Institute of Marine Research, Norway

The hidden impact of oil spills: very low concentrations of crude oil impair swimming of haddock larvae at sea

Haddock (*Melanogrammus aeglefinus*) is a fish of great ecological and economic importance that has supported fisheries, in the North Sea and elsewhere, for more than a hundred years. Together with the closely related gadoid Atlantic cod, haddock spawning, feeding and nursery grounds overlap with areas of interest for oil exploration and extraction in Norway. When exposed to an oil spill, haddock eggs accumulate oil droplets on their surface, which damages developing embryos and larvae. This makes this species particularly vulnerable to oil pollution.

For this reason, researchers are trying to understand what dose of oil causes negative impacts in haddock larvae. Previous work revealed that exposure to oil causes malformations, damages the nervous and musculoskeletal systems, and causes abnormal heart function in fish larvae. This leads to increased mortality, which will impact future haddock stocks. This seems obvious, but what happens when the oil dilutes down to very low concentrations, below the levels currently thought to have an impact? If there are no "visible" morphological signs of an effect, can we assume that larvae are not in danger?

To answer this question, a team of scientists from the *Norwegian Institute of Marine Research's* (IMR) *Ecosystem Acoustics* and *Marine Toxicology* groups, in collaboration with the *University of Miami*, conducted cutting-edge experiments in the archipelago of Austevoll (Austevoll Research Station) in Norway, funded by the IMR and the Research Council of Norway. The team reared two groups of haddock embryos: one was exposed to very low concentrations of oil, and one was not (controls). When the eggs hatched, young haddock larvae were monitored during the earliest stages of life.

Neither group of larvae showed any "visible" malformations. Larvae looked perfectly healthy and exposure to the low concentration of oil did not appear to have caused any negative effects. However, it turns out that there were subtle but important effects of oil exposure.

The team used a unique approach to look at the behavior of tiny, few millimeter-long haddock larvae *in situ* in Norwegian fjords. Haddock larvae were observed in a transparent behavioral chamber (Drifting *in situ* Chamber, DISC) so that scientists could record their behavior while drifting with the current under the natural conditions that they would encounter during their dispersal at sea. The team also measured the expression of a protein that is an indicator of oil toxicity: cytochrome P4501a (cyp1a).

The researchers found that, although they looked perfectly normal, exposed larvae swam 30-40% slower than non-exposed larvae. This lower swimming at sea was associated with an

increase in expression of cyp1a, showing that toxicity occurred even when embryos were exposed to very low concentrations of crude oil.

“These results demonstrate that impacts of oil on young fish go beyond what we can see with a microscope. If larvae swim slower at sea, they have less chance to escape predators or catch prey, and thus to survive” - says Alessandro Cresci, postdoctoral scientist at IMR and first author of the study. “This study presents a new approach to look at subtle behavioral effects of pollutants on larval fish. “What if we are currently underestimating the impacts of oil toxicity on wild fish?” – asks Elin Sørhus, a scientist at the IMR and co-leader of the project. “In this unique study we observed impacts on swimming behavior at concentrations of crude oil that were three times lower than we previously thought would give an effect.”

This study represents a first step towards the application of a novel approach in ecotoxicology. Assessing impacts of pollutants on behavior at sea is of great importance to understand subtle, previously hidden effects that human activities can have on fish.

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