Nordic Council of Ministers

Cleaner Nordic Seas

Contents

ANP 2010:731

ISBN 978-92-893-2071-9

Ved Stranden 18, DK-1061 Copenhagen K, Denmark
Telephone (+45) 3396 0200. For further information, please go to www.norden.org

Text: Annika Luther, Science Journalist, Finland.
Professional background group: The Nordic Sea and Air Quality Group/ Aquatic Ecosystems group:
Tonny Niilonen, Maria G. Hansen, Helgi Jensson, Marianne Kroglund, Sverker Evans, Markku Viitasalo and Mikael Wennström.
Editorial group: Jens Perus, Camilla Hagedorn Trolle and Tonny Niilonen.
Photos: Kuvaliiteri,
Johannes jansson, Nikolaj Bock /norden.org
Layout: Otto Donner
Printed by: Arco Grafisk A/S, Skive
Print run: 550

Printed on environmentally friendly paper
This publication can be ordered on www.norden.org/order. Other Nordic publications are available at www.norden.org/publications

Printed in Denmark

NORDISK MILJØMÆRKNING
TRYKSAG NR. 541-618

Nordic cooperation
Nordic cooperation is one of the world's most extensive forms of regional collaboration, involving Denmark, Finland, Iceland, Norway, Sweden, and three autonomous areas: the Faroe Islands, Greenland, and Åland.

Nordic cooperation has firm traditions in politics, the economy, and culture. It plays an important role in European and international collaboration, and aims at creating a strong Nordic community in a strong Europe.

Nordic cooperation seeks to safeguard Nordic and regional interests and principles in the global community. Common Nordic values help the region solidify its position as one of the world's most innovative and competitive.

Foreword

The seas constitute an important Nordic resource, so protecting them from harmful human activity and pollution is a high priority in the Region.

In eutrophied marine areas, the quantity of nutrients must be controlled in order to maintain or restore ecological balance. Nordic policy requires emissions of substances that are harmful to marine areas to be reduced within the next generation to levels that do not exceed natural background levels. Man-made substances are to be reduced to virtually zero. Man's impact on the climate and on fish stocks, pressure from alien species, oil spills and the exploitation of natural resources are to be kept within limits compatible with natural sustainability so that the sea and its resources remain available to future generations.

The Sea & Air Quality Group runs projects within the framework of an annual budget from the Nordic Council of Ministers. Nordic work on sea and air quality also contributes to the Nordic Environmental Action Programme and to the Strategy for Sustainable Development.

The over-arching objective of Nordic co-operation on marine areas is to improve understanding of the ecosystem in the management of the seas and marine resources. Ensuring that resources are used in a sustainable manner is critical to maintaining their diversity, structure, functions and productivity.

Nordic co-operation complements the work of the European Union and regional marine conventions, primarily the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM).

The Sea & Air Quality Group funds and supports projects that:

- provide a basis for a joint Nordic approach to international co-operation on sea and air issues
- create a common pool of knowledge of conditions and developments in sea and air pollution in the Nordic Region and Adjacent Areas
- promote Nordic co-operation on preventing sea and air pollution.

This brochure presents seven examples of research projects funded by the Sea & Air Quality Group. They have been selected in order to provide organisations and members of the general public who are interested in the environment with insights into the Group's work on the Nordic Environmental Action Plan (2004–2008).

In 2007, the Sea & Air Quality Group published the "Cleaner Air in Our Lungs" brochure, which showcased Nordic co-operation on combating air pollution.

Tonny Niilonen
Chairperson, Nordic Sea & Air Quality Group

Sverker Evans
Chairperson, Nordic Aquatic Ecosystems Group

The Sea and Air Quality group was re-organized to Aquatic Ecosystems group in the beginning of 2009.

The Nordic Environmental Action Plan 2009–2012

These days, nobody can ignore the fact that the economy and the environment are inextricably linked. Our patterns of production and consumption impact on the environment – in our home countries, throughout the Nordic Region and around the world.

Nordic co-operation is based on the principle of Nordic synergy. In order to achieve more than the individual countries are capable of in isolation, the Nordic countries agree a common course of action and allocate tasks and resources accordingly. The Environmental Action Plans determine the nature of the Region's joint efforts over four-year periods. The 2009–2012 plan will focus on the following themes: climate and air; seas and coastal zones; biological diversity and ecosystem services; and sustainable consumption and production.

Seas and coastal zones

The Environmental Action Plan contains specific guidelines for the seas and coastal zones. The Nordic countries are surrounded by highly varied marine areas, which are home to a wide diversity of habitats, and are of vital importance to human welfare. The core objectives are to ensure that the seas are exploited in a sustainable fashion and to achieve good environmental status by 2020.

The most acute threats facing the marine ecosystem today are excessive nutrients, over-fishing and toxins. Excessive nutrients are a major environmental problem in Skagerrak and Kattegatt, and in the Baltic they already pose a direct threat to economic development. It was partially for this reason that, in autumn 2007, the Baltic countries agreed to the Baltic Sea Action Plan drawn up by the Helsinki Commission (HELCOM). For the first time, all of the HELCOM member states and the EU agreed country-specific reductions of nitrate and phosphate emissions into the Baltic. The UN maritime organisation IMO has classified the Baltic Sea as a particularly sensitive sea area that needs improved safety standards in order to reduce the risk of shipping collisions that could result in oil or chemical spills. The Nordic countries play an important role in all issues that affect the Baltic marine environment, by promoting co-operation within the region and the adjacent areas. Via funding bodies such as NEFCO, NIB and the EU, they also make sure that it is possible to implement decisions and planned projects.

During the programme period, work in the North Atlantic will concentrate on preventing further concentrations of persistent organic compounds, heavy metals and radioactive substances, which often originate elsewhere.

Global warming exacerbates environmental problems – particularly in the Baltic and Arctic marine areas. The polar ice cap is shrinking, and previously inaccessible marine areas are opening up to transport, fishing and other forms of exploitation. In order to prevent potential damage, the risks have to be identified in good time.

Agreements, strategies and definitions of long-term goals are important elements of international co-operation on the environment. However, this work may seem somewhat abstract and far too slow to people who find their beaches invaded by algae, their fish stocks shrinking or their tourist income disappearing. The Nordic Environmental Action Plan sets out important objectives and principles, but it also incorporates a large number of specific measures that are to be implemented by 2012. For example, the Nordic countries are helping to set up a network of protected marine areas; to regulate discharges of ballast and waste water according to the sensitivity of the local seas; and to implement tangible measures stipulated in various EU directives on the sea and coastal areas. They are also working to restrict the spread of persistent chemical compounds in the sea, and to develop knowledge of how climate change impacts transport and the breakdown of chemicals in the marine environment.

Modelling marine conditions

– Nutrients: What they are, where they come from, and how and why they circulate in the North Sea and Baltic Sea?

Climate-change sceptics and others who fill the letters pages of newspapers often express annoyance with researchers who do not make clear predictions about the future, but instead point to models and prognoses. However, the truth is that sometimes the situation is so complex, and conditions so new and unknown, that exact answers are not actually possible – and models are often the best science has to offer. Models contain a great deal of information and can provide an indication of how marine areas would be affected by various protective measures.

At the beginning of this century, Nordic researchers began holding annual workshops to exchange experiences of the use of modelling tools in marine environmental research. For several years, **Morten D. Skogen**, from Norway's Institute of Marine Research, has headed up a modelling co-operation project that brings together researchers and data from Norway, Denmark, Sweden and Finland. Based on indicators suggested in what is known as the OSPAR procedure (see box below) for characterising eutrophication in marine environments, a network of research areas has been established in the North Sea, Kattegatt, Skagerrak and the Baltic Sea. Data from the stations is used to test four different models that describe eutrophication in different ways. Morten explains the aim of the project:

"What we are trying to do is develop a coherent modelling system capable of explaining the state of the seas by using all of the available information on the sources, spread, dilution, transformation and decomposition of nutrients in coastal waters and the open sea."

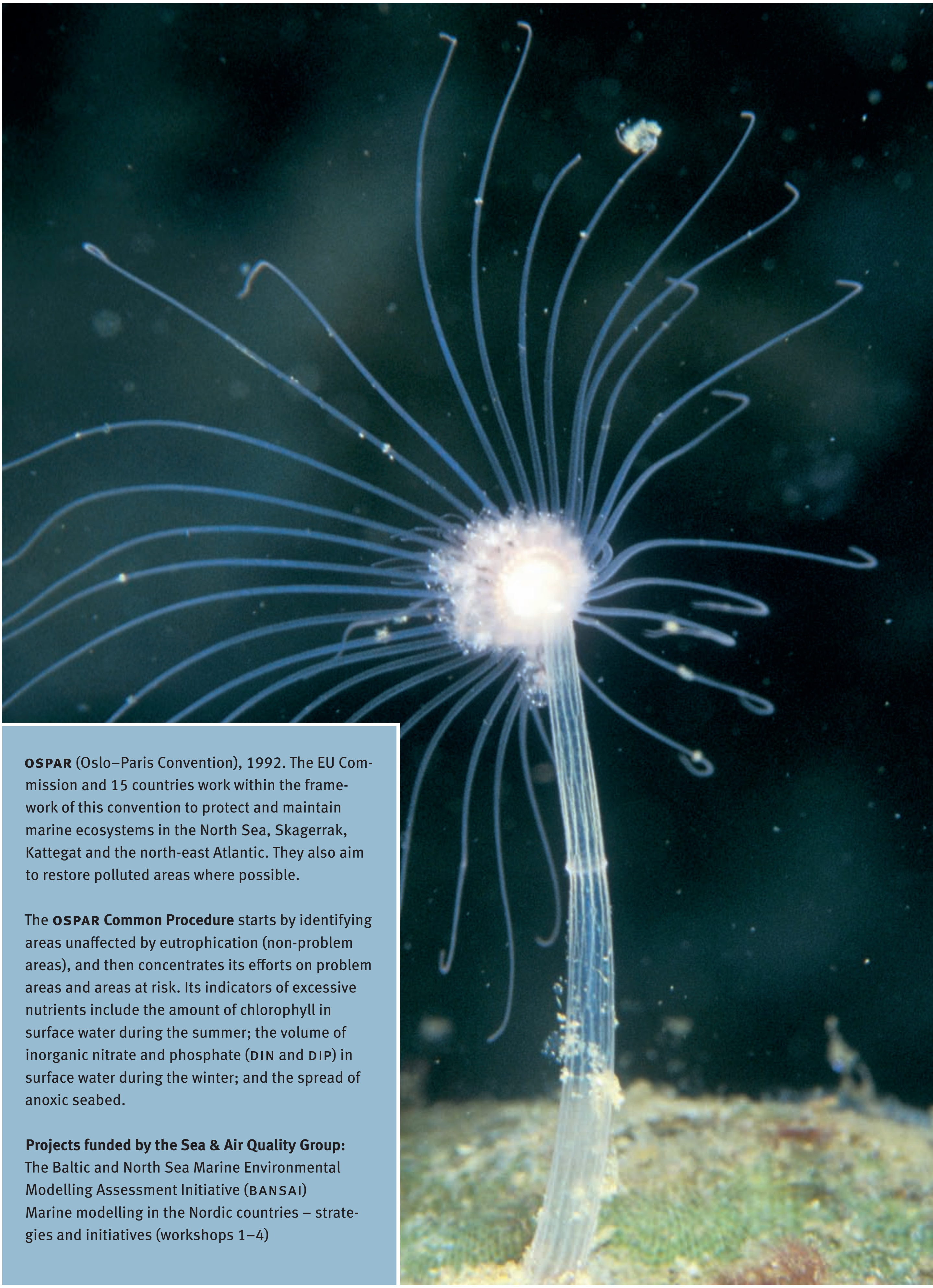
What progress has been made?
"The most important results to date consist of annual reports on the environmental status and eutrophication levels in the research areas in each of the participating countries. The reports show how models can be used to describe marine conditions, the advantage being that models describe conditions in all of the areas at all times, whereas individual measurements only provide a snapshot of specific conditions at specific points in time. Models can also calculate the effects of particular changes that are difficult to measure directly – for example, our models predict what would happen if discharges of nitrates and phosphates into various rivers were reduced. Until we actually reduce those discharges, there will be nothing to measure directly."

Can you explain how you construct the models?
"The circulation in the sea can be described as a type of physical equation, while the model is a solution to that equation. It more or less resembles the way meteorologists analyse weather patterns. We also test models against each other by inputting measurement data from the research areas to assess to what extent the results are in agreement with each other, and what their limits are."

What do you do if two models generate different results?
"Unfortunately, that situation does arise quite often. The important thing is to understand why the results differ. In our project we have chosen to express the eutrophication status of a given area as a weighted median of different modelling results. The weighting is a function of how well the models match available data. It is also important to understand that all models have their strengths and weaknesses – a model can provide a good result in one area and a bad one in another."

What do your models tell us about the current situation?
"The whole of the southern North Sea, Kattegatt, Skagerrak, the Danish Sound, the Gulf of Finland and large parts of the southern Baltic are designated as problem areas in terms of the OSPAR classification system. Much the remainder consists of potential problem areas. To make progress, better reference values and measurement data are needed to establish thresholds between eutrophication levels."

What can your models tell us about future developments?
"The future depends on the political will to do something about eutrophication. Both OSPAR and HELCOM are working to reduce discharges in the individual countries. Even so, it will be many years before the situation is positive across the whole of the Baltic Sea."



OSPAR (Oslo–Paris Convention), 1992. The EU Commission and 15 countries work within the framework of this convention to protect and maintain marine ecosystems in the North Sea, Skagerrak, Kattegat and the north-east Atlantic. They also aim to restore polluted areas where possible.

The **OSPAR Common Procedure** starts by identifying areas unaffected by eutrophication (non-problem areas), and then concentrates its efforts on problem areas and areas at risk. Its indicators of excessive nutrients include the amount of chlorophyll in surface water during the summer; the volume of inorganic nitrate and phosphate (DIN and DIP) in surface water during the winter; and the spread of anoxic seabed.

Projects funded by the Sea & Air Quality Group:
The Baltic and North Sea Marine Environmental Modelling Assessment Initiative (BANSAI)
Marine modelling in the Nordic countries – strategies and initiatives (workshops 1–4)

One hand should know what the other is doing

– Co-ordination of EU water-quality and habitat directives with marine strategy

The seas cover two-thirds of the Earth's surface and account for about one third of the planet's primary production. Europe's coastal areas are generally heavily populated, and it is here that human activity has the greatest impact – the effects of which include declining fish stocks, excessive algae and bathing bans on once-popular beaches. Various conventions and directives regulate protection of the marine environment, but they are not always well co-ordinated. A joint Nordic project has analysed overlaps and potential synergies.

The sea often bears the brunt of human activity. Valuable fish stocks are threatened and ecosystems are damaged by waste and toxins. Marine transport spreads alien species, and climate change alters salinity levels and currents. Plastic bags and nylon ropes strangle seabirds and marine animals, or result in them being starved to death. When it comes to discharges and marine waste, it is as if we still believe that they can be ignored, or that they do not even exist. In 1999, researcher **Robert Costanza** estimated that the marine ecosystems in the EU coastal states provide so-called "ecosystem services" worth €2,500 billion p.a. – roughly €25,000 per inhabitant! Calculations such as this can, of course, be disputed, but they at least give an indication of what is at stake.

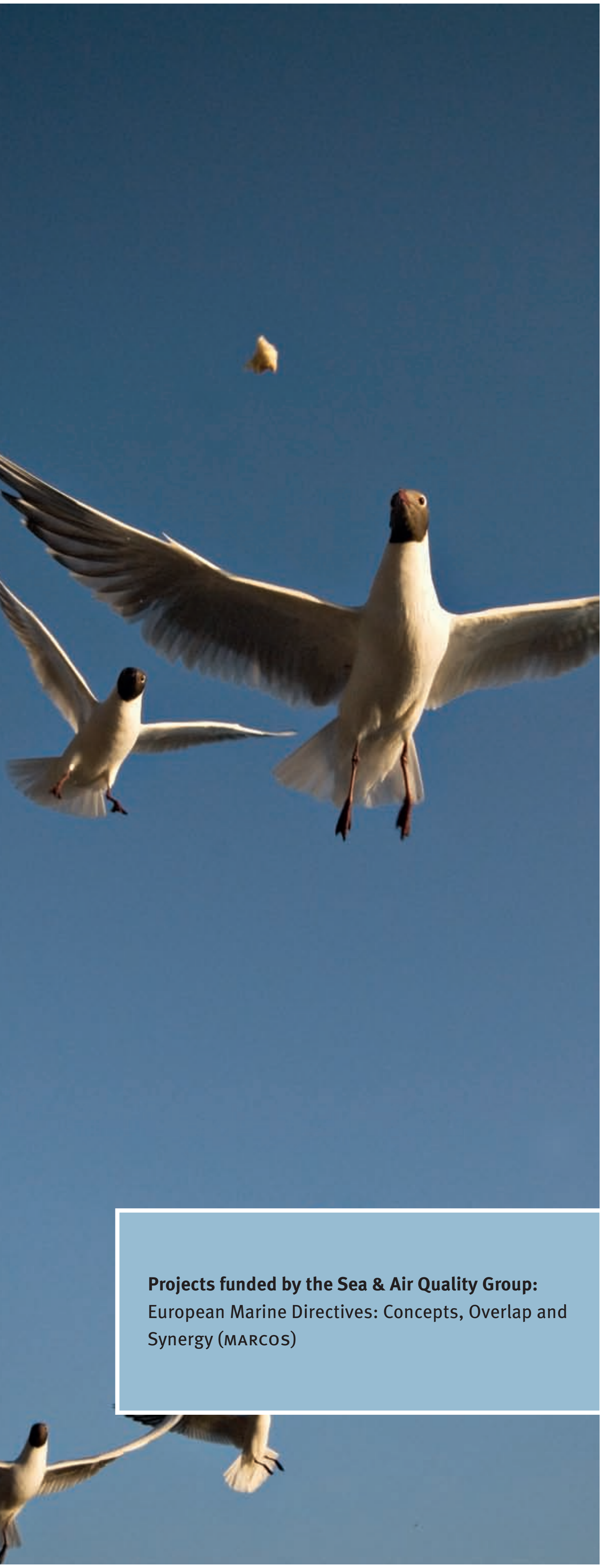
The traditional fishing industry is already suffering from rising unemployment. Plans to further reduce fishing quotas or to establish marine reserves and protected areas regularly provoke intense local protest in areas already hit by unemployment and depopulation. Fishing bans or limits in sensitive areas, tougher discharge controls and bans on unsustainable tourism can seem very costly to the local community in the short term. However, measures such as these have often proved effective in restoring threatened fish stocks and creating new, sustainable businesses. Doing nothing quickly becomes more expensive than acting to protect ecosystems.

The individual EU member states are committed, through various directives, to implementing jointly formulated objectives within their territories. Non-members Norway, Iceland, the Faroe Islands and Greenland also comply with many of these directives. There are three important directives relating to marine environments[1]:

The Habitats Directive aims to secure biodiversity by establishing a network of representative natural habitats throughout the EU. Known collectively as *Natura 2000*, the habitats aim to ensure the survival of a large number of designated species in their natural environments. The directive was originally devised for habitats on land, but it also covers marine ecosystems. Areas are selected solely on ecological grounds, with no provision for exceptions.

The Water Framework Directive (see case study 4) covers groundwaters, seas, rivers and coastal waters. It requires all EU countries, plus Norway and Iceland, to classify their waters according to a five-point scale, and to maintain or improve their ecological conditions. The objective is for all European waters to achieve a "good ecological status" by 2015.

The EU's Marine Strategy Directive covers the Baltic, the Mediterranean and the Black Sea, plus part of the Arctic Ocean and the north-east Atlantic. It states that all European seas must achieve good environmental status by 2020. This means that the seas' biological diversity and natural resources, upon which all social and economic activity in the surrounding areas is dependent, must be protected, restored and utilised in a sustainable manner. The European seas are divided into marine areas based on their geography and ecology. In order to achieve good environmental status, each marine region's countries must co-operate on national marine strategies and cost-effective measures. The co-operation is co-ordinated by regional marine environment conventions (e.g. HELCOM and OSPAR in the Nordic Region).



Projects funded by the Sea & Air Quality Group:
European Marine Directives: Concepts, Overlap and Synergy (MARCOS)

So far, so good – on paper, it looks as if Europe's seas are in safe hands. However, in reality there are far too many different agreements and systems to function holistically. Directives and conventions are rarely identical in terms of their definitions, concepts and geographical divisions. Different directives may refer to the same issue in terms of "ecological status", "sensitive and non-sensitive areas", or "problem areas and non-problem areas". An area of coastal water may be covered by both the Water Framework Directive and the Habitats Directive at the same time. In addition, it will also naturally be a marine region. Which regulations actually apply?

From overlap to synergy

All three directives are aimed at achieving sustainable, ecosystem-focused management of the marine environment, which is an important aspect of ongoing sustainable development throughout the European Union. However, we must first analyse what the directives actually say, where they overlap and where synergies might be achieved. A major problem is that the directives' regulations are monitored by a range of organs whose work is not always co-ordinated. Cutting down on overlaps would reduce the amount of unnecessary reporting work in the member countries. There are also gaps in the system – areas and problems not covered by any of the directives. Our researchers are working to identify these gaps so that they may be closed using, for example, the Marine Strategy Directive. A comprehensive, unified system would also give the national authorities responsible for the marine environment the necessary knowledge and tools to work as effectively as possible for cleaner seas in Europe.

[1] Norway and Iceland are only bound by the directives, or parts of directives, that are included in the EEA Agreement. The Habitat Directive is not included, so habitats must be protected by domestic legislation and the Bern Convention. However, the majority of the Water Framework Directive is included, and has been implemented in both countries. The Marine Strategy Directive will probably have consequences for the management of the seas in Norway and Iceland, even though it has not yet been clarified whether it will be included in the EEA Agreement.

Nordic quality in environmental monitoring and reference values

– How are critical load limits fixed?

The Baltic Sea absorbs nutrients from the land and the air. The wind carries nitrogen compounds from traffic and agriculture out over the sea, where they rain down upon the water and feed algae and aquatic plants. When a mass of algae dies, it is broken down by bacteria that consume the seabed's oxygen supply. In anoxic conditions, phosphates embedded in the sediment are once more released into the water and fertilise new growth. This process, called "internal loading", means that excessive nutrients and algae persist long after the influx of new nitrates and phosphates ceases. At irregular intervals, large bodies of salt water from the Atlantic rush into the depths of the Baltic. These pulses introduce oxygen-rich water, but also force the nutrient-rich deeper layers to the surface, resulting in even more algae.

If we are to justify costly measures to reduce excessive nutrients, then we need to understand all of these processes and how they interact. Case study 3 describes two projects designed to establish when and how loading exceeds critical levels.

Living plankton algae binds and stores a proportion of the nitrates in the sea. Wind and rain add more nitrites, nitrates and ammonia. The nitrogen compounds that stimulate algae growth are often grouped under the term **DIN** (*dissolved inorganic nitrogen*). However, 85–95% of all nitrates in the Baltic are bound to dissolved organic matter and are therefore not directly accessible to algae. These bound nitrates, or **DOM** (*dissolved organic matter*), originate on land and are absorbed by the sea via rivers, streams and minor watercourses. Dissolved organic matter, or the humic substances that colour water brown or yellow, is therefore important for transferring nitrates from land to sea, and also between different waters.

Since DOM is not directly accessible to algae, it might be presumed that it does not play a major role in the origin of algae blooms. Unfortunately, it is not that simple. During the summer, strong solar radiation serves as the catalyst for a series of photo-chemical reactions that transform DOM into inorganic ammonia. The sun therefore not only provides energy for photosynthesis, but also produces a form of nitrate-building material useful to algae.

A project was implemented to assess the significance of DOM in various parts of the Baltic. The chosen test areas in the south were the bay of Gdansk and Arkona, on the most northerly point of Rügen island. The northern test area was the sea off Uleåborg, on the Finnish side of the Gulf of Bothnia, and in the east, the Gulf of Finland, off the port of Kotka.

The results show that DOM is far more significant than previously thought. While the addition of DIN from the air is at its peak during the winter months, it was found that, during periods of peak rainfall, the photo-chemical production of ammonia from DOM was equal to or even greater than airborne deposits. Previously, DIN, which is often carried great distances through the air, received much of the blame for deteriorating water quality. We may now need to look more closely at DOM, which originates from our own shores.

Eutrophication maps and comparison of models

The unique nature of the Baltic – an inland sea with very specific topographical and hydrographical features – can make it difficult to discriminate between natural variations and changes resulting from human activity. The second

project therefore combined hydrodynamic and ecosystem models to simulate bio-geochemical circulation in the Baltic when the inflow of nutrients is constantly greater than the outflow. The models were tested both against each other and against external data.

The Gulf of Finland was chosen as a test area because it is easier to study changes within a limited area than across the whole of the Baltic Sea. This area is influenced both by salt water pulses from the Baltic and by an influx of fresh water from rivers and streams. The varied coastal areas also offer good conditions for testing the effects of currents and topography on eutrophication.

The results were presented both as maps of ecological indicators of eutrophication, and as a series of nutrient reports highlighting particularly sensitive areas. The project also resulted in recommendations for effective water-protection measures in open seas and coastal areas, and advocated specific changes in the network of environmental monitoring stations.

Projects funded by the Sea & Air Quality Group:
Dissolved Organic Nitrogen as Key Nutrient for Marine Plankton (DONKEY)
Ensemble Model Simulations as a tool to study the Baltic Sea and the Gulf of Finland Eutrophication (EMAPS).

Clean water for all!

– But what does “good ecological status” actually mean?

The Water Framework Directive of 2000 is the most ambitious European regulation to date aimed at halting deterioration in the quality of our water. The objective is to achieve sustainable management of water resources and good ecological status for ground water, fresh-water lakes, running water and coastal areas by 2015 – in other words, clean water everywhere and for all.[2]

Jacob Carstensen of NERI, the Danish National Institute for Environmental Research, reports that the Nordic countries possess good monitoring data in general and that it is important that they share their experiences. Although “good ecological status” will not mean exactly the same for open seas, coastal waters, inland lakes and running water, it would be appropriate to reach agreement on how to interpret the concept and identify what needs to be done to achieve clean water for all.

Nutrient discharges, environmental toxins and oxygen depletion do not respect national boundaries, so all countries that share, or have an impact upon, any given body of water must work together. The authorities responsible must also be prepared to accept help from both NGOs and individual citizens.

The first step is to divide all of Europe’s waters into specific types according to five quality classifications (see the box below) based on ecology, physics, chemistry and hydrology: How much phytoplankton does the water contain, and of what species? What is the condition of fauna and fish on the seabed? What are the trends in visibility, depth and oxygenation, and what pollutants are found in the water? Does the water run freely or are there obstacles that determine flow and water levels?

This is where the challenges begin. Europe is big and the same species criteria cannot be applied everywhere. For example, regardless of the human impact, the river deltas of the southern Baltic are more nutrient-rich than the waters around the open coasts of Iceland. The directive specifies that each country should set its own classification criteria, but that the resulting evaluation must be comparable across all member countries. Any given environmental condition must also have the same environmental status, no matter where in Europe the test is conducted.

Evaluating water quality is no simple matter either, since factors such as the time of year, salinity and wind conditions all affect the results. The different countries’ monitoring programmes measure more or less the same things, but in ways that are not fully comparable. Worse still, according to Jacob Carstensen, we no longer really know what “clean” water is. For example, the Baltic has been absorbing excessive nutrients and pollutants for more than a century, but serious efforts to monitor them only began 20 or 30 years ago. Throughout Europe, seas and coastal waters are being affected by fishing, traffic, pollution and alien species, and in the future they are likely feel the effects of accelerated global climate change.

Diatoms show the way

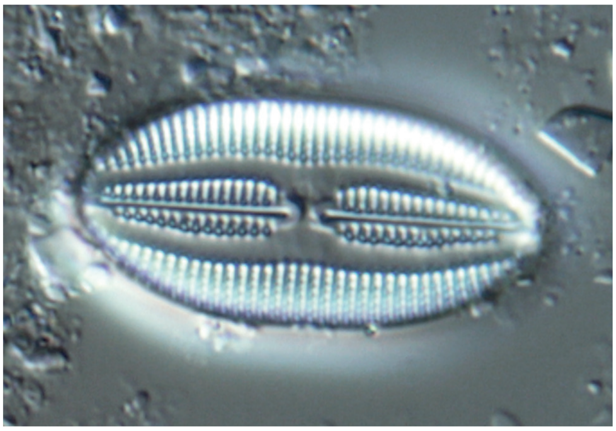
In Sweden, **Elinor Andrén**, of Södertörn University, ran a project that combined analysis of diatom algae in seabed sediment with the chemical data extracted from environmental monitoring in order to reconstruct the background values for nutrients in coastal zones. Why diatoms in particular?

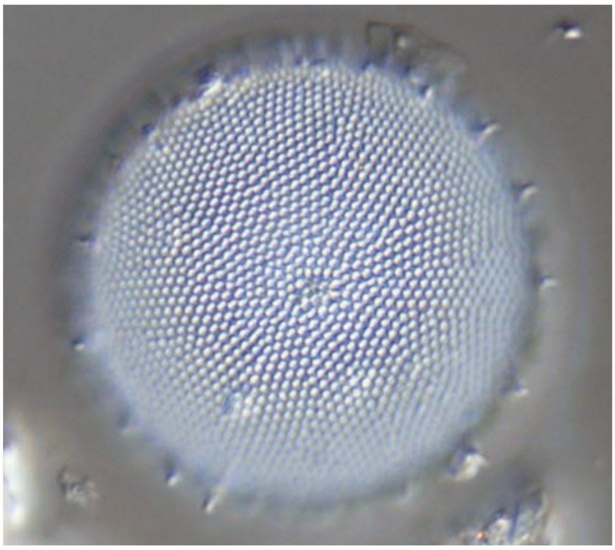
“Diatoms are preserved as fossils in the sediment, so the current ecology of algae allows us to understand historical environmental conditions. The method has previously been used in lakes and oceans, and a previous Baltic project established that our species determination is consistent. So when we take a sediment sample, if we find a diatom species combination resembling that found in Baltic coastal waters today, we are able to reconstruct nitrogen levels in the surface water in that area throughout the lifetime of the algae. The project also shows that diatoms as a group, not just phytoplankton, can be a useful complement to the biological classification element of the Water Framework Directive.”

How can the Nordic region help clean up coastal waters in Europe?

Several different Nordic projects are jointly developing new methods of environmental monitoring. The focus in Denmark is on various types of aquatic plant and bottom fauna in Skagerrak and Kattegatt. As these kinds of fauna live in the same location for long periods, they can reveal how pollution has changed there during their lifetime. Another Danish project chose species that could act as bio-indicators – i.e. living measurements of water quality.

Each country has its own methods of determining water quality. In order to indicate the same environmental status, irrespective of country, it must be possible to compare the various methods in a meaningful manner. Nordic and Baltic researchers gather at joint meetings and workshops in order to compare national methodologies and examine how macroalgae (e.g. seaweed) might be used in environmental monitoring. The results of these exercises are then tested in practice.





Water Framework Directive quality classifications for coastal areas
High: Water body in undisturbed condition, or show very minor anthropogenic alterations.
Good: Slight deviation from undisturbed conditions.
Moderate: Moderate moderately from undisturbed conditions. Some sensitive species have disappeared.
Increased incidence of tolerant species
Poor: Major deterioration in water quality. Animal and plant communities deviate substancially from undisturbed conditions.
Bad: Severe deterioration in water quality. Major elements of animal and plant communities normally found in water of undisturbed conditions absent

According to the Water Framework Directive, each country is responsible for implementing measures to ensure that all surface water, ground water and coastal water achieves "good ecological status" or "good ecological potential" by 2015.

Projects funded by the Sea & Air Quality Group that are developing methods for environmental monitoring and joint reference systems:
Reference Conditions and Typologies for Aquatic Vegetation and Macrozoobenthos in the Skagerrak and Kattegat (RETRO)
Estuarine Quality Classes for Water Framework Directive Indicators (EQUAL)
Harmonisation of Nordic Bottom Fauna Index of Ecological Quality in Poly- to Euhaline Areas (HARMEX)
Nordic Intercalibration of Hard Bottom Macroalgae Methodologies (ALGAMONY)
Defining Reference Conditions for Coastal Areas in the Baltic Sea for the Water Framework Directive (DEFINE)

[2] Norway and Iceland, via the EEA Agreement with the EU, have slightly different deadlines.

Ecology and economics for the good of the Baltic

– Which environmental investments provide the best return?

Eutrophication of the seas is not just an ecological problem, but an economic one too. Catches of commercially valuable fish and shellfish are in decline, and tourists are abandoning beaches where the water is cloudy with algae and the sandy seafloor is covered by a layer of stinking sludge. A Swedish study (Söderqvist, 1996) estimated the economic benefits of restoring the Baltic Sea at around €55 billion. In order to combat eutrophication, efforts have been made to reduce nutrient seepage from agriculture and forestry, provide treatment plants for built-up areas and industries, and reduce airborne emissions from power stations and traffic. The question of how best to deal with eutrophication remains to be answered.

Case study 5 deals with research aimed at helping decision-makers choose cost-efficient measures to combat eutrophication.

Eutrophication is a huge man-made problem– in effect, we are being punished for the sins of our fathers. Emissions have been going on for so long, and the nutrient deposits in sediment are on such a scale, that it will be a long time before lower emissions have a positive effect on water quality. Although a localised discharge ban may produce results in a limited coastal area, algae will continue to thrive further out at sea. In addition, reductions in discharges have not been on the same level everywhere, so it may be more attractive for Finland and Sweden to invest in Russia, Poland and the Baltic states, where treatment facilities are currently ineffective, than to improve their own plants.

Costs and benefits

Finnish, Swedish, Estonian and Russian researchers have been involved in a project tackling issues of ecology and economy. They looked at how the Gulf of Finland is affected by nutrient deposits in the water and sediment, how they are eliminated from circulation, and how new ones are added. The goal was to develop reliable long-term scenarios and identify which measures would be most effective for the Gulf of Finland – and, by extension, for the whole of the Baltic Sea.

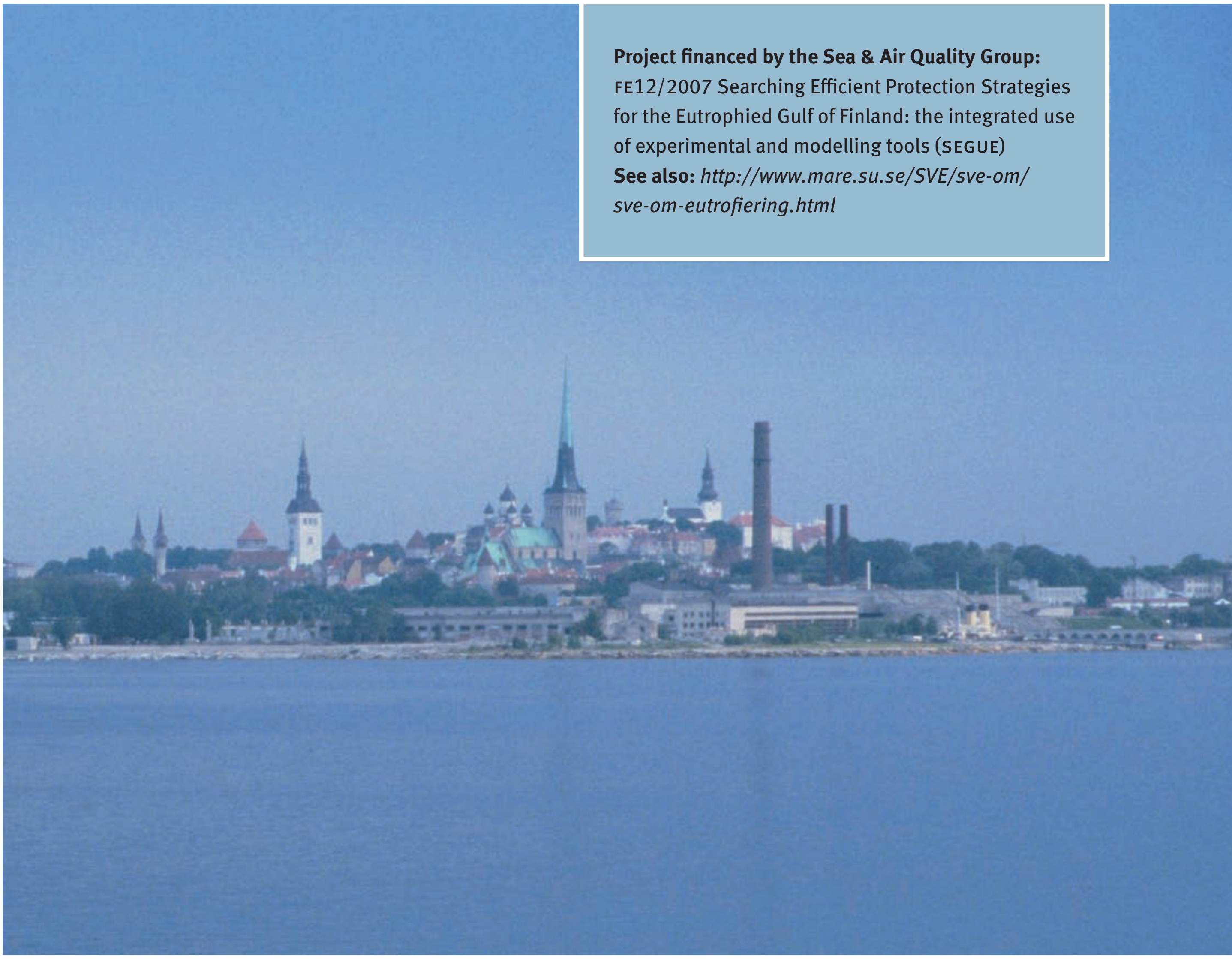
The project brought together researchers from a range of disciplines: natural sciences, social sciences and economics. The first step was to examine which measures would achieve a given objective at the lowest possible cost. The researchers then performed cost-benefit analyses, assessing various alternatives in terms of their total benefit to society and the environment.

One reason why eutrophication is such a major problem in the Baltic is that its run-off area is four times greater than its water-surface area. The Gulf of Finland is an ideal location for studying eutrophication, as its run-off area is 14 times greater than the Gulf itself, and its loading is 2–3 times greater than that of the whole of the Baltic Sea. St Petersburg, a city of 4.7 million people, also sits at the head of the Gulf. The river Neva carries nitrates and phosphates from large agricultural areas, and the Gulf also absorbs nutrients from other parts of the Baltic Sea.

The nitrate and phosphate loading of the Gulf of Finland is partly due to faulty water- and sewage-treatment plants, and partly due to agriculture. Is it therefore more effective to invest in urban treatment plants, or in preventing seepage from fields? The researchers fed data into mathematical and ecological models and cross-checked the results against verified data. A model that produces “correct” answers may prove useful for developing future scenarios.

It is difficult to test the changes in nutrient-discharge levels over time, as they are generally so small that it is difficult to make any accurate comparison. At least, that was the case until the early 1990s when the Soviet Union collapsed and the region descended into a deep economic depression. Industrial and agricultural production fell sharply, with dramatic results. Between 1987 and 2000, phosphate discharges fell by 39%, and nitrate discharges by 36%. These changes provided material for three scenarios for discharge reduction in the short, medium and long terms.

Project financed by the Sea & Air Quality Group: FE12/2007 Searching Efficient Protection Strategies for the Eutrophied Gulf of Finland: the integrated use of experimental and modelling tools (SEGUE)
See also: *http://www.mare.su.se/SVE/sve-om/sve-om-eutrofiering.html*



Scenario 1, "Finland", tested the possibility of Finland adopting maximally stringent emission controls while neighbouring countries continued to act as before.

Scenario 2, "St Petersburg", was based on all waste water from the St Petersburg region being cleansed to 75–80% purity while others continued to act as before.

In scenario 3, "Poland", Polish agriculture succeeded in cutting emissions by around 25% while others continued to act as before.

The results deviated significantly. Scenario 1 suggested that there would be a considerable improvement in the Finnish archipelago over the next three decades, while the St Petersburg scenario would reduce algae in the Gulf of Finland and surrounding areas within five years. The Polish scenario proved the most effective by far, leading to significant improvement throughout the Baltic as well as reducing algae in the Gulf of Finland. However, the results would not be visible for another 30 years. In other words, decision-makers who invest in the most effective alternative would have difficulty maintaining the trust of their voters while they waited for a return on their investment.

In general, politicians throughout the Baltic Region are good at tackling the major sources of eutrophication, irrespective of their origins. Unfortunately, the results show that, at least as far as the Gulf of Finland is concerned, even the toughest measures may not achieve "good ecological status" within the timeframe specified in the EU Water Framework Directive.

New/old toxins in the sea

– DDT *is under control, but what about* TBT, HCB, BCPS *and* PFC*?*

Even 30 years ago, it was clear that persistent organic compounds were a major problem for animals such as birds of prey and seals. Today, levels of the best-known toxins have been reduced significantly thanks to decades of environmental work, but both old and new persistent organic compounds and toxic substances continue to spread throughout the marine environment. Together with organisations such as the Nordic Environmental Monitoring and Data Group, the Sea & Air Quality Group supports a number of projects studying how POPS (persistent organic pollutants) in everyday use are spread by wind and water, get into the food chain and turn up, far from all major pollution sources, in marine mammals and birds in the seas around Norway, the Faroe Islands, Iceland and Greenland.

Quite simply, we still know very little about the effect on health and the environment of many of the chemical pollutants still in general use. More research is also needed into what happens when substances are broken down and transformed into other compounds.

Poisoned seabird eggs

One Nordic project compared the amounts of several different halogenated compounds in guillemot eggs in the Baltic Region and the West Nordic Region. The guillemot (*Uria aalge*), a fish-eating auk that lives to a great age in dense colonies, has already proven to be a very good bio-indicator of marine pollution. A number of halogenated organic compounds were analysed, including chlorinated, fluorinated and brominated hydrocarbons stemming directly from the well-known toxins DDT and PCB, as well as their decomposition products. Many of the substances analysed are now banned under the Stockholm Convention.

Using modern analysis methods, the project established that all of the substances tested for were found in both the Baltic and the Atlantic – even though some of the locations were far from any pollution sources. Levels of chlorinated compounds were five to ten times higher in the Baltic than in the West Nordic Region, but roughly equal levels of hexachlorobenzene were found at all research stations. As far as brominated compounds were concerned, the differences were less pronounced, suggesting that the West Nordic Region may be just as polluted by them as the Baltic Sea. Perfluorinated compounds had a unique spread with no discernible pattern.

Nordic and baltic partnerships

Follow-up work on these results continues in the Baltic Region and in the West Nordic Region, with an emphasis on why different substances spread in different ways. Why, for example, are levels of hexachlorobenzene almost the same in Iceland, the Faroe Islands and Norway as in the Baltic? The follow-up work will look at another indicator species, the char (*Salvelinus alpinus*), and investigate the actual take-up mechanisms. One important objective is to build upon models for the spread of POPS in the Nordic marine environment and provide grounds for extending the list of organic environmental toxins banned under the Stockholm Convention.

The work of preventing the continued pollution and poisoning of the marine environment largely consists of devising analytical models and systems in order to monitor local emissions and the transfer of harmful substances by wind and rain over huge distances. In the areas of the Baltic belonging to Russia, the Baltic states and Poland, a screening system for nine dangerous organic toxins – including polychlorinated dioxins (PCDD), dibenzofurans (PCDF) and biphenyls (PCB) – will be developed in collaboration with Nordic experts. New environmental pollutants also need to be considered, e.g. brominated diphenyl ethers (PBDE). Some of the substances covered by the screening project are still used for a wide range of purposes: to combat fungal infections; as basic ingredients in plastics manufacture; as flame-retardants in furniture, insulation and home electronics; and for the surface treatment of textiles. What they all have in common is that they degrade slowly and are fat-soluble, so they can be absorbed into the food chain and end up in, for example, guillemots and char. A new project funded by the Sea & Air Quality Group will study concentrations of new POP compounds in marine mammals in the Nordic parts of the Arctic Region over the last three decades.

Stockholm Convention list of the 12 worst organic environmental toxins:
Aldrin, Chlordane, DDT, Dieldrin, dioxins, Endrin, polychlorinated dioxins and dibensofurans, Heptachlor, Hexachlorobenzene, PCB and Toxaphene.

Dioxins: Common name for all substances with dioxin-like effects. A total of more than 200 substances have emerged as by-products of processes such as incineration. The main sources today are the smelting of metals and the uncontrolled burning of waste. Most toxic is TCDD, a substance that first came to attention following a chemical accident in Seveso (Italy). It is stored in fatty tissue and absorbed into the food chain. Human exposure can cause severe acne, liver malfunction, problems with fat metabolisms, cancer and developmental difficulties in infants.

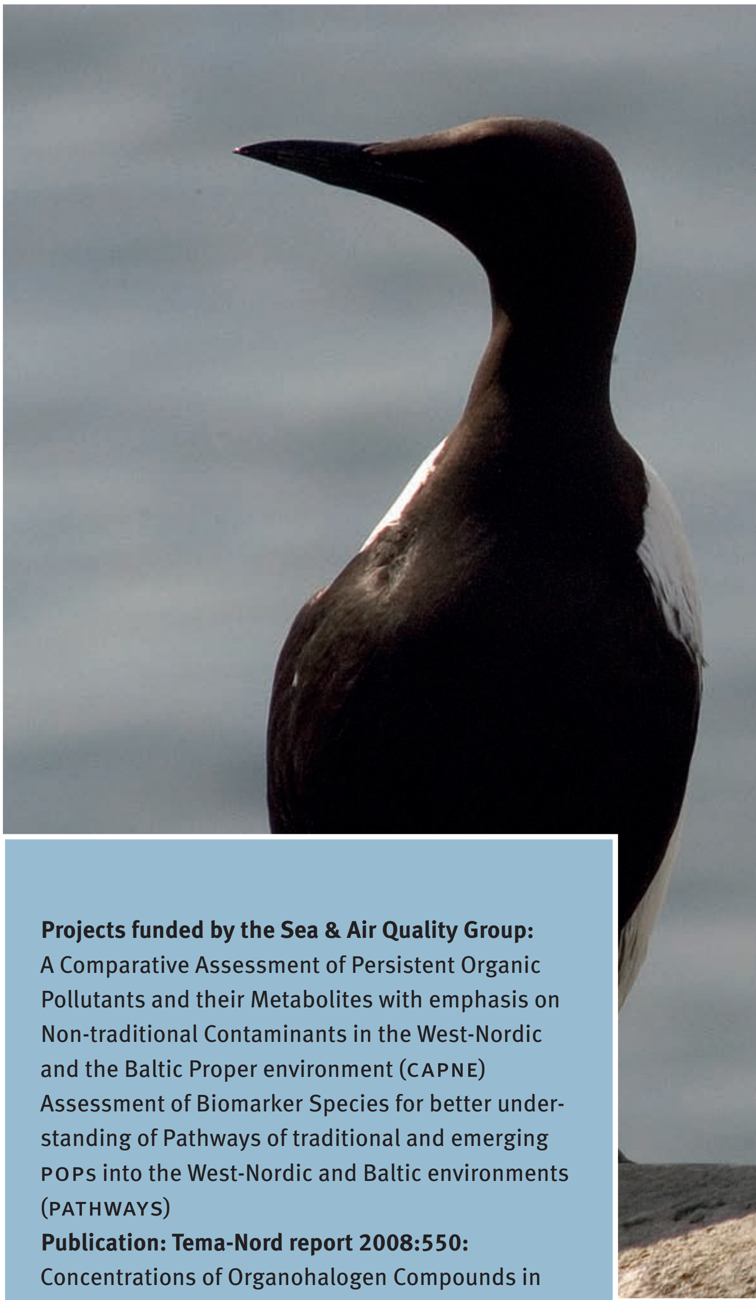
Tributyltin (TBT): Long-lasting environmental toxin mainly spread by vessels using anti-algae hull paints. TBT is also used as a preservative in the forestry and textiles industries. The substance concentrates in sediment. It disrupts immune and hormonal systems, and as early as the 1970s was known to affect reproduction in snails.

Hexachlorobenzene (HCB): A fungicide that has been in use since 1945, formerly used in seed treatment. HCB is mainly formed as a by-product of a wide range of processes, so is spread over large areas. The substance is absorbed into the food chain and has been found to affect blood production in mammals.

Bis(4-chlorophenyl) sulfone (BCPS): Produced in very large quantities as a component of heat-resistant plastics, it was discovered in the food chain around a decade ago. The substance is absorbed by marine organisms, particularly guillemots. Levels have remained more or less unchanged, despite falls in the levels of other toxins.

Polybrominated diphenyl ethers (PBDE) and hexabromocyclododecane (HBCDD): Flame-retardants used in textiles, insulation materials and home electronic devices. High levels of PBDE have been traced in breast milk, foodstuffs and wild animals. Its effects resemble those of PCB.

Perfluorinated compounds (PFC): Used to treat the surfaces of textiles and leather, and in detergents and hydraoils. Spread from products, shipyards and waste depots. Knowledge of the nature and prevalence of their biological effects is limited. These compounds are absorbed into the blood and liver of animals and humans.



Projects funded by the Sea & Air Quality Group:
A Comparative Assessment of Persistent Organic Pollutants and their Metabolites with emphasis on Non-traditional Contaminants in the West-Nordic and the Baltic Proper environment (CAPNE)
Assessment of Biomarker Species for better understanding of Pathways of traditional and emerging POPs into the West-Nordic and Baltic environments (PATHWAYS)
Publication: Tema-Nord report 2008:550:
Concentrations of Organohalogen Compounds in the West-Nordic compared to the Baltic Region.

Oil pollution is not just about major disasters

– Tougher action against minor spills at sea

At present, roughly 15% of global sea traffic passes through the Baltic, and oil shipments in particular are rising rapidly. In 1995, a total of 20 million tonnes of oil passed through the Baltic Sea, a figure estimated to rise to 250 million tonnes by as early as 2015.

Oil production in Norway and the Norwegian areas of the Barents Sea is expected to fall to around half of its current level over the next decade but gas production will double. Oil exploration in the waters off the Faroe Islands has been going on since 2001. Oil and gas production will probably increase in some parts of the Barents as climate change makes the area more accessible. More shipping in the newly ice-free passages around the North Pole will increase the risk of oil pollution throughout the Arctic and West Nordic Region, but particularly around Norway.

Oil is acutely toxic to plants and animals, and many oil hydrocarbons decompose slowly, posing a long-term threat to the environment. However, the intensity and duration of the effects of an oil spill depend on a range of factors. The Nordic seas are cold, sometimes frozen, so the bacteria that break down oil are not as active as they are in warmer climes. In vulnerable areas, e.g. around the Norwegian oil rigs, spills are diluted more quickly and the environment recovers more easily than in protected bays on the Baltic Sea. In general, small organisms that reproduce rapidly recover better than large species that produce just one or a small number of offspring each year. Surface-dwellers, such as birds and seals, and stationary bottom fauna in the splash zone suffer more than animals that are able to escape under water or which live at greater depths. Oil spills in the spring affect fish spawn, while winter spills, particularly in the southern Baltic, can have a serious impact on wintering seabirds.

The oil itself also varies in viscosity and density: heavy oil sinks and coats the seabed, while light oil is much more toxic but evaporates quickly. The worst effects occur when large quantities of crude oil are discharged into an enclosed coastal area and wash up on shore. The impact of a clean-up on some types of coast, especially if dispersal agents are used, can be worse than the spill itself. In these cases, it is better to let the natural, self-cleaning and self-healing processes take their course.

Mussels, seaweed and long-tailed ducks

One Nordic research project compared the effects of oil spills on a range of **key marine biotopes** – natural areas that, by virtue of their physical environment and combination of species, are of great significance for local plant and animal life. A key marine biotope may, for example, have a hard seabed of rock and stone that provides a habitat for mussels and seaweed. These in turn are called **key species**, since a whole range of other species depends on them.

Major oil disasters are by definition harmful to the marine environment, but is it not equally important to try to prevent the minor spills that occur in the course of normal shipping activities?

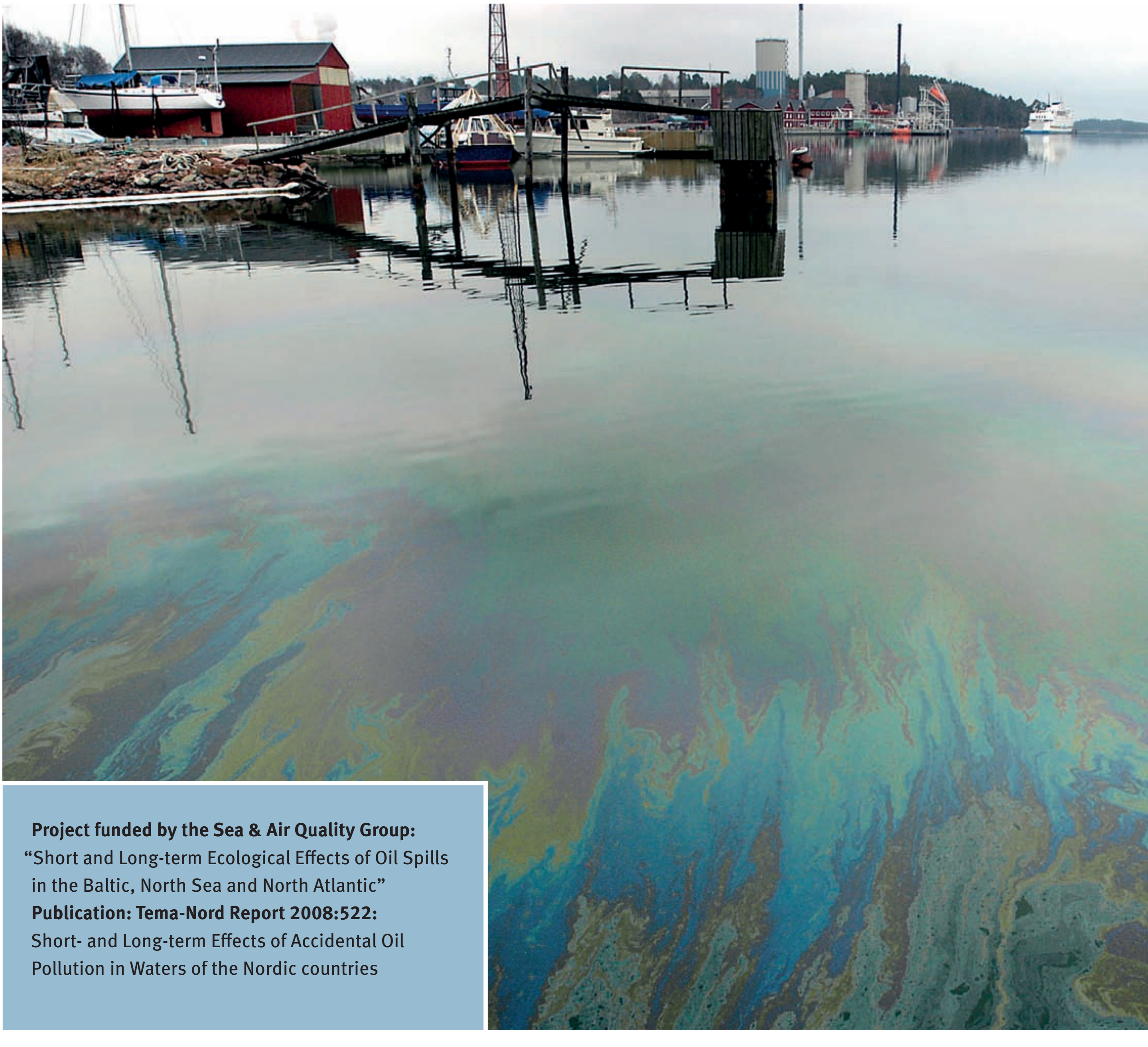
"Yes, it is," says **Jonas Fejes**, the project manager and an oil-spill adviser at the IVL Swedish Environmental Research Institute. "Large areas of the Nordic seas are particularly sensitive to oil spills, since they are already under heavy pressure from other pollutants and exploitation. Both spills and oil exploration are increasingly common in the Nordic seas, and constitute a serious threat to our key marine biotopes. For certain species of bird, fish and invertebrates, oil spills in their breeding or feeding areas are the greatest threat they face, and could lead to extinction, long-term disruption or economic catastrophe."

The Arctic long-tailed duck (*Clangula hyemalis*), which breeds in huge colonies, is one example of a particularly vulnerable species. Just one spill close to a colony in the

Barents Sea could threaten the survival of the entire species. The situation is not helped by the fact that about a quarter of the birds' total European population winters on the Hoburg Bank, south of Gotland, where it is estimated that about 10% are already dying due to small, "normal" oil spills.

Jonas Fejes explains the role that research plays in preventing spills and ameliorating their effects:

"We need to know more about how oil affects the Nordic marine environment and how we can limit and prevent disasters in the future. This is not just an issue for oil transport, but for all shipping. We need tougher regulation of permitted discharges and we need to move shipping lanes. The situation can be compared with the growth of road traffic and the way we continue to build larger, safer roads in sensitive areas while demand for reduced traffic emissions is growing. We urgently need better knowledge of the impact of the sharp increase in sea transport and emissions so that we can tighten up regulation and alter destructive shipping patterns."



Project funded by the Sea & Air Quality Group:
"Short and Long-term Ecological Effects of Oil Spills in the Baltic, North Sea and North Atlantic"
Publication: Tema-Nord Report 2008:522:
Short- and Long-term Effects of Accidental Oil Pollution in Waters of the Nordic countries

Nordic Council of Ministers

Ved Stranden 18
DK-1061 København K
www.norden.org

Cleaner Nordic Seas

The seas surrounding the Nordic coastlines are subjected to major environmental problems. The most immediate ones are eutrophication, overfishing, and hazardous substances. Supply of nutrients is the biggest problem in the Baltic Sea, while the Western Nordic and Arctic regions are threatened primarily by oil, and persistent toxins that are transported from far away. The ocean and coastal zones are a key area of focus in the Nordic Environmental Action Program for the years 2009 – 2012 and the goal is that all the Nordic seas to be used in a sustainable manner and having reached good environmental status by 2020.

This brochure contains seven stories of how Nordic researchers join and together with their European neighbors try to solve the problems that human activities has led to. The overarching goal is to enhance the understanding of how marine ecosystems work and how we should manage our common resources.

All the described researchprojects are funded by Sea and Air Quality Group/Aquatic Ecosystem group at the Nordic Council of Ministers.

For further information about Nordic environmental initiatives, go to: www.norden.org/aeg.

ANP 2010:731
ISBN 978-92-893-2071-9