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

14–17 March 2016

Lisbon, Portugal

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

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Contents

Executive summary

The ICES Working Group on Zooplankton Ecology (WGZE) met at the Instituto Português do Mar e da Atmosfera (IPMA), Lisbon, Portugal, 14–17 March 2016. The meeting was hosted by Antonina dos Santos of IPMA and chaired by Piotr Margonski. It was attended by 35 scientists in person and 1 by correspondence. They were representing 11 nations. The objective of the meeting was to discuss and address the 9 terms of reference (ToRs) and to exchange information on recent activities in zooplankton ecology.

Final preparations for the 6th Zooplankton Production Symposium (9–13 May, Bergen, Norway) were presented and discussed. Contribution to the organization of the Symposium is one of the highest WGZE priorities and the group thanked the Conveners and the Scientific Steering Committee for their efforts.

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 the extension of information and data collected by the group and periodically presented in the Zooplankton Status Report.

A review article is being prepared on image analysis systems within the ToR (e) that will summarize a rapid development of those tools supporting the automatic and semi-automatic plankton identification. Thanks to the Publication Committee support, revision and updating of zooplankton species identification keys especially including ICES Zooplankton Identification Leaflets have already started under ToR (k).

The group continued to review the progress in development of zooplankton indicators (ToR g) relevant for biodiversity and food web status assessment at different regional scales. In 2016 we focused on Mediterranean approach and experience. Results of tests of one of the HELCOM core indicators carried out based on the Polish monitoring data from the southern Baltic Sea was presented.

Future areas of coordinated and collaborative activities between WGZE, WGIMT, and WGPME were discussed under the ToR (h). The three groups supported an idea to work together on delivering potential products useful for the advisory system. One of the possible examples is to provide an innovative approach to indicator development including molecular and genetic information relevant to e.g. biodiversity, food webs, and non-indigenous species (NIS). The other area of cooperation considered was the common analyses of the plankton long-term data series initiated at the WKSERIES workshop.

Continuing with the ToR (c) that is a WGZE contribution to the Advisory Programme, the group reviewed the management plan for *Calanus finmarchicus* in Norwegian waters, focusing on the fishery and how to set the quotas.

The next meeting of the WGZE will be hosted by Elvire Antajan, IFREMER, Boulogne-sur-Mer, France, 27–30 March 2017.

1 Administrative details

Working Group name

Working Group on Zooplankton Ecology (WGZE)

Year of Appointment within current cycle

2015

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

2

Chair(s)

Piotr Margonski, Poland

Meeting venue

Lisbon, Portugal

Meeting dates

14–17 March 2016

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) and identifying and developing information and data useful for modelling needs (ToR b), however, we decided to continue with ToR a) in Year 2.

Year 2 We continue with remaining ToRs except for micro-plastics (ToR d) which has to be shifted to Year 3. Originally, we expected that three of ToRswould be completed during the Year 2: *Calanus* assessment (ToR c), micro-plastics (ToR d), and automatic/semi-automatic identification (ToR e), However, we decided to continue with all of them in Year 3. Detailed rationale is provided in each case in the description of ToR activities.

Year 3 During Year 3 we will focus on completion of all of the outstanding ToRs.

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

- The 6th Zooplankton Production Symposium is ready to be launched.
- Future areas of coordinated and collaborative activities between WGZE, WGIMT, and WGPME were presented and discussed.
- Progress has been made regarding preparations of several scientific publications
- The following paper has been published:

  Wiebe P., Harris R., Gislason A., Margonski P., Skjoldal H.R., Benfield M., Hay S., O'Brien T., Valdes L. 2016. The ICES Working Group on Zooplankton Ecology: Accomplishments of the first 25 years. Progress in Oceanography 141: 179–201, DOI: 10.1016/j.pocean.2015.12.009

5 Progress report on ToRs and workplan

ToR a) Progress on the final phase of planning and preparations to the 6th Zooplankton Production Symposium (9–13 May, Bergen, Norway) was presented and discussed. WGZE thanked the Scientific Steering Committee for their work and suggested continuation of the ToR until next year to allow evaluation of the outcomes of the symposium.

ToR b) Completed in 2015.

ToR c) Continuing with this ToR that is WGZE contribution to the ICES Advisory Programme, the group reviewed the management plan for *Calanus finmarchicus* in Norwegian waters, focusing on fishery and how the quotas are set. The group agreed to conclude this ToR next year, when the final version of the management plan is available together with the outcome of the special workshop on zooplankton as a potential harvestable resource, at the upcoming 6th Zooplankton Production Symposium in Bergen (9–13 May 2016).

ToR d) Shifted to 2017 due to the ToR Leads absence.

ToR e) The progress of a planned review article on image analysis systems was presented. This review article is the final outcome of ToR e. WGZE discussed the contents and the scope of the paper and it was decided to continue it next year when the manuscript is ready for submission.

ToR f) The next edition of its Zooplankton Status Report (ZSR) series will be released next summer (2017). The progress of the IOC/UNESCO International Group for Marine Ecosystem Time-series (IGMETS) was also discussed. WGZE is a significant contributor of North Atlantic time-series to the IGMETS global time-series study. The next generation time-series analysis tools both for ZSR and IGMETS have been developed. Through the cross-group work and collaboration, a new time-series explorer will be created and added to the WGZE.net web pages. The IGMETS version of this interactive tool is online at: http://igmets.net/explorer.

ToR g) The group continued to review progress in development of zooplankton indicators relevant for biodiversity and foodweb status assessment at different regional scales. In 2016 we focused on Mediterranean approach and experience. Results of tests of one of the HELCOM core indicators carried out based on the Polish monitoring data from the southern Baltic Sea was presented.

ToR h) Three groups (WGZE, WGIMT, and WGPME) supported an idea to work together on delivering potential products useful for the advisory system. One of the possible examples is to provide an innovative approach to indicators development including molecular and genetic information relevant to e.g. biodiversity, food webs, and NIS. The other area of cooperation considered was the common analyses of the plankton long-term data series initiated at the WKSERIES workshop.

ToR i) An overview of the soon-to-be-published *Marine Plankton: A practical guide to their identification and ecology for the North Atlantic* (Oxford University Press) was presented. This book will serve as a modern plankton identification and reference manual aimed at students, academicians, and practitioners. It will cover plankton identification, methodology, and ecology and distribution.

To support the collaborative goals and needs of WGZE, WGIMT, and COPEPOD (The Global Plankton Database), Todd O'Brien created a new taxonomic-based information database called "COPEPEDIA" (http://copepedia.org). This single, shared database benefits from the expertise of all parties, and provides combined information that is greater than the sum of its parts.

ToR j) After discussion, the group agreed that deliverables of this ToR will include: (i) an oral presentation during the 6th Zooplankton Producton Symposium in Bergen on *Zooplankton Production and Metabolic Activity in the North Atlantic and Adjacent Seas*, (ii) submission of a manuscript based on this presentation and considering the outcomes of the discussion, and (iii) various contributions to the next Zooplankton Status Report in 2017.

ToR k) WGZE reviewed the current status of the work to develop, revise, and update zooplankton species identification keys and to ensure their availability via the web, including especially the ICES Zooplankton Identification Leaflets.

ToR l) Completed in 2015.

6 Revisions to the work plan and justification

Originally, we expected that three of ToRs would be completed during the Year 2: *Calanus* assessment (ToR c), micro-plastics (ToR d), and automatic/semi-automatic identification (ToR e). However, we decided to continue with all of them in Year 3.

ToR c will be completed by reviewing the final version of the Norwegian management plan as well as the report from the *Workshop 3: Zooplankton as a potential harvestable resource* organized at the 6th Zooplankton Production Symposium in Bergen. ToR d had to be shifted to Year 3 due to the absence of the ToR leads. ToR e will be finalized next year when the manuscript of the peer-review publication is ready for submission.

Morover, the group decided that the ToR a (*Review progress and planning of the 6th Zooplankton Production Symposium*) will be completed in Year 3 by providing and discussing the summary report prepared by the Symposium conveners.

7 Next meetings

The next meeting of the WGZE will be hosted by Elvire Antajan, IFREMER, Boulogne sur Mer, France, 27–30 March 2017.

Annex 1: List of participants

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Annex 2: Recommendations

RECOMMENDATION	ADRESSED TO
1. Theme Sessions for the 2017 ASC	SCICOM

Annex 3: Agenda

Monday, 14 March 2016

09:00 – 09:30 Opening, Introduction, Logistics, and Agenda Adoption (Antonina Santos and Piotr Margonski)

09:30 – 10:30 Discussion on planning the completion of MA ToRs in 2017 (Piotr Margonski)

10:30 – 11:00 Coffee Break

11:00 – 12:30 Review progress and planning of the 6th Zooplankton Production Symposium (**ToR A**, Astthor Gislason, Padmini Dalpadado, and Lidia Yebra)

12:30 – 14:00 Lunch Break

14:00 – 15:30 Review the new methods of automatic and semi-automatic plankton identification (**ToR E,** Klas Ove Möller, Elvire Antajan, Astthor Gislason, André Gonçalves, Mark Benfield by correspondence)

15:30 – 16:00 Coffee Break

16:00 – 16:40 ICES Workshop to Plan and Integrate Monitoring Program in the North Sea in the 3rd quarter (Sophie Pitois)

16:40 – 17:00 Discussion of 2017 Theme Sessions (part 1) (Piotr Margonski)

Tuesday 15 March 2016

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

10:30 – 11:00 Coffee Break

11:00 – 12:30 Expand and update the WGZE zooplankton monitoring and time-series compilation (**ToR F,** Todd O'Brien, Tone Falkenhaug, and Peter Wiebe)

12:30 – 14:00 Lunch Break

14:00 – 15:30 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,** Maria Grazia Mazzocchi and Piotr Margonski)

15:30 – 16:00 Coffee Break

16:00 – 16:30 Discussion of 2017 Theme Sessions (part 2) (Piotr Margonski)

16:30 – 17:00 WGZE "history" article (Peter Wiebe)

Wednesday 16 March 2016

09:00 – 10:30 Design and carry out coordinated and collaborative activities with WGIMT and WGPME (**ToR H,** Ann Bucklin, Alexandra Kraberg, and Piotr Margonski)

10:30 – 11:00 Coffee Break

11:00 – 12:30 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)

12:30 – 14:00 Lunch Break

14:00 – xx:00 Field trip

Thursday 17 March 2016

09:00 – 10:30 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, Todd O'Brien, and Patrik Strömberg)

10:30 – 11:00 Coffee Break

11:00 – 11:30 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)

11:30 – 12:00 'WGZE and pteropods' (Mark Benfield by correspondence)

12:00 – 12:20 Report on the 2015 Theme Session S 'Basin-scale dynamics at lower trophic levels in the North Atlantic' (Astthor Gislason and Peter Wiebe)

12:20 – 12:40 Progress Report on Review on Biochemical methods to AMB (as an update of the Chapter of Growth of the ZP Manual) (Lidia Yebra)

12:40 – 14:00 Lunch Break

14:00 – 14:20 Progress Report on Seasonal patterns of zooplankton at four monitoring sites of the Northeast Atlantic Shelves Province (Arantza Iriarte)

14:20 – 14:40 Progress Report on Presenting the MarinEye project – A prototype for multitrophic oceanic monitoring (Cátia Bartilotti *et al.*)

14:40 – 15:00 Progress Report on Zooplankton Biodiversity in seamounts: the Madeira-Tore and Great Meteor (Rita Pires *et al.*)

15:00 – 15:20 Progress Report on The CascaisWatch Biodiversity monitoring station time-series (Raquel Marques *et al.*)

15:20 – 15:40 Progress Report on Life cycle and seasonal vertical distribution of *Calanus hyperboreus*, *C. finmarchicus* and *Metridia longa* in Iceland Sea (Astthor Gislason)

15:40 – 16:00 Coffee Break

16:00 – 17:00 AOB, Next Year Venue & Timing, Work Plan, and Closure

Annex 4: Additional information

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

Lead: Astthor Gislason, Padmini Dalpadado, Lidia Yebra; Rapporteur: Webjörn Melle

Astthor Gislason presented the status of the planning of the Symposium by the Scientific Steering Committee (SSC) 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), Lidia Yebra (Spain/ICES). The work done by the SSC and the local organising committee was very well received by the group.

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.

Also several Workshops are in place on topics such as: 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 was developed and a symposium website set up (http://ices.dk/6zps) where further details can be found.

The group expressed some concern about the plans for the publication of the proceedings. The ICES JMS has accepted to take on the task of publishing the proceedings, but the group felt that the number of papers accepted for publication, as indicated by the editor to the SSC, may not be sufficient to convey the full outcome and diversity of the symposium presentations. Ann Bucklin commented that she had mentioned her role in co-convening ZPS-2016 Session 4 to an Editor of the Journal of Experimental Marine Biology and Ecology, published by Elsevier, and asked about a possible special issue of papers by session presenters (either oral or poster). Depending upon the interest of the Symposium organizers and permission from ICES, Ann would be willing to continue this dialog with the JEMBE editor and would offer to serve as one of likely several special editors. The group asked the SSC to contact the editor of ICES JMS to have more details on the plans of proceedings of the symposium publication.

The group thanked the SSC for their work and suggests to continue the ToR till next year allowing to evaluate the outcomes of 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

Completed in 2015.

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

Leads: Webjörn Melle, Rapporteur: Astthor Gislason

Webjörn Melle introduced this point of the Agenda by reviewing the management plans for *Calanus finmarchicus* in Norwegian waters, focusing on fishery and how the quotas are set.

Based on field data and modelling, the total annual biomass of *C. finmarchicus* in the Norwegian Sea is estimated as ~33–40 million tonnes wet weight. Most of the biomass is located in the region of the Norwegian Sea influenced by Atlantic Water. During May, by far the main part of this biomass stays in the upper 200 m of the water column.

The Norwegian company Calanus AS is involved in experimental fishery of *C. finmarchicus* in Norwegian waters. From 2003 until present the annual catches of *C. finmarchicus* have ranged from ~10 – to 500 tonnes, the highest catches being taken in 2014 and 2015 (~300–500 tonnes). The main product is Calanus oil. The company is instructed by the Norwegian Fishery Department to take samples of the catches for bycatch of fish eggs and larvae. The analysis of the samples is done by IMR on instruction from NFD. Together Calanus AS and IMR work towards improved sampling and conservation routines.

Webjorn also presented an example of how bycatch of fish eggs and larvae might affect cod recruitment. In a total catch of ~200 000 kg *Calanus* in 2014 there were estimated 2.3 million eggs and 2.3 million larvae as bycatch. To examine the consequences of this bycatch, the number of cod eggs and larvae surviving to recruits was assessed. The calculations show that this bycatch would result in 1158 cod not recruiting to 3 year old group. When these data were scaled up to the total allowable catch of *Calanus* (1000 tonnes), estimates suggest that 5669 cod would not recruit to 3 year old fish. This is an insignificant number in comparison with the number of 3 year old cod as estimated by ICES in 2012 (693 million individuals).

Webjörn continued by providing an overview of the spawning areas of important commercial fish stocks in Norway. The spawning areas of several of the fish species are located in the Lofoten area, where the fishery of *Calanus* is most concentrated. The importance of the Lofoten area for the *Calanus* fishery, might be explained by relatively high *Calanus* concentrations there and also by fact that the ships used for the fishery are relatively small and not suitable for operating in open oceanic waters.

Model results of potential changes in biomass of *Calanus* and the consumption by herring due to a *Calanus* fishery was presented. Model results showed that even with a fishery of 3.3 million tonnes wet weight of *Calanus* removed evenly from the entire Norwegian Sea during summer, would have insignificant effect on *Calanus* consumption by herring.

The biological advice of IMR and the management considerations of the Norwegian Fisheries Directorate consider the following elements:

- *Calanus* is considered to have a key role in the Norwegian Sea ecosystem.
- The standing stock of *Calanus* in the open waters of the Norwegian Sea (~1.2 million km^2) is estimated as 33 million tonnes wet weight.
- Biological advice suggests a catch of 10% of standing stock giving 3.3 million tonnes wet weight.
- 50% area restriction makes 1.65 million tonnes wet weight.
- The effects of bycatch in coastal waters are considered minimal – still it is considered advisable to limit the major quota to bottom depths greater than 1000 m.
- The fishery should be limited both geographically and temporally and a precautionary approach should be used when issuing the quotas to 10% of 1.65 million tonnes giving 165 000 tonnes.
- The coastal areas (<1000 m bottom depth) are at present only fished by Calanus AS. In these areas it is considered sufficient to issue a quota of 3000 tonnes to continue and further develop the fishery.
- In the oceanic areas (>1000 m bottom depth) the quota will then be 165 000–3000 = 162 000 tonnes.

The following discussion revealed that the management plan would be changed if biological conditions were to change. Also that it was important to take into account year-to-year variability in biomass and productivity of *Calanus*. It was felt important that a multi-species approach be taken regarding an eventual fishery for *Calanus*.

The group agreed to conclude this ToR next year, when the final version of the management plan is available together with the outcome of the special workshop on zooplankton as a potential harvestable resource, at the upcoming 6th Zooplankton Production Symposium in Bergen (9–13 May 2016).

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

Shifted to 2017 due to the ToR Leads absence.

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

Leads: Klas Ove Möller, Elvire Antajan, Astthor Gislason, André Gonçalves, Mark Benfield by correspondence, Rapporteur: Tone Falkenhaug

Klas Ove Möller presented the progress of a planned peer reviewed journal review article on image analysis systems. This review article is the final outcome of ToR e. Klas presented the outline of the article which will include descriptions of *in situ* systems, such as the VPR, UVP, ZooVIS, ISIIS, OPC, and lab instruments like Flowcam, Zooscan, and bench VPR. Capabilities of the systems, calibrations, inter comparisons, classification software, and a summary of useful publications will also be included in the review.

It is the second year of Tor e, and the plan is to submit the manuscript in 2017. It can be considered as completed by the submission of the manuscript. Thus, the ToR will be finalized next year when the manuscript of the peer-review publication is ready for submission.

The group suggested to also include Flow Cytobot, Flowcam Macro, and non-commercial image analysing systems (such as the ZooImage) in the review article. Protocols should be included as supplementary material or as links to updated protocols. The group also agreed that the next step is to approach individual people and ask them to contribute to each section. The first draft of the manuscript will be distributed to the whole group for comments. All contributors to the different sections will be included as co-authors.

André Sobrinho Gonçalves presented an image analysis system based on a flatbed scanner (3200 dpi) and a free R-software package (Lotofpel 0.6 R-package). The analysis does not identify organisms to species level, but can distinguish between different copepod genera and at a higher taxonomic level of other taxa. Conversion from numbers to biomass is made by using a non-species specific conversion factor.

Elvire Antajan presented a Zooscan Image analysis system used to distinguish anchovy and sardine eggs. It is also able to distinguish between 15 different copepod genera. The instrument is used to analyse old zooplankton samples taken during ichthyoplankton cruises.

Astthor Gislason presented a non-commercial image analysis system based on a flatbed scanner (2400 dpi, grey images) with a free software (ZooImage). The results show good agreements between ZooImage and the results from microscopy. Conversion from numbers to biomass are made by using algorithms. This method is used to analyse historical samples that would otherwise not be analysed.

The group discussed advantages and disadvantages of image analysis methods such as ZooImage. Webjørn Melle asked if biomass estimates using ZooImage are more advantageous than direct biomass measurements of different size fractions and larger taxa. Astthor replied that the ZooImage method is used on samples that will otherwise not be analysed. In addition, the ZooImage has a better resolution than the direct biomass measurements of size fractions, especially for the smallest size fraction.

Image analysis could also be useful for analysing microplastics, but a good method for the characterization of different microplastics using image analysis is not well developed.

The group also discussed if the image analysis methods have procedures to detect new (introduced/invasive) species. Astthor replied that image analysis systems are not suitable for the detection of new species, since all specimens are put in to one of the available categories in the system. Thus, the analysis needs to be validated manually on a regular basis, in order to update the categorization.

Another problem with image analysis is that the recognition by the software is not constant, but changes if specimens are attached, or if there are aggregates of phytoplankton and detritus in the sample. It is thus necessary to spend time to separate aggregates. Image analyses software procedures are available to separate specimens that are attached. Such problems and details are usually not well described in the method sections of papers.

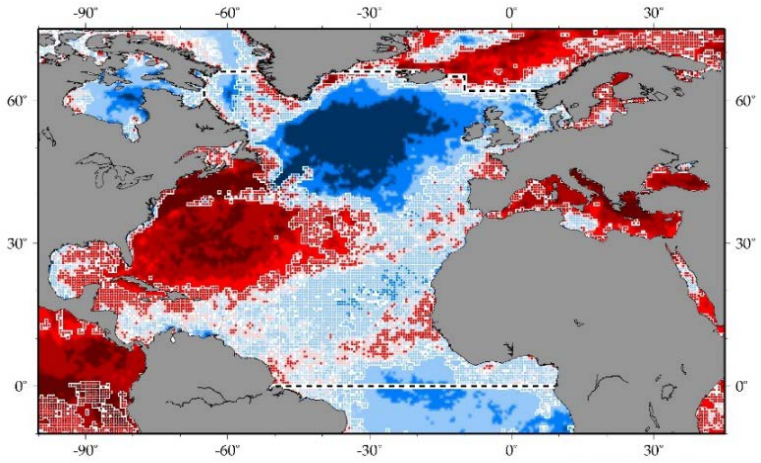
ToR f) Expand and update the WGZE zooplankton monitoring and time-series compilation

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

WGZE is slated to create the next edition of its Zooplankton Status Report series next summer (2017). Todd O'Brien reminded the group that ICES will no longer be creating paper printed versions of these reports. A high-resolution PDF, with full review, editing, and professional layout, will still be prepared by the ICES printing group. This PDF is still publication quality, and one could easily have it printed and bound, but at their own cost. ICES also encouraged the creation of corresponding digital and interactive content to go along with these reports. The end result would ideally be a web-based resource with a citable publication at is base.

The WGZE was a significant contributor of North Atlantic time-series to the IOC/UNESCO International Group for Marine Ecological Time-series (IGMETS) global time-series study. Todd O'Brien is a member and products developer for both groups, and has been co-developing WGZE's next generation time-series analysis tools during his work with IGMETS. Through the cross-group work and collaboration, a new time-series explorer will be created and added to the WGZE.net web pages. The IGMETS version of this interactive tool is online at: http://igmets.net/explorer.

The WGZE version of this interface would be similar in design, but would focus on sub-areas of the North Atlantic (versus different oceans of the world). It would also include newer data. While the IGMETS publication covered a time period up through the end of 2012, the next WGZE status report will go through the end of 2015. This three year period has seen dramatic changes in the North Atlantic and even globally.



An IGMETS/WGZE spatio-temporal trend plot showing ten-year (2006–2015) sea surface temperatures trends in the North Atlantic region. Red areas indicate warming, blue areas indicate cooling.

The next generation of the WGZE Status Report will examine both interannual and month-based trends. The addition of monthly examination is important as some regions are seeing strong changes in a single season (e.g., spring or winter) that are dampened or less obvious from a twelve month (annual) view. Strong spring or winter changes, for example, can affect the strength of the spring bloom and/or productivity that may impact

the rest of the season. Likewise, strong summer warming can lead to stratification and reduced production. Together, these possibly opposite effects can counter each other and show a "flat" annual pattern, even though large changes are happening at the seasonal level.

It was suggested that the next report could include special "two page" topic discussions. These topics would include topics that are relevant to zooplankton research and may have been discussed by WGZE in previous years. Current topic ideas would include:

- A general "Introduction to Zooplankton", briefly describing the major net-caught zooplankton groups and including a note about the importance of gelatinous members that can play a huge role in the ecosystem yet cannot always be quantitatively sampled by traditional net methods.
- A discussion on the merits and disadvantages of measuring total biomass vs species abundance vs individual biomasses.
- An introduction to image-based sampling techniques.
- An introduction to molecular identification techniques (a tie-in to WGIMT).

The next version of the status report will also include species lists within each individual site summary, which will tie the report into ToR I and "COPEPEDIA" discussed later in this report. This will be a first step in WGZE's path toward looking at species-level changes in the zooplankton.

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: Maria Grazia Mazzocchi and Piotr Margonski, Rapporteur: Antonina Santos

This part consisted of three presentations:

- Implementation of the EU Marine Strategy Framework Directive - A marine ecologist's perspective
- The Mediterranean approach to zooplankton indicators
- Testing of the zooplankton mean size and total stock (MSTS) indicator calculated based on the Polish monitoring data from the southern Baltic Sea

Implementation of the EU Marine Strategy Framework Directive – A marine ecologist's perspective (Piotr Margonski)

WGZE monitors various activities linked to zooplankton ecology in the North Atlantic region and various, recent scientific and management activities in Europe focus on subsequent steps of the EU Marine Strategy Framework Directive (MSFD) implementation. The main aim of the MSFD is to protect more effectively the marine environment across Europe. To introduce and summarize the MSFD concept to non-European group members, Piotr Margonski provided a general overview of its basic assumptions and goals, steps in the process, role of EU Member States and Regional Conventions, descriptors,

concept of good environmental status (GES), indicators and pressures, reference condition, (integrated) monitoring programmes, and programmes of measures. Special emphasis of the presentation was focused on the indicators and their role in evaluation of and achieving of GES.

The Mediterranean approach to zooplankton indicators (Maria GraziaMazzocchi)

The Mediterranean Sea is the largest semi-enclosed sea in the world and is considered a biodiversity hotspot. Its high diversity concerns not only the marine fauna but also human beings. In fact, bordered by 26 between countries and territories of Europe, Africa, and the Middle East, the Mediterranean is not only one of the most densely populated regions of our planet, but the site of a large variety of populations and cultures. In 1975, under the umbrella of the UNEP (United Nations Environment Programme), the Mediterranean Action Plan (MAP) was adopted as a cooperative effort involving countries bordering the Mediterranean Sea, as well as the European Union. The initial focus of the MAP was on marine pollution and in 1976 in Barcelona, these Parties adopted the Convention for the Protection of the Mediterranean Sea against Pollution (Barcelona Convention, BC), which in 1995 was revised for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. Today, the 22 Contracting Parties (including the EU) (of which 8 are also EU Member States) are also boosting regional and national plans to achieve sustainable development. The BC/UNEP-MAP framework provides the regional legal basis for the Mediterranean for setting common environmental standards and targets for all Contracting Parties (COP) to agree on, take coordinated measures and monitor their implementation.

In 2008, during the 15th conference of the contracting parties (COP15), the ecosystem approach (EcAP) was endorsed as an overarching principle of the UNEP/MAP system and 4 years later it was recognized as a guiding principle for the overall work under the BC. The EcAp has adopted 11 Ecological Objectives, which mirror the 11 descriptors of the EU Marine Strategy Framework Directive (MSFD). Among the work currently ongoing for the EcAp Roadmap there is the preparation of the Integrated Monitoring System based on the agreed indicators and Targets, in full synergy with MSFD. The initial phase (2016-2019) of the Integrated Monitoring and Assessment Programme (IMAP) implementation will focus only on a set of core common indicators where data and practice are more mature. After the initial phase, the IMAP will be implemented with possible adjustments and the inclusion of additional (candidate) common indicators. The initial core of common indicators includes Biodiversity, but not Food Webs, though. The Food Web is partially addressed by the biodiversity-related common indicators.

In relation to Biodiversity, the indicators agreed for the core of the IMAP that should be the basis of a common monitoring program in the Mediterranean are 5 and only one is applicable to plankton: Condition of the habitat's typical species and communities. For monitoring changes in zooplankton, simple life forms are considered: small and large copepods, holo- and meroplankton. The first pair is also proposed by OSPAR, while in OSPAR the second pair is constituted by copepod grazers and non-copepod grazers. The life-form pairs can provide an indication of changes in: the transfer of energy from primary to secondary producers, the pathway of energy flow and top predators, the benthic/pelagic coupling. It is proposed that this approach be adopted on an optional basis for the Mediterranean Contracting Parties, with a view to investigating the applicability

of the methodology for Parties with existing time-series. As the knowledge base increases, new pairs can be developed as indicators. Data on pairs can be expressed in abundance or biomass, whatever is most relevant to the group in question and available from monitoring programmes.

Next to the EcAp MED project, which is an EU funded project, specifically assisting the BC Secretariat in achieving this Roadmap, there were several other projects on Marine Research in the Mediterranean and Black Sea that were financed by the EC under the FP7 and are critical for the achievement of GES in the Mediterranean by 2020. The project PERSEUS (Policy-oriented marine Environmental Research for the Southern EUropean Seas), which ended in 2015 and was closely linked to MSFD, merged natural and socio-economic sciences to predict the long-term effects of natural and human pressures on marine ecosystems. Within PERSEUS, a comparative analysis of Initial Assessments for five SES countries (Spain, France, Greece, Cyprus, and Romania) was performed to identify the major pressures jeopardizing the environmental state of SES and link them directly to possible impacts in a coherent and integrated manner (Crise *et al.*, 2015). Despite the increasingly important effort made by Mediterranean countries, there are still critical gaps in the information and data for many key components of Mediterranean marine biodiversity. The main knowledge gaps consist in the lack of a proper understanding of marine biological diversity and food web functioning, which is far from operational and deserves a targeted study, being the backbone of any holistic approach to the management of the marine environment.

The latest recommendations of the UNEP-MAP for monitoring of biodiversity in the Mediterranean open and coastal waters highlight the need to build on existing:

- national databases such as checklists, lists of species at representative sites including ones for invasive species, information from existing national monitoring networks;
- existing time-series, e.g. minimum 20 years;
- network of marine protected areas (MPA);
- networks of observation systems, such as LTER, EMBOS, LIFEWATCH, CIESM Jelly Watch;
- network of laboratories.

In order to ensure feasibility and cost efficiency and at the same time scientific accuracy, the following realistic approach was recommended:

- agreement of *de minimis* common monitoring specifics, most cost-efficient methodologies that could be applicable for the whole Mediterranean;
- use of already existing and in place methods, tools or indices should be preferred or adopted;
- using the MPA's monitoring data also as a comparison, a point to calibrate level of difference or as a baseline in cases historical data do not exist;
- identification of key specific sites, so-called representative sites for biodiversity monitoring per country (and ideally also sub-regional stations with joint monitoring, possibly on a pilot basis).

Monitoring of plankton communities was recommended as an additional area where important changes in biodiversity could be identified.

References

Crise A, Kaberi H, Ruiz J. *et al.* (2015) A MSFD complementary approach for the assessment of pressures, knowledge and data gaps in Southern European Seas: the PERSEUS experience. Marine Pollution Bulletin, 95, 28–39.

UNEP-MAP (2015) Draft Integrated Monitoring and Assessment Guidance. Agenda item 3: Draft Integrated Monitoring and Assessment Programme, 5th Meeting of the Ecosystem Approach Coordination Group, Rome (Italy), 14-15 September 2015. UNEP(DEPI)/MED WG.420/4.

UNEP-MAP (2015) Draft Decision: Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria. Agenda item 3: Thematic Decisions, 19th Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean and its Protocols. UNEP(DEPI)/MED IG.22/10.

Testing of the zooplankton mean size and total stock (MSTS) indicator calculated based on the Polish monitoring data from the southern Baltic Sea (Piotr Margonski & Joanna Calkiewicz)

Results on mesozooplankton community structure dynamics provide valuable information on understanding of ecosystem functioning, changes in pelagic food webs, and contribute to the assessment of Good Environmental Status as defined in the EU Marine Strategy Framework Directive (MSFD).

The zooplankton Mean Size and Total Stock (MSTS) is a Baltic Marine Environment Protection Commission (HELCOM) core indicator primarily relevant for food webs (MSFD criterion 4.3: abundance/distribution of key trophic groups/species) with a secondary link to biodiversity (MSFD criterion 1.6: habitat condition). MSTS indicates that the investigated pelagic food web structure is or is not optimal for energy transfer from primary producers (phytoplankton) to fish.

The MSTS indicator was applied to test changes in the pelagic food web structure in the southern Baltic Sea. This core indicator appears to be very useful for this role: it considers the zooplankton mean size change as a consequence of an increase of small taxa biomass (along with an increasing eutrophication) and especially a decrease in abundance of larger copepods (due to the impact of hydrological conditions' change as well as predatory pressure of small pelagic fish). The MSTS indicator provides estimates of the feeding conditions for sprat, herring, and cod larvae, and the grazing pressure on phytoplankton.

MSTS is strongly linked to two anthropogenic pressures listed in the MSFD Annex III, Table 2: selective extraction of species and nutrient and organic matter enrichment.

Data that are the Polish contribution to the HELCOM COMBINE Programme were used for indicator testing. In most of the cases, samples were taken 5 times per year using a WP-2 net. The longest data series (since 1979) were collected at deepwater stations whereas those taken at more coastal ones started within the last twenty years. Considering the different length of presented data, two alternative strategies for setting reference conditions had to be applied: (i) for coastal stations the long term mean and the corresponding variance was calculated based on the entire dataset and (ii) for the open-water

stations the reference periods were defined based on chlorophyll a concentrations and weight-at-age of clupeid fish.

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

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

Ann Bucklin updated the group on WGIMT activities. WGIMT has achieved desired membership growth (ToR A), increasing from 12 members in 2012 to currently 42 members from 15 countries. Progress is continuing on development of a WGIMT web portal (ToR B), with pages for morphological, molecular, optical, and integrative approaches to taxonomic identification of zooplankton (see http://wgimt.net). A successful integrative taxonomy workshop was held (ToR C): the SAHFOS Crustacean Zooplankton Workshop (Plymouth, UK; June, 2015) provided hands-on training for 22 students from 15 countries, with invited presentations by international experts, including several WGIMT members. WGIMT will have excellent opportunities to promote its core mission of integrative molecular and morphological taxonomy (ToR D) at the ICES-PICES Zooplankton Production Symposium (Bergen, Norway; May, 2016); WGIMT members will serve as convenors and invited speakers for Session S4 and Workshop W7. Whether and how WGIMT can play a larger advisory role in marine science and management (ToR E) is being explored via discussions with other SSGEPD and ACOM EGs, including WGPME and WGAGFM. In contrast, formal cooperation with WGITMO and WGBOSV (ToR F) was ended by mutual agreement, in light of WGIMT's exclusive focus on zooplankon, which excludes many important introduced / transported species in ballast water. WGIMT members published 7 peer-reviewed journal articles on diverse aspects of integrative taxonomy of zooplankton, including a HORIZONS article in the Journal of Plankton Research on metabarcoding by 5 WGIMT co-authors (Bucklin *et al.*, 2016), again exceeding our goal of 2 papers per year (ToR G).

Piotr Margonski presented the areas in which the possible future cooperation were suggested by Alex Kraberg (WGPME Chair):

1) WGPME continues their analysis of the long-term data series (WKSERIES follow-up). Unfortunately the data were so heterogeneous that integrating/analysing them took much longer than anticipated.

   Zooplankton is still not included in those analyses, but there is a potential for future discussions.

2) WGPME is interested to explore how to contribute together with WGZE to the further plankton indicator development.

In summary, the three groups supported an idea to work together on delivering potential products useful for the advisory system. One of the possible examples is to provide an innovative approach to indicators development including molecular and genetic information relevant to e.g. biodiversity, food webs, and NIS. The other area of cooperation might be the common analyses of the plankton long-term data series initiated at the WKSERIES workshop.

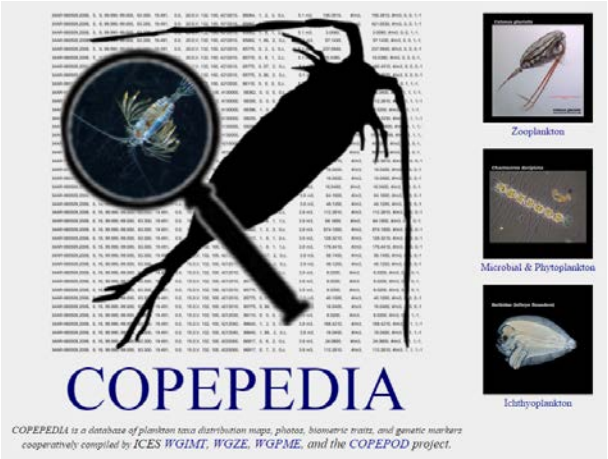
ToR i) Refine and expand the compilation of information on zooplankton species, taxonomic categories, and life stages that are currently monitored in the ICES area

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

Claudia Castellani started the session with an overview of the soon-to-be-published *Marine Plankton: A practical guide to their identification and ecology for the North Atlantic* (Oxford University Press). This book will serve as a modern plankton identification and reference manual aimed at students, academicians, and practitioners. It will cover plankton identification, methodology, and ecology and distribution. The identification aspect will focus on North Atlantic (sub-Arctic to sub-Tropical) phytoplankton and zooplankton species, featuring taxonomic keys, photos and drawings, and distribution maps. The methods section will give an overview of plankton sampling methodologies, including some of the latest technologies and identification techniques. The ecology section will include topical mini reviews on plankton habitat, eco-physiology, their role in food-webs and in biogeochemical cycles, and their link with climate change.

Todd O'Brien then gave brief history of this ToR and its progress over the years, starting first with a spreadsheet of species compiled for 23 WGZE time-series sites (created by Damien Eloire many years back). This information was updated and built into a simple interactive web map that listed what species were found at each WGZE time-series location. Finally, this work was expanded into spatial maps showing North Atlantic species distributions based on SAHFOS-CPR and WGZE time-series sites.

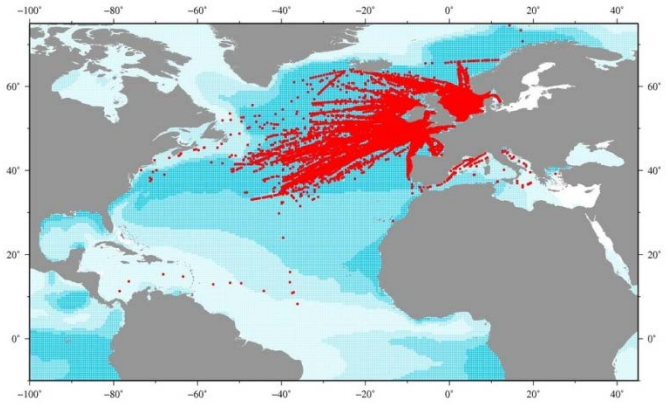
Over the last year, it became evident that this ToR, and multiple other WGZE activities (e.g., ToR j - biomass and metabolic rates, ToR f – the zooplankton status report taxa lists), and co-occurring WGIMT activities (e.g., their photo library and molecular primers data) all required a similar taxonomy-based, underlying database structure. To support the collaborative goals and needs of WGZE, WGIMT, and COPEPOD, Todd O'Brien has created a new taxonomic-based information database called "COPEPEDIA" (http://copepedia.org). This single, shared database benefits from the expertise of all parties, and provides combined information that is greater than the sum of its parts.



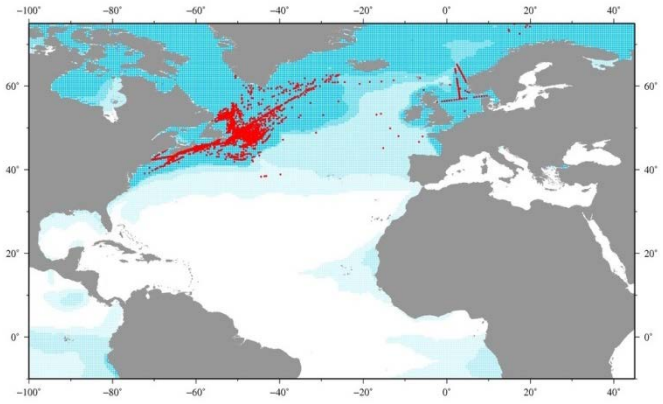
COPEPEDIA will cross-link taxonomic information across many ToRs and resources. A user looking at species found in one WGZE time-series can click on a link to find out where else this species was observed within the North Atlantic or even globally. Through its tie-in with WGIMT, photographs of this species may be available. Through its tie-in with WGZE ToR j), there may also be individual biomass, length, or life-history rate information for the taxa. This in turn all benefits from COPEPEDIA's collaborative development of new data and features by COPEPOD and also the global IOC/UNESCO International Group for Marine Ecological Time-series (IGMETS) efforts.

To integrate COPEPEDIA into all varieties of tables, documents, and web pages, it has a direct-linking feature to any taxa entry in the database. For example, the two map titles (below) are active hyperlinks to their corresponding COPEPEDIA species entries. These links use a unique identifier (e.g., "T4000170" for *Calanus glacialis*) and a standardized html address: http://copepedia.org/?id=T4000170

Calanus helgolandicus



Calanus glacialis



COPEPEDIA maps showing observation locations (red dots) of two copepods species: *Calanus helgolandicus* (upper map) and *Calanus glacialis* (lower map). The blue background fields show areas of theoretically compatible environments for each species, based on temperature and salinity. The darkest blue areas represent the most likely compatible areas, while white areas represent the least compatible areas. *Calanus glacialis* prefers cooler waters than *Calanus helgolandiscus*, as seen in both distribution and blue-shaded regions.

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, Todd O'Brien, and Patrik Strömberg, Rapporteur: Lidia Yebra

This ToR covers two main aspects: (i) "Calculate zooplankton productivity and metabolic rates in the ICES area based on allometric approaches" and (ii) "Build a database of zoo-

plankton individual species biomass, productivity, and metabolic rate equations". Work to complete this task started in 2013. Expected deliverables are:

- Contributions to the next Zooplankton Status Report (ZSR) in 2017, and
- A peer-reviewed publication.

Lutz Postel repeated the principles of calculations and reported on progress and further steps of aspect (i) :

- Zooplankton productivity and metabolic activity were calculated using individual specific rates obtained from mass scaling equations. This size-based approach combines concurrent assessments of total mesozooplankton and total abundance to derive a mean mass per individual. The attempt widely covers the ICES area based on a number of time-series available.
- Currently sixteen data sets of different measuring length and sampling intervals had been considered in the analysis covering Labrador Sea (1), Scotian Shelf (1), Nordic and Barents Seas (1), Baltic Sea (4), North Sea and English Channel (3), Bay of Biscay and western Iberian Shelf (5), and Mediterranean Sea (1). The central North Atlantic, the US shelf, and the Malaga area will be added in the next round.
- Mesh size, method of biomass determination, and organisms occasionally occurring in samples are factors influencing the average body mass, which is the main input variable for the calculations:
    - In principle, mesh sizes select a certain plankton fraction.
    - Occasionally occurring organisms larger than mesozooplankton (>200μm) and smaller mesozooplankton (>100μm, in the Baltic Sea) were excluded from the analysis by a statistically based outlier rejection procedure.
    - The input parameter dry mass was mainly applied. Wet mass was used in three cases, displacement volume and carbon determinations one time in each case. Conversion factors were used reasonably.

Deliverables of this ToR will include:

- Oral presentation during the 6th Zooplankton Producton Symposium (ZPS) in Bergen. Norway, in May 2016 on *Zooplankton Production and Metabolic Activity in the North Atlantic and Adjacent Seas* by Lutz Postel *et al.* The presentation is part of Workshop 2, which will allow opportunities for discussion of methodological aspects.
- Submission of a manuscript based on this presentation and considering the outcomes of the discussion.
- Contributions to the next Zooplankton Status Report (ZSR) in 2017:
    - Description of the method including restrictions and potentials.
    - Figures on seasonal and inter-annual variations of productivity and metabolism according to the current style of classical parameter.

Lutz Postel showed that the O/N ratio calculated by Ikeda equations is close to 7 in all time-series. Claudia asked if this is correct as Ikeda's paper was based on spring biomass, and there may be a bias on data with the summer time-series. Lutz replied that the adequacy of equations to be used will be discussed at the Workshop 2 of the ZPS. Also, in relation to production calculations, Claudia expressed concern about the effect of latitude on production, but Lutz showed that there is not a clear pattern in the data. Results primarily rely on body size rather than on latitudinal temperature effects according to the equations applied.

The plan to include these figures in the ZSR was discussed. Piotr and Todd commented that not all data series may be presented online. Piotr pointed out that it would be great if all the data published by the group online have DOI as well as a very precise note on how to cite this data when used in publications. Lutz replied that the paper to be published in the proceedings of the ZPS can be cited. Peter noticed that in order to be able to cite the data, they have to be fully available as it is already requested by some journals. Lutz asked Astthor if supplementary material will be included in the ICES Journal of Marine Science publication. If not, the data included in the paper could be uploaded to the WGZE webpage as supplementary part in the ICES JMS publication.

After Lutz's presentation, Todd O'Brien noted that the WGZE/WGIMT/COPEPOD collaborative taxonomic information database called "COPEPEDIA" (http://copepedia.org, presented earlier in the meeting and introduced in the ToR i section of this report) could be used to store all of this information (e.g., individual species biomass, productivity, and metabolic rates) at their respective taxonomic levels (e.g., species or genus or higher). In terms of access and application, COPEPEDIA stores the information in a way such that same-taxa biomass and rate information would be easy to co-combine into secondary ratios, products, and calculated data elements (supporting the proposed productivity equations mentioned during Lutz' presentation). The combined information in COPEPEDIA would be an incredible asset to the zooplankton research and modelling community, and a worthy future ToR and focus topic for WGZE. Populating this database (with ToR j materials) would have to be a joint group effort, with people forwarding publications or personal measurement data for inclusion in the database.

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: Elvire Antajan

The Category 1 Resolution to PUBCOM To update and continue the publication of ICES Identification Leaflets for Zooplankton (formerly Fiches d'Identification du Zooplankton) series was submitted with the support of WGZE & WGIMT. It was approved at the SCICOM September 2015 meeting.

The historical ICES Identification Leaflets for Plankton will be revived and maintained on the following basis:

- Compile a list of experts covering the different taxa to act as authors for the update and creation process (There is already a first list of experts based on the SAHFOS Marine Crustacean Zooplankton Workshop 2015);
- All the leaflets need to be updated. The leaflets that require urgent updating will be identified and prioritized by the editors, with the help of the experts;
- Prepare a list of key plankton taxa (i.e., abundant and widespread in the ICES regions of the North Atlantic) that are not yet included in the series;
- The leaflets will be peer-reviewed under the editorship of Antonina dos Santos and Claudia Castellani;
- The series will be given a DOI number;
- The ICES secretariat will provide standard proofing and formatting services;
- The success and utility of the series will be reviewed in 2019.

The new template has been prepared by ICES. It was also decided to keep the existing numbering system of leaflets, and replace the current versions when updates are ready. The new structure and content has been suggested:

- Abstract
- Introduction
- Keys
- Figures and photos
- Geographical distribution
- Links to molecular information and Worms/ITIS
- References

ICES requested that the total length of the individual document should not exceed 10–12 pages.

The editors decided that the first new leaflets to be updated will be on *Oithona*, *Temora*, and Chaetognatha. The group supported the editors' efforts and discussed the potential contribution of the WGZE members.

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

Completed in 2015.

Possible WGZE contribution to the work of the ICES Workshop to Plan and Integrate Monitoring Program in the North Sea in the 3rd quarter

Lead: Sophie Pitois, Rapporteur: Kathryn Cook

In February 2016, The Workshop to Plan and Integrate Monitoring Program in the North Sea in the 3rd quarter (WKPIMP) met at ICES headquarters in Copenhagen. The workshop aimed to create a framework for an integrated monitoring programme to address

the monitoring and assessment requirements for fisheries, changes in ecosystem productivity, and the impact of fisheries on the environment. The final survey objectives should represent ecosystem function as well as the regulatory needs, and the prioritization follows from both ecosystem function and societal relevance. The framework was:

- using the current North Sea International Bottom Trawl Survey (NS-IBTS) conditions as a starting point (ship time, temporal and spatial coverage),
- taking the current NS-IBTS 3rd quarter obligations (provide information for fish stock assessment) into account,
- taking the needs as defined by other bodies (EU, ICES groups, OSPAR) into account,
- following a stepwise approach as described in Annex 5 of WGISUR report 2015.

The collection and analysis of zooplankton samples was discussed during the workshop and the framework recommends the use of underway sampling combined with vertical or oblique deployment of nets of mesh size selected to catch various fractions of the plankton (i.e. gelatinous plankton, fish eggs and larvae, mesozooplankton). Because of budget pressures for monitoring programmes, the use of automated and semi-automated methods was also discussed. The Framework was presented to the WGZE participants who were asked to provide recommendations and suggestions for an optimum zooplankton programme.

Discussion:

Elena Gorokhova began the discussion be asking how the work from this workshop is linked to existing monitoring efforts. Elena was concerned that some of the work undertaken by the workshop fell into the HELCOM area where monitoring is currently being revised and it is unlikely that ICES recommendations would be considered. Sophie replied that the workshop was all about redesigning the current monitoring program and not adding pressure for ICES or the individual countries. It is a known issue that ICES and HELCOM do things differently, but the way things are currently done in the ICES area is not working as different institutes collect different 'extra' data which aren't comparable.

Piotr Margonski noted that HELCOM has separate environmental and fisheries sampling programs and enquired whether it is the same in the North Sea. Sophie responded that environmental sampling in the North Sea is very ad-hoc, which is why there was a need for this workshop. There is no environmental sampling that covers the whole of the North Sea and Channel. The largest area is covered by fisheries stock assessment cruises, but usually only temperature and salinity data are collected. However, these cruises present an opportunity as the ship and scientific staff are already paid for so the only extra cost involved in collecting extra data are analysis costs. Piotr asked whether the extra sampling would require more people on board the ship. Elvire responded that in France they are not using extra staff and are trying to maximise automatic analyses that can be done during the cruise as anything analysed afterwards carries an extra cost. These costs may sometimes be met as part of a research project, but the idea behind this workshop was to create ideas for making this sampling more official and work out what is possible for fisheries surveys to add.

Elena noted that there are already guidelines for the Kattegat and Skagerrak so if this workshop produces different guidelines, these cruises will have extra work to do. Sophie replied that the ships currently only work during the day. There is a need to think about how to use the night time for extra data collection and sample analysis which doesn't have to be the same for each institute. It is now being recognised that sampling by ICES box is not the best strategy.

Piotr commented that the hydrology data in the ICES database is very spatially and temporally unbalanced with lots of overlap between vessels. This could be improved if there was co-ordination. Lutz Postel noted that this is a general problem in ICES. There are many activities but a lack of co-ordination and data exchange. There needs to be a group looking for gaps in monitoring in the ICES area and potential areas to address them. Sophie stated that this workshop was a first look to produce a crude plan of what people recommend. This will then be trialled this summer or next summer and then re-evaluated. Peter Wiebe asked what the recommended plan was. It would be interesting to see the contrast between what we want to monitor and what we must monitor, and there would have to be a subsequent discussion on how to proceed. Sophie replied that at the first meeting they had agreed to focus on the North Sea, and the report is now complete and should be available on the WKPIMP page soon. The current recommendations are 10 WP2 net, 10 MIKT net, and 10 WP3 net samples on each survey, but that different areas may need different sampling strategies.

Tone Falkenhaug asked whether there is a complete list of monitoring cruises in the North Sea each year and whether they are all fisheries surveys. She noted that Norway has zooplankton and environmental cruises in the northern North Sea, Kattegat, and Skagerrak each year and wondered whether these data would be used in an integrated monitoring plan. Sophie replied that zooplankton data has been recognised as a gap, so this workshop was looking at ways to implement extra sampling without extra cost where needed.

Piotr commented that the vessel used for a survey would affect what samples could be taken. For example, some of the ships that are used in the Baltic would be too small to cover the extended integrated sampling programme. Adding fishing to an environmental cruise would require extra fishing crew, which would leave less room for scientists on board. Integrated monitoring is fine for big ships but smaller vessels need to have more focus. Sophie agreed that there needs to be discussions to get the right people on board. The next step after the initial plan has been tried will be to evaluate whether it worked well enough, whether sampling technology is sufficient, and then redesign if necessary. If it works in the North Sea the process could be repeated for the Baltic to fit the sampling requirements and technology available there.

Lidia Yebra noted that there was a pilot study as part of the IRIS-SES (Integrated Regional monitoring Implementation Strategy in the South European Seas) project in the Mediterranean using a large fisheries survey vessel to implement several MSFD descriptors including plankton sampling (but not analysis). They managed to have enough staff and sampling equipment, but found that the vessel couldn't go close enough to the coast to sample there, and that all samples had to be taken at night. They concluded that fisheries surveys should remain as they are and smaller boats should be used for plankton monitoring. The pilot report is available on the IRIS-SES webpage at http://iris-ses.eu/category/outreach/results-outreach/. Piotr asked whether fisheries surveys that

are currently deploying CTDs could easily add WP2 net hauls to these stations. In the Baltic it is routine to deploy CTDs with a water bottle rosette. However, Lidia replied that many fisheries surveys don't deploy a rosette, and usually the fish sorting is done as the ship steams between stations. Elvire noted that French sampling in the Channel and Bay of Biscay uses a large ship and there is time before each trawl to do a CTD/WP2/WP3 station. However, in the Mediterranean they use a smaller boat and there is not much time between stations so they only do CTDs and plankton sampling at night and at the first and last stations of each day.

Sophie noted that this workshop had focussed on IBTS surveys, which use large ships, in Q3 where there is plenty of down time at night. The other quarters still need to be considered, but it is difficult to convince people to change their way of doing things. Piotr noted that this needs top down pressure from decision makers because the MSFD requires more monitoring without extra funding so there needs to be optimisation. Elvire commented that in France they have proposed that the extra data collected could fit MSFD needs so the French Ministry has agreed to pay the extra analysis costs as long as data collection is covered by the fisheries surveys.

Piotr noted that a key requirement is to analyse information on what is currently collected and identify the gaps. Elena agreed that an inventory of methods, sampling area, and frequency, and a search for the most cost effective and reliable methods (which are probably those most commonly used) is the starting point. It was generally agreed that the importance of an inventory and gap analysis would be the recommendation from this group. Lutz asked whether this should be a task for the ICES data centre as the information must be available there. Piotr noted that this would work for the Baltic as the HELCOM database is located at ICES. He is not sure how well it would work for the North Sea, but ICES should have the best knowledge. Sophie stated that she was not sure that environmental and zooplankton data was even provided to ICES for the North Sea. So one would have to check country by country to get the information needed for a mapping exercise.

Sophie requested that any further thoughts and comments be directed to the workshop via Sophie. Sophie will put the workshop report on the WGZE SharePoint.

Report on the 2015 Theme Session S 'Basin-scale dynamics at lower trophic levels in the North Atlantic'

Leads: Astthor Gislason, Claudia Castellani, Peter Wiebe

Astthor Gislason reported on Theme Session S, *Basin scale dynamics at lower trophic levels in the North Atlantic*, at the ICES ASC 2015. The session was proposed by the WGZE in 2014 recognizing that the shelf and oceanic ecosystems of the North Atlantic are influenced at basin scale by a common atmospheric forcing, effects of which needed to be explored holistically. The session therefore encouraged people to present findings from a large area, preferable with a comparative view from both sides of the North Atlantic. More specifically, the purpose of the session was to explore:

1) The role of key species in the biological carbon pump.

2) Distribution of key species and ecosystem types.

3) Trophic pathways and production.

4) The dynamics of living resources and their utilisation.

5) Modelling efforts that integrate the biological and physical characteristics of the region.

The session was very successful. It attracted 26 high quality research contributions from 11 countries of which 18 were presented orally and 8 as posters. The presentations may be grouped broadly into presentations on dynamics of lower trophic levels (16 presentations) and living marine resources (10 presentations), both with modelling components. The session was concluded by a discussion in the end. One presentation (S16, Small-scale distribution of plankton and marine snow in the North Atlantic by Klas O. Möller, M. St. John, B. Christiansen, and C. Möllmann) was awarded (The ICES Early Career Scientist Award) among nominations from all sessions.

'WGZE and pteropods'

Lead: Mark Benfield by correspondence, Rapporteur: Piotr Margonski

WGZE was discussing 'request from the Joint OSPAR/ICES Ocean Acidification Study Group (SGOA)' at our 2015 meeting:

i) Collect and exchange information on biological effects on plankton, and macrozoobenthos; and

ii) Inform the development of biological effects indicators for ocean acidification, including the identification of suitable species and key areas.

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.

WGZE agreed to revisit this issue at the following meeting after determining whether other options or approaches might exist. The challenge that we face with regard to developing monitoring and preservation guidelines is that this will by necessity require experimental work to evaluate the proposed protocols.

In September 2015 Piotr Margonski received an e-mail from Evin McGovern who co-chaired SGOA along with Mark Benfield with request to develop sampling and perseveration methodologies with focus on sampling pteropods for archiving and retrospective analysis of shelf dissolution/morphology (once metrics are developed).

SGOA was interested in WGZE contribution to producing recommendations for monitoring and guidelines. Consideration on target species/abundance in NE Atlantic regions, metrics, sampling, and preservation would be very helpful.

It was mentioned that it would be of huge interest to OSPAR as to whether sampling for pteropods could be integrated into other zooplankton sampling taking place and indeed any sampling recommended for the MSFD (D1/D4).

There was information that since SGOA completed its report the British Antartic Survey has held a workshop on pteropods in the UK and a position paper is expected shortly.

Moreover, it was acknowledged that NOAA is progressing with the development of indices for monitoring pteropods as an OA indicator. Nina Bednarsek (NOAA) was contacted and she kindly provided the Guidelines for Pteropod monitoring presented below:

Guidelines for Pteropod monitoring (Nina Bednarsek, NOAA)

1 Introduction

The guidelines aim to address pteropods as related to ocean acidification (OA). The guidelines aim to ensure the delivery of consistent, high-quality pteropod observations related to ocean acidification.

2 Objectives

Pteropods as indicator of OA should be monitored for the purpose of determining the presence, extent, severity and spatial distribution of shell dissolution in sampled pteropods (% individuals affected by dissolution) to establish current temporal and spatial exposure to conditions.

3 Sampling strategy

3.1 General considerations

To correlate biological responses to OA, carbonate chemistry needs to be co-located along the biological measurement to provide estimates of spatial and temporal extent of dissolution. Establishing spatial and temporal variability in the natural environment is the base to devise the frequency and location of sampling. Sampling frequency should take place seasonally while taking into account the seasonal variability in the relative abundance and of the species of interest. It is recommended to include coastal and off shore localities with sampling at high temporal resolution year around and in addition to carry out monthly surveys with sampling at many locations.

3.2 Choice of sampled species

Measuring the response should be relevant to the most dominant and ecologically important in certain ecosystem. The recommendation for the OA monitoring in this manuscript relies on sampling and analytic procedures for *Limacina helicina*, but other species that inhabit similar water layer depths as *Limacina helicina* can also be considered for OA assessment, one of them e.g. *Heliconoides inflatus* which is abundant in temperate environments. The change in species choice should be accompanied by testing the procedure to get accurate, reproducible results that can be standardized to *Limacina helicina*. Meso- or bathypelagic species (e.g. *Clio pyramidata*) should be excluded from sampling as their responses and strategies at depths with more corrosive waters might be different from *Limacina helicina*.

3.3 Sampling methods and equipment for Limacina helicina

The sampling should take into account pteropod diel vertical migration (DVM). If the sampling occurs during the night, it should focus on the near surface water (0–25 m), while daily sampling should be prolonged and integrate sampling depth up to 100 m. To determine shell dissolution and abundance, integrating depth sampling is an acceptable technique, although stratified samples give better vertical resolution and can replace integrated sampling providing the resources and available sampling time. Oblique towing is preferred over vertical towing as it catches higher abundances of pteropods that can be used for bioassessments. Sampling can be with a variety of nets; using a 0.5m di-

ameter Bongo net usually provides sufficient number of individuals to be used for shell dissolution. Depending on the length of the sampled organisms, a net with 335 or 200μm mesh can be used, preferentially 335μm to catch larger size individuals that are easier to handle and less prone to damage. During the retrieval, care should be taken not to damage the fragile shells with recommendation of tows dragged vertically at no more than 30 meters per minute and horizontally lower than 0.5 knots per hour.

4 Supporting parameters

To interpret data on pteropod shell dissolution and abundance several supporting parameters are recommended: Chlorophyll a, inorganic nutrients, oxygen, temperature, and salinity. Highly relevant parameters are also other photosynthetic pigments (HPLC-analysis), total nitrogen, total phosphorus, particulate phosphorous, and nitrogen. Relevant for ocean acidification are: pH, pCO2, total alkalinity, and DIC (two parameters are samples, remaining to be calculated). Coloured Dissolved Organic Matter (CDOM) is a parameter important in areas influenced by river runoff. It is used e.g. to correct ocean colour data.

5 Preservation and storage of samples for shell dissolution

Upon retrieval samples, immediate preserving of organisms in 95% non-denatured ethanol with pH at around 8.5 is recommended.

6 Analytical procedures

6.1 Abundance analysis

Each sample containing pteropods should be enumerated for abundance data, otherwise zero value should be reported. Individuals per m^{-3} are calculated using data from a flow meter attached to the Bongo net.

6.2 Shell preparation for SEM analyses

On average, 15–20 shells should be included for analysis from each sample. A series of steps is included into washing the shell to remove precipitated minerals, bacteria and the periostracum from the shell (Bednarsek *et al.*, 2012). For this, shells are placed in successive batches of decreasing ethanol concentration and rinsed with DI water to remove precipitate crystals; followed by washing in 6% sodium hypochlorite to remove any bacteria and mineralization samples; and treated with either a) 1% bath of potassium hydroxide; b) 30% peroxide for 25–30 minutes or c) were plasma etched to remove the organic layer. The procedure is necessary for improved detection and quantification of shell dissolution, especially in the cases where shell dissolution is at its minimum extent and not yet intruded deeper into the mineral layers of the shell. Regardless of the procedure used, we demonstrated that the choice of the technique does not impact shell dissolution or introduces any methodological artefacts, although some treatments were more efficient than others (e.g. plasma etching works faster in comparison with 30% peroxide per time unit). The choice of the techniques largely depends on the availability of the equipment in the working lab, and given that plasma etching is not part of the biological laboratory equipment, we recommend a simplified protocol based on Bednarsek *et al.* (2012):

Cleaning Procedure:

1. Clean with 70% ethanol for 2-3 minutes, 2. Clean with 50% ethanol for 2-3 minutes; 3. Clean 2x with DI for 5 minutes; 4. Clean with 6% hydrogen peroxide 2x for 20 minutes; 5. Clean with DI 2x for 5 minutes; 6. Clean with 1% KOH for 2 hours for removal of organics; 7. Clean with DI 2x for 5 minutes and let completely dry.

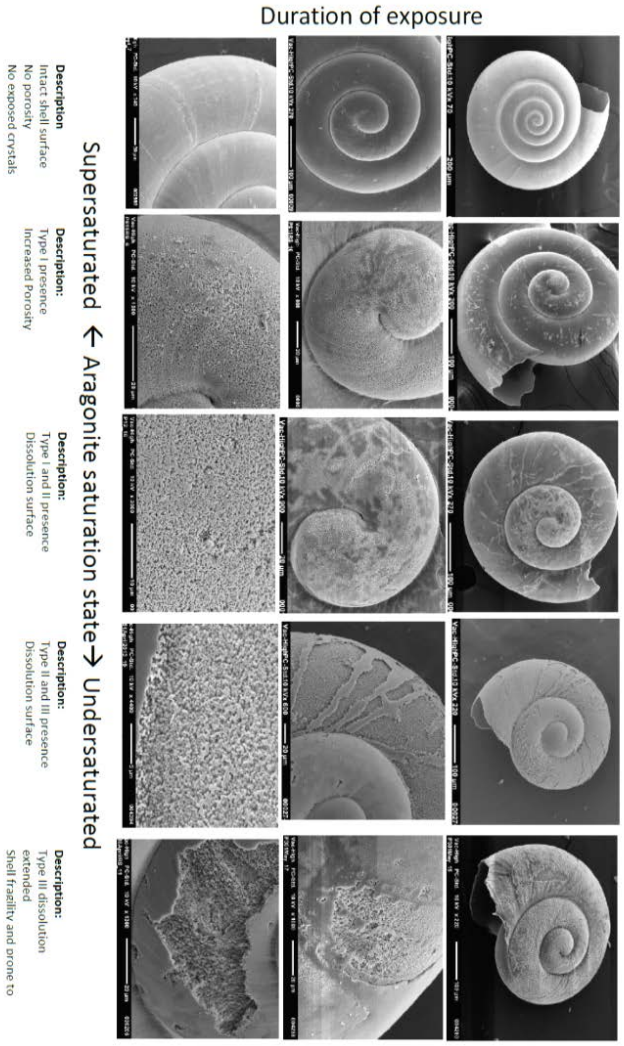
Once dried, shells should be carefully mounted on stubs with carbon tape and coated with gold palladium using a sputter coater. Typical coating thicknesses ranged from 7 nm (30 seconds) to 21 nm (90 seconds).

6.3 SEM examination and shell dissolution assessment

Using SEM, the shell is recommended to be photographed from its dorsal-ventral shell surface to completely cover shell surfaces with up to 20 SEM micrographs taken in small incremental steps around and across the shell (Supplementary Figure S1). SEM can be substituted with Environmental Scanning Electron Microscope (ESEM) for faster shell examination. SEM photos are to be analyzed for dissolution following protocols by Bednarsek *et al.* (2012). Measuring shell dissolution encompasses quantitative estimates on the extent of individual's affects and recognition and quantification of different types of dissolution. A scale that separated the progression and severity of dissolution into three categories (Type I, II, III) of dissolution was used, with a fractional scale used to quantify the approximate surface covering of each type of dissolution on the surface of the shell. Following Bednarsek *et al.* (2012), Type I represents the initial stage of dissolution, with the upper prismatic layer showing increased porosity and dissolution appears in form of 'cauliflower heads'. Type II progressively follows Type I with deeper and more extensive dissolution of prismatic layer with simultaneous exposure of lower laying cross-lamellar layer. The more severe type of dissolution, Type III, describes shells where severe dissolution of cross-lamellar layer appears in a form of thicker and chunkier crystals with less compact shell structure and compromised shell integrity (Supplementary Figure S1).

6.4 Shell dissolution quantification

Estimating shell surface dissolution can also be done with the software designed to recognize the patterns and the extent of shell dissolution in pteropods. Although currently not operational (previously found at http://www.uea.ac.uk/~vtt07vju/segmentation/).



Supplementary Figure S1: Atlas of dissolution patterns in *Limacina helicina* as a function of aragonite saturation state and duration of exposure. Images depict different extents and types of dissolution, ranging from intact surfaces to Type I, II, III (from left to right).

Progress Reports

WGZE "history" article (Peter Wiebe)

A project to review the history of the WGZE began at the WGZE meeting in Iceland in 2014. The impetus was ToR h: *Review of the WGZE scientific achievements as a basis for preparing the multi-annual activities planning* (Peter Wiebe, Roger Harris, and Piotr Margonski). Peter Wiebe presented a brief overview that included nine topics:

1) Zooplankton Sampling Methods and Analysis

2) Taxonomic Analyses

3) Taxa Reviews

4) Zooplankton Studies

5) Zooplankton Monitoring

6) Zooplankton/Ecosystem Interactions – meeting with other WG

7) Zooplankton Symposia

8) Other WGZE Activities

9) ICES - WGZE Topics

After the meeting in 2014, R. Harris and P. Wiebe outlined a paper based on the presentation and over the next two years worked by correspondence with other members of the WGZE (L. Valdes, H.R. Skjoldal, P. Margonski, M. Benfield, A. Gislason, and T. O'Brien). The manuscript was submitted in May 2015 to Progress in Oceanography, accepted for publication in December 2015, and published in January 2016:

Wiebe, P.H., Harris, R.P., Valdes, L.J, Skjoldal, H.R., Margonski, P., Benfield, M., Gislason, A., and O'Brien, T. 2016. A History of the ICES Working Group on Zooplankton Ecology: The first 25 years. Progress in Oceanography. 141, 179–201.

At this meeting, Peter Wiebe provided anoverview of the published paper touching on the topics:

1) Population statistics of the SGZP & WGZP group.

2) Review of the Tors.

3) Major accomplishments.

4) Outstanding Issues for Future Meetings.

The outstanding issues were:

- Identify and evaluate zooplankton indicators relevant for biodiversity and food web status assessment.
- Refine and expand the compilation of information on zooplankton species, taxonomic categories, and life stages that are currently monitored in the ICES area in collaboration with the WGIMT.
- Continue the development and updating 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.
- Summarize zooplankton productivity and metabolic rates based on allometric approaches in order to produce an online resource of zooplankton individual species biomass, productivity, and metabolic rate equations useful for modelling.
- Review new methods of automatic and semi-automatic plankton identification.
- Compile information on micro-plastics pollution and its effects on zooplankton communities.

At the end of the talk, Peter presented working group meeting photos taken over the years.

Review on Biochemical methods to Advanced in Marine Biology (as an update of the Chapter on Growth in the Zooplankton Manual); (Lidia Yebra)

Lidia Yebra presented a summary of the review entitled *Advances in biochemical indices of zooplankton production* by Lidia Yebra, Toru Kobari, Akash Sastri, Felipe Gusmão, and Santiago Hernández-León, submitted in February 2016 to Advances in Marine Biology. This work is a WGZE contribution related to the WGZE 2011 – ToR C: Update of the ICES Zooplankton Methodology Manual.

In this review paper, we summarize the biochemical approaches for measuring weight-specific growth rates which have been developed after the publication of the ICES Zooplankton Methodology Manual (Harris *et al.*, 2000). We describe the general concepts behind the most widely used methodologies and review the advantages and limitations of their in situ application to zooplankton communities. We also provide detailed protocols for the existing methods and information relevant to scientists willing to apply, calibrate or develop new biochemical indices for zooplankton production.

Seasonal patterns of zooplankton at four coastal monitoring sites of the Northeast Atlantic (Alvaro Fanjul, Fernando Villate, Ibon Uriartea Arantza Iriarte, Angus Atkinson, Kathryn Cook)

In this study a comparison of time-series of mesozooplankton (1999–2013) from 4 different sites in the North Atlantic (Urdaibai 35 (U35), Bilbao 35 (B35) located on the southeastern bay of Biscay, the latter with a higher anthropogenic influence and higher trophic status; L4, located in the English Channel and Stonehaven (SH), located in the North Sea) was carried out with the aim of assessing the influence of latitude and trophic state on the seasonal dynamics. Different latitudinal patterns of variation in the seasonal cycle were identified. Groups such as *Cladocerans* and their genera *Podon* and *Evadne*, the copepod genus *Acartia* and *Appendicularians* showed a clear latitudinal delay of their annual maxima of abundance from early spring at U35 to late summer at SH. For Decapods, Copepods and their genera *Temora*, *Calanus*, *PCPCalanus* (which includes the dominant genus *Paracalanus* (mostly *P. parvus*), and the less abundant *Clausocalanus* (several unidentified species), *Pseudocalanus elongates,* and *Ctenocalanus vanus*), and *Oithona*, their early annual peak showed a delay and their late peak moved forward from U35 to SH; in some cases a bimodal distribution at U35 became unimodal distributions at SH. Other groups (e.g. *Cirripedes, Chaetognaths*, and *Doliolids*) showed no latitudinal effect in the seasonal pattern and annual maxima occurred almost simultaneously at different latitudes. Differences in the seasonal patterns due to the influence of trophic state were also observed. Thus, changes from unimodal or bimodal cycles to trimodal cycles from U35 to B35 in Bryozoans, Copepods, *PCPCalanus* and *Oithona* were detected. Also a delay in the annual maxima from early spring or spring at U35 to late spring-summer at B35 in *Cirripedes, Calanidae, Appendicularians*, *Bivalves, Decapods*, *Cladocerans*, and *Evadne* were observed. The number of annual maxima of taxa/month showed a latitudinal gradient from U35 (skewed towards early spring) to SH (skewed towards late summer), with the peak value occurring in early summer at L4. The seasonal span of the annual maxima showed a decrease with latitude from B35 (7 mo.) and U35 (6 mo.), to L4 (5 mo.) and to SH (3 mo.) for holoplankton groups. No such pattern was observed for meroplankton.

Presenting the MarinEye project – A prototype for multitrophic oceanic monitoring (Cátia Bartilotti, Raquel Marques, Rita F. T. Pires, João Pastor, Ana Teresa Pereira, Lígia Sousa, Inês Dias, Inês Farias, Guida Camacho, Antonina dos Santos)

The understanding of the complex exchanges among biological, chemical, physical, atmospheric, and geological processes in the ocean basins is severely limited by the paucity of infrastructure able to support sustained and timely observations. The present work aims to develop an autonomous system for integrated marine chemical, physical, and biological monitoring. The MarinEye system will combine different technologies in a modular, compact system that can be deployed on fixed or mobile platforms. The data acquisition system will include high-resolution imaging (targeting plankton), acoustic techniques (targeting plankton and small pelagic fishes), a hydrophone (targeting mammals and anthropogenic sound), fraction filtration systems (targeting prokaryotes and unicellular eukaryotes), and sensors (for physical-chemical variables such as salinity, dCO_2, dO_2, temperature, and pH). The project is organized in a total of seven work-packages (WP), all supporting and complementing each other in an overarching holistic approach. A bottom up approach has been used to link tasks that start with a lower level of complexity, until achieving the full objectives of the proposal. The first four work-packages are: WP1-optical sensors, WP2-fraction filtration system, WP3-image system, and WP4-acoustics. In these work-packages, the individual components of the autonomous system for marine integrated physical-chemical and biological monitoring will be developed, tested, and validated. In WP3, coordinated by IPMA, an imaging *in situ* system will be developed to assess the pelagic planktonic biodiversity. This WP will assess pelagic community diversity and abundance, dominated by plankton in its different fractions (phyto- and zooplankton communities). The high resolution imaging system will have the capacity to detect plankton across a wide range of size classes (detection range > 20 μm) and their utility is not restricted to quantify highly abundant plankton. The data acquired with the plankton imaging system will be validated by morphological and molecular techniques. WP5 will be dedicated to the integration of the individual components in a compact system that will be benchtop validated and tested to ensure that the different components function together in a unique compact system. The data infrastructure and the software platform development were centralized in WP6, which aims to integrate and analyze the disparate data generated by the autonomous system. Finally, WP7 will coordinate the project, the internal communication, and the dissemination of the activities and results obtained. MarinEye will increase the ocean knowledge, complementing the information from existing observatories by providing novel integrative data that are not currently supplied. MarinEye will also give an extremely important contribution for the consolidation of infrastructures dedicated to the observation of the marine environment, implementing adaptive management approaches, as the European Union Marine Strategy Framework Directive (EU- MSDF), and allowing the development of strategies for the continuous assessment of the marine waters Good Environmental Status (GES).

Zooplankton Biodiversity in seamounts: the Madeira–Tore and Great Meteor (Rita F. T. Pires, João Pastor, Ana Teresa Pereira, Cátia Bartilotti, Inês Dias, Lígia Sousa, Inês Farias, Guida Camacho, Raquel Marques, Antonina dos Santos)

Seamounts are complex geological features associated with volcanic and tectonic activities, extending to at least 100 m above the surrounding ocean floor. These systems provide appropriate conditions for the colonization and growth of diverse fauna and flora, attracting many species. As obstacles to water flow, seamounts affect the hydrodynamics in their vicinity, promoting the upwelling of nutrients from deeper waters. Seamounts and their surrounding areas are therefore considered biodiversity hotspots, with a high primary production and diversity. Biophysical coupling has a crucial effect on the production at seamounts by enhancing retention and/or horizontal advection processes, with expected effects on planktonic communities. Despite the extreme importance of seamounts, scientific knowledge is sparse and more information is required to fully understand these ecosystems.

BIOMETORE project, led by "Instituto Português do Mar e da Atmosfera" (IPMA) with the support of a consortium of more than 16 Portuguese institutions, focuses on the study of two important seamount complexes in the Northeastern Atlantic: the Madeira-Tore and the Great Meteor. BIOMETORE objectives comprise the characterization and mapping of the target seamounts, the acquisition of knowledge on biodiversity and the assessment of the human pressures in the region, understanding the effects of exploitation on local communities. In the scope of the Marine Strategy Framework Directive (MSFD) implementation, the assessment and monitoring of these systems will provide information for the implementation of a sustainability plan on these critical oceanic areas, towards a sustainable management and conservation.

Sampling surveys targeting both benthic and pelagic habitats took place in the Great Meteor complex during 2015 and will be repeated in 2016 on the Madeira-Tore complex. Meteorological, physical, chemical, and biological data were collected and are currently being analysed. Project progress was presented and information on surveys, methodology, and collected specimens was provided, as well as the forthcoming steps for data analyses and preliminary/expected results.

The CascaisWatch Biodiversity monitoring time-series and the GelAvista program (Raquel Marques, João Pastor, Cátia Bartilotti, Rita F. T. Pires, Ana Teresa Pereira, Inês Dias, Lígia Sousa, Antonina dos Santos)

The Cascais Watch time-series is one of the stations included in the WGZE zooplankton monitoring and IGMETS time-series that were used to produce the last ICES Zooplankton Status Report (O'Brien *et al.*, 2013). The station is located in the western coast of mainland Portugal, 4km off Cascais city, with 36m depth. It is highly influenced by one of the biggest estuaries of Europe, the Tagus Estuary, and by the North-eastern Atlantic Upwelling system, which promotes high levels of productivity (Santos *et al.*, 2007). However, the station is located in an upwelling shadow supporting higher water stability when compared with the exposed western coast (Moita *et al.*, 2003).

Monthly sampling was carried out between 2005 and 2014 with some gaps resulting from financial and logistic limitations. Environmental parameters were registered *in situ* with a

CTD and a Seapoint Chlorophyll Fluorometer (conductivity, temperature, chlorophyll a, and depth). Zooplankton samples were collected by oblique tows with a WP2 net with 200μm of mesh size. These sampling events were conducted two hours before the high tide in order to reduce the Tagus influence and to represent the marine zooplankton community. Biovolume was determined from the displacement volume method and then converted to biomass according to Wiebe (1988), while abundance and identification to the lowest taxonomic level were assessed following traditional methods. Data was analysed according to O'Brien *et al.* (2013) (zero-representation value replacing real zero values) and presented by season.

Temperature reveals a two-tier seasonal pattern, with temperatures below 16°C until May, increasing to above 18°C during summer and autumn months. Such a pattern appears to be associated with a higher level of water stratification, promoted by the upwelling shadow. Over time, temperature by season appears to stabilize. The seasonal pattern of chlorophyll shows a peak in April and a decreasing trend in autumn, with a high interannual variability. Salinity shows a variable pattern through the year, which is highly dependent on the Tagus River discharges. The upwelling index registered off Cabo da Roca demonstrates a unimodal peak in summer months with a drastic decrease in autumn, and a low interannual variability by season.

Preliminary results reveal that Cascais Watch station zooplankton biomass has three seasonal peaks, with higher values in summer, coincident with the upwelling index maximum. Over time, zooplankton biomass appeared to be highly variable. However we underline the high values of biomass in summer in recent years. Overall, the majority of the community is represented by small copepod species, especially *Paracalanus spp./Clausocalanus spp.*, *Acartia spp*. and *Oncaea spp*. representing alone 50% of the community. Surprisingly, veligers of Bivalvia appear to have a large importance in the zooplankton community, being in fourth place in the rank of the most common species.

Regarding zooplankton abundance, two seasonal peaks are clear in summer and autumn. The autumn peak matches the increasing abundance of copepods. However, the presence of other taxonomic groups might explain the summer peak. Species indicators point towards a possible succession of meroplankton and gelatinous organisms in summer that also seems to increase during the warmer months in recent years. A species specific analysis revealed that veligers of Bivalvia might contribute to the increasing trends of meroplankton relevance in zooplankton community. In recent years they represent an average of 50% of the total zooplankton abundance in summer months, justifying the need for further studies to species level. We hypothesize that such trend might be associated with the presence of the invasive species *Ruditapes philippinarum*, introduced in the Tagus River about 10 years ago. Nevertheless, species confirmation is still required.

Gelatinous zooplankton were also identified as important contributors to zooplankton abundance summer peaks, revealing an increasing trend in recent years, especially in warmer months when they usually bloom.

Trends of copepod abundance are more complex and difficult to unveil. However, the available data suggest that some species might be decreasing over time and that a species succession might be occurring, at least at a seasonal level, for example for *Temora longirostris* and *T. styifera*.

Overall, this study sheds some light on the seasonal and temporal species succession at the Cascais Watch station. However, the available data do not allow outlining robust conclusions regarding long-term changes in the community's biodiversity. Still, it discloses some important species specific trends, which should be addressed in detail, e.g., veligers of Bivalvia and gelatinous zooplankton. It should be performed not only at Cascais Watch but also on a larger spatial scale. To meet such requirements, a citizen science program was recently launched with the purpose of monitoring gelatinous populations on the Portuguese coast: the GelAvista program.

The GelAvista program started by sharing, at the IPMA website, a leaflet encouraging the population to send information regarding the presence of gelatinous organisms on the Portuguese coast. In the first page of the leaflet, pictures of the species that might be observed are presented, as well as key information that should be registered in every sighting (picture, date and time of record, and number of specimens). In the second page, a simple protocol of what to do if someone gets stung is provided and, in the remaining pages, information about gelatinous species' ecology and curiosities is presented.

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Life cycle and seasonal vertical distribution of copepods in Iceland Sea (Astthor Gislason)

Abundance and seasonal vertical migrations of dominant zooplankters were studied in the oceanic subarctic Iceland Sea as based on data collected on 6 cruises covering all seasons of the year from 2006 to 2008. Six taxa constituted ~96% of copepod biomass, *Calanus hyperboreus*, *C. finmarchicus*, *Metridia longa*, *Pseudocalanus spp*., *Oithona spp*. and *Euchaeta glacialis*. A seasonal migration pattern was evident in most of these species. Due to their high biomasses, *C. hyperboreus*, *C. finmarchicus,* and *M. longa* are key species in the system. *C. hyperboreus* stayed deep during winter (~800–1000 m) at temperatures ~0°C. The animals probably reproduced at depth during winter. The animals stayed in the surface layers from May to July. The offspring from the winter reproduction may not have developed beyond stage 3 during the first summer. Thus, the seasonal stage structure suggests that *C. hyperboreus* may have a 2–3 year life cycle. *C. finmarchicus* overwintered shallower (~200–600 m) than *C. hyperboreus*. The animals had ascended to the surface layers by early May where reproduction and growth took place, mainly in the upper 50 m of the water column. After August the animals then returned to deep waters for over-

wintering. The depth distribution of *M. longa* was more variable. Adults of both sexes were prominent in the samples at all sampling times, indicating that *M. longa* may reproduce throughout the year.