Invasive species threaten marine biodiversity in Danish waters

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The round goby came to Danish waters 15-16 years ago and has been very successful in establishing itself here. Credit: Sune Riis Sørensen, DTU Aqua

Not all new underwater residents are polite. Some overshadow other species or gorge themselves on food sources at the expense of the species already living there. There is little data on invasive species in the Danish waters, fjords, and streams, but with the help of an underwater robot and DNA analyses, we can gain much more knowledge quickly

and relatively cheaply.

Denmark has recorded approximately 2,600 non-native species, i.e., plants, animals, and fungi that do not originate from the Danish natural environment. The vast majority of these species pose no problems, and some will not even survive our climate in the long term.

However, according to the Danish Environmental Protection Agency, 77 of the non-native species are invasive. This means that they have successfully established themselves in the Danish environment with consequences for the native flora and fauna or the economy. In other words, an invasive species can become so dominant that it severely affects other animals or plants in our environment.

The UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) has identified invasive species as one of the five drivers threatening biodiversity worldwide.

In the autumn of 2023, the panel published the Invasive Alien Species Report, which further emphasized the seriousness of the problem. The report was made by 86 researchers from 49 countries, and it shows that invasive species are estimated to have played a role in 60 percent of cases where a plant or animal has become globally extinct.

In 16 percent of cases, the invasive species were the sole reason why animals or plants became extinct. Invasive species spread through human activity, and IPBES expects the problem to grow in the coming decades.

Introduced through ballast water

On land, it is easy to spot invasive species, which in Denmark include raccoon dogs, Rosa rugosa, and killer slugs. It is much harder to see what is happening below the surface in our seas, fjords, lakes, and streams,

but there are also invasive species here. A total of 85 alien marine species have been recorded in Denmark.

Four of them are considered invasive, i.e., they can cause damage to our ecosystems. Some may remember the comb jelly Mnemiopsis leidyi from the media or the round goby—a fish originating from the Black and Caspian Seas. They are both marine species that were introduced into Danish waters through ship ballast water 15-16 years ago and immediately settled in.

At DTU Aqua, Senior Researcher Jane Behrens helped keep track of the round goby from 2014—six years after the 10-20 cm long fish first appeared in the waters of southern Denmark.

"By studying the round goby, we learned about its spread and the characteristics of a successful invasive species," says Jane Behrens.

Successful invasive species—animals and plants alike—often share the same characteristics: They multiply rapidly, they have good conditions for spreading, they're competitive, and they are capable of withstanding varying environmental conditions. This also applies to the round goby.

"It's extremely tough. It thrives in water with both a high and low salt content and in different temperatures, which means that it can spread in many types of aquatic environments. It's also slightly larger than the native gobies and very aggressive when defending its territory, so it ends up dominating food sources and breeding grounds. And it's not picky and will eat many types of food," says Jane Behrens about the fish, which is a perfect example of a successful invasive species.

Little knowledge about the damage

According to Jane Behrens, little is known about how much damage the

round goby is causing to the Danish ecosystems.

"We've only done one study, which showed that the round goby can change the fauna in the areas where it establishes itself and multiplies. It does so by selectively feeding on its preferred foods, such as small clams and snails, as long as they're present. This changes the composition of the benthic fauna, which then affects the rest of the fauna because the other animals that also feed on benthic animals will have to find other food sources or feeding grounds."

"In Denmark, the round goby hasn't been given much attention, so the data available is limited. We have to look to other countries, such as the U.S., for more knowledge, and their studies show that the round goby has a negative effect on biodiversity, including when it comes to other species of fish. We have good reason to believe that the same is true for us," says Jane Behrens.

According to Professor Jens Kjerulf Petersen from DTU Aqua, there are many other invasive marine species in Denmark that are not continuously monitored. He has created a report in which he describes selected threats to Denmark's marine and aquatic environment, including invasive species.

"We don't know much about the invasive marine species in this country. Their prevalence and harmful effects are an understudied area because we have no coordinated monitoring systems for invasive marine species. We get random recordings from citizens or our researchers. The knowledge we have mainly comes from singular studies of a single species through a couple of years. And when the project ends, so does the collection of data," says Jens Kjerulf Petersen.

Underwater robot can acquire data

His colleagues at DTU Aqua, headed by Professor Einar Eg Nielsen, have a technological solution that can reduce the gaps in our knowledge of invasive marine species: an underwater robot that can identify species using DNA analyses. The robot has been given the name ESP (Environmental Sample Processor). The technique of collecting DNA from the environment is called eDNA or environmental DNA.

"The robot can operate in water and take samples of the water for up to three months before running out of battery. We can program it to identify up to five different species from the water samples. We can also control how often it takes water samples and whether the samples are taken close to the surface or at the bottom."

"With the robot, we can gain a wealth of information about the species we want to monitor, and we can do it day and night and any time of the year. This way, we can gather the information in a much cheaper way than the traditional method of going out on a boat and collecting water samples manually," says Einar Eg Nielsen, who specializes in genetic methods for identifying biodiversity.

The ESP was developed in the U.S., where it is used to measure algal blooms, among other things, but the Danish version was further developed by Einar Eg Nielsen's colleagues at DTU Aqua a few years ago, so it can be used to detect DNA traces in the environment. The ESP is connected to the mobile network, so its mission can be changed remotely if necessary. This also enables it to continuously transmit data to the researchers.

Einar Eg Nielsen and his colleagues are currently planning a collaboration project with Iceland where the ESP will be used to monitor humpback salmon, an invasive species in the Icelandic streams. In addition, the researchers have a third-generation ESP ready for action in 2024.

This version is even more advanced as it can move around and collect eDNA samples rather than remain stationary. Next year, it will be involved in a project involving Ørsted and the Danish Environmental Protection Agency to map the biodiversity of the offshore wind farms at Horns Rev and Anholt in Denmark.

"We can provide the data that will enable us to track the development of biodiversity around the offshore wind turbines. However, we must first define what we want that biodiversity to look like because it's not necessarily a good thing if the biodiversity increases around the offshore wind farms. One of the concerns regarding offshore wind farms is that they might create a kind of corridor for invasive species. We will be able to help clarify this through the eDNA," says Einar Eg Nielsen.

Invasive species come at a high price

Many other countries are already aware that invasive marine species may come at a high price for both the environment and the economy, while Denmark pays very little attention to them, even though they have a negative impact on our environment, says Professor Jens Kjerulf Petersen.

"In Denmark, we see Pacific oysters spreading in the Limfjord and other areas with several negative consequences: They pretty much take over the entire seabed and outcompete other mussels. Those mussels are a source of food for various birds, which will then have to find their food somewhere else. In other words, Pacific oysters create a different biodiversity both above and below the water. They also destroy the recreational value of the area because the bathing beaches become full of sharp oyster shells," says Jens Kjerulf Petersen.

The international researchers behind the IPBES report also warned that invasive species—on land and in the waters—can be associated with

high costs because they can disrupt entire ecosystems and thus threaten food safety and the drinking water supply. The researchers estimate that the global economic costs caused by invasive species in 2019 amounted to nearly DKK 3,000 billion.

Jens Kjerulf Petersen calls for an increased focus on reducing the spread of invasive species in Danish waters:

"It's widely accepted that we can't get rid of invasive marine species. But we could limit their spread, just like we do with hogweed, Rosa rugosa, and the black rat. No one expects them to be eradicated completely, but we still spend considerable amounts on reducing the damage they do to our environment. We should do the same for our aquatic environment."

Provided by Technical University of Denmark

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