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"OIL EXPLORATION IN NEW OFFSHORE FIELDS. FISH LARVAE AS THE CRITICAL COMPONENT IN THE ASSESSMENT OF POTENTIAL CONSEQUENCES FOR THE FISH RESOURCES"

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ABSTRACT

The effects of oil and other pollutants on fish larvae are depending both on species and age/weight/length of the larvae. Critical factors in an assessment of consequences of oil activities on fish resources are both the sensitivity of the species as well as the timing of and the distribution in the marine environment of the sensitive stages.

## INTRODUCTION

The norwegian continental shelf is spawning and breeding grounds for some of the most important fish stocks in the North East Atlantic. The same shelf area have, during the last twenty years gradually been explored for oil and gas resources. In this lies an obvious possibility of conflicts between the interests of the fisheries and the oil industry. The norwegian authorities have paid great attention to these and the environmental problems in concern, and they have during the years presented several "white papers" and public reports to the norwegian parliament for political actions.

To coordinate the scientific efforts of assessing the impact of the oil activities, both on the environment and on the sosio-economical aspects as well, the Ministry of Oil and Energy initiated, in 1984, an interdepartemental group for assessment studies (AKUP). Membership in this group is held by representatives of the interested government departments and their subsidiaries, the fisheries is represented both from Ministry of Fisheries, the Directorate of Fisheries and the Institute of Marine Research. The work presented in this paper is part of an assessment study undertaken before the opening of the norwegian southern part of the Barents Sea for oil exploration.

The background for the study presented in this papers and in Føyn and Serigstad 1987 was the wish to establish the age or the size at which the fish no longer had to be considered vulnerable for an impact from oil. Serigstad et al. 1988 have described the biotest setup, installed at the Institute of Marine Research, for the determination of sensitive stages in marine organisms.

## MATERIALS AND METHODS

Earlier experiments (Serigstad 1986; 1987 and Serigstad & Adoff 1985) have shown that the only clear negative effect from oil exposure to cod was a reduced oxygen uptake of the yolk sac larvae. The oxygen uptake and thus the metabolic activity of a fish larvae depends on a sufficient oxygen supply from the ambient water to the mitochondria in the cells where the areobic energy production for synthesis,

regulatory processes and locomotory activities take place. An impact of oil on the oxygen uptake of yolk sac larvae may therefore have a severe negative effect in the sensitive stage where the larvae are changing from endogenous to exogenous food uptake (Føyen & Serigstad, 1987).

An experimental setup have been installed at the Institute of Marine Research (Serigstad et al. 1988) which enable us to determin the vulnerable stages of the species in question.

Biotests have been performed on eggs and larvae of cod (Gadus morhua L.), herring (Clupea harengus) and capelin (Malotus vilosus), (Føyen & Serigstad, 1987 and Serigstad et al. 1988).

### OXYGEN UPTAKE RATE

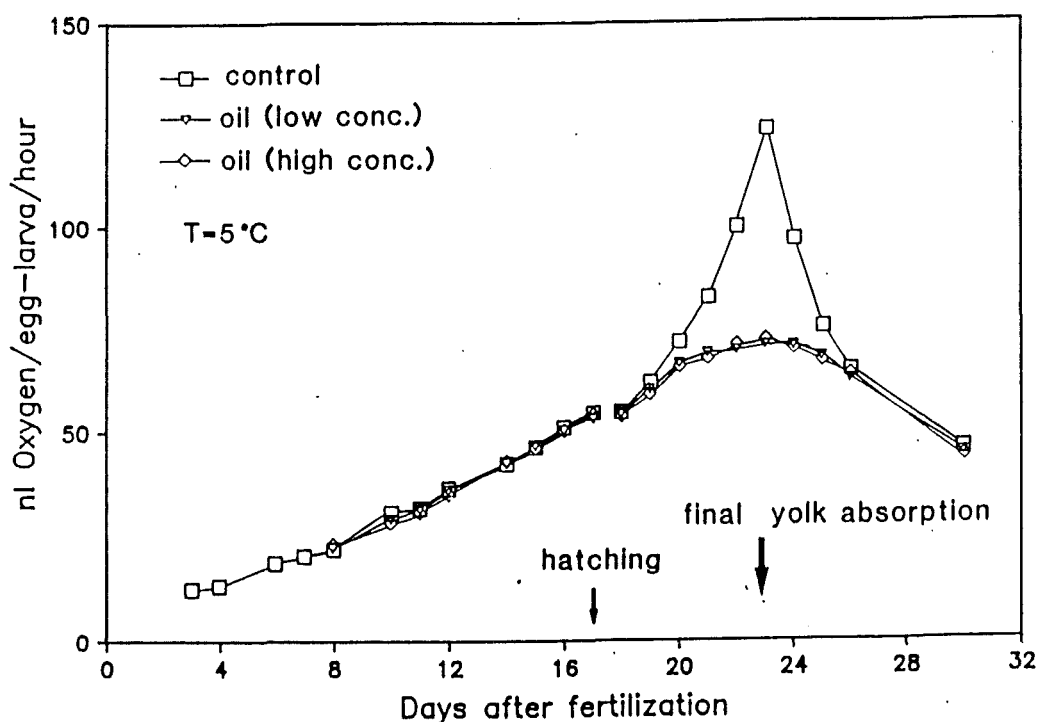


Figure 1. Oksygen uptake of control and oil exposed cod eggs/larvae. Oil exposure at low concentration: 50+20 ppb WSF and high concentration: 230+ 110 ppb WSF. Each point represent the mean of 4 parallels with 10 eggs or 5 larvae each. (SD is less than 5% for all the means)  $T = 5^{\circ}\text{C}$ , Salinity = 34.

## RESULTS

### Cod

Exposure of cod eggs to oil ( $50 \pm 20$  ppb WSF) only of a few hours results in reduced oxygen uptake during the development stage where the larvae change from endogenous to exogenous food uptake.

Reduced oxygen uptake is recorded when larvae with size less than 20 mm are exposed to oil ( $50 \pm 20$  ppb WSF). Cod larvae bigger than 20 mm are not effected.

There is no difference in effects for exposure to low concentrations ( $50 \pm 20$  ppb WSF) and high concentration ( $230 \pm 110$  ppb WSF) as presented in Fig. 1.

Cod eggs and larvae show no recovery when placed in clean water.

### Herring

No effects from oil exposure (85-200 ppb WSF) to eggs and larvae. Even fertilization performed within seawater mixed with cuttings from oilwells drilled with oil-base drilling mud did not effect the development.

### Capelin

Oil exposed larvae, 70 ppb WSF, showed about 20% lower oxygen uptake than the control group. Capelin eggs within drilling mud had a hatching success of about 90% while about 80% of the control eggs hatched.

## DISCUSSION

As an instrument to determine critical stages in marine organisms and critical concentrations of a pollutant, the biotest system based on measurements of oxygen uptake as described by Serigstad et al. 1988, seems to be a suitable tool. The biotest system enable us to follow

various critical stages in development of the organisms. It also make it possible to test realistic concentrations of the said pollutant likely to be found in the marine environment. Field experiments have shown that concentrations of oil in the water just below fresh released oil on the surface are in the order of 300 ppb WSF, and consequently impact studies have to be done on concentrations less than 300 ppb WSF.

Falk-Pettersen & Kjørsvik, 1987, found from acute toxicity tests of oil on various marine fish eggs and larvae that cod was the most sensitive of the species tested. Our tests on cod, capelin and herring (Føyn & Serigstad, 1987, and Serigstad et al. 1988), clearly demonstrate a pronounced difference with cod representing the most sensitive and herring the less sensitive species.

1-2 hours exposure of cod eggs to concentrations of oil in sea water of  $50 \pm 20$  ppb WSF have an effect on the oxygen uptake of the cod larvae during the critical stage when the larvae start to search for food. As shown in Fig. 1 there is a clear reduction in the oxygen uptake compared to the oxygen uptake of the controls. The increasing oxygen uptake of the larvae when the larvae start to search for food reflects the activity in the larvae. The effected larvae, however, do not show the same activity, i.e. increasing oxygen uptake, and they are therefore likely to be losers in the fight for sufficient food. The effect of oil on cod eggs in low concentrations, likely to be found in the marine environment during oil spills, is not of an acute character but represents a more long term effect leading to starvation of the cod larvae. As our experiments have shown there is no recovery from the effects of exposure to oil, and this strengthen the justification of using cod eggs/larvae as a suitable test organism .

Our experiments show that cod larvae with a size less than 20 mm are effected by oil in the water,  $50 \pm 20$  ppb WSF. The experiments have also demonstrated less effects on capelin and no effect on herring larvae and eggs. Our experiments on capelin and herring are not extensive enough and need to be continued so that we can follow the stages of development during feeding of the larvae.

However, in impact assessment studies there is a need to define critical parameters. We have found cod eggs and larvae <20 mm to be more sensitive for low oil concentrations than capelin and herring. Reference to impacts on cod may, depending on the area of the pollution, be sufficient for the purpose of impact assessments. In our work, by using cod, i.e. eggs and larvae, as the critical organism, we have a marine organism which is vulnerable to fairly small concentrations of pollution (oil), and which we may follow throughout all the stages of development from egg to adult fish. This gives us an opportunity to detect hidden long term effects.

Cod eggs have a positive buoyance and will therefore be found in the upper layer of the sea where the highest oil concentrations also are to be found. Sundby, 1983, and Westgård, 1988 have demonstrated models for the vertical distribution of pelagic eggs under different environmental conditions. This model may also describe the vertical distribution of oil in the water column. By combining the vertical distributions the factor of overlapping and thus the percentage of effected eggs, can be calculated.

The vertical distribution of oil have been calculated by the model described by Westgård, 1988, for various windforces and with and without pronounced density layers.

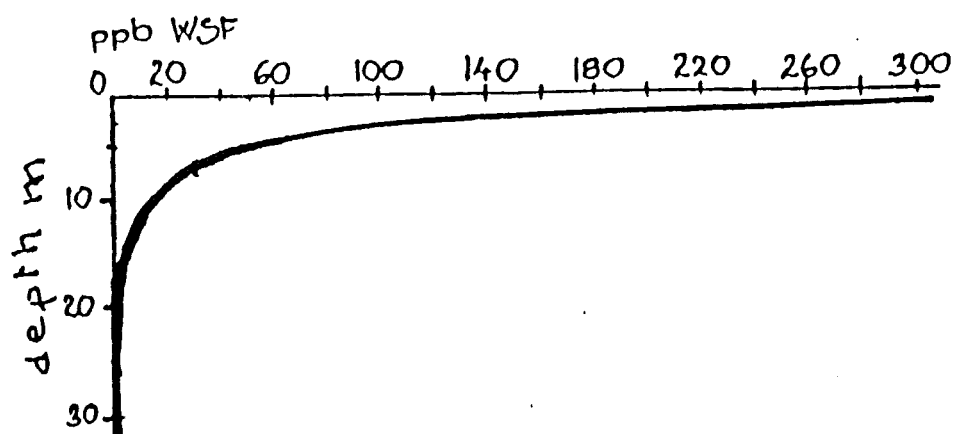


Figure 2. The mean vertical distribution of water soluble oil fraction calculated after a model for vertical distribution of pelagic eggs (Westgård, 1988). Wind force 5 m pr. sek. and no density layers.

Fig. 2 presents the calculated vertical distribution of the water soluble fraction at a wind force of 5 m pr. sek and no pronounced density layer. When doing calculations of this kind one has to bear in mind that there will be a dilution factor which is not taken care of in the equation and therefore, the calculated vertical profile of oil, WSF, will only be valuable for low wind forces. The oil available for dilution is determined by the amount of oil on the surface which under an actual oil spill is rather limited. And further, since only a small fraction of the oil is soluble in water there is a limitation to the possible found vertical concentration profile.

In impact assessments there has also to be a consideration of the probability to find the critical organisme in a defined area. Fig. 3 (Bjørke et al., 1988) shows an example of the time distribution of cod eggs at the Buagrunden a small area on the northwest coast of Norway, an area in the vicinity of a field considered opened for oil exploitation.

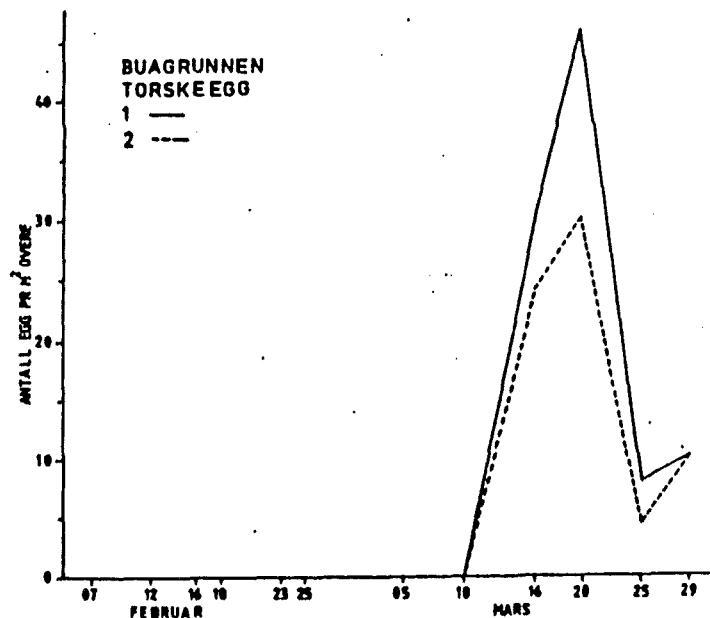


Figure 3. The abundance of cod eggs at Buagrunden in 1986.

(Bjørke et al. 1987). 1 = total amount, 2 = newly spawend.

The bulk of the eggs are present from the 10th, to 25th of March which

means that an oil pollution in this area covering these 15 days is likely to effect all the eggs spawned in the area. As shown by this example only a very limited periode may be critical in this special area while other areas may have a longer critical periode. However an assessment has to be based on a worst case situation which in this example referes to 15 days in March when all the cod eggs in the area are concentrated.

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