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Assessing the health of the seas: the ICES contribution

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This paper traces the development of ICES work on marine environmental quality from the first tentative steps more than 50 years ago to the present position with ICES as a world leader in the field. It shows how the difficulties of monitoring and assessing contaminants in biota, water, and sediments were progressively overcome, how an understanding of the biological effects was built up, and how a comprehensive strategy eventually evolved. It also examines the activities of ICES in providing advice on these matters to Member Country governments and regional commissions.

Keywords: assessing contaminant effects, ICES history, marine environmental quality, marine contaminant monitoring.

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Introduction

There are two conflicting views on the impact of contaminants on the marine environment. One suggests that the seas are dying and their ecology is progressively being destroyed. The other argues that the oceans are too vast and turbulent to be significantly affected and could handle everything we might introduce. The truth, of course, lies somewhere between the two extremes. The present consensus is that, while the open ocean is in relatively good condition, coastal waters are certainly under pressure, with hot spots of major deterioration, particularly in estuaries (GESAMP, 1990). That assessment has gradually developed over the decades, and this paper aims to trace how ICES contributed to the understanding.

Early attitudes within ICES to contaminants

From a viewpoint at the start of a new millennium, it is easy to look back at the beginnings of ICES in the previous century and criticize it for being too narrow, for focusing entirely on fish stocks and associated hydrography. But, given the way that ICES has evolved, we can see today that criticism of this kind is invalid. Indeed, it is only fair to recognize that, although the Council may have been somewhat conservative, the early structure of ICES, however restricting, did allow it to adapt to changing circumstances, to focus on priorities, and to build new initiatives. The account of how the Council took on board the issues of marine contamination well illustrates this. It is not a straight-forward story with a clear beginning and an even progression of plot. On the contrary, ICES work on contaminants had an extremely slow start, and for the first 50 years, pollution was scarcely mentioned, although this is perhaps understandable since it was much less significant at that time. The strict focus on fisheries meant that the only other aspects of marine ecosystems which attracted effort were those with some direct bearing on commercial stocks, such as how atmospheric conditions might affect hydrography and thus influence catches.

But still, I like to think that even in the very early days, there were at least signs of the activity to come. For example, the "Central Laboratory", set up by ICES and operated in Oslo from 1902 to 1908 to conduct investigations of general interest to oceanic research, had among its aims to ensure uniformity of instruments and methods, to secure comparability of results, and "to detect possible real differences due to the method of keeping". It was also responsible for an international service providing standard seawater for research purposes (Went, 1972). All these activities foreshadow present-day interests.

Further, as long ago as 1912, we find the first concern with pollution. A Baltic Sea programme at that time, designed to address the decline in salmon stocks, noted

that among the possible causes was contamination of rivers "by sewage outfalls, cellulose factories, dye works and sawmills, or other industrial works; also by timber works and steeping of flax and hemp" (ICES, 1912). This was taken up again in the following decade in an extensive report on "River Pollution and Fisheries". Although these initiatives refer to rivers, not the sea, they do indicate early awareness of the topic within ICES, and are forerunners of future interests. In the 1920s, there was another hint of pollution concerns when work was proposed on shellfish diseases, but it took several years for this to be carried forward and for a method of bacteriological examination of molluscs eventually to be drawn up. In the same decade, the topic was raised of pollution from oil in the sea, particularly from "thick tarry oil discharged by tankers on various parts of the coast". The conclusion was that the general effect on marine life was negligible, and usually very local, but nevertheless undesirable, because nets and foreshores were contaminated. It is interesting that this view, advanced in 1922, was well ahead of its time, since such an assessment was not widely accepted until some 60 years later. In 1927, the effects of oil in seawater were again raised, this time by the Spanish Delegate. Attention was drawn to a conference in Washington on a proposed international convention on oil in the sea, and the Delegate, paying the penalty for speaking out, was asked to produce a report and proposals, for which input was requested from other members. His conclusions were circulated, but thereafter the matter lapsed.

ICES becomes involved

These examples show that at least some notice was taken of contaminants, but during the first 50 years, they were always minor matters for the Council. Environmental concern at that time was directed to impacts resulting from natural variability in the oceans and the atmosphere, and it was only much later that a change of view brought human inputs significantly onto the agenda. This change occurred in the 1950s and the early 1960s when a number of events strikingly altered the perspective (McIntyre, 1995). The fallout from nuclear weapon testing, the human deaths from mercury poisoning at Minamata (Smith and Smith, 1975), the finding of heavy metals in open-ocean fish, and the effects of pesticide residues in the marine environment all had major impacts on public opinion worldwide. This stimulated ICES to divert some of its effort to the general issue of chemical wastes in the ocean, and a new Fisheries Improvement Committee was set up in 1996. It has to be admitted that this Committee aimed primarily at acclimatization, transplantation, and artificial cultivation of fish. However, the word "environment" was included in its terms of reference, and it was requested to consider pollution. It consequently set up a Working Group on the Pollution of the North Sea and a Working Group on the Pollution of the Baltic Sea to gather information on potentially harmful substances discharged into the North Sea and the Baltic. They examined, *inter alia*, sewage, industrial wastes, pesticides, and oil, but radioactive wastes were specifically excluded "since more highly qualified groups, e.g., the European Nuclear Energy Agency, were already working on this topic" (ICES, 1969, 1970). The Working Group felt that, given the relevance of water movements and diffusion, the Hydrography Committee should be asked to look into these matters, and later the Mariculture, the Shellfish, the Marine Mammals, and the Biological Oceanography Committees were all called in, often in joint sessions, to contribute their expertise, illustrating the ability of ICES to mobilize a wide range of specialist knowledge through its committee structure. Also, Member Countries were urged to intensify programmes on pollution.

These were the first major steps of ICES into the pollution field, and one might wonder if the Council, in approving them, realized just what a can of worms it was opening. While data collection can cast light, it can also expose gaps and emphasize deficiencies, and the reports of the late 1960s certainly did this, generating activities that are still going on more than 30 years later. Other papers in this volume expand on some of that work.

Increased commitment to contaminant issues

Thus, Council initiatives on marine contaminants in the mid-1960s led to an increasingly expanding attack on the subject which developed into a major component of the overall ICES agenda. It is possible to recognize two basic elements; the first constitutes a comprehensive approach to the general assessment of marine environmental quality, including extensive monitoring; the second encompasses specific treatment of selected issues of priority concern. Also, the Council accepted a major responsibility to provide advice on these matters to Member Country governments and other relevant customers, and took appropriate action, including the establishment, in 1973, of the Advisory Committee on Marine Pollution (ACMP) and, in 1977, of the Marine Environmental Quality Committee. These are discussed in more detail in a later section of this paper.

Environmental quality assessment

This developed directly from the original North Sea and Baltic working groups. In 1971, the Fisheries Improvement Committee was instructed to focus its main attention on pollution, and a new Working Group for the International Study of the Pollution of the North Sea and Its Effects on Living Resources and Their Exploitation, set up to expedite progress, met between

1972 and 1974. As well as further quantifying direct inputs, it arranged a baseline study of selected metals and organochlorines in tissues of fish and shellfish, surveys of "dissolved" metals in water, and an exercise to compare results from different laboratories. Also, since the development of oil production in the North Sea carried the risk of pollution, this was listed for investigation. In addition, atmospheric deposition was considered. The aim was to produce a snapshot of conditions in biota and water, initially with a view to assessing possible threats to human health from consumption of fish and shellfish (ICES, 1974a). It was accepted that the next step must be to ascertain direct hazards to fish stocks and then to the ecosystem in general. An extensive and continuing programme of monitoring was seen to be an essential part of this work. At the same time, information on the flushing time of the North Sea and on natural processes at the mouths of estuaries was clearly relevant, and arrangements were made to address these topics (ICES, 1982). For the former, a Study Group on Flushing Times of the North Sea was set up which discussed mean transit and flushing times. For the latter, a Mini-Symposium on "Transport Processes in Estuarine and Nearshore Zones" was held, and this was followed up later with a more comprehensive workshop on Contaminant Fluxes through the Coastal Zone.

In 1974, a new expanded Working Group on Pollution Baseline and Monitoring Studies in the Oslo Commission and ICNAF [International Commission for the Northwest Atlantic Fisheries] Areas took over. Baseline and monitoring were now firmly built into the terms of reference, and an even more comprehensive outlook was adopted (ICES, 1975a). The biota had been selected for the early work because the accumulation of chemicals in animal tissues facilitated analysis. Even so, many questions remained, including which species to sample, which tissues to use, which sex, which season of the year, and should samples be lumped or analysed individually? These matters were given due consideration.

At the same time, the possibilities of using water and sediments for monitoring were examined. Each of these compartments has its own group of problems. For water, perhaps the main one was in conducting analyses on low concentrations of contaminants. Sediments are potentially useful since most contaminants show a high affinity to particulate matter and preferentially to the fine-grained fraction of suspended solids. Unfortunately, their use in monitoring is particularly tricky, not just in the analyses, but also in the selection of sampling areas and the interpretation of results, so an *ad hoc* Meeting of Specialists in the Field of Pollutants in Sediments was arranged to look at the role of sediments, both suspended and deposited, in retention and recycling of pollutants. The group reported (ICES, 1977) that most of the work had been focused on metals and conducted around discharge points and in estuaries and nearshore zones where the situation is dynamic and complex. At that time, in 1977, it was not felt that a coordinated programme of monitoring pollutants in sediments could be recommended in these areas, but pilot-scale studies were proposed for certain offshore sites, and also a programme on suspended sediments. The next few years saw considerable activity within ICES in this field, including, in 1979, a Workshop on Sediment and Pollutant Interchange in Shallow Seas (Postma, 1981). Eventually, in 1980, it was agreed to establish a Working Group on Marine Sediments in Relation to Pollution which would promote relevant studies of physical, chemical, and biological processes and, in particular, review the role of sediments in pollution monitoring (ICES, 1982). Over the past 20 years, the Working Group has been a source of invaluable guidance and advice. The problems of sediments are further discussed in this volume (Rowlatt, 2002).

The first working groups had noted that atmospheric deposition could be an important source of pollutants, but that there were few data. Further studies suggested that significant quantities of metals reached the sea via rainfall, and of organochlorines by dry deposition, but it was clear that before reliable conclusions could be reached about the magnitude of inputs from this pathway, some means of direct measurement would need to be devised. Given the difficulties, ICES agreed that linking with other international groups such as the World Meteorological Organization (WMO) and the Organisation for Economic Cooperation and Development (OECD) was desirable, while at the same time research and review papers should be requested (ICES, 1978a). Thereafter, the topic of atmospheric inputs of contaminants to the sea featured regularly on the ICES agenda, and in discussing a review of the knowledge in 1987 (Jickells, 1988), the ACMP suggested that in open-sea areas, the atmosphere may well be the major source of a wide variety of contaminants, but that nearshore the combination of riverine and other land discharges could be dominant.

In association with the monitoring studies, ICES made another major advance. It recognized that the provision of good data on contaminant concentrations did not by itself necessarily answer the relevant questions, since it was the impact of the concentrations that mattered, so the general issue of biological effects and how their measurements might be built into the monitoring work was addressed by a Sub-Group on the Feasibility of Effects Monitoring. This group reported that pollutants could produce a wide spectrum of effects, ranging from the levels of cells and tissues, to individuals, populations, and communities, and encompassing physiology, morphology, and genetics (ICES, 1978b). Today, this is a well-established part of our thinking, and we tend to forget that it was ICES that brought it to the fore. The topic was expanded through an international workshop in 1979 which identified a suite of procedures to be considered for monitoring biological effects (McIntyre and Pearce, 1980). At that time, it was accepted that no single monitoring procedure would be adequate. Rather, a

suite of techniques should be put together, and the package must be supported by chemical residue analysis and appropriate hydrographic observations. During the 1980s, ICES developed the topic and, in 1984, established a Study Group on Biological Effects Techniques to assess the various approaches. This was transformed two years later into a Working Group on Biological Effects of Contaminants with a much broader remit. In 1990, an ICES/IOC Workshop was held, based at Bremerhaven, involving eight research vessels on which techniques at different levels of biological hierarchy were tested. As a result of this and other studies, the ACMP felt able to recommend a number of biological effects methods for application and evaluation in pollution monitoring programmes (ICES, 1991). Throughout the rest of the decade, ICES continued to develop and expand the use of biological effects techniques. Addison (2002) addresses this topic. One aspect is the use of fish diseases in a monitoring context, and an *ad hoc* meeting considered this with particular reference to liver pathology of flatfish in 1996/1997. The topic of fish disease is discussed further in a paper in this volume (Lang, 2002).

An unexpected early setback in the monitoring work had occurred when comparison of results showed that serious discrepancies existed between different institutes, and that examination of methodologies coupled with intercalibrations would be required. This started off as an apparently straightforward exercise on trace metals in biological tissue in 1972, but it mushroomed to a diversity of calibrations and comparisons involving, at different times, metals, organochlorines, hydrocarbons, and nutrients in tissues, water, and sediments. The general philosophy of these exercises was reconsidered in 1982 when it was recognized that, in addition to merely intercalibrating chemical analyses, the whole sequence of procedures for sampling would need to be carefully examined, from collection at sea through preservation, storage, processing, and even the reporting of the results. This was the beginning of an extensive quality assurance programme (ICES, 1983a). Such work was still under way in the year 2000 when a report on the Seventh Intercomparison Exercise on Trace Metals in Seawater was published (ICES, 2000a).

All this effort produced vast quantities of data, and discussion developed on how best to deal with these statistically, resulting in the formation of a Working Group on Statistical Aspects of Environmental Monitoring and the holding of a Workshop on the Identification of Statistical Methods for Trend Monitoring. Another paper in this volume expands on the application of statistics within ICES (Bignert, 2002).

Thus, by the early 1970s, ICES had embarked on a series of long-term monitoring initiatives covering three marine environmental compartments (biota, water, and sediments) and had provided advice on inputs from the atmosphere. Further, in addition to the necessary routine field observations, attention was paid to ensuring that the best general approach was adopted. A Working Group on Environmental Assessment and Monitoring Strategies was set up, and the ACMP, in 1988, discussed the philosophy, principles, and strategy of monitoring. This turned out to be an ongoing exercise culminating in a paper in 1995 on the ICES role in environmental monitoring. It is interesting to note that the Fisheries Improvement Committee was at first reluctant to take part in monitoring, arguing that ICES, as a scientific body, should not engage in inspectorial responsibilities, which should be discharged through the international conventions. However, by the late 1980s, ICES was fully involved.

Specific issues

The ICES pollution agenda encompasses a diversity of topics that vary in importance from time to time. For example, dumping of wastes at sea, although now largely under control thanks to the Oslo Convention, initially attracted considerable attention, while at the more specific level, ICES has, for a long time, promoted studies of selected contaminants, either as chemical categories or as individual substances.

Dumping

Several operations have been examined. One was the dumping at sea of waste from bauxite processing. This consists of a slurry known as "red mud" which is toxic only to the extent of its high pH, but which can have a smothering effect on the bottom due to its significant solids content. Another operation was the disposal of wastes from titanium dioxide production which have a low pH and a high content of iron. In both of these cases, ICES was able to assess the problem and advise on how disposal could proceed without significant environmental effects (ICES, 1975b, 1985). Incineration of toxic liquid chemical wastes at sea is a form of dumping, and the ACMP discussed the problem of identifying ocean sites for incineration vessels and assessed the harmful effects of the operation, bringing in the expertise of the Hydrography Committee and the Marine Chemistry Working Group. It was concluded that incineration at sea could be an effective and acceptable way of destroying certain organic wastes provided that the codes of practice were strictly adhered to. However, there were still concerns about possible accidents during transport and about dispersal of the plume gases. These concerns prevailed, and incineration at sea was eventually phased out in the Oslo Commission area.

Selected contaminants

Arising from papers presented to ICES committees and the Marine Chemistry Working Group and from tasks commissioned by the ACMP, a major body of informa-

tion has been built up on the sources, distribution, and effects of a wide range of substances with actual or potentially damaging effects on the marine environment. In particular, well-documented, referenced overviews have been produced of heavy metals and synthetic organic compounds of continuing concern, as well as of less well-known substances such as octachlorostyrene, nonylphenols, and endocrine disruptors. This work has been presented to the ACMP and ACME (Advisory Committee on the Marine Environment) and published in the ICES Cooperative Research Report series since 1981. The overviews are produced by specialists and go through several stages of review before acceptance. The information is put to good use by the ICES community, but it is unfortunate that these publications tend to be seen as "grey" literature and do not receive the widespread attention they deserve.

While some topics are picked up from time to time as interest is aroused, it is worth exploring in more detail two subjects, oil and nutrients, which attracted much longer-term interest, and one, radioactivity, which was neglected.

Oil

As already mentioned, the question of oil pollution had been raised in ICES as long ago as the 1920s in the context of discharges from ships, but the wreck of the "Torrey Canyon" in 1967 and the subsequent series of tanker accidents brought new concerns, and these were exacerbated in the 1970s by the introduction of oil exploitation in the North Sea. ICES reviewed the experience of marine oil pollution in different countries. It was noted that, in general, mechanical methods were used to remove oil from beaches, but sinking of floating oil was not favoured since it could cause tainting of fish and contamination of gear, and there were reservations about the use of dispersants because of their toxicity (ICES, 1969).

Thereafter, the Council showed considerable interest in oil and, in 1974, arranged an international workshop. This covered a wide range of topics, including the occurrence of oil in the sea and its fate and effects. It was concluded that "any extreme view of the hazard to the marine environment from petroleum is not justified", again foreshadowing the evaluation of later years (McIntyre and Whittle, 1977).

ICES meetings then echoed with the names of ships and oilfields, including "Argo Merchant", "Amoco Cadiz", "Ekofisk", and "Ixtoc". Subsequently, an *ad hoc* Group on Research Activities Related to Oil Pollution Incidents was established. It identified the scientific work needed to assess effects, but also examined both pre- and post-spill situations (ICES, 1981). From then on, ICES devoted appropriate attention to oil spills, with papers on the Bantry Bay disaster, the "Thesis" spill, the "Exxon Valdez" incident, and covered a diversity of topics, including the concentrations of hydrocarbons in water and sediments and the best approaches to their analyses.

In the context of subsea drilling, a study in 1977 dealt with the interactions between the fishing industry and the offshore oil and gas industries. National regulations were reviewed, and the interactions between trawlers and pipelines were examined (McIntyre and de Groot, 1980). At the analytical level, intercalibrations were organized on petroleum hydrocarbons in biological tissues, and the problems of measuring hydrocarbons in seawater were considered. Also, the effects of using concentrated oil dispersants were assessed. Further, a comprehensive study covered the impact of continuous releases of oil at low concentrations, reviewing discharges from offshore platforms, and listing other point sources such as shipping and pipelines and diffuse sources like rivers and the atmosphere (ICES, 1986). It concluded that there was no evidence of significant deterioration of marine communities due to low-level, long-term oil pollution, but it was admitted that such deterioration would be difficult to detect in time to act, so every effort should be made to reduce oil inputs.

As a result of all this work, our understanding of oil in the sea greatly increased. We now know how it behaves and degrades, how it affects organisms, and we are better able to react to incidents, in particular recognizing that leaving an oil slick alone is an acceptable environmental option.

Nutrients

Another subject that was always of interest to ICES is nutrients. From its earliest days, the Council had been concerned with the basic properties of seawater, and work was done in the Central Laboratory at the beginning of the 20th century on the determination of ammonia and the solubility of nitrogen in the sea. In 1928, a special session was held on the estimation of nitrogen and phosphorus in water, and in the following decades, these methods were again reviewed. When the Working Group on the Pollution of the North Sea was set up in 1969, it covered nutrients and noted that increased levels resulting from sewage inputs could be associated with algal blooms, which were sometimes toxic. Later, the Working Group for the International Study of the Pollution of the North Sea and Its Effects on Living Resources and Their Exploitation quantified inputs of nutrients from sewage and reported, in 1974, that, while they saw no danger of eutrophication in the North Sea as a whole, increasing levels of nutrients in the Southern Bight might be linked with sewage discharges.

The Oslo Commission asked the ACMP to investigate the possibility of using indices of primary production to monitor the condition of seawater. The conclusion then was that it would not be easy to link changes or lack of

changes in primary production to the input of a contaminant nor to use them as measures of pollution loads (ICES, 1975b). While considering this problem, the Advisory Committee also discussed the general issue of eutrophication. It noted that, as the word had been used in several different ways, it might be helpful to distinguish between "hypertrophication", where the effects are harmful, and "eutrophication", where the effects are neutral or even beneficial. It was not felt likely that added nutrients would be harmful in the open sea, but there might be adverse effects in restricted waters.

On an associated matter, the relationship between eutrophication and red tides had been raised earlier by the Fisheries Improvement Committee. This was now taken up by the ACMP in the context of dinoflagellate blooms causing toxicity in mussels, and an observational programme was recommended. The stimulation for investigations by ICES often came from papers presented to committees on the initiative of individual scientists, and in the late 1970s, several papers on red tides and algal blooms appeared. From 1980 onwards, plankton blooms were regularly on the ACMP agenda. Implications for fisheries, mariculture, and public health were noted, and suggestions were made for research on species identification and the prediction of blooms. A joint session on "Plankton Blooms" held at the 1982 ICES Statutory Meeting formed the basis of an interim statement on current knowledge on exceptional blooms (ICES, 1983b). Later, the general question of nutrients was again examined, and the need to measure fluxes as well as concentrations was emphasized. The evidence available on the possible role of nutrient enrichment in increasing primary production and inducing exceptional bloom events appeared to be either inadequate or contradictory. It was felt that deeper study was merited, especially in enclosed waters inshore, and this was followed up at a special meeting on "Exceptional Plankton Blooms" (Parker and Tett, 1987). One result of this meeting was that ICES established a Working Group on Exceptional Algal Blooms which first met in 1985 and, *inter alia*, advised on overcoming bloom effects on mariculture. It was later renamed the "Working Group on the Effects of Exceptional Algal Blooms on Mariculture and Marine Fisheries", with broader terms of reference. In discussing all this, the Advisory Committee had noted the confusion generated by the use of the term "bloom" to refer to several different events. It introduced the expression "Exceptional Marine Blooms" to distinguish between the normal spring and autumn outbursts and other blooms which might have deleterious effects, such as toxicity or oxygen reduction. In 1988, a Study Group on the Ecology of Algal Blooms was established, and a mini-symposium was held on "Coastal Eutrophication System Productivity and Harmful Algal Blooms" focusing on the use of enclosures for relevant research. This topic now had high priority within ICES, and in the 1990s, considerable attention was paid, not just to the generation of exceptional blooms, but also to primary production, in general, and to its measurement. In this context, ICES recognized the value of interacting with experts in other bodies, including the Intergovernmental Oceanographic Commission (IOC) and the Scientific Committee on Oceanic Research (SCOR), and by the end of the decade, an extensive collaborative programme was under way (ICES, 2000b).

Radioactivity

While ICES was always willing to address fisheries matters that were obviously within its competence, the Council, for a time, tended to be uncomfortable in linking with other international bodies. Thus, at the 1960 Bureau meeting, when close collaboration with the United Nations Food and Agriculture Organization (FAO) was discussed, not all members were in favour, but it was eventually agreed that the Council should be represented at meetings of international organizations having mutual interests (Went, 1972). Reticence was also evident in the range of topics selected for study and reluctance to engage in activities which might stretch the available expertise. While this desire to conserve resources is no doubt laudable and understandable, it did result in some isolation, which is well illustrated in the context of radioactivity. In 1955, a lecture by M. Fontaine of France (Went, 1972, p. 120) on the dangers of radioactive pollution stimulated the Council to transmit to Member Countries as well as to appropriate UN agencies, a recommendation calling for an international study of discharges into marine waters of "waste products from atomic industries". This subject came up again at the Council meeting in 1962 when the Hydrographic Committee proposed the establishment of a subcommittee on marine radioactivity. However, the proposal was rejected mainly because many members felt the subject was already adequately covered by other organizations. This reasoning prevented the inclusion of radioactive contamination in the terms of reference of later committees and working groups, closing ICES off for decades from direct involvement in a topic of considerable environmental significance. It is only in more recent years that radioactivity again appeared on the agenda, first through an interest in radioactive tracers for hydrographic studies (Livingston, 1986; Pentreath, 1987) and then, in 1994, with reports on two Norwegian/Russian surveys in the Kara and Barents Seas assessing the impact of radioactive contamination on the Arctic marine ecosystem and establishing the uptake of radionuclides by fish and the impact on fisheries (Føyn, 1994a, 1994b). Three years later, in a theme session on "Arctic Oceanographic Processes", a summary was presented of work from the Arctic Monitoring and Assessment Programme (AMAP) on radioactivity in the Arctic environment (Bewers, 1997). This subject is apparently no longer taboo within ICES.

Advisory activities of ICES on pollution

The work of ICES was, from the beginning, designed to shed light on matters affecting fisheries and implicitly to provide advice on their management to Member Country governments. In the same way, the occasional studies on pollution in the 1920s aimed to assist management decisions. But in the early days, advice tended to be contained in recommendations attached to reports issued in connection with individual studies, and it was not until later that a formal advisory mechanism was developed for fisheries. It was later still that a comparable mechanism for pollution was put in place. Initially, such work was coordinated by the Fisheries Improvement Committee set up in 1967, but the establishment of the Advisory Committee on Marine Pollution (ACMP), which first met in 1973, was recognition that the provision of this advice needed a special focus. The ACMP at that time consisted of an elected chair and four co-opted members together with the chairs of five appropriate committees. It was to be responsible for "providing scientific information and advice on marine pollution and its effects on living resources and their exploitation to Member Governments and any intergovernmental body for the control of pollution which might request such advice". It was able, in the traditional ICES style, to draw on the activities of a wide range of study groups, working groups, and standing committees, not least on the Marine Chemistry Working Group and the Marine Environmental Quality Committee, which was set up in 1977. The ACMP, in its first report (ICES, 1974b), was particularly concerned with the needs of the Oslo Commission, but in 1976, it also began to include the Interim (as it then was) Helsinki Commission, and in later years, came increasing requirements from the Paris Commission.

In the 1980s, a major new area of activity emerged. The First International Conference on the Protection of the North Sea, which met in Bremen in 1984, brought together a great deal of information on conditions in the area, and ICES noted that this was relevant to its own regional assessment work (ICES, 1986) as well as to its experience on oceanography and contaminant baselines. The ACMP later spent some time assessing the Report on the Quality Status of the North Sea (DoE, 1987), which had been prepared by the Secretariat to the Conference for the second meeting in London in November 1987, and thereafter, ICES became progressively more involved. It agreed to cooperate with the Oslo and Paris Commissions in co-sponsoring the development of a comprehensive programme to enhance scientific knowledge and understanding of the North Sea environment in relation to pollution. Further, following the Third North Sea Conference in 1990, ICES accepted the lead role in assessing the impact of fisheries on the ecosystem, and established a new study group on the topic. The North Sea work included a major monitoring exercise, and ICES made commitments to handle and assess the data collected. A North Sea Task Force had been set up by the Conference Secretariat in 1988 which worked until 1993 to produce a monumental North Sea Quality Status Report (QSR) (North Sea Task Force, 1993), to which ICES contributed chapters and assisted by reviewing the scientific sections prior to final submission and overseeing its publication. It was understood that such a QSR should be developed at regular intervals thereafter, and ICES continued to be closely involved.

By then, the Council was widely accepted as a source of international advice on marine pollution, and in 1992, the ACMP was reconstituted, with a broader remit, national representation, and a new name: "Advisory Committee on the Marine Environment" (ACME). The revised remit required the Committee "to assess the risks to the marine environment and its biota from, *inter alia*, contaminants, fishing activity, mineral extraction, nutrient inputs, introductions and enhancements, and changes in climate". This change signalled an appreciation of the extended definition of the pollution concept and of the need to take account of more than just contaminant inputs. The ACME, like its predecessor, responds to requests from ICES Member Countries and regulatory commissions and also assists proactively by alerting them to current and emerging issues and commenting on problems that have not always been clearly defined by its clients.

ICES: present and future

From this review, it is clear that ICES is entering its second century with a much more balanced and comprehensive agenda than when it started. From the early 1960s, it has been building up a formidable body of knowledge and expertise on marine contamination. What began as a simple survey of inputs has developed into an extensive and complex interdisciplinary component of the overall integrated ICES programme which now covers the whole spectrum of concerns associated with life in the sea and is engaged in issues which are high on the global agenda.

In summary, I have identified two approaches. First, there is the general consideration of environmental quality involving broad-based monitoring and assessment; second, the focus on specific contaminants or categories of pollution: oil, nutrients, metals, synthetic organics. The conduct of such work at the international level requires a complex and reliable administrative machine backed up by a strong technical and scientific group. We might reasonably ask how well ICES is equipped to cope with the demands. The unique character of ICES, and one of its great strengths, is that it integrates both a top–down and a bottom–up approach. Member Countries and clients table their requests for information and advice and thus generate major programmes. But in addition, the scientists, meeting together without politi-

cal constraints, identify problems, recognize issues, and suggest solutions. All the proposals, from whatever source, are passed through the machinery and are eventually considered for the final agenda.

When an organization is celebrating its centenary, it is perhaps reasonable to wonder how much longer it might be expected to survive. This leads to the question: what is ICES? It is not the Bureau, not the Council, not the scientists or the members; it is all of these, acting together with governments. This constitutes a formidable combination, well suited to tackle the problems of the new century. Its future success seems assured.

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