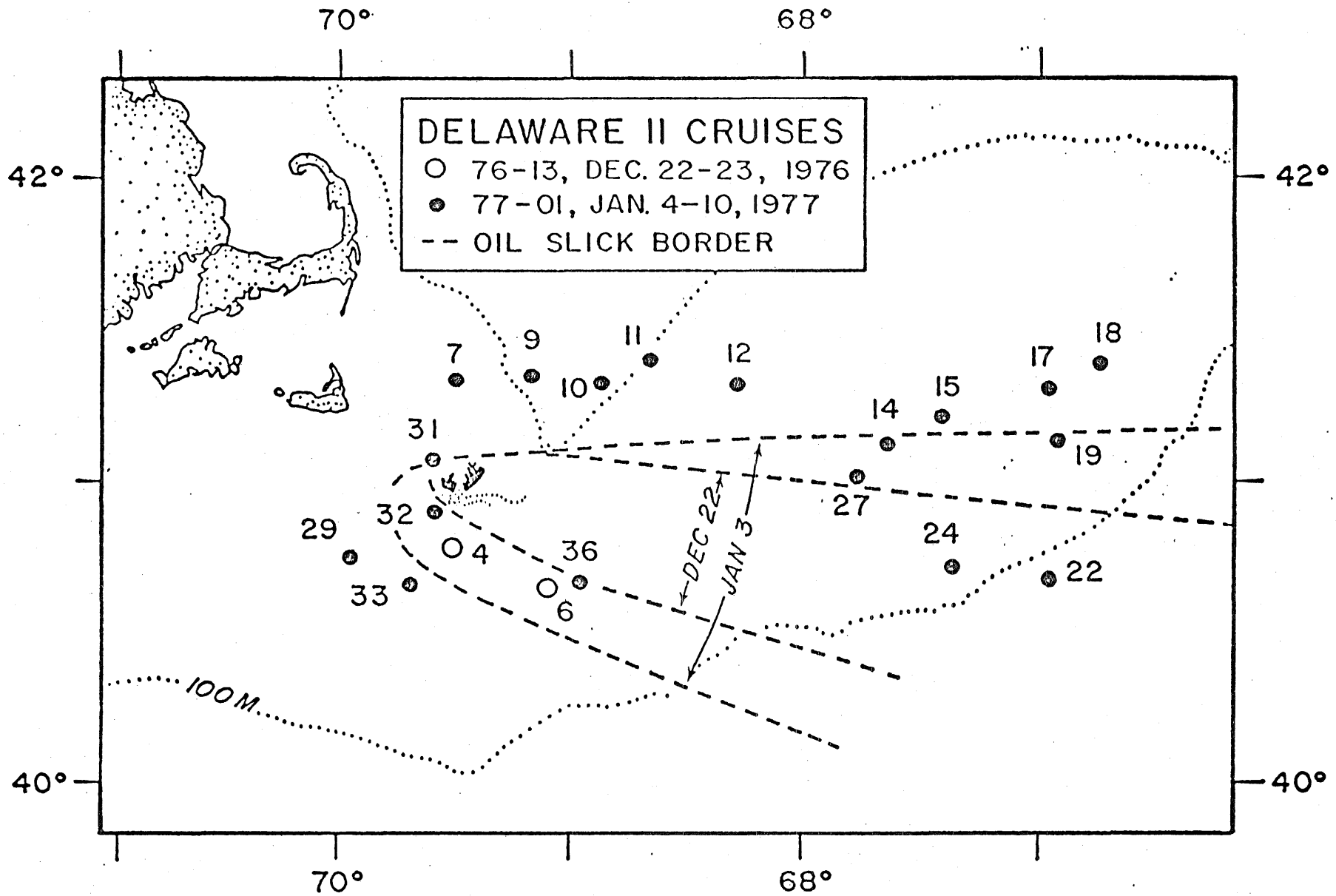

Figure 1. Stations where fish were collected for food habits analysis following the ARGO MERCHANT oil spill. An oil like material was found in the stomach of cod collected at station 29 and little skate collected at station 36.

Table 1. Station data for DELAWARE II cruises 76-15 and 77-01 where fish were collected for food habits analysis.

Station	Date Day	Date Month	Date Year	Time (EST)	Latitude	Longitude	Depth[1] (M)	Wind Dir	Wind Sp	Wave hgt (ft)	Air temp. (°C)	Surf.temp.[1] (°C)	Bot temp.[1] (°C)
4	22	12	76	2380	40°49'	69°30'	44	24	18	6	4.4	5.7	5.7
6	23	12	76	0317	40°43'	69°05'	84	24	15	4	6.7	6.7	6.8
7	5	01	77	0835	41°22'	69°30'	32	36	24	5	2.8	4.7	4.7
9	5	01	77	1330	41°23'	69°10'	144	36	15	5	3.9	6.6	7.1
10	5	01	77	1608	41°22'	68°51'	126	36	14	4	4.4	6.7	7.1
11	5	01	77	1800	41°27'	68°39'	96	33	8	4	3.3	6.6	6.8
12	5	01	77	2112	41°22'	68°15'	50	32	15	2	3.3	5.4	5.8
14	6	01	77	0105	41°10'	67°38'	51	34	10	3	4.4	5.4	6.4
15	6	01	77	0250	41°15'	67°24'	49	35	16	3	3.9	5.7	5.8
17	6	01	77	0737	41°21'	66°57'	66	03	20	4	3.9	5.9	5.9
18	6	01	77	0945	41°27'	66°42'	66	01	20	3	2.8	6.3	6.5
19	6	01	77	1215	41°10'	66°55'	70	03	17	4	3.9	6.1	5.8
22	6	01	77	1742	40°43'	66°57'	143	05	10	4	2.2	8.4	9.1
24	6	01	77	2333	40°45'	67°21'	97	36	-	2	2.2	6.7	6.9
27	7	01	77	0505	41°04'	67°45'	54	10	8	2	3.9	5.3	6.1
29	8	01	77	2037	40°46'	69°57'	26	32	18	4	0.6	4.1	4.1
31	8	01	77	2353	41°06'	69°36'	31	31	18	4	-2.2	5.4	5.4
32	9	01	77	0153	40°56'	69°34'	39	31	20	4	-1.7	4.7	4.9
33	9	01	77	0405	40°41'	69°41'	52	30	18	4	-2.2	5.4	5.4
35	9	01	77	1030	40°42'	68°56'	67	29	20	4	0.0	5.9	5.9

[1]Depth, surface and bottom temperature as recorded from XBT trace.

Table 2. Stations and number of fish sampled for stomach content analysis (Delaware II cruises 76-13 and 77-01).

Fish species sampled	CRUISE																				Species totals
	DEL II 76-13									DEL II 77-01											
	Station									Station											
	4	6	7	9	10	11	12	14	15	17	18	19	22	24	27	29	31	32	33	36	
Spiny dogfish		9											10								19
Little skate	40						11	6												6	63
Winter skate	7																			2	9
Thorny skate						4															4
Alewife																				10	10
Red hake														6							6
Haddock				5					6						10						21
Pollock				2		4											4				10
Atlantic cod	26			5				3		1					2	20				8	65
Ocean pout		4									2	2				5			6		19
Windowpane	5						13								15						33
American plaice					5																5
Blackback			3															2			5
Yellowtail			7						3										9		19
Sea raven											5										5
Longhorn sculpin						12															12
																			Grand total		305

Table 3. Stomach contents of fish species, as percent weight, collected during DELAWARE II cruise 76-13.

Stomach contents	Spiny dogfish	Little skate	Winter skate	Atlantic cod	Ocean pout	Windowpane
HYDROZOA	+	+	-	+	0.4	0.1
NEMATODA	-	+	0.1	+	0.2	-
POLYCHAETA	-	8.0	21.8	4.0	16.9	-
Opheliidae	-	0.6	21.8	-	-	-
Aphroditidae	-	-	-	3.9	16.9	-
Glyceridae	-	0.6	-	-	-	-
Maldanidae	-	0.7	-	-	-	-
Other Polychaeta	-	6.1	-	0.1	-	-
CRUSTACEA	-	84.2	2.0	62.0	29.4	96.8
Cancridae	-	2.9	-	6.9	28.7	-
Crangonitae	-	4.5	-	4.3	-	3.3
Paguridae	-	12.5	-	0.3	-	-
Pandalidae	-	-	-	0.7	-	-
Other decapoda	-	-	-	1.5	-	3.3
Gammaridea	-	63.8	+	47.8	0.7	90.2
Caprellidea	-	+	-	-	-	-
Isopoda	-	0.5	2.0	0.5	+	-
MOLLUSCA	0.3	5.3	-	0.7	0.3	-
Pelecypoda	-	0.2	-	0.7	0.3	-
Cephalopoda	0.3	5.1	-	-	-	-
ECHINODERMATA	-	-	-	0.7	16.6	-
Strongylocentrotus	-	-	-	-	0.7	-
Echinarachnius	-	-	-	0.7	15.9	-
PISCES	99.7	-	50.3	27.6	-	2.9
Ammodytes amer.	7.6	-	50.3	25.7	-	-
Other Pisces	92.1	-	-	1.9	-	2.9
MISCELLANEOUS	-	2.5	25.8	5.0	4.1	0.2
SAND and ROCKS	-	-	-	-	32.1	-
# Stomachs	9	40	7	26	4	5
# Empty	6	2	0	1	0	0
$\bar{X}$ wt per stomach(g)	4.93	2.41	10.99	3.90	7.48	3.13
Length range (cm)	76-99	30-49	52-94	35.86	46-69	27-38

+ indicates <0.1%

Table 4.--Part I. Stomach contents of fish species, as percent weight, collected during DELAWARE II cruise 77-01.

Stomach contents	Spiny dogfish	Little skate	Winter skate	Thorny skate
COELENTERATA	-	0.6	-	-
Cerianthidae	-	-	-	-
Other coelenterates	-	0.6	-	-
POLYCHAETA	-	19.5	60.7	29.5
Aphroditiae	-	1.1	-	2.3
Other polychaetes	-	18.4	60.7	27.2
CRUSTACEA	+	48.1	0.8	4.1
Caprellidea	-	-	-	-
Gammaridea	+	28.0	-	+
Hyperidea	-	-	-	-
Cancridae	-	5.1	-	-
Crangonidae	-	5.9	-	-
Paguridae	-	4.5	-	4.1
Pandalidae	-	-	0.7	-
Isopoda	-	3.6	-	-
Euphausiacea	+	-	-	-
Other Crustacea	-	1.0	0.1	-
MOLLUSCA	2.7	1.4	24.9	0.1
Pelecypoda	-	1.4	24.9	-
Gastropoda	-	-	-	-
Cephalopoda	2.7	-	-	0.1
ECHINODERMATA	-	-	-	-
Echinoidea	-	-	-	-
Ophiuroidea	-	-	-	-
PISCES	97.3	15.5	12.9	43.4
Cottidae	-	-	-	-
Gadidae	52.6	15.5	-	-
Ammodytidae	-	-	3.0	-
Other fish	44.7	-	9.9	43.4
MISCELLANEOUS	-	14.9	-	22.9
SAND and ROCKS	-	-	0.7	-
# Stomachs	10	23	2	4
# Empty	4	5	0	0
$\bar{X}$ wt. per stomach	5.28	1.38	19.41	17.28
length range(cm)	43-95	44-51	77-87	73-85

+ indicates <0.1%

Table 4.--Part II. Stomach contents of fish species, as percent weight, collected during DELAWARE II cruise 77-01.

Stomach contents	Red hake	Haddock	Pollock	Atlantic cod	Ocean pout
COELENTERATA	-	59.5	-	+	0.1
Cerianthidae	-	59.5	-	-	-
Other coelenterates	-	-	-	+	0.1
POLYCHAETA	-	24.2	-	2.8	9.0
Aphroditiae	-	-	-	2.7	9.0
Other polychaetes	-	24.2	-	0.1	-
CRUSTACEA	81.1	1.4	29.6	38.7	9.8
Caprellidea	-	+	-	-	-
Gammaridea	-	0.8	0.1	14.8	2.1
Hyperidea	-	-	0.1	+	-
Cancridae	23.7	-	-	6.6	6.0
Crangonidae	1.0	+	0.5	3.1	-
Paguridae	-	0.4	-	10.3	-
Pandalidae	-	-	7.0	0.4	0.2
Isopoda	-	0.2	-	0.3	0.1
Euphausiacea	-	-	0.3	-	-
Other Crustacea	56.4	+	21.6	3.2	1.4
MOLLUSCA	1.0	2.0	+	2.3	+
Pelecypoda	1.0	1.9	-	0.8	+
Gastropoda	-	0.1	-	1.5	-
Cephalopoda	-	-	+	-	-
ECHINODERMATA	-	1.3	-	-	79.6
Echinoidea	-	0.1	-	-	79.6
Ophiuroidea	-	1.2	-	-	-
PISCES	-	1.6	69.8	53.3	-
Cottidae	-	-	0.5	-	-
Gadidae	-	-	-	-	-
Ammodytidae	-	1.6	68.0	20.8	-
Other fish	-	-	1.3	32.5	-
MISCELLANEOUS	-	0.4	0.2	2.8	1.0
SAND and ROCKS	17.9	9.6	0.4	0.1	0.5
#Stomachs	6	21	10	39	13
#Empty	1	2	0	2	1
$\bar{X}$ wt. per stomach	1.75	11.33	22.95	19.37	13.93
length range(cm)	31-35	34-72	28-87	33-100	53-81

Table 4.--Part III. Stomach contents of fish species, as percent weight, collected during DELAWARE II cruise 77-01.

Stomach contents	Windowpane flounder	American plaice	Winter flounder	Yellowtail flounder
COELENTERATA	-	-	-	-
Cerianthidae	-	-	-	-
Other coelenterates	-	-	-	-
POLYCHAETA	4.5	93.5	-	12.5
Aphroditiae	-	93.5	-	-
Other polychaetes	4.5	-	-	12.5
CRUSTACEA	43.1	-	-	66.1
Caprellidea	-	-	-	-
Gammaridea	0.4	-	-	4.9
Hyperidea	-	-	-	-
Cancridae	-	-	-	-
Crangonidae	41.6	-	-	60.8
Paguridae	-	-	-	0.4
Pandalidae	-	-	-	-
Isopoda	0.1	-	-	-
Euphausiacea	1.0	-	-	-
Other Crustacea	-	-	-	-
MOLLUSCA	-	-	-	4.1
Pelecypoda	-	-	-	4.1
Gastropoda	-	-	-	-
Cephalopoda	-	-	-	-
ECHINODERMATA	-	6.5	-	-
Echinoidea	-	-	-	-
Ophiuroidea	-	6.5	-	-
PISCES	28.2	-	-	0.3
Cottidae	-	-	-	-
Gadidae	-	-	-	-
Ammodytidae	28.2	-	-	-
Other fish	-	-	-	0.3
MISCELLANEOUS	24.2	-	-	9.5
SAND and ROCKS	-	-	-	7.5
#Stomachs	28	5	5	19
#Empty	17	3	5	1
$\bar{X}$ wt. per stomach	0.38	0.43	0	0.39
length range (cm)	27-38	28-48	33-46	26-41

Table 4.--Part IV. Stomach contents of fish species, as percent weight, collected during DELAWARE II cruise 77-01.

Stomach contents	Alewife		Sea raven		Longhorn sculpin	
COELENTERATA	+		0.1		-	
Cerianthidae		-		-		-
Other coelenterates		+		0.1		-
POLYCHAETA	-		-		0.5	
Aphroditiae		-		-		-
Other polychaetes		-		-		0.5
CRUSTACEA	99.1		0.4		98.5	
Caprellidea		-		-		-
Gammaridea		96.4		-		0.1
Hyperidea		0.2		-		-
Cancridae		-		-		-
Crangonidae		-		0.4		5.5
Paguridae		-		-		-
Pandalidae		-		-		65.6
Isopoda		-		-		-
Euphausiacea		2.2		-		-
Other Crustacea		0.5		-		27.3
MOLLUSCA	-		0.2		-	
Pelecypoda		-		-		-
Gastropoda		-		-		-
Cephalopoda		-		0.2		-
ECHINODERMATA	-		-		-	
Echinoidea		-		-		-
Ophiuroidea		-		-		-
PISCES	-		99.3		0.3	
Cottidae		-		60.8		-
Gadidae		-		2.0		-
Ammodytidae		-		-		-
Other fish		-		36.5		0.3
MISCELLANEOUS	0.9		-		0.7	
SAND and ROCKS	-		-		-	
#Stomachs	10		5		12	
#Empty	0		2		2	
$\bar{X}$ wt. per stomach	2.54		15.34		0.95	
length range (cm)	22-49		22-49		18-22	

generally similar between cruises. However, it is difficult to evaluate any differences observed because of the relatively small number of fish collected. For example, the winter skate collected on the first cruise (76-13) consumed a greater percentage of fish (50.3% vs 12.9%) while more polychaetes (60.7% vs 21.8%) had been eaten by the fish collected during the second cruise. The sample size was small, two and seven fish for the 76-13 and 77-01 cruises, respectively, and therefore these differences may only reflect sampling variance. The small sample size also makes it difficult to accurately assess the differences in food habits between the windowpane and the ocean pout for the two cruises. The Atlantic cod also differed in its food habits but in this case, the sampling size was larger; 26 for cruise 76-13 and 39 for cruise 77-01. The cod collected during cruise 76-13 ate more crustacea (62.0% vs 38.7%) while the amount of fish in the diet decreased (27.5% vs 53.3%). The most striking difference was in the quantity of food consumed. The mean weight per stomach was 3.90 gms for the 76-13 cruise versus 19.37 gms for the fish collected during the second, 77-01 cruise. The length range of the fish sampled on both cruises overlap (35-86 cm vs 33-100 cm) but the average length of the fish is slightly larger (44 cm vs 57 cm) for the 77-01 cruise. Little skate were also sampled in relatively large numbers during both cruises (Tables 3 and 4). Again there were some differences in the food habits, however, in both cases the major food items were crustaceans (84.2% and 48.1%). The mean weight per stomach was also similar although there was a difference in the length range of the fish examined (Tables 3 and 4).

Food Habits of Phyletic Groups--Both Cruises Combined

In the following discussion the stomach samples of each predator species are considered utilizing data from both cruises. The major dietary components of each fish within a designated category (determined phyletically) are described.

The first group, the Chondrichthyes, is comprised of the spiny dogfish, *Squalus acanthias*, winter skate, *Raja ocellata*, thorny skate, *Raja radiata*, and little skate, *Raja erinacea*. Over 95% of the diet of the dogfish was fish. The major prey items of the winter skate were polychaete worms (21.8% and 60.7%) and the sand launce, *Ammodytes americanus* (50.3% and 3.0%). The stomach contents of the thorny skate were composed of a high percentage of fish (43.4%) and polychaete worms (29.5%). The little skate primarily consumed crustaceans (84.2% and 48.1%) and in particular gammarid amphipods (63.8% and 28.0%). In one sample from cruise 77-01, Station 36, an oily material was found on one caprellid amphipod. The sample consisted of the stomach contents from three male little skate ranging in length from 45 to 49 cm.

The gadids included red hake, *Urophycis chuss*; haddock, *Melanogrammus aeglefinus*; pollock, *Pollachius virens*; ocean pout, *Macrozoarces americanus* and Atlantic cod, *Gadus morhua*. The red hake diet consisted primarily of mud crabs (*Axius serratus*) and rock crabs (*Cancer* sp.) which made up over 50% of the crustaceans (81.1%) eaten. Haddock consumed polychaete worms (24.2%) and ceriantharian anemones (59.5%). The major

component of the stomach contents of the pollock was the sand launce, Ammodytes americanus (69.8%), while the prey of the ocean pout was primarily sand dollars, Echinarachnius parma (47.7%). The cod preyed on a variety of Crustacea (62.0% and 38.7%), rock crabs, Cancer irroratus and C. borealis; caridean shrimp, Crangon septemspinosa and Dichelopandalus leptocerus; the hermit crab, Pagurus acadianus; gammarid amphipod Gammarus annulatus and the isopod, Cirolina polita. The sand launce, A. americanus was the major species of fish identified in the cod stomachs (25.7% and 20.8%). In two samples from cruise 77-01, Station 29, an oily material was found mixed in with the stomach contents. In the first sample of nine fish, ranging in length from 41-45 cm, the oily substance was found in one stomach on the gammarid amphipod Gammarus annulatus. In the second sample of six fish, ranging in length from 49-87 cm, the oily material was found on the gammarid amphipod Anonyx sarsi.

The stomach contents of four species of Pleuronectiformes (flatfish), the American plaice, Hippoglossoides platessoides; winter flounder, Pseudopleuronectes americanus; windowpane, Scophthalmus aquosus; and yellowtail; Limanda ferruginea were examined. Over 90% of the diet of the American plaice consisted of polychaete worms of the family Aphroditidae. The five winter flounder stomachs examined were empty. The wndowpane was collected on both cruises and in each case crustaceans were the major prey item being either primarily gammarid amphipods (90.2%) on cruise 76-13 or the caridean shrimp Crangon septemspinosa (41.6%) on cruise 77-01. The stomach contents of the yellowtail were also comprised of a high percentage of Crustacea with the major prey item being C. septemspinosa (60.8%).

Alewives, Alosa pseudoharengus, the only clupeid examined, fed almost exclusively on gammarid amphipods (96.4%) of the genus Gammarus.

The last group of fish examined were the cottids, the sea raven; Hemitripterus americanus, and the longhorn sculpin; Myoxocephalus octodecemspinosus. The sea raven almost exclusively ate fish (99.3%). Over 98% of the stomach contents of the longhorn sculpin were decapod crustaceans with the major prey item being the pandalid shrimp Dichelopandalus leptocherus (65.6%).

Discussion

The food habits of the 16 fish examined in this survey differ little from data previously collected on the food habits of these same species (Maurer and Bowman 1975; Bowman 1975 and Bowman et al., 1976). Only the data collected on the American plaice and haddock appear to differ in terms of the major prey item categories.

The stomach contents of the American plaice consisted almost exclusively of polychaete worms. However, only five fish were examined of which three had empty stomachs and one of the two remaining had eaten polychaetes. In a larger sample of fish from Southern New England and Georges Bank, Bowman et al. (1976) have shown that the major food items

are usually crustaceans or echinoderms. Annelids are also a smaller part of the diet of these fish, especially in southern New England, and it is likely that a larger sample would have reduced the apparent significance of polychaetes in the diet of American plaice.

In the Georges Bank area haddock have generally been found to eat crustaceans, molluscs, echinoderms, annelids and fish (Wigley 1956; Wigley and Theroux 1965). The occurrence of large quantities of coelenterates in the diet, as reported here, is apparently rare. The stomach contents of 21 haddock, collected from three stations, were examined. The coelenterates occurred in the stomachs of the fish at only one station and probably reflect a local abundance of this prey item.

The impact of the oil spill on the food habits of various species of groundfish was assessed by surveying the stomach contents. Of the 305 fish stomachs examined, three samples, representing the stomach contents of two species of fish, contained an oil-like material. In two different samples of Atlantic cod, collected at Station 29, 25-30 miles southwest of the wreck site, oily gammarid amphipods comprised part of the stomach contents. At Station 36 a sample of the stomach contents collected from little skate contained an oily caprellid amphipod. Since 1963 more than 38,000 stomachs, representing 82 species of fish, have been analyzed at the Northeast Fisheries Center and no oil-like materials have previously been reported. Since 1969, a total of 393 little skate and 1,706 cod have been examined as part of the routine assessment of fish food habits and, again, no oil-like materials have been identified in the stomach contents (Maurer and Bowman 1975).

3.3.7. Temperature Structure of the Water Column, Delaware II 77-01, Redwood Wright, Northeast Fisheries Center, Woods Hole.

Water temperatures during the cruise were very similar to the average values shown on the charts of Colton and Stoddard (1972) for 1940-1959. Temperatures were nearly isothermal, surface to bottom, except in the deeper stations along the southern edge of Georges Bank. Bottom values were usually a few tenths of a degree warmer than those at the surface. The coldest values (less than 5°C) were in water close to shore, with temperatures as low as 2° at the two shallowest positions south of Nantucket and Martha's Vineyard. Over Georges Bank the range was 5° to 6°, with water warmer than 6° in the vicinity of Great South Channel and the extreme southern edge of the Bank. Subsurface values warmer than 10°, indicative of Slope Water, were found at Stations 21 and 23, in deeper water south of the Bank. Otherwise the temperatures were all typical of the Shelf Water of the region in January.

3.3.8. Bottom Sediments from the Argo Merchant Oil Spill Region, Roland Wigley, Northeast Fisheries Center, Woods Hole.

Samples of surfacial bottom sediments were collected by the R/V Delaware II during two cruises conducted shortly after the Argo Merchant

grounded and sank on Nantucket Shoals. The first samples were collected in December 1976 at two stations, 4 and 6, on cruise 76-13. In early January 1977 a series of 23 samples was collected on cruise 77-01 (see attached listing for station numbers). The location of each sample is plotted in Figure 1. The samples were collected by means of a pipe dredge and a Digby dredge. Samples were stored in glass containers; sediment volume ranged from approximately 50 to 750 cc.

Each sample was analyzed microscopically for tar-balls or other evidence of the presence of oil or oil-like substances.

Dominant components of the sediments were found to be sand, pebbles, and mollusk shell fragments. These components, plus some of the less common items, are listed for each station in Table 1.

No evidence of any oil-like substance was detected in any of the samples.

Through arrangements made by G. Kelly (NMFS) and G. Heimerdinger (EDS) these samples have been forwarded to the U.S. Coast Guard, Groton, Connecticut, for detailed hydrocarbon analyses.

4. LONG-TERM ASSESSMENT PLANS

The *Argo Merchant* oil spill in its passage over Nantucket Shoals and Southeast Georges Bank encompassed the spawning grounds of cod, haddock, pollock, herring, flounders (yellowtail, blackback, four-spot, sand dab) and our important scallop and silver hake fishing grounds. Considering the importance of the area of actual or potential impact, assessments of fish, shellfish, ichthyoplankton and benthos will be continued by the Northeast Fisheries Center through extension and augmentation of ongoing MARMAP surveys during the next eighteen months.

It is intended through Center reprogramming and temporary reassignments to complete 6 to 9 MARMAP surveys over the area of the spill. That will provide important statistical information on species composition and relative abundance, but these data will provide little substantive information on the sublethal effects of the spill on the "health" or condition of the stocks.

If the impact of petroleum hydrocarbons on the fisheries resources of the area is to be assessed with any reasonable probability of success, it is essential to examine selected species of fish, shellfish, benthos and ichthyoplankton for: genetic damage, disruption of normal physiological processes, pathobiological conditions and for levels of petroleum hydrocarbon contaminants.

Plans have been developed to carry forward a comprehensive long-term assessment that will include the following studies:

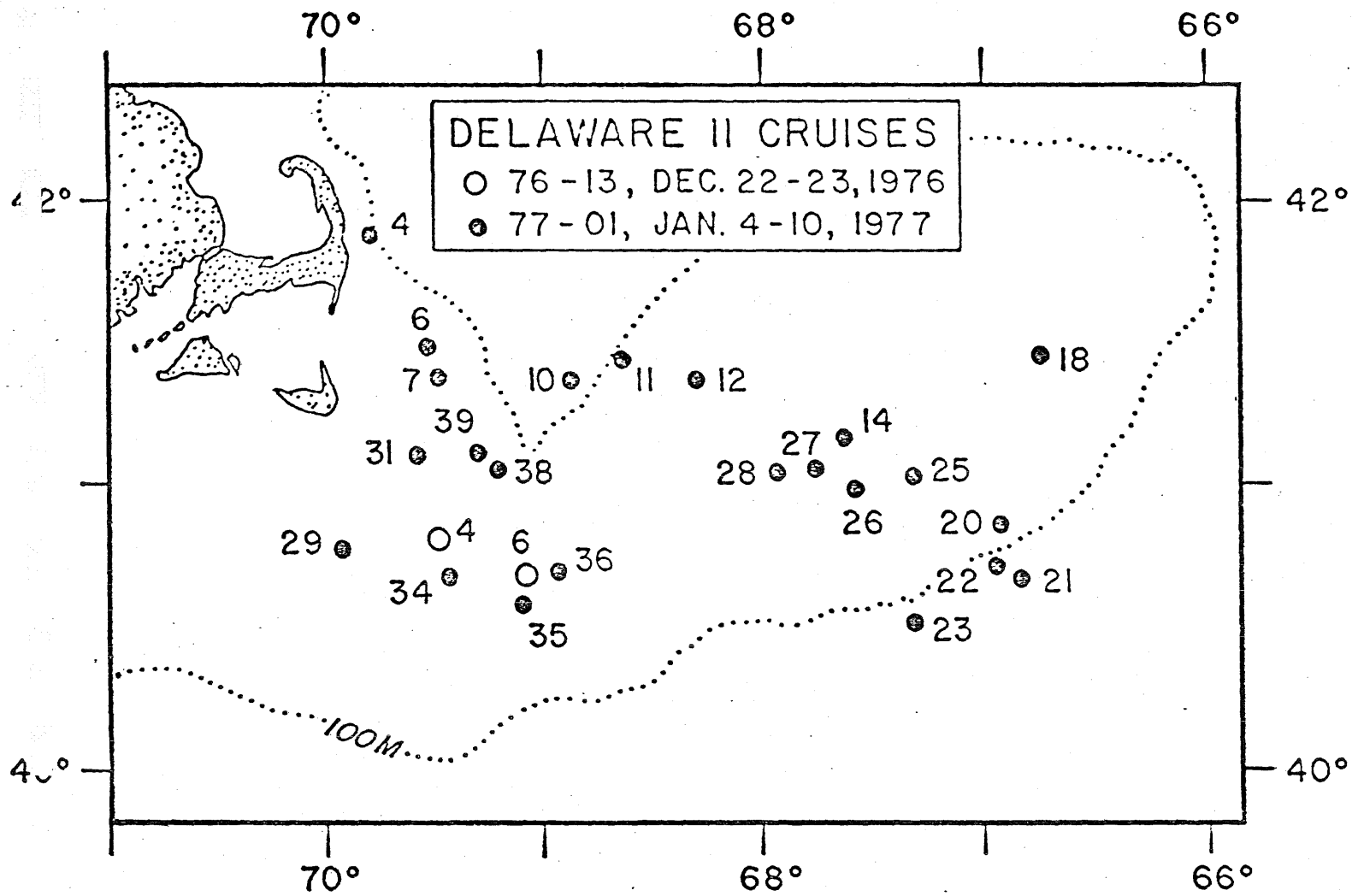

Figure 1. Locations of bottom sediment samples collected on R/V Delaware II cruises 76-13 and 77-01.

Table 1. Surfacial bottom sediments from the *Argo Merchant* oil spill region.

R/V DELAWARE II Cruise 77-01

Station	Gear	Remarks
4	Digby Dredge	*Arctica* shell and worm tubes
6	Pipe Dredge	Coarse brown sand
7	Pipe Dredge	Coarse brown sand
10	Pipe Dredge	Medium to fine sand with silt-clay
11	Pipe Dredge	Coarse sand. Slight amount of silt-clay
12	Pipe Dredge	Coarse sand, clean, pale brown
14	Pipe Dredge	Fine sand, light gray
18	Pipe Dredge	Medium sand, medium brown Slight amount of silt-clay
20	Digby Dredge	Shell fragments ¼-5 cm., and black rock ca. 5 x 7 cm. *Venericardia*, *Astarte*, *Arctica*, *Onuphis*
21	Pipe Dredge	Medium to coarse sand, medium brown
22	Digby Dredge	Shells and skate egg *Astarte*, *Apporhais*, *Arctica*, *Dentalium* *Placopecten* - some live.
23	Pipe Dredge	Medium-fine sand, greenish brown Small amount silt-clay
25	Digby Dredge	Large shells-*Arctica*, *Colus stimpsoni*, *Lunatia heros*, *Placopecten*. Clinker 5 x 7 ½ cm. *Crangon*-decaying.
26	Digby Dredge	Large shells-*Arctica*, *Buccinum*, *Balanus crenatus*, *Echinarachnius*. Trace of fine sand. *Pagurus acadianus*.
27	Pipe Dredge	Fine sand, light gray
28	Digby Dredge	Shell fragments ½-5 cm., white, clean *Crepidula fornicata*, *Echinarachnius*. *Crassostrea*, *Nassarius trivittatus*. Small (½ cm.) pebbles; *Anomia*, *Spisula*, *Ensis*, *Astarte*.
29	Pipe Dredge	Fine sand, light gray

Station	Gear	Remarks
31	Pipe Dredge	Medium sand - 15% small mollusk fragments - pale brown
34	Digby Dredge	2 *Arctica* shells 5 - 10 cm. 1 *Echinarachnius* 1 ¼ cm.
35	Digby Dredge	Coarse sand, brown Small (¼-1 cm.) pebbles, brown Shells - *Placopecten* Hydroids
36	Pipe Dredge	Medium - coarse sand Few small (1/8-1 cm.) pebbles, medium-brown
38	Pipe Dredge	Pebbles (1/8-3½ cm.) black to white Sand - wide range in size, black to white Mollusk shell fragments - 3%.
39	Digby Dredge	Pebbles (1/8-6 cm.) white to black Coarse-medium sand, brown-white to black Shell - *Venericardia*, *Spisula*, *Placopecten* *Strongylocentrotus* - fresh dead, 7 mm. diam. *Amaroucium* ?, 2 pieces 5-10 cm.
23	Samples Cr. 77-01	

R/V DELAWARE II Cruise 76-13

Station	Gear	Remarks
4	Pipe Dredge	Medium-fine sand, pale brown *Echinarachnius* shell fragments, well rounded
6	Pipe Dredge	Medium-fine sand, pale brown < 1% shell fragments 1-2% pebbles, 1-10 mm.
2	Samples CR 76-13	
25	Samples Cruises 77-01 and 76-13	

Benthos-Shellfish Assessments

Two cruises are planned to assess changes in populations of important benthos and shellfish. Specimens of several shellfish species will be collected for evidence of pathological conditions and toxic effects from petroleum hydrocarbons in the environment.

Ichthyoplankton--Juvenile Fish Assessments

a. Monitoring: Expanded monitoring of larval and juvenile fish would encompass the area of the oil spill to assess changes in population levels.

b. Laboratory Studies: Ongoing cooperative efforts between NMFS (Drs. Laurence and Kühnhold,[1] Narragansett) and EPA (Jackim and Lefcourt, Narragansett) will be augmented to determine effects of No. 6 fuel oil on pelagic fish eggs and larvae. In addition, eggs and larvae of cod, and other demersal species such as winter flounder will be used to test for responses of eggs and larvae to treatment with No. 6 or 7 fuel oil.

c. Genetics: Chromosomal studies of fish eggs and embryos (Dr. Longwell, NMFS, Milford) will be extended to examine fish species in the Georges Bank-Nantucket Shoals area. Genetically based egg mortality occurring in populations of fishes will be assessed and the relative importance of hydrocarbons and natural environmental factors inducing lethal chromosome errors in developing fish eggs will be investigated.

Pathobiology

Specimens of tissue from selected fish and shellfish species from clean and impacted areas will be analyzed (Dr. Rosenfield, NMFS, Oxford) for evidence of abnormalities, tissue and cellular diseases. Also, incidence of anatomic lesions in fish and shellfish from clean and contaminated areas will be monitored.

Physiology and Biochemistry

Analyses of tissue samples (Gould, Thurberg, NMFS, Milford) from fish/shellfish (e.g., ocean scallops and horse mussels) would continue to identify indicators of the physiological/biochemical health of the organism (e.g., hematology and respiration rates, shifts in metabolic pathways, induction or suppression of enzymes).

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[1]Visiting expert on effects of petroleum hydrocarbons on fish eggs and larvae from Univ. of Kiel, FRG.

Petroleum Hydrocarbon Analyses

Hydrocarbon analyses on selected fish and shellfish (adults, juveniles and embryos) will continue at the NOAA Analytical Lab in Seattle, Washington.

5. EFFECTS ON MARINE ECOSYSTEMS

Most of the studies on biological effects of oil have been done in the laboratory or in near shore areas. Extensive field studies which distinguish real effects from naturally occurring ecosystem variability are virtually non-existent.

Although before-after studies can be designed to assess the impact of predictable events such as oil drilling on the continental shelf and ocean dumping of wastes, adequate studies of this nature are lacking because it is both difficult and expensive to plan and execute these investigations given the limitations of time and available funding.

The grounding and breaking of the Argo Merchant and subsequent groundings of other oil tankers on the continental shelf are dramatically illustrative of events that are not predictable. For example, during the past 18 months, the Northeast Fisheries Center has been requested by responsible officials--local, state, and Federal--to assess the impact of four major environmental incidents on the fishery resources of the northeast Continental Shelf. In each of these incidents special studies were mounted to assess the impact on the environment and living resources. These efforts, however, were of limited duration, and conducted with little information on the initial condition of the living resources. Only limited information on the baseline conditions or health of the stocks is available. We are dealing with a complex ecosystem that requires a combination of short-term tactical observations that can be evaluated against a background of long-term baseline information on the condition and health of fish and shellfish stocks.

In order to effectively deal with these problems a program is needed that: 1) encompasses the coordination of the studies of various groups and agencies, 2) provides for the fundamental and long-term study of the ocean ecosystem that is ultimately necessary, and 3) provides suitable information for interim or near-term policy guidance and decision making.

An integrated field approach is necessary which couples in-depth "process oriented" studies at specific sites with long-term monitoring of productivity of fish stocks.

At present, no single program exists that can accommodate these objectives. However, the Northeast Fisheries Center, NMFS/NOAA, has recently outlined a plan to monitor and assess selected systems and biological and environmental parameters that are critical indicators of the state of health of the ocean. The program will acquire, process, analyze and disseminate information concerning the condition, stability,

and productivity of the principal fish stocks off the northeast coast.

The plan outlined in this report to assess the long term effects of the Argo Merchant incorporates the principal elements of the new NEFC program for assessing the health of marine resources. The Argo Merchant area represents only one of twenty sites, both clean and impacted, on the Continental Shelf that would be systematically monitored during the next several years. They will represent the baselines against which the impact of future oil spills can be evaluated.

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