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Report of the Steering Group on Climate Change (SGCC)

3 June 2009

ICES Headquarters,
Copenhagen, Denmark

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The ICES Steering Group on Climate Change (SGCC) met at the ICES Headquarters, Copenhagen, Denmark, on 3 June 2009. This is a high level group created by Council decision at the Council's 2007 Annual Meeting, recognizing the strategic importance of ICES in being pro-active in marine scientific research related with climate change. SGCC presented a work-plan to the Council, which was also discussed and adopted by the SGCC kick-off meeting in June 2008.

Update on the new ICES Science structure. The SGCC is a basic element for the visibility of ICES activities in climate change and it aspires to be the coordinating body on climate change within ICES. Among other decisions, SCICOM have proposed to rename the SGCC as Working Group on Climate Change, and put the SGCC under the authority of the Steering Group on Ecosystem Functions (SGEF). There was overall strong concern among SGCC members that climate issues would be hidden under the new structure, which came as a surprise to the group, as one of the driving forces for the structure in the Council had been the need to raise the profile and visibility of climate change with the science structure. SGCC felt that Climate Change would have been an excellent candidate for a crosscutting programme and this opportunity is now diluted in the new structure. Concern was also raised that the capacity and authority of SGCC to recommend Terms of Reference (ToRs) for other ICES Expert Groups would be reduced. SGCC was created by the Council as a group with certain autonomy and competences, and the membership is made by the Chairs of many other expert groups (which respond to the cross-cutting nature of climate change and also crystallised the group as a high level group). Now, if converted into a standard EG, the group would not be able to coordinate and influence in others and it will also lose the autonomy needed to act with the desired dynamism. Also, the point was made that the Steering Group on Climate Change had been created for a three-year term with a view to prepare ICES to make a programme on climate change, and therefore the message from SCICOM was received with surprise and disappointment. The entire SGCC think that SCICOM should reconsider its decision and create an independent and crosscutting programme on Climate Change.

ICES guidelines regarding publication of SGCC position paper on climate change. Recommendations on the definition, the purpose, and the identification of audience were discussed. There was agreement in SGCC to target the scientific community but a little broader (non-scientist specialist), writing style and time schedule were given (the ASC 2010 will be the target objective). The group recommends that this report should be seen as the official ICES view on climate change, this implies that we should have a prior authorisation of ICES (which means the Council or at least the SCICOM) and that the time schedule to have it published is even shorter and will add a lot of pressure to the group. (SCICOM should have the entire manuscript in a final version by next spring meeting). The people involved will author each chapter. The ICES Executive Editor provided the printing cost for an CRR special issue. The group recommends that whatever will be the cost for the publication, it must be understood that it will be distributed free of charge for the recipients. Producing only a CRR will not achieve the aim of raising the profile of ICES science in climate change, and it was therefore suggested to produce a parallel high-impact paper.

Intersessional activities 2008–2009. The group has been very active in publishing new ICES material on Climate Change and in reviewing manuscripts for publication in the ICES CRR series on this same topic. A compilation of the Terms of Reference

directly related to climate change addressed by ICES Expert Groups during the period 2000-2008 had been prepared by the ICES Secretariat (Annex 5). This is a 125 pages document reviewing the contributions of DFC, LRC, MCC, MHC, OCC and RMC. It lists more than 50 expert groups, although only 15 (SGRESP, WGFE, WGEIM, WGPDMO, WGAGFM, WGMASC, BEWG, WGMS, WGICZM, WGCCC, WGZE, WGOH, SGNARO, WGFS, WGSAM) have included ToRs related with climate change for 3 or more years, and only a few of them have taken climate change as one of the main drivers for their discussion on more than 6 occasions.

Review of contents and contributions for the ICES position paper in climate change. This entire section was dedicated to review and discuss the status and options to continue in the development of the 14 different sections and content for the ICES position paper in climate change. Sections No. 0, 1, 5 and 14 will be the direct responsibility of the SGCC members. Sections No. 2, 3, 4, 7, 8, 9 and 11 were endorsed as ToRs to be developed during 2009 to different ICES expert groups (SGCC agreed that first drafts from the expert groups would need to be prepared by the ASC in September, and then as the next step a final draft prepared in time for the editorial workshop). Drafts for Sections No. 6, 9, and 10 will be the outcome of 4 Theme Sessions convened during 2009 ASC promoted by the SGCC (The deadline for preparing the first draft resulting from the TS will be the end of October, and then the final draft will be prepared in time for the editorial workshop). SGCC agreed that the sections No. 12 and 13 of the position paper on socio-economy and models should be drafted by workshops specifically tasked to produce draft manuscripts for "How models help us to understand climate change evolution in the near future" and "Socio-economic consequences of climate change in the North Atlantic". In addition and in order to review the drafts and give unity to the entire manuscript, it will be also necessary to convene an editorial workshop. It will be necessary to hire a guest editor.

Prepare/discuss options for new and on-going ICES activities on Climate Change. SGCC reviewed the participation of ICES in several symposia promoted by ICES, workshops produced by ICES or by other councils and agencies and discussed new theme sessions for 2010 and beyond. It was also mentioned that PICES will have increased focus on climate change in its annual meeting in Seattle 2010, and there would probably be opportunities for ICES to co-sponsor theme sessions there.

Election of Co-Chair. The current Chair of the SGCC, Dr Luis Valdés, asked SCICOM about the convenience of having a Co-Chair for a better coordination and to guarantee the continuity of this group. The proposal was well received and also accepted by the SGCC members. The group proposed that Jürgen Alheit (Germany) should take this position.

Proposed Budget 2008–2010. The ICES Bureau had asked for a detailed business plan with concrete information on how the SIF money allocated to SGCC will be spent. A business plan was prepared and submitted to the Bureau meeting (9–10 June 2009). The Bureau adopted the proposed use of the SIF fund for the Climate Change Group.

1 Welcome

The Steering Group on Climate Change (SGCC) (Chair: Luis Valdés, Spain) met at the ICES Headquarters, Copenhagen, Denmark, on 3 June 2009. The Chair welcomed all participants (Annex 1), who were invited to introduce themselves around the table. Apologies had been received from José Ozer (Belgium) and Sarah Hughes (UK). Daniel Duplisea (Canada) participated via WebEx.

The meeting opened with some words of encouragement from the Chair, who drew the attention of the group to keep in mind that climate change and their consequences to the management of marine ecosystems is becoming increasingly important within the ICES community and elsewhere, and that ICES have to have a more prominent role in this topic.

2 Adoption of Agenda

The meeting agenda was adopted. It was based on the Terms of Reference approved by the Council (Resolution 2008/2/SCICOM04) and in reviewing the intersessional activities. In addition, two items that were considered of importance for the subsequent discussion of the ToRs were included. Both items: 'Update from SCICOM: changes for a new ICES Science structure' and 'ICES guidelines regarding publication of SGCC position paper on climate change' were discussed in first place as introductory material needed for a better understanding of the meeting.

A. Jelmert (Norway) and V. Piil (ICES Secretariat) were appointed as Rapporteurs.

3 Introduction

3.1 Update from SCICOM: Changes for a new ICES Science structure

Adi Kellerman (HoS) updated the group on the development of the new ICES Science structure. SCICOM was formally approved by the Council last October. SCICOM met in January and established a SCICOM Working Group on Science Leadership (SWGSL) tasked to develop a proposal for the new science structure. SWGSL proposed the creation of five new bodies, three of which are aligned with the Science Plan Themes: Theme 1: Ecosystem Functions; Theme 2: Human Interactions on Ecosystems; Theme 3: Sustainable use of Ecosystems, and two additional Steering Groups on "Regional Seas" and "Ecosystem Surveys Science and Technology". This proposal was agreed by SCICOM at its recent meeting held 18–20 May 2009. Since the five bodies are expected to be called Steering Groups, SCICOM recommended that SGCC should change its name to become a coordinating or planning group, reporting to the Steering Group on Ecosystem Functions.

In early May, the SCICOM Chair also requested from the SGCC Chair a briefing for their information and submission to the Bureau including objectives, tasks, membership, etc., which was sent on time (15 May to ICES Secretariat, Annex 2). The SGCC Chair also raised the issue of electing a SGCC Co-Chair, which was then included in the SCICOM report.

Additionally, the Bureau had asked for a detailed business plan with concrete information on how the SIF money allocated to SGCC will be spent and exactly what output can be expected in terms of workshops and other activities over the next 12 months or longer.

In summary:

- SGCC will be renamed Working Group on Climate Change,
- the new WGCC will report to the SCICOM Steering Group on Ecosystem Functions,
- SGCC agreement with SCICOM to appoint a Co-Chair, and
- SGCC to prepare a detailed business plan for the consideration of the Bureau, which will meet next 9–10 June.

In response to the request for a detailed plan and justification for the use of the SIF money, SGCC agrees that a detailed breakdown will be prepared by the Chair in the light of the proposals of the present meeting (the budget is included at the end of the report as an addendum).

Regarding the new science structure approved by SCICOM, there was overall strong concern among SGCC members that climate issues would be hidden under the new structure, which came as a surprise to the group, as one of the driving forces for the structure in the Council had been the need to raise the profile and visibility of climate change with the science structure. SGCC felt that Climate Change would have been an excellent candidate for a crosscutting programme and this opportunity is now diluted in the new structure.

Concern was also raised that the capacity and authority of SGCC to recommend ToRs for other ICES Expert Groups would be reduced. SGCC was created by the Council as a group with a certain degree of autonomy and competences, and the membership is made by the Chairs of many other expert groups (which respond to the cross-cutting nature of climate change and also crystallised the group as a high level group). Now, if converted into a standard EG, the group would not be able to coordinate and influence other EGs and it will also lose the autonomy needed to act with the desired dynamism. Also, the point was made that the Steering Group on Climate Change had been created for a three-year term with a view to prepare ICES to make a programme on climate change, and therefore the message from SCICOM was received with surprise and disappointment. The entire SGCC recommends that SCICOM should reconsider its decision and create an independent and cross-cutting programme on Climate Change.

3.2 ICES guidelines regarding publication of SGCC position paper on climate change

B. Anthony, ICES Executive Editor, gave a presentation on ICES CRRs and the possibility of publication of the ICES Position Paper on Climate Change as a special CRR, and based on his experience with ICES publications offered his advice to the group. The presentation included recommendations on the definition, the purpose, the identification of audience, language, and schedule (main points extracted from the presentation are synthesised in Annex 3).

The Chair thanked the Executive Editor for the excellent presentation and the valuable advice and then opened the floor for comments on the points covered in the presentation but also on other points that the group considered relevant for the logistics of the publication. The main items raised were:

Use of CRRs as vehicle for publishing the report

The Executive Editor outlined the different choices for publication. The CRR is like an in-house publication and we can work in this format or prepare as CRR and make a second printing with another cover. There are many advantages to the CRR series, i.e. there is no restriction on the number of pages (our estimate is to publish a volume of 125–150 pages), colour figures are admitted and even preferred, the entire process of publication is under the control of ICES, it is edited in both paper and electronic format, the pdf version is freely available on ICES website, etc. There was also a discussion on some constrains that need to be considered. The main one is that hardcopies of CRRs are sold, which is against the policy of distribution that is expected for the planned publication, and thus SGCC recommends that this publication be delivered for free. It was said that for this special publication the ICES Secretariat would be willing to make an exception and distribute the publication for free.

Timing

It was questioned whether December 2010 would be a good date for putting the position paper on the market. SGCC agreed that the ASC would be a more appropriate timeline, which would also mean that it would be ready for distribution at the PICES meeting and a much larger audience. PICES 2010 will have a big focus on climate change. We have to bear in mind that this deadline is reducing the time available for drafting, reviewing, editing, etc.

What are the implications of considering the contents of this report to be 'the official ICES view on climate change'

The group considered that this report should be seen as the official ICES view on climate change, but most of the CRRs (if not all) include a disclaimer stating that "*This document is a report of an Expert Group under the auspices of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council*". To avoid the inclusion of such disclaimer we should have a prior authorisation of ICES (which means the Council or at least the SCICOM). That implies that the time schedule to have it published is even shorter and will add a lot of pressure to the group (SCICOM should have the entire manuscript in a final version by next spring meeting, i.e. May 2010).

Authorship of the sections

If the final manuscript is approved by SCICOM, and takes the form of a CRR, who will sign it? Most CRRs are signed by the editorial committee and the citation only gives credit to the editor. This is not fair to the rest of the authors. One option is that each chapter is authored by the people involved, such as in the North Sea Benthos Report (CRR 288). The group unanimously favoured this approach.

Peer-reviewed or not?

M. Benfield raised the point that we should be basing the contents of the position paper on material that has already been peer reviewed and since workshops are not peer reviewed this would be problematic. This is a sensible point that must be managed properly and respecting the scientific standards. The group recommends that the draft of the position paper should be peer reviewed.

Audience

Who are we writing for? Scientist or non-scientist (e.g. marine specialist, climate change specialist, NGOs, policy makers, broad general public, press)? SGCC needs to send a clear signal to the contributors. The agreement in SGCC was to target the scientific community, but a little broader (non-scientist specialist). The language should not be too scientific. Guidelines from ICES Executive Editor are valid.

The executive summary should be digestible by managers and elsewhere.

Cost of publication and distribution

The ICES Executive Editor provided the printing costs for a CRR special issue with 100 pages, these are as follow

- For 2000 copies DKK 49,990
- For 3000 copies DKK 62,090
- For 4000 copies DKK 73,600

For any number of copies, the overall cost should be increased by ca. DKK 35,000 to cover the layout.

The group estimated that ca. 2000 copies will be needed. So the final price will be ca. DKK 85.000.

Whatever will be the cost for the publication, it must be understood that it will be distributed free of charge for the recipients.

ICES lists can be used for an initial distribution list.

A parallel high impact paper

It was suggested to produce a parallel high-impact paper. CRR will be attractive for people beyond the scientific community, but producing another CRR will not achieve the aim of raising the profile of ICES science in climate change. IPCC specifically concentrates on peer-reviewed research. A parallel document (distilled version) to go into a high impact journal such as Nature or Science paper could be a follow-on to the CRR, taking the high points which makes it different to other reports.

SGCC was positive to creating a parallel publication based on the ICES position paper for publication in a high-impact journal.

4 Intersessional activities 2008–2009

The Chair presented a summary of the activities of the Oceanography Committee (OCC) during 2008 with a special mention of the different products delivered by the committee. These include:

4.1 Recent ICES Publications

ICES Journal of Marine Science

This year one of the 9 issues of Volume 66 of the ICES *JMS* will be fully dedicated to the impacts of climate change in the oceans. This is a special volume following the Gijon Symposium on Effects of climate Change on the World's Oceans promoted by ICES.

This volume contains three articles authored by members of the SGCC, these are:

Rijnsdorp, A. D., Peck, M. A., Engelhard, G. H., Möllmann, C., and Pinnegar, J. K. 2009. Resolving the effect of climate change on fish populations. – ICES Journal of Marine Science, 66: 1570–1583.

Hughes, S. L., Holliday, N. P., Colbourne, E., Ozhigin, V., Valdimarsson, H., Østerhus, S., and Wiltshire, K. 2009. Comparison of in situ time-series of temperature with gridded sea surface temperature datasets in the North Atlantic. – ICES Journal of Marine Science, 66: 1467–1479.

Valdés, L., Peterson, W., Church, J., Brander, K., and Marcos, M. 2009. Our changing oceans: conclusions of the first International Symposium on the Effects of climate change on the world's oceans. – ICES Journal of Marine Science, 66: 1435–1438.

ICES Cooperative Research Reports

In the ICES CRR series the following volume directly related with climate change was published after the ASC 2008:

Tasker, M. L. (Ed.) 2008. The effect of climate change on the distribution and abundance of marine species in the OSPAR Maritime Area. ICES Cooperative Research Report No. 293. 45 pp.

Also the draft "Report on the Resolving climatic impacts on fish stocks" coordinated by Adrian Rijnsdorp was submitted for revision and publication as a CRR (C. Res. 2008/1/LRC19).

In this respect Adrian Rijnsdorp presented the material, which is proposed to be reviewed and approved by the Study Group on Climate Change. The estimated number of pages is 250. The forthcoming ICES Cooperative Research Report presents a thorough review about observed past, current and predicted future effects of climate change on fish and shellfish, as well as approaches to study any potential effects in an objective way. The focus is on the processes that govern the response of fish and shellfish to climate change. A large proportion of the material was presented at the Gijón meeting in 2008 and two of the 23 sections have been published in ICES JMS.

The challenge now is how to review a report covering these many aspects and the task has been assigned to SGCC as the most appropriate group for doing the job.

SGCC members congratulated the authors on the draft CRR, noting that this is exactly the model we are looking for. Some raised their concern that this material is huge and perhaps not within the competence of this group. Penny Holliday made a strong point that the group would put itself in a bad light if refusing to review the paper.

The main concern was the time constraint to review a draft of 250 pages. It was decided to divide the task. The table of contents was circulated and participants were asked to put their names against the sections. The group agreed to send review comments to Adrian Rijnsdorp, who would work together with CRR Editor, Emory Anderson and SGCC Chair, Luis Valdés.

The review of most of the sections was already done in July and the draft was accepted for publication once all comments from the referees have been incorporated.

4.2 Special issues on climate change and recent reports published by other International Councils

Jürgen Alheit brought the attention of the group to a special issue to be published by the Journal of Marine Systems entitled 'Impact of climate variability on marine ecosystems: a comparative approach' (*in press*). The corrected proofs were electronically available to the members.

The Chair informed the group that many international councils have published reports and policy papers dealing with different aspects of climate change and impacts in marine ecosystems during the last year, and that some others will be released in the following months. For example:

FAO. 2008. Report of the FAO expert workshop on climate change implications for fisheries and aquaculture. FAO Fisheries Report No. 870, 41 pp.

UNEP. 2008. In Dead Water, Merging of climate change with pollution, over-harvest, and infestations in the world's fishing grounds. United Nations Environment Programme, ISBN: 978-82-7701-048-9, 64 pp.

ESF. 2009. Impacts of Ocean Acidification. European Science Foundation, Science Policy Briefing, August 2009. 12 pp.

IGBP. 2009. Ocean acidification, a summary for policy makers. July 2009, 8 pp.

University of Copenhagen. 2009. Synthesis Report from climate change global risks, challenges & decisions. ISBN 978-87-90655-68-6, 39 pp.

CBD. Scientific synthesis on the impacts of ocean fertilization on marine biodiversity. (in press).

IUCN. Tools and Guidelines for Oceans and Climate Change Actions. (in press).

This evidences that many relevant organizations are concerned by climate change and are transmitting to the policy makers and to the society their view at institutional level.

4.3 Nomination of ICES experts for the IPCC scope panel

SGCC noted that ICES had put forward (February) a list of experts for the Scoping Meeting for the IPCC Fifth Assessment Report (AR5), but unfortunately none was included in the final list of experts (June). SGCC noted that the panel selected by the IPCC lacks expertise in oceanography, however the list of contents for the AR5 (July) has incorporated new sections related with the impacts of climate change in the ocean, such as ocean acidification and sea level rise.

4.4 Compilation of ToRs discussed by the different ICES expert groups in relation with climate change since the year 2000

Many ICES expert groups have included in their annual meetings Terms of Reference directly related with climate change. SGCC considers that a compilation of these ToRs will be useful for consultation, to identify the groups that are maintaining a sustained activity in climate change, to realise the dimension of ICES involvement in climate change, etc.

The ICES Secretariat produced such inventory for the period 2000-2008 (Annex 5). This is a 125-page document reviewing the contributions of DFC, LRC, MCC, MHC, OCC and RMC. It lists more than 50 expert groups, although only 15 (SGRESP, WGFE, WGEIM, WGPDMO, WGAGFM, WGMASC, BEWG, WGMS, WGICZM,

WGCCC, WGZE, WGOH, SGNARO, WGFS, WGSAM) have included ToRs related with climate change for 3 or more years, and only a few of them have taken climate change as one of the main drivers for their discussion on more than 6 occasions.

5 Review of contents and contributions for the ICES position paper on climate change

This entire section was dedicated to review and discuss the status and options to continue the development of the different sections and contents for the ICES position paper on climate change. The list of contents agreed at the meeting held during the ASC 2008 was shown to guide the discussions.

Proposal of contents for the ICES position paper in climate change

TITLE	LEAD ROLE
0. Executive summary (what we know, gaps, future)	SGCC
1. Introduction: (a) Role of ICES in promoting marine science and in climate change, (b) global overview [zoom into the ices area, specifically describing what is happening in the ices area. It will be important to make that distinction].	Luis Valdés + Markus Quante
2. Warming in the North Atlantic. Interdecadal varibility. Climatic indices and their meaning in a climate change context, mechanisms that link climatic indices with processes, other mechanims linking climate with biological populations.	WGOH + Workshop 2010 (?)
3. Hot spots in climate change: the Ice cover in ICES's region. Sea level rise. Coastal erosion.	WGOH + other
4. Circulation and changes in physical and chemical properties and processes	WGOH
5. Acidification and biogeochemistry (reference to deep sea corals).	Liam Fernand
6. Chlorophyll and Production in the North Atlantic (Atlantic gyre, upwelling regions, shelf seas). [Would be useful to show the Atlantic as one region. What happens if the primary production decreases?]	Theme session 2009 (Approved)
7. Trends in plankton communities (including jellyfish and harmful algal blooms).	WGZE+HABD
8. Benthos and phenology in coastal areas (because phenology is well traced in benthic species)	BEWG
9. Changes in migratory routes, geographic distribution of fish and effects in the fisheries	WGFE + Theme session 2009 (Approved)
10. Sensitivity of marine ecosystems to climate variability, fisheries, and regime-shifts in marine ecosystems	Theme session 2009 (Approved)
11. Climatic events and bioinvasions in a changing world	WGITMO
12. Socioeconomic consequences of climate change in the Noth Atlantic (direct and indirect effects - opening of sea passages in the Artic, biogeochemistry changes in nutrients, carbon cycle, etc.)	Workshop
13. How models help us to understand climate change evolution in the near future	Workshop
14. Conclusions and ICES position in future research in Climate Change	SGCC

5.1 Plans and actions for the sections to be prepared by SGCC for the ICES position paper on climate change

Sections No. 0, 1, 5 and 14 will be directly under the responsibility of SGCC members.

Section 0 (Executive summary, what we know, gaps, future) and 14 (Conclusions and ICES position in future research in Climate Change) will be drafted at the very end of the entire process to allow SGCC to incorporate new findings and projections for the short and mid-term in the manuscript. It will be pragmatic to leave these two sections to the latest stage possible.

Section 1 (Introduction). A first draft was prepared, but it should be condensed and pruned as many topics will be repeated later in the following sections. The draft for revision will be ready for the ASC.

Section 5 (Acidification and biogeochemistry). Liam Fernand informed that more work in ocean acidification is going on right now, and so this section will be drafted as late as possible. He also mentioned that a wider group to help with this would be recommendable. Liam has contributed to the European Science Foundation (ESF) report titled 'Impacts of Ocean Acidification. European Science Foundation', which will be delivered in August. The ICES chapter will develop some of the points raised in this document.

The point ended with a discussion about the group vision for Section 14 (Conclusions and ICES position in future research in Climate change), and how to best manage this section. The Chair mentioned that the objective of this section is to put into a context all the things that have been stated in relation to the future. In principle SGCC should be able to do this, but perhaps additional expertise will be needed. It was suggested that WGPBI perhaps could take part in developing this section.

In addition there was a suggestion to send one or two people to the workshop promoted by CLIVAR "Predicting the climate of the coming decades", which will take place at the Rosenstiel School of Marine and Atmospheric Sciences (Miami, USA) next 11–15 January 2010, and ask them to write Section 14. The candidates suggested were Elisabeth North (WGPBI) and Miguel Bernal.

In any case the manuscript has to be prepared and made available to SGCC before the end of January.

5.2 Review and assess on the outcomes of ToRs endorsed to other expert groups in order to contribute to the ICES position paper on climate change

Sections No. 2, 3, 4, 7, 8, 9 and 11 were endorsed as ToRs to be developed during 2009 to different ICES expert groups. The SGCC Chair has been in contact (February) with the chairs of the EGs who responded very positively to the call, and in June they were invited to give an account of the progress made by the individual EGs:

WGOH

Penny Holliday informed SGCC that the group talked about this during the meeting in March. The Working Group on Oceanic Hydrography (WGOH) supports the work of SGCC enthusiastically and formed a subgroup and assigned a topic. A summary report on this had been posted on SGCC SharePoint site. WGOH were asked to contribute also towards hot spots and sea level rise (we don't have an expert on this). So far contributors prepared an outline of what they think should go into the report, i.e. key issues, pertinent to be addressed at the moment.

Penny welcomed comments from SGCC on emphasis or if anything appeared to be missing or duplicated. Jürgen Alheit noted that it will be necessary to establish a mechanism for cross checking for both sides.

WGZE

Mark Benfield reported that the Working Group on Zooplankton Ecology (WGZE) met in March and convened a subgroup for editors. They have a nice first draft divided in four sections, in terms of geographical coverage. They still need to update the report.

WGHABD

Joe Silke informed that the contribution from the ICES - IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD) regarding HABs Phytoplankton and Climate Change is still a rough draft (uploaded to SharePoint). In conjunction with work of WGZE could tie together nicely. Ocean acidification has not been included. The editorial workshop would be very useful in knitting this together.

In reply to a question on whether climate change is changing the harmonics of harmful algal blooms, Joe Silke replied that there is no real firm evidence that we can come up with.

BEWG

Steven Degraer reported that the Benthos Ecology Working Group (BEWG) had produced an overview on benthos in relation to climate change last year. This document was used as a base for the section in the ICES position paper. There are 11 contributors from BEWG, who will write half a page on the different topics. All in all there will be approx. 20 pages of text, which should be fitted into three overarching themes: distribution shifts, reproduction match/mismatch, and production.

They left the original idea of benthos and phenology because of the lack of accurate information.

Jürgen Alheit brought up the work done by S. Hawkins and by Southward. Both have worked on time-series going a long way back, showing the climate impact over a long time and this would be useful for the BEWG sections of the report. The BEWG Chair noted this comment and would include this under one of the topics. It will be up to the contributors to pick up these ideas to bring it all together to one page of text.

WGFE

Daniel Duplisea attended the meeting via WebEx, he informed SGCC that the group will come up with a plan to provide a draft by late September cribbed from the previous Working Group on Fish Ecology (WGFE) reports and CRR 293 and then after the October meeting of WGFE it should be possible to improve upon this work.

WGITMO

Judith Pederson pointed out that the group has two concerns; one issue is that a lot of the physics is offshore and our problems (invasive species) are closer to shore, the second concern is how to deal with uncertainty. Modelling predictions and the socio economic issues of introduced species were partially covered in the OSPAR report

(CRR 293). They will prepare a draft by the ASC. Inger Wallentinus has done a great job with introduced species, and this will be added to the draft as well.

Timing

SGCC agreed that first drafts from the expert groups would need to be prepared by the ASC in September, and then as the next step a final draft prepared in time for the editorial workshop.

The Chair thanked all the groups for their good work.

5.3 ICES ASC Theme Sessions endorsed by the SGCC. Statistics and plans to follow up the expected outcomes

Drafts for Sections No. 6, 9, and 10 will be the outcome of 4 Theme Sessions convened during 2009 ASC and promoted by the SGCC. This was a solution to deal with those aspects not well covered within ICES expertise, i.e. on remote sensing. Here we need to bring expertise from the academia and many good papers are expected to be presented during the Theme Sessions.

The statistics for the theme sessions D, E, F and G are showed in the following table.

CODE	SESSION	PAPERS	POSTERS	TOTAL
C	Advances in marine ecosystem research: what we have learned from GLOBEC and what we can carry forward in future climate related programs	9	2	11
D	Trends in chlorophyll and primary production in a warmer North Atlantic	12	3	15
E	Climate impacts on marine fishes: discovering centennial patterns and disentangling current processes	34	7	41
F	How does fishing alter marine population's and ecosystem's sensitivity to climate?	10	1	11
G	Comparative study of climate impact on coastal and continental shelf ecosystems in the ICES area: assessment and management	15	4	19

Theme Session C (not directly promoted by the SGCC) is also included in the table, as they may contribute to Section 14 'Conclusions and ICES position in future research in Climate Change'.

The conveners have been made aware that this should be turned into a publication. The Chair confirmed that all the conveners have confirmed their willingness to cooperate on this.

Timing

The deadline for preparing the first draft resulting from the TS will be the end of October, and then the final draft will be prepared in time for the editorial workshop.

5.4 ICES Workshops

SGCC agreed that the sections No. 12 and 13 of the position paper on socio-economy and models should be drafted by workshops specifically tasked to produce draft manuscripts for "How models help us to understand climate change evolution in the near future" and "Socio-economic consequences of climate change in the North Atlantic". In addition and in order to review the drafts and give unity to the entire manuscript, it will be also necessary to convene an editorial workshop.

It is important to bear in mind that the workshops need to be approved by SCICOM, which is determinant on the dates that these workshops may be convened.

SGCC Workshop on socio economics (section 12)

The Chair expressed his concern that socio-economics in relation to climate change is not very well defined and perhaps the most speculative section topic in the document, but if not included this would send the wrong message that ICES is not putting value in this field. However, our perception is that ICES expertise in this field is limited (mostly in fish and fisheries, but the section should include other coastal, marine and maritime activities), so SGCC had some doubts on how to best proceed, one option being to exclude this chapter.

Therefore, before any further action, it would be convenient to get the opinion of SCICOM at this respect and then proceed as suggested.

If the workshop is considered to be the preferred option, it will be necessary to invite experts from outside ICES to help write this chapter. The following experts were suggested to take responsibility of the SGCC position paper chapter on socio-economics:

- Ekko van Ierland, Chair in Environmental Economics, Ph.D. in Economics and Econometrics, University of Amsterdam, 1993
- Doug Wilson,
- Jon Pinegar
- Knut Korsbrekke
- Kerry Turner: Director of CSERGE and a Professor in the School of Environmental Sciences at the University of East Anglia (UEA)
- Herman Held, Potsdam Institute for climate change research, Professor in fisheries economics, University of Iceland,
- Martin Pastoors, The Netherlands, (former Chair of ACFM, whose work is now linked to policy questions and universities)

SGCC workshop on the accuracy of models (Section 13)

Firstly SGCC discussed the concrete contents of this chapter, as it could be ambiguous and lacking accurate conclusions. In fact, part of the discussion about the accuracy of the models will be spread into other sections, for example WGOH would mention model studies in their sections. Also a discussion on climate change against natural variability would be included in the WGOH sections. Harald Loeng also mentioned that in a lot of papers on climate change we see assumptions that the sea-level rise is linear, but even in global temperature this is never the case. How far could they predict the changes in climate? What are the main uncertainties, changes in temperature, downscaling. The ecosystem element is missing, are there any limitations here?

In addition to these points, SCICOM also suggested to consider a Workshop on comparison/validation of models and needed complexity for predicting effects of climate change.

So, perhaps SGCC should consider to change the title of this chapter (*How models help us to understand climate change evolution in the near future*) to something more concrete. Some suggestions were: (1) Role of models in understanding marine climate change and climate impacts in the near future, (2) "How accurate are models at predicting

climate change for relatively narrow set of hydrographical variables and for ecosystems?"

It is clear that a chapter incorporating a discussion on the accuracy of the models is needed, but also in this case there is very little ICES expertise in this area. Therefore SGCC proposes to draft this chapter by convening a workshop in November aimed to discuss this topic, and also covering the topic as suggested by the SCICOM, but with the clear objective that what we expect from the workshop is a manuscript to be publish as an individual chapter in the position paper.

There were several suggestions on accredited scientists that could guide us in this chapter. In the days following the meeting Steve Degraer established formal conversations with the group MUMM (Management Unit North Sea Mathematical Models) to check out their interest and possibilities in contributing to the SGCC Position Paper. MUMM is specialized in modelling aspects of (mainly) physical processes in the marine environment. They responded to this request saying that:

> *"MUMM (Belgian Management Unit of the North Sea Mathematical Models) wishes to contribute, according to its experience, to the chapter "How models help to understand climate change evolution in the near future" within the ICES position paper on climate change. We are currently involved in projects aiming at the design of scenarios for climate change impacts on the Belgian zone of the North Sea by 2040 and 2100. Our modelling tools are used to assess changes in storminess and sediment transport patterns for the Belgian coast. Our approach and our results need to be compared to similar studies in other coastal zones. So our contribution could be a few paragraphs (or a few pages) on "How models help understand climate change evolution in the regional oceans". Please, let us know if this proposition meets your needs".*

In short, they are interested in contributing according to their expertise and await any further communication on this issue. The contact person in this is Stephanie Ponsar (S.Ponsar@mumm.ac.be).

The offer of MUMM was very welcome and in fact the group seems to be very competent in what they are doing, but several aspects which would be very important for SGCC, might not be covered by this group. Therefore, SGCC suggests to convene the workshop reinforcing the MUMM expertise with experts on ecosystem modelling including throphic interactions up to the highest level (MUMM include only phytoplankton, no zooplankton and fish), and SGCC should also ensure expertise in forecasting scenarios covering the short term (next 5 to 20 years).

A second suggestion was to invite the Joint PICES/ICES Working Group on Forecasting Climate Change Impacts on Fish and Shellfish (WGFCCIFS) to participate in the workshop and to co-operate on the modelling chapter.

In summary SGCC will try to bring together MUMM and WGFCCIFS with some other selected experts from marine labs and Universities and make a group covering the areas atmosphere, hydrography, ecosystem modelling to write the draft for this chapter.

The workshop will be covered by the SGCC budget.

Editorial workshop back-to-back with SGCC meeting

Once all the drafts have been received and reviewed by SGCC it will be necessary to identify the main gaps and metamorphose the compilation of sections in a unit with an uniform stile. This implies an intense workload that will demand a time commitment that cannot be guaranteed by SGCC. Therefore, SGCC discussed the possibility of contracting an editor who would be asked to dedicate a significant portion of time to this task.

However, the editor will need the assistance of the main authors to polish the style and clarify the concepts where necessary. To do this in a coordinated and effective manner, it will be necessary to convene an editorial workshop in time to fit the calendar and plans for publication. Thus the editorial workshop has to be scheduled early in 2010 (proposal dates were 25-27 January), and it will be funded within the SGCC budget.

Regarding the number of participants it was decided that attendees will be the key contributors of the individual sections, i.e.: the editor, some members of the expert groups, and the conveners of the Theme sessions and Workshops. The SGCC will follow the editorial workshop by having the annual meeting back to back to the editorial workshop.

For both groups to meet back to back SGCC will need some extra facilities in terms of large and small meeting rooms (to work in plenary and in subgroups), photocopies, etc. We will consider offers for the venue in addition to ICES headquarters (it was considered that January is not the best season of the year to meet in Copenhagen and also the increasing daily cost of the hotels in Copenhagen is dissuading the people to meet here).

This block of items was completed with a discussion on how to define a 'final draft' version, if crucial topics are missing, and how should SGCC look at the various regions (Arctic, Baltic, etc.) in terms of the set-up of the position paper.

For example it was mentioned that the trophic relationships between plankton and fish are not well addressed in any chapter as this is a cross-cutting issue involving all the trophic levels. Also regime shifts should be addressed in a specific chapter.

The Chair realised that SGCC will have to include these items (and perhaps others) in some concrete sections. This will require a detailed discussion in light of the texts received and should be discussed in depth with the editor. We will bring these points to the informal meeting of SGCC to be held during the ASC in Berlin.

The discussion was closed with a recommendation from the Chair, who encouraged SGCC members to use as much as possible the ICES data bank, to make the ICES data bank more visible.

6 Preparing the schedule for the ICES Position Paper for the next 12 months

Endorsement

SGCC agreed to give the ICES position paper visibility via endorsement by the Science Committee (SCICOM). This means that SGCC will need to have a first draft ready in March 2010 and the final draft would need to be submitted to the Secretariat by 1 August 2010 in order to launch the document at the ASC.

HoS confirmed that it would also be possible for SCICOM to endorse the position paper by correspondence, which would give more flexibility.

Editor

As explained it will be necessary to hire a guest editor. The names of Emory Anderson (who is actually already involved as the ICES CRR Editor), Bob Dickson or P.C. Reid were suggested. This should be part of the SGCC budget and the ICES Secretariat will coordinate the procedure for contracting (by 9 June, the Bureau approved the breakdown of the SGCC budget, which includes 75,000 DKK for the editor, so we understand that we have the authorisation of the Bureau to contract an editor). The editor should be ready to start by December and the contract will finish once that the position paper is published.

Length

15–20 submitted pages per section, i.e. all in all 150–225 written pages (including illustrations).

Gaps and topics not well addressed should be identified (at the latest) at the Editorial Workshop.

Roadmap from now till ASC 2010

WGCC ICES Position Paper on climate change science, draft timetable 2009–2010	
ASC Theme Session contributions (C D E F G), drafts by	31 October 2009
Two thematic workshops (socio-economy, modelling)	November 2009
Editorial workshop (3 days), back-to-back with WGCC, before	31 January 2010
Draft manuscript to Expert Groups by	1 March 2010
Draft manuscript to SCICOM for review by	15 May 2010
Manuscript to ICES editors by	31 May 2010
Launch of CRR at the ASC 2010, print by	15 September

Peer review process

Can EGs handle this? It might be useful for individual EGs to identify someone from the outside. However it must be borne in mind that most meetings will be scheduled in March/April and thus there will not be much time for the review process.

7 Prepare/discuss options for new and on-going ICES' activities on Climate Change

Symposia

ICES is promoting (as originator or as co-convener) several symposia in climate change in the next few years. The attendance in two symposia (by one SGCC member each) can be sponsored by the SGCC funding.

- 2010: Climate Change Effects on Fish and Fisheries: Forecasting impacts, assessing ecosystem responses, and evaluating management strategies (Sendai, Japan). ICES/PICES/FAO.
- 2011: Symposium on hydrobiological and ecosystem variability in ICES area during the first decade of the XXI century (Spain). ICES main originator.

- 2012: Second International Symposium on the Effects of climate change on the worlds' oceans (Yeosu, Korea). ICES/PICES/IOC, this is a direct activity of the SGCC.

Workshops (not related to the position paper)

"Predicting the climate of the coming decades" is a workshop promoted by CLIVAR, which will take place at the Rosenstiel School of Marine and Atmospheric Sciences (Miami, USA) next 11–15 January 2010. The goal of this workshop is to bring together people from different communities who have shared interests in predicting the climate of the coming decades. This will include researchers involved in developing prediction systems, understanding mechanisms of decadal and forced climate variability, and assessing the needs of potential users. Discussions will focus on bridging the gap between what is feasible from a technical and scientific perspective and the realities of what kind of information users need.

HoS suggested that SGCC should promote more workshops in 2011 and take more initiatives with special emphasis on activities lacking in ICES. One deficit is that we have to attract more academia. Ocean acidification could bring into ICES a new generation of scientists. There is a perspective of rapid research development over the next years with involvement primarily from academia.

J. Pedersen suggested setting up a workshop in terms of introduced species, about how things are changing coastally in the context of climate change.

SCICOM also suggested to SGCC to plan a Workshop on "Comparison/validation of models and needed complexity for predicting effects of climate change". A discussion on the opportunity of combining this topic with the workshop planned to draft the Section 14 of the position paper is reported in item 5.4. of this report.

Theme Sessions for 2010 and beyond

There is an EU-funded FP6 project named EPOCA and the option of a joint ASC theme session has been offered by the HoS to coordinators which could be used as a forum for presenting their results.

HoS informed SGCC that PICES will have increased focus on climate change in its annual meeting in Seattle 2010, and there would probably be opportunities for ICES to co-sponsor theme sessions there.

The Chair urged the members to send proposals for workshop and theme sessions for 2010 and 2011.

Next Meetings

SGCC will meet for the second time in 2009 during the ASC in Berlin (informal meeting, not at Council expenses) to draft the resolutions for next meeting and the workshops among other items (e.g. coordination of sections of ICES position paper) in the agenda. It was suggested to have the meeting preferably once all theme sessions are completed and before the SCICOM meeting. The HoS responded that this will be difficult because the TS promoted by the SGCC are scheduled along the week in order to avoid competition for the audience in the same days. However, Wednesday afternoon is free, with no theme sessions, so we agreed in scheduling a meeting for Wednesday 23 at 14:00.

Next SGCC meeting agreed to be back to back with Editorial workshop 25–27 January 2010. Venue is still to be decided. This meeting will be at Council expenses. See draft resolution in Annex 4.

8 Election of Co-Chair

SGCC is a basic element for the visibility of ICES activities in climate change and it aspires to be the coordinating body on climate change within ICES. The group was created by Council decision in 2007 and Luis Valdés was appointed as Chair. The objectives of SGCC are ambitious and complex and difficult to be managed by only one chair; in addition the current chair needs to make his present occupation at the IOC compatible with this responsibility in ICES.

For these reasons Luis Valdés asked SCICOM about the convenience of having a co-chair for a better coordination and to guarantee the continuity of this group. The proposal was well received and also accepted by the SGCC members.

The group proposed that Jürgen Alheit (Germany) should take this position. Jürgen Alheit is a longstanding member of the ICES community and he is willing to undertake the task of co-chairing the group.

9 AOB and Closing

The Chair thanked all participants, and expressed hope that all efforts will result in a good position paper. Next year in January, we will have our last meeting to complete this task and we should prepare the roadmap for the continuation of this SGCC, in the new form of WGCC, as the main instrument of ICES work in climate change. If everything follows the natural course, ICES will use the expertise in this SG in the future.

The Chair also thanked the Secretariat for meeting preparations. The meeting was closed at 17:30 on 3 June 2009.

10 Addendum

The Council had been generous in allocating DKK 600.000 for the work of SGCC. At this stage, approx. 20% had been spent and the group was committed by the Bureau to prepare a detailed business plan on how the SIF money will be spend.

In accordance with the future actions agreed at the SGCC meeting, the Chair of SGCC prepared the following budget, which was submitted to the Bureau meeting (9–10 June 2009).

WGCC PROPOSED BUDGET 2008-2010	
Three meetings of SGCC on Council's expense	195.000 DKK
Editorial workshop, 3 days, January 2010	125.000 DKK
Two thematic workshops, November 2009	125.000 DKK
Attendance of relevant conferences, T&S (2 trips)	20.000 DKK
Printing costs (CRR)*	60.000 DKK
Guest editor	75.000 DKK
Total	600.000 DKK

The Bureau **adopted** the proposed use of the SIF fund for Climate Change Group.

*The printing costs updated after receiving the data provided by the ICES Executive Editor sum up DKK 85,000 (DKK 49.990 for 2000 copies, plus DKK 35,000 to cover the layout).

Annex 1: SGCC List of Participants – June 2009

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Annex 2: Briefing prepared at the request of SCICOM

The **Steering Group on climate Change [SGCC**] was founded by Council decision in its 2007 annual meeting, recognizing the strategic importance of ICES in being pro-active in marine scientific research related with climate change and in major crosscutting issues. The SGCC will have a lifetime of 3 years and afterwards it will be evaluated and its continuation analyzed as Programme, Steering Group or as ICES consider most convenient. The SGCC will be funded from the SIF 600,000 DKK for the period 2008-2010.

The **SGCC presented a workplan to the Council**, which was also discussed and adopted in the SGCC kick-off meeting in June 2008.

According with this workplan, **the mission of the SGCC** is to develop and maintain ICES as an effective agent to provide information on sound management in Climate Change in concert with the emerging ICES Science Strategy.

The objectives of the Steering Group is to look at the research, services and operational issues, related to Climate Change supported by ICES in their expert groups, to assess the quality and adequacy of the assessment process, and to manage the start up transit of ICES toward the establishment of a programme in Climate Change [this is now more relevant at the light of the new scientific structure and at the guidance of the SCICOM]

The main **immediate tasks** for the next two years are:

- Identify functions and services that ICES can assume and provide in relation to climate change in the North Atlantic, provide “added value” to existing activities and so meets a demand of services and assessment presently not addressed,
- Establish liaisons with international organizations, convention and panels with interest in the effects of climate changes in the oceans,
- Define what science we need to assist policy makers,
- Determine how best to contribute to the IPCC processes,
- Promote and participate in workshops to develop project ideas and made recommendations for actions,
- Developing the documents requested by ICES and ICES stakeholders,
- Lead the publication of a white paper (position paper) on the impacts of climate change on marine ecosystems in the ICES oceans areas

The membership of the SGCC is mainly made by chairs and ex-chairs of EGs. The intention of having the Chairs as members was to ensure the bottom up science, another criterion had been performance in terms of contributions to the OSPAR Climate Request, and a third criterion was to provide equitable geographic and regional representation. In order to guarantee a good coordination of the group, the number of members should not exceed of 20. Currently the group is leaded by Dr. Luis Valdés, and a proposal for appointment of a co-chair will be discussed in next meeting (3rd of June 2009).

The SGCC is already acting as a **coordinating body on climate change within ICES** and specific Tors were endorsed to several EG. In the same line of action the SGCC is supporting 5 different Theme Sessions during the ICES ASC 2009. It is intended that the outcomes of these theme session will be collated and used as information for the ICES position paper on Marine Climate Change. The ICES position paper on climate change is planned by the end of 2010. The list of contents has been prepared by the SGCC and now the drafting of sections has started.

In summary, **this group is a basic element for the visibility of ICES activities in climate change**, it combines the expertise of existing expert groups with *ad hoc* theme sessions in order to structure our current capacity in a cross-cutting project/programme. The group members bring a wide range of experienced expertise and enthusiasm to bear on this topic that is a central question in ICES concerns. Thus the work of this group must be considered of very high priority and central to new ICES Science structure.

Annex 3: Guidelines for publication of the ICES Position paper on Climate Change (extracted from PPT presentation)

- Many organizations are publishing papers and reports about climate change. "What is the unique contribution of this position paper"
- Committee's reason for being: "major cross-cutting issues". Relating data to other fields and issues is likely to affect the structure of the report.
- Is it the paper's purpose to propose solutions? How far will it go in its conclusions? Is its purpose to make projections? Can these be summarized at the end? Can all this be summarised in the end?
- Should the committee's objectives be addressed in the report?
    - address issues of climate change
    - formulate appropriate responses to the issues
    - The objectives of the Steering Group are to look at the research, services and operational issues, related to Climate Change supported by ICES in their expert groups, to assess the quality and adequacy of the assessment process, and to manage the start up transit of ICES toward the establishment of a programme in Climate Change.
- Identify audience – focus on which part of the audience you wish to address. Think like one of your audience, how would they like it presented?:
    - Scientists
    - Non-scientists
        - Press
        - Marine science specialists/interested: fishery managers, fishers, academics, etc.
        - Climate change specialists/interested: agencies, NGOs
        - Governmental ministers/representatives: not scientists, not even specifically trained in the subject of the ministry. They are trained in language and communication and, like media representatives, are very (critically) aware of presentation.
        - Broad general public
- Combining high scientific quality and interest with a written language, which is accessible to a non-technical but knowledgeable readership
- Articles should stimulate discussion.
- An informal tone, use acronyms and abbreviations sparingly.
- Tell a story, be narrative, what tools to be used to get the story over.
- Create a reasonable schedule and meet it.
- Figures must have 300 dpi resolution.
- Guidelines for authors and editors of CRRs and TIMES

Annex 4: WGCC Draft Resolution for 2010

The **Steering Group on Climate Change (SGCC**), chaired by Luis Valdés, France, and Jürgen Alheit, Germany, will be renamed the **Working Group on Climate Change (WGCC),** and will meet back to back with the **Editorial Workshop for the Position Paper on Climate Change (EWPPCC**) at (venue to be decided), 25-27 January 2010 to:

a) Prepare the first draft of the ICES Position Paper on climate change science to be sent out to relevant EGs for review;

b) Promote and review status for ICES Symposia, theme session for the ASC and workshops related with climate change;

c) Review ongoing ICES' activities on climate change;

d) Make recommendations for future ICES work on climate change and related aspects under SCICOM;

e) Draw up a procedure for providing the most recent information available on climate change for the ICES website with a view to establish direct access and improved use by ICES science and advisory programmes;

f) Develop plans for cooperation with relevant international organizations on issues related with climate change and identify durable working relationships.

WGCC will report by 15 March for the attention of SSGEF and SCICOM.

Supporting information

Priority	This group is a basic element for the visibility of ICES activities in climate change, it combines the expertise of existing expert groups with ad hoc workshops in order to structure our current capacity in a cross-cutting project/programme. The group members bring a wide range of experienced expertise and enthusiasm to bear on this topic that is a central question in ICES concerns. Thus the work of this group must be considered of very high priority and central to new ICES Science structure.

Scientific justification and relation to action plan	(a) The ICES position paper on climate change is now planned by the next ASC (2010). The list of contents have been prepared by the WGCC and now the drafting of chapters has started. The group have to review and correct the contributions in time. It is also necessary to be aware of recent discoveries and documents publisehd by others in order to access to the best sources of information and avoid undesirables duplications in the contents with other bodies. (b) WGCC is promoting several symposia on climate change during 2010–2012. The details in the preparation of these symposia and the promotion of other symposia and workshop is a main tak for the group. (c) The review of Tors related with climate change by the different comittees and expert groups done by the Secretraiat as a Tor of this group have demonstarted the involvement of ICES in issues related with climate change under different optics. The current work of the different expert groups will be reviewed every year in order to avoid duplications, explore synergies and to ensure that key scientific issues are addressed by the Expert Groups and that there are appropriate interactions between scientific disciplines. (d) WGCC is ending the 3 years mandate of the Council and it is necessary to identify possible avenues for the group under the new scientific structure. (e) ICES visibility in climate change aspects needs to be increased at the different levels of ICES structure: advisory, scientific and communication (Secretariat). WGCC would like to help in making this role of ICES more prominent. (f) There are many international councils and agencies working on the diffferent aspects and implications of climate change and ICES should play a lead role in some topic or topics related with climate change and should aspire to be seen as a robust and permanent consultant body in these activities.
Resource requirements	The group will need the usual resources and facilities as in other meetings
Participants	The group has an enthusiastic core membership made by chairs of other expert groups from several Committees. The Group is normally attended by some 15-20 members and guests.
Secretariat facilities	Assistance of the Head of Science Programme, Head of Data Center, and Departamental Secretary.
Financial	WGCC is funded by the ICES SIF, and this meeting is at ICES expenses
Linkages to advisory committees	The Group reports to SCICOM, but their advances are also relevant for ACOM.
Linkages to other committees or groups	WGCC results are relevant for many working and study groups interested in climate change.
Linkages to other organizations	Links with other organizations are intended and some contact is maintained. For example some theme sessions and symposia proposed by this group are in collaboration with our PICES and IOC colleagues.

Annex 5: Climate Change Expert Group Compilation 2000–2008

Climate Change Expert Group Compilation 2000–2008

ICES Secretariat

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Contents

Diadromous Fish Committee (DFC) and (I)

ICES/EIFAC Working Group on Eels (WGEEL) –ICES CM 2005/I:01

6.1 Conclusions from this report

Review of the available information on the status of the stock and fisheries of the European area, that the stock is eel supports the view that the population as a whole has declined in most of the distribution outside safe biological limits and that current fisheries are not sustainable.

Recruitment is at a historical minimum and most recent observations indicate the decline continues in many areas. There is some evidence that depensation in the reproductive phase might be involved, triggering a new and heightened level of precautionary advice. Under this situation, the advice is to restore SSB above levels at which depensation is expected not to occur.

Evidence has been given in earlier reports that anthropogenic factors (e.g. exploitation, habitat loss, contamination and transfer of parasites and diseases) as well as natural processes (e.g. climate change, predation) have contributed to the decline. Measures aimed at recovery of the stock are well known and may include control of exploitation, restocking of recruits and restoration of habitats (including access to and from).

The continental population extends throughout Europe and northern Africa and fisheries are scattered over many large and small water bodies, both marine and fresh water. Management at the local level has not adequately addressed the global decline of the stock, and no coordinated stock-wide management framework has been set up. The continuation of the decline demonstrated by most recent data makes the development and implementation of an international stock recovery plan a necessity.

Study Group on the Status of Diadromous Fish Species (SGSDFS) – ICES CM 2005/I:02

4.4 European eel – Anguilla anguilla International Status

ICES/EIFAC (2003) report that a review of the available information on the status of the stock and fisheries of the European eel supports the view that the population as a whole has declined strongly in most of the distribution area, that the stock is outside safe biological limits and that current fisheries are not sustainable. Recruitment is at a historical minimum. Evidence has been given that anthropogenic factors (e.g. exploitation, habitat loss, contamination and transfer of parasites and diseases) as well as natural processes (e.g. predation, climate change) have contributed to the decline.

The continental eel population extends throughout Europe and northern Africa and fisheries are scattered over many large and small water bodies. Management at the local level has not adequately addressed the global decline of the stock, and no coordinated stock-wide management framework has been set up. The continued depleted state of the stock, as

demonstrated by most recent data, makes the compilation and implementation of an international stock recovery plan a matter of growing urgency.

The eel is not formally classified under the Texel-Faial classification system, nor is it included in the Habitats Directive, the Bern Convention or the IUCN Red List. However, it is assessed annually by a joint EIFAC/ICES Working Group on Eels (WGEEL).

Living Resources Committee (LRC) and (G)

Report of the Study Group on Regional Scale Ecology of Small Pelagics (SGRESP) – ICES CM 2004/G:06

4.3 Next meeting and ToRs

The Study Group on Regional Scale Ecology of Small Pelagic Fish [SGRESP] (Chair: P. Petitgas, France) will meet at the end of February 2005 either in Plymouth, UK (GLOBEC IPO) or Galway, Ireland with the following terms of reference:

a) Identify gaps in the data inventory and continue to assemble data on life history stages (adult, egg, larva, juvenile) of pelagic fish (mackerel, sardine, anchovy, sprat, herring, and horse mackerel) in ICES waters at regional scale and in a long-term perspective.

b) Continue to characterise habitats of life cycle stages (spawning, nursery, feeding and wintering grounds) with particular attention to physical meso-scale processes and multi-species context, evidence inter-annual changes and reconstruct long-term history of the spatial pattern of populations.

c) Assemble long-term series of environmental indices using survey data, meteorological data and model outputs at basin-scale and meso-scale in order to reconstruct long-term history of environmental changes at different scales.

d) Review and update adult fish behaviour in relation with oceanographic and ecosystem features and characterise how adult fish migration, feeding and spawning impact the environment-population interaction.

e) Identify situations which have potential impact on the assessment, projection or management processes: update the relevant assessment working groups and survey planning groups with the information through working documents and provide these groups with quantitative information on fishery-ecosystem interactions.

SGRESP will report by 31 March 2005 for the attention of the Living Resources Committee, ACFM, and ACE.

Supporting Information

Priority:	The work of the Group is essential if ICES is to progress the understanding of environmental forcing on life history, spatial and population dynamics of pelagic fish to provide alternative basis to management on stocks recognised to fluctuate under environmental forcing.

Scientific Justification:	Present Study Groups and Planning Groups of LRC consider survey methods and tools for a variety of surveys on small pelagics in ICES areas (eggs, larvae, acoustics, aerial). On the other hand, assessment WGs of ACFM cannot deal with data integration although they consider that small pelagic stocks fluctuate under environmental forcing. The purpose of the SG is i) to integrate various survey data together as well as with meteo, satellite, fishery and/or ecosystem model outputs and ii) feed in the assessment WG with synthetic understanding of how the spatial dynamics of the biological cycle and the stock dynamics are related to the ecosystem thus increasing ICES ability to use ecological information in assessment and prediction of small pelagics. The SG will work on different case studies in the ICES waters.
Relation to Action Plan:	This group responds to Goal 1 Understand the physical, chemical, and biological functioning of marine ecosystems, in particular action numbers 1.2.2 Changes in spatio-temporal distributions in relation with environmental change, 1.6 assess and predict impact of climate variability and 1.7 play an active role in collaborations between ICES and other international research such as GLOBEC. This group is also related to Goal 4 Advise on the sustainable use of living marine resources, in particular action number 4.11 Develop the scientific basis for an ecosystem approach to management.

4.2 Theme Session proposal 2005

ICES ASC 2005 Theme Session (SGRESP)

Title: Large scale changes in the migration of small pelagic fish and the factors modulating such changes.

Conveners: J. Alheit (Germany), D. Reid (UK)

Description: This session aims to bring together studies on observed changes in migration patterns. These could include; track, timing, distance or speed. Papers are invited on any documented changes in such migrations, but particularly where potential explanatory phenomena have been identified. These could include:

- Environmental change e.g., upwelling and other oceanic events (e.g., ENSO), or climate change e.g., NAO, current changes etc. These may include both physical (e.g., temperature) and biological (e.g., food availability) factors
- Population structure: For example stock abundance and demography (age structure) as well as population parameters such as condition factor, maturity ogives etc. The role of experienced adult fish in modulating migrations would be of particular interest
- Anthropogenic factors: This is principally aimed at the impact of fishing activity, particularly before and after stock collapses, but can in-

clude the direct result of fishing activity on migration paths and timings.

(SGRESP) – ICES CM 2005/G:06

3.2 ToR b) – page 6

Continue to characterise habitats of life cycle sages(spawning, nursery, feeding and wintering grounds) wth particular attenion to physical meso-scale processes and multispecies context, evidence inter-annual changes and reconstruct long-term hiory of the spatial patternof populations

In SGRESP 2004 report, life cycle ID cards were produced for Norwegian spring spawning herring, North East Atlantic mackerel, sardine around Iberia and in Biscay, anchovy in Biscay, and Baltic sprat. This year, new stocks were considered for which similar ID cards were produced.

Characterising meso-scale physical features was recognised essential for the understanding of the variability in spatial patterns and population dynamics. Tools were presented that allow extraction from circulation model outputs: fronts, eddies, vortices, water column stratification. A workshop was proposed to deal with this issue as tools need to be transferred to users for building the meso-scale features time series in each area.

Results from the German-GLOBEC program on Baltic sprat were an example of how physics impacted the plankton food web making resource availability varies across years, in a multi-species competition context. (The ID card for Baltic sprat is in the 2004 SGRESP report).

Long-term variations in population distributions was analysed on anchovy. In Biscay, the an-chovy population is seen to have lost spawning grounds. Data were assembled that questioned whether encountering adults was necessary for juveniles to effectively colonise lost habitats. (The ID card for anchovy in Biscay is in the 2004 SGRESP report). At large scale in ICES waters in the context of climate change; data were compiled from all available bottom trawl surveys from 1990 to 2004. Anchovy distribution expanded in northern waters since 1995 with no particular change in the southern limit. There was presumption that expansion came from good recruitments from micro local residual populations. …….

4.4 ICES ASC 2007 Theme Session proposal

The group proposed last year a Theme Session which is standing for the 2007 ASC.

Title: Large scale changes in the migration of small pelagic fish and the factors modulating such changes. Co-Chairs: J. Alheit (De), D. Reid (UK).

This session aims to bring together studies on observed changes in migration patterns. These could include; track, timing, distance or speed. Papers are invited on any documented changes in such migrations, but particularly where potential explanatory phenomena have been identified. These could include:

- Environmental change e.g. upwelling and other oceanic events (e.g. ENSO), or climate change e.g. NAO, current changes etc. These may include both physical (e.g. temperature) and biological (e.g. food availability) factors;

- Population structure: For example stock abundance and demography (age structure) as well as population parameters such as condition factor, maturity ogives etc. The role of experienced adult fish in modulating migrations would be of par-ticular interest.

Anthropogenic factors: This is principally aimed at the impact of fishing activity, particularly before and after stock collapses, but can include the direct result of fishing activity on migra-tion paths and timings

4.5 SGRESP 2006 meeting

The **Study Group of Regional Scale Ecology of Small Pelagic Fish** [SGRESP] (Chair P. Petitgas, France) will meet from 27 February to 02 March 2006 in Galway (Ireland) to:

a) Continue the assemblage of primary level data (e.g., sample based) on life history stages (adult, egg, larva, juvenile) of pelagic fish (mackerel, sardine, anchovy, sprat, herring, blue whiting) in ICES waters at regional scale and in a long-term perspective;

b) Combine second level data (e.g., rectangle based) on fish life cycle stages with that on their environment (measurements or model outputs), with particular atten-tion to physical meso-scale processes, lower trophic levels and multi-species con-texts, to evidence inter-annual changes in long-term history and spatial popula-tion patterns;

c) Update the understanding of particular phases in the life cycle (e.g., recruitment, spawning habitats, migration) that are critical for life cycle closure in the contexts of population collapse or expansion;

d) Increase knowledge on the expansion of anchovy and sardine in ICES waters north of 50°N;

e) Identify situations with potential impact on the assessment, projection and man-agement processes and explore the means by which projections and management strategies can be developed and report findings to relevant ICES groups (e.g., WGMHSA, WGRED);

f) Review state of the art in modelling of population life cycles (e.g., spatial popula-tion models), report on their adequacy and identify the knowledge necessary to support modelling;

g) Summarize the knowledge produced by SGRESP and suggest a scientific plan for further progress on environment - population interaction.

Supporting Information

Priority:	The work of the Group is essential if ICES is to progress the understand-ing of environmental forcing on life history, spatial and population dy-namics of pelagic fish to provide alternative basis to management on stocks recognised to fluctuate under environmental forcing.

Scientific Justification:	Present Study Groups and Planning Groups of LRC consider survey methods and tools for a variety of surveys on small pelagics in ICES areas (eggs, larvae, acoustics, aerial). On the other hand, assessment WGs of ACFM cannot deal with data integration although they consider that small pelagic stocks fluctuate under environmental forcing. The purpose of the SG is i) to integrate various survey data together as well as with meteo, satellite, fishery and/or ecosystem model outputs and ii) feed in the assessment WG with synthetic understanding of how the spatial dynamics of the biological cycle and the stock dynamics are re-lated to the ecosystem thus increasing ICES ability to use ecological information in assessment and prediction of small pelagics. The SG will work on different case studies in the ICES waters.
Relation to Action Plan:	This group responds to Goal 1 Understand the physical, chemical, and biological functioning of marine ecosystems, in particular action numbers 1.2.2 Changes in spatio-temporal distributions in relation with envi-ronmental change, 1.6 assess and predict impact of climate variability and 1.7 play an active role in collaborations between ICES and other international research such as GLOBEC. This group is also related to Goal 4 Advise on the sustainable use of living marine resources, in par-ticular action number 4.11 Develop the scientific basis for an ecosystem approach to management.

(SGRESP) – ICES CM 2006/LRC:05

Executive Summary

A component of the ecosystem approach to fisheries management is to include the environmentally induced variation in fish stocks. In that respect, the Study Group on Regional Scale Ecology of Small Pelagic Fish (SGRESP) was concerned with cross-mapping fish population life cycle and oceanographic features, and identifying favourable habitats together with variation in their forcings across years.

Original data sets were collated at regional scale, initiating unique data analyses. The compilation of CUFES egg data and CTD profiles in Biscay and around the Iberian Peninsula enabled the full scale analysis of potential spawning habitats of sardine and anchovy. The compilation of anchovy catch by length in all ICES coordinated bottom trawl surveys in the North East Atlantic enabled the long-term large-scale analyses of anchovy fluctuations in the NEA. In particular, North Sea IBTS surveys coupled with the ICES oceanographic data base allowed for an understanding of the expansion of anchovy in the North Sea since the mid-1990s and its seasonal life cycle spatial pattern.

Hydro-climatic forcing on the drift and retention of larval stages is commonly identified as critical for life cycle closure. But the importance of adult fish spatial behaviour

in selecting spawning grounds was identified as key in generating an interaction between the climate conditions and the fish populations. A hypothesis was built, named the 'Entrainment hypothesis', which stated that life cycle closure resulted from spawning migrations and that spawning migrations were sustained by repeat spawners and adult behavioural processes. The hypothesis explained both tradition and novelty in life cycle spatial patterns. Different ways of falsifying the hypothesis were listed and a workshop is proposed on the thematic for 2007. The hypothesis provided a conceptual framework to envisage population functioning under climate change, stock collapse and recovery plans……..

"2.7 ToR g) summarize the knowledge produced by SGRESP and suggest a scientific plan for further progress on environment/population interaction.

2.7.1 The period 2004–2006 and its achievements

SGRESP was set up for connecting life cycle spatial patterns of pelagic fish populations with the hydro-climate features, understand population responses to environmental forcing and identify situations of importance to the assessment and management. The originality of the work was the spatial approach matching life cycle patterns with that of oceanographic features. SGRESP was active for the 3-year period 2004–2006. The group has worked with terms of reference dealing with (i) fishery data assemblage at regional scale and long-term; (ii) environmental characterisation of habitats; (iii) adult behaviour and space/time patterns in life cycles; (iv) identification of situations in the environment-population interaction of importance for the assessment and management. Life cycle patterns have been documented with a standard template for many pelagic fish stocks in the ICES European waters: NEA mackerel, NEA sardine, NEA blue whiting, Biscay anchovy, North Sea sprat, Baltic sprat, North Sea herring, Norwegian spring spawning herring, herring around Ireland. For each stock, life cycles have been cross mapped with maps of oceanographic features, leading to an understanding of the major driving forces in the environment and their space-time scale on the fish habitats.

Life cycle patterns and the importance of adults in their maintenance has been theorised by the entrainment hypothesis. The theory is about the maintenance/change in the spatial organisation of the life cycles in the context of climate change and population collapses and recoveries. This conceptual understanding suggests methods for spatial population modelling taking into account stock substructure and environmentally-controlled habitat quality.

The environment used by the fish in any of its habitats relates to meso-scale physical features (e.g. fronts, eddies, …). The group recommended the venue of the 2006 workshop WKIMS, also supported by WGPBI, to advance ideas in defining and estimating indices for meso-scale oceanographic features using satellite images or hydrodynamic models. …."

3 Recommendations

3.1 Further data assemblage on anchovy in the North Sea: proposed ToR for WGLESP

SGRESP has paid attention to the expansion of anchovy in the North Sea as an example of colonising species under climate change. Analyses performed so far have dem-

onstrated that anchovy expanded into the North Sea since the mid 1990s, that hydrological summer/autumn conditions in the North Sea are potentially favourable for the spawning of anchovy. Length distribution in surveys support the hypothesis that anchovy is effectively spawning in the North Sea in summer/autumn and that winter recruited juveniles are in coastal areas not accessible to quarter 1 bottom trawl surveys. The group recommends that the future WGLESP considers a term of reference allowing the finalisation of the work initiated by SGRESP on North Sea anchovy. The proposed ToR to WGLESP could be:

- assemble additional data to the IBTS (e.g. ichthyoplankton surveys on the German Bight, coastal beam trawl surveys, catch data from the fisheries) and complete the description of the life cycle of North Sea anchovy

ICES/GLOBEC Working Group on Life Cycle and Ecology of Small Pelagic Fish (WGLESP) – ICES CM 2007/LRC:04

2.5 ToR e) Program new workshops

The WGLESP list of topics for workshops was:

- Connecting the fish to the ecosystem (oceanographic features, plankton production, top predators);
- Habitat modelling that combines environmental forcing and population memory.

WKLTVSE evidenced long-term changes in clupeiform fish in SW Europe in relation to regimes in the ecosystem and climate indices. On the climate change topic, thematic cooperation with GLOBEC/SPACC would be desirable, based on the large experience that this group has worldwide. The OSPAR request on climate change impact on fish dynamics and distributions is thought to require more interdisciplinary work as well as more work on the mechanisms driving changes in distributions.

It is thus recommended to convene an ICES/GLOBEC workshop in 2008 on 'Climate impact and regime changes of clupeiform pelagic fish in European and NW African waters'. The workshop activity would encompass topics such as (i) changes in distribution, population abundance and condition of pelagic fish in relation to changes in hydrodynamics and sea temperature, (ii) connecting the fish to the ecosystem.

Annex 2: WGLESP Terms of Reference for 2008

The **ICES/GLOBEC Working Group on Life Cycle and Ecology of Small Pelagic Fish** [WGLESP] (Chair: P. Petitgas, France) will meet by correspondence to:

a) Prepare a document compiling the knowledge assembled by SGRESP on life cycle patterns and meso-scale oceanographic features for small pelagic fish in the North East Atlantic, to be proposed for publication as a Cooperative Research Report;

b) Summarise outcomes from past activity (e.g. SGRESP, OSPAR request, 2006 Theme Session B, 2007 Theme Session G, WKLTVSWE, WKTEST) to document the mechanisms and controls of changes in spatial distributions and migration patterns;

c) Report new results and methods for modelling habitat occupation;

d) Liaise with other ICES groups of the Oceanography Committee and suggest ways to collaborate to address hydro-climate forcing on spatial distributions of pelagic fish.

WGLESP will report by *** to the attention of the Living Resources Committee, the Oceanographic Committee and GLOBEC/SPACC.

Supporting Information

PRIORITY:	The work of the Group is essential if ICES is to progress the understanding of environmental forcing on life history, spatial and population dynamics of pelagic fish to provide alternative basis to management on stocks recognised to fluctuate under environmental forcing. There is no other group within ICES on this thematics that is also key for recovery plans of depleted stocks.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	The purpose of the WG is i) to integrate various survey data together as well as with meteo, satellite, fishery and/or ecosystem model outputs and ii) develop understanding of how the spatial dynamics of the biological cycle and the stock dynamics are related to the ecosystem thus increasing ICES ability to use ecological information in assessment and prediction of small pelagics. The WG will work on different case studies in the ICES waters. This WG addresses Goal 1 Understand the physical, chemical, and biological functioning of marine ecosystems, in particular action numbers 1.2.2 Changes in spatio-temporal distributions in relation with environmental change, 1.6 assess and predict impact of climate variability and 1.7 play an active role in collaborations between ICES and other international research such as GLOBEC. This WG is also related to Goal 4 Advise on the sustainable use of living marine resources, in particular action number 4.11 Develop the scientific basis for an ecosystem approach to management.
RESOURCE REQUIREMENTS:	No specific resource requirements beyond the need for members to prepare for and participate in the meeting.
PARTICIPANTS:	The Group is normally attended by some 15 members and guests. These would include scientists working on survey data, population modelling, environmental change and scientists participating to GLOBEC/SPACC.
SECRETARIAT FACILITIES:	None specific
FINANCIAL:	None specific
LINKAGES TO ADVISORY COMMITTEES:	Link with ACFM through WGMHSA and WGRED (advise on recruitment scenrios as deduced from environment & spawning habitat selection); Link with ACE through particular ToRs (e.g. Ospar request)
LINKAGES TO OTHER COMMITTEES OR GROUPS:	Link with WGPBI and WGRP of the Oceanography Committee (link fish populations to meso-scale physical structures, use of hydrodynamics model outputs). Link with groups dealing with environmental and fisheries survey data.
LINKAGES TO OTHER ORGANIZATIONS:	This group

Annex 3: WKCLISP Terms of Reference for 2008

The ICES/GLOBEC Workshop on Climate impact and regime changes of clupeiform pelagic fish in European and NW African waters [WKCLISP] (Chair: J. Alheit*, Germany) will meet in Warnemünde, Germany xxxxx June 2008 to:

a) Document changes in distribution, population abundance and condition of pelagic fish;

b) Explain these changes in relation to changes in hydrodynamics and sea temperature;

c) Explain these changes in relation with changes in the plankton ecosystem.

WKCLIM will report by *** to the attention of the Living Resources Committee, the Oceanographic Committee and GLOBEC/SPACC.

Supporting Information

PRIORITY:	The work of the Group is essential if ICES is to progress the understanding of the mechanisms driving changes in pelagic fish populations by connecting fish to the environmental and the ecosystem.
SCIENTIFIC JUSTIFICATION AND RELATION TO ACTION PLAN:	The WK addresses Goal 1 Understand the physical, chemical, and biological functioning of marine ecosystems, in particular action numbers 1.2.2 Changes in spatio-temporal distributions in relation with environmental change, 1.6 assess and predict impact of climate variability and 1.7 play an active role in collaborations between ICES and GLOBEC. This WG is also related to Goal 4 Advise on the sustainable use of living marine resources, in particular action number 4.11 Develop the scientific basis for an ecosystem approach to management. The WK will further allow ICES to answer the OSPAR request on the impact of climate change on fish population dynamics and distributions
RESOURCE REQUIREMENTS:	No specific resource requirements beyond the need for members to prepare for and participate in the meeting.
PARTICIPANTS:	Participants would include scientists from WG of the LRC and OCC as well as from GLOBEC/SPACC.
SECRETARIAT FACILITIES:	None specific
FINANCIAL:	None specific
LINKAGES TO ADVISORY COMMITTEES:	Link with ACE through particular ToRs related to the Ospar request
LINKAGES TO OTHER COMMITTEES OR GROUPS:	Link with WGPBI and WGRP of the Oceanography Committee (link fish populations to meso-scale physical structures, use of hydrodynamics model outputs). Link with groups dealing with environmental and fisheries survey data.
LINKAGES TO OTHER ORGANIZATIONS:	This group will be proposed for approval by GLOBEC/SPACC steering committee

(WGLESP) – ICES CM 2008/LRC:13

"2 ToR b) Summarise outcomes from past activity (e.g. SGRESP, OSPAR request, 2006 Theme Session B, 2007 Theme Session G, WKLTVSWE, WKTEST) to document the mechanisms and controls of changes in spatial distributions and migration patterns

The life cycles of fish populations are organized geographically. Recent work within ICES has revisited the topic of the controls of fish spatial distributions and migration patterns for predicting climate change effects as well as for the conservation of essential habitats. The work is here summarized. Controls on fish spatial distributions and migration patterns are both external and internal to the populations. External factors are driven by environmental forcing and will affect habitat suitability as well as migration cues. Internal factors relate to stock abundance, density dependence, age structure, fish condition, contingent diversity and behaviour including learning. Internal factors will modulate populations' response to hydro climate forcing or the way populations recover after collapse. Fishing will impact the interaction between a population and its environment, as it will modify population abundance, demography and contingent diversity. …"

4. ToR d) Liaise with other ICES groups of the Oceanography Committee and suggest ways to collaborate to address hydro-climate forcing on spatial distributions of pelagic fish

In preparing WKSPCLIM, contacts have been made to allow for linking oceanography with fish population responses. Also, the work of WGLESP has been presented to the WG on Physical-Biological Interactions (WGPBI) to envisage modelling the full life cycle of fish using outputs of biogeochemical models. A Theme Session co-promoted by WGLESP and WGPBI is proposed for the ASC in 2010 on modelling the full life cycle of fish (Annex 5). The steering group on climate change SGCC is expected to be a future forum providing guidance on how to make plans on the topic. In that context, small pelagic fish could be taken as indicators of climate change.

Annex 3: WGLESP terms of reference for the next meeting

The ICES/GLOBEC Working Group on Life Cycle and Ecology of Small Pelagic Fish [WGLESP] (Chair: P. Petitgas, France) will meet at XXXX (location and date to be confirmed) to:

a) Complete the CRR on life cycle patterns initiated in 2008;

b) Report new results of relevance to LESP, and the impact of climate change

c) Review causes and mechanisms explaining changes in small pelagic fish species occurrence;

d) Building on WKSPCLIM and SGCC work, propose a workplan to envisage small pelagic fish as indicators of climate change.

WGLESP will report by XXXX to the attention of the LRC Committee.

Supporting Information

Priority:	The work of the Group is essential if ICES is to progress the understanding of environmental forcing on life history, spatial and population dynamics of pelagic fish to provide

	alternative basis to management on stocks recognized to fluctuate under environmental forcing. There is no other group within ICES on this thematics that is also key for recovery plans of depleted stocks.
Scientific justification and relation to action plan:	The purpose of the WG is i) to integrate various data sources and ii) develop understanding of how the spatial dynamics of the biological cycle and the stock dynamics are related to the ecosystem thus increasing ICES ability to use ecological information in assessment and prediction of small pelagics. The WG works on different case studies in the ICES waters and links with GLOBEC and PICES work on similar topics.The WG addresses Goal 1 Understand the physical, chemical, and biological functioning of marine ecosystems, in particular action numbers 1.2.2 Changes in spatio-temporal distributions in relation with environmental change, 1.6 assess and predict impact of climate variability and 1.7 play an active role in collaborations between ICES and other international research such as GLOBEC. This WG is also related to Goal 4 Advise on the sustainable use of living marine resources, in particular action number 4.11 Develop the scientific basis for an ecosystem approach to management

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Working Group on Fish Ecology (WGFE) – ICES CM 2004/G:09

2.3.2.4. Discusion .....

Other responses to climate may be driven by environmental conditions that can influence growth, survival and food availability during early life history. These include temperature effects of growth rate. Temperature effects may carry through the life history and if average growth rate changes across the community there are implications for age/size at maturity of fish in the community, reduced generation time and faster turnover time of individuals. Temperature, the timing of algal blooms (O'Brien *et al*. 2000, Planque and Frédou, 1999, Platt *et al*., 2003) and the North Atlantic Oscillation signal (Attrill and Power, 2002; Dippner, 1997) have been correlated with fluctuations in marine fish populations. These processes are thought to influence the variability in the production of fish stocks that comprise the community. Theoretical and/or simulation modelling of hypothesized processes influenced by temperature (such as bioenergetics and system metabolism) combined with exploitation effects could help to shed light on the sensitivity of the metrics when both changes are occurring simultaneously.

The influence of large-scale environmental factors related to climate change could be influencing fish assemblages over a much larger area considered here (i.e., the entire Northeast Atlantic Shelf). Understanding how these factors interact to influence the structure of communities and ecosystems at different spatial scales would appear to be an important prerequisite for the effective development of size-based ecosystem and community metrics.

(WGFE) – ICES CM 2006/LRC:06

2.4 Simulation environments

2.4.1 Introduction

While trying to evaluate of the usefulness of ecosystem indicators (see for example section on "what is a large fish?"), it is difficult, *a priori*, to score the sensitivity, responsiveness and specificity of ecosystem indicators to fishing pressure because these features are case specific and result from complex multiple and nonlinear species interactions. It is also a difficult task *a posteriori* because we are not always able to provide reliable estimates of multispecies fishing mortality, and even if we are able to, the dynamics of fishing mortality is multidimensional and its direct effects are combined with indirect trophic effects and climate variability.

In this context, model simulations can help us to better understand the response of ecosystem indicators to various levels of fishing, owing to the fact that the forcing factors are controlled and that direct "observation" of simulated data is possible. One of the candidate multispecies models for undertaking such sensitivity analyses is the Osmose model. Because this model explicitly considers size and species dimensions, it can be used to study of the properties of a large subset of the ecosystem indicators such as those proposed by the SCOR/IOC Working Group 119 (size-based and species-based indicators).

(WGFE) – ICES CM 2008/LRC:04

"Page 7 of WGFE Report

Overall changes in fish distribution by OSPAR regions (Pages 7 and 8)

Rose (2005) compiled a literature review and analysed factors that might influence the distribution of fish species in the North Atlantic. Those analyses indicate that the limits of both spawning and feeding distributions are influenced by environmental factors that are partially controlled by climate variability, and likely, by climate change. Not all species may be impacted in the same manner and changes depending on ecological associations. Species who's spawning is limited to the cold waters of the arctic or boreal regions are expected to be most affected (e.g. the small pelagic capelin), and to respond relatively quickly to environmental change. Shelf species in general and cold-water species such as winter flounder, several species of sculpin, eelpouts, Arctic cod, the gadoids and several flatfish and other boreal species are mid-range in vulnerability and might directly benefit from warmer conditions though indirect effects (e.g. declines in abundance of their main prey) may have negative effects. ….."

2.7 Climate change and the depth and latitudinal change in the North Sea demersal fish assemblage

European shelf seas are warming faster than the adjacent land masses and faster than the global average. Climate change impacts have been observed on individual species and species subsets, however it remains to be seen whether there are systematic, coherent assemblage-wide responses to climate change that could be used as a representative indicator of changing state.

We explore the year-by-year distributional response of North Sea bottom-dwelling (demersal) fishes to temperature change over 25 years from 1980–2004. The centres of latitudinal and depth distributions of 28 fishes were estimated from species-abundance-location data collected on an annual fish monitoring survey.

Individual species responses were aggregated into 19 assemblages reflecting physiology (thermal preference and range), ecology (body size & abundance-occupancy patterns), biogeography (northern-southern & presence of range boundaries), and susceptibility to human impact (fishery target, bycatch & non-target species).

North Sea winter bottom temperature has increased by 1.6°C over 25 years, with a 1°C increase in 1988-9 alone (refer to figures above for a spatial representation of these changes). During this period the whole demersal fish assemblage deepened by ~3.6 m decade^{-1} and the deepening was coherent for most assemblages.

The latitudinal response to warming was heterogeneous, and reflects (i) a northward shift in the mean latitude of abundant, widespread thermal specialists, and (ii) the southward shift of relatively small, abundant southerly species with limited occupancy and a northern range boundary in the North Sea.

The deepening response of North Sea bottom-dwelling fishes to climate change is the marine analogue of the upward movement of terrestrial species to higher altitudes. The assemblage-level depth responses, and both latitudinal responses, covary with temperature and environmental variability in a manner diagnostic of a climate change impact. The depth response of the demersal fish assemblage to temperature could be used as a biotic indicator of the effects of climate change in the North Sea and other semi-enclosed seas (Dulvy *et al.* in press).

Planning Group on North Sea Cod and Plaice Egg Surveys in the North Sea (PGEGGS) – ICES CM 2006/LRC:02

14 Communications

At the previous planning meeting (held in Lowestoft, 10–12 May, 2005: ICES CM 2005/G:11) the group proposed a number of publications arising from this work. Various individuals were appointed to lead on different aspects. At the present meeting progress reports were presented.

a) A short communication to a high impact journal focussed on cod spawning (Clive Fox). This has been drafted and submitted to Nature. It has been accepted for review but the reviewers had difficulties with the overall conclusions that climate change has not caused a shift in cod spawning grounds compared with data from the 1940s. In particular the fact that this conclusion was based on results from a single egg survey caused problems. This comment highlights the importance of repeating the North Sea survey to validate the 2004 findings. The article may be re-submitted elsewhere.

b) A more detailed scientific paper covering cod, haddock and whiting – this has been covered as a paper prepared for the ICES 2005 Annual Science Conference (CM 2005/AA:04). This CM will be redrafted and submitted for peer review once the issues around publication a) are resolved

STUDY GROUP ON RECRUITMENT VARIABILITY IN NORTH SEA PLANKTIVOROUS FISH (SGRECVAP) – ICES CM 2006/LRC:03

5.3 The gadoid outburst, the subsequent development in the North Sea cod, and long-term climate change

The "gadoid outburst" was a large increase in the SSB and the recruitment in North Sea cod during the 1960s and 1970s (Daan et al. 1994). The SSB peaked around 1970, decreased during the 1970s before it reached a secondary maximum in the early 1980s. After then SSB has steadily decreased. The development in the North Sea gadoids has, consequently, many common features with the development of the *C. finmarchicus*. It is no doubt that the decline in the cod recruitment after the beginning of the 1980s is associated with a parallel warming of the marine climate of the North Sea (O'Brien et al. 2000) and that the gadoid outburst coincided with a cool period in the marine climate. However, the mechanisms behind the rise and fall of the North Sea cod are less clear. Cushing (1984) proposed that the increased recruitment was caused by a better synchrony in the abundance of the cod larvae and their prey, while Daan et al. (1994) speculated that overexploitation of herring and mackerel could have reduced predation on larval cod. Other hypotheses have also been proposed.

The long-term change in marine climate is clearly parallel to a similar long-term change in the species composition, abundance and productivity of the zooplankton populations (Beaugrand et al. 2003). . The core production and over-wintering region for the dominant copepod *C. finmarchicus* in the northeastern North Atlantic is the Norwegian Sea proper (Sundby 2000). The over-wintering region extends to a certain degree into the Norwegian Trench in the North Sea. Hence, a warming of the marine climate of the North Atlantic, as observed during the recent 25 years has resulted in northward displacement of the *C. finmarchicus*-dominated ecosystem with a consequent decrease of this species in the central and northern North Sea (Beaugrand et al., 2002). Sundby (2000) proposed a generic mechanism for the linkage between temperature and recruitment in North Atlantic cod stocks as described by Planque and Frédou (1999). They showed that the cod stocks inhabiting the cold part of the North Atlantic (e.g. northern codand Barents Sea cod) generally show a positive recruitment response to increase in ambient temperature while those cod stocks inhabiting the warm part of the North Atlantic (e.g. the Irish Sea cod and the North Sea cod) shows a positive recruitment response to reduction in ambient temperature. The generic mechanism proposed for the linkage between temperature and cod recruitment is that the temperature is a proxy for the advection of *C.finmarchicus*-rich water mass from the core over-wintering region (NSIW) in central part of the Norwegian Sea.

10 Conclusions

....

vi) It is already well known that a change in the planktonic community occurred in the North Sea after the mid 1980s. Change has continued to date, on a gradual basis and is linked to the broader, and well documented, process of climate change/variability (Section 5). Reponses at other trophic levels to this gradual change in the zooplankton may result in abrupt changes. Within an abrupt change there is recognition of spatial gradients of patterns that could lead to differences in conclusions if the patterns are not analysed on the correct spatial scale.

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4.2 Evidence of North east Atlantic processes and influence of climate change

4.2.1 Large scale climate influences

Evidence has been accumulated that marine ecosystems undergo large-scale fluctuations, occurring over decadal time periods which seem to be driven by climate forcing (Stenseth *et al*., 2002), as clearly demonstrated for the North Pacific (e.g. Hare and Mantua, 2000) and eastern boundary current systems (e.g. Chavez *et al*., 2003; Alheit and Niquen, 2004). Shifts in climate regimes can reorganize marine communities and trophodynamic relationships and induce changes in the mix of dominating species over decadal time scales. An ecological regime shift in the North Sea in the late 1980s has been extensively described in a number of publications and been related to changes in the index of the North Atlantic Oscillation (NAO) (Reid *et al*., 1998; Kröncke *et al*., 2001; Reid and Edwards, 2001; Reid *et al*., 2001a; Reid *et al*., 2001b; Beaugrand and Ibanez, 2002; Beaugrand *et al*., 2002; Reid and Beaugrand, 2002; Beaugrand, 2003; Beaugrand and Reid, 2003; Beaugrand *et al*., 2003; Reid *et al*., 2003; Beaugrand, 2004, Alheit *et al*., 2005; Weijermann *et al*., 2005). Interestingly, regime shifts have been suggested recently for the central Baltic Sea (Alheit *et al*., 2005), the northwestern Mediterranean and European lakes coinciding with the North Sea shift in the late 1980s whereby the NAO appears to synchronize dynamics in the different ecosystems (Souissi *et al*., 2007; Alheit and Bakun, subm.). Dynamics of the NAO have been tracked backward for several centuries using a number of different proxies and it appears that historical fish population fluctuations have been forced by NAO dynamics such as the Bohuslän herring periods and alternating periods of herring and sardine populations in the NE Atlantic (Alheit and Hagen, 1998). However, there are a number of European fish populations where the dynamics do not seem to be associated with the NAO. Since the early part of the last century, fluctuations of anchovy and sardine populations seem to correspond to the dynamics of the Atlantic Multidecdal Oscillation (AMO). Also, large-scale biogeographical shifts of zooplankton (Beaugrand *et al*., 2002) and fish (Quero, 1998; Brander, 2003; Poulard and Blanchard, 2005) have been reported for European shelf seas which have been related to the increasing trend in Northern Hemisphere temperature.

The residuals from a segmented–regression stock-recruitment model reveal a strong background periodicity (see Section 2.1, Figure 2.1.2), i.e. the residuals show a cyclic behaviour of positive and negative deviations. As residuals are ideally supposed to be white noise, this is a strong suggestion of external periodic factors that are not accounted for by the stock-recruitment model; hence the analysis of environmental time series. Cyclic patterns of this nature may be triggered by exogenous factors at a range of scales on either a regional or a global scale.

To identify and characterize the underlying cyclic pattern, spectral analysis was applied to both the recruitment residuals and the "raw" recruitment time series. Using Fourier decomposition and a Kappa test as part of a stepwise regression procedure significant periods and cycles can be found in the herring stock to recruitment time series, one of them is 7.6 years. It is of interest to note that the winter-NAO (North Atlantic Oscillation; Hurrell, 1995) also consists of a 7.6 year period. However SGRECVAP 2006 pointed out that the NAO does not provide a mechanism for recruitment variability itself, and is a proxy for change in the system. This apparent concordance between the periodicities requires further analysis.

WORKING GROUP ON SEABIRD ECOLOGY (WGSE) – ICES CM 2007/LRC:05

7. Climate change and seabirds in the OSPAR Maritime Region – Pages 88–95 inclusive

OSPAR has requested ICES to assess the changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to hydrodynamics and sea temperature.

WGSE has worked on this request, considering primarily how much evidence of climate related changes exists for seabirds in the OSPAR Maritime Region.

7.1 Overview

Seabirds have long generation times, raise few young per year but live for many years (Ashmole 1971; Jouventin and Mougin, 1981). Because of this life history, populations are able to "integrate" over many consecutive years, so that years in which resources are scarce may take some time to become evident in population trajectories. Also, seabirds seem to be able to sustain episodic, disastrous years, such as occur during El Niño conditions, for example but be more susceptible to more long-term trends in unfavorable conditions (Schreiber, 2002; Veit and Montevecchi, 2006). When searching for responses by seabirds to "climate change", it is important to include changes that occur as long-term trends as well as those that seem to cycle. In the sections that follow, we show how seabirds are impacted by changes in the North Atlantic Oscillation index, which fluctuates periodically, and also how seabirds have responded to more long-term, monotonic change.

Most changes in seabird populations that have been linked to climate are likely mediated through seabird prey. Declines (or increases) are due to changing abundance of prey (Thompson and Ollason, 1981; Veit *et al.*, 1996; Montevecchi and Myers, 1997; Frederiksen *et al.*, 2006), which are in turn driven by environmental change, such as changes in sea temperature. Usually, it has been difficult to establish the link from physical climate forcing through phytoplankton, zooplankton, fish to birds. In the sections that follow we draw what conclusions we feel are reasonable and recognize that some pieces of the puzzle inevitably will be missing.

Annex 2 WGSE Terms of Reference 2008

The **Working Group on Seabird Ecology** [WGSE] (Chair-elect: Jim Reid, UK) will meet in Lisbon or Madeira, Portugal, 10–14 March 2008 to:

a) Review the effects of climatic variability (e.g. NAO) and climate changes on seabird distribution, abundance, productivity and life-history parameters in the North Atlantic;

b) Review the extent to which bycatch may affect seabirds in the North Atlantic;

c) Review ways in which fisheries management may minimize impacts on seabirds;

d) Finalise to consider ecological issues linked to the circulation of parasites and pathogens within seabird populations.

WGSE will report by 30 April 2008 to the attention of the Living Resources Committee. EU, OSPAR, HELCOM……..

(WGSE) – ICES CM 2008/LRC:05

"Executive summary – Page 1

Highlights:

- WGSE considered further the effects of climate change on seabirds and presents two new case studies using data provided by the Working Group on Oceanic Hydrography, data also provided to other WGs. The data were of some use in highlighting effects of sea surface temperature on black-legged kittiwake populations; the overall importance of choosing appropriate hydrographic data to explore associations between physical and biological components of the ecosystem is stressed.
- In response to a request by the European Commission, the problem of incidental catch of seabirds in longline fisheries in EU waters was reviewed by WGSE. Although there are few data to indicate the true extent of the bycatch problem, enough information exists to recognise that there is indeed a problem, and that the EU should develop and implement a Community Plan of Action aimed at investigating the issue further and at reducing this bycatch.
- An updated review of the ecological role and effects of viral and bacterial parasites in seabird populations is presented……."

"2. Climate change and seabirds in the OSPAR Maritime Region (Pages 5-20 inclusive)

OSPAR has requested ICES to assess the changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to hydrodynamics and sea temperature. WGSE has worked on this request, considering primarily how much evidence of climate-related changes exists for seabirds in the OSPAR Maritime Region. The following text relies heavily on chapter 7 in the 2007 WGSE report, with additional text and new analyses.

2.1 Overview

Seabirds are almost without exception colonial breeders, which means that it is reasonably easy to collect data on a wide variety of aspects of their biology. The population size and demography of many seabird species are monitored in detail at several colonies throughout the OSPAR maritime area, although these colonies constitute a small fraction of the total population. Lower intensity monitoring of population size occurs at a larger number of colonies. It is important to note that generally only the size of the actively breeding segment of the population can be monitored accurately, and that the size of the non-breeding segment is poorly known. This has important implications for the detection of effects of environmental change. At-sea surveys can also be used to monitor trends in abundance for entire populations, but need to be standardised, sustained and of sufficient spatial coverage."

WORKSHOP ON MACKEREL AND HORSE MACKEREL EGG STAGING AND IDENTIFICATION (WKMHMES) – ICES CM 2006/LRC:17

6.2 The occurrence of Snake pipefish on the German WGMEGS survey 2004

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Abstract

A major side outcome of the German 2004 MEGS was the occurrence of snake pipefish in a large number of plankton samples. In the surveyed area between 46°00′ and 58°30′ N west of the British Isles snake pipefish occurred almost exclusively and regularly in samples off the shelf over deep waters. The occurrence of snake pipefish in the samples presumably was the first notice of a mass occurrence of pelagic snake pipefish in the Northeast Atlantic (Kloppmann and Ulleweit 2006). In the following years pelagic snake pipefish appeared to become even more numerous in the Northeast Atlantic as well as in the North Sea with a northward extension of its occurrence up to Spitsbergen (Harris *et al.*, 2006). Because of the strong increase in abundance, snake pipefish were regularly observed to be utilised as food by fish and dolphins (van Damme and Couperus 2006) as well as by seabirds (Harris *et al*., 2006). Because of the poor digestibility of snake pipefish particularly for the chicks this change in seabird feeding habit subsequently caused serious failures in breeding success in populations of some species such as puffin and terns (Harris 2006; Harris *et al*., 2006).

Because increase of snake pipefish abundance is an ongoing process, probably linked to phenomenon associated to climate change, participants of the 2007 MEGS were encouraged to note any occurrences of snake pipefish in the plankton samples, and to measure and sex the specimens. Results should be sent to Cindy van Damme (IMARES) and Jens Ulleweit (BFA Fisch).

ICES/GLOBEC WORKSHOP ON LONG-TERM VARIABILITY IN SW EUROPE (WKLTVSWE) – ICES CM 2007/LRC:02

Executive summary

The WKLTVSWE-Workshop is a joint effort of ICES and GLOBEC and was endorsed by EUR-OCEANS (http://www.eur-oceans.org). In 1997 the SPACC (Small Pelagic Fishes and Climate Change) initiative of GLOBEC held a joint meeting with SCOR Working Group 98 on world-wide large-scale fluctuations of sardine and anchovy populations (Schwartzlose *et al*. 1999). It was decided then to continue this "global" undertaking with a series of regional workshops. Previous meetings focused on the Benguela Current in 2001 (e.g. Cury and Shannon 2004), the Humboldt Current in 2002 (e.g. Alheit and Niquen 2004) and the Japanese waters in 2003. During the annual meeting in 2005 of the former ICES Study Group on Regional Ecology of Small Pelagics (SGRESP), now a permanent ICES Working Group (WGLESP, ICES/GLOBEC Working Group on Life Cycle and Ecology of Small Pelagic Fish), it was recommended to continue this series of workshops with a meeting focusing on the waters surrounding the Iberian peninsula including the western Mediterranean

Sea. A synthesis of the hydrography, oceanography and biology of the South Western European waters is presented in section 3.

The goals of this workshop were:

1) to provide a survey of large-scale, long-term changes throughout the ecosystems surrounding the Iberian peninsula; are there signals of regime shifts in the region?

2) to identify apparent synchronies (teleconnection patterns) with other regions of the north Atlantic or northern hemisphere.;

3) to gain insight into the causes and mechanisms underlying the major ecosystem changes, e.g. identifying possible links of those changes in the ecosystems to climate variability

2 Introduction

2.1 Rationale

Understanding the role of natural variability, occurring over a variety of time scales, is essential if we are to effectively manage marine living resources. Evidence is accumulating that marine ecosystems undergo large-scale, decadal fluctuations which seem to be driven by climate forcing (Stenseth *et al*., 2002), as clearly demonstrated for the North Sea and the Baltic Sea (Beaugrand 2004, Alheit *et al*. 2005), the North Pacific (e.g. Hare and Mantua, 2000) and eastern boundary current systems (e.g. Chavez *et al*., 2003; Alheit and Niquen, 2004). Shifts in climate regimes can reorganize marine communities and trophodynamic relationships and induce changes in the mix of dominating species over decadal time scales.

Respective evidence was gained largely through retrospective studies, i.e., the analyses of historical atmospheric and marine data. In some instances, paleo-records have allowed us to look much further back in time and, most importantly, at periods when human intervention through fishing was not important. The impact of climate variability on marine ecosystems has been the focus of a number of national and international regional projects which have been carried out in local waters through a combination of retrospective investigations, modelling efforts and process studies.

All these GLOBEC workshops were/are concentrating on ecosystems in which small pelagic fishes such as anchovies and sardines are important, as well as horse mackerel which was also mentioned. Reasons are (Hunter and Alheit 1995): Small pelagic fishes such as sardine, anchovy, herring, sprat and others represent about 20 – 25 % of the total annual world fisheries catch. They are widespread and occur in all oceans. They support important fisheries all over the world and the economies of many countries depend on those fisheries. They do respond dramatically and quickly to changes in ocean climate. Most are highly mobile; have short, plankton-based food chains and some even feed directly on phytoplankton. They are short-lived (3-7 years), highly fecund and some can spawn all year-round. These biological characteristics make them highly sensitive to environmental forcing and extremely variable in their abundance (Hunter and Alheit 1995). Thousand-fold changes in abundance over a few decades are characteristic for small pelagics and well-known examples include the Japanese sardine, sardines in the California Current, anchovies in the Humboldt Current, sardines in the Benguela Current or herring in European waters. Their drastic stock fluctuations often caused dramatic consequences for fishing communities, entire regions and even whole countries.

Their dynamics have important economic consequences as well as ecological ones. They are the forage for larger fish, seabirds and marine mammals. The collapse of small pelagic fish populations is often accompanied by sharp declines in marine bird and mammal populations that depend on them for food. Major changes in abundance of small pelagic fishes may be accompanied by marked changes in ecosystem structure. They are often accompanied by rigorous changes in abundance and species composition of zooplankton. The great plasticity in the growth, survival and other life-history characteristics of small pelagic fishes is the key to their dynamics and makes them ideal targets for testing the impact of climate variability on marine ecosystems and fish populations and in general marine ecosystems.

2.2 Terms of Reference

The Terms of Reference for the Workshop on Long-term Variability in SW Europe (WKLTVSWE) were to:

a) rescue, collate and jointly analyze decadal-scale; long-term time series of physical, chemical and biological data from ecosystems surrounding the Iberian peninsula with a focus on long-term changes of small pelagic fish;

b) identify possible links to climate variability;

c) look for possible telecommunication patterns with European and other marine ecosystems.

WKLTVSWE will report by 31 March for the attention of the Living Resources Committee.

Mariculture Committee (MCC) and (F)

REPORT OF THE WORKING GROUP ON ENVIRONMENTAL INTERACTIONS OF MARICULTURE (WGEIM) – ICES CM 2000/F:02

6.1 Discuss and Assess Progress Made in the Performance, Environmental Compatibility, and Economic Viability of Modern Re-Circulation Technology, with an Emphasis on Saltwater Systems

The increasing pressure on resources in the coastal zone and other factors such as the possible impacts of global climate change, the abundance of supplies from wild fisheries, and other socioeconomic factors are leading to increased interest in closed system (re-circulation) technologies for the production of fish.

In support of this agenda item, a presentation was made to WGEIM by Richard Slaski, of the Scottish Finfish Association, on the current state of development of closed saltwater systems for fish production in Scotland. Interest was currently centred on several flatfish species and sea bass. Funding had been received for the creation of a developmental unit with the assistance of the Sea Fish Industries Authority laboratory at Ardtoe.

WGEIM then prepared a review of the current position regarding performance, environmental compatibility, and economic viability of modern saltwater re-circulation technology (Annex 9). The main subjects covered in the review were the relationship between aquaculture and wild fisheries, the principles of re-circulation systems, areas or recent and anticipated technical advances, economic viability. Consideration was given to the sustainability of re-circulation based aquaculture.

(WGEIM) – ICES CM 2002/F:04

9.3.1 Case studies ... page 37

In the Netherlands, the family of COSMO-models (COastal zone Simulation MOdel) has been developed and modified for a number of applications. The main aim of the set of models and subroutines is to foster the decision-making process by developing conflict scenarios and visualising the potential interactions and threats between various developments that have been developed. The modules allow an interactive operation with communities, local authorities and regional planners. Although initially a training tool, several modules with specific applications have been developed. One especially useful element is helpful in creating awareness of potential long-term effects of sea level rise on nearshore economic activities and is, therefore, useful in training decision-makers in multiple-effect considerations. Long-term planning involving site selection and changes in system dynamics may benefit from such tools, while also being linked to more general DSS systems as described in the section on "multi-objective optimisation".

Another expert system that contains elements useful for consideration in evaluating resource use interactions is the IterWad monitoring and environmental management DSS for assessing seabird population status in relation to coastal economic activities. Again, this system (developed in the Netherlands) does not contain a specific model

linking with mariculture needs. Since seabirds and mussel beds in the Wadden Sea are ecologically and economically linked, it would be advisable to promote this and similar systems to develop modules that particularly link to mariculture needs and interactions. The potential for developing this tool further should be evaluated as it is designed to collect data on the Wadden Sea in general.

Reference is also made to the RamCo development, a modelling tool for rapid assessment of the coastal zone that also was developed by several Dutch experts to prepare site-specific scenarios on general coastal habitat changes in the face of climate change (e.g., sea level rise). The RamCo methodology does not claim to be a decision support system (DSS), but can be utilized in support of such systems, in particular, when considering long-term investments and their fate in face of global climate change. …….

(WGEIM) – ICES CM 2003/F:04

6. That MARC/ACME recommend that the **Working Group on Environmental Interactions of Mariculture** [WGEIM] (Chair: E. Black, Canada) meet in late March 2004 in Galway, Ireland, to:

a) receive, and prepare comments on, a report of a Workshop to be organised jointly by the Xunta de Galicia and the Instituto Español de Oceanografia in 2003 on stock enhancement in the Galician rias;

b) continue to monitor and review the progress of the implementation of the Water Framework Directive, and activities arising from the European Commission policy on sustainable aquaculture, and to report on developments;

c) continue preparation of a review of the potential impacts of escaped non-salmonid candidates for aquaculture on localized native stocks in order to develop, at an early stage, risk assessment and management strategies;

d) continue formulation of a strategy to protect aquaculture against the harmful effects of external influences (e.g., contaminants, habitat alterations) arising from other resource users and their environmental impacts, with the aim of gaining better cooperation in developing modern tools to prevent or mitigate negative interactions;

e) continue preparation of a report on an evaluation of existing Decision Support System (DSS) tools, GIS and other expert systems in order to derive strategic advice on the content of a DSS for mariculture, and also to identify potential linkages to existing tools presently being developed, tested or already used in coastal management schemes;

f) hold a joint session with GESAMP WG 31, to discuss risk assessment methods in relation to mariculture.

Justifications:

Priority:	WGEIM is of fundamental importance to ICES.
Scientific Justification:	a) The rias of Galicia are the most important area for the production of farmed shellfish in western Europe. However, the very heavy reliance on mollusc (mussel, oyster, etc.) cultivation has resulted in large numbers of

	small businesses, which comprise the bulk of the industry, being vulnerable to external factors such as harmful algal blooms, climate change, market forces, etc., which are outside their control. There is therefore considerable interest in Galicia in both diversification and expansion of the industry. Similar pressures applying elsewhere in European aquaculture, for example the heavy reliance on salmon in Scotland and Norway, have similarly led to moves towards diversification. The purpose of the review is to assess the approach taken to resource allocation and prioritisation of species/techniques for development, which must balance environmental, technological, social, and economic factors. The workshop report will also contribute to the continuing WGEIM task to report on the potential impact of escaped (stocked) organisms on localized native stocks. b) The EC policy on Sustainable Aquaculture sets a new context for the aquaculture industry in the EU. It holds out the possibility, among other things, that Integrated Coastal Zone Management will become the normal approach to the management of the aquaculture development, and that new tools and processes will arise from the new policy. The Water Framework Directive will determine the direction of water quality regulation and improvement in the EU over the next 10–20 years. The coincidence of major new policy initiatives in both industrial development strategy and environmental quality presents European aquaculture with a unique set of opportunities and risks.

(WGEIM) – ICES CM 2004/F:02

The **Working Group on Environmental Interactions of Mariculture** [WGEIM] (Chair: E. Black, Canada) will meet in Galway, Ireland from 5–9 April 2004 to:

a) comment on the report of a Workshop to be organised jointly by the Xunta de Galicia and the Instituto Espanol de Oceanografia, Spain in 2003 on stock enhancement in the Galician rias;

b) update developments in the implementation of the Water Framework Directive, and activities arising from the European Commission policy on sustainable aquaculture;

c) prepare for possible publication a report on the "state of knowledge" of the potential impacts of escaped aquaculture marine (non-salmonid) fin-

fish species on local native wild stocks (e.g., sea bass, sea bream, cod, turbot, halibut);

d) discuss risk assessment methods in relation to mariculture in a joint session with GESAMP WG 31;

e) conduct an analysis of the literature and research on the current bath treatments and in-feed additives (treatments) used to treat salmon for sea-lice, and produce a synthesis (state of knowledge) on their fate in the near and far field environment and their effects on non-target organisms (e.g., crustaceans and invertebrates).

WGEIM will report by 15 April 2004 for the attention of the Mariculture Committee and ACME

Scientific Justification	a) The rias of Galicia are the most important area for the production of farmed shellfish in western Europe. However, the very heavy reliance on mollusc (mussel, oyster, etc) cultivation has resulted in the large numbers of small businesses which comprise the bulk of the industry being vulnerable to external factors such as harmful algal blooms, climate change, market forces, etc, which are outside their control. There is therefore considerable interest in Galicia in both diversification and expansion of the industry. Similar pressures applying elsewhere in European aquaculture, for example the heavy reliance on salmon in Scotland and Norway, have similarly led to moves towards diversification. The purpose of the review is to assess the approach taken to resource allocation and prioritisation of species/techniques for development, which must balance environmental, technological, social, and economic factors. The workshop report will also contribute to the continuing WGEIM task to report on the potential impact of escaped (stocked) organisms on localized native stocks.

6. RISK ASSESSMENT – Page 87

RISK ASSESSMENT OF SEA LICE THERAPEUTANTS

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Ecological risk assessment is a process for objectively defining the probability of an adverse effect to an organism or collection of organisms when challenged with an environmental modification such as climate change, xenobiotic exposure , infection with a disease organism or some other potential stressor (Roberts Jr et al., 2001). Sea

lice therapeutants have the potential to negatively impact the environment through effects on sensitive non-target organisms. There may be a significant body of information relevant to efficacy and safety that is known only to the regulatory authorities and the specific manufactures (Alderman et al., 2004). The absence of these data from the public domain has the unfortunate consequence that neither its quality nor its nature can be debated by those scientists and non-scientists with interests in these areas. Critical evidence quantifying the extent of such impacts when the agents are employed under the conditions of a commercial fish farm is limited. Anti-lice treatments have the potential to significantly alter the population structures of the fauna in the immediate environments

10.6 Knowledge gaps and recommended research

- Preliminary risk analyses, as outlined in Section 5a, should be done to identify knowledge gaps with respect to exotic species in bivalve culture.
- Directed research should be used to address these knowledge gaps prior to the introduction of bivalves into a system for aquaculture.
- Obtain baseline information on the receiving environment (physical and biological) to make predictions with respect to exotics and to evaluate and understand their influence. Concomitantly, the tolerance of culture species and potential hitchhikers to physical stresses might be elucidated.
- Predict the ability of exotics to establish and spread in the receiving environment.
- More information is needed with respect to the relative importance of natural (currents, dispersion rates, etc.) and anthropogenic (stock transfers, processing, hull fouling, etc.) spread of exotic species.
- Predict the impact of exotic species on receiving ecosystems, including
- interactions with local species, habitat modifications, energy flow, etc.
- More information is needed on the requirements and influence of hitchhiking species in the environment. This is particularly true for a number of currently problematic species (e.g., tunicates).
- More information is needed with respect to the natural history of most exotic species.
- Remedial measures need be developed to mitigate impacts and minimize spread.
- Research is needed to understand the cumulative impacts of exotic species and other stressors in the environment (e.g., eutrophication, climate change, fishing activities, contamination, etc.).
- Can one (or a group) of exotics be representative of others (i.e. surrogates) in terms of predicted response in an area?

(WGEIM) – ICES CM 2008/MCC:03

14. Summary of Recommendations and Actions from WGEIM 2008

	Recommendations	Action
1	**Recommendation:** WGEIM to expand the Term of Reference on Sustainability Indices by presenting a worked example on the development of general sustainability indicators for finfish farming activities in member countries with a view to reporting at WGEIM in 2009.	WGEIM/MARC
2	**Recommendation:** WGEIM recommends that the review of existing Integrated Multi-Trophic Aquaculture IMTAprograms and specific projects continues as a Term of Reference for WGEIM 2009. In addition it is proposed to expand this ToR in order to address the issue of energy and nutrient cycling associated with IMTA systems. and report in 2009..	WGEIM/MARC
3	**Recommendation:** WGEIM to continue with the ToR to investigate fouling hazards associated with the physical structures used in mariculture with a view to developing integrated pest management strategy using case studies from Canada and Spain.and report in 2009.	WGEIM/MARC
4	**Recommendation**: WGEIM further review the use of seed stock quality criteria in mariculture and their applications in term of ecological performance with the view to producing a full report in 2009.	WGEIM/MARC
5	**Recommendation:** The working group considered assessing the potential impact of climate change on aquaculture activities a useful scenario setting exercise that might be conducted in all member states involved in marine aquaculture.	MARC/ICES
6	**Recommendation:** WGEIM to provided an update on fin fish feed usage and constituents from member countries to included in the meeting report in 2009.	MARC/ICES
7	**Recommendation**: WGEIM to await an advice request from a member country to ICES on the subject of a review of the science underlying advice relating to sea lice and salmon farming.	MARC/ICES
8	**Recommendation:** WGEIM recommends that given the global importance of mariculture, it is important that ICES continue to include mariculture as a primary focus in Action and Science plans.	MARC/ICES
9	**Recommendation:** WGEIM recommend that Dr. Chris McKindsey be appointed Chair of WGEIM.	MARC/ICES
Recommendations Carried over from 2007		
10	**Recommendation:** WGEIM recommends to the Mariciulture Committee and ICES, that a meeting is facilitated and organised with the participation of key representatives from ICES groups dealing with AES, (i.e. WGEIM, WGMASC, WGITMO and SGBOSV). This meeting (group) would be tasked to prepare a joint document highlighting, among other things, an update on the extent of introductions related specifically to aquaculture activities, the mechanism and interactions of the exotics with their new environment and; on the basis of these, identify information gaps and recommend specific research goals to fill these gaps.. It is clear that ICES could play a key role in addressing the growing need for information and advice on the management of AES. Presently, AES is mainly being addressed on national basis	MARC/ICES

	with significant inconsistencies in data collection, monitoring and management approaches. ICES could address some of these challenges and offers an international forum to provide coherent advice for the North Atlantic Zone. Further to this, WGEIM recommends to ICES, that a business case is prepared to organize a symposium to initiate the discussion among member countries on working collaborately to address identified research gaps, collection and sharing of data and provide advice on the mitigation and management of AES and their impacts on the marine ecosystem.	
11	**Recommendation:** WGEIM recommends a review of the state of the art (for both fish and shellfish) of off-shore aquaculture systems be carried out. That a Risk Analysis on the potential environmental interactions be carried out. That all analysis be carried with a strong industry and regulatory input (in order to identify technological, economical and regulatory challenges).	ICES/MARC
12	**Recommendation:** WGEIM recommends that it broaden it range of expertise to invite both industry and non-governmental organisation representatives, to deal with subject matters specific to their areas of interest and expertise. This will provide balanced and comprehensive advice to client organisations as well as member states. For example, industry representative could inform the development of integrated pest management strategies while NGOs could help to compare indicators for aquaculture and conservation. .	ICES/MARC
ACTIONS		
1	**Action:** WGEIM agreed that the documents relating to risk analysis of non-salmonid species be completed and submitted to an appropriate journal (Aquaculture) intercessionally.	WGEIM
2	**Action**: Member of WGIEM attend WGMASC meeting in 2009 and vica-versa to ensure compatibiliy of ToRs and to ensure no redundancy of effort.	WGEIM

Annex 6: WGEIM Terms of Reference for 2009

The **Working Group on Environmental Interactions of Mariculture** [WGEIM] (Chair: Chris McKindsey*, Canada) will meet at the Marine Institute, Galway, Ireland from 14–18 April 2009.

a) further evaluate the examples of sustainability indices proposed for mariculture activities and critically evaluate those SI's recommended by WGEIM and other fora;

b) further investigate fouling hazards associated with the physical structures used in mariculture with a view to developing integrated pest management strategies;

c) review the outputs of a number of integrated aquaculture (multi-trophic culture systems) projects and address the issue of energy and nutrient cycling associated with IMTA systems and report in 2009;

d) review the use of seed stock quality criteria in mariculture and their applications in term of ecological performance;

e) assess the potential impact of climate change on aquaculture activities relevant to each ICES member state;

f) provide an update on fin fish feed usage and constituents from member countries to included in the meeting report in 2009.

WGEIM will report by XX May 2009 for the attention of the Mariculture Committee and ACOM.

Supporting Information

Priority	The activities of this group are fundamental to the work of the Mariculture Committee. The work is essential to the development and understanding of the effects of man-induced variability and change in relation to the health of the ecosystem. The work of this ICES WG is deemed high priority.
Scientific justification and relation to action plan	ToR a) The group agreed to progress the work on **sustainability indices** by conducting intercessional work on developing practical indices for finfish aquaculture. This will be achieved by examining data from existing monitoring programmes in member countries. **Lead: Ian Davies, Scotland.** ToR b) Structure associated with mariculture activities can provide considerable surface area for colonisation of species not typically found in the culture area. This is presumably due to the increased habitat complexity and appropriate substrate for epifuanal organisms. In addition to the potential to provide a pathway for the introduction of an exotic nuisance species to a system, additional problems encountered are those associated with the management of the uisance to reduce the impact on the culture acitivity. This ToR will highlight existing examples and will address the management implications and potential mitigation strategies by examinaning a range of case studies from Canada and Spain specifcially. **Lead: Chris McKindsey, Canada.** ToR c) Evaluation of the outputs of a number of **integrated aquaculture** (multi-trophic culture systems) projects has been covered by WGEIM for the last number of years and will continue to be evaluated by the group. In addition, the output of nutrients in IMTA or production systems in general, may lead to increased productivity or anoxic systems with consequences at both ends of the spectrum (water column and benthos). In bivalve culture, planktonic communities may be altered directly through grazing with respect to flushing and differential reproduction of plankton communities (e.g. compare copepod reproduction to heterotrophs). Various nutrient fluxes (from bivalves and structures as well as benthos) may impact water column nutrient dynamics and thus the whole pelagic ecosystem. This ToR will examine the fate of energy and nutrients form aquaculture systems and discuss the consequences for the environment and IMTA systems in general. **Lead: Stephen Cross and Shawn Robinson, Canada.** ToR d) For economical reasons, mariculture development is based on the continuous improvement of seed and fry, being wild or produced in hatcheries. How these improvements, particularly those which contribute to increase the physiological fitness and food efficiency may impact the use of the resources from the natural environment is a question of high relevance for decision making. The trade off between the economical and the ecological performance of mariculture, and consequently the regulations (e.g. licensing) to follow, is consistent with the objectives of sustainability and responsible natural resources management. The aim of this work will be to review the use of seed stock quality criteria in mariculture and their applications in term of ecological performance. **Lead: Thomas Landry, Canada.** **Tor e)** Predicting the impact of climate change on marine systems has become an important and topical exercise for numerous authorities in recent years. Numerous predictions relating to sea level rise and water temperature changes have sparked considerable speculation on

	the potential to influence the distribution of marine species. Aquaculture species, particularly those found on the boundaries of climatic regions, may be at risk of greatest impact due to climate change. The geographical distribution of some highly productive and important aquaculture processes and species could expand as a consequence of a rise in sea temperatures (e.g. range expansion of reproducing populations of *Crassostrea gigas* to more northerly parts of Europe). Other issues that might be covered are the influene changing climate might have on the prevalence of disease causing organims, the potential to culture new species, influence on harmful algal blooms, the impact of increased run-off might have on shellfish waters classification and the impacts of increased storminess might have on mariculture activities. **Lead: no lead assigned yet.** Tor f) WGEIM and other ICES group have previously reviewed the issue on fin fish feed usage and constituents from member countries. However, the sustainability of utilising fish based feed products for marine fish farm activities continue to be questioned and justification continues to be sought. Feed producing companies are apparently endeavouring to find alternative sources. The goal of this work package is to provide an update within each member country of the proportion and constituents of alternative feeds used in finfish aquaculture. **Lead: no lead assigned yet.**
Resource Requirements	None
Participants	The Group is normally attended by some 12–15 members and guests
Secretariat Facilities	None
Financial	No financial implications
Linkages to Advisory Committees	ACOM
Linkages to other committees or groups	WGEIM interacts with WGMASC, WGAGFM, MARC
Linkages to other organisations	The work of this group is undertaken in close collaboration with the DFO Gesamp group, BEQUALM, OIE, EU, EAS, PICES

Report of the Working Group on Pathology and Diseases of Marine Organisms (WGPDMO) – ICES CM 2002/F:02

4. Intensity of parasitic infection as an indicator of environmental health

As part of the NOAA Mussel Watch Program, oysters and mussels are sampled yearly from the East, West, and Gulf Coasts of the United States and the Great Lakes. Biological responses are evaluated in parallel to concentrations of metals, PAHs, and pesticides. Dr E. Powell (The State University of New Jersey) and his team have examined the influence of climate change and contaminant body burden on the prevalence and intensity of infection of oysters by various parasites. Their studies reveal that the intensity of parasitic infections was strongly influenced by large-scale climatic changes. In the Gulf of Mexico, the health of each oyster population sampled was evaluated by measuring size, condition index, reproductive stage, and the preva-

lence and intensity of infection by the parasite responsible for "Dermo" disease, Perkinsus marinus. Length, condition index, reproductive stage and P. marinus infection intensity were characterized by strong concordance in interannual variations between 1986 and 1990, when a strong El Niño/La Niña shift occurred, and a weak concordance in the period of 1990–1993, characterized by weak climatic shifts (Kim and Powell, 1998). The distribution of some contaminants, particularly metals, also appears to be markedly influenced by weather and less by watershed-dependent processes, such as land use and river flow. This may be correlated to food supply and feeding rates being influenced by climatic changes, thereby affecting the body burdens of contaminants (Kim et al., 2001).

Mussels are often exposed to high hydrocarbon concentrations in their natural habitat from petroleum seep and, thus, offer the opportunity to examine the relationship between parasitism, disease, and contaminant exposure. The parasitic fauna was highly variable between populations. Forty percent of the populations were severely reproductively compromised by a Bucephalus sp. digenean flatworm infection. Variation in two parasite infection levels: gill ciliates and Bucephalus sp., explained most of the variation in PAH body burden between mussel populations. PAHs are known to be sequestered preferentially in gametic tissue. Bucephalus sp. may reduce the PAH body burden by replacing gametic tissue (Powell et al., 1999).

The **Working Group on Pathology and Diseases of Marine Organisms** [WGPDMO] (New Chair: T. Lang, Germany) will meet 11–15 March 2003 in Aberdeen, Scotland to:

a) analyse national reports on new disease trends in wild and cultured fish, molluscs and crustaceans; **(all members)**

b) report on progress in the ongoing investigations of the effect of temperature on Bonamia infection dynamics and report on the confirmation of the agent of Crassostrea angulata gill disease and its infectivity to Crassostrea gigas and other oyster species; **(Tristan Renault, Susan Ford)**

Scientific Justification:	b) Experimental work is required to confirm field observations and the hypothesis of Bonamia suppression vs. destruction over long periods of low temperatures. This question is important for accurately assessing climate effects on Bonamiasis and European oyster culture. There are historic records of an iridoviral infection of Crassostrea gigas gills, associated with low/transient pathology. This suggests that the gill disease agent may have multi-host infection potential, which needs to be addressed for like-to-like C. gigas and Ostrea edulis transfers.

(WGPDMO) – ICES CM 2003/F:03

2F03 The Working Group on Pathology and Diseases of Marine Organisms [WGPDMO] (Chair: T. Lang, Germany) will meet in Aberdeen, UK from 11–15 March 2003 to:

c) analyse national reports on new disease trends in wild and cultured fish, molluscs and crustaceans;

d) report on progress in the ongoing investigations of the effect of temperature on *Bonamia* infection dynamics and report on the confirmation of the agent of *Crassostrea angulata* gill disease and its infectivity to *Crassostrea gigas* and other oyster species

PRIORITY:	WGPDMO IS OF FUNDAMENTAL IMPORTANCE TO THE ICES SCIENCE AND ADVISORY PROCESS.
Scientific Justification:	**a) New disease conditions and trends in diseases of wild and cultured marine organisms continue to appear and an assessment of these should be maintained.** **b) Experimental work is required to confirm field observations and the hypothesis of Bonamia suppression vs. destruction over long periods of low temperatures.** **This question is important for accurately assessing climate effects on Bonamiasis and European oyster culture. There are historic records of an iridoviral infection of Crassostrea gigas gills, associated with low/transient pathology. This suggests that the gill disease agent may have multi-host infection potential, which needs to be addressed for like-to-like C. gigas and Ostrea edulis transfers.**

(WGPDMO) – ICES CM 2005/F:02

Annex 11: Draft Terms of Reference 2005 (Cat. 2)

The **Working Group on Pathology and Diseases of Marine Organisms** [WGPDMO] (Chair: T. Lang, Germany) will meet at ICES HQs from 7–11 March 2006 to:

a) produce a report on new disease trends in wild and cultured fish, molluscs and crustaceans, based on national reports;

b) update information on the causes and effects of Heart and Skeletal Muscle Inflammation (HSMI) affecting farmed salmon in ICES Member Countries;

c) produce an update of current information from ICES Member Countries on the development of sea lice vaccines and management measures for sea lice control;

d) compile a report on effects of climate change on host-pathogen interactions;

e) assess spatial and temporal variations in the pathogenesis of diseases of fish and shellfish and their effects;

f) propose a set of diagnostic techniques for the identification and characterisation of microcell-type parasites in oyster species;

g) produce a review on the current status of studies carried out in ICES Member Countries on infectious diseases in shellfish hatcheries;

h) review the results of an intersessional risk assessment pilot study on population effects due to diseases in wild fish, using epidemiological methods and popula-tion dynamics modelling;

i) review the results of an intersessional pilot study assessing the feasibility of constructing a 'disease index', using disease data from North Sea dab (*Limanda limanda*);

j) review progress made with regard to international collaborative actions including disease and pathology aspects:

i) the REGNS Integrated Assessment of the North Sea Ecosystem, and

ii) the Baltic Sea Regional Project (BSRP);

k) k) produce ICES publications on pathology and diseases of marine organisms.

Supporting information

Scientific Justification:

4) d) A significant component of the work of the WGPDMO is to assess trends in disease occurrence, both in aquaculture and in wild populations. It is recognised that long-term climate change will have an effect on the spatial distribution and prevalence of disease in fish and shellfish and therefore the potential for such effects needs to be considered in assessments of disease trends. The WGPDMO considers it necessary to review the available information on this topic (**S.W. Feist, D. Bruno, S. Jones, A. Mansour, S. Ford)**.

(WGPDMO) – ICES CM 2006/MCC:01

8 The effects of climate change on diseases of marine fish and Shellfish – Pages 23-24 of the report and

Annex 2: WGPDMO Terms of Reference for 2006

The Working Group on Pathology and Diseases of Marine Organisms [WGPDMO] (Chair: T. Lang, Germany) will meet at ICES Headquarters, Denmark, from 7–11 March 2006 to:

a) produce a report on new disease trends in wild and cultured fish, molluscs and crustaceans, based on national reports;

b) update information on the causes and effects of Heart and Skeletal Muscle Inflammation (HSMI) affecting farmed salmon in ICES Member Countries;

c) produce an update of current information from ICES Member Countries on the development of sea lice vaccines and management measures for sea lice control;

d) compile a report on effects of climate change on host-pathogen interactions;

e) propose a set of diagnostic techniques for the identification and characterisation of microcell-type parasites in oyster species;

f) produce a review on the current status of studies carried out in ICES Member Countries on infectious diseases in shellfish hatcheries;

g) conduct a pilot study assessing the feasibility of constructing a 'disease index', using disease data from North Sea dab (*Limanda limanda*);

h) review progress made with regard to international collaborative actions including disease and pathology aspects:

- the REGNS Integrated Assessment of the North Sea Ecosystem. Review and update sub-regional data tables and where necessary include new data (parameters) and/or existing data (parameters) updated where relevant. The data tables will be subject to thematic assessment to be undertaken at a REGNS thematic assessment workshop, and
- the Baltic Sea Regional Project (BSRP);

i) produce ICES publications on pathology and diseases of marine organisms;

j) provide expert knowledge and advice on fish disease and related data to the ICES data Centre on a continuous basis;

k) discuss and report on potential contributions for the ecosystem overview of the advisory reports describing the quantity and quality of marine habitat and/or the health of the marine ecosystem, and to consider and report on potential indicators of significant change in these ecosystem attributes;

l) review available data for each biological effects method to clarify whether data can be compared across the range of recommended fish species and review selection of species, gender and size ranges (WKIMON).

(WGPDMO) – ICES CM 2007/MCC:04

5.2.6 Recommendations

The WGPDMO recommends that:

iii) ICES Member Countries continue to fund fish disease monitoring programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance to integrated assessments of the health of marine ecosystems and will provide useful baseline data, e.g., to serve as a reference prior to establishing the culture of non-salmonid marine species. In addition, fish disease monitoring data will be useful in evaluating the effects of climate change on fish health and provide better understanding of pathogen interactions between wild and farmed fish.

…..

Recommendations

General Recommendations

REPORT SECTION	RECOMMENDATION	ACTION
5.1	1. ICES Member Countries continue to fund fish disease	ICES Member

	monitoring programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance to integrated assessments of the health of marine ecosystems and will provide baseline data, e.g., to serve as a reference prior to establishing the culture of non-salmonid marine species. In addition, fish disease monitoring data will be useful in evaluating the effects of climate change on fish health and provide better understanding pathogen interactions between wild and farmed fish.	Countries
5.2	2. ICES Member Countries conduct studies on *Francisella* sp and visceral granulomatosis in farmed cod and review the potential disease interaction between farmed and wild cod.	ICES Member Countries

….

(WGPDMO) – ICES CM 2008/MCC:01

6.2.6 Recommendations

The WGPDMO recommends that:

i) ICES Member Countries continue to fund fish disease monitoring programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance to integrated assessments of the health of marine ecosystems and will provide useful baseline data, e.g. to serve as a reference prior to establishing the culture of non-salmonid marine species. In addition, fish disease monitoring data will be useful in evaluating the effects of climate change on fish health and provide better understanding of pathogen interactions between wild and farmed fish.

ii) the WGPDMO reviews the status and impact of red vent syndrome in wild Atlantic salmon at its 2009 meeting.

iii) the WGPDMO reviews the information on the aetiology of hyperpigmentation in common dab.

iv) in light of the red vent syndrome in UK salmon, the WGPDMO reviews the information on *A. simplex* in marine mammals, fish and other intermediate hosts (zooplankton and other invertebrates).

v) the WGPDMO reviews the information on diagnostic methods for *Francisella* and the impacts of francisellosis on populations of wild cod and other fish species

14.2 Publication on the effects of climate change on marine fish and shellfish diseases

The WGPDMO agreed that the manuscript entitled Effects of climate change on marine fish and shellfish diseases' (authors: S. W. Feist, D. Bruno, S. Ford, S. R. M. Jones, T. Lang, M. Longshaw, A. Mansour and G. D. Stentiford) presented at the 2006 WGPDMO meeting should be published as soon as possible (preferably in the ICES Journal of Marine Science) without including results of the analysis of further datasets as originally planned.

Annex 12: Recommendations

General Recommendations

Report Section	Recommendation	Action
5.1	1. ICES Member Countries continue to fund fish disease monitoring programmes to sustain fish health surveillance of wild stocks. Information obtained is of vital importance to integrated assessments of the health of marine ecosystems and will provide baseline data, e.g., to serve as a reference prior to establishing the culture of non-salmonid marine species. In addition, fish disease monitoring data will be useful in evaluating the effects of climate change on fish health and provide better understanding pathogen interactions between wild and farmed fish.	ICES Member Countries
5.2	2. ICES Member Countries conduct studies on *Francisella* sp and visceral granulomatosis in farmed cod and review the potential disease interaction between farmed and wild cod.	ICES Member Countries
5.3	3. ICES Member Countries conduct further studies on the picorna-like virus in the clam *Ruditapes decussatus*, on *Candidatus xenohaliotis californiensis* in European abalone, *Haliotis tuberculata*, and on gill epithelia nuclear virus in soft-clam *Mya arenaria*.	ICES Member Countries
5.3	4. Electron microscopy studies should be conducted on gonadal tissue lesions in *Crassostrea gigas* from Germany.	ICES Member Countries
6	5. Bacteriological, virological and electon microscopy studies should be conducted on dab (*Limanda limanda*) affected by hyperpigmentation, and literature on malpigmentation in farmed fish be reviewed.	WGPDMO members
7	6. A review of the evidence for increased tolerance by *Lepeophtheirus salmonis* to chemotherapeutants be conducted.	WGPDMO members
7	7. Updates on salmon louse vaccine development and sea lice management strategies made in ICES Member Countries be reviewed in national reports at the WGPDMO 2008 meeting.	WGPDMO members
8	8. Baltic Sea fish disease monitoring data be submitted to the ICES Environmental Databank in order to make them available for integrated assessments, such as those carried out by the ICES Working Group on Integrated Assessment of the Baltic Sea (WGIAB) and as part of the periodic HELCOM assessments.	ICES Member Countries
8	9. A workshop on methodologies for monitoring fish diseases/parasites in coastal fish species from the Baltic Sea be organised in 2007 (or in 2008, depending on funding requirements) under the co-sponsorship of ICES, HELCOM and the BSRP, at the BSRP Lead Laboratory for fish disease issues, AtlantNIRO, Kaliningrad, Russia.	ICES Member Countries
8	10. Laboratories conducting fish disease monitoring programmes participate in the BEQUALM programme in order to achieve implementation of quality assurance procedures needed for acceptance of data for international monitoring and assessment programmes.	ICES Member Countries
9	11. Laboratories involved in research on pathogens of molluscs initiate collaborative testing, intercalibration, and validation of current and newly developed techniques for the purpose of recommending molecular diagnostic techniques.	ICES Member Countries

10	12. The FDI be applied to disease data sets for other geographical areas and species, e.g., Baltic cod and flounder.	WGPDMO Members
10	13. Results of the FDI development and analysis on dab be published.	WGPDMO Members
12	14. ICES Member Countries submit their fish disease data generated according to established ICES/BEQUALM guidelines as soon as possible to the ICES Environmental Databank by using the ICES Environmental Data Reporting Format (current version 3.2).	ICES Member Countries
12	15. ICES provides a screening programme on its website to be used by labs to check their fish disease data sets converted into the ICES Environmental Data Reporting Format (current version 3.2) before submission to ICES.	ICES Secretariat
12	16. The fish disease data submitted to ICES be used by OSPAR for assessments made in preparation of the 2010 OSPAR 2010 Quality Status Report (QSR 2010).	OSPAR

Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM) – ICES CM 2003/F:01

Why preserve genetic diversity? – page 11 of report....

Genetic diversity is the product of thousands of years of evolution, yet irreplaceable losses can occur very quickly (cf. Nielsen and Kenchington, 2001; Kenchington, 2003). This diversity is important for the long-term ability of a species to adapt to climate change, and loss of populations (extirpation) most likely equates to a loss of adaptive variation. Yet management units are often discordant with population structure. For example, in the blue whiting, Micromesistius poutassou, the main oceanic distribution is considered to represent a single stock and is managed accordingly. Population genetic studies have, however, indicated that partially separated stocks exist in the Mediterranean and in the eastern Barents Sea (Giæver and Mork, 1995; Giæver and Stien, 1998). If there are some relatively local stocks, the overall catch depletions could conceal community extirpation of a valuable prey resource to higher predators. Similarly, Ruzzante et al. (2001) report on the decadal stability of the genetic differentiation of five cod, Gadus morhua, spawning banks off Newfoundland and Labrador, Canada. This genetic structure persisted through the recent population collapse, with only some suggestion of post-collapse mixing between two of the spawning banks. This information is critical to recovery management as it indicates that population regrowth will be the mechanism for rebuilding the stocks, as opposed to migration from other areas. Pragmatically, genetic diversity is also very important for aquaculture, providing the raw material for selective breeding programmes and revitalization of inbreed broodstock.

(WGAGFM) – ICES CM 2004/F:04

The **Working Group on the Application of Genetics in Fisheries and Mariculture** (Chair: Dr E. Kenchington, Canada) proposes to meet in Silkeborg, Denmark, 3–6 May 2005 to:

a) review information on the nature and rates of environmental change as well as key factors to determine the evolutionary ability of fish stocks to respond to climate change (lead P. McGinnity (Ireland));

b) review of methods for, and application of mixed-stock and assignment analysis for the elucidation of stock components, with an emphasis on marine fishes, and provide recommendations for applications in different species and types of fisheries (lead D. Bekkevold (Denmark));

c) review methods and evidence for elucidating local adaptation in marine fishes (lead G. Carvalho (UK));

d) evaluate the usefulness of probabilistic maturation reaction norms as ecological quality objectives (EcoQOs) as an early warning signal for the negative impact of fishing and other anthropogenic activities (lead P. McGinnity (Ireland) with support from U. Dieckmann (Austria) and B. Ernande (France);

e) investigate possible genetic erosion and changes in life history characteristics of local stocks due to mariculture activity (lead G. Dahle (Norway)).

Scientific Justification and Relation to Ac-tion Plan:	a) The Potential Impact of Climate Change on Fisheries. Significant progress has been made in modelling past environments and pre-dicting likely future marine climate states. Fish stocks will re-spond in yet unpredictable ways to such changes. Consideration of such responses will include potential impacts on distribution and abundance, as well as evolutionary capacity. Part of these considerations will include reference to contemporary anthropo-genic-induced direct and indirect genetic change as a result of se-lective fishing, introgresssion, habitat change, pollution, aquaculture activity. This exercise will yield information on the nature and rates of environmental change as well as key factors to determine the ability of fish stocks to respond to this change.

(WGAGFM) – ICES CM 2005/F:01

Document the evolutionary ability of fish stocks to respond to climate change by reviewing the information on the nature and rates of environmental change (ToR a)

2.1.1 Climate change

The rates and characteristics of climate change have been well documented in the most recent Intergovernmental Panel on Climate Change report (2001), which outlines the magnitude and rate of contemporary and future climate change. Mean global temperature has increased by 0.5ºC over the last 100 years and is expected to increase by a possible 3 ºC over the next century. However, the increase is unlikely to be even across the world and is expected to be greater in boreal and arctic regions. The North Atlantic Oscillation (NAO) is the dominant mode of recurrent atmospheric variabil-ity over the North Atlantic (Hurrell, 1995). A substantial fraction of the recent warming in this area is linked to the behaviour of the NAO. In particular there has been a trend in the NAO index from large amplitude anomalies of one phase in the

1960s to large amplitude anomalies of the opposite phase since the 1980s (Hurrell *et al*., 2003). The existence of a deterministic relationship between greenhouse gas forc-ing and the NAO is strongly supported, and continu-ing major changes in the NAO can be expected in the future as greenhouse gas levels increase.

Trends in sea surface temperatures in the Northeast Atlantic, Northwest Atlantic, North Sea and Baltic Sea show a warming trend. However, as is the case globally, there is also spatial variation in the impact within the North Atlantic region, with some areas showing warming trends (e.g., Barents Sea) and other areas becoming colder (e.g., Labrador Sea). A compre-hensive review of the NAO and its influence on oceanic conditions in the North Atlantic is provided by Drinkwater (2003), Hurrell et al. (2003), and Visbeck et al. (2003).

2.1.2 Climate change and species

Climate is a major determinant of species distribution. Application of global meta-analysis to a large number of mostly terrestrial species has shown substantial range shifts averaging 6.1 km per decade toward the poles and significant mean advancement of spring life-history events by 2.3 days per decade over the last 40 years (Parmesan and Yohe, 2003). Numerous studies link the NAO index and the climate dynamics associated with NAO to the biology of the North Atlantic fauna (Drinkwater *et al*., 2003). This suggests the observed changes are likely to also have a major impact on the majority of North Atlantic fisheries. Drinkwater *et al*.(2003) and colleagues include studies of changes in biomass, distribution and growth of several commercial species of fish, as well as in the abundance of benthos, the spread of marine diseases, cetaceans, and sea birds. Their review spans the North Atlantic, and includes deep ocean basins, the continental shelves and coastal embayments. A recent report by Beaugrand *et al*. (2002) is fairly indicative of the biological response of keystone species which can be expected in the North Atlantic. They showed that strong biogeographical shifts in all copepod assemblages have occurred with a northward extension of more than 10o latitude of warm water species associated with a decrease in the number of colder water spe-cies. They conclude that these biogeographical shifts are consistent with recent climate changes in the spatial distribution and phenology detected for many taxonomic groups in ter-restrial European ecosytems. They are also related to both the increasing trend in northern Hemisphere temperature and the North Atlantic Oscillation.

Overall, six major types of climate change effects on biological systems are identifiable (Par-mesan and Galbraith, 2004):

2.1.3 Genetic responses to climate change

2.1.3.1 Overview

The potential impacts of climate change on fisheries can be expected to involve the character, abundance, and distribution of species; changes with implications for the level and distribution of their exploitation. As such, these affects need to be taken into account in how fisheries are managed.

The potential impact of climate on fish character has implications for both intra-specific bio-diversity and for phenotypic trait expression. Biodiversity, which is fundamentally genetic diversity, will be reduced due to the loss of populations on the southern limits and general reductions in abundance elsewhere through increased genetic drift. Evolutionary processes will only slowly restore lost among-population diversity where a species is able to extend its range northward. With regard to phe-

notypic traits, the impacts are less predictable but, in general, a reduction in abundance and changes in traits would be expected. Detailed consideration of existing information may allow identification of the probable nature of some of these changes, particularly expected geographical shifts.

Overall, fisheries productivity is expected to be depressed, though some fisheries will decline while others will expand. This scenario offers management both challenges and opportunities. It represents a challenge where fisheries are in decline, and an opportunity to bring in more sound management regimes where new fisheries emerge.

Within management timeframes, the overall genetic capacity and environmental range of a species (i.e., thermal niche – a trait determined by its evolutionary history) can be expected to remain the same. No overall evolutionary genetic response can be expected and the only possible response by a species can be to shift its range. If anthropogenic factors have reduced abundance and increased fragmentation the capacity of species, it may be more difficult for species to readjust their distributions to their new distributional optima, i.e., the normal evolutionary and demographic response to climate change may be impaired or slowed down. Where isolated populations exist on the colder limits of species' distributions, these can be expected to be lost or integrated into the advancing centre of the distribution. The result will be a loss of the unique biodiversity they represent. This will only gradually be restored over evolutionary timescales as new fringe populations at the new northern limit are established.

2.1.3.2 Ecosystem and community levels

Species are fundamentally genetic entities, and genetic changes at these levels will relate to the loss or gain of species at the ecosystem or community level. The consequences of such changes will be the development of new community complexes with new and altered species interactions. Species responses to climatic change in a given biogeographical circumstance can be expected to be individual, depending on their biology with regard to factors as dispersal capacity and degree of thermal niche specialisation. Some species will benefit from climate change and others will be negatively affected, altering community structure. While ocean warming is likely to facilitate non-indigenous species invasions in the marine environment, there are few studies to evaluate the effects of climate change on this type of invasion. Studies by Stachowicz *et al*. (2002) on sessile marine invertebrates suggest that the greatest effects of climate change on biotic communities may arise from changing maximum and minimum tem-peratures rather than from changes in annual means. Consequently, global warming may fa-cilitate a shift of dominance by non-native species by giving introduced species an earlier start, and increasing the magnitude of their growth and recruitment relative to native species.

2.1.3.3 Species level

A species' range is defined and constrained by its genes and gene interactions at the genome level, and by the habitat to which it has access. The former determine the range of environ-mental conditions under which a species is able to develop and survive to reproduce success-fully. At the same time, a species range will only include suitable habitat to which it has had historical access.

At the species level, there are two possible genetic responses to climate change. The first is the evolution of the species as a whole to adapt *in situ* within its existing distributional range to the new climatic regime. The second is to shift the species distri-

bution to areas with conditions to which it is pre-adapted, i.e., its existing species niche. A review of the literature indicates the second option is more likely. Species establish in new regions more readily than they evolve a new range of climate tolerances (Davis and Shaw, 2001). The rate of climatic change occurring and predicted will be too great for evolutionary change to allow for a niche shift. Therefore the dominant genetic response at the species level will be for species to shift their ranges rather than adapt quickly enough where they are to the new circumstances. Sup-port for this view comes from short-term observations of contemporary situations (Root *et al*., 2003). However, long-term historical (paleoclimatic) studies can be even more insightful. Hewitt (2000) provides a good review of research in this area. Given global climate has fluctuated widely in the past 3 million years, with dramatic periods of global cooling and warm-ing, an inescapable consequence for most living organisms is great changes in their distributions. These changes are expressed differentially in boreal, temperate and tropical zones, and can be expected to have consequences for the genetic character of affected species. Evolutionary in nature, they will involve the distribution of variation within and among a species' con-stituent populations. Though species are not expected to change (extend or shift) their niches, genetic changes will occur at the population level within a species and may lead to overall species' niches becoming more limited. In some situations where there is no new suitable habitat for a species to shift into (e.g., a shelf-constrained species), the range of a species may contract in the absence of any niche change.

(WGAFM) – ICES CM 2006/MCC:04

2.2.1 Background and Issue

Understanding of biodiversity (i.e. genetic diversity) within currently recognised Linnean fish species, and how it is impacted by factors such as fisheries exploitation and global climate change, is critical for the development of effective management programmes for the conservation and restoration of fish stocks. Analysis of the distribution of genetic variation, in both space and time, can deliver valuable insights in support of fisheries management in relation to:

- the structuring of fish stocks into genetic populations, the fundamental biological units underpinning fisheries recruitment; this understanding of intraspecific biodiversity is important for the support of biodiversity conservation and restoration under national and international legislation such as the Rio Convention, and the EU Water Framework and Habitats Directives
- the proportional contribution of different genetic populations, or regional groups of populations to fish aggregations and fisheries catches, to help manage exploitation of individual populations within sustainable levels
- the impacts of exploitation on fisheries, to avoid detrimental changes and guide stock restoration initiatives
- the impacts of global climate change on fisheries, to understand how these affect fish abundance and distribution and, thereby, fisheries catches

The potential of genetic studies to contribute to understanding of population structuring and intraspecific biodiversity, and to mixed stock analysis, is well illustrated by work on salmonids fishes, particularly in the northeast Pacific Ocean (e.g. Beacham *et al.,* 1999; Shaklee *et al.,* 1999). Potential also exists to apply molecular genetic analyses to help understand the impacts of fisheries exploitation and global cli-

matic change but this application is more recent and currently less advanced. Methods for the direct analysis of DNA variation are now widely available and there is an increasing amount of genetic information available. As a result for many species, we are now starting to be able to resolve population structuring and assess population change. However, the growth in DNA data can be expected to be substantial as new and increasingly rapid and cost-effective methods of genetic screening are developed. This should lead to increasing insights in the coming years.

The contribution of genetic studies is dependent on the quality and amount of genetic information available. This depends on individual studies with respect to the type and number of the molecular markers screened and the statistical analyses carried out. However it is also dependent on 1) the availability of both contemporary and historical samples, and 2) the integration and utilisation of genetic data across studies. The extensive geographical range of most species, the complexity of species' genomes, and the limitations on resources for genetic screening mean that gaining a clear overview of the population genetic character of a species poses a major challenge and most studies only provide a limited geographical and genomic insight. However, this insight can be substantially increased where it is possible to link genetic studies, something which can increase the extent and quality of geographical and temporal analyses (e.g. Verspoor *et al.*, 2005), provided common sets of genetic loci are screened.

Linkage of contemporary work to historical information from the past studies or availability to DNA in archival materials is critical for assessing the genetic impacts of global climate change, habitat change (e.g. as caused by fish farming activities), and fisheries. If not, such assessments are impossible or can only be carried out once suitable temporal time series of data or materials have been accumulated, something which will be both costly and require decades to achieve. This can be avoided in many cases if contemporary data sets are linked to historical data, or by exploiting DNA in historical soft tissue, scale and otolith collections.

For this reason, archival material is an important resource and needs to be protected. Yet historical material in many cases is at serious risk of being lost. Its importance is not always appreciated by its custodians and a lack of awareness of its existence means it may not be considered in the design of scientific studies. The risk of loss is serious as collections of useful material are often maintained within organisations only through the care and attention of individuals and once they leave or retire are at risk of being lost or neglected.

2007/2/MCC04 The **Working Group on the Application of Genetics in Fisheries and Mariculture** [WGAGFM] (Chair: E. Eg Nielsen, Denmark) will meet in Pitlochry, UK from 1–4 April 2008 to:

a) review the potential for application of SNP's (single nucleotide polymorphisms) in fisheries genetics and aquaculture;

b) review current and future prospects of QTL based studies in fisheries and aquaculture;

c) update progress on the establishment of a meta-data base for genetic data

d) review progress for optimizing the storing of otoliths and scales;

e) evaluate prospects for genetic monitoring for evaluating the conservation status, intraspecific biodiversity and population health in fishes.

WGAGFM will report by 28 April 2008 for the attention of the Mariculture and Diadromous Fish Committees, ACOM and WGECO.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries and mariculture, especially with regard to the application of the Precautionary Approach. Consequently these activities are considered to have a very high priority.
Scientific Justification and relation to Action Plan:	Action Plan references: a)-2.5, -2.6 b) -2.5, - 1.10, c)-1.10 , d)-1.10,-3.7 e) 1.10 Term of Reference a) Single nucleotide polymorphisms (SNPs) seem to have become the marker of choice for most genetic studies, and the marker have had an increasing popularity in population genetic studies. These markers can be analysed in large numbers and access variability around the chromosomes. Most present population genetic studies normally include a number of SNPs. The Gene Conservation Laboratory in Alaska routinely performs SNP analyses during the fishing season for stock identification studies. The laboratory provides inseason estimates of the composition of the Cook Inlet sockeye salmon commercial harvest and of the Kenai River to aid in the management of the drift and set net fisheries. WGAGFM acknowledge the need to review the present state of these markers, including the possible applications and limitations, in addition to possibilities for fisheries management. (lead: J. G. Dahle, T. Johansen) Term of Reference b) An increasing number of studies aim to identify quantitative trait loci (QTLs) in species of interest for fisheries and/or aquaculture. Such studies imply the availability of medium to high density linkage maps, informative biological material and high through-put genotyping facilities. Until now, most of these studies relate to marker assisted selection (MAS) in species of major aquaculture interest. QTL mapping is also of more general interest to better understand the genetic architecture of quantitative traits. The identity and number of loci controlling quantitative trait variation are indeed central to the understanding of their evolutionary potential and patterns of population differentiation. However, the usage of QTL-based approaches in the assessment of genetic variability in adaptive traits and for prediction of trait values from known QTLs in natural populations of fish and shellfish remains largely untested. We will review the present status and prospects of QTL mapping in fisheries in aquaculture in the light of the current research in plant and animal genetics and breeding. (lead: E Gosling, P. Boudry) Term of Reference c) An initiative was put in place as part of the response to the 2006-2007 ToR e) to

	set up a metadata base on genetic information related to Atlantic salmon stocks. This ToR will provide an update on this initiative. (Lead E. Verspoor, J. Martinsohn). Term of Reference d) Understanding the impact of fishing pressure and climate change on a fish population relies on identifying biological changes incurred by that population over time. Such a task is potentially possible for fisheries molecular geneticists due to the availability of unique sources of time series data in the form of scales and otoliths collected over the decades and subsequently stored in cupboards. Technical advances mean DNA can now be extracted and analysed from these hard tissues, and in some instances the collections provide very comprehensive time series of molecular data. The WGAGFM accepts that such sources of data are invaluable and that the optimal conditions for storage of these samples be considered as a priority. At present samples are generally stored in uncontrolled environmental conditions. This ToR aims to identify optimal conditions for the storage of these tissues to ensure minimum DNA degradation until such time as the samples are used. (lead: M. O´Sullivan, E. Cross, E. Gosling). Term of Reference e) Advances in molecular biology over the last decade provide fisheries geneticists with cost-effective tools for resolving unprecedented levels of genetic diversity within the genomes of marine fish and shellfish species. Analysis of the amount and distribution of this diversity can be highly informative, not only as regards the structuring of a species into breeding populations but also, potentially, about the reproductive status of the populations themselves. Departures of the distribution association of alleles within and among loci from random reflect historical levels of mutation, natural selection, gene flow, patterns of mating, numbers of breeders and variance in the contribution of breeders to the next generation family survival to breeding (genetic drift). Theory indicates that these factors, and how they have acted historically, have characteristic effects on the pattern of distribution of allelic variation within and among individuals and loci, in a population. Using recently developed Bayesian statistical methods it is now possible, in principal, to assess the pattern of distribution to determine parameters such the effective numbers of breeders, effective population sizes, and levels of gene flow, in addition to classic indicators such as allelic diversity and heterozygosity. Estimation of these parameters using cost-effective molecular markers offers a potentially valuable approach to monitoring the reproductive and evolutionary "health" of a breeding population, and therefore has the potential to be a valuable management tool. The extent to which this is, and is likely to be, the case in practise is considered in this ToR. (lead: E. Verspoor, P. McGinnity)
Resource Requirements:	None required other than those provided by the host institute.
Participants:	The Group is normally attended by some 15–25 members and guests
Secretariat Facilities:	None required
Financial:	None required
Linkages To Advisory Committees:	ACOM.
Linkages To other Committees or Groups:	SIMWG , WGECO, WGMAFC, WGMASC
Linkages to other Organisations:	Linkage with the EC Joint Research Centre at Ispra, Italy.

(WGAGFM) – ICES CM 2007/MCC:03

Executive Summary

There is an urgent need for ICES member states to secure and provide proper storage conditions for historical tissue collections such as scales and otoliths, since they contain invaluable DNA evidence of natural historical demographic processes in fish and shellfish populations and allow for evaluating genetic effects climate change and harvesting.

The Working Group on the Application of Genetics in Fisheries and Mariculture (WGAGFM) met at the European Joint Research Centre (JRC), Ispra, Italy 19–23 March 2007. The meeting was well attended; within total 20 representatives present from 9 countries (10 national delegates and 10 experts appointed by the chairman). In addition we were very pleased to be hosted by the European Science Centre (JRC), which was also represented at the meeting.

Six terms of reference (ToR) were on the agenda for 2007. The first issue addressed was to update the general knowledge on the population genetics of eel. A number of scientific papers have been produced since our last evaluation, generally suggesting some degree of genetic structuring among eels collected at different European sites. Eel fisheries management should be cognisant of the putative genetic structure suggested. Accordingly, long distance transplantations of eel should be avoided. More emphasis should be put on elucidating the biology of the species, in particular in the marine phase, and genetic sampling should be conducted as close to the suspected spawning grounds as possible (adults or larvae).

The second issue was on the application of large scale genome wide DNA methods, so-called "genomics". The technological revolution in high throughput DNA and RNA based methods offer many new opportunities in fisheries and aquaculture. In relation to fisheries, the application of many markers will lead to higher power for detection of population structure and more precise genetic assignment of individuals to population and mixed stock analysis.

Also, by studying functional genes, direct evidence of adaptations to local environmental conditions can be obtained. In aquaculture, genomics will, enable easy construction of DNA pedigrees and "marker assisted selection", i.e. breeding on a trait of interest by using the information on the association between the trait and numerous genome wide markers facilitating a faster selection response. ICES should promote the implementation of genomics in fisheries and aquaculture by supporting international collaborative networks and open access web-based resources.

Annex 1: Proposed Draft Resolutions for 2008

2007/2/MCC04 The **Working Group on the Application of Genetics in Fisheries and Mariculture** [WGAGFM] (Chair: E. Eg Nielsen, Denmark) will meet in Pitlochry, UK from 1–4 April 2008 to:

a) review the potential for application of SNP's (single nucleotide polymorphisms) in fisheries genetics and aquaculture;

b) review current and future prospects of QTL based studies in fisheries and aquaculture;

c) update progress on the establishment of a meta-data base for genetic data

d) review progress for optimizing the storing of otoliths and scales;

e) evaluate prospects for genetic monitoring for evaluating the conservation status, intraspecific biodiversity and population health in fishes.

WGAGFM will report by 28 April 2008 for the attention of the Mariculture and Diadromous Fish Committees, ACOM and WGECO.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries and mariculture, especially with regard to the application of the Precautionary Approach. Consequently these activities are considered to have a very high priority.
Scientific Justification and relation to Action Plan:	Action Plan references: a)-2.5, -2.6 b) -2.5, - 1.10, c)-1.10 , d)-1.10,-3.7 e) 1.10 Term of Reference a) Single nucleotide polymorphisms (SNPs) seem to have become the marker of choice for most genetic studies, and the marker have had an increasing popularity in population genetic studies. These markers can be analysed in large numbers and access variability around the chromosomes. Most present population genetic studies normally include a number of SNPs. The Gene Conservation Laboratory in Alaska routinely performs SNP analyses during the fishing season for stock identification studies. The laboratory provides inseason estimates of the composition of the Cook Inlet sockeye salmon commercial harvest and of the Kenai River to aid in the management of the drift and set net fisheries. WGAGFM acknowledge the need to review the present state of these markers, including the possible applications and limitations, in addition to possibilities for fisheries management. (lead: J. G. Dahle, T. Johansen) Term of Reference b) An increasing number of studies aim to identify quantitative trait loci (QTLs) in species of interest for fisheries and/or aquaculture. Such studies imply the availability of medium to high density linkage maps, informative biological material and high through-put genotyping facilities. Until now, most of these studies relate to marker assisted selection (MAS) in species of major aquaculture interest. QTL mapping is also of more general interest to better understand the genetic architecture of quantitative traits. The identity and number of loci controlling quantitative trait variation are indeed central to the understanding of their evolutionary potential and patterns of population differentiation. However, the usage of QTL-based approaches in the assessment of genetic variability in adaptive traits and for prediction of trait values from known QTLs in natural populations of fish and shellfish remains largely untested. We will review the present status and prospects of QTL mapping in fisheries in aquaculture in the light of the current research in plant and animal genetics and breeding. (lead: E Gosling, P. Boudry) Term of Reference c) An initiative was put in place as part of the response to the 2006-2007 ToR e) to set up a metadata base on genetic information related to Atlantic salmon stocks. This ToR will provide an update on this initiative. (Lead E. Verspoor, J. Martinsohn). Term of Reference d) Understanding the impact of fishing pressure and climate change on a fish population relies on identifying biological changes incurred by that population over time. Such a task is potentially possible for fisheries molecular geneticists due to the availability of unique sources of time series data in the form of scales and otoliths collected over the decades and subsequently stored in cupboards. Technical advances mean DNA can now be extracted and analysed from these hard tissues, and in some instances the collections provide very comprehensive

	time series of molecular data. The WGAGFM accepts that such sources of data are invaluable and that the optimal conditions for storage of these samples be considered as a priority. At present samples are generally stored in uncontrolled environmental conditions. This ToR aims to identify optimal conditions for the storage of these tissues to ensure minimum DNA degradation until such time as the samples are used. (lead: M. O´Sullivan, E. Cross, E. Gosling). Term of Reference e) Advances in molecular biology over the last decade provide fisheries geneticists with cost-effective tools for resolving unprecedented levels of genetic diversity within the genomes of marine fish and shellfish species. Analysis of the amount and distribution of this diversity can be highly informative, not only as regards the structuring of a species into breeding populations but also, potentially, about the reproductive status of the populations themselves. Departures of the distribution association of alleles within and among loci from random reflect historical levels of mutation, natural selection, gene flow, patterns of mating, numbers of breeders and variance in the contribution of breeders to the next generation family survival to breeding (genetic drift). Theory indicates that these factors, and how they have acted historically, have characteristic effects on the pattern of distribution of allelic variation within and among individuals and loci, in a population. Using recently developed Bayesian statistical methods it is now possible, in principal, to assess the pattern of distribution to determine parameters such the effective numbers of breeders, effective population sizes, and levels of gene flow, in addition to classic indicators such as allelic diversity and heterozygosity. Estimation of these parameters using cost-effective molecular markers offers a potentially valuable approach to monitoring the reproductive and evolutionary "health" of a breeding population, and therefore has the potential to be a valuable management tool. The extent to which this is, and is likely to be, the case in practise is considered in this ToR. (lead: E. Verspoor, P. McGinnity)
Resource Requirements:	None required other than those provided by the host institute.
Participants:	The Group is normally attended by some 15–25 members and guests
Secretariat Facilities:	None required
Financial:	None required
Linkages To Advisory Committees:	ACOM.
Linkages To other Committees or Groups:	SIMWG , WGECO, WGMAFC, WGMASC
Linkages to other Organisations:	Linkage with the EC Joint Research Centre at Ispra, Italy.

(WGAGFM) – ICES CM 2008/MCC:04

Annex 2: Proposed Draft Resolutions for 2009

The **Working Group on the Application of Genetics in Fisheries and Mariculture** [WGAGFM] (Chair: E. Eg Nielsen, Denmark) will meet in Sopot, Poland from 1-3 April 2009 to:

a) Report on progress with the establishment of a meta-database for genetic data on fish and shellfish genetics covered under the ICES remit;

b) Review current status of the application of traceability methods in the fisheries sector based on genetics;

c) Update and insights from the EU project SalseaMerge on establishment of a large scale genetic database for assigning individuals to population of origin;

d) Assess the possibility for the development of an integrated global management model for Atlantic cod based on genetic information;

e) To evaluate prospects for application of genetics/genomics to study and reduce the impact of fish and shellfish diseases in natural and cultured populations.

WGAGFM will report by 30 April 2009 to the attention of the Mariculture Committee.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the ecosystem affects of fisheries and mariculture, especially with regard to the application of the Precautionary Approach. Consequently these activities are considered to have a very high priority.
Scientific Justification	**Term of Reference a)** The WGAGFM recommended in 2007 to establish a meta-database cataloguing existing data in the field of fish and shellfish genetics in order to counteract the increasing discrepancy between data generation and data storage, management and accessibility in the field of fish and shellfish genetics (see WGAGFM report 2007). It was argued that the existence of such a meta-database would significantly help to promote coherence across research programmes, enhance research progress, and facilitate the translation of results from fundamental research to support other stakeholders such as fisheries managers. After consultation of the ICES Data Centre (DC), and further discussion between the WGAGFM members, nine recommendations were forwarded aiming at streamlining and facilitating the development and implementation of the fish genetic meta-database. These recommendations will serve as a basis to monitor and scrutinize the progress of the database development. Results from our discussions with the ICES DC as well as our experience with the database prototype will be reported to the WGAGFM panel and serve as a basis for reviewing the database utility and to establish prospects. (Lead: J. Martinsohn, E. Verspoor) **Term of Reference b)** The latest FAO report on the state of fisheries and aquaculture 2007 estimates that globally, 60% of marine fish stocks are at their maximum sustainable limits or overexploited. This disquieting level is even more alarming due to the growing serious global problem of Illegal, Unreported and Unregulated (IUU) fishing, a major impediment to the achievement of sustainable world fisheries. Worth between $4bn and $9bn per year, IUU fishing leads to major revenue losses, and effective measures to fight IUU fishing are still lacking. To reduce the market for illegal catches is of utmost importance, and the development of an effective traceability system to verify the species and origins of fish and shellfish caught would greatly support such an approach, both for regulatory enforcement but also for consumer protection. In addition to species verification, a traceability system based on the identification of regional stocks is necessary to preclude fraudulent allocations. There is an urgent need to identify traceability markers that can be used throughout the food supply chain, from on-board samples, to processed product ("fish to fork"), and which exhibit minimal variance. Furthermore, it is essential that tools based on such

markers are validated to internationally recognized forensic standards. Only under such stringent conditions can traceability data be used for legal enforcement and as evidence in a court of law. We will review briefly the range of genetic markers available for traceability of species and population identity, and then consider critically the potential contribution of molecular genetic approaches to traceability systems, with particular emphasis on the development of technologies that facilitate forensic validation.
(Lead: G. Carvalho, J. Martinsohn)

Term of Reference c)

Over the past two decades, an increasing proportion of North Atlantic salmon are dying at sea during their oceanic feeding migration. The specific reasons for the decline in this important species are as yet unknown. However, climate change is likely to be an important factor. In some rivers in the southern part of the salmons range, wild salmon now face extinction. This is in spite of unprecedented management measures to halt this decline. Arguably the greatest challenge in salmon conservation is to gain insight into the spatial and ecological use of the marine environment by different regional and river stocks, which are known to show variation in marine growth, condition, and survival. Salmon populations may migrate to different marine zones, whose environmental conditions may vary. To date it has been impossible to sample and identify the origin of sufficient numbers of wild salmon at sea to enable this vital question to be addressed. SALSEA-Merge will provide the basis for advancing our understanding of oceanic-scale, ecological and ecosystem processes. Such knowledge is fundamental to the future sustainable management of this key marine species. Through a partnership of 9 European nations the programme will deliver innovation in the areas of: genetic stock identification techniques, new genetic marker development, fine scale estimates of growth on a weekly and monthly basis, the use of novel high seas pelagic trawling technology and individual stock linked estimates of food and feeding patterns. In addition, the use of the three-dimensional Regional Ocean Modelling System, merging hydrography, oceanographic, genetic and ecological data, will deliver novel stock specific migration and distribution models. This widely supported project provides the basis for a comprehensive investigation into the problems facing salmon at sea. It will also act as an important model for understanding the factors affecting survival of many other important marine species. This ToR will report on progress made in the first year of this important ocean ecology project, particularly with regard to the application of genetics.
(Lead P. McGinnity, E. Verspoor).

Term of Reference d)

A lot of information has been gathered on the genetic population structure of commercially important marine fish. However, to date this knowledge has been poorly utilized in management. Even in cases where genetic data has shown that previously defined management areas conflict with the biology of the species, little or no action has been taken to change management practices. This is in contrast to the intention of e.g. the EU Common Fisheries Policy, which has identified the population the natural unit of evolutionary change, and as such, provides the genetic resources required for adaptive response to natural and man-made changes in the environment. In this ToR we aim at incorporating genetic information, in joint framework with previous ecological insights, to attempt the development a global management model for Atlantic cod. We will particularly focus on the identification of geographical areas where management operates in conflict with knowledge on population structure and come up with suggestions for a new design of management areas. Also, we will identify areas with limited or lacking genetic information where more studies are warranted.
(Lead: E. Nielsen, E. Kenchington, T. Johansen).

	Term of Reference e) Pathogens and parasites negatively affect natural and cultured populations of fish and shellfish by induction of diseases. Wild populations can be reduced in numbers, which decreases fishery resources. Cultured populations are often more susceptible to diseases because of high rearing densities compared to wild populations and therefore undergo widespread mortality when infected. Economical implications of diseases are difficult to overestimate. Breeding of resistant stocks is often proposed to overcome such loss in aquaculture. Recently developed genomic methods can significantly increase our understanding of pathogen – host relationship, stress and immune response of the host. This knowledge will facilitate diagnostic, treatment and vaccination against diseases. Genomic approaches usually involve construction of cDNA libraries from various tissues of infected and non-infected organisms or by suppressive subtractive hybridisation (SSH) followed by sequencing of expressed sequence tags (ESTs). Microarray technology enables to identify up- and down- regulated fish and shellfish genes related to susceptibility or resistance to diseases. These candidate genes can be further characterised. A variety of molecular markers is available for identification of QTLs for disease resistance, which can ultimately be used in marker assisted selection (MAS) programmes. (Lead: R. Wenne, P. Boudry)
Resource Requirements:	None required other than those provided by the host institute.
Participants:	The Group is normally attended by some 15–25 members and guests
Secretariat Facilities:	None required
Financial:	None required
Linkages To Advisory Committees:	ACOM.
Linkages To other Committees or Groups:	SIMWG , WGECO, WGMAFC, WGMASC
Linkages to other Organisations:	Linkage with the EC Joint Research Centre at Ispra, Italy.

Working Group on Marine Shellfish Culture (WGMASC) – ICES CM 2003/F:05

8.2.2.4 Other potential effects – page 14

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- Any attempt to assess environmental effects on bivalve aquaculture must consider the complexity of natural and human actions in estuarine and coastal systems. Shellfish responses to multiple stressors (nutritive, contaminant, fishing activities, invasive species, habitat loss, climate change, coastal construction, etc.) are intimately connected. For example, infectious diseases associated with shellfish overstocking, combined with enhanced food limitation and exposure of cultured organisms to "exotic" pathogens introduced with seed or broodstock, can have a significant and frequently permanent impact on shellfish physiological and nutritional status.

(WGMASC) – ICES CM 2007/MCC:01

6.2 Investigate climate change effects on shellfish aquaculture distribution and production

The issue of climate change and the possible impact of temperature rise and hydrodynamic changes on shellfish aquaculture have received little research effort. However, climate changes will ultimately have a direct impact on which species are suitable for farming in a given region and will indirectly influence other factors that influence aquaculture, such as primary production, microalgal biodiversity, the presence of nuisance species, oxygen levels and the incidence of harmful algal blooms (University of Victoria, 2000). The increased carbon dioxide would cause an acidification of the oceans, which may reduce the shell growth of molluscs (Gazeau et al. 2007). Climate change may also cause sea level rise and alter salinity, weather extremes, storm surges, tidal regimes, waves and coastal erosion, all of which can impact shellfish aquaculture with a largely unknown net positive or negative result. It is believed that climate change will impact shellfish aquaculture, particularly in the intertidal zone, but knowledge is needed to more fully identify the threats and potential opportunities. Such knowledge will allow farmers to adapt to climate change. ICES (e.g. WGMASC) should consider the current scientific evidence for and effect of climate change in ICES countries and worldwide. For example, can summer mortalities in *C. gigas* be attributed to climate change in certain European countries or simply be a result of poor broodstock selection?

As a first step to predicting the potential effects (positive or negative) of the effects of climate change on shellfish aquaculture, any available evidence on climate change impacts on cultured species needs to be accumulated and assessed. This includes information related to a recent OSPAR request for ICES "to prepare an assessment of what is known of the changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature." The WGMASC recommends to the MCC that the WGMASC undertake a new ToR in 2008 to address this high priority topic.

Terms of Reference for 2007

The Working Group on Marine Shellfish Culture [WGMASC] (Chair: P. Cranford, Canada) will meet in Copenhagen, Denmark from 10–14 April 2007 to:

a) Identify emerging shellfish aquaculture issues and related science advisory needs for maintaining the sustainability of living marine resources and the protection of the marine environment. The task is to briefly highlight new and important issues that may require additional attention by the WGMASC and/or another Expert Group as opposed to providing a comprehensive analysis;

b) complete the development of a recommended framework for the integrated evaluation of the impacts of shellfish aquaculture activities in the coastal zone by identifying a suite of tools (e.g. modelling, technologies) and indicators (ecosystem and shellfish performance) specific for monitoring ecosystem status in relation to shellfish aquaculture and for evaluating ecosystem quality objectives and effects on the productive capacity of coastal systems. This will also provide guidelines for monitoring programmes and the selection of management reference points (operational objectives) and mitigations;

c) review knowledge and report on the significance to wild stocks of bivalve aquaculture transfers between sites/countries. This will include information on what species are transported where, what records are kept, and what guidelines are in place in ICES countries related to the transfer of cultured species. Also, review and assess: the potential for transfer of non-indigenous species and diseases; the potential genetic implications for wild stocks; the impact on recruitment to existing stocks by large scale transfers, and scientific tools for decision support on cultured shellfish transfer issues; and

d) review the state of knowledge on the evidence for and effect of climate change on shellfish aquaculture distribution and production in ICES and countries worldwide.

WGMASC will report by XX (to be decided jointly by WGEIM and WGMASC) April, 2008 to the attention of the Mariculture Committee.

Supporting Information

Priority:	WGMASC is of fundametal importance to ICES environmental science and advisory process and addresses specific issues of the ICES Strategic Plan.
Scientific justification and relation to action plan:	Action Plan No: 1. a) 1.1, 2.1, 3.1, 4.1 b) 2.2, 3.14, 3.3, 4.14, 4.11.3, 4.11.4 c) 2.5, 2.6, 2.10, 4.7 d) 1.3, 1.6 Term of Reference a) For the WGMASC to be responsive to the rapidly changing science advice needs of aquaculture and environmental managers, important emerging shellfish aquaculture issues need to be rapidly identified and screened for potential science advisory needs to maintain the sustainable use of living marine resources and the protection of the marine environment. The intention is for this activity to flag issues that may require future attention and communication between one or several ICES Expert Groups. The Chair of the WGMASC will cross-reference all work with the Chairs of the MCC and relevant Working Groups. Term of Reference b) Shellfish production accounts for half of the mariculture production in ICES. As such, issues related to shellfish production, in relation to the environment and technological development of the industry need to be addressed within ICES. A framework is needed for the integrated evaluation of the effects of shellfish aquaculture activities in the coastal zone consisting of a suite of tools (e.g. modelling, technologies) and indicators (ecosystem and shellfish performance) specific for monitoring ecosystem status in relation to shellfish aquaculture and for evaluating ecosystem quality objectives and effects on the productive capacity of coastal systems. Science-based decision support is needed for the development of an environmental monitoring framework, based on identification of predetermined impact limits (operational thresholds) intended to trigger shellfish culture management actions. The Chair of WGMASC will cross-reference all work with the Chairs of the MCC and the WGEIM. Term of Reference c) Different shellfish life stages are transported from hatcheries and field sites to new culture sites, and often cross international boundaries, with potential implications for the introduction of non-indigenous species and diseases and the potential for interactions with wild stocks (impact on recruitment, genetic composition, diversity and polymorphism, and physiological and morphological traits). There is a need to identify the significance of shellfish relocations on the geographic distribution of wild stock traits. The significance to wild stocks of such transfers requires information on

	what species are transported where, what records are kept, and what guidelines are in place in ICES countries related to the transfer of cultured species. Scientific tools for decision support on cultured shellfish transfer issues should be reviewed and assessed. The Chair of WGMASC will cross-reference all work with the Chairs of the MCC, WGEIM, WGPDMO and WGITMO. Term of Reference d) Climate variability affects the recruitment and production of important commercial species and affects site suitability for shellfish culture. Increased knowledge on the effects of climate change on shellfish culture is needed to predict and assess impacts on aquaculture distribution and production. The Chair of WGMASC will cross-reference all work with the chairs of the MCC and the WGEIM.
Resource Requirements	None
Participants:	Representatives of all Member Countries and specialists invited by the Chair. The Group is normally attended by some 8-12 members and guests.
Secretariat facilities:	Meeting facilities for 2008 WGMASC meeting and joint session with WGEIM.
Financial:	Hospitality for health breaks and lunches during 2008 meeting.
Linkages to advisory committees:	ACOM.
Linkages to other committees or groups:	There is a working relationship with the WGPDMO, WGEIM and all the groups of the Mariculture Committee.
Linkages to other organizations:	The work of this group is closely aligned with similar work in GESAMP, WAS, and EAS.
Secretariat marginal cost share:	ICES:NASCO – 80:20.

(WGMASC) – ICES CM 2008/MCC:02

Executive summary

….

ToR d) Preliminary work has been undertaken to review the state of knowledge on the evidence for and effect of climate change on shellfish aquaculture distribution and production in ICES and countries worldwide. Climate changes will ultimately have a direct impact on world ecosystems, determining which shellfish species are suitable for farming in a given region and will indirectly influence other factors that influence aquaculture (primary production, microalgal biodiversity, the presence of nuisance 2 | ICES WGMASC Report 2008

species, oxygen levels, the incidence of harmful algal blooms, sea level rise, salinity, ocean pH, weather extremes, storm surges, tidal regimes, waves, coastal erosion, etc.). As a first step to addressing the potential implications of climate change to aquaculture, a work plan has been established, observations and model scenarios of coastal and ocean climate change are being compiled and a preliminary literature conducted (Section 6; linkages to MCC, ACME, WGEIM)…

6. Review the state of knowledge on the evidence for and effect of climate change on shellfish aquaculture distribution and production in ICES and countries worldwide. (ToR d) - PAGES 54-58 inclusive..

6.1 Background

Climate change has been defined by the United Nations Convention on Climate Change as the "change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods". The Intergovernmental Panel on Climate Change (IPCC) defines climate change as "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" which includes changes resulting from both natural variability and human activity. Regardless of the source of climate change, interactions with shellfish aquaculture are unavoidable.

The IPCC analysed global climate observations and concluded that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level". Recent mean temperatures in the Northern Hemisphere are likely the highest in at least the past 1300 years. Precipitation and the frequency of large precipitation events have increased significantly in many ICES countries. These changes are linked with high confidence to increased runoff and the occurrence of earlier spring discharges and shifts in the geographic distribution and abundance of algae, plankton and fish

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Annex 3: WGMASC Terms of Reference for next meeting

2008/2/MCC02 The **Working Group on Marine Shellfish Culture** [WGMASC] (Chair: Pauline Kamermans*, the Netherlands) will meet in Bremerhaven, Germany from 7–9 April 2009 to:

a) identify emerging shellfish aquaculture issues and related science advisory needs for maintaining the sustainability of living marine resources and the protection of the marine environment;

b) complete the development of a recommended framework for the integrated evaluation of the impacts of shellfish aquaculture activities in the coastal zone by identifying a suite of tools (e.g. modelling, technologies) and indicators (ecosystem and shellfish performance) specific for monitoring ecosystem status in relation to shellfish aquaculture and for evaluating ecosystem quality objectives and effects on the productive capacity of coastal systems;

c) review knowledge and report on the significance to wild stocks of bivalve aquaculture transfers between sites/countries. This will include information on what species are transported where, what records are kept, and what guidelines are in place in ICES countries related to the transfer of cultured species.

d) review and assess: the potential for transfer of non-indigenous species and diseases; the potential genetic implications for wild stocks; the impact on recruitment to existing stocks by large scale transfers, and scientific tools for decision support on cultured shellfish transfer issues; and

e) review the state of knowledge on the evidence for and effect of climate change on shellfish aquaculture distribution and production in ICES and countries worldwide.

f) WGMASC will report by 30 April 2009 to the attention of SCICOM.

Supporting Information

Priority:	WGMASC is of fundamental importance to ICES environmental science and advisory process and addresses many specific issues of the ICES Strategic Plan. The current activities of this Group will lead ICES into issues related to the ecosystem affects of the continued rapid development of shellfish aquaculture, especially with regard to the application of Ecosystem Based Management, and the implications of changing environmental conditions on shellfish cultures Consequently, these activities are considered to have a high priority.

Scientific justification and relation to action plan:	Action Plan No: 1. **Term of Reference a)** For the WGMASC to be responsive to the rapidly changing science advice needs of aquaculture and environmental managers, important emerging shellfish aquaculture issues need to be rapidly identified and screened for potential science advisory needs to maintain the sustainable use of living marine resources and the protection of the marine environment. The intention is for this activity to flag issues that may require future attention and communication between one or several ICES Expert Groups. The Chair of the WGMASC will cross-reference all work with the Chairs of the MCC and relevant Working Groups. **Term of Reference b)** Shellfish production accounts for half of the mariculture production in ICES. As such, issues related to shellfish production, in relation to the environment and technological development of the industry need to be addressed within ICES. A framework is needed for the integrated evaluation of the effects of shellfish aquaculture activities in the coastal zone consisting of a suite of tools (e.g. modelling, technologies) and indicators (ecosystem and shellfish performance) specific for monitoring ecosystem status in relation to shellfish aquaculture and for evaluating ecosystem quality objectives and effects on the productive capacity of coastal systems. Science-based decision support is needed for the development of an environmental monitoring framework, based on identification of predetermined impact limits (operational thresholds) intended to trigger shellfish culture management actions. The Chair of WGMASC will cross-reference all work with the Chairs of the MCC and the WGEIM. **Term of Reference c)** Different shellfish life stages are transported from hatcheries and field sites to new culture sites, and often cross international boundaries, with potential implications for the introduction of non-indigenous species and diseases and the potential for interactions with wild stocks (impact on recruitment, genetic composition, diversity and polymorphism, and physiological and morphological traits). There is a need to identify the significance of shellfish relocations on the geographic distribution of wild stock traits. The significance to wild stocks of such transfers requires information on what species are transported where, what records are kept, and what guidelines are in place in ICES countries related to the transfer of cultured species. Scientific tools for decision support on cultured shellfish transfer issues should be reviewed and assessed. The Chair of WGMASC will cross-reference all work with the Chairs of the MCC, WGEIM, WGPDMO and WGITMO. **Term of Reference d)** Climate variability affects the recruitment and production of important commercial species and affects site suitability for shellfish culture. Increased knowledge on the effects of climate change on shellfish culture is needed to predict and assess impacts on aquaculture distribution and production. The Chair of WGMASC will cross-reference all work with the Chairs of the MCC and the WGEIM.
Resource requirements:	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible.
Participants:	The Group is normally attended by some 10 – 12 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.

Linkages to advisory committees:	ACOM.
Linkages to other committees or groups:	There is a working relationship with all the groups of the Mariculture Committee and specifically the WGPDMO, and WGEIM and the work is relevant to WGICZM.
Linkages to other organizations:	The work of this group is aligned with similar work in GESAMP, WAS, and EAS and numerous scientific and regulatory governmental departments in ICES countries.

Marine Habitat Committee (MHC) and (E)

Study Group on Ecosystem Assessment Monitoring (SGEAM) – Report: (ICES CM 2000/E:09)

Annex 5: Why regional coastal monitoring for assessment of ecosystem health? By Kenneth Sherman

Public Concerns and Responses

During recent years, the public and the scientific communities have signaled concern over growing degradation of ecosystem health, depleted fisheries, pollution, and habitat loss. Public concern has been registered in newspapers, electronic media, and congressional actions. Scientific concern has moved from the pages of journals to the actions of professional societies, as for example the Sustainable Biosphere Initiative of the Ecological Society of America (Lubchenco *et al*., 1991). Responsive actions at the national and international levels have resulted in Conventions and Protocols on Climate Change, Biodiversity, Ozone, and internationally recognized declarations for sustaining marine fisheries.

Ecosystem Health and the "Why" Paradigm for Monitoring and Assessment

Before the 1992 Earth Summit in Brazil, the Global Environment Facility (GEF) was established within the World Bank as a pilot programme to test new approaches and innovative ways to respond to global environmental challenges in four focal areas: climate change, biodiversity conservation, ozone depletion, and international waters. In March 1994, after 18 months of intergovernmental negotiations, agreement was reached in Geneva to transform the GEF from its pilot phase into a permanent financial mechanism. The restructured facility, which has so far committed more than $2.5 billion in grant funding, is open to universal participation (currently 165 countries) and builds upon the partnership between the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank.which are its implementing agencies. In addition to the four focal areas, activities to address land degradation are also eligible for funding insofar as they relate to one or more of the four focal areas.

Benthos Ecology Working Group (BEWG) – ICES CM 2000/E:08

16.2 Action List

5) Jan Helge Fosså to report on further results on deep-water *Lophelia* reefs in Norwegian waters.

6) Jan Helge Fosså to report on the development of an acoustical method for biomass estimation of kelp.

7) Gerard Duineveld to report on the effect of climate change on bivalve growth.

Joint report of the Working Group on Marine Mammal Habitats and the Working Group on Marine Mammal Population Dynamics and Trophic Interactions (ICES CM 2000/E:02/G:05)

5.2 Ladoga Seal (*Phoca hispida ladogensis*)

Incidental catches in commercial fisheries and direct killing by fishermen are assumed to be the main immediate threats to the Ladoga seal. The commercial fishery (mainly gillnets) and fishermen kill between 200 and 400 seals every year.

Intermediate potential threats include episodic mass mortalities, habitat degradation including pollution, depletion of prey populations, disturbance, and changes in the physical environment. Long-term threats also include climate changes and depletion in genetic diversity.

(BEWG) – ICES CM 2001/E:08

14.3 Recommendations for the 2002 Meeting

Propopsal for next year's ToR c)review studies in northern seas in comparison with, e.g., the Baltic Sea and North Sea, with a view to gaining insights into ecosystem functioning, human impacts, and gaps in knowledge;

Justification ToR c) a perspective on the benthic ecology of northern seas deserves more attention, e.g., in order to strengthen the advisory role of ICES. The review will also be relevant to OSPAR, ICES and EEA in relation to the extension of habitat mapping towards northern waters. The comparative nature of the review should allow wider appreciation of the influence of climate change in benthic communities;

7.2 Long-term Benthic Studies

Ingrid Kröncke reported on long-term variability in macrofauna species composition off the island of Norderney (East Frisia). Macrofaunal samples were collected quarterly from 1978 to 1999. Abundance, biomass and species numbers of single species or taxonomic groups showed different long-term variability. Different patterns were found over time according to different zoogeographical distribution or feeding mode. Temperature seemed to be a major factor structuring the community. Cold winters in 1978/1979 and 1995/1996 had severe negative effects on the community. A clear shift in community structure has become obvious since 1988, which occurred in direct connection with an increasing North Atlantic Oscillation Index (NAOI). The mediator between the NAOI and the benthos seems to be the sea-surface temperature. But also increasing storm frequency since the late 1980s changed the hydrodynamics of the area and led to higher resuspension of sediments and organic matter. This changed the food availability for macrofauna species as well as sediment stability. The results are similar to others observed in long-term studies in the North Sea and indicate a system shift at the end of the 1980s.

Ingrid Kröncke also reported on decadal changes in macrofauna communities on the Dogger Bank caused by large-scale climate variability. In the frame of a long-term comparison between 1985–1987 and 1996–1998, Wieking and Kröncke (2001) found marked changes in macrobenthic communities of the Dogger Bank (central North Sea) as a result of the rise in the NAO. Due to an increase in bottom temperatures, southern species such as the amphipod *Megaluropus agilis* and the ophiurid *Amphiura brachiata* increased in abundance on top of the Dogger Bank and on the southern

slope, and occurred even in the deeper parts in 1996–1998. In contrast, abundance of northern species (e.g., *Corophium crassicorne*, *Siphonocoetes kroyeranus* [Amphipoda], *Nuculoma tenuis* [Bivalvia]) decreased on top, and to the south of the Dogger Bank. The additional increase in abundance of interface-feeding species such as the polychaete *Spiophanes bombyx* coincided with a higher primary production in the central North Sea.

(BEWG) – ICES CM 2002/E:07

9.4 Trajectories of Marine Ecosystem Response to Arctic Climate Change

M. Carroll gave a presentation on trajectories of marine ecosystem response to Arctic climate change.

The idea of this American-Norwegian-Russian project is to explore older archives of benthic fauna in the Barents and Bering Seas, and relate the variation in the benthos to large-scale variation in climatological conditions.

A comprehensive abstract can be found in Annex 11.

G. Duineveld asked whether short-term fluctuations in climate would cause variations in the benthic communities. M. Carroll replied that every individual taxon would respond in a different way but that there would be correlations. H. Rumohr noted that were still problems with availability of Russian data, because institutes are still in the process of transferring data into the computer. S. Dahle remarked that there was ongoing effort with regard to exploring the huge Russian data archives. These Russian data are of great interest, but cause many problems because of the methods used.

ANNEX 11: TRAJECTORIES OF MARINE ECOSYSTEM RESPONSE TO ARCTIC CLIMATE CHANGE: A BARENTS–BERING SEA COMPARISON

10 DEVELOPMENT OF THEME SESSION FOR ASC 2003 OR 2004—THE ROLE OF BENTHIC COMMUNITIES AS INDICATORS OF MARINE ENVIRONMENTAL QUALITY [ToR d]

BEWG prepared a proposal for a theme session to be included in the programme for the 2003 ASC, focusing on the role of benthic communities as indicators of marine environmental quality and ecosystem change.

A Theme Session on this subject will allow the synthesis of state-of-the-art knowledge, which will contribute to the further development of operational ecological quality objectives for marine benthic communities. This is relevant for application in the context of the EU Habitats Directive, the EU Water Framework Directive, and the OSPAR and HELCOM Conventions. There will be a great demand for operational indices, performance indicators, metrics for ecological quality of the benthic system, since the 5th North Sea Conference (Bergen, March 2002).

Contributions are welcome using different organism groups of the benthos, e.g., bacteria, algae, higher plants, invertebrates, and levels of integration (species vs. communities). Also welcome are critical reviews of applicability and limitations of used indices, indicators, etc., as well as innovative developments in this field. Finally, papers are welcome illustrating the use of benthos to document ecosystem changes due to anthropogenic or natural causes, e.g., climate variability.

13.5 Benthic invertebrates as included in a draft OSPAR priority list of threatened and endangered species

Arctica islandica (Ocean quahog)

BEWG agrees that this species is impacted by bottom trawling fisheries. The decline reported by Witbaard and Klein (1994) is acknowledged, but there is no indication that the entire population of this long-lived bivalve species is threatened. For instance, there is no decline in the Baltic Sea. The species is common along the Norwegian coast. The threat due to bottom trawling is to a large extent of a regional nature.

There is, however, a possible point of concern, because for many years recruitment did not occur in the North Sea. This may be a signal. There is, however, no clue as to the cause. One might think of climate change. BEWG concluded that recruitment biology of this species should be studied in order to find possible explanations.

(BEWG) – ICES CM 2006/MHC:09

Benthos of soft sediments

4.3.1 Comprehensive Everglades Restoration Plan (CERP)

B. Tunberg reported on three projects in Florida. Benthic Infaunal Monitoring of the St. Lucie Estuary (SLE) and the Southern Indian River Lagoon (IRL)

The main objectives of the project are: 1) to evaluate the present health status of the St Lucie Estuary (SLE) and the Indian River Lagoon (IRL) south as baseline data, 2) to record and follow long term changes in these ecosystems, 3) to attribute causative factors to observed changes (i.e., freshwater runoff/release, natural successions and oscillations, climate change, other anthropogenic impacts), 4) to pinpoint and evaluate anthropogenic disturbances, 5) to provide reference data for possible intensive short term local monitoring programs.

(BEWG) – ICES CM2007/MHC:10

Annex 5: Benthos and climate change in the Bay of Biscay

By Angel Borja (AZTI-Tecnalia)

The distribution of many benthic species, including macroalgae, molluscs and arthropods, was studied by Alcock (2003) along the Bay of Biscay, between the end of 19th century and 2000- 2001. He determined some shifts northwards and southwards, depending on the warm and cool periods, during the 20th century, and several examples were shown for species such as *Fucus spiralis*, *Pelvetia canaliculata*, etc.

Taking into account this evolution and the IPCC scenarios of temperature increase for next 50 years, Alcock (2003) modelled the future shift of some benthic species in the Bay of Biscay, North Sea, and Norwegian Sea. In this presentation, the predicted shifts for *Balanus perforatus*, *Chthamalus montagui*, *Patella rustica* and *Pollicipes Pollicipes* were presented.

These scenarios can be useful, for future monitoring programmes, in order to check the northwards migration of benthic species, due to climate change.

Some studies, undertaken in the Basque coast, were presented. Hence, the relationships between NAO and benthic diversity and precipitation and richness, in the Nervion estuary, were presented. Long term series of *Gelidium sesquipedale* biomass have

shown a close relationship with irradiance (Borja *et al*., 2004). Finally, strong relationships between wave energy and biomass, abundance and cover of *Pollicipes Pollicipes*, have been found in the area (Borja *et al*., 2006).

Taken into account the predicted increasing NAO values, for the next 50 years, some scenarios have been built for the Basque coast. This fact will lead to an increase of northwesternly wind circulation over the area, and, consequently, to an increase of wave energy and clouds. Hence, there are possibilities of an increase of *Pollicipes* biomass, a decrease of *Gelidium* biomass, and a reduction of richness and diversity of benthic populations.

See Annex 7: Changes in benthos related to climatic factors

Marine Chemistry Working Group (MCWG) – ICES CM2001/E:02

7.1 Charles Gobeil

Recent changes in organic carbon flux to Arctic Ocean deep basins: Evidence from acid volatile sulfide, manganese and rhenium discord in sediments.

Dr Gobeil from the Canadian Department of Fisheries and Oceans gave a talk on the influence of climate change on the organic carbon flux at the sea floor in the Arctic Ocean. Dr Gobeil reported that evidence of recent large-scale change in redox conditions in Arctic Ocean basin sediments is found in profiles of solid phase acid volatile sulfide (AVS), manganese, and rhenium. He showed that AVS occurs at 2.5.5.5 cm in sediment cores collected from all of the Arctic basins, implying that there is presently a sufficient supply of organic matter to deplete oxygen to the point of forming sulfide. However, rhenium, which precipitates under suboxic or anoxic conditions, is not found enriched in these same sediments. The absence of rhenium enrichment suggests that the AVS has been produced recently under enhanced organic carbon fluxes. Estimated diffusion rates suggest that such enhanced organic fluxes must have occurred within the past 50 years. The most likely origin for such widespread change is the ice climate. The reduction in ice observed over the past several decades in the Arctic Ocean has been accompanied by enhanced organic carbon fluxes to the sea floor.

(MCWG) – ICES CM 2004/E:03

ANY OTHER BUSINESS

11.5 Another item was raised by Klaus Nagel. Now that we are able to analyse most contaminants satisfactorily, we are being asked to develop background concentrations and other data quality criteria as a means of assessing progress towards environmental targets. How can we best use monitoring data in the future? And do we have, or can we develop, suitable tools? The input to REGNS is likely to form a significant part of the work of MCWG in the near future – how can MCWG provide a structured scientific input? Currently, there are a number of large-scale programmes running in the marine environment (IGBP, SOLAS) intended to further develop the ecosystem approach and feed discussions on biodiversity, climate change, etc. How can MCWG best contribute to this approach? This discussion will help to focus future MCWG work in a number of related areas.

Working Group on Biological Effects of Contaminants (WGBEC) – WGBEC (ICES CM 2002/E:02)

12.2 The use of indicators for biological effects

Indicators in Europe

The selected indicators are intended to cover the main issues affecting water quality in Europe, namely, eutrophication and organic pollution, hazardous substances, groundwater quality and quantity, water stress, climate change, drinking water quality, microbiological contamination, impacts of fishing, ecological quality, aquatic biodiversity and integrated coastal zone management. The core set comprises 86 indicators in total, of which ~ 25–30 relate to transitional, coastal, and marine waters. Not all 86 are available at present because for some there are no comparable/appropriate data sets available.

(WGBEC) – ICES CM 2006/MHC:04

WGBEC terms of reference l; discuss and report back to ACME on potential contributions for the ecosystem overview of the advisory reports ie WGRED reports of 2005 and 2006.

WGBEC was invited by ACME "to discuss and report on potential contributions to the ecosystem overview of the advisory reports describing the quantity and quality of marine habitat and/or the health of the marine ecosystem, and to consider and report on potential indicators of significant change in these ecosystem attributes."

The partner commissions have asked ICES to find a clearer way of providing its advice on how to pursue an ecosystem-based approach to the management of human activities that impact marine waters - and ICES wants feedback from the ICES working groups.

The basis for the WGBEC discussions were the WGRED reports for regional ecosystem description 2005 and 2006 (draft) and the REGNS document (agenda item 4), which include 'ecosystem overviews' or short descriptions of the regional ecosystems. In these, the focus was on information required for the stock assessment and fisheries management advice. Very typically, the conclusive chapter of WGRED 2006 is titled "Advancing the use of environmental information in ICES fisheries (and other) advice", and following examples are addressed:

- Long-term climate changes and Global warming
- Regime shifts and its implications to fisheries management
- Recovery strategies and ecological niche theory

(WGBEC) – ICES CM 2007/MHC:03

On page 67:

19 Identify and report on changes in the distribution, population abundance and condition of marine species in the OSPAR maritime area that are driven by contaminants or by interactions between the effects of contaminants and changes in hydrodynamics and sea temperature (ToR p)

This provides a clear link between pollution and climate change, with increasing temperature, decreasing pH or salinity (as predicted for the Baltic Sea) or UV radiation possibly acting as additional or synergistic stressors. In addition, an altered

composition in primary production as shown in the Baltic, might influence food availability with more serious pollutant effects. Climate related changes in fish communities might also result in a modified transfer of contaminants within the food web.

Generally, on-going and predicted future changes in SST are very much related to the physiological acclimation capacity of native biota. Differences among species concerning their thermal tolerance limits and in their capacities to adjust to these limits (Somero 2005) may determine how populations will be affected by climate change (Pörtner and Knust 2007). The ability to cope with additional stress due to pollution under a changing climate regime may thus also differ among species.

Another major area of change with respect to contaminant exposure, distribution and effects will relate to shifts in land use and agricultural distribution/practices. This, to respond to climate change, will bring about changes in chemical treatments and hence in pesticide distributions.

In the report to the European Water Directors on "Marine and Coastal Dimensions of Climate Change in Europe" (2006), it is stated that "eutrophication is, and will remain, an issue for the coastal zone because both agriculture and in particular urbanisation are the main drivers.

Pollution (e.g. from toxic chemicals) is considered of relatively lesser importance although the report considers the legacy of past contaminations an important issue. As noted there, "toxic chemicals are stored in waste dumps, behind dams, in soils and are present in deposited sediments in catchments. These natural and man-made repositories are, in principle, subject to erosion and further transport in the direction of the coastal zone. Changes in the hydrological regime (e.g. through climate change) can mobilize these stored contaminants."

WGBEC does not, however, believe that contaminants are only a "legacy of the past". There is sufficient evidence that "new" contaminants have been produced and are released and we have only just started to understand the biological effects they cause.

Conclusions

Presently, WGBEC is not in the position to provide the data needed to perform an in-depth assessment concerning the role of contaminants as additional drivers for observed changes in species distributions for the entire OSPAR area in retrospect (e.g. covering the past 50 years or even the last 10-15 years with an appropriate spatial coverage).

However, sufficient data should be available to test the effect of temperature increase during the past 20 years relative to fish diseases (WGPDMO), imposex in whelks and EROD activity in dab (North Sea) and perch (Baltic Sea).

WGBEC believes that changes in climate variables are also likely to alter the transport, transfer, deposition and fate of contaminants. Bioavailability, metabolism and toxicity will also be affected.

More research is required to evaluate the interactions between climate change and contaminants to better understand and predict how on-going and future climate changes may interact with anthropogenic impacts (e.g. chemical pollution).

Experimental studies and modelling efforts are needed to test various scenarios concerning transport, transfer and cycling of chemical pollutants and to assess the coun-

teracting effects on important species including the impact on their well-being/fitness, and the potential effects on populations/ecosystems.

WGBEC is well positioned to provide up-dates on research reported in the literature on this topic, e.g. as an outcome of the SETAC (Europe) 17th Annual Meeting in May 2007 in Porto.

(WGBEC) – ICES CM 2008/MHC:07

10 Confounding factors of salinity, temperature, season and genetic differences and how they affect biological effect responses (TORj)

Toxic chemicals in most cases do not act alone in affecting a given aquatic animal or population. Fish face other additional stresses from climate change, introduction of invasive species/pathogens and alterations of habitat and hydrologic regime. Fish populations exposed to multiple environmental stressors may respond in ways not expected from examination of the direct effect of toxic chemicals alone. Compliance with environmental regulations that target specific chemicals or specific industrial or municipal activities is not necessarily sufficient to protect fish populations, some of which continue to decline. These papers review current research on the interactions among toxic chemicals, environment and fish in the context of estimating risks to fishery resources. To illustrate how interactions change the equation of risk to fish, we provide several case studies drawn from across Canada. Knowledge gaps are also identified.

Key recommendations from this review are:

- Move from a chemical-oriented risk assessment approach to a fish-oriented cumulative risk assessment approach based on biological effects monitoring, integrated assessment of exposure to multiple environmental stressors including toxic chemicals and experimentation.
- Assess the effect of environmental factors on exposure and vulnerability of fish
- populations, fish habitats or ecosystems to toxic chemicals, and the effect of toxic chemicals on the exposure and vulnerability of fish to other environmental stressors.
- Conduct field and laboratory studies to identify conditions of *maximal exposure* and *maximal vulnerability* to toxic chemicals (e.g., critical life-stages, times of the year and locations). This knowledge is needed to design efficient risk management of toxic chemicals adapted to the unique characteristics of sites and species.
- Investigate the effect of climate change on the risk of toxic effects in fish.
- climate prognoses, conduct projections of change in risks from toxic chemicals with the intent to develop strategies to reduce this risk.

6 REVIEW OF APPROACHES TO ENVIRONMENTAL IMPACT ASSESSMENT AND RELATED ENVIRONMENTAL RESEARCH

The UK provided updated information on 1) the Southern North Sea Transport Study, which is due to finish in July/August 2002, 2) the MarLIN project which seeks to identify sources of marine biological data and to assess, grade and use that data to identify distributions of biotopes and species, 3) a study on the potential for cumulative environmental effects arising from marine aggregate extraction which is due for completion in April 2002, 4) the assessment of the rehabilitation of the seabed following marine aggregate dredging, and 5) progress with the procedural guidelines for the conduct of benthic studies at aggregate dredging sites. A number of new studies were reported, including one to develop and test hypotheses on the impact of climate change on rocky intertidal animals and plants, a scoping study to assess the applicability of a development plan for the seabed, a study assessing the utility of seabed habitat mapping for the monitoring and management of several human activities that disturb the seabed (including aggregate dredging), and a study examining the direct and indirect biological impacts of aggregate extraction in the Southern North Sea.

4.2 REBENT Study

A study named REBENT (for "Réseau Benthos") was begun in 2001 over coastal waters of Brittany as a pilot-area. It concerns a new survey network of the macrobenthos in relation to oil pollution and long-term climate change.

7.3 Marine Biodiversity and Climate Change (MarClim)

The MarClim project is coordinated by the Marine Biological Association in Plymouth and includes an extensive list of Government, Research, Conservation, Non-Governmental and Public Bodies in England, Scotland, Wales and the Republic of Ireland. The project started in April 2001 and it will run for four years.

The project is using novel synthesis of existing long-term data on temperature-sensitive, readily observed intertidal climate indicator species to make predictions on changes in coastal diversity that may result from global warming. The species investigated include *Bifucaria bifucaria*, *Chthamalus montagui*, *Gibbula umbilicalis*, *Semibalanus balanoides*, *Fucus serratus*, *Osilinus lineatus* and *Patella vulgata.*

Aims:

- To use a combination of archival and contemporary data to develop and test hypotheses on the impact of climate change on rocky intertidal animals and plants.
- Forecast future community changes based on climate models.
- Establish a low-cost fit-for-purpose network to enable regular updates of climatic impact projections.
- Assess and report likely consequences of predicted changes on coastal ecosystems.
- To provide general contextual time-series data to support marine management and monitoring.
- Evaluate use of intertidal indicator species as sustainability indices.

- Disseminate the results as widely as possible.
- Provide a basis for the development of a pan- European monitoring network.

Table 12.2.1. Summary Table of Environmental Impact Studies and Related Research.

Project	Country	Description	Start	Contact	Reported
REBENT Study	France	Relation between macrobenthos and oil pollution and long-term climate change	2001	B.Guillaumont	Y
Marine Biodiversity and Climate Change (MarClim)	United Kingdom	Synthesising existing long-term data on temperature-sensitive, readily observed intertidal indicator species			

(WGEXT) – ICES CM 2003/E:07

REBENT Study

A study named REBENT (for "Réseau Benthos") was conceived in 2001 over coastal waters of Brittany as a pilot-area. It concerns a new survey network of the macrobenthos in relation to oil pollution and long-term climate change. The main partners undertaking the research project are IFREMER and the European University Institute of the Sea (Brest). The Project is being funded by the Territorial Assemblies of Brittany, DIREN and other scientific organisations. The first step will be targeted towards intertidal areas and inshore waters (maximum depth 30 metres) in relation to the EC Water Directive. This work will use maps to synthesise information about morphosedimentology, the main habitats, algal cover, etc., providing a zonal approach of the seabed in relation to the main abiotic factors.

Two others aims will be developed:

1) spatial evolution of some local and characterised habitats and populations;

2) long-term survey of reference stations selected according to their representative features, interest and sensitivity.

This new benthic survey will be described in the frame of the 2002 WG Marine Habitat Mapping report, but it is also

relevant for WG EXT because such a study will have to be developed for the Eastern Channel using similar methodology.

This will improve scientific capacity for assessment of the effects of dredging on benthos and the seabed.

ICES Study Group on Information Needs for Coastal Zone Management (SGINC) – ICES CM 2003/E:10

2.7 The Netherlands

Sustainable Coastal Zone Management of Marine Resources (SUCOZOMA, http://www.sucozoma.tmbl.gu.se/). It was started in 1997 and will finish its second phase in 2003. Among the programme deliverables are, for example, guidelines for integrated coastal management, principles and methods for management of coastal fisheries, and an analysis of how the EU Water Framework Directive can be integrated with the national coastal water quality management system.

The coastal zone is the relatively small and dynamic zone between land and sea. It is defined as a strip of land and sea of varying width depending on the nature of the environment and management needs. It seldom corresponds to existing administrative or planning units. The natural coastal systems and the areas in which human activities involve the use of coastal resources may therefore extend well beyond the limit of territorial waters and many kilometres inland. The coastal zone system is an integrated complex of marine coastal and land sub-systems. The coast-subsystem includes the foreshore, the beach area and natural coastal protection systems such as dunes.

Natural ecological processes on the one hand, and socio-economic and political processes on the other hand, act on different temporal and spatial scales. Human activities as for instance dredging, sand-nourishment and recreation have their implications on a short-term scale of days to several years or even decades, while for instance habitat alteration and climate change have effects on larger time scales of decades to centuries. Local authorities are responsible for coastal defence and recreation, while fishing management is carried out within a European framework, and global warming for instance should be addressed on a global scale. An important question now arises concerning what temporal and spatial scales information is needed on ecological processes to play a role in integrated coastal zone management.

2.8 UK

In England and Wales the key issues are: (fourth bullet)

- Coastal defence: Climate change, sea level and isostatic sinking are more of an issue around the south and east of England. Therefore the threat from flooding and erosion are important factors.

(SGINC) – ICES CM 2004/E:08

2.8 The Netherlands

Natural ecological processes on the one hand, and socio-economic and political processes on the other hand, act on different temporal and spatial scales. Human activities such as dredging, sand-nourishment, and recreation have their implications on a short-term scale of days to several years or even decades, while for instance habitat alteration and climate change have effects on larger time scales of decades to centuries. Local authorities are responsible for coastal defence and recreation, while fishing management is carried out within a European framework, and global warming should be addressed on a global scale. An important question now arises on what temporal and spatial scales information is needed on ecological processes, entities to play a role in integrated coastal zone management.

Section 5:

The SGINC identified key environmental issues related to the coastal zone and these are:

- Dynamics of abiotic parameters (eutrophication, chemical contamination, oxygen depletion);
- Habitat destruction/restoration;
- Natural coastal dynamics;
- Biodiversity/endangered species;

- Change in trophic structure;
- Introduced species;
- Climate change.

Table 5.1. Relation between the key issues and nature and human activities.

NATURAL INFLUENCES	KEY ISSUES
Climate change	Habitat change
Changed freshwater runoff	
Changed water temperature	

Working Group on Marine Sediments in Relation to Pollution (WGMS) – ICES CM 2004/E:02

Presentations

SPM contents in Skagerrak increases as result of climate change? (K. Naes)

7 USE OF SPM IN MONITORING PROGRAMMES (TOR E) (extract from p. 13)

Generally, SPM represents the mobile particulate matter with the currently available contamination level. In discussion, the potential of the use of SPM for the following occasions and purposes was pointed out:

1) Studies on suspended particulate matter and on its environmental impacts:

- studies of mass balances and flux calculations;
- estimation of transport of particulate matter;
- evaluation of impact on growth of organisms due to a decrease of transparency;
- reflection of climate changes.

2) Studies on contamination of suspended particulate matter:

- studies of short-term changes in contamination;
- investigations near contaminant sources and, e.g., on the effectiveness of remediation measures;
- use of SPM instead of sediments for monitoring when depositional sites are not available;
- use of SPM instead of sediments for monitoring when sediments are bioturbated, and mixing of freshly deposited and old sediments occur.

(WGMS) – ICES CM 2006/MHC:01)

Discuss and report on potential contributions for the ecosystem overview of the advisory reports describing the quantity and quality of marine habitat and/or the health of the marine ecosystem, and to consider and report on potential indicators of significant change in these ecosystem attributes

Review of WGRED reports

The reports of the 2005 and 2006 meetings of the Working Group for Regional Ecosystem Description (WGRED) (ICES, 2005b; 2006) outline Ecosystem overviews for the nine ICES Advisory Regions (Eco regions) recommended to DG Environment by ACE in 2004; East Greenland & Iceland, Barents Sea, Norwegian Sea, Faeroe Plateau, Celtic Seas, North Sea, Baltic Sea, Iberian Seas, Deep sea Atlantic. Overviews follow a common structure addressing; Bathymetry, substrate and currents, Physical oceanography, Primary production, Zooplankton and secondary production, Benthos and large invertebrates, Fish and fish communities, Seabird and marine mammals, Effects of ecosystem on fisheries and Effect of fisheries on ecosystem.

The ToR of WGRED 2006 was to ask for feedback from other Working Groups regarding the report template for ecosystem descriptions in advisory reports, to adapt the template as appropriate and to identify any major environmental or anthropogenic events in each of the regions that should be taken into special account in ICES assessments and advice in 2007. WGRED is also required to review available information sources regarding ecosystem characteristics and major events, important environmental drivers for ecosystem productivity and important human impacts on the ecosystems.

Slow uptake of ecosystem information by assessment working groups has been noted in the reports of WGRED. WGRED feels that ICES needs to increase the attention it gives to environmental information in its fisheries assessments. WGRED refers to climate change and global warming and their impact as being the main long-term environmental considerations relating to stock depletion and low abundance of species.

WGMS response to WGRED

WGMS has noted the request from WGRED for potential contributions to the ecosystem overviews in relation to expanding the ICES advice to the broader integrated management objective. WGMS noted that the immediate concern of WGRED was in relation to environmental processes and events that could have significant immediate impacts on stocks and therefore on fisheries advice for the next year.

In general terms, sedimentary processes, and processes that are known to be reflected in sediments (e.g. benthic production, eutrophication, impact on availability of organic contaminants, trends in seabed – reflection of water column processes) also have the potential to affect fisheries. Benthos abundance is determined by differences in bottom topography and food supply (largely pelagic primary production). Composition is highly dependent on predominating type of water, bottom substrate and depth. Also, certain species are affected by the benthic community, which in turn relates to sediment types, grain size and organic content. Sediment dynamics may also have an effect on ecosystem and fisheries.

However, the main areas of activity of WGMS are in relation to pollution, to contaminant concentrations and their potential biological effects. Members of WGMS are also involved in OSPAR MON, which undertakes regular assessments of the temporal trends of contaminant concentrations in marine sediments. Their reports provide information on general trends in contaminants in the majority of the nine ICES Advisory Regions listed in the ecosystem

overview. However, WGMS particularly noted that the time scales on which these trends occurred were generally rather longer than those required by fisheries assess-

ments (i.e. there is a temporal mismatch). Therefore, the information on contaminants in sediment considered by WGMS should perhaps be viewed as providing a medium term overview of status and trends in the environment, rather than a monitoring system that is responsive to short term changes and events.

WGMS suggested that contaminant (including nutrient) input data, which are collated and available from OSPAR, may be of interest in future assessments by WGRED.

WGMS also refers WGRED to WGSAEM who are currently working on developing methods for making regional assessments of changes in contaminant concentrations in sediment and biota.

(WGMS) – ICES CM 2007/MHC:05

4.1 AMAP 2002 Heavy Metals and Persistent Organic Pollutants Assessments

4.2 Conclusions

Reference is made to contaminant concentrations in marine sediment being dependent on grain size, organic matter content, regional and local geology and proximity to local (including natural) inputs, but these factors do not appear to be used in the assessments. The small amounts of data presented are not corrected for grain size or organic carbon content.

The 1998 assessment identified gaps in the knowledge obtained; however, these gaps are still apparent in the 2002 assessment.

Although AMAP consider sediments as inappropriate for examining spatial distributions, climate change in the Arctic region could result in changes in the amount and distribution of sea ice and land run-off. In turn, these may well lead to changes in the distribution and intensity of processes that sequester atmospheric contaminants in Arctic regions, and consequently alter the patterns of deposition of solid matter on the Arctic sea bed. Such changes involving both sediment supply and exchange processes with particles will make sediments monitoring important in the future.

WGMS suggest that sediments be considered in more detail in future assessments and that their interpretation could possibly be improved if AMAP adopts OSPAR MON Guidelines and assessment practices, and relevant OSPAR Technical Annexes. A representative of AMAP could attend MON 2007 to observe their assessment methods.

It was agreed the Chair to communicate the above with AMAP (Simon Wilson).

(WGMS) – ICES CM 2008/MHC:03

9 Receive and comment on reports containing new information concerning the importance of sediment dynamics for sediment monitoring

This work was initiated by ICES WGMS with the intention of advising OSPAR, HELCOM, the EU and others of physical aspects of sediment dynamics and estuarine structure as factors to that need to be considered when designing sediment monitoring programmes in the marine environment.

A sub-group, consisting of Maria J. Belsunce, Per Jonsson, Claire Mason and Stefan Schmolke, added some new information to the document finalised in 2005. Besides

minor text changes and editing of the 2005 document, the following two new sections were added:

- Dynamic processes affecting sediment concentration distributions in the Bay of Biscay;
- Possible changes in sediment dynamics in the Baltic Sea due to climate change.

WGMS agreed that the revised document includes the available information on sediment dynamics of importance for interpreting sediment monitoring in the ICES area and that the document at present concludes the WGMS work with sediment dynamics. The group proposed that subject area could be reviewed again after approximately 5 years, or earlier if any new results of importance arise.

Steering Group on Quality Assurance of Biological Measurements in the Northeast Atlantic (SGQAE – ICES CM 2003/E:01

Annex 7: Potential ICES/SGQAE Contributions to the Framework for the implementation of Themes B, E, H, O and R of the revised JAMP

BA-2 The general assessment of the development in the quality status of the maritime area should include:

a. an assessment of the status of the species and habitats in the OSPAR maritime area against agreed EcoQOs;

[b. an assessment of the possible effects on coastal habitats of climate change.] Delivery date: 2009!

Working Group on the Statistical Aspects of Environmental Monitoring (WGSAEM) –ICES CM 2004/E:01

10.2.1 Description of programme

The main purpose of integrated fish monitoring is to contribute to assessments of ecosystem health by analysing observations from sub-cellular to population and community levels. Ideally, integrated effects of all stressors should be detectable and low-level basin-wide perturbations should be distinguishable from natural variation. Although it is not the purpose of regular monitoring to provide a full understanding of all observations, integrated monitoring should allow a primary analysis of observed changes to verify whether or not changes are relevant and related to environmental stressors. The objectives of the integrated monitoring of coastal fish were set to:

- document long-term development in biological variables on different levels of organisation, i.e., from sub-cellular to population and community levels;
- document long-term development in contaminant concentrations;
- provide data for comprehensive/integrated interpretations;
- provide data on natural variations for variables under study;
- provide assessments of the cause and significance of observed changes;

- provide time-series for contaminants of relevance for human and wildlife risk assessments;
- provide reference data for local monitoring.
- The following criteria were set up for the selection of sampling sites and the delimitation of coastal monitoring areas:
- there should be no local environmental impact in reference/control sites (avoid hot spots);
- the probability of future impact must be low;
- the area must be large enough to ensure that the probability of irregular impact from the surroundings is low;
    - abundant populations of stationary fish must occur, allowing long-term sampling of indicator species for monitoring (long-term availability);
    - habitats suitable for all life stages of indicator species must be available within the selected area for population studies.
    - The monitoring variables included in the programme were selected to indicate:
    - trends in contaminant concentrations in fish tissues indicating changes in background levels;
    - changes on cellular or sub-cellular levels following exposure to toxic/endocrine-disrupting substances;
    - changes in vital physiological functions indicating impacts on recruitment or adult mortality patterns;
    - population responses to changes in recruitment and mortality;
    - changes in fish community structure relative to eutrophication or climate change.
    - The contaminant variables were also selected to serve in human and wildlife risk assessments and to assess the results of regulatory measures.

Study Group on North Sea Benthos Project 2000 (SGNSBP) – ICES CM 2005/E:04)

Annex 7: Advantages/constraints of a repeat exercise (survey and/or data compilation) in 2010

Advantage:

Time-series (1986–2000–2010): climate changes, NAO oscillations.

Working Group on Integrated Coastal Zone Management (WGICZM) (ICES CM 2005/E:09)

2.4 Norway

Key issues are:

- Ecosystem structure and function, and effects of intervention. An important part of this is knowledge about life history in marine organisms and dispersal/spreading of marine organisms.

- The environment's carrying capacity (including the significance of varying physical framework conditions and studies of species and system vulnerability).
- Species-demand on the environment including suitability and their vulnerability with respect to toxins and eutrophication (anthropogenic).
- The effect of the size of local fish stocks; cod, herring, capelin and invertebrates such as bivalves, crustaceans and echinoderms, on the environment.
- Interaction between wild and reared organisms, sustainable multi-mariculture and the interplay and interaction between wild species.
- There is little knowledge today on the effect of rearing and stock enhancement on local spawning grounds for e.g., cod, herring, capelin, etc., and areas for eggs, larvae and juveniles (cod, herring, etc).
- Climate changes.
- Knowledge to avert and reverse unwanted processes, rehabilitation and environ-mental actions (habitat improvement in the form of e.g., fertilizing and artificial reefs.
- Introduced species.
- EU's Water Frame Directive.
- Coastal management has to find the balance between exploitation and protection issues in the coastal zone.

2.8 The Netherlands

Natural Resources: identification of these resources (e.g., fish, invertebrates, minerals, land), the requirements for their sustainability, needs for conservation, exploitation levels, anthropo-genic impacts (e.g., beach erosion, landfill or reclamation, habitats, climate change, etc.) or problems that may arise such as xenobiotic organisms introduced directly or indirectly by hu-man activities.

(WGICZM) – ICES CM 2006/MHC:08

Annex 5: Activities and information of relevance to ICZM of different ICES Working and Study groups

Table A5.1. ICES Working or Study Groups that address climate change influence or impact of different human activities on coastal ecosystems, or address key issues of relevance tocoastal ecosystems/ICZM (Tor a). The following table is not comprehensive and only 2005 reports were available.

NATURALINFLUENCES: Climate change
KEY ISSUES Habitat change
COMMITTEE KEY TASK Oceanographic: understand and quantify the role of climate variability.
RELEVANT WG/SGS GAPS IDENTIFIED
WGAGFM: Local adaptation in fish species/evolutionary potential
REGNS#: Available data on Modelled tidal currents /surge, tidal heights for coastal North Sea.
Also sea level observations at fixed points.
Predictions of habitat change?
Habitat changes due to climate change in coastal zone may be more pronounced?

Executive Summary:

The ICZM process has been initiated in all the countries that reported to this WG, but different approaches were taken and different stages of the process had been reached. ICZM is perceived as a continuous and iterative process that should be adapted as more information is generated, new sectors developed and new questions are asked. For example, the effects of climate change may require some adjustments to ongoing efforts and indicators associated with monitoring programmes. All countries recognise the need for comprehensive coastal programmes designed to resolve conflicting demands on the use of coastal resources, maintain coastal biodiversity and ensure long-term economic sustainability. The main driving pressures may differ between countries, varying from human activities such as mariculture, tourism and coastal defence to issues such as eutrophication and pollution.

3.1 Update and report on activities of relevant ICES Working and Study groups to identify information pertaining to coastal zone and evaluate this information relative to ICZM needs (ToR a), p. 4

Recommendation: WGICZM recommends continuing to update and report on activities of relevant ICES working and Study groups to identify information pertaining to coastal zone and evaluate this information relative to ICZM needs and review progress from the EU and IOC.

The information for this ToR is compiled in Annex 5, Table A5.1.

The ICES WG/SG reports that were available on the ICES website were reviewed. Due to the timing of the meeting, only the 2006 reports were available. This means that some of the comments or identified needs for information may already have been taken up and considered by a group during 2006 but would not be registered in this report.

The information for this ToR is summarised in Table A5.1. Several WG/SGs have taken on a sector approach, compiling information on ecosystem effects of a human activity such as mariculture or mineral extraction, whereas others focus on Key Issues that may be relevant to a number of human activities such as eutrophication or chemical contamination.

In the 2006 report of the WGICZM it was decided to use the Sector approach for this ToR which was based on Table 5.1 of the SGINC report (ICES CM 2004/E:08). This structure was maintained and the table updated in this year's report. However it should be kept in mind that ICZM attempts to overcome single sector management and to overcome compartmentalized approaches. The different reports were reviewed for information on coastal impacts of Natural influences such as climate change and Human Activities such as Mariculture, Fisheries, Oil and Gas, Mineral Extraction, Tourism/Recreation, Transport/Port, Residential/Urban development, Physical structures and Land use Practices/Dams. For each Human Activity a number of Key Issues were also listed, so the WG/SG information was listed according to Key Issue under each Human Activity or Natural Influence. A few WGs have a regional focus (eg. Baltic Sea, North Sea) and their task is not unlike that of this WG; with a major difference that this WG does not compile data. A disadvantage to this approach is that several Key Issues are common to a number of human activities and the generic approach of the WG made the information relevant to several Human Activities, which resulted in some repetition.

United Kingdom (Scotland), p 14

The Fisheries Research Services (FRS) Coastal Long Term Monitoring project was set up in 1999 to monitor water quality parameters at 10 sampling sites around Scotland. The measurements taken as part of this monitoring are used to create a continuous *time series* of the variation in key properties of the sea. This time series data set will enable us to study the impact of climate change on Scottish coastal waters, as well as giving us information on typical background conditions. Parameters measured include water temperature, salinity, nutrients (such as phosphate, silicate, nitrate and ammonia) and phytoplankton.

Annex 5

Table A5.1. ICES Working or Study Groups that address climate change influence or impact of different human activities on coastal ecosystems, or address key issues of relevance to coastal ecosystems/ICZM (ToR a). Only 2006 reports available.

Natural Influences	Key Issues	Relevant WG/SGs	Gaps identified
Climate change	Habitat change	**WGAGFM:** Local adaptation in fish species/evolutionary potential **REGNS[#]:** Available data on Modelled tidal currents /surge, tidal heights for coastal North Sea. Also sea level observations at fixed points.	Predictions of habitat change? Habitat changes due to climate change in coastal zone may be more pronounced?
	Alien species		The response and effect of alien species to climate change in the coastal zone.
	Coastal erosion		Monitoring the impacts on coastal systems.
	Changes in freshwater runoff	**WGAGFM:** Local adaptation in fish species	Changes in salinity as well as flow/currents, depth, etc.
	Changes in water temperature	**WGAGFM**: Genetic response to increasing water temperatures. Evolutionary ability of fish stocks to respond to climate change. **WGCCC**: effects of inc. temperature on cod, zooplankton effects, **WGPE**: to look at timeseries data to examine climate change impacts on phytoplankton. **WGZE**: zooplankton has been primary research area that has demonstrated regime shifts and climate change, yet not included in monitoring under WFD, OSPAR, etc. Time series monitoring lower priority.	What about "coastal stocks" and their evolutionary potential? Changes in temperature, salinity etc. may be more pronounced in coastal zone. More information is needed on juvenile stages, their habitats and effects/impact of climate change. Information on coastal zooplankton abundance.

Study Group on Biodiversity Science (SGBIODIV) – ICES CM 2008/MHC:06

9 Contribution of existing ICES Study and Working Groups to Biodiversity Science and uptake of this information by Advisory and Science Committees (ToR d)

(extracts)

Biodiversity issues addressed by expert groups include (Annex 4):

impacts of alien species on native aquatic biodiversity;
changes in the distribution of biodiversity as a result of climate change;

A total of nine expert groups have addressed ecosystem-level questions, including climate change, habitat mapping, impact of sand and gravel extraction and seasonality of plankton distributions. Effects of hydrodynamics and sea temperature on species distributions presented a cross-cutting theme for various expert groups in 2007.

9.1 Uptake of Biodiversity Science in ICES advice

(extract)
In recent years, the Advisory Committee on Ecosystems (ACE) has translated an OSPAR request related to climate change effects on marine biodiversity into relevant ToRs for several Working Groups. The response to ICES has been coordinated by the Working Group on Ecosystem Effects of Fishing Activities (WGECO, see Annex 4 – 7). To date, biodiversity-related requests from OS PAR requiring an integrated approach across Study and Working Groups have been rare. These include, for example, requests to:

Workshop on Benthos Related Environmental Metrics (WKBEMET) – ICES CM2008/MHC:01

Environmental Indicators: Utility in Meeting Regulatory Needs (ICES Symposium, London, Nov 2007)

The employment of environmental indicators to simplify the communication of trends to regulators has a long history, none more so than in the area of marine sci-ence. Presently, there is renewed impetus for indicator development arising from global initiatives on sustainable development, climate change and the conservation of biodiversity, and regional incentives such as the evolution of an ecosystem approach to marine environmental management. Distinctive features of current effort include a shift of emphasis towards evaluations of the biological consequences of human activities, and towards the wider employment of indicators as explicit enforcement tools in the regulatory process.

Workshop on the role of phytobenthic communities in ICES waters (WKPHYT) – ICES CM2008/MHC:02

Adverse effects of fishery on phytobenthos

While coastal *Zostera* beds are normally safe for trawling effects due to local legisla-tions, deeper algae beds may be adversely affected by heavy rock-hopper gears

which may result in the loss of refuge and shelter for fish inhabiting these special habitats ,

Further research is needed on the effects of Global change and Climate change effects total phytobenthic community.

Oceanography Committee (OCC) and (C)

ICES/GLOBEC WORKING GROUP ON COD AND CLIMATE CHANGE (WGCCC) – ICES CM 2000/C:11

The terms of the reference (C: Res.1999/2C11) for the CCC meeting were:

a) review and evaluate work carried out to date on Cod and Climate Change by the Workshops (Environmental Data in Stock Assessment, Decadal-Scale Ocean Climate Fluctuations, Backward Facing III and IV) and subsequent follow up activities;

b) produce a short synthesis of the major findings from the programme and prepare a plan for a more complete synthesis of results;

c) plan and prepare workshops to be held over the next two years on "Applying Environmental Data in Stock Assessments" (possibly examining the transport of cod larvae between Iceland and West Greenland as a specific example) and on "long-term Climate Change and Prediction" and consider the possibility of a fifth Backward- Facing Workshop;

d) consider and, where feasible, develop data products and summaries that can be provided on a routine basis to the ICES community via the ICES website;

e) examine the 1999 Oceanography Committee Working Group reports and the Terms of Reference for 2000 to identify where intergroup input could be provided or required with the view to formulating key questions requiring interdisciplinary dialogue during concurrent meetings of the Committee's Working Groups in 2002.

The WGCCC will report to the Oceanography and Living Marine Resource Committees at the 2000 Annual Science Conference.

(WGCCC) – ICES CM 2001/C:04

The ICES/GLOBEC Working Group on Cod and Climate Change (Chair: Dr K. Drinkwater, Canada) will work by correspondence over the next year (2001) to:

a) review and evaluate the outcome of the Workshop on the Dynamics of Cod Growth and determine follow-up activities;

b) prepare for the Workshop on the Transport of Cod Larvae;

c) plan and initiate the synthesis of work to date on Cod and Climate Change by:

  i) requesting funds for the preparation of a book on cod and climate change and if successful, holding a meeting of a small steering group to develop an outline for the book as well as plan the necessary activities and determine the people required to write and publish the book;

ii) assembling references and additional data on cod stocks throughout the North Atlantic with the purpose of making the information available through publication and on a CD;

iii) examining possible ways by which environmental information can be incorporated into the assessment process;

d) initiate plans for a symposium on Climate Variability and Fisheries;

e) consult with Oceanography Committee Working Groups on possible joint activities and data requirements.

The Workshop will report to the Oceanography Committee at the 2001 Annual Science Conference.

(WGCCC) – ICES CM 2002/C:15

The **ICES/GLOBEC Working Group on Cod and Climate Change** (Chair: Dr K. Drinkwater, Canada) will meet in Copenhagen, Denmark, on 19–20 April 2002 to:

a) continue with the review and evaluation of work carried out to date on Cod and Climate Change including results and possible follow-up work from the Workshop on Transport of Cod Larvae.

b) plan and prepare workshops over the next two years in order to:

i) coordinate the synthesis work and prepare material for the book

ii) continue the evaluation of studies on Long Term Climate Change and Prediction

c) foster further cooperation and interaction with the Working Group on Recruitment Processes, the Study Groups on the Incorporation of Process Information into Stock-Recruitment Models and the Study Group on Modelling of Physical/Biological Interactions.

d) determine the Working Group's contribution to the GLOBEC Open Science in October 2002.

e) prepare a summary report listing relevant marine bio-ecological variables and indicators suitable for operational use.

The Workshop will report to the Oceanography Committee at the 2002 Annual Science Conference.

(WGCCC) – ICES CM 2003/C:11

The **ICES/GLOBEC Working Group on Cod and Climate Change** [WGCCC] (Co-Chairs: K. Drinkwater, Canada, and G. Ottersen, Norway) will meet in New Bedford, USA from 7–9 May 2003 to:

a) review and evaluate the outcome of the Workshop on Synthesis of Cod and Climate Change and determine follow-up activities;

b) update data and information on the life history of the various North Atlantic cod stocks as part of the synthesis work of the Cod and Climate Change programme;

c) review plans for:

i) the theme session for the 2003 ASC on the Transport of Eggs and Larvae to Cod Stocks of the North Atlantic,

ii) the 2004 ICES Symposium on The Influence of Climate Change on North Atlantic Fish Stocks;

d) discuss the future directions of the Cod and Climate programme.

(WGCCC) – ICES CM 2004/C:13

The **ICES/GLOBEC Working Group on Cod and Climate Change** (Co-Chairs: Dr. K. Drinkwater, Canada, and Dr. G. Ottersen, Norway) will meet in Bergen (Norway) in May 2004 to:

a) review and evaluate the progress on the Synthesis Activities including

i) the book on cod

ii) the update of the CRR on the life history aspects of cod stocks throughout the North Atlantic

b) review and evaluate the results from the Workshop and Theme Session on the transport of cod larvae.

c) to plan and prepare the Workshop on the Impact of Zooplankton on Cod Abundance and Production

d) to initiate plans for other Workshops.

(WGCCC) – ICES CM 2005/C:11

The **ICES/GLOBEC Working Group on Cod and Climate Change** [WGCCC] (Chair: G. Ottersen, Norway) worked by correspondence during 2005. The Terms of Reference (ICES CM 2004/C:13) for WGCCC in 2005 are:

a) review and evaluate the progress on the Synthesis Activities including:

i) publication of the book on cod,

ii) publication of the CRR on the life history aspects of cod stocks throughout the North Atlantic,

iii) publication of the proceedings of the Symposium on the Influence of Climate Change on North Atlantic fish stocks;

b) plan and prepare the Workshop on the Impact of Zooplankton on Cod Abundance and Production;

c) plan the back-to-back Workshops on the Decline and Recovery of Cod Stocks Throughout the North Atlantic and on the Influence of Climate on Tropho-Dynamics of Cod Ecosystems;

d) initiate plans for a Workshop on Cod and Future Climate Change and discuss other Workshops;

e) review and evaluate the results from the Workshop on the transport of cod larvae;

f) plan the Theme Sessions on Cod in a Changing Climate (ASC 2005) and Physics Relevant to Marine Ecosystems (ASC 2006).

(WGCCC) – ICES CM 2006/OCC:11

ICES/GLOBEC Working Group on Cod and Climate Change [WGCCC] (Co-Chairs: G. Ottersen, Norway and K. Wieland, Greenland) will meet in St John's, Canada, from 8–9 May 2006 to:

a) review and evaluate the progress on the Synthesis Activities including:

i) publication of the book on cod,

ii) publication of the proceedings of the Symposium on the Influence of Climate Change on North Atlantic fish stocks;

b) review and evaluate the Workshop on the Impact of Zooplankton on Cod Abundance and Production;

c) review and evaluate the Theme Session on Cod in a Changing Climate (ASC 2005);

d) make final preparations for the Workshop on the Decline and Recovery of Cod Stocks Throughout the North Atlantic including tropho-dynamic effects;

e) continue planning for a Workshop on Cod and Future Climate Change and discuss other Workshops.

WGCCC will report by 31 May 2006 for the attention of the Oceanography Committee

(WGCCC) – ICES CM 2007/OCC:9

The **ICES/GLOBEC Working Group on Cod and Climate Change** [WGCCC] (Co-Chairs: Geir Ottersen, Norway and Kai Wieland, Greenland) will work by correspondence in 2006–2007. The Terms of Reference (ICES CM 2006/OCC:11) are:

a) review, evaluate and develop results from the Workshop on the Decline and recovery of cod stocks throughout the North Atlantic including tropho-dynamic effects;

b) plan the Workshop on the Integration of Environmental Information into Management Strategies and Advice (WKEFA, ACFM) in 2007;

c) initiate plans for the Workshop on Cod and Future Climate Change, which is postponed to 2008;

d) initiate plans for a Synthesis workshop or Theme Session in 2009

The WGCCC proposes that the **Workshop on Cod and Future Climate Change** will be held in 2008 (instead of 2007 as envisaged in the CCC Strategic Plan) under the chairmanship of K. Drinkwater (Norway). Because of the delay of one year a Resolution is not required at this stage and the recommendation is directed at WGCCC, for further consideration and to be put forward as a Resolution in 2007.

The terms of reference are:

In response to future climate change scenarios

a) to determine the most likely response of the physical oceanography, including nutrient concentrations, in the North Atlantic;

b) to develop impact scenarios for phytoplankton and zooplankton production and distribution, especially those species eaten by cod and their predators or prey during their life histories;

c) to determine the most likely response of the prey or predators of cod including the forage fishes, such as capelin, herring, sprat and mackerel;

d) to develop future scenarios for cod production (growth, reproduction, mortality, recruitment) and distribution.

Justification:

The Symposium will contribute to Goals 1, 4, 5 and 10 of the ICES Strategic Plan

Many of the regions presently occupied by Atlantic cod are predicted to undergo significant warming in response to climate change and in recent years much of the North Atlantic has experienced such warming. Increasingly, managers, politicians and the general public have been asking what will be the impacts of future climate change. Such information for cod and the marine ecosystems have been limited. Indeed, the few published studies have usually considered the response of individual species to increased warming without considering other components of the marine ecosystem, such as their prey or predators. However, climate change is expected to impact both the structure and function of marine ecosystems and to develop more plausible impact scenarios we must consider the species as part of the ecosystem. Using our increased understanding gained through the ICES/GLOBEC Cod and Climate Change program, including past workshops, plus other research on the effects of climate variability on cod and its supporting ecosystem, the impact of future climate scenarios on the marine ecosystems of the North Atlantic and especially cod will be developed

(WGCCC) – ICES CM 2008/OCC:08

Working Group on Cod and Climate Change [WGCCC] (Chairs: G. Ottersen, Norway and K. Wieland, Denmark) will meet at ICES Headquarters, Copenhagen, Denmark, from 16–17 June (noon) 2008 to:

a) review and evaluate the Workshop on the Integration of Environmental Information into Fisheries Management Strategies and Advice [WKEFA];

b) review and evaluate the Workshop on the Decline and Recovery of Cod Stocks Throughout the North Atlantic including trophodynamic effects [WKDRCS];

c) review and evaluate the progress on the publication of the WGCCC book;

d) make final preparations for the a Workshop on Cod and Future Climate Change;

e) continue planning for a WGCCC Synthesis Theme Session at ICES ASC 2009.

f) Synthesis Theme Session at ICES ASC 2009: "Beyond Cod and Climate Change: Effects of climate variability on marine ecosystems in the ICES area". [TOR e] (*Geir Ottersen*)

Workshop on Cod and Future Climate Change [WKCFCC] – ICES CM 2008/OCC:09

Terms of reference:

(Co-Chairs: K. Drinkwater, Norway, J. Dippner1, Germany, and, C. Schrum, Norway, will meet at ICES Headquarters, Copenhagen, Denmark from 17 June (12 noon) –20 June (12 noon) 2008 to:

In response to future climate change scenarios:

a) adopt 20–50–year probabilistic projections of future temperature and salinity as a basis for projections of fish population dynamics and distribution (also nutrients)

b) develop methodologies and make projections of likely changes phytoplankton and zooplankton production and distribution, especially those species eaten by cod and their predators or prey during their life histories;

c) develop methodologies and make projections of likely changes in prey and predators of cod including the forage fishes, such as capelin, herring, sprat and mackerel;

d) develop methodologies and make projections of likely changes in cod production (growth, reproduction, mortality, recruitment) and distribution.

ICES/IOC WORKING GROUP ON HARMFUL ALGAL BLOOM DYNAMICS (WGHABD) – ICES CM 2001/C:04

The **ICES-IOC Working Group on Harmful Algal Bloom Dynamics** [WGHABD] (Chair: Dr K Kononen, Finland) will meet in Dublin, Ireland, from 12 – 16 March 2001 to:

a) collate and assess national reports, update the mapping of HABs and summarize the information in the harmful algae event database (HAEDAT) on a regional, temporal and species basis

b) evaluate the modified harmful event report form

c) continue examining the possible ways of analysing historical data and fossil records

d) evaluate and assess the use of remote sensing and in situ optical sensing technology in HAB dynamics studies

e) discuss the potential sensitivity of HABs to climate changes

f) review the implementation of the GEOHAB research programme in the ICES area

g) prepare a resolution for a workshop, possibly co-sponsored by regional programmes, such as GEOHAB, GLOBEC and GOOS, on 'Real-time observation systems applied to Harmful Algal Bloom Dynamics studies and global ecosystem functioning'

WORKING GROUP ON ZOOPLANKTON ECOLOGY (WGZE) – ICES CM 2002/C:07

The agenda for the WGZE meeting (Annex 2) followed the terms of reference adopted as a resolution of the Annual Science Meeting in Oslo (C. Res. 2001/2C07). As stated in the same resolution the WG will report to ACME by 15 April 2002 and to the Oceanography Committee at the 2002 Annual Science Conference.

The terms of reference are:

a) review results from Standards Sections and Stations from member countries, update them into the Summary status report on the zooplankton monitoring structure in the ICES area and analyse possible links with other data sets.

b) analyse what are the consequences of ocean climate changes for zooplankton processes and community structure.

c) search and evaluate possible biological indices of ecological significance for the fisheries and environmental assessment groups.

d) review and evaluate the electronic version of the ICES leaflets.

e) prepare activities for a second Workshop on zooplankton taxonomy in 2003.

f) consider and review plans for a workshop on modelling phytoplankton-zooplankton interactions in 2003.

g) review and evaluate the advances in the organisation of the ICES/PICES/GLOBEC Symposium.

h) future developments of Trans-Atlantic studies.

i) provide the scientific merits and operational possibilities of incorporation of zooplankton as a monitoring goal in environmental programmes as e.g., the OSPAR/JAMP with inclusion of QA and standardisation procedures.

j) prepare a summary report listing relevant marine bio-ecological variables and indicators suitable for operational use.

k) any other business. (e.g., European networks of excellence: is there capacity to build a network of excellence in zooplankton research?)

l) l) nomination of new Chair.

(WGZE) – ICES CM 2003/C:01

The **Working Group on Zooplankton Ecology** [WGZE] (Chair: Steve Hay, UK) will meet in Gijón, Spain, from 24–26 February 2003 to review:

a) review the preparation of the annual zooplankton summary status report: standardisation of data sets, critics and improvements.

b) approve and adopt guidelines for metadata standards for zooplankton data in the ICES area;

c) review climate change and Trans-Atlantic studies on Calanus;

d) review perturbations in coastal marine ecosystems and changes in zooplankton community structure due to human impacts;

e) evaluate possible biological indices of ecological significance for the fisheries and environmental assessment groups, taking into account the evaluation framework adopted by ACE (2000) and described by WGECO (2000, 2001);

f) evaluate the local organization and facilities for the ICES/PICES/GLOBEC Symposium;

g) consider sampling and analytical methodologies focussed in gelatinous zooplankton;

h) review state of the art of enzymatic activity methods to estimate secondary production in zooplankton.

i) review progress in the digitisation of the plankton leaflets;

j) consider the potential of ITIS as a common taxonomic system within ICES

3)

(WGZE) – ICES CM 2004/C:07

The **Working Group on Zooplankton Ecology** [WGZE] (Chair: Steve Hay, UK) will meet in Hamburg, Germany, from 5–8 April 2004 to review:

a) Update the annual ICES plankton Status Report, including extending the time-series with new sites, phytoplankton series, and advances in monitoring technology. lead – Luis Valdes; Rapporteur – Steve Hay

b) Consider future developments and collaborative approaches in time-series measurements and interpretation. lead - Steve Hay; Rapporteur – Luis Valdes

c) Review impacts of climate change on plankton communities using biological indicators, with special consideration of fisheries. lead – Webjørn Melle; Rapporteur – Claudia Halsband-Lenk

d) Review publications and outputs from the ICES/PICES/GLOBEC Symposium (Gijon, May 2003) and the implications for plankton research. lead – Luis Valdes; Rapporteur – Peter Wiebe

e) Review of achievements of the ICES Zooplankton Taxonomic Workshop (CM 2003/C:14). lead - Alistair Lindley; Rapporteur – Rabea Diekmann

f) Review and consider new technologies for identification and enumeration of plankton species. lead – Peter Wiebe; Rapporteur – Todd O'Brien

g) Review the state of the art of enzymatic activity methods to estimate plankton secondary production. lead - Rob Campbell; Rapporteur – Delphine Bonnet

h) Start preparations to summarise status and trends of zooplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 2000-2004, and any trends over recent decades in these communities; for input to the Regional Ecosystem Study Group for the North Sea in 2006. lead – Wulf Greve;

(WGZE) – ICES CM 2005/C:02

The **ICES Working Group on Zooplankton Ecology [**WGZE] (Chair: Steve Hay, UK) proposes to meet in Lisbon, Portugal, from 4–7 April 2005 to review:

a) Update of the annual ICES plankton status report. It is planned to extend it to new sites and include concurrent hydrographic data, phytoplankton series and advances in monitoring technologies.

b) **b)** Future development and collaborative approaches in plankton time-series measurements and interpretation, including collaboration with global synthesis attempts and regional comparisons.

c) **c)** Comparison of geographic and seasonal patterns across the range of plankton monitoring sites in the ICES area with emphasis on key species; approaches and preparation for North Sea ecosystem assessment (REGNS).

d) **d)** Consider multivariate statistical methods and other models as means to evaluate and assess zooplankton population and community dynamics in relation to environmental factors, ocean climate changes and fisheries assessment.

e) **e)** Review preparations and progress towards:

i) a workshop on enzymatic and other biochemical and molecular methods to measure or assess rate processes in zooplankton.

ii) the 4th international zooplankton production symposium to be held in Japan 2007.

iii) a "virtual" workshop to further the collaborative comparison and analyses of plankton time-series and other zooplankton data in the North Sea areas.

iv) a further taxonomic workshop to advance the Fiches plankton ID sheets, also to encourage the training and retention of plankton taxonomic skills. This should focus to a large extent on gelatinous plankton taxonomy.

v) discussion to be held during the 2004 ASC and inter-sessionally to coordinate the conjunction of the zooplankton and phytoplankton monitoring reports into the ICES Plankton Status Report.

f) Review and consider the role of meroplankton in pelagic shelf seas ecosystems and their contribution to productivity in these areas.

g) Review progress with ICES data management of biological information.

(WGZE) – ICES CM 2006/OCC:03

Terms of reference:

a) Update the ICES Plankton Status Report; consider progress towards consolidation, interpretation with appropriate statistical methods and recommended monitoring standards;

b) Plan and prepare for additional analyses and products utilising the Plankton Status Report Time-series;

c) Plan and consider an agenda for a joint meeting with CIESM plankton scientists;

d) Review the causation and impacts of introduced or disappearing plankton species, particularly from regions in the ICES and CIESM areas;

e) Consider and consolidate the use of web site and virtual resources for support of WGZE endeavours;

f) Review and comment on the draft text on the application of AQC Criteria (Annex 8, SGQAE 2004). (The answer to this TOR demands intersessional work by WGZE);

g) Provide expert knowledge and guidance to ICES Data Centre (possibly via sub-group) on a continuous basis;

h) Review and report on the results of the North Sea ecosystem (overview) assessment undertaken by REGNS and prepare recommendations for further or modified analysis made where appropriate. The tables of gridded data used for the 'overview' assessment should be checked and where necessary new data (parameters) included and/or existing data (parameters) updated if relevant;

i) Review achievements, progress and prospects for:

ii) Workshop on the Impact of Zooplankton on Cod Abundance and Production [WKIZC];

iii) Workshop on enzymatic and other biochemical and molecular methods to measure rate process in zooplankton;

iv) SCOR Working Group, Global Comparisons of Zooplankton Time-series.

v) ICES/PICES/GLOBEC International Zooplankton Production Symposium in Japan 2007;

vi) GLOBEC/ SPACC workshop "Image analysis to count and identify zooplankton" (ZooImage), San Sebastian 2005;

vii) A taxonomic workshop to advance the Fiches plankton ID sheets, also to encourage the training and retention of plankton taxonomic skills;

viii) Plans and progress in relevant national and international projects relating to plankton studies (e.g., MARBEF, BASIN and others);

ix) Data management issues at ICES and elsewhere, including expert knowledge and guidance to the Data Centre.

(WGZE) – ICES CM 2007/OCC:04

Terms of reference:

a) update the ICES Plankton Status Report.

b) review the role of microzooplankton, including metazoans, in marine food web.

c) compare the zooplankton ecology of the North Atlantic and the Mediterranean;

Justification:

c) It is recognized that there is a movement towards broader and more global syntheses and comparisons in the research community, particularly being driven by the process and implications of climate change for marine ecology generally. The WGZE members are keen to forge links with their fellow plankton scientists in CIESM as there is much to be learned and gained through exchange and collaboration. There is need for coordinated approaches to plankton monitoring in the two areas (e.g. overview of metadata, harmonization of sampling and sample processing), and comparison of the zooplankton ecology in the two areas. Links between plankton in the North Atlantic and the Mediterranean need to be explored.

d) review the use of numerical methods in exploring and predicting long-term plankton variability in relation to climate;

e) review and consider the impact on zooplankton communities of introduced or disappearing species;

f) consider rate process studies and zooplankton phenology in association with time-series monitoring;

g) consider the development of web-based taxonomic training and the promotion of the ICES WGZE to a wider community;

h) review and consider species biodiversity in zooplankton from coastal zones to oceanic deep sea: progress and prospects for the European Census of Marine Life Project (EuroCoML);

i) discuss and report on quality assurance and control guidelines for sampling and analytical practices for zooplankton;

j) provide expert knowledge and guidance to ICES Data Centre (possibly via subgroup) on a continuous basis;

k) take part in the intersessional work led by PGPYME in developing the mission and draft resolutions for a new working group related to phytoplankton and microbial ecology;

l) assess and report on changes in the distribution, population abundance and condition of zooplankton in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature (further details on the interpretation and handling of this ToR will be provided by ACE);

m) assess and report on changes in the distribution, population abundance and condition of phytoplankton in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature (further details on the interpretation and handling of this ToR will be provided by ACE).

(WGZE) – ICES CM 2008/OCC:05

Terms of reference:

a) Consider the reports of the Ad Hoc Groups on;

i) Hydrographic Attributes

ii) Trend Analyses & Quantifying Relationships

iii) Formulating Hypotheses and Predictions about Mechanisms

iv) Selecting Species for More Intensive Investigations and use their recommendations concerning (1) recommended time series, (2) analytical methods and suitable software, (3) hypotheses and guidance for their use, and (4) a suggested list of species for intensive study, to complete the assessment of changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature;

b) update the ICES plankton status report and consider ways of incorporating biophysical modeling approaches in interpretation;

c) prepare species lists from time series stations and/or areas in the ICES area;

d) report on approaches for combining field and laboratory data together with biological-physical models to examine processes controlling zooplankton populations;

e) compare and report on different nets and mesh sizes and their efficiency;

f) compare and report on different measures for zooplankton biomass from regions within the ICES area;

g) finalize preparations for the WGZE/CIESM Workshop;

h) review the planning of a new working group related to phytoplankton and microbial ecology;

i) produce an evidence based rationale for incorporating zooplankton monitoring into regulatory assessment frameworks;

j) assess and report on the outcomes of the 4th ICES/PICES/GLOBEC International Zooplankton Production Symposium;

k) provide expert knowledge and guidance to the ICES Data Centre (possibly via sub-group) on a continuous basis.

Prioritized Research themes that have been identified by ICES (Draft ICES Science Plan 2009–2114):

1) Climate Change Processes: Impact of climate change on the distribution, physiology and behaviour of marine biota from coastal areas to the deep ocean.

2) Operational ecosystem modelling combining operational oceanography, ecosystem and population processes) leading to comprehensive assessments and medium term forecasts (3–5 year horizon).

3) Climate Change Predictions: Predictions of the responses of marine ecosystems within the ICES area to climate change scenarios, with attention to region shifts and changes in trophic structure. Investigate the response of marine ecosystems within the ICES area to climate change scenarios, with attention to regime shifts and change in the trophic structure.

4) Ecosystem Surveys: Integration of surveys and observational technologies into operational ecosystem surveys in support of EAM.

5) Invasive Species: Introduced and invasive species, their impacts on ecosystems and interactions with climate change.

6) .....

7) .....

Section 8. OSPAR climate request

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In winter of 2007, the ad-hoc groups worked by correspondence. Priscilla Licandro, Eilif Gaard, Jesus Cabal and Mike Heath were the WGZE representatives in one group, Study Group on Working Hypotheses Regarding Effects of Climate Change, SGWRECC.

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The final draft of the SGWRECC report was presented to the WGZE. It included two terms of reference:

a) Develop hypotheses on ecosystem responses to climate change and other major drivers.

b) Develop hypotheses about future potential for plankton/climate change scenarios.

The main hypotheses were related to climate change. A subset of these hypotheses were related to plankton, and A few members of WGZE including Mike Heath contributed to developing these hypotheses.

1) Climate changes are associated with plankton geographic changes

2) Climate change is resulting in decline in abundance of zooplankton.

3) Future changes that are expected in the plankton in relation to climate change are the following:

3.1) Changes in temperature can increase invasive species abundance.

3.2) Zooplankton phenology will change due to increased stratification.

3.3) Match-mismatch between plankton cycles and fish production will be affected by climate change.

3.4) Community changes will be difficult to predict.

3.5) Increased ocean acidity will decrease the abundance of calcareous organisms.

Working Group on Seabird Ecology (WGSE) – ICES CM 2004/C:05

The **Working Group on Seabird Ecology** [WGSE] (Chair: R.W. Furness, UK) will meet in Aberdeen, U.K. from 29 March–2 April 2004 to:

a) review the factors influencing trends in abundance of seabirds in the Baltic Sea;

b) review progress in studies of seabirds in relation to marine wind farms;

c) review relationships between seabirds and oceanographic features, with particular reference to effects of climate change;

d) consider the selection of seabird species and populations that would be appropriate to use in an EcoQO relating to seabird population trends in the North Sea as indices of seabird community health;

e) complete the work carried out in 2003 to compare seabird communities and prey consumption between the east and west North Atlantic;

f) provide the Study Group on Multispecies Assessments in the North Sea (SGMSNS) with data on the consumption of different prey by seabirds in the North Sea, in a format specified by SGMSNS;

g) reconsider the formulation of the EcoQOs listed below, determine whether a more specific EcoQO is needed in terms of its specification to the metric, time and geographical area, and as necessary propose more specific EcoQO(s) [OSPAR 2004/1]:

i) EcoQ element (f) Proportion of oiled common guillemots among those found dead or dying on beaches,

ii) EcoQ element (g) Mercury concentrations in seabird eggs and feathers,

iii) EcoQ element (h) Organochlorine concentrations in seabird eggs,

iv) EcoQ element (i) Plastic particles in stomachs of seabirds;

v) EcoQ element (j) Local sandeel availability to black-legged kittiwakes,

vi) EcoQ element (k) Seabird population trends as an index of seabird community health.

h) start preparations to summarise the size, distribution and status of seabird populations in the North Sea for the period 2000–2004, and any trends over recent decades in these populations, for input to REGNS in 2006.

4)

Working Group on Oceanic Hydrography (WGOH) – ICES CM 2004/C:06

The **Working Group on Oceanic Hydrography** [WGOH] (Chair: A. Lavín, Spain) will meet in Southampton, UK, from 29 March–1 April 2004 to:

a) update and review results from Standard Sections and Stations;

b) consolidate inputs from Member Countries and NORSEPP into the ICES Annual Ocean Climate Status Summary (IAOCSS);

c) review national monitoring programmes in order to improve climate monitoring activities;

d) review Proceedings of the ICES Symposium on Hydrobiological Variability in the ICES Area, 1990–1999 in order to evaluate gaps in knowledge;

e) review relations with international climate monitoring programmes;

f) review two proposals for new work, viz:

i) discuss the possibility to undertake long-term storage of water samples of key locations for future analysis

ii) undertake an isopycnal analysis of in situ data.

g) start preparations to summarise the ocean climate of the North Sea for the period 2000-2004, and any trends over recent decades in this climate; for input to the Regional Ecosystem Study Group for the North Sea in 2006.

7. REVIEW NATIONAL MONITORING PROGRAMMES IN ORDER TO IMPROVE CLIMATE MONITORING ACTIVITIES (TOR C);

Most ICES countries have extensive monitoring activities, but these are not always very well coordinated between nations. The WGOH was supposed to evaluate the existing activities and look for improvement. It was agreed that all countries should sustain long-term national time-series. In a few areas, such as the North Sea and the Nordic Seas, several nations are operating different sections. To some extent a few standard sections are coordinated in the way that the same positions are occupied by different nations, but the field season overlaps, so there is difference in time between the occupations of sections. WGOH are presently developing a web-page that will include details of all standard hydrographic sections carried out by the member counties. This information will make it easier to review the monitoring activities, and it was suggested to revisit the TOR next year.

The WGOH noticed that the OSPAR monitoring programme for the North Sea contains no mandatory physical oceanography. Recognising that climate change is of international concern, the WGOH strongly recommends that the Oceanography Committee and ACME should support OSPAR to strengthen the measurements of standard physical oceanography parameters in the OSPAR's Co-ordinated Environmental Monitoring Programme (CEMP), and additionally physical oceanographic monitoring as a basis for understanding of the ecosystem and climate change. The WGOH will discuss the demands of OSPAR for physical oceanography information on the meeting next year.

Additionally information of a workshop to deal a question from OSPAR to ICES about assistance in developing criteria and guidelines for integrated biological effects and chemical monitoring was presented to the members.

9. REVIEW RELATIONS WITH INTERNATIONAL CLIMATE MONITORING PROGRAMMES (TOR E);

Katy Hill, (project scientist) from the CLIVAR office came to discuss possibilities for improved links between CLIVAR and the WGOH.

CLIVAR (**Climate Variability** and Predictability) is an international research programme addressing many issues of natural climate variability and anthropogenic climate change (http://www.clivar.org/).

The specific objectives of CLIVAR are:

- To describe and understand the physical processes responsible for climate variability and predictability on seasonal, interannual, decadal, and centennial time-scales, through the collection and analysis of observations and the development and application of models of the coupled climate system, in co-operation with other relevant climate-research and observing programmes.
- To extend the record of climate variability over the time-scales of interest through the assembly of quality-controlled paleoclimatic and instrumental data sets.

- To extend the range and accuracy of seasonal to interannual climate prediction through the development of global coupled predictive models.
- To understand and predict the response of the climate system to increases of radioactively active gases and aerosols and to compare these predictions to the observed climate record in order to detect the anthropogenic modification of the natural climate signal.

The WGOH agreed that it would be beneficial to strengthen links with the CLIVAR programme. At present, the CLIVAR website does not contain any information about the WGOH or the ICES standard sections. This information would fill a significant gap in the CLIVAR field programme and research.

The following actions were agreed:

- Sheldon Bacon (UK) and Tom Rossby (USA) will present a review of the activities of the WGOH to the CLIVAR Atlantic Panel meeting in June 2004.
- Members of the WGOH should consider attending the CLIVAR workshop on the North Atlantic Thermohaline Circulation (13-16 September, Kiel Germany)
- Members of the WGOH will submit articles to a special issue of the CLIVAR newsletter 'Exchanges'. Sheldon Bacon (UK) and Penny Holliday (UK) will liaise with the CLIVAR office an appropriate timeline for publication of this issue.

Annex D: Mini-Symposium on Climate, Southampton 2003

Arctic Environmental Change: Promise or Threat / Howard Cattle

International CLIVAR Project Office, Southampton Oceanography Centre, University of Southampton

This paper will firstly provide an overview of changes in Arctic climate observed over recent decades. In particular the changes to surface temperature, permafrost temperatures, river runoff, northern hemisphere snow extent and Arctic Sea ice extent and thickness will be illustrated. Many of these changes have been attributed to the positive phase of the North Atlantic Oscillation over the period, though recent model simulations from the Hadley Centre indicate that positive heat flux anomalies into the Arctic may also play a role. Climate model simulations also show the Arctic to be the globally most sensitive region in terms of the response of climate to greenhouse gas-induced climate change. This presentation will also provide an overview of the likely changes in Arctic climate through the 21st century as revealed by climate model simulations. Uncertainties in model simulations will be discussed. Changes in the Arctic due to greenhouse gas-induced change are likely to be of significant societal importance affecting indigenous peoples and with economic and ecological consequences. The likely impacts will be discussed with particular reference to the outputs from the IPCC's Third Assessment Report.

Rapid Climate Change – what is happening?

M. A. Srokosz

Southampton Oceanography Centre

The possibility of rapid climate change (that is, significant change over a period of the order of a decade) is of interest to both scientists and policy makers. Evidence from palaeo data (for example, Greenland ice cores and marine sediments) shows that over the last 11,000 years (the Holocene) the climate has been relatively stable. However, prior to that rapid changes in temperature of the order of 5-10 degrees have occurred in perhaps as short a time as 5-10 years. The palaeo data suggest that the oceanic thermohaline circulation (THC) is implicated in these changes. Computer models indicate that under global warming similar rapid changes might occur in the future, with a slowdown or shutdown of the N. Atlantic THC. Such rapid changes could have major climatic impacts particularly in NW Europe. The UK Natural Environment Council (NERC) has funded the Rapid Climate Change (RAPID) programme (£20M over 6 years), which is using a combination of palaeo data, observations in the N. Atlantic and models to study rapid climate change, with the aim of reducing uncertainties and improving predictions. NERC is working with NSF and NOAA in the USA, and with the Netherlands Organisation for Scientific Research and the Research Council of Norway in Europe. At the present time a major observational array is being deployed in the N. Atlantic to measure changes in the meridional overturning circulation (of which the THC is the dominant component). In addition, improved palaeo data on past rapid changes are being acquired. Both the palaeo data and observations will be used to test and so improve climate models so that the possibility of future rapid climate change may be better assessed. For more information on RAPID e-mail M.Srokosz@soc.soton.ac.uk or see the web page http://rapid.nerc.ac.uk/

Plankton and Climate Change: the Continuous Plankton Recorder (CPR) survey

Philip C. Reid

Sir Alister Hardy Foundation of Ocean Science, The Laboratory, Citadel Hill, Plymouth, UK. . pcre@mail.pml.ac.uk

Evidence from the Continuous Plankton Recorder (CPR) survey suggests that the plankton can integrate hydro-meteorological signals and may be used as a possible index of climate change. As many species undergo strong seasonal vertical migrations and spend much of their year in waters down to 2000m, they may reflect changes in intermediate and deep layers as well as the surface of the ocean. Strong links have been demonstrated between the plankton and Northern Hemisphere temperatures, the North Atlantic Oscillation (NAO) and sea surface temperatures. The colour index of the CPR survey has shown a substantial increase in season length and intensity and implies increases in chlorophyll and primary production in a wide belt across the North Atlantic and especially in shelf seas. Parallel increases in the benthos imply that sedimentation from the plankton has also increased in the last decade. These events are part of what has been termed a regime shift in the North Sea after 1987. Part of the cause of the change appears to be linked to varying oceanic advection into shelf seas. The source, characteristics and volume flow of these inputs appears to have a major impact on the biological productivity of shelf seas with associated changes to fish stocks. This was demonstrated recently when a reduction in the size and biomass and changes in timing of plankton were shown to be the cause of large reductions in cod recruitment in the North Sea. Superimposed on the changes associated with the regime shift has been a northerly movement of warmer water plankton on the eastern side of the Atlantic and a southerly movement of

colder plankton in the western Atlantic. The rate of change has been substantial, 10° of latitude in only forty years in the eastern Atlantic.

The third report of the international panel on Climate Change (IPCC) has shown that the rapid rise in mean global temperature seen in the last century was exceptional in the context of the last millennium. Mean surface (land and sea) global temperatures increased by 0.6_C _ 0.2_C in the twentieth century. There is now a scientific consensus that these increases are attributable to the even greater rate of increase seen in greenhouse gases. Concentrations of CO2 for example have increased by 30% since 1750 at a rate that has been unprecedented in the last 20 000 years. Greenhouse gases are expected to continue to rise at a rapid rate over the next 100 years. Modelled projections for CO2 suggest increases of 540 to 970ppm in the next hundred years compared to ~380ppm in 2000 and ~280ppm in 1800. On the basis of these greenhouse gas projections surface temperatures are expected to increase by a further 1.4 to 5.8_C by 2100. It is likely that changes in temperature at this scale and rate are likely to have a pronounced effect on northern latitudes in the Arctic and in turn on the circulation of the North Atlantic which plays such a key role in the 'Global Conveyor Belt'. The extent to which climatic variability may be contributing to the marked changes observed in the plankton over the last five decades will be assessed with a forecast of potential future ecosystem effects in a climate change scenario. The scale of the changes seen over five decades emphasises the importance of maintaining existing and establishing new, long term and wide scale monitoring programmes of the world's oceans under the flag of the Global Ocean observing System (GOOS).

RECOMMENDATIONS AND FINDINGS

In most areas of the North Atlantic during 2003, temperature and salinity in the upper waters remained higher than the long-term average, with new records set in several regions.

Recognising that climate change is of international concern, the WGOH strongly recommends that the Oceanography Committee and ACME should support OSPAR to strengthen the measurements of standard physical oceanography parameters in the OSPAR's Co-ordinated Environmental Monitoring Programme (CEMP), and additionally physical oceanography monitoring as a basis for understanding of the ecosystem and climate change.

The WGOH consider that understanding the changes in the physical marine environment is indispensable for any ecosystem and fisheries assessment. The WGOH strongly recommends that they continue to meet and produce the IAOCSS on an annual basis. The WGOH wishes to ensure that the IAOCSS is more widely available than in the past and as such they strongly recommend that the IAOCSS have no restrictions for printing. To raise the profile, the WGOH will request a news item regarding the publication of the new IAOCSS on the front page of the ICES website.

The WGOH agree that for ecosystem assessment, a regional approach is necessary, but it is still necessary to understand regional climate in the context of the wider North Atlantic.

The WGOH request input from the new ICES database manager regarding the future direction of the ICES database.

The WGOH strongly recommends that the ICES website be improved.

(WGOH) – ICES CM 2005/C:06

Working Group on Oceanic Hydrography [WGOH] (Chair: A. Lavín, Spain) will meet in Rhode Island USA, from 11–14 April 2005 to:

a) update and review results from Standard Sections and Stations; During the first day a large number of standard Sections and stations were revive and the main features occurred during 2004 were remarked.

b) consolidate inputs from Member Countries and NORSEPP into the ICES Annual Ocean Climate Status Summary (IAOCSS);

c) review national monitoring programmes and OSPARs Coordinated Environmental Monitoring Programme (CEMP), in order to improve climate monitoring activities;

d) review and improve relations with international climate monitoring programmes (CLIVAR - climate variability)

e) undertake an isopycnal analysis of *in situ* data;

f) WGOH will provide summary datasets on the physical properties of the North Sea (to include salinity, temperature, tidal vectors, peak surface, mid- and bottom currents, maximum annual and 50 year significant wave heights). The data should be time averaged (annual average, seasonal cycles and annual peaks) for the period of 1984 to 2004 (where available) and spatially averaged at the scale of ICES rectangles. The data should be submitted to the secure REGNS website in preparation for the REGNS Integrated Assessment Workshop from 9–11 May 2005.

g) discuss requirements for data management in ICES and provide input to SGMID;

h) review website developments.

(WGOH) – ICES CM 2006/OCC:08

The Working Group on Oceanic Hydrography [WGOH] (Co-Chairs: S. Bacon*, UK, and P. Holliday*, UK) will meet in Galway, Ireland, from 19–22 April 2006 to:

a) update and review results from Standard Sections and Stations;

b) consolidate inputs from Member Countries to, and continue development of the ICES Annual Ocean Climate Status Summary (IAOCSS), and align data source acknowledgements in IAOCSS with IOC policy;

c) review and improve relations with international climate monitoring programmes;

d) formulate advice to the ICES Data Centre manager on the development of data products and services to improve access to physical oceanographic data for nonexpert users;

e) take action for strengthening the role of WGOH and physical oceanography within ICES;

f) continue and extend the isopycnal analysis of *in situ* data;

g) review and report on the results of the North Sea ecosystem (overview) assessment undertaken by REGNS and prepare recommendations for further or modified analysis made where appropriate. The tables of gridded data used for the 'overview' assessment should be checked and where necessary new data (parameters) included and/or existing data (parameters) updated if relevant;

h) recommend equipment and protocols for collecting oceanographic data on ICES coordinated bottom trawl surveys and to determine the expected precision and accuracy of data thus collected. Report outcome to OCC and IBTSWG.

i) WGOH will report by 2 May 2006 for the attention of the Oceanography Committee, ACME and ACE.

(WGOH) – ICES CM 2006/OCC:08

The Working Group on Oceanic Hydrography [WGOH] (Co-Chairs: S. Bacon*, UK, and P. Holliday*, UK) will meet at the Swedish Meteorological and Hydrological Institute in Västra Frölunda, Sweden, from 27–30 March 2007.

a) update and review results from Standard Sections and Stations;

b) consolidate inputs from Member Countries to, and continue development of, the ICES Report on Ocean Climate (IROC), and align data source acknowledgements in IROC with ICES policy; archive data used to compile report;

c) review and improve relations with international climate monitoring programmes;

d) take action for strengthening the role of WGOH and physical oceanography within ICES;

e) conclude and report on the isopycnal analysis of *in situ* data

(WGOH) – ICES CM 2008/OCC:01

The **Working Group on Oceanic Hydrography** [WGOH] (Co-Chairs: S. Bacon, UK, and P. Holliday, UK) will meet in ICES HQ, Copenhagen, Denmark in March 2008 (date to be confirmed by ICES) to:

a) update and review results from Standard Sections and Stations;

b) consolidate inputs from Member Countries to, and continue development of, the ICES Report on Ocean Climate (IROC), and align data source acknowledgements in IROC with ICES policy; archive data used to compile report;

c) provide support to other Expert Groups requiring information on oceanic hydrography in support of their responses to the OSPAR request on 'An assessment of the changes in the distribution and abundance of marine species in the OSPAR maritime area in relation to changes in hydrodynamics and sea temperature. review and improve relations with international climate monitoring programmes;

d) review and improve relations with international climate monitoring programmes;

e) take action for strengthening the role of WGOH and physical oceanography within ICES;

f) provide expert knowledge and guidance to ICES Data Centre (possibly via sub-group) on a continuous basis;

g) take part in the intersessional work led by PGOOP in developing the mission and draft resolutions for a new Expert Group related to operational oceanographic products and services;

Working Group on Recruitment Process (WGRP) – ICES CM 2005/C:12

The **Working Group on Recruitment Processes** [WGRP] (Co-Chairs: R. D. M. Nash, UK, and T. Miller, USA) will work by correspondence during 2005 to:

a) prepare a synthesis of multidisciplinary projects relevant to the understanding of recruitment processes and highlight unresolved issues which deserve further consideration;

b) report on recent meetings that concern recruitment in fish populations (e.g., Climate Change – Bergen) so that information or progress relevant to the status or assessment of stocks in the ICES area can be highlighted;

c) assess the role of spatial and temporal variability in the distribution and abundance of organisms together with the implications of these sources of variability on the design of sampling programmes and inferences drawn from them;

d) review the development of new approaches or techniques used in the study of factors and processes that influence the development and survival of fish eggs and larvae in relation to recruitment of the formation of year-class strength.

e) Critically review the work undertaken by WGRP and prepare a clear set of guidelines for the future direction of this Working Group in relation to the other current WGs.

ICES/IOC Steering Group on GOOS (SGGOOS) – ICES CM 2004/C:10

International GOOS activities

i) Update on EuroGOOS activities (*Hans Dahlin*)

One main question was how do non-member institutes interact with EuroGOOS? There is a duty on national member institutes to represent national interests.

NOOS presently exchanges daily storm surge models for the North Sea. NOOS members are becoming familiar with this, and to now that some models are better in certain situations. This "model" of operational model product exchange is a good one and should be used for NORSEPP.

The new Ocean Climate Task Team will focus on climate change. There is a need to understand how operational systems should be built to deliver to climate change concerns. One product is to consider climate change scenarios, and to co-ordinate

existing national climate scenario generation which is currently occurring within Europe.

Members were reminded of the 2005 4th IOC conference 6–9 June 2005, Brest France. The proceedings appear as a book published by Elsevier.

It was questioned that CLIVAR has few inputs from northern Europe. EuroGOOS may address this lack.

ICES commenced a parallel activity to BOOS in the Baltic funded by the World Bank. This was not perceived as a useful development by EuroGOOS, and tended to dilute GOOS activities in the Baltic. There are many linkages between BOOS and the ICES GEF project, but ICES is further encouraged to co-operate fully with BOOS, and to try and focus on existing GOOS activities rather than recreating parallel projects.

ICES countries collect 5–10,000 CTD profiles per year, but these are not entered into the operational system. There should be some way of funnelling these profiles into the operational community.

Steering Group for the ICES/GLOBEC North Atlantic Programme and Regional Office (SGNARO) – ICES CM 2004/C:15

The **Steering Group for the ICES/GLOBEC North Atlantic Programme and Regional Office** [SGNARO] (Co-Chairs: K. Drinkwater, Canada, and F. Köster, Denmark) will work by correspondence in 2004, and meet as appropriate at national expense, to:

a) review and advise on the further evolution of the ICES/GLOBEC North Atlantic Programme and the workplan of the ICES/GLOBEC office, taking into account:

   i) the strategic goals for ICES/GLOBEC research and the strategic approach for the ICES/GLOBEC office as agreed by the Council,

   ii) developments in the international GLOBEC programme, and

   iii) available funding;

b) review and advise on the action plan of the Working Group on Cod and Climate Change.

(SGNARO) – ICES CM 2005/C:13

The **Steering Group for the ICES/GLOBEC North Atlantic Programme and Regional Office** [SGNARO] (Co-Chairs: K. Drinkwater, Norway, and F. Köster, Denmark) will work by correspondence in 2006, and meet as appropriate at national expense, to:

a) review and advise on the further evolution of the ICES/GLOBEC North Atlantic Programme and the workplan of the ICES/GLOBEC office, taking into account:

i) the strategic goals for ICES/GLOBEC research and the strategic approach for the ICES/GLOBEC office as agreed by the Council,

ii) developments in the international GLOBEC programme, and

iii) available funding;

b) review and advise on the action plan of the Working Group on Cod and Climate Change.

(SGNARO) – ICES CM 2006/OCC:14

The Steering Group for the ICES/GLOBEC North Atlantic Programme and Regional Office [SGNARO] (Co-Chairs: K. Drinkwater, Norway, and F. Köster, Denmark) will work by correspondence in 2006, and meet as appropriate at national expense, to:

a) review and advise on the further evolution of the ICES/GLOBEC North Atlantic Programme and the workplan of the ICES/GLOBEC office, taking into account:

i) the strategic goals for ICES/GLOBEC research and the strategic approach for the ICES/GLOBEC office as agreed by the Council,

ii) developments in the international GLOBEC programme, and

iii) available funding;

b) b) review and advise on the action plan of the Working Group on Cod and Climate Change.

SGNARO will report by 31 May 2006 for the attention of the Oceanography Committee and the Bureau.

WORKING GROUP ON PHYTOPLANKTON ECOLOGY (WGPE) – ICES CM 2005/C:01

The Working Group on Phytoplankton Ecology [WGPE] (Chair: F. Rey, Norway) will meet in Oldenburg, Germany, from 16–18 March 2005 to:

a) Critically review the work undertaken by WGPE and prepare a clear set of guidelines for the future direction of this Working Group in relation to other relevant WGs, and take action to encourage wider participation to the group;

b) Start assessing satellite remote sensing data and numerical modelling results for revealing new information on phytoplankton dynamics;

c) Review and report on information on the impact of climate variability on phytoplankton dynamics and phytoplankton-zooplankton-fish interactions;

d) Evaluate and report on annual Phytoplankton Summary Reports and the standardization of the data sets;

e) Review the Phytoplankton Checklist compiled intersessionally and compare if species from checklist fit into ITIS structure to report phytoplankton data to ICES;

f) Plan a Workshop devoted to evaluation of new methods of PP measurements in Bergen 2007;

g) Continue preparations to summarise status and trends of phytoplankton communities in the North Sea (biomass, species and size composition, spatial distribution) for the period 1984–2004, and any trends over recent decades in these communities;

…for input to REGNS initial assessment in 9–11 May 2005, and final assessment in 2006.

(WGPE) – ICES CM 2006/OCC:

The **Working Group on Phytoplankton Ecology** [WGPE] (Chair: Francisco Rey, Norway) will meet in Brorfelde, Denmark from 29 to 31 March 2006 to:

a) Evaluate and report on annual Phytoplankton Summary Reports and further improve the standarization of the data sets;

b) Review new additions to the ICES Phytoplankton Name List that have been compiled intersessionally;

c) Review the contribution to REGNS to be prepared intersessionally;

d) To held an internal mini-workshop on the uselfuness of long-term data series for evaluating the impact of climate variability on phytoplankton dynamics and phytoplankton-zooplankton-fish interactions;

e) Assess the activities and frequency of quality control routines concerning phytoplankton parameters (species composition, abundance, biomass, pigments, primary production) performed at the national and international level;

f) Prepare a more detailed set of guidelines for the future work of WGPE based on the outcome of the 2005 meeting;

g) Continue assessing satellite remote sensing and numerical modelling results for revealing new information on phytoplankton dynamics.

WORKING GROUP ON MODELLING OF PHYSICAL/BIOLOGICAL INTERACTIONS (WGPBI) – ICES CM 2008/OCC:06

The **Working Group on Modelling Physical Biological Interactions** [WGPBI] (Co-Chair: C. Hannah, Canada and U. Thygesen, Denmark) will meet in Sète, France from 1–3 April 2008 to:

a) present and discuss new results concerning physical-biological interactions;

b) complete the publication of papers from WKAMF;

c) complete the draft of the Manual of Recommended Practices for Modelling Physical-Biological Interactions in Fish Early-Life History and suggest future coordinated research actions;

d) demonstrate potential effects of climate change on the lower trophic levels of marine ecosystems;

e) develop a statement of requirements for monitoring data to be useful for development and validation of models of physical-biological interactions;

f) report on lessons learned from application of holographic imagery to zooplankton-phytoplankton-turbulence interactions;

g) document how PBI tools can be useful in estimating fish habitats potentials and survival windows and their variation in the context of climate change;

h) review proposed approaches for coupling regional models of NPZD-type bi o-geochemistry with higher trophic levels;

i) report on approaches for combining field and laboratory data together with biological-physical models to examine processes controlling zooplankton populations;

j) discuss and report on how WGPBI fits into the new ICES structure.

Resource Management Committee (RMC) and (D)

Working Group on Fishery Systems (WGFS) – ICES CM 2003/D:06

Objective 4. Identify and quantify interactions between human activities and the ecosystem

key words:

- • ecosystem impacts of by-catch, discards, fish processing offal
- • habitat impacts of fishing gear;
- • habitat disturbance or loss due to human activities other than fishing.

Nine research areas have been identified: Physical oceanography, plankton, benthos, fish and shellfish, marine birds, marine mammals, social system, governance institutions and interactions between the social and natural systems (Figure 3.3.2**)**. The programme will focus on the processes and linkages between these areas. Modelling will be an integrated

part of the programme. Research will include ecosystem, community and population modelling including community structure, exploitation rates, ways of exploitation, stock interactions and social science analysis.

The results are expected to comprise:

- an improved understanding of the **marine climate system** and possible implications of climate change for the structure and functioning of the eco- and social systems and governance institutions;
- an improved knowledge-base as a contribution towards sustainable man
- agement of natural resources; and
- the development of ecosystem-based management tools, taking a multidisciplinary approach by integrating natural and social sciences.

(WGFS) – ICES CM 2005/D:07

2.1.3 Analysis of the perceptions and communication of science and knowledge among the fishing public

Introduction

Work package 6 of PKFM concerns the perception and communication of knowledge among the fishing public. The overall aim is to describe how scientific knowledge and other knowledge claims are articulated in public debates about the management of North Sea cod. In this context the 'public debate' involves the 'fishing public' which is collectively all the voices (of individuals, groups or organisations) expressing publicly some stake or opinion in the past, present or future of cod fisheries and their management. Knowledge includes not just 'scientific knowledge', the output of the formal

knowledge production system studied in other PKFM work packages, but also other forms of knowledge or information brought to the de-bate by those involved.

Throughout 2003 and 2004, partners in Demark, France, Holland, Norway and the UK have collected written material from national press sources, websites, newsletters, discussion group meeting minutes etc., concentrating on the period 2001 to autumn 2004. Interviews with key people taking part in the debate have also been carried out. Research material has been analysed to:

- identify the main discourses that are active in the public debate and review the main arguments of each and ;
- to look for the reasoning structure of the discourses, to see how each discourse is justified.

National summaries are being compiled into a European summary, which identifies commonalities and differences in the different countries and examines the positions adopted by the various actors. The structure of this synthesis and the main topics featuring in the debate are outlined below.

The synthesis – mapping the debate

The synthesis groups the elements of the debate under three main headings, each of them linked to the perception and management of nature, as follows:

5) The cause of the decline of the North Sea cod stock, questioning the relative roles of various ecosystem/environmental and anthropogenic factors and the responsibility of different actors for the current state of the stock. Many different stake-holders take part in this debate, sharing experiences and viewpoints.

6) The 'true' status of the stock. This concerns mainly the scientific methods used to assess the stock, and the results of assessment as compared with fishermen's perceptions of the state of the stock.

7) The management system and measures applied to the stock. The debate with ranges from the specifics of recovery measures to conceptual issues including humankind's capacity to manage 'nature'.

Many of the elements of the debate are, however, linked or used in combination by actors to establish or support positions.

(1) Causes of decline

The key issue in this regard is the relative contribution of ecosystem/environmental factors and fishing or over-fishing to the decline of the stock. The ecosystem/environment factors which feature most prominently include:

Climate change. A causal link between climate change and the decline of cod is debated in all countries at various levels. It is a particularly active debate in the UK and France. Impacts are discussed in relation to young cod survival, food sources and changes in the spatial distribution of the stock.

Nutrients. The part of the debate linking nutrients to recruitment and growth of cod seems to be specific to the Netherlands. It relates mainly to arguments developed by D. Boddeke, concerning changes in phosphate concentration and productivity in the southern North Sea.

Pollution. Pollution is sometimes mentioned as a possible cause for cod stock depletion. In Denmark and Norway, activities such as oil exploration, seismic surveys and drilling are identified as possibly having detrimental effects on the stock.

Predators and prey. The impact of seals is a long-standing issue in the UK. Fishermen express a view that seals are one possible reason (among others) for stock depletion and that seal populations should be managed. In eastern Norway, seals and sea birds are a recurring theme in the public debate. In Denmark, there is long standing discussion on the relationship between cod and herring stocks, the possibility that herring predation on cod may be holding the stock down.

Sandeels and industrial fisheries. The impact of industrial fisheries, particularly sandeel fisheries, on cod is a major conversation in the UK and France. It is argued that these fisheries deprive cod and other fish of an important food source. Stakeholders also take issue about unre-ported by-catch in sandeel fisheries. A similar debate in Norway concerns shrimp and crayfish fisheries which have been blamed for the poor state of cod in the North Sea and Skagerrak.

Habitat degradation. The problems of destruction of cod habitat are debated particularly in the Netherlands, where trawlers are pointed to as major cause of habitat degradation.

Over-fishing and over-capacity. The European Commission identifies over-fishing, more specifically over-capacity as the main factor to be controlled to limit cod stock depletion. Environmental organisations usually support this argument with a broader perspective, majoring on the impact of fishing on marine ecosystems in general, rather than cod in particular.

Fishing versus other factors. The debate on the relative importance of the various factors which may be implicated in the decline of cod involves fishermen, scientists, governments. It is a vociferous debate in the UK, France and the Netherlands but also conducted at a lower level in Denmark and in Norway. Fishermen commonly express a view that they are being demonised. They hold that fishing is not solely responsible for the state of the stock and that other factors are clearly influential

(WGFS) – ICES CM 2008/RMC:07

3.2.2 Uncertainty in the Science–Policy Interface

Dr Jeroen P. van der Sluijs, Utrecht University, the Netherlands

The lecture started with introducing three fundamentally different understandings of uncertainty in knowledge in the science-society interface: the deficit view, the evidence evaluation view and the complex systems / post-normal view. Within the **deficit view**, uncertainty is considered to be a deficit of our knowledge. Uncertainty is seen as a temporary problem that will disappear if more objective research will be performed. In this view, management of uncertainty equals reduction of uncertainty and there is a strong belief that science is ultimately able to provide certainty. One tendency typically seen to achieve this is the production of ever more complex and detailed models, and calculation is seen as key to truth. The techniques applied include Monte Carlo, Bayesian belief networks and other quantification techniques. The pitfall of this paradigm is that a false certainty is created, because the numbers obtained from these models suggest more knowledge than there actually is.

The second view, **evidence evaluation view**, considers uncertainty to be a problematic lack of unequivocalness. When science speaks with multiple voices to policy, conflict-

ing certainties may emerge. The solution proposed is a comparative evaluation of individual research results, focused on building scientific consensus. The focus shifts from establishing certainty to evaluation of evidence to establish gradations of certainty.

Multidisciplinary expert panels such as the Intergovernmental Panel on Climate Change (IPCC) have been established for this purpose. This approach focuses on generating robust conclusions and widely shared interpretations of the available limited knowledge. The pitfall of this paradigm is that matters on which no consensus can be reached continue to receive too little attention, whereas, in fact, this dissension is often highly policy-relevant. One example is that in the first assessment report of the IPCC very little attention was given to non linear climate risks such as a possible shut down of the ocean circulation or a collapse of the West Antarctic Ice Sheet. There were (and still are) only weak signals that such scenario's may occur but it was impossible to reach any consensus interpretation of these weak signals of early warning (see also Patt, 1999)

Study Group on Growth, Maturity and Condition in Stock Projections (SGGROMAT) – ICES CM 2004/D:02

2.6 Witthames: Reproduction and stock evaluation for Recovery (RASER)

Summary

This presentation describes a research partnership between IMR (Norway), CEFAS (England), AZTI (Basque Country, Spain) and CSIC (Spain) which has been funded (Oct 2002-Sept 2005) under EU Framework 5. The purpose of the project is to study the reproductive biology of cod and hake (see http://raser.iMrno/ for details). In the first stage the project will focus on fecundity method development to reduce costs and increase the precision in estimating realised fecundity. Experiments in this part of the project aim to develop realised fecundity models that include condition indices and previous spawning investment. The rates of post ovulatory and atretic follicle degradation will be determined for use in estimating previous spawning history, and to develop models to estimate production rates of atretic follicles (and thus realised fecundity). These improved methods will be used to assess the reproductive potential of each species across their latitudinal range in 2003 and 2004 in relation to the observed variation in environmental conditions including fishing pressure. During the synopsis of the project the consequences for current assessment and advice procedures will be evaluated using a simulation framework that includes mathematical representations of both the 'real' system (the fish population and fleet dynamics) and the 'observed' system (data collected, assessment model used and reference points used to guide management strategies and their implementation, see Figure 1.1). Because the framework includes both the 'real' and 'observed' systems, it is an ideal tool to investigate the robustness of assessment models and management strategies to uncertainty in biological processes.

Figure didn't copy very well

Figure 1.1. Simulation model structure for RASER.

In the last part of the project the new experimentally proven data on atretic and post ovulatory follicle duration will be applied to previous ICES egg production based assessments to determine the potential bias in the assessment of realised fecundity and SSB.

Discussion

This project will yield very novel information, e.g., effect of temperature on realised fecundity. This is potentially important in **assessing the impacts of climate change.** Over the longer term, the results will also lead to new insights into the magnitude of variability in reproductive potential.

International Bottom Trawl Survey Working Group (IBTSWG) – ICES CM 2004/D:05

APPENDIX III NORSEPP (NORTH SEA ECOSYSTEM PILOT PROJECT)

1. Introduction

At the Intermediate Ministerial Meeting (IMM) on fisheries in Bergen in 1997, the Ministers of the North Sea countries agreed as one of the guiding principles:

Further integration of fisheries and environmental protection, conservation and management measures, drawing upon the development and application of an ecosystem approach which, as far as the best available scientific understanding and information permit, is based on in particular:

- the identification of processes in, and influences on, the ecosystems which are critical for maintaining their characteristic structure and functioning, productivity and biological diversity;
- taking into account the interaction among the different components in the food-webs of the ecosystems (multi-species approach) and other important ecosystem interactions; and
- providing for a chemical, physical and biological environment in these ecosystems consistent with a high level of protection of those critical ecosystem processes.

As a follow-up activity, a Workshop on the Ecosystem Approach to the Management and Protection of the North Sea was held in Oslo in June 1998. This workshop identified monitoring as a key component of an ecosystem approach in relation to ecological objectives, to assessments, and to scientific advice to management.

The 5th North Sea Ministerial Conference met in Bergen, Norway, 20–21 March 2002 with the aim of agreeing to implement an ecosystem approach, based on a conceptual framework developed at the 1998 workshop.

In 1997 an ICES Steering Group on GOOS (SGGOOS) was formed in order to prepare an action plan as to how ICES should take an active and leading role in the further development and implementation of GOOS at a North Atlantic regional level, with special emphasis on operational fisheries oceanography. At a workshop convened in

Bergen in 1999 a draft design and implementation plan was conceived. This had three essential components:

- To promote global / regional linkages in a GOOS context.
- To promote the ICES Annual Ocean Climate Status Summary as a contribution to GOOS.
- **To design and implement a North Sea ecosystem component of GOOS in collaboration with EuroGOOS**.

In order to develop these suggestions further the SGGOOS was re-nominated in 1999 as a joint ICES/IOC Steering Group on GOOS with the terms of reference to further develop an Implementation Plan. The SGGOOS initiated a workshop co-sponsored by IOC, ICES, OSPAR, the North Sea Conferences and EuroGOOS in September 2001 to agree on a strategy for a pilot North Sea Ecosystem GOOS project.

In order to meet the challenges identified at the meeting, the workshop agreed to increase the efficiency and effectiveness of the use of data products from current relevant national and international monitoring, and therefore invited the national agencies responsible for monitoring of the North Sea to:

- establish a co-ordinated mechanism that could add value to existing activities by integrating data from various sources (physical, chemical, biological) to aid development of an ecosystem approach,
- collaborate by means of a pilot project sponsored by ICES and EuroGOOS to demonstrate the usefulness of this approach by integrating data on oceanography and fisheries.

Further efforts will be required in consultation with appropriate bodies to develop a strategy for establishing and implementing the co-ordinated mechanism.

Although considerable progress has been made recently by a variety of national agencies and through EuroGOOS on monitoring, modelling, and forecasting physical parameters, until now no attempt has been made to establish an integrated information system for the North Sea which include ecosystem parameters. Such an approach would have the synergistic effect of integrating many current national activities.

The present monitoring of the North Sea is insufficient to discriminate between human impacts and natural variation on the ecosystem. There is a need for improved, integrated monitoring through co-ordination and harmonisation of existing national and international monitoring activities, as well as through implementation of new methods and technology.

For marine ecosystems, meteorological and climatic variability are primary driving forces for ecosystem variability. Improved knowledge of the relationship between climate and changes in ecosystems would greatly benefit the difficult task of distinguishing between anthropogenic impacts and natural variability in environmental assessments. A particular and new challenge in the future will be the use of environmental data within the annual assessment cycle for fish stocks by the fisheries research and management community. Such an approach will involve the bringing together of very diverse data sets and the application of new approaches to fishery assessment modelling.

The North Sea, because of the intensive work that has already been carried out in this area, is an obvious candidate for a pilot project. Developing an ecosystem approach for the management of the North Sea will need an integrated monitoring and infor-

mation system and a continuous updating of information, which could be seen as a North Sea ecosystem component of GOOS.

4.1.3 Time series of 60 North Sea fish species based on IBTS-Q1 data

Based on the IBTS quarter 1 data series, RIVO (Netherlands) has calculated time series of 60 North Sea fish species for the years 1977 to 2004 (see table 4.1.3). The analysis has been restricted to the more common species, and to species that are of importance for the southeastern North Sea. The series are based on average catches per roundfish area, all length classes combined (see Figure 4.1.6).

For each species, 9 plots are presented, based on a logarithmic scale: for roundfish areas 1 to 7 separately, for areas 8 and 9 combined, and for the average North Sea value (for area 1 to 7).

This enables a comparison of the result per area with the total North Sea picture. Furthermore, for each species, the average North Sea catch is given on a linear scale. A short description of the results is given per species, including an indication of the overall North Sea trend.

Figure 4.1.6: North Sea roundfish areas.

Table 4.1.3: Species of which time series have been analyzed (presented in taxonomical order).

1. Scyliorhinus canicula 21. Pollachius virens 41. Trigla lucerna
2. Squalus acanthias 22. Trisopterus esmarki 42. Myoxocephalus scorpius
3. Mustelus mustelus 23. Trisopterus luscus 43. Agonus cataphractus
4. Mustelus asterias 24. Trisopterus minutus 44. Cyclopterus lumpus
5. Raja radiata 25. Ciliata mustela 45. Liparis liparis
6. Raja naevus 26. Gaidropsurus vulgaris 46. Lepidorhombus whiffiagonis
7. Raja clavata 27. Molva molva 47. Phrynorhombus norvegicus
8. Raja montagui 28. Enchelyopus cimbrius 48. Psetta maxima
9. Alosa fallax 29. Trachurus trachurus 49. Scophthalmus rhombus
10. Clupea harengus 30. Mullus surmuletus 50. Arnoglossus laterna
11. Sardina pilchardus 31. Echiichthys vipera 51. Glyptocephalus cynoglossus
12. Sprattus sprattus 32. Scomber scombrus 52. Hippoglossoides platessoides
13. Engraulis encrasicolus 33. Callionymus lyra 53. Hippoglossus hippoglossus
14. Merluccius merluccius 34. Callionymus reticulatus 54. Limanda limanda
15. Gadiculus argenteus 35. Callionymus maculatus 55. Microstomus kitt
16. Gadus morhua 36. Anarhichas lupus 56. Platichthys flesus
17. Melanogrammus aeglefinus 37. Helicolenus dactylopterus 57. Pleuronectes platessa
18. Merlangius merlangus 38. Sebastes viviparus 58. Buglossidium luteum
19. Micromesistius poutassou 39. Aspitrigla cuculus 59. Solea vulgaris
20. Pollachius pollachius 40. Eutrigla gurnardus 60. Lophius piscatorius

Over the period investigated considerable changes have taken place in the composition of the fish community of the North Sea. In a number of species no long-term trend can be detected, but several others have increased over the observed period and some species have shown a decrease. Most of the species that increased have no or a rather low commercial value. The observed decreases are most likely due to a considerable fishing pressure, and some of the increases may be attributed to species that have filled gaps in the ecosystem. But also the effect of gradual climate changes may play a role, both regarding declining and increasing species.

Quite a number of species have shown a remarkable increase over the years 1977 to 2004:

Scyliorhinus canicula (lesser-spotted dogfish), *Enchelyopus cimbrius* and *Ciliata mustela* (4- and 5-bearded rockling), *Scomber scombrus* (mackerel) and *Trachurus trachurus* (horse mackerel), *Echyichthus vipera* (lesser weever), possibly *Callionymus maculatus* (spotted

dragonet), *Aspitrigla cuculus* and E*utrigla gurnadus* (red and grey gurnard), and the flatfish species *Limanda limanda* (dab), *Hippoglossoides platessoides* (American plaice), *Microstomus kitt* (lemon sole) and *Buglossidium luteum* (solenette). Except for mackerel and horse mackerel, these are mainly species for which no directed fishery exists.

A few species only have shown an increase approximately since 1990. These are *Mustelus asterias* (starry smooth hound), *Alosa fallax* (twaite shad), *Mullus surmuletus* (red mullet) and *Arnoglossus laterna* (scaldfish). *Engraulis encrasicolus* (anchovy) has increased since the mid 1990ies.

Some other species showed an increase during the first part of the time series and were later at a more or less stable level. These are *Clupea harengus* (herring), *Platichthys flesus* (flounder) and *Pleuronectes platessa* (plaice).

The few species that have shown a decrease are *Gadus morhua* (cod), *Squalus acanthias*(spurdog) and *Anarhichas lupus* (catfish). All three are large-sized species, the first one a major commercially important species while the latter two are landed as a by-catch and have a relatively low fecundity.

5.3 Quality assurance of species identification and composition

5.3.1 Background

It has been highlighted that the IBTS has potential problems associated with the misidentification of selected taxa, primarily non-commercial fish species (Daan, 2001; ICES, 2005). Additionally, there are several taxa that member states report at a range of taxonomic levels (species, genus or family). Although these problems will have no impact on the assessment of commercial fish stocks, it does have implications on the utility of the IBTS dataset for studies on fish assemblages, including biodiversity studies and the derivation of metrics for fish communities (e.g. in relation to studies examining the impacts of fishing impacts and climate change). Potential problematic taxa in the North Sea and in the southern and western IBTS surveys include:

- Deep-water sharks (Squalidae)
- Smoothhounds (*Mustelus* spp.)
- Skates and rays (Rajidae)
- Shads (*Alosa* spp.)
- Argentines (*Argentina* spp.)
- Rocklings (Gadidae, Lotinae)
- Rat-tails (Macrouridae)
- Clingfishes (Gobiesocidae)
- Sticklebacks (Gasterosteidae)
- Myctophids (Myctophidae)
- Hatchet fish (Sternoptychidae)
- *Beryx* spp.
- *Hoplostethus* spp.
- Pipefish (Syngnathidae)
- Redfish (*Sebastes* spp.)
- Scorpion fish (*Scorpaena* sp.)
- Sea scorpions (Cottidae)
- Sand eels (Ammodytidae)
- Dragonets (*Callionymus* spp.)
- Wrasse (Labridae)
- Eelpouts (Zoarcidae)
- Snake blennies (Stichaeidae)
- Mullets (Mugilidae)
- Gobies (Gobidae)
- Sea breams (Sparidae)

- Horse mackerel (*Trachurus* spp.)
- Flatfish (certain sister taxa, e.g. *Bathysolea-Diclogoglossa*)

Groundfish surveys provide the most appropriate data for the examination of large-scale spatial and temporal analyses of fish communities for offshore EU waters, and therefore for the derivation of metrics with which to assess changes in the structure, function and diversity of fish communities.

(IBTSWG) – ICES CM 2007/RMC:05

12.3.2 GSBTS (German Small-Scale Bottom Trawl Survey) (BFA-ISH, Germany)

The GSBTS is embedded in the German part of the IBTS Q3 survey. Additional to the allocated rectangles 12 selected areas each of 100nm² and distributed over the whole North Sea are fished under IBTS protocol conditions. In 6 areas also nutrients, benthos and occasionally sea birds are monitored.

The GSBTS has established a multi-disciplinary scientific survey time series (20 years; ca. 4300 hauls). Beside the evaluation of long-term shifts in benthic and fish species assemblages in relation to fishing pressure and climate change, the high-intensity sampling at small spatial and temporal scales allows for additional process studies which cannot be conducted in the frame of routine large-scale surveys like the IBTS. The IBTSWG agrees that the outcomes of this survey and especially the additional studies like comparative fishing experiments are very useful for a further standardisation of the IBTS. Recently the survey fulfils none of the 3 criteria given in the SGRN report.

A detailed description of the methods of the GSBTS and a review of the results are given in a paper by Ehrich *et al.* (2007).

REGIONAL ECOSYSTEM STUDY GROUP FOR THE NORTH SEA (REGNS) – ICES CM 2005/D:08 –

2.2.4 Discussion

The results from this preliminary analysis are very similar to published analyses of substantially the same data set (Reid *et al*., 2003; Beaugrand, 2004) which examined the evidence for the "regime shift" in 1987–1988 and moved on to explore causes, mechanisms and consequences. Large scale hydro-meteorological forcing was identified as a major contributor to the observed changes and acted in a number of ways. The Working Document presented to REGNS by Skjoldal *et al*. reinforces the published analyses in showing that inflows into the northeastern North Sea increased sharply in 1988 (Figure 5),

More detailed published analyses of changes in the North Sea plankton show that the population of the previously dominant copepod species, *Calanus finmarchicus* declined and was re- placed by southern species. (Beare *et al*, 2004). The seasonal timing of plankton production also altered in response to climate changes. This has consequences for plankton predator species, including fish, whose life cycles are timed in order to make use of seasonal production of particular prey species (Edwards and Richardson, 2004). The survival of young cod in the North Sea appears to depend on the abundance, seasonal timing and size composition of their prey. Changes in all of these since 1958 resulted in increased survival and good recruitment of cod through-

out the 1960s and 1970s and then a progressive decline over the past thirty years (Beaugrand *et al*, 2003).

We now consider the methodology and presentation used in the analysis presented here. The integration and visual display of data sets in a 'traffic light' approach have been used effectively as part of the Eastern Scotian Shelf Integrated Management (ESSIM) process (Choi *et al*, 2005) and similar methods have been used by Link *et al* (2005) for the US NE shelf area. Although the method has broad application in regional ecosystem assessments, the availability of consolidated and time-series data, normalised to an appropriate mean value, is a fundamental requirement. In the eastern Scotian Shelf example, a wide range of biotic and abiotic variables were available for the description and interpretation of underlying causes. Thirty nine first-order indicators of the ecology of the ESS were chosen based upon data availability, reliability and relevance. Most data were annual and extended back to at least 1960. Biotic variables included the abundance, distribution and composition of finfish, invertebrates, phyto-plankton, zooplankton and marine mammals while abiotic variables included oceanic and atmospheric indicators of ocean climate. Human variables included fishery landings and revenue, area of bottom trawled and the population size of Nova Scotia.

The interpretation of visual patterns in the traffic light display highlights important signals in the ESS ecosystem. As with the preliminary analysis for the North Sea shown above, the presentation provides an overview of changes in key ecosystem components and can therefore form an important part of an integrated ecosystem assessment at the regional scale. However there are a number of limitations with the approach and other forms of analysis, targeted assessments and data interpretations should also be employed (ICES, 2005).

One of the limitations relates to the need to represent multidimensional relationships between data in only two dimensions. Relationships between individual ecosystem attributes (displayed as rows) can only be inferred by their adjacency within the display. Therefore every attribute, except the very top and bottom rows, has two equally close linkages, two linkages one step removed, and so on. This will distort the reality that some attributes have many linkages that are strong and direct, while other attributes may have few linkages that are weaker and indirect. This aspect will be considered further during intersessional work.

Careful selection of the biotic, abiotic and human variables for use in the integrated assessment is essential, and need not be dependent only on those that are available, well understood and routinely collected. Ideally the selection of attributes should reflect fundamental under-standing of the ecosystem and have clear links to management process. Using only easily available datasets in such an integrated assessment may lead to an unbalanced presentation. Some ecological components (e.g., fish abundance) have multiple measurements and can therefore occupy many rows in the matrix whereas others (e.g., benthos, phytoplankton) that are difficult to measure are represented by only one or a few rows. This in effect introduces a weighting and will distort the interpretation of the different types of ecosystem components, because an entity represented by many rows would look much more important than one represented by few.

The transitions in colour-coding, are consistent within a variable, but are not calibrated across different types of variables. Thus a change over time in colour-coding (e.g., green to red) does

Annex 6: Recommendations

The **Regional Ecosystem Study Group for the North Sea** (REGNS) (Chair: A. Kenny, UK) will meet at place??, dates ?? 2006 to:

k) Hold a workshop to evaluate and plan the finalisation of the 2006 integrated ecosystem assessment for the North Sea.

iii) review the outcome of the work of an intersessional correspondence group (sub-group of REGNS) with compilation and analyses of a comprehensive integrated data set for different aspects and components of the North Sea ecosystem;

iv) review the outcome of intersessional work on relating state variables of the ecosystem with human pressures according to themes (eutrophi-cation, pollution, conservation, fisheries, climate, and management);

v) prepare plans for finalisation of the integrated ecosystem assessment which must take account of the relationship between the thematic human pressures assessments (in ii above) and the overview integrated assessment (in i above);

vi) prepare plans for presenting the outcome of the integrated ecosystem assessment at the 2006 ICES Annual Science Conference.

l) Advise on follow-up work to translate the experiences of REGNS in produc-ing an integrated ecosystem assessment into a regular process in ICES of producing or contributing to the production of updated integrated assess-ments for the North Sea ecosystem.

m) Based on the experience with the production of the 2006 North Sea integrated assessment, consider requirements that need to be taken into account in a design of a holistic monitoring of the North Sea ecosystem.

n) in joint session with IBTSWG hold a one day workshop to

8) rent policy drivers (e.g., the reformed Common Fisheries Policy, the EU Marine Strategy, the ICES requirement for Integrated Ecosystem Assessment)

9) Identify important components of the North Sea ecosystem, which if subject to systematic monitoring, would contribute to regular ecological assessment of the North Sea.

10) Highlight known key interactions and relationships between these components that would enable integrated ecological assessment of the North Sea.

11) Define a basic integrated monitoring protocol for obtaining ecosystem information from the IBTS surveys on an annual / multi-annual basis.

12) Determine a process for reporting the results of regular integrated IBTS ecological assessment.

13) Assess the additional cost of the proposed integrated ecosystem IBTS monitoring survey

4.2.5 To evaluate and predict long-term changes in food-webs and ecosystems. [Including the impact of climate change and emergent/resurgent species]

[M] [E] According to the ICES Strategic Plan, "new exploitation strategies that take account of complexity (such as trophic interactions) and uncertainty (such as effects of natural variability and climate change) need to be evaluated" and "robust exploitation strategies for living marine resources, taking into account ecosystem complexity and uncertainty [need to be designed]."

This is consequently also reflected in the first goal of the ICES Action Plan (Understand the physical, chemical, and biological functioning of marine ecosystems), which aims specifically to "understand and quantify the biology and life history, stock structure, dynamics, and trophic relationships of commercially and ecologically important species."

Besides the multispecies models developed and applied by the ICES Study Group on Multispecies Assessment in the North Sea (SGMSNS) and the Baltic Sea (SGMAB), there are no other ICES groups with the expertise of linking stock assessment of commercial fish species to the effects of emergent or resurgent predators or potential prey animals.

Shortcomings of the existing models and current data

4.3.1 Distribution, size structure and overall abundance of predators and prey have changed since the last sampling efforts in 1991

Since 1991 the North Sea ecosystem has been subject to substantial changes due to fishing and long-term climate change. The gadoids have shown a further decreasing trend in abundances while clupeids have shown increasing trends (ICES, 2005/ACFM:7; ICES, 2005/ACFM:16). The most important prey species, Norway pout and sandeel, collapsed in recent years (ICES 2005/ACFM:7). In addition, the size spectrum of the North Sea fish assemblage has changed towards smaller size classes due to growth overfishing of the larger predators (Daan *et al.*, 2005).

Water temperatures increased during the 1990s and species with southern geographic affinities, such as red mullet and horse mackerel, increased in abundances (Beare *et al.*, 2004). The higher water temperatures have also been associated with to substantial shifts in the distribution of commercial predator and prey species such as cod (Perry *et al.*, 2005; Blanchard *et al.*, 2005). This means, in turn that the spatio-temporal overlap between predator and prey species, an important factor determining the large-scale diet composition of predator populations, has changed substantially over time.

Consequently, there is a high probability that the North Sea food web has changed substantially and the 1991 stomach data no longer reflect the current condition of the North Sea food web. Since our process understanding is not enough to allow predictions from 15-year-old stomach data (see Section 4.3.6 regarding structural uncertainties), multi-species model runs without new, up to date, stomach data become questionable.

WORKING GROUP ON MULTISPECIES ASSESSMENT METHODS (WGSAM) – ICES CM 2007/RMC:08

3.15 Ecoregion E: Celtic Seas – page 25

Ecopath with Ecosim: Irish Sea

Ecopath with Ecosim: West of Scotland

The west of Scotland (ICES area VIa) has been modelled by Haggan and Pitcher (2005), who constructed a food web of 37 functional groups, including 21 fish groups and 8 fishing fleets. This model, which draws heavily on data from adjacent areas, has not been 'tuned' to time-series data, but preliminary spatial simulations (using 'Ecospace') have been conducted in an effort evaluate marine-protected areas (MPAs). Efforts are currently underway (S. Heymans – personal communication) to develop a more detailed Ecopath model for this region, relying more heavily on locally derived survey and diet data.

Ecopath with Ecosim: English Channel (see also North Sea ecoregion for east channel model)

Two EwE models are available, which cover the western English Channel, namely those of Stanford and Pitcher (2004) and Araüjo *et al*. (2005). The former encompasses ICES areas VIId and VIIe, whereas the latter only includes area VIIe. Both models include 50 functional groups and 9 fishing fleets, and both draw on similar literature sources. Stanford and Pitcher (2004) include policy exploration and an examination of possible future climate effects. By contrast, Araüjo *et al*. (2006) has conducted a detailed time-series fitting exercise, whereby the model

3.15 Ecoregion: US Northwest Atlantic continued – page 26

ECOGOMAG

NMFS are currently constructing a model of the Gulf of Maine (GOM) ecosystem based on results from Ecopath modelling exercises. The authors have structured the system based on 16 aggregated biomass nodes spanning the entire trophic scale from primary production to seabirds and marine mammals. Parameters from the Ecopath model of the GOM system were used to construct a simulation model using recipient controlled equations to model the flow of biomass and the biomass update equation used in Ecosim to model the annual biomass transition. Various performance measures and metrics such as throughput, total flow, biomass ratios (i.e. pelagic fishes to zooplankton), and trophic reference points (i.e. marine mammal biomass to pelagic fish biomass) can be monitored over the simulated time horizon. The model will be used to evaluate how the GOM ecosystem responds to large and small scale changes to the trophic components and system drivers. Specifically events such as climate change, various fishing scenarios, and system response to changes in the biomass of lower and upper trophic levels could be evaluated.

ECOGOMAG has not been through a formal model review. This remains a research tool and has not been used for management purposes.

... Section 3.15 continued

Biophysical Coupled Models – page 30

As part of the synthesis phase of GLOBEC, in collaboration with colleagues at the Institute of Marine Research, Bergen, comparative biophysical coupled model studies are being developed for transport and growth of larval and early juvenile fish in the two marine ecosystems Georges Bank and the Norwegian shelf/Barents Sea (the northern and southern extremes of the distribution of Atlantic cod). These studies will contribute to basic understanding of the interactions between fish populations and zooplankton and how these interactions are influenced by climate variability and change. Realistic physical conditions are being developed to hindcast selected years using the Regional Ocean Modelling System (ROMS) forced by a common set of variables with increased resolution within the regional domains. Lagrangian (particle tracking) models and Individual-based trophodynamic models for larval and early juvenile fish growth are embedded in the regional circulation models.

The core of the trophodynamic model is the standard bioenergetic supply-demand function, in which growth is represented as the difference between the amount of food absorbed by a larva and the metabolic costs of its daily activities. The formulation includes: (i) variable composition of prey fields; (ii) effect of turbulence, swimming behaviour and satiation on encounters and ingestion of larval fish and their prey; (iii) light limitation on ingestion rates at low and at high light intensities and (iv) effects of temperature on metabolic costs, ingestion rates and growth.

Data collected during selected years will be used to examine the space-time variability of the larval fish feeding environment. The distribution and evolution of the zooplankton fields will be specified based on the observed structures. If available, evolving prey (zooplankton) fields will be computed from NPZ models.

Comparative basin-scale, spatially explicit simulations can be made (NAO high vs. low years), but full model implementation requires extensive data fields. ROMS forced with CORE or ERA data sets have significant spin-up time before good solutions are realized. This model has not been through a formal model review. This remains a research tool and has not been used for management purposes.

(WGSAM) – ICES CM/2008/RMC:06

7.15.3 ECOGOMAG

NMFS are currently constructing a model of the Gulf of Maine (GOM) ecosystem based on results from Ecopath modelling exercises. The authors have structured the system based on 16 aggregated biomass nodes spanning the entire trophic scale from primary production to seabirds and marine mammals. Parameters from the Ecopath model of the GOM system were used to construct a simulation model using recipient controlled equations to model the flow of biomass and the biomass update equation used in Ecosim to model the annual biomass transition. Various performance measures and metrics such as throughput, total flow, biomass ratios (i.e. pelagic fish to zooplankton), and trophic reference points can be monitored over the simulated time horizon. The model will be used to evaluate how the GOM ecosystem responds to large and small-scale changes to the trophic components and system drivers. Specifi cally events such as climate change, various fishing scenarios, and system response to changes in the biomass of lower and upper trophic levels could be evaluated. EC-

OGOMAG has not been through a formal model review. This remains a research tool and has not been used for management purposes.

Study Group on Risk Assessment and Management Advice (SGRAMA) – ICES CM 2006/RMC:04

Review of IPCC Workshop on "Describing Scientific Uncertainties in Climate Change to Support Analysis of Risk and of Options" (IPCC, 2004)

The reviewed document from Intergovernmental Panel on Climate Change (IPCC, 2004) is a report from a workshop and presents risk and uncertainty from several angles. The main issue is uncertainty rather than risk: uncertainty related to science and socio-economic factors but also communication of uncertainty is emphasized. The workshop conclusions are more recommendations for future work within IPCC on uncertainty and risk so that it does not conclude on any framework for risk assessment or risk management. However there are some elements from this report that is worth noting. One is a presentation of the UKCIP approach, which is reviewed in Section 4.4. We will thus concentrate on the workshop's recommendations on how to handle uncertainty questions and some considerations on risk that are presented in different parts of the report.

Workshop recommendations

One of the conclusions at the workshop was a list of recommendations on how to handle uncertainty questions. These were:

- Authors should consider how to deal with uncertainty early on in their planning.
- Key issues requiring careful treatment of uncertainties should be identified as soon as possible.
- Consistency across the report should be maintained by using techniques for communicating uncertainty from among a set of options summarized in the guidance notes.
- Authors should consider both structural and statistical sources of uncertainty
- Authors should note the difference between likelihood and level of confidence in the underlying science.
- Probability distributions should only be used where there is high confidence in the underlying science.
- Traceable accounts should document the basis used for making expert judgment.

Risk

The goal of the workshop was not to agree on a risk framework, but frameworks are presented in papers at the workshop. The report shows that there is an agreement from 1998 on how to use the term "risk": "the likelihood that some event will occur or its expected frequency of occurring and the magnitude of the consequences of that event".

The report recognizes that there are a number of different approaches to assessing risk, from formal and quantitative to largely personal responses based on experience and perceptions. All these deal with uncertainty in one way or another and the qualitative and contextual aspects are always important. For example, asymmetry is often recognized in the sense that being wrong in one direction may have more serious consequences than being wrong in the other.

The report says that an aim is to enable users of the IPCC assessments to more easily relate effects of climate change to other risks, and to integrate decision on climate change with existing decision making frameworks for dealing with risks.

Further the report argues that it is important to distinguish between uncertainties in predicting the frequencies of events and the uncertainty in their consequences.

This is an example of how it links risk to uncertainty: "Probabilistic approaches can be applied to risk analysis when strict numeric probabilities can be defined, e.g. when long term statistics are available for stationary phenomena. Because of this, risk analysis is most easily linked to probabilistic approaches to uncertainty. However, risk analysis techniques are frequently adapted to deal with circumstances in which strict numeric probabilities cannot be defined. In either case, uncertainty analysis plays a key role in risk assessment."

Uncertainty aspects (selected)

In the report it is highlighted that there is a difference between the level of uncertainty and the level of confidence. By the level of uncertainty they mean the quantified uncertainty while the level of confidence refers to the degree of belief or confidence in a science community that available models or analyses are accurate. The confidence is based on both evidence and the more subjective interpretation of results. The report argues that both the quantified uncertainty and the confidence should be stated.

It is expressed that rather than presenting the single most likely prediction, a range of possible outcomes should be presented.

It is recommended that a comprehensive view of all plausible sources of uncertainty should be presented.

The report suggests how to present the knowledge that climate assessments are based on to reflect uncertainty aspects:

- Known: summarize present knowledge;
- Unknown: describe research needed to improve that knowledge;
- Unknowable: summarize what we are unlikely to be able to know before the changes actually occur.

The report presents an interesting view on the nature of uncertainty:

"The goal of making scientific understanding of climate change widely accessible raises particular challenges when it comes to dealing with uncertainty. Uncertainties are usually more difficult to quantify than the factors to which they apply; their treatment is more complex both conceptually and operationally; and the normal use of language to describe uncertainty is often ambiguous. In order to deal with uncertainty in a way that is coherent [...] and useful for decision making it is recommended that descriptions of uncertainty be designed in ways that will improve risk assessment. This approach recognizes that climate change will modify existing risks and in doing so introduce additional sources of uncertainty into risk assessment.

4.4 Review of the UKCIP Technical Report on "Climate adaptation: risk, uncertainty and decision making" (Willows and Connell, 2003)

The technical report of the United Kingdom Climate Impacts Programme (UKCIP) (Willows

and Connell, 2003) aims at providing guidance that helps decision and policy makers to take into account the risk and uncertainty associated with climate variability and future climate change and to identify and evaluate measures to mitigate the impact or exploit the opportunities presented by future climate. The report is structured in two parts. The first part presents a decision-making framework. The second part provides supporting material on risk assessment in general and risk-based climate change impact assessments in particular, including an overview of concepts related to risk and uncertainty.

Terminology

The basic definitions related to risk and uncertainty that are given in the report are as follows:

Hazard: Situation or event with the potential to cause harm.

Risk: Product of the probability or likelihood of an event occurring and the magnitude of the impact or consequence associated to that event. The reports remarks that in some cases in might be more useful to retain and communicate the likelihood and impact components of risk separately, as this will allow the decision-maker to decide policy and ethical issues. For example, if the decision-maker may wish to implement a policy of risk-aversion.

Uncertainty: Lack of knowledge. Thus, concerning risk uncertainty may result when the probabilities of the hazards and/or the magnitudes of their associated consequences are uncertain. However, even when there is a precise knowledge of these components there is still uncertainty because outcomes are determined probabilistically.

Three types of uncertainty are distinguished:

o) Natural variability

p) Data uncertainty arising from measurement error, incomplete or insufficient data

q) or extrapolated data.

r) Knowledge uncertainty referring to lack of knowledge about the processes or future outcomes. Model uncertainty is a particular case of knowledge uncertainty and includes uncertainty on model choice and structure; model input values, model parameters and model output variables.

Risk analysis: Process, by which knowledge concerning the probabilities, uncertainties and magnitude of future events is brought together, analysed and organised by the decision-maker.

Risk analysis includes risk assessment, risk evaluation, and the identification and assessment of risk management alternatives.

Risk identification: Process by which hazards are recognized and characterized.

Risk assessment: Process by which hazards and consequences are identified, characterized as to their probability and magnitude, and their significance assessed. Risk assessment may involve either quantitative or qualitative techniques. Qualitative

techniques are particularly useful in circumstances where we lack knowledge of the probabilities.

Risk evaluation: Component of risk assessment in which judgments are made about the significance and acceptability of risk.

Risk estimation: Rigorous determination of the characteristics of risks, usually progressing from qualitative to more quantitative approaches. These characteristics include the magnitude, spatial scale, duration and intensity of adverse consequences and their associated probabilities as well as a description of the cause and effect link.

Risk screening: Following initial identification of hazards and risks, risk screening is the process by which it is determined which risks should be investigated in more detail. Risk screening is usually based on ranking or scoring methods

Risk assessment endpoints: Explicit expression of the attributes, associated with a receptor that is to be protected or achieved. Risk assessment endpoints may represent an intrinsic threshold or an agreed, policy-defined threshold, at which decisions to manage the risk will be required. A measurement endpoint may be defined for the attribute in terms of the probability that a certain level of performance will be achieved over a defined period of time, and with a specified level of confidence.

Risk management: Any action or portfolio of actions that aim to reduce the probability and magnitude of unwanted consequences or manage the consequences of realized risks.

Tolerable risk: The willingness to live with a particular level of risk, in return for certain benefits, based upon a certain confidence that the risk is being properly controlled or managed.

Decision making framework

The decision-making framework is illustrated in Figure 4.4.1.

Study Group on Risk Assessment and Management Advice (SGRAMA) ICES CM 2007/RMC:02

Sections 4.1 and 4.4 of the 2007 report is the same as that in 2006 report (see above) – ICES CM 2006/RMC:04

Study Group on Fisheries Induced Adaptive Change (SGFIAC) – ICES CM 2007/RCM:03

Adoption of the agenda

The Terms of Reference for the Study Group on Fisheries Induced Adaptive Change [SGFIAC] are as follows:

s) assemble and review empirical evidence of fisheries-induced adaptive change and its consequences for conservation of biodiversity and sustainable exploitation of marine species, within an ecosystem context, including previous work by WGAGFM and WGECO;

t) evaluate the impact of existing management measures and tools, such as minimum mesh and landing sizes, precautionary reference points and ma-

rine protected areas, effort regulations, on fisheries-induced adaptive change;

u) develop appropriate scientific and methodological tools to monitor and respond appropriately to risk to biodiversity and sustainable exploitation posed by fisheries-induced adaptive change;

v) relate consequences of fisheries-induced adaptive change to current mangement objectives and evaluate possible more specific objectives for managing fisheries-induced adaptive change.

Introduction

While traditional fisheries management focuses on the demographic effects of fishing, ecological and evolutionary implications of fishing have received less attention. In particular, even though the earliest discussions about the possible evolutionary implications of fishing (Rutter, 1902) go back to the founding years of fisheries science, evolutionary thinking remained on the sidelines. The current drive towards an ecosystem approach to management recognizes a broader range of values and services of aquatic ecosystems than the classic yield-focused management paradigm (Garcia and Cochrane, 2005), and ecological and evolutionary effects of fishing are receiving increasing attention (Pikitch *et al*., 2004; Olsen *et al*., 2004). The ecosystem approach and the precautionary approach mandate assessing the broader impacts of exploitation. In particular, a precautionary approach "exercises prudent foresight to avoid unacceptable or undesirable situations, taking into account that changes in fisheries systems are only slowly reversible, difficult to control, not well understood, and subject to change in the environment and human values" (FAO, 1996). The ecosystem approach strives "to balance diverse societal objectives, by taking into account the knowledge and uncertainties about biotic, abiotic, and human components of ecosystems and their interactions and applying an integrated approach to fisheries within ecologically meaningful boundaries" (FAO, 2003). However, fisheries scientists are only now beginning to recognize that evolutionary effects of fishing do occur on top of ecological impacts, and that these effects can both ameliorate and aggravate demographic and ecological effects of fishing.

Fisheries-induced evolution is largely inevitable: fishing is essentially always selective (Law, 2000), and breeding programs with cultured fish show that heritable variability is essentially always present. The question then is not whether, but how fast, the induced evolutionary changes are occurring. Recent empirical and experimental evidence summarized later in this report clearly demonstrates that the rate of fisheries-induced evolution can be much faster than was believed earlier on, occurring at time scales directly relevant to fisheries management. In addition, fishing is not the only selective force that fish experience. Environments where fish are living are always changing, be it due to natural fluctuations, local anthropogenic impacts such as eutrophication, or climate change. Thus, fish populations are constantly under evolutionary selection pressures, and will continue to evolve, whether we want this or not.

Section taken from Section 11 of SGFIAC Report

Enhanced research The European Union's recent Green Paper on maritime policy (European Commission 2006b) emphasizes the importance of staying at the cutting edge of knowledge via marine-related science and research. Evolutionary change in exploited stocks is still a relatively new concept within fisheries science and management and the aim of promoting developments in this burgeoning field would thus

be in line with EU priorities. The Green Paper also stresses the importance of innovation under changing environmental circumstances. Like climate change, the evolution of exploited resources is a fundamental, and often still underappreciated, process requiring such innovation. For future progress, the Green Paper strongly encourages the development of processes and methods that help reduce uncertainties in impact and scale of environmentally unfriendly practices through the use of risk assessment methods.

Promising research approaches for addressing the four main goals set out in the Study Group's terms of reference are as follows:

- *ToR (a)* – Assemble and review empirical evidence. Measures to achieve this include the taxonomic and geographic extension of empirical studies of fisheries-induced evolution; the exploration of molecular evidence of fisheries-induced evolution; and the examination of fisheries-induced evolution in behavioural traits such as gear avoidance and mating preferences.
- *ToR (b)* – Evaluate the impact of existing management measures. Measures to achieve this include empirical and theoretical studies of the evolutionary effects and utility consequences of common management measures; understanding the evolutionary determinants of probabilistic maturation reaction norms; identification of fisheries-induced evolution syndromes resulting from multi-trait evolution; understanding the evolutionary dimensions of stock collapse and recovery processes; identification of the utility functions implicitly or explicitly applied in current management practices; and closer integration of eco-genetic models with bio-economic approaches.
- *ToR (c)* – Develop appropriate scientific and methodological tools. Measures to achieve this include the development of a decision-tree approach to evolutionarily enlightened fisheries management; adoption of risk assessment methods suitable for tackling fisheries-induced evolution; and the development of standardized approaches for removing phenotypic plasticity from life-history traits such as growth rates and reproductive efforts.
- *ToR (d)* – Relate consequences of fisheries-induced adaptive change to current management objectives. Measures to achieve this include the specification of practical measures and protocols for assessing susceptibility, desirability, and vulnerability to fisheries-induced evolution; development of new indicators and reference points suitable for monitoring and mitigating fisheries-induced evolution; and propositions for integrating requirements resulting from fisheries-induced evolution into current practices for monitoring, assessment, and advice.

It is hoped that the aforementioned agenda of enhanced communication and research will help overcome the current status of fisheries-induced evolution as a blind spot of contemporary fisheries management.