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Two recent problems in oil pollution research

by

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INTRODUCTION

Recently, two developments have taken place which indicate a need for further work on certain aspects of oil pollution. Firstly, a revolutionary method of using dredged sand as an oil-sinking agent has been developed by one of the major oil companies; secondly, following the spillage of a highly toxic aromatic fuel oil at West Falmouth, Massachusetts, the suggestion has been made (Blumer et al. 1970, Blumer 1971) that petroleum hydrocarbons persist in the lipids of marine animals for long periods. Furthermore, Blumer suggests, certain of these hydrocarbons may accumulate in marine food chains and ultimately cause cancer in man and other predators.

The newly-developed sinking agent represents a significant advance in oil-spill clean-up technology, while the suggestions put forward by Blumer would, if they represented a correct interpretation of the facts, necessitate a serious reappraisal of the methods presently used to deal with oil spills. In this paper, work in progress on the fisheries implications of both these developments is described.

EFFECTS OF SINKING AGENTS

Until the development of the sand-sinking process, the only available sinking agents consisted of various powdered minerals chemically treated to render them oleophilic. These powders are applied dry and it was soon discovered that their controlled application to oil slicks in the open sea can be a difficult operation. In addition, unless the oil is heavily weathered and therefore of high specific gravity, very large quantities of the sinking agent are required. These factors, and the fear that sunk oil could foul fishing gear, have tended to limit the usefulness of sinking agents of this type around the United Kingdom. A further consideration, which applies to all sinking agents, is that the sunk oil might exert a toxic effect on the benthos.

With the appearance of the new method the opportunity was taken to compare the net fouling potential of a dry sinking agent (stearate-treated chalk) with that of the amine-treated sand. In addition, the possible toxic effects of oil sunk by sand were investigated.

Fouling of nets by stearate-treated chalk

It is a characteristic of dry sinking agents that the sunken lumps of oil and powder produced by these agents tend to be comparatively large. To some extent the size of these lumps depends upon the thickness of the oil, but even with slicks 1 mm thick the trials showed that lumps up to 4 cm in diameter could result.

In our trials the chalk was applied to the oil either by hand or via a boom rigged over the ship's side (Fig. 1). During the trawling experiments, it was found that lumps would collect on the ground rope (Fig. 3) and a few of the larger pieces found their way into the cod-end (Fig. 4). In addition, smearing of the belly of the trawl took place.

Fouling of nets by amine-treated sand

In this process, sand dredged from the sea bed is treated aboard ship with an amine and is pumped as a wet slurry on to the oil slick. The effect of this forceful application is to break the slick into small fragments (Fig. 2) which sink to the bottom.

Trawling experiments showed that, although this method does cause a certain amount of fouling (Fig. 5 and Fig. 6), because the lumps are relatively small there is less tendency for them to be picked up and passed into the cod-end than in the case of the chalk. Nevertheless, a dogfish, Scyliorhinus caniculus, caught during one of the trials was found to have oily smears on its skin (Fig. 7). However, fish of this group, in which the dermal denticles are not covered by a mucus-secreting epidermis, are especially liable to pick up the oil. With most fish, tainting is more likely to take place during gutting and handling by oily-handed fishermen than while they are in the net itself. Another danger is that pieces of oil might get into boxes of fish on deck, and this could also result in tainting or the rejection of the catch at the fish market.

Toxic effects of sunk oil on benthos

The toxicity of oils is to a large extent caused by the lower boiling fractions. These are lost quite rapidly by evaporation and this, together with the fact that light oils are difficult to sink, would suggest that sunk oil would have minimal toxic effects on the benthos. There is a need for caution here, however, because following a large sea trial held last year off the Hook of Holland, De Veen (personal communication) observed that common starfish, Asterias rubens, and heart urchins, Echinocardium cordatum, had ingested the oil. No dead animals were seen but a local reduction in the numbers of urchins was recorded. It should be borne in mind, of course, that the continued use of the heavy beam trawl in the area of the sinking might itself have locally reduced the number of heart urchins. Nevertheless, the fact that oil was ingested by benthic animals highlighted the need for experimental work in the laboratory on the effects of sunk oil.

Work on the effects of sunk oil on Asterias rubens and the brown shrimp, Crangon crangon, is now in progress at Burnham-on-Crouch. A small-scale sand-sinking apparatus, built by scientists of the Department of Trade and Industry, has been set up and is being used to sink oil into 10 litre test tanks where the animals are held. In the initial experiment, 18 shrimps and 12 starfish were exposed to sunken globules, measuring 0.2-1.5 cm in diameter, of Kuwait atmospheric residue (equivalent to a well-weathered Middle East crude oil) for a period of 28 days. No mortality took place, although on dissection it was discovered that the starfish, but apparently not the shrimps, had been ingesting the oil. This latter observation was a little surprising because both the lobster, Homarus gammarus, and the crab, Cancer pagurus, have been found to pick up and ingest sunk oil. It is possible that the lumps were a little too large for the shrimps to handle. Further experiments with less weathered oil are now being planned.

OIL AS A PERSISTENT POLLUTANT

Until recently, it has generally been assumed that mineral oils, because they are biodegradable and because of their biological origin, are not persistent pollutants. Based on his observations on the retention of various fractions of a light fuel oil (containing 41 per cent of aromatic hydrocarbons) by certain bivalve species, Blumer (Blumer et al. 1970, Blumer 1971) has challenged this long-held opinion. It is Blumer's hypothesis that polynuclear aromatic hydrocarbons (PAH) may accumulate in the lipids of marine animals in a way comparable to the polychlorinated biphenyls or the chlorinated hydrocarbons. Before discussing this further it is as well to point out that the light fuel oil studied by Blumer bears little relation to the crude oils which are responsible for the great majority of oil spills off north-west Europe. The PAH content of these oils is very much lower than in light fuel oil and in any case much of the PAH fraction evaporates within hours of spillage.

In a recent review, ZoBell (1971) has concluded that biosynthesis by bacteria and phytoplankton and organic wastes of terrestrial origin are much more important sources of PAH than oil pollution and he has cited the considerable evidence, apparently neglected by Blumer, that even the most carcinogenic of PAH's are biodegradable.

One of the best known of the PAH group is benzo(a) pyrene (BP), and, in an initial search for field evidence of the oceanic contamination envisaged by Blumer, analyses for BP were carried out by the Laboratory of the Government Chemist (Department of Trade and Industry) on fish and shellfish collected from a number of areas (Table 1).

Table 1 Occurrence of benzo(a) pyrene (BP) in fish and shellfish. Results were calculated on a wet weight basis of muscle (fish) or whole animal (bivalves)

Species	Source	Benzo(a) pyrene content in μg/kg
Fish:		
Pleuronectes platessa	Arctic Ocean	Not detected
Gadus morhua	"	"
Merlangius merlangus	Northern North Sea	0.1
"	English Channel	0.1
Trisopterus luscus	Southampton Water	0.1
Clupea harengus	Northern North Sea	< 0.05
"	English Channel	Not detected
"	South Irish Sea	"
"	Mull of Kintyre	0.4
Bivalve molluscs:		
Cardium edule	South Wales	8.0
"	Thames Estuary	12.0
Pecten maximus	English Channel	6.7
"	Western English Channel	4.0

It is immediately apparent from the table that the BP content of the bivalves is greater than that of the fish. Since phytoplankton and bacteria are both major sources of PAH in the sea and also the principal food of bivalves, this result is perhaps to be expected. In the case of the cockles, where the BP levels are highest of all, it is possible that terrestrial drainage is also adding a component. In the case of the fish the highest level was observed in the Mull of Kintyre herring; these fish belong to a coastal race and their higher BP content may also reflect the effects of land drainage.

In areas of chronic pollution by refinery wastes a significant local contribution to the PAH may be attributable to certain mineral oil fractions.

This is especially true if the wastes contain catalytically-cracked material. The opportunity was taken to examine hard-shell clams, Mercenaria mercenaria, from such an area and to observe the BP levels both before and after transfer to an area free of oil and other forms of pollution. The results are shown in Table 2.

Table 2 Occurrence of benzo(a) pyrene (BP) in Mercenaria mercenaria. Results were calculated on a wet weight basis

Sample	Notes	Benzo(a) pyrene content in µg/kg
1	As collected from an area of chronic oil and organic waste pollution	16.0
2	7 weeks after transfer to an unpolluted area	8.2
3	16 weeks after transfer to an unpolluted area	0.9
4	> 60 weeks after transfer to an unpolluted area	1.1

These results show that BP is not retained indefinitely by Mercenaria mercenaria but is either metabolized or lost by solution in the water.

CONCLUSIONS

Research on the effects of sunk oil on benthos, and an experimental programme to further investigate Blumer's hypothesis, will continue at the Burnham-on-Crouch laboratory.

Present results indicate that from the fisheries point of view sinking is not an ideal way of dealing with floating oil. All the methods available can cause the fouling of fishing gear, though this effect is much worse in the case of dry techniques than in the case of amine-treated sand which is applied wet. Little is known about the toxic effects of sunk oil, but initial results tend to suggest that they are likely to be small.

At the present time there is little evidence to support the view that carcinogenic hydrocarbons derived from oil are accumulating in the marine environment, but there is some evidence to suggest that local increases in PAH may occur under conditions of chronic oil pollution, especially if certain refinery wastes are involved. In most areas, biosynthesis by bacteria and phytoplankton together with organic wastes derived from the land are likely to be the major sources of PAH in the sea.

ACKNOWLEDGEMENT

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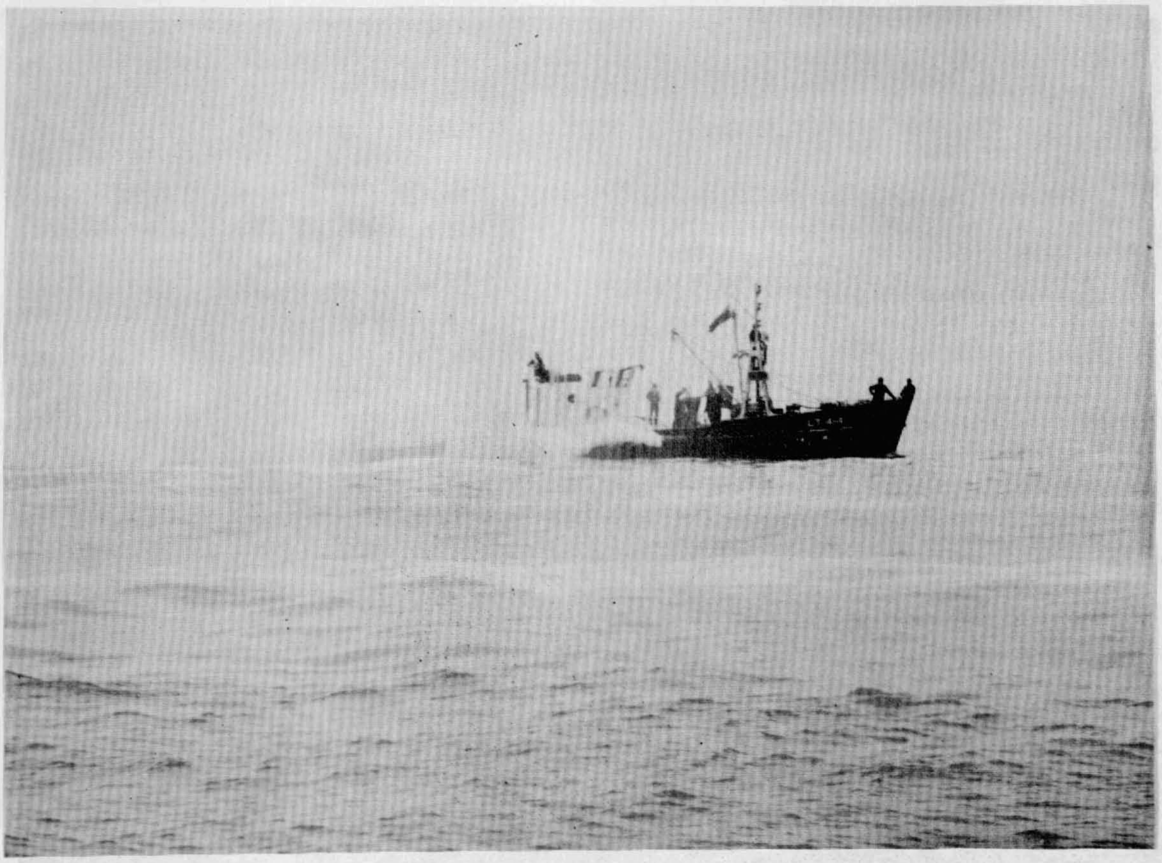

Figure 1 Spreading stearated chalk on to an oil slick.

Figure 2 Application of amine-treated sand on to oil held in a boom.

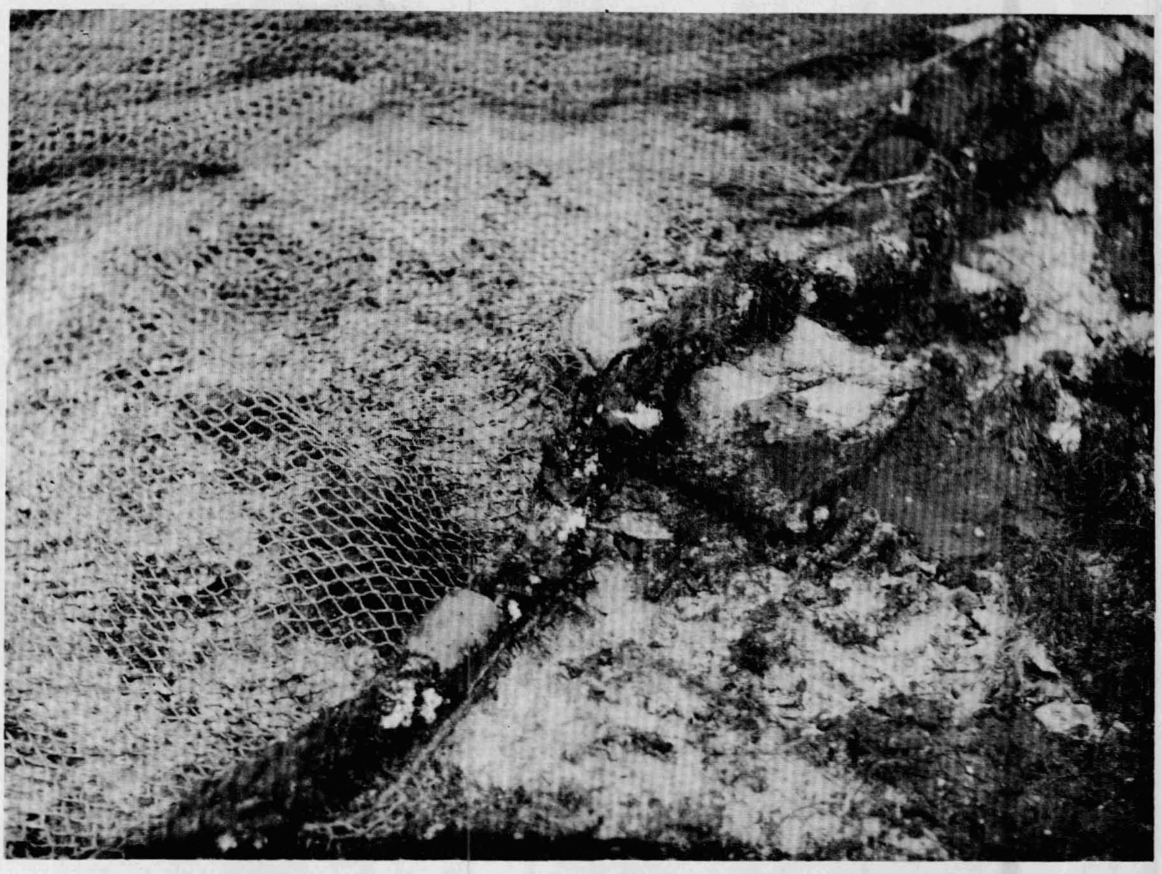

Figure 3 Ground rope of a shrimp trawl fouled by lumps of chalk and oil.

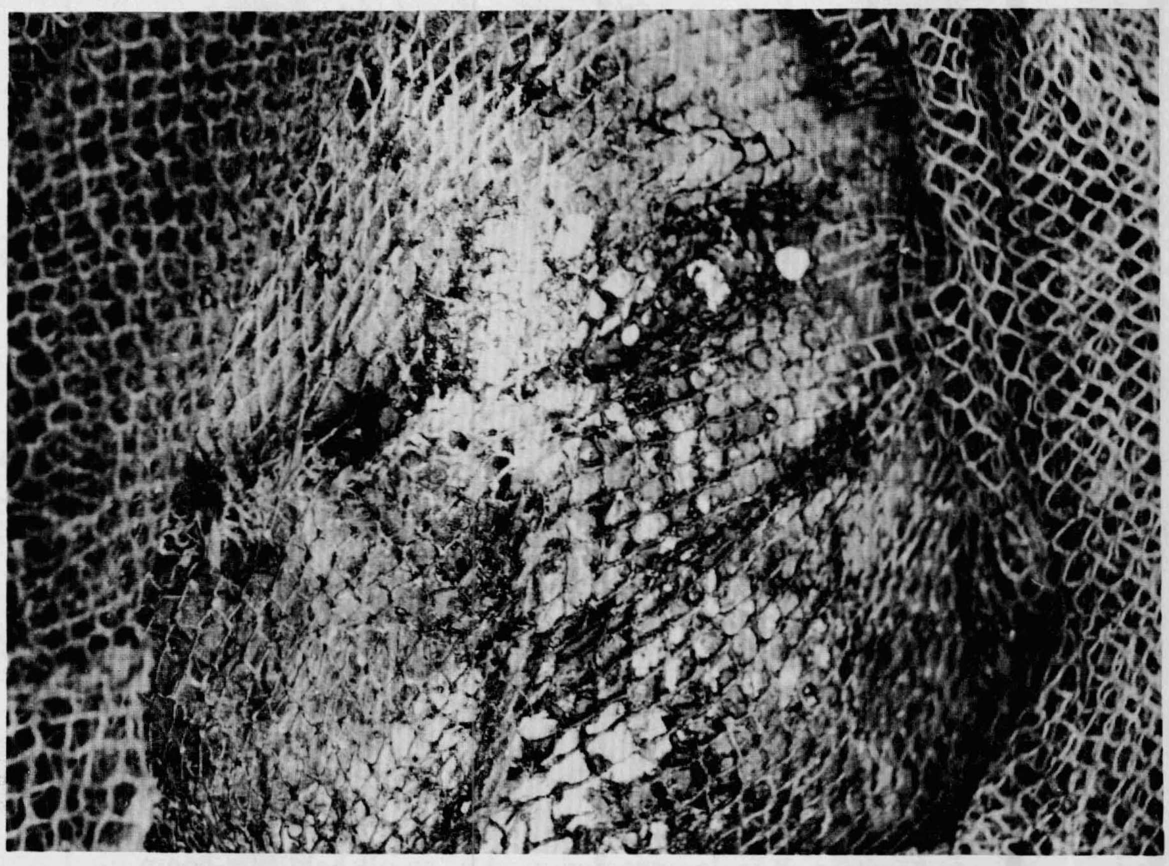

Figure 4 Chalk and oil in the opened-out cod-end of a shrimp trawl.

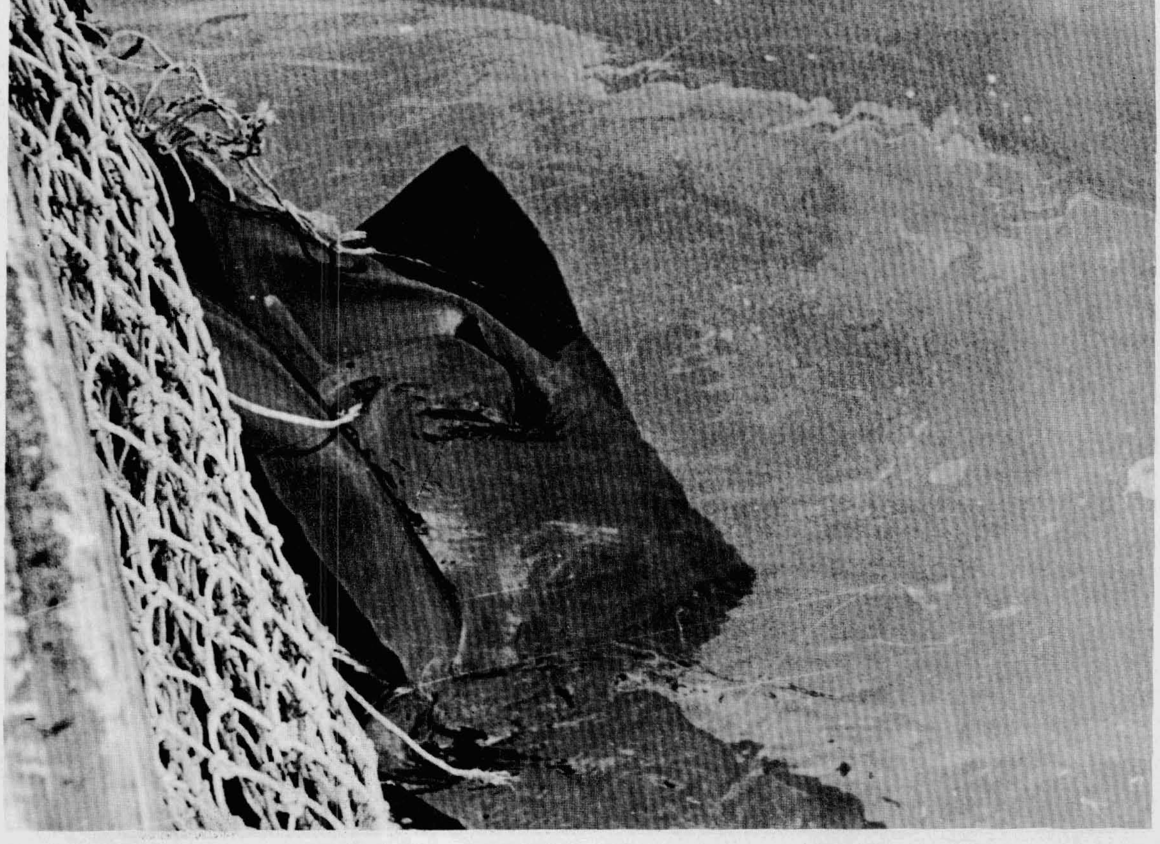

Figure 5 Oil slick spreading from a fouled net. The black objects are the rubber cod-end chafers.

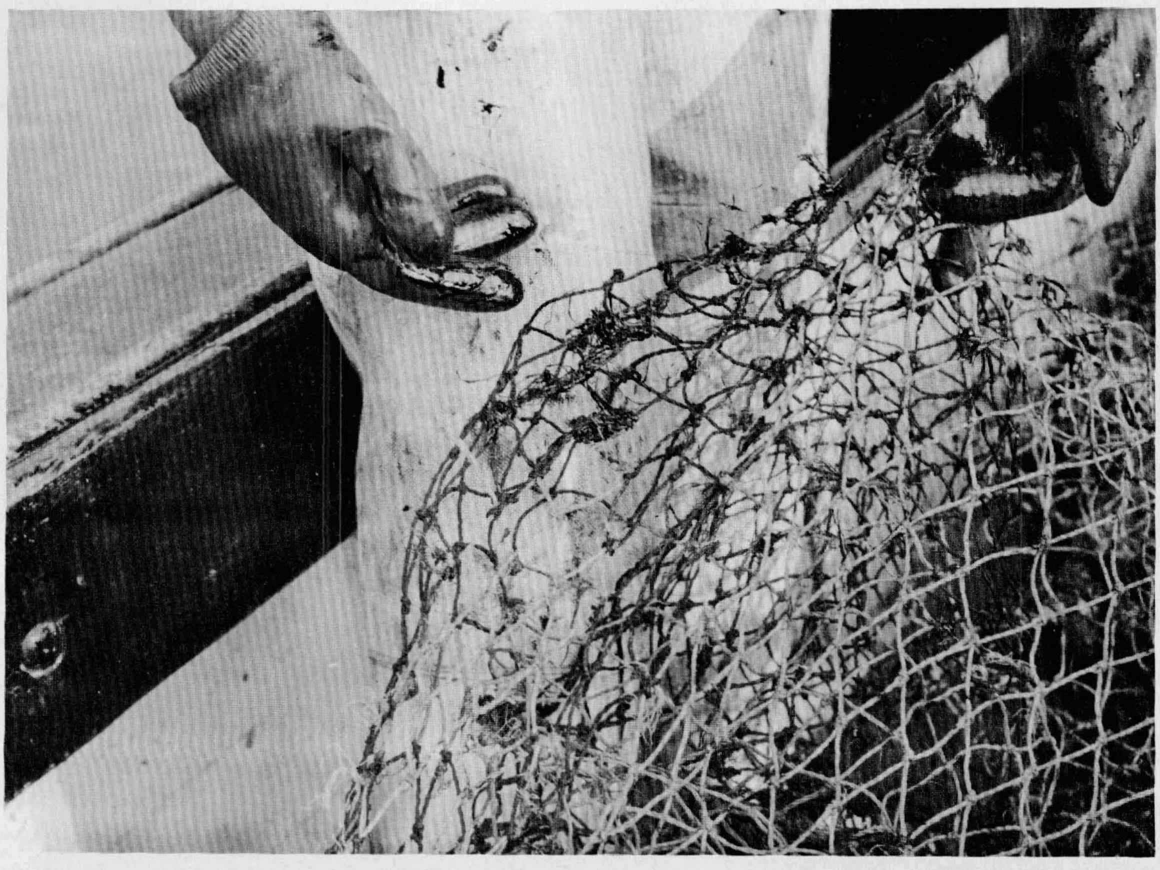

Figure 6 Oil on the hands of a fisherman and on the net he has just hauled.

Figure 7 Two oil patches on the skin of a lesser spotted dogfish caught in a fouled net.