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Avoidance from petroleum hydrocarbons by the cod (*Gadus morhua*)

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ABSTRACT

In laboratory experiments cod was presented a choice situation between different concentrations of petroleum hydrocarbons, appearing as "water soluble fraction" and emulsified droplets derived from Fuel Oil No. 2. In most experiments, the fishes seemed to avoid water containing hydrocarbons, though some fishes for periods was indifferent also to considerable contaminated water. The over all results indicates that a majority of the fishes avoided water containing total hydrocarbons down to 50-100 µg/l sea water. At still lower concentrations, the behavioural respons most often seemed indifferent.

INTRODUCTION

The understanding of impacts of oil to fisheries is still deficient. Despite close observations in the sea and experimentation in laboratories for decades, until now very few acute effects from realistic concentrations (0-500 µg/l) on mature fish in the sea has been observed. More obscure to mature fish is sublethal effects. These may be very difficult to observe directly and it is necessary to find extra sensitive parameters to demonstrate any sublethal effects. OLLA and SAMET (1974) and OLLA *et al.* (1980) have stressed the possibility of using behaviour of fish in studying effects from petroleum.

What is important to fisheries, is not only whether the fishes dies or not, but also migration and presence of fish which influence the catchability. The present experiments intends to study whether cod showed behavioural respons, i.e. avoided petroleum hydrocarbons and to determine concentration thresholds for such responses.

METHODS

Two types of experimental aquaria were used. Between the compartments was small openings through which the experimental fish (20-40 cm length) could move freely. In the sex angular aquarium (Fig. 1) the fish activity inside the three compartments were continously recorded by means of photoelectric equipment. In the rectangular aquarium, fish movements were recorded by means of ultrasound.

Before an experiment was started, the fish was acclimated to the aquaria, to exhibit an unstressed behaviour and ideally to share their activity equally between the different compartments.

Sea water with hydrocarbons was prepared in an "oil column" (Fig 2) where clean water sank by gravity down through the Fuel Oil No. 2. The oiled sea water was then mixed with clean water and this mixture was directed to one of the compartments. Due to the open connections between, some of the oiled water also intruded the other compartment (-s).

Water samples taken in the aquaria were extracted with dichloromethane, analyzed on GC equipped with FID and column 1/4" x 9 ft. packed with SP 2100. The oven temperature was programmed at 8°C/min to 290°C. Accuracy of estimates of total hydrocarbons was in the order of magnitude ± 20%. Content of total hydrocarbons was estimated as "total hydrocarbons" (THC). Due to the laboratory procedure, the most volatile components ($C_n < 8$) could not be exactly quantified.

The experimental strategy was to introduce hydrocarbons to one of the compartments and to record changes in fish distribution. If the fish did not distribute evenly between the compartments when no hydrocarbons were present, hydrocarbons usually was directed to the compartment where the fish showed highest activity.

The behavioural responses of the fishes is given as percent distribution in each compartment. Compared with the hydrocarbon concentration, the responses were characterized as either attraction, indifference or avoidance. Totally, 16 experiments of duration 3 to 30 days were performed.

RESULTS AND DISCUSSION

In Table 1 and 2 is given a summary of the results from the 16 experiments. The data is pooled from periods of a few hours to some days and should give base for summarizing the behavioural responses from different levels of hydrocarbon concentrations.

It is seen that the responses are variable, both between fish specimens and also during one experiment. It seems as if some fish specimens are more sensitive to hydrocarbons than others.

In Experiment no. 104 "attraction" has been noted at concentrations of 110-150 µg THC/l. In the Experiment No. 108, "attraction" at concentrations up to 400 µg/l seems very unreasonable. The recordings may be explained from stressed and frightened fish which refused to move away from the oiled compartment. On the other hand, it might be reasonable to assume that one or more petroleum hydrocarbons in low concentrations are attractive to fish, in that respect that the fish may perceive the odour as presumptive food.

Respons called "indifference" was most often recorded at still lower concentrations, when estimates approached the level of analytical sensitivity.

In some periods, the fish did not alter its distribution, although the hydrocarbon concentration was increased to a relatively high level, for example 180 µg/l in Experiment No. 13. The author could ascribe this to "variation", but prefer to label it as stressed fish.

Responses characterized as "avoidance" has been noted at concentrations down to 30 µg/l. However, the reliability of so low estimates with this laboratory procedure is not good. This entails that judgement of behavioural respons related to hydrocarbon concentration at this level is very uncertain.

What can be seen from the results in Table 1 and 2 is that avoidance respons very often were noted at concentrations down to 50-60 ug/l, both in the same experiment and in different experiments with different fishes. "Avoidance" was in the same way to a high extent also recorded at concentrations of 100-300 µg/l.

Although the results varied, it is concluded that the fish to a large extent avoided hydrocarbons from Fuel Oil No. 2 at concentrations down to 50-100 µg/l.

To what extent these results can be applied to natural conditions in the sea, is uncertain. Of its senses, it is widely agreed that fish mainly use the smell to detect food items and for example chemical pollutants. It is supposed that in the sea undisturbed fish will have the same or slightly lower threshold for detecting pollutants and eventually giving a behavioural respons. In the sea, the fish also are exposed to odours "competing" with hydrocarbons and those could mask effects from petroleum hydrocarbons.

REFERENCES

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Table 1. Effects of exposure to hydrocarbons in the two-compartment aquarium

Experiment no.	Concentration of hydrocarbons (μg/l)	Behavioural respons
103	130	Avoidance
	90	Attraction
	90 - 110	Indifference
	100	Avoidance
104	30 - 40	Indifference
	110 - 150	Attraction
	220	Avoidance
105	110 - 200	Avoidance
106	25 - 60	Attraction
	70 - 75	Indiffernce
	120	Attraction
107	60 - 70	Avoidance
	50	Indifference
108	40 - 60	Indifference
	130	Avoidance
	100 - 120	Indifference
	120 - 130	Attraction
	400	Indifference
	400	Attraction

Table 2. Effects of exposure to hydrocarbons in the sex-angular aquarium

Experiment no.	Concentration of hydrocarbons (µg/l)	Behavioural respons
8	190 - 600	Avoidance
11	160 - 550 220	Avoidance Attraction
12	30 - 50 100 200	Avoidance (Avodance) Avoidance
13	140 - 370 70 - 90 180 50 - 60	Avoidance Avoidance (Indifference) Avoidance
14	80 -(350)	Avoidance
16	50 - 70 90 130	Avoidance Avoidance Avoidance
18	40 - 60 170 30	Avoidance Avoidance Indifference
19	60 90 - 120	Avoidance Avoidance
20	60 - 100 30 10 10	Avoidance Avoidance Attraction Indifference
21	100 - 130 20 - 30 20 - 40	Avoidance (Avoidance) Indifference

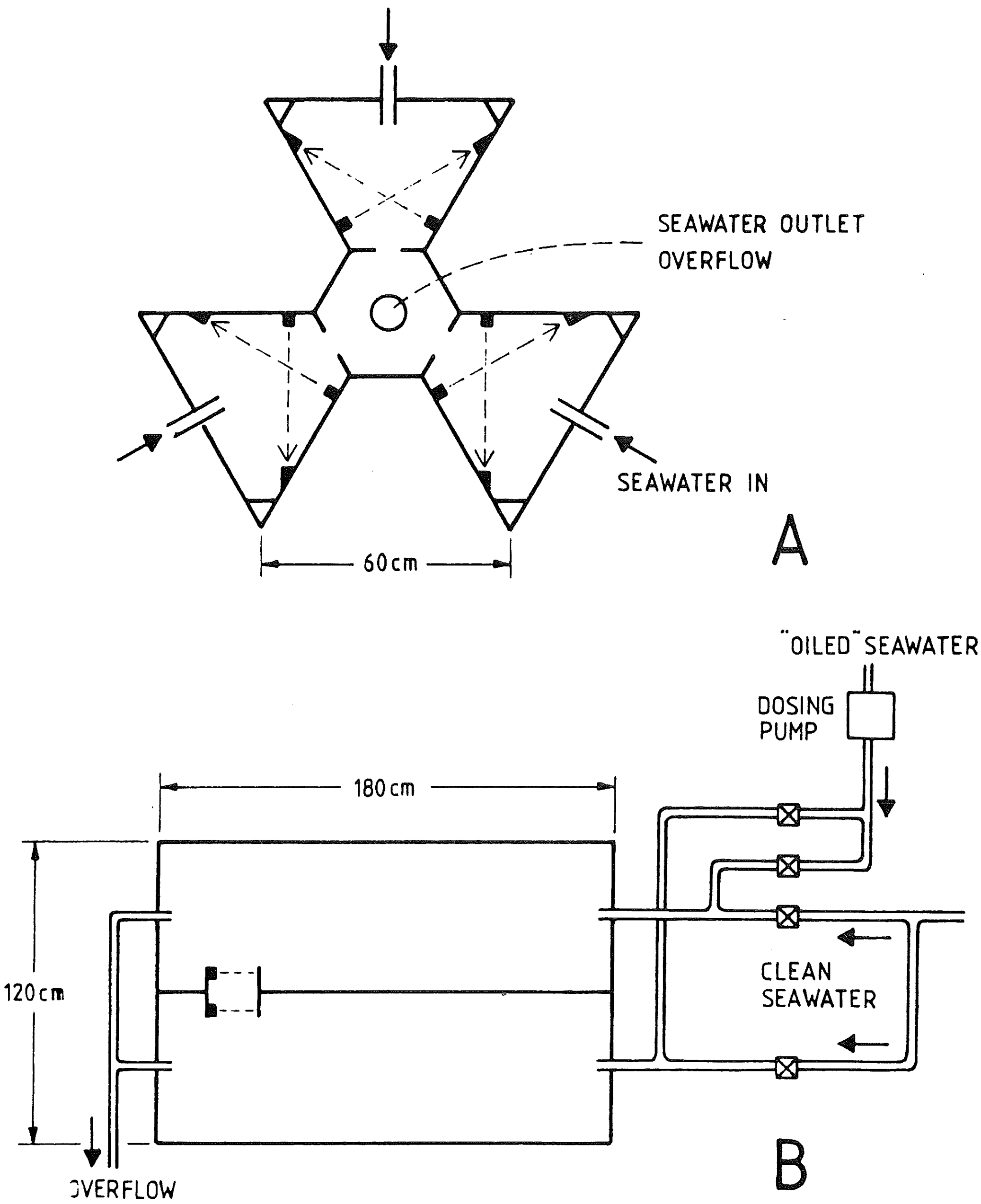

Fig. 1. The sex angular (three-compartment) aquarium (A) and the rectangular (two-compartment) aquarium (B)

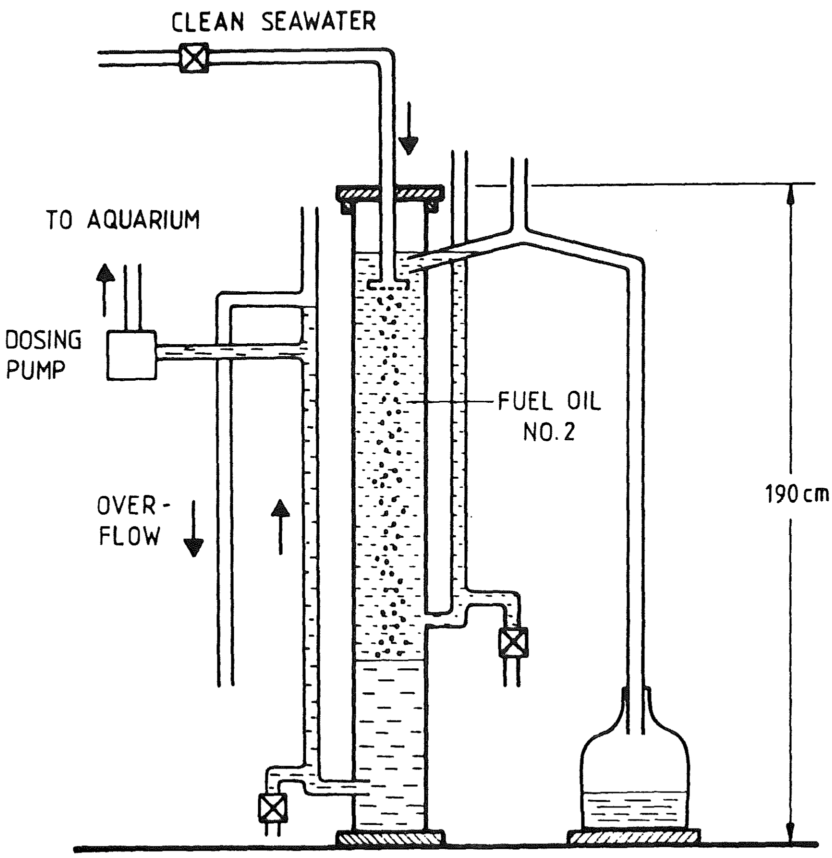

Fig. 2. The "oil column" for preparing seawater containing hydrocarbons

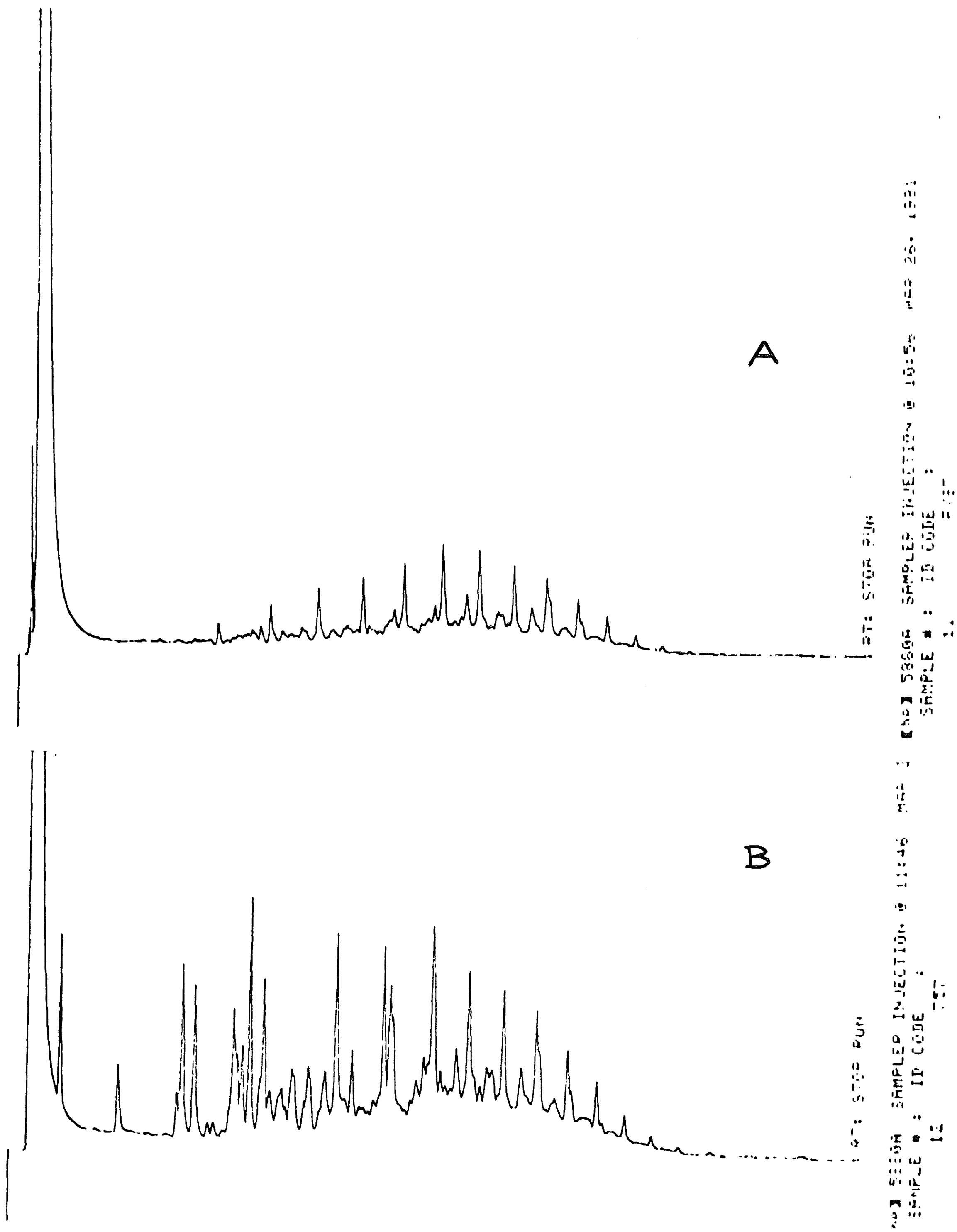

Fig. 3. Chromatograms of No. 2 Fuel Oil-Standard (A) and an example of sea water - extract from the aquaria (B)