Learning the limits for marine species

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Credit: Elisabeth Tønnessen

Work by biologists and marine scientists at various Norwegian research institutions over the past 10 years has covered such commercial resources as shrimp, scallops, herring and cod.

Establishing tolerance levels for these and other species is one of the tools needed to determine how Barents Sea oil production can be pursued in an environmentally acceptable way.

The organisations involved in this work are the International Research Institute of Stavanger (IRIS), the Norwegian Institute of Marine Research, Sintef and Akvaplan-Niva.

Tolerance levels are measured when a species is at the larval stage, the phase in its growth where it has the greatest vulnerability to oil pollution.

The tolerance level is defined as the point at which a hydrocarbon concentration begins to cause effects which might indicate a possible influence on populations.

"When we measure, we look at mortality, growth and development aspects," explains Chief scientist Steinar Sanni at IRIS and Associate Professor at the University of Stavanger (UiS).

"Larvae of both invertebrates and fish, for example, go through several development stages, so we can study whether the test organisms complete these in a normal manner."

Sanni is one of the three authors of a report commissioned by the Research Council of Norway on long-term effects of discharges to the sea from petroleum operations.

Completed earlier in 2012, this report brings together the findings of Norwegian research work on such impacts over the past decade.

Key

Having established tolerance levels for key Barents Sea species, such as cod, herring, halibut, deepwater shrimp and Iceland scallops, IRIS researchers are now doing the same for krill.

The scientists have established that herring can tolerate no more than 0.02 milligrams of total hydrocarbons per litre (mg thc/l) of seawater.

Cod and halibut have rather higher tolerances, at 0.08 and 0.26 mg thc/l respectively, according to research by the Institute of Marine Research on cod and at IRIS on halibut. The limit for deepsea shrimp is 0.01 mg thc/l.

Mussels are at the limit of their range in these far northern waters, so scientists are interested in establishing tolerances for more typical species – such as Iceland scallops.

"We're not quite finished studying scallops," says Sanni. "They aren't always cooperative in the lab, so we're currently using the tolerance level established for mussels.

"That's 0.5 mg thc/l. While we expect the real value for Iceland scallops to lie a little lower, it's likely to be in the same order of magnitude.

"We're not certain why tolerances differ between these species, but it's perhaps more important to note that the variations are fairly small.

"The range from the lowest measured tolerance level to the highest among the species investigated is no greater than from 0.01 to 0.26 mg thc/l."

Preliminary data obtained by the scientists for krill suggest that the figure for these small crustaceans will also lie close to those found for other species.

Tolerances have also been determined for adult individuals of some species, and these have lain – as expected – at a higher level.

"It's useful to know this, but measuring at the larval stage means we can be more assured that the levels provide a suitable foundation for protecting stocks," says Sanni.

"A number of species could naturally prove to lie outside the range we've identified so far. But the data give a reasonably good basis for specifying practical and reasonably secure figures for permissible oil concentrations."

Cope

Based on their findings, the scientists at the four institutions concluded early in 2012 that Barents Sea life appears to cope just as well with toxicity of oil as fauna further south.

"We've conducted trials with a number of organisms, and some of these actually seem rather more robust in dealing with oil spills than their counterparts in more southerly waters," says Sanni.

"So it isn't the case that such species intrinsically become more vulnerable to pollution the further north you go."

He emphasises that environmental challenges in the far north depend on the area concerned, and cites the waters off Lofoten and Vesterålen in the Norwegian Sea.

These are known to be major spawning grounds for commercial cod, haddock, saithe and herring fisheries, and protecting the ecosystem there is important.

"An oil spill in this part of the Norwegian continental shelf (NCS) during the breeding season would pose a threat to fish stocks, including those in the Barents Sea," Sanni observes.

That is because herring, cod, haddock and saithe move north as they mature and live their adult lives in the south-western and central Barents Sea.

The fish have become much more robust by then, and this part of the NCS is also the location of promising recent oil discoveries such as Skrugard.

"In other words, the fish species we're concerned with off Lofoten and Vesterålen will be more resistant to pollution in the Barents Sea," Sanni explains.

"They're also more mobile there and can escape a possible oil spill more easily. That helps to reduce the vulnerability of the Barents Sea ecosystem compared with areas further to the south."

Lower

But this does not mean that the oil industry can forge ahead without restraint in these waters, because they also harbour key organisms lower down the food chain from fish.

That includes krill and other zooplankton such as Calanus finmarchicus, and Sanni says that more precise data are needed about the possible risk to stocks and the impact on the ecosystem.

"Nor can we exclude the possibility that a blowout in the middle of the Barents Sea might drift north to the edge of the pack ice," he notes.

"That would present us with a serious problem, and we don't have adequate solutions for dealing with such a challenge at the moment."

In fact, a third type of ecosystem exists along the edge of the ice cap in the northern Barents Sea, where Atlantic and Arctic ocean currents meet and mix.

Arctic waters are significantly colder than further south in the Barents Sea, often at or even below freezing point. And the ecosystem comprises a different set of organisms.

These include Arctic cod and capelin, while krill and Calanus finmarchicus are replaced by Arctic amphipoda (another group of crustacean zooplankton), which live on ice algae which are also absent from Atlantic water.

"This ecosystem functions differently in the icy water, and oil spills will also have a different effect on organisms," says Sanni.

"But the Norwegian petroleum industry isn't drilling as far north as this, so the risk of such discharges happening is not that great."

Discharge

From last year, the government has in principle permitted the discharge of produced water – which comes up from a reservoir along with the oil – at fields in the Barents Sea.

This represents "operational" – planned and smaller – oil spills to the sea, and scientists are reasonably well acquainted with their environmental significance in the North Sea.

After several years of research in the Proof and ProofNy programmes, Norwegian scientists have found the answers to a great many of the issues involved here.

"We've recently concluded that there's not much doubt or cause for concern over produced-water discharges in Norway's North Sea sector today, although some uncertainty remains," says Sanni.

"Both risk and monitoring tools have also been developed to provide much safer environmental management, and we naturally assume that these are being utilised to protect the seas."

He and his colleagues are now pursuing research on the significance of such existing tools in the Barents Sea, and adapting them for conditions there.

The environmental department at IRIS is working, for instance, to establish the tolerance of krill to small volumes of planned oil discharges over time.

Monitoring

In recent years, IRIS has investigated whether the environmental monitoring methods utilised in the Norwegian North Sea can be transferred to the country's Barents Sea sector.

"It transpires that we can apply the same methodology and more or less the same interpretation techniques used at the southern end of the NCS," reports Sanni.

In many cases, too, this involves transferring existing knowledge to new fields. But some additional data are also needed, especially when conditions differ from those in the North Sea.

Seasonal variation, for example, includes such aspects as the relative lengths of day and night. Scientists are studying if oil components become more toxic in 24-hour daylight, and have already shown that these could affect typical Barents Sea organisms.

"This represents a potential environmental hazard in the far north which would normally yield little harm or risk," Sanni explains.

"But we want to look more closely at whether it could cause population damage to key Barents Sea species in some specific scenarios, such as discharging produced water in the summer."

Technology

The scientists must constantly adapt and develop new technology for environmental monitoring, given such trends as the shift from staffed platforms to subsea installations.

Over time, the need for automated environmental monitoring systems will increase – in areas remote from land, for example. Such solutions already exist, and further progress is rapidly being made with them.

"These systems currently utilise species common further south, such as mussels," says Sanni. "They're now being adapted for scallops and other Arctic fauna found in the Barents Sea."

The IRIS environmental department and environmental technology researchers at the UiS are involved in these developments.

This work is being pursued in part together with BiotaGuard, an IRIS subsidiary which has developed a very advanced monitoring system integrating physical, chemical and biological sensors.

A similar collaboration exists with BiotaTools, an independant company involved in developing new biological sensors.

IRIS also has an interesting partnership with California's Monterey Bay Aquarium Research Institute (MBARI), a world leader in developing systems for marine observation.

Sanni is convinced that these developments will result in new technological solutions which mean that future environmental monitoring is done very differently from today.

"This technology is progressing rapidly, with the oil industry as a driving force. That's important, because these new systems are relatively expensive today.

"Not many industries can play a part in promoting these advances. But cost efficiency will increase considerably on the basis of user experience acquired in the offshore sector."

However, he expects the results and the technology will also ultimately benefit other sectors as well as governments.

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