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Report of the Working Group on Phytoplankton and Microbial Ecology (WGPME)

26–29 March 2012

Malaga, Spain

ICES International Council for the Exploration of the Sea
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Executive summary

Meeting: ICES WGPME annual meeting was held at the Universidad de Málaga, Spain from 26 to 29 March 2012.

Participants: The meeting was co-chaired by William K.W. Li (Canada) and Xosé Anxelu G. Morán (Spain) with 24 scientists representing 11 countries in attendance.

Mandate and Objectives: The mandate of the group is to provide a primary focus for phytoplankton and other microbial plankton (bacteria, archaea, protists, viruses) within the ICES Science Plan. The objectives of the meeting were to address ToRs adopted at the statutory meeting, with particular attention directed to a comparative analysis of multiyear time series data of phytoplankton and microbes in support of various elements in the ICES Science Plan.

Approach: The meeting was held concurrently with the WGZE annual meeting over a four day period, with joint sessions of the two expert groups on the first and last days of the period. The meeting was conducted in an informal atmosphere with open discussions and ample opportunity for all to contribute.

Structure of the report: This report is organized by the ToRs in sequential order and concludes with a summary and future plans. Documentation details are provided in Annexes.

Main message: Time series of phytoplankton and other microbial plankton, together with associated environmental variables in the ICES region and adjacent seas have been assembled for standardised output to indicate climatologies and multiyear trends for assessment of local, regional, and basin-wide response to natural and anthropogenic forcing. It is anticipated that the Cooperative Research Report will be available September 2012. Few, if any, indicators of phytoplankton or microbial diversity available in time series seem to be predictably linked to changes in ecosystem function. The exception may perhaps lie in keystone taxa with unique ecological roles, although a general framework for identifying keystone microbes has yet to be fully developed. Nevertheless, some measurable quantities such as the relative proportions of diatoms and dinoflagellates in the microphytoplankton communities, though regionally idiosyncratic, might contribute in a general way towards integrated multi-trophic frameworks for ecosystem assessment. It is proposed to further explore these and related ideas in multi-annual ToRs, and in a joint workshop on the topic of long-term change in the lower trophic levels of North Atlantic and adjacent seas ecosystems.

Recommendations: Workshop in 2013 on synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time series in the North Atlantic and adjacent seas. Multi-annual ToRs for 2013–2015, with Year 1 annual meeting in Helgoland, Germany.

1 Opening of the meeting and adoption of the agenda

The ICES Working Group on Phytoplankton and Microbial Ecology (WGPME) met at the Facultad de Derecho, Universidad de Málaga, Campus de Teatinos, Spain at the kind invitation of WGZE member Lidia Yebra. The WGPME meeting was attended by 24 scientists representing 11 countries (Annex 1).

On behalf of the host institution, Lidia Yebra opened the meeting in a joint session of WGPME and WGZE to welcome the participants. This was followed by instructions on the logistical arrangements and a round of introductions by each person.

The group reviewed the agenda (Annex 2), which had been circulated prior to the meeting, and this was adopted with only a minor change in the sequence of events on Wednesday afternoon.

2 Terms of Reference

At the ICES Statutory Meeting (2011), Gdańsk, Poland, the Council approved the WGPME Terms of Reference as follows:

a) Hold a joint session with WGZE for exchange of information of mutual concern; and to discuss new findings pertaining to phytoplankton and microbes in the ICES area;

b) Discuss and prepare sections for a Cooperative Research Report on ICES Phytoplankton and Microbial Plankton Status to be completed for June 2012;

c) Continue to explore additional ecological indicators in phytoplankton and microbial time series; where possible (e.g. CPR), cross-verify molecular and traditional methods of taxonomic identification to recognise commonality and complementarity;

d) Discuss cross-ocean basin patterns/trends and regional synchronies in microbial groups with a view towards possible collaborative peer reviewed manuscripts;

e) Review the considerations for which good/bad environmental status may be informed by microbial biodiversity and ecological knowledge, such as from key taxa lists, life cycle stages, abundance/biovolume/biomass relationships, assemblage dendograms, phylogenetic trees, and biogeochemical fluxes;

f) Continue interactions with and linkages to other working groups such as WGZE/WGOOFE/WGHABD/WGOH/HELCOM_PEG/SCOR; explore possibilities for future joint meetings with other groups;

g) Outline a 3-year strategic roadmap for WGPME by assessing the current state of ecological knowledge on marine microbial plankton (e.g. viruses, bacteria, fungi, flagellates, protists) with reference to the indicated areas of WGPME contribution to the ICES Science Plan priorities;

h) Review and report on existing indicators of biodiversity that are linked to predictable changes in ecosystem function and/or to develop, assess and report on the feasibility and performance of such indicators;

i) Identify and report on functional characteristics that could lead to species being defined as ‘keystone’.

3 Term of Reference A

Hold a joint session with WGZE for exchange of information of mutual concern; and to discuss new findings pertaining to phytoplankton and microbes in the ICES area

Monday March 26, 09:00–10:30

Leads: Bill Li (WGPME), Piotr Margonski (WGZE); Rapporteur: Erica Head

A short presentation was made by Bill on strategic areas of mutual concern to both WGPME and WGZE. The areas of highest priority are the same for both groups: namely ICES Science Plan Topic 1 (Understanding Ecosystem Functioning), in particular, sub-topic 1.1 (Climate change processes and predictions of impacts), and sub-topic 1.2 (Biodiversity and the health of marine ecosystems).

Many unresolved questions concerning lower trophic levels were discussed, including:

- Microzooplankton: multiannual change from time series observations; trophic interactions related to phytoplankton blooms and ecosystem health, especially with respect to grazing pressures assessed against those exerted by mesozooplankton; role of microzooplankton in larval fish feeding.
- Climate change: effects on trophic interactions (mesozooplankton – microzooplankton – phytoplankton – bacterioplankton); biochemical effects at different trophic levels (e.g. will changes in the species and biochemical compositions of phytoplankton affect lipid-storing copepods and their predators?); changing phenologies and match-mismatch of functional groups.
- Taxa that have been poorly-addressed: mysids, parasites (e.g. of dinoflagellates), viruses, fungi, pathogens (e.g. cholera).
- Integrating ecological themes: "Link-and-sink" (e.g. carbon flows from primary producers to metazoans versus protozoans); size spectrum approach; ecological modelling.
- Ocean acidification: how to move ahead from the Fernand *et al.* chapter on acidification in the Reid and Valdés 2011 ICES Cooperative Research Report No. 310.

Monday March 26, 11:00–12:30

Update and discuss expanded content for the 2012 Phytoplankton and Zooplankton Status Reports and consider areas where the Phytoplankton and Zooplankton Status Reports could be harmonized

Lead: Todd O'Brien; Rapporteur: Alex Kraberg

The session started with a presentation by Todd introducing the background database systems used by both the zooplankton and phytoplankton groups to archive their data: the Coastal & Oceanic Plankton Ecology, Production & Observation Database (COPEPOD) and COPEPOD's Interactive Time-series Explorer (COPEPODITE). The talk also outlined the data and text requirements for Status Reports in both groups, described the data status of both projects and provided example information from previous reports by the zooplankton group.

The first WGZE report produced contained only 10 sites, plotted with different graphing styles, formats, and bins and with only one variable per site (2001). The next two reports (2004 and 2005) started working with anomalies, featured 15 and then 23 sites, and included *in situ* chlorophyll data when available. From 2005 onward, the unitless anomalies and WGZE/WG125 calculation method was employed (see O'Brien *et al.* 2010). As many of the initial zooplankton monitoring sites did not have co-sampled hydrographic data, global time series products like the Hadley SST and the GlobColour satellite chlorophyll were used to provide these parameters for each zooplankton site (These products are less important for the phytoplankton sites, which almost always include co-sampled hydrographic data, but the Hadley SST still provides a 100 year history of SST in the sampling region). Other ancillary data added to each site includes regional climate indices, data from the nearest CPR standard area "box", and sixty years of ICOADS wind time series data (based on the findings of Hinder 2012). By the 2008 zooplankton report, the number of sites had increased to 40, multi-variable comparisons were included in the reports, but only a few zooplankton sites provided species data. This year's zooplankton report will feature 60 sites with more of them now containing co-sampled hydrographic data (many coming from their sister WGPME phytoplankton/microbial plankton counter-parts) and species data.

The first WGPME report will contain over 80 sites, most of them with hydrographic, nutrient and at least some species data. In addition to total copepod abundance, the CPR standard area boxes no include plankton colour index, total dinoflagellates, and total diatoms data. Many members and sites of WGPME are also collaborating with the global SCOR phytoplankton working group (WG137), which has helped bring in more sites and authors to both working groups.

In describing the plan for the 2012 reports, Todd gave an example of a site summary from the last zooplankton report, including text information and examples of standard graphs using data from L4 station and CPR. Hundreds of figures might be available from the standard graphics set, therefore, priorities should be set for use in the reports. For example:

- A seasonal site summary plot will be included with each site. For the zooplankton this plot includes the primary zooplankton variable, chlorophyll, and temperature. For the phytoplankton group, this may include total diatoms, total dinoflagellates, chlorophyll, wind, and temperature.
- Multivariate comparison plots can be used to show multiple variables and interrelationships. As an example, a Baltic zooplankton plot of five variables was used to illustrate that while total biomass data did not change there was a shift at the species level that corresponded to changes in increasing temperature and decreasing salinity.
- Long-term comparison plots are offered as an optional plot. While a given time series may only be 10 or 20 years long, the long term plot can show the data in comparison with 100 years of SST data and 50 years of CPR plankton data. This may be helpful in showing that SST values are the highest seen in 100 years, or that a recent large increase in a plankton group may be part of a recovery after a 30 year decreasing trends.
- Group plots were shown as an additional option for displaying species data. In the Arendal Station example, the group plot quickly highlighted a disappearance in the two dominant species over a 20 year period.

As many of the WGPME data sets include species data, the problem of how to handle zero values (in log transformed data) needed to be addressed. The use of the traditional "log (N+1)" method is not the best option because it affects smaller range values (i.e. "dry weights values from 0.1 to 2.4") quite differently from larger range values (i.e. "count values from 1000 to 30 000") and reduces the seasonal signals. The proposed WGZE/WGPME method is to not use an offset at all but to instead represent zero with a value equal to ½ of the lowest measured value present in the entire variable value set.

A collection of possible new visualization and calculated indices were displayed for consideration in future reports. These included relative composition plots (similar to the diatoms:dinoflagellates ratios) and analysis based on monthly or seasonal anomalies. A variety of examples plots were shown. In one example, a site with no clear trends in its annual anomalies was shown to have strong but opposite spring and fall anomaly trends. In another example, a strong annual anomaly trend was found to be due to strong trends in only three of its months. While both groups will stay with the annual anomalies for this year's reports, monthly and seasonal anomalies will be examined before the next report cycle.

Reference

O'Brien, T. D., Wiebe, P. H., and Hay, S. (Eds). 2010. ICES Zooplankton Status Report 2008/2009. ICES Cooperative Research Report No. 307. 152 pp.

Monday March 26, 14:00–15:30

Identify analytical approaches and the potential for publications arising from more advanced analysis of existing time-series data on phytoplankton, zooplankton, hydrography and climate

Lead: Todd O'Brien; Rapporteurs: Pablo León, Ana Luisa Amorim, Sebastien Putzeys

The main questions addressed were: "Once databases are gathered, how to proceed and what can we do with all this information?" Given the different nature of data included in databases collected by ICES, it is difficult but necessary to find common and useful tools in order to show results properly. Thus, during this session different analytical approaches were discussed.

The first topic discussed was the analysis of the time series. What scale of time and space is appropriate to show possible trends in ecosystems? During the morning plenary session it was shown that trend tendencies appear to vary dependent on the scale considered (e.g. 30, 20 or 10 years) and dependent on when the time series started. These considerations can lead to different conclusions or even to opposite conclusions. Such time approaches seem to be especially important when the range between minimum and maximum values in different areas is studied. This is particularly significant in several areas included in ICES analysis where changes are more marked. For some variables, marked differences seem to exist between oceanic and coastal regions. Oceanic patterns are more easily discerned whereas coastal patterns seem to be confounded by the influence of numerous different processes. Several examples described by participants seem to support that conclusion.

At this point, the main question could be summarised as: "if ICES wants to analyze those variations, which time interval should be considered as minimum without losing the general pattern? Should it be considered fixed or as an "open window"?" Peter Wiebe recommended a long time series for determining inflexion point of the trends in order to determine if cycles exist or their oscillations. Todd's analysis indicated that the longer the time series the better relationships are obtained. It was agreed that analysis of the time series by month and/or by season might be useful in discerning phenological change over the years.

A discussion followed on effective ways to describe the change in annual anomalies over the length of a time series. Bill and Todd presented a North Atlantic wide description of multi-annual change based on the slopes of simple linear regression of the annual anomalies, but pointed to the need for possible alternate descriptions that recognised the existence of non-linearities. Pep Gasol suggested using curves of accumulative frequencies and Priscilla Licandro suggested deriving the trends from some pre-filtering statistics. Norbert Wasmund suggested running means as the most useful method to describe annual anomalies. But there are other difficulties to be considered, such as differences in taxonomic resolution amongst the datasets. A suggestion was made to explore meta-analysis as a way to synthesise the many time series, and the need for a proper choice of variables in such an analysis. The data compiled by both WGPME and WGZE could be explored together in meta-analytic fashion.

Monday March 26, 16:00–17:00

Lead: Piotr Margonski (WGZE); Rapporteurs: Pablo León, Ana Luisa Amorim, Sebastien Putzeys (with input from Erica Head and Peter Wiebe)

A plenary discussion was held to consider some possible themes for a joint WGZE-WGPME venture, such as a symposium, workshop, publication or study group, addressing:

1) The role of microzooplankton in controlling primary production and reciprocally toxic algae affecting zooplankton production – Will there be climate effects?
2) The link or sink issue: Proportion of carbon respired versus flowing into higher trophic levels? – What will happen under climate change?
3) The size spectra of plankton communities – Is climate change changing the slopes?
4) The health of marine ecosystems – What should be observed and how can it be assessed?
5) Bloom timing, magnitude and fate (e.g. within the pelagic or benthic regime) – How might these change with climate change? What will happen to systems currently dominated by lipid-rich copepods (e.g. Gulf of Maine).
6) The disconnection between what is measured and what modellers use, e.g. functional relationships between phytoplankton and zooplankton, responses to environmental variables.
7) What limits the distribution and abundance of phytoplankton and zooplankton in the ocean?
8) Implementing regional models – what descriptors are needed for those models?
9) Integrated assessments and their application across the North Atlantic – How to represent plankton in the integrated approach to fisheries management

Thursday March 29, 14:00–15:30

WGZE-WGPME collaborative plan

Leads: Bill Li (WGPME), Piotr Margonski (WGZE); Rapporteur: Mark Benfield (WGZE), with input from Erica Head (WGZE)

From the list of themes earlier proposed for collaborative work, a plenary consensus seemed to form around a proposal for an ICES Workshop. The term of reference might be to synthesise hydrographic, phytoplankton, microbial plankton and zooplankton time-series observations in the North Atlantic and adjacent seas, with an emphasis on comparative analysis of major North Atlantic regions and shelf seas. The goal might be an issue of papers (perhaps in the ICES Journal of Marine Science) that summarize the state of lower trophic levels and their relationships to hydrographic and other environmental properties. Possible topics, inter alia, might include time series analysis techniques; trophic interactions (phytoplankton/zooplankton/fish larvae); zooplankton phenology; the timing, intensity and fate of annually recurring phytoplankton blooms; species distributions; incidences of jellyfish blooms and nuisance/toxic algae blooms.

This proposed joint workshop will be chaired by Lidia Yebra (WGZE) and Alexandra Kraberg (WGPME). A draft resolution was prepared (Annex 4) and the workshop will be recommended to SCICOM.

4 Term of Reference B

Discuss and prepare sections for a Cooperative Research Report on ICES Phytoplankton and Microbial Plankton Status to be completed for June 2012

Lead: Bill Li; Rapporteur: Eileen Bresnan

Progress with the CRR since the last WGPME meeting was presented and reviewed. Todd O'Brien has uploaded the data supplied by group members and a selection of data plots were made available on the WGPME.net website. Authors responsible for site summaries were referred to the 'Authors Guide' of this website for details of what should be included in the summaries to be written for each site. Authors can go to the multivariable comparison plots for their sites and select variables for inclusion. Some variables are common for most sites such as diatoms, dinoflagellates and chlorophyll. Diatom:dinoflagellate ratios as well as percent contribution of diatoms can also be calculated. Most phytoplankton data were submitted in the form of abundance and the data supplied are to be checked to confirm when they have been supplied in the form of biomass. Heterotrophic bacteria, cyanobacteria, picocyanobacteria as well as coccolithophores data have been supplied from some sites and should be included in the report when appropriate.

Contributors reviewed data submitted for each location and identified parameters to be used in the report. Any issues with the site data were raised. In some instances some time series were shorter than ten years but these would also included in the report. Question of quality within the time series was raised and some countries are doing a thorough QC on their data. The World Register of Marine Species (WoRMS) is being used as the authority to confirm taxonomic names. Sites where sampling is too sparse to calculate an annual mean will have a separate symbol to show that this is not a true mean.

Names and delineations for the different regions were finalised and agreed. For example the Bay of Biscay region has been given the name 'Bay of Biscay and Western Iberian Shelf'. The North Sea and the English Channel have been grouped as one region. The Celtic Sea and the North East Atlantic Shelf have also been grouped together. Authors were assigned responsibility for regional summaries. The responsible persons are listed below:

- Northwest Atlantic Shelf (Bill Li)
- Labrador Sea (Bill Li)
- Norwegian and Barents Sea (Lars-Johann Naustvoll)*

- Northeast Atlantic Shelf (Joe Silke, Eileen Bresnan)
- Bay of Biscay and Western Iberian Shelf (Xelu Morán, Ana Barbosa)
- Baltic Sea (Norbert Wasmund, Sirpa Lehtinen)
- North Sea (Alex Kraberg, Claire Widdicombe)
- Mediterranean Sea (Pep Gasol, Yves Collos)
- North Atlantic Basin CPR (Martin Edwards, Rowena Stern)

* L-J N indicated that the relevant data for this chapter may not be ready for the first CRR, but could be submitted to WGPME.net in the interim before the second CRR.

Authors are to note that there will be a strict 150 page limit for the report. The deadline for submitting the regional summaries is May 1st.

5 Term of Reference C

Continue to explore additional ecological indicators in phytoplankton and microbial time series; where possible (e.g. CPR), cross-verify molecular and traditional methods of taxonomic identification to recognise commonality and complementarity

Lead: Rowena Stern; Rapporteur: Eileen Bresnan, Ana Luisa Amorim

Molecular genetic techniques are becoming essential tools to explore additional ecological indicators and to identify unknown or challenging planktonic species. At the moment, the tree of eukaryotes (Keeling *et al.* 2005) is comprised primarily of microbial eukaryotes often referred to as protists, protozoa or algae. Due to their small size, simple morphology, complex life cycles, anatomy, phenotypic plasticity, convergence and alternation of heteromorphic generations, it is not surprising that algal systematists have come to rely on genetic tools such as DNA barcoding.

DNA barcoding system is used for rapid and accurate identification of species in culture based on a small, standardised genomic region, classically cytochrome oxidase I (COI), but has extended to other DNA regions such as the ribosomal internal transcribed spacer (ITS) region. Most protist species are uncultivable, with few or no type species (López-García and Moreira 2008), have complex evolutionary history and thus, lack a well-defined species concept with which to compare to DNA barcode. In addition, there is no universal genetic marker that can catalogue all protist, partly because of habitat- COI, that codes for a respiratory gene cannot be used to identify an anaerobe. The second real problem is that protists have evolved at different rates that means identification is a compromise: either to use a marker that identifies more organisms but with less phylogenetic resolution, or determine species-level resolution with different genes but only in a limited taxon group that cannot be compared with other taxa. For unknown protists (which are likely to vastly outnumber known ones), heterogeneous evolution means that their diversity is very difficult to determine.

The categorisation of unknowns with the existing database was discussed. It was agreed that DNA barcoding works if species are already referenced and then compared with existing databases. However, if it is unknown, estimation of species-level diversity can only be achieved if the organism can be identified to a known higher taxon group, for which species-level identities have been established for related taxa. Sequences of unknown protists can be deposited in general genetic databases such as Genbank, or specialised DNA barcoding databases such as the Barcode of Life Database. The choice of DNA markers that encompass all protists is difficult. At a recent meeting of the Protist Working Group (ProWG) initiated by the Consortium for the

Barcode of Life (CBOL), a 2-step barcode approach was suggested: the first being the V4 region of the ribosomal small subunit (called 18S), which is universal and the most represented DNA marker in genetic databases and could be compared directly to other taxa. The second genetic marker would be one that can identify a taxon group to species-level, although may not be comparable to other taxa. Several molecular diversity studies on time-series from the North Atlantic have been published, and a synopsis revealed that most only lasted 1 year, with three lasting 2 or more years. So, the question of time scales was raised. The general agreement of WGPME was that useful information could only be obtained from a minimum of 10 years and more preferably 30 years, to determine climate-related events, it was agreed that most current published molecular work was not useful. P. Gasol mentioned that BioMarks project was coming to a close and several European stations had long-term molecular time-series such as Station Zoologica Naples. At the moment there is no agreed consensus on the best DNA marker(s) to identify protists, and workers use a plethora of DNA markers. Thus, cross-study comparisons and data integration will be difficult. Rowena asked whether it would be better to use standard markers for time-series studies in order to achieve comparability. The species-concept in bacteria and archaea are even more loose. Finally, molecular and taxonomic definitions differ so the question of how molecular data could be integrated into COPEPODITE and other related datasets was raised by Rowena. At this point, it was mentioned the need of a standard method for comparison of results between laboratories and for cross comparison different regional molecular time series.

The use of archived Continuous Plankton Recorder (CPR) samples to investigate long term drivers of species distributions and population dynamics of phytoplankton and marine microbes was discussed. CPR is the longest marine biological time series in the world, recording more than 400 species making it one of the richest ecological data sets. In the future, species identified using molecular methods from CPR sample archives could provide long-term species information from 10 years or more with increased species-breadth, which could be directly compared with taxonomic data. This dataset, together with those from BioMarks project and other long-term molecular time series could be useful starting point to generate a broader microbial dataset for WGPME.

It was widely recognized in the session that molecular techniques are essential to identify unknown or challenging planktonic species. It was agreed to be an important qualitative method, but was not advanced enough for quantification, i.e., at this point, molecular techniques would contribute for a presence/absence time series, species biodiversity and new species. Furthermore, additional taxa were recommended for inclusion into databases: bacteria, archaea, marine viruses, parasites, such as apicomplexa, entamoeba, acanthamoeba; delicate species, often destroyed by preservation such as cercozoa and choanozoa. Finally marine fungi and other novel lineages, potentially making up a large proportion of diversity should be recognised.

Bill Li asked for some advice on the best preservation method for molecular analysis and the possibility of analyses on existing preserved samples. Rowena mentioned that there is no universal good way. Ethanol is the best for molecular studies, but does not preserve cell structure. DNA can be extracted from formalin-preserved samples, but that neutral pH should be maintained so the DNA is not degraded. Lugol solution is attractive in that it preserves cell structure for many organisms and can be used for DNA studies on filtered frozen samples, although it has a limited lifespan and non-uniform in its preservative abilities, even within a genus.

References

Keeling, P.J., Burger, G., Durnford, D.G., Lang, B.F., Lee, R.W., Pearlman, R.F., Roger, A.J., Gray, M.W. (2005). The tree of eukaryotes. Trends Ecol. Evol. 20: 670-676

López-García, P. and Moreira, D. (2008). Tracking microbial biodiversity through molecular and genomic ecology. Research in Microbiol. 159: 67-73

Discussion

Lead: Alexandra Kraberg; Rapportuer: Glen Tarran

This session began with a continuation of the discussion regarding biodiversity indicators. The use of molecular techniques was discussed first. Molecular techniques generate taxonomic information that could be used as health indicators, although a number of limitations are apparent with this technique. These include general inability to provide quantitative data, the cost of carrying out molecular analyses and a lack of time series data to date. With respect to the latter point, costs meant that molecular work tended to be confined to specific pieces of work, not time series. However, it was possible to carry out retrospective analysis on preserved samples and several working group members said that they had samples, in some cases going back decades that might be of use, depending on storage and preservation conditions. Samples stored in ethanol were good. Samples stored in formaldehyde, paraformaldehyde and neutral Lugol's were OK but those stored in acid Lugol's differentially affected certain species. It was felt that there was probably a lot more data in various institutes than was available within the working group and it might be worthwhile finding out more.

Action

Rowena Stern is to identify other people/institutes carrying out molecular studies to ascertain existence of additional time series data sets within the ICES area and to discuss with them a suitable way forward to progress the use of molecular data in time series.

6 Term of Reference D

Discuss cross-ocean basin patterns/trends and regional synchronies in microbial groups with a view towards possible collaborative peer reviewed manuscripts.

Lead: Xelu Morán; Rapporteur: Bill Li

In a brief introduction, Xelu outlined that one of the outcomes we should seek in order to keep group members engaged, and possible attract new ones, was peer-reviewed manuscripts made available to the community in top leading journals. The group then agreed that we were in a suitable position to attempt this task during the next months. As a catalyst for a discussion on possible syntheses of the time series data collection on hand, Xelu presented four topics for consideration based on the results collected by different time series appearing in our first CRR:

- Seasonal patterns of chlorophyll along the Bay of Biscay coastal waters.
- Seasonal patterns in sub-groups (HNA, LNA) of heterotrophic bacteria in the northen Iberian region.
- Seasonal patterns of picocyanobacteria (*Synechococcus, Prochlorococcus*): Gijón/Xixón, Blanes Bay, Thau Lagoon, English Channel L4, Bedford Basin, Boothbay Harbor, etc.
- Climate effects on phytoplankton community size structure.

After some discussion about these and related topics, the group agreed to split into two sub-groups that would propose tentative titles and contents for at least one "more microbial" oriented (picoplankton size-class) manuscript and another one dealing with larger phytoplankton. In the latter sub-group, the discussion on the ratio of diatoms to dinoflagellates (ToR h) was continued, and a proposal was made to examine any large-scale geographic patterns that might arise from the time series analysis at individual sites. The two sub-groups finally agreed on producing at least two manuscripts within 2 years time on any of these issues: a) macroecological patterns of cyanobacteria, b) ratios of diatoms to dinoflagellates and c) comparison of drivers causing temporal dynamics of diatom species.

7 Term of Reference E

Review the considerations for which good/bad environmental status may be informed by microbial biodiversity and ecological knowledge, such as from key taxa lists, life cycle stages, abundance/biovolume/biomass relationships, assemblage dendograms, phylogenetic trees, and biogeochemical fluxes

Lead: Eileen Bresnan; Rapporteur: Bill Li

A review was made of the "Good/Bad environmental status" concept from the Marine Strategy Framework Directive (MSFD). Earlier EcoQO (Ecological Quality Objectives) described in the 2004 Report of ICES Study Group to Review Ecological Quality Objectives for Eutrophication [SGEUT] outlined the criteria for good Ecological Quality metrics (indicators). Of particular relevance to the work of WGPME, a good indicator should be based on an existing body or time series of data to allow a realistic setting of objectives. In the MSFD (Official Journal of the European Union 2.9.2010), the criteria for assessing the extent to which good environmental status is being achieved have been specified in relation to each of the eleven descriptors of good environmental status. The criteria are accompanied by a list of related indicators to make such criteria operational and allow subsequent progress. For a number of such criteria and related indicators, the need for further development and additional information is identified.

A discussion of such criteria and related indicators was made in conjunction with ToR h) (see Section 10). A key consideration in the assessment of environmental status indicators is whether they fall in line with prevailing oceanographic conditions, implying a need for knowledge on the climatology and natural variability of such conditions.

8 Term of Reference F

Continue interactions with and linkages to other working groups such as WGZE/WGOOFE/WGHABD/WGOH/HELCOM_PEG/SCOR; explore possibilities for future joint meetings with other groups

Lead: Joe Silke; Rapporteur: Bill Li

A recapitulation was made of the ICES Science Mission (To advance the scientific capacity to give advice on human activities affecting, and affected by, marine ecosystems) and its enabling mechanisms, one of which is collaboration within ICES and with other (organisations) to deliver and add value to ICES science and advisory programmes. In this context, a short review was made of the relevant activities of WGOOFE, WGHABD, WGOH, HELCOM-PEG, SCOR-WG137, and WGZE. According to discussion arising from ToR a) (see Section 3), WGPME may explore the possibility of conducting a joint ICES Workshop with WGZE on the synthesis of hydrographic, bacterioplankton, phytoplankton, and zooplankton time series observations in the North Atlantic and adjacent seas.

9 Term of Reference G

Outline a 3-year strategic roadmap for WGPME by assessing the current state of ecological knowledge on marine microbial plankton (e.g. viruses, bacteria, fungi, flagellates, protists) with reference to the indicated areas of WGPME contribution to the ICES Science Plan priorities

Lead: Xelu Morán; Rapporteur: Claire Widdicombe

The strategic roadmap for WGPME in the next 3 years will be guided by the need to respond to ICES Science Plan High Priority Topic 1 (Understanding Ecosystem Functioning), in particular, sub-topic 1.1 (Climate change processes and predictions of impacts), and sub-topic 1.2 (Biodiversity and the health of marine ecosystems). To this end, the forward-looking workplan may include the following:

1) Explore current marine microbial sampling techniques: is harmonisation required?

It was suggested that a comparison and/or harmonisation of methods used by different groups within WGPME be made to agree a 'Best Practice' in terms of sampling, preservation methods, flow cytometry techniques and phytoplankton taxonomy. The following discussion concluded there are several manuals/protocols (e.g. HELCOM, IOC JGOFS) that address phytoplankton taxonomy methods but information/manuals addressing pico- and nanoplankton identification by flow cytometry are lacking and needed. Question asked whether the WGPME should produce a fine-detail manual for Phytoplankton Methods along the same lines as the Zooplankton Manual, which could include statistical tools for time-series analyses. The use of automation and the constraints of not being able to change methodology in a time-series may make writing a definitive manual difficult. It was agreed that this would also be very time-consuming and too ambitious within the proposed 3-year strategy period. It was agreed that a comparison of different detailed methods (how, when, where, what) could be compiled and published as a web-based tool. Glen Tarran to lead.

2) Identify microbial and functional groups with observed changes in distribution and range patterns.

Examples of taxa that may have changed distribution and/or occurrence include *Dinophysis* and *Mediopyxsis* (North Sea). Thorough examination of different time-series may reveal further species that exhibit a response to potential drivers.

3) Report progress on the discovery of novel lineages and cryptic taxa of phytoplankton and microbial microbes.

Large phytoplankton can be identified by microscopy and viruses and bacteria can be labelled and quantified on an ataxonomical perspective by flow cytometry but in general the smallest groups may require molecular techniques for identification/quantification. Exploring novel lineages may also help to identify 'unidentified taxa' that are routinely counted. New (and already existing) variables may be progressively incorporated into present time-series with an emphasis on selecting sites that may be prone to anthropogenic pressures, e.g. pollution.

4) Explore the use of hydrographic models and other statistical analyses to provide further understanding of distribution patterns of phytoplankton and microbial assemblages.

This method has already been explored at Helgoland Roads using the bacteria and hydrography time-series i.e. modelling transport mechanisms (currents) with bacterial community. Changes in hydrography may also explain observed changes in the occurrence and distribution of *Dinophysis acuminata* vs. *Dinophysis acuta* and the patchy occurrence of *Mediopyxsis*.

5) ICES WGPME 2nd Phytoplankton and Microbial Plankton Status Report.

It was discussed whether the report should be complied and delivered by 2014 and would include any additional datasets and new statistical analyses. In post-session discussion, Todd O'Brien indicated that it would be better to plan for a delivery date in 2015, so that there would be a stagger between the next WGZE report (2014) and the next WGPME report.

6) Preparation of peer-reviewed manuscripts.

The potential for several papers to be written was discussed in ToR b) and break-out groups continued to develop ideas for specific papers. Three putative topics were identified:

i) Macroecological patterns of picocyanobacteria across North Atlantic coastal waters

ii) Ratios of diatoms and dinoflagellates in North Atlantic and North American coastal waters (it was agreed to separate and exclude heterotrophic dinoflagellates from this study)

iii) Comparison of drivers causing temporal dynamics of the diatoms *Leptocylindrus* and *Guinardia* in the North Sea

10 Term of Reference H

Review and report on existing indicators of biodiversity that are linked to predictable changes in ecosystem function and/or to develop, assess and report on the feasibility and performance of such indicators

Lead: Norbert Wasmund; Rapporteur: Glen Tarran

The session began with a presentation outlining work that was currently being conducted for the Baltic Sea by the Helsinki Commission (HELCOM). Within HELCOM there have been several meetings to discuss and attempt to define indicators of biodiversity, eutrophication and anthropogenic pressures. The requirement for such indicators stems from legislation such as the EU Water Framework Directive. Of particular interest was the HELCOM CORESET project, begun in 2010, specifically tasked with the development of biodiversity indicators. There are also other environmental indicators such as nutrients, oxygen and temperature which are easy to measure. In terms of biodiversity estimates, there are a number of existing tools available, e.g. indices by Margalef, Menhinick, Shannon, Hulbert, etc. that have been available for over 50 years. However, they are complex and there are problems due to differences in analysis leading to lots of unidentified taxa, making the indicators difficult to use. As an outcome of HELCOM CORESET meetings, the following core indicators for phytoplankton have been proposed:

1) Phytoplankton diversity

2) Seasonal succession of functional groups

Supplementary indicators for biodiversity:

1) Ratio of diatoms to dinoflagellates (in the spring bloom)
2) Ratio of autotrophic and heterotrophic planktonic organisms
3) Cyanobacterial blooms
4) Abundance and distribution of non-indigenous invasive species

All of the above supplementary indicators had limitations associated with them. For the diatom:dinoflagellate ratio it is rare to find the bloom's peak, therefore the data are highly variable, year on year. With the autotrophic-heterotrophic flagellate ratio, differentiation between the two is often difficult and in many cases has not been carried out with existing data. With cyanobacterial blooms they tend to be very patchy so that sampling is not representative. Non-indigenous invasive species are often not specifically targeted and so are not identified or are identified as something else.

To date, not much progress has been made on defining indicators relating to phytoplankton within HELCOM CORESET as many of the project members are involved with higher trophic levels: mammals, birds and fish.

At this point the discussion focused on the use of the diatom:dinoflagellate ratio as a useful biodiversity-related indicator of ecosystem change and factors affecting its utility. One good reason to focus on diatoms and dinoflagellates is that there is a lot extant time series data and individual study data for both groups e.g. in the Kiel Bight studies have been conducted since at least 1905. Here, phytoplankton biomass is dominated by diatoms and dinoflagellates (>95%) so if there are major changes in the diatom:dinoflagellate ratio there should also be major changes in the ecosystem. There was also a discussion about the use of biomass vs. abundance, as other phytoplankton groups, such as flagellates, whilst not having a high biomass, would have significant abundance, so their seasonality would be missed. Other studies using diatom and dinoflagellate data in the Baltic Sea were presented, highlighting problems associated with under-sampling and the use of other indicators, such as silicate concentration changes to estimate diatom bloom magnitude. At the end of the presentation and discussion it was proposed that the best measure to use with respect to diatoms and dinoflagellates would be: [Diatoms · (Diatoms + Dinoflagellates)$^{-1}$].

Discussion

Lead: Alexandra Kraberg; Rapporteur: Glen Tarran

The question was asked whether there were examples/case studies using any form of indicator that had been successful in showing change. It was felt that this was not yet the case, e.g. the EU Water Framework Directive identifies biodiversity indicators as an aid to define ecological status, but it has yet to be tried. It was felt that the group had invested a lot of time in discussing biodiversity indicators such as the diatom:dinoflagellate and should move forward under its own terms and not be distracted by other untried recommendations. One way forward would be to test that the diatom:dinoflagellate works using data sets from within the working group. Another suggestion was to use data from a polluted site from a single event (e.g. from an oil spill) and see how the diatom:dinoflagellate changed with site recovery. This could also be tested using the ratios of other groups of organisms (e.g. bacteria, flagellates). One suggestion was to link phytoplankton and zooplankton data and study phytoplankton:zooplankton. This would also bring us together with the WGZE to strengthen our ability to address ToR h), given to us by ICES. In addition, linking with the zooplankton group would enable greater understanding of trophic transfer of phytoplankton through to zooplankton grazers and see whether there have been shifts in feeding behaviour in past years. The current perception is that higher trophic levels, from fish upwards, tend to be better indicators of ecosystem health because they respond to changes in the plankton. The flaw with this perception is that if there is bottom up control then, by the time changes are seen in the higher trophic levels the ecosystem may have irreversibly changed.

In terms of indicators, the discussion turned to asking what constituted an indicator species in terms of the plankton. One possibility was that an indicator species should be very sensitive to change, at the boundary of its tolerance. Indicator species could not be universal as it would not be possible to find a single (set of) species to cover all areas. There was also a discussion on the use of lipids in phytoplankton as a measure of biodiversity. To date there simply was not enough data.

Action

Test the utility of the diatom:dinoflagellate index using existing time series data.

11 Term of Reference I

Identify and report on functional characteristics that could lead to species being defined as 'keystone'

Lead: Pep Gasol; Rapporteur: Bill Li

A review was presented of the keystone species concept in its original context of trophic complexity and community stability, and also in its contemporary context of conservation biology related to charismatic macro- and mega-fauna. The published literature on the keystone concept in phytoplankton and microbial ecology is notably poor, and where it exists (e.g. *Skeletonema costatum*), the concept is sometimes used in a vague manner.

Therefore, as a working definition for the purpose of present discussion, one might consider a species to be keystone if it has an effect on the environment (including inter alia biogeochemical cycling, diversity maintenance, and ecosystem structure) that is disproportionately large in relation to the abundance or production of the species. A schematic representation of this might be a quadrant plot of ecological impact (y-axis) versus proportional biomass or production (x-axis), wherein dominant species would occupy the upper-right quadrant (indicating high impact from high contribution), rare species would occupy the lower-left quadrant (indicating low impact from low contribution), and keystone species would occupy the upper-left quadrant (indicating high impact from low contribution). An operational definition of keystone species might require community importance to be linked to specific ecosystem processes.

Considering the rank-frequency distribution of marine bacterial taxa, in which the number of individuals of each taxon is graphed against the rank of the taxa ordered by decreasing abundance, one might surmise that perhaps keystone taxa are those positioned intermediate between the highly abundant core taxa and the extremely rare members of the seed bank.

Two case studies of candidate keystone bacterial taxa were presented from measurements and experiments at the Blanes Bay Microbial Observatory. The first described the dynamics of the hydrocarbon-degrading *Cycloclasticus* bacteria during mesocosm-simulated oil spills (Teira *et al.* 2007 Environ. Microbiol. 9:2551-2562). Here, despite low abundance, *Cycloclasticus* clearly exerted an idiosyncratic and significant effect on ecosystem functioning (namely degradation of polycyclic aromatic hydrocarbons). A second case study described the use of microautoradiography combined with fluorescence in situ hybridization to determine dimethylsulfoniopropionate incorporation by marine bacterioplankton taxa (Vila *et al.* 2004 Appl. Environ. Microbiol. 70:4648-4657).

What are some keystone characteristics for marine microbes? Perhaps the microbe is a conspicuous component of the community; perhaps it is a dominant member of the community according to measures of biomass or carbon flux; perhaps it is strongly resistant to grazing; perhaps it is a structural engineer; etc. Might the following microbes be considered keystone: *Emiliania huxleyi, Trichodesmium, Phaeocystis, Micromonas, Microcystis*, diatoms (which ones?), ecologically-HABs (e.g. *Karenia*), microzooplankton (e.g. *Gymnodinium, Strombidium*)?

It was concluded that the concept of keystone taxa is generally underexplored in marine microbial ecology, and that integration into general ecosystem theory and management would be a challenging but fruitful endeavour.

12 Summary and Future Plans

12.1 Recommendations

WGPME recommends an ICES Workshop held jointly with WGZE on the synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time series in the North Atlantic and adjacent seas. Supporting information is given in Annex 4.

12.2 Draft Resolutions

a) Examine current marine microbial time-series sampling techniques with an effort towards harmonization if required.

b) Examine distribution and range patterns of microbial taxa and functional groups to discern significant change over time and to identify potential environmental drivers.

c) Report progress on discovery of novel lineages and cryptic taxa of phytoplankton and marine microbes.

d) Explore the use of hydrographic models and other statistical analyses to pro-vide further understanding of distributional patterns of phytoplankton and microbial assemblages.

e) Discuss and prepare sections for the second Cooperative Research Report on ICES Phytoplankton and Microbial Plankton Status to be completed for June 2015.

f) Prepare peer-reviewed manuscripts using extant phytoplankton and microbial plankton time-series.

12.3 Chairpersons 2013–2015

The term for the current co-chairs expires at the end of calendar year 2012. Bill indicated his intention not to re-offer for a second term. Xelu accepted a nomination to serve for a second term but indicated the need for a co-chair. A call for nominations from the floor was made. Bill nominated Alexandra Kraberg (seconded by Xelu). No other nomination was received after 3 calls. Xelu and Alex received unanimous approval to serve as WGPME co-chairs 2013–2015.

12.4 Next Meeting

The next meeting of WGPME will be held in Helgoland, Germany from 19 to 21 March 2013 at the kind invitation of Alexandra Kraberg of the Alfred Wegener Institute.

Annex 1: List of participants

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Annex 2: Agenda

Monday March 26, 2012

Plenary Session

09:00 – 09:30	Meeting Open, Introductions, Logistics, Adopt Agenda (Lidia Yebra and Xosé Anxelu G. Morán, IEO, Spain)
09:30 – 10:00	WGZE-WGPME exchange of information of mutual concern (WGPME **ToR a** Bill Li, BIO, Canada and Piotr Margonski, MIR, Poland)
10:00 – 10:30	Discussion
10:30 – 11:00	Coffee Break
11:00 – 12:00	Update and discuss expanded content for the 2012 Phytoplankton and Zooplankton Status Report and consider areas where the Phytoplankton and Zooplankton Status Reports could be harmonized (WGZE **ToR c**) (Todd O'Brien, NOAA-NMFS, USA); Joint session of WGPME and WGZE for exchange of information of mutual concern (WGPME **ToR a**)
12:00 – 12:30	Discussion
12:30 – 14:00	Lunch
14:00 – 15:00	Identify analytical approaches and the potential for publications arising from more advanced analysis of existing time-series data on phytoplankton, zooplankton, hydrography, and climate (WGZE **ToR d**) (Todd O'Brien, NOAA-NMFS, USA); Joint session of WGPME and WGZE for exchange of information of mutual concern (WGPME **ToR a**)
15:00 – 15:30	Discussion
15:30 – 16:00	Coffee Break
16:00 – 17:00	Discussion

Tuesday March 27, 2012

09:00 – 10:30	Discuss and prepare sections for a Cooperative Research Report on ICES Phytoplankton and Microbial Plankton Status to be completed for June 2012 (WGPME **ToR b** Bill Li, BIO, Canada)
10:30 – 11:00	Coffee Break
11:00 – 12:30	Discussion and assignments
12:30 – 14:00	Lunch
14:00 – 15:00	Continue to explore additional ecological indicators in phytoplankton and microbial time series; where possible (e.g. CPR), cross-verify molecular and traditional methods of taxonomic identification to recognise commonality and complementarity (WGPME **ToR c** Rowena Stern, SAHFOS, UK)

15:00 – 15:30	Review and report on existing indicators of biodiversity that are linked to predictable changes in ecosystem function and/or to develop, assess and report on the feasibility and performance of such indicators (WGPME **ToR h** Norbert Wasmund, Leibniz Institute, Germany)
15:30 – 16:00	Coffee Break
16:00 – 17:00	Discussion

Wednesday March 28, 2012

09:00 – 10:30	Discuss cross-ocean basin patterns/trends and regional synchronies in microbial groups with a view towards possible collaborative peer reviewed manuscripts (WGPME **ToR d** Xosé Anxelu G. Morán, IEO, Spain)
10:30 – 11:00	Coffee Break
11:00 – 12:30	Discussion
12:30 – 14:00	Lunch
14:00 – 15:00	Review the considerations for which good/bad environmental status may be informed by microbial biodiversity and ecological knowledge, such as from key taxa lists, life cycle stages, abundance/biovolume/biomass relationships, assemblage dendograms, phylogenetic trees, and biogeochemical fluxes (WGPME **ToR e** Eileen Bresnan, Marine Laboratory, Scotland)
15:00 – 15:30	Identify and report on functional characteristics that could lead to species being defined as 'keystone'. (WGPME **ToR i** Pep Gasol, Institut de Ciències del Mar, Spain)
15:30 – 16:00	Coffee Break
16:00 – 16:30	Discussion
16:30 – 17:00	Continue interactions with and linkages to other working groups such as WGOOFE/WGHABD/WGOH/HELCOM_PEG/SCOR and explore possibilities for future joint meetings with other groups (WGPME **ToR f** Joe Silke, Marine Institute, Ireland)

Thursday March 29, 2012

09:00 – 10:30	Outline a 3-year strategic roadmap for WGPME by assessing the current state of ecological knowledge on marine microbial plankton (e.g. viruses, bacteria, fungi, flagellates, protists) with reference to the indicated areas of WGPME contribution to the ICES Science Plan priorities (WGPME **ToR g** Xosé Anxelu G. Morán, IEO, Spain)
10:30 – 11:00	Coffee Break
11:00 – 12:30	Discussion
12:30 – 14:00	Lunch

Plenary Sessions

14:00 – 15:00	WGZE-WGPME collaborative plan (Bill Li and Piotr Margonski)
15:00 – 15:30	Discussion
15:30 – 16:00	Coffee Break
16:00 – 17:00	Wrap-up assignments and Closure (WGPME **ToR b** Bill Li and Xelu Moran)

Annex 3: Draft - WGPME meeting resolution for multi-annual ToRs (Category 2)

Working Group on Phytoplankton and Microbial Ecology (WGPME), co-chaired by Xosé Anxelu G. Morán, Spain, and Alexandra Kraberg*, Germany, will meet in Helgoland, Germany, 19–21 March 2013 to:

a) Examine current marine microbial time-series sampling techniques with an effort towards harmonization if required.

b) Examine distribution and range patterns of microbial taxa and functional groups to discern significant change over time and to identify potential environmental drivers.

c) Report progress on discovery of novel lineages and cryptic taxa of phytoplankton and marine microbes.

d) Explore the use of hydrographic models and other statistical analyses to provide further understanding of distributional patterns of phytoplankton and microbial assemblages.

e) Discuss and prepare sections for the second Cooperative Research Report on ICES Phytoplankton and Microbial Plankton Status to be completed for June 2015.

f) Prepare peer-reviewed manuscripts using extant phytoplankton and microbial plankton time-series.

WGPME will report on the activities of 2013 (Year 1) by 15 May 2013 to SSGEF.

Supporting Information

Priority:	The activities of this Group are related to issues of climate change, lower trophic level biodiversity, and ecological dynamics of coastal waters. Consequently, these activities are considered to have a high priority.
Scientific justification and relation to the ICES Science Plan:	**Scientific scope** Understanding ecosystem functioning **Science Plan priorities to be addressed** 1.1 Climate change processes and predictions of impacts 1.2 Biodiversity and the health of marine ecosystems
ToRs justification:	**Term of Reference a)** To support Science Plan Code 112 WGPME can provide a summary of current methodologies used in microbial plankton time-series with the ultimate goal of achieving better comparability between sites. **Term of Reference b)** To support Science Plan Code 113 After finding examples of taxa and/or functional groups that have actually changed their distribution we need to know the environmental drivers underlying these changes before we can make sound projections. **Term of Reference c)** To support Science Plan Code 121 By providing state of the art knowledge of novel microbial biota we will be able to better understand unexplained variation of current time series datasets. **Term of Reference d)** To support Science Plan Codes 111, 114, 115 We need to incorporate other perspectives and the expertise of researchers from different fields and ICES WGs in order to disentangle

	the factors causing changes of distribution in microbial plankton groups. **Term of Reference e)** To support Science Plan Codes 11, 12 The CRR needs to be updated regularly to better establish the climatologies and long-term trends for phytoplankton and other planktonic microbes as well as introduce new analyses, providing the basis for informed assessments of distributional changes at all organizational levels. **Term of Reference f)** To support Science Plan Codes 11, 12 WGPME is currently entering the position to provide multi datasets comparisons of microbial time series to a wider scientific community, potentially of use also by policy makers.
Summary of work plan	**Year 1** Gather and discuss methods used with WGPME (ToR a), find examples of microbial taxa and/or functional groups that have actually changed distribution (ToR b), analysis of data (ToR d), report on what is known (ToR e), review available modelling tools, statistical relationships and macroecological patterns (ToR f). **Year 2** Harmonize methods if required (ToR a), explore potential environmental drivers (ToR b), update existing time series, include additional datasets and explore new analyses and presentations of data (ToR c), prepare and submit manuscripts (ToR d), explore geographical and recurring patterns (ToR e), hindcast models and hypothesis testing using new datasets (ToR f), **Year 3** Presentation of best practice recommendations on a website (ToR a), delivery of second WGPME CRR (ToR c), provide an ecological syntheses and promote incorporation into extant time series (ToR e), make projections under IPCC and other possible scenarios (ToR f).
Working Group expected deliverables/outputs(e.g. publications, datasets, advice, networking tools)	**Output 1** Second ICES CRR Phytoplankton and Microbial Plankton Status Report, June 2015, research community and policy makers. **Output 2** Best practice recommendations for microbial plankton time series provided in the WGPME website (wgpme.net), 2014 with regular updates, biological oceanographers but especially phytoplanktologists and microbial ecologists. **Output 3** Joint peer-reviewed articles with data across North Atlantic coastal waters on at least two of these issues: a) macroecological patterns of cyanobacteria, b) ratios of diatoms to dinoflagellates and c) comparison of drivers causing temporal dynamics of diatom species, 2015, oceanographic and marine ecology scientific community.
Resource requirements:	The research programmes which provide the main input to this group are already underway, and resources are already committed. ICES sponsorship and support must continue for covering publication costs of the 2nd Phytoplankton and Microbial Plankton Status Report due for 2015.
Participants:	The Group is attended by some 15-20 members.
Secretariat facilities:	None, beyond communication support.
Financial:	Beyond the publication costs for the Phytoplankton and Microbial Plankton Status Report, there are no other current financial implications.
Linkages to advisory committees:	There are no obvious direct linkages since WGPME reports directly to SSGEF.

Linkages to other committees or groups:	There is a very close working relationship with WGZE. It has also established interactions with WGHABD and SSICC.
Linkages to other organizations:	The work of this group is synergistic with that of SCOR WG137.

Annex 4: Draft Resolution - ICES Workshop "Synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time-series in the North Atlantic and adjacent seas"

A **Workshop on Synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time series in the North Atlantic and adjacent seas** (WKSERIES), chaired by Lidia Yebra, Spain (WGZE), and Alexandra Kraberg, Germany (WGPME), will be held at ICES Headquarters, Copenhagen, Denmark, in late 2013 to:

a) Review plankton and hydrographic time series data in ICES and adjacent areas;

b) Define time series analysis techniques;

c) Analyse variability and trends in plankton and hydrographic conditions;

d) Analyse variability and trends in taxa distribution and phenology;

e) Review trophic interactions amongst taxonomic or functional groups within the time-series;

f) Discuss pan-regional trends;

g) Prepare one or more synthesis papers that summarize the state of lower trophic levels and their relationship to hydrography and other environmental properties.

Potential participants: Members of the WGPME and WGZE.

WGZE and WGPME will report by 31 October 2013 (via SSGEF) for the attention of SCICOM.

Supporting information

Priority	The results of the Workshop will provide ICES with synthetic pan-regional view of the relationships between the physical, chemical environment and plankton communities in the context of climate change. The Workshop aims relate to SCICOM Codes 113, 115 and 162. This activity is of high priority and central to ecosytem approaches.
Scientific justification	There is potential for more complex joint analysis of existing time-series data on phytoplankton and other planktonic microbes, zooplankton, hydrography, and climate as summarized in existing ICES Plankton Status Reports time-series data. The Zooplankton and the Phytoplankton and Microbial Plankton Status Reports now cover time-series of 40 and close to 100 sites, respectively, located in Western and Eastern North Atlantic, Nordic, Barents, Baltic, North Sea, Northwestern Iberian, and Mediterranean Seas. Parallel reports on hydrography also exist. Synthesis of these data provides an opportunity to create a more comprehensive examination of long-term plankton community changes, foodweb dynamics/shifts and more precise model parametizations. An example of similar analysis carried out for seven different subregions of the Baltic Sea (ICES CRR 302) gives an example how the understanding of the ecosystem change due to e.g. climate and anthropogenic impact may benefit from the multiple time-series analyses.
Resource requirements	Resource required to undertake the activities of this group is negligible.
Participants	The Workshop will consist of 10-20 participants (WGPME and WGZE members).
Secretariat facilities	Meeting room for Workshop.
Financial	No financial implications.

Linkages to advisory committees	The Groups involved report to the SSGEF, SCICOM and ACOM. Mainly WGZE and WGPME provide scientific information on plankton and ecosystems to the SSICC and welcome input from other committees, working/ study groups etc.
Linkages to other committees or groups	Any and all expert groups interested in marine ecosystem monitoring and assessments (e.g. WGOH, WGNARS), modelling and/or plankton studies, including fish and shellfish life histories and recruitment studies. Strong working links have been developed between WGZE and WGPME, as well as with Mediterranean colleagues (CIESM).
Linkages to other organizations	Links with WGHABD are intended and some contact is maintained. The WGZE input to REGNS is an ongoing effort. The Zooplankton and Phytoplankton and Microbial Plankton Status Reports are of interest and practical use for a wide range of national and international research groups, programs and agencies such as PICES, CIESM, GOOS , and IMBER. Increasingly marine research, marine management and even marine institutes are re-aligning to take an ecosystem view. These linked and collaborative approaches between many working and study groups must be encouraged. IGBP, SCOR, ESF, COML/ CMarZ, and others have research activities meetings etc., of interest and relevant to the activities of the WGZE and WGPME. Contacts are maintained through networking and collaborative activities.

Annex 5: Recommendations

Recommendation	For follow up by:
1. Workshop on synthesis of hydrographic, phytoplankton, microbial plankton and zooplankton time series in the North Atlantic and adjacent seas.	SCICOM
2. Multi-annual ToRs for 2013-2015, with Year 1 annual meeting in Helgoland, Germany.	WGPME, SCICOM