According to Erkki Leppäkoski, no less than some 110 invasive species have been encountered in the Baltic Sea, 60-70 of which have formed reproducing populations.

ECOLOGICAL ROULETTE IN THE BALTIC SEA

Will invasive species disrupt the balance of the marine ecosystem?

"It is commonly thought that because it is a brackish water body, the Baltic Sea is protected against new invasive species. But let's take a look at the map: Almost all the world's major ports are located in estuaries where salinity levels at one point or another are always the same as in the Baltic Sea. This means our sea is not protected at all, quite the contrary," says Professor Erkki Leppäkoski, head of the invasive species project under the BIREME programme at Åbo Akademi University.

Text: Paula Böhling
Photos: Tapio Vanhatalo

According to Professor Erkki Leppäkoski, no less than some 110 invasive species have been encountered in the Baltic Sea, 60-70 of which have formed reproducing populations. In the Baltic Sea Proper almost all aquatic invaders have been animals, but in the Kattegat there are also new types of seaweed that have spread to Europe with planted oysters, for example.

The best known among the new arrivals are the bay barnacle Balanus, which originates from North America and that grows on ship hulls and wharf poles. The species spread to the Baltic Sea in the mid-nineteenth century, presumably with shipping, but it has now become so widespread it is almost considered an indigenous species.

The most recent newcomers to the Baltic Sea include the fish hook water flea Cercopagis, the mysid shrimp Hemimysis, the zebra mussel Dreissena and the polychaete worm Marenzelleria. The single biggest source of invasive species is North America, followed by the Black Sea and Caspian Sea region. The most distant new arrivals have come all the way from China and New Zealand.

The earliest invader species began to arrive in the Baltic Sea from North America with the Vikings, but the process began to gather pace in the 1880s when ships started using water as ballast. Things have been moving ever faster since World War II with the opening up of new trade routes and the dramatic increase in transport volumes.

A GIANT NATURAL LABORATORY

The Baltic Sea provides a uniquely receptive environment for new invasive species in that salinity levels in the sea range from 25 per mille in the Danish Straits to almost zero in the Gulf of Finland and the far end of the Gulf of Bothnia. In the Gulf of Finland alone, which is just 400 km long, the figure ranges from zero to seven per mille.

"Most organisms originating from either salt water or fresh water habitats will find a suitable salinity level within such a broad

→

"The research we do is traditional animal geography, but our tools are more accurate, the resolution is higher", says Senior Curator Risto Väinölä.

range. And since there are not very many indigenous species, there is plenty of room for them to settle," Leppäkoski explains.

There are also several different routes via which new species can spread to the Baltic Sea, which makes it an even more intriguing focus of research.

"Most of the new invasive species arrive here with ballast water. With the growing volume of oil shipments from the Russian eastern end of the Gulf of Finland, this is an issue of great current concern. Oil tankers are coming here with a full load of water ballast and are emptying those loads at their ports of call and filling their tanks with crude oil.

Many of the new arrivals have their origins in plantings that were carried out in Finland and Sweden from the beginning of the twentieth century, especially in the 1920s. In the 1960s the Soviet Union transported huge quantities of fish food animals to western parts of the country, including the water reservoirs in the Baltic States. From these reservoirs these animals have subsequently spread to the low-salt coastal waters of the Baltic Sea.

Rivers provide one route for the spreading of new species because the large river systems of Eastern and Central Europe are connected to one another via canals.

The Baltic Sea is not only a recipient of new invasive species, but also a source and a transit area. For example, some species originating

from the Caspian Sea and Black Sea area have found their way via the Baltic Sea all the way to the Great Lakes of North America.

FIELD STUDIES AND EXPERIMENTS

The invasive species project under the umbrella of the BIREME programme was focused on four ports on the south coast of Finland, namely Naantali, Koverhar, Sköldvik and Hamina.

"We studied the bottom fauna of these ports as well as the periphyton of harbour structures, and took samples from water ballasts and the sediments accumulated at the bottom of the ballast tanks. We were interested to explore the role of these ports as both recipients and sources of invasive species. This is the first time that this kind of research has been done in the Baltic Sea."

"When we cultivated resting stages of plankton algae, which can survive in the dark for months, we found that they come out of this stage equally well at 10°C and 20°C. In other words, as we had expected, even low temperatures do not provide very much protection for the Baltic Sea."

The single biggest source for the samples was a water ballast of 22,000 cubic metres, but a large tanker can carry up to twice that amount of water. Indeed, a vessel discharging its water ballast may pump hundreds of millions or billions of organisms into the harbour basin.

"It is possible that only very few of them survive, but it is nonetheless a kind of ecological roulette: there is no way of knowing what will happen and it is virtually impossible to reverse any adverse consequences."

RISK ASSESSMENTS BASED ON SALINITY LEVELS

For purposes of risk assessments the researchers on the team collected vast amounts of data from the literature. They compiled lists of all the possible new invasive species in European brackish-water seas and on the basis of salinity levels estimated the likelihood the Black Sea and Baltic Sea species might be mixed through ballast water loads.

A volume edited in 2002 by Professor Leppäkoski and his German and Lithuanian colleagues on the invasive aquatic species of Europe provided a sound platform for this undertaking.

"According to our studies many of these invaders have settled in habitats that have the smallest number of indigenous species, i.e. in areas with salinity levels of 5-7 per mille. This provides an important clue for further studies aiming to identify the most likely target and source areas of invasive species."

DO AQUATIC INVADERS PRESENT A THREAT TO THE BALTIC SEA ECOSYSTEM?

"It is impossible to know in advance what kind of effects the spread of a new species may have; therefore every new arrival is a potential threat," Leppäkoski points out. Species that adapt readily to the prevailing conditions present the most serious threat to the balance of the ecosystem.

The most successful species in this regard have shown extraordinary qualities of ecosystem engineering, allowing them to modify their habitat and interactions between different organisms. In extreme cases they can even destroy an indigenous species altogether.

As far as humans are concerned, however, most newcomers have been both harmless and useless; to some extent they have actually enriched the Baltic Sea. Among the species that have arrived so far, twenty or so have in one way or another had adverse effects for humans.

"For any new species to become well established you will need to see a string of fortunate coincidences, but in principle one single fertilised female is enough to produce a new population and to trigger the invasion. The world's aquatic habitats are inevitably converging," Leppäkoski says. He can think of just two cases where an established invasive species has been successfully eradicated.

And there is another new threat on the horizon. What will happen when the ban on organotin, the dangerous but highly effective chemical used in ship hull paints, takes full effect in 2008? Will new compounds provide an effective enough replacement? The marine paints that are currently in use have been highly efficient in keeping out new aquatic invaders attached to ship hulls.

PRACTICAL KNOWLEDGE FOR PRACTICAL NEEDS

"When I published my first article on invasive species some 20 years ago, not many people were interested", Professor Leppäkoski recalls.

It was only in the early 1990s that interest in new aquatic invaders began to rise in the wake of two events that very nearly amounted to ecocatastrophes: the zebra mussel spread from Europe to the Great Lakes of North America and the American comb jellyfish travelled in the opposite direction to the Black and Caspian Seas, where it has caused severe damage to the local fishing industry.

Now, research in new invasive species is monitored much more closely and intently, among others by the Baltic Marine Environment Protection Commission HELCOM, the International Council for the Exploration of the Sea (ICES) and the shipping industry. Major changes lie ahead for the shipping industry because the new IMO (International Maritime Organisation of the UN) ballast

water convention is currently being ratified by IMO member states.

"As from the beginning of 2009 all new vessels will be expected to have the necessary technology to process ballast water loads or at least to provide risk assessments. Old tankers will have to address these issues by 2016," Leppäkoski explains. He was involved in an expert capacity in drafting the convention.

HELCOM has recently launched a project to assess the applicability of the international convention to the Baltic Sea area.

"This is a challenge to which our BIREME project could offer some answers," Leppäkoski continues. He is also involved in the HELCOM project and is therefore in the position to make his research knowledge available for the practical needs of Baltic Sea protection.

GROWING NEEDS FOR TECHNOLOGY RESEARCH AND FOLLOW-UP

Professor Leppäkoski says he would now like to see increased investment in the development of technologies that can help to deter the spread of organisms into the Baltic Sea. This development effort has in fact got under way elsewhere, but not in brackish water conditions.

"Ozonation, heating ballast water, using ultraviolet light or ultrasound, removing oxygen from the tanks – even if these methods might be effective in the oceans, they will not necessarily do the trick with the organisms that we have in our cold brackish waters of the Baltic Sea."

It would also be important to have an effective warning system for the Baltic Sea. New aquatic invaders are currently discovered haphazardly in connection with other follow-ups, but the circle of scientists actively monitoring the situation is very small.

"BIREME has been a pioneering programme in this respect, with 3-4 scientists working full-time on aquatic invaders. Finland has received much praise for investing in this area, for it is the only Baltic Sea state that has provided funding for this kind of research project.

New invasive species also provide an excellent opportunity for marine biologists to do basic ecological research. Their research interests might include the question of how these species adapt to the local indigenous populations of organisms and what kind of interactions develop between different species.

CHANGING CONCEPTS OF SPECIES DIVERSITY AND INVASION HISTORY

The spread and distribution of species is also studied on a time scale of millennia. "The research we do is traditional animal geography, but our tools are more accurate, the resolution is higher, " says Senior Curator **Risto Väinölä** of the University of Helsinki Museum of Natural History.

Väinölä and his colleagues are using molecular characteristics to study the bottom fauna and the species distribution history of northern European margin seas. The joint Finnish-Russian project under the BIREME programme is based on information obtained from DNA and proteins.

"We have found in our analyses at molecular level that many species which were thought to be well-known are in fact split up," Väinölä explains. Examples are provided by the blue mussel Mytilus, which dominates the hard bottoms of the Baltic Sea, as well as the Baltic clam Macoma in the soft bottoms of the sea.

"On the basis of their outer characteristics these mussels and clams were regarded as homogeneous species, especially in northern sea areas, but more detailed analyses have shown that each traditional species is in fact made up of several closely related species or subspecies."

It turned out that the mussels of the North Sea and those living in the Baltic Sea have different origins: the predominant strain in the North Sea comes originally from the Atlantic, whereas the main component in the Baltic Sea and also in the White Sea is a Pacific strain.

"In the Baltic Sea these separate species have hybridized to some extent, and distinctive biological units have formed in the sea. In this merging of different strains, we have effectively seen a process of species level evolution. The only way we can properly unravel these processes is by means of genetic tools."

It is not yet known whether the invading strain of Pacific mussels has superseded the North Sea species that possibly used to live here before, or whether the more distant newcomers have invaded the Baltic Sea immediately after the Ice Age.

Väinölä is extremely pleased with the opportunities for research cooperation opened up by the BIREME programme. "Comparisons of the Baltic Sea and White Sea can help us understand what exactly has happened in the Baltic Sea in the past. It now seems that the same phenomena are recurring in the White Sea." ■