ICES Insight

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A vision worth sharing

We believe that ICES has a vision worth sharing. It aspires to be an international scientific community that is relevant, responsive, sound, and credible concerning marine ecosystems and their relation to humanity.

Established in 1902, ICES grew from a small body of like-minded researchers to an organization involving about 1600 scientists, with 20 Member Countries, as well as Observer Countries and non-governmental organizations. The ICES Convention outlines ICES fundamental purposes:

- to promote and encourage research and investigations for the study of the sea particularly related to the living resources thereof;
- to draw up programmes required for this purpose and to organize, in agreement with the Contracting Parties, such research and investigations as may appear necessary;
- to publish or otherwise disseminate the results of research and investigations carried out under its auspices or to encourage the publication thereof.

ICES plans and coordinates marine research in the North Atlantic Ocean, the Baltic Sea, and the North Sea through a system of committees, more than 100 working groups, science symposia, and an Annual Science Conference. ICES uses its knowledge of marine ecosystems to develop unbiased, non-political advice that is used by its Member Countries, which fund and support ICES, to manage human activities in their territorial waters. Today, ICES provides the scientific underpinning for most of the regulatory commissions concerned with fisheries and the environment in the Northeast Atlantic and the Baltic Sea.

The ring of Member States around the Baltic is now complete with Lithuania's accession to ICES. This issue of *ICES Insight* opens with reflections on our newest Member State: its successes and challenges and aspirations.

More Baltic and North Sea issues surface in articles about a parasitic threat to Northern European salmon and a proliferation of alien jellies. New developments are considered: a new computer simulation that points the way to smarter quotas and regulations, the development of size-based models, and passive sampling techniques for hydrophobic contaminants.

We include the memories of an *ICES Journal of Marine Science* Editor and an overview of ICES work in climate-change research. Finally, we ask, can the conditions of seabird breeding colonies serve as an indicator of the state of our seas?

These few articles give only a glimpse of the many and various subjects currently being tackled by ICES scientists.

We are always happy to hear from you – your reactions and suggestions – and we welcome story ideas for upcoming issues. Our e-mail address is below.

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Lithuania's

History in ICES

Bringing Lithuania into the ICES family took much longer than anyone anticipated, William Anthony reports. The process spanned the terms of four general secretaries, but finally, after the Lithuanian Parliament had ratified the ICES Convention, Lithuania became ICES 20th Member Country. It is now possible to walk (and swim) around the ring of ICES Member Countries from the Iberian Peninsula to Florida without entering a non-ICES country.

After the three Baltic states declared independence in 1990 and 1991, Emory D. Anderson, ICES General Secretary between 1988 and 1993, encouraged Latvia, which had joined ICES in 1923, and Estonia, which had joined in 1924, to re-enter the organization, after their memberships had been interrupted by the events of the Second World War. Latvia acceded to the Convention on 17 September 1993, and Estonia joined 16 December 1993. Anderson also opened channels of communication with Lithuania, and his initiatives were warmly received.

In 1996, Chris Hopkins, ICES General Secretary between 1994 and 1999, took the first of several trips to Lithuania and was greeted with agreement all round that Lithuania should join ICES. He remembers particularly the support that he received from Šarūnas Toliušis and Algirdas Rusakevičius, who are now Lithuanian delegates to ICES.

On 17 September 1997, the government of Lithuania submitted an application for membership in ICES, with the Danish Ministry of Foreign Affairs as depository of the ICES Convention, and almost immediately, the required three-fourths majority of ICES Member Countries voted to endorse the application. It was left to the Lithuanian Parliament to ratify the ICES Convention.

Hopkins says that, on the eve of his departure from ICES,"All of the official documents were piled neatly on my desk, but I left office without fulfilling that mission. They had repeatedly told me that the basic agreement had been lined up, but I believe that they had to prioritize, at the level of Parliament, financial commitments to a number of international organizations".

Lithuanian representatives had been attending ICES committees and meetings as observers for some time, but there was frustration on both sides. David Griffith, ICES General Secretary between 2000 and 2005, visited the country more than once, with Jan Thulin (then working on the Baltic Sea Regional Project (BSRP)) and ICES President Pentti Mälkki.

According to Griffith, "Nothing continued to happen. Whatever their hopes and goals, they were repeatedly overruled, I guess, over financial considerations". Griffith recalls an official in the Ministry of Environment reassuring him, "Yes, yes. It's definitely going to happen this time. We'll be a member of ICES before we join the EU".

Jan Thulin, who was instrumental in maintaining contacts between Lithuania and ICES, directed the ICES section of the GEF BSRP between 2000 and 2007. For him, realizing one of the BSRP's main goals, the implementation of the ecosystem approach to management in the Baltic, required the active participation of all Baltic countries, including Lithuania.

"Several BSRP planning meetings were held at the Ministries of Agriculture and Environment, and at the Klaipeda Fishery Research Laboratory and Klaipeda University. The project also provided economic support for delegates and scientists to attend ICES Annual Science Conferences and working group meetings. We considered it a priority".

▲ *The Curonian Spit is famous for its 31 km long coastal ridge of 40–60 m high drifting barchans. In 2000, the entire Curonian Spit, with its mature pinewoods, was added to the UNESCO World Heritage List as a Cultural Landscape of Outstanding Value. The Lithuanian Fishery Research Laboratory is located at the northern end of the spit.*

▲ *The sand dunes overlooking the town of Nida, on the Curonian Spit. Photo by A. Varanka.*

Welcoming the new member

On 30 March 2006, more than eight years after the application, Lithuania's Foreign Relations Committee recommended that Parliament ratify the ICES Convention. On 31 May, Lithuania deposited its instrument of accession with the Danish Ministry of Foreign Affairs, and on 1 October 2006, ICES welcomed its new member officially, proud that its membership now included all of the Baltic countries.

Like all ICES members, Lithuania benefits from the shared information and cross-fertilization that takes place within the organization, and now through its voting rights, the country is also part of ICES decision-making process. ICES benefits as well from Lithuania's participation, not the least from the data that Lithuania contributes, but according to ICES General Secretary Gerd Hubold, the synergy goes deeper.

"We can't evaluate an ecosystem or give advice without comprehensive scientific information on the area. Looking at it from the ecosystem approach, it is clear that we need to cover all the geographical areas, which means that input from scientists from all parts of the Baltic must be obtained and included in the ICES scientific process. This adds value to the work of the regional groups by making their research more relevant, when communicating intensively with other ICES scientists".

Lithuania became the first Baltic state to proclaim its independence on 11 March 1990. Lithuania joined the United Nations in September 1991 and, in May 2001, became the 141st member of the World Trade Organization. In March 2004, little more than a decade after independence, Lithuania was welcomed as a NATO member, and in May of the same year, Lithuania joined the EU.

Like most former members of the Eastern bloc, Lithuania has had to face the challenges of the necessarily rapid transition from a planned to a market economy. Today, Lithuania has one of the fastest-growing economies in the EU, and its 3.4 million citizens make up one of the most educated labour forces in Europe. The outlook for growth is generally encouraging, and this will have a positive effect on the development of Lithuania's marine research activities.

Maritime prosperity

Despite Lithuania's key location on the Baltic, the facts don't exactly recommend it as a maritime nation. Its coast is only 99 km long, with only 38 km of it bordering the open Baltic Sea (the rest of the coastline is sheltered by the sandy peninsula of the Curonian Spit). This means that it has the shortest coastline of any of the Baltic countries. The capital city, Vilnius, is far from the sea, and Lithuanian cuisine is not exactly renowned for its fish specialities. (Lithuanians eat 14 kg of fish per capita compared with a little more than 20 kg per capita in the EU.)

▲ *Algirdas Rusakevičius, Deputy Director General of the Fisheries Department, Ministry of Agriculture.*

▲ *Inesis Kiškis, Undersecretary of the Ministry of Environment.*

▲ *The Baltic fleet at anchor in Klaipeda harbour.*

In the second half of the last century, Lithuania was part of a large network, in which this whole corner of the Baltic coast was treated as one administrative unit. Lithuania, because of its deep-water harbour, Klaipeda, became part of a maritime network that stretched around the world.

Today, activities related to fishing and fish products contribute substantially to the total food industry output. In addition to the fishers themselves, many other people are employed in jobs that directly support the fishing industry, as well as in research, aquaculture, hatcheries, and restocking. The fish-processing industry produces approximately 80 000 tonnes of salads, smoked products, and frozen filets annually (from the Baltic fleet, the distant-water fleet, as well as imports), nearly 80% of which is exported to Western Europe, reflecting the overwhelming change in economic orientation from east to west.

Fisheries in Lithuania

Delegate Algirdas Rusakevičius, sitting in the new offices of the Fisheries Department in Vilnius, where he is Deputy Director General, enjoys telling the story. "It was huge, the Soviet system. For the fisheries, it was very good. The Soviet Ministry of Fisheries employed 5500 scientists. The sea institutes were part of a network that included colleges, universities, huge fishing fleets and supporting infrastructure, and research vessels. And the education has never been matched".

Although strictly centralized and dominated by Communist ideology, the system provided an excellent education in the sciences. As Rusakevičius adds, "You were guaranteed a job. This is something that we can't do today, and we're losing some of our best scientists to emigration and private industry".

The centre for marine research for the Baltic States was in Riga, Latvia, with other institutes in Tallinn, Estonia, and Kaliningrad, in Kaliningrad Oblast. Rusakevičius comments, "There was no research institute in Lithuania. At the time, the Klaipeda institute specialized in the research and design of electro-fishing equipment".

Hundreds of people were involved in fishing expeditions, which were meticulously planned to avoid waste of fuel and other resources. Rusakevičius recalls, "Even though fuel was extremely cheap, almost free at that time, one ship scouted target species and called the fishing ships directly to the spot. No wasted movement of the fleet. When they were full, the ships unloaded their catch on a mother ship that brought it to port while the others continued fishing".

The Fisheries Department of Lithuania, which is part of the Ministry of Agriculture, is primarily responsible for the fishing and fish-processing industries, as well as aquaculture. Its key activities are directed towards fishery development, scientific training, research, restocking, fish selection and breeding, and fish disease prevention. Much time is now spent complying with the EU fisheries policy, both regional and international, but clearly there is a great emphasis on maintaining and developing jobs and wages.

When Lithuania became independent, it lost its entitlement to the fishing rights covered by 62 earlier agreements. "At first, Lithuania had nothing to offer", says Rusakevičius. "The fishing companies suffered absolute collapse. No fuel, no salaries. Some of the ships were sold by the crews to get their salaries or were seized by countries for fishing in their waters when the agreements ran out". The collapse of the marine fishing industry is only one of the trials that Lithuania has had to endure, and the only option has been to keep going. Through privatization, the industry has been consolidated and is beginning to grow again.

Rebuilding the fisheries

At one time, the port of Klaipeda supported a large, distant-water fleet and the Baltic fleet. The combined fleet consisted of 138 vessels employing 11 000 people, including 90 stern trawlers. The distant-water fleet sailed to the Atlantic and Arctic oceans, and as far away as the Pacific and the east African coast.

Today, the distant-water fleet numbers 20 vessels (trawlers longer than 24 m), which are located in the North Atlantic off the southern tip of Greenland and the southwest coast of Iceland, in the Barents Sea near Svalbard, and off the west coast of Africa. Recently, Lithuania sent the second largest trawler in the world (with a length of 135 m) to the waters off Chile.

From its former total of 45 stern trawlers, the Baltic fleet now has 37 vessels (most less than 12 m long), which operate in waters up to the 20 m isobath. After the collapse of the fishing collectives, some of the ships were sold to individuals, while others were scrapped to comply with EU regulations. Funds have been provided by the EU to reduce the fleet's excess capacity and for the training of specialists.

Still, fishers are caught in the middle. Lower fishing quotas, resulting in diminished catches, as well as increasing expenses (booming fuel prices, rising salaries, maintenance and repair costs), conspire to prevent vessel owners from modernizing their ships or purchasing new ones. The existing fleet is out-of-date. Slowly, funds are being made available to modernize fishing equipment and onshore infrastructure, improve education, and promote scientific research.

Of course, after independence, declines were inevitable. Industrial production plummeted by 51.6% in 1992, as a result of the breakdown of traditional trading ties, especially the import of raw materials from the former Soviet Union.

Threads of culture

Delegate Šarūnas Toliušis has these matters on his mind as we take the car ferry to the Curonian Spit and the Klaipeda Fishery Research Laboratory, which he directs and which is Lithuania's only institute for marine fishery science. He reflects, "When we gained independence, there was euphoria. But independence must stand on firm economic ground. Many people lost their jobs. As soon as privatization started, the machinations began. Speculation and the bank crisis of 1995 robbed many people of what little savings they had".

He detects a shift in favour of English over Lithuanian, which of all the living Indo-European languages has best retained its ancient system of phonetics and most of its characteristic forms.

Cultural forms, such as the age-old custom of gender-specific surnames, are now being challenged. "For example, my name is Toliušis. My wife's name is Toliushienė. My unmarried daughter's name is Toliushaitė". Recently, Lithuanian law was changed to allow the use of the short form, which is gender-neutral and does not disclose marital status.

Lithuania's embrace of all things western puts pressure on the Lithuanian culture to confront influences competing with traditional ways. However, as in an ecosystem, there comes a tipping point when the consequences of such apparently insignificant erosions suddenly reveal unforeseen results. As Toliušis says, not without irony, "There's no regulation for this in the EU".

▼ *The sand dunes of Nida. Photo by A. Varanka.*

▲ *Hill of Crosses. The hill-fort of Jurgaičiai near Šiauliai, known as the Hill of Crosses, is one of the most prominent examples of the traditional Lithuanian handicraft of cross-crafting. The site has been named a UNESCO Masterpiece of the Oral and Intangible Heritage of Humanity. The tradition has its origins in the pre-Christian world. Adorned with symbolic geometric and floral decorations, crosses are erected in graveyards, by roads or at crossroads, or close to dwelling places.*

Research in Klaipeda

Toliušis has worked for 36 years at the laboratory and became its director in 1991, prior to its reorganization. The laboratory's ageing facilities have been partly renovated, and Toliušis points to a huge concrete basin (200 m long, 30 m wide, and 6 m deep), which was built entirely without metal in case it interfered with the electro-fishing experiments conducted in it years ago. He looks forward to the day when its renovation will allow the creation of an entire ecosystem in the basin for use in aquaculture experiments.

Romas Statkus, the laboratory's Deputy Director for Science, laments the lack of training currently available in fisheries. He recalls his experience. "Young scientists had to go abroad to gain knowledge and experience. We had to learn the procedures of fisheries research. It took a long time, I'd say ten years, to get where we are now".

Toliušis and Statkus are looking forward to the establishment of the Klaipeda "Valley of Science and Technology". This is one of six "Valley" projects, which are being developed to support research and education by integrating them with businesses, with the aim of developing marketable products and services. This "Valley of Science" is being planned in cooperation with Klaipeda University and will create laboratories for the study of all aspects of the marine environment. Renovation of the world's largest concrete basin will be one of the projects.

Another interesting development is the Klaipeda fish auction. With its overhead doors opening on to the docks that shelter Klaipeda's Baltic fleet, the auction, which opened last April, enables fish-buyers to bid for fish, using a state-of-the-art electronic system, as the fish are being sorted and cleaned in the halls below. According to auction director Vaidas Marcinkėnas, the facility will typically handle 25–40 tonnes of fresh fish daily.

Vaclovas Petkus, Director of the Baltic Sea Fisheries, believes, "The auction will stabilize and raise prices and improve the fishers' working conditions. Market demand will dictate the price, not the retailers. But primarily the aim is to discourage the selling of illegal catches. The auction will be the only legal place for fishers to sell their catches".

So, despite the problems created by sudden independence and the transition to a market economy, there are many hopeful signs that, materially, Lithuania will soon catch up with the rest of Europe.

Environmental issues

Inesis Kiškis, Undersecretary of the Ministry of Environment, was an early supporter of Lithuania's bid to join ICES. "When independence came", he says, "we started with a clean slate. The learning curve was steep, and we learned by doing. There were many bruises, even some black eyes".

But he is proud of the rate at which Lithuania is moving towards compliance with existing EU requirements, such as the Water Framework Directive and the Urban Wastewater Directive. Kiškis

◀ *Šarūnas Toliušis, Director of the Klaipeda Fishery Research Laboratory, and Romas Statkus, the Laboratory's Deputy Director for Science, stand beside the largest concrete basin in Europe.*

points out the difficulties, however. "Even without the problem of increasing costs, if we invest in new infrastructure to meet the targets, we will have to raise the cost to consumers. Given current income levels, people won't be able to pay for services, which is worse than not providing any services".

Another environmentally charged issue is the closure, by the end of 2009, of its only remaining nuclear power plant, one of the conditions of its admission to the EU. The plant produces 80% of the country's electrical power, and this has become a point of friction between Lithuania and its new partners.

In Kiškis's view, "What can we do but improve our energy efficiency? The long-term answer is to create a clean, integrated, region-wide energy scheme that doesn't rely on Russian gas. Lithuania, Latvia, Estonia, and Poland are discussing the construction of a 3200 megawatt reactor that would supply a Baltic-wide power grid".

Lithuania has scored high marks in many international environmental performance rankings, certainly spurred on by EU membership, but also by a sense of responsibility. It gives a hopeful message that the problems involved in the development of the vulnerable areas of marine research and education are being taken seriously.

In spite of sibling rivalries, the countries surrounding the Baltic have always formed a family. Lithuania's membership in ICES, and the cooperation and shared experience that is a natural result of ICES work, is one more way that those ties will be strengthened.

It has been observed that Lithuania and the other Baltic nations are moving towards a more Scandinavian economic and social model, with all that that implies for the environment and funding for science programmes. Nevertheless, although Lithuania is not special in the problems that it has, it will be unique in the solutions that it finds.

Biography

William Anthony is ICES Executive Editor. Jan Thulin contributed to this article.

A related interview with Jan Thulin is available on the ICES website: http://www.ices.dk/products/insight/extra.asp. In it, Thulin discusses the changes that he has observed in the Baltic during his many years of intimate involvement in the region, as well as the things revealed to him behind the Iron Curtain since his first visit there as a young sailor in 1963.

Technical University of Denmark, National Institute of Aquatic Resources (DTU–Aqua)

Activity was intense this summer on board and in the laboratories of DTU–Aqua's largest research vessel, RV "Dana", during a cruise to West Greenland.

The 70-meter vessel carried 20 scientists from five institutes from mid-July until the start of August, each with a different scientific background. Their purpose was to investigate the dynamics of the marine ecosystems in West Greenland, including the relationship between climate change and conditions of cod larvae in their nursery areas.

During the cruise, the crew launched various equipment no less than 375 times – equipment that was used for everything from catching fish larva to measuring carbon on the fjord bed.

The "Dana" began its work on the fishing banks off Nuuk and continued sampling in the beautiful Godthåb fjord, using a series of stations extending to the edge of the ice, where water from the glacier freshens the water. As a result of global warming, such freshening could be increasing in these areas.

Peter Munk of DTU–Aqua explains, "The overall aim of the cruise was to investigate how climate change can affect the marine life around Greenland. This will contribute to evaluation of the effect of climate change on Greenland's economy. For example, we might expect changes in the amount of shrimp and cod in West Greenland, or we might see other changes in the biological resources that can have significant consequences for the Greenland people".

West Greenland's marine ecosystems are very productive and provide the basis for an important fishery, especially halibut and shrimp, which makes up a large part of Greenland's export. The area is also important for large groups of seals and whales, who search for food in the area during summer, as well as for millions of seabirds from the North Atlantic who overwinter in the ice-free area.

A possible future scenario might be that increasing amounts of melting water, flowing into fjords such as Godthåb, will enhance the water exchange between the fjord and the sea. More fresh water will flow to the area outside the fjord, while nutrient-rich water is drawn into the fjord. This can lead to greater production of algae and finally provide more food for fish, birds, and mammals in the fjord. A further scenario of climate change might include changes in the major currents flowing along the Greenland coast, which would alter conditions for plants and animals living in these areas.

Earlier the advice considered, to a large extent, the development in single populations. However, a changing climate demands increasing understanding of the effect on the environment and the interrelationships between the species, to improve advice for the fishery.

The "Dana's" cruise in the Godthåb fjord is a part of the ECOGREEN project, which focuses not only on individual species but also on a long chain of relationships in the ecosystem and subsequently on the possibilities for modelling the influence of climate change. The research team on the "Dana" have been looking at almost everything from sedimentation on the seabed, algal growth, and number of shellfish to fish larvae in the water.

Torkel Gissel Nielsen, DMU's head of ECOGREEN said recently, "This project is particularly useful because we gain knowledge from many different research areas and combine them. This means that we gain an understanding of a fjord and a neighbouring sea area that is unique in an international connection".

ECOGREEN is a joint project of Greenland's Nature Institute, Denmark's National Environmental Research Institute (DMU), Denmark's Meteorological Institute (DMI), Denmark's Technical University (DTU–Aqua), and several other Danish and international partners.

▼ *RV "Dana" in Godthåb fjord.*

Along for

A Parasitic Threat to Northern

For three decades, a tiny parasite with an impressive talent for reproduction has caused severe problems among wild populations of Norwegian salmon. Kurt Buchmann wonders if it is too late to prevent other European salmonids from falling victim to Gyrodactylus salaris.

Half a century ago, Swedish scientist Göran Malmberg discovered and named a tiny parasite living among the salmon in a local hatchery. The otherwise ordinary flatworm had one distinguishing characteristic: It reproduced blindingly fast. Inside each millimetre-long worm, a daughter worm was already developing, which in turn held its own embryonic offspring – three generations nested inside each other like Russian matryoshka dolls. In a matter of weeks, thanks to their viviparous birth strategy, two worms could become two thousand.

The salmon in the Swedish hatchery, however, didn't seem much bothered by *Gyrodactylus salaris*, and so the parasite took its unremarkable place among the hundreds of other leech-like *Gyrodactylus* species, where it stayed for nearly three decades.

In 1975, a devastating epidemic attacked salmon in the rivers of northern Norway. At the same time, a die-off of fresh-water salmon struck a farm in the Norwegian city of Sundalsøra. Both populations were found to be overrun with *Gyrodactylus*. Thirty years after his initial discovery, Malmberg was called upon to investigate. With detailed reports and a series of subsequent investigations, he proved beyond a doubt that *G. salaris* was responsible for the salmon die-off. Only a small percentage of the Norwegian salmon that had been struck with the parasite survived.

The tiny but fruitful parasite that Malmberg had observed living harmlessly with Swedish salmon in 1957 was deadly to the Norwegian strain, which had never encountered it before. Whereas the hatchery salmon came from a Baltic strain that had adapted to survive *G. salaris* over thousands of years of exposure, the Norwegian salmon had never shared waters with the parasite.

The devastating attacks on the Norwegian salmon by this monogenean ectoparasite were caused by anthropogenic introduction. In the 1970s, infected Baltic juvenile salmon were trucked to Norway and released. In the following decades, the flatworm spread to 46 rivers, decimating the salmon population. Thanks to the parasite's impressive capacity for reproduction, a fish infected with just a few parasites can be dead within weeks. After five to six weeks, a single fish fry can be covered with more than 2000 parasites; the dissection microscope reveals a fish totally covered with the parasite.

Keep me hanging on

The parasite, an ectoparasitic flatworm, does its damage not only while feeding (meal of choice: mucus and epithelial cells of the host's skin) but through its attachment technique, which requires the insertion of 16 hooklets that pierce the fish's epithelium, compromising its osmoregulatory function and leaving it vulnerable to fungal and bacterial infection.

Norwegian researchers believe that the parasite's quick spread could have been helped along by the migration of infected salmon from one river to another via low-salinity fjords. The parasites may have also hopped a ride on a range of fish species that can carry the parasite without allowing excessive propagation, such as brown trout, Arctic charr, grayling, eel, stickleback, flounder, and other species that can sustain low infections for weeks.

the Ride:

European Salmon

In addition, humans may have unintentionally had a hand in spreading the parasite beyond the release point by transferring infected fish and fishing tackle from one water body to another. Anglers may even have accidentally transported the parasite by using infected gear in a previously uninfected river.

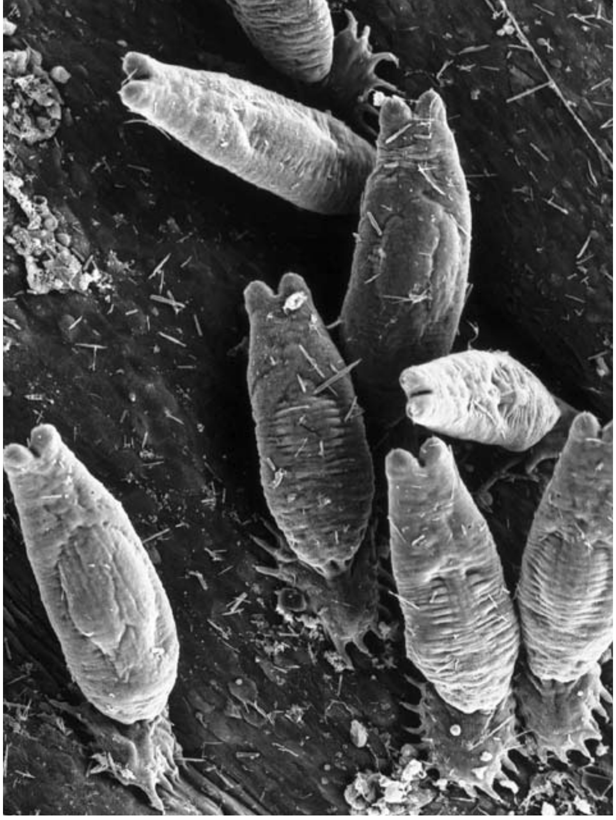
A careful watch

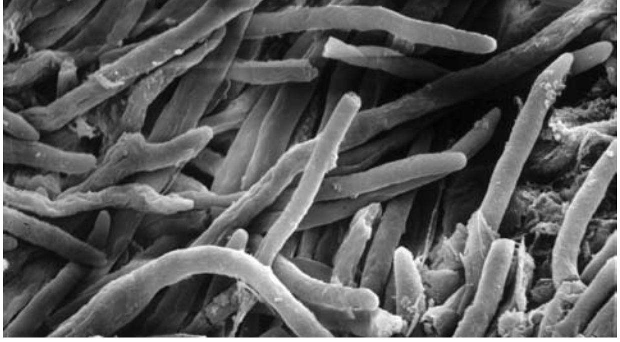
The parasite's original area of distribution is believed to be the Baltic drainage area, including rivers in Sweden, Finland, Russia, the Baltic republics, where it is still widespread, and probably also Poland and Germany. In contrast, Norwegian rivers draining into the Atlantic were probably free of the parasite until its unintentional introduction during the 1970s.

Today, a careful watch is being kept for the parasite throughout Europe. The pathogenic type has not been reported in Italy, Spain, Portugal, France, and Denmark, and when German isolates are fully characterized, they may prove to be non-pathogenic. The parasite has not been found in the UK and Ireland so far, and an extensive monitoring programme is already underway there in conjunction with strict fish import regulations.

Denmark seems to have inherited a non-pathogenic strain of the parasite. Laboratory experiments have shown that stocks in Denmark, despite their exposure to the non-pathogenic form of the parasite, are still highly susceptible to the deadly Norwegian form. Monitoring programmes there should take advantage of currently available molecular methods to distinguish between the two forms.

In a matter of weeks, two worms could become two thousand.





▲ *Injuries caused by the worm's feeding activity can provide access for secondary pathogens, such as fungi. Shown here is the fungal pathogen* Saprolegnia parasitica *hyphae on the skin of infected salmon. Scanning electron micrograph by K. Buchmann and J. Bresciani.*

◀ Gyrodactylus salaris *is a hermaphroditic flatworm that infects the skin and fins of salmon. The attachment organ, the so-called opisthaptor, is in the worm's hindquarters. It carries 16 small marginal hooklets that are inserted into the epithelium of the host. Scanning electron micrograph by K. Buchmann and J. Bresciani.*

Today, a careful watch is being kept for the parasite throughout Europe.

Chemical solutions

Preventative measures to keep the pathogenic parasite from spreading begin with strict new rules and sanitation measures, regulating traffic between fishing sites, and requiring potentially contaminated fishing gear to be dipped in disinfectant before being used at another site.

Once the parasite has gained a foothold, however, more radical solutions are called for. Some local governments have treated entire river systems with chemicals, such as Rotenone. Pumped or sprayed into a river system, Rotenone effectively eradicates the parasite – but it takes the fish with it! Though rivers are subsequently repopulated with uninfected fish, this baby-with-the-bathwater approach has drawn criticism from media, appalled by the spraying of chemicals and images of floating dead fish, and environmentalists who fear greater environmental fallout. And although a number of Rotenone-treated river systems have remained disease-free, the parasite has made its way back to several previously treated rivers.

Low concentrations of aluminium sulphate are able to kill the parasite without seriously damaging the salmon population. The chemical is now being fed into Norwegian water systems, but is unlikely to be a "quick fix". The struggle against this invasive parasite is likely to continue for decades.

Reading the blueprint for resistance

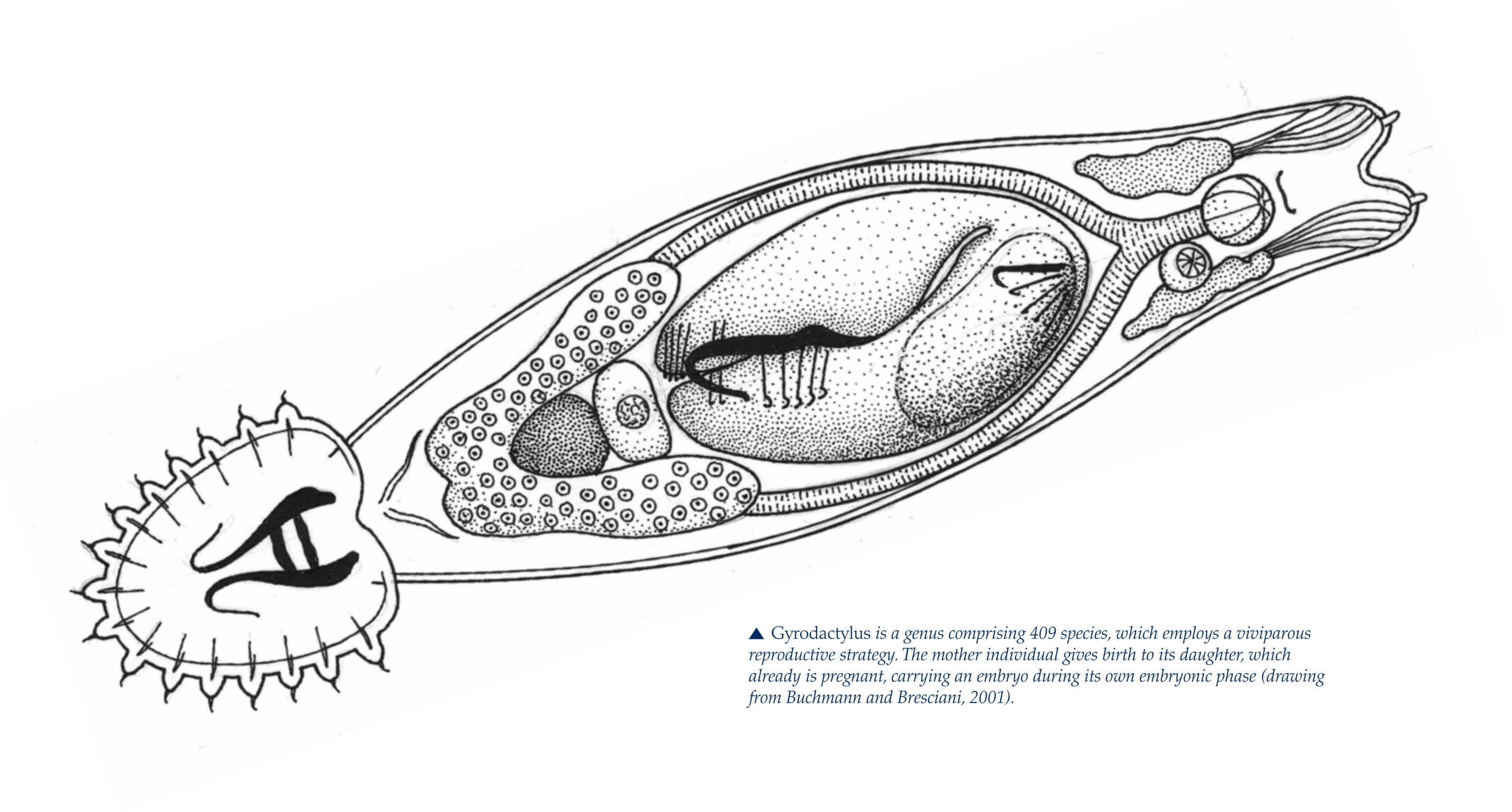
Baltic salmon strains have developed innate mechanisms to control excessive parasite growth, eliminating the need for chemical extermination. Although the parasite attaches easily to juvenile Baltic salmon, within three weeks, the parasite virtually disappears from the Baltic strain, leaving only a few parasites per fish.

How do Baltic salmon stave off the kind of overwhelming infections that devastate Norwegian strains? Researchers believe that this resistance is the result of a selection process that occurred after the Baltic salmon's first exposure to the parasite, which dates back to the formation of the fresh-water Lake Ancylus at the end of the last glacial period. The lake later became connected to marine Atlantic waters by a strait running through southern Sweden. It is likely that the Baltic salmon first met the endemic parasite at this time. After several thousand years, the Baltic salmon developed resistance, probably as a result of high mortality at the fry stage.

Researchers have found that the resistance mechanisms are linked to cellular and molecular elements in their skin.

In contrast, the regulation of immune factors in the skin of vulnerable East Atlantic salmon (from Scotland, Ireland, and Denmark) is unbalanced. Even low infections initiate expression of the cytokine IL-1 beta, encouraging skin mucus production, which only serves to support the propagation of parasites that feed on mucus and epithelial cells.

Resistant salmon exhibit no early expression of interleukin, avoiding this vicious immunological cycle. Instead, they activate genes linked to immunity, such as Mx, MHC-I, IFN-gamma, SAA, and CD8, which causes a rapid decline of the parasite on fins and skin. Important among immune components, the so-called innate factors (such as serum factor SAA, complement, natural killer cells) are ready to use even if the host has never encountered the parasite before. They can bind to pathogens and, in some cases, will eliminate the intruders. So-called adaptive immune factors (including antibody production and specific T-cells) may be less important. In any case, specific antibodies against *G. salaris* are not produced in infected salmon skin.



▲ *Gyrodactylus is a genus comprising 409 species, which employs a viviparous reproductive strategy. The mother individual gives birth to its daughter, which already is pregnant, carrying an embryo during its own embryonic phase (drawing from Buchmann and Bresciani, 2001).*

Thus, millennia of natural selection have given Baltic salmon an effective arsenal against the parasite. In the future, breeding programmes could introduce resistance factors into susceptible populations to control the prevalence of the disease in certain stocks.

Prevention first

Despite the promise of breeding programmes and chemical treatments, it is clearly better to prevent these pests from ever entering vulnerable areas than trying to amend the problem after *G. salaris* has already set up shop. The drastic chemical approaches applied in Norway are both environmentally and economically costly and talk their own clear language. Manipulating the genomes of native salmon populations represents an equally unsavoury option from the preservationist's point of view.

The first, sound step, therefore, would be to protect uninfected populations by implementing strict monitoring and import restrictions in areas infected with the pathogenic parasite form.

Thirty years of research have given us an impressive arsenal against *G. salaris*, but each of these weapons has ethical, environmental, and economic consequences. Through meticulous preventive methods, we hope to protect vulnerable waters and avoid the need to take up these weapons at all.

Gyrodactylus salaris' attachment technique requires the insertion of 16 hooklets that pierce the epithelium.

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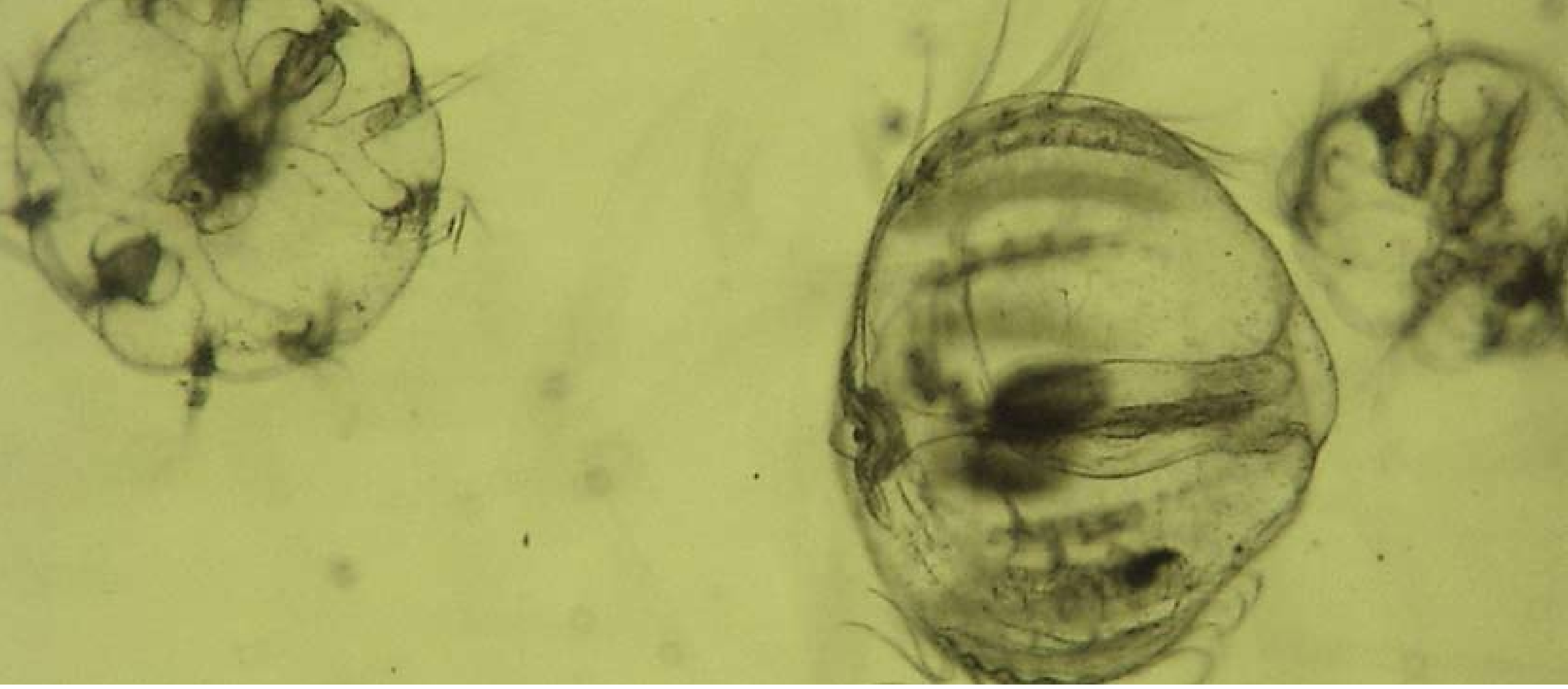
Biography

Kurt Buchmann is professor of Aquatic Pathobiology on the faculty of Life Sciences, University of Copenhagen, Denmark. He has devoted the past 25 years to the study of fish pathology, with an emphasis on parasitology and immunology and their ecological aspects. His special interests are skin parasites and skin immunity.

Kate Becker contributed to this article.



▲ *An example of the polymorphic species* Mnemiopsis leidyi *A. (Agassiz, 1865) taken from the western Baltic Sea in autumn/winter 2006. Cydippe stages, size approximately 0.01 cm. Photo by L. Postel.*

A Matter of Time and Temperature: The Spread of *Mnemiopsis leidyi*

The proliferation of alien jellies in northern European waters is causing alarm. The potential for serious harm to the ecosystem has been acknowledged, but Mnemiopsis leidyi's *(A. Agassiz, 1865) introduction might not have the severe consequences that led to the collapse of the Black Sea anchovy industry in the 1980s. Lutz Postel and Sandra Kube call for the evaluation of possible environmental and economic impacts that the comb jelly could have, but emphasize that currently lower abundances put the potential damage into perspective.*

The incursion was unexpected. Initial reports of the lobate ctenophore *Mnemiopsis leidyi* appeared in 2006, with first sightings along many coastal areas of northern Europe, from the southern North Sea to the southwestern Baltic Sea. Although ctenophores native to the middle and surface waters of these areas had never seriously affected the foodweb, this alien invasion had unfortunate precedents in the Black and Caspian seas.

A black day

Mnemiopsis leidyi was first sighted in the Black Sea in 1982, following its probable transfer from the Atlantic coast of North America via the ballast waters of oil tankers. In Black Sea waters, full of nutrients, *M. leidyi* found ideal feeding conditions, and the absence of a natural predator along with optimal reproduction temperatures allowed *M. leidyi* to spread massively. Within ten years, the zooplankton mass of the Black Sea had been drastically reduced, and the fishing industry, based on the already extremely exploited European anchovy (*Engraulis encrasicolus*) stocks, collapsed.

In 1999, *M. leidyi* was sighted in the southern Caspian Sea and, over the next few years, it spread northwards. Again, the zooplankton biomass decreased massively (by almost tenfold from 1998 to 2000), and from 2000 to 2004, catches of the anchovy kilka (*Clupeonella engrauliformis*), the most abundant species of fish in the Caspian Sea, dropped fivefold (Shiganova, 2002; Daskalov and Mamedov, 2007).

An appetite for reproduction

These ctenophores have two major characteristics that should cause concern in northern European waters: their remarkable nutritive demand and their large reproductive capacity.

When feeding, *M. leidyi* ingests any organism that it can capture in its oral lobes, including mainly planktonic crustaceans, such as the minute cladocerans and crustaceans, as well as fish eggs and fry. When food is abundant, it continues feeding, despite a full "stomach" (stomadeum), then regurgitates excess undigested food in a bolus of mucus. Conversely, it can survive starvation periods, during which it might undergo a two- to threefold reduction in size in as little as two weeks of starvation. However, it grows to a maximum size of more than 20 cm under ideal conditions.

As all planktonic ctenophores, *M. leidyi* is a self-fertilizing hermaphrodite, with both ovaries and spermatophore bunches. Thus, viable offspring are produced from each adult with the start of egg production, generally considered to indicate the adult stage; this occurs approximately two weeks after spawning and long before they reach their upper size limits. With egg production highly correlated with wet weight (Shiganova, 2002), each adult will produce 600 to 1000 eggs per day on average, with maximum levels of more than 7000 eggs per individual per day.

At the same time, *M. leidyi* demonstrates broad ecophysiological plasticity regarding environmental factors (Kube *et al.*, 2007a), mainly sea temperature, salinity, and dissolved oxygen. Indeed, sea temperature is the main factor determining the abundance of *M. leidyi.* It can be found at temperatures from 1°C to 32°C in its natural habitat in North American Atlantic coastal waters (Shiganova and Panov, 2003), although its ideal reproductive temperature starts around 20°C. Similarly, the salinities of its natural habitat can vary from 5 PSU to 38 PSU, and it can survive at very low dissolved oxygen of 0.2–0.3 mg l^{-1}. The success of *M. leidyi* in the eutrophic seas of the eastern Mediterranean is thus closely linked to water temperatures ranging from 4°C to 31°C and salinities of 3 PSU to 39 PSU.

Coming to a sea near you

Although the first North Sea sightings occurred in 2006, it is likely that *M. leidyi* was introduced to the North Sea earlier. Earlier sightings were probably misidentified. For example, in 2001, a mass occurrence of ctenophores was reported in Dutch waters and was attributed to *Bolinopsis infindibulum* (Faasse and Bayha, 2006). On first inspection, these two polymorphic species are similar; however, differentiation is restricted to middle-aged and adult specimens. Indeed, indications are that transfer occurred following a mass occurrence of *M. leidyi* in and around Boston Harbor in 2000, carried in ballast water along the permanent shipping lanes between the US and Rotterdam and Antwerp.

The potential threat of this invasion makes close monitoring of the patterns of spread imperative. After the 2006 sightings and into spring 2007, *M. leidyi* spread from the southwestern Baltic Sea to the southeastern Gotland Basin. Although it was found in the entire water column in Kiel Bight (up to 90 individuals m^{-3} in autumn 2006), it occurred exceptionally below the halocline in the deep stratified central Baltic basins in low concentration. Abundance was less than 1 individual m^{-3} throughout the entire winter/spring period at temperatures around 10°C, salinities between 10 PSU and 14 PSU, and dissolved oxygen between 1 and 3 mg l^{-1}. Thus, *M. leidyi* clearly survived the 2006/2007 winter in the Baltic Sea and began to extend its distribution range farther into the northern Baltic Sea during 2007 (Kube *et al.*, 2007b; Lehtiniemi *et al.*, 2007).

Within ten years, the zooplankton mass of the Black Sea had been drastically reduced, and the fishing industry collapsed.

By late summer 2007, *M. leidyi* had spread to the entrance of the Gulf of Finland and the central Bothnian Sea, with the highest densities, including juveniles, found in water layers around the halocline. There were also reports of clusters of *M. leidyi* in a number of locations around the Gulf of Gdansk in the southern Baltic Sea off Poland in October and November 2007 (Janas and Zgrundo, 2007). In December 2007, it was also found in small numbers in the eastern Gulf of Finland (Lehtiniemi *et al.*, 2007). Current model computations support the space-temporal spreading by passive transport (T. Neumann, pers. comm.).

The earliest reports of *M. leidyi* from Danish waters relied on photographed specimens collected in late summer 2005 and 2006. From early 2007, numerous sightings and some mass occurrences were reported throughout inner Danish territorial waters along the coastal and estuarine areas of Jutland, Funen, and Zealand (Tendall *et al.*, 2007). From 2007 to 2008, *M. leidyi* again overwintered in the southwestern Baltic Sea and in Danish waters (Riisgård *et al.*, 2007). Interestingly, a report in early 2008 also showed *M. leidyi* overwintering in the deep waters of the Åland Sea in the northern Baltic Sea (Lehtiniemi *et al.*, 2008).

There was a considerable west–east gradient in the summer 2007 abundance of *M. leidyi* in the southwestern Baltic, ranging from 500 individuals m^{-3} in Kiel Bight in June 2007 and 100 individuals m^{-3} in Mecklenburg Bay in September 2007 to tenfold to 100-fold lesser abundance east of Darss Sill.

▼ *Examples of the polymorphic species* Mnemiopsis leidyi *(A. Agassiz, 1865) taken from the western Baltic Sea in autumn/winter 2006. Middle-aged specimen, views from the side (photo left) and top (photo center), size approximately 3 cm; (photo right) adult specimen, size approximately 8 cm. Photos by L. Postel.*

Sightings of M. leidyi *from 2006 to 2008 in the southern North Sea and the relevant sources.*

1 – *November 2006 (possibly as early as 2001). Faasse and Bayha (2006).*
2 – *November–December 2006. 0.1 ind. m^{-3}. Boersma* et al. *(2007).*
3 – *Late August 2006. "Thousands per catch…." Hansson (2006).*
4 – *Oslofjord. Oliveira (2007).*
5 – *17 October 2006 (first record). 109 ind. m^{-3} in November, declining to 0.2 ind. m^{-3} in March 2007. Javidpour* et al. *(2006).*
6 – *First records from summer 2006. Identification as* M. leidyi *in October; overwintering in deep waters of the central Baltic Sea and in shallow areas of the western Baltic Sea. Kube* et al. *(2007a).*
7 – *Late summer 2007 (halocline). Lehtiniemi* et al. *(2007).*
8 – *Gdansk Bight. Janas und Zgrundo (2007).*
9 – *Danish waters. Tendall* et al. *(2007).*
10 – *Overwintering in deep waters of Åland Sea. 3800 ind. m^{-2}; approximately 13 ind. m^{-3}. Lehtiniemi* et al. *(2008).*

Limiting factors

It is interesting to note that, although some 80% of the individuals from Mecklenburg Bay were juveniles 1–2 mm in size, overall for the Baltic Sea, the adult specimens have been three times smaller than those found in the Black Sea. Owing to the close relationship between size and reproduction capacity of *M. leidyi*, this offers some limiting effects on the spread of *M. leidyi* in the waters of northern Europe.

How might this year-to-year spread affect the fishing industries of northern Europe? Although to date, there is little direct data available to define the possibilities with any certainty, initial indications are that the spring spawning of herring (*Clupea harengus*) in the southwest Baltic Sea and cod (*Gadus morhua*) in the Belt Sea should be safe, inasmuch as the distribution of their fry does not coincide with any reported mass occurrences of *M. leidyi*.

Reminiscent of the anchovy industry of the Black Sea, however, the summer spawning of the already highly exploited cod stocks of the central Bornholm Sea could be at risk, as indicated by reports of the co-occurrence of *M. leidyi* and fish eggs and fry in the same water layer near the halocline in central Bornholm Basin in summer 2007 (Haslob *et al*., 2007). Similarly, although stocks of sprat (*Sprattus sprattus*) are currently high in the Baltic, competing for food with *M. leidyi*, the sprat spawning migration into the Bornholm Basin during spring and early summer could well promote the spread of *M. leidyi* (Huwer *et al*., 2008).

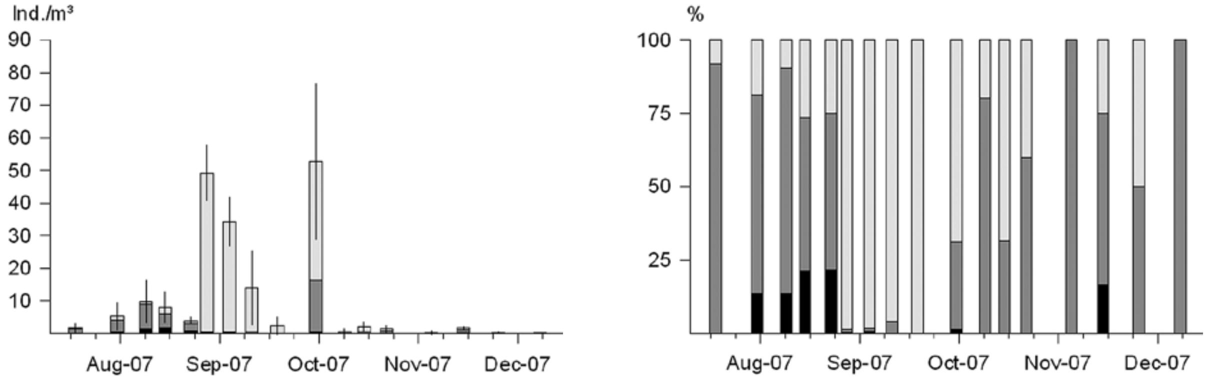
Although the abundance reported in 2008 for *M. leidyi* in the Baltic has remained low – by a factor of three compared with 2007 – observation of the spread and stock development of *M. leidyi* in these waters must be maintained. With its overwintering in the Baltic Sea now established, and with some reports of great abundance in the warmer and more eutrophic inland areas of coastal Denmark that could well act as donor areas, *M. leidyi* might be capable of spreading into the important fish spawning grounds of the central Bornholm Basin (Huwer *et al*., 2008).

Considering *M. leidyi's* capacity for physiological and genetic adaptation and the fragility of the foodweb, it is clear that urgent and resolute evaluation of these conditions is necessary. Memories of the Black Sea disaster will impel action.

Memories of the Black Sea disaster will impel action

Mnemiopsis leidyi *and a copepod,* Temora longicornis. *The photo was taken last January on board RV "Aranda" (FIMR) in the central Baltic by Jan-Erik Bruun, Finnish Institute of Marine Research.*

Mnemiopsis leidyi. *The photo was taken last January on board RV "Aranda" (FIMR) in the central Baltic by Jan-Erik Bruun, Finnish Institute of Marine Research.*



▲ *Average abundance ± standard deviation (top) and relative abundance (bottom) of* Mnemiopsis leidyi *of three different size classes in summer/autumn 2007, off Warnemünde (Western Baltic Sea). >2 cm (black), 0.5–2 cm (grey), <0.5 cm (light grey). The specimens were caught with WP2 net (400 µm mesh size; Kube* et al.*, 2007b).*

M. leidyi is a self-fertilizing hermaphrodite, with both ovaries and spermatophore bunches.

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Note that all issues of Aquatic Invasions are available free online at www.aquaticinvasions.ru/

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Biographies

Lutz Postel is senior scientist at the Leibniz Institute for Baltic Sea Research, Rostock-Warnemünde, Germany, and lecturer at Rostock University. In addition to his contributions to the ICES Zooplankton Methodological Manual, his areas of research include space–temporal distribution, decadal-scale variability, metabolic activity and growth of zooplankton, foodwebs, oxygen minimum zones, neozoa, and jellies.

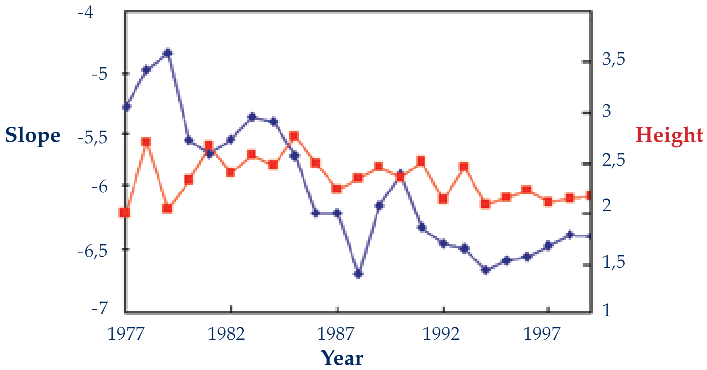
Sandra Kube is employed at the recently founded Interdisciplinary Faculty of Rostock University, Germany. She was engaged in a short-term project for monitoring and assessment of Mnemiopsis leidyi *in the southern Baltic Sea at the Leibniz Institute for Baltic Sea Research, as well as in EU-funded projects on Changes in Biodiversity (BIOCOMB) and Biological Effects of Environmental Pollution (BEEP).*

Chris Berrie, a freelance science writer based in Italy, contributed to this article.

That's About the Size of It

The role of predator–prey interactions in the dynamics of populations has engaged marine researchers for decades, and is one of the "hard problems" facing them. In this companion piece to his 2008 Annual Science Conference plenary lecture on size-based models, Jake Rice traces their early development (by a group of scientists whose members have subsequently become elder(ly) ICES statesmen) to the intriguing insights that they are currently providing.

Marine foodwebs tend to be highly reticulate: Most predators eat many different types of prey; most prey is food for many types of predators. Moreover, as Rodney Jones emphasized more than half a century ago, a single marine species is likely to eat many types of prey as it grows from larva to adult, and it will grow through the prey fields of many different predators on its journey to adulthood. Capturing these patterns of marine predation in datasets requires an extensive sampling effort; capturing them in models requires many different interaction parameters.



▲ *Temporal change in the slope and height of the North Sea size spectrum, 1977–1999*

ICES mounted a major attack on the challenges of quantifying and modelling marine foodweb interactions in the 1980s and early 1990s. During the Year of the Stomach in 1981 and Return of the Year of the Stomach in 1991, many tens of thousands of predator stomachs in the North Sea were collected and analysed. The Multispecies Assessment Working Group, which counted some of the best modellers in the ICES community as members, laboured for several meetings (and intersessional periods) to get an operating run of a multispecies virtual population analyses (MSVPA) for the North Sea and estimate its several thousand parameters.

It took a few more years before it was possible to test and validate the model with sufficient rigour to allow its use as a component of the scientific basis for management advice. Even then, the role of MSVPA was modest – periodically updating the estimates of natural mortality in the single-species stock assessments that form the basis for management advice. Moreover, only five or six species of predators and about the same number of prey were initially included in the model, although by the beginning of the 1990s, a few more species had been added.

Then and now

That was then: In the 1980s, the very notion that accounting for predator–prey interaction in marine population dynamics might be of value was questioned. The accomplishments, although easy to present as modest, were in fact conceptual and practical breakthroughs. However, they were a long way from being able to address the interactive dynamics of marine foodwebs. Only a few of the species in the system could be captured quantitatively, and yet the number and complexity of their interactions pushed the limit of the science of the day.

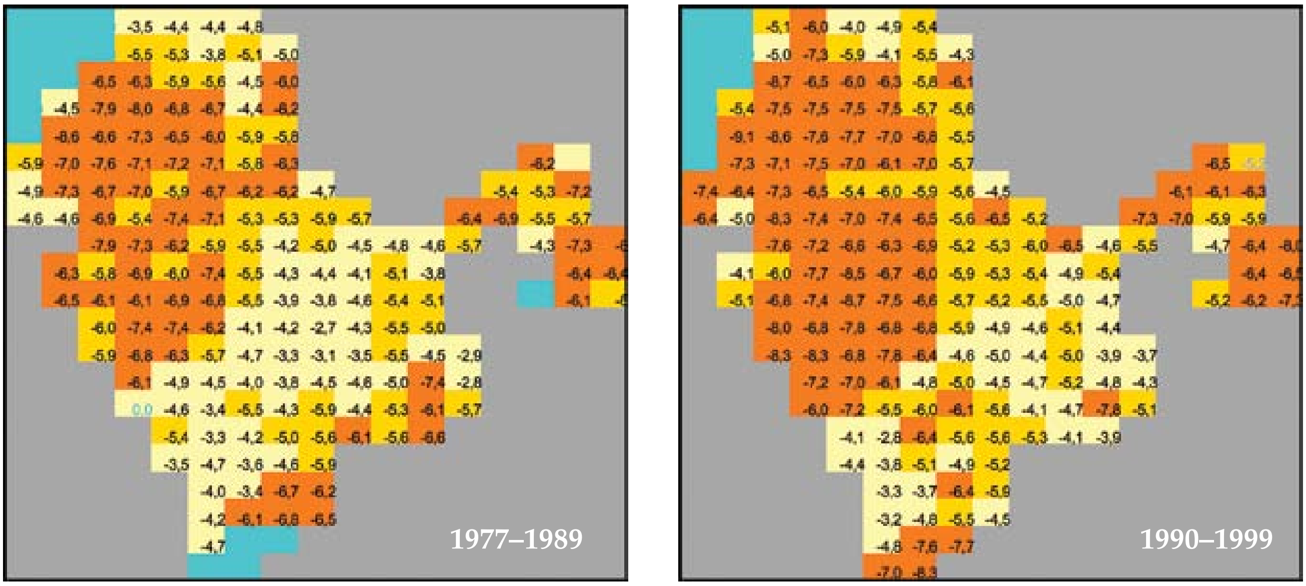
This is now: Virtually every fishery management authority on the planet has made an explicit policy commitment to applying an ecosystem approach to its management, and at least an implicit commitment to applying it to the population analyses that make up the scientific basis for management decisions. The ecosystem approach makes substantial demands: extensive bookkeeping of the role of species interactions in the dynamics of the populations in the community; continued consideration of the expected variation in the living resources being managed; and management of the fishery's impact on the structure and flow of energy in the foodweb.

Experts involved in the MSVPA drew two important conclusions from the exercise that today are highly relevant to the endeavour of applying the ecosystem approach to science and management advice. First, species interactions are sufficiently important to be a required part of the scientific basis for taking an ecosystem approach. Second, these interactions are simply too numerous and complex for a species-based approach to the interactions to be practical.

None of us believes that species are wholly irrelevant, either in foodwebs or in fisheries.

Size vs. species

By the end of the 1990s, experts were exploring the insights provided by viewing the process of predation in the sea as a fundamentally size-based process rather than a species-based one. This approach is built on a well-developed body of research into the "biomass size spectrum" in the sea, where "size spectrum" refers to the linear negative slope of a plot of biomass by size class of organisms in the sea. This was first observed empirically but was quickly grounded in a theoretical and conceptual explanation based on the flow of energy in marine ecosystems.



▲ *Temporal changes in the distribution of size spectrum slopes*

These studies began by looking for patterns in the slopes and intercepts of fish community size spectra, using data from research surveys. In a given survey, biomass and abundance slopes over size classes of the surveyed fish community became steeper over time, at rates that corresponded well to the intensity of fishing during those periods. For surveys in large areas like the North Sea, the slopes in different subareas were also different, again corresponding to the differences in the areas' fishing histories. These findings were encouraging enough for researchers to develop dynamic size-based models, where the intensity and selectivity of fisheries could be manipulated and assumptions about the processes underlying the patterns that were being found could be explored.

The rewards of simplicity

Adopting this size-based view of predation paid a couple of important dividends. First, the modelling was much more tractable than with species-based models. Against several performance benchmarks derived from real-world North Sea data, our size-based models, needing only a couple of dozen parameters to represent fishing, predation, growth, and survivorship of the fish community, performed as well as or better than competing species-based models that needed a couple of thousand parameters. This simplicity makes it possible to track the consequences of manipulating individual parameters, something quite difficult in models that are more structurally complex.

Second, we were able to integrate many advances in life-history theory and evolution with our dynamic size-based models. This brings a rich theoretical field of research directly into our exploration of the interactions between fisheries and marine foodwebs.

We have only begun to explore the insights made possible by the linkage of two lines of research with long histories, but the results are exciting. Most recently, we have even been able to include environmental forcing in these size-based models, adding only a few additional parameters to reflect how the environment, particularly temperature, may affect the life-history processes in these models. The prospect of having both species interactions and environmental forcing dynamically present in models that are still simple enough to understand brings us even closer to the science tools that are needed for an ecosystem approach to management.

▼ *The results of the work done during the Year of the Stomach: stomach contents.*

Left to right, Jake Rice, Niels Daan, John Pope, and Henrik Gislason.

Although I have referred several times to a "small group of experts" left over from the early MSVPA days, in no sense do they claim to have a monopoly on these dynamic size-based investigations of marine fish community foodwebs. A number of teams throughout Europe, North America, and the southwest Pacific are pursuing size-based models and empirical studies, with insights appearing from many directions. What is the nature of some of these insights?

We have only begun to explore the insights made possible by the linkage of two lines of research with long histories, but the results are exciting.

Raising questions, seeking answers

It is becoming clear that the linearity of the size spectrum is an oversimplification, especially when the breadth of the size axis is increased, making three or even more steps in the predator–prey chains possible. Trophic cascades, rather than just an overall increase in slope, can occur in the models. The intercept of the size spectrum has information as well – reflecting not only the overall productivity of the ecosystem but also the sustainability of fishing pressure at the ecosystem scale. Finally, the "recovery" of the "populations" in size-based models when fishing is relaxed may look different from "recovery" in species-based models, particularly when recovery plans are only implemented for selected species in the model. More work needs to be done to resolve these types of questions, even in research contexts, but our size-based glasses may help us see why many recovery plans have not produced the expected results.

However excited we are about the performance and prospects of our size-based models, none of us believes that species are wholly irrelevant, either in foodwebs or in fisheries. However, we have been pleasantly surprised by how far one can go with a model – or analyses of data – that pretends that only size matters. In fact, it seems that one can go just as far with such a model, at least in terms of the many questions that are important to both scientific knowledge and support for management and policy, as one can with a model that pretends that only species matters (even if a "species" might be presented as larval, juvenile, and adult stages). And the path is simpler and more direct.

As size-based investigations continue, the results will encourage researchers to formulate new questions, some of which we can't even imagine yet.

Biography

Jake Rice is a familiar face in the ICES community as chair of several ICES working groups. He has served on many international boards and working groups, including Department of Fisheries and Oceans Canada (DFO) science planning and review committees, NOAA, UN, FAO, IOC, MSC, CBD, and currently the UNEP/IOC GRAME Assessment of Assessments. He is National Senior Advisor, Ecosystem Sciences, for the DFO. His research has focused on many aspects of what is now considered the ecosystem approach to integrated management.

This approach is built on a well-developed body of research into the "biomass size spectrum" in the sea.

Turns in a Long Road

John Ramster reflects on his 25 years as an Editor of the ICES Journal of Marine Science.

My first direct contact with ICES was at the 1965 Statutory Meeting (as the Annual Science Conference was then called) held in Rome. On the plane over, John Steele mentioned *en passant* "the conceptual analysis approach" to something or other, and I was very impressed. I still am.

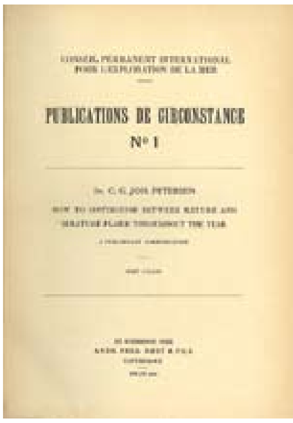
Other things that stay with me from that meeting are the late-September English fogs that always seemed to put at risk either the train to London from Lowestoft, where I then lived, or the flight from London, trying saltimbocca for the first time, and being very taken by the sense of order that prevailed. ICES was a very well oiled machine.

Over the next 20 years, I attended other annual meetings at about decadal intervals, enjoying the experience each time, and worked on or chaired various ICES groups between them. All the time, I now see, I was building up what the late Ed Thomasson, former ICES Information Officer and Librarian, used to call the ICES "family feeling". Consequently, when asked, out of the blue in 1983, if I would like to become the assistant to Ray Beverton, the new Editor of the then *Journal du Conseil*, I had no hesitation in accepting. Twenty-five years later, it seems appropriate to record some of the highways and byways on which that request has taken me.

not expected to be offered the many positions that were suddenly dangled in front of him, and ICES was very fortunate to be one of those he accepted. I always thought that it could well have been the family feeling that drew him back to be Editor.

Turning it around

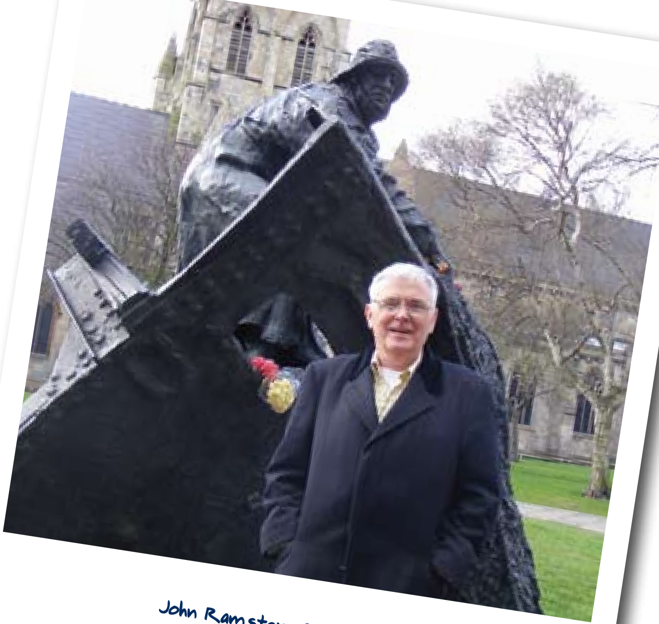
As I write this, I have in front of me the handwritten draft I sent him of our first report after we had been nine months in office, and the polished, typed version he posted to Denmark. Twenty-eight papers had been received for consideration: half from the UK. We thought that about 12 of the texts would be suitable, meaning that one volume of the *Journal* would appear in our first year. The paucity of supply and lack of general interest among ICES members were causes for concern. We also worried that the topics being written about were not representative of the work of the ICES community as a whole. We envisaged a time when there would be four issues a year, with papers coming from a large spread of countries and representing all of the fields in which ICES scientists were working. We had taken up our duties with "a degree of euphoria born of innocence" and had been disappointed by the standard of the first contributions. That was Ray gritting his teeth.



▲ *By any other name:* Publications de Circonstance, *July 1903;* Journal du Conseil, *February 1926;* ICES Journal of Marine Science, *as published by Academic Press;* ICES Journal of Marine Science *today, as published by Oxford University Press.*

At the time, Ray was "God" as far as many people in fishery research were concerned. In the same way that people crowded round Sidney Holt in 2000 at the ICES History Symposium on "100 Years of Science under ICES" in Helsinki just to get a word with one of the actual authors of "Beverton and Holt, 1957", so in the early 1980s, Ray Beverton was the darling of successive ICES annual meetings. By then, he had emerged triumphant, although he would never have said so himself, from a difficult time when, in 1979, he had been almost summarily deposed from an important executive position in UK science by a new overlord. For some reason, he had

By the time he passed the editorship to John Blaxter in 1991/1992, he had turned the whole *Journal* operation around. We not only had more than 70 manuscripts coming in each year, but in cooperation with our ICES Secretariat colleagues, it had become a joint venture with London-based Academic Press (later absorbed by Elsevier).



John Ramster, Grimsby

▲ *John Ramster visiting his hometown, Grimsby, in front of the statue commemorating the town's fishermen lost at sea. During the 19th and 20th centuries, the Lincolnshire town vied with Hull on the River Humber for the title of "The Biggest Fishing Port in the World". In 1912, the deep-sea fishing industry in Grimsby landed 200 000 tonnes of fish; last year, just 40 000.*

On the road

One of Ray's innovations was that the Assistant Editor should accompany him to ICES annual meetings of ICES in alternate years. He was very serious about the need to attend the scientific sessions and discover potential *Journal* papers among the presentations. I found this to be something of a chore, but did not moan about it since, by the early 1990s, I only had to do it every third year – shared with Stephen Smith, Assistant Editor from 1992 to 1997 – and it was accompanied by a bundle of nice things.

The exercise came into greater focus in the late 1990s when I was asked to lead the group that spotted the "Best Paper by a First-Time Attendee", "Best Paper", and "Best Poster". I found this to be an exciting and stimulating task and did discover several good papers for the *Journal* in the process.

At some stage too, the idea of groups of papers within sessions emerged, and the mini-symposium was born. Out of one of these came Bern Megrey as a future Assistant Editor. His topic was mapping phenomena by computer in the relatively early days of the cyber world, and some of his products foretold what would be possible in due course, i.e. the accepted norm today. Out of the chat and darkness of a reception in the aquarium at the 1997 Statutory Meeting in Baltimore, Mike Chadwick materialized as another Assistant Editor at a time when there was a vacancy. (The word "Assistant" was later dropped when the "Editor" became known as the "Editor-in-Chief".)

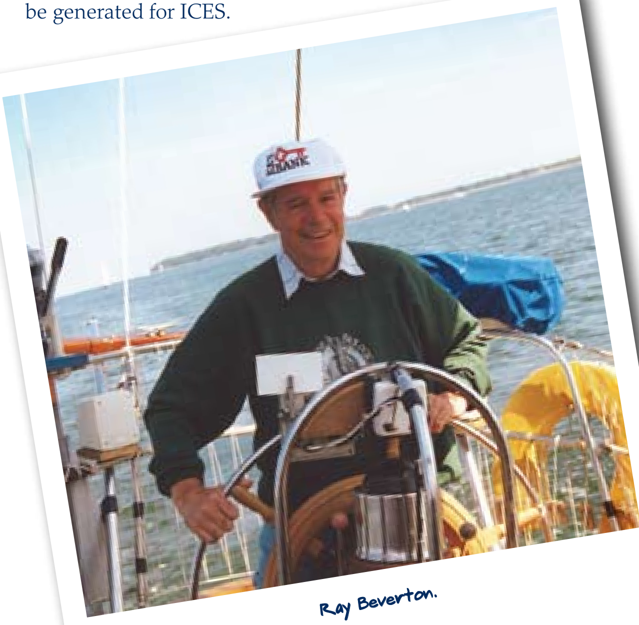
Joining up with Academic Press proved to be a real turning point in the development of the *Journal* as part of the marine-science scene. From the start with them in 1991, we increased to four issues a year and then gradually to five or six annually. For me as Assistant Editor, things had not changed all that much since 1983, because the professionals at Academic Press started to share, with the ICES Secretariat and especially Judith Rosenmeier, the ICES Publications Editor at the time, the work of checking that our formats and conventions were being met and also most of the proof-reading.

This thing called the Web

Looking back, I wonder just how it all came together so well, working as we did at arm's length from these new colleagues. The development of computing helped, of course, but it was not until 1997 that manuscripts started to move around electronically in any real numbers. I recall very clearly Gunnar Stefánsson remarking to John Shepherd and me at the 1993 Statutory Meeting in Dublin, "All these data could go on the World Wide Web", which was the first time I had heard the Web named, never mind being linked to something that we might use.

I now know from Gillies and Cailliau's *How the Web Was Born* that I was more-or-less four years behind what was happening at the sharp end of developments. Perhaps even more immediately sensational had been the introduction, in 1984, of Telefax machines to the *Journal's* world. I had just successfully "sold them" to my own senior management at Lowestoft by making two-way contact over a dinner hour with colleagues in Vienna and La Jolla and, as I remember, did much the same with Judith Rosenmeier. Their value in linking us with authors and referees was a big step forward. For most of the 1980s, getting packages ready for posting by airmail to countries all over the world was a Thursday-night job after a day's work at Lowestoft that was an essential ingredient in the editing process.

As I mentioned before, John Blaxter succeeded Ray Beverton as Editor in 1992 and implemented the terms of the package negotiated by Ray, Judith Rosenmeier, and then General Secretary Emory Anderson with Academic Press. His main new task was the production of the annual "symposium" numbers in conjunction with the guest editors, some of whom were not very experienced at editing, from the specialism featured in each case. He handled the final assessment stages of all papers for these symposia himself. I knew nothing of the extra work involved, and my main memory of the agreement with Academic is that I could never make out how the "expenses incurred in publication" were summed and deducted from the joint account by the publishers, to leave the surplus monies to be divided between the two parties (Academic Press and ICES). Nevertheless, with the advent of Internet access and regular quarterly publication complemented by the appearance of annual symposium volumes, relatively important sums of money began to be generated for ICES.



Ray Beverton.

John Blaxter (left) and John Ramster in Dublin, 1993.

This compared starkly with the losses incurred by the self-publication process of earlier decades and during the first years of the joint operation, and is greatly to the credit of John Blaxter and the Academic Press Executive Editor in charge of *ICES Journal* matters. John was of the same stock as Ray in many ways, and he was very clear that science rather than marketing should be the keystone of the exercise. At an early meeting with the publishers, he told a senior personage in no uncertain terms that, as Editor, he would have the final say in all aspects of the selection and presentation of the papers for publication, and this seems to have been something of a departure from their norms at the time. Our day-to-day contact with the publishing house was through the very convivial Executive Editor, who came to work on a huge, black motorcycle and staggered to his desk each day wearing the required black leathers and a fearsome helmet.

Last year, as I sat at the annual publisher's dinner for ten or so people in Helsinki, a memory surfaced of its equivalent for four in autumnal Gothenburg one evening in the mid-1990s, just as the first benefits of our being part of the publisher's Internet package for libraries around the world began to emerge. In John Blaxter's last year in office (1997), 99 possible manuscripts were received, following 87, 85, 82, 88, and 63 in each preceding year of his term working back to 1992.

The fruit of many labours

Niels Daan became Editor-in-Chief in 1998 and retired from the post in 2003, the year that saw the publication of the 60th volume of the *Journal*. His time saw the full flowering of on-screen editing, which he had pioneered as the guest editor of symposia proceedings a few years earlier. In an editorial in the final number of Volume 60, he reviewed the progress made in the previous ten years and commented on the editing process. A note in that issue marks the anniversary, with photographs of each of the former principal Editors, as well as one of the six Editors at the time. A big change for me occurred when Niels realized that, with the turnover growing in all senses, we had to become more professional. Accordingly, he arranged to have my job of distributing the manuscripts done by a Secretariat staff member, providing appropriate cover for times of sickness and my falling off the twig.

Søren Lund came over to Scotland to see what I was doing in this part of the work and then took over: the relief was pretty considerable. It felt as if I was no longer banging my head against a wall, a condition caused by the steady increase of manuscripts that, in my time, eventually climbed to 222. For me, this reveals the response of scientists to both the advances made in the field of computing and the need to provide evidence of the worth of their work by publishing in a reputable journal. Whatever the cause, it is good business for journal editors.

These days, our time is pretty fully occupied in the cycle of receiving manuscripts assigned fairly between the whole team of Editors by Editor-in-Chief since 2004, Andy Payne, via Søren, finding at least two appropriate and willing referees for each, assessing the referees' comments, making a decision as to whether a paper should be accepted, resubmitted revised, or rejected, and, if the second, requesting revisions in light of the comments made. We then check that the revised paper meets the Journal's conventions before sending it to our publisher, now Oxford University Press, checking the proofs two weeks later, and then ticking that paper off the list. This means that for about an hour each day, on average, seven days a week, I have a task to turn to that imposes a structure

Current *ICES Journal* Editor-in-Chief Andy Payne writes about John Ramster, their first meeting, and John's work on the *Journal*.

John, who I have known since joining the *Journal* myself as Editor in 2000 (I had never met him before that) is one of those jewels in the coffers of a working team who always has the time and willingness to offer assistance, comment – you should see the comments he makes on my annual editors' report – and general morale-building support that is an essential component of any team as successful as ours. Why he didn't take over from Niels Daan as Editor-in-Chief, or at least apply for the job, I will never know, but I could not have taken on the task myself without his wise counsel and wit.

John and Niels, of course, were my own mentors, and it was with trepidation that I was introduced to John for the first time at ASC 2000. Friend and colleague Carl O'Brien had said to me"don't worry, you'll easily recognize him – he stands out!", and he did, dressed to kill in a bright red kilt and beaming from ear to ear as he walked up to me. Personally, I now dread the day when John decides to hang up his editor's green pen, but fortunately I see little sign of that happening yet.

Practitioners and authors of acoustic manuscripts, in particular, should be grateful for John's insistence on handling most submissions to the *Journal* in that discipline – the *ICES Journal* is currently one of the top marine acoustic publications worldwide, due solely to John's endeavours and unstoppable enthusiasm. Everything he says in his article is true, but he should not be so modest about his own contribution. May the *Journal* continue to grow with John's hand among the several on the tiller.

on my day and thus meets Dan's Law, viz."It's best that you have a reason for getting out of bed". Through the honorarium paid, it also underwrites my holidays.

After ten years in retirement from full-time work, this has proven to be an interesting halfway house that sustains my links to ICES and provides such lovely moments from time to time. One of these came after toiling through symposium paper after paper on esoteric methods of counting krill and coming across an approach that allowed one to carry out the task with untold accuracy in a bucket, or so it seemed to this reader.

So far, most memorable of all, was opening an envelope in the late 1990s and reading that "Aristotle explained the dynamics of objects in nature by the four causes, namely the efficient cause, the material cause, the structure cause, and predestined fate. The last was decided by the 'cause of causes'; the positions of the Sun, the Moon and the stars. Does this doctrine have any relevance today?" There was no way I was going to let that one slip through the net if there was anything at all in the approach being taken. Five years and six more papers on this theme later, I got a very nice "mention in dispatches" in the acknowledgements section of a doctoral thesis.

Biography

John Ramster says that retirement has been a good career move. During his 36 years at the Centre for Environment, Fisheries and Aquaculture Science in the Lowestoft Laboratory, he carried out research in physical oceanography and managed the Research Section Group. Among his many publications, he is co-author of the Atlas of the Seas around the British Isles*. Since retiring in 1997, he has lived in Scotland where, in addition to his ICES-related work, he is involved in several community-based organizations including the Buckland Foundation, the Scottish Arts Council, the Royal Philosophical Society of Glasgow, and the Greensyde Carers' Committee.*

In addition to his scientific writing for the ICES Journal of Marine Science*, his articles about working with Ray Beverton appear in Volume 48 (1991), pp. 373–374 and Volume 53 (1996), pp. 1–9. In Volume 60 (2003), pp. 1169–1171, he is first author of an article celebrating the* Journal's *60th volume.*

ICES Journal of Marine Science: A Brief History

Publication and dissemination of information about the seas' living resources and their environment have been at the heart of ICES from the first, and today's *ICES Journal of Marine Science* has its foundations in the *Publications de Circonstance* series, which first appeared in 1903. The decision to establish the *Journal du Conseil* was actually taken at the Council Meeting of 1925, and the first volume appeared between February and November 1926 as four issues. From 1927 through 1991 (Volumes 2–48), there were three issues to a volume.

In 1991, the title of the series was changed to the *ICES Journal of Marine Science* (with the subtitle *Journal du Conseil*), and Academic Press became ICES formal publication partner. When Academic Press became an Elsevier imprint in 2001, the *Journal* moved with it. From 1992 through 1994 (Volumes 49–51), four issues appeared in each volume. Six issues a year became the norm in 1995, when ICES Symposium proceedings (formally the *Rapports* series) became part of the *Journal's* remit, and continued through 2003 (Volumes 52–60).

In 2004 and 2005 (Volumes 61–62), eight numbers were issued per volume. Elsevier published the *Journal* through 2006, when nine issues became the standard, and this continues today with Oxford University Press, who took over publication in 2007. Currently, seven editors are on the team led by Editor-in-Chief Andrew I. L. (Andy) Payne. The team's overall aim, supported by the staff at Oxford University Press, is to get into print within a year of formal submission any paper that gets a fair wind from referees. For the 2007 volume, the average time to hard copy publication was just 11 months, and electronic publication much less (as much as three months less).

Particularly since 1991, interest in the *ICES Journal of Marine Science* from the marine science community has grown prodigiously. In 1983, for example, 28 papers were submitted for publication. By 1993, this had risen to 88, to 155 in 2002 (excluding symposium proceedings), and in 2007, 232 papers were put forward for consideration. Of course, not all papers even make it to reviewers, but about 80% do, a substantial load for editors.

Oxford University Press has strengthened the *Journal's* online presence. Now all volumes, starting with the first 1903 issue of *Publications de Circonstance*, are available on the IJMS–OUP website (http://icesjms.oxfordjournals.org/). Back issues are available free online from 1996 until 12 months before the current issue. Issues prior to 1996 can be purchased individually or as part of the Oxford Journals Archive. The ICES publication department hopes soon to make the *Rapports* (Symposium) series freely available on the ICES website.

As the *Journal's* standing increases, the editorial team will seek to further the *Journal's* development to the advantage of the ICES community and marine and fishery science worldwide. If anyone has ideas on how to enhance development, or is willing to consider joining the team of editors in years to come when vacancies arise naturally, then do communicate your views to an editor – their contact information is on the inside front cover of all issues of the *Journal.*

News from institutes in the ICES network

Finnish Institute of Marine Research (FIMR)

State of the Baltic Sea unimproved – American comb jelly survived the winter

On 12 June, the RV "Aranda" returned from a four-week monitoring voyage in the Baltic Sea. The oxygen conditions in the deep seabeds of the Baltic Sea are still poor, and hydrogen sulphide occurs over large areas. The deep seabeds in the Gulf of Finland are completely dead, i.e. there is no benthic life. On the other hand, the oxygen conditions in the Bothnian Sea and the Bay of Bothnia have improved to a good level, and communities of *Monoporeia affinis* have begun to recover. The American comb jelly survived winter in near-bottom waters, although its frequency has diminished in all parts of the Baltic.

The "Aranda" was investigating the state of the Baltic seabed as part of a project carried out by HELCOM and FIMR for monitoring long-term changes in benthic fauna communities. The voyage covered most of the Baltic Sea, and samples were taken from 90 research stations around the Baltic. During the voyage, samples were taken to study both benthic fauna species, and additionally, the extent of oxygen depletion in deep waters was charted. Another focus was the distribution of the invasive species, the American comb jelly (*Mnemiopsis leidyi* (A. Agassiz, 1865)), in the Baltic Sea basins. Water and sediment samples were also collected for the Radiation and Nuclear Safety Authority, for use in monitoring radioactivity.

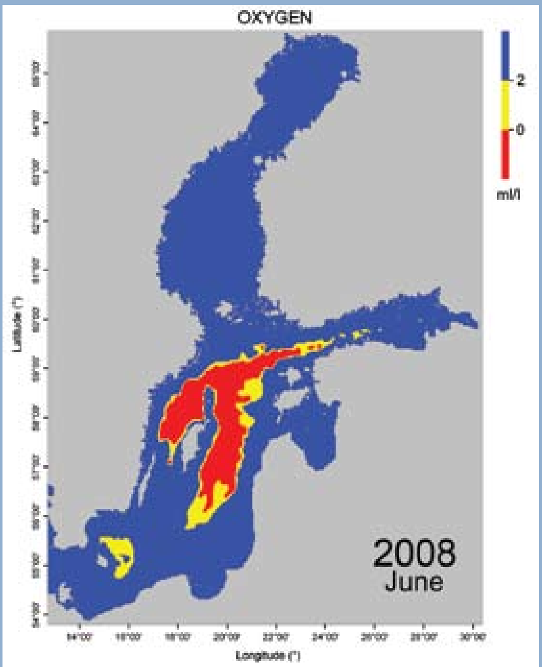
The oxygen conditions at the Baltic seabed were extremely poor last year in the Baltic Sea proper. Although a slight recovery was noticeable in the area of the southern Baltic, in the central and northern areas, oxygen conditions have deteriorated in near-bottom water. There is also a high level of hydrogen sulphide in these areas, where it occurs up to depths of 65–70 m in deep waters. The water layer containing hydrogen-sulphide in the Baltic Sea has in fact increased.

At most deep research stations in the Gulf of Finland, there was no sign of benthic fauna, in other words, the deep seabed is completely dead. Although the oxygen conditions on the bottom of the Gulf of Finland have improved somewhat, there is still no sign of recovery of the benthic fauna community.

In previous years, the oxygen conditions in the Gulf of Bothnia have begun to deteriorate seriously. Happily however, in the Bothnian Sea and the Bay of Bothnia, the oxygen conditions have returned to a good level. There was abundant oxygen at all the research stations in near-bottom waters. In the Bothnian Sea, communities of *M. affinis* are also recovering after more than ten years of regression, and they had increased significantly in 70% of the research areas. The spread of the invasive species *Marenzelleria viridis* has also continued in the Bothnian Sea and the Bay of Bothnia, although the increase in its occurrence has slowed down.

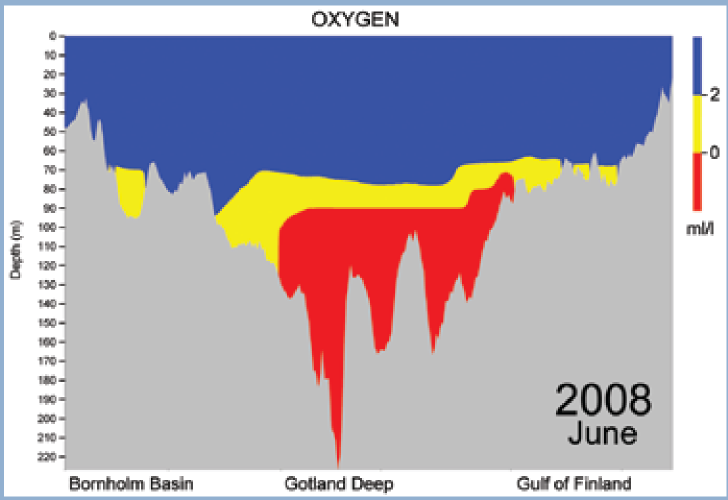
The American comb jelly survived winter in most parts of the Baltic Sea. The Bay of Bothnia has, however, so far remained unaffected by this invasive species.

The species occurs most abundantly in the deep waters to the southwest and west of the Åland Islands and in the northern parts of the Bothnian Sea. However, their numbers have fallen somewhat in all Baltic Sea basins since January. The incidence of the species is highest in the water layer above the seabed, where salinity is higher.



◄ *The oxygen situation in the Baltic Sea in early summer 2008. Graphic by Janne Bruun.*

▼ *Depth distribution of oxygen from the Bornholm Basin to the Gulf of Finland in early summer 2008. Graphic by Janne Bruun.*



The ABCs of PBTs:
Reading the Signs of Pollutants

Measuring the true environmental significance of marine pollutants has been an intractable problem. Foppe Smedes and Ian Davies are advocates and developers of passive sampling techniques for hydrophobic contaminants, which can be used to determine the pollutant stress experienced by organisms. The authors believe that passive sampling may gradually replace classical monitoring methods.

An accurate and reliable means of measuring concentrations of organic marine contaminants remains a major challenge in controlling pollution in the sea. That challenge is now even more pressing with the EU's agreement last year on the Marine Strategy Framework Directive, which aims to ensure healthy European marine waters by 2020, through protection and preservation of the marine environment. Already firmly established as targets in such pollution control are familiar groups of organic chemicals such as polycyclic aromatic hydrocarbons (PAHs), chlorobiphenyls (PCBs), and dioxins. However, although the offending pollutants are relatively well known, a reliable means of measuring their availability – as represented by freely dissolved concentrations in water or sediment pore water – has proven far more elusive.

> Although the offending pollutants are relatively well known, a reliable means of measuring their availability has proven far more elusive.

Currently, the most promising means of monitoring the availability of such pollutants, and particularly their potential availability to other organisms in the sea, lies in a technique known as passive sampling, which has been progressively developed in marine pollution research over the last few years. Indeed, ICES Working Groups on Marine Sediments and Marine Chemistry have been using one type of sampler made of silicone rubber sheets with evident effect. These thin sheets, measuring approximately 100 cm^2, are exposed to water for a given period and absorb dissolved hydrophobic contaminants, sampling at a relatively high volume per day. Concentrations of the pollutants are calculated from the amount of pollutant accumulated and a validated mathematical model to determine the sampling rate.

Freely dissolved concentrations

Many organic pollutants are virtually insoluble in water and, once in the marine environment, are usually found bound firmly to the organic matter in suspended sediment. Their final sink is deposited sediment on the seabed. However, because these chemicals do bind to sediment, particularly to the organic matter in suspended or deposited sediment, they may be only weakly available for uptake by filter-feeding or sediment-dwelling organisms. Thus, even though we may be able to measure the total concentrations of pollutants in sediment or water samples, it is still difficult to assess how much of that concentration is actually available to organisms or potentially available in the future.

The key measure of their availability is the "freely dissolved concentration", but, because of the almost complete insolubility in water of such hydrophobic pollutants, the actual dissolved concentrations are generally very low. Various approaches have been made to overcome this problem, such as more sensitive analytical instruments or the collection of very large volumes of water for sampling. But, because the freely dissolved components of these pollutants bind easily to sediment particles (and also to the samplers and filters), even these strategies have proven less than effective. So far, any precise measurement of their dissolved concentrations has proven difficult to undertake reliably, even though their effects on marine organisms are clear. This is an area of uncertainty in marine environmental monitoring, which passive sampling may now overcome. The challenge of accurate measurement is great, and the need is even greater.

◀ Exposed passive samplers can present a new home for organisms, leading to different levels of biofouling. Here is a sampler exposed for six weeks in Spanish waters. Unexpectedly, the results from severely fouled samplers do not stand out as anomalous. The procedure that takes account of the effect of local hydrodynamic conditions on sampling rate also includes instances where biofouling may affect the uptake process.

▲ *Loading sheets of silicone rubber passive sampler for hydrophobic contaminants onto a supporting frame in preparation for deployment in the sea.*

▲ *Fouling of the samplers is common, but the procedure for estimating sampling rate takes fouling into account.*

Persistent, bioaccumulative, toxic

Trials of silicone rubber samplers have already found high concentrations of pollutants in areas around European coasts, particularly where exposure to urban and port activity, industry, and agriculture is evident. Moreover, substances such as PAHs and PCBs unequivocally meet the classical "PBT" identity criteria for a significant marine pollutant. That is, they tend to degrade slowly (i.e. they **P**ersist) in sediment. If not metabolized by marine organisms, they accumulate in the lipids of fish and shellfish (i.e. they **B**ioaccumulate) and are found in much higher concentrations farther up the food chain. Finally, their direct adverse effects on the health of birds and animals have been known for more than three decades (i.e. they are **T**oxic).

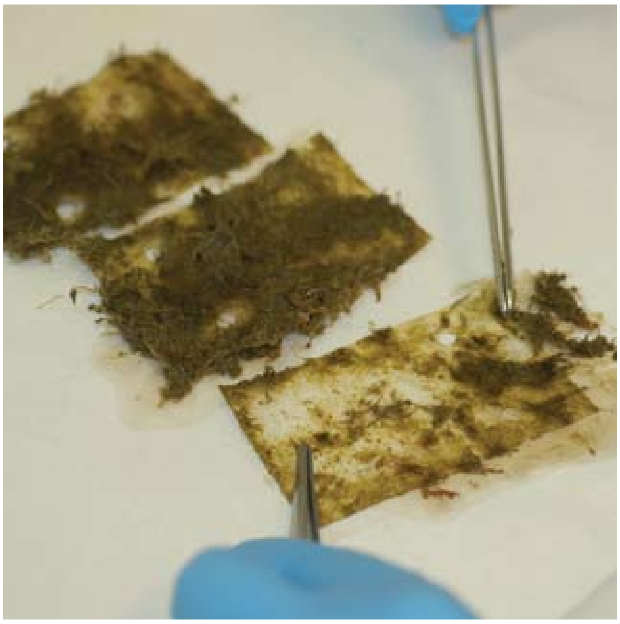
> Trials of silicone rubber samplers have already found high concentrations of pollutants in areas around European coasts.

Thus, with knowledge of such toxicity, measuring the availability of hydrophobic compounds to organisms has long been a fundamental research objective. Because the low solubility of "persistent" compounds seemed directly associated with their accumulation in the lipid cells of organisms, a theoretical model of predicting dissolved concentrations from the concentrations found in lipids was developed.

Not until passive sampling came along, however, was a more precise and direct form of measurement available for sampling the freely dissolved compounds in water or sediment. For sampling water, trials have demonstrated that six silicone rubber sheets exposed to water for periods of four to six weeks can sample up to 40 l per day. Such high volumes reduce analytical problems and the impact of short-term field variability in concentrations. For sampling sediment, the silicone rubber sampler is shaken with sediment for about three weeks, which allows accurate calculation of the freely dissolved concentrations of contaminant in pore water. Manipulation of the rubber-to-sediment ratio also allows estimation of how much hydrophobic contaminant currently bound to sediment solids may potentially be released into the water. Passive samplers, therefore, can not only provide real-time measurements of freely dissolved concentrations of hydrophobic pollutants but can also estimate the long-term polluting potential of sediment.

Two ICES working groups have collaborated on a passive sampling trial for water and sediment. Set up in 2006, this study, involving 12 laboratories from ICES Member Countries and one from Australia, has been designed to assess the reliability of silicone rubber passive samplers in the measurement of PAHs and PCBs. Papers presented at last year's ICES Annual Science Conference, where an entire session was devoted to wide-scale passive sampling, showed that the repeatability of sampling results and agreement between laboratories were good. Each laboratory conducted its own fieldwork and laboratory analysis, whereas duplicate samples were analysed by a single coordinating laboratory. A separate six-year study using passive sampling in parallel with monitoring pollutant uptake in mussels revealed a strong correlation between the two sets of data, confirming the environmental relevance of the data. Data from field sampling sites also demonstrated that the dissolved concentrations of contaminants can be measured down to the level of picograms per litre, an impossible task by classical sampling.

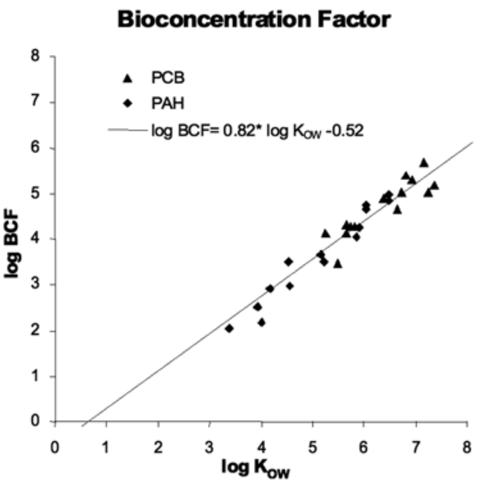
Thus, with the evidence from the ICES trial now emerging, it seems that passive sampling does indeed have huge potential in monitoring marine pollution from hydrophobic organic compounds, particularly concerning their availability to organisms. Already,



▲ *Fouling should be removed by wiping or, if necessary, with tweezers before the samplers are analysed.*

▲ *Existing mooring or navigation buoys make ideal supports for passive sampler frames.*

regional monitoring programmes such as those of the Royal Netherlands Institute for Sea Research or Belgium's Integrated Risk Assessment and Monitoring project are using passive sampling as a means of measuring contaminant pressure in their own coastal-zone environments. And, because the EU's new Marine Strategy Framework Directive is likely to require contaminant measurements at very low concentrations in open sea areas, passive sampling now seems set to become a key tool for marine chemists and toxicologists. As yet, passive sampling is the only way to assess the low concentration requirements for good environmental status assessment.



▲ *The freely dissolved concentration obtained from passive sampling is highly correlated with the uptake in deployed or local mussels. This relationship is expressed in the bioconcentration factor (BCF), being the ratio between concentration in mussel and water. Very hydrophobic compounds are more strongly bioconcentrated, and therefore the BCF shows a strong relation to the octanol-water partition coefficient (K_{OW}), a standard expression of hydrophobicity.*

Biographies

Foppe Smedes currently works at Deltares, which specializes in the fields of water, soil, and the subsurface. In 1991, he became a member of the ICES Marine Chemistry Working Group and, for seven years, was Chair of the Working Group on Marine Sediments. He has also been active in quality assurance through the QUASIMEME and QUASH initiatives. His background in analytical chemistry has allowed him to develop analytical methods in the fields of industry, medicine, and the environment, which are used worldwide. He has contributed greatly to the interpretation of environmental chemistry data, for example, through the establishment of normalization procedures in OSPAR methods for temporal and spatial trend analyses of sediment chemistry monitoring data.

Ian Davies leads a research and advisory group with diverse interests ranging from environmental chemistry and biological effects of contaminants, to aquaculture and sealice biology, coastal hydrography, environmental monitoring and assessment, seabed mapping and benthic ecology, and renewable energy systems. He has been involved in various ICES working groups related to environmental quality or aquaculture for 30 years, chairing several, and is currently chair of the Fourth ICES/OSPAR Workshop on Integrated Monitoring of Contaminants and their Effects in Coastal and Open-sea Areas.

History of climate-related research in ICES

– science and management

Keith Brander traces ICES work in climate change, looking at the science and management of it.

History and background

ICES has played a prominent part in research on climate change and its impacts throughout its existence. The research is built on two fundamental ideas: (i) that the distribution and abundance of marine life is affected by climate (and environmental variability in general) and (ii) that the processes (growth and survival) governing the numbers of young fish occur principally during the early life stages. A major part of the research was directed at investigating the causes of the resultant interannual variability in recruitment. Helen Rozwadowski's book on the history of ICES describes the historical development of the two fundamental ideas and their influence on the scientific programme and institutions of ICES.

Warming in the north

From the 1920s to the 1940s, when the organization was young, the North Atlantic warmed considerably, causing widespread shifts in the distribution and abundance of fish and other marine and terrestrial biota around Greenland, Iceland, and in the Barents Sea. We now recognize this "warming in the north" as part of a pattern of Atlantic Multidecadal Oscillations (AMO), and it stimulated a great deal of research into climate impacts, culminating in an ICES Special Scientific Meeting in 1948. The AMO is a major regional component of the climate that will play a large part in determining the rates of climate change in the North Atlantic and adjacent seas over the next 20 to 50 years.

ICES role in climate research

ICES has contributed in several vital areas to long-term studies of change in ocean climate and its impacts. One is through the systematic collection, collation, and interpretation of data on hydrography, fish, and other marine life, which was published previously in the *Annales Biologiques* (discontinued after 1986) and more recently in the Decadal Symposia, which took place in 1991 and 2001. The ICES oceanographic data service used to be the major provider of high-quality ocean climate data for the North Atlantic. Although ICES is no longer the principal organizer of large-scale oceanographic research, it still plays a prominent part in fisheries and some aspects of marine environmental research.

ICES has contributed in several vital areas to long-term studies of change in ocean climate and its impacts.

Another ICES contribution was the active part it played in setting up the scientific and institutional framework for GLOBEC (Global Ocean Ecosystem Dynamics), which became the major regional, national, and international scientific programme of research into the influences of physics on marine ecosystems. The principal ongoing ICES activity within GLOBEC has been more than a decade of detailed research on Cod and Climate Change (CCC), which, together with the International GLOBEC programme, is due to end in 2009. Although Atlantic cod (*Gadus morhua*) is the principal subject of the CCC, much of the regional and national research in ICES and GLOBEC has been directed at lower trophic levels, particularly zooplankton and small pelagic fish species.

With the accumulating evidence of anthropogenic effects on climate, the focus of interest has progressed from studying the effects of natural, interannual climate variability on fisheries and marine ecosystems to evaluating longer term impacts of past climate change and predicting future impacts. These areas of research overlap and complement each other; for example, studies of what happened during the warming period of the 1920s provide a powerful analogue for predicting the impacts of the warming now occurring in areas such as Greenland. However, we also need to recognize the differences between questions that relate to specific short- to medium-term concerns (e.g. how will recruitment and growth of particular fish stocks vary during the next 1–3 years) and questions dealing with the long-term state of marine ecosystems (e.g. how will the distribution, productivity, and biodiversity of marine biota respond to climate change).

One of the differences is that the longer term questions have only appeared on the agenda fairly recently, which means that data, methods, and the presentation of results need to be developed and coordinated.

Scientific and management issues

"Climate variability" here refers to short- to medium-term (annual to decadal) variability, and "climate change" refers to the (mainly anthropogenic) changes in climate that are taking place.

The need to tackle climate change both by mitigation (i.e. reducing emissions of the greenhouse gases that cause warming) and by adaptation (i.e. diminishing the harmful consequences of climate change) is now universally accepted. Oceans and the human activities affecting their physical, chemical, and biological dynamics are critical to the climate system. Oceans are a major sink for carbon dioxide and also play a role in the absorption and release of other greenhouse gases. Research in ocean biogeochemistry is highly relevant to mitigation strategies, but ICES has little activity in this field. Nevertheless, within the areas of marine science in which ICES is active, there is a need to consider climate change and how ICES can contribute to tackling it.

ICES remains the major source of international fisheries data for the North Atlantic.

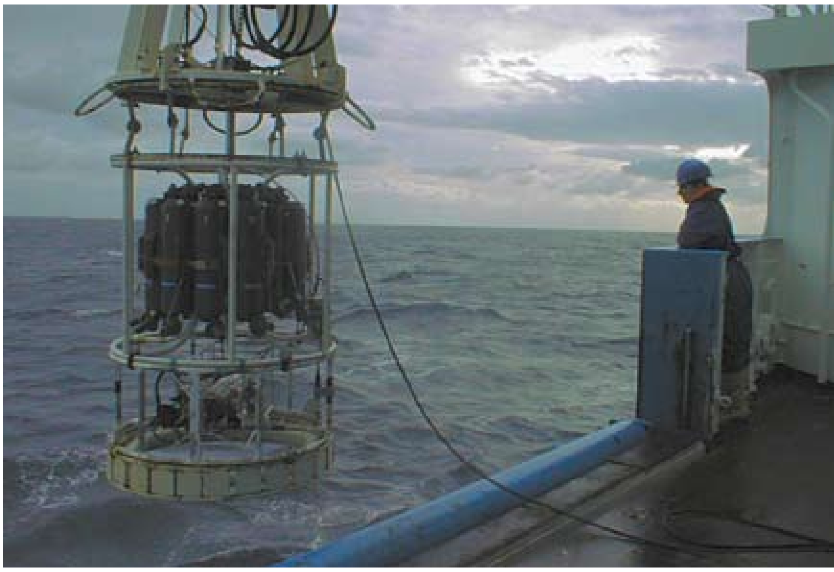
A second difference is that long-term questions generally need to be dealt with at larger scales, both geographically and taxonomically. They relate to higher levels of biological organization (e.g. "fish community", "trophic level") and often need to be looked at in a global rather than a regional or local context. Regional predictions of ocean climate derive from global models. This requires cooperation with global science programmes (e.g. those within the International Geosphere–Biosphere Programme) and coordination of specialists working on different taxa, areas, and disciplines.

Mitigation by reducing greenhouse gas emission

Fishery management would seem to have little to do with reducing greenhouse gas emissions, but can, nevertheless, contribute by continuing to strive for reductions in fishing mortality and increases in the biomass of exploited species. About 1.2% of global oil consumption is used in fisheries. A European life-cycle analysis of fish products found that the catching sector was the main contributor to global warming in the production chain. Beam

▼ *Back deck of FRV "Scotia" during a sampling cruise in the Faroe–Shetland Channel. Image courtesy of Fisheries Research Services, Aberdeen.*

▼ *A conductivity/temperature/depth deployment from FRV "Scotia". Image courtesy of Fisheries Research Services, Aberdeen.*



trawling, for example, consumes 4 kg of fuel per kg of fish landed. Higher biomasses, higher catch rates, and improved catching methods would reduce energy use in fish capture. Conversely, some of the fishery-management measures currently in force, such as catch quotas, probably reduce energy efficiency and add to greenhouse gas emissions.

Adapting to a changing climate

ICES can probably make a greater contribution by identifying and promoting measures for adapting to climate change. Marine ecosystems are already affected by climate change, with changes in the distribution and abundance of fish, shellfish, plankton, seabirds, marine mammals, and pathogens. What impacts, positive and negative, will future climate have on the productivity of fisheries and on the biodiversity and health of marine ecosystems? How can we ensure that our management of fisheries and marine systems is adapted to such climate-induced changes? Management agencies are already asking these kinds of questions, and the scientific and institutional arrangements for providing answers are in their infancy.

One of the first challenges here is that the models used to make predictions of likely future climate under different social and economic scenarios are only just beginning to represent ocean climate adequately. There is a need for prolonged dialogue between modellers and their user community in order to ensure that processes which matter are sufficiently represented and that output is produced for the required fields and with the required resolution. ICES can play a key role in bringing about such a dialogue. An example is the recent ICES Workshop on Cod and Future Climate Change, which identified and discussed some of the difficult issues in providing adequate regional climate predictions.

ICES expert groups are currently being asked to deal with issues related to both short- and long-term climate.

The second challenge is to evaluate the impacts on marine ecosystems of the climate (ocean and atmosphere) forecasts. The application of environmental information (including climate) in fishery assessment and management is a key area for ICES in relation to its advisory role in fishery management and one that will probably require development for a number of years. A recent request from OSPAR for information on changes in distribution is another application.

A number of ICES scientists have taken part in climate impact assessments at regional, national, and global levels. ICES can play a key role in providing a forum for the development and evaluation of such impact assessments, which include observation strategies, modelling and analytical tools, evaluation of risk and uncertainty, and presentation to a variety of audiences ranging from specialists to the general public.

Recording and understanding changes in the sea

ICES has, in the past, played a key role in coordinating, standardizing, archiving, and presenting observations and time-series for the marine environment. This role has been taken over by other agencies for some variables, but ICES remains the major source of international fisheries and some environmental data for the North Atlantic and still has a major part to play in the development of monitoring strategies and the design and evaluation of indicators. This data-related activity does not rely on climate change for its justification, but its value in relation to climate change should be promoted. This applies also to the monitoring of pathogens, invasive species, and harmful algal blooms.

There is a major scientific challenge to improve our ecological understanding of the functioning of marine ecosystems in order to make better predictions of the consequences of the combination of stresses (fishing, environmental variability, climate) to which they

are subjected. ICES recognized and took up this challenge many years ago, as can be seen in successive ICES Strategic Plans and in the debates that led to the establishment of the ICES/GLOBEC Cod and Climate Change programme.

It becomes evident, however, when working with colleagues from other areas of science (e.g. agriculture and forestry), that the basis for making predictions concerning fisheries and the marine environment is weak, for obvious reasons. The sea is an unfamiliar place. On land, it is relatively easy to conduct controlled experiments on plants and animals as a basis for predicting the consequences of climate change. Fishery management relies on crude and often ineffective regulation of harvesting, whereas in agriculture and forestry, there is control of species, growing conditions, pests, and predators.

For marine ecosystems and fisheries, our predictive capability relies mainly on comparative studies and population or ecosystem modelling. Climate change is predicted to affect marine primary production (there is some evidence that this is already happening), but the relationship between primary production and fisheries production is complex, and fisheries harvest a large variety of species at several trophic levels. There is much scientific work to be done, and ICES should continue to play a key role in coordinating and facilitating it.

The nature of the scientific and management issues that ICES will have to deal with in the future is likely to change. Sustainable global fish production is threatened by a number of factors, foremost of which is overfishing, but fishing also interacts with several of the others. Climate has direct and indirect effects on distribution, productivity, and risk of extinction. Spread of competitors and pathogens (introduced or indigenous) is already occurring. Loss of structures, such as coral reefs, is likely to result in reduced species richness, local extinctions, and loss of species within key functional groups. Unknown but potentially very large threats arise from changes in global marine primary production and acidification of the oceans. Future climate adaptation and mitigation strategies (coastal defence, carbon sequestration, offshore energy generation) may also have large impacts on the marine environment and fisheries.

Another rapid and influential change is the increasing proportion of fisheries production from aquaculture. Global aquaculture production has been projected by FAO to equal capture production by 2030. This will have far-reaching consequences for capture fisheries, but may also affect (improve?) our ability to predict the consequences of climate change as the systems for producing fish increasingly come to resemble terrestrial intensive farming.

Biography

Keith Brander joined the Fisheries Laboratory, Lowestoft as a PhD student in 1969. He has worked on the ICES/GLOBEC Cod and Climate Change programme since 1993, based in the ICES Secretariat from 1996 to 2008 and currently at the Technical University of Denmark, National Institute of Aquatic Resources (DTU–Aqua) in Charlottenlund. During the past three years, the main focus of his work has been on the synthesis and application of results. He was lead author for the fisheries and marine ecosystem sections of the fourth IPCC report, which was awarded a share of the 2007 Nobel Peace prize.

Part Two of this article will be available on the ICES website: It will review recent climate related work by ICES expert groups and will outline a programme for future research on topics where ICES can make a particular contribution. You can find the article here http://www.ices.dk/products/insight/extra.asp

Mixed Fisheries and the Ecosystem Approach

A dilemma in the North Sea illustrates a greater problem in how we regulate fishing fleets. A new computer simulation could point the way to smarter quotas and regulations that reflect the complicated reality of modern fisheries, and Clara Ulrich, Stuart Reeves, and Sarah B. M. Kraak were there at its inception.

In 2006, fishers in the North Sea faced a dilemma. The cod stock had fallen to a very low level. The stock of haddock, on the other hand, which is often caught together with cod, had reached its highest biomass in 30 years (ICES, 2006b). Yet, the total allowable catch (TAC) for each species – the quota a fisher may legally capture – had been set without consideration of the other. So, after quickly exhausting the quota for cod, fleets had two options: either stop fishing and underutilize the quota for haddock, or continue fishing and discard or illegally land over-quota cod.

The fishers' decision to continue fishing after their cod quota was exhausted undermined the conservation objective of the TAC regulation. Moreover, the reliability of the cod stock assessment was jeopardized, because the catch data on which it was based were compromised by discarding or unreported landings.

The ecosystem approach – the latest buzz phrase in fishery management – seeks to avoid situations like this by shifting focus from the sustainable exploitation of single stocks in isolation to a much broader range of impacts caused by fishing activities. In reality, most European demersal fisheries capture a mix of species, including both targeted and non-targeted marketable species as well as non-commercial species, which are sometimes caught in substantial quantities (imagine a net full of starfish).

Fishing also affects the ecosystem in other ways; for instance, through disturbance of the seabed and its benthic communities. To advise on such a broad range of eco-impacts, we need a framework that addresses the simultaneous impacts of fishing activities on target and bycatch stocks, as well as on other species and non-biotic ecosystem components. That framework must also address the critical flaw in applying single-species TACs to mixed fisheries: the implicit assumption that once the TAC is exhausted, fishing on the stock will stop. In reality, fisheries are rarely that simple, and TACs alone may not limit fishing pressure.

A new framework for fishery advice

Over the last three years, we have had the pleasure to be involved in the development of such a framework. This new framework, named Fcube or F^3 (Fleets and Fisheries Forecast; Ulrich *et al*., 2006; Reeves and Ulrich, 2007), focuses on fisheries and fleets rather than stocks. Fcube provides a much more flexible and realistic framework for management advice, one that recognizes that fishery impacts extend far beyond the major target species. Because Fcube suggests a way to evaluate the extended impact of fishing, it provides a bridge between the traditional single-species advice and the ecosystem approach to fishery management.

Fcube provides a much more flexible and realistic framework for management advice, one that recognizes that fishery impacts extend far beyond the major target species.

Fcube also recognizes that fleets can allocate their fishing effort across a range of different fisheries. Instead of only one incentive, like the single-species quota, fleets can respond to a range of different incentives – stock biomass, market conditions, regulations – and have a far wider range of responses at their disposal than simply to stop fishing.

▲ *Photo by John T. Everett, OceansArt.us (www.OceansArt.US).*

Fcube was born January 2006 at the ICES Workshop on Simple Mixed Fisheries Management Models, WKMixMan, which brought together fishery researchers from around the world (ICES, 2006a). The goal of the workshop was to devise "something new", to come up with a fresh modelling approach to the mixed-fisheries problem. The daunting task of conjuring up a new idea on cue seemed somewhat less so when Fcube was presented, and we spent a large portion of the workshop discussing Fcube, its development, and possible implementation. Fcube was developed further during 2006 and 2007, and evaluated at meetings of the SGMixMan Study Group (ICES, 2007, 2008). It is now available within the FLEcon package, compatible with the open-source FLR simulation framework, which is used widely in the investigation of fishery-management problems (Fisheries Library in R, Kell *et al.*, 2007; http://flr-project.org. "R" is a computer language used for statistics). Fcube's applicability is being explored further in the EU-funded project AFRAME.

Looking inside Fcube

Fcube employs a variety of different scenarios to estimate potential fleet catches. In one scenario, Fcube assumes that fleets fish until the *first* TAC is exhausted; in another, it assumes that fleets fish until *all* TACs are exhausted; and in a third, the model supposes that fleets fish according to the TAC of their most valuable species. Such predictions illustrate that single-species TACs imply very different fleet effort, depending on how a fleet chooses to meet its quota.

Using Fcube, regulators could establish a set of multiple TACs—taking into account the extent to which the different species are caught together—that implies a similar level of fishing effort by fleet (Vinther *et al.*, 2004). This set of TACs could be tuned to the conservation needs of the most threatened or most valuable species. The key point is that such mixed-fisheries advice must incorporate information on what the fishers and their vessels are doing, rather than just relying on the information available from single-species stock assessments. In the end, fleets will find it easier to comply with TACs that represent similar fishing effort.

Fcube can also build complex regulation constraints on a single fishery into its predictions. For example, we used Fcube to evaluate the benefits of only reducing the effort of large-mesh, towed gears, thus mimicking the current days-at-sea system implemented in the North Sea under the cod recovery plan, which limits the total numbers of days that a fleet may be at sea for fishing (ICES, 2006b, 2008). This system restricts fishing mortality not only by the biomass of fish the fishers are allowed to land, but also by the fishing effort they are allowed to spend.

Instead of only one incentive, like the single-species quota, fleets can respond to a range of different incentives.

Advice with a custom fit

To see how Fcube applies to the ecosystem approach, let's view fisheries as a continuum ranging from simple, single-species, single-gear fisheries, where the only concern is for the target species, right through to complex, mixed-species, multi-gear fisheries, where there is additional concern for the impact of fishing on other components of the ecosystem (Reeves and Ulrich, 2007).

For the first type of fishery, advice will be given in a prescriptive form as single-species TAC advice. When a limited number of species and gears are involved, prescriptive advice can be given as a set of TACs that are consistent across the species in terms of the effort they imply.

In a more complex mixed-fishery situation with more species and more gears involved, it is less likely that precise stock assessments will be available for all of the stocks concerned. As advice may need to be framed in terms of effort, and because there is rarely a well-defined relationship between fishing effort and fishing mortality, advice may need to be given in a form that is more adaptive than prescriptive; for instance, by specifying a fixed percentage reduction each year until a specific target is met. Using Fcube, annual advice for this more complex situation might look something like this:

Under this set of assumptions about fleet effort, catchability, and allocation of effort between fisheries in year Y:

- *The estimated catches of each species by each fleet will be…*
- *This will lead to estimated total catches of each species of…*
- *The implied fishing mortalities on the major stocks will be…*
- *The resulting SSBs of the major stocks will be…*
- *The changes indicated for the minor stocks are…*

By using a range of indicators of commercial fish stocks, including stock assessment results, the Fcube provides advice that strikes a balance between stock assessments and ecosystem indicators.

At the far end of the continuum lies ecosystem-based management, which considers a wide range of components of the ecosystem, not just the commercial species. Such management will likely involve a complex of different management measures, including closed areas, partially closed areas, and effort management.

The key here is to classify fishing activity in a way that reflects the distinctive impacts associated with the use of a specific gear in a particular area. Although information on landings of commercial species should be available from landings declarations, unfortunately, there is no corresponding information available for species that are discarded or affected on the seabed. A system that aims to reflect these impacts, then, may need to assess these impacts in a more qualitative way. As such, the hypothetical advice could look something like this:

Under this set of management measures in year Y:

- *The (modelled) allocation of effort between fisheries is indicated to be…*
- *This will have these implications for the main target species…*
- *These implications for the secondary (assessed) species…*
- *These implications for non-commercial species…*
- *These implications for selected benthos (some fisheries only)…*
- *These implications for seabed disturbance…*
- *And these implications for the fleets…*

In this case, the implications would be expressed in relative, not absolute, terms. By nature, advice will need to be multi-annual and adaptive. It will not be possible to say, "Do this, and this will be the result". It will be more like, "Keep taking these actions, adjust as necessary, until some or all of these indicators reach these reference points".

Fcube in your future

Fcube is already unique in its reliance on existing and available data. Because it is so flexible, we look forward to being able to adapt the framework to new data and to future developments in the ecosystem approach. As a next step, we hope to integrate new data that will allow us to make a quantitative estimate of impacts per fleet per fishery per unit of effort, equivalent to catchability estimates per fleet per fishery. With these data, we will be able to extend the application of Fcube even further.

The key scientific challenge in the development of the Fcube approach will be to incorporate fleet- and fishery-based approaches in a management-strategy-evaluation framework to explore how such a system might work, at least in a mixed-species context. With this as our starting point, we will be better equipped to provide advice that is sensitive to the reality of modern fishing fleets and the kaleidoscope of ecosystems that are impacted by fishing.

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Biographies

Clara Ulrich-Rescan is a fisheries biologist and agronomist who has worked, since 2002, as a scientist and, since 2005, as a senior scientist at DIFRES, now Technical University of Denmark, National Institute of Aquatic Resources (DTU-Aqua). Her fields of research include fishery management, fish stock assessment, mixed fisheries, management strategy evaluations, bioeconomy, and fisher behaviour.

Stuart A. Reeves is currently leader of the Fishery Dynamics team at Cefas, in Lowestoft, UK. He joined Cefas in late 2005. Prior to that he was a senior advisory scientist at the Danish Institute of Fisheries Research at Charlottenlund, Denmark. He has participated in many ICES and STECF expert groups, and was chair of the ICES Study Group on Mixed Fishery Management (SGMixMan).

Sarah B. M. Kraak began in her current position as Senior Scientist in Fisheries Science at IMARES, the Netherlands in 2002, and now moves to the Marine Institute, Ireland. Prior to that, she was Lecturer in Behavioural and Evolutionary Ecology, University of Nottingham, UK. She has participated in many ICES groups and is an Editor of the ICES Journal of Marine Science.

Kate Becker contributed to this article.

Advice may need to be given in a form that is more adaptive than prescriptive.

Helping Seabirds Help Us:

Recognizing Their Power as Indicators

Northen Fulmar (Fulmarus glacialis).

With seabirds sitting at the top of the marine food chain, Ian Mitchell asks if the conditions of their breeding colonies can serve as an indicator of the state of our seas, one that can be used by scientists, managers, and policy-makers for the seabirds' management and protection.

Seabirds are already being used as indicators of pollution in the North Sea. For instance, the amount of plastic present in the stomachs of fulmars (*Fulmarus glacialis*) and the amount of oil on the plumage of guillemots (*Uria aalge*) are currently monitored against "acceptable" levels. More specifically, however, can seabirds actually provide an indicator of the state of the marine food chain, and thus the state of our seas?

As most seabirds spend much of the year at sea roaming over large areas, it is only really possible to monitor changes in their populations when they return to land in order to breed. They do so in large colonies at a few favoured locations and are, therefore, relatively easy to count and study. Recent data strongly suggest that these seabird colonies can indeed provide clear indications of the state of their food chain: When their food supply is reduced, clear impacts on colony size and structure can be seen.

Most evidence linking seabird populations to changes at other trophic levels of the food chain comes from studies of single colonies.

Two puffin tales

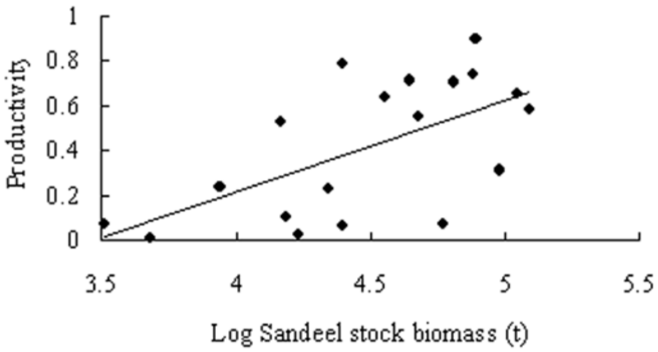
Tycho Anker-Nilssen, senior researcher at the Norwegian Institute for Nature Research, is currently studying the Atlantic puffin (*Fratercula arctica*) on the island of Røst in the Norwegian Sea. In 1980, the colony there contained almost three million puffins but subsequently has seen a 70% decline in numbers.

At this time of year, the sky over Røst should be filled with thousands of puffins, each returning to its roost with bunches of silvery herring dangling from their Technicolor bills. Instead, the colony is unseasonably quiet: All of the burrows have been abandoned before the eggs hatched.

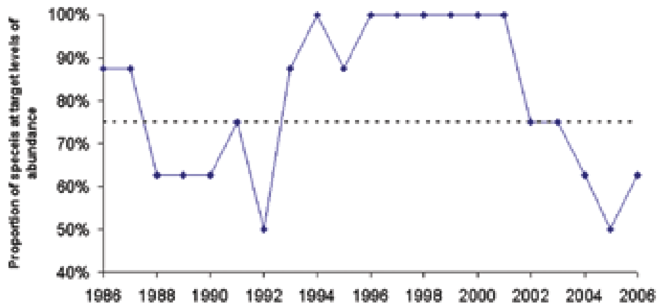
"Abandonment this early only happened once before, in 1995, when just one of the eggs in our 300 study nests hatched", Tycho recalls. "We still have no hatchlings in any of the burrows that we've inspected so far. All of the eggs, which are far fewer than normal, are ice cold, with no adults present". Although recently, they heard one chick calling, they didn't see a single adult returning to the colony with food. Indeed, the last time any adults returned in significant numbers was in June.

The puffins on Fair Isle in the Scottish North Sea, however, are faring better than those on Røst, although only half have managed to hatch their chicks. Warden of the Fair Isle Bird Observatory, Deryk Shaw warns, "The prospects for these chicks are not good". Although he has seen some of the puffins returning with their preferred chick food of small 0-group lesser sandeels (*Ammodytes marinus*), most have been carrying back other species, such as rockling (*Gaidropsarus vulgaris*) and various gadoids.

According to Shaw, many birds appear not to be breeding this year. He is unsure whether they have not come into breeding condition or have just decided not to breed this year. He notes, however, that "The number of shag [*Phalacrocorax arsitotelis*] nests on monitored plots fell by 58% since last year – an all-time low – and most of these were abandoned at an early stage".



▲ ***Figure 1:*** *A direct correlation (R^2 = 0.38; p <0.01) is seen between the breeding productivity (as average number of chicks fledged per nest) of the black-legged kittiwake (*Rissa tridactyla*) and the estimated sandeel abundance in the Shetlands from 1986 to 2004 (Parsons* et al.*, 2008. ICES Journal of Marine Science, 65: in press).*



▲ ***Figure 2:*** *The proportional abundance of the bird species (n = 8) in the OSPAR Celtic Seas Region, 1986–2006, showing that the EcoQO recommendation of 75% target abundance was not achieved in 1988–1990, 1992, and 2004–2006 (ICES Document CM 2008/LRC:06. 57 pp).*

Small comfort can be found in the fact that, because most seabird species breed for twenty years or even substantially longer, such isolated years of breeding failure will not have a significant impact on the lifetime productivity of any individual. Ominously, such poor seasons are becoming more frequent, particularly in the North Sea, with a decline in the numbers of breeding adults.

Recent data strongly suggest that these seabird colonies can provide clear indications of the state of their food chain.

Data to stand on

But what are the data supporting the growing anecdotal evidence that seabirds are failing to find enough fish to raise their young?

First, there are the annual estimates of the breeding success of the black-legged kittiwake (*Rissa tridactyla*), collected over the past 20 years in Shetland: The significant correlation between their breeding productivity and the size of the local sandeel stock supports this dependence on foodstock (Figure 1).

Second, the results from a long-term study by the Centre for Ecology and Hydrology found that the quality (as well as the quantity) of the sandeels may be limiting seabird breeding success. The study, located on the Isle of May off the east coast of Scotland, demonstrated that the size of the sandeels caught by the puffins has declined by 40% over the past 30 years.

The same research group also found that, in 2004, when the islands seabirds experienced their worst season on record, the calorific content of the sandeels, and the other fish caught by the seabirds, was significantly lower than in previous years. This would indicate that the sandeels themselves are struggling to find adequate food.

Chain of evidence

The problems encountered by sandeels, which in turn affect the seabirds, are being increasingly attributed to climate change. These claims rely on two separate, and as yet unconnected, pieces of evidence.

The first relates to sandeels in the North Sea. Around the mid-1980s, increasing sea surface temperatures led to a shift in the plankton communities, during which species composition and biomass completely changed. At the same time and probably as a consequence, there was a reduction in sandeel recruitment.

The second piece of evidence comes from the growing number of studies that have demonstrated the effects of sea surface temperatures on seabird populations. For instance, both breeding success and individual survival of the black-legged kittiwakes in the North Sea have been lower following warmer winters, when sea surface temperatures have been higher.

▲ *Black-legged kittiwake* (Rissa tridactyla)*. Photo by Matt Parsons, Joint Nature Conservation Committee, UK.*

▲ *Atlantic puffin* (Fratercula arctica)*.*

▲ *Common Guillemots* (Uria aalge)*.*

Other studies have also demonstrated that seabird survival is lower during or after mild winters. This is generally assumed to be the result of low recruitment to fish stocks during warm winters, caused either by a lack of suitable food at the right time or by increased predation.

Nevertheless, it is not clear how much these climate-induced changes in sandeel populations might actually contribute to their low breeding performance. Indeed, many other factors might be involved. It has been suggested that, in Shetland, the recovery of the herring stock to levels not seen for 40 years has increased the predation pressure on larval sandeels, thus reducing the number of sandeels available to seabirds.

Seeing a bigger picture

As seen here, most evidence linking seabird populations to changes at other trophic levels of the food chain comes from studies of single colonies. Would it not be preferable to study changes in seabird populations on much larger geographic scales? This would provide a better understanding of the complex processes underlying ecosystem productivity. But do sufficient data exist at the scale of Europe's seas?

My survey of monitoring schemes in 51 countries found that, of the 28 responding countries, 21 held time-series data on seabird numbers dating back, on average, 30 to 40 years. Not surprisingly, seabird monitoring was better established in northern and western Europe, where most of Europe's 50 million pairs breed.

The opportunity to incorporate some of these data into a multinational indicator came in March of this year, when I attended, along with 23 delegates from 13 countries bordering the Northeast Atlantic, the North Sea, and the Barents Sea, the ICES workshop in Lisbon, whose goal was to develop an Ecological Quality Objective (or EcoQO) on "Seabird population trends as an index of seabird community health".

EcoQOs, developed during this and similar meetings, are presented to the OSPAR Commission for the Protection of the Marine Environment of the North-East Atlantic, which has so far adopted

News from institutes in the ICES network

Wageningen Institute for Marine Resources and Ecosystem Studies (IMARES)

Ecological sea defence for the Netherlands

The creation of tidal marshes on the mud-flat side of the Dutch Closure Dike (Afsluitdijk) will provide the Netherlands with a sea defence and a new nature area, according to advice given by a consortium consisting of Wageningen IMARES, engineering consultancy DHV, and the design firm Alle Hosper.

The consortium proposes the establishment of 1500 hectares of new natural area in the form of tidal marshes – overgrown high sands, of which the top parts are submerged only under storm conditions. Plant growth and the introduction of sediment will encourage the tidal marshes to grow on their own, accompanying the rise in the sea level.

The tidal marshes will lead to the formation of a nature area 30 km long with a protected bicycle path with a view over the flats. The consortium also suggests setting up a visitors' centre, from which development of the mud-flat works can be followed.

The concept draws on centuries-old technology in a modern format that can be implemented quickly. Furthermore, the proposed solution fits within the available budget. The mud flats thus constitute a serious alternative to the "conventional" reinforcement, which must be completed by 2015.

12 of them to help in achieving their goal of "Managing human activities in such a way that the marine ecosystem will continue to sustain the legitimate uses of the sea and will continue to meet the needs of present and future generations".

After two days of intensive debate, we recommended the following EcoQO to the OSPAR Commission: "Changes in breeding seabird abundance should be within target levels for 75% of the species monitored in any of the OSPAR Regions or their subdivisions".

Our EcoQO aims to ensure the intrinsic health of seabird communities and to provide triggers for appropriate actions, as required. Each year, assessments will be made to determine whether or not this EcoQO recommendation has been met. Failure to do so will trigger the appropriate action, in the form of further research or management.

We are now waiting to hear whether or not OSPAR will adopt the EcoQO. In the meantime, we have begun monitoring seabird populations collectively across borders at an ecosystem scale. The data is available elsewhere across Europe. All we need is the collective will, fuelled perhaps by a political need for information.

Biography

Ian Mitchell works for the UK Government's advisor on nature conservation, the Joint Nature Conservation Committee, leading the team that coordinates the UK and Republic of Ireland's Seabird Monitoring Programme (SMP). For 20 years, the SMP has collected data annually on numbers and breeding success from hundreds of colonies throughout the British Isles. Ian chaired the ICES Workshop on Seabird Ecological Quality Indicators held in Lisbon in March 2008.

Chris Berrie, a freelance science writer based in Italy, contributed to this article.

Small comfort can be found in the fact that such isolated years of breeding failure will not have a significant impact on the lifetime productivity of any individual.

Assessments will be based on indicators for each of the five OSPAR regions, for the monitoring of species-specific trends in breeding population sizes. Within each indicator, target levels are set for the magnitude of change compared with predefined reference levels, which relate to the population sizes that are considered desirable for each individual species. This can be seen in Figure 2, which shows this indicator (as the proportion of species at target-level abundance) for the OSPAR Celtic Seas Region.

The figure clearly shows that the EcoQO target level was not met in seven out of 21 years: 1988–1990, 1992, and 2004–2006, demonstrating how this EcoQO provides a simple way of communicating the health of seabird communities. Furthermore, the very process of assessing and updating these seabird trends annually will ensure that important changes in individual species do not go unnoticed, regardless of whether the EcoQO is actually achieved in any given year.

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