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

16–19 March 2015

Plymouth, UK

ICES CIEM
International Council for the Exploration of the Sea
Conseil International pour l'Exploration de la Mer

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Executive summary

The ICES Working Group on Zooplankton Ecology (WGZE) met at the Plymouth Marine Laboratory, UK from 16 to 19 March 2015. The meeting was hosted by Elaine Fileman of PML and chaired by Piotr Margonski. It was attended by 32 scientists in person and 2 by correspondence. They were representing 13 nations. The objective of the meeting was to discuss and address the 12 terms of reference (ToRs) and to exchange information on recent activities in zooplankton ecology.

A joint session between WGZE and WGIPEM participants to address our ToR (b), to identify and develop information and data useful for modelling needs especially regarding to exploitation resources at the lower trophic level, was definitely a major event of the 2015 meeting. It was organized around selected plenary talks in order to provide an overview of the work currently achieved within each working group and the subsequent sub-group discussions. The meeting concluded with two actions recommended: (i) a joint presentation at the 6th Zooplankton Production Symposium in 2016 and (ii) to initiate a comprehensive list of data required by modellers and applied zooplanktologists.

Three of the ToRs: (f) to expand and update the WGZE zooplankton monitoring and time-series compilation, (i) to refine and expand the compilation of information on zooplankton species, taxonomic categories, and life stages that are currently monitored in the ICES area, and (j) to calculate zooplankton productivity and metabolic rates in the ICES area based on allometric approaches and to build a database of zooplankton individual species biomass, productivity and metabolic rate equations were very much focused on extending the information and data collected by the group and periodically presented in the Zooplankton Status Report.

Rapid development of in situ and lab image analysis systems was discussed within the ToR (e), to review the new methods of automatic and semi-automatic plankton identification. The other task contributing to the general capacity building of our community was ToR (k) to develop, revise and update of zooplankton species identification keys especially including ICES Zooplankton Identification Leaflets.

The Working Group summarized the current state-of-the-art regarding the impact of microplastics on zooplankton communities (ToR d). We also started our work to revise lists of currently suggested (e.g. by OSPAR, HELCOM, and EU Member States) zooplankton indicators relevant for biodiversity and foodweb status assessment (ToR g) in which a presentation summarizing the indicator work done in OSPAR and HELCOM areas within the MSFD implementation was provided.

Future areas of coordinated and collaborative activities between WGZE, WGIMT, and WGPME were presented and discussed (ToR h). Those include: (i) cooperation in preparations to the next Status Reports, (ii) possible, common analyses initiated by WKSERIES, and (iii) the compilation of data from both groups by IGMETS, (iv) development of the web portal on morphological keys and photographs, (v) joint efforts to organize taxonomic workshops, and (vi) common publications.

Progress on planning and preparations to the 6th Zooplankton Production Symposium was presented and discussed (ToR a).

Two WGZE tasks were contributing to the ICES Advisory Programme: (c) to review the ICES response to the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment and (l) to produce four short paragraphs for the ICES Ecosystem Overviews on the zooplankton community status and dynamics.

The next meeting of the WGZE will be hosted by Antonina dos Santos at the Instituto Português do Mar e da Atmosfera (IPMA), Lisbon, Portugal, 7–10 March 2016.

1 Administrative details

Working Group name

Working Group on Zooplankton Ecology (WGZE)

Year of Appointment

2015

Reporting year within current cycle (1, 2 or 3)

1

Chair(s)

Piotr Margonski, Poland

Meeting venue

Plymouth, UK

Meeting dates

16–19 March 2015

2 Terms of Reference a) – z)

a) Review progress and planning of the 6th Zooplankton Production Symposium;

b) Identify and develop information and data useful for modelling needs in collaboration with WGIPEM especially regarding to exploitation of resources at the lower trophic level;

c) Review the ICES response to the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment;

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

e) Review the new methods of automatic and semi-automatic plankton identification;

f) Expand and update the WGZE zooplankton monitoring and time-series compilation;

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;

h) Design and carry out coordinated and collaborative activities with WGIMT and WGPME;

i) Refine and expand the compilation of information on zooplankton species, taxonomic categories, and life stages that are currently monitored in the ICES area;

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;

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;

l) Produce four short paragraphs for the ICES Ecosystem Overviews on the zooplankton community (spatial variability, hot spots and seasonality), one paragraph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea.

3 Summary of Work plan

Year 1 We dealt with all of the ToRs in Year 1. Originally, there was a plan to finalize two of them: tasks regarding the Zooplankton Production Symposium (ToR a) or discussion on information and data needs of WGIPEM (ToR b), however, we decided to continue with ToR a) in Year 2.

Year 2 We will continue with remaining ToRs. We expect that three of those will be completed during the Year 2: Calanus assessment (ToR c), micro-plastics (ToR d), and automatic/semi-automatic identification (ToR e).

Year 3 During Year 3 we will focus on completion of all of the long-lasting ToRs.

4 List of Outcomes and Achievements of the WG in this delivery period

- Good progress has been made regarding preparations to the 6th Zooplankton Production Symposium.
- Joint WGZE-WGIPEM meeting provided an opportunity to discuss common interests and gaps in data and knowledge as well as concluded with the action plan.
- Future areas of coordinated and collaborative activities between WGZE, WGIMT, and WGPME were presented and discussed.
- The group provided four paragraphs for the ICES Ecosystem Overviews on the zooplankton community (spatial variability, hot spots, and seasonality), one paragraph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast, and Baltic Sea.

5 Progress report on ToRs and workplan

ToR a) Progress on planning and preparations to the 6th Zooplankton Production Symposium (9–13 May, Bergen, Norway) was presented and discussed. WGZE sup-ported the work and suggested to continue with this ToR till next year when the WGZE will meet shortly before the symposium.

ToR b) Preparations to the joint meeting between WGZE and WGIPEM were carried out well in advance to use this opportunity in the most efficient way. The meeting was organized around selected plenary talks in order to provide an overview of the work currently achieved within each working group and the subsequent sub-group discussions. The meeting concluded with two actions recommended: (i) a joint presentation at the 6th Zooplankton Production Symposium to be held in 2016 in Bergen and (ii) to initiate a comprehensive list of data required by modelers and applied zooplanktologists.

ToR c) Continuing with this ToR (WGZE contribution to the ICES Advisory Programme), the group decided to discuss the current status of the Norwegian Management Plan for the *Calanus finmarchicus* fishery. The document provides an overview of the stock assessment based on modelling data including the assessment of by-catch. It also presents results of different management scenarios tests. The group agreed to continue this ToR next year and include discussion of the *Calanus* fishery within the workshop on zooplankton fisheries at the 6th Zooplankton Production Symposium.

ToR d) The Working Group summarized the current state-of-the-art regarding the impact of microplastics on zooplankton communities. The outcomes of two international conferences as well as six recent papers were discussed. Presentations were followed by the discussion on possible future activities.

ToR e) Rapid development of in situ and lab image analysis systems was presented. The group discussed options for presenting this information: (i) submitting a new chapter for the Zooplankton Methodology Manual or (ii) a series of peer reviewed journal articles that could be linked to Manual via the WGZE website (preferred option).

ToR f) The progress of the IOC/UNESCO International Group for Marine Ecosystem Time Series (IGMETS) was discussed. IGMETS has compiled a global collection of over 300 time series, covering open ocean, coastal areas, and estuaries. Of all the oceanographic regions, the best coverage within IGMETS is for the North Atlantic. The WGZE and WGPME time series are the largest contributions to this region. The group discussed also the analytical methods for the next Zooplankton Status Report. Future explorations and analyses in the plankton reports will look for synchrony across sites (e.g., "what sites are seeing strongly warming winters?", "what sites are seeing decreases in fall biomass or abundance?").

ToR g) A presentation on indicator work done in OSPAR and HELCOM areas within the MSFD implementation was provided. The group discussed various issues connected to the indicator analyses: an impact of regime shifts on reference conditions, different ways of calculating individual biomasses, including meroplankton, and possible application of modelling tools.

ToR h) Future areas of coordinated and collaborative activities between WGZE, WGIMT, and WGPME were presented and discussed. Those include (i) cooperation in preparations to the next Status Reports, (ii) possible, common analyses initiated by WKSERIES, and (iii) the compilation of data from both groups by IGMETS, (iv) development of the web portal on morphological keys and photographs, (v) joint efforts to organize taxonomic workshops, and (vi) common publications.

ToR i) A compilation of existing information on zooplankton species, taxonomic categories, and life stages, which are currently monitored in the ICES area, was presented. So far this information includes data from 62 WGZE monitoring stations including number of taxa and observations, length of time series, sampling frequency, sampling method, and spatial coverage, as well as the CPR standard areas. It is of crucial relevance not only to zooplankton scientists, but also expert groups on fisheries, and ecosystem managers.

ToR j) The group agreed that it would be very beneficial to provide the community with a database of zooplankton individual species biomass, productivity, and metabolic rate equations across the ICES area, based on the large number of time series available. We discussed the use of empirical relationships to calculate zooplankton production and metabolic rates, and the construction of a database of zooplankton individual species biomass, production, and metabolic rate.

ToR k) The group reviewed the current status of the work to develop, revise, and update of zooplankton species identification keys and to ensure their availability via the web, including especially the ICES Zooplankton Identification Leaflets. The discussion concluded by general agreement that we should follow up and submit a renewed proposal to ICES following the guidelines of PUBCOM. Thus, the renewed proposal will incorporate the suggestions made by PUBCOM in their review and provide a three-year plan of activities.

ToR l) After a short discussion on data availability, the group decided to prepare the relevant paragraphs on the zooplankton community plus figures illustrating the changes. Chapters on the Bay of Biscay and the Iberian coast as well as for the Baltic Sea will be prepared by the WGZE members. The overview of changes and the current status in the Greater North Sea and Celtic Seas was possible only using the CPR data series collected by SAHFOS. Martin Edwards kindly offered the SAHFOS contribution in that respect.

6 Revisions to the work plan and justification

WGZE regarded the existing ToR a (Review progress and planning of the 6th Zooplankton Production Symposium) as a crucial activity and after discussion decided to continue with this ToR next year when the WGZE will meet two months before the symposium.

7 Next meetings

The next meeting of the WGZE will be hosted by Antonina dos Santos at the Instituto Português do Mar e da Atmosfera (IPMA), Lisbon, Portugal, 7–10 March 2016.

Annex 1: List of participants

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Annex 2: Recommendations

Recommendation	Adressed to
1. Nominate Antonina dos Santos and Claudia Castellani as editors of the Zooplankton ID series (for details see the ToR k summary text)	PUBCOM, SCICOM
2. Propose Theme Sessions for the 2016 ASC	SCICOM

Annex 3: Agenda

Monday March 16, 2015

09:00 – 9:30	Joint Opening, Introduction, and Logistics (Hosts and Chairs)
09:30 – 10:00	Adoption of the WGZE Agenda (Piotr Margonski)
10:00 – 10:30	Review progress and planning of the 6th Zooplankton Production Symposium (**ToR A**, Astthor Gislason, Padmini Dalpadado, and Lidia Yebra)
10:30 – 11:00	Coffee Break
11:00 – 12:30	Compile the information on micro-plastics pollution and its effects on zoo-plankton communities (**ToR D,** Maiju Lehtiniemi & Elaine Fileman)
12:30 – 14:00	Lunch (at the MBA)
14:00 – 15:30	Review the new methods of automatic and semi-automatic plankton identification (**ToR E,** Klas Ove Möller, Elvire Antajan, Astthor Gislason, Mark Benfield)
15:30 – 16:00	Coffee Break
16:00 – 17:30	Expand and update the WGZE zooplankton monitoring and time-series compilation (**ToR F,** Todd O'Brien and Peter Wiebe)
17:30 – 18:00	Discussion of 2016 Theme Sessions (part 1) (Piotr Margonski)

Tuesday March 17, 2015

09:00 – 09:10	Welcome, general goals, schedule/structure (details in the separate file), questions
09:10 – 10:30	Joint WGZE – WGIPEM workshop (plenary talks)
10:30 – 11:00	Coffee Break
11:00 – 12:00	Joint WGZE – WGIPEM workshop (discussion in subgroups)
12:00 – 12:30	Short Summary of questions by three facilitators (in plenary)
12:30 – 14:00	Lunch (at the PML)
14:00 – 15:30	Joint WGZE – WGIPEM workshop (plenary talks)
15:30 – 16:00	Coffee Break
16:00 – 16:30	Joint WGZE – WGIPEM workshop (discussion in subgroups)
16:30 – 17:00	Short Summary of questions by three facilitators (in plenary)
17:00 – 18:00	Final Comments from Groups: discussing things like joint session and papers

Wednesday March 18, 2015

09:00 – 10:30	Review the ICES response to the Norwegian request regarding the *Calanus finmarchicus* exploratory assessment (**ToR C,** Erica J. Head and Webjörn Melle)

10:30 – 11:00	Coffee Break
11:00 – 12:00	Design and carry out coordinated and collaborative activities with WGIMT and WGPME (**ToR H,** Ann Bucklin, Alexandra Kraberg, and Piotr Margonski)
12:00 – 12:30	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 (**ToR K,** Antonina Santos and Claudia Castellani)
12:30 – 13:30	Lunch (at the PML)
13:30 – 14:00	Recommendation from the Joint OSPAR/ICES Ocean Acidification Study Group (SGOA) (Mark Benfield)
14:00 – 15:00	**Progress Reports**
	WGZE Dark Data Presentation (Peter Wiebe)
	Sources of variability in measurements of egg production rates for *Calanus finmarchicus* (E.J.H. Head and M. Ringuette)
15:00 – 22:00	Field trip

Thursday March 19, 2015

09:00 – 10:30	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 (**ToR G,** Alexandra Chicharo, Elena Gorokhova, Maria Grazia Mazzocchi, and Piotr Margonski)
10:30 – 11:00	Coffee Break
11:00 – 12:15	Refine and expand the compilation of information on zooplankton species, taxonomic categories, and life stages that are currently monitored in the ICES area (**ToR I,** Claudia Castellani and Todd O'Brien)
12:15 – 12:30	Director Nicholas Owens talk on SAHFOS data
12:30 – 13:30	Lunch (at the PML)
13:30 – 14:00	**Progress Reports**
	A Mediterranean long-term plankton observatory: station LTER-MC in the Gulf of Naples (Tyrrhenian Sea) (Maria Grazia Mazzocchi)
	ICES/PICES cooperative initiative on global zooplankton production (Lidia Yebra)
14:00 – 15:30	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 (**ToR J,** Lutz Postel, Peter Wiebe, and Patrik Strömberg)

15:30 – 16:00	Coffee Break
16:00 – 16:30	Produce four short paragraphs for the ICES Ecosystem Overviews on the zooplankton community (spatial variability, hot spots and seasonality), one paragraph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea (**ToR L,** Piotr Margonski, Maiju Lehtiniemi, Joerg Dutz, Patrik Strömberg, Lidia Yebra, Antonina Santos, Arantza Iriarte, Martin Edwards (SAHFOS))
16:30 – 17:00	Discussion of 2016 Theme Sessions (part 2) (Piotr Margonski)
17:00 – 17:30	AOB, Discussion, and Closure

Annex 4: Common WGZE-WGIPEM Session initial document

The structure of the joint session should allow exchange on ideas (discussion) on specific topics of interest to the group. An extremely positive outcome would be to create viable collaboration on research to be presented at the 6th Zooplankton Production Symposium in Bergen in spring 2016. A second outcome would be a joint manuscript describing emerging issues.

During one day, we could potentially discuss two topics. Our idea was to have 4 short talks on each topic. Three sub-groups would then discuss a list of common questions. Discussion moderators/facilitators would summarize the answers in plenary. Thus, for each topic the schedule includes time for four 15 minute presentations + questions (two from each WG), 1 hr discussions by 3 sub-groups and 3 10 min plenary summaries from each discussion group leader.

Here is a draft schedule with two suggested topics. These are open for discussion.

9:00 am	Welcome, general goals, schedule/structure, questions		
TOPIC 1 - Observing and simulating zooplankton: Research Frontiers			
9:10 am	Plenary Talks with time for questions (2 talks from each working group; each talk ~ 20 minutes, including questions) **WGIPEM speaker 1: Rubao Ji** - Zooplankton modeling: Frontiers and WGIPEM activities. **WGIPEM speaker 2: Huret M., Davies K., Sourisseau M., Vandromme P. -** Zooplankton size structure for E2E (plankton to fish) applications: from observation to modelling in the Bay of Biscay. **WGZE speaker 1: Todd O'Brien** - Zooplankton time-series – spatial and temporal resolution **WGZE speaker 2: Espen Strand** - Virtual *Calanus* fishery using norwecom.e2e		
10:30	Coffee/health Break		
11:00	Sub-group Group 1 **Myron Peck**	Sub-group 2 **Jeff Runge**	Sub-group 3 **Morgane Travers-Trolet**
12:00	Short Summary of questions by three facilitators (in plenary)		
12:30	Lunch		
TOPIC 2 - Spatiotemporal variability in zooplankton dynamics: From observations to models			
2:00	Plenary Talks with time for questions (2 talks from each working group; each talk ~ 20 minutes **WGZE speaker 1: Lutz Postel and Peter Wiebe** - Background of Biomass Determinations , Conversion Factors, Length to Biomass Equations, and Allometric Approaches **WGZE speaker 2: Angus Atkinson** - Models, experiments, meta-analyses, time series: ideas and thoughts on how we can link them **WGIPEM speaker 1: Sévrine Sailley, Jorn Bruggerman, Luca Polimene et al.** - Modelling Zooplankton: How and what can we do **WGIPEM speaker 2: Anja Eggert, Martin Schmidt, Lutz Postel** - Zooplankton dynamics on the northern Benguela hypoxic shelf: Integrating numerical modelling, field and laboratory studies		
3:30	Coffee/health Break		
4:00	Sub-group Group 1 **Erica J. Head**	Sub-group 2 **Momme Butenschön**	Sub-group 3 **Todd O'Brien**
4:30	Short Summary of questions by three facilitators (in plenary)		
5:00	Final Comments from Groups: discussing things like joint session and papers		
6:00	Close for the day		

Annex 5: Additional information

ToR a) Review progress and planning of the 6th Zooplankton Production Symposium

Leads: Astthor Gislason, Lidia Yebra, Padmini Dalpadado, Rapporteur: Webjörn Melle

Astthor Gislason presented the status of the planning. A Scientific Steering Committee (SSC) has been formed consisting of the following people: Atsushi Tsuda (PICES), Astthor Gislason (ICES), Padmini Dalpadado (Norway/ICES), Se-Jong Ju (Republic of Korea/PICES), Desiree Tommasi (USA/PICES), Piotr Margonski (Poland/ICES), and Lidia Yebra (Spain/ICES).

In co-operation with the scientific community, sessions have been defined. They include Application of optical and acoustical methods in zooplankton studies, Response of zooplankton communities to changing ocean climate, The diversity and role of macrozooplankton in marine ecosystems, Zooplankton diversity in the oceans by integrative morphological and molecular techniques, The role of microzooplankton in marine food webs, Individual level responses of zooplankton to environmental variability and climate change, Zooplankton in high-latitude ecosystems, New technologies and approaches in zooplankton trophic studies

Several Workshops are also planned on topics including Use of zooplankton indicators to characterize state of pelagic ecosystems, ICES/PICES cooperative research initiative: towards a global measurement of zooplankton production, Zooplankton as a potential harvestable resource, Effects of microplastics on zooplankton, Zooplankton as the "to" in end-to-end models.

A Symposium poster and a symposium flyer are being developed and a symposium website set up (http://ices.dk/6zps) where further details about the meeting can be found.

The group supported the work and felt that the planning was in good progress. Co-conveners for some Workshops and sessions were still missing and suggestions to the Scientific committee were welcomed. Also 1-2 themes for workshops were still open for suggestions. The group thanked the SSC for their work and recommended that this ToR continue until next year when the WGZE will meet just before the symposium.

ToR b) Identify and develop information and data useful for modelling needs in collaboration with WGIPEM especially regarding to exploitation resources at the lower trophic level

On March 17th a joint meeting between WGZE (Working Group on Zooplankton Ecology) and WGIPEM (Working Group on Integrative Physical-Biological and Ecosystem Modelling) was held. The day was organised around plenary state-of-the-art talks in order to provide an overview of the work currently achieved within each working group, and sub-group discussion on the following topics:

Topic 1 – Representing (climate-driven) spatiotemporal variability within models

1) What are the best examples of research combining observations and models to address temporal-spatial variability in zooplankton dynamics? Hopefully several studies will be listed.

2) What do these studies have in common? Is the same approach applicable across different regions?

3) How much model complexity and/or spatio-temporal resolution in field data is needed to adequately represent variability.

4) For linking models and observations, what are the implications for modeling approaches and data requirements (type, format, resolution,…)? What is the most urgent area of co-operation?

Topic 2 Observing and simulating zooplankton diversity: Frontiers in zooplankton ecology and modeling

1) What traits help define biogeographical changes in zooplankton composition among species and how have these been represented in trait-based models?

2) Within species (complexes), what natural barriers to populations have been inferred from genetic / taxonomical analyses of species/complexes and do models reproduce these barriers to gene flow?

3) If models do not capture observed population boundaries, are biological processes responsible which may not be adequately captured in models? The general question would be: Can we use models to understand processes establishing different populations of zooplankton species?

Topic 3 – Harvesting zooplankton (krill, *Calanus*): Observations and modelling carrying capacity

1) What are critical physical/biological processes affecting Calanus population biomass, distribution and productivity, how are they represented within models such as behavior (DVM, diapause) and mortality/loss terms, and are critical processes (sensitive parameters) similar across regions?

2) What are current gaps in knowledge and what new data exist that may provide answers?

3) Regarding ongoing Calanus modelling, how can various models help to increase our understanding of zooplanktons role in the ecosystem as well as the response of zooplankton community to the dynamics at lower trophic levels?

4) What are viable harvest rates of Calanus (among regions?) and how much are these expected to vary from year-to-year? Can models be used to forecast exceptionally poor or strong year classes?

Topic 1: Representing (climate-driven) spatiotemporal variability within models

Several examples of research combining observations and models to address temporal-spatial variability in zooplankton dynamics were listed:

- Pires *et al.* (2013) used a bio-physical model to track/predict dispersal and recruitment of two species, one coastal and the other estuarine. Pires RFT, Pan M, Santos AMP, Peliz Á, Boutov D, dos Santos A. (2013) Modelling the variation in larval dispersal of estuarine and coastal ghost shrimp: *Upogebia congeners* in the Gulf of Cadiz. Marine Ecology Progress Series, 492:153-168. doi: 10.3354/meps10488
- In Lewis *et al.* (2006), CPR data are used to validate the ERSEM model for the North Sea region. (Lewis, K., Allen, J. I., Richardson, A. J., and Holt, J. T. 2006. Error quantification of a high resolution coupled hydrodynamic-ecosystem coastal-ocean model:

Part 3, validation with Continuous Plankton Recorder data. Journal of Marine Systems, 63: 209–224.)

- In Padmini *et al.* (2012) the Norwegian model "NORWECOM" is used to study seasonal and spatial variability of zooplankton biomass in Barents Sea. (Padmini, Ingvaldsen, Stige, Bogstad, Knutsen, Ottersen, Ellertsen, 2012. Climate effects on Barents Sea ecosystem dynamics. ICES Journal of Marine Science. doi:10.1093/icesjms/fss063)
- Chust *et al.* (2013) used statistical model (GAMS) and CPR data to study the northward shift of *Calanus*. (Chust, G., Castellani, C., Licandro, P., Ibaibarriaga, L., Sagarminaga, Y., and Irigoien, X. Are *Calanus spp*. shifting poleward in the North Atlantic? A habitat modelling approach. – ICES Journal of Marine Science, doi:10.1093/icesjms/fst147.)
- Chust *et al.* (2014). Using GAMS model in the North Atlantic (essentially habitat modelling), study on biomass changes/diversity in a warmer ocean. (Chust *et al.* 2014. Biomass changes and trophic amplification of plankton in a warmer ocean. Global Change Biology (2014) 20, 2124–2139, doi: 10.1111/gcb.12562)
- Li *et al.* (2005) studied the population dynamics of *Calanus finmarchicus* distribution and abundance on Georges Bank using a Finite element model (Li, X., McGillicuddy, D.J., Durbin, E.G., and P.H. Wiebe, 2006. Biological control of the vernal population increase of *Calanus finmarchicus* on Georges Bank. Deep-Sea Research II , 53 (23-24), 2632-2655, doi:10.1016/j.dsr2.2006.08.001).
- Carlotti and Wolf (1998). Population dynamics model on *Calanus finmarchicus* IBM model, with a field data component (Carlotti, F. and Wolf, K.-U. (1998), A Lagrangian ensemble model of *Calanus finmarchicus* coupled with a 1D ecosystem model. Fisheries Oceanography, 7: 191–204. doi: 10.1046/j.1365-2419.1998.00085.x).
- Neuheimer, Gentleman *et al.* published a modelling study of *Calanus finmarchicus* mortality on Georges bank adjusting stage dependent mortality rates to give observed stage structures. (Neuheimer, A.B., W.C. Gentleman, P. Pepin & E.J.H. Head, 2010. Explaining regional variability in copepod recruitment: Implications for a changing climate. Progress in Oceanography 87: 94-105.)
- McGillicuddy *et al.* (1998) used a Lagrangian model with data assimilation on Georges Bank. (McGillicuddy, D. J., Jr., D. R. Lynch, A. M. Moore, W. C. Gentleman, C. S. Davis and C. J. Meise, 1998. An adjoint data assimilation approach to diagnosis of physical and biological controls of *Pseudocalanus spp*. in the Gulf of Maine Georges Bank region. Fish. Oceanogr., 7, 205–218.)
- Lutz Postel cited a study of Namibia in 2011 that used an Eulerian approach with measurements at differing distance from shore over a 4 week period. They are currently using the Cushing approach that uses different distance from upwelling to mimic seasonal difference. (Postel, L., V. Mohrholz and T. T. Packard (2014). Upwelling and successive ecosystem response in the northern Benguela region. J. mar. syst. 140, Part B, Special issue: Upwelling Ecosystem Succession: 73-81, doi:10.1016/j.jmarsys.2014.07.014). The *in situ* experiment covered changes in the pelagic and benthic domain over a wide set of stock and process parameters, which might be suitable for model adjustments.

Concerning what these approaches have in common and why people thought they were significant was that most if not all studies listed above involved broad spatial scale monitoring data with monthly or better sampling, i.e. dense data in space and time. In some cases, additional (spatially focused) sampling was used to supplement the otherwise regular sampling periods. The question of whether the predictive modelling community considered “statistical models” to really be models was raised and it was concluded that there should be a distinction between statistical models that try to match/explain already sampled data and predictive models that use mechanism or interactions to better understand ecosystem structure and functioning, and couple them to projections into the future. It was mentioned that none of the listed studies so far included sized-based models but were all focusing on biomass based or NPZD type models.

The use of model data and outputs is already a common practice and all scientists present regularly include model data in their analysis. Modelling of currents, circulation, and drift was the most common model element in combined observation+model approaches which in several cases further include behaviour (most often diel vertical migration) in different degrees of complexity. Concerning future work the question of the possible use of satellite data in combined approaches was raised.

During the discussions it became obvious that clarifications between commonly used definitions were needed. The different groups (and also scientists within the groups) had different interpretations of the word ”high frequency”. It further became apparent that while some of the WGZE members regarded “data assimilation” as a process to derive parameters, WGIPEM members regarded it as a method to be used within an “operational” context to enhance the predictive capacity of models. Following that discussion questions were raised such as: whether data assimilation allows for interpolation or prediction, whether it should rather be used to improve models and, how it should/can be applied for population models?

While the sub-groups tried to answer the question: “How much model complexity and/or spatiotemporal resolution in field data are needed to adequately represent variability?” the simple global answer would be “as much as possible”, but also “it depends on the question that is being addressed”. Concerning resolution and model complexity it is not possible to draw simple conclusions such as the larger or smaller the scale the simpler or more complex the model should be. Studies (and models) addressing life stage dynamics in small but dynamic regions require rather complex biological models, high resolution physical models and a detailed understanding of the underlying biological processes. Studies that address large scale questions require a high complexity as well as here a large variety of processes and organisms need to be included (and simplified) to resolve the interacting processes.

There seemed to be a tendency that models designed by modellers are generally “simpler” than those designed by biologists which are often rather complex. Re-worded: A modeller may focus on how to create the best (but still possible to program and manage) model for a question, while a taxonomist may get so tied up in the smallest details that the model is never formulated (or is overly complex). It was asked if anyone had read a study on primary production models that found that the more complex models were less accurate than simpler models or vice versa. It was noted that it is often necessary to start with a simplified “first step” before trying to capture every fine detail.

The main consensus of this discussion topic was that more taxon-specific size and biomass information is required to improve modelling capabilities. More species specific information especially from time-series sites and for taxa other than copepods. The biomass of these species can large (e.g. for gelatinous, macrozooplankton) in certain areas and during certain times of the year. In some systems, meroplankton can be a large/dominant component of the seasonal biomass, but often they are neglected or not included in models. One problem of linking observations and modelling efforts is the use of different units. While in models biomass is often used, biologists generally generate species counts. There is a need to generate seasonal and regional specific conversions between the two forms. The avoidance of sampling systems by some species, especially euphausiids, will cause bias in biological sampling data. Simplifying models or taxonomic analysis also depends on the region. While at northern latitude models can be species-specific lower latitude need to simplify and combine species groups. It was also pointed out that seasonal cycles and inter-annual variability in zooplankton abundance could not be modelled without an appropriate estimate of zooplankton mortality. Simply using a "closure term" for zooplankton in NPZD models will never adequately represent inter-annual or spatial zooplankton variation. Existing models and studies are not always transferable to other areas and have less explanatory power for the coastal ocean if they were designed for offshore areas. There are big differences in the questions asked about coastal/estuarine areas relative to the deep ocean. Modelling tools could be used to manage coastal areas as long as it is clear what the important variables are. Cooperation between modellers and observationalists is thus very important, but it remains a challenge to bring groups together for longer term studies or to at least study annual cycles. The holistic approach and the ecosystem based approach for management is moving more and more into focus, hence it is important to also have a holistic approach to observations, to obtain as much information as possible from expensive survey time and to include/provide these data in end-to-end models to obtain a better understanding of the ecosystem functioning.

The discussion focused on how useful data from the WGZE Zooplankton Status Report are and how they can be used. If "best" areas could be identified and analysed by representatives of both groups this could result in a presentations to be given at the Zooplankton Production Symposium. Such a presentation would constitute a major outcome of this joint meeting.

A remark was made on the degree to which patchiness is considered. Models tend to operate on rather coarse spatial scales while observations collected within these cells are usually limited. Since zooplankton distributions are inherently patchy, collecting only a few samples will result in a mean value (biomass, abundance) with very high variance. It is likely that model predictions will fall within this error range but if higher resolution data were collected, it is possible that model predictions will not fall anymore within the error bars. The question remains: How can we do a better job of collecting data to validate models and how can we mimic stochasticity and patchiness in models to fit observations? It might be useful to consult with the PGDATA - who provide guidance to those collecting standardized data - on how to provide the obtained information to the ICES data centre in a unified format (e.g. standardized units, measurements).

Topic 2: Observing and simulating zooplankton diversity: Frontiers in zooplankton ecology and modelling

Depending on the question being asked, considering size as the only trait will not be sufficient. Diapause, ratio of volume versus biomass, growth rate (linked to temperature and tolerance for low oxygen) could be used. There is also a large variability in zooplankton stoichiometry (nutritional value for higher trophic level) and for example *Calanus finmarchicus* is quite lipid-rich. It has been shown that reproductive strategy is associated with the seasonality of the species. Egg-carrying species for example have an increased visibility to predators and lower fecundity, but egg mortality rates are very low. It is important to consider traits important for the question asked: considering *C. finmarchicus* being replaced by *C. helgolandicus* with temperature, will it have impact on fish only through size spectrum or does it also involve change in their caloric content of food? Furthermore behaviour needs to be included as behaviours of species differ, and this will influence for example catchability or feeding interactions as different hunting strategies (visual or filtering) are used by different species. One possibility to address this diversity is by using trait-based models that include other factors in addition to size. These models already exist and use a number of traits that could also help to define bio-geographical changes in zooplankton composition among species. For these models knowing the diversity and taxonomy is critical. Information at the taxa (species) level may reveal important differences in traits. A summary by Thomas Kiørboe in a recent review lists specific differences in key attributes (the information is also available on Pangea). While full trait based models including all species and all important factors seem to be, due to the data basis, unrealistic at the moment, one first step could be to start with size-based models. When collecting data, it is recommended to record several traits but at least taxon and size. There is a need to have size distribution of species for trait-based (and size spectrum) studies.

At larger scales, a trait based approach might allow for differences in life history strategies to emerge. As several traits are linked, a suitable first step would be to identify "macro-traits". It was concluded that the trait-based approach may be a good avenue of cooperation between zooplankton ecologists and zooplankton modellers, e.g. by linking species lists and trait lists. A roadmap would be to identify which data for which trait already exist, which traits should be focused on and which information should be collected in the future and which traits matter most.

In terms of monitoring programs in Europe, it is hard to reconcile all the data needs. Modellers might be interested in one certain aspect while stakeholders and policy makers are interested in other aspects (e.g. biodiversity, indicators, productivity, etc.). It is time to start with an inventory of what the various stakeholders/users need in order to then decide what is tractable. It is worth pointing out that while there is a tendency to collect a lot of smaller datasets because they are tractable, it is often hard to reconcile/combine these datasets for examination of questions over larger domains. Open access, integration of information, and standardization of measurements and reporting is therefore required from both sides: observations and model results. Modellers and observationalists do not encounter the same constraints but need to communicate more on the possible areas of information exchanges. On one hand modellers could focus on models that utilize data that can be collected and that have practical applications, on the other they should also emphasize which data are required to improve predictions and ecosystem understanding. Given the limited budgets for monitoring, there is a need to know precisely which data are needed to inform the models, or if relatively inexpensive value-added measurements could be collected to enhance and inform models. For example, if modellers only need biomass in 3 or 4 size fractions in addition to total counts and total biomass - which are often/generally used for monitoring purposes - this could be obtained without an excessive extra effort. Since EU-MSFD budgets will not be expanded, there is a limit as to what can be done and provided by individual nations. Due to the number of countries involved, the observing systems are fragmented thus it might be useful to develop a proposal for unified collection of monitoring/observing data across national boundaries. For the modellers, it is important to know which data are available and where/for how long these data have been/are being collected in order to reconcile their ideal data requirements with the reality of what is actually being measured. The uncertainty of the observations would also be very useful information. From this, modellers could provide a priority list of data needed for the models. This list could be discussed in a second step to adjust measurements and data collections or to identify knowledge gaps. Furthermore models (and data) should be critically tested by, for example, Litmus tests following the general guidelines: 1) do the results make sense given the expert knowledge of zooplankton ecologists of the system and 2) do the model fit the observations? This might start an iterative process such that if the model does not fit the data and yet includes all known major processes, then the question becomes - what is missing? On the other hand, if the model fits the data well, and the major processes are represented and understood, we can move on to provide predictions and prognosis.

When moving towards the question of genetic (taxonomical) analyses of species (complexes) to infer natural barriers to populations, it appears that in most of the subgroups there was not enough expertise in the room to discuss the barriers. Some study results were briefly mentioned, that showed no genetic variation on a basin scale. However, that could have been linked to the genes selected for analysis. Some are conserved over broad spatial scales. A question was whether genetics might be used to determine some sub-populations?

Time was also spent discussing within-species plasticity. Zooplankton ecologists want to understand how the distribution of species will change, and this requires information on the species physiology. Latitudinal gradients exist in specific traits – growth, reproduction, and survival (temperature-dependent vital rates) but these are intra-specific traits. Could it be that physiological plasticity is not the result of genetic differences? This could be an interesting future area of work: examining the genetic differences among populations and how these differences are linked to key life history traits. Incubation experiments have shown that metabolic rates and reproductive performance change among populations. Do we need to know what they experienced beforehand? Perhaps yes, and temperature versus length-at copepod C6 was one example. A comment was made regarding *Calanus finmarchicus,* that is difficult to maintain in the laboratory and that can interbreed with *Calanus* congeners. Phenotypic plasticity may or may not have a genetic basis, and it is also important to know how quickly traits can change within a species.

One very important question is: What limits the northern and southern distribution of species in the ocean? Stages and diapause traits can provide answers for Arctic systems, but can we use a similar approach in more temperate areas? Studying sub-population distributions may provide a successful method to understand the overall presence of a species. Thus modelling populations instead of species would help but this requires us to look at genetics in order to identify populations within a species. Another idea would be to use a trait-based approach where traits are linked to geographical presence.

When transported (e.g. through ballast water) some species can establish themselves in new areas, but for such processes that are not "natural": what and where are the barriers to range expansion? Also, what controls inter-annual or seasonal changes in species distributions and community composition? How can models deal with invasive species (e.g. size based models do not take account of taxonomic variability)? Some examples were mentioned: *Pseudodiaptomus marinus* has invaded the Dover Strait area, and its abundance is strongly increasing year after year.

As well, concerning the shift from *Calanus finmarchichus* to *Calanus helgolandicus* (e.g. in the North Sea), if we understand the shift, can we model it? In models we have control on the habitat, so habitat change could drive distributions. However, one has to be careful when using these kinds of results, since habitat may not be the only determining factor for the success of a particular species.

A recent paper (Melle *et al.* 2014 The North Atlantic Ocean as habitat for *Calanus finmarchicus*: Environmental factors and life history traits. Prog. Oceanogr., 129: 244-284) shows that there are differences in *C. finmarchicus* populations between the eastern and western North Atlantic. Mortality is an important process that may limit the northern distribution of *C. finmarchicus*. Where the species co-occur, *C. glacialis* and *C. hyperboreus* may prey on younger stages of *C. finmarchicus* and limit its northward expansion as the North Atlantic warms. On the other hand, it is more likely that the dependence of *C. finmarchicus* on phytoplankton to fuel its reproduction in spring limits its ability to reach a stage with the capacity to overwinter in areas where the growth season is short. One question is: why is *C. finmarchicus* not shifting northward from the Gulf of Maine? The Gulf of Maine is now warmer than the statistical models suggest should be optimal for *C. finmarchicus*. Mean annual surface temperature appears to be an important limit defining the range of *C. finmarchicus*. An annual average of 10°C is thought to represent the statistical limit, but the Gulf of Maine has been warmer than this for quite a while. One interpretation is that the Gulf of Maine is seeded annually by *C. finmarchicus* from the Scotian Shelf via a cold coastal current, which provides conditions for high production by *C. finmarchicus.* These individuals then diapause in the deep basins of the Gulf of Maine. When they emerge from diapause, they enter warm waters which accelerate metabolism of their stored lipids. A large proportion of these animals and their offspring are likely advected south and ultimately lost from the Gulf of Maine, so that the Gulf is a one-way system. This shows the complex system understanding required if one wants to make future predictions.

Variables that could be considered include interspecies competition, temperature effects (noting that increasing temperature also increases the activity of (and potentially overlap with) predators), differences in inflow (e.g. in the Baltic), feeding environment (but note that most of the models only discuss "Chlorophyll a", which is probably a poor representative/predictor of food quality). It was noted that ecosystem complexity is easy to model when simple, but requires a lot of elements to be considered in more complex (e.g. tropical) areas.

Topic 3: Harvesting zooplankton (krill, Calanus): Observations and modelling carrying capacity

A presentation of the potential *Calanus* fishery and the current model was made in plenary, but based on this talk a full assessment of knowledge gaps was not possible.

Several questions arose, notably about:

- Which predators of *Calanus* have been identified (e.g. so far have only commercial fish predators been included?)
- What is the current knowledge about the extent and location of *Calanus* fishing? If the fishing is only on the shelf, what is the magnitude of the catch compared with the standing stock of *Calanus finmarchicus* on the shelf?
- If, as estimated by the model, only 10% of the *Calanus* production is consumed by the commercial species, where does the other 90% go?
- There is a general need for more information about how the model is being applied (e.g. the variables, parameters etc.)
- Does the model (mathematical or conceptual) consider effects on lower trophic levels as well as on species subject to commercial fisheries?
- It had been shown that herring condition varied with total zooplankton biomass (interannually), which was dominated by *C. finmarchicus*, but it was not clear how fishing might affect this relationship.

It was also suggested that the model being used (NORWECOm) should be further developed and tested at different catch levels and that its performance should be examined by other modelers. It was concluded that this issue should be a topic for exploration by the WGZE and WGIPEM working together, since the proposed "plan" involves models and knowledge of *Calanus finmarchicus* ecology. Both WGZE and WGIPEM are science working groups that do not report to (or discuss results with) an advisory counterpart group. If these two ICES WG groups do not explore this, who will/can/should do it?

It was suggested that the "*Calanus* question" should be a topic at the upcoming Zooplankton Production Symposium. Although there will be a workshop on zooplankton fishing (in general) it was suggested that the issue of *Calanus* fishing should be highlighted.

Summary and general conclusions of the joint meeting

- Observation activities across countries and programs are fragmented and are not coordinated: data are not always standardized and only partially represented in databases.
- It is not clear that the sampling frequency and sample analysis best suits modelling needs.
- There is a need for information exchange and guidance from modeling community as to their data requirements.
- There is a need for data collection that contributes to a dynamic, mechanistically driven understanding of change and impacts on ecosystems and processes

- There could/should be a synthesis presentation from WGZE and WGIPEM: "Reconciling zooplankton data collection with modelling needs in observing systems to understand ecosystem change"
    - What is being done vs what is needed?
    - What are the questions and types of models that need observing data? (biogeochemical, ecosystem, coupled physical biological population dynamics)
    - What variables needed by these models that are not presently or consistently measured by present observing activities?
    - Data distribution and management issues.
    - Making best use of WGZE data archiving efforts.
    - Making use of fisheries data management experience to help streamline data distribution and availability for modelling needs.
- Examples
    - Analysis of zooplankton samples to provide information on energy (lipid) concentration of zooplankton community, as determined from zooplankton species abundance and laboratory measurements of lipid content/species and developmental stages within species.
    - High frequency (monthly to semimonthly) sampling with stage resolution for coupled physical biological models of key species population dynamics.
- Are the zooplankton indicators recommended for MSTS by HELCOM and OSPAR needed by models?
    - Biomass calculations.
    - Mean size of zooplankton community.
    - Plankton life form analysis.

Actions

1. Propose a joint presentation at the 6th Zooplankton Production Symposium to be held in 2016 in Bergen

Geir Huse and Rubao Ji will co-convene a workshop at the Zooplankton Production Symposium on the following topic: "Zooplankton as a "to" in end-to-end models". Since this workshop is 'hands-on' can we address the question "What do the modellers need in terms of data?" "How can we fit zooplankton into the end-to-end models?" Furthermore there might be one or two talks that would be relevant to the Symposium with at least two possible sessions where modelling/zooplankton ecology could fit in (see Session 2: Response of zooplankton communities to changing climate and Session 6: Individual variability and its response to environment and climate).

2. Initiate a precise list of data required by modelers and applied zooplanktologists (including traits to be informed by keeping the taxonomic information) to inform zooplankton ecologists in charge of data collection or data analysis.

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

Leads: Erica J. Head and Webjörn Melle, Rapporteur: Mark Benfield

A management plan for the *Calanus finmarchicus* fishery is being prepared in Norway. Given that ICES has not taken any action with regard to *Calanus*, it is recommended that WGZE will discuss the overview of the Norwegian plan (written in Norwegian). Webjorn also presented an overview of the stock assessment based on modelling data including the assessment of bycatch.

Total annual production of *Calanus* was estimated to be about 200 million MT. Presented table summarized the mean annual consumption of *Calanus* (primarily pelagic fishes: blue whiting, mackerel, and herring, based on model results). *Calanus* makes up about 50% of the total zooplankton consumption. This value is based on a model on how much fish need to consume combined with the proportion of *Calanus* in the zooplankton assemblage, however, within the consumption model, fish migration cannot be effectively modelled. Consumption by mesopelagic fishes is about same level (45 million MT) as the total pelagic fish consumption. Consumption by invertebrates (krill, amphipods, predatory copepods, chaetognaths, cnidarians, etc) is high (698 million MT). There is very little (if any) 'free' *Calanus* biomass available to be taken by a fishery. The seasonal production cycle of *Calanus* was illustrated based on cruise data from 1996 – 2012. These data were corrected for year-day and station effects since cruises cannot start on exactly the same day each year. These data provide what is considered the best estimate of variability in stock size of *Calanus*. During the period when the pelagic fishes had a very high abundance, the abundance of *Calanus* was relatively low. The range of *Calanus* abundance was about ½ - double the mean.

In 2006 the Ministry of Fisheries banned fishing for zooplankton in Norwegian waters without a permit/quota. From 2003–2007 there was an experimental quota of 1000 MT of *Calanus*. In 2014 the highest catch ever was at 280 MT level. Company goal is to fish 1000 MT. Institute of Marine Research (IMR) suspects that there will be attempts to catch more *Calanus* in-order to address the growing demand for aquaculture feed supplements.

The fishery uses 500 micrometer mesh nets targeting primarily C4 – C6. The trawls are large and fished within the upper 30 m of the water column. Fishing occurs during both day and night during the spring. Small test nets are deployed prior to fishing to assess both the *Calanus* abundance and the amount of by-catch (primarily fish and fish eggs). Relative by-catch (hr^{-1} tow^{-1}) was estimated. 48 samples were analyzed and the bycatch were classified into fish eggs, herring larvae, cod larvae, and unidentified larvae. In total catch from sampling location (85075 kg), which took 303 hours of fishing, there were: 79,513,600 fish eggs, 5,853,570 unidentified fish larvae, 1,960,000 cod larvae, and 9,433,700 herring larvae identified.

To examine the consequences of this by-catch, the number of cod surviving to recruits was assessed. Known mortality data for eggs based on stages was used. Similar exercise was done for the larvae to juvenile period. When these data were scaled up to the total quota of *Calanus*, 41,724 cod would not recruit to 3 year old fishes.

The worst case scenario assuming the highest larval cod densities indicates the loss of 327,370 kg of cod. These results indicate that *Calanus* fishery needs to be regulated. It raises the question, what we would like to fish: *Calanus* or cod? The value of the *Calanus* oil is higher than then value of the cod. This is, however, an economic decision not a biological one.

During the joint WGIPEM-WGZE session there was evidence that herring condition was correlated with zooplankton biomass (with a 1 yr lag). This relationship is related to the NAO index of the prior year and it enables forecasting of the herring condition. This was used for many years but in 2004 the relationship broke down, possibly due to a change in the herring migration pathways and the fact that zooplankton biomass was not being measured at the herring feeding grounds.

The CPR data appear to show that *Calanus* are moving further north. Will this lead to a northward shift in the spawning grounds of cod? Could this lead to increased mortality of cod eggs and larvae due to by-catch? When the last 10 years' data are taken into account, the area is cooling thus the argument is probably not valid for now, but under warming conditions it has to be considered.

Jeff Runge asked if the recommendation of the management plan would be to sustain the 1000 MT quota? Webjörn Melle responded that the analyses are testing the potential effect of the 1000 MT and higher quotas on the by-catch. It is up to the Fisheries Directorate to decide whether to continue with the 1000 MT quota. Given that Calanus AS are not interested in fishing more than the current quota and in fact have not even reached that level, it is possible that the current quota will be sustained.

There is some interest by Calanus AS in a *Calanus* and krill fishery off Iceland. Company visited and carried out some mapping in 2012. This visit was purely an exercise in mapping. In 2013, an Icelandic fishing company requested to start an exploratory fishery for *Calanus*. Marine Research Institute recommended a catch quota of 300 MT but no further activities were recorded.

The group agreed to continue this ToR next year and include discussion of the *Calanus* fishery within the workshop on zooplankton fisheries at the 6th Zooplankton Production Symposium.

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

Leads: Maiju Lehtiniemi and Elaine Fileman, Rapporteur: Elvire Antajan

Maiju Lehtiniemi introduced this ToR by presenting conclusions of the workshop on "Achievements and future research on microplastics in the marine environment" that was held during the 2nd International Ocean Research Conference (IORC) in Barcelona from the 17th to the 21st of November 2014. The workshop was attended by 30 people from 17 countries or international organisations and provides an opportunity for the international marine research community to review recent development, research priorities, and stressed some gaps. Although evidence exists on microplastic ingestion by some invertebrates, we do not have convincing proof of harm. MSFD is underlining the harm of marine litter. If we cannot prove that they cause harm, we do not have to monitor, or manage microplastics, except if we apply the precautionary principle. Knowledge is lacking on microplastics in sediments, fragmentation of different plastics, age of plastics found in the oceans, and on role of microplastics as vectors for pathogens or aliens. We need monitoring guidelines, information on abundance and distribution of <333μm size fraction, and a microplastic database.

Elaine Fileman presented an overview of topics addressed during a session on "Microscopic Plastic Debris and Its Impact on Aquatic Ecosystems" that was held during the Aquatic Science Meeting in Granada from the 22nd to the 27th February 2015. Contributions included spatial distribution and monitoring of microplastics via remote sensing, ingestion studies on fish, shore crabs, and blue mussels, but only one on zooplankton, plastic colonisation by bacteria and diatoms, and identification methods (imaging, Fourier Transform infrared (FT-IR) spectroscopy).

More details are available on:
http://www.sgmeet.com/aslo/granada2015/sessionschedule.asp?SessionID=101.

Elaine reminded everyone that a workshop dedicated to "Effects of microplastics on zooplankton: assessing the risk" will be held during the 6th Zooplankton Symposium in Bergen, with Maiju and herself as convenors.

Elaine presented some images of microplastics obtained with FlowCAM. The difficulty of distinguishing microplastics from other kind of detritus using imaging tools (FlowCAM, ZooScan, ZooCam) was discussed. Microplastics have first to be sorted before being scanned. Elaine said it would be useful to have image library, and she would like to couple FlowCam and FT-IR methods. Marc Benfield suggested subjecting the sample to wet peroxide oxidation to digest labile organic matter before running it through FlowCAM while the plastic debris remains unaltered.

Six recent papers on impact of microplastic on zooplankton, all based on lab experiments were highlighted. Some of the impacts observed on copepods include a decrease in fecundity (*Tigropus japonicus, Calanus helgolandicus*), reduction of algal feeding rates (*Centropages typicus, C. helgolandicus*), reduction of density and sinking rate of faecal pellets and increased fragmentation (*C. helgolandicus*). Review on two papers on identification methods for microplastic was also provided (Song *et al.* 2015 Mar. Pol. Bul., and Hildago-Ruz *et al.* 2012 Env. Sci. Tech.).

Maiju Lehtiniemi presented preliminary results on microlitter abundances in the northern Baltic Sea. High variability in microplastic composition (plastics, paint flakes, fibres, combustion particles, and others) and abundance was observed according to season and between the eastern and western Gulf of Finland (visual counting method). Comparison of effectiveness of Manta trawl (333μm) and of a pump (300 and 100μm) for sampling microplastics was presented: microplastic abundances collected with the Manta net and the pump (300μm) are of the same order of magnitude (<2 particles m^{-3}). However, the smaller fraction collected with the pump (using the 100μm mesh size) was often much more abundant, up to 9 particles m^{-3}. According to Jeffrey Runge these concentrations of particles are too low (when compared to prey abundance) to be significant threat for zooplankton. Peter Wiebe asked if microplastic is found in the gut of zooplankton collected *in situ*? Discussion on the presence of microplastic in fish larvae gut provided some answers to that question: there were no microplastics in wintering herring larvae gut in the English Channel according to Elvire Antajan and Webjørn Melle said that juvenile salmon in Nordic Seas contained microplastic but other fish species had not.

Presentations were followed by the discussion on possible future activities. Maria Grazia Mazzocchi is involved in a new project to study the effect of microplastics on zooplankton in the whole Mediterranean Sea. Samples are collected with a Manta net for concentration estimate and chemical analyses. Maria Grazia would be interested in an intercomparison study with the other areas sampled by WGZE members.

ToR e) Review the new methods of automatic and semi-automatic plankton identification

Leads: Klas Ove Möller, Elvire Antajan, Astthor Gislason, Mark Benfield, Rapporteur: Paul Bouch

Elvire Antajan showed preliminary results from the second prototype of a new imaging tool that was tested in January 2015. By offering the possibility of analysing samples at sea, Zoocam allows better integration of plankton sampling into fisheries surveys. Samples can be collected using traditional methods or CUFES systems (Continuous Underway Fish Egg Sampler). The sample is diluted into a fixed volume of filtered sea water and pumped past a fixed camera, which takes between 15-20 images per second.

The image files can be rapidly processed and validated using the Plankton Identifier (PID) software as used by Zooscan. The system has been successfully utilised in the Bay of Biscay to count and identify anchovy and sardine eggs, with the target of automating the staging of these eggs. Trials on copepod species have also been conducted in early 2015. There is an issue of some specimens being split into multiple images or 'cut' by the edge of the image. These specimens are easily handled in the post processing and validation process. Calibrating the flow rate correctly reduces this issue and ensures all specimens are detected. There are plans to improve the software around the system and to compare results with that of microscope analysis.

Klas Ove Möller highlighted the rapid development of image analysis systems, and how far they have come since the publication of the Zooplankton Methodology Manual. These include in situ systems, such as the VPR, UVP, ZooVIS, ISIIS, Holocam, and lab instruments like Flowcam, flowcytobot, Zooscan, and a bench VPR. It would be useful to have reviews of the capabilities of these systems that would factor in methods, calibrations, inter comparisons, classification software, and a summary of useful publications. One option for presenting this information would be to submit a new chapter for the Zooplankton Methodology Manual, but this would be problematic. The preferred option would be a series of peer reviewed journal articles that could be linked to Manual via the WGZE website.

Mark Benfield discussed the capabilities of the new ZOOVIS-DEEP, a high resolution zooplankton imaging system. The system uses red LEDs to provide a long depth of field and rapid pulse width. It was initially tested in Chesapeake Bay, and despite the turbid conditions, it produced excellent results. It proved especially adept at imaging transparent and gelatinous specimens that would not normally be well sampled from a net. Every image is a hologram, so out of focus specimens can be brought into focus using a MATLAB toolbox. Results have been excellent so far for taxonomic identification and abundance calculations.

ToR f) Expand and update the WGZE zooplankton monitoring and time-series compilation

Leads: Todd O'Brien, Peter Wiebe, Rapporteur: Patrik Strömberg

In 2001, the first WGZE "Zooplankton Status Report" was created as an Annex within the WGZE annual meeting report. This seventeen page text briefly summarized results from ten monitoring sites. WGZE has now produced nine zooplankton status reports, with the last report published in the fall of 2013. This 208-page, full-colour, ICES Cooperative Research Report featured data from 62 individual time-series sites plus an additional 40 time series based on the Continuous Plankton Recorder standard areas running across the North Atlantic. The standardized graphical presentation and data analysis for this report was based on time-series data collected through the end of 2010.

The next zooplankton status report is scheduled to be created in the spring of 2017. This is a one year delay from the originally-planned 2016 release, intended to avoid time conflicts with WGZE's heavy participation within the ICES/PICES Zooplankton Production Symposium, happening in May of 2016. This additional preparation time will be used to add new analyses, add additional data (new sites, more years, additional variables), and to develop an interactive web-component to be co-released with the next report.

During this discussion, WGZE was reminded that ICES will no longer be creating paper-printed copies of the Cooperative Research Report (CRR) series. Future reports will still go through the full ICES editorial review and graphical layout steps, but will be distributed via high-resolution (electronic) PDF files instead of paper copies. In addition to reducing printing costs and saving trees, this switch to an electronic format better facilitates web visibility as well as within-PDF links to online components and supplemental materials.

In 2012, the ICES Working Group on Phytoplankton and Microbial Ecology (WGPME) produced its own, first Phytoplankton Summary Report. As WGPME plans for its next report, due out in late 2015, ideas discussed for their next report were shared with WGZE by Todd O'Brien (co-editor on both report series). WGPME is intending to include special "mini-topics" within their next report. These two-page features will give a brief, graphical introduction to "phytoplankton" (e.g., "what are phytoplankton vs. algae vs. microbial plankton?") as well as discuss issues of taxonomic identification and using/measuring abundance vs. biomass. These new elements are intended to bring key background information and current research topics into the report, specifically those regularly discussed by the working group in other ToRs. It was suggested that the next WGZE report may want to do a similar introduction to "zooplankton" (e.g., "mesozooplankton" vs. "microzooplankton" vs. "macrozooplankton") as well as repeating the "biomass vs abundance" topic (with regard to zooplankton). Unique to WGZE, additional topics could discuss "crustaceous vs. gelatinous zooplankton" (e.g., challenges in sampling and/or relative biomass contributions to the ecosystem), and/or providing an introduction to image-based/ genetic/ automated zooplankton analysis (vs. traditional microscope methods).

Analytical methods for the next report were discussed. Historically, WGZE (and WGPME) used the seasonally-corrected, annual anomalies method developed by Dave Mackas and SCOR Working Group 125 (Global Comparisons of Zooplankton Time Series). Based on suggestions from the joint WGZE/WGPME meeting in Malaga (2012), and the joint WGZE/WGPME "WKSERIES" time-series workshop (2013), the WGZE analysis will shift to more powerful, non-parametric methods (e.g., Mann-Kendall, Seasonal Mann-Kendall) and will include both annual and monthly based analyses. Todd displayed a handful of examples from initial explorations, showing multiple cases where the annual trend (e.g., increasing or decreasing over time) was created by a handful of months (e.g., a strong spring increase or warmer winters). Future explorations and analyses in the plankton reports will look for synchrony across sites (e.g., "what sites are seeing strongly warming winters", "what sites are seeing decreases in fall biomass or abundance").

The progress of the IOC/UNESCO International Group for Marine Ecosystem Time Series (IGMETS) was discussed. IGMETS has compiled a global collection of over 300 time series, covering open ocean, coastal areas, and estuaries. Of all the oceanographic regions, the best coverage within IGMETS is for the North Atlantic. With the WGZE and WGPME time series being the largest contributor to this region, there was question as to how or if the IGMETS report will duplicate the WGZE or WGPME status reports. Todd O'Brien summarized that the IGMETS report is focused on giving a very general and broad overview of each ocean (e.g., the North Atlantic), and it will be very unlikely they will discuss anything in detail close to what WGZE can pursue. In contrast, IGMETS will very likely lightly touch on topics that WGZE may want to pursue in detail for its next report.

The final discussion of this ToR brought up concerns of providing actual time-series data access through the WGZE web portal or a similar interface. Last year, an example interactive website created to support the ICES Report on Ocean Climate (IROC) was shown to WGZE. That website featured interactive time-series plots as well as links to download the data used to generate those plots. At the WGZE meeting last year, the question was asked whether WGZE members would be comfortable with providing access to its own calculated data elements (e.g., annual anomalies, monthly anomalies) used in the zooplankton status report. At that time, the group seemed fairly open to the idea, and agreed to discuss it at this year's meeting.

Between these two yearly meetings, the general climate and attitude to this suggestion completely changed. Members from both WGPME and WGZE, who already had some of their data publicly accessible, reported cases of people misusing, misinterpreting, and/or publishing data from their projects without contacting them or properly acknowledging their time series. Multiple sites also reported funding decreases and/or now lived under the threat of their sampling program being discontinued. To justify continuation of their programs, these sites must know exactly who is using their data and how often. This tracking usage information becomes more and more difficult as the data are served farther and farther away from the original source and creators.

The current WGZE online time-series information elements (http://wgze.net/time-series) do not provide data directly, but provide either a web link or email contact info for requesting or getting those data directly from the collecting entity. The same system would hold for IGMETS. It was agreed upon by both WGPME and WGZE that this was the best solution to address the broad range of institutional data policies and access restrictions found within the larger WGZE group.

ToR 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

Leads: Elena Gorokhova, Alexandra Chicharo, Maria Grazia Mazzocchi, and Piotr Margonski, Rapporteur: Maiju Lehtiniemi

Elena Gorokhova gave a presentation on indicator work done in OSPAR and HELCOM areas within the MSFD implementation. Until recently, both regional conventions were mainly working independently. HELCOM is more advanced - indicators will be operationalized in June 2015 and they will be used in a Holistic Assessment (HOLAS). HOLAS work will be ready in mid-2017. The Zooplankton Expert Network (ZEN) started developing indicators in 2010 within the CORESET project using zooplankton monitoring data from the Baltic Sea. Mean size and total stock (MSTS) developed by HELCOM shows 4 different states of the zooplankton community. The best status (Good Environmental Status) is attained when large zooplankton species are abundant. This means that there is a high grazing pressure, moderate food limitation for fish feeding conditions, and high energy transfer efficiency. The worst community would be when the zooplankton abundance is low and composed of small sized species, which means that there is low grazing pressure, poor fish feeding conditions, and an unproductive pelagic food web. To calculate the indicator, the total zooplankton abundance (TZA) and the total zooplankton biomass (TZB) is needed. The indicator is then calculated as TZB:TZA. This is the only zooplankton indicator at present in HELCOM that belongs to the core category.

ICES Workshop to develop recommendations for potentially useful Food Web Indicators (WKFooWI) was organised in 2014. Seven indicators were recommended for food webs. One of them was the mean weight of zooplankton describing food web structure.

In general, if stock size is combined with mean size, the higher discrimination can be obtained.

For defining the reference conditions, a period when herring and sprat (planktivorous fish) weight-at-age (WAA) have been at good levels together with the period when chlorophyll level has been acceptable. Future work in the Baltic Sea will include biomass calculation/measurement improvements and continuation of the validation process. It would also be good to establish better communication with OSPAR concerning indicator development.

Elena Gorokhova gave also a presentation prepared by Alexandra Chicharo for the OSPAR area. Biodiversity indicators suggested have been ratios between different groups: phytoplankton/zooplankton, large copepods/small copepods, and copepod grazers/non-copepod grazers. The food web indicators suggested were also ratios between different groups: gelatinous zooplankton/fish larvae, copepods/ phytoplankton, and holoplankton/ meroplankton (benthic-pelagic coupling, how much benthic species are part in the pelagic communities).

There was a joint workshop for HELCOM and OSPAR indicator experts organised in October 2014. There were two indicators that could be potentially developed and tested together. The problem is that the areas are ecologically dissimilar meaning that separate calculations and assessments are required.

OSPAR work will include further development of indicators by developing standard methodologies for using zooplankton within MSFD maybe by linking to other descriptors e.g. D2 in the future.

Discussion:

The group discussed whether regime shifts could be taken into account when defining the reference conditions. For short data sets and for some monitoring programs this would be even easier, by taking the whole period as a baseline.

The other issue was how the individual biomass was measured for the indicator data sets. Lutz Postel replied that, at the moment, it is wet weight, which is not measured but calculated based on species- and life stage-specific weights.

It was discussed why meroplankton are not considered in the Baltic Sea indicators. The reason being that the larvae of benthic animals are released during a very short period in May-June, which may easily be missed by a monitoring programme.

The next question was on how the small and large copepods were separated in the data. This concerns only the OSPAR area, and is probably based on species (small and large) distinction and not really on actual measurements of individuals. It was agreed that rate measurements e.g. zooplankton production have to be considered in the future ZEN work in the Baltic Sea. It was also discussed that although food web indicator discussions are often dominated by fish experts, there are aspects that could be useful in our zooplankton work as well, e.g. guild aspects.

Also modelling could be better linked with the ongoing work. E.g. in Sweden modelling has been discussed concerning D4 (food webs) and would help in the indicator work. It was mentioned that statistical models may show that there is a change in the community but we should be able to link it with pressures to reveal the cause-consequence-relationships. It was noted that it would have been beneficial from the beginning to foster discussions between experts working with different indicator groups (benthic, fish, pelagic, planktonic) but this could be improved now with increased communication. The conclusion of the HELCOM and OSPAR joint work was that it is still beneficial to continue the joint discussions as the work is continuing and the developments are ongoing. An unbalanced set of indicators affects the final assessment, thus we should get a set of indicators that represents all descriptors in a balanced manner.

ToR h) Design and carry out coordinated and collaborative activities with WGIMT and WGPME

Leads: Ann Bucklin, Alexandra Kraberg, and Piotr Margonski, Rapporteur: Lidia Yebra

Ann Bucklin reviewed WGIMT over-arching goals and pointed out that WGIMT and WGZE share several priorities from the ICES Science Plan. She continued with a progress report on the multiannual ToRs. In the first year several deliverables were achieved:

a) expand membership to a balance between morphology and molecular experts.

b) a web portal has been created (wgimt.net), work in progress will make available morphological keys, photographs, primers, etc.

   Todd O'Brien proceeded to explain how the available online primer tables with downloadable data and taxa information related are being prepared. He also prepared the photo collection (a hierarchically orientated record with niche map and primer of the species in the photo, which is linked to photos of the genus, family, etc.). This web approach reflects the integrative mission of the WGIMT. Ann Bucklin continued explaining that within the molecular methods section there will be downloadable protocols and primers. Also, optical methods can contribute with images to the web portal.

c) a taxonomy workshop will be held in June at SAHFOS (22-26th). Claudia explained the details of the integrated workshop that can be found at website http://www.sahfos.ac.uk/zooplankton-2015.aspx. There will be fixed, live, and molecular samples available.

d) Ann Bucklin summarized the meetings held in 2014 to promote integration activities: a poster session on integrative taxonomy of marine animals at the ASLO/AGU/TOS Ocean Sciences Meeting (Hawaii, Feb. 2014) and a workshop at IORC-2 (Barcelona, Nov. 2014).

e) She, then, defined metagenetics and pointed out that standardized metagenetics protocols might be a useful tool for the MSFD. The SSGEPD-SIBAS joint meeting outcome proposed that metagenetics will be also useful for fisheries management plans, and the Working Group on Application of Genetics in Fisheries and Mariculture (WGAGFM) is also interested in metagenetics development as advisory tool.

f) Ann mentioned the development of WGITMO-WGBOSV joint protocols for detection of invasive species in ballast waters.

e) During the 2013–2015 period, there were 10 peer-reviewed articles published by WGIMT members on topics directly related to the EG's mission and goals.

Next, Piotr presented a message from Alexandra Kraberg, co-chair of the Working Group on Phytoplankton and Microbial Ecology (WGPME) on important, future collaborative activities between WGZE and WGPME: (i) cooperation in preparations to the next Status Reports, (ii) possible, common analyses initiated by WKSERIES, and (iii) the compilation of data from both groups by IGMETS. Maria Grazia Mazzocchi informed that in Naples phyto- and zooplankton experts are already working together on their time series. Lidia Yebra volunteered to resume the WKSERIES work and to contact interested parties.

Piotr mentioned the ongoing WGZE-WGIMT collaboration in updating the ICES identification leaflets.

ToR i) Refine and expand the compilation of information on zooplankton species, taxonomic categories, and life stages that are currently monitored in the ICES area

Leads: Claudia Castellani and Todd O'Brien, Rapporteur: Klas Ove Möller

As a decision from last year's group meeting Claudia Castellani and Todd O'Brien presented a compilation of existing information on zooplankton species, taxonomic categories, and life stages which are currently monitored in the ICES area. So far this information includes data from 62 WGZE monitoring stations including number of taxa and observations, length of time series, sampling frequency, sampling method, and spatial coverage, as well as the CPR standard areas. These data are of crucial relevance not only to scientists, but also expert groups on fisheries and ecosystem managers.

Claudia Castellani first showed example data outputs of taxon-specific distribution patterns from SAHFOS CPR data between 1958 and 2014 with a focus on copepods. These data included the distribution of key species such as *Calanus helgolandicus* and *Calanus finmarchicus* in relation to ambient hydrographic parameters (including sea surface temperature, salinity, phytoplankton colour index, and bathymetry). Claudia highlighted the potential and variety of possibilities to use this existing dataset and encouraged the group to do so. Finally, Claudia presented a modelling approach to extend the CPR sampling by Eric Goberville *et al.* Her presentation was followed by an active discussion of the group about CPR route updates in the North Atlantic area, inclusion of one sampling point into yearly averages and the differentiation between no data and zero abundance of a species. Additionally, it would be useful to superimpose the currents on these distribution maps. Further points of discussion were to define the end-users needs, the integration of different information from different datasets, and potential ways of dissemination in terms of an interactive, web-based map system as well as peer-reviewed publications and reports.

Following this, Todd O'Brien presented a review of earlier efforts and the current status of the WGZE database. He showed major changes and improvements of the spread sheets in the database and presented an overview of the information he received for the taxa lists. Furthermore, Todd pointed out how useful these data are in terms of identifying changes and trends in distribution patterns, like Claudia presented before. He explained some improvements, e.g. how to remove outliers from the datasets, by showing examples and interesting results where he focused on the distribution of different *Calanus* species in relation to temperature and salinity. Furthermore, he pointed out the use of statistical frequency distributions (e.g. standard deviation) and existing literature to carefully set (tighten or expand) the temperature and salinity ranges, as well as considering the bathymetry. Finally, Todd presented the idea of a WGZE database of plankton including locations where they are sampled (WGZE sites and globally in COPEPOD), seasonal cycles and interannual trends, and metric information ("rates, weights, and traits"). However, one major problem here includes working with historical data and their taxonomic verification.

Lidia Yebra gave a short presentation entitled: "Barriers in the pelagic: Population structuring of *Calanus helgolandicus* and *Calanus euxinus* in European waters." Lidia presented an overview of the study area including the sample collection sites, showing the regional co-occurrence of these species in the Atlantic. Following this, she presented PCR results, showing the relative distribution pattern of most common haplotypes. An analysis of molecular variance (AMOVA) as well as the 16S haplotype network showed significant differences between the study sites. A morphological analysis showing prosome/urosome length differences indicated a similar relationship between the Atlantic and the Eastern Mediterranean data.

Finally she presented a map combining the structuring barriers of genetics, morphology, and sea surface temperature data, and concluded that there are important barriers between the Eastern and Western Mediterranean Sea, so Gibraltar is not the main populations' barrier. There were also important barriers between the East Mediterranean and the Black Sea. Hydrography (currents, fronts, etc.) was an important structuring factor both in the Mediterranean and the Atlantic; although within the Atlantic Ocean temperature might be the main factor controlling the latitudinal distribution. Further research is needed to ascertain relationships between the populations in the Western Mediterranean Sea and the Atlantic as well as the differences within the Eastern Mediterranean.

ToR 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

Leads: Lutz Postel, Peter Wiebe, and Patrik Strömberg, Rapporteur: Angus Atkinson

Context

Simple equations and allometric relationships are often used to convert one unit to another, for example abundance and body length to mass and biomass, wet mass or dry mass to carbon mass, and biomass to production using P:B ratios. Size based approaches are very commonly used in models and meta-analyses, and these often convert individual rates, R, of feeding, growth, excretion, respiration, etc. from organisms body mass, m, using the formula:

$R = a\, m^{b}$

Where a and b are constants, the latter having a value often of 0.75 or thereabouts.

However, the ecological theory behind mass scaling is hotly debated and a wide number of all of these above-mentioned conversion and scaling factors are found and used in the literature. It would be very beneficial to provide the community with both a readily-available database of the most common factors, and a defined, consistent, estimation of key rate processes (e.g. secondary production) across the ICES area, based on the large number of time series available.

Presentation to the group

This was in two parts:

A. Use of empirical relationships to calculate zooplankton production and metabolic rates (presented by Lutz Postel)

Suitable deliverables were suggested as a Chapter contribution to the next Zooplankton Status Report (2017) and a publication.

The aim is to collate abundance and biomass data from as many as possible of the 62 ICES time-series sites and 40 CPR areas as possible. So far twelve sites have been assessed. The approach basically combines concurrent assessments of total mesozooplankton biomass and total abundance to derive a mean mass per individual. It then uses the mass scaling equation above to derive key rate processes per individual and sums over total abundance to derive a total mesozooplankton value, which can then be plotted as a time series. The mass currency is carbon. The end results are compared with literature values e.g. of P:B compiled by Mauchline and others. The same principles were applied to other metabolic rates such as respiration, ammonium, and phosphate excretion.

Next steps are methods evaluation, inter-regional comparisons e.g. of production in mg C m^{-2} d^{-1}, calculation of other metabolic rates, and mortality evaluation. The aim is for a draft paper this year leading to a contribution to the 2017 Zooplankton Status Report.

B. Build a database of zooplankton individual species biomass, production, and metabolic rate (presented by Peter Wiebe).

Suitable deliverable was suggested to collate a user-friendly database on the WGZE site of the diversity of zooplankton mass and rate inter-conversion factors. These would be tailored so that they were useful to the wider, sometimes non-specialist community, and were attributable to a citable source.

The first step was to locate and capture electronically and then collate the key references that either a) provide individual species and stage-specific mass, or b) link mass (in its various currencies) to length, volume, and various rate processes, or c) provide inter-conversions between various currencies of a single unit e.g. of mass (example given included Pitt's C: wet mass conversions).

Next step is to digitize the actual data, for instances the appendices and tables and equations.

Third step is to compile this into a database in first instance on the WGZE website that is a useful resource for example to modellers.

In building a database of this sort the attribution (i.e. author) is glued to the conversion to provide a traceable path e.g. for modellers who might want data in terms of calorific value etc.

Large quantities of grey/unpublished literature as well as older data exist (example given was Davis 1985 silhouette photography). However several key taxa are lacking in data. This exercise will highlight these taxa.

The fourth step recognizes that these relationships change according to study site.

This site-specific information will be kept separate from the overall biomass and will be linked to the individual time series sites.

General discussion

During discussion Peter Wiebe explained that data sources he was presenting are extremely variable in terms of format and contents, i.e. some of those are bulk measurements and others are species-specific. They are also expressed in various units including e.g. wet mass, dry mass, ash free dry mass, protein, carbon.

It is also possible to incorporate key traits like suspension versus ambush feeders, but there is a need to prioritise which are key traits. A strong focus on getting info compiled on the basics is needed to avoid losing focus and the project stalling.

Getting info on seasonal variability is important but hard, since seasonal conversions factors often not available. Lutz Postel added that validation of the rates is important – some data exist.

Angus Atkinson pointed out that the multiplying up a single arithmetic mean animal mass by allometric scaling equations to get a community mean has to be done carefully because of the different scaling of mass and length. Lutz Postel replied that comparison with more refined calculations based on known biomass-size spectra within these assemblages is possible – it requires multiple net types to capture the size spectrum across the assemblages.

Erica Head asked how variable O:N ratios through the year were achieved and if they were linked with size-based variation in C:N. Lutz Posted replied that the species-specific conversion factors were used.

ToR 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

Leads: Antonina Santos and Claudia Castellani, Rapporteur: Astthor Gislason

Antonina Santos introduced the topic. The ICES Zooplankton Identification leaflets consist of 186 leaflets published during 1939–2001. Dr Alistair Lindley was a long-standing editor of the series. He stepped down as editor in 2007 and now there is no editor of the leaflets. The WGZE feels the Plankton leaflets are an extremely important resource for taxonomic work.

On behalf of the group, Antonina Santos and Claudia Castellani are coordinating efforts to update the taxonomic keys. Last year they submitted category 1 resolution to ICES for a publication and update of the series. ICES PUBCOM answered the request and decided not to support the resolution in its present form. In answering the request, PUBCOM gave guidance how to work towards publication in future. PUBCOM requested the WGZE to consider the following steps: 1) Identify the leaflets that require updating; 2) Prepare a list of key plankton taxa that are not included in the series; 3) Compile a list of experts for the different taxa willing to act as authors of leaflets; 4) Ensure that independent peer-review will be conducted; 5) Define the time horizon needed to complete the leaflets; 6) Resources required to publish the ID leaflets online.

Stressing that the WGZE considers the update of taxonomic leaflets as a very important issue it was discussed whether publishing leaflets outside ICES might be an option. Antonina Santos explained that should be done through the ICES system if we want to revise/update the existing ICES series. The other solution could be to prepare a completely new collection of leaflets with different publisher. Todd O'Brien stressed that we should pursue the issue within ICES. A list of experts willing to contribute should be created and then the group should submit a new proposal to ICES. Piotr noted that ICES has very limited funds to support an initiative of this kind and that the organization wants to be sure that we have a good and solid plan with realistic time schedule. Piotr recommends making a 3-year proposal. Peter Wiebe suggested that a "mock-up" leaflet be made to be presented to PUBCOM.

The group felt that PUBCOM's answers were really helpful and constructive – even though they declined our request - they provided good advice on how to proceed in order to pursue the work further. The discussion concluded by general agreement that we should follow up and submit a renewed proposal to ICES following the guidelines of PUBCOM. Thus the renewed proposal will incorporate the suggestions made by PUBCOM in their review and will be for a 3 year ToR.

ToR l) Produce four short paragraphs for the ICES Ecosystem Overviews on the zooplankton community (spatial variability, hot spots and seasonality), one paragraph for each of the following ICES ecoregions: Greater North Sea, Celtic Seas, Bay of Biscay & the Iberian coast and Baltic Sea

Leads: Piotr Margonski, Maiju Lehtiniemi, Joerg Dutz, Patrik Strömberg, Lidia Yebra, Antonina Santos, Arantza Iriarte, Martin Edwards

The group was asked to contribute to the ICES Ecosystem Overviews providing info on recent changes and the current state of the zooplankton community. At the moment ICES is preparing four reports on the Greater North Sea, the Bay of Biscay and the Iberian coast, the Celtic Seas, and the Baltic Sea. The WGZE role is to provide priority information on the "state of habitat and biological characteristics" (section 4 of reports). It is to describe the state of the ecosystem (in space and time) and to comment on pressures accounting for changes in state.

After a short discussion on data availability, group decided to prepare the relevant paragraphs on zooplankton community plus figures illustrating the changes. Chapters on the Bay of Biscay and the Iberian coast will be prepared by Lidia Yebra, Antonina Santos, and Arantza Iriarte; the Baltic Sea text will be drafted by Maiju Lehtiniemi, Joerg Dutz, Patrik Strömberg, and Piotr Margonski. It was agreed that figures will be generated by Todd O'Brien based on data used for preparations of the "Zooplankton Status Report". The overview of changes and the current status in the Greater North Sea and Celtic Seas was possible only using the CPR data series collected by SAHFOS. Martin Edwards kindly offered the SAHFOS contribution in that respect.

Progress Reports

Sources of variability in measurements of egg production rates for *Calanus finmarchicus* (E.J.H. Head and M. Ringuette, Fisheries and Oceans Canada, Ocean and Ecosystem Sciences Division, Bedford Institute of Oceanography, Dartmouth, Canada)

Egg production rates increase with increasing in situ chlorophyll concentration for freshly caught female *Calanus finmarchicus* incubated for 24 h. These relationships rise to an upper limit and always show a high degree of scatter for individual points about the fitted curve. A variety of environmental and intrinsic factors may contribute to this variability, but here we consider how different experimental procedures might affect measured rates, especially with regard to cannibalism and diel egg-laying behavior. In particular, we compare results from experiments in which females were (a) incubated individually in Petrie dishes for 24 h (Method A), (b) incubated as in Method A, but separating eggs and females at 6 hourly intervals (Method B), and (c) incubated individually in Plexiglass cylinders, with false mesh bottoms and funnels through which eggs are collected after 24 h (Method C). The number of experiments carried out was relatively limited, but provided evidence (i) that cannibalism is possible with Method A or Method C, but seems more problematic with the latter, (ii) that female *C. finmarchicus* from the Labrador Sea do not exhibit dial egg-laying behavior, (iii) that capture stress and/or experimental handling seem to promote premature egg-laying in females that are ready to spawn and, finally, (iv) that inadvertent increases in temperature during incubation promote spawning for females that are replete, but not for females that are food-limited. The implications of these and other observations are discussed in relation to their potential for contributing to variability in measurements of *C. finmarchicus* egg production rates.

WGZE Dark Data Presentation (Peter Wiebe, Woods Hole Oceanographic Institution, Woods Hole, USA)

Data generated as a result of publicly funded research in the USA and other countries are now required to be available in public data repositories. However, many scientific data over the past 50+ years were collected at a time when the technology for curation, storage, and dissemination were primitive or non-existent and consequently many of these datasets are not available publicly. These so-called "dark data" sets are essential to the understanding of how the ocean has changed chemically and biologically in response to the documented shifts in temperature and salinity (aka climate change). An effort is underway to bring into the light, dark data about zooplankton collected in the 1970s and 1980s as part of the cold-core and warm-core rings multidisciplinary programs and other related projects. Zooplankton biomass and euphausiid species abundance from 306 tows and related environmental data including many depth specific tows taken on 34 research cruises in the Northwest Atlantic are online and accessible from the Biological and Chemical Oceanography Data Management Office (BCO-DMO). The data under the project North Atlantic Dark Data may be accessed via http://www.bco-dmo.org/project/529105.

A paper describing the effort is a contribution to the GeoResJ Special Issue Titled "Rescuing Legacy Data for Future Science" and is:

Wiebe, P.H., and Allison, M.D. 2015. Bringing Dark Data into the Light: A case study of the recovery of Northwestern Atlantic zooplankton data collected in the 1970s and 1980s. GeoResJ. 6: 195–201. http://dx.doi.org/10.1016/j.grj.2015.03.001.

A Mediterranean long-term plankton observatory: station LTER-MC in the Gulf of Naples (Tyrrhenian Sea) (Maria Grazia Mazzocchi, Stazione Zoologica Anton Dohrn, Napoli, Italy)

The Mediterranean Sea (Med) is considered a hot spot for marine biodiversity, where species of Atlantic and Indo-Pacific origin coexist as a result of the complex geomorphological history of the basin. The Med is characterized by oligotrophic conditions, especially in the eastern basin, and higher chlorophyll values are recorded only in the coastal regions. In the Med, seven time series are ongoing for the long-term study of zooplankton; one of them is carried out in the Gulf of Naples in the Tyrrhenian Sea (western Mediterranean). Station LTER-MC is located in the inner Gulf of Naples, at the border between the littoral and the open-waters systems, 2 miles from the coast of a densely populated area. Plankton monitoring at station LTER-MC started in 1984 and had a major interruption from 1991 to ’94. Since 2006, it has become part of the international Long Term Ecological Research network. The sampling frequency was biweekly in the first part of the time series and it is weekly since ’95. Numerous environmental parameters are monitored together with chlorophyll, phyto- and zooplankton, with high taxonomic resolution (Ribera d’Alcalà *et al.*, 2004). This station represents not only a monitoring site but a sort of natural laboratory to test many of our questions and hypotheses. The activities include retrospective analysis and investigations on both ecological and biological traits at community and population levels.

The site is characterized by a strong seasonal signal in the environmental parameters and plankton communities. The seasonal stratification of the water column starts in April and is completely disrupted from December onwards. Chlorophyll has a slight increase in winter, the annual peak in late spring-summer, and a new increase in autumn (Ribera d’Alcalà *et al.*, 2004). In the long term, a remarkable interannual variability was observed, with a few significant long-term trends, such as an increase in summer temperature. No clear trend was observed in total zooplankton abundance. The bulk of the highly diverse zooplankton communities remained the same in the long-term, and only a few significant changes were recorded among the most abundant species. This was the case of *Acartia clausi* and *Centropages typicus*, which decreased in abundance in the second part of the time series, while *Calocalanus*, chaetognaths, appendicularians, and doliolids increased. Among the rare species, we recorded the disappearance of a few species among acartiids (Mazzocchi *et al.*, 2012). The zooplankton community appears structured in robust associations, which are mainly shaped by the seasonal forcing (Mazzocchi *et al.*, 2011). A strong seasonal signal is also visible in the temporal succession of congeneric species of the copepods *Clausocalanus* and *Oithona* (Mazzocchi and Ribera d’Alcalà, 1995; Mazzocchi *et al.*, in preparation). The strong seasonal signature highlights resilience in the whole copepod assemblage that maintains a clear seasonal cycle also in case of a marked variability of the environmental conditions (Mazzocchi *et al.*, 2012).

The analysis of phenology of copepod species has revealed that *A. clausi* and *C. typcius* showed similar changes in their phenology, with an anticipation of the end-of-the-season timing, which is significantly correlated to surface temperature anomalies (Mackas *et al.*, 2012; Wright *et al.*, in preparation). In contrast, the summer species did not show any significant variation in the timing of their phenology; this was the case of *Paracalanus parvus* and cladocerans (Wright *et al.*, in preparation). A comparative study has been recently conducted on the common and abundant cyclopoid copepod *Oithona similis* at station LTER-MC and at station L4 in the English Channel. The analysis of the seasonal and long term variability of the abundance of this species in the two time-series has enabled relevant insights on its ecological traits along latitudinal cline (Castellani *et al.*, in preparation).

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ICES/PICES cooperative initiative on global zooplankton production (Lidia Yebra, IEO, CO Málaga, Málaga, Spain)

Lidia Yebra presented the description of the workshop entitled "ICES/PICES cooperative research initiative: towards a global measurement of zooplankton production" that she will co-convene together with Toru Kobari (Japan, PICES), at the 6th Zooplankton Production Symposium to be held in Bergen in 2016 (www.ices.dk/zp6).

This workshop will share the applicability of existing methods (i.e. traditional methodologies) as well as the development of novel methods (i.e. biochemical-based approaches) for measuring zooplankton production rates. Contributions are welcome on the topics regarding:

1) Assumptions, limitations, and recent advances of the traditional methodologies and novel biochemical-based approaches used to estimate production of zooplankton populations or communities;
2) Validation and calibration of zooplankton production rate estimates measured by biochemical-based approaches, traditional methodologies, and models.

Through this workshop, conveners aim to foster cooperative research activities and working groups on zooplankton production among PICES (North Pacific Marine Science Organization) and ICES (International Council for the Exploration of the Sea) members.

Recommendation from the Joint OSPAR/ICES Ocean Acidification Study Group (SGOA)

Lead: Mark Benfield

The joint ICES/OSPAR Study Group on Ocean Acidification has concluded it three year remit and submitted a final report and recommendations to OSPAR. Two of the SGOA ToRs are relevant to the activities of the WGZE: (1) Collect and exchange information on biological effects on plankton, and macrozoobenthos; and (2) Inform the development of biological effects indicators for ocean acidification, including the identification of suitable species and key areas. Given the large geographic extent of the OSPAR area, SGOA reviewed the available literature in an attempt to identify potentially-appropriate biological indicators.

Thecosomate pteropods such as *Limacina helicina* and others appear to be sensitive to ocean acidification (OA) and were identified by SGOA as potentially useful indicator organisms. Development of metrics that could be used to quantify the deleterious effects of OA on pteropod shells or other tissues remains to be developed. Moreover, it is likely that given the morphological diversity in pteropod shells, metrics that are appropriate for one species may not be of general utility. Rates of dissolution, changes in shell thickness, length, width, shell mass:soft tissue mass, and other metrics that might provide useful information on OA will therefore likely be species specific. In the absence of sufficient information about how these organisms respond to OA, SGOA has initially recommended that pteropods as well as other taxa with calcareous structures (such as foraminifera) be collected and archived.

SGOA specifically requested guidance from WGZE on how to best archive potential indicator organisms such as pteropods and foraminiferans so that their soft tissues and calcareous structures are preserved without degradation. Archival is essential because, until appropriate metrics to assess OA impacts can be developed, the archived specimens will provide a retrospective repository of evidence about how OA has affected potentially-sensitive indicator organisms.

A summary of the relevant work conducted on potential indicator organisms by SGOA was presented to the WGZE followed by a request for specific guidance on how to best collect and archive pteropods and foraminiferans so that their calcareous and soft tissues could best be preserved for future analysis. The discussion within the WGZE was that preservation in liquid nitrogen at sea followed by storage in an ultracold (-80°C) freezer would be preferable. Storage in formalin was not recommended due to its potential to acidify over time. The group agreed to revisit this issue at the next meeting after determining whether other options or approaches might exist.

Discussion of 2016 Theme Sessions

Leads: Angus Atkinson and Piotr Margonski

Group reconsidered submitting the theme session proposal which was initially discussed last year: "The role of zooplankton in exploited ecosystems: top-down and bottom-up stresses on pelagic food webs" with potential co-convenors: Angus Atkinson, Erica Head, Webjørn Melle

There was a substantial discussion over the exact wording of the title, but overall the consensus among the group was that a wide range of contributions were welcomed, and importantly, these could come from modelling and fisheries backgrounds as well as zooplankton studies. The original emphasis of the session was to look more specifically into exploited systems but as this suggested theme session evolved during its delayed path, a wider perspective was felt appropriate. This was because the relative strengths of top down and bottom up control through food webs are a fundamental topic in wider ecology, not just in terms of fisheries and their management. Although we specifically aim to attract papers that consider more than two trophic levels, we acknowledge that most submissions will consider a single forcing direction and its outcome on physiology or population dynamics. Erica Head agreed to step down as a potential co-convenor if necessary for a more fisheries based co-convenor, who still needs to be appointed to join Webjörn Melle and Angus Atkinson.