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Report of the Working Group on Zooplankton Ecology (WGZE)

24–27 March 2014

Reykjavik, Iceland

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Contents

Executive summary

The ICES Working Group on Zooplankton Ecology (WGZE) met at the Marine Research Institute, Reykjavik, Iceland from 24 to 27 March 2014. The meeting was hosted by Astthor Gislason of MRI and chaired by Piotr Margonski. It was attended by 28 scientists in person and 4 by correspondence. They were representing 17 nations. The objective of the meeting was to discuss and address the 9 terms of reference (ToRs) and to exchange information on recent activities in zooplankton ecology.

Three of the tasks, (b) to examine regional and transatlantic distribution and temporal patterns with zooplankton time-series, (c) to refine and extend the compilation of information on taxonomic categories that are currently monitored in the ICES area, and (d) to calculate zooplankton productivity and metabolic rates in the ICES area based on allometric approaches, were very much focused on extending the information and data which are already collected by the group and periodically presented in the Zooplankton Status Report. Results of those ToRs give an opportunity to examine regional and transatlantic distribution and temporal patterns within the zooplankton time-series, to distinguish significant changes over time and to identify potential environmental or climate drivers; to define thermal ranges in the seasonal, latitudinal, and transatlantic distribution of key zooplankton species which is fundamental information needed in order to recommend indices and how to apply them; and to convert routinely collected monitoring data into estimates of zooplankton standing stock that are requested for the assessment and management of the marine ecosystem.

The urgent need for the revision of the zooplankton monitoring programs was pointed out and discussed as in many cases the existing monitoring design is insufficient in terms of providing the relevant information for scientific as well as management requirements. In EU countries, implementation of the Marine Strategy Framework Directive created the necessity of collecting data of much wider scope. The issue of micro-plastics pollution and its effects on zooplankton communities (ToR g) might be one of good examples.

Review the progress in development of the software and hardware for "automatic" identification and counting of zooplankton organisms (ToR f) attracted more contribution and longer, vivid discussion than originally expected. Sample analyses including taxonomic identification, counting and measuring procedures are costly and time consuming but there is also a continuous progress in development of different "automatic" methods.

WGZE continued addressing the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment. The current status of *Calanus* exploitation was summarized. In Norway, work towards a management plan (including a harvest rule, quota, and assessment of *Calanus* in the Norwegian Sea) has now been resumed, and will be completed by the end of 2014. Plans for *Calanus* fishery in Icelandic waters were also presented.

As WGZE is switching to the first three-years term starting in 2015, the review of the group scientific achievements as a basis for preparing the multi-annual activities planning (ToR h) was discussed. Based on the review of the WGIMT progress (ToR e), the need to design and carry out the coordinated and collaborative activities between WGZE, WGIMT, and WGPME appeared and it was included in multi-annual ToRs.

The meeting concluded with nomination of Piotr Margonski, Poland, as a WGZE Chair for the period 2015–2017. The next meeting of the WGZE will be held in Plymouth, UK, 16–19 March 2015.

1 Opening of the meeting

The ICES Working Group on Zooplankton Ecology (WGZE) met at the Marine Research Institute, Reykjavik, Iceland from 24 to 27 March 2014. The local host was Dr. Astthor Gislason of MRI. The meeting was attended by 28 scientists in person and 4 by correspondence. They were representing 17 nations (for details see List of Participants in Annex 1).

The meeting started on Monday at 9:00. Piotr Margonski (WGZE Chair) opened the meeting and welcomed the members and guests of the group to Reykjavik.

Following a round of introductions, the participants were welcomed by Astthor Gislason who summarized logistics of the meeting.

2 Adoption of the agenda

The agenda for the WGZE 2014 meeting (see Annex 2) followed the Terms of Reference adopted as a resolution by the ICES SCICOM (2013/2/SSGEF05).

The agenda had been circulated among the working group members prior to the meeting and modified according to the suggestions and comments. Last minute adjustments were discussed and the agenda was adopted by unanimous vote. The Terms of Reference for this meeting were to:

a) Finalize production of videos on zooplankton sampling/processing techniques as part of progress in updating the Zooplankton Methodology Manual;

b) Examine regional and transatlantic distribution and temporal patterns with zooplankton time-series to discern significant changes over time and to identify potential environmental or climate drivers;

c) Refine and extend the compilation of information on taxonomic categories that are currently monitored in the ICES area including species and stages, individual specific biomass, and ecologically relevant information such as existence ranges, genetic primers for species identification, to be made available and displayed via the WGZE website as an interactive web-based map system;

d) Prepare the background data needed for calculation of zooplankton productivity and metabolic rates in the ICES area based on allometric approaches i.e. a database in terms of total abundance and total biomass, metadata, with the first calculations available before the meeting in 2014;

e) Review the progress of the WGIMT;

f) Review the progress in development of the software and hardware for "automatic" identification and counting of zooplankton organisms;

g) Compile the information on micro-plastics pollution and its effects on zooplankton communities;

h) Review of the WGZE scientific achievements as a basis for preparing the multi-annual activities planning.

i) Review the ICES response to the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment.

3 ToR a) Finalize production of videos on zooplankton sampling/processing techniques as part of progress in updating the Zooplankton Methodology Manual

Lead: Piotr Margonski; Rapporteur: Elaine Fileman

Piotr Margonski summarised the current status of this ToR: so far videos from Mark, Maiju, and Piotr were received and presented during previous meetings (the first one in the "ready-to-use" stage, the others as a raw material requiring lots of editing). It was generally accepted that we should close this ToR this year. All videos when ready, should be posted to the zooplankton methodology folder at the WGZE.net site. Piotr concluded that these videos if successful would make a valuable addition to the methodology manual, with an advantage being that the videos can be produced in a variety of languages. As an alternative we may set up a YouTube channel to link them to other existing video materials.

During discussion, various members provided information on other existing sources presenting a similar information:

University of Hamburg produced videos which are ready to use, the text is in German so this would need to be translated into English. Janna has checked for permission for the group to make use of these videos, whilst they are licensed, they may be used for non-commercial purposes, although full credit must be given and no changes to the original may be made except for language change. Janna provided the following link to a CTD video which is available online now. A further Bongo net video will be available shortly:

http://webapp6.rrz.uni-hamburg.de/elb-min/media/CTD_v9b-1080at4500.mp4

Tone Falkenhaug (Institute of Marine Research) presented links to videos from the Euro BASIN cruise, showing sampling and processing on board. However, they need some additional editing in order to be used as a method guide.

http://www.youtube.com/watch?v=jjGK9aEAQV4

http://www.youtube.com/watch?v=HRf7AJPGYMg

http://www.youtube.com/watch?v=cL5RshJMm2A

http://www.youtube.com/watch?v=c4ded4L6i2I

http://www.aqua.dtu.dk/english/News/Nyhed?id=DB08331A-0DEB-4DC7-9807-CCD75064A628

4 ToR b) Examine regional and transatlantic distribution and temporal patterns with zooplankton time-series to discern significant changes over time and to identify potential environmental or climate drivers

Lead: Todd O'Brien; Rapporteur: Astthor Gislason

Todd O'Brien introduced this ToR by presenting the latest Plankton Status Reports. ICES currently publishes two Plankton Status Reports, one done by the Working Group on Phytoplankton and Microbial Ecology (WGPME, the ICES Phytoplankton

and Microbial Plankton Status Report) and the other done by the Working Group on Zooplankton Ecology (WGZE, the ICES Zooplankton Status Report). Both reports are published in the ICES Cooperative Research Report series and Todd O'Brien is the lead editor on both. In addition, ICES issues a report on ocean climate (ICES Report on Ocean Climate, IROC) that is available both as ICES Cooperative Research Report and as an interactive webpage (http://ocean.ices.dk/iroc).

The last Zooplankton Status Report, 212 pages long, was published in August 2013, based on data from 62 sites through 2010/2011. Within ICES there is concern about growing printing costs for this paper (non-electronic) media form. WGZE authors requested 47 copies of the last report. Although some authors still would prefer printed copies, or would be willing to pay for parts of printing costs, future reports will likely have little or no printed copies or may appear on the web only. Piotr Margonski noted that ICES is looking for savings, especially as contribution from member countries to ICES had not increased for the last four years.

As a supplement or alternative to paper printing, ICES has suggested electronic options for future status reports. Todd went on to describe the new interactive webpage on ocean climate prepared by the Working Group on Oceanic Hydrography. The webpage provides summary information on climatic conditions in the North Atlantic, and displays derived anomaly values (T, S) that can be downloaded. Todd aired the idea that WGZE may want to consider something similar.

The original WGZE analysis employs a similar approach as the SCOR WG on Global Comparisons of Zooplankton Time-series (WG125), which focuses on annual anomalies. Todd said that this works well with "once-per-year" and "one season" time-series. However, initial month-based analyses suggest that changes are occurring on a monthly. For example in Figure 4.1, the interannual trends (bottom right panel surrounded by a red box) show a long-term decrease. Looking at the individual months (panels in the upper left three columns) and the three-month seasons (panels in the far right upper column), these decreases occurred primarily in the fall and winter months (represented by green linear regression lines). These strong decreases also countered slight increases seen in March and April and May, giving an overall decrease at the interannual level. Based observations from this and other sites, a new month-by-month analysis is being developed for the next zooplankton status report.

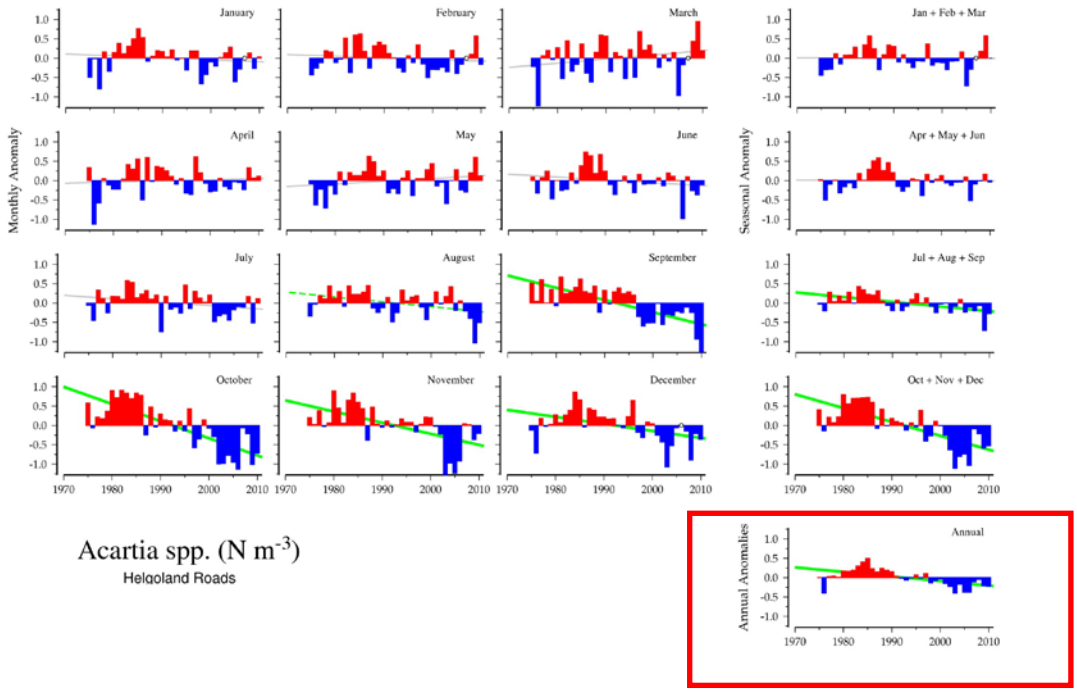

Figure 4.1. Monthly, seasonal, and interannual trends of the copepod Acartia (spp.) sampled at the Helgoland Roads time-series site.

Todd went next on to describe an R-based tool kit made by Alan D. Jassby and James E. Cloern (2014). The name of the package, "wq" stands for "water quality" and reflects the original focus on time-series data for physical and chemical properties of water, as well as the plankton. The package is intended for time-series that sample approximately monthly intervals. It may be used to fill in gaps in data, explore seasonal and long-term trends, and relationships with temperature and chlorophyll a. In addition there are tools for performing multivariate analysis. The toolkit is available on-line (Alan D. Jassby and James E. Cloern (2014). wq: Some tools for exploring water quality monitoring data. R package version 0.4-1. http://cran.r-project.org/package=wq).

Todd then showed some slides illustrating how the temporal extension of a particular time-series may affect the linear trends exhibited by the data. A particular series may show a decline over the last 10 years but an overall increase over the last 30 years, all depending on the time-window under exploration. This is important to keep in mind when comparing long-term trends of several time-series of different lengths.

Todd then went on to present slides illustrating 10 year anomaly plots of increasing phytoplankton biomass in surface waters in the northwestern parts of the North Atlantic and decreasing biomass in the northeastern parts. He also showed plots based on 10 years of data showing positive and significant correlations between sea surface temperature and Chl a in the western parts and negative correlations in the western and southwestern parts (Figures 4.2. and 4.3.).

Todd presented a few ideas for the next report that is due May 2016 (which will be based on data through 2013/2014). To meet page saving requirements by ICES and in order to make it more incisive, it would be desirable to reduce its size. Two pages per site, one of text and another page of standard figures would probably do. Trends and correlations should preferably be shown by spatial summaries (as in Figure 4.2.). Fu-

ture reports might also contain topical summaries like evaluations of the value of data on abundance vs. biomass.

There was consensus that the report is a very useful product and central to the activities of the group. With the proposed improvements, further integration of abiotic (temperature, salinity nutrients, etc.) and biotic factors (phytoplankton and zooplankton biomass and composition) will be sought.

In the following discussion the issue was raised how the future analyses for zooplankton summary report would link to the newly held Workshop on Synthesis of Hydrographic, Phytoplankton, Microbial Plankton and Zooplankton Time-series in the North Atlantic and Adjacent Seas (WKSERIES), organized by WGZE and WGPME. This workshop was held at ICES Headquarters, Copenhagen, Denmark, on 15–18 October 2013. Todd suggested including similar time-series analysis as used at the WKSERIES in the time-series in the next zooplankton summary report. Tone Falkenhaug, who participated in the WKSERIES, noted that due to the low number of zooplankton participants at the WKSERIES, the main focus was on phytoplankton. She felt that further WKSERIES work may even continue without the zooplankton part.

Roger Harris asked if the two reports (the Phytoplankton and Microbial Plankton Status Report and the Zooplankton Status Report) could be combined, thus making a more integrated assessment (and in addition saving on publication costs). A discussion followed on the need for an integrated assessment of long-term data series. Very relevant to the discussion, Todd reported that Luis Valdes, a former member of the group and a key person in the history of the Zooplankton Status Report as editor during the first years of its existence, had approached him with an interesting offer, namely that some of the data of the zooplankton status report be included in a new global biogeochemical and plankton time-series status report effort that Luis is leading.

The International Group for Marine Ecological Time-series (IGMETS, http://IGMETS.net) is an effort led by the Intergovernmental Oceanographic Commission of UNESCO (IOC), the International Ocean Carbon Coordination Project (IOCCP) and the Ocean Carbon and Biogeochemistry Program (OCB). ICES is also taking part in the effort. The initiative seeks to integrate a suite of abiotic and biotic variables from time-series stations and satellites to look holistically at changes within different ocean regions. The work will end in a comprehensive, integrated report which will be published under the auspices of IOC-UNESCO. The global overview would be mainly based on satellite derived data and global data products, highlighting key trends in the regional chapters. One of the regions that is in focus is "our" area, the north Atlantic and marginal seas. Todd went on to list the variables called for by the IGMETS analysis. Relevant for this group, they included data on zooplankton species, numbers and biomass. Todd said that IGMETS aims at publishing a 2015 UNESCO report in November 2015 that will be on the level of IPCC Climate Report series.

The following discussion revealed that IGMETS needs participation from as many as possible. Potential data providers should sit and wait, as an e-mail would arrive requesting participation. Data provision will be easy as Todd already has most of the data "in hand" from last ZSR. The issue of data safety and authorship was raised. In answer to that, Todd said that he would be the only one handling the data and that IGMETS is following standard WGZE/WGPME data policies, meaning that these data will only be used to make the report figures and on-line site summary plots. Authorship would be given to data contributors and writing authors.

Todd thought that the work in IGMETS would not interfere with the WGZE/WGPME reports, as the former initiative would focus on large marine ecosystem summaries and will not have the page-count to go into any in-depth sub-analyses. He also said that the IGMETS report will only use data through 31 December 2012, while the ZSR (in 2016) will come out a year after the IGMETS report (in 2015) and will thus include two more years of data (through 31 December 2014).

There was common agreement that participation in the IGMETS initiative was important and that it would contribute greatly to an integrated and holistic analysis of all data, enabling us to explore plausible reasons and connections at a global level, and highlight any locations of especially large changes that may be of special importance.

When asked if data on microzooplankton would be included in the IGMETS work, Todd answered that the WGPME had clearly expressed willingness to include them. The following discussion revealed that icthyoplankton would be considered too, if enough sites had these data. Todd said that the aim was to include as many long-term data series as possible. For example, new contacts would be established with Chinese and Russian scientists. As to data from Greenland, Sigrún Jónasdóttir said that Kristine Arendt was the person to approach for long-term data around Greenland.

A discussion followed, on how the data displayed by the zooplankton summary report might be made more visible to the wider scientific community. It was felt as important to try to seek for a scientific publication based on all or parts of the data. Peter Wiebe suggested that one way of achieving this might be to take the zooplankton status report and turn it into a data publication. One approach would be to produce one basic data summary paper of the zooplankton summary report on one hand and a paper summarizing all or parts of the data on the other.

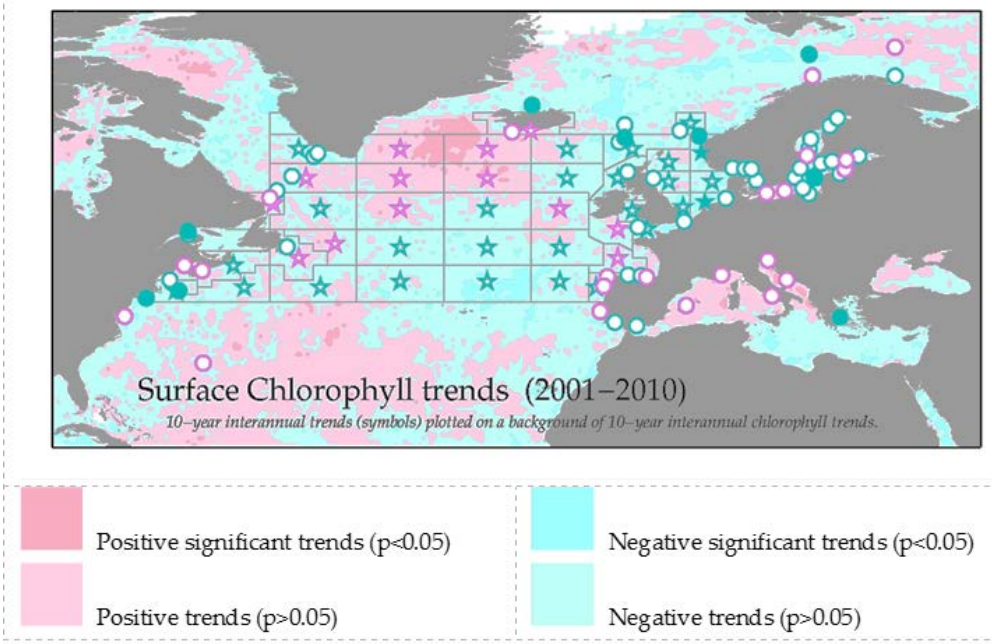

Figure 4.2. Spatio-temporal map of 10 year interannual trends in surface chlorophyll concentrations (satellite-derived). Circle symbols represent locations of WGZE time-series sites. Star symbols represent center-points of Continuous Plankton Recorder standard areas (also outlined with gray boxes).

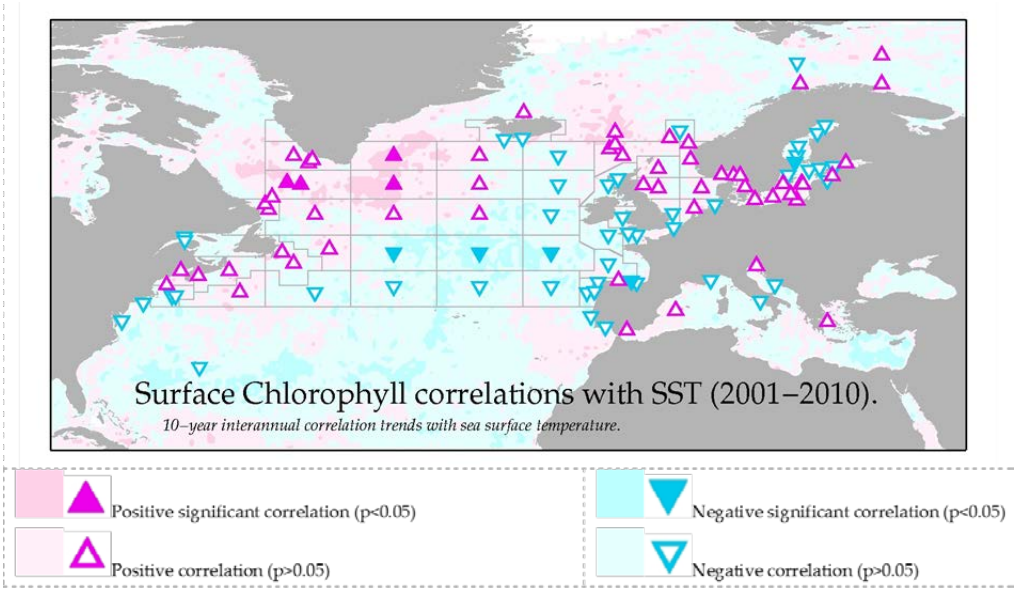

Figure 4.3. Spatio-temporal map of 10 year interannual correlations between surface chlorophyll concentrations (satellite-derived) and sea surface temperature. Triangle symbols indicate positive or negative correlations within specific WGZE time-series sites and Continuous Plankton Recorder (CPR) standard areas. A positive correlation (pink shades) indicates that chlorophyll concentrations increased with increasing water temperatures in that region. A negative correlation (blue shades) indicate chlorophyll concentrations decreased with increasing water temperatures in that region.

5 ToR c) Refine and extend the compilation of information on taxonomic categories that are currently monitored in the ICES area including species and stages, individual specific biomass, and ecologically relevant information such as existence ranges, genetic primers for species identification, to be made available and displayed via the WGZE website as an interactive web-based map system

Leads: Todd O'Brien, Peter Wiebe, and Lutz Postel; Rapporteur: Kathryn Cook

Damien Eloire, as a PhD student, was the first to create a comprehensive table of taxonomic categories and species that were actively being identified and sampled by the WGZE zooplankton time-series at that time (~20 sites). Damien's simple spreadsheet was then updated and expanded by Peter Wiebe to a collection of 31 time-series and over 900 taxonomic categories. This was presented at last year's WGZE meeting (2013, ToR e, see Figure 5.1). Todd O'Brien also created a simple interface map of time-series sites to supplement this table. Clicking on any site in that map would display a listing of the taxonomic categories and species sampled at that site (Figure 5.2).

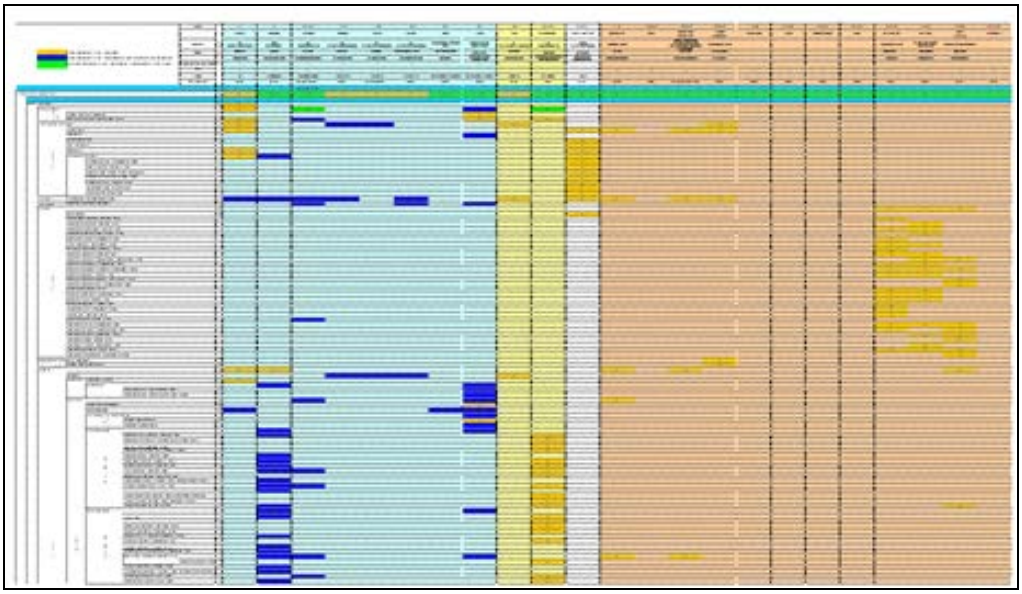

Figure 5.1. Screen shot of the updated table created for the WGZE 2013 ToR e. Each column is a WGZE time-series site. Each row is a taxonomic category that may or may not be sampled/identified within that site.

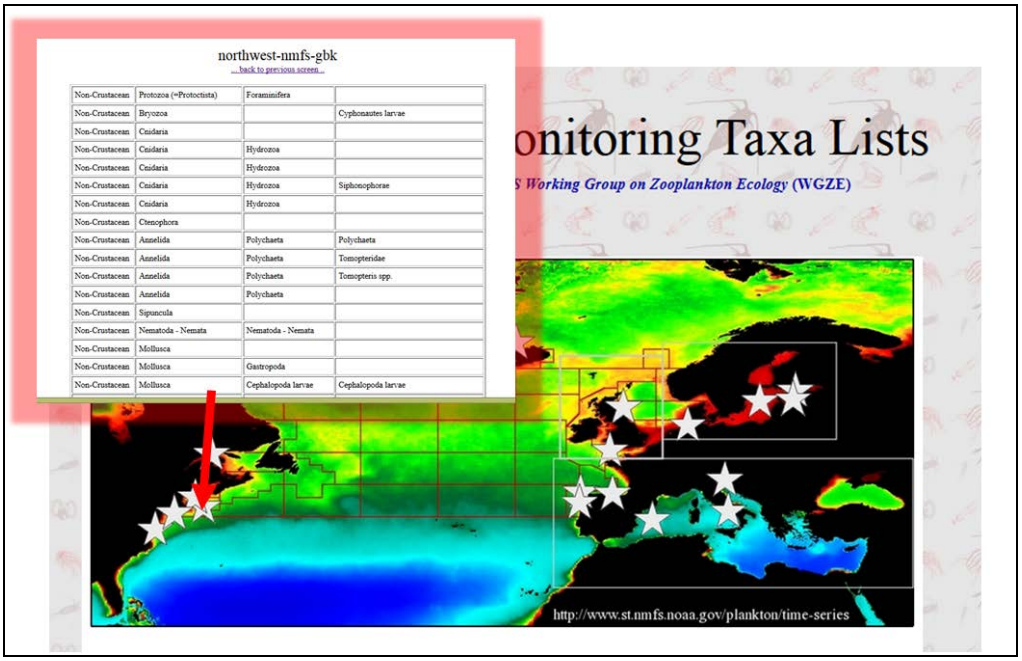

Figure 5.2. Screen shot of the site-based interface create for last year's meeting. Clicking on a site's start (left screen) would display a table of all taxonomic categories sampled/observed within that site.

For this year's meeting and ToR, a taxa-based display was developed. In this new visualization, maps were created for each taxonomic category, showing which sites observed/sampled that specific taxa. For example, Figure 5.3 shows all WGZE sites that sampled/identified *Calanus finmarchicus* (top panel) and *C. helgolandicus* (bottom panel). The warmer/cooler water preferences of these two copepod species was evident in their spatial distribution.

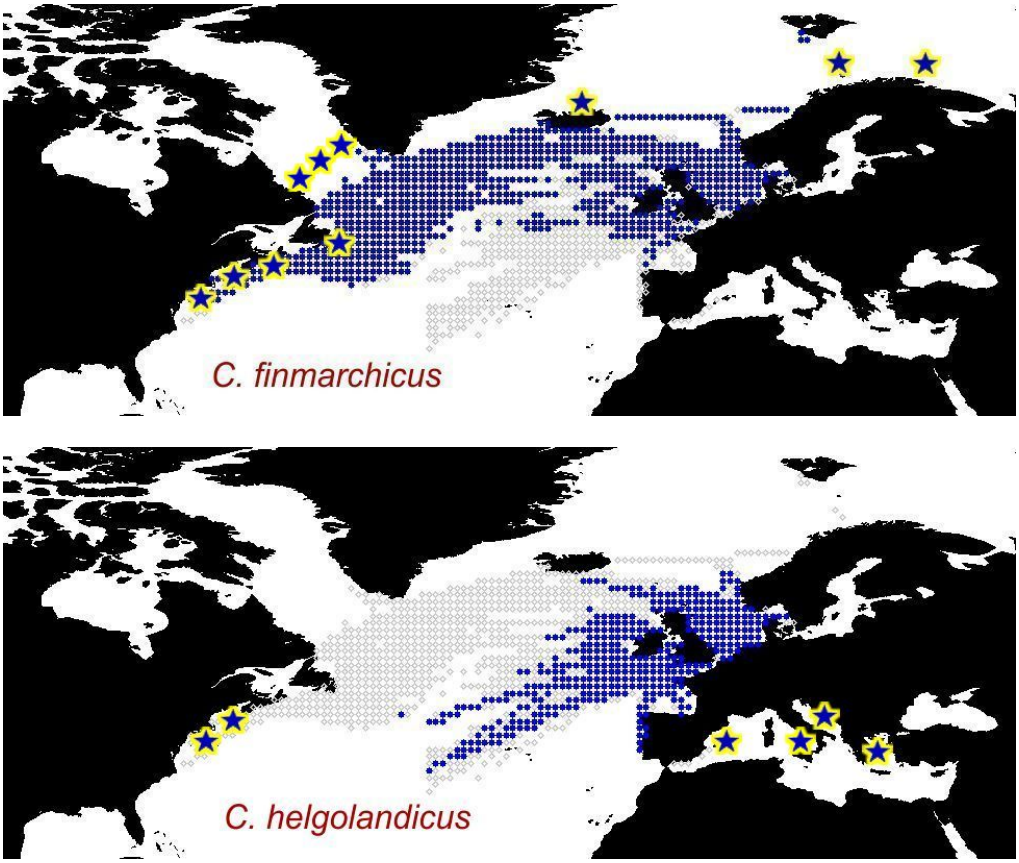

Figure 5.3. Spatial presence/absence distribution plots of the cooler water copepod *Calanus finmarchicus* and the warmer water copepod *Calanus helgolandicus*. Blue symbols indicate locations where this species was found in Continuous Plankton Recorder (circles) and other WGZE zooplankton time-series sites (stars).

Prior to this year's meeting, Todd requested lists of taxa identified and sampled from each and every WGZE time-series site. A wide variety of different listing criteria and ranking criteria was received, ranging from lists of only the most frequently seen taxa to lists of everything ever seen at a site. The taxa categories themselves were a mix of scientific names and non-scientific groupings, single species and groups of species, size classes and stages, and different taxonomic levels. While this gave an excellent overview of the types and applications of lists being used by the WGZE investigators, it also demonstrated that a standardized list and criteria would be required to further this potential new product for WGZE.

Todd presented some examples of plots created with the data provide (Figure 5.3.), and then discussed what sort of standard taxa listing contents would be necessary for various applications. For example:

- With a simple list of only the taxa names (and not other information), it is possible to map which sites sample which taxa, and a list of species sampled can be added to each time-series summary on the WGZE website.
- With a list that also includes presence and absence data, it is possible to add frequency based rankings.
- With a list that includes presence/absence and date, seasonal presence/absence properties can be displayed.

- With a list that includes full numeric abundance and species data, it is possible to add abundance based rankings, relative seasonal contribution, and maps of inter-annual change (by species or taxonomic category).

Discussion

Piotr Margonski suggested that empty stars could be added to the map to signify that a species was looked for and not found. This is important to differentiate this site from other sites where the species is not looked for (and therefore may or may not be present).

There was some discussion on the accuracy of the OBIS species distributions presented, e.g. one showed *Calanus finmarchicus* in the north Pacific. *Calanus helgolandicus* was found in WGZE time-series in the northwest Atlantic only in 1971-2 (Gulf of Maine) and in 1981-83 (mid-Atlantic bight). Roger Harris noted that an early Fleminger paper had also found *C. helgolandicus* in the mid-Atlantic bight (Fleminger and Hulsemann, 1977). Peter Wiebe suggested that it may be necessary to go back to old samples to check for *C. helgolandicus* as it is very easy to overlook if you are only expecting to see *C. finmarchicus*.

Todd suggested that, by using the WGZE time-series data, an interactive map could incorporate temporal patterns as well as spatial patterns and could even include environmental variables such as temperature and salinity. He also noted that a simple list of species with no data is not the ideal way to pursue this type of interactive map and that the title of ToR c) specifically includes stages. Maiju Lehtiniemi suggested the idea to produce TSP (temperature, salinity, plankton) plots with a colour scale to reflect abundance that could be used to track changes in taxa distribution over time. (This would require WGZE site investigators to submit taxonomic abundance data, which only about 1/3 of the sites currently provide.)

Erica Head suggested that it might be better to use the size of a symbol to reflect abundance, with an empty symbol to reflect absence. Piotr suggested that a cross could be used instead to reflect absence. Erica stated that the time aspect is important as some locations may not be sampled in some years, but this wouldn't be obvious without plots over time. Piotr agreed that this would also be important for the Baltic sampling.

Todd suggested that this interactive map could be the next big WGZE product, as one of the new multi-annual ToRs, and could incorporate links to WGIMT information on the taxa. Peter Wiebe suggested that species specific allometric relations could be included. Piotr asked whether the next step would be to wait for clear guidelines to improve the submission of taxa lists from the time-series. Todd replied that the best product would be delivered if he was given all the taxa with abundance/biomass data for each individual site. If anyone was concerned about releasing their data, presence and absence data would be the next best alternative. All the data/maps could be kept within WGZE on a password-protected section of the website until the product is finalised.

Piotr noted that datasets from long time-series could have problems with changes in expertise, switching analysts etc. Todd suggested that being able to visualise the data spatially and temporally would actually help to pick up some of these problems. Tone Falkenhaug noted that this would be very useful, but that the use of presence and absence data would make it easier for many to get permission to release the data. Todd reiterated that presence and absence data will still produce a useful tool and

that a simple list of species can also be added to each site as metadata on the WGZE website.

The Integration of Time-Series Stations Species Lists, allometric relationships for species, genetic data, and identification sheets needs further development. This will be pursued in proposed ToR j) submitted for next year.

Reference

Fleminger, A. and Hulsemann, K. 1977. Geographical range and taxonomic divergence in North Atlantic *Calanus* (*C. helgolandicus*, *C. finmarchicus*, and *C. glacialis*). Marine Biology. 40: 233-248.

6 ToR d) Prepare the background data needed for calculation of zooplankton productivity and metabolic rates in the ICES area based on allometric approaches i.e. a database in terms of total abundance and total biomass, metadata, with the first calculations available before the meeting in 2014

Leads: Lutz Postel and Peter Wiebe; Rapporteur: Eilif Gaard

Lutz Postel started with a presentation which summarized methodologies for determining secondary production, based on calculation:

P= (Biomass conc.* P/B) – Mortality,

Three main methods were presented:

1) The classical (time consuming) method on in situ cohort analysis and in vivo incubations of organisms (measuring somatic growth, reproduction or using difference methods (e.g. P = A-R-E)).
2) In vitro biochemical approaches on molecular and subcellular level e.g. RNA/DNA ratios, RNA content, DNA polymerase activity, Nucleoside diphosphate kinase (NDPK), Aspartate transcarbamylase activity (ATC), Degradation of chitobiase, Aminoacyl-tRNA synthetase (AARS).
3) Models, based on results of the first category.

Formulas for metabolism and growth often based on KLEIBERs rule:

$$P = aB^b$$

where:
P is productivity, respiration, excretion etc.,
B is body mass
a & b are constants which depend on e.g. temperature, food concentration and other intrinsic and external factors.

For zooplankton, allometric (body mass specific) approach can be made based on

P/B = 0.64 W -0.37 (Banse and Mosher, 1980).

Nine institutes had submitted time-series data to Lutz Postel. These data were from monitoring sites off Halifax, Canada in west, the Barents in the North, the Baltic Sea in east to the Spanish and Portuguese coasts in the south.

Lutz presented calculations and inter-regional comparison of zooplankton mean ind. spec. carbon mass, turnover time and production in the Bornholm Basin (Baltic), Ar-

endal station 2 (Northern Skagerrak) and the Halifax line 2. These three time-series contained monitoring data from July-August back to 1979, 1994 and 1999 respectively.

Results will be presented on the WGZE website

The next step of this activity should be:

- More sites analysed
- Description and evaluation of the method
- Calculation of metabolic rates (Respiration, HN4+ and PO43- excretion)
- Inter-regional comparisons
- Discussion of differences in relation to sampling gear, eutrophication, temperature, boreal regions vs subtropical areas
- Estimation of the impact of the missing mortality rate
- Paper on these aspects as pre-study

In addition (as a parallel activity) there is an idea present the detailed information on SCOR WG 125 and ICES WGZE webpages.

The group members were encouraged to submit their data to Lutz.

7 ToR e) Review the progress of the WGIMT

Lead: Ann Bucklin; Rapporteur: Janna Peters

The conversion of SGIMT to its new status as a Working Group, WGIMT, was reviewed. Summaries were provided of WGIMT's over-arching goals, multi-annual Terms of Reference, and summary plan of work. More detailed descriptions of WGIMT's seven ToRs were provided, with background summaries and deliverables. WGIMT member contributions and future responsibilities were described for each ToR.

Discussion of WGIMT activities focused in particular on WGIMT ToR (c) Provision of standards, training materials, and taxonomy workshops. WGZE has accepted the SGIMT 2013 Resolution to assist in the development, revision and updating of the ICES zooplankton species identification keys. Last updated in 2001, only very few of the ICES Zooplankton Identification leaflets have been updated. WGIMT member, Antonia dos Santos, volunteered to lead and/or coordinate efforts to update taxonomic keys, including the ICES microfiche Zooplankton Leaflets, in partnership with Claudia Castellani.

Claudia informed that SAHFOS is in the final stages of preparing a new book on taxonomy of mesozooplankton in the North Atlantic. This could be used as foundation and feedback to the ICES Taxonomy Leaflets updates.

Plans to submit proposals for ICES Taxonomy Workshops yielded a discussion about possible sources of funding, including a new ICES Science Fund. It was decided that the group members will explore if the "Integrative Taxonomy" workshops are likely to be appropriate for this new funding mechanism.

Other topics were referred to the WGIMT meeting (scheduled for Friday, 28 March) for discussion and resolution.

8 ToR f) Review the progress in development of the software and hardware for "automatic" identification and counting of zooplankton organisms

Leads: Janna Peters, Elaine Fileman, and Klas Ove Möller by correspondence; Rapporteur: Claudia Castellani

Elvire Antajan provided an update on the development of hardware and software carried-out by the IFREMER. The presentation focused on the new system Zoocam which is currently under development. This system allows onboard rapid identification of zooplankton organisms.

The second part of the talk was a demonstration of Plankton Identifier software which is a free software and when used in conjunction with Tanagra, another free software, it is suitable for automatic classification of zooplankton taxa. Special emphasis was given to the validation procedure. One the main aims of this new system is to improve the efficiency of the validation process. Nevertheless, this system will not be able to replace taxonomic expertise since i) ground-thruthing is essential and ii) the resolution is generally limited to higher taxonomic level.

Elaine Fileman presented a brief overview of the use of flowcam for plankton analysis at PML where the system is being successfully applied to monitor the vertical distribution of plankton in the western English Channel and for the determination of food size spectra in zooplankton feeding studies.

Astthor Gislason gave a presentation on MRI experience with ZooImage. There is a high consistency between results from microscopic counts and optical methods when looking at larger taxonomic groups and size classes. Astthor also presented that the Random Forest algorithm came out best for classification of training test as for Zooscan.

Lutz Postel presented a software called "Easy-measure" that is used by IOW for analyses of monitoring samples, i.e. for zooplankton abundance and biomass calculations. Biomass is estimated based on implemented allometric relationships.

The group also discussed the importance of standardising allometric measurements between different zooplankton taxa.

Peter Wiebe gave a presentation on the "Silhouette" method developed at Woods-Hole using high resolution imaging based on classical photography. This allows libraries of photographic images to be analysed using a computer software (via scanned files) as well as reanalysis of the high resolution image with a microscope.

Astthor Gislason presented the application of VPR in Icelandic waters. Potential of this system was highlighted to determine changes in distribution of different taxa and marine snow in relation to small scale hydrographic events. Next developments should focus on improving sampling volume estimates and considering the avoidance rate.

Outcomes

Existing semi-automatic methods are becoming more established and widespread for plankton studies and non-plankton particles such as microplastics, marine snow and detritus.

Since the last review carried out by the WGZE in the "ICES Zooplankton methodology manual" there have been further development and therefore an update on the semi-automatic methods is timely. As a result of this discussion the group suggested a multi-annual ToR on the revision of new methods with the aim to write an update of the methodology chapter.

9 ToR g) Compile the information on micro-plastics pollution and its effects on zooplankton communities

Leads: Maiju Lehtiniemi, and Elaine Fileman; Rapporteur: Sigrun Jonasdottir

Three short presentations were given on the ToR. First, Maiju Lehtiniemi presented information on micro-plastic monitoring and experimental work in institutes collected from the WGZE members before the meeting. The compilation from the 9 institutes that replied to the questionnaire showed that monitoring programs are ongoing in 5 countries and 10 institutes are currently planning, developing and testing monitoring. Methods used in monitoring development are variable. Most common sampling methods were pumps, WP-2 nets, Manta trawls and other net types with mesh sizes of 10, 63, 90, 125, 200, 250, 300, 330, 333 μm; most common 63 μm and 330/333 μm. Also sampling by hand has been used for sediment and mussel samples. Three institutes note presence/absence of microlitter particles in the samples while most institutes count the number of particles and 7 monitoring programs analyse the type of litter. Three institutes have done/are conducting experiments on the effects microplastics on zooplankton and their possible effect on the food web. These have mainly been experimental work on ingestion and/or egestion of plastic beads by zooplankton. Experiments have been conducted with protists, rotifers, cladocerans, various copepod species, decapod and polychaeta larvae, mysids, euphausiids, siphonophores, bivalves. Also toxicity and impacts of microplastics on copepods and blue mussels have been done or are planned.

The second presentation was also by Maiju Lehtiniemi where she presented results from experiments on the potential ingestion of microplastics by Baltic Sea zooplankton. Mysid shrimps, copepods, cladocerans, rotifers, polychaete larvae and ciliates were exposed to 10 μm fluorescent polystyrene microspheres and all taxa ingested the microspheres. The pelagic polychaete larvae, *Marenzelleria spp*. had the highest percentage of individuals ingesting spheres. The copepod *Eurytemora affinis* and the mysid shrimp *Neomysis integer* showed egestion of microspheres within 12 h. Food-web-transfer experiments were conducted by offering mysid shrimps zooplankton with ingested labelled microspheres. The presence of the zooplankton prey and their microspheres were evident in the mysid gut after 3 h incubation. This study shows for the first time the potential of plastic microparticle transfer via planktonic organisms from one trophic level to another. Maiju stressed that the impacts of plastic transfer and possible accumulation in the food web need further investigations.

Elaine Fileman presented the consequences of microplastic exposure to copepods. Microscopic plastic debris, termed 'microplastics', are of increasing environmental concern. Recent studies have demonstrated that a range of zooplankton can ingest microplastics, with impacts on their feeding. An integrated approach was used, combining feeding rate studies and novel bio-imaging techniques to document ingestion and egestion rates for a range of zooplankton species zooplankton. Experiments have been carried out to demonstrate the uptake and biological effects of microplastics. It was found that microplastics can adhere to the animal which limits movement and sensitivity; ingestion of microplastics caused significant reduction in feeding in

the copepod *Calanus helgolandicus*. Faecal pellets containing microplastics were typically less robust and slower to sink than faecal pellets from *Calanus* fed on algae alone and showed lower sinking rates. Whilst there was no significant reduction in egg production rate it was found the eggs to be significantly smaller when *Calanus* was fed microplastics and these showed reduced hatching success.

The discussion on the ToR focussed on 3 major topics; the possible effects of microplastics on the biota, identification of microplastics and monitoring methods.

Discussion on the effects on zooplankton: Peter Wiebe brought to mind the copepod feeding experiments using plastic beads from the 1970s & 1980s and these old experiments could be used to estimate the impact of microplastics on zooplankton. Piotr Margonski commented that ingestion of microplastics may also affect growth rates. He wondered if the response showed in the experiments were a physiological mechanism or reduction due to filling of the plastic in the gut, and called for further studies to clarify the issue. Presence of microplastics should be wider monitored when zooplankton samples are analysed. Peter Wiebe mentioned that sinking faecal pellets packed with plastic could also affect the benthic community. Some discussion was on the potential toxicity of microplastics, if the beads absorb toxic chemicals that affect the animals or on opposite if they could be a substrate for bacteria and provide nutrition. The general consensus was that this is a topic that needs to be further addressed in the future studies.

The consortium discussed what is the best method to identify microliter. Elvire Antajan mentioned that SEM microscopy of fish larvae showed a lot of unrecognizable objects in the gut and she wondered how to identify microlitter. Elena Gorokhova mentioned that fragments that were thought to be microplastic in animal guts turned out to be natural cellulose, so it is very difficult to recognize those elements visually. Polarization may help to recognizing the particles. Infrared microscopy might be helpful as well. The problem is when plastics are oxidised and degraded to the extent it is difficult to identify the type. Even then sometimes it is possible to classify them as synthetic objects. Claudia Castellani informed that CPR analyses started in SAHFOS to monitor plastics classifying them into different categories.

The discussion continued on monitoring and methods. It was asked if archived samples could be used to increase data coverage in time and space and the conclusion is that it is absolutely possible. Plastic in formalin can fluorescence and is therefore more visible if preservation last for some time. Elena Gorokhova stated that zooplankton samples provide the easiest way to monitor plastics, and it would just be like adding a species to the counting procedure. However, the mesh size used in zooplankton sampling is usually 100–300µm so the potential food particle size for zooplankton will not be counted. Scanning the guts in fixed samples may be possible. It was commented on that there is a problem with contamination during sampling from clothes (fleece jackets) from the ship, buckets, containers, so a very careful sampling procedure is needed. Piotr Margonski called for more specific guidelines. There may be picture guides available in some of the labs. Piotr expressed his willingness to be involved in such procedure and the group agreed that there is a need for a sub-group to work on such guidelines on monitoring and analysing to be put on the WGZE website.

The question of size and concentration was raised – what is important to measure? The size of beads used in cosmetics, creams, scrubs and toothpaste that are thought to be one of the big plastic contaminators are around 500µm but microplastics are usually considered to be under 5µm while particle size for zooplankton is from 5 to

100µm. Also, do zooplankton ever meet similar plastics concentrations as used in the experiments? There are different answers. Concentrations of the anthropogenic fibers are estimated to be about 0–4 L^{-1} but may be higher.

The consensus of the group was that WGZE needs to continue with the ToR and have 2-3 persons to establish methods.

10 ToR h) Review of the WGZE scientific achievements as a basis for preparing the multi-annual activities planning

Leads: Peter Wiebe, Roger Harris, and Piotr Margonski; Rapporteur: Sophie Pitois

As background for this ToR, Peter Wiebe described the history of the working group to set the stage for future working group activities. Four topics were presented:

1) Population statistics of the SGZP & WGZP group
2) Review of the ToRs
3) Major accomplishments
4) Outstanding Issues for Future Meetings

The Working Group for Zooplankton Ecology began as the ICES Study Group on Zooplankton Production. The Study Group worked by correspondence in 1991 and had its first meeting in Bergen, Norway in 1992. It has met each year since 1992 at 19 sites around the North Atlantic Basin and once in Honolulu, Hawaii. It became the ICES Working Group on Zooplankton Ecology in 1995 and it has continued under this name to the present. The 22 meetings were at attended by 144 individuals. Twenty-one countries had representatives attend the SGZP or WGZE meetings. Nineteen were ICES countries and 2 were Pacific Rim countries (Japan, China).

Approximately 197 terms of references were considered between 1992 and 2013. They were assigned to one of 9 topic groups:

1) Zooplankton Sampling Methods and Analysis
2) Zooplankton Taxonomic Analyses
3) Zooplankton Taxa Reviews
4) Zooplankton Studies
5) Zooplankton Monitoring
6) Zooplankton/Ecosystem Interactions – meeting with other WG
7) Zooplankton Symposia
8) Other WGZE Activities
9) ICES<->WGZE Topics

These topics have been addressed over a number of years and have resulted in significant scientific achievements. For the first decade of its existence, the SGZP/WGZE main focus was on the review of existing methods for measuring biomass and production processes. It carried out a two-ship zooplankton collection gear intercomparison as part of a "Workshop at Sea" in 1993 and a pair of shore-based zooplankton experimental studies to inter-calibrate experimental methods in 1993 and 1994. This work resulted in several publications and provided a basis for the preparation of the "ICES Zooplankton Methodology Manual" that was published in 2000. A synthesis gear inter-comparison paper was published in 2013.

During the second decade, the focus of the group shifted to zooplankton monitoring in the ICES region and production of a zooplankton status report. This initiative was stimulated by ICES recognizing in 1999 that there was a need to make scientific information more accessible to fisheries and environmental groups as well as the public and instructed the working groups to develop data products and summaries for the ICES community. The WGZE produced its first status report in 1999. The first four of nine status reports were provided as appendices to the WGZE meeting reports; the last five were published as ICES Cooperative Research Reports. The time-series data have been used by a SCORE working group in doing a global comparison of zooplankton time-series.

A ToR that has been revisited over the past 22 years has been to review the progress on new technologies related to zooplankton research activity. Several working group members have organized SCOR workshops to advance the field of automatic visual plankton identification. In a related effort, WGZE has organized morphological and genetic taxonomy training workshops and has worked to improve the access to the ICES Zooplankton Leaflets and to stimulate their revision where necessary.

Meetings of the WGZE have been coordinated with other working groups in an effort to foster synergistic activities between the working groups. Face to face meetings have taken place with the Working Group for Cod and Climate Changes (1996), the PICES zooplankton group (2000), the Working Group for Phytoplankton Ecology (2001), The Working Group for Physical Biological Interactions (2008), the Working Group for Phytoplankton and Microbial Ecology (2012), and the Study Group for Integrated Morphological and Molecular Taxonomy (2012, 2013, 2014).

The members of the WGZE have played an integral role in the development and planning of zooplankton symposia and workshops including the Zooplankton Production Symposia in 1995, 2003, 2007, and 2011. These symposia have all produced symposium volumes published by ICES JMS. The working group members have participated in other ICES, ICES/GLOBEC, or ICES/CIESM workshops designed to explore the dynamics of *Calanus* in the North Atlantic and zooplankton impacts on Cod abundance and production, and to compare zooplankton ecology and methodologies between the Mediterranean Sea and North Atlantic.

The WGZE has contributed to the ICES Annual Science Conferences by successfully proposing eleven theme sessions since 1997. The topics ranged from GLOBEC Interdisciplinary program review (1997), physical phenomena and biological production: implications for GLOBEC (1998), linkages between the environment (climate), plankton, and fish (2000, 2008, and 2011), plankton as food for higher trophic levels (2006, and 2013), deep-sea zooplankton community and biomass structure (2007), comparative descriptors of marine ecosystem structure (2007), biochemical and molecular approaches to the study of plankton ecology and diversity (2009), and the integration of micro and mesozooplankton food web research (2011).

The WGZE has also responded positively to requests from ICES for advice to clients with respect to the 2008 OSPAR assessments of changes in the distribution and abundance of plankton in the OSPAR region, for input into methods for monitoring methodologies for ocean acidification in 2010, and for an overview of trends in plankton communities for the 2011 ICES Study Group for Climate Change white paper (CRR 310). The working group has also provided input to REGNS, the ICES data Center, and to the Steering Group on Quality Assurance of Biological Measurements (STGQAB).

The ICES also requested that the WGZE consider how to assess the fishing impact on stocks of *Calanus finmarchicus*. This species is now being harvested by an exploratory fishery and the impacts such fishing on predatory species that rely on *Calanus* as a food resource are unknown. This topic has been discussed at WGZE and a workshop to consider the impacts has been proposed, but not funded or scheduled.

This review ended with a summary of outstanding issues for future WGZE meetings. They include:

1) How to update the Methodology Manual?
2) Providing input into the next Zooplankton Symposia (6th International Zooplankton Production Symposium).
3) Zooplankton Status Reports – Coordination with International Group for Marine Ecological Time-series (IGMETS).
4) Future of ICES Identification Leaflets for Plankton.
5) Joint meetings with other WGs (WGIPEM - 2015).
6) Theme Sessions for ASC meetings.
7) Integration of Time-Series Stations Species Lists, allometric relationships for species, genetic data, and identification sheets.
8) *Calanus finmarchicus* exploratory assessment.

These topics should be considered in the discussion about the ToRs for WGZE's next three years.

11 ToR i) Review the ICES response to the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment

Leads: Erica J. Head, Astthor Gislason, Webjörn Melle by correspondence; Rapporteur: Tone Falkenhaug

Background and present status

Erica Head presented an overview of the background and the latest status of this ToR. In advance of the WGZE meeting, held in Malaga in March 2012, our group was requested by ACOM, via SCICOM, for an "exploratory assessment of *Calanus finmarchicus* in the Norwegian Sea". The request originated with the Norwegian Royal Ministry of Fisheries and Coastal Affairs.

At the March 2012 WGZE meeting, Jeff Runge presented results of synthesis paper on aspects of *Calanus finmarchicus* ecology, for which data had been compiled from studies carried out by various groups working at numerous sites throughout the North Atlantic (Melle *et al.* 2014). A lively discussion ensued arising from this presentation and the implications and potential pitfalls of establishing a fishery for this key species.

The outcome of the meeting was a decision to host a workshop to consider not just the request, but its broader context. Subsequently, Jeff Runge and Webjørn Melle (from the WGZE), Jason Link (from ACOM) and Mike Heath (from SCICOM) were approached to assess their willingness to chair such a workshop: they all accepted.

During summer 2012 the four Co-Chairs collaborated to produce the following list of ToR for the proposed Workshop, which was to be titled "An Exploratory Assessment of *Calanus finmarchicus* (WKCALANUS):

1) To review the understanding of the ecology and dynamics of *Calanus finmarchicus*,

2) To evaluate the data sources and methodology that would be needed to conduct an exploratory assessment of *C. finmarchicus*, including survey and modelling needs.

3) To make an exploratory assessment of the abundance and production of *C. finmarchicus* based on available data, and evaluate appropriate candidates for Biological Reference Points.

4) To evaluate quantitatively the ecosystem effects of harvesting of *Calanus finmarchicus*, including effects on dependent species, and the potential by-catch effects of the fishery.

5) To evaluate future assessment schedules and frequencies of both the stock and demands on it; in order to improve the understanding of the functioning of the ecosystem and to ensure resource sustainability.

6) To provide advice on improved data collection for the development of future assessments of *C. finmarchicus*.

Funds were sought then sought to enable the Co-Chairs to assemble a panel of experts, having a sufficiently broad knowledge basis, to attend and inform the proposed workshop on the various ToRs. The suggestion was made that since Norway was the nation that had made this request (and was the only one proposing to fish the resource), it should be responsible for all, or at least part, of the required funding. ICES approached Norway, but Norway, as paying the national contribution to the ICES budget, insisted to follow the regular advisory procedure in this case engaging the appropriate scientific expert group(s).

This topic was discussed again at the WGZE meeting, held in Lowestoft in March 2013, and at this meeting the results of an exploratory *Calanus finmarchicus* fishery in Icelandic waters were presented by Hildur Petursdottir. The conclusion of the WGZE was that the Chair should re-apply to ICES for funding to hold the proposed Workshop, and that the WGZE members would examine and discuss the plans for the fishery that were supposedly in the process of being produced by Norway.

During summer 2013, Jeff Runge resigned, citing lack of financial support to continue. Erica Head agreed to take his place. During the fall of 2013, IMR agreed to provide up to 7000 Euros, to fund the three non-Norwegian Co-Chairs to attend the Workshop to discuss the *Calanus* fishery, in anticipation that it would be held in Bergen. Jason Link and Mike Heath both decided that this would be inadequate, since they considered that a panel of experts was required, which could not be assembled unless all participants were to receive external funding. At this point they both resigned as workshop Co-Chairs.

WGZE summarised the current status of *Calanus* exploitation: a small scale exploratory fishery (quota 100 tonnes, approved by the Norwegian Ministry of Fisheries and Coastal Affairs) started in Norway in 2003, with the quota rising to 1000 tonnes in 2008. Catches have not been greater than 140 tonnes, and have been taken within 30 miles of the Norwegian coast. *Calanus finmarchicus* are fished during April-June, when individuals from the new year's generation have accumulated high lipid concentrations and are preparing to enter diapause, but are still at the surface. As a pre-

requisite for the allowance, subsamples of all trawl catches must be taken by Calanus AS and examined for bycatch of fish eggs and larvae by independent experts. The Norwegian Fisheries Directorate can decide to place inspectors onboard during the fishery. There has been by-catch of larvae of cod, herring and other fish species, although quantitative data have not yet been forthcoming.

In Norway, work towards a management plan (including a harvest rule, quota, and assessment of *Calanus* in the Norwegian Sea) was planned by the Norwegian Fisheries Directorate and the Institute of Marine Research in 2013, but this work was postponed. The task has now been resumed, and will be completed by the end of 2014. This work will be led by Katja Enberg at the Institute of Marine Research.

Icelandic waters

Astthor Gislason presented the plans for *Calanus* fishery in Icelandic waters: in June 2012, an exploratory survey on *Calanus* was made on the southwest shelf off Iceland in collaboration with Calanus AS, Tromso, Norway. Although the annual mean biomass of *Calanus* within the Icelandic Exclusive Economic Zone is lower compared to the much larger Norwegian Sea, the results from the cruise indicated that *C. finmarchicus* south of Iceland may be harvested in some areas using the methodology of Calanus AS. In January 2013, a request was made by Hraðfrystihúsið Gunnvör Ltd to the Icelandic Ministry of Industry and Innovation for harvesting 300 tons of *Calanus* during summer 2013. Based on recommendations from the Icelandic Marine Research Institute (MRI), this application was approved, conditioned on that the areas selected for fishing were determined in consultation with the Marine Research Institute to avoid bycatch and that the harvesting be done with an observer on board. Fisheries in 2013 were, however, cancelled due to lack of fishing vessel, but plans are now being made for fishing activities in 2014.

Discussion

The WGZE discussed the way forward. There was consensus that the WGZE needs to include expertise from other ICES expert groups in order to address this ToR.

WGZE suggested approaching the modelling group in order to make a joint effort on this task. In 2015, the WGZE will meet back to back with the ICES WGIPEM (Working Group on Integrative, Physical-biological, and Ecosystem Modelling). The conclusion of the WGZE was to suggest a joint WGZE- WGIPEM ToR for the meeting in 2015, on the assessment of *Calanus*. This will be a good opportunity to foster future co-operation between WGZE and WGIPEM .

Conclusions:

- The Chair (Piotr Margonski) will approach the WGIPEM (Myron Peck) regarding a joint ToR on the *Calanus* assessment. The preparation of this ToR should be made prior to the group meeting, and work should start as soon as possible by correspondence.
- Additional ecological modellers should be contacted and get involved in this work as soon as possible. Modellers at the Norwegian Institute of Marine Research, that have been working on *Calanus* populations modelling should also be contacted: (e.g. Solfrid Sætre Hjøllo, solfrid.hjollo@imr.no).
- The WGZE decided to keep the *Calanus* assessment as a "Multi-annual ToR" 2015–2016 (1–2 years) led by Erica Head and Webjørn Melle.

- The WGZE decided to apply for a theme session on "*Calanus* assessment" at the ICES ASC in 2015.

Reference

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12 Pending Question: How to improve monitoring for zooplankton?

Lead: Sophie Pitois; Rapporteur: Maiju Lehtiniemi

Sophie Pitois provided an introduction presentation to summarise the state of the art and start participants' discussion. She was mentioned that CEFAS is developing an integrated sampling program, which takes into account different approaches, surveys and monitoring programs. Every method has its pros and cons. It would be important to study integrated use of data from different surveys and by different methods to get a better picture of how to combine different approaches and data. As part of a new Defra funded project, CEFAS will organize a workshop to discuss how to improve the monitoring of zooplankton in order to satisfy the needs of scientists (including modellers) as well as decision makers. The planned workshop is very welcome to gather ideas and discuss what kind of data and methods are needed for different purposes (e.g. modelling, assessments). We should have an idea what are the minimum data requirements in order to know how to proceed and how 'low' we can go to still have useful data. Workshop proposal is currently under revision and if funded, most probably, it will be organised in 2015. It was suggested to invite expert(s) from Canada, where zooplankton monitoring has been conducted for a long time. It was mentioned that a paper came out last year (Wiebe *et al.*), about comparison of methods, which has a similar approach as the planned workshop. It was agreed that the workshop comes to a good time as now it is the right moment to act, at least for European countries due to revision of the monitoring programs for MSFD. In some countries there is a clear lack of zooplankton data for MSFD purposes and the suggestions for monitoring programs are in many cases too weak. It was noted that it would be good to have an opinion of the group for how to organize zooplankton monitoring in an integrated way to help the implementation of the directive and to fulfil the data needs of modellers and ecological studies. We need a suggestion for a text for monitoring needs to be distributed for countries. Modellers need certain kind of data (not the total biomass but taxonomic groups, abundances), thus it would be good to meet with the modelling group to discuss the needs. However, governmental needs are also very important and they focus on obtaining data to calculate the relevant indicators. It was noted that detection of invasive species needs a species level resolution. So far proposed zooplankton indicator for food web functioning for the HELCOM area (Baltic Sea) needs only data for total abundance (or biomass) and individual size (length). Other suggested indicators need group level data for copepod or microphagous zooplankton abundance. OSPAR (North Sea) indicators need data for holoplankton vs. meroplankton, jellyfish vs. fish larvae, copepods (zooplankton) vs. phytoplankton for the suggested food web indicators. Not one method can cover all these data needs and different mesh sizes are needed. It was also noted that

present monitoring concentrates on mesozooplankton, but also microplankton should be monitored.

What should be measured? Methods for open sea are different compared to coastal areas but a standardization is needed. These issues should be taken up in the workshop. However, the methods will not be changed to the same standard one(s) because there are valuable long-term data, which collection should not be stopped. One of the pragmatic solutions could be introducing of the additional sampling method (i.e. different gear, mesh size, location, or depth strata) to cover the whole spectra of data needs. It was discussed if ferrybox sampling could be better used in zooplankton monitoring. Ferrybox systems take water/samples from ~4 m depth thus no vertical profiles are possible to obtain. Also the use of fisheries cruises to take zooplankton samples was mentioned.

Lutz Postel summarised the discussion on monitoring design in Germany stressing that according to the Marine Strategy Framework Directive: "The marine environment is a precious heritage that must be protected, preserved and, where practicable, restored with the ultimate aim of maintaining biodiversity and providing diverse and dynamic oceans and seas which are clean, healthy and productive. In that respect, this Directive should, inter alia, promote the integration of environmental considerations into all relevant policy areas." This demands a holistic approach for achieving a good environmental status (GES) considering sustaining and harvesting the sea at the same time. For this purpose, an indicator for GES must be of a certain flexibility. Most approaches orientate on empirically derived limits or statistical metrics of certain concentrations. Zooplankton experts in the Baltic Sea area consider the descriptor D4 "Stability of food webs" as a major goal in this context. It is related to the descriptors D3 (fishery), and D5 (eutrophication). Also, one need to keep an eye on descriptor D2 (invasive species) because they can disturb food web relationships significantly. In other areas D1 (biodiversity) might also be an important indicator for GES. According a discussion of German zooplanktologists in February, 2014, the balance between the healthy and productive sea might be achieved by the balance between zooplankton (food) production and food requirements of planktivorous fish, which means a status between "bottom up" and "top down" regulation of zooplankton stock. The participants of the discussion agreed upon distinguishing between food requirements of larval and of adult fish because of different food sources. Estimation of food production and food requirements are a matter of calculations basing on stock sizes and body mass, which can be obtained by classical monitoring of both components. In an ecosystem context, the balance between gross production P and community respiration R. can avoid eutrophication. P/R = 1 is known as the climax stage of a community succession as pointed out by Eugene P. Odum in the late nineteens sixties. In "The Strategy of Ecosystem Development" he mentioned that "An understanding of ecological succession provides a basis for resolving man's conflict with nature." A monitoring of such an aim would require measurements of primary productivity and community respiration (plankton of various size classes, nekton, benthos).

Lidia Yebra presented the MSDF indicators related to zooplankton which are being considered by the Spanish government to be submitted to the Commission. Indicators have been listed together for D1 (biodiversity), D2 (invasive species), D4 (food webs) and D6 (sea floor integrity). Originally they have been proposed by OSPAR and some of them overlap:

- Changes in indices of plankton functional groups (life forms)
- Biomass, species composition and spatial distribution of zooplankton

- Biomass and abundance of functional groups
- Changes in biomass and species distribution by trophic level or size (Biomass Trophic Spectrum)
- Ecological Network Analysis (trophic efficiency, flux diversity)

Erica J. Head provided a description of the Atlantic Zona1 Monitoring Program (AZMP) in Canada. The AZMP was implemented in 1998 with the aim of collecting and analyzing the biological, chemical, and physical field data that are necessary to:

1) Characterize and understand the causes of oceanic variability at the seasonal, interannual, and decadal scales.

2) Provide multidisciplinary data sets that can be used to establish relationships among the biological, chemical, and physical variables.

3) Provide adequate data to support the sound development of ocean activities.

AZMP involves the Gulf, Québec, Maritimes, and Newfoundland regions of DFO. Its sampling strategy is based on:

1) Seasonal and opportunistic sampling along "sections" to quantify the oceanographic variability in the Canadian NW Atlantic shelf region.

2) Higher-frequency temporal sampling at more accessible "fixed sites" to monitor the shorter time scale dynamics in representative areas.

3) Fish survey and remote sensing data to provide broader spatial coverage and a context to interpret other data.

4) Data from other existing monitoring programs such as CPR (Continuous Plankton Recorder) lines, Sea Level Network, near-shore Long-Term Temperature Monitoring, Toxic Algae Monitoring, etc., or from other external organizations (e.g., winds and air temperatures from Environment Canada) to complement AZMP data.

More detailed information may be found in the following documents:

Therriault, J.-C., B. Petrie, P. Pepin, J. Gagnon, D. Gregory, J. Helbig, A. Herman, D. Lefaivre, M. Mitchell, B. Pelchat, J. Runge et D. Sameoto. 1998. Proposal for a northwest Atlantic zonal monitoring program. Can. Tech. Rep. Hydrogr. Ocean Sci. 194: vii+57p.

Mitchell, M.R., G. Harrison, K. Pauley, A. Gagné, G. Maillet, and P. Strain. 2002. Atlantic Zonal Monitoring Program Sampling Protocol. Can. Tech. Rep. Hydrogr. Ocean Sci. 223: iv + 23 pp.

http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/azmppmza/index-eng.html

Maiju Lehtiniemi informed that the zooplankton related indicator proposed by Finland for Descriptor 4 (food webs) of the MSDF is mean size vs. total abundance of the zooplankton community. This indicator has originally been proposed by HELCOM Zooplankton Expert Network (ZEN). In order to obtain more reliable data for the indicator and to be able to assess the state of the lower trophic levels, Finland is proposing to increase the sampling frequency of mesozooplankton from one annual sampling and to start microzooplankton monitoring.

It is clear that a common guideline that covers the minimum requirements for zooplankton monitoring in European waters is needed to put forward to decision-makers. Without such guidelines there is a danger of a failure to fulfil the MFSDs requirements and wasted monitoring effort that is of no use to knowledge based assessment of framework directives. The guideline should include recommendation for:

sampling frequency, spatial coverage or key stations, minimum requirement of analysis of zooplankton (species, stages, key species, abundance, biomass) within each European member-states exclusive economic zones. The recommendations should fulfil the basic needs to cover the MFSD requirements of indicating changes in biodiversity, invasive species and food webs. The workshop planned in CEFAS could be the venue for preparing and discussing such minimum guidelines.

13 Progress Reports: Time-series of the Basque coast zooplankton

Authors: Fernando Villate, Ibon Uriarte, Arantza Iriarte; Presenter: Arantza Iriarte, University of the Basque Country, Bilbao, Spain

A preliminary analysis of the inter-annual and seasonal patterns of variation of the abundances of major zooplankton taxa from the coastal sites of Bilbao 35 and Urdaibai 35, located on the south-eastern Bay of Biscay, for the period 1998–2012 was carried out. Data were obtained from zooplankton samples collected monthly using a 25 cm diameter rig net of 200 μm mesh size. The inter-annual pattern was assessed using a multiplicative model as in Cloern & Jassby (2010); for the seasonal pattern monthly mean values and seasonal centres of gravity (as in Mackas *et al.*, 2012) were used. The inter-annual pattern of variation showed general increasing trends at both sites for total zooplankton and most taxa, but in some taxa, such as the dominant group of copepods, the increasing trends were to some extent driven by the unusually high abundances of 2012, i.e. the last year of the series. In fact, the increasing trends were only significant for appendicularians, cirripedes, gastropods and bivalves in Bilbao 35 and for medusae in Urdaibai 35. The doliolids were the only group that showed decreasing trends at both sites. In addition, year-to-year fluctuations in abundance were common, and some cyclic patterns could be guessed for most taxa. It was noticed that the NAO (North Atlantic Oscillation) index showed the highest positive value (>2) for the period of the present study during winter 2012, coinciding with the unusually high zooplankton (mainly copepods) abundance observed for 2012. Within each site, the inter-annual variability of total zooplankton correlated positively only with those of copepods and cladocerans in Bilbao 35, and with those of copepods, appendicularians, cirripedes, gastropods, bivalves and polychaetes in Urdaibai 35. The inter-annual variability of medusae and doliolids correlated negatively or showed opposite trends with those of several taxa (5 to 10) in both sites. Correlations of the inter-annual variability of taxa between Bilbao 35 and Urdaibai 35 evidenced that total zooplankton, copepods, siphonophores, bivalves, decapods and fishes correlated between sites, and that doliolids showed the highest number of opposite trends with taxa of the other site. In general, total zooplankton and copepods appear to respond to inter-annual environmental variations in a similar way in both sites. Regarding seasonal variations, total zooplankton and most taxa peaked earlier in the year in Urdaibai 35 than in Bilbao 35. This may be related to differences in the seasonal pattern of chlorophyll a concentration between sites. The seasonality for total zooplankton and most taxa showed changes between the first (1998–2005) and the second (2006–2012) parts of the series. The comparison of the two periods showed that total zooplankton and copepods peaked later in the second period, and showed a delay of the centre of gravity from the first to the second period of the series in Bilbao 35, but not in Urdaibai 35. Most of the other taxa peaked later in the second period of the series in both sites, but only the appendicularians showed a delay of the centre of gravity at both sites. Medusae was the only group that peaked earlier in the second period of the series in both sites, although they showed a delay of the centre of gravity in Urdaibai, but not in Bilbao. It is hypothesized that differences in seasonal trends

of taxa between sites might be a response to winter temperature and similarity in seasonal trends of taxa between sites a response to spring temperature.

Cited literature

Cloern, J.E., Jassby, A.D. (2010). Patterns and scales of phytoplankton variability in estuarine-coastal ecosystems. Estuaries and Coasts 33, 230-241.

Mackas D.L., Greve W., Edwards M. *et al.* (2012). Changing zooplankton seasonality ina changing ocean: Comparing time-series of zooplankton phenology. Progress in Oceanography 97-100, 31-62.

14 Progress Report: Multidecadal dynamics of copepods in a shallow temperate bay (NE Baltic Sea)

Presenter: Marilyn Kalaus, Estonian Marine Institute, University of Tartu

Systematic high-frequency (weekly resolution) sampling of zooplankton started in Pärnu Bay (Gulf of Riga, NE Baltic Sea) already in the late 1950s. These surveys were mostly connected to larval herring investigations and performed during the presence of herring larvae (i.e. in May–July). Both sampling design – vertical tows with Juday net (mouth opening 0.1 m^2; mesh size 100 μm) from bottom to surface – and analysis methodology has remained unchanged since the beginning of surveys. The study area was separated into two sub-areas: i) very shallow (depth 5m) and sheltered coastal area which is under direct river inflow at the northernmost coast of the bay, and ii) a bit more distant and less sheltered area (depth 10m) where spring development starts later and which is under the impact of the Gulf of Riga waters.

We have collated and verified all the original observational data and established database on copepods by the dominating taxa (*Eurytemora affinis*, *Acartia spp*. and *Limnocalanus macrurus*) by the following four developmental stages: nauplii, small copepodites (I-III), large copepodites (IV-V) and adults. At first, we will establish long-term time-series and investigate the multi-annual abundance/biomass patterns of the copepods in the two sub-areas separately. Then we will relate these changes to a set of global/regional/local hydro-climatic drivers. And finally, we will investigate population dynamics of the copepod species (incl. stage-specific analysis) as a function of thermal winter regime (e.g, winter severity, spring/summer SST).

15 Progress Report: Presentation on Gravelines plankton time-series

Presenter: Elvire Antajan, IFREMER, France

In the framework of an ecological survey of the Gravelines nuclear power plant (French coast of the North Sea), a long-term zooplankton monitoring was established since 1978. The Gravelines station is located in the entrance of the channel inflow into the power plant and is not impacted by the power plant water discharge. The sampling strategy changed over time in terms of sampling frequency, plankton net used and identification level. Zooplankton samples were collected monthly or seasonally with a standard WP2 net from 1978 to 1991 and then monthly with a small conical net (opening diameter 34 cm, 113 cm length, 200 μm mesh size) from 1992 to 2007. Since 2008 the sampling is carried out with a standard WP2 net, bi-monthly from March to September and monthly from October to February. Preliminary analyses have not allowed us to highlight differences in zooplankton abundance accord-

ing to the plankton net used. Up to the 1990s only most abundant species were counted (mainly copepods). We have recently built and validated a database on the full time-series which also include environmental parameters (temperature chlorophyll and nutrients), phytoplankton abundance (since 1990), gelatinous zooplankton and ichthyoplankton abundances (since 2010). Future work on these plankton time-series will focus on temporal variation in plankton species composition and abundance, and on comparison with other long-term zooplankton data in the English Channel and the southern North Sea.

16 Progress Report: EURO-BASIN contribution

Authors: Astthor Gislason, Todd O'Brien, Padmini Dalpadado, Tone Falkenhaug, Eilif Gaard, John Hare, Erica Head, Catherine Johnson, Webjörn Melle, Pierre Pepin, Stéphane Plourde; Presenter: Astthor Gislason, Marine Research Institute, Iceland

The report summarizes the long-term changes of *Calanus finmarchicus, C. hyperboreus* and *Oithona spp*. at national monitoring sites on both sides of the North Atlantic and off Iceland. Principal components analysis based on a subset of 16 year time-series (1995–2010) that was common to most sites was used to elucidate differences and similarities between the different series. For *C. finmarchicus,* the first principal component showed a minimum in the late 1990s, a shift in 2000 and generally high values since then. The *C. finmarchicus* populations off Iceland and in the Gulf of Maine and on Georges Bank have followed this trend. For *C. hyperboreus*, the PCA arranged sites rather randomly on the ordination plot which indicates little relationship among them. For *Oithona spp*., the first principal component reached a maximum in the late 1990s (indicating high anomalies on Georges Bank and in the Gulf of Maine and low at sites north of Iceland and on the south Icelandic shelf), a shift towards low values in 2002, thereafter values have remained low. Further work is planned with the aim of developing an approach for setting the interannual anomalies of abundance of the three species against the basic physical attributes and phytoplankton development at the different sites.

The results of the PCAs have in common that they show limited grouping of sites for all species. This suggests limited interannual co-variability among sites. This is perhaps not surprising given the basin-wide spatial scale of the study. Some of the groupings that were identified are hard to interpret biologically (e.g. the long-term covariability of *C. finmarchicus* populations off Iceland and in the Gulf of Maine and on Georges Bank), while others seem more reasonable (covariability among the Labrador Shelf and slope series for *C. hyperboreus*, and among the Georges Bank and in the Gulf of Maine series for Oithona). It should also be noted that the first 2 axes of the PCAs only explain ~48, 62, and 47% of the total long-term interannual anomalies for *C. finmarchicus, C.hyperboreus* and *Oithona spp*., respectively, so much variability remains unexplained.

17 Progress Report: Progress report of SCOR working group proposal for secondary production methodologies and its application

Presenter: Toru Kobari, Kagoshima University, Japan; Rapporteur: Erica J. Head

Zooplankton production is important for quantifying the functional roles of trophodynamics and material cycles in marine ecosystems because zooplankton community

occupy the ecological niche between lower and higher trophic levels. This presentation gave brief reviews of the contemporary methodologies to estimate zooplankton production and progress report of working group on zooplankton production measurement methodologies and its applications.

While several traditional and biochemical methodologies are now available for estimating zooplankton production, the problems were pointed out at the PICES workshop 2012. Major problems were little knowledge for pelagic zooplankton, no information on validation or comparison among methodologies, low temporal and spatial resolutions due to the laborious and time-consuming procedures, and limited application to crustacean zooplankton due to the age within stage. To discuss the solution strategies of these problems, 14 members from ICES and PICES nations established a working group on zooplankton production measurement methodologies and its application. They submitted proposals for new SCOR working group and for research projects. While these proposals were not approved, they continue to work with the following issues:

1) To share the problems and solution strategies of the contemporary methods for measuring zooplankton production rates in discussion forum (e.g., Aquatic Science Meeting 2015, Zooplankton Production Symposium 2015, Ocean Science Meeting 2016);

2) To make guidelines to review the advantages/disadvantages, protocols and recommendations of the traditional methodologies and biochemical approaches for measuring zooplankton production rates;

3) To establish a working group on zooplankton production methodologies in SCOR (i.e., submission of the revised proposal);

4) To conduct collaborative research programs to compare zooplankton production rates among the contemporary methods (including proposal submission for funding).

Lidia Yebra subsequently clarified that the rejected by SCOR proposal was not focused on production of the manuscripts, but to actually undertake the experimental comparison.

Alexandra Chicharo offered to contribute to the MS to be prepared, since she has had a PhD student, who has been comparing biochemical methods (RNA/DNA ratios) vs. traditional methods (egg production) in *Acartia*.

Toru Kobari pointed out that there are papers published with many different comparisons, but there is a need for a complete comparison, which includes (ideally) all recognised methods. He also noted that some researchers (e.g. Andrew Hirst) have noted that egg production rates are not always good proxies for secondary production.

Roger Harris related that there have been WGZE-sponsored workshops looking at production in *Acartia*, and other species, which used the Bergen mesocosms. He suggested this might be a good spot for "Toru Kobari *et al.*" to do a modern re-working of those workshops. Other mesocosm facilities exist in Kiel, Seattle (Washington), Narragansett and Svalbaard.

Peter Wiebe suggested that this subject might be proposed for a session at the UNESCO-sponsored Ocean Research conference in the fall Barcelona 2014.

18 Progress Report: Little auks as zooplankton samplers: a long-term study in East Greenland

Authors: David Grémillet, Jérôme Fort and Françoise Amélineau

Little auks are the most abundant seabirds in the North Atlantic with 40 to 80 million pairs (Stempniewicz 2001). They breed in Arctic regions and often forage in the marginal ice zone (Jakubas *et al.* 2013). They feed on zooplankton and bring back food for their chick in a gular pouch. Prey items in this pouch are well preserved (no digestion or chewing) and can be easily collected using a soft paintbrush. As a part of the ADACLIM program funded by the French Polar Institute (IPEV, Progr.388), we sampled each year since 2005, 20 gular pouches of breeding adults from a colony on Liverpool Land, East Greenland. Each sample contained a mean of 1553±187 prey items (Harding *et al.* 2009). A subsample of at least 200 prey items was analyzed per sample. Main prey species were *Calanus* copepods; they were identified to the species' level. Other prey species were identified at least to the genus, and when possible to the species. Main prey species are *Calanus hyperboreus*, *Calanus glacialis*, *Calanus finmarchicus*, *Apherusa glacialis*, *Themisto libellula*, *Themisto abyssorum*, *Thysanoessa inermis*, *Thysanoessa longicaudata*, *Limacina helicina* and a few Gammaridae. In parallel, we also equipped some birds with miniaturized GPSs or temperature-depth recorders so that we know where the birds collected zooplankton. In East Greenland, they dived down to 50m and foraged up to 100km from the colony. This monitoring will continue each year, and this study has been identified as key monitoring site by the Arctic Council.

19 Progress Report: Zooplankton Abundance, Biomass and eco-physiological condition in Southwest Iberia

Authors: Maria Alexandra Teodósio Chicharo, Joana Cruz, André Dias, Luis Chicharo; Presenter: Alexandra Chícharo, University of Algarve, Portugal

Zooplankton monitoring in this coastal area began in 1997, and was motivated by the need of a reference description of communities before the finalization of the construction of the Alqueva Dam, a relevant anthropogenic pressure in the catchment of the Guadiana estuary. The aims of our work were to: i) update trends in zooplankton from Southwest Iberia using food web indicators within the MSFD (European Union's (2008/56/EC) Marine Strategy Framework Directive); ii) describe biochemical condition of major zooplanktonic groups using nucleic acids (growth, biomass indicator); iii) relate the copepod ecophysiological status (RNA/DNA ratio) and egg production method. In the south west Iberian peninsula, the lower area of the Guadiana estuary and the coastal area were sampled monthly both for hydrological variables (e.g., temperature, salinity, turbidity, flow, chlorophyll) and zooplankton characterization. The samples were collected using a horizontal tow with a WP2 net. An increase trend in interannual abundance of total zooplankton was registered, justified by the increase of copepods, cladocerans and gelatinous organisms (medusas and siphonophores). Mesozooplankton patterns of ecophysiological condition and potential growth follow the phytoplankton proxy, chlorophyll a and microzooplankton with maxima usually occurring between March and October, suggesting a high efficiency of planktonic system regarding biomass transfers. Food availability and temperature have major influence on the copepod production rate (EPR) and RNA/DNA ratio seems to be a good proxy of EPR. Further investigations of trophic relations between planktonic groups through gut content analysis and ingestion rates are planned.

20 Progress Report: Estimation of mortality for *Calanus finmarchicus* eggs in the Labrador Sea

Authors: Erica Head, Wendy Gentleman, Leslie Harris and Marc Ringuette; Presenter: Erica J. Head, DFO, Canada

Mortality rates were estimated for eggs being produced by *C. finnmarchicus* at 88 stations in the Labrador Sea, using VLT (Vertical Life Table) methods. The Basic method, in which egg production rates are equated with egg hatching and mortality rates, is expected to give the most reliable estimates, since it requires that steady state conditions apply over only 2–3 days. Surprisingly, this method gave negative rates at about one third of the stations. These negative rates did not seem due to calculation errors associated with bad input variables, and could be rendered positive if it was assumed that some of the eggs being produced were not viable (i.e. did not hatch). Mortality estimates increased further, if it was assumed that predators consumed viable eggs in preference to non-viable eggs.

21 Progress Report: Marine environmental monitoring data at the Swedish National Oceanographic Data Centre – An introduction and examples from zooplankton data

Presenter: Patrik Strömberg, Swedish Meteorological and Hydrological Institute

The Swedish Meteorological and Hydrological Institute, SMHI, has very large quantities of environmental data and times series dating back to the 1860s. The National Oceanographic Data Centre at SMHI maintains time-series of physical, chemical and biological data (the latter since 2007). These data are sent in by data suppliers and are made available through a web interface that also provides various ways of exploring the data (sharkweb.smhi.se, in Swedish). Currently also a REST-server is under development enabling machine-machine transfer of data and the sharkdata.se will be finished this year (2014).

The environmental monitoring data comprise of several parameters and taxa. Regarding zooplankton there are data available from 1970 to 2014. Starting from 2007 the monthly records are complete. The zooplankton data are available for several stations in the Baltic Sea region and out to Skagerrak.

Data Centre at SMHI is under constant development to ensure more parameters and data are made available in several ways to suit various needs. One example of improvement in the very near future, is that it will be possible to download biogeochemical data though the same web-interface in the standardized format.

22 Report on WKSERIES

Presenter: Lidia Yebra by correspondence and Todd O'Brien

The Workshop on Synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time-series in the North Atlantic and adjacent seas (WKSERIES), chaired by Alexandra Kraberg and Lidia Yebra, met at ICES Headquarters, Copenhagen, Denmark, on the 15–18 October 2013. The principal aim of WKSERIES was to synthesize hydrographic, phytoplankton, microbial plankton and zooplankton time-series for the North Atlantic and adjacent areas. The workshop analyses were based on the time-series data collected by the WGPME and WGZE expert groups, and a common

time-series analysis approach was adopted for the WKSERIES workshop. Exploratory analyses were run before estimating the spectral properties of all datasets and fitting models to the data to estimate trends and climatology. The preliminary analyses were run in R (TSA and TTA interface) for sites in the German Bight, English Channel, Skagerrak and offshore from the Eastern Scottish Coast which are all located in different Atlantic Inflow/impact regions. In addition, the zooplankton time-series in Málaga (W Mediterranean) was also analysed, as it is influenced by Atlantic waters entering the Gibraltar Strait. These analyses will be developed further using standardized results report sheets. Based on these results further sites/parameters will be added before summarizing the analyses for a peer reviewed publication.

Based on WKSERIES discussions it was recommended that there should be closer links between the relevant ICES working groups (hydrography, oceanography, zooplankton and phytoplankton) and a further workshop to explore the links between observed patterns in our time-series with hydrographic conditions will be proposed.

23 Report on 2013 Theme Session F: "Complexity and structure of planktonic foodwebs: who really eats whom?" co-chaired by Elaine Fileman, Ann Bucklin, Pennie Lindeque, and Janna Peters

Presenter: Elaine Fileman, Plymouth Marine Laboratory, Plymouth, UK

The session attracted 15 contributions (10 oral and 5 poster presentations) and brought together scientists from 9 nationalities and an audience of around 60–80 people. Session contributions fell within 4 prominent themes; diversity (potential prey, prey items), trophic pathways (AFC, fatty acids, PCR qPCR), impact on predator performance (metabolic rates, nutrient limitation) and the response to environmental drivers (increase SST, phenology, field & modelling studies). A wide variety of traditional and emerging techniques (e.g. biochemical and molecular; PCR, qPCR) are currently under development and being adopted in marine ecology and the application of such novel approaches has yielded new insights into understanding the structure and complexity of planktonic food webs. Methods presented demonstrated their high potential to (1) accurately determine species diversity, which is essential for understanding ecosystem functioning and (2) enhance understanding of linkages between trophic levels within the plankton community. However, it was apparent that no method alone, either traditional approaches or new techniques, will be able to unravel the complexity of pelagic food web interactions. A multi-disciplinary approach is essential.

Annex 1: List of participants

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Annex 2: Agenda

Monday March 24, 2014

09:00 – 9:30	Opening, Introduction, Logistics, Adoption of the Agenda (Astthor Gislason, MRI, Iceland and Piotr Margonski, NMFRI, Poland)
09:30 – 10:30	Finalize production of videos on zooplankton sampling/processing techniques as part of progress in updating the Zooplankton Methodology Manual (**ToR a**, Piotr Margonski, NMFRI, Poland)
10:30 – 11:00	Coffee Break
11:00 – 12:00	Examine regional and transatlantic distribution and temporal patterns with zooplankton time-series to discern significant changes over time and to identify potential environmental or climate drivers (**ToR b,** Todd O'Brien, NOAA-NMFS, USA)
12:00 – 12:30	Progress Reports: Time-series of the Basque coast zooplankton (Arantza Iriarte, University of the Basque Country)
12:30 – 14:00	Lunch
14:00 – 14:30	Progress Report: Multidecadal dynamics of copepods in the NE Baltic Sea (Marilyn Kalaus, Estonian Marine Institute, University of Tartu)
14:30 – 15:00	Progress Report: Presentation on Gravelines plankton time-series (Elvire Antajan, IFREMER, France) Progress Report: EURO-BASIN contribution (Astthor Gislason, MRI, Iceland)
15:00 – 15:30	Discussion on Multi-annual ToRs and Theme Sessions (part 1) (Piotr Margonski, NMFRI, Poland)
15:30 – 16:00	Coffee Break
16:00 – 17:30	Review of the WGZE scientific achievements as a basis for preparing the multi-annual activities planning (**ToR h,** Peter Wiebe, Roger Harris, and Piotr Margonski)

Tuesday March 25, 2014

09:00 – 10:00	Pending Question: How to improve monitoring for zooplankton? (Sophie Pitois, CEFAS, UK) + Discussion
10:00 – 10:30	Progress Report: Progress report of SCOR working group proposal for secondary production methodologies and its application (Toru Kobari, Kagoshima University, Japan)
10:30 – 11:00	Coffee Break
11:00 – 12:30	Prepare the background data needed for calculation of zooplankton productivity and metabolic rates in the ICES area based on allometric approaches i.e. a database in terms of total abundance and total

	biomass, metadata, with the first calculations available before the meeting in 2014 (**ToR d,** Lutz Postel and Peter Wiebe)
	Progress Report: Little auks as zooplankton samplers: a long-term study in East Greenland (Françoise Amélineau by correspondence, Centre d'Ecologie Fonctionnelle & Evolutive, Montpellier, France)
	Refine and extend the compilation of information on taxonomic categories that are currently monitored in the ICES area including species and stages, individual specific biomass, and ecologically relevant information such as existence ranges, genetic primers for species identification, to be made available and displayed via the WGZE website as an interactive web-based map system (**ToR c,** Todd O'Brien, Peter Wiebe and Lutz Postel,)
12:30 – 14:00	Lunch
14:00 – 15:30	Review the progress of the WGIMT (**ToR e,** Ann Bucklin, Univ. of Connecticut, USA)
	Discussion on Multi-annual ToRs and Theme Sessions (part 2) (Piotr Margonski, NMFRI, Poland)
15:30 – 16:00	Coffee Break
16:00 – 17:30	Review the ICES response to the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment (**ToR i,** Erica J. Head, Astthor Gislason, and Webjörn Melle by correspondence)

Wednesday March 26, 2014

09:00 – 10:30	Review the progress in development of the software and hardware for "automatic" identification and counting of zooplankton organisms (**ToR f,** Elvire Antajan, Janna Peters, Elaine Fileman, and Klas Ove Möller by correspondence)
10:30 – 11:00	Coffee Break
11:00 – 12:30	Review the progress in development of the software and hardware for "automatic" identification and counting of zooplankton organisms (**ToR f,** Elvire Antajan, Janna Peters, Elaine Fileman, and Klas Ove Möller by correspondence)
12:30 – 13:30	Lunch
13:30 – 22:00	Field trip

Thursday March 27, 2014

09:00 – 10:30	Compile the information on micro-plastics pollution and its effects on zooplankton communities (**ToR g,** Maiju Lehtiniemi, and Elaine Fileman)
10:30 – 11:00	Coffee Break
11:00 – 11:30	Progress Report: WKSERIES update (Lidia Yebra by correspondence and Todd O'Brien)

11:30 – 12:30	Discussion on Multi-annual ToRs and **Theme Sessions** (part 3) (Piotr Margonski, NMFRI, Poland)
12:30 – 13:30	Lunch
13:30 – 14:00	Progress Report: Zooplankton ecophysiological condition in coastal area of South Portugal (Alexandra Chícharo, University of Algarve)
14:00 – 14:30	Progress Report: Estimating mortality rates for Calanus finmarchicus eggs in the Labrador Sea (Erica J. Head, DFO, Canada)
14:30 – 15:00	Progress Report: Marine environmental monitoring data at the Swedish National Oceanographic Data Centre - An introduction and examples from zooplankton data (Patrik Strömberg, Swedish Meteorological and Hydrological Institute)
15:00 – 15:30	Report on 2013 Theme Session F: "Complexity and structure of planktonic foodwebs: who really eats whom?" co-chaired by Elaine Fileman, Ann Bucklin , Pennie Lindeque, and Janna Peters (Elaine Fileman, Plymouth Marine Laboratory, Plymouth, UK)
15:30 – 16:00	AOB, Discussion, and Closure

Annex 3: WGZE draft resolution for multi-annual ToRs2015–2017

A **Working Group on Zooplankton Ecology** (WGZE), chaired by Piotr Margonski, Poland, will meet in Plymouth, UK, 16–19 March 2015, to work on ToRs and generate deliverables as listed in the Table below.

WGZE will report on the activities of 2015 (the first year) by 1 May 2015 to SSGEPD.

ToR descriptors

ToR	Description	Background	Science Plan topics addressed	Duration	Expected Deliverables
a	Review progress and planning of the 6th Zooplankton Production Symposium	a) Scope of the 6th Zooplankton Production Symposium is directly relevant to the work of WGZE. Our group was significantly contributing to the programme of the previous Symposia	(to be confirmed)	Year 1	List of recommended sessions and keynote speakers
b	Identify and develop information and data useful for modeling needs in collaboration with WGIPEM especially regarding to exploitation resources at the lower trophic level	c) close cooperation between WGIPEM and WGZE will be of mutual benefit for both of the groups as WGZE also desperatelly needs the modelling experise regarding the *Calanus* request. Face-to-face meeting is planned for 2015	4.1.1; 4.3.1	Year 1	Direct contribution to the WGIPEM work
c	Review the ICES response to the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment	b) WGZE considered response to the Norwegian request as a very important step towards lower trophic level assessment	2.2.1; 2.3.1	Years 1 & 2	Advice
d	Compile the information on micro-plastics pollution and its effects on zoo-plankton communities	a, b) Monitoring of microplastics and their potential impact on individual organisms and zooplankton communities will be further discussed leading to recommendation on the best practise. It is an important contribution to the implementation of	4.1.1; 4.3.1	Years 1 & 2	Recommendation regarding the best practice via the WGZE webpage

		the MSFD			
e	Review the new methods of automatic and semi-automatic plankton identification	a) Sample analyses including taxonomic identification, counting and measuring procedures are costly and time consuming. Development of the new methods of automatic and semi-automatic plankton identification needs to be further reviewed	4.2.2; 4.3.2	Years 1 & 2	Peer-reviewed publication to update the methodology chapter in the ICES Zooplankton Methodology Manual
f	Expand and update the WGZE zooplankton monitoring and time-series compilation.	a, b, c) It gives a rare opportunity to examine regional and transatlantic distribution and temporal patterns within the zooplankton time-series, including new methods identified by WKSERIES, to discern significant changes over time and to identify potential environmental or climate drivers.	1.1.1; 1.2.1; 2.1.1; 2.2.2;	Years 1, 2, 3	Next edition of the Zooplankton Status Report (ZSR) Webpage content update Additional peer-reviewed publication
g	Revise lists of currently suggested (e.g. by OSPAR, HELCOM, and EU Member States) zooplankton indicators relevant for biodiversity and foodweb status assessment. Based on gap analysis, identify and test new, candidate indicators considering their response to various pressures	a, b) Contribution to the implementation of high level marine policies including MSFD.	2.1.1; 2.2.2	Years 1, 2, 3	Report available through the WGZE website Publication if findings appear to be encouraging
h	Design and carry out coordinated and collaborative activities with WGIMT and WGPME	c) Synergy is expectected based on development of the common activities strategy	3.1.2; 4.2.2	Years 1, 2, 3	Plan of activities
i	Refine and expand the compilation of information on zooplankton species,	a, b, c) Use this compilation in combination with SAHFOS lab studies	4.1.1; 4.2.1;	Years 1, 2, 3	via WGZE website as an interactive web-based map

	taxonomic categories, and life stages that are currently monitored in the ICES area.	to define thermal ranges in the seasonal, latitudinal, and transatlantic distribution of key zooplankton species in the ICES area. Such a list is fundamental information needed in order to recommend indices and how to apply them			system Peer-reviewed publication Contribution to the next ZSR
j	Calculate zooplankton productivity and metabolic rates in the ICES area based on allometric approaches. Build a database of zooplankton individual species biomass, productivity and metabolic rate equations	a, b, c) Allometric relationships are commonly used to quickly convert routinely collected monitoring data into estimates of zooplankton standing stock that are requested for the assessment and management of the marine ecosystem. At present a wide variety of allometric relationships are available for many zooplankton taxa in the literature; however, there are many taxa for which, useful allometric equations are lacking.	4.3.1	Years 1, 2, 3	Contribution to the next ZSR (as a new chapter) Peer-reviewed publication
k	Develop, revise and update of zooplankton species identification keys initially focusing on the most abundant taxa at the ICES time-series sites and ensuring their availability via the web, including especially ICES Zooplankton Identification Leaflets.	a) Extremely inporatant tool in terms of capacity building of the scientific community	4.2.2	Years 1, 2, 3	Taxonomic Leaflets uploaded to the web page

Summary of the Work Plan

Year 1	We will be dealing with all of the ToRs during the Year 1 (certainly with various intensity). Some of ToRs will be finalized as e.g. tasks regarding the Zooplankton Production Symposium (a) or discussion on information and data needs of WGIPEM (b)

Year 2	We will continue with remaining ToRs and we expect that three of those will be completed during the Year 2: *Calanus* assessment (c), micro-plastics (d), and automatic/semi-automatic identification (e)
Year 3	During Year 3 we will focus on completion of all of the long-lasting ToRs.

Supporting information

Priority	The activities of this group are a basic element of the SSGEF, 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.
Resource requirements	Resource required to undertake the "normal" activities of this group is negligible. However, due to the limited availability of the external funding we stuck with the idea of organizing the WKCALANUS workshop.
Participants	The Group is normally attended by some 25–30 members and guests.
Secretariat facilities	None.
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	The Group reports to the SSGEF, SCICOM and ACOM. Mainly WGZE provides scientific information on plankton and ecosystems but irregularly contributing to the advisory part of ICES activities as well. Currently, WGZE is working with the *Calanus finmarchicus* exploratory assessment in response to the Norwegian government request.
Linkages to other committees or groups	Any and all expert groups interested in marine ecosystem monitoring and assessments, modelling and/or plankton studies, including fish and shellfish life histories and recruitment studies. Close cooperation with the WGPME and WGIMT is planned and expected. Contacts with WGIPEM were initiated to contribute togeteher to the *Calanus* assessment.
Linkages to other organizations	The Plankton Status Report is of interest and practical use to a range of interested groups within ICES, PICES, CIESM, and GOOS with other national and international research groups and agencies. Exchange of information and cooperation is expected with other organisations as IOC, IGBP, SCOR, COML/CMarZ, and others which have research activities meetings etc., of interest and relevant to the activities of the WGZE. Contacts are maintained through networking and collaborative activities.

Annex 4: Recommendations

RECOMMENDATION	ADRESSED TO
1. Nominate Astthor Gislason as a co-convenor of the 6th Zooplankton Production Symposium.	SCICOM
2. Nominate Antonina dos Santos and Claudia Castellani as editors of the Zooplankton ID series.	PUBCOM, SCICOM
3. Contribute to the revision of the *Calanus* assessment.	WGIPEM
4. Develop the coordinated, collaborative activity plan together with: WGZE, WGIMT & WGPME.	WGZE, WGIMT & WGPME
5. Propose Theme Sessions for the 2015 ASC.	SSGEF
6. Nominate Piotr Margoński as a WGZE Chair for the 2015-2017 period.	SCICOM