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Report of the ICES/GLOBEC Working Group on Cod and Climate Change (WGCCC)

by correspondence

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Contents

Executive summary

According to the recommendations given in the WGCCC 2008 report, ICES CM 2008/OCC:08, the ICES/GLOBEC Working Group on Cod and Climate Change (WGCCC), chaired by Dr. G. Ottersen, Norway, and Dr. Kai Wieland, Denmark, will, in its present format, be closing down at the end of 2009 together with GLOBEC.

WGCCC worked by correspondence in 2008–2009 (with a brief meeting in connection with the 2009 ASC) to:

a) publish the reports on three recent workshops, as reviewed by the Chair of the Oceanography Committee, in the *ICES Cooperative Research Report* series:
   i. Decline and Recovery of cod Stocks throughout the North Atlantic, including tropho-dynamic effects (WKDRCS),
   ii. Integration of Environmental Information into Fisheries Management Strategies and Advice (WKEFA),
   iii. Cod and Future Climate Change (WCFCC).

b) continue working towards finalizing the WGCCC book on cod;

c) contribute to the GLOBEC synthesis book;

d) plan and hold a theme session at the 2009 ICES ASC on Advances in marine ecosystem research: what we have learned from GLOBEC and what we can carry forward in future climate related programs;

e) organize a workshop at the 3rd GLOBEC Open Science Meeting Victoria, Canada, 22–26 June 2009, on *CCC – the past, the present and future challenges*.

1 Publication of group paper from the Workshop on the Decline and Recovery of cod Stocks throughout the North Atlantic, including tropho-dynamic effects (WKDRCS)

This workshop was held in St John's, Newfoundland, Canada, May 2006 and a report was promptly published (ICES CM 2006/OCC:12). More recently a peer-review group paper on Decline and Recovery of cod based upon the results of WKDRCS was published. This paper (Lilly *et al*., 2008) was co-authored by most of the participants at WKDRCS and presented at the Lowell Wakefield Fisheries Symposium on Resiliency of Gadid Stocks to Fishing and Climate Change in Anchorage, Alaska, USA, 31 October – 3 November 2006. Several WGCCC members participated at this symposium.

2 CCC contribution to 3rd GLOBEC Open Science Meeting

In addition to being an ICES working group, CCC has also been the North Atlantic regional programme of GLOBEC. CCC researchers contributed significantly to the 3rd GLOBEC Open Science Meeting held in Victoria, Canada, 22–26 June 2009. Plenary talks included an invited lecture by Svein Sundby on Impacts of climate and three presentations in the Ecosystem structure and functioning session: Christian Möllmann: "Induced synchronous regime shiftsalong environmental and diversity gradients in Baltic Sea sub – systems", Jeffrey Runge: "Bottoms up: potential effects of environmental forcing on apex predators in the Gulf of Maine", and Geir Ottersen: "Spawning stock and recruitment relationship in North Sea cod shaped by food and climate". Further, former CCC chair Kenneth Drinkwater co-convened a workshop on "Comparisons of processes and climate impacts in sub-Arctic and Antarctic marine ecosystems: observations and modelling approaches". The main contribution of CCC to the meeting was the workshop dedicated to the group: "Cod and Climate Change - the past, the present and the future". The workshop was co-convened by Drs Øyvind Fiksen (University of Bergen, Bergen, Norway) and Jeff Runge (University of Maine, Portland, ME, USA). Their report, as published in the GLOBEC Newsletter (Fiksen and Runge, 2009), is given below:

"The workshop attracted an audience of 20–30 scientists, and consisted of a series of scientific presentations with time for discussions in between. Geographically, we obtained a good spread covering most large stocks in the North Atlantic. Thematically we covered time - series analysis, comparative analysis, numerical modelling and genetics, reflecting former activities in the Cod and Climate Change (CCC) working group. Also, in the spirit of GLOBEC, the workshop was remarkably multidisciplinary, with physical oceanographers, ecologists, geneticists, physiologists and fisheries science well represented in the audience and among speakers. In retrospect, the intellectual nursery area and trans - boundary, trans – Atlantic or cross - disciplinary meeting point that CCC (and GLOBEC) has been, is difficult to measure, but may be an important achievement in itself.

As our first keynote speaker, Keith Brander reviewed the aims, history and evolution of CCC. Brander pointed out that there has been a transition in focus of the activities of the working group since its beginning in 1992: 1) from recruitment to productivity of fish stocks; 2) from climate variability to anthropogenic global warming, 3) from single - species book - keeping assessments to ecosystem approaches. In his presentation, Keith integrated the meetings and activity - history of CCC spiced with scientific highlights. Apparently, most progress has been achieved in understanding growth

processes of cod, both larval and adults, particularly in how these are influenced by temperature and food. Some concern was raised on our limited predictive ability, which also relates to the weakness of global and regional climate models in capturing essential modes of North Atlantic variability. As a conclusion, he pointed at the current high levels of fishing mortality in many cod stocks, and argued that reduced fishing mortality is a win - win - win, no regret strategy.

Geir Ottersen has also been instrumental to the CCC programme, and gave an invited talk about applications of time - series analyses and retrospective studies of cod and climate. One of the main points in his talk was the evidence suggesting that cod is more sensitive to climate variability as mean age of spawning stock decline and at lower levels of SSB. On the positive side, he also referred to a study suggesting that cod had survived the last ice - age on both sides of the Atlantic. This may mean that cod are quite resilient to climate change – at least given the appropriate time for natural selection to act on the gene pool, a topic also addressed by Ian Bradbury during the workshop.

Christian Möllmann reviewed the story about the Baltic cod stock, emphasizing that it is different from most other stocks in many respects, such as its dependence on oxygen and salinity conditions rather than temperature in recruitment variability. Also, compared to elsewhere, the ecological interactions of Baltic cod with zooplankton and sprat is quite well understood, and is an obvious textbook example of ecological dynamics. Christian presented some new and rather complex simulations using 'Biological Ensemble Modelling' with the reassuring prediction that reduced fishing pressure will increase stock and yield in any climate scenario.

Ian Bradbury discussed his research on fine scale genetic differentiation among cod stocks, addressing questions about the meaning of differences in genetic population structure and in terms of adaptive responses. Genes associated with temperature - physiology were found to vary among different stocks. The findings suggest parallel temperature associated clines on either side of the Atlantic, consistent with parallel adaptive co - evolution of multiple genes in response to gradients in ocean temperature. Such polymorphism is important to maintain to increase the resilience of stocks to climatic fluctuations. The research documents the presence of small - scale local adaptation despite high dispersal potential and provides a foundation of knowledge for spatial management of Atlantic cod based on its genetic population structure.

Brian Rothschild and colleagues presented a large compilation of time - series data on heat - budgets in the Gulf of Maine and Georges Bank region. Their analysis suggests that a dramatic net increase in heat flux has taken place over measurements. Their analysis indicates that the impact of the Arctic Ocean and Labrador Sea climates on the Gulf of Maine region has significantly increased. This upstream effect is much stronger than the change of heat flux due to climate – induced local weather change. It is likely that major oceanographic events in the 1990s indicated by lower surface salinity have affected fish stocks including cod by reducing condition and increasing natural mortality rate.

Jeffrey Runge put forward a combined observing and modelling strategy for forecasting effects of climate change on the dynamics of spatially structured cod populations spawning in the western Gulf of Maine. Present understanding indicates at least two genetically differentiated complexes that likely diverge in trophic interactions and physiological and behavioural responses to different winter and spring environments. Coupled physical - biological modelling has advanced to the point where forecasting of environmental conditions for recruitment into each of the two popula-

tions is feasible, backed by hydrographic, primary production and zooplankton data collected by local remote sensing and fixed station sampling. Forecasts of environmental influences of dispersal and growth of planktonic early life stages, combined with understanding of possible population - specific usage of coastal habitat by juveniles and differential resident and migratory patterns of adults can be used to develop scenarios for spatially explicit population responses to multiple forcings, including climate change, anthropogenic impacts on nearshore juvenile habitat and management interventions such as regional fisheries closures.

Anna Neuheimer presented a very interesting attempt to disentangle the effects of fishing and climate on size - at – age changes in cod. Is the decreasing size - at - age caused by temperature, food or fisheries - induced evolutionary effects? By calculating the 'growing degree - days' for various species, she showed that this effectively captures the temperature - effect of size - at - age. She then checked for food - effects on the slope of the length - at - age vs. degree - days, but found none, and concluded that the decreasing length - at - age is not caused by reduced immature growth rates. Instead, she suggested that fisheries targeting the largest proportion of the stock have led to fisheries - induced evolution, earlier maturation and reduced post - mature growth rates.

Trond Kristiansen is one of the young modellers doing the hard work of building and debugging large computer codes integrating physical oceanography, larval fish physiology, behaviour and plankton ecology. In his talk, he presented model confirmation of how the different latitudes and in particular, the light regimes, of Georges Bank and the Barents Sea creates differences in the phenology of these cod stocks.

In the end, it was perfectly natural for Svein Sundby and Brian Rothschild to provide closing statements for the CCC programme, representing the continuity from beginning to end. They emphasized the integrative effects this activity has had in the marine science community, creating common ground for many disciplines. The closing discussion highlighted: ongoing and further needs to provide an overall synthesis of CCC findings, the need for processes to put findings into a management context and to interact with the stock assessment community (why the stock assessments need GLOBEC), the role of coupled physical biological modelling, data and modelling needs for mechanistic depictions of climate forcing for recruitment forecasting 3–4 years ahead and for predicting changes to overall ecosystem productivity, relationships and synthesis between the Foci and GLOBEC programmes, and the need to consider genetic population structure in ecosystem approaches to management.

A group of interested workshop participants met later in the week after the workshop to discuss possible final synthesis actions to complete the work of the ICES Cod and Climate Change working group. A two day workshop, scheduled to take place in Copenhagen in November, has been supported by the GLOBEC office to plan the writing of a final, forward looking synthesis paper. Possibilities include: 1) a paper directed to the stock assessment community indicating advances in and applications for approaches to forecasting environmental conditions for recruitment and ecosystem productivity changes, 2) a paper discussing the important problems for understanding cod and climate change in the future, including the contribution of new approaches in genetic analysis and study of fine scale population structure or 3) a final "synthesis of syntheses" paper highlighting the findings of CCC and next steps forward.

3 Synthesis Theme Session at ICES ASC 2009

Theme Session C. Advances in marine ecosystem research: what we have learned from GLOBEC and what we can carry forward in future climate related programs

Conveners: Geir Ottersen (Norway), Keith Brander (Denmark), and Mike Fogarty (USA)

The Cod and Climate Change programme (CCC) has stimulated a wide range of research on cod, the ecosystems in which it occurs and the physical, biological and human drivers which shape its life history and population dynamics. The Theme Session, which included ten oral presentations, was intended to be an opportunity to take stock of what we have learned and to ask what progress we have made in resolving some of the issues which provided the scientific and management impetus for the CCC programme. The CCC programme was set up to take a broad ecological approach to issues in fisheries management and to widen the scientific community who attend and contribute to the work of ICES. The papers represented a range of scientific disciplines, from physiology to global climate models. We can learn from GLOBEC that collaboration across disciplinary boundaries can be readily achieved and new scientists brought into ICES work by a strategic plan that has well defined and tractable problems in which they can recognize how their special expertise will contribute to a solution. Several of the specific scientific advances reported at the Session (see details below) can clearly be carried forward in future fisheries and ecosystem assessment and management. However another lesson from GLOBEC is that integrating such knowledge is difficult and the advisory side of ICES has not been welcoming to the programme or to the results it has produced. A report from the Theme session has been given to ICES

(http://www.ices.dk/iceswork/asc/2009/Theme%20sessions/TS-C-report.pdf) and is included as Appendix 1.

4 Contributions to GLOBEC book

The book (Barange *et al*., 2010) will be published in spring 2010. A number of scientists who are active in CCC wrote parts of this book.

5 CCC book - status

Most of the major chapters prepared for the book have now been published as review papers in journals and are thus available as separate chapters. great deal of work is required to transform them into a coherent book as planned. Unfortunately the two editors have been heavily committed to other work, including the GLOBEC book, and have not been able to carry out this task. The publishers have been sympathetic to this difficulty and have agreed to extend the submission date.

6 Contributions to the workshop on the "Impact of Climate Variability on Marine Ecosystems: A Comparative Approach"

The outcome of this workshop, held on 4–8 September 2006 in Berlin, Germany, is to be published as a special issue of Journal of Marine Science, due out February 10 2010. One of the current co-chairs (Geir Ottersen), the former chair (Ken Drinkwater), and the former ICES/GLOBEC coordinator (Keith Brander) were all active participants, each being lead authors of one paper and contributing to others. A total of 30

scientists, including several other CCC members, from nine countries participated in the workshop. The goals of the workshop were to survey large-scale and long-term ecosystem changes throughout the world's oceans, to identify apparent synchronies between these changes, and to gain insights into the causes and mechanisms underlying the major changes. This was accomplished by bringing together representatives of GLOBEC programmes and others to discuss the interactions, ramifications, and potential connections between climate and marine ecosystems. The workshop built on the already strong interdisciplinary participation between physical oceanographers, biological oceanographers, and fisheries scientists in the GLOBEC national and regional projects. To strengthen this interdisciplinarity, paleo-oceanographers, climatologists and historians were also invited to provide additional insight into the mechanisms leading from atmospheric signals to changes in marine populations and ecosystems.

7 Final synthesis workshop (Copenhagen)

Due to other commitments only three people were able to take part in this meeting to discuss further follow-up work from CCC. The main discussion focussed on outlining a draft for a paper that would address the central theme from the GLOBEC programme, namely the role of zooplankton in the physical and biological coupling of marine ecosystems leading to fish. The paper will deal with the impact of zooplankton abundance and production on Atlantic cod, taking climate into account, with Jeff Runge and Øyvind Fiksen as lead authors.

8 Plans for future WGCCC related work

Since WGCCC was founded in 1992 many aspects within the large field of climate and environmental effects on fish populations have been covered. Workshops resulting in comprehensive reports have dealt with topics including (relatively recently) larval transport, growth, the role of zooplankton, decline and recovery of cod stocks, integration of environmental information into fisheries management strategies and advice, and the future in a changing climate. Cod has been the study species throughout, but much of the knowledge is applicable in a wider context. The group has built areas of expertise including the relationship between ecosystem change and fish population dynamics, the application of environmental information in the fisheries advisory process, and the role of climate in determining spatio-temporal dynamics in fish populations. WGCCC will, together with GLOBEC, be terminating its activities as a group at the end of 2009, but the expertise gathered should be carried forward in future climate related programs or groups within ICES. ICES is developing a climate related programme, but the outcome of this still remains unclear. Hopefully, when established, this will give an opportunity for our line of work. Ottersen, on behalf of WGCCC, is contributing to the "white paper" currently being developed on climate related work within ICES.

Ongoing GLOBEC programmes, and especially the relatively recently started ESSAS, CLIOTOP and ICED are expected by IGBP to amalgamate into ongoing IMBER activities. IMBER could then be a natural home also for CCC related work. However, it is difficult to say how IMBER will evolve from 2009. This, to a large degree, depends on the IMBER SSC, which currently is swayed towards ocean biogeochemistry, not ecology. However, the transition task theme (lead by John Field) is looking at amalgamation.

There are several international programmes that may be an outlet for work now done within WGCCC. This includes EUROCEANS, BASIN, and ESSAS (within or independent of IMBER).

9 References

Barange, M., J. Field, R. Harris, E. Hofmann, R.I. Perry, F. Werner (eds.). 2010. Marine Ecosystems and Climate Change. Oxford University Press, Oxford.

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Lilly, G.R., Wieland, K., Rothschild, B.J., Sundby, S., Drinkwater, K.F., Brander, K., Ottersen, G., Carscadden, J.E., Stenson, G.B., Chouinard, G.A., Swain, D.P., Daan, N., Enberg, K., Hammill, M.O., Rosing-Asvid, A., Svedäng, H., and Vázquez, A. 2008. Decline and recovery of Atlantic cod (Gadus morhua) stocks throughout the North Atlantic. In Resiliency of gadid stocks to fishing and climate change. Edited by G.H. Kruse, K. Drinkwater, J.N. Ianelli, J.S. Link, D.L. Stram, V. Wespestad, and D. Woodby. Alaska Sea Grant, University of Alaska Fairbanks. pp. 39–66.

Annex 1: Theme Session C

Theme Session C. Advances in marine ecosystem research: what we have learned from GLOBEC and what we can carry forward in future climate related programs

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RESEARCH THEMES OF THE CCC PROGRAMME	C:01	C:02	C:03	C:04	C:05	C:06	C:07	C:08	C:09	C:10
Recruitment and the role of environmental variability	*		*	*	*		*	*		
Linkages with zooplankton dynamics	*							*	*	
Growth, Maturation										*
Productivity and sustainability		*	*		*			*	*	
Transport and Biophysical modeling						*				
Trophic relationships	*		*				*		*	
Climate impacts – past present and future	*		*	*	*			*	*	
Analysis of time series	*	*	*	*	*		*	*		

The CCC programme was set up to take a broad ecological approach to issues in fisheries management and to widen the scientific community who attend and contribute to the work of ICES. Two of the speakers were new to ICES and the papers represented a range of scientific disciplines, from physiology to global climate models. We can learn from GLOBEC that collaboration across disciplinary boundaries can be readily achieved and new scientists brought into ICES work by a strategic plan that has well defined and tractable problems in which they can recognise how their special expertise will contribute to a solution. Several of the specific scientific advances reported at the Session (see details below) can clearly be carried forward in future fisheries and ecosystem assessment and management. However another lesson from GLOBEC is that integrating such knowledge is difficult and the advisory side of ICES has not been welcoming to the programme or to the results it has produced.

Martin Lindegren's talk (C:01) on Ecological Forecasting under Climate Change – the case of Baltic cod argued that statistical food web models can represent interactions between species and effects of fishing and environmental factors with sufficient precision and confidence to provide a basis for fisheries management. Such ecological forecasting tools must account for uncertainties and provide quantitative assessments

of the risks associated with management actions under different climate change scenarios. He showed using a multivariate autoregressive model for the Baltic Sea ecosystem (BALMAR – see Figure 1) how the risk of extinction of cod depends on adjusting the fishing mortality to the changes in salinity over the period to 2100. The model could also be adjusted to include new species, such as anchovy, which may become more abundant in the Baltic as it becomes warmer.

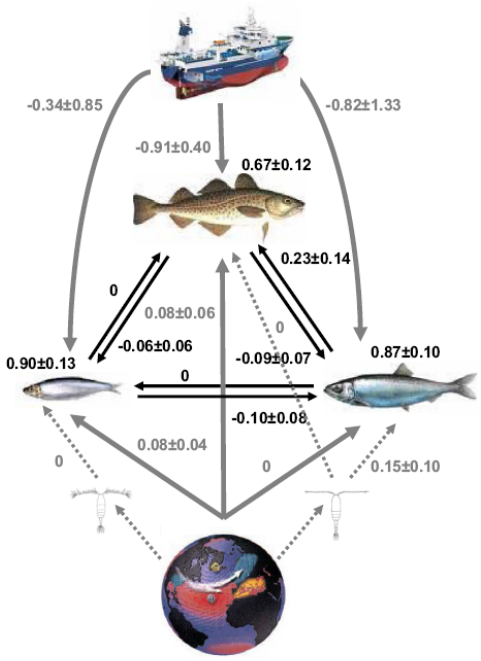

Fig. 1. A schematic view of the Baltic Sea upper-trophic food web. Black arrows and parameters represent species interactions between cod (*Top*), sprat (*Left*), and herring (*Right*). Gray arrows and parameters demonstrate the effects of fishing, climate, and zooplankton on the three species. Interactions with the key zooplankton species *Acartia* spp. (*Left*) and *P. acuspes* (*Right*) are illustrated by dotted arrows. Negative parameter values indicate negative effects on the biomass of the species and vice versa. Intraspecific parameters <1 indicate an increasing degree of density dependence in the population. Zero parameter values indicate interactions excluded during model selection. Note that even though it is statistically uncertain we decided to include the fishing effect on sprat and herring because they are heavily exploited by commercial fishing. Climate image is from www.ldeo.columbia.edu/res/pi/NAO.

Ray Hilborn's talk (C:02) on Comparative changes in fish communities in marine ecosystems was based on an article (Boris Worm *et al*., Science 325, 578 (2009)) that analysed recent trends in 20 marine ecosystems around the world from a fisheries and conservation perspective. It arose from a wish to reconcile opposing views concerning the state of exploitation of global fisheries and the effectiveness of current fisheries management. While there is agreement that many stocks have been overfished and that fishing mortality remains high in many cases it is also clear that levels of fishing have been reduced in recent years and some ecosystems are showing evidence of recovery. Exaggerating the failures is unhelpful in dealing with the problem of overfishing and we can learn a great deal from the successes of fisheries management, rather than oversimplifying and calling for extensive protected areas (which are only one tool among many).

Kai Wieland (C:03) described the geographic changes that have taken place in the fisheries for cod and shrimps at Greenland since the 1920s. The question posed in the title is whether climate change can reverse the shift from cod to shrimp as the dominant fishery? He did not think we knew enough to answer this as it depends not only on the climate but also on geographic overlaps, predation by other species (although

Greenland halibut predation is probably minor) and the rebuilding of cod stock biomass, probably with a major input of juvenile fish from Iceland.

Irene Mantzouni (C:04) extended the meta-analysis she presented a year ago to include haddock and to contrast their dynamics with cod. Her principal finding was that temperature has a positive effect on haddock recruitment across the ten stocks she studied and this effect is stronger than for cod (where the effect of temperature switches to negative above a median value of temperature). She found that density dependent regulation is related to the area of available habitat for both species. A questioner stated that the area occupied by haddock had greatly increased at Iceland and asked how habitat area is measured. It is the area within a fixed depth contour for each stock.

Anatoly Filin (C:05) developed a model (STOCOBAR) that predicts changes in cod biomass, growth and maturity and resilience to fishing pressure in the Barents Sea. Coupled physical-biological models predict an increase in plankton production and the rates of cod recruitment growth and maturation are expected to increase. However predation and cannibalism will likely also increase. Scenarios with a 1 and 2°C rise in temperature produced increases in cod yields in the model and increases in the fishing mortality that the stock could sustain (from 0.4 at status quo to 0.55 for a 1°C increase and 0.8 for 2°C). Recruitment is expected to increase in spite of a projected decrease in spawning biomass.

Manuel Hidalgo (C:06) combined particle tracking modelling with spatial analysis to explore the dynamics of cod larvae and 0-group in the Barents Sea during the period 1986-1991. Spawning biomass, inflows and NAO all varied during this period. Survival and growth were affected by spatial location of spawning and by temperature during two "regimes" (1986–88 and 1989–91). Future improvements to the model will include vertical movement, spatial variation of spawner by size and survival during the first weeks of life.

Dag Hjermann's work (C:07) stemmed for an earlier paper that looked at the consequences on northeast Arctic cod stock of "competition between fishermen and fish" for the Barents Sea capelin and re-examined the roles of fishing and trophic interactions in causing capelin stock fluctuations. The time series extends back to 1970 and the analysis shows strong predation effects on capelin due to herring (on larvae) and cod (on spawners and offspring), but also strong density dependent mortality when other food is less abundant. Harvesting probably had quite a small effect on the 1990s collapse in capelin. The study identifies trophic interactions as important in determining the dynamic structure of high latitude marine ecosystems.

Geir Ottersen (C:08) fitted stock-recruit curves to North Sea cod and included both environmental (temperature) and biological (zooplankton) information. He concluded that the form of the relationship between spawning stock biomass and recruitment shifted from a more asymptotic (Beverton-Holt) shape when temperatures were low and zooplankton values high towards a more overcompensatory (Ricker) fit during the opposite conditions. This means that fisheries reference points such as F_{msy} change with the food and metabolic environment for larvae, probably due to effects on their survival. The conclusion is that "recovery" of the North Sea cod stock to earlier levels should not be expected unless the environmental (and biological) conditions become more favourable.

Charles Stock (C:09) questioned the traditional trophic pyramid view and sought to estimate how global variability in the ratio of mesozooplankton production to primary production (the z-ratio) may be affected by nutrient enrichment, temperature

and euphotic zone depth. The aim was to look for patterns in complex foodwebs and the data came from widely different ecosystems and included small and large phytoplankton groups. The z-ratio increased with primary productivity; low-productivity subtropical gyres had z-ratios an order of magnitude smaller than upwelling systems. The transition from low to high z-ratios occurs at lower primary productivity in cold-water ecosystems. The causes of this pattern in z-ratios is probably higher zooplankton gross growth efficiency once ingestion exceeded basal metabolic requirements and reduced trophic distance between primary producers and mesozooplankton when phytoplankton are bigger. The implication of this pattern in relation to increasing sea temperature is of concern for future marine productivity.

In the final talk (C:10) Jonna Tomkiewicz explored the relationship between changes in timing of cod spawning in the Baltic Sea and seasonal changes in the availability of essential fatty acids (EFA) in their diet. It appears that maturation of the ovaries of Baltic cod could be delayed because of lack of arachidonic acid (ARA) in their diet even though their total lipid levels are higher than North Sea fish, which have not changed their spawning time. Since EFAs originate from phytoplankton it is likely that the change in timing of cod spawning is caused by ecosystem changes that affect phytoplankton composition. Changes in the timing of cod spawning have occurred in other areas (e.g. the Scotian Shelf) and it would be interesting to investigate whether similar processes are at work

Annex 2: WGCCC Terms of reference 2008

The **ICES/GLOBEC Working Group on Cod and Climate Change** (WGCCC) Co-Chairs: G. Ottersen, Norway and Kai Wieland, Denmark, will, in its present format, be closing down at the end of 2009 together with GLOBEC. WGCCC will work by correspondence in 2008–2009 (with a 2 hour meeting in connection with the 2009 ASC) to:

a) publish the reports on three recent workshops, as reviewed by the Chair of the Oceanography Committee, in the *ICES Cooperative Research Report* series:

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e) organize a workshop at the 3rd GLOBEC Open Science Meeting Victoria, Canada 22-26 June 2009 on *CCC – the past, the present and future challenges*.

WGCCC will report by 1 November 2009 for the attention of the SCICOM.

Supporting Information

Priority:	The group is developing the application of environmental information in the Advisory Process and also the relationship between ecosystem change and fish population dynamics. It therefore has high priority.
Scientific justification and relation to action plan:	The work will be carried out to review past activities, and carry out synthesis activities including books, the workshop and theme sessions. By the end of 2009 we aim to have thoroughly covered all items in our Strategic plan.
Resource requirements:	The research programmes which provide the main input to this group are already underway, and resources 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 15–20 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.
Linkages to advisory committees:	Linkages with advisory committees are being developed.
Linkages to other committees or groups:	Living Resources Committee, WGZE, and WGRP Expert Groups
Linkages to other organizations:	Close linkages with other GLOBEC activities and also some links to PICES.