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Hydrobiological Variability in the ICES Area, 1990-1999

Introduction

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This volume records the proceedings of the second in a series of Decadal Symposia, in this case focusing on the decade of the 1990s and set up by ICES to meet a quite specific purpose. As in the first volume (Dickson *et al.*, 1992), it is worth recalling why the series was begun, since this explains the aims and content of the Symposium.

In October 1987, during the 75th Statutory Meeting in Santander, the Council endorsed the conclusion of its Consultative Committee that annual publication of the *Annales Biologiques* series was no longer feasible within the available budget, and Volume 41 for the year 1984 became the last in that distinguished series. From the expressions of regret recorded by many Standing Committees at its discontinuation (*Procès-Verbal*, 1987), it was plain that the *Annales* had been providing a valuable compilation of data and information not readily available elsewhere. Hence, as there remained a scientific justification, ICES aimed to meet the same scientific purpose via a different and more affordable route.

On the advice of a small working party, consisting of the Chairs of the (then) Hydrography, Marine Environmental Quality, and Biological Oceanography Committees, together with the ICES Hydrographer and ICES Environment Officer, the Consultative Committee recommended that the essential purpose of *Annales Biologiques* might be met by promoting symposia on "Overviews of the Decade", in which, following the approach of NAFO, the relevant climatic, oceanographic, and biological material might be pulled together and compared. This recommendation was accepted by the Council, and at the 76th Statutory Meeting in Bergen it was given substance when it was decided that the first such symposium should be held in Mariehamn in the Baltic during June 1991 (C. Res. 1988/2.2).

While the above describes the bare facts of the decision, it fails to describe the continuity of purpose which has maintained the issue of long-term change in the forefront of ICES activities throughout its century-long existence.

As early as 1890, Otto Pettersson and Gustav Ekman had begun the process of applied hydrographic monitoring in the Baltic and North Seas, and it was the utility of Pettersson's scheme that was a key factor in prompting the founding of ICES in 1902. Though these early initiatives were invaluable in establishing a basis for the long-term detection of "change", something more was required for this to develop into the wealth of decade-to-century time-series that today form so much of the focus, interest, and expertise of ICES. That extra stimulus was provided by the large-scale, long-period shifts in ocean climate that have successively worked their way through ICES waters during much of the present century: the "Warming in the North", the "Russell Cycle", the "Great Salinity Anomaly", and the varied effects of the North Atlantic Oscillation (NAO).

The stimulus of extreme climatic events has certainly continued in the decade under review. During the early 1990s, the NAO evolved to positive values unprecedented in the instrumental record. In fact, in his invited Keynote Address, Dr Phil Jones of the Climate Research Unit, University of East Anglia, suggests that the recent amplification of the NAO from the 1960s to the 1990s may be unique even in proxy records of 600 years' duration (Jones, 2003). The latter part of the decade was hardly less spectacular; following a rapid drop to extreme low-index values in the winter of 1996 (again, one of the largest year-on-year changes of record), the two main pressure-anomaly cells of the NAO pattern showed a marked tendency to shift eastwards during the last winters of the decade.

As the principal recurrent mode of atmospheric forcing in the Atlantic Sector, such extreme patterns of NAO behaviour were associated with changes of large amplitude throughout the ocean-atmosphere system of the Atlantic. As varied examples of that response, we note that in the early 1990s the storm index for the southern Norwegian Sea rose to a 100-year maximum, an extreme freshening visited

the two dense overflows, the transport of the eastern overflow slackened by 20%, convection in the Labrador Sea reached unprecedented depths, contributing to a full-depth change in the NW Atlantic that is thought to be the largest of the modern oceanographic record, the main Atlantic gyre circulation spun up to a century-long maximum, as did the transport of Atlantic Water passing through the Faroe—Shetland Channel, and the warmth recorded off northern Norway rose to a 40-year peak. These and other remarkable changes in the physical environment will be documented in the papers that follow, together with evidence of the ecosystem response.

Had the climate of the 1990s been rather less anomalous, there would still have been point to this decadal review. Only by achieving continuity of observation are we able to recognize what is extreme from what is normal and identify the subtle shifts in the marine climate that may have important effects on the ecosystem. Yet it is a sobering fact, captured by Duarte *et al.* (1992), that although there has been an exponential increase in the initiation of new time-series monitoring programmes in European marine stations in recent decades, there has also been an exponential increase in their termination, so that "long-term monitoring programmes are, paradoxically, among the shortest projects in marine sciences: many are initiated, but few survive a decade". Put differently, policy-makers are rather easily startled into initiating actions, but the time scales of policy, funding, and even of scientific "fashion" are not normally imbued with much stamina.

"Consequently", as Duarte *et al.*, point out, "the continuation of long-term monitoring programmes is often heavily dependent on the personal effort and dedication of individual scientists", and nowhere is the truth of that statement better recognized than in the Standing Committees of ICES, where individuals and groups of individuals have long taken the responsibility for piecing together the evidence for change in their regional marine environments and for attributing these changes as to cause.

The early history and purpose of these efforts were beautifully captured by Johan Hjort, the ICES President at the time, in his Preface to the first volume of the *Annales Biologiques* series, when he explained the watershed in scientific thought and the progression in our thinking which had necessitated the new publication. There were three main links to that new chain of thought: first, "the hypothesis, which at the beginning seemed so daring . . . that the statistics of the catches of the fishermen or research vessels may be considered as representative of the existing stock"; second, the idea that "samples collected from a series of years disclosed the important fact of fluctuations in the stock from the one year to the other"; and finally "from the closer understanding of these changes arose the conviction that such changes were governed by the influence of the environment which might be investigated not only for a rational understanding of the contemporary situation but also for prognoses as to events in future" (Hjort, 1943).

Though the idea of a permanent International Commission to make and administer such prognoses was proposed at the Berlin Meeting of the International Council, such a degree of official international cooperation proved impossible in the climate of May 1939. At the level of the individual scientist, however, there was no such problem, and the Consultative Committee under Chair E. S. Russell, Vice Chairs A. Hagmeier and E. Le Danois, and its Sub-Committee on "Hydrographical and Biological Investigations" chaired by Martin Knudsen, went right ahead with a plan to collect the biological and environmental data that such an International Commission would one day require when hostilities ceased.

Annales Biologiques was the expression of that plan, and with an energetic Jens Smed returning from his Master's degree in physics in 1939 to play his key dual role in developing the Service Hydrographique as an effective regional data centre, and in piecing together the accumulated data into reliable long time-series, the plan was rapidly equipped with the necessary physical infrastructure to match the data products of the Fish Committees.

These actions, however necessary and effective, still do not add up to the long time-series of multidisciplinary data against which the slow shifts of environmental change can be recognized and explained. To achieve that required simple continuity of enthusiasm and effort while the time-series and data sets lengthened. As we noted in the first of these symposium proceedings, if we sometimes appear to be unduly preoccupied with the personalities and history of this subject within ICES, it is a preoccupation that is readily explained as one practical way of acknowledging and encouraging these efforts.

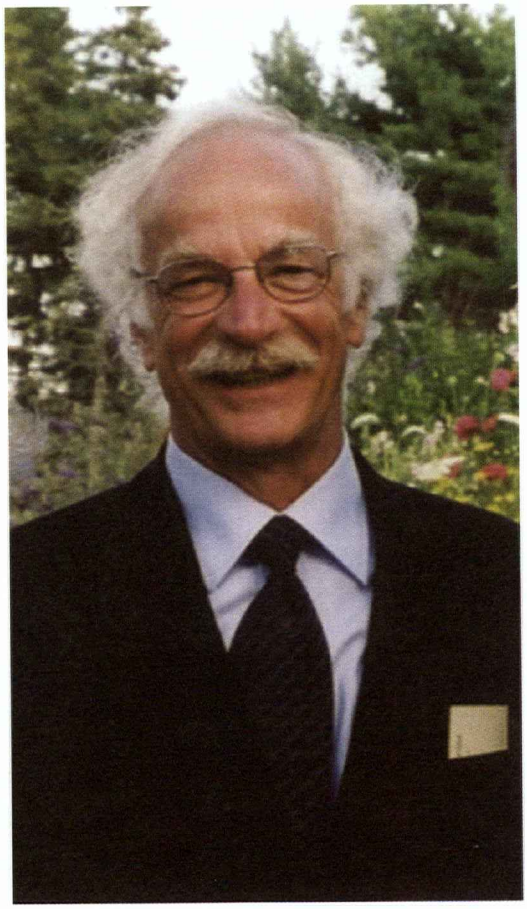
Hence, a further purpose of the Decadal Symposium series was to acknowledge the actions of the individuals who had taken part in lengthening and broadening our description of the marine environment throughout recent decades, still fired with the idea that motivated the *Annales* in the first place; namely that changes in the ecosystem and the physical environment are linked in some understandable way.

In many ways their task was the hardest of all, as the certainty with which Hjort and his contemporaries viewed the connection between the great fisheries and their physical environment sometimes proved difficult to pin down, as the time scale of

Government policies and the stamina of their funding both shortened, and even to some extent as the fashions of science switched away from the long haul of monitoring and description to the short-term intensive study of process.

As in Mariehamn, the five individuals whose efforts are especially acknowledged in this proceedings volume were leaders and long-time contributors to the study of environmental variation and effects on biota over many decades within ICES. On this occasion the scientists honoured at the Symposium were John Lazier (BIO, Dartmouth, NS, Canada), Svend-Aage Malmberg (MRI, Reykjavík, Iceland), David Ellett (DML, Oban, Scotland, UK), Johan Blindheim (IMR, Bergen, Norway) and Leo Otto (NIOZ, The Netherlands). Though ill-health prevented David Ellett from attending, Stig Fonselius and Odd Sælen, whose contributions were celebrated at the original Mariehamn Symposium in 1991, were able to participate once again on this occasion. We are profoundly sorry to note Stig Fonselius' death in January 2003. It is perhaps one of the best design features of the "Decadal Symposium" idea that it will provide a recurring opportunity to acknowledge and encourage the efforts by others into the future.

For the present, these individuals will forgive us if, with five long careers to consider, we are forced to describe them in only a few inadequate sentences.



John Lazier

John Robert Nicholas Lazier (born 1 November 1936) entered oceanography via a BA in physics at the University of Toronto, then an MSc in oceanography at the University of British Columbia in 1963, ultimately completing a PhD at Southampton University under Henry Charnock in 1977. So far as oceanography is concerned, the gap between the MSc and PhD is highly significant, since it was during this period that he completed his first pioneering studies of the oceanography of the NW Atlantic.

Already since June 1960 a scientist at BIO, the young John Lazier was able to seize on a lull in ship schedules to undertake two long campaigns of hydrography, first to the Davis Strait in 1965 aboard CCGS "Labrador", then to the Labrador Sea in late winter 1966 aboard CSS "Hudson". The impetus for the latter came from conversations with Val Worthington of Woods Hole, who, along with John Swallow, had recently surveyed the northern North Atlantic as part of the IGY surveys on the "Erika Dan". They had not found indications of convection capable of renewing the intermediate Labrador Sea Water, and Val had encouraged John Lazier to try again with a denser survey. The result was the first, and to date the only, fully three-dimensional survey of the physics, oxygen, and nutrients of the Labrador Sea. It could probably not be afforded today.

Of course, as we now know, the NAO in winter 1966 was in the middle of its most strongly negative state in the instrumented record, with exceptionally gentle conditions in the Labrador Sea and no deep convection to be found, no matter how closely spaced the stations. But as a result, this survey gave us the vital benchmark for what Peter Rhines has called the "Crouching Tiger stage" of the NW Atlantic circulation. It came none too soon. From the explosive resumption of convection in winter 1972 to the NAO-positive extreme of the early 1990s, the continuation of hydrographic time-series from the Labrador Sea by John Lazier, Allyn Clarke, and others has described a remarkable intensification and deepening of convection, reaching to 2300 m by 1993.

The radical nature of the change is evident from John's own 1995 assessment. From 1966 to 1992, the overall cooling of the water column of the

Labrador Sea has been equivalent to a loss of 8 W m^{-2} continuously for 26 years, the overall freshening was equivalent to mixing in an extra 6 m of freshwater at the sea surface, and as a result the steric height in the central Labrador Sea was typically 6–9 cm lower than in the late 1960s. These full-depth changes are arguably the largest ever observed in the modern instrumental oceanographic record. Maintenance of the WOCE AR7W Section into the late 1990s identified a new period of restratification in which convection was confined to 1000–1500 m and the deeper convected water drained away from the region.

There have been other accomplishments. Ninety days with Val Worthington in the Denmark Strait in 1967 failing to measure its outflow, failed also to dampen John's enthusiasm for direct current measurements in difficult environments. By maintaining current meters on the Labrador Shelf and slope during the late 1970s and throughout the 1980s, in spite of losses to corrosion, icebergs, and trawlers, he measured the 30 Sv return flow of the subpolar gyre which had been predicted but not observed, as well as the annual cycle in strength of the Labrador Current.

In 1994 John changed state at BIO from Scientist to Scientist Emeritus, though with such discoveries, and prompted throughout his career by such delightful and stimulating mentors as the late Val Worthington, John Swallow, Henry Charnock, and George Needler, it is unsurprising that John has found retirement unappealing. A glimpse at his current and recent fieldwork plans on the BIO Website will explain just how unretired he is, to our great benefit!

Svend-Aage Malmberg

Perhaps more than any other, **Svend-Aage Malmberg** (born 8 February 1935) has epitomized the collaborative international spirit of ICES in observing and then piecing together the evidence for the dramatic hydrographic changes that have passed through ICES waters over the past several decades. Though born and schooled in Reykjavík, his initial oceanographic training, qualifications, and employment were obtained at the University of Kiel (1955–1962) and, although employed at the Marine Research Institute in Reykjavík from 1963 to 2001, he has taken care to refresh and renew his international links from time to time through study periods at the Universities and/or Marine Research Institutes of Gothenberg, Bergen, Copenhagen, and Washington. Over this entire period, he also served as Icelandic representative on the Hydrography Committee of ICES and its Working Groups.

As a research scientist, Head of the Hydrography Division (1976–1985), and Head of the Physical Oceanographic Group within the Ecology Division at MRI (to 2000), Svend-Aage had responsibility for providing an annual description of the hydrographic status of Icelandic waters as necessary input to the successful management of Iceland's marine fisheries and ecosystem. While the requirement itself may have been routine its delivery was not, since it relied on the annual working of a radiating network of standard hydrographic sections around Iceland each season for decades in some of the most daunting weather on Earth. Straddling the Ocean Polar Front and crossed by the cold dense overflows that ventilate the deep ocean, these Icelandic waters have also formed a key component of a succession of physical oceanographic campaigns that have explored the local, regional, and global importance of Atlantic ocean-climate variability; the ICES Overflow '73 project, the Iceland Sea Project (1974/1975), the ICES Deep Water Project of 1980/1981, the ICES NANSEN Project of 1986–1990, the Greenland Sea Project of 1987–1991, the World Ocean Circulation Experiment of 1992–1998, and the EC VEINS project of 1997–2000. As his long series of publications will show, Svend-Aage and his Group contributed significantly to all of these.

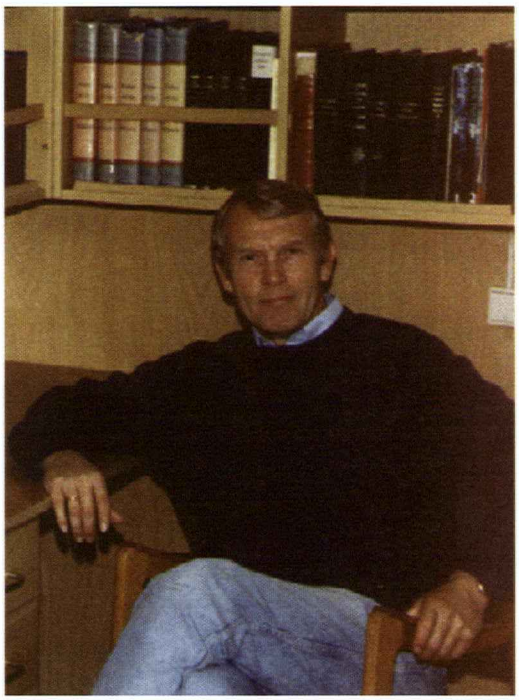
Rather than deal inadequately with a longer list, the description of a single key paper will serve to underline both the remarkable nature and long ramifications of the changes Svend-Aage describes and the importance of his contribution. His 1969 Jokull paper "Hydrographic changes in the waters between Iceland and Jan Mayen in the last decade" provided just such a benchmark in our understanding. During the NAO minimum of the 1960s, a record northerly airflow swept the Norwegian-Greenland Sea, bringing an increasing proportion of Polar Water south to the seas north of Iceland in a swollen East Greenland Current. The East Icelandic Current, which had been

an ice-free Arctic current in 1948–1963, became a Polar Current in 1965–1971 as Malmberg described, transporting drift ice and preserving it.

Aided by active ice formation in these Polar conditions, sea ice extended to the north and east coasts of Iceland, and the 14-year propagation of the "Great Salinity Anomaly" through the Northern Gyre (foreshadowed, then co-authored by Malmberg in 1988) was one dramatic result. Jakobsson has concluded that "the 'Great Salinity Anomaly' has probably generated more variability in fisheries during the last quarter of a Century than any other hydrographic event in recent years"; during its passage, Cushing found a significant reduction in recruitment in 11 out of 15 deepwater fish stocks examined. Its harsh conditions not only closed down the larval drift that had supplied and supported a major cod fishery at West Greenland in the middle decades of the century but also set in train an ecological upheaval in Icelandic waters that changed the species composition of the zooplankton community north of Iceland from boreal to Arctic in character and brought about a progressive dislocation in the traditional migration pattern of the Norwegian spring-spawning herring in the Nordic Seas that has taken 35 years to unfold, as Vilhjalmsson showed in 1997.

It will be a source of satisfaction to Svend-Aage in his retirement that the remarkable physical changes he discovered and described should have had as fundamental an importance to the functioning of the ecosystem in Icelandic waters as it has to our understanding of change in ocean climate at all scales out to those of "global change".

NOTE: The President of Iceland recently conferred the title of "Riddari" on Svend-Aage Malmberg in recognition of his work for his country and for its environment. In the photograph he is seen wearing the medal that was presented to him on that occasion. We extend to him our heartiest congratulations on this well-deserved honour.



Johan Blindheim

When **Johan Blindheim** (born 25 January 1933) joined the Section of Physical and Chemical Oceanography of the Institute of Marine Research (IMR), Bergen, in 1961, he already had experience both as a sailor and fisherman. In parallel with studies in physical oceanography at the University of Bergen, he became responsible for hydrographic fieldwork in Greenland waters as part of the international NORTH WESTLANT surveys. His demand for accurate and precise observations and his interest and knowledge in electronic data-logging and data-processing made him a key person at the IMR from the 1960s to 1970s, the beginning of the "digital age" in marine science.

Johan's responsibilities included calibration and maintenance of oceanographic instruments, planning design and maintenance of the data-logging systems (oceanographic, acoustic, biological) aboard the then new "G. O. Sars" (1970), and he served as the leader of the group that developed and maintained the computer and data-logging systems at the Institute as a whole. Although he must at times have been bored by explaining to his less well-informed colleagues how computer systems worked, he always brought back Arctic char as large and tasty gifts to co-workers when returning from his East Greenland cruises, gifts that were delivered along with stories about the unbelievable amounts and size of fish in the East Greenland rivers and the vast amounts of midges which made fishing a real challenge.

Besides his extensive work in preparing modern and adequate computer facilities for co-workers, Johan managed to conduct his own research. His comprehensive and detailed descriptions of the variability of the hydrography, in particular the Atlantic influence in northern waters from Labrador to the Barents Sea, have been benchmark studies. For a long period he also was his institute's "counterpart" to Jens Smed and responsible for the quality control of data delivered to the Service Hydrographique. During the 1970s he was heavily involved in work for FAO and in 1974/1975 he served as project manager for the Pelagic Fishery Project in Cochin, India.

After returning home, he was given overall responsibility for oceanographic investigations in the Norwegian and Greenland Seas. He strongly advocated the value of the IMR's standard hydrographic sections in the routine monitoring of ocean climate variability on occasions when these were threatened. He was an active participant in the planning group of the IMR research vessel "Johan Hjort" delivered in 1990, where he had the main responsibility for specifying its oceanographic equipment. His colleagues experienced and appreciated his scientific knowledge when he acted as head of the oceanographic division for six years, since in this position he always kept science before bureaucracy.

Johan has also been heavily involved in the administration of marine science at national and international levels, for example in his role as Chair of the ICES Hydrography Committee, as member of the ICES Working Group on Oceanic Hydrography,

where he strongly advocated the necessity of regularity and accuracy in ocean measurements, and as Chair of the ICES Working Group on Marine Data Management.

This continuous involvement in time-series of hydrographic observations, notably in the Nordic Seas, has clearly shaped the topics of his research in the period approaching his retirement (2001) and beyond. With several high-level articles, he has documented and interpreted the decadal scale water-mass changes which are of utmost importance for the highly productive ecosystem of the northern seas and are pivotal to understanding the controls that the processes in the Nordic Seas exert on the North Atlantic climate system. Friends and colleagues from the community very much hope that they can continue to draw on Johan's expertise for many more years to come.

David Ellett

David James Ellett (born 22 July 1934) began his career in ocean science by transfer from the Met Office to the Lowestoft Laboratory in January 1954 as assistant to Lt Cdr J. R. Lumby and Arthur Lee. Over the next decade he learned Atlantic hydrography by participation in wide-ranging cruises to the Barents Sea, North Sea, Irish Sea, and Atlantic, including, notably, the ICES Faroe—Iceland Overflow Experiment of 1958. With long spells on both Irish and UK Weather Ships, this period also saw the beginnings of his life-long involvement with Ocean Weather Ships and their data.

The themes of David's career can be traced from the research interests of his two mentors. Arthur Lee had begun his own career in 1948 with the amazing events of the "Warming in the North" when such a protracted wave of warmth passed though the Atlantic subpolar gyre as to influence the global mean temperature curve. Jack Lumby and Haakon Mosby of Norway had been fastest to react when in 1946 the International Civil Aviation Organization set up a committee to see how the North Atlantic Ocean Weather Stations could be used for oceanographic investigations; the former set up hydrographic sampling en route and on station at OWS "India", "Juliett", and "Kilo", the latter at OWS "Mike" and "Alpha". Couple these influences to the shift in UK fisheries hydrography from distant to home waters in the 1960s and early 1970s and you have the essential "building blocks" of David's career in ocean variability west of Britain.

The Rockall Trough was to be David's main working area and interest to the end of his career, bringing a succession of new insights to what had so long been a data desert; the so-called "shadow of Europe". His collaboration with the Dunstaffnage Laboratory began when he sailed with SMBA aboard RRV "Challenger" for the second ICES Overflow Survey in 1973. This led to his secondment in 1975 and ultimately to his transfer to Oban. Until his official retirement in 1994, he thoroughly explored these waters, deploying the first long-term current-meter moorings in the Trough from 1975, planning then participating in the JASIN Air–Sea Interaction Experiment in 1978, recovering the first unequivocal evidence of a Slope Current west of Scotland in 1979, and making the first direct measurements of overflow crossing the Wyville-Thomson Ridge in 1987/1988.

Many campaigns, but one suspects that David would have derived greatest satisfaction from being designated (1992–1995) a Data Quality Evaluator for WOCE, from the adoption by the community of the term the "Ellett Line" for his repeat hydro-section across the Rockall Trough, and from the use of its time-series to record the arrival-time of particular vintages of Labrador Sea Water, thus establishing for the first time their trans-Ocean spreading rates. As he happily admitted, he was first and foremost a "watermass man". In 1997 he shared the Oceanography Prize of the Society for Underwater Technology with John Gould for his work.

Though unable to join us in Edinburgh through ill health, David will have known better than most of the high esteem in which he was held by the marine science community. Sadly he passed away on 5 October 2001.

Leo Otto

Dr Leonard Otto (born 24 September 1929) received his academic education in physics at the Delft Technical University, from which he graduated in 1955. While on military service with the Royal Dutch Navy he worked on infrared detection systems. In 1957 he entered the Oceanography Department at the Royal Netherlands Meteorological Institute and participated in campaigns on board the submarine HMS "Walrus" in the Caribbean and the Eastern Pacific, carrying out gravity measurements with the famous Vening Meinesz pendulum instrument. These were part of the Dutch Gravity Expeditions of 1948–1958 with their final publication by the National Geodetic Commission in 1960.

Back to the surface, Leo was engaged in the estuarine and North Sea hydrography at KNMI with special interest in optical tracers. Among the many results were the analysis and descriptions of the long-term oceanographic observations at the Netherlands lightvessels in the North Sea for the period 1910–1939 (published 1964) and also his doctoral thesis on the oceanography of the Ria de Arosa, northwest Spain (1975).

This work led into Leo's active interest in the ICES Hydrography Committee and in North Sea projects like JONSDAP (Joint North Sea Data Acquisition Programme). He was in charge of the ICES Study Group on Flushing Times of the North Sea, which provided the physical base for the then much debated issues of dumping industrial wastes in the North Sea. He played an important role in raising political awareness for the need to continue the oceanographic observations at the North Atlantic Ocean Weather Stations when the aviation agencies stopped their support, and he managed to maintain a Dutch contribution to OWS "Mike" for the years beyond.

In his period as Chair of the Hydrography Committee from 1980 to 1982, Leo succeeded in providing effective support for the Service Hydrographique. The annual meetings when he held the chair were at a high scientific and social level.

In 1980 Leo took office with the Netherlands Institute of Sea Research in Texel and became active in the organization of the Dutch observational programmes in North Atlantic hydrography. It was in particular with the World Ocean Circulation Experiment in its initial phase that he fruitfully merged national and ICES interests for this core activity in contemporary oceanography.

Leo retired from his official duties in 1994. He is now following his interest in the history of oceanography as exemplified by his co-authoring a contribution on the Dutch involvement in fisheries research prior to and within early ICES. His friends and colleagues in the ICES community wish him all the best and will keep looking out for his further contributions to our field.

Continued overleaf

Despite the inadequacy of these few remarks to describe such very different people, it is hoped at least that a common thread shows through: namely, that each has been concerned with maintaining the time-series, which are the only means we have of determining if change has taken place in our environment, of assessing its cause, and of identifying its effects on the ecosystem. In other words, the goals that Hjort's ICES had in setting up *Annales Biologiques* in the first place.

The ICES Symposium on Hydrobiological Variability in the ICES Area, 1990–1999, was held at the Royal College of Physicians in Edinburgh, 8–10 August 2001. Scientifically, the "2nd Decadal Symposium" was highly successful, attracting 155 participants and a full programme of 42 selected talks and 55 posters over three days to describe the variability of the plankton, fish, ocean, and atmosphere of the ICES Area during the 1990s. Following a selection and review process conducted by an Editorial Panel, the great majority of the contributions to the meeting were revised for publication in the current volume under the guidance of the Chair of the Panel, William Turrell, and the editors: Alicia Lavin, Kenneth F. Drinkwater, Michael St John, and Jennifer Watson. It is now for the ICES Council to decide whether the provision of a "state description" of the ICES Area at decadal intervals as represented by these proceedings will continue to meet their purpose and budget as a replacement for the *Annales Biologiques.*

The present volume has been organized as follows; the oral presentations are represented by full papers, followed by extended abstracts describing the poster presentations. Manuscripts in each of these two sections are organized first by subject (General Ocean Climate, Regional Ocean Climate, Plankton Communities, Fish Populations), then by geographical region. The convention currently in use by the ICES Annual Ocean Climate Summary has been used, whereby the regional descriptions are presented roughly following the path of the sub-polar gyre in the North Atlantic, commencing west of Greenland.

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