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THE TAINTING OF LOBSTER MEAT BY BUNKER C OIL ALONE OR IN COMBINATION WITH THE DISPERSANT COREXIT

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THE TAINTING OF LOBSTER MEAT BY BUNKER C OIL ALONE OR IN COMBINATION WITH THE DISPERSANT COREXIT

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On February 4, 1970, the tanker *ARROW* hit a rock off Isle Madame in Chedabucto Bay, N.S. Four days later the *ARROW* broke in two and lost possibly 1,500,000 gallons of her Bunker C oil cargo. The stern section, which sunk in 15 fathoms, contained about the same amount.

The effect of this spill on the fisheries of Chedabucto Bay was one of the major concerns. Of the various inshore fisheries in this area, the lobster fishery was by far the most important. Although effects of the spill would presumably be greatest in the Isle Madame area, it was conceivable that the lobster fishery in Richmond County and the eastern end of Guysborough County (statistical districts 14 and 15) could be adversely affected. Lobster landings in this area from 1965 to 1969 averaged 490,000 pounds worth $338,000. About 700 fishermen were engaged in the fishery.

Accordingly, teams of biologists surveyed the intertidal zone, made underwater observations on the bottom conditions to depths of 70 feet and conducted laboratory tests to determine the toxicity of Bunker C oil and dispersants to lobsters, clams and fish. These studies will be reported elsewhere. This particular report describes laboratory experiments conducted to determine whether Bunker C oil alone or in combination with the dispersant Corexit would taint lobster meat; if so, under what conditions would tainting occur and how long would it persist; and finally to determine whether feasible methods of cleaning Bunker C oil from live lobsters could be devised. Answers to these questions were needed urgently because the lobster season in the southern part of Chedabucto Bay was scheduled to open April 10 (Lobster Fishing District 5) and in the northern part on May 1 (District 7A).

Underwater observations near the site of the wreck had revealed virtually no oil on bottom, so it appeared unlikely that adult lobsters would become seriously contaminated in nature. There was, however, a danger that during fishing operations the gear would become contaminated and the lobsters smeared by handling or affected by eating smeared bait. Lobsters stored in floating crates or cars would, of course, be subject to heavy contamination from surface oil slicks.

To obtain information quickly, a series of experiments was planned to simulate conditions that might occur during actual fishing operations or during commercial storage. There was, of course, no basis to judge how extensively lobsters would become

contaminated in practice. Of necessity, the experiments were modified from day to day on the basis of preliminary results. Bunker C oil is difficult to handle and measure, particularly when cold. It mixes poorly in cold sea water even in the presence of the dispersant Corexit and adheres to containers and apparatus. Precise measurements are therefore rather meaningless at times. In an effort to obtain fairly intimate contact between Bunker C oil, sea water and lobsters, aerators and motor-driven stirrers were used continuously to agitate the mixtures. At best this was only moderately successful. Taste panels of up to 24 persons were used in most experiments to judge flavour. Such judgments are subjective, variable and difficult to evaluate. Some persons like lobsters so well that they find inferior quality quite acceptable. Others refuse to eat tomalley or if they do, tend to give it a low rating. The flavour of lobsters tainted with Bunker C oil is so persistent that judgment of other samples is probably affected. This gives importance to the order of tasting. The texture and appearance of claw meat, tail meat and tomalley vary enough to affect flavour judgments. For these reasons and others, the results of the taste panels should be interpreted with caution.

D. E. Graham set up the experiments and made most of the observations. E. I. Lord conducted most of the taste panels. Special thanks are extended to members of the taste panel who continued to help after having been subjected on several occasions to quite unpleasant samples. The individual experiments are described below but for convenient reference the general conclusions are summarized as follows:

1. Lobsters liberally smeared with Bunker C oil and promptly returned to running sea water lose 90% of the oil within 6 hours.

2. No tainting of meat or tomalley from smeared lobsters could be detected after 4 and 8 days in running sea water.

3. Lobsters readily eat bait smeared with Bunker C oil.

4. No definite tainting of meat or tomalley from lobsters fed smeared bait could be detected after 4 and 8 days in running sea water.

5. Meat and tomalley of lobsters immersed for 90 hours in sea water containing 1 part per 1000 Bunker C oil or 1/1000 Bunker C oil and 1/1000 Corexit 8666 acquire a very objectionable, oily flavour.

6. Tomalley becomes more strongly flavoured than meat.

7. Tainting persists in meat for more than 3 weeks and in tomalley for more than a month.

8. Meat becomes tainted before lobsters are boiled.

9. Clean lobsters boiled in water containing appreciable amounts of Bunker C oil do not become tainted.

10. Meat or tomalley from lobsters immersed for 116 hours in sea water containing 1 part per 1000 Corexit 7664 does not become tainted.

11. Lobsters can withstand short immersion in sea water containing 1/10 Corexit 7664.

12. Short immersion of smeared lobsters in high (10%) concentrations of Corexit 7664 does not quickly and completely remove Bunker C oil.

13. Short immersion of smeared lobsters in high (10%) concentrations of Corexit 7664 does not taint their meat.

14. Short immersion of smeared lobsters in high (10%) concentrations of Corexit 7664 does not appreciably facilitate the complete removal of Bunker C oil over a 12-day period in running sea water.

15. Short immersion of smeared lobsters in full strength Varsol facilitates the removal of Bunker C oil.

16. The meat and tomalley of smeared lobsters briefly immersed in Varsol become tainted.

17. Wiping smeared lobsters with full strength Corexit 7664 or Corexit 8666 is an effective, initial step in removing Bunker C oil.

18. If used with caution, wiping lightly smeared lobsters with full strength Corexit may have commercial application.

April 15, 1970.

Experiment #1

Purpose: To determine whether lobsters smeared with Bunker C oil, as might occur during fishing or storage operations, will survive and whether the meat or tomalley becomes tainted.

Materials and Methods: At 8.30 a.m. on March 5, 1970, 20 vigorous 1-lb lobsters were taken from running sea water at 2.2 C and allowed to dry in air for 30-60 minutes. Using cotton gloves dipped in Bunker C oil at room temperature (about 20 C), each lobster was liberally smeared on the dorsal surfaces of the claws, carapace and abdomen (Fig. 1). They were then returned to a 3' x 3' x 1' fiberglass tank filled to a depth of 10⅛" with 48 imperial gallons of sea water being replaced at the rate of 1.6 gallons per minute at 2-3 C. An air stone was also provided to ensure an adequate supply of oxygen and to increase water movement. The smearing was completed by 9.40 a.m.

Observations: Almost immediately after placing the smeared lobsters in running sea water, oil droplets started rising to the surface, escaping through the outflow or adhering to the polyethylene tank liner. Within 6 hours, possibly less than 10% of the oil remained on the lobsters. Most of this was concentrated in crevices around the bases of the walking legs and on the ventral surface of the abdomen at the bases of the pleural spurs. The ventral surfaces had become contaminated when lobsters crawled over each other.

On March 9, 1970, at 10.00 a.m., 4 lobsters were removed for taste panel. These still retained a few globules of oil in crevices on the ventral surface. These lobsters were boiled for 20 minutes in a gallon of tap water containing 3% table salt. Their gill surfaces were perfectly clean before cooking. Stomachs examined after cooking were empty and clean with no visible traces of oil. A panel of 23 tasters was offered about 10 grams of either claw or tail meat and 1-2 grams of tomalley from test and control lobsters (Fig. 2). Of the 23, only 12 tasted the tomalley. The tasters were asked to judge flavour only as excellent (A), good (B), fair (C), or poor (D). Results of this test were as follows:

Taste panel 1. March 9, 1970 – Smeared lobsters after 96 hours in running sea water.

	Meat		Tomalley	
Rating	Control	Smeared	Control	Smeared
A	8	10	1	4
B	8	11	3	6
C	7	2	8	2
D	0	0	0	0
Totals	23	23	12	12

On March 13, 1970, at 10.00 a.m., 8 days after smearing, 4 lobsters were removed for taste panel. These retained a few globules of oil on ventral surface and the rubber bands used to inactivate the claws were still smeared (these were removed before cooking). The gill surfaces of one lobster were dark but not oily. The others appeared to be normal. Three stomachs were virtually empty, one contained a few milligrams of almost black material that possibly included some oil. Results of this taste panel were:

Taste panel 2. March 13, 1970 – Smeared lobsters after 8 days in running sea water

	Meat		Tomalley	
Rating	Control	Smeared	Control	Smeared
A	11	10	2	4
B	8	9	8	6
C	4	5	5	4
D	1	0	0	1
Totals	24	24	15	15

As of April 9, 1970, at 10.00 a.m., 12 of the test lobsters remained alive and vigorous with no evidence of injury from the treatment. There was no mortality over a 35-day period that can be ascribed to Bunker C oil. Three of these lobsters still showed traces of oil on the ventral surface.

Conclusions: Low temperature lobsters, dried in air for ½ to 1 hour and liberally smeared with room temperature Bunker C oil lose 90% of this oil within 6 hours when placed in running sea water at 2-3 C. After 4 and 8 days in running sea water, there was no indication that either the meat or tomalley was tainted. The smearing caused no mortality over a 35-day period.

It is difficult to conceive that during actual fishing operations lobsters would become as heavily contaminated as these test animals.

Experiment #2

Purpose: To determine whether lobsters would consume bait smeared with Bunker C oil and whether such consumption would affect their survival or the flavour of the meat or tomalley.

Materials and Methods: At 9.40 a.m., March 5, 1970, 20 1-lb lobsters were placed in a 3' x 3' x 1' polyethylene-lined fiberglass tank containing 48 imperial gallons of aerated sea water that was being replaced at the rate of 1.1 gallons per minute. This tank contained 4 pounds of fresh frozen herring that had been liberally smeared with Bunker C oil (Fig. 3). The water temperature which initially was 2.5 C was gradually raised to 4.7 C over a 28-hour period to encourage feeding. The temperature was maintained at 4.7 C as long as the herring was left in the tank (96 hours).

Observations: On March 5, several lobsters were observed feeding quite actively in spite of the low water temperature. During the next 4 days up to 50% of the herring was consumed. Within 24 hours relatively few oil droplets remained on the herring but an appreciable amount was floating on the surface of the tank. When the herring was removed it smelled fresh and showed no visible traces of oil.

At 10.00 a.m., on March 9, 1970, after being exposed to smeared herring for up to 96 hours, 4 lobsters were removed for tasting. There was virtually no oil on the exterior or gill surfaces of these lobsters. The stomachs were about half full of a dark grey, silvery mass containing slender bones – almost certainly partially digested herring. The gut of each lobster was black. The contents of the gut sometimes contaminated the tomalley when the meat and tomalley were being removed. The results of this 96-hour taste panel were as follows:

Taste panel 1. March 9, 1970 – Lobsters allowed to feed on smeared herring for 96 hours.

	Meat		Tomalley	
Rating	Control	Fed smeared herring	Control	Fed smeared herring
A	8	8	1	2
B	8	10	3	7
C	7	5	8	3
D	0	0	0	0
Totals	23	23	12	12

On March 13, 1970, at 10.00 a.m., 8 days after lobsters were initially fed smeared herring and 4 days after herring residue was removed from test tank, 4 more lobsters were removed for tasting. The gill surfaces and dorsal body surface of these lobsters showed no trace of oil. A few very small patches of oil were observed at bases of pleural spurs and between bases of walking legs. All four stomachs were stained but were virtually empty, one containing a few dark fragments and another a few 1-mm diameter oil droplets. The guts were partially filled with brownish material. The results of this taste panel were:

Taste panel 2. March 13, 1970 – 4 days after smeared herring removed.

	Meat		Tomalley	
Rating	Control	Fed smeared herring	Control	Fed smeared herring
A	11	10	2	1
B	8	6	8	4
C	4	6	5	7
D	1	2	0	3
Totals	24	24	15	15

As of April 9, 1970, at 10.00 a.m., 12 of the test lobsters remained alive and vigorous with no evidence of injury from the treatment. There was no mortality over a 35-day period that can be ascribed to Bunker C oil. Nine of these lobsters still showed traces of oil on the ventral surface.

Conclusions: At relatively low temperatures (2.5 to 4.7 C) lobsters will feed readily on herring liberally smeared with Bunker C oil. This caused no mortality over a 35-day period and there is no evidence that the meat was tainted. The tomalley from the test lobsters scored somewhat lower than that from the controls but considering the nature of the tests, the difference is regarded as of questionable significance.

It is difficult to conceive that during actual fishing operations bait would become as heavily contaminated as that used in this test.

Experiment #3

Purpose: To determine whether the meat and tomalley of lobsters stored in sea water containing (a) Bunker C oil (1 part per 1000 by weight), (b) Bunker C oil and the dispersant Corexit 8666 (1 part per 1000 of each) and (c) Corexit 8666 alone (1 part per 1000) would become tainted and if so, how long would the tainting last in running sea water.

Materials and Methods: On March 6, 1970, 8 rectangular fiberglass tanks were lined with polyethylene and filled with 11 imperial gallons of sea water. Pairs of these tanks were placed in 3' x 3' fiberglass tanks containing 7-8 inches of running sea water to maintain reasonably constant temperatures in the test tanks. One set of 4 tanks was maintained at 4±0.8 C for 118 hours. The other set initially at 6 C was gradually raised to 10 C by 68 hours and maintained there (±1 C) for an additional 50 hours. Each test tank was provided with an air stone and was stirred continuously by a motor-driven stirring rod encased in a plastic, coarse-mesh cage to ensure adequate aeration and thorough mixing (Fig. 4). Dissolved O_2 concentrations were maintained at 9 ppm in the cold tanks, and at 7 ppm in the warm tanks. Ten vigorous 1-pound lobsters were placed in each tank. At 5.00 p.m., Bunker C oil, vigorously stirred in a few liters of sea water, was added to a cold and a warm tank to bring the final concentration to 1 part per 1000. Bunker C oil plus Corexit 8666 and Corexit 8666 alone were similarly treated and added to the test tanks. Two of the tanks served as controls. After 118 hours' exposure, the lobsters remaining in the cold and warm tanks were combined by treatments and placed in about 35 imperial gallons of running sea water that was replaced at the rate of about 1.5 gallons per minute. The ambient temperature in these tanks from March 11 to April 9 ranged from 2 to 5 C (av. 3.3 C).

Observations: Even with continuous stirring and aeration, the Bunker C oil and the combination of Bunker C and Corexit 8666 did not mix well with sea water but remained for the most part as thick floating masses. In the relatively shallow water, 7-8 inches, the lobsters' antennae or claws frequently broke the surface and became heavily coated with oil. Lobsters exposed to a combination of Bunker C and Corexit became less heavily but more uniformly coated.

At 11.00 a.m., on March 10, 1970, after 90 hours' exposure, 4 lobsters were removed from each of the 4 warm test tanks. These were boiled for taste panel as in previous tests.

The 4 lobsters from the Corexit tank were weak (the liner of this tank had torn in such a way that lobsters became separated from air supply causing weakness and 4 deaths). The body surface was clean and normal in appearance, the gills were clean and the stomachs were clean and empty except for a few shell fragments.

The 4 lobsters from the Bunker C tank were vigorous, the gill chambers showed virtually no oil, and there was only a light oil film on the dorsal body surface. Some oil in crevices of ventral surface. Three of the stomachs were virtually empty with no evidence of oil; a few 1 mm drops of oil in one stomach.

Of the 4 lobsters from the Bunker C and Corexit tank, 2 were weak and 2 were vigorous. All were covered with a film of oil which was wiped off major exposed surfaces before boiling. There was some oil in gill chambers of 2 weak lobsters and less in the chambers of the vigorous lobsters. The stomachs were virtually empty but all were coated with a film of oil.

The results of this taste panel were as follows:

Taste panel 1. March 10, 1970 — After 90 hours' exposure.

Rating	Control	Bunker C 1/1000	Bunker C 1/1000 + Corexit 8666 1/1000	Corexit 8666 1/1000
Meat				
A	13	1	1	10
B	8	5	1	11
C	3	9	12	2
D	0	9	10	1
Totals	24	24	24	24
Tomalley				
A	7	0	0	3
B	8	2	0	8
C	1	0	1	1
D	0	14	15	4
Totals	16	16	16	16

This test showed clearly that both the meat and the tomalley had become tainted in the lobsters exposed to Bunker C alone or to a combination of Bunker C and Corexit. Many tasters noted a strong, very objectionable, oily taste particularly in the tomalley. There was no suggestion that Corexit alone affected the flavour of the meat. The somewhat lower score of the tomalley from the Corexit test is considered to be of doubtful significance. On the basis of this test, it was decided that further exposure to Bunker C or Bunker C plus Corexit was unnecessary and that tasting of lobsters exposed to Corexit alone could be discontinued. At 3.00 p.m., on March 11, after 118 hours' exposure, the lobsters from the cold and warm tanks were combined and maintained at ambient temperatures (2-5 C). Observations were continued

to find out how long the tainting persists in clean running sea water and to examine external surfaces, gill chambers and digestive tracts for oil.

At 2.00 p.m., on March 13, 2 lobsters from the control tank, 2 from the Bunker C tank and 2 from the Bunker C + Corexit were removed for examination and tasting. These lobsters had been in running sea water for 47 hours.

The lobsters from the Bunker C tank had patches of oil at bases of pleural spurs and between bases of walking legs — possibly a gram or more of oil remained on each lobster. The gill surfaces were clean but wall of gill chamber stained with oil. Digestive tract not examined.

The lobsters from the Bunker C + Corexit tank had about the same quantity and distribution of oil on the body surface as those in Bunker C. The stomachs were empty except for brown liquid. The guts were clean.

The results of this taste panel were as follows: Taste panel 2. Mar. 13/70 — 118 hr exposure + 47 hr in running sea water.

Meat

Rating	Control	Bunker C 1/1000	Bunker C 1/1000 + Corexit 1/1000
A	7	0	0
B	5	4	0
C	0	3	4
D	0	5	8
Totals	12	12	12

Tomalley

A	5	0	0
B	5	0	0
C	0	2	1
D	0	8	9
Totals	10	10	10

At 9.00 a.m., March 20, 1970, 4 lobsters were removed from each tank for examination and tasting.

The 4 lobsters exposed to Bunker C retained considerable amounts of oil at bases of the pleural spurs and of the walking legs. The gills were clean but the gill chamber wall showed some staining. The rubber claw bands were still oil smeared, the wooden plugs were clean.

The 4 lobsters exposed to Bunker C and Corexit were much cleaner than those exposed to Bunker C alone. Gills were clean with slight staining of gill chamber. The results of the third taste panel were as follows:

Taste panel 3. March 20, 1970 – 118 hours' exposure + 8 3/4 days in running sea water.

Meat

Rating	Control	Bunker C 1/1000	Bunker C 1/1000 + Corexit 1/1000
A	8	2	2
B	12	9	7
C	4	7	7
D	0	6	8
Totals	24	24	24

Tomalley

A	7	0	0
B	7	2	1
C	2	4	3
D	0	10	12
Totals	16	16	16

At 9.00 a.m., on April 3, 1970, 4 lobsters were removed from each tank for examination and tasting.

Two of the 4 lobsters exposed to Bunker C had large droplets of oil in crevices on ventral surface, the other 2 were cleaner. The water channel in the gill chamber was definitely smeared. The stomach of one lobster was heavily smeared with oil, the other 3 were lightly stained.

The 4 lobsters exposed to Bunker C + Corexit had a few small droplets of oil in crevices on ventral surface. The gills and gill chambers were clean. The stomachs were empty with no visible traces of oil. The results of the fourth taste panel were as follows:

Taste panel 4. April 3, 1970 – 118 hours' exposure + 22 3/4 days in running sea water.

Meat

Rating	Control	Bunker C 1/1000	Bunker C 1/1000 + Corexit 1/1000
A	10	5	5
B	12	9	5
C	2	10	10
D	0	0	4
Totals	24	24	24

Tomalley

Rating	Control	Bunker C 1/1000	Bunker C 1/1000 + Corexit 1/1000
A	3	1	1
B	7	3	1
C	2	5	1
D	2	5	11
Totals	14	14	14

On April 14, 1970, at 10.00 a.m., after 33 3/4 days in running sea water, the 2 remaining lobsters that had been exposed to Bunker C oil and the remaining 2 exposed to Bunker C oil and Corexit were removed for examination and tasting.

The 2 lobsters that had been exposed to Bunker C oil showed no trace of oil externally. The gill surfaces were stained with oil and the water channel of the gill chamber was heavily stained with oil. One stomach contained a small quantity of Bunker C oil, the other considerably more.

The 2 lobsters that had been exposed to Bunker C oil and Corexit showed no trace of oil externally. The gill surfaces were clean but there were oil stains on the body wall of the gill chamber at each end of the water channel. The stomachs and guts were empty and clean. Results of the fifth taste panel were as follows:

Taste panel 5. April 14, 1970 – 118 hours' exposure + 33 3/4 days in running sea water.

Meat

Rating	Control	Bunker C 1/1000	Bunker C 1/1000 + Corexit 1/1000
A	1	2	5
B	9	5	6
C	3	6	3
D	1	1	0
Totals	14	14	14

Tomalley

A	1	0	0
B	4	0	1
C	5	5	3
D	1	6	7
Totals	11	11	11

This somewhat smaller than usual taste panel did not detect significant differences in flavour of the meat from the test and control lobsters. In fact, lobsters that had been exposed to Bunker C + Corexit rated somewhat higher than the controls. The tomalley from the test lobsters was still definitely tainted.

In these experiments no mortalities occurred among the control lobsters. Of those in Corexit 8666, 5 died during the 118-hour exposure period, presumably from asphyxiation resulting from a tear in the tank liner, and one other died during the next 34 days. Of those in Bunker C, 1 died during the exposure period and 1 subsequently. Of those in Bunker C + Corexit 8666, 2 died during the exposure period and 1 subsequently.

Conclusions: The meat and tomalley of lobsters exposed to 1 part per 1000 Bunker C or to Bunker C 1/1000 and Corexit 8666 1/1000 for 90 hours acquire a very objectionable oily flavour.

The tomalley becomes more strongly flavoured than the meat.

These flavours persist in the meat for more than 3 weeks and in the tomalley for more than a month after the lobsters are returned to running sea water.

The flavour of lobsters held in Bunker C + Corexit is slightly but consistently more objectionable than those held in Bunker C only.

Conditions during these tests were much more severe than lobsters living naturally on the bottom would be expected to encounter in Chedabucto Bay. Contamination paralleling test conditions could conceivably occur if a large oil slick drifted inshore where lobsters were stored in floating crates or cars.

Experiment #4

Purpose: To determine whether meat of lobsters exposed to Bunker C oil, Bunker C + Corexit or Corexit only becomes tainted prior to boiling.

Materials and Methods: On March 13, 1970, one control lobster and one from each treatment (Exp. #3) were dismembered and the raw meat removed as thoroughly as possible. The tomalley was not used. The meat from each lobster was boiled for 20 minutes in a quart of tap water containing 3% table salt by weight. The results of the small taste panel were as follows:

Taste panel. March 13, 1970 – Raw meat removed from tainted lobsters and cooked.

	Meat			
Rating	Control	Bunker C 1/1000	Bunker C 1/1000 + Corexit 1/1000	Corexit 8666 1/1000
A	3	0	0	4
B	2	3	1	1
C	0	2	2	0
D	0	0	2	0
Totals	5	5	5	5

Observations: There was difficulty in extracting the raw meat in a reasonably intact condition and in cooking it consistently. Some observers commented that the texture was "short". Others found it too salty. Two of the 5 observers specificially mentioned oil in the Bunker C lobster and 3 of 5 did so in the lobster from Bunker C + Corexit.

Conclusions: The meat of lobsters exposed to Bunker C 1/1000 or to Bunker C 1/1000 + Corexit 1/1000 for 118 hours becomes tainted prior to boiling.

Experiment #5

Purpose: To determine whether Bunker C oil added to the water in which clean lobsters are boiled will taint the flesh.

Materials and Methods: On March 17, 1970, at 9.00 a.m., three lots of two 1-lb lobsters were boiled for 20 minutes in separate containers in one gallon of tap water to which 3% NaCl had been added. To one container 0.2 gram of Bunker C was added, to another 2.0 grams. These test animals were taken as representing lobsters that might become lightly or heavily smeared during commercial fishing or storage operations. The lobsters in the third container were controls.

Observations: When the container with 2 grams of oil was opened after the cooking was completed, there was a strong smell of oil. The lobsters themselves were virtually clean. The results of the taste panel were as follows:

	Meat			Tomalley		
		0.2 g	2.0 g		0.2 g	2.0 g
Rating	Control	Bunker C	Bunker C	Control	Bunker C	Bunker C
A	7	8	7	5	4	2
B	4	3	5	4	5	7
C	2	2	1	2	3	3
D	0	0	0	1	0	0
Totals	13	13	13	12	12	12

Conclusion: Neither the meat nor the tomalley of clean lobsters becomes tainted when they are boiled with 0.1 or 1.0 gram of Bunker C oil per lobster – amounts that might be involved in light or heavy smearing during commercial fishing operations.

Experiment #6

Purpose: To determine whether immersing lobsters in Corexit 7664 1/1000 for an extended period would taint the meat or tomalley.

Materials and Methods: On March 18, 1970, at 2.00 p.m., 10 vigorous 1-pound lobsters were placed in 11 imperial gallons of sea water 1 part per 1000 of Corexit 7664. An air stone was used to ensure adequate aeration and a motor-driven stirrer was used to keep the Corexit and sea water well mixed. The lobsters were held in this tank until 10.00 a.m., on March 23, an exposure of 116 hours.

Observations: Water temperatures which were controlled by a bath of running sea water averaged 4.5±.5 C during the exposure period.

At 10.00 a.m. on March 23, 1970, 4 test lobsters were removed for examination and tasting. These lobsters were vigorous and seemed normal in all respects. External surfaces and gill surfaces were clean and the stomachs were virtually empty containing traces of brownish liquid commonly found in control lobsters. The results of the taste panel were as follows:

Taste panel. March 23, 1970 – Lobsters immersed for 116 hours in sea water containing 1/1000 Corexit 7664.

	Meat		Tomalley	
Rating	Control	Corexit 7664 1/1000	Control	Corexit 7664 1/1000
A	10	10	5	3
B	11	9	5	5
C	3	5	3	6
D	0	0	1	0
Totals	24	24	14	14

The slight difference in the ratings of control and test lobsters is not considered to be significant.

The six remaining lobsters were alive and vigorous at 2.00 p.m. on March 24, 1970, when they were discarded. No mortality had occurred over a 144-hour exposure period.

Conclusion: Exposure of lobsters to Corexit 7664 1/1000 for 116 hours does not taint the meat or tomalley.

There is nothing to suggest that Corexit 7664 1/1000 is lethal to lobsters.

These results indicate that Corexit 7664 1/1000 would be safe to use to clean lobsters smeared with Bunker C oil.

Experiment #7

Purpose: To determine whether lobsters can withstand short exposures to higher concentrations of Corexit 7664, whether such treatment would clean lobsters that had been smeared with Bunker C oil, and whether the meat would become tainted.

Materials and Methods: On March 31, 1970, at 11.30 a.m. 2 lobsters were liberally smeared with Bunker C oil and placed in a tank containing 11 imperial gallons of sea water and 1 part per 100 of Corexit 7664. This mixture was mixed continuously by means of a small pump. The lobsters were left in this tank for 3 hours. Temperatures, which were not controlled, rose from 4 to 12 C.

At 3.00 p.m., 2 clean lobsters were placed in a tank containing 11 liters of sea water and 1 part in 10 of Corexit 7664, mixed continuously. The lobsters were left in this mixture for 15 minutes.

At 3.15 p.m., 2 lobsters smeared with Bunker C oil were placed in the 1/10 Corexit 7664 bath for 30 minutes.

Observations: After 3 hours in 1/100 Corexit 7664, the 2 lobsters were still vigorous. They had lost possibly 90-95% of the Bunker C oil, particularly from the dorsal surfaces which were almost clean. Small patches remained among the crevices on the ventral surface.

The 2 clean lobsters were vigorous after 15 minutes in 1/10 Corexit 7664.

The 2 smeared lobsters in 1/10 Corexit 7664 for 30 minutes were quite weak when removed and had lost about 90% of the Bunker C oil. They recovered quickly in running sea water at 4 C.

After 45 to 46 hours in running sea water, these lobsters were cooked and tasted by 4 persons. No objectionable flavour was detected.

Conclusions: Lobsters can withstand exposure to 1/100 Corexit 7664 without obvious ill effects. Exposure to 1/10 Corexit for 15 minutes had no obvious immediate effect but exposure for 30 minutes weakened the lobsters.

The treatment did not clean lobsters satisfactorily, significant amounts of oil remaining in the crevices on the ventral surface, after nearly 2 days in running sea water.

Short exposure to relatively high concentrations of Corexit 7664 did not taint the meat.

Experiment #8

Purpose: To determine whether short immersion in 1/10 or 1/100 Corexit 7664 is an effective step in cleaning lobsters smeared with Bunker C oil.

Materials and Methods: On April 1, 1970, at 3.15 p.m., 9 vigorous lobsters were removed from sea water and allowed to dry for 30 minutes. They were then liberally smeared with Bunker C oil which adhered quite well to the reasonably dry surfaces. At 4.00 p.m., 3 lobsters were placed in running sea water, 3 were immersed in 4.5 gallons of 1/10 Corexit 7664 for 10 minutes and 3 were immersed in 4.5 gallons of 1/100 Corexit for 10 minutes. These treated lobsters were then placed in running sea water at 4 C.

Observations: Each of the 10 minute Corexit treatments removed about 50% of the Bunker C oil. When these lobsters and the controls were placed in sea water. the oil quickly gathered in large beads over the dorsal surfaces. These gradually broke free, floated to the surface and passed through the outflow. Within an hour the control lobsters had lost about 25% of their oil, the test animals more than 50%.

At 9.00 a.m., April 3, 1970, after 41 hours in running sea water, the 3 groups did not differ appreciably having lost 70-80% of their oil. All 9 lobsters were vigorous.

By 9.00 a.m., April 6, 1970, after 4 2/3 days, all 3 groups had lost possibly 90% of their oil, small amounts remaining in crevices on ventral surfaces. The rubber claw bands remained smeared. The three groups did not differ noticeably and all were vigorous.

At 9.00 a.m., April 14, 1970, after 12 2/3 days, the rubber claw bands were still smeared. All 9 lobsters were virtually clean. Two of the controls showed no external trace of oil, the other one small ventral patch. The three lobsters from 1/100 Corexit each had 4 to 7 very small ventral patches in crevices. Two of the 1/10 Corexit were clean, the other with 2 very small ventral patches. The 9 lobsters were cooked at 9.00 a.m.

The gill surfaces of one control lobster were clean, those of another were appreciably darker and those of the third lobster showed a moderate-sized dark patch. Two of the control stomachs were empty or nearly so, the third was about half full of medium brown, gelatinous material.

The gills from the lobsters exposed to 1/10 Corexit were clean to medium grey. Two of the stomachs were empty, the third full of a greenish grey, gelatinous mass.

The gills from the lobsters exposed to 1/100 Corexit were grey to dark grey, one stomach was empty and clean, another was empty but oil stained and smelled of oil, the third was a quarter full of brown, gelatinous material with no visible oil.

No formal taste panel was conducted with these lobsters but one person who tasted samples of meat from each lot could detect no objectionable flavour.

Conclusions: Immersing lobsters for 10 minutes in 1/10 Corexit 7664 or 1/100 Corexit 7664 and then returning them to running sea water is not lethal.

Smeared lobsters immersed in Corexit lose about half their Bunker C oil in 10 minutes.

By 13 days, both the Corexit-treated lobsters, and the controls retained minute amounts of oil in the crevices of the ventral surfaces.

The minute amounts of oil remaining at 13 days would not likely be noticed without a detailed examination. Judging from previous experiments, the amount remaining would be unlikely to taint the flesh.

Although rubber claw bands were still smeared after 13 days, such bands are not in wide use and the more common wooden claw plugs do not retain smears. If bands are used and become smeared, they should be replaced before the lobsters are marketed.

Experiment #9

Purpose: To determine whether lobsters can withstand brief immersion in full strength Varsol, whether such treatment would clean lobsters that had been smeared with Bunker C oil and whether their meat or tomalley would become tainted.

Materials and Methods: On April 2, 1970, 3 vigorous lobsters were dried in air at room temperature for 30 minutes and then liberally smeared on the dorsal surface with Bunker C oil. At 3.15 p.m., one of these was dipped for 60 seconds in and out of a gallon of full strength Varsol that was being vigorously agitated by compressed air through an air stone. A second lobster was so treated for 10 seconds and a third for 1 second. The 3 lobsters were promptly returned to a tank containing 11 gallons of sea water that was being replaced at the rate of 1 gallon per minute.

Observations: Immediately following treatment, all 3 lobsters were weak but started to revive as soon as they were returned to running sea water at 4 C. Within 2 hours, the 3 lobsters exhibited normal vigour.

Immersion in Varsol, thinned and loosened the Bunker C oil but did not completely clean the lobsters immediately.

On April 3, 1970, at 8.30 a.m., after 17 hours in running sea water. the lobsters were vigorous but were covered with a light film of oil and smelled of Varsol.

By 4.00 p.m. on April 3, 1970, after 24½ hours in running sea water, the lobsters were vigorous, were virtually clear of Bunker C oil but showed a light film of oil.

By 8.30 a.m. on April 6, 1970, after 3½ days in running sea water, the lobsters were vigorous with no visible traces of oil but with an odour of Varsol.

At 9.00 a.m., April 7, 1970, the 3 Varsol-treated lobsters were carefully examined and then boiled. There were no visible traces of oil externally, on the gill surfaces or in the stomachs. There was, however, a faint odour of Varsol.

The results of the taste panel were as follows:

Taste panel. April 7, 1970 – Lobsters immersed in Varsol for 1, 10 and 60 seconds, tasted after 4½ days in running sea water.

	Meat			Tomalley		
Rating	1 Sec.	10 Sec.	60 Sec.	1 Sec.	10 Sec.	60 Sec.
A	2	2	2	0	0	0
B	2	0	1	0	0	0
C	2	3	2	1	1	0
D	0	1	1	4	4	5
Totals	6	6	6	5	5	5

No control was run with this small panel, but the ratings assigned to the meat were somewhat lower than those generally given to controls in earlier experiments. Clearly, however, several tasters found nothing objectionable in the meat. The tomalley, however, was given a low rating by all tasters and most found it very objectionable. No clear relationship between rating and time of exposure was obvious in this small-scale test.

Conclusions: Short immersion in full strength Varsol is an effective way of cleaning lobsters smeared with Bunker C oil.

Lobsters immersed in full strength Varsol weaken rapidly but appear to recover fully.

The tomalley and probably the meat of lobsters so treated become tainted. This tainting persists for at least 4½ days.

Because of tainting and the high risk of killing lobsters through over-exposure, the treatment is not recommended.

Experiment #10

Purpose: To determine whether it is feasible to use full strength Corexit 7664 or 8666 to wipe Bunker C oil off smeared lobsters.

Materials and Methods: At 8.30 a.m. on April 15, 1970, 8 vigorous 1-pound lobsters were removed from 4.5 C sea water and allowed to dry at room temperature (20 C) for 30 minutes. The dorsal surfaces of these were then moderately smeared with room temperature Bunker C oil and they were again allowed to dry for 30 minutes.

At 9.30 a.m. a rag soaked in Corexit 7664 was used to wipe the oil from 4 of the lobsters. This cleaning required 4-5 minutes and used up 50-60 ml of Corexit. The other 4 lobsters were similarly treated with Corexit 8666 in about the same time and using about the same amount of Corexit.

The 8 lobsters were promptly placed in 2 tanks, each containing 14 gallons of 5 C aerated sea water being replaced at the rate of 1 gallon per minute.

Observations: The lobsters appeared to weaken during treatment, particularly those wiped with Corexit 8666, one of which became very weak after 2 hours in running sea water. At 11.30 a.m., 6 of the lobsters were vigorous, one slightly weak and one extremely weak. By this time the dorsal surfaces of the lobsters were virtually clean except for small droplets on the claws or legs close to the body. Several droplets of oil remained in crevices on the ventral surface.

At 8.30 a.m., April 16, one of the Corexit 8666 lobsters was dead. Its dorsal and ventral surfaces were free of visible oil, its gills were dark but not oily and its stomach was empty.

At 10.30 a.m., April 16, 25 hours after cleaning with Corexit, 3 lobsters from each treatment were examined and cooked for tasting. The lobsters cleaned with Corexit 7664 were externally free of oil except for a few small patches at bases of walking legs and pleural spurs. The gills were clean but one lobster has a slight smear of oil at the posterior end of the gill chamber. One stomach and gut were empty and clean, one stomach was a quarter full of brownish liquid and the gut dark brown. The other stomach was half full of brown gelatinous mass and the gut dark brown. The lobsters cleaned with Corexit 8666 were virtually free of oil externally, except for very small amounts on the ventral surface -- they seemed cleaner than those wiped with Corexit 7664. The gills of the 8666 lobsters were clean

but one had a trace of oil in the gill chamber. The guts of all 3 were dark brown. One stomach was empty, the others a quarter full of brownish mass with no visible traces of oil. The results of the taste panel were as follows:

Taste panel. April 16, 1970 – Smeared lobsters wiped with Corexit 7664 or Corexit 8666 and returned to running sea water for 25 hours.

	Meat			Tomalley		
Ratings	Control	Corexit 7664	Corexit 8666	Control	Corexit 7664	Corexit 8666
A	4	6	8	1	0	1
B	12	8	10	8	6	5
C	2	4	0	3	4	6
D	0	0	0	0	2	0
Totals	18	18	18	12	12	12

Conclusions: Wiping smeared lobsters with full strength Corexit 7664 or Corexit 8666 is an effective, initial step in removing Bunker C oil.

Corexit 8666 may be slightly more effective than Corexit 7664.

Corexit 8666 used this way may be somewhat more harmful to lobsters than Corexit 7664.

Liberal use of Corexit 7664 or Corexit 8666 to clean lobsters smeared with Bunker C oil does not taint the meat or tomalley within a 25-hour period.

This treatment, if used with caution, may have commercial application for cleaning lobsters that become lightly smeared with Bunker C oil.

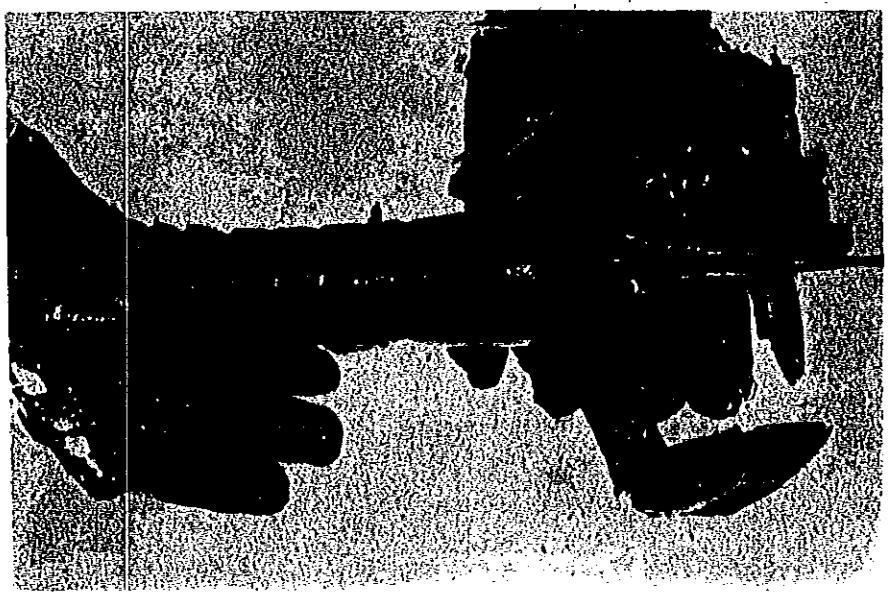

Fig. 1. Lobster liberally smeared with Bunker C oil (Exp. #1).

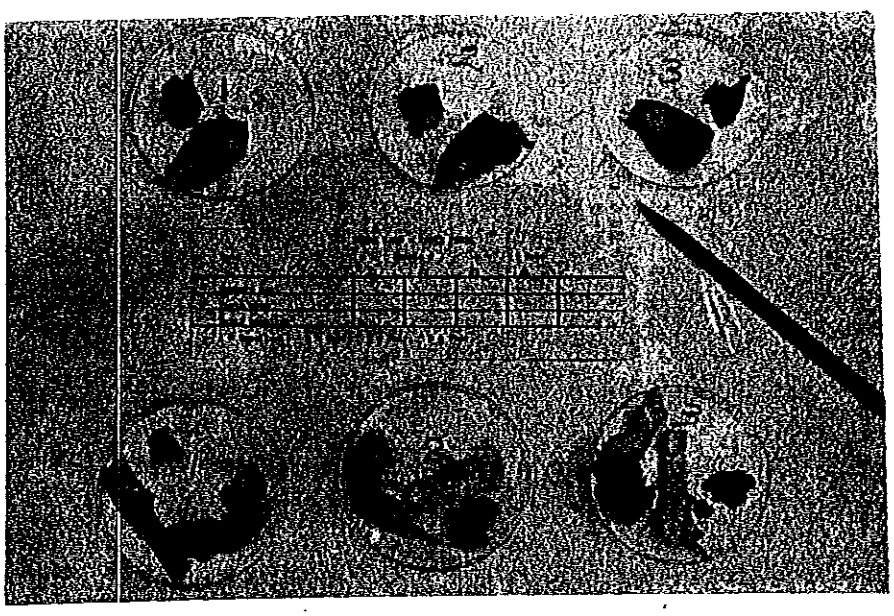

Fig. 2. Lobster claw meat, tail meat and tomalley as arranged for taste panels.

Fig. 3. Frozen herring smeared with Bunker C oil (Exp. #2).

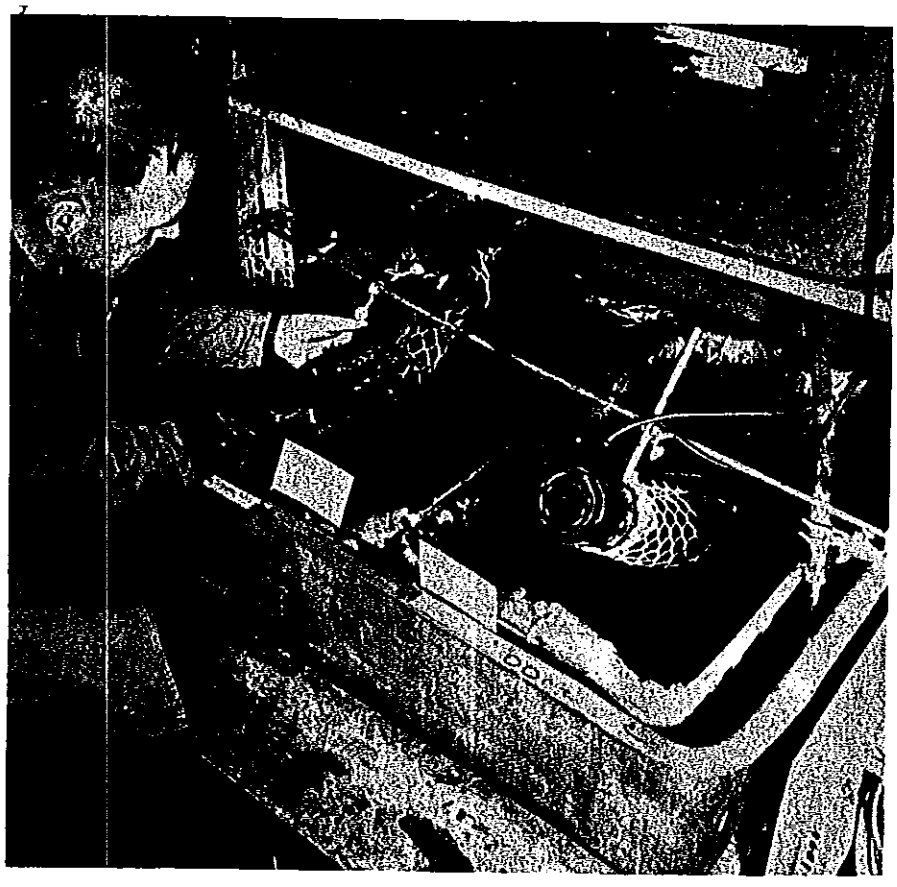

Fig. 4. Tank on left Bunker C oil 1/1000 and Corexit 8666 1/1000; tank on right Bunker C oil 1/1000 (Exp. #3).