

Preliminary Investigations of the Effects of the *Braer* Oil Spill

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Summary

Trials were carried out to investigate the short-term effects of crude oil on adult, juvenile and larval lobsters and on lobster eggs. The results provide clear evidence that oil concentrations ranging from 4 ppm to 10 ppm have significant adverse effects on lobsters in all stages of their life cycle. The feeding, movement, responsiveness and aggression of adult and juvenile lobsters were all reduced by exposure to oil, while high rates of mortality were observed amongst larvae and eggs. The effect of oil on egg and larval stages indicates the potential for oil spills to adversely affect the reproduction of lobsters. Although no direct mortalities were observed amongst the adult lobsters, the behavioural abnormalities observed could place juvenile and adult lobsters at a severe disadvantage in the natural environment, possibly resulting indirectly in their death.

Introduction

In January 1993 the oil tanker Braer was wrecked at the southern tip of Shetland, spilling some 85,000 tonnes of crude oil and some 500 tonnes of bunker (heavy fuel) oil. The oil spilled was thoroughly mixed into a turbulent sea under the severe wind and wave conditions prevalent at the time and dispersed rapidly.

Following the spill all fishing activities were prohibited in the area affected by the spill. For most shellfish species this ban



The oil tanker Braer leaking oil shortly after grounding near the southern tip of Shetland. G. Storey - Force 10 Photos

remained in force until the spring of 1995 when the main commercial species were judged to be free of any remaining contamination. Shortly after the area was reopened to fishing complaints were received from fishermen that catches of lobsters (*Homarus gammarus*) in the area around the site of the spill were much lower than they had been before the spill and that the proportion of small (i.e. young) lobsters in their catches was abnormally low.

Following an approach by the Shetland Fishermen's Association the North Atlantic Fisheries College undertook to investigate whether the Braer oil spill could have had an adverse impact on lobster stocks in the area. Experiments were carried out to determine what, if any, effects exposure to crude oil had on larval, juvenile and adult lobsters. Gullfaks crude oil was used in the experiments, the same type as the Braer's cargo.

Oil Concentrations Measured Following the Spill*

Immediately following the grounding of the Braer, while oil was spilling from the wreck, the concentration of oil in the area close to the wreck was measured at some hundreds of parts per million (ppm; 1 ppm = 1ml of oil per tonne of water). In the days following the spill the waters around the wreck site exhibited oil concentrations as high as 50 ppm (20,000 times 'normal' levels), but by ten days after the spill this had fallen to about 4 ppm. About 120 tonnes of dispersants were sprayed within a few days of the spill but compared to the effects of the wave action at the time this would have had a negligible effect on the oil, dispersing at most only 2-3% of the amount spilled.

ADULT LOBSTERS

Materials & Methods

Eighteen adult female lobsters were held in three large (4m², 800l) tanks, with three berried and three spent lobsters in each tank. The lobsters' claws were banded to prevent them damaging each other, and all tanks were continuously aerated. The lobsters were transferred to, and allowed to adjust to, the tanks before any oil was added. Tank 1 was used as a control,

* Figures from Ritchie, W. & O'Sullivan, M. *The Environmental Impact of the Wreck of the Braer* - Report of the Ecological Steering Group on the Oil Spill in Shetland. The Scottish Office, 1994.

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with no oil added, while oil was added to tanks 2 and 3 to give concentrations of 4 ppm and 10 ppm respectively. The oil concentration in tank 3 was increased from 10 to 50 ppm 120 hours after the start of the trial.

To try and ensure that the oil was mixed into the water (as it was following the spill), as opposed to just forming a slick on the surface, the oil was first thoroughly mixed into a small volume of seawater. This was then poured into the tanks which were again thoroughly mixed. Tank 1 received the same mixing treatment as the other tanks, although no oil was added, in case the mixing itself had any adverse effects on the lobsters, e.g. by stressing them.

Observations were made of the behaviour of the lobsters, including the level of aggressiveness towards an inanimate object (a plastic rod) and their responses to food, over the following week. The condition of the eggs on the berried lobsters was also assessed.



Adult and juvenile lobsters.

Results

No mortalities occurred in any of the tanks during the trials.

Behaviour

One hour after the addition of oil the lobsters exposed to 10 ppm of oil were observed to be exhibiting very aggressive behaviour; the lobsters standing on their walking legs and raising their claws, frequently out of the water. Some lobsters were actively aggressive and appeared to provoke other into conflict. The lobsters exposed to 4 ppm of oil exhibited some aggressive behaviour, but to a lesser extent than in 10 ppm, while those in the control tank (no oil) did not display any marked level of aggression. When the lobsters were confronted with a plastic rod an aggressive reaction proportional to the concentration of oil was noted, i.e. those in 10 ppm showed the most aggressive reaction, those in the control tank the least.

After 24 hours the aggressive behaviour of the lobsters in 10 ppm and 4 ppm of oil had declined to a level similar to that of those in the control tank. All the lobsters exhibited an aggressive reaction when confronted with the plastic rod, but the response time in those exposed to oil was, on average, greater than in those in the control tank whose response was immediate.

The responsiveness of the lobsters exposed to oil continued to decline during the remainder of the trial. After 30 hours the average response times to the plastic rod by the lobsters was 9 seconds (range 2-20) at 10 ppm and 5 seconds (range 1-8) at 4 ppm. The lobsters in the control tank reacted immediately, as they continued to do throughout the trial.

After 48 hours an aggressive response could only be elicited from the lobsters in 10 ppm of oil if their claws were actually touched, otherwise the only response was movement of the lobsters' antennae and antennules. After 120 hours responses could only be elicited from two of these lobsters, and their response time was over 10 seconds. The remaining four lobsters showed no response at all, not even antennal or antennule movement. At 4 ppm two lobsters did not respond to the plastic rod while two exhibited only antennal responses.

After 140 hours (20 hours after the oil concentration in tank 3 was increased to 50 ppm) the lobsters exposed to 50 ppm of oil took up to 30 seconds to respond to the plastic rod. None of the lobsters changed position in their tank following the test of their reaction time, while 4 of those exposed to 4 ppm of oil and all of the control lobsters moved to the other side of their tank or attempted to hide behind another lobster.

Feeding

When the lobsters were fed 90 minutes after the start of the trial (they had been starved prior to the trial) those in the control tank immediately consumed all the food offered to them. In contrast, those exposed to 10 ppm of oil appeared to be actively "rejecting" the food, picking it up as if to eat it then "kicking" it away with their maxillipeds and claws. They would also frequently walk over the food without responding to it. However, the food was eventually consumed over a period of some 24 hours. Of the lobsters in 4 ppm two immediately consumed the food when it was offered to them, two actively rejected the food while the remaining two appeared uninterested. All of the food was consumed over a three hour period.

The lobsters were next fed 150 hours after the start of the trial. The control lobsters were obviously hungry and lifted their claws to grab the food before it fell to the bottom of the tank. All the food provided was immediately consumed and the lobsters appeared to search for more. The lobsters at 4 ppm also consumed all the food offered but those at 10 ppm (increased to 50 ppm after 120 hours) generally ignored the food. If they picked up the food this was usually only momentarily and after tasting it was usually dropped.

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Eggs

All of the berried lobsters had eggs in good healthy condition, i.e. a uniform navy-blue/black colour, at the start of the experiment. The condition of these eggs was reassessed 125 hours after the addition of the oil. No changes were discernable in the control tank, but there had been a marked deterioration in the condition of the eggs of the lobsters exposed to oil. At 4 ppm of oil each berried female had fewer eggs and, on average, about 20 eggs which were obviously dead (an opaque red colour) or dying (an opaque brown/red). Similar damage was noted in the lobsters exposed to 10 ppm of oil, particularly in the more posterior regions, with 20 to 30 dead or dying eggs on each berried female. The connective tissue which held the egg mass together was also obviously damaged in the lobsters exposed to oil.

It was noticed at this time that there were a number of shed eggs floating in the water of tank 3 (10 ppm, later 50 ppm) and also a number of larvae at various developmental stages. Many of the larvae were alive and were a deep orange colour. By the time the trial was terminated after 168 hours the majority of these larvae had died, and the survivors did not appear very lively. A number of dead and semi-hatched eggs were also found on the bottom of the tank.

JUVENILE LOBSTERS

Materials & Methods

One hundred and twenty stage IV juvenile lobsters (the stage where they change from a free floating to bottom living lifestyle) were divided between six 10l glass tanks, two with oil concentrations of 10 ppm, two with 4 ppm and two control tanks with no oil. Each tank had a continuous air supply. The juveniles were held in trays consisting of individual mesh bottom compartments (these were required to keep the intensely cannibalistic juveniles separate). The oil was added

A Stage IV Juvenile lobster



to the tanks, and thoroughly mixed into the water, before the juveniles were placed in them.

Observations were made at intervals to determine the relative amount of activity by the juvenile lobsters in each tank when undisturbed and in response to a physical stimulus (tapping of each tray). Food was offered to each lobster 96 hours after the addition of oil, and their responses noted.

Results

Behaviour

An immediate and obvious adverse reaction was noted in the juvenile lobsters exposed to oil. After one hour they showed less movement than those in the control tanks. When the trays were tapped only five of the 40 juveniles exposed to 10 ppm of oil were seen to actively respond (by moving around their compartment) compared to 13 at 4 ppm and 23 in the control tanks.

After 72 hours the juveniles in 10 ppm of oil appeared effectively lifeless with little or no movement even when their trays were tapped. These juveniles only exhibited active movement, e.g. an escape response, when an object such as a pair of tweezers was actually placed in the compartment. At 4 ppm of oil only eight of the 40 juveniles responded when their trays were tapped, while two were found to be dead. The juveniles in the control tanks exhibited no loss of responsiveness with all responding when their trays were tapped.

Feeding

When food was offered to the juvenile lobsters after 96 hours those in the control tank were obviously hungry and keen to feed. Many of them approached the food as it was placed in their compartment and all of them consumed the food offered. The juveniles exposed to 4 ppm of oil appeared less eager to eat. Only a few approached the food as it was placed in their compartment but only two failed to eat the food offered. At 10 ppm none of the juveniles approached the food as it was being added and many of them waited for up to one minute before approaching the food. Eight of these 40 juveniles failed to eat their food at all.

LARVAL LOBSTERS

Materials & Methods

Three hundred planktonic lobster larvae were divided amongst six 4l plastic tanks, each with a continuous air supply. Two tanks had oil concentrations of 10 ppm, two had 4 ppm, and two were controls with no oil added. As with the adult lobsters the oil was thoroughly mixed with a small volume of seawater before adding it to the tanks.

The larvae were observed periodically over seven days and their level of activity assessed.

Results

Immediately after the addition of oil the larvae exposed to 10 ppm displayed increased levels of movement compared to

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those at 4 ppm and the controls. This difference decreased with time and by 48 hours there were no differences between the different groups of larvae.

After 120 hours exposure to oil many of the larvae at 10 ppm appeared almost lifeless, only occasionally flicking their tails. The larvae at 4 ppm, and the controls were much more lively. By 144 hours after the addition of the oil only 16 of the 100 lobsters exposed to 10 ppm remained alive, compared to 34 at 4 ppm and 41 in the control tanks. When the trial was concluded after 168 hours there were only 7 survivors at 10 ppm and 16 at 4 ppm, while 24 controls left alive.



A larval lobster

DISCUSSION

This preliminary investigation has demonstrated that short term exposure to oil concentrations of 4 ppm, 10 ppm and 50 ppm did have an adverse effect on adult, juvenile and larval lobsters and on lobster eggs.

Although there were no mortalities amongst the adult lobsters and only a very small number amongst the juveniles, both exhibited marked behavioural abnormalities, as a result of exposure to oil. The movement, level of aggression, responsiveness to stimuli, and feeding of adults and juveniles were all reduced by exposure to oil with the degree of the effect directly related to the concentration of oil (i.e. the more oil the greater the effect). The onset of these effects was extremely rapid, frequently immediate on exposure to oil, although their severity commonly increased with longer exposure.

Although exposure to oil caused few, if any, mortalities amongst adult and juvenile lobsters during this trial it is highly probable that the behavioural abnormalities observed would place them at a severe disadvantage in the wild; if they were unable/unwilling to find and/or consume food for

example, or respond appropriately to threats. Exposure to oil could, therefore, cause mortalities amongst adult and juvenile lobsters indirectly rather than through a direct toxic effect. It is possible also that a direct toxic effect could occur if exposure to oil continued for a longer period of time than during this trial.

Amongst lobster eggs and larval lobsters, exposure to oil was found to cause high levels of mortality, as well as reducing the activity of the larvae. It appeared that exposure to oil resulted in loss of eggs from berried lobsters, possibly through damage to the connective tissue which binds the egg mass together. The fact that dead larvae were observed in a semi-hatched state suggests either that the oil induced premature hatching, or that the oil had an immediate acute toxic effect on the hatching larvae. The reduced levels of activity amongst the larvae exposed to oil would again place them at a severe disadvantage in the wild, reducing their ability to escape predators for example, even if the oil did not kill them directly. The severe impact of oil on the egg and larval stages of the lobster's lifecycle has serious implications for the reproduction of lobsters exposed to oil.

These trials have clearly demonstrated that exposure to oil concentrations similar to those measured following the wreck of the Braer does have significant lethal and sub-lethal effects on lobsters. It would seem reasonable to conclude, therefore, that the Braer spill could have had an adverse effect on lobster stocks in the area affected by the spill, resulting in decreased catches following the resumption of commercial fishing. The results suggest that the impact would be most severe on the younger stages of the lobster's life cycle.

The results of this study agree well with those of other published work on the effects of oil on lobsters. Some of this work indicates that bunker oil has a much more toxic effect on lobsters than crude oil. It is possible, therefore, that the Braer spill (which included 500 tonnes of bunker oil) could have had an even more severe impact on lobster stocks than is suggested by this study.

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