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## Report of the Working Group on Zooplankton Ecology (WGZE)

30 March – 2 April 2009

Torshavn, Faroe Islands



**ICES**

International Council for  
the Exploration of the Sea

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## Executive summary

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The ICES Working Group on Zooplankton Ecology (WGZE) met at the Faroe Marine Research Institute (FAMRI), Tórshavn, Faroe Islands from 30 March–2 April 2009. Our local host was Eilif Gaard from FAMRI. The meeting was attended by 25 scientists representing 12 countries (Annex 1).

During the meeting the WGZE addressed our current five terms of reference (ToRs), discussed ideas for future WGZE initiatives, considered several addition items of relevance to the group and our mission, and presented updates from several members on current research initiatives. Refer to section 2 for a summary of each ToR.

The discussion of ToR a) focused on developments in plankton research and monitoring that advance priority research objectives identified in the ICES Science Plan 2009–2013. The collection of zooplankton time-series is relevant to all of the Science Plan objectives. As the time-series data accumulate, relationships are emerging with climate forced physical processes. The Plankton Status Report has developed into a particularly valuable summary of how zooplankton respond to climate change. Multinational zooplankton observing programs in the Baltic Sea were examined for strengths and weaknesses in addressing ICES Science Plan objectives. While those sampling programs have the capacity to indicate changes in biodiversity including planktonic forms of marine invasive species, work needs to be done to understand mechanisms of climate change influence and to integrate zooplankton observing into surveys supporting ecosystem assessment and management. Observational data on zooplankton combined with developments in coupled physical biological modelling, will advance our mechanistic understanding of climate forcing on marine ecosystems and lead to predictions of ecosystem state and processes influencing fish population dynamics. Physical circulation models of appropriate resolution for the spatial scale in question have been coupled to NPZ, copepod life history and larval fish trophodynamic models with increasing success, demonstrating potential to predict environmental conditions for recruitment. Such coupled physical-biological models can be applied in the context of spatially explicit planning and management. One aspect of zooplankton research that is of particular importance for understanding climate change impacts on marine ecosystems is the effect of ocean acidification, not only on calcareous organisms, but also on physiological processes in non-calcareous zooplankters.

ToR b) summarized the outcomes of past meetings (joint WGZE/CIESM, joint WGZE/WGPBI, ASC Theme Session Q). The joint WGZE/CIESM workshop in Greece was successful with very good presentations and good discussions though contributions from research in the North Atlantic could have been greater. Papers resulting from the workshop will be published in an ICES Cooperative Research Report. The joint WGZE/WGPBI meeting was also productive and provided a basis for future joint ventures between the two groups. Theme session Q (Evidence of global warming effects on zooplankton populations and communities, including larvae of benthic invertebrates and fish), was part of the ICES Annual Science Conference in Halifax. The session attracted a total of 22 contributions that addressed a diverse range of topics.

ICES is funding digitization of historical data. ToR c) tasks the WGZE with evaluating the progress of this initiative. This project was regarded by the group as highly important and we recognized the challenges associated with an undertaking of this magnitude. The group recommends that a sub-group of the WGZE should evaluate

the progress of the project based on a review of the next semi-annual report. The WGZE is highly supportive of this initiative and recognizes the value of conservation of historical data and looks forward to the next report from SAHFOS.

Todd O'Brien summarized recent developments and proposed improvements to the Plankton Status Report (ToR d). This Report Series, started in 2001, has now completed seven publications. For the 2008 Cooperative Research Report, several new features were introduced, including: (1) a dedicated section describing in detail the analysis and standard figures; (2) each region now starts with a summary introduction and map of all sites; (3) highlights and summaries for each sampling area, including a summary of the top ten taxa; (4) standard figures for results; (5) multivariate plots were provided to show interannual and seasonal patterns within each monitoring site; (6) each site was compared to a 100 year time series of Reynolds sea surface temperature anomalies; and (7) an update to the CPR analysis of standard areas within the North Atlantic. Steps have been taken to improve access to the report via the ICES Data Centre website. At the time of the working group meeting, the ICES website was three years behind in listing the available zooplankton reports. An update request was sent to the ICES web master, and these updates were finally added in late April. A mechanism for providing access to the time-series data would be for the WGZE to release the anomaly fields and monthly means through the WGZE site (<http://wgze.net>) as these data must be cited to be usable anyway. The WGZE site will provide PI and contact person information for each dataset and include links to institutional websites. As an expansion to the Plankton Summary report, or as a new WGZE data product, there is a potential to post seasonal or monthly climatologies (perhaps pentadal (i.e. 5 year)) for spatial zooplankton summaries and fields (gridded mean fields of biomass and/or group abundance data, hydrographic parameters, nutrients, chlorophyll). These fields would summarize the North Atlantic zooplankton ecosystem and environment, and would be very useful for modellers.

Taxonomy, the general loss of taxonomic expertise, and new molecular and image-processing approaches to taxonomy were a central focus of discussion (ToR e) and elsewhere) during this meeting. Of importance was development of practical mechanisms for ICES to promote marine taxonomy and to provide a support service to scientists within the ICES domain of expert groups and advice generators, and to a wider public. The group strongly supported the urgent need for proper integration of molecular genetics methods and the traditional morphology based approaches. The group further recognized that marine species include many more than just plankton, although most benthic species and fish develop through planktonic stages, which are often notoriously hard to identify. The group supported a statement recognizing the fundamental importance of taxonomy in general and evolutionary biology, ecology, and environmental management. The WGZE recommends to ICES that a Study Group on Integrated Morphological and Molecular Taxonomy be established to provide oversight of existing and future developments and continuity of taxonomic best practice for the wider ICES research community. Membership in the Group should be drawn from relevant ICES expert groups (e.g. WGZE, WGHABD, WGFE, WGBE) and others across ICES nations.

The forthcoming ICES Position Paper on Climate Change will require input from the WGZE (ToR f) in the form of a chapter (Overview of trends in plankton communities in the ICES area, including jellyfish) to be written jointly by WGZE and HABD. The group noted the short time for delivery of this chapter, but felt that a recently prepared report for OSPAR could form the basis of this new product. The group agreed

upon a structure for the chapter and a deadline for submission of 1 June 2009. Priscilla Licando and Michel Harvey agreed to act as editors for this document.

In addition to these ToRs, the group discussed collaboration for a pan regional synthesis of life histories of *Calanus* species in the North Atlantic and North Pacific, potential funding opportunities from a forthcoming FP7 request for proposals, an overview of the BASIN program, and an update on the Census of Marine Zooplankton (CMarZ) with a request that the WGZE consider playing a role in assisting with Steering after funding for CMarZ ends in 2010. The group developed plans for new WGZE initiatives for the future, which included suggestions that we consider theme sessions for the forthcoming 5<sup>th</sup> International Zooplankton Production Symposium, mechanisms for updating the ICES Zooplankton Methodology Manual, a workshop to compare new optical (and perhaps) molecular techniques for studying zooplankton, developing means of sustaining, training, and integrating new and traditional taxonomic tools, and conducting of studies to determine the physiological tolerances and factors that control the ranges of zooplankton.

Seven new ToRs for 2010 were identified:

- a) review the outcomes of new initiative proposals and select one or more future initiatives based on a review of planning letters summarizing potential programs;
- b) review progress towards a proposal for a Study Group on Integrated Morphological and Molecular Taxonomy focused on the broader ICES community;
- c) review the progress of:
  - 1) the ICES historical dataset digitization project;
  - 2) new enzymatic and size-classed methods for zooplankton;
  - 3) the outcome of the 2009 ASC Session A;
- d) prepare and improve the ICES Plankton Status report including an examination of regional and cross-basin trends and recommend a means of incorporating species information into the report;
- e) review plans for sessions and activities during the 5<sup>th</sup> Zooplankton Production Symposium;
- f) review the report on Zooplankton and Climate Change for the ICES Position Paper on Climate Change and revise as necessary based on comments from the SGCC;
- g) assess and report on potential linkages and encourage joint activities with the proposed Microbial Oceanography Working Group, should it be established by SCICOM.

The WGZE proposes to meet next time at the Gulf of Maine Research Laboratory, Portland, Maine USA from 23 to 26 March 2010 at the kind invitation of Jeffrey Runge.

## **1 Opening of the Meeting, Introductory Remarks, Logistical Information**

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The ICES Working Group on Zooplankton Ecology (WGZE) met at the Faroe Marine Research Institute, Tórshavn, Faroe Islands from 30 March–2 April 2009 at the kind invitation of Eilif Gaard from the Faroe Marine Research Institute. The meeting was attended by 24 scientists representing 12 countries (Annex 1).

Mark Benfield (Chair) opened the meeting at 11:00 and welcomed the attending scientists. This was followed by a round of introductions and a welcome and comments on the logistical arrangements from Eilif Gaard, our local host.

## **2 Adoption of the Agenda**

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The agenda for the WGZE meeting (Annex 2) followed the Terms of Reference adopted as a resolution by the ICES 2008 Annual Science Conference and Statutory Meeting. The agenda had been circulated amongst the working group membership prior to the meeting and incorporated most suggestions and comments. Last minute adjustments were discussed and the agenda was adopted. The Terms of Reference for this meeting are to:

- a) produce a summary of recent developments in plankton research and monitoring (e.g. seasonality, abundance, community structure, biodiversity, evidence/rationale for incorporating zooplankton in monitoring) with a view to further analysis and subsequent publication.
- b) assess and report on the outcomes of WKZEM, the ASC 2008 theme session Q, and the 2008 WGZE/WGPBI joint meeting.
- c) provide expert knowledge and guidance to ICES Data Centre on a continuous basis including a progress on the digitizing project and begin an inventory of historical data and samples.
- d) review the ICES Plankton Status Report and report on the progress of linking the Status Report data to the ICES data centre.
- e) review progress in zooplankton taxonomy with particular reference to developments within ICES.
- f) produce an overview of trends in plankton communities in the ICES area, including jellyfish, for the ICES Position Paper on Climate Change.

As several of these ToRs were interrelated, the group had decided to discuss ToRs a), d) and f) on the same day. WGZE will report by 1 May 2009 for the attention of the SCICOM and ACOM.

### 3 Overview of the BASIN Program

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**Lead: Peter Wiebe, Rapporteur: Arno Põllumäe**

BASIN (Basin-scale Analysis, Synthesis, and Integration) is an initiative to develop a joint EU/North American ocean ecosystem research program for resolving the impact of climatic processes on ecosystems of the North Atlantic basin and shelf seas.

Biological consequences or changes in water mass structure expected under climatic warming are: changes in the range and spatial distribution of species; shifts in the location of biogeographical boundaries, provinces, and biomes; change in the phenology of species (e.g. earlier reproductive season); modification in dominance (e.g. a key species can be replaced by another one); change in diversity; change in other key functional attributes of marine ecosystems; change in structure and dynamics of ecosystems with possible regime shifts.

In Europe warm-water species have extended their distribution northwards by more than 10° of latitude, while cold-water species have decreased in number and extension. In the northwest Atlantic New England region, temperature change has been less noticeable, but salinity change has been large. Between the late 1980s and early 1990s, upper-ocean circulation in the Arctic Ocean changed substantially after an atmospheric regime shift. These changes included an increased discharge of relatively low-salinity water into the North Atlantic through both the Canadian Archipelago and Fram Strait. There was a major low salinity event in the 1990s in the Gulf of Maine/Georges Bank linked to a change in zooplankton community structure, which favoured smaller copepods during the 1990s. Changes in plankton caused further changes in cod and haddock egg hatching and recruitment on Georges Bank.

Physical conditions reflect the ocean's response to climate-scale forcing and biological effects follow. The coupling between physical and biological processes is being translated through models into assessments and predictions of climate change on marine resources and marine ecosystems.

There is a need for coordination of basin-scale North Atlantic studies: (1) Connectivity in the North Atlantic is determined by the large-scale gyres that span the basin; (2) Basin-scale forcing impacts biogeography and ecosystem structure and function both locally and across the entire region; (3) The North Atlantic system is a key ocean basin globally for the sequestration of carbon; and (4) The ecosystem approach to management of widely distributed fish and other key species requires a basin-scale approach.

The BASIN programme is divided into two phases, the first containing data synthesis and modelling, New data acquisition and development of management applications are in the second phase. There are many existing data sets, but they are mostly in isolated repositories or largely not available. The assembly and integration of the current digital data sets and recovery of other historical data sets that are in papers and reports etc is badly needed.

Basic modelling objectives are hindcast modelling studies to understand the observed variability of the North Atlantic ecosystem over (at least) the last 50 years, and to construct scenarios of possible ecosystem changes in response to future climate variability. The focus is on four major trophic components: primary production and biogeochemical cycles, zooplankton, planktivorous fish and demersal fish.

Integrating across trophic levels will require some selective analysis of organisms to target. For selection of targeted species functional importance, size of data sets, concurrence with other relevant datasets, understanding of life history and physiology, resolved taxonomy, wide distribution and economic importance of the species are considered.

New technologies will be implemented for observation and new data acquisition within BASIN such as satellite salinity, in situ nutrient sensors, optical imaging and molecular genetics for biological observations. A new generation of ocean sampling platforms will allow a high resolution multiscale sampling of ocean physics, chemistry and biology.

The presentation was followed by a short discussion. The BASIN Science Plan and Implementation Strategy is ready and printed. Copies were distributed during WGZE meeting. An Implementation Plan and cost analyses are not ready yet, but work is going on. The steering committee is looking for funding organizations to launch a joint call for the BASIN program and the steering committee will meet next time during GLOBEC Open Science Meeting in June 2009.

#### **4 Discussion of a Collaboration in a Pan Regional Synthesis of Life Histories of *Calanus* Species in the North Atlantic and North Pacific**

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**Lead: Jeffrey Runge, Rapporteur: Cabell Davis**

Jeff Runge presented the work he is doing in the Pan-Regional US GLOBEC program. The title of his presentation was: "Life histories of *Calanus* in Northwest Atlantic and Northeast Pacific in response to climate forcing" with the co-PIs on the NSF award being J. Runge, A. Pershing, J. Pierson and D. Kimmel. Related US GLOBEC Pan-Regional synthesis projects are those by Davis *et al.* on copepod species biogeographic patterns and McGillicuddy *et al.* on N. Atlantic *Calanus finmarchicus* distributions. Other North American collaborators include C. Johnson, A. Leising, S. Plourde, and D. Mackas. European collaborators include D. Bonnet, A. Gislason, R. Harris, W. Melle and D. Speirs.

Jeff said his goal for the meeting related to this NSF project was to exchange information and foster data exchange. The question his GLOBEC project is addressing is how will populations of *Calanus* species in the N Atlantic respond to interannual and longer term climate change. His work focuses on 1D for the Runge *et al.* project and deals with congener pairs in the Pacific and Atlantic. For this WGZE meeting he will discuss only *Calanus finmarchicus* versus *Calanus helgolandicus*. His project is developing an individual-based model (IBM) for a mechanistic understanding of dormancy, parameterized with life history traits for each species and tested in different regions.

Several regions are being examined in the NW Atlantic based on time-series stations of the Canadian Atlantic Zone Monitoring Programme (AZMP): Anticosti gyre (AG), Scotian Shelf (SS), Gulf of Maine (GoM), Georges Bank (GB), Rimouski (R), lower Gulf of St Lawrence (GSL), and Newfoundland Shelf (NS); and other data. The time series sampling in the GoM had to be stopped this year due to lack of funding. A four-panel plot was presented that showed time series of life stage composition for NS, AG, GSL, and SS. The series showed different patterns for each region in the entry to and emergence from diapause.

Several environmental proxies were examined to determine possible causes of dormancy entry and exit. Onset of diapause was defined as one-half of 80% of the maximum C5 proportion. Dormancy exit happens when the proportion of adults is >10%. Of the environmental proxies examined (photoperiod, temperature, chlorophyll), no clear relationship with emergence and onset was found. No single observed environmental cue could explain diapause entry and emergence over a broad range of times, among individuals and years.

Instead of environmental proxies per se, the idea that lipid content could be a determinant of diapause timing was examined. The Lipid Accumulation Window (LAW) hypothesis was examined. Most dry weight increase occurs during the C4 and C5 stages due to lipids.

A life cycle plot was presented showing the developmental sequence in copepods. The LAW hypothesis is based on the observation that development rate increases faster with temperature than growth rate does. Lipid production integrates temporal variations in food and temperature. An additional cue acting prior to stage C5 may be required. Mortality also influences the probability of reaching C5.

Steve Hay said there is a lot of individual variability and it's not as simple as a titer being reached that stops animals from developing to adults. Jeff said that there is potential for individual variability as the animals proceed to enter diapause when lipids reach 30% as stage CIV and then proceed to accumulate lipids according to environmental conditions as CV, then stopping to diapause or molt to female depending on the decision made at the previous stage.

Jeff then presented an overview of the *Calanus* IBM. Rates of growth, development, and mortality are important. The initial model output results were shown, comparing food index versus temperature. The model-data comparison 6-panel figure had data on the left and the model on the right. The relative stage composition was very similar between model and data, providing justification for the model.

The objectives for this Pan-Regional US GLOBEC synthesis project are to:

1. **Compile and analyze data sets across species and regions and publish a series of comparative synthesis papers on: a) demographics and b) physiological rate characteristics: egg production, growth, and development rate.**

Jeff believes that the *Calanus finmarchicus* in the eastern and western Atlantic may be different. In the western Atlantic, egg production is dependent on chlorophyll, but in the eastern Atlantic, oil reserves may be more important. Erica Head and Steve Hay both agreed that egg production is function of oil stores but augmented with spring bloom. Jeff said that early oogenesis is lipid dependent but then animals deplete their lipid stores and need the spring bloom.

The regions of focus for the comparison of *Calanus finmarchicus* and *Calanus helgolandicus* include the AZMP regions (GSL, SS, NS, GoM) with other possible re-

regions including the Irminger, Norwegian, and North Seas. The GSL is the area of main focus over next year. Jeff wants to look for *C. helgolandicus* in the AZMP samples. Peter Wiebe said he found *C. helgolandicus* in the NW Atlantic. Steve Hay said he found it in the Irminger Sea, but Wiebe said that the Irminger Sea is really far to the east. The Polish Sorting Centre, who process the ECOMON data, do not look for *C. helgolandicus*.

Region specific datasets will be examined including, for example, the Campbell and Head data from the Labrador Sea, SS, GSL, GB showing egg production versus chlorophyll. Although chlorophyll is an imperfect proxy, it is a proxy nonetheless. The focus will be on the winter-spring period, not summer, when the chlorophyll proxy could break down where microzooplankton can be high where chlorophyll is low. Development rate as a function of temperature is different for *C. marshallae*, *C. finmarchicus*, *C. pacificus*, and *C. helgolandicus*.

Ann Bucklin said that *C. marshallae* and *C. glacialis* are close genetically and that Jeff has chosen a nice spectrum of *Calanus* species to study.

**2. To construct synoptic climatologies for each species in order to examine the sensitivity of species to climate forcing.**

PCA analyses by Kimmel showed that wind and temperature patterns match the dominant mode of variation in *Calanus* abundance in the NW Atlantic. Similarly, the NE Atlantic populations also have a match between this mode and wind/temperature patterns.

**3. To investigate mortality by compiling mortality estimates in time and space and comparing them with climatological mortality.**

They will look for common regional or global patterns of mortality. They will use optimal life history theory. This theory assumes populations are at evolutionary stable strategy (ESS). The ESS will be the survival and reproductive schedule  $l_x$  and  $m_x$  (where  $x$  is age in days) with maximal intrinsic rate of increase. Jeff had used this method previously with Landry's *Calanus* data (Myers and Runge 1983) and found that the predator regime was higher in summer than winter ... which appeared to be a temperature-dependence of mortality.

**4. To refine the stage-structured IBM life cycle model;**

**5. To use this model with climate change scenarios.**

They will address the question: How do sibling species *C. finmarchicus* and *C. helgolandicus* respond to climate? They also will examine length of diapause versus temperature. What is the maximal potential diapause duration for *C. finmarchicus* as function of ambient temperature (e.g. Saumweber and Durbin 2006)? If temperature is important for duration of diapause, then climate change can be important for *Calanus*.

Jeff suggested having a synthesis workshop in 2010 to compare and standardize data sets, compare models and predictions, designate regional sites, plan comparative experiments.

Steve Hay has found that *C. finmarchicus* overwintering depths can vary with location. In Irminger Sea they were less active than in the Eastern Atlantic. Erica Head said that *C. finmarchicus* are found deepest in the eastern Labrador Sea and shallower in western Labrador Sea. Roger Harris noted that you can find *C. helgolandicus* below

4000m in the Mediterranean Sea. Peter Wiebe pointed out that the Mediterranean is fairly warm throughout the water column ( $>14^{\circ}\text{C}$ ).

## **5 Review Progress in Zooplankton Taxonomy with Particular Reference to Developments within ICES**

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**Leads: Steve Hay, Sophie Pitois, Rapporteur: Priscilla Licandro**

Steve Hay provided some background and pointed out that the existing sheets in the ICES Plankton Identification Series were now available online from ICES, but that further development in this format or updating of the several outdated sheets was very unlikely. He described the report he had submitted to the ICES Publications committee prior to the Halifax ASC 2008. In that report Steve had suggested 5 actions:

1. The current ICES Fiches Plankton Identification sheet series should be updated, amended and completed where possible or where existing arrangements can be fulfilled;
2. ICES must include a taxonomic information provision and future developments in its strategies for developing its products, particularly as web deliverables and through information exchange processes as internet enabled applications;
3. That ICES stop production of paper copies and instead redirect resources to the development of online information. Perhaps they should seek an extended alliance with a scientific journal publishing company in developing this;
4. That the Publication Committee propose a collaborative effort by ICES editorial staff, including the editor of the Plankton Fiches d'Identification sheets, with the Working/Expert Group on Zooplankton Ecology, and other concerned experts; to approach the principles/individuals/ organizations working in the appropriate existing Internet-based initiatives to establish an Integrated Information Portal (IIP) on the ICES web site. Initially focused on plankton in the ICES area, the aim of this IIP initiative would be: To gather and provide as a searchable standard taxonomic tree, a coded database listing of marine species with summary information on the taxonomic status, identification keys, appearance, habitat, biology etc of each, with associated web links, acknowledgements and references; and
5. That ICES put aside and allocate sufficient funds and staff resources to enable these actions.

Steve explained that since his 2008 report he had some very recent responses and questions from ICES' Bill Anthony and Pierre Pepin regarding these suggested actions. In general the responses were positive and encouraging regarding the need for change, but cautionary in terms of what was practical and possible given ICES limited resources. Steve also outlined some of the very significant efforts being made globally to advance the science of systematics and taxonomy and to communicate these widely through Internet-based developments. He cited several examples; including ZIMNES a UK web-based plankton ID manual that is now online and in development on the SAHFOS website, and others such as ETI, PlanktonNet, CMarZ,

ITIS, ERMS, Species 2000 and the World Register of Marine Species. Some are semi-commercial, some are publicly funded and most are enthusiast driven, though many are also short lived. Many give detailed species lists, references and descriptions for some groups of taxa, some deal only in taxonomic naming and lists, while others have developed sophisticated tools for generating ID keys and species descriptions. Steve does not believe ICES can “compete” by developing its own system; rather he sought the views of the group to help him define a practical way forward for ICES to promote marine taxonomy and to provide a support service to scientists within ICES domain of expert groups and advice generators and to a wider public.

Various points were made in the ensuing discussion. Anne Bucklin pointed out that CMarZ was in its final synthesis phase and so had determined that they would seek to preserve the project’s taxonomic work by contributing to the Encyclopaedia of Life (EoL), which has the benefit of being a persistent endeavor. There were some comments that the EoL was not always accurate or balanced and it was suggested that for marine species, ICES experts could help to provide and maintain this fundamental information. Steve had suggested that ICES create a web site and forum for developing taxonomy and providing authoritative information, links to web resources and opportunities for comment and discussion. Although many in the WGZE support this, it was decided that it would be a fairly major endeavor that might prove impossible for ICES secretariat to provide or support.

Antonina dos Santos, as a plankton ecologist and expert in decapod larval taxonomy, pointed out that in the past she had revised an ICES Plankton ID sheet, but that now she and her colleagues were developing an interactive online key to decapod larvae identification and at least two universities had shown interest in hosting the facility. This is definitely the way forward, but covers only a small part of the whole range of taxonomy, which is a diverse and rapidly developing field. It is required information for all biology in support of ICES work and to ensure that ICES advice uses modern, accurate taxonomic data. The taxonomic name also reveals the history and literature information of a species and thereby links scientific studies. As such, taxonomic identifiers tie form, function and evolution together.

Sophie Pitois of CEFAS voiced concern about the lack of people able to identify fish larvae in the UK. Antonina pointed out that while this may be so in UK there were several fish larvae experts in Portugal and Spain, thus the distribution of taxonomic expertise is both sparse and uneven, as is training.

There was discussion of the use of, and some examples of image based approaches to plankton identification, which were considered very useful methods, but to be deployed with care as they can fail when they are not supported by good keys and morphological data (the naming of parts is necessary!) The previous ICES WGZE sponsored zooplankton workshops and others were noted as successes. It was suggested that WGZE should actively promote further such workshops and seek hosts and venues. Ann Bucklin emphasized the need to expand the species barcoding initiative of CMarZ and other molecular approaches as tools in future training, and she noted that expertly identified voucher specimens were required to obtain the barcodes and other sequence data initially. The group strongly supported the urgent need for proper integration of molecular genetics methods and the traditional morphology based approaches. It was also pointed out in discussion that taxonomy of marine species includes many more than just plankton, although most benthic species and fish develop through planktonic stages, which are often notoriously hard to identify.

The group asked Steve Hay to consider the discussion and he agreed to discuss further with group members and later present the group with ideas for them to modify as required and put forward as a proposal to ICES. The recommendation and justification (Annex 5) was developed jointly by Steve Hay, Janna Peters and Jasmin Renz and supported by the WGZE.

The WGZE deliberated with the series editor on the many examples and approaches that they had noted or experienced, aiming to determine their recommendation as to how ICES might best achieve a solution. It was recognised that the very considerable taxonomic expertise of the WGZE members could contribute to, but not enable a long term solution to the problems. Moreover, the subject of taxonomy crossed boundaries and related to expertise and dependencies in several expert groups and wider science forums.

The WGZE recommends that a Study Group on Integrated Morphological and Molecular Taxonomy be established in order to provide oversight and continuity of taxonomic best practices for the wider ICES research community (Annex 4).

## **6 Provide Expert Knowledge and Guidance to ICES Data Centre on a Continuous Basis Including Progress on the Digitizing Project and Begin an Inventory of Historical Data and Samples**

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**Lead: Mark Benfield, Rapporteur: Erica Head**

Mark said that he had spoken with Dr. Abigail McQuatters Gollop, who is the project lead at SAHFOS. They have started a website and it currently contains the first project report. The project is a very large undertaking including the digitization of 109 data tables totalling over 200 pages. Of these, 31 have been entered and 31 are in the process of being entered. Data entry is being performed by students with quality control being done by Dr. McQuatters Gollop after data entry. One of the challenges was determining the locations of data collection station coordinates because a number of them were either missing or incorrectly located.

The first semi-annual report has been submitted and they are about 33% through entering the data. The problem is that often there is only presence/absence data or qualitative estimates of abundance (e.g. common, very abundant, rare, etc.). These terms were used differently by different investigators complicating their usage. For some species, the names have changed several times and this requires a search to determine what the current identification is. The next semi-annual report is due soon (within a week of the 2009 WGZE meeting). There will be data dissemination via OBIS. They will also compare species distributions with environmental conditions.

Data analysis will start following data entry. Based on the issues identified previously, the initial level of analysis will likely be presence/absence and will include a spatio-temporal comparison and a comparison with contemporary distributions.

The group recommends that a sub-group of the WGZE should evaluate the progress of the project based on a review of the next semi-annual report. The WGZE is highly supportive of this initiative and recognizes the value of conservation of historical data and looks forward to the next report from SAHFOS. Upon completion of the project, these data should be made publicly as soon as possible (e.g. through the ICES database, through the COPEPOD website).

## 7 Update on the Census of Marine Zooplankton (CMarZ) Programme

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**Lead: Ann Bucklin, Rapporteur: Michel Harvey**

The Census of Marine Zooplankton (CMarZ) is a component of the Census of Marine Life (CoML). CMarZ was initiated in 2004 with the goal of producing a taxonomically-comprehensive, global survey of holozooplankton biodiversity. Since that time the 16 Steering Group members have led 25 cooperating projects that have sampled many ocean regions using ships of opportunity and dedicated cruises. CoML will wrap up field work and sample analysis by the end of 2009. Synthesis activities are underway now for CMarZ, and all CoML field projects, and will continue through 2010.

The CoML synthesis plan includes a number of products that incorporate CMarZ activities. These include a book (Marine Life: Diversity, Abundance and Distribution) targeted at the general scientific reader and a web-based mapping and visualization initiative headed by Peter Wiebe and WHOI Data Managers. There are several cross-project synthesis groups and products: a complete list of all named species and individual web pages for each species (both initiatives headed by Nancy Copley *et al.*). Annelies Pierrot-Bults is assembling new global biogeographies for marine zooplankton. A fresh estimate of the changes in size distribution of animals and an updated estimate of zooplankton biomass are being undertaken (the latter by Peter Wiebe), and there is a summary of the roles of rare taxa being prepared by Ann Bucklin.

Results from CMarZ will be disseminated via a variety of media including a special issue of Deep-Sea Research examining species diversity of zooplankton in the global ocean (P. Wiebe, S. Nishida, and S. Schnack-Schiel, Eds.), a web-based clearinghouse for taxonomic tools of utility to zooplankton, and a poster of photographs of living marine zooplankton is an activity that is being conducted in conjunction with some members from the WGZE by Russ Hopcroft and Larry Madin. It was noted that in addition to the Deep-Sea Research special issue, there are now 150 papers in press or preparation that attribute CMarZ data. DNA barcodes for zooplankton are being processed and assembled into a Leafy Tree of Life by the CMarZ Barcoding Association. Peter Wiebe and Chris Reid are writing a popular article on the Superpowers of Plankton for publication in Scientific American.

Examples of the societal benefits of CMarZ research included invasive species monitoring of ballast water and impacts of a marine bioinvasion in the Caspian Sea. The number of new species discovered by CMarZ is estimated to exceed 100. CMarZ Steering Group members are completing or have completed group-by-group analyses for radiolaria (Handbook of the Radiolaria, Demetrio Boltovskoy), chaetognaths (Taxonomy, phylogeography, and phylogeny of chaetognaths, Annelies Pierrot-Bults), and ostracods (Atlantic Atlas for the Planktonic Ostracods, Natural History Museum, London, UK, website, Martin Angel).

CMarZ is an international initiative. Research initiatives from Southeast Asia, the Atlantic Ocean, and South Atlantic off Namibia and South Africa, the Celebes Sea, and the Andaman Sea were summarized. Work on barcoding calanoid copepods is yielding new insights into their phylogenetic relationships. Examples of such data were shown for both calanoid copepods (Leo Blanco Bercial *et al.*), euphausiids (Ann Bucklin *et al.*, 2007), ostracods (Martin Angel *et al.*), cnidarians medusozoa (Ortman *et al.*),

planktonic molluscs (Jennings *et al.*), and Atlantic zooplankton (Bucklin *et al.*). A summary of the species diversity of holozooplankton included 5,664 non-protist species and 1,349 protist species.

The challenge now is that funding from the Sloan Foundation for the CoML ends in 2010. This raises a question: Could ICES provide a co-ordination function to take over from CMarZ? Would the WGZE like to adopt a ToR that "takes over" from CMarZ? It would include traditional (morphological) and molecular genetic analysis roles. A discussion of this issue followed. In general it was felt that this could be a good role for ICES to bring together data and to coordinate interpretation. This would promulgate taxonomy and it would naturally lead to looking at species distributions versus environment. This would be good for taxonomy. It was mentioned that CMarZ has a global focus whereas ICES has a North Atlantic focus. Ann Bucklin pointed out that CMarZ is sufficiently advanced that it might be feasible to continue their work focusing on ecosystem monitoring [of zooplankton] for fisheries management, which might have appeal for ICES. No firm decision was arrived at regarding integration of CMarZ activities with the WGZE.

## **8 Potential EU Funded Project: ENV.2010.2.2.1.2. Global Plankton Data Set Building in View of Modelling**

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**Lead: Mark Benfield, Rapporteur: Heike Helmholz**

Mark Benfield and Roger Harris received an email from Xabier Irigoien regarding a forthcoming call for proposals as part of the FP7 Program: ENV.2010.2.2.1.2. Global plankton data set building in view of modeling. The project synopsis states:

"Plankton monitoring and the observation of changes in plankton ecology have become very important indicators of the effects of climate change on the oceans. There is a need to build a global plankton and plankton ecology data set, which builds upon and expands existing data sets to include marine areas where these data are missing, or insufficiently developed more particularly in the Southern Ocean. The project should therefore expand plankton monitoring into new marine areas to expand the global dataset. The plankton data should be complemented with additional biological, environmental and climatic indicators. Based upon the use of this data, modelling applications should be developed to address environmental management issues such as climate change, fisheries, pollution and harmful algal blooms. The data and applications should be made freely available to marine scientists, with the results being reported to policy makers. The project should seek to make use of cooperative links with other plankton monitoring and analysis surveys around the globe".

Funding scheme: Collaborative Project (small- or medium scale focused research project) for specific cooperation actions (SICA) dedicated to international cooperation partner countries.

Expected impact: The project should contribute to the development of global plankton and plankton ecology datasets. The modelling applications developed using the expanded datasets will deliver new insights in key environmental domains such as climate change and fisheries, with the results being introduced into the relevant policy making processes.

The group discussed whether this call was targeted at a specific program such as the CPR surveys by SAHFOS or perhaps the BASIN initiative. It seemed highly specific

and therefore was likely generated with a particular target proposer in mind. Priscilla Licandro indicated that she was not aware of any discussions at SAHFOS to submit to this call. The general consensus was that it was a very good opportunity for someone in the group, perhaps Xabier Irigoien, to submit a proposal, that the WGZE was in favour of such a proposal, and that individual members could collaborate with Xabier as he saw fit. Mark Benfield indicated that he would convey this information to Xabier Irigoien.

## **9 Discussion of Future Directions/Projects for the Working Group**

### **Lead: Roger Harris, Rapporteur: Jasmin Renz**

Roger Harris shortly introduced the topics of the talk, which were: (1) to review what has been achieved by the WGZE; (2) focus on practical projects of interest to the WGZE and wider zooplankton community; (3) summarize ongoing projects; and (4) plan possible new initiatives and directions for the WGZE. Roger pointed out that our group has always been highly productive and has embraced numerous challenging projects. He highlighted the main achievements/actions by the WGZE:

- 1992: The WGZE was initiated.
- 1993: A sea going workshop was organized, with the main goal to compare different sampling equipment. A workshop was held to compare experimental techniques for *Acartia*.
- 1994: A workshop was held to compare experimental techniques for *Calanus*.  
The 2nd Zooplankton Production Symposium was developed and organized, the output of this published in the ICES Journal of Marine Science.
- 1997: The first zooplankton monitoring report with CPR transects was produced.
- 1999: The TASC symposium was organized.
- 2000: A joint ICES / PICES meeting was organized in Hawaii. The first taxonomic workshop in Wilhelmshaven was organized. The ICES Zooplankton Methodology Manual published.
- 2001: A joint meeting with the Working Group on Phytoplankton Ecology (WGPE) was held in Bergen. The Plankton Status Report became an annex of the WGZE report.
- 2002: The ICES Fiches were scanned and published on the web.
- 2003: The 3rd Zooplankton Production Symposium was held in Gijon, Spain.
- 2005: The BASIN workshop was held in Reykjavik, Iceland. The WGZE website was established by Todd O'Brien. The plankton status report was published as an ICES Cooperative Research Report
- 2006: A workshop on new methodologies/image analysis was held in San Sebastian. A taxonomic workshop was organized in Plymouth
- 2007: The 4th Zooplankton Production Symposium was organized and held in Hiroshima, Japan.
- 2008: A joint ICES / CIESM meeting was organized and held in Crete, Greece.

For the near future, Roger introduced two ongoing activities of relevance to the WGZE. First, the 5<sup>th</sup> Zooplankton Production Symposium will be held in Pucon, Chile in March 2011 under the title: "Population connections, community dynamics, and climate variability". The conveners will be Ruben Escribano, Julie Keister and Delphine Bonnet. No special sessions have been outlined yet and the conveners are open to discussion. It is proposed that the WGZE makes suggestions for special session topics. Second, there is a new Working Group on Microbial Oceanography (WGMO), which will focus on the importance of microbes in ecosystem functioning. Bill Li is seeking input from people interested in joining the MOWG and hopes that those people could attend the next ASC meeting in Berlin this September.

In addition to the 5<sup>th</sup> Zooplankton Production Symposium and potential collaborations with the WGMO, there is a special journal issue based on time-series data, which emerged as a product from the joint WGZE/CIESM workshop in Heraklion, and the potential for a special issue to update the Zooplankton Methodology Manual. A short discussion followed on whether the ZMM is currently out of print. Roger commented that he will ask the publisher whether they will restart printing or reprint it if it is out of print. A suggestion was made that there could be a soft cover revision or new sections or chapters that might be published elsewhere.

Several more brainstorming topics were introduced by Roger. These included: an article on the history and achievements of the WGZE, so that this information is not lost; a zooplankton taxonomy manual, and a practical workshop on optical techniques for studying zooplankton. Mark Benfield proposed to use mesocosms for the gear comparison for optical methods to avoid the problem of patchiness of plankton. This could be a first step towards a ship based intercomparison / sea going workshop, which could follow the mesocosm study. Roger Harris mentioned several existing mesocosm facilities, e.g. those in Kiel (Germany), Heraklion (Crete) and Bergen (Norway). He suggested writing a proposal to use these sites, as earlier workshops, like the ones on *Calanus* and *Acartia*, were successfully performed in Bergen.

Following this discussion Peter Wiebe gave a report on a workshop on gear comparisons, conducted on 2 research vessels in Storfjorden in the early 1990s. A huge collection of a comparison of different gears resulted from this workshop. There was no imaging optics (although optical plankton counter (OPC) data were recorded), or genetic analyses were done on samples, but a lot of supporting hydrography and bioacoustics data were collected. The counting of net tows was processed in three different labs and the first results were published in an ICES research report along with four CDROMs with abundance data and videos and images. In addition, two papers have already been published. A publication, giving an overview on the results, is in progress and will probably be finished this summer. Peter proposed for the new seagoing workshop to include concrete plans on how to finish the workshop, and that Webjörn Melle be contacted regarding the Norwegian mesocosm site and possible use of a Norwegian ship. A short discussion followed on the possibility to include molecular methods in this intercalibration.

Steve Hay noted that this workshop would also be a good opportunity to look at processes, biochemical methods and growth, in order to have indicators of what is happening in the population, while Juha Flinkman reported about the Assessment Working Group that is currently analyzing several plankton datasets. A couple of years ago there was a seagoing workshop aiming to compare different gears in the Baltic Sea. With respect to the regular monitoring activities and HELCOM guidelines the project focused mainly on the analysis aspect, not on the different gear types.

These data are currently statistically analyzed; a final report is expected soon. Following this discussion it was suggested that the Baltic Sea might be a good study area because of the low species number and it was proposed that together with the analysis of the samples, a taxonomic workshop could be done. Juha Flinkman mentioned the possibility of hiring taxonomic experts from Finland, which are selling their expertise. Roger Harris summarized the discussion with the main topics discussed being the seagoing workshop and the question where it should be held (Baltic Sea, Norway?), the comparison of optical techniques and the funding for this project.

Afterwards other ideas were discussed by the WGZE members. Antonina dos Santos mentioned the importance of standardizing time-series and reported that the data from the Portuguese time-series will be made available. Steve Hay said that we have all these status reports and that it might be good to review the monitoring sites and do intercomparisons. He mentioned the metabolic theory of ecology and that it might be a good idea to bring together a biochemical approach, biogeochemistry, size spectra etc. in a workshop. Steve also supported the idea of working in the Baltic. Erica Head suggested building on the status report and trying to do some synthesis products from reports and what has already been put together, not only the species information that are currently in the reports (which currently contain only the 10 top species). This would be a topic for a workshop. Maybe it could be a possibility to investigate changes that are coherent in the ICES area.

Peter Wiebe gave a report of a plankton meeting in the Canary Islands, where a synthesis on experimental methods (incubations, biochemistry, respiration, etc) from different areas will probably be done. A discussion on the importance of standardizing these methods followed and it was also emphasized how important this would be for the ICES work. Though current methods used for the different time series might not be changed in the future, advice for people starting a new time series would be important. Peter suggested that Lutz Postel should be invited for next year to give an update to the group on these methods.

After adjourning for the day and an opportunity to further consider this topic, the WGZE reconvened to continue discussions. Following the discussion of the previous day, the session started with a proposal to plan a seagoing comparison with acoustics and optical methods between a fjord and the Baltic Sea. Juha Flinkman explained the specific hydrography of the Baltic Sea. A question was raised regarding whether barcoding could help with the identification of inflowing species and the rapid characterisation of transition events. Steve Hay noted that the Baltic Sea is an extremely good opportunity to look at the adaptive range of zooplankton species. A recent publication by Beaugrand looks at the range distribution of species using multivariate techniques. Steve proposed some experimental work to investigate whether the adaptation of species is due to phenotypic plasticity or genetic variability.

Peter Wiebe pointed out that we do not know much about the environmental limits in which species occur and that maybe we could use the status report to start with a review and get a picture of the limits of different species as this kind of information does not exist. As this has not been answered yet, it is a fundamental question that can be addressed. We discussed whether the Baltic Sea is a region that could stand as a model for other estuarine systems, though it might be different from other regions. Because of its huge blooms and the high abundance of *Calanus*, it was also suggested that a study might be conducted in the Labrador Sea.

Jeff Runge mentioned the problem of the loss of the taxonomic expertise. The advice of the group might be needed regarding this problem. Steve Hay said that he will put

together a paragraph for ICES, to get institutional recognition for the need of the preservation of taxonomic knowledge (see above). A discussion about the potential to fund these things followed. The statement that the taxonomic expertise has to be preserved was supported by all group members (see section 5) and it is emphasized how important the recognition of this need by ICES is.

Following topics were listed as potential topics for future initiatives for the WGZE: (1) Update the Zooplankton Methodology Manual via a journal or 2<sup>nd</sup> edition (Leads: Wiebe, Harris, Benfield); (2) Conduct a seagoing workshop on high-tech zooplankton ecology (Leads: Davis, Flinkman, Benfield); (3) Sustain, train, integrate new and traditional taxonomic tools (this could that be a subgroup of the WGZE or a new WG. Leads: (Hay, Bucklin, Peters); and (4) Conduct studies to determine the physiological tolerances and the factors that determine the ranges of species (Head, Runge, Cook).

Regarding the problem of taxonomic expertise Steve Hay proposed that it would be a good idea to firstly create a study group within the WGZE and probably later a working group. This may be better than to leave it within the WGZE and this would give it a higher importance. The importance of an initiative addressing the problem of the loss in taxonomic expertise will be recommended to ICES. As the new taxonomic group would have a much wider approach it was suggested to outsource the taxonomic part into a new working group as the expertise of this group would not only be needed by the WGZE.

## **10 Review the Plankton Status Report and Report on the Progress of Linking the Status Report Data to the ICES Data Centre. Discuss Preparations for the Next Status Report**

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**Lead: Todd O'Brien, Rapporteur: Ann Bucklin**

Todd O'Brien summarized the analysis methods used to produce previous versions of the Plankton Status Report. The report is now in its seventh year, originating in 2001. Starting with the 2005–2006 Report, interannual anomalies were calculated using a unit-less linear ratio. While this method allowed one to compare between different measurement types and units (e.g. "biomass per m<sup>3</sup>" to "counts per m<sup>2</sup>"), it did not adjust for influence from large amplitude seasonal cycles and was sensitive to large outliers (e.g. very large or very small values). In 2008, the analysis switched to a log<sub>10</sub> monthly weighted annual anomaly calculation (MWAAC). This method, co-developed with SCOR WG125) is robust with regard to outliers and removes the seasonal cycle from the interannual anomaly calculations.

For the 2008 Cooperative Research Report, several new features were introduced, including: (1) a dedicated section describing in detail the analysis and standard figures used in the document; (2) each region now starts with a summary introduction and map of all sites in that region; (3) each monitoring site contained highlights and summaries for that sampling area, including a summary of the top ten taxa when available; (4) all results were presented via standard figures; (5) multivariate plots were provided to show interannual and seasonal patterns within each monitoring site; (6) each site was compared to a 100 year time series of Reynolds sea surface temperature (SST) anomalies; and (7) there was an update to the CPR analysis of standard areas within the North Atlantic.

Across the North Atlantic, the graphical presentation of Reynolds SST illustrates that while warm periods occurred during the 1930s and 1990s, since 2000 the tempera-

tures in many regions are higher than seen in the last 100 years. Peter Wiebe noted that these trends fit other data analyses and publications that make references to 100 year time-series (rather than 50 years).

Problems noted during the assembly and editing of the 2008 Report included obtaining data from all sites in a timely manner. The solution is to move up the deadlines and agree to a 2-year delay in providing data. The next report, prepared in 2010, will be for 2007–2008. Data for 2008 and the top-ten taxa tables were due by 31 January 2009. Updated figure sets will be provided back to the site managers (authors) by 15 February 2009, and the authors will return results and summary text by 15 March 2009. The goal for the next WGZE meeting will be to review all site results and craft a basin wide summary at that meeting.

There was a discussion of other ideas for 2010. These include chapter based publications in which individual PIs will have separate chapters that can be cited individually. This could be done every two years using the off years to address other issues and conduct planning. Regional summary chapters of 2–3 pages each could be developed for the NW Atlantic, Icelandic-Norwegian Basin, Barents Sea, North Sea and English Channel, Bay of Biscay and Iberian Coast, and the Mediterranean. Special Analysis or Basin Summary Chapters could be included.

Beginning in 2010, additional standard graphics (for each and every site) could include sunrise-sunset day length plots as well as depth profiles of temperature, salinity, and other variables at the site. Todd solicited other expansion ideas from the group. Mark Benfield suggested adding an NAO Index. Todd said that it was omitted last year but would be put back in to the report. Cabell Davis inquired about indicator species regardless of whether they were in the top ten list or not. Todd indicated that it was up to the PI and depends on the region as to which species might serve as useful indicators. Mark Benfield wondered if this report will evolve into a climate-change report. Steve Hay felt that it should remain focused on plankton and provide data that could be interpreted by climate folks. Peter Wiebe felt that some climate-change interpretation should be included in the report, especially in terms of key species and apparent changes over time with climate. Cabell suggested that we might use the data to identify trends in how climate is affecting plankton and plan for a high-impact article (Science or Nature) to have more impact on the IPCC. This would be good activity for out-year activities.

The discussion then turned to linking the status report to the ICES Data Centre. Todd pointed out that it was very difficult to even find the reports on the ICES website, and once found they were behind by three years. Todd sent an update request and links to the missing reports to the ICES web master. Actual time-series data is not available via ICES; nor were these data available via the WGZE site, but one can find raw data from BATS and Plymouth at their respective sites. The proposed solutions were to suggest that WGZE can safely release the anomaly fields and monthly means through the WGZE site (<http://wgze.net>) as these data must be cited to be usable anyway. The WGZE web site will give citation information and require registration and/or email address for access to the data. Todd will specify PI and contact person for each dataset and include links to institutional website links. Todd will post draft data and text summaries for each PI to review before releasing publicly and only after PI permission. The consensus of the WGZE was that the group agreed with this plan.

Finally, there was a discussion of changing the climatology cut-off data (currently 2005) and reducing the minimum length requirement for time-series to be included in the WGZE analysis and report. It was proposed to move the climatology cut-off data

to 2008 and to reduce the minimum time length to five years. This will allow the addition of sites from Portugal as well as sites from several other regions. The group agreed with this plan.

As an expansion to the Plankton Summary report, or as a new WGZE data product, we discussed whether WGZE should post seasonal or monthly climatologies (perhaps pentadal) for spatial zooplankton summaries and fields (gridded mean fields of biomass and/or group abundance data, hydrographic parameters, nutrients, chlorophyll). These fields would summarize the North Atlantic zooplankton ecosystem and environment and would be very useful for modellers. This would require submission of a full (non-released) version of the data from each region. The field data are currently shown in aggregate form (e.g. maps and fields). The suggestion now is that original or raw data would be released through the product. Erica Head asked how all data can be integrated, given different mesh sizes, gear, deployments, etc. How can CPR data be integrated? Mark Benfield asked whether some of Peter Wiebe's publication on gear intercalibration might help with this integration. Peter felt that it could and some kinds of analyses will not be sensitive to mesh size. For example, Norwegian data will allow assessment of mesh size effects in particular. The consensus was that it was OK for Todd to explore how to do this.

## **11 Produce a Summary of Recent Developments in Plankton Research and Monitoring (e.g. Seasonality, Abundance, Community Structure, Biodiversity, Evidence/Rationale for Incorporating Zooplankton in Monitoring) with a View to Further Analysis and Subsequent Publication**

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**Lead: Jeffrey Runge, Rapporteur: Solvita Strake**

The discussion focused on developments in plankton research and monitoring that advance priority research objectives identified in the ICES Science Plan 2009–2013. The relevant objectives in the Science Plan include:

1. Climate change processes and predictions of impacts;
2. Fish life history information in support of ecosystem approaches to management (EAM);
3. Biodiversity and the health of marine ecosystems;
4. Operational modelling combining oceanographic, ecosystem, and population processes;
5. Introduced and invasive species, their impacts on ecosystems and interactions with climate change processes.
6. Integration of surveys in support of EAM
7. Marine spatial planning, including the effectiveness of management practices [e.g. Marine Protected Areas (MPAs)], and its role in the conservation of biodiversity

Collection of zooplankton time-series is relevant to all of the above objectives. The time-series and data are compiled and summarized in the ICES Plankton Status Report (ToR b). As the time-series data accumulate, relationships are emerging with climate forced physical processes contributing to predictions of impacts. For example, the Canadian AZMP datasets now indicate significant correlations among St. Law-

rence river discharge, zooplankton biomass in the Estuary and Gulf of St. Lawrence, production rate of copepod prey and recruitment of S. Gulf of St. Lawrence mackerel, and relationships between zooplankton biomass and composition and excursions of Labrador slope water in the Gulf of St. Lawrence point to mechanisms by which climate change alters plankton biodiversity and fish stock recruitment.

The multinational zooplankton observing programs in the Baltic Sea were examined for strengths and weaknesses in addressing ICES Science Plan objectives. A trial overview of for a Baltic Sea integrated assessment (IA) has been conducted for the first time for the Gulf of Riga (GOR) and Central Baltic Sea (CBS) during ICES/BSRP/HELCOM Workshop on Developing a Framework for Integrated Assessment for the Baltic Sea (1–4 March 2006, Tvärminne, Finland) (ICES 2006). As many as 39 (GOR) and 90 (CBS) time-series on biological, physical and chemical variables, covering the period 1973 (1974 for CBS) to 2004, were used. The trial showed that the methodology is capable of providing an integrated view on ecosystem state and development. Based on the time-series collected and conducted analyses, short Ecosystem Status Reports have been produced to provide environmental information relevant to commercial fish stocks, and information on the effects of fishing on the Baltic Sea ecosystem (ICES 2006). Since 2007 the ICES/HELCOM Working Group on Integrated Assessments of the Baltic Sea has been established. WGIAB was setup as a forum for developing and combining ecosystem-based management efforts in the Baltic Sea region.

The approach of WGIAB is to assess the cumulative impact of climate, fisheries and eutrophication on the ecosystem (ICES 2008). Zooplankton data series were always included in the analysis, usually providing a strong signal (e.g. the observed regime shift in late 1980s was best recorded in fish and zooplankton populations). High cod stocks in the late 1970s – early 1980s have been replaced by a period of sprat dominance since the 1990s (ICES 2006). The decrease in the cod stock is mainly caused by recruitment failure due to low salinity and oxygen conditions (Köster *et al.*, 2005), while the higher water temperatures during the 1990s favoured sprat recruitment (MacKenzie and Köster, 2004). Similarly the shift in the zooplankton from *Pseudocalanus acuspes* to *Acartia spp.* is caused by opposite hydrographic preferences (Möllmann *et al.*, 2003).

A series of workshops to analyze recruitment-environment relationships for small pelagics in the Baltic Sea were organized recently under the ICES umbrella: ICES/BSRP Workshop on Recruitment Processes of Baltic Sea herring stocks (WKHRPB), Hamburg, Germany in 2007 (ICES CM 2007/BCC:03); ICES/BSRP Workshop on Developing and Testing Environmentally-Sensitive Stock-Recruitment Relationships of Baltic Herring and Sprat Stocks (WKSSRB), Ponza, Italy in 2008 (ICES CM 2008/BCC:05); and planned for 2009 the ICES Workshop on Combining Climatic Scenarios and Medium-Term Predictions for Baltic Herring and Sprat stocks (WKCSMPB). Different Baltic Sea herring stocks, i.e. the Western Baltic (ICES D IIIa & SD 22–24), the Main Basin (SD 25–29&32 excl. Gulf of Riga), the Gulf of Riga, the Bothnian Sea (SD 30) as well as the Bothnian Bay (SD 31) and sprat stock (SD 22–32) were included in those analyses and several biological as well as hydro-climatic variables were tested for their effect on fish recruitment. For all stocks where complete zooplankton data were available, the food supply was a significant predictor, suggesting that some of the changes in climate and hydrography affect herring and sprat recruitment indirectly.

Clearly, while the sampling program has capacity to indicate changes in biodiversity including planktonic forms of marine invasive species, work needs to be done to understand mechanisms of climate change influence and to integrate zooplankton observing into surveys supporting EAM. The measurement of plankton biodiversity itself has limitations, due to the small size of numerically dominant zooplankters in relation to sampling mesh sizes and the challenges presented to proper enumeration and identification.

Combining zooplankton observing data with developments in coupled physical-biological modelling, will advance mechanistic understanding of climate forcing on marine ecosystems and lead to predictions of ecosystem state and processes influencing fish population dynamics. Physical circulation models of appropriate resolution for the spatial scale in question have been coupled to NPZ, copepod life history and larval fish trophodynamic models with increasing success, demonstrating potential to predict environmental conditions for recruitment. This approach has been advanced for example in the Gulf of Maine/Georges Bank ecosystem as well as ecosystems in the Baltic and NE Atlantic. The approach is a foundation for the Science Plan developed for the North Atlantic BASIN program. Coupled physical-biological modelling integrates across physical and biological data sets and has the potential to evolve into operational modelling providing information support for fisheries management in ICES regions.

The coupled physical-biological models can be applied in the context of spatially explicit planning and management. For example, in the western Gulf of Maine, at least two genetically distinct adjacent cod stocks have been discovered, one spawning in winter and one in late spring. Semi-monthly fixed station zooplankton sampling in the coastal Gulf of Maine can be integrated with physical data on winds and currents in linked coupled physical biological models that predict transport and survival success for larvae of each population, providing information support for spatial management strategies.

One aspect of zooplankton research important to understanding climate change impacts on marine ecosystems is the understanding of effects of ocean acidification not only to calcareous organisms but also to physiological processes in non calcareous organisms. Problems associated with the effects of ocean acidification on marine plankton are of very major and growing concern. The physical facts and possible consequences of acidification and climate change have been reviewed extensively and recently (e.g. Fabry *et al.*, 2008). In many nations, efforts to research the problems are rapidly expanding but studies at realistic levels are as yet sparse. Whatever slowing or remediation of global climate change is accomplished, acidification of the oceans will progress for centuries to come.

The effects of acidification may be gross, such as those that directly affect the ability of organisms to form calcareous skeletons, or to use calcium compounds in skeletal structures. Examples include pteropod molluscs, foraminifera, larvae of many benthic species such as the mollusca, echinodermata, cnidaria, bryozoa, etc.. The metastable (i.e. soluble) aragonite shells of euthecosomatous pteropods are especially vulnerable. Many of these organisms are critical to ocean biogeochemistry and they act as the prime movers in export flux of carbon to deep sea sediments. Many effects of acidification will be subtle, and hard to measure. The influences on marine organism physiology, through acid-base imbalance or reduced oxygen transport ability, or through synergistic effects with other stresses, may cause significant changes in marine plankton communities. Many species use carbonate complexes for osmoregulation or store

carbonates as mineral secretions in statoliths, statocysts, etc and in many crustacean species the chitin cuticle is calcified to a greater or lesser extent during development and this process is critical in moulting.

There is the potential, therefore, for motility, feeding, mate finding, defences against predators, and other behaviours relying on such balance organs, along with the fundamental processes of growth, fertilization, reproduction and development to be affected. These changes will vary regionally and with species, propagating effects through the communities and trophic web affecting ecosystem productivity. Solubility of  $\text{CaCO}_3$  increases with increasing pressure and decreasing temperature. Effects on plankton will likely be stronger in high latitude regions and regions where raised  $\text{CO}_2$  partial pressures cause calcium carbonate saturation horizons to shallow, and plankton communities in the increasing areas with permanent or seasonal hypoxic zones may be severely affected. The risk to global biodiversity, productivity, and ecosystem health is certain; therefore it is critical for marine science to study and quantify the currently unknown effects across a wide range of species, including their development and behaviours, and to rapidly incorporate research findings into descriptive and predictive models. Physiological mechanisms of organisms to adapt to, compensate for, or reduce the effects of acidification are few and conservative. While it may seem as though there will be time to do this research, the process of acidification is now inevitable, we really know very little and it seems likely that threshold levels for community changes and chronic effects are lower than we can now appreciate.

## **12 Produce an Overview of Trends in Plankton Communities in the ICES area, Including Jellyfish, for the ICES Position Paper on Climate Change**

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**Lead: Astthor Gislason, Rapporteur: Antonina dos Santos**

Astthor Gislason started the session explaining the origin of the Steering Group on Climate Change (SGCC) and how the present ToR came into being as a task for the WGZE. The SGCC was established by ICES Council decision in 2007 in order to answer a need to increase ICES involvement in research on climate change, thus increasing scientific expertise and capacity within ICES and to answer requests from various entities.

The main tasks of SGCC as defined by the ICES Council are to: (1) prepare a popular document on climate variability; (2) write an ICES position paper detailing current knowledge on climate change; and (3) supervise the OSPAR request on climate change. The first point is already done as SGCC has already produced a brochure for the general public (Climate Change: Changing Oceans, ICES 2008) that is available in print and online on the ICES website. The brochure addresses the role of ICES in marine science, informs about evidence that climate change is really occurring, and provides several examples from the ICES area as to how the ecosystem is responding to these changes. The importance of monitoring the marine environment is especially highlighted.

Workshops would be instrumental in the work of SGCC. Two approaches will be followed: Using other program workshops that are relevant to the work (e.g. WGCCC, GLOBEC Open Science Meeting June 2009 and, ICES/PICES Workshop on Small Pelagics 2008), or establishing *ad hoc* workshops within the ICES structure

(preferably organized by existing EGs). The SGCC already has ideas for such workshops dealing with climate indices, data, and bioinvasions and shifts in marine ecosystems.

The lifetime of SGCC is estimated to be 2008–2012. The parent Science Committee is the SCICOM. Membership of SGCC includes Luis Valdés as Chair, and Chairs of CONC, ACOM, and OCC. In addition, several relevant expert groups (WGOH, WGZE, WGHABD, WGFE, and more) are represented. To date the SGCC has met twice: the first meeting took place in Copenhagen 11 June 2008 with about 15 participants and the second in Halifax on 24 September 2008 during the ASC with circa 20 participants. The next meeting is planned in Copenhagen on 3 June 2009.

The main product of SGCC will be the White Paper (ICES position paper) on climate change. A tentative title is “ICES Position on Future Research on Climate Change”. The main aim of the paper/book will be to make an overview of current knowledge about effects of climate on marine ecosystems and to provide guidance on directions that research and/or education should proceed in the future.

The plan is to complete the ICES Position Paper by 2010 and the number of pages is expected to be between 80 and 125. The consensus in SGCC is that the ICES Position Paper has a thematic approach instead of a geographical or regional one. There is already a table of contents proposed with several chapters planned. The writing up of one chapter (Overview of trends in plankton communities in the ICES area, including jellyfish) is to be lead jointly by WGZE and WGHABD. Astthor said that the task of the WGZE is now to provide written text as input for this chapter. He noted that the Arctic should be included in the work. The overview produced will be reviewed by SGCC when they meet on 3 June 2009.

The note was made that this was a very short deadline and more time would be needed to prepare the chapter properly. Astthor felt that if the group decided to build on the already made assessments the group has made for OSPAR (see WGZE Reports 2007 and 2008), this would be achievable.

Astthor Gislason gave an overview of the contents of the earlier WGZE OSPAR reports (see Annexes to 2007 and 2008 WGZE reports). There are two reports from WGZE in answer to the request from OSPAR. The first one was produced in 2007 and contains information on both phyto- and zooplankton and a conclusion section highlighting how the observed changes are affected by climate. The other one is from 2008 and adds information from the Norwegian Sea and gelatinous zooplankton. There was consensus in the group that this information be utilized for the work. However, Astthor said that in order to make the chapter for the ICES Position paper the group would need to expand on the OSPAR reports by extending the area covered westwards towards North America, but that we might be able to use a similar structure for the chapter as used in the OSPAR reports. We should also aim to use a thematic approach in our report as requested by SGCC.

Based on the WGZE OSPAR reports, Astthor proposed the following outline structure for the content of the plankton chapter for the ICES Position Paper:

- A. Importance of plankton (How climate changes are likely to affect plankton)
- B. Changes in Phytoplankton
  - a) Abundance/biomass
  - b) Community structure
  - c) New/Invasive species

- C. Changes in Zooplankton, including jellyfish
  - a) Abundance/biomass
  - b) Distribution
  - c) New/Invasive species
  - d) Phenology/life history
- D. Ecosystem shifts
- E. Effects on higher trophic levels- Implications for fisheries

Since the chapter would be reviewed by SGCC on 3 June, the deadline to produce the report would have to be set to 1 June 2009. An editor to co-ordinate the work would be needed.

There was general consensus as to the framework proposed by Astthor Gislason. Mark Benfield asked where information on jellies may be found. Priscilla Licandro suggested searching in published papers and reports and added that SAHFOS have information on some species. In answer to Astthor Gislason's suggestion that the framework of the OSPAR report be used for the plankton chapter, Mark Benfield said that he agreed, however the literature must be updated. Roger Harris inquired on the number of pages expected for the chapter. Astthor Gislason answered that the total length of the paper/book was set around 100 printed pages (80 – 125), our chapter would be one of approximately 15 chapters. Erica Head suggested that everyone should supply information from their respective areas. She suggested providing the information to an editor that would be responsible for the integration of everything. Peter Wiebe, considering that there is not much information on gelatinous plankton for the area, suggested to include information from other areas as well, since gelatinous plankton are being considered with increasing interest by several research groups in other parts of the world. A further discussion followed as to what the report should contain. Roger Harris suggested treating the gelatinous plankton as invasive species and giving them prominence as being part of the zooplankton. Steve Hay said that most of the importance allocated to gelatinous plankton is due to the disturbances they may make for the commercial fisheries. Steve said that another aspect to be highlighted in the chapter is how climate change will affect plankton and he thought it would be of importance to mention acidification as one of the aspects of this change. Although acidification is planned to be the theme of one of the chapters along with phenology, he considered that these topics should nevertheless be included in our overview of plankton.

A discussion followed as to who should act as editors for the writing up of the chapter. Astthor Gislason informed that he could not be editor because as one of the members of SGCC he will be one of the reviewers. After a short discussion it was decided that the editors of the chapter would be Priscilla Licandro and Michel Harvey. They both kindly agreed to take on this important task for the group.

Mark Benfield reminded the group that the task ahead is that everyone consider the previous OSPAR reports and provide relevant additions where needed. Care should be taken to provide information from the western North Atlantic (i.e. the areas not included in the OSPAR reports). Thus, contributions with regional descriptions for the Arctic, the Norwegian Sea, the North Sea, Iceland-Faeroes, Labrador Sea-West Greenland, Georges Bank and North American East coast are needed. The task of the editors will be to collate this information into the framework outlined above. Everyone should contribute, and good images are also important.

The following roadmap for the work ahead on the plankton chapter was discussed and accepted by the group: 1 May 2009: Contributions from all sent to the editors (Priscilla Licandro and Michel Harvey); 1 June 2009: Editors submit final draft chapter to Luis Valdés Chair of SGCC.

### **13 Assess and Report on the Outcomes of WKZEM, the ASC 2008 Theme Session Q, and the 2008 WGZE/ WGPBI Joint Meeting**

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**Lead: Astthor Gislason, Rapporteur: Janna Peters**

Astthor Gislason reported on the outcome of (1) the WKZEM workshop held in Heraklion 2008, (2) the ASC 2008 theme session Q held in Halifax, and (3) the joint meeting of the WGZE/WGPBI held in Sete, France 2008.

The WKZEM workshop was held by members of the ICES and the CIESM in Heraklion, Crete, Greece (27–30 October 2008) to compare zooplankton ecology and methodology between the Mediterranean and the North Atlantic, to start coordinated approaches on the standardisation of sampling protocols in plankton monitoring and to foster communications between the two working groups as well as to stimulate further projects. The workshop was organised by a committee (Astthor Gislason (ICES), Gabriel Gorsky (CIESM), Ioanna Siokou-Frangou (CIESM)) and a scientific advisory committee. The meeting was attended by 43 participants (28 from CIESM and 15 from ICES).

The workshop was structured into four sessions: (1) Overview of ongoing time series programmes and methodology in the Mediterranean and the North Atlantic, (2) Comparative zooplankton ecology of the North Atlantic and the Mediterranean and autoecology of key species, (3) The marine foodweb from microzooplankton–small pelagic fish, (4) Appearance or disappearance of species vs. global warming. Furthermore two workshops were run on time series analyses and zooplankton databases, respectively. The workshop report with abstracts of all presentations can be downloaded from the ICES website (<http://www.ices.dk/reports/OCC/2008/WKZEM08.pdf>). The initiative for a volume in the ICES Cooperative Research Series with extended abstract versions of all presentation is still ongoing, the deadline was extended to 1 July 2009. Currently there are 11 contributions that have been submitted, and 7 more are expected. Astthor Gislason expressed disappointment that so few extended abstracts were submitted, but the aim is still to publish the extended abstracts in ICES Coop. Res. Ser. The idea to publish selected papers of the workshop in a scientific journal, either as a collection of papers or a single review article, was discussed at the end of the WKZME meeting. It was felt that a possible avenue for such a venture would be the online journal JORD. The workshop was funded by the EUROCEANS, CIESM, and the Hellenic Centre for Marine Research.

After the presentation the workshop by WKZEM was evaluated by the WGZE members that attended the meeting. Astthor Gislason rated the workshop as success with very good presentations and good discussions. Priscilla Licandro mentioned that the discussion on data and the data centre was especially of interest for the WGZE. It was pointed out that in some data bases (e.g. PANGAEA) there is no quality control of the data. Within EUROCEANS, data were provided under the premise that authors will be contacted before use of the data, but there are examples, where data are used without a further quality check with the responsible scientists. In the discussions that

followed, the issue was raised that scientists who collected the data should be recognized or acknowledged. Peter Wiebe stated that in the GLOBEC programme some data are open to the public right away, and others after two years, but ownership of the data was always clear and mentioned. Roger Harris emphasized the value of the scientific exchange between scientists during the WKZEM workshop, but he also mentioned that only very few of the presentations really compared the North Atlantic and the Mediterranean regions, so the comparative aspect was lacking. He suspected that one of the difficulties in getting the extended abstracts together is rooted in the fact that people do not want their data be published in this way, rather they would want another avenue for publication, and that the overall outcome of the Workshop is a bit disappointing in light of the effort that has been put into organizing it. Pricilla Licandro added as a positive outcome, that at least a link has now been established between the two research communities, which will be valuable for future joint projects. With regard to the comparative aspects, Astthor Gislason stated that there were relatively few contributions being given from the North Atlantic, with most presentations from studies exclusively dealing with the Mediterranean.

Astthor Gislason introduced the background for Theme session Q “Evidence of global warming effects on zooplankton populations and communities, including larvae of benthic invertebrates and fish”, which was part of the ICES Annual Science Conference, 22–26 September 2008, Halifax, Canada. Similar Theme sessions had been proposed by the WGZE for the 2006 and 2007 ASCs, but they were not approved by ICES, probably because for these ASCs the group had other theme session proposals that were approved.

The aim of Theme session Q was to bring together zooplankton specialists studying: (1) the variability in spatial distribution, productivity, and timing of life cycles; (2) the population dynamics in varied species and environments; (3) the rates and functional relationships of species; and (4) the modelling of these processes. The conveners were: Wulf Greve (Germany), Steve Hay (UK), and Peter Wiebe (USA), all from our group. The session attracted a total of 22 contributions with 14 presented as talks and eight presented as posters.

The presentations addressed topics such as: Responses of larval fish to changes in zooplankton composition with special focus on the match-mismatch concept; State of the art coupled physical/biological models with special emphasis on spawning and migration of fish; Impact of food and temperature on the recruitment of crustaceans; Evidence of climatic effects on the zooplankton community structure; Impact of CO<sub>2</sub> with special focus on the effects on the low oxygen zones in the oceans. Astthor said that the session was well attended with between 50 and 150 individuals being present for the talks.

In answer to whether or not papers have to be delivered with presentations given at ICES Annual Science Conferences, Astthor said that ICES requested that a paper be delivered with every oral talk, however this was ignored by several authors, and in those cases only abstracts are submitted. Peter Wiebe informed that the submitted abstracts and papers are available on the conference web site.

Astthor Gislason then went on to report on the WGZE/WGPBI Joint meeting that was held in Sete (France) on 2 April 2008, when both groups met there simultaneously for their annual meetings. The objective was to bring modellers and field scientist together in order to explore how data and models could be combined to elucidate ecosystem dynamics and functioning. The workshop was attended by a total 53 participants, 29 from WGZE and 24 from WGPBI. The workshop was structured into

three sessions: (1) Modelling (WGPBI), lead by Uffe H. Thygesen; (2) Data (WGZE), lead by Astthor Gislason; and (3) Future collaboration between WGZE and WGPBI, lead by Charles Hannah. There were five presentations being given under each of the two first topics and they are published in the annual reports of both groups (2008 WGZE Report, Annex 7). During the summary discussion at the end of the Workshop the following topics were raised: Experiments are needed to quantify processes and fluxes, whereas field work is needed to quantify standing stocks and population structure. Models may be used to identify gaps in knowledge. While data are needed for validation, the validation should be an interactive process between modellers and observationalists. The models are valuable tools for forecasting responses under different scenarios. It was recognized that there are errors inherent in both approaches, i.e. both models and data have errors. It was emphasized that the models do not have to be mathematical but can also be conceptual. The discussion revealed that the models can help to design the field work. In this regard an overview was given on the BASIN project, which will provide an opportunity to involve both modellers and the observationalists from the onset.

A discussion followed as to the success of the joint workshop. The group felt that the workshop was not as successful as it could have been, because the presentations on modelling were too specific and did not identify or illustrate general modelling approaches or methods for elucidating ecosystem dynamics and functioning. In spite of these limitations the group felt that the workshop was a good beginning for further cooperation between the two groups.

## **14 Summaries of Recent Developments/Advances in Zooplankton Ecology**

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This section of the meeting was an opportunity for members of the WGZE to highlight recent research conducted either by themselves or by colleagues from their member nations. A series of 15 minute presentations were given over the course of the meeting. Abstracts of each presentation are summarized below.

### **14.1 Gulf SERPENT Project**

#### **Mark Benfield**

As demand for energy increases, oil companies are moving into the deep-sea to search for new sources of petroleum. Many of the regions where production and exploration are active are also poorly studied by oceanographers. The presence of stable deepwater platforms and ships equipped with powerful remotely operated vehicles (ROVs) provides a unique opportunity to study life in the deep sea. The SERPENT Project (Scientific Environmental ROV Partnership using Existing Industrial Technology) brings academia and industry together in a collaboration to learn more about marine life. Headquartered in the UK, the SERPENT Project has regional partnerships around the world. The Gulf SERPENT Project is based at Louisiana State University and works with BP, Chevron, and Shell to study plankton and nekton in the mesopelagic and bathypelagic regions of the Gulf of Mexico. A short video presentation was shown that summarized SERPENT research and highlighted recent findings in the Gulf of Mexico.

#### **14.2 Latest results of the NW Atlantic GLOBEC program: Climate forcing of plankton in the Gulf of Maine-Georges Bank region**

**Cabell Davis, Rubao Ji, R. Beardsley and C. Chen**

Over the past decade, the US Global Ocean Ecosystem Dynamics (GLOBEC) NW Atlantic program has been studying the physical-biological processes controlling plankton and fish populations in the Gulf of Maine-Georges Bank region to better understand the combined effects of climate forcing. Field studies and retrospective analyses reveal changes in the ecosystem that coincide with changes in Scotian Shelf surface salinity and intrusions of deep Labrador Slope Water. Data from broad-scale surveys covering Georges Bank revealed a 3-fold increase in abundance of small copepods during the GLOBEC field years 1995–1999. This copepod increase coincided with a low salinity anomaly that was identified using oxygen isotopic analysis as originating from the Labrador Sea. The freshening is thought to originate from Arctic ice melt and subsequent southward advection along the Labrador and Scotian shelf. The increase in small copepods was subsequently found in other independent data sets including CPR and MARMAP/ECOMON surveys. These data reveal a significant increase in small copepod abundance from the 1980s to the 1990s, coinciding with freshening of the surface waters. This increase in small copepod abundance also was coincident with higher haddock recruitment on Georges Bank. A PCA of CPR data found that this shift happened all along the shelf from Newfoundland to the mid-Atlantic Bight. The shift also coincided with a shift in the fishery ecosystem of the NW Atlantic shelf (from PCA analysis). Satellite data analysis indicated that the spring phytoplankton bloom on the Scotian Shelf and Gulf of Maine occurs earlier as a result of freshening. It is hypothesized that the earlier spring bloom caused earlier growth of copepod populations. To examine this possibility, numerical experiments were conducted using a 3-D biological-physical model of this region, which included NPZD and copepod species population dynamics. The 1999 low-salinity year was used as a test case and compared to the same year, but without allowing low-salinity water to enter the system. The model revealed that although the phytoplankton bloom occurred earlier and copepod abundances were higher in the low-salinity case, this increase occurred only on the Scotian Shelf and eastern Gulf of Maine. Additional, multi-year modelling will be done to explore this mechanism further, allowing the low-salinity water to penetrate further westward in the GoM. This modelling approach is a useful diagnostic tool for exploring potential links between climate and plankton populations.

#### **14.3 Advances in Digital Holographic Imaging**

**Cabell Davis and N. Loomis**

A fundamental need in the study of aquatic ecosystems is autonomous collection of high-resolution spatio-temporal data on species-specific population structure of plankton. Current sampling methods cannot provide this information. Recent advances in digital holographic imaging (DHI) have made it possible to image organisms in 3 dimensions with high-resolution. A compact prototype DHI system was developed that can be deployed on a variety of platforms. This unit images plankton and particulate matter in the size range of 30–100 $\mu$ m, with a pixel resolution of 3–9 $\mu$ m. The volume imaged can be up to 1 liter, depending on the distance between the imager and the laser source. The prototype system consists of a digital camera and a fiber-coupled laser diode. The entire system runs on a small lithium battery and collects 400 holograms on an 8GB CF card. The images are downloaded via firewire.

Both the data download and battery charging is done through the connectors on the underwater housing. The present housing is rated to 1000m. The entire unit, including frame, has an air weight of 8kg and an in-water weight of 2kg. The system is currently being made smaller for incorporation in to ocean gliders and drifters for global coverage. Example images from several recent deployments reveal important features of plankton and demonstrate the utility of the method.

#### **14.4 State of the zooplankton in the Lower St. Lawrence Estuary (LSLE) and the Gulf of St. Lawrence (GSL) in 2008**

##### **Michel Harvey**

In 2008, the numerical abundances of the dominant copepods at the Anticosti Gyre (AG), Gaspé Current (GC), and Shediac Valley (SV) stations were between 37% and 46% higher than in 2006 and 2007, and 55% higher than the time-series minimum observed in 2001 and 2002. This large increase in copepod abundance was mainly due to a strong increase in abundance of the small copepod species *Temora longicornis* at the end of the summer season (August–November); this species is usually abundant in the more southerly part of the GSL. The presence of this small species had no impact on the overall biomasses of the dominant copepods at AG, GC, and SV in 2008, which were between 14% and 43% lower than in 2006 and 2007 and between 30% and 50% lower than the time-series maximum observed in 2003 at the three stations. At the Rimouski (RI) station, there was no change in terms of zooplankton abundance with respect to the time series (2005–2007) and a slight decrease in terms of zooplankton biomass (-20%). The average abundances of *Calanus finmarchicus* at AG, RI, GC, and SV in 2008 were the same as those of the two previous years and half the magnitude of the time-series maximum observed in 2003 (AG, GC, SV). In addition, some changes in the zooplankton community structure were observed at all stations, including some variations in the rank of the top ten taxa (i.e., the dominant species that represent more than 90% of the total zooplankton abundance) and the appearance for the first time of some new taxa in the top ten. A series of new indicators of zooplankton biomass and abundance were developed in four regions including the LSLE, the North West GSL, the North East GSL, and the Southern GSL from 2000 to 2007. These new indicators include: 1) biomass of *Calanus hyperboreus*, 2) biomass of mesozooplankton without *C. hyperboreus*, 3) total abundance of copepod, 4) abundance of copepod nauplii, 5) abundance of small copepods, 6) abundance of large copepods, 7) abundance of *Calanus finmarchicus* (CIV-CV), 8) abundance of mesozooplankton other than copepod (ex. Cladocera, Ostracoda, Appendicularia), 9) abundance of meroplankton (e.g. Cirripedia, bivalve larvae, Polychaete larvae, Echinoderm larvae), 10) abundance of carnivorous zooplankton (chaetognaths, *Aglantha digitalis*, hyperiid amphipod, *E. norvegica*), 11) abundance of krill larvae (furcilla, calyptopis). The significance of these indicators was tested in making some correlations between both biological and physical indicators and the result indicate that the interannual variation of some of the biological indicators are highly correlated (positively or negatively) with some physical variables.

#### 14.5 Late-summer zooplankton community structure, abundance and distribution in the Hudson Bay System and their relationships with environmental conditions, 2003–2006

R.A. Estrada, M. Harvey, M. Gosselin, M. Starr

Zooplankton communities were examined for the first time in three different hydrographic regions of the Hudson Bay System (HBS) in early August and early September of 2003 to 2006 during the DFO-MERICA program. Sampling was conducted at fifty stations distributed along different transects located in the Hudson Bay (HB), Hudson Strait (HS) and Foxe Basin (FB). The variations in zooplankton biomass, abundance, species composition and diversity in relation to environmental variables were studied using multivariate (MDS, ANOSIM) and Redundancy Analysis (RDA) techniques. In all years, the average total zooplankton biomass was 4 times lower in HB ( $14.1 \text{ g wm} \cdot \text{m}^{-2}$ ) than in HS ( $64.2 \text{ g wm} \cdot \text{m}^{-2}$ ) and FB ( $60.0 \text{ g wm} \cdot \text{m}^{-2}$ ). Clustering samples by their relative species compositions revealed no interannual variation in zooplankton community (ANOSIM test,  $R = 0.10$ ), but did reveal a markedly interregional variability between the three regions (ANOSIM test,  $R = 0.68$ ). Water column stratification explained the greatest proportion (25 %) of this spatial variability in the structure of zooplankton communities within the HBS. In the HB, the environmental variables analysed in a partial RDA allowed identification of three regions inside the bay (HB West, Central, and East) with different environmental gradients and zooplankton assemblages. In general the RDA models tested among the regions of the HBS were very consistent with its general surface layer circulation pattern for the summer condition in terms of environmental variables and distinct zooplankton assemblages. Overall, both the zooplankton biomass and diversity indices ( $H'$ ,  $J'$  and  $S$ , on total zooplankton occurring more than 5 times in the data,  $202 \mu\text{m}$ ) were lower in the most strongly stratified environment (i.e. HB) than in the deeper and more turbulent regions (i.e. FB & HS, respectively).

#### 14.6 Long-term variability in phytoplankton and zooplankton abundance in the NW Atlantic in Continuous Plankton Recorder (CPR) samples

Erica Head

The changes in annual average abundances and seasonal cycles over the decades from the 1960s to 2007 are described for 9 categories of CPR taxa (species groups) for 8 geographic regions along the Z (Reykjavik-St Johns) and E (St Johns–Western Scotian Shelf) lines. Changes in the annual average temperatures, derived from satellite data, are also presented for 1982–2007.

Average long-term phytoplankton abundance (PA) is higher on the shelf than in the deep ocean. PA increased in the 1990s on the shelf, mainly in the winter, but decreased somewhat during the 2000s. PA values were maximal in the deep ocean in 2005–2006, with no changes in seasonality over the decades.

On the Scotian and Newfoundland shelves *Calanus finmarchicus* early and late stages decreased in abundance in the 1990s, but they increased again on the Scotian Shelf in the mid-2000s, although not on the Newfoundland Shelf. On the Scotian Shelf the peak in abundance of young stages has occurred earlier since the 1990s. This may be linked to the earlier seasonal occurrence of high levels of PA. On the Z line beyond

the shelf *C. finmarchicus* abundance (especially young stage abundance) has been relatively high since 2000, with no change in seasonality.

Long-term abundances of small copepods are higher in shelf regions than in the deep ocean, whereas the reverse is true for copepod nauplii. Both groups appear to respond similarly to changes in temperature, however, with maximal abundances for both in warm years on the shelf (1999–2000) and in the deep ocean (2005–2006).

The arctic copepods *Calanus glacialis* and *Calanus hyperboreus* are mainly seen in shelf waters, which are influenced by arctic outflow. Their abundances have increased since the 1990s, when the contribution of arctic water on the shelf increased.

#### **14.7 Zooplankton trends and related environmental parameters (hydrography and chlorophyll) based on monitoring surveys**

##### **Eilif Gaard**

In the Norwegian Sea, two different water masses dominate in the upper layers: cold water from the East Icelandic Current in the western part and warmer Atlantic water in the eastern and Southernmost part. Monitoring of zooplankton and environmental variables have been on a transect from the Faroes covering the warm Atlantic Water (AW) (southern part of the transect) and the colder East Icelandic Current Water (EICW) (northern part of the transect) in May since the early 1990s. These data have revealed phenological changes in *Calanus finmarchicus* since the early 2000s. These changes can be seen both in both water masses, but are more pronounced in the EICW than in the AW. Overwintering individuals dominated until 2002 in May in the EICW but since 2003 they have been replaced by G<sub>1</sub> dominance of young copepodite stages. Thus, although the monitoring data show an increase in total abundance in May since 2003, the copepod biomass have decreased in this time series. Smaller phenological changes have been observed in the AW. No changes are observed in chlorophyll concentrations during the monitoring period.

The Faroe shelf water is relative well-separated from the surrounding oceanic environment, by a persistent front that surrounds the islands at the 100–150 m bottom contour. The Shelf zooplankton community is in most years dominated by neritic copepods (mainly *Acartia* and *Temora*), mixed with variable abundances of *C. finmarchicus*. Zooplankton monitoring on the shelf has shown a clear increasing trend in abundance of *Temora* since the early 2000s in the shelf water. No clear trend can be observed in total abundance of *C. finmarchicus*. However, phenological changes in *C. finmarchicus* can be observed: In the 1990s and the early 2000s, monitoring samples in late June in generally showed dominance of C<sub>1</sub>–C<sub>3</sub>. However, since the mid 2000s this has changed to C<sub>4</sub> and C<sub>5</sub> dominance. Frequent monitoring of chlorophyll in the shelf water reveal no trends timing or chlorophyll abundance. However the temperature has increased about 1°C during this period.

#### **14.8 Video plankton recorder (VPR) and acoustic registrations along a transect across the subarctic front north of Iceland**

##### **Asthor Gislason**

In mid-May 2008 test deployments were made with a digital autonomous colour VPR (Seascan) along a ~37 km long transect running perpendicular to the subarctic front north of Iceland, separating the relatively warm Atlantic water onshore from the colder Subarctic or Arctic water offshore. The VPR was undulated up and down along the transect from surface to 100–200m depth in a tow-yo fashion while the ship

cruised at slow speed (~2 knots). The test deployment yielded excellent set of observations with thousands of high quality colour images of plankton and other particles being sampled. Images with biological particles were extracted as regions of interest (ROIs) using the Autodeck image analysis software (Seascan). The ROIs were then classed automatically into broad taxonomic entities using the Visual Plankton software (Davis *et al.*, 2005). The results showed marked differences in abundance and composition of plankton and marine snow from north to south, with the subarctic front clearly influencing the distribution of plankton and particles. Thus copepods (mainly *Calanus finmarchicus* and *C. hyperboreus*) were much more abundant north of the front than south of it, while the reverse was true for the marine snow. Attempts were made to relate the VPR observations with acoustic registrations using SIMRAD EK500 at 38 kHz and 120 kHz. Initial results were inconclusive, but further work is in progress.

#### 14.9 Acoustic properties of *Salpa thompsoni*

**P. Wiebe, D. Chu, S. Kaartvedt, A. Hölter, W. Melle, E. Ona, P. Batta-Lona**

Aggregations of the salp, *Salpa thompsoni*, were encountered in the vicinity of Bouvet Island (54° 26'S; 3° 24'E) during the Antarctic krill and ecosystem studies (AKES) cruise on the Norwegian research vessel G.O. SARS from 19 February to 27 March 2008. The salp's in situ target strength (TS), size, number of individuals in aggregate chains, and chain angle of orientation were determined from acoustic and optical data collected with a submersible TS-sonde instrument. Shipboard measurements were made of *Salpa thompsoni*'s material properties -sound speed contrast h and density contrast g. In addition, a model of salp acoustic backscattering was developed that takes into account the fact that aggregate salps occur in multi-individual chains. Individuals of *Salpa thompsoni* in aggregates were mostly 45.5 to 60.6 mm in mean length and the relatively rare solitaries were about 100 mm. Aggregate chains ranged from 3 to at least 121 individuals and in the upper surface waters (<20 m) showed no preferred angle of orientation. Sound speed contrast (h) ranged from 1.006 to 1.0201; the density contrast (g) estimates varied between 1.0 and 1.0039. The in situ TS-distributions peaked between -75 and -76 dB at 38 kHz, with a secondary peak of stronger targets at ~-65 dB. TS ranged between -85 and -65 dB at 120 kHz and 200 kHz, and peaked around -74 dB. The measured in situ TS of salps with TS-sonde at three frequencies match the Distorted Wave Born Approximation theoretical scattering model predictions reasonably well. The backscattering from salps when aggregates (chains made up of multiple individuals rather than from single individuals) dominate gives rise to TS values that can be similar to krill and other zooplankton with higher density and sound speed contrasts.

## **15 Summary. Discussion and Future Plans**

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### **15.1 Recommendations**

The ICES Working Group on Zooplankton Ecology recommends to the Science Committee the following Theme Sessions for the 2010 ICES Annual Science Conference:

'North Atlantic Ecosystem: Basin-scale Analysis, Synthesis, and Modelling.' Convenors: Roger Harris (UK), Peter Wiebe (USA), and Erica Head (Canada).

Supporting information is given in Annex 3.

### **15.2 Draft Resolutions**

#### **15.2.1 WGZE Terms of Reference Proposed for 2010**

After discussions of future ToRs, the following suggestions were made, which cover development of new initiatives for the WGZE, mechanisms to advance taxonomic skills and practices, oversight of digitization of historical data, the forthcoming Zooplankton Production Symposium, the ICES Position Paper on Climate Change, linkages with microbial ecologists, and the highly useful ICES Plankton Status Report (Annex 4):

- a) review the outcomes of new initiative proposals and select one or more future initiatives based on a review of planning letters summarizing potential programs.
- b) review progress towards a proposal for a Study Group on Integrated Morphological and Molecular Taxonomy focused on the broader ICES community.
- c) review the progress of: 1) the ICES historical dataset digitization project; 2) new enzymatic and size-classed methods for zooplankton; 3) the outcome of the 2009 ASC Session A,
- d) prepare and improve the ICES Plankton Status report including an examination of regional and cross-basin trends and recommend means of incorporating species information into the report,
- e) review plans for sessions and activities during the 5<sup>th</sup> Zooplankton Production Symposium
- f) review the chapter 'Overview of trends in plankton communities in the ICES area, including jellyfish' for the ICES Position Paper on Climate Change as edited by Priscilla Licandro and Michel Harvey and revised by the SGCC.
- g) assess and report on potential linkages and encourage joint activities with the proposed Microbial Oceanography Working Group, should it be established by SCICOM.

### **15.2.2 WGZE Proposal for a Study Group on Integrated Morphological and Molecular Taxonomy**

The WGZE recommend to ICES that a group of experts be established that will provide oversight of existing and future developments and continuity of taxonomic best practice for the wider ICES research community. To sustain and promote taxonomic expertise the group will develop and initiate strategies to:

- a) Identify resources, current gaps and important issues in taxonomic research;
- b) Provide a platform for promotion and exchange of relevant scientific information;
- c) Initiate and support provision of standards, training materials and taxonomy workshops;
- d) Assist in the revision and development of species identification keys;
- e) Develop the continuing integration of molecular and morphological taxonomy; and
- f) Advise on the implications of developments for marine science and management.

These experts should be drawn from relevant ICES expert groups (e.g. WGZE, WGHABD, WGFE, WGBE) and others across ICES nations. This group should be provided with an ICES web portal and SharePoint facility to enable communication and dissemination of their findings and expertise with ICES expert groups and more widely. Further background on this recommendation is available in Section 5.

### **15.3 Next Meeting (2010)**

The next meeting of the WGZE will be held in Portland, Maine USA at the Gulf of Maine Research Institute from 23 to 26 March 2010 at the kind invitation of Jeffrey Runge.

## **16 Closure of Meeting**

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Mark Benfield (Chair) thanked all members for their contributions, time, and enthusiasm. He also thanked our colleagues from the Faroe Marine Research Institute (FAMRI) for their support of the meeting and Drs. Eilif Gaard and Høgni Debes for their kind hospitality and the excellent facilities. During the course of our meeting our host institution celebrated its 50<sup>th</sup> anniversary and changed its name from the Faroese Fisheries Laboratory to FAMRI. Mark looked forward to seeing the participants at the meeting next year in Maine. The meeting was closed at 13:30 on 2 April 2009.

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## Annex 1: List of participants

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## Annex 2: Agenda

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### Monday March 30

- 10:30 – 11:00 Coffee
- 11:00 – 12:00 Opening, Agenda, Introductions, and Logistics
- 12:00 – 13:30 Lunch
- 13:30 – 14:00 Overview of the BASIN Program  
(Lead: Peter Wiebe, Rapporteur: Arno Põllumäe)
- 14:00 – 15:00 Discussion of a collaboration in a pan regional synthesis of life histories of *Calanus* species pairs in the North Atlantic and North Pacific.  
(Lead: Jeff Runge, Rapporteur: Cabell Davis)
- 15:00 – 15:30 Coffee
- 15:30 – 17:00 ToR e): Review progress in zooplankton taxonomy with particular reference to developments within ICES. This will also include a discussion of the loss of taxonomic expertise on zooplankton and ichthyoplankton within the ICES community.  
(Lead: Steve Hay, Sophie Pitois, Rapporteur: Priscilla Licandro)
- 17:00 – 18:00 Reception at the Faroese Fisheries Lab

### Tuesday March 31

- 09:00 – 10:00 Tor C: Provide expert knowledge and guidance to ICES Data Centre on a continuous basis including a progress on the digitizing project and begin an inventory of historical data and samples.  
(Lead: Mark Benfield: Rapporteur: Erica Head)
- 10:00 – 10:30 Update on the Census of Marine Zooplankton (CMarZ) Program  
(Lead: Ann Bucklin, Rapporteur: Michel Harvey)
- 10:30 – 11:00 Coffee Break
- 11:00 – 12:00 Potential EU Funded Project: ENV.2010.2.2.1.2. Global plankton data set building in view of modelling.  
(Lead: Mark Benfield, Rapporteur: Heike Helmholz)
- 12:00 – 13:30 Lunch
- 13:30 – 15:00 Discussion of future directions/projects for the Working Group  
(Lead: Roger Harris, Rapporteur: Jasmin Renz).
- 15:00 Sightseeing tour by bus

### Wednesday April 1

- 09:00 – 10:30 ToR d): Review the ICES Plankton Status Report and report on the progress of linking the Status Report data to the ICES data centre. Discuss preparations for the next Status Report.  
(Lead: Todd O'Brien, Rapporteur: Ann Bucklin)
- 10:30 – 11:00 Coffee

- 11:00 – 12:00 ToR a): Produce a summary of recent developments in plankton research and monitoring (e.g. seasonality, abundance, community structure, biodiversity, evidence/rationale for incorporating zooplankton in monitoring) with a view to further analysis and subsequent publication.  
(Lead: Jeff Runge, Rapporteur: Solvita Strake).
- 12:00 – 13:30 Lunch
- 13:30 – 15:00 ToR f): Produce an overview of trends in plankton communities in the ICES area, including jellyfish, for the ICES Position Paper on Climate Change.  
(Lead: Astthor Gisslasson, Rapporteur: Antonina dos Santos)
- 15:00 – 15:30 Coffee
- 15:30 – 17:00 ToR b): Assess and report on the outcomes of WKZEM, the ASC 2008 theme session Q, and the 2008 WGZE/WGPBI joint meeting  
(Lead: Astthor Gisslasson, Rapporteur: Janna Peters)

#### Thursday April 2

- 09:00 – 10:30 Summaries of recent developments/advances in zooplankton ecology (15 min each)
- |                    |   |
|--------------------|---|
| Peter Wiebe        | Sound scattering by salps   |
| Mark Benfield      | SERPENT Project   |
| Erica Head         | Update on analysis of data from the CPR E and Z lines   |
| Astthor Gisslasson | VPR and 120 kHz acoustic surveys off Iceland  |
| Michel Harvey      | Late summer zooplankton community structure, abundance and distribution in the Hudson Bay System and their relationships with environmental conditions, 2003–2006 |
| Eilif Gaard        | Zooplankton trends and related environmental parameters (hydrography and chlorophyll) based on monitoring surveys   |
- 10:30 – 11:00 Coffee Break
- 11:00 – 12:00 Selection of ToRs for 2010, suggestions for Theme Sessions for ASC, workshops ...
- 12:00 Adjourn

### Annex 3: Theme Session Proposal for ASC 2010

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The **Working Group of Zooplankton Ecology** (WGZE) proposes a Theme Session for the ICES 2010 Annual Science Conference:

#### Title: North Atlantic Ecosystem: Basin-scale Analysis, Synthesis, and Modelling

Conveners: Roger Harris, Plymouth Marine Laboratory, UK, r.harris@pml.ac.uk; Peter Wiebe, Woods Hole Oceanographic Institution, USA, pwiebe@whoi.edu; Erica Head, DFO, Bedford Institute, Dartmouth, Nova Scotia, CA, HeadE@mar.dfo-mpo.gc.ca.

#### Description

The session will focus on topics including

1. Changes in: temperature, stratification, transport, acidification, and their influence on the seasonal cycle of primary productivity, trophic interactions, and fluxes of carbon to the benthos and the deep ocean; and
2. Changes in life history strategies of target organisms, population dynamics and community structure; and the dynamics of exploited species.

We welcome contributions, both retrospective and future scenarios, that present analysis and modelling studies of oceanographic plankton, benthos and fisheries data that provide insight into the basin-scale changes that are now taking place.

#### Supporting information

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Priority:

Scientific justification:	It is timely to coordinate studies at the basin scale, including connections with shelf seas such as the North Sea and the Newfoundland and Labrador shelves, given the importance of the North Atlantic for climate change and for exploited resources such as fisheries. The goal of this session is to advance understanding of the changes occurring in the North Atlantic and associated shelf seas and their relevance to resource management strategies.
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Participants:

Linkages to advisory committees:

Linkages to other committees or groups:	SCICOM
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Linkages to other organizations:

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## Annex 4: WGZE Terms of Reference for the 2010 meeting

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The **Working Group on Zooplankton Ecology** [WGZE] (Chair: M. C. Benfield, USA) will meet in Portland, Maine, USA from 23–26 March 2010 to:

- a) review the outcomes of new initiative proposals and select one or more future initiatives based on a review of planning letters summarizing potential programs;
- b) review progress towards proposal for a Study Group on Integrated Morphological and Molecular Taxonomy focused on the broader ICES community;
- c) review the progress of the ICES historical dataset digitization project, new enzymatic and size-classed methods for zooplankton, and the outcome of the 2009 ASC Session A;
- d) prepare and improve the ICES Plankton Status report including an examination of regional and cross-basin trends and recommend means of incorporating species information into the report;
- e) review plans for sessions and activities during the 5<sup>th</sup> Zooplankton Production Symposium;
- f) review the report on Zooplankton and Climate Change for the ICES Position Paper on Climate Change and revise as necessary based on comments from the SGCC; and
- g) discuss potential linkages and encourage joint activities with the proposed Microbial Oceanography Working Group, should it be established by SCICOM.

The WGZE will report by 1 May 2010 for the attention of the **Science Committee**.

### Supporting Information

Priority:	The activities of this group are a basic element of the Oceanography Committee, fundamental to understanding the relation between the physical, chemical environment and living marine resources in an ecosystem context. Reflecting the central role of zooplankton in marine ecology, the group members bring a wide range of experienced expertise and enthusiasm to bear on questions central to ICES concerns. Thus the work of this group must be considered of very high priority and central to ecosystem approaches.
Scientific justification and relation to action plan:	<p>Term of Reference a)</p> <p>Current possibilities for future projects/initiatives include: updating the zooplankton methodology manual, a seagoing high-tech zooplankton ecology workshop, developing a means to sustain and strengthen taxonomic capability and to integrate new and traditional taxonomic tools into zooplankton ecology, developing a study to determine the physiological tolerances and factors that determine the ranges of species including mining and extending the Plankton Status Report.</p> <p>The WGZE has a strong history of practical, intersessional projects with broader and lasting outcomes. For example, the ICES Zooplankton Methodology Manual was a major achievement of the WGZE and is in need of updating. A second seagoing workshop would enable high-tech zooplankton ecology approaches to be evaluated. The WGZE has actively supported training in new and traditional taxonomic tools. Determination of the physiological tolerances and the factors that determine the ranges of zooplankton species is key to a</p>

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better understanding of the responses of zooplankton to climate variability and change in the ICES area.

Term of Reference b)

The WGZE has actively supported training in new and traditional taxonomic tools and has a strong interest in this wider proposal. Given the WGZE's active interest in defending taxonomic skills in the ICES region, this WG is ideally-situated to provide a positive supporting role in assessing taxonomic methods, information, and potential new techniques by coordinating and promoting developments and information feed-back to the scientific community who support ICES data provision, analyses, and advice. ICES as a stable, long lived and international institution has a major role to play in the collation, review, and application of these efforts, in promoting best practices and in coordinating development and dissemination of such information.

Term of Reference c)

All three topics are initiatives of the WGZE and it is appropriate that the WG monitors their progress and evaluates their outcomes.

For the Dataset Digitization Project, the WGZE recognizes the importance of making available and analyzing older time series data so that the information they contain can be compared with more recent material. This is especially important in our present era of recognized changes in climate, plankton and fisheries. Long-term time series of plankton from the North Atlantic are relatively rare and further they tend not to extend very far back in time. The project for the digitization, analysis and interpretation of plankton data for pre-1914 ICES sampling in the North Sea and adjacent waters will rescue a unique historical dataset from the turn of the last century. Against this background, the group feels it is important to monitor the success of the project.

Recognizing that the more traditional approaches to measuring zooplankton feeding and growth rates are hampered with weaknesses, the WGZE feels as important to monitor new approaches based on new enzymatic and size-classed methods.

Theme Session A for the 2009 ASC, 'Biochemical, biogeochemical, and molecular approaches to the study of plankton ecology and species diversity', will be a major international event. The outcomes will be important to the future aims and plans for plankton research. As the proposers of this Theme session we would like to follow up on progress made in this event.

Term of Reference d)

This is a repeating task established by the Working Group in 2000 to monitor the plankton abundance in the ICES area. The material presented under this item updates and expands the annual Summary Plankton Status Report in the ICES area. Reported results are significant observations and trends based on a wide range of time-series sampling programmes. Efforts are in hand to expand the report spatially and to include phytoplankton and elementary physics and to facilitate comparative analyses and setting monitoring standards and recommendations.

Term of Reference e)

As one of the organizers of the upcoming 5th Zooplankton Production Symposium, WGZE feels committed to contribute to its success. The symposium will be a major international event, the outcomes of which will be important to the future aims and plans for plankton research. The WGZE has a good practical history of sponsoring, running and organizing past Zooplankton Production Symposia. The successful organization of the Symposium is essential to successful collaboration with other sponsors and to its success.

Term of Reference f)

This is an important input from the WGZE to the ICES Position Paper and it will be timely to review progress and comment as appropriate. Having contributed a draft chapter for the ICES Position Paper on Climate Change, which will include substantial evidence that zooplankton abundance and distributions are being strongly impacted by climate change, the WGZE would like to consider the

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	<p>responses of SGCC and provide feedback.</p> <p>Term of Reference g)</p> <p>The potential formation of this new WG is of great interest and significance for the WGZE. Moreover, the WGZE supports the initiative and looks forward to joint activities that will facilitate an ecosystem based approach. Given that microzooplankton constitute a significant component of the plankton community in many marine environments, and owing to their small size, they typically have higher weight-specific growth rates than larger metazoans. Consequently, they are important phytoplankton grazers in many marine systems, capable of exploiting pico- and nanoplankton. Microzooplankton may in turn be eaten by larger metazoans of the plankton community and thus they form an important link in the “microbial loop” between pico- and nanoplankton and higher trophic levels. Due to lack of proper methodology for collection, preservation and difficulties in identification, their ecology is relatively poorly understood. With all this in mind WGZE members feel it is important to follow progress towards the establishment of a Working Group devoted to Microbial Ecology.</p>
Resource requirements:	Resource required to undertake the activities of this group is negligible. However, ICES must be committed to provide some sponsorship and support for workshops, publication costs for the Plankton Status Report, and the 5th Zooplankton Symposium.
Participants:	The group has an enthusiastic core membership, and is successfully making efforts to attract broader participation both across ICES nations and across relevant skills. The WGZE Annual Meeting is normally attended by some 20–25 members and guests.
Secretariat facilities:	None, beyond communication support.
Financial:	Beyond the publication costs for the Plankton Status Report and the Proceedings of the WKZEM Workshop, there are no other current financial implications.
Linkages to advisory committees:	The Group reports to the Science Committee, ACE and ACME (information also relevant to some ACFM aims). Mainly WGZE provides scientific information on plankton and ecosystems and welcomes input from other committees, working/study groups etc.
Linkages to other committees or groups:	Any and all working and study groups interested in marine ecosystem monitoring and assessments, modelling and/or plankton studies, including fish and shellfish life histories and recruitment studies. Strong working links have been developed between WGZE and Mediterranean colleagues (CIESM), and with the Census of Marine Zooplankton (CMarZ) and SCOR WG130: Automatic Visual Plankton Identification.
Linkages to other organizations:	

## Annex 5: Study Group on Integrated Morphological and Molecular Taxonomy

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The WGZE recommend to ICES that a **Study Group on Integrated Morphological and Molecular Taxonomy** [SGIMT] be established (Co-Chair: to be determined) that will provide oversight of existing and future developments and continuity of taxonomic best practice for the wider ICES research community. The group will meet in **VENUE** on **DATE** [to be determined]. To sustain and promote taxonomic expertise the group will develop and initiate strategies to:

- a) identify resources, current gaps, and important issues in taxonomic research;
- b) provide a platform for promotion and exchange of relevant scientific information;
- c) initiate and support provision of standards, training materials, and taxonomy workshops;
- d) assist in the revision and development of species identification keys;
- e) develop the continuing integration of molecular and morphological taxonomy; and
- f) advise on the implications of developments for marine science and management.

The SGIMT will report by **DATE** to the attention of the **SCICOM**.

### Supporting Information

Priority:	The work of the Group is essential if ICES is to progress the developments of techniques in fish stock assessment.
Scientific justification:	<p>The WGZE recognizes taxonomy as a fundamental discipline in general and evolutionary biology, ecology and environmental management. Taxonomy is critical to successful understanding, assessment and management of the species diversity and relationships in undisturbed ecosystems and in those affected by natural or human activities such as climate change/ acidification, industrial pressures or eutrophication. The group are also aware that there are globally increasing efforts to reverse the decline in marine taxonomic expertise and to advance traditional morphology-based phylogenies into the new frontiers opened up by molecular genetics. Indeed the WGZE has sponsored and arranged plankton taxonomic workshops and has strong associations with several of these global initiatives. Taxonomic experts are relatively few in many but not all ICES nations and they tend to specialise in certain taxa rather than generally across the diversity of plankton species.</p> <p>The current series editor (Steve Hay) presented the WGZE with a summary of his ICES Plankton ID series editor's report for 2008. This report looked at the background, recognised extensive difficulties with the series and commended ICES historical work in making the sheets available as web downloads and on CD. The report recommended several actions that ICES could pursue to take forward their support for taxonomy of marine plankton. These were discussed. The WGZE considered that the existing sheets, although many are outdated, are still a resource that is widely used and appreciated and they must remain available. Also, although those outdated sheets could be revised or redone this is unlikely to happen; as the format and production are outdated by the very many internet based approaches. Indeed the ICES</p>

web pages should carry warnings to users that in these historical ICES classifications the nomenclature may be out of date and names of species identified using the sheets should be checked for synonymies with such as the World or European Registers of Marine Species or ITIS.

ICES major role is the collation, archiving, and dissemination of scientific data, analyses and evidence based advice to support policy making, regulatory control and the conservation and sustainable use of marine resources and ecosystems. ICES facilitates international collaborative science to achieve these aims. The WGZE consider that ICES has critical supporting and training roles in global marine science, through promoting scientific standards, new research and developments and training opportunities. Taxonomic standards and descriptions are subject to constant change and development. Particularly, taxonomy grows with new molecular approaches to species phylogeny, evolution, species adaptive capacities, environmental sensitivities and community diversity. These are highly significant new developments that in a few years will have revolutionised the monitoring and study of marine species and ecosystems. The WGZE consider it essential that ICES adopts a positive supporting role in assessing taxonomic methods, information and potential new techniques by coordinating and promoting developments and information feed-back to the scientific community who support ICES data provision, analyses, and advice. Considering the plethora of internet and other developments in taxonomic information, the WGZE considered it unlikely that ICES could or should develop its own web served database of taxonomic information. However, the majority of existing efforts are short-term funded and evolve through multiple and often uncoordinated short term efforts. Even major programs such as CoML and CMarZ or the EU MARBEF network have limited lifespans and have problems conserving and developing the gains they have made. Collectively and specifically these global efforts on traditional and molecular taxonomy amount to a valuable basic and developing resource. ICES as a stable, long lived and international institution has a major role to play in the collation, review, and application of these efforts, in promoting best practices and in coordinating development and dissemination of such information.

Resource requirements:	No specific resource requirements beyond the need for members to prepare for and participate in the meeting.
Participants:	These should be drawn from relevant ICES expert groups (e.g. WGZE, WGHABD, WGFE, WGBE) and others within ICES member countries.
Secretariat facilities:	This group should be provided with an ICES web portal and SharePoint facility to enable communication and dissemination of their findings and expertise with ICES expert groups and more widely.
Financial:	None specific.
Linkages to advisory committees:	
Linkages to other committees or groups:	SCICOM.
Linkages to other organizations:	

## Annex 6: Draft Resolution for an ICES Internal Publication

The **ICES Zooplankton Status Report 2007/2008**, edited by members of WGZE, as reviewed and approved by the Chair of the Oceanography Committee, will be published in the *ICES Cooperative Research Report* series. This report will be the eighth such report in this successful series.

The Working Group on Zooplankton Ecology agrees to submit the final draft of the proposed publication by 1 July 2010.

### Supporting information

Priority:	This draft resolution covers preparation and printing (publication costs) of the next update in the Zooplankton Status Report series. This report, a comprehensive basin-wide view of zooplankton trends across the North Atlantic, is unique to ICES and is a valuable scientific work. Distribution via the CRR format makes it an official and citable ICES product.
Scientific justification:	<p>The Cooperative Research Report series offers a good venue for the annual publication of the Plankton Status Report, making it available to the scientific community as a citable publication.</p> <p>This status report represents a basin-wide assessment which can support the new advice format, providing regionally-based assessments of plankton in the ICES area.</p> <p>This resolution will contribute towards Scientific Objectives; 1a (Describe, understand and quantify the state and variability of the marine environment in terms of its physical chemical and biological processes.); 1b (Understand and quantify the role of climate variability and its implications for the dynamics of the marine ecosystems); 5c (Co-ordinate international, monitoring and data management programmes which underpin ongoing ICES core science.); 4c (To publicize the work of ICES and the contributions that ICES can make for its stakeholders, and for the wider public audience, regarding the understanding and the protection of the marine environment), and Institutional Objective 6 (Make ICES' scientific products more accessible to the public.)</p>
Resource requirements:	Cost of production and publication of a 150 page CRR.
Participants:	N/A
Secretariat facilities:	Help with document preparation/publication. Final editing..
Financial:	The most recent CRR cost DKK 98700
Linkages to advisory committees:	ACOM and Publications Committee
Linkages to other committees or groups:	Science Committee
Linkages to other organizations:	CIESM

**Annex 7: Recommendations**

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<b>RECOMMENDATION</b>	<b>FOR FOLLOW UP BY:</b>
1. Establishment of a Study Group on Integrated Morphological and Molecular Taxonomy	SCICOM, Council
2. Theme session for 2010 ASC	SCICOM
3. ToRs for 2010 WGZE Annual Meeting in Portland, Maine, USA	WGZE, SCICOM
4. Plankton Status Report Publication	Publications Committee