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Contents

i Executive summary

The ICES Working Group on Phytoplankton and Microbial Ecology (WGPME) provides tools and expert perspectives on the sampling methods, ecology and diversity of phytoplankton and other planktonic microbes. The group set out terms of reference to improve access to data, cross-disciplinary approaches and to develop ecological interpretations of the changing phytoplankton seascape. The group published 16 papers between 2019–2021, including key tools, high-profile synthesis papers and science reports.

Tools: The group has progressed efforts to collect images of commonly used Lugol's-preserved phytoplankton, alongside live images to aid those in correctly identifying species. Members have noticed and published records of new phytoplankton species. The group aims to produce a New Records database to assist in notifying new or reoccurrence of a species. WGPME work, with other Expert Groups (EG) to improve access to molecular genetic tools and records. A multi-EG thematic session has been submitted for ICES ASC 2022 in cooperation with other EGs, whilst phytoplankton barcoding information will be incorporated into the Working Group on Integrated Morphological and Molecular Taxonomy (WGIMT) barcoding Atlas (https://metazoogene.org/atlas).

Information and access: The group is gathering information on nano and picoplankton (small phytoplankton less than 10 and 2µm respectively) to incorporate into global datasets such as GLOMICON. Multiple data sources point to an increasing trend in picoplankton and few indicators exist in current EU or national legislation to measure their impact on marine ecology. Many members are involved in indicator development for governmental and pan-governmental organisations such as OSPAR. However, the number and level of indicators vary in each country.

Long-term ecology: The cooperative zooplankton and phytoplankton report has been delayed but initial analysis has indicated ≥30 years of data reliably shows spatio-temporal trends in phytoplankton and the effects of temperature on key phytoplankton groups. Two research papers are being produced on climate change effects on key marine phytoplankton species with the additional aim of improving indicators of change using species-specific information.

ii Expert group information

Expert group name	Working Group on Phytoplankton and Microbial Ecology (WGPME)
Expert group cycle	multiannual
Year cycle started	2019
Reporting year in cycle	3/3
Chair(s)	Rowena Stern, UK
	Marie Johansen, Sweden
Meeting venue(s) and dates	11–14 March, 2019, Gran Canaria, Spain (13 participants)
	28–30 April 2020, online meeting (23 participants)
	26–28 April 2021, online meeting (23 participants)

1 Generate improved knowledge of small food web components that are poorly monitored/assessed

Picoplankton are increasingly becoming important to measure and make up the majority of diversity and abundance in the oceans (de Vargas *et al.* 2015). A key report revealed picophytoplankton was increasing its proportion of the total phytoplankton biomass over the last 20 years and an emergent risk for food supply to primary consumers as this component lacks key nutrients (Schmidt *et al.* 2020). However, as most monitoring is carried out through microscopy, this component is either not measured or measured on less-informative aggregate groups. Consequently, data is less available for indicator development for legislative purposes e.g. EU Marine Strategy Framework Directive. The group agreed that knowledge on data sources for the smallest phytoplankton and bacterioplankton and their spatio-temporal patterns, would be useful for researchers and for application in measuring marine health. A draft questionnaire was circulated to WGPME members prior to the meeting. Once finalised the survey would be made available on the website, on other pan- global databases such as GLOMICON and the results could be used for a review paper. Ideas for identifying other similar surveys were discussed e.g. the Best Practices in Flow Cytometry Questionnaire currently available on the Joint European Research Infrastructure for Coastal Observation website. Standardised methodology and terminology may be essential, and the group discussed examples of this, such as agreeing names for each functional group e.g. bacterioplankton.

Often genetic methods are the only way to measure other picoplankton groups such as parasites or pathogenic bacteria and efforts have been made by members to take advantage of their sample archive or develop parallel efforts for molecular identification of phytoplankton.

Outcomes

- A survey questionnaire was prepared and circulated to members, some of who have provided information. Work will continue to finish the questionnaire for presentation at ICES WGPME 2022.
- Three publications have been produced by members on the benefit on the development or accessibility of picoplankton datasets (Buck *et al.* 2019) using genetic methods applied to archival material to extract genomic information that can trace patterns of marine pathogens or augment existing microscopic datasets (Vezzulli *et al.* (2021) and the development of picoplankton-sized parasite datasets using genetic methods (Käse *et al.* 2021):
    - Vezzulli, L., Martinez-Urtaza, J., **Stern, R.,** (2021) Continuous Plankton Recorder in omics era: from marine microbiome to global ocean observations. Curr. Opin. Biotechnol.73: 61-66.
    - Buck, J. J. H., Bainbridge, S. J., Burger, E. F., **Kraberg, A. C**., Casari, M., Casey, K. S., Darroch, L., Rio, J. D., **Metfies, K**., Delory, E., Fischer, P. F., Gardner, T., Heffernan, R., Jirka, S., Kokkinaki, A., Loebl, M., Buttigieg, P. L., Pearlman, J. S., Schewe, I. (2019) Ocean Data Product Integration Through Innovation-The Next Level of Data Interoperability. Front Mar Sci https://doi.org/10.3389/fmars.2019.00032
    - Käse L, **Metfies K**, Neuhaus S, Boersma M, **Wiltshire KH, Kraberg AC** (2021) Host-parasitoid associations in marine planktonic time-series: Can metabarcoding help reveal them? PLoS ONE 16(1): e0244817. https://doi.org/10.1371/journal.pone.0244817

- Co-chair Rowena Stern has recently won a funding for the UK to assist in assessing picoplankton indicators and will be using this information and engage with members to progress this.

2 Update on exploring the use of indicators and provide recommendations for methods

HELCOM and OSPAR are pan-governmental organisations that cooperate on measuring marine health for the Baltic Seaand North Atlantic Ocean respectively. The Baltic Sea states are using total phytoplankton biomass (Aroviita *et al.* 2019) as an indicator of the phytoplankton component of food webs (Lehtinen *et al.* 2016). Additional phytoplankton indicators are diatom: dinoflagellate index (HELCOM), seasonal succession of dominating groups (HELCOM) and most recently the cyanobacterial bloom index which is a HELCOM-specific indicator, derived from total biomass from remote sensing. Member states are exploring different variables and monitor using Ferrybox (https://www.finmari-infrastructure.fi/ferrybox/) and genetic methods to look at diversity for pelagic small and cryptic producers (HELCOM-OSPAR target spp.) and sparsely occurring taxa. The Baltic Sea lacks phytoplankton reference genetic data and researchers are aiming at combining DNA metabarcoding and standardised microscopy methods to incorporate DNA metabarcoding into the Finnish marine phytoplankton monitoring programme and to write a manual on the methodology. In the future they are looking at a number of automated imaging platforms.

Outcomes:

- Members are attending an IFCBS workshop to compare automated imaging tools in Kristineberg, 2022 to enhance data collection.

- Publications: The group is very active in developing indicators and has contributed to substantial publications in the development of indicators for prokaryotes which, so far are not routinely monitored outside a small number of pathogenic prokaryotes for the Water Framework Directive. Very little indicator development work has been carried out using genetic data due to the recent technological status. Lanzén *et al.* (2020) provided a predictive framework for measuring marine health risk using prokaryotic genetic information (see ICES science highlights 2020). Bedford *et al.* (2020) was a holistic review of how phytoplankton and zooplankton indicators have measured health of the Atlantic Ocean from multiple time-series, much of which revealed similar findings on phytoplankton to other independent datasets (e.g. Schmidt *et al.* 2020) that revealed robustness of some of these indicators. There has been a reduction in dinoflagellate abundance in shelf and oceanic NE Atlantic waters since 1958 but an increase in coastal waters. Diatom abundance showed weak a decrease or was neutral.

    - **Lanzén, A**., Mendibil, I., Borja, A., Alonso Sáez, L. (2020) A microbial mandala for environmental monitoring – predicting multiple impacts on estuarine prokaryote communities of the Bay of Biscay. Molec. Ecol. (accepted). https://onlinelibrary.wiley.com/doi/abs/10.1111/mec.15489
    - Bedford, J, Ostle, C, Johns, DG, Atkinson, A., Best, M., **Bresnan, E**. *et al.* (2020) Lifeform indicators reveal large-scale shifts in plankton across the North-West European shelf. *Glob Change Biol*. 26: 3482– 3497. https://doi.org/10.1111/gcb.15066.

3 Conduct an integrated analysis of phytoplankton and microbial plankton responses to global warming

This ToR was to produce two papers on different phytoplankton groups measured by multiple time-series to obtain a basin-scale perspective on its biogeographic range and sensitivities to climate change but was delayed for various reasons and was started before 2019 (change in WGPME membership, COVID-related reasons). Another impetus for these papers is to develop potential additional indicators using individual species which are present over a broad range but show different responses to their environment. Such indicators would not suffer the same issues of aggregate datasets (such as total diatoms) that can be uninformative or difficult to interpret. The first paper focuses on photosynthetic prokaryotes (e.g. cyanobacteria) as initial analysis revealed photosynthetic prokaryotic data showed consistent seasonal patterns and would be a good candidate to publish a multi-site report on its distribution and phenology, especially as picocyanobacteria were noted as increasing an component of phytoplankton (Schmidt *et al.* 2020). The second paper to be prepared was on the diatom *Guinardia*, as an example of changing biogeographic distribution of phytoplankton that is monitored by most stations. Many new species have been observed since this ToR was agreed and may signal changing phytoplankton assemblage in the North Atlantic. It was agreed the best approach was to start again with a more updated time-series and this ToR has been extended another 3 years.

Outcomes

- Publications: Published work was carried out using basin-scale data on a number of harmful algae based on ICES, PICES and HAEDAT data, to study the main ecological and socio-economic effects in different European regions. The study revealed that cyanobacteria are the main issue in brackish waters such as the Baltic Sea alongside emerging phycotoxin threats. Lange *et al.* (2020) revealed new remote sensing methodology for detecting photosynthetic prokaryotes using *in situ* data from oceanic samples as training sets, improving the detection of cyanobacteria.
  - Karlson, B., Andersen, P., Arneborg, L., Cembella, A., Eikrem, W., John, U., West, J.J., Klemm, K., Kobos, J., **Lehtinen, S**., Lundholm, N., Mazur-Marzec, H., Naustvoll, L., Poelman, M., Provoost, P., De Rijcke, m., Suikkanen, S. (2021). "Harmful algal blooms and their effects in coastal seas of Northern Europe" Harmful Algae 102: 101989.
  - Lange, P.K., Werdell, P.J., Erickson, Z.K., Dall'Olmo, G., Brewin, R.J.W., Zubkov, M.V., Tarran, G.A., Bouman, H.A., Slade, W.H., Craig, S.E., Poulton, N.J., Bracher, A., Lomas, M.W., Cetinić, I. (2020) Radiometric approach for the detection of picophytoplankton assemblages across oceanic fronts Optical Express 28 (18) 25682. **https://doi.org/10.1364/OE.398127**

- An overview of the status of phytoplankton ecosystems was requested by D. Predreschi for ICES. WGPME members produced a short overview along with WGHABD members with key long-term trends for dinoflagellates, diatoms and picoplanktonic phytoplankton, maps and consequences of HABs for shellfisheries. Additionally, a high-level and high impact science advisory report in Marine Climate Change Impacts Partnership (MCCIP) co-authored by WGPME and WGZE members was published last year, aimed towards policy makers. This is a comprehensive review and is likely to be widely read and cited.

- Stern, R., Edwards, M., O'Brien, T., Clarke, D., Tarran, G., Widdicombe, C., Bresnan, E., Artigas, L.F., Creach, V. (2021) Celtic Sea Ecosystem Overview for Phytoplankton. Ed. Predreschi, D. (in press)
- Edwards, M., Atkinson., Bresnan, E., Helaouet, P., McQuatters-Gollop, A., Ostle, C., Pitois, S. & **Widdicombe, C.** (2020). Impacts of climate change on Plankton and jellyfish. *MCCIP Science Review 2020*, 321–352. doi: 10.14465/2020.arc15.plk. No pdf sent to ICES

4 Produce a guide of live vs Lugol's-fixed key species from existing samples

This ToR addresses the issue of altered morphology using the common phytoplankton preservative, Lugol's and a lack of literature that shows comparative images of Lugol's and unpreserved phytoplankton images that can lead to misidentification. There is a need for such a microscopy guide, especially one that is free and readily available on the internet. For harmful algae species, this would jointly benefit WGHABD. A presentation on the output style of such a guide that could be put on the WGPME website and/or linked to other free web guides was produced and this guide can also be linked to the First Records Database. A wider issue is the difficulty in interpreting images from a wide variety of sources, especially those that are processed through artificial intelligence or machine learning algorithms.

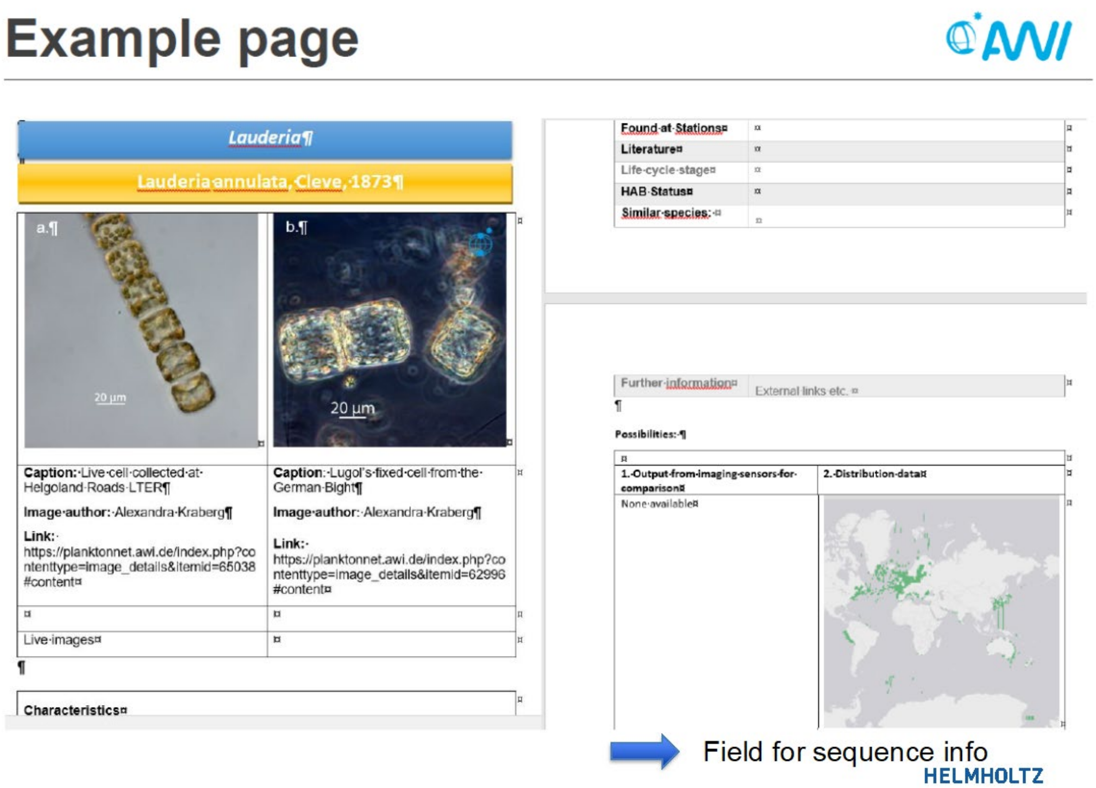

Figure 4. Example page for Lugol's versus unpreserved phytoplankton guide, incorporating metadata that can easily be accessed via internet.

Outcomes

- Publications: Members have been active in generating a technical guide for reporting and interpreting plankton from a variety of automatically generated images such as FlowCytoBot or flow cytometry. This is an extremely useful guide to ensure accurate reporting that can be used to validate remote sensing data and improve predictive models.

- Neeley, A., Beaulieu, S., Proctor, C., Cetinić, I., Futrelle, J., Soto Ramos, I., Sosik, H., Devred, E., Karp-Boss, L., Picheral, M., **Poulton, N**., Roesler, C., and Shepherd, A.. 2021: Standards and practices for reporting plankton and other particle observations from images. 38pp. DOI: 10.1575/1912/2737
- **Poulton N. J.** (2019). Imaging Flow Cytometry for Phytoplankton Analysis: Instrumentation and Applications. J. Biomolec Techniques: *JBT*, *30*(Suppl), S52.

5 Produce a Cooperative Research Report on Phytoplankton and Zooplankton in collaboration with WGZE

The joint WGZE/WGPME *Plankton Status Report* (PSR) continues to be delayed after multiple start-then-stop attempts to assemble and complete it. A large part of this is due to the unusual challenges of leaders and participants working around COVID-restrictions, including limited laboratory and cruise access (e.g., leading to delayed sampling, sample processing, and/or data processing/QC by the submitting time-series programs). Work will continue with the hope of finishing it this winter (December 2021/January 2022). The PSR report will focus more on multi-site analyses and the regional and Transatlantic scale, similar to the IGMETS report but shorter and compatible to the ICES IROC report (ICES Report On Climate). The format will have short summaries of regional areas rather than per site, plus a glossary.

Outcomes

- Trend Analysis for the Cooperative Research Report on Phytoplankton and Zooplankton

Since our last report, 7 years ago, a comparison of year clusters 2003–2012 and 2009–2018, in large areas of the Atlantic reveals an increase in Sea Surface Temperature (SST), data not shown. Spatio-temporal trend maps show an increase in SST and salinity, although it was noted the UK coast showed a decrease in salinity. Preliminary data maps also show increasing chlorophyll levels (data not shown), although by contrast, NPP (Net Primary Productivity) is another measure of global change measuring the difference between energy fixed by autotrophs like phytoplankton and their respiration and measured in grams of carbon or biomass per area per unit time (usually per year). These show a downward trend between 2003–2012 and 2009–2018. This and other measurements highlight issues in comparing data collected in different ways, which could be resolved by comparing relative values instead of absolute values. This may need further investigation.

Overall, 30 year trends are more reliable than 10 year trends which are noisy. The 30 year total diatom trends (1989–2018, Figure 5.1) revealed increase in diatom abundance in the North Sea and Central North Atlantic. The 30 year dinoflagellate trends show a strong decrease in the North Sea “subregion” (Figure 5.2) and mixed trends in the Central North Atlantic. WGPME may consider subgroups and other categories e.g. those that describe trophic types but will need a consistent definition or database.

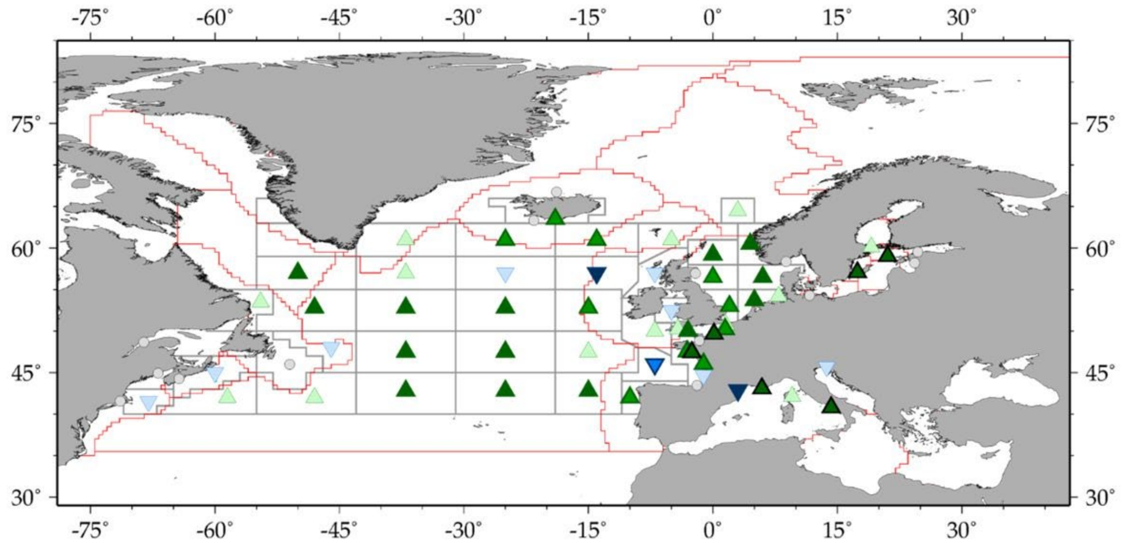

Figure 5.1. Diatom trend over the last 30 years (1989–2018), excluding Baltic Sea as data is not yet processed.

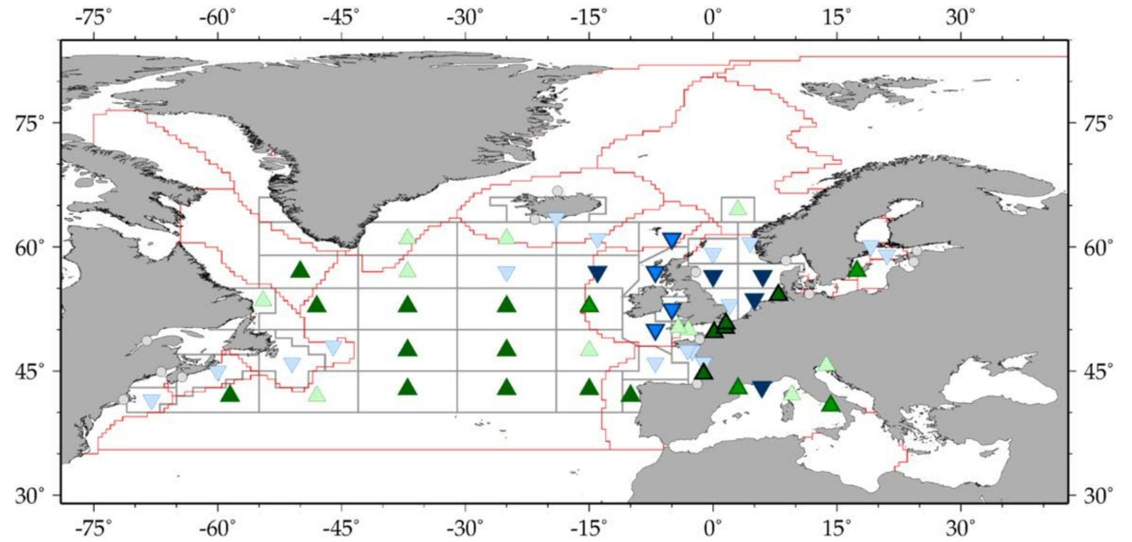

Figure 5.2. Dinoflagellate trend over the last 30 years (1989–2018).

6 Promote joint activities with other Expert Groups

Phytoplankton and microbes are at the base of the food web and are intricately interconnected with biological and physical drivers. WGPME are keen to expand access to cross-disciplinary tools that allow greater breadth of phytoplankton and microbial research applications. Key tools are integrated databases accessible on the internet and common guidelines for molecular and imaging methodology

6.1 WGIMT North Atlantic barcoding Atlas

This ToR started out contribution towards a molecular database that WGIMT had initiated but now has tied in with the SCOR Working Group 157 ("MetaZooGene") efforts. MetaZooGene gave a demonstration of their zooplankton-focused, barcoding database, available online at https://metazoogene.org/atlas, also published (Bucklin *et al.* 2021). One unique feature of the MZGdb is its "atlas" interface that summarizes existing species presence and barcoding coverage divided into major ocean regions and taxonomic groups. For example, the Atlas reports that less than half of the 500 species of calanoid copepods found in the North Atlantic have COI barcodes. Through the interface, one can further determine that while 100% of the members of the copepod family Calanidae have barcodes, other families have little or no barcodes currently available. This type of information can help researchers focus future barcoding efforts on the plankton groups and geographic regions that are in greatest need of new barcode sampling.

While the initial MZGdb database focused only on cytochrome-oxidase-subunit-1 (CO1) genes (currently the most common/abundant method used for mesozoolankton), the MZGdb is now being expanded to also include 18S, 16S, 12S, and 28S genes (Figure 6.1). This figure shows the current breakdown of barcode types for Copepoda species, according to publicly available records in the GenBank database (https://www.ncbi.nlm.nih.gov/genbank/). At least for Copepoda (and most crustaceans), COI is the dominant method, while other methods can be more common within the gelatinous zooplankton groups.

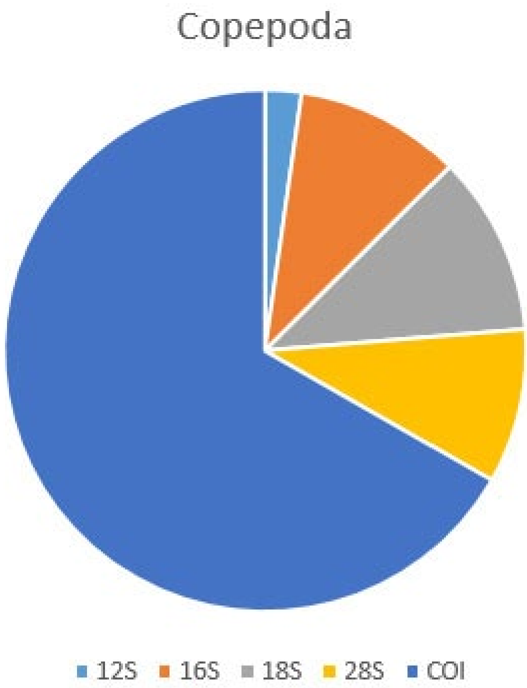

Figure 6.1. Common genes used to identify zooplanktonic Copepoda. The most common being the 12S gene. From T O'Brien (pers. comm).

Working with WGPME members that had molecular expertise, an initial GenBank content survey was carried out to determine what additional gene types may be needed/available to add "phytoplankton" (algae and microbial plankton members) to this currently zooplankton-only database. In this initial analysis, the most readily available and used gene type differs heavily between each of the shown "phytoplankton" taxa groups. From this plot, however, it appears that adding phytoplankton to the expanded MZGdb database might only require adding ***rbcL*** to their planned expansion list, which has the additional benefit of being specific to photosynthetic plankton. (i.e., they are already planning on adding 18S, 16S, 28S). The PhytoRef database, a curated 16S database would assist in separating prokaryotic-based 16S genes from eukaryotic mitochondrial-based 16S genes (Decelle *et al.*, 2015). Based on this initial finding, Todd proposed a future WGPME/WGIMT/WGZE joint ToR that would continue adding both zooplankton and phytoplankton content to the MZGdb after the SCOR WG157 group completes its four year life cycle. In this future work, the "North Atlantic" region would also be broken down into ICES-relevant sub-regions.

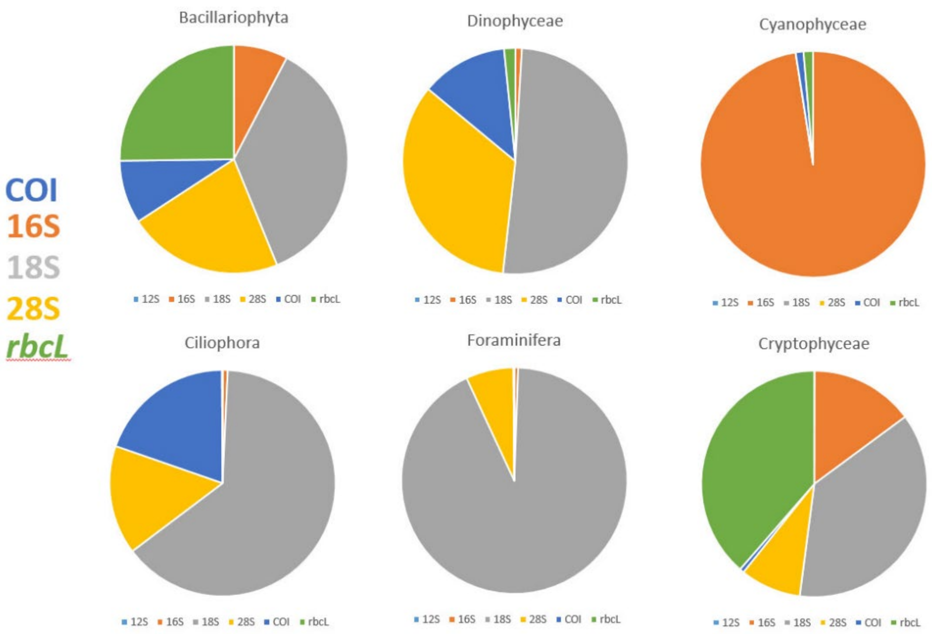

Figure 6.2. Common gene markers obtained from Genbank that are used to identify phytoplankton taxa added to the MZGDb from T. O' Brien (pers. comm). Many gene markers overlap with those used to identify Copepoda, allowing the zooplankton map to be easily adapted to accommodate phytoplankton.

6.2 Joint themes at the ICES Annual Science Conference 2022

WGHABD-WGPME joint activity: A new cycle of ToRs is being generated, including protocols and guidelines of qPCR methods and metabarcoding and the establishment of international groups. WGPME could participate in protocol guides for specific phytoplankton species and it was agreed a joint thematic session at the next ICES ASC in 2022 on approaches to identifying harmful phytoplankton. This has now been submitted entitled "Evaluation of molecular tools in assessing biodiversity and risk of bioinvasive species" along with other working groups, WGHABD, WGITMO, WGBOSV. An additional joint WGPME-WGZE theme was submitted on indicators with Jasmin Renz.

7 Incorporate and validate new and emerging groups in monitoring time-series

Members of WGPME have recently observed new species distributions, occurrences or re-occurrences in their regions. These observations are at risk of being overlooked or misidentified, losing valuable data on environmental or anthropogenic drivers of these occurrences. To keep track of new and emerging species for different areas, a new ToR was agreed last year to develop a First Records database recording presence of a new species in our different time-series during the last 10 years and continue on an on-going basis. This would provide a good overview of new species occurrence and their ecological adaptation strategies such as *Mediopyxis* and *Plagiolemma* diatoms in the North Sea (Nézan *et al.* 2018, Kraberg *et al.* 2018). It is important that new species are reported for the area or novel/unnamed species, rather than those that are seldom observed. A suggestion was to add information on DNA barcoding information, where possible, although only on samples which have been identified by microscopy and DNA in parallel to avoid mislabeling. This initiative is aimed at being published on the WGPME web-page where this information can be collected.

This First Records database should be linked with the Lugol's guide - a collection of images of fresh and preserved phytoplankton as a microscopy guide to improve recognition of new species under fixed and fresh conditions.

Outcomes

This is the first year of this ToR so data will be sent to Todd O' Brien by e-mail. The information required is as follows:

1. name of the species (if it has a name, that is)
2. date or dates when the species occurred, name of the time-series
3. the latitude and longitude for where it was found.
4. and a picture or a link to a picture of the species.

Members have published new species records between 2019-2021 describing two new dinoflagellates, one parasitic using taxonomic and phylogenetic systematic approaches, one of which is the first molecular characterisation since its first description.

- Gómez F., **Artigas, L.F**, Gast, R. J. (2021). Molecular phylogeny and synonymy of *Balechina gracilis* comb. nov. (= *Gymnodinium gracile*), a widespread polymorphic unarmored dinoflagellate (Dinophyceae). *J. Phycol*, 57(2), 694-697. https://doi.org/10.1111/jpy.13135.
- Gomez F.**, Artigas, L.F**, Gast, R. J. (2019). Molecular phylogeny of the parasitic dinoflagellate *Syltodinium listii* (Gymnodiniales, Dinophyceae) and generic transfer of *Syltodinium undulans* comb. nov. (=*Gyrodinium undulans*). *Eur J Protistol.* 71, 125636 (10p.). https://doi.org/10.1016/j.ejop.2019.125636 (First molecular report).

8 References

Bedford, J, Ostle, C, *et al.* (2020) Lifeform indicators reveal large-scale shifts in plankton across the North-West European shelf. *Glob Change Biol*. 26: 3482– 3497. https://doi.org/10.1111/gcb.15066.

Bucklin, A. K.T.C.A. Peijnenburg, K.N. *et al.* (2021) Toward a global reference database of COI barcodes for marine zooplankton. Marine Biology. DOI: 10.1007/s00227-021-03887-y.

Decelle J, Romac S *et al.* (2015) PhytoREF: a reference database of the plastidial 16S rRNA gene of photosynthetic eukaryotes with curated taxonomy. Mol Ecol Resour. 15(6):1435-45. doi: 10.1111/1755-0998.12401. Epub 2015 Apr 6. PMID: 25740460.

De Vargas, C. *et al.* (2015) Eukaryotic plankton diversity in the sunlit ocean. Science 348 (6247): 1261605-1

Edwards, M., Atkinson., Bresnan, E., Helaouet, P., McQuatters-Gollop, A., Ostle, C., Pitois, S. & **Widdicombe, C.** (2020). Impacts of climate change on Plankton and jellyfish. *MCCIP Science Review 2020*, 321–352. doi: 10.14465/2020.arc15.plk.

Gómez F., **Artigas, L.F**, Gast, R. J. (2021). Molecular phylogeny and synonymy of *Balechina gracilis* comb. nov. (= *Gymnodinium gracile*), a widespread polymorphic unarmored dinoflagellate (Dinophyceae). *J. Phycol*, 57(2), 694-697. https://doi.org/10.1111/jpy.13135.

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Karlson, B., Andersen, P., *et al.* (2021). "Harmful algal blooms and their effects in coastal seas of Northern Europe." Harmful Algae 102: 101989.

Kraberg AC, Widdicombe CE, Beckett R, Rick J, Rooks P, van Wezel R (2018) Further records of a new diatom species in the English Channel and North Sea: the importance of image-referenced data. Marine Biodiversity Records 11:21 doi.org/10.1186/s41200-018-0155-0

Lanzén, A., Mendibil, I., *et al.* (2020) A microbial mandala for environmental monitoring – predicting multiple impacts on estuarine prokaryote communities of the Bay of Biscay. Molec. Ecol. (accepted). https://onlinelibrary.wiley.com/doi/abs/10.1111/mec.15489

Lange, P.K., Werdell, P.J., *et al.* (2020) Radiometric approach for the detection of picophytoplankton assemblages across oceanic fronts Optical Express 28 (18) 25682. https://doi.org/10.1364/OE.398127

Neeley, A., Beaulieu, S., Proctor, C., Cetinić, I., Futrelle, J., Soto Ramos, I., Sosik, H., Devred, E., Karp-Boss, L., Picheral, M., Poulton, N., Roesler, C., and Shepherd, A.. 2021: Standards and practices for reporting plankton and other particle observations from images. 38pp. DOI: 10.1575/1912/2737

Nézan E, Bilien G, Boulben S, Mertens KN, Chomérat N (2018) Description and phylogenic position of *Plagiolemma distortum* sp. Nov., a new raphid diatom (Bacillariophyceae) from French coastal waters. Diatom Research doi.org/10.1080/0269249X.2018.1468359

O'Brien, T. D., *et al.* 2021. https://wgpme.net/plankton-status-report

Poulton N. J. (2019). Imaging Flow Cytometry for Phytoplankton Analysis: Instrumentation and Applications. J. Biomolec Techniques: *JBT*, *30*(Suppl), S52.

Schmidt, K, Birchill, AJ, *et al.* (2020) Increasing picocyanobacteria success in shelf waters contributes to long-term food web degradation. *Glob Change Biol*. 26: 5574– 5587. https://doi.org/10.1111/gcb.15161

Stern, R., Edwards, M., O'Brien, T., Clarke, D., Tarran, G., Widdicombe, C., Bresnan, E., Artigas, L.F., Creach, V. (2021) Celtic Sea Ecosystem Overview for Phytoplankton. Ed. Predreschi, D. (in press)

Annex 1: List of participants

WGPME 2021 meeting

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WGPME 2020 meeting

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WGPME 2019 meeting

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Annex 2: WGPME Resolution

The **Working Group on phytoplankton and microbial ecology** (WGPME), chaired by Marie Johansen, Sweden, and Rowena Stern, UK, will work on ToRs and generate deliverables as listed in the Table below.

	Meeting dates	Venue	Reporting details	Comments (change in Chair, etc.)
Year 2019	11–14 March	Las Palmas de Gran Canaria, Spain		Meeting in association with WGZE and WGIMT
Year 2020	28–30 April	by corresp/ webex		physical meeting cancelled - remote work
Year 2021	26–28 April	Online meeting	Final report by 15 June to SCICOM	

ToR descriptors

ToR	Description	Background	Science Plan codes	Duration	Expected Deliverables
a	Generate improved knowledge of small food web components that are poorly monitored/assessed	There is a lack of consideration of microbial biomass in monitoring and assessment studies.	1.3	3 Years	Review paper (in year 3). Feed into relevant national and international working groups as appropriate
b	Explore the use of indicators and provide recommendations for methods development.	a) Potentially harmonize methodological approaches (e.g. molecular tools) b) Provide more precise phytoplankton descriptors (MSFD)	1.3; 4.1; 4.4	3 years	The group will review and evaluate available science dealing with indicator development as needed. National updates on the topic will be requested from EG members.
c	Conduct an integrated analysis of phytoplankton and microbial plankton re-sponses to global warming.	Understand consequences of long-term changes e.g. in phenology and body size for foodweb func-tioning and associated eco-system services.	1.3; 2.5	3 years	Papers producrion depending on the key outcomes.
d	Produce a guide of live vs Lugol-fixed key species from exisitng samples.	Facilitate better comparabil-ity between time series, producing representative images for to facilitate better comparability between time series, producing representative images for all of the species included in each time series relevant to WGPME,	4.4	3 years	Recommendation document to ICES to set up a database and ICES identification leaflets.

		provide realistic images pointing out limits of species IDs.			
e	Produce a Cooperative Research Report on Phytoplankton/ Zooplankton (in collaboration with WGZE)	Develop an integrated plankton report presenting trends in occurrence of both phyto and zooplankton	1.3; 1.9	Year 2	CRR: Phytoplankton and Zooplankton Status Report
f	Investigate factors affecting the closeness of correlations between chlorophyll a and phytoplankton biomass.	There is a need to further develop phytoplankton related indicators. The phytoplankton biomass indicators developed so far for the MSFD only consider Chl a as a rough estimate of plankton biomass.	3.3; 4.1	Year 3	Position paper with recom-mendations for the scope of using chlorophyll:biomass (biovolume) correlations in different contexts

Summary of the Work Plan

Year 1	A joint workshop with WGIMT, WGZE with the goal of further methods standardization. This is of high priority, to finalize the plankton status report. Most of the ToR will run for the whole 3 years period.
Year 2	Assemble data for (online), to continue work on manuscripts already in preparation. Finilize the integrated plankton report.
Year 3	Discuss assesment efforts historically made of the small food web components. The generation of recommendations to improve how they best can be concidered and applied in food web assessments.

Supporting information

Priority	The current activities of this Group will lead ICES into issues related to the ecosystem effects of fisheries, especially with regard to the application of the Precautionary Approach. Consequently, these activities are considered to have a very high priority.
Resource requirements	The research programmes which provide the main input to this group are already underway, and resources are already committed. The additional resource required to undertake additional activities in the framework of this group is negligible. However the resource of a database with identification leaflets of phytoplankton would be recommended.
Participants	The Group is normally attended by some 20–25 members and guests.
Secretariat facilities	Standard secretarial support
Financial	No financial implications.
Linkages to ACOM and groups under ACOM	There are no obvious direct linkages.
Linkages to other commities or groups	There is a close working relationship with WGZE, WGIMT and also some linkage to WGHABD.
Linkages to other organizations	None specific