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5th International Zooplankton Production Symposium
Pucon, Chile, 14–18 March 2011

ICES/NAFO Symposium on the Variability of the North Atlantic and
its Marine Ecosystems during 2000–2009
Santander, Spain, 10–12 May 2011

Symposium on “Comparative studies of climate effects on polar and
subpolar ocean ecosystems: progress in observation and prediction”:
Seattle, Washington, USA, 22–26 May 2011

2nd International Symposium on Integrated Coastal Zone Management
Arendal, Norway, 3–7 July 2011

ICES/NASCO Symposium on "Salmon at Sea:
Scientific Advances and their Implications for Management"
La Rochelle, France, 11–13 October 2011



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1 5th International Zooplankton Production Symposium

Conveners: Ruben Escribano (Chile), Delphine Bonnet (France) and Julie Keister (USA)

Venue and dates: Pucon, Chile, 14–18 March 2011

The 5th International Zooplankton Production Symposium was held in Pucón, March 14–18, 2011. Despite the earthquake and Tsunami which destroyed completely the laboratory of the local organizers in Dichato and damaged the University of Concepción two years ago, the Chair Rubén Escribano, went ahead with the planning of the meeting and welcomed participants to Pucón. This was the second zooplankton symposium held outside Europe after Hiroshima, Japan, in 2007. The start of the symposium was overshadowed by news of the earthquake and tsunami in Japan and Japanese colleagues were very much in the thoughts of the participants during the meeting. 293 participants from 36 countries attended.

The event was funded by North Pacific Marine Science Organization (PICES), International Council for the Exploration of the Sea (ICES), and Center for Oceanographic Research in the Eastern South Pacific (COPAS), and cosponsored by the Global Ocean Ecosystem Dynamics (GLOBEC) project, EUR-OCEANS Consortium (EUR-OCEANS), Fisheries and Oceans Canada (DFO), Intergovernmental Oceanographic Commission of UNESCO (IOC), Institut de Recherche pour le Développement (IRD), National Marine Fisheries Service of NOAA (NMFS), North Pacific Research Board (NPRB) and the University of Concepción.

The primary sponsors were represented by three conveners: Delphine Bonnet, (ICES, France), Julie Keister (PICES, U.S.A.) and Rubén Escribano (COPAS, Chile). A Scientific Steering Committee (SSC) made up of Sanae Chiba (Japan), Catherine Johnson (Canada), Angel López-Urrutia (Spain) and David Mackas (Canada) assisted with planning of scientific sessions and recruitment of session conveners.

The opening session took place on the morning of Monday 14, and included five excellent plenary talks:

- Climate change and planktonic ecosystems: detection, understanding and projection by Gregory Beaugrand (presented by Dave Mackas as G. Beaugrand could not attend);
- Zooplankton role in biogeochemical cycles: Progress and prospects for the future, by Deborah K. Steinberg;
- The Giant jellyfish (*Nemopilema nomurai*) bloom in East Asian Seas: Causes, consequences and countermeasures, by Shin-ichi Uye;
- Modes of climate and food web variability in high latitude oceans, by Kendra L. Daly;
- Composition and succession of zooplankton communities: a global comparison, by Torkel Gissel Nielsen.

The Symposium programme consisted of 9 sessions and 5 workshops.

The sessions were run each day in parallel.

- S1: 'Effects of climate variability on secondary production and community structure', conveners: Delphine Bonnet (France), Catherine Johnson (Canada), Angel Lopez-Urrutia (Spain) and Anthony Richardson (Australia)

- S2: 'Ecological interactions: Links to upper and lower trophic levels', convenors: Sanae Chiba (Japan) and Enric Saiz (Spain)
- S3: 'Zooplankton life histories: Spatial connectivity, dormancy, and life cycle closure' convenors: Hans-Jürgen Hirche (Germany), Toru Kobari (Japan) and Jeffrey Runge (U.S.A.)
- S4: 'Small-scale biological-chemical-physical interactions in the plankton', convenors: David Fields (U.S.A.)
- S5: 'Zooplankton in upwelling and coastal systems' convenors: Jenny Huggett (South Africa) and Julie Keister (U.S.A.)
- S6: 'Zooplankton in polar ecosystems and extreme environments' convenors: Carin Ashjan (U.S.A.) and Angus Atkinson (UK)
- S7: 'Zooplankton physiology and bioenergetics' convenors: Maria Koski (Denmark) and Andrew Hirst (UK)
- S8: 'The role of zooplankton in biogeochemical cycles' convenors: Hiroaki Saito (Japan) and Deborah Steinberg (U.S.A.)
- S9: 'The diverse role of meroplankton in the biology and ecology of marine systems' convenors: Claudio DiBacco (Canada), Heidi L. Fuchs (U.S.A.) and Fabian Tapia (Chile)

The workshops were run in parallel in the morning of day 3 of the meeting.

- W1: 'Zooplankton Individual Based Models', convenors: Harold Batchelder (U.S.A.) and Douglas C. Speirs (UK)
- W2: 'Advances in genomic and molecular studies of zooplankton', convenors: Erica Goetze (U.S.A.), Ryuji Machida (U.S.A.), and Katja Peijnenburg (The Netherlands)
- W3: 'Updates and comparisons of zooplankton time series', convenors: David Mackas (Canada) and Martin Edwards (UK)
- W4: 'Impacts of ocean acidification', convenors: So Kawaguchi (Australia) and M. Brady Olson (U.S.A.)
- W5: 'Automated visual plankton identification', convenors: Mark Benfield (U.S.A.) and Phil Cilverhouse (UK)

In all the symposium gave the floor to 159 oral presentations including 5 plenary speakers and 14 invited speakers. Topics not elected in a session were presented in a poster session. The 203 posters were displayed during two poster sessions. A selection of papers from the symposium will be published as a special issue of the *ICES Journal of Marine Science* in 2012. The Chief Editor and the Guest Editors for this volume are respectively Julie Keister (U.S.A.), Dave Mackas (U.S.A.), Sanae Chiba (Japan), Catherine Johnson (Canada), and Delphine Bonnet (France).

The closing ceremony was concluded by Roger Harris, who, as at the previous meeting in Hiroshima, gave an overview of the science presented during the Pucón symposium. He noted that the long history of Zooplankton Symposia (extending from the first 1961 ICES meeting in Charlottenlund, through subsequent symposia in Plymouth (1994), Gijon (2004), Hiroshima (2007) and Pucón (2011)) demonstrated the vitality and strength of our field. Reviewing the breadth and variety of the presentations in Pucón, Roger emphasized the benefits of international collaboration and free access to data. A focus on integration, synthesis and meta-analysis and the comparative approach should lead to significant advances to be reported on at the 6th International Zooplankton Symposium.

2 ICES/NAFO¹ Symposium on the Variability of the North Atlantic and its Marine Ecosystems during 2000–2009

Conveners: Sarah Hughes (UK), Alicia Lavin (Spain), Stephen Dye (UK), Hedinn Valdimarsson (Iceland) and Glenn Nolan (Ireland)

Venue and dates: Santander, Spain, 10–12 May 2011

The symposium was attended by 116 participants from 12 countries. Five keynote talks and 39 oral presentations as well as 77 posters made up the scientific programme which was structured in six plenary theme sessions. The presentations focused mostly on regional variability, such as the Faroe Islands shelf sea, the Bay of Biscay and Cantabrian shelf, the Barents Sea, the North and Baltic Seas, and the Northeast-American shelf Seas.

Theme sessions were preceded by excellent invited overview keynotes:

- [The ICES Report on Ocean Climate: variability in the ICES region](#), by Sarah Hughes (Marine Scotland, UK) and the ICES Working Group on Oceanic Hydrography;
- [Climate variability in the North Atlantic, causes and consequences](#), by Peter Rhines (University of Washington, USA);
- [Plankton variability in the ICES area](#), by Peter Wiebe (Woods Hole Oceanographic Institute, USA);
- [Seal-Cod Interactions on the Eastern Scotian Shelf: Decadal Scale Processes and 'The Balance of Nature'](#), by Michael Sinclair (ICES);
- [Ecosystem variability, preparing an integrated assessment of the North Sea](#), by Andrew Kenny (Centre for Environment, Fisheries and Aquaculture Science, UK).

The symposium provided a comprehensive status report on the North Atlantic Ecosystem, and served as a firm basis to proceed with advances in ecosystem approaches to ICES science and advice. Since their formations, ICES and NAFO¹ have approached questions in marine science and resource management from an ecosystem perspective. This approach has been reflected in a decadal series of symposia focused on describing variability in the North Atlantic ecosystem in the 1950s.

The overwhelming observation across all regions of the North Atlantic was a general warming trend. Warming was associated with freshening of seawater in most regions. As the principal drivers of seawater density, changes in temperature and salinity produced distinct changes in ocean circulation patterns such as position of major currents, strength of gyres, and depth of mixed layers. Biological responses to oceanographic changes varied among regions, but common observations were changes in timing of plankton blooms or fish migrations, shifts in latitudinal or depth distributions of fish populations, and a variety of changes in system productivity. One common theme in the symposium is that system changes have been so pronounced in the last decade that some common metrics used to monitor atmospheric or oceanic patterns are no longer tracking the processes as originally intended. Many advances in understanding ecosystem processes were presented that involved the

¹ NAFO is the Northwest Atlantic Fisheries Organization; and its predecessor is ICNAF, International Convention for the Northwest Atlantic Fisheries.

formation of conceptual linkages between physical processes and biological responses.

Technological advances have greatly improved our ability to sample and monitor the North Atlantic, and many scientists are helping us to understand all of the information. The next stage of marine ecosystem science is to apply our knowledge to wise management of human activities that depend on the North Atlantic ecosystem. Both ICES and NAFO have several strong initiatives that apply ecosystem approaches in their resource management advice.

The advantages of developing conceptual understandings of ecosystem variability were best illustrated by the accomplishments of several honourees at the symposium. Several pioneers in marine science were honoured for their contributions to our understanding of the North Atlantic ecosystem: R. Allyn Clarke (Canada), R.R. (Bob) Dickson (UK), Catherine Maillard (France), Jens Meincke (Germany), Tom Rossby (USA) and Manfred Stein (Germany). Pentti Mälkki (Finland) offered a particularly inspiring history of the decadal symposium at the symposium dinner. The honourees challenged the rest of us to rise to the challenges of ecosystem science and continue to advance our understanding.

The ICES/NAFO decadal symposium on the North Atlantic ecosystem helped to summarize and synthesize the information we have. It also promoted knowledge and understanding of ecosystem linkages. Hopefully this knowledge base will support ecosystem approaches to advice and resource management.

3 Symposium on “Comparative studies of climate effects on polar and subpolar ocean ecosystems: progress in observation and prediction”

Conveners: George Hunt (USA), Ólafur Astthórsson (Iceland) and Michio Kishi (Japan)

Venue and dates: Seattle, Washington, USA, 22–26 May 2011

Introduction

The GLOBEC/IMBER Regional Program *Ecosystem Studies of Sub-Arctic Seas* (ESSAS) was established in 2005 to address the need to understand how climate change affects and will affect marine ecosystems of the Sub-Arctic Seas and their sustainability. The Sub-Arctic Seas support stocks of commercial fish that generate a major portion of the fish landings in the nations bordering them. They also support subsistence fishers along their coasts, and vast numbers of marine birds and mammals. Climate-forced changes in these systems will have major economic and societal impact. ESSAS conducts research to compare, quantify, and predict the impact of climate variability and global climate change on the productivity and sustainability of Sub-Arctic marine ecosystems.

ESSAS recently held its second Open Science Meeting (OSM) entitled “Comparative studies of climate effects on polar and sub-polar ocean ecosystems: Progress in observation and prediction”, on 22–26 May 2011, in Seattle, Washington, USA. The meeting’s co-chairs were George L. Hunt, Jr. (USA), Olafur S. Astthorsson (Iceland) and Michio Kishi (Japan) and were supported by a Scientific Steering Committee. The meeting was co-sponsored by the international organizations, PICES (North Pacific Marine Science Organization), ICES (International Council for the Exploration of the Sea), IMBER (Integrated Marine Biogeochemistry and Ecosystem Research) and GOOS (Global Ocean Observing System), as well as several US marine science organizations. The meeting was attended by 195 scientists (of whom 23 were early career scientists and 28 were students) from 13 countries. There were 98 oral and 61 poster presentations. The OSM presented an opportunity to showcase the progress made both in ESSAS working groups, and in the national and multi-national programs affiliated with ESSAS. It helped to identify remaining knowledge gaps, and pointed toward future research needs within ESSAS. It also provided an excellent opportunity to envision ways that ESSAS can interact with IMBER, ICES, PICES and other international programs in future comparative ecosystem studies. It is expected that four special volumes of referred journals will result from the ESSAS OSM.

The scientific programme was structured by eight theme sessions and 5 workshops.

ICES invited keynote speakers were:

- Trond Kristiansen, IMR Norway for the W1 Workshop “Biological consequences of a decrease in sea ice in Arctic and Sub-Arctic Seas”;
- Dag Slagstad, IMR Norway, for the S3 Session “Modelling marine ecosystem dynamics in high latitude regions”;
- Marit Reigstad, IMR Norway, for the S3 Session “Modelling marine ecosystem dynamics in high latitude regions”.

The OSM began with a series of three 1-day workshops:

- The workshop on “*Biological consequences of a decrease in sea ice in Arctic and Sub-Arctic seas*” was organized by the ICES/PICES Working Group on *Forecasting Climate Change Impacts on Fish and Shellfish* (WGFCIFIS). This workshop reviewed

life history information and habitat associations to assess the risk of immigration and settlement of new biological populations in the Arctic and surrounding shelf seas in response to the retreat of sea ice. Criteria necessary to establish new species in the Arctic Ocean and surrounding areas were discussed and compared to expected conditions based on climate scenarios.

- The workshop on “*Arctic–Sub Arctic interactions*”, co-sponsored by ESSAS and ASOF (Arctic–Subarctic Ocean Fluxes), brought together several diverse groups studying the fluxes between the Arctic and the Sub-Arctic and their biophysical effects. Following presentations, discussion focused upon some of our knowledge gaps, what research could be carried out to address these gaps, and how the research on these issues can be better coordinated.
- The workshop on “*Zooplankton life histories: Developing metrics to compare field observations and model results in order to predict climate effects*” brought together researchers interested in understanding how climate and life history patterns of zooplankton interact to produce the observed distributions and abundances of key species found throughout the boreal Sub-Arctic and Arctic seas, especially *Calanus* copepods.

Two additional half-day workshops were held:

- The ESSAS Working Group on *Gadid–Crustacean Interactions* convened a workshop on “*Comparative analyses of gadid and crustacean dynamics across sub-Arctic ecosystems*” to summarize and synthesize the main findings to date of their work and to discuss future directions for this Working Group.
- The workshop on “*Comparative analyses of marine bird and mammal responses to climate change*” focused on how to best integrate on-going and new research on marine birds and mammals into long-term PICES and ESSAS programs and objectives.

Instead of the usual introductory speeches by dignitaries, OSM plenary sessions began with 8 elementary and junior high students from the Pribilof Islands of St. Paul and St. George off the coast of mainland Alaska, USA, who gave a joint presentation entitled “*Discovering the Pribilof Domain*”. The human inhabitants of these islands, who are mostly of Aleut descent, depend almost exclusively upon the sea for their food and livelihood. The students attend Marine Science Camps during the summer where, with guidance from their teacher/scientist Michelle Ridgway, they have conducted studies into the marine ecosystem around their islands using some of the latest oceanographic techniques. Their presentation addressed the climate of the Pribilofs; physical oceanography surrounding the islands; phytoplankton and zooplankton; principal fish and shellfish species and their life histories; marine mammals; and socio-economic consequences of fish and fisheries. During their studies of the flora and fauna, they discovered the second-known population of a species of large brown marine algae, *Aureophycus*, near St. George Island. The students have integrated traditional knowledge with conventional scientific knowledge to learn more about their marine ecosystem. They also presented a poster on their research.

Each day began with plenary talks by invited speakers who covered various aspects of the 3 parallel theme sessions held in the afternoon. On the last day brief summaries from each of the workshops and the parallel topic sessions were given by one of the session co-chairs in order to inform all of the participants of some of the main findings under each topic. Following these reports, a special musical presentation was given by a group from Norway known as “Science Fair”. Led by Oded Ben-Horin (vocals), and with Svein Folkvord on bass and Stein Inge Brækhus on drums, they

perform science-inspired music at scientific meetings and conferences. At the ESSAS OSM they performed a number of pieces, some of which were based on their impressions gathered during the meeting. In addition, two of the Pribilof students joined in and sang 2 songs. The wrap-up to the OSM was provided in the form of 3 special invited lectures, one on phytoplankton production by Kevin Arrigo, one on fish and fisheries by Steve Murawski, and one on human dimensions by Keith Criddle.

Most of the presentations, including those of the students from the Pribilofs, are posted on the OSM website at: <http://pices.int/publications/presentations/2011-ESASS/ESSAS-2011-presentations.aspx>.

Sixty-one posters were on display throughout the meeting, with each covering some aspect of one of the workshop or theme session topics; all workshops and theme sessions were represented. A dedicated poster session was held on Wednesday evening during which the many participants were able to discuss the science and results behind the posters. The session with the most posters was that on results from the Bering Sea, which was bolstered by a good turnout from the local oceanographic community in Seattle.

The planned products from the OSM include: 1) a special volume of up to 30 papers in the ICES Journal of Marine Science; 2) a theme section in Marine Ecology: Progress Series stemming from the Session on interactions between gadoids and crustaceans; 3) a special volume of the Journal of Marine Systems stemming from the Session on Ecosystem Modelling that will be dedicated to Bern Megrey; 4) a special volume of Progress in Oceanography stemming from the Session on the Bering Sea.

4 2nd International Symposium on Integrated Coastal Zone Management

Convener: Erlend Moksness (Norway)

Venue and dates: Arendal, Norway, 3–7 July 2011

This international multi-disciplinary conference intended to promote science and integration of knowledge for the sustainable management of coastal resources. It provided a venue for scientists, engineers, managers and policy-makers to discuss recent advances and innovative ideas, share experiences and develop networks. A total of 131 persons (including 19 students) from 31 countries participated in the symposium (Australia, Bangladesh, Brazil, Canada, Cuba, Cyprus, Denmark, Estonia, France, Germany, Greece, Iceland, India, Indonesia, Iran, Italy, Japan, Lithuania, Malaysia, New Zealand, Norway, Portugal, Rep. of Korea, Russia, Spain, Sweden, The Netherlands, Turkey, UK, USA). The symposium offered financial support to 17 persons from 11 countries: Australia (1), Bangladesh (2), Brasil (1), Canada (1), Cuba (2), India (2), Iran (2), Malaysia (1), Philippines (2), Russia (3), and USA (1). Many of the conference participants (and several of the presentations given) were from the EU integrated project "SPICOSA" (www.spicosa.eu). The project encompassed 18 study site applications and involved 54 partners. The project developed a "System Approach Framework" (SAF), which aims at incorporating the ecological, social and economic dimensions for the assessment of policy options for the sustainable management of complex coastal zone systems.

During the Symposium, a total of 133 presentations (8 key-note, 55 oral and 70 posters) addressed issues within the following four themes:

- Coastal habitats and ecosystem services
- Adaptation/mitigation to change in coastal systems
- Coastal governance
- Linking science and management

Coastal waters around the globe suffer from strain due to a wide range of human activities. The situation calls for a holistic approach, combining expertise from nature science and social science, to reach a balanced and sustainable development of the coastal zone. The concept ICZM was born in 1992 during the United Nations Conference on Environment and Development (UNCED). ICZM is defined as a decision making process focused on sustainable use, development and protection of seaside terrestrial and coastal marine areas and their resources, in continuous realization. The coastal zone includes both coastal waters and narrow strip of land separating the marine and terrestrial environment. The coastal zone thus offers a myriad of goods and services ranging from production to protection. Despite its relatively small coverage in percentage of global surface area, this zone is highly productive and sustains a high biodiversity.

Growing pressure from increasingly diverse human activities coupled with climate change impacts threaten the functional integrity of these coastal ecosystems. A multi-disciplinary approach towards understanding drivers, pressures and impacts in the coastal zone requires effective integration of data and information in policy and management. Competing claims to the coastal areas of a given nation are nothing new, but they are likely to intensify in the future. Currently, about 60 % of the world population lives within 60 km of the coast but at the current rate of growth, this percentage is predicted to increase to 75 % within just two decades. In addition, tourism is grow-

ing in importance worldwide, adding its share of pressure on the coastal zone and increasing pressure on these coastal resources. Aquaculture, yet another competitor for coastal resources, is also on the increase as capture fisheries stagnate or decline globally. Competition for resources can result in either cooperative or conflictual responses. In the case of coastal resources, the expansion of the aquaculture industry represents the reallocation of common pool resources such as coastal and sea areas onto private hands – converting once common areas into private areas from which others are excluded. In addition, aquaculture carries the potential to impact those resources that remain held in common – wild fish stocks (particularly salmon), the seascape and the coastline. The specific mechanisms for handling distribution of coastal goods are to be found within the institutions that exist for ICZM. One key idea behind the concept of ICZM is to create cooperative management solutions for the use of the areas, making them both politically as well as ecologically sustainable. A range of plans may be ecologically sustainable, but for any plan to work, stakeholders must be invested in it. This implies, that stakeholders, whether they are local fishermen or local municipalities, have access to and understanding of the problems and issues with which they are confronted and the choices with which they are faced.

One of the prominent key note speakers at the conference Prof. Tom Hopkins, science coordinator of SPICOSA, asked why we are moving too slowly towards Sustainability. The answer to the question, of who is responsible for Sustainable Development, is no one and everyone. This may give us a clue as to why we won't get there in time. We are starting to study complex human systems and we know that they have the capacity to reorganize to lower entropic states and that this capacity depends on the health and diversity of its components. The unfortunate reality is instead that these systems are degrading to higher entropic states. We know some scenarios of change that could make the degradation worse, but we don't seem to have any complete scenarios that would reverse this degradation trend. This is where everyone comes in and everyone needs to cooperate. The chain of interacting components that constitutes the circle of responsibility necessary for a sustainable society may start or end with appropriate science and public awareness, but in between there is a lot of inertia against change in the societal components that needs to be overcome in order to make the cycle complete. According to Prof. Hopkins the SPICOSA project has arguably demonstrated a method by which science might help jump-start this reorganization process. It would require accelerating two coupled trends that are already in place, an expansion to complex systems science, and a more interactive role between science and society. To provide specific material for this discussion, Prof. Hopkins presented how the 'systems approach' was applied to policy issues in eighteen European coastal sites and what was learned about how scientific research, coupled with local societies, can better address coastal issues and guide coastal management for the transition to Sustainable Development.

The strength of the first and present symposium was that there were no parallel sessions, resulting in that all participants had to learn from each other independent of their own background and interest. This resulted in a wide thematic spread, from micro algae to big whales. A selection of the work presented will be published during late 2012.

5 ICES/NASCO Symposium on "Salmon at Sea: Scientific Advances and their Implications for Management"

Conveners: Lars Petter Hansen (Norway), David Reddin (Canada) and Malcolm Windsor (NASCO)

Steering Committee: Lars P. Hansen (Norway), Maurice Heral (France), Jens Chr. Holst (Norway), Peter Hutchinson (NASCO), Dave Reddin (Canada), Chris Poupard (UK), Malcolm Windsor (NASCO)

Venue and dates: La Rochelle, France, 11–13 October 2011

Executive summary

Over the last 30 years there has been a major decline in the marine survival of Atlantic salmon and the lack of understanding of the factors responsible for this decline is an obstacle to rational management. Since 2008, a major research programme, the SALSEA Programme, coordinated by NASCO's International Atlantic Salmon Research Board (IASRB), has been conducted to improve understanding of the distribution and migration of salmon at sea in relation to feeding opportunities and predation.

The 'Salmon Summit', an international symposium entitled 'Salmon at Sea: Scientific Advances and their Implications for Management', was Co-Convened by the North Atlantic Salmon Conservation Organization (NASCO) and the International Council for the Exploration of the Sea (ICES) and was held at L'Aquarium, La Rochelle, France, during 11–13 October 2011. The objectives of the Symposium were to:

- review recent advances in our understanding of the migration, distribution and survival of salmon at sea and the factors influencing them;
- consider the management implications of recent advances in understanding of the salmon's marine life;
- identify gaps in current understanding and future research priorities; and
- increase awareness of recent research efforts to improve understanding of salmon at sea and encourage support for future research.

The symposium was funded by NASCO's IASRB and ICES with generous support from the TOTAL Foundation and ONEMA (The French National Agency for Water and Aquatic Environments). A total of 128 participants from 14 countries attended the symposium. The symposium was the culmination of an extensive planning process, following an original proposal that arose from the joint meeting in 2002 on 'Causes of Marine Mortality of Salmon in the North Pacific and North Atlantic Oceans and in the Baltic Sea' organised by IBSFC, ICES, NASCO, NPAFC and PICES (www.npafc.org/new/pub_technical4.html). While the focus of the meeting was on the marine phase of Atlantic salmon, there were also presentations from the North Pacific Ocean and the Baltic Sea. There were 18 keynote/invited speakers whose participation in the symposium was funded from the symposium budget.

The Steering Committee was responsible for all the arrangements and a Sub-Committee (Lars Hansen, Peter Hutchinson and Dave Reddin) developed the scientific programme. Valuable assistance with the local arrangements was provided by the TOTAL Foundation.

The Symposium Programme comprised the following four themes:

- Introductions and scene-setting overviews (7 oral presentations);
- Distribution and migration of salmon at sea (13 oral and 9 poster presentations);
- Food production, growth, trophic and other ecological interactions (8 oral and 4 poster presentations); and
- Implications for salmon management (7 oral and 2 poster presentations).

In total, there were 35 oral and 15 poster presentations. During the final session, focusing on the implications of the new information presented at the symposium for salmon management and future research, there were summaries by the session Chairs, 'take home' messages from invited scientists and managers and a general discussion period. The symposium programme, session summaries, 'take-home' messages, press release and other documents from the symposium are available at www.nasco.int/sas/salmonsummit.htm. A selection of the papers will be refereed and published in a symposium issue of the ICES Journal of Marine Science (ICES JMS), under the direction of the Guest Editor, Dr Peter Hutchinson. There will be a separate report by the Convenors and ICES JMS Guest Editor focusing on the management implications and applications of the research.

A brief outline of some of the main points to emerge from the sessions is provided below.

1. Introductions and scene-setting overviews

The keynote speaker, Daniel Pauly, presented an overview of global challenges in the sustainable utilization of marine ecosystems. The issues highlighted included 'fishing down' the marine food web, the expansion of fisheries towards the poles, the dependency of developed countries on fish imports rather than harvests, and the need to rebuild most commercially exploited fish stocks. A future, more sustainable approach based on local and smaller-scale fisheries was proposed, and it was suggested that Atlantic salmon fisheries were consistent with this approach. It was also stressed that far from reducing the pressure on wild fish, the farming of salmon, poses risks to the wild salmon stocks and has the potential to stifle the rebuilding and long-term sustainability of other fish stocks because of the current dependency of the salmon farming industry on diets containing fish meal and fish oils.

Reviews of the status of salmon stocks in the North Atlantic and North Pacific Oceans and in the Baltic Sea indicated that in both the Atlantic and Baltic, post-smolt survival has declined over the last twenty or thirty years. In the North Atlantic, the pre-fishery abundance of salmon has declined from ~10 million fish in the 1970s to ~ 3.5 million fish today. Despite major reductions in marine fisheries, marine survival has declined due to, as yet, unknown but broad-scale factors. The decline in abundance is most marked for multi-sea winter salmon in the southern parts of the Atlantic salmon's range. In the Baltic, modelling studies suggest that grey seal predation of post-smolts may determine trends in marine survival while availability of suitably sized herring and other prey may determine short-term variation in survival. Conversely, in the North Pacific salmon production in recent years has been at near record highs, particularly for pink and chum salmon, although some southern stocks are experiencing low abundance.

The SALSEA Programme, a major, innovative programme of research throughout the North Atlantic, has led to greatly increased knowledge of the biology of salmon at sea

in recent years but significant challenges remain. It was suggested that while dedicated marine surveys for salmon conducted under this programme were justified at the time, in future the inclusion of salmon in existing monitoring programmes for pelagic marine fish species may provide a means to continue this important research.

Analyses of trends in Northern hemisphere air temperature, sea surface temperature, and phytoplankton, zooplankton and salmon abundance indicate marked increases in phytoplankton production but marked reductions in zooplankton production and salmon abundance associated with increasing air and sea temperatures since the late 1980s. A northward movement of fish species and key zooplankton prey of salmon has been detected. Further change in the North Atlantic is anticipated but the predictions of the nature and extent of the change is uncertain.

2. Distribution and migration of salmon at sea

While the salmon's marine phase was, until recently, considered as a 'black box', it is clear from the information presented during this session that there have been major advances in recent years in understanding of the stock specific distribution and migration of salmon in the North Atlantic through a variety of research methods including analysis of historical tag recoveries, marine surveys, use of stable isotope analysis, acoustic tagging, use of 'pop-up' tags, genetic stock assignment methods and modelling. However, scientific challenges remain, not least the quantification of by-catch which is important given the deployment of larger and more effective pelagic gears and new information from Iceland and the Faroe Islands that suggests that by-catch of salmon may be more widespread than originally thought. The improved understanding of the distribution of salmon at sea should assist in the assessment of the spatial and temporal overlap of salmon and the pelagic fisheries.

The session also highlighted the new tools that are available to support future research and management. A key element within the SALSEA Programme was the development of genetic stock assignment methods. The calibration and integration of baseline microsatellite genetic data across Europe and validation of assignment methods provides a powerful tool for assignment of salmon caught at sea to region of origin. Other molecular markers, SNPs, are being developed that provide cost effective methods to provide higher definition (regional or river specific) assignment. These genetic tools have considerable potential to support management, e.g. in relation to management of mixed-stock fisheries, identifying the origin of salmon caught as by-catch in pelagic fisheries and in identifying the source of escaped farmed salmon. During the symposium, there were informal discussions on how genetic data from North America can be integrated into the database and there will then be an enormously powerful tool available to scientists and to inform management, e.g. in relation to the stocks contributing to the West Greenland fishery. Recent advances in acoustic tagging technology and methodology provide a reliable and effective method of deriving quantitative estimates of salmon survival at points along the migration pathway starting in rivers and moving increasingly further out to sea. These estimates can assist in identifying factors affecting post-smolt survival and consequently can support rational management. Migration models can assist in predicting post-smolt distribution to assist in assessing the likelihood of by-catch in pelagic fisheries, in planning research surveys and in forecasting returns.

A full analysis of the data derived from the SALSEA Programme should further improve understanding of salmon migration and distribution at sea.

3. Food production, growth, trophic and other ecological interactions

During this session, valuable information was presented on food production and salmon growth and the influence of ocean climate on salmon growth and survival.

Episodic and sustained periods of thermal stress for salmon are likely as a result of increasing temperatures in the rearing habitats. Ocean thermal conditions in key post-smolt nursery areas are expected to continue to change, and may make marine survival unsustainable for some segments of salmon stock complexes from both North American and Europe.

There are several papers in the literature linking plankton and Atlantic salmon production. However, information from the Pacific indicates that salmon production is not a simple function of plankton production in the California Current and Alaska Coastal Current systems. A bioenergetics framework is required to understand the effects of ocean conditions on salmon growth in the marine environment. Relationships between salmon survival and ocean conditions can be used to forecast returns of Pacific salmon and may be used to establish effective management and conservation strategies.

Stable isotope signatures from Atlantic salmon scales can be used to identify temporal fluctuations in diet. For salmon populations from the Bay of Fundy to southern Labrador there is considerable variation in the diet of smolts, but considerably less variation for 1SW and 2SW fish. This reduced range of variation reflects a significant narrowing of feeding opportunity with respect to the ecosystems salmon inhabit, although within the foodweb in which they function, salmon continue to source prey from multiple trophic levels. Isotopic analyses suggest Atlantic salmon move from generalist feeders in freshwater to specialist predators in the marine environment. Stable isotopes also provide a method to explore stock- and cohort- specific patterns in marine mortality. Stocks feeding in different regions are distinguished by their contrasting temporal isotope records. Fluctuations in carbon isotopes in scale archives reflect changes in phytoplankton community dynamics that can be linked to large-scale oceanographic patterns such as the Sub-Polar Gyre. Salmon feeding in the Norwegian Sea appear to be more sensitive to climate-induced changes in the phytoplankton community than those feeding further west in the Iceland Basin.

Studies of the stomach contents of salmon indicate that in the Northeast Atlantic, post-smolt diet was dominated by 0-group pelagic fish, *Themisto* and the epi-pelagic copepod, *Anomalocera pattersoni*. The post-smolt diet was more directed towards the epi-pelagic community than the diet of herring and mackerel. There was a decrease in stomach content of post-smolts from 2002/2003 to 2008/2009. In the Northwest Atlantic, post-smolts consumed Atlantic herring and euphausiids in nearshore waters in the Gulf of Maine, while hyperiid amphipods were the dominant dietary item in the Labrador Sea. The diet of 1SW salmon at West Greenland was dominated by capelin, amphipods, and squid.

An interesting point to emerge from this session was that for some stocks not only has abundance declined but there have been changes in the 'quality' of those fish that survive to return to spawn. In Scotland, for example, there has been a marked decline in condition of salmon with implications for both the number and quality of eggs produced. This has management implications since conservation limits are based on numbers of spawning fish (or estimated eggs deposited). However, in the Miramichi River, Canada there has been an increase in the number of repeat spawning salmon, both those that spawn in consecutive and alternate years, and this will also have implications in terms of assessments of attainment of conservation limits.

Several presentations reported direct links between marine climate and growth and indirectly to survival. For example, studies in the North-East Atlantic have shown that for an Irish stock poor growth was correlated with low marine survival. Synchronous growth was shown among some stocks but not others. The main period of concern for growth and consequently survival appears to be in the early months after migration to sea and this has implications for management.

4. Implications for salmon management

This session focused on factors operating in fresh water that may subsequently affect survival at sea and the opportunities to counteract them. It was noted that water temperatures in freshwater in the southern part of the range may increase by up to 7°C over the coming century. Observed increases in water temperature are already resulting in increased growth rates in salmon parr, production of younger smolts and earlier migration of smolts to sea. The latter may result in smolts entering a sub-optimal ocean environment and consequently in reduced survival. This lower survival could be offset to some extent by the reduction in the freshwater rearing period if younger, smaller smolts do not suffer higher mortality. Factors operating in fresh water, including contaminants, have been shown to affect subsequent marine survival by interfering with the ability of smolts to adapt physiologically to the marine environment. The need for managers to optimise the evolutionary potential of salmon stocks in the face of a warming climate was stressed, for example by habitat management to provide shade, minimising abstraction, minimising impacts from salmon farms and careful evaluation of the pros and cons of stocking. Greater involvement of stakeholders in salmon management will be important in future as will long-term planning to adapt management to the changing environment. With the exception of by-catch, there are probably limited opportunities to manage the marine environment but managers should ensure that the maximum number of healthy smolts go to sea. This will involve redoubling efforts to rationally manage salmon fisheries so as to exploit only harvestable surpluses, protecting and restoring habitat and minimising impacts from salmon aquaculture. Management will need to be flexible and adapt quickly to expected changes in salmon populations resulting from climate variability.

Conclusions

There have been significant advances in our understanding of the biology of salmon at sea as a result of the implementation of the SALSEA Programme and the symposium provided an excellent forum to present these and to discuss the findings of this research and the implications for management of salmon in the future. The presentations were of a high quality and the discussion periods lively and informative. There was a valuable information exchange among scientists and managers from the Atlantic, Pacific and Baltic regions.

Climate change has implications for salmon in all the environments it inhabits (rivers, estuaries, coastal waters and the open ocean) and that there will be continuing challenges to conservation and management in the future in the face of an uncertain climate. The Convenors have received very positive feedback about the symposium from many participants but it will be some time before all the implications of the new research are fully realised and future research needs formulated. It is, however, already clear that major new tools have been developed that can assist rational management in the future. New genetic baselines have been established and integrated into powerful new databases and advances in genetic stock assignment should assist *inter alia* in rational management of salmon fisheries, in identifying escapees from

salmon farms and in identifying stocks exploited as by-catch in fisheries for pelagic species. Similarly, advances in modelling techniques should provide a means for predicting the distribution and migration patterns of salmon and assist in planning future research and forecasting returns. In this regard, while future dedicated salmon surveys are unlikely to be conducted in the current economic climate, and may not be necessary, the opportunities to include migratory fish in existing monitoring of marine pelagic species might be explored. It was also clear from the symposium that the long-term data derived from monitored rivers around the North Atlantic is essential in assessing trends in marine survival and the quantity and quality of smolts produced. While there may be limited opportunities to address the factors affecting mortality of salmon at sea, other than by-catch in pelagic fisheries if this is shown to be an issue, the challenge for managers will be to ensure that natural smolt production and quality is maximised.

One of the objectives of the symposium was to increase awareness of recent research efforts to improve understanding of the marine phase of salmon. The reports from the symposium will be widely distributed. There was considerable media coverage of the symposium and a series of follow-up meetings is envisaged. In this regard, NASCO has already supported a one day meeting held in December 2011, entitled 'Ocean Silver, the Atlantic Salmon's Ocean Odyssey: Implications for Fishery Managers', organised by the Atlantic Salmon Trust to disseminate the findings from the symposium (see www.atlanticsalmontrust.org/oceansilver).

The Convenors would like to thank all who contributed to making the symposium such a successful event, particularly the speakers for their high quality presentations, the staff at L'Aquarium for the excellent facilities and their support in running the symposium and the TOTAL Foundation and ONEMA for financial assistance.