

OSPAR CEMP Guideline

Common indicator: PH1/FW5 Plankton lifeforms

(OSPAR Agreement 2018-07)¹

This OSPAR biodiversity indicator is still in the early stages of implementation and as a result of iteration and learning, it is anticipated that there will be evolution of the methods and approaches documented in the CEMP guidelines. Version updates will be clearly indicated and be managed in a phased approach via ICG-COBAM through its expert groups and with the oversight and steer of BDC.

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¹ This document exists in English only

1 Introduction

Indicators based on lifeforms (also known as functional groups) can be used in some hydrographic conditions to assess community response to sewage pollution (Charvet et al. 1998; Tett et al. 2008), anoxia (Rakocinski 2012), fishing (Bremner et al. 2004), eutrophication (Helcom 2012) and climate change (Beaugrand 2005). Changes in plankton lifeform pairs can provide information on ecosystem structure and energy flow. Combination of lifeform pairs will depend on the habitat and the objective of the indicator, e.g. as a measure of GES for pelagic habitats, food webs, seafloor integrity or eutrophication. An important advantage of these plankton indicators is that the proposed concepts are relatively easily transferable to other European waters (Gowen et al. 2015; Gowen et al. 2011; Rombouts et al. 2013).

In practice, the use of functional groups is often favoured over indicator species since indices of species abundance are frequently subject to large inter-annual variation, often due to natural physical dynamics rather than anthropogenic stressors (De Jonge 2007). Cryptic speciation within the plankton community alongside the limitations of identifying plankton using routine light microscopy techniques make the true diversity of plankton communities difficult to assess at a species or genus level. Functional group abundance is more appropriate. It is often less variable because variability in the abundances of the group's constituent species averages out. Moreover, indicators based on functional groups have been proved relevant for the description of the community's structure and biodiversity, and are more easily intercompared than taxonomic-based indicators (Estrada et al. 2004; Gallego et al. 2012; Garmendia et al. 2012; Mouillot et al. 2006).

Lifeform pairs can provide an indication of changes in: the transfer of energy from primary to secondary producers (changes in phytoplankton and zooplankton); the pathway of energy flow and top predators (changes in gelatinous zooplankton and fish larvae); benthic/ pelagic coupling (changes in holoplankton (fully planktonic) and meroplankton (only part of the lifecycle is planktonic, the remainder is benthic) (Table 1; see also Gowen et al. 2011). Both abundance and biomass data can be used to inform pairs, depending on the lifeform in question and data availability from monitoring programmes.

The plankton index of lifeform pairs has been developed to track changes in the state of the plankton in marine waters over time. The main features of the method are: (i) the grouping of species of planktonic organisms into functional types or lifeforms; (ii) the display of changes in the abundance of each of these lifeforms using a state-space approach; (iii) calculating a Plankton Index (PI) to quantify possible changes in the state of the plankton relative to baseline or starting conditions; (iv) relate trends in the PI to trends in human pressure and climate change indices.

Pairs chosen will depend on the ecohydrodynamic area types (Van Leeuwen et al. 2015), so regional adaptation will be needed. As the knowledge base increases, new pairs can be developed as indicators for other pressures than those currently measured. See Gowen et al (2015; 2011) and Tett et al (2008) for further technical information on the method.

For pelagic habitats, three common OSPAR indicators have been identified based on species (PH3), functional groups (PH1) and community abundance/biomass (PH2). Each indicator will provide specific and complementary information on the state/change and functioning of plankton communities. Currently, these indicators are developed in parallel but for a robust assessment of the pelagic habitat, these should be considered simultaneously to 1) understand changes and dynamics within the community, 2) reduce the uncertainty in the assessment and 3) to understand the links with anthropogenic pressures. Moreover, plankton strongly depend on physico-chemical properties in the environment so these should be integrated in the assessment; that way, if environmental status must be improved, measures can be taken at the habitat rather than the biological community level.

2 Monitoring

2.1 Purpose

What is the objective of the assessing the indicator; only status of the environment, or also to support identification of pressures and programmes of measures?

- Currently, PH1/FW5 is a state indicator which does not provide a direct link to pressures. With continued development PH1/FW5 can be used for the identification of deviation from natural variability for D1, D4 and D6, and will provide information supporting D2, D3, and D5.

2.2 Quantitative Objectives

Plankton sampling collects data which can be used for not only pelagic indicators, but also for food web indicators as well. One plankton sample can be used to inform PH1/FW5, PH2 and PH3. Data collected can also be used to inform D2, D3 and D5. Therefore one set of monitoring data can be used in multiple ways.

Which parameter needs to be measured?

- Plankton abundance or biomass (per species/genera/taxa)

2.3 Monitoring Strategy

Plankton abundance and biomass must be monitored. PH1/FW5 has been developed using existing datasets which are required for informing the indicator.

Several protocols can be used. It's most cost effective to go with what we already have than to get all CPs to use the same methodology; this also enables establishments of baselines through use of historical data. Integration of existing time-series is key – the pelagic team has considered this practical approach throughout.

- As of the IA2017 assessment, data are from three sources:
 - 1) the Continuous Plankton Recorder (CPR) survey, a regional monitoring programme at the European scale, including offshore areas; the CPR's regional scale is scientifically critical for understanding plankton dynamics. The CPR survey is funded by the UK and not the EU or other CPs.
 - 2) Fixed point time-series datasets from the UK (Plymouth Marine Laboratory) and Sweden (Swedish Meteorological and Hydrological Institute)

There are further important single station long-term datasets in Europe, particularly in coastal regions. Some of these have been submitted to OSPAR for use in assessments but there is not enough resources to integrate the datasets into the pelagic database and use them for assessment, as of June 2017.

2.4 Sampling Strategy

PH1/FW5 is important at the regional level and will be assessed at the ecohydrodynamic scale where possible.

Table 1. Minimum sampling strategy:

	Coastal	Shelf	Offshore
Frequency of data collection*	Monthly	Monthly	Monthly
Monitoring method	In situ	In situ	In situ
Who is responsible for	Member state	Member state	Member state

monitoring?			
Freq of indicator update and assessment	Annual update	Annual update	Annual update
Minimal amt of monitoring locations	Monitoring must cover all ecohydrodynamic areas.	Monitoring must cover all ecohydrodynamic areas.	Monitoring must cover all ecohydrodynamic areas.
<u>Current data availability</u>	Single point stations exist mainly in coastal waters but there are gaps in some regions.	The CPR is a European scale plankton monitoring programme, focusing on the shelf and offshore regions. Regular (monthly) fisheries and research cruises could be used for sample collection.	The CPR is a European scale plankton monitoring programme, focusing on the shelf and offshore regions. Regular (monthly) fisheries and research cruises could be used for sample collection.
*A complementary need exists for both long-term time-series as well as high frequency monitoring, particularly in habitats considerably influenced by anthropogenic pressures.			

2.5 Quality assurance/ Quality Control

The CPR has a QA/QC method which has remained virtually unchanged since 1948. SAHFOS procedures are documented, plankton analysts have International Phytoplankton Intercomparison (IPI; formerly known as BEQUALM) qualifications and SAHFOS chairs the NE Atlantic Marine Biological Analytical Quality Control (NMBAQC) scheme which is working to develop first a standard and then quality control scheme for zooplankton analysis. The main Plymouth Marine Laboratory (PML) analyst for L4 was trained by a skilled SAHFOS CPR analyst and holds NMBAQC qualifications. The analysts of the Swedish samples do yearly intercalibrations using either the service of IPI or HELCOM. The analysts are taxonomically trained continuously and updated with taxonomic changes.

Information on QA/QC of other datasets will be included here as those datasets are incorporated.

2.6 Data reporting, handling and management

- *Reporting format (Available via a link in the CEMP Appendices)*
- *Data metadata schema (Link to ODIMS, INSPIRE compliant)*
 - Each dataset is responsible for its own metadata
- *Confidence levels in data*
 - CPR data: The CPR has a QA/QC method which has remained virtually unchanged since 1948. SAHFOS procedures are documented, plankton analysts have International Phytoplankton Intercomparison (IPI; formerly known as BEQUALM) qualifications and SAHFOS chairs the NE Atlantic Marine Biological Analytical Quality Control (NMBAQC) scheme which is working to develop first a standard and then quality control scheme for zooplankton analysis.
 - PML data: The main PML analyst for L4 was trained by a skilled SAHFOS CPR analyst and holds NMBAQC qualifications.
 - SMHI data: The analysts of the Swedish samples do yearly intercalibrations using either the service of IPI or HELCOM. The analysts are taxonomically trained continuously and updated with taxonomic changes.

- Information on QA/QC of other datasets will be included here as those datasets are incorporated.
- *Data flows described (Additional to information in CEMP Appendix)*
 - Each dataset will eventually perform its own analysis once the methodology is finalised. The indicator lead will then aggregate this information.
- *Data storage*
 - A vulnerability of the process is that there is no central storage area for data or documents. Instead these items are stored on personal laptops and hard drives. A central storage area, such as a server at Defra or OSPAR or a Dropbox is required.

3 Assessment

3.1 Data acquisition

- *How you extract the data specifically for your assessment question*
 - Data were extracted by SAHFOS, SMHI and PML. Additional data have been submitted via the pelagic data call which came out in April 2016, but those data have not yet been incorporated into the assessment due to a lack of resources.

3.2 Preparation of data

- *Normalisation of data (If it has come from different monitoring methods)*
 - Because the data are from different sources, it is important that they are kept separate and not directly combined.
- *Aggregation and integration of data acquired*
 - Data are aggregated into means for each calendar month (e.g. January 1958, February 1958, etc).
 - In the North Sea and Celtic Seas, data are analysed at the ecohydrodynamic area spatial scale. Because no EHD model exists for the Bay of Biscay, the Bay of Biscay is treated as one subregion (see below for further detail).
- The standard species list should be used for lifeform creation. This is maintained/updated by the COBAM pelagic group and a copy is held by OSPAR. Check with the pelagic expert group chair for most current version.



PH1 masterlist
12062017.xlsx

- The Matlab code (one control script and six functions) for data processing can be found at:
 - <http://www.sams.ac.uk/paul-tett>
 - --> go to 'resources tab and look for 'plankton index' under software-
 - --> 'guide to theory and software' section 4 specifies data format

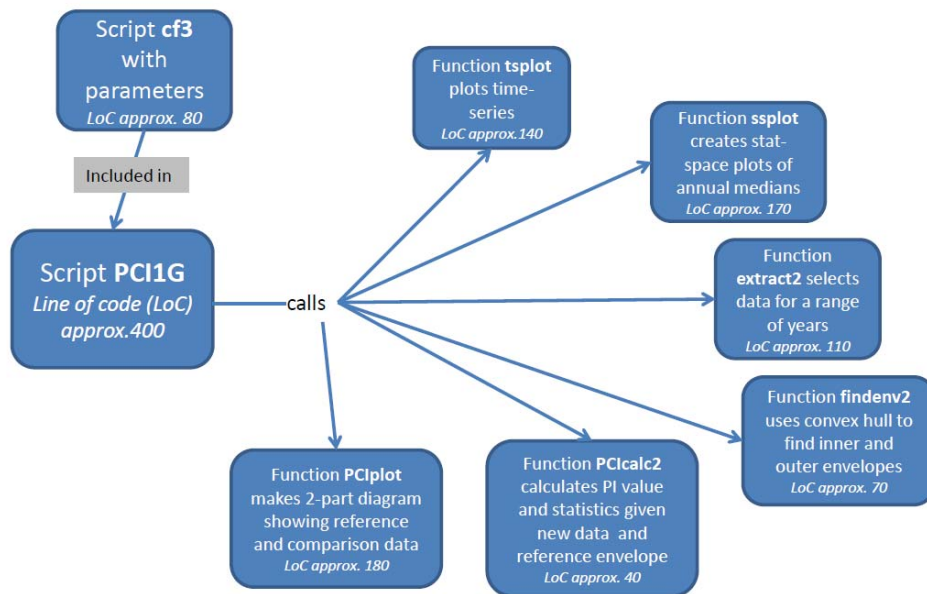


Figure 1. Diagram showing the relationships of MatLab control script and six functions needed to create the lifeform plankton index.

3.3 Assessment criteria

- *Defining assessment unit/scale (Temporal and spatial)*
 - For the North Sea and Celtic Sea we report state according to ecohydrodynamic areas (Level 2). For the Bay of Biscay this is not yet possible (as of August 2016) so we will report state according to Level 1 areas.
- *Baseline/ reference condition / assessment value*
 - The baseline will be set in the past (*but not as a reference pristine condition, just as a starting point for change*) and assessment value will be evaluated as “change away from the baseline”. A set period of years will be selected as the reference envelope; for the IA2017 the period 2004-2008 was selected. A comparison was made with the most recent six-year period available (for IA2017 this was 2009-2014). In accordance with our proposed assessment value the absence of a significant trend in an indicator or lack of a significant correlation between the indicator trend and the trend in a human pressure will be used as evidence that the assessment value has been met (for that criterion and the plankton community as a whole). However, this presupposes that the starting point of the time-series represented by the baseline represented (reference condition) Good Environmental Status. This may not be the case. Where data exist, it will be necessary to use this to determine the current status of the plankton at those locations but 2 – 3 years of data will have to be collected to characterise the status of the plankton. If, however, existing data sets can be used to characterise Good Environmental Status for plankton communities (using ecological theory, modelling, the absence of obvious human pressure and expert opinion), it may be possible to use such data as reference conditions for new monitoring sites and existing sites at which the status of the plankton does not meet GES.
- *Proposed assessment value*
 - Plankton community is not significantly influenced by anthropogenic pressure (proposed)

3.4 Spatial Analysis and / or trend analysis

- *Statistical analysis (e.g. Method for trend analysis, Establishment of confidence limits)*

State-space theory:

Tett et al. (2008) proposed to track changes in the state of the phytoplankton community by means of plots in a state-space and calculating a Plankton Community Index, referred to here as a Plankton Index, (PI). The conceptual framework is that ecosystems can be viewed as systems with an instantaneous state defined by values of a set of system state variables which are attributes of the system that change with time in response to each other and external conditions. Building on this approach and plotting plankton lifeform abundances in a multi-dimensional state-space provides a means of monitoring changes in the organisation of plankton communities. A state can be defined as a single point in state-space, with co-ordinates provided by the values of the set of state variables, in our case two lifeform abundances, which together are used as a pair.

In the example illustrated in **Figure 2**, the axes of the two dimensional (2D) space are the abundances of two lifeforms. Each point represents the state of the ecosystem in terms of the two lifeforms at the time the water sample was collected. Subsequent samples yield additional pairs of abundance values that can be mapped onto the lifeform state space.

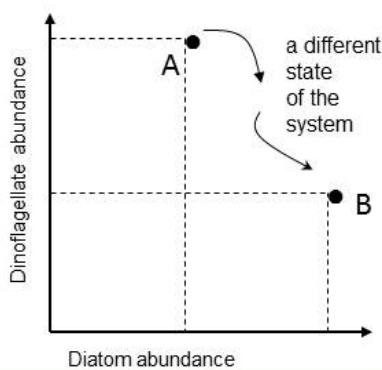


Figure 2 : Mapping the abundance of two lifeforms in state space. Point A is the ecosystem state at the instant a water sample was taken and is characterised by the abundances of two lifeforms. Another sample, taken in the same location, yields abundances that map to a different point in the diatom-dinoflagellate state-space (point B).

The path between the two states is called a trajectory, and the condition of the phytoplankton is defined by the trajectory drawn in the state-space by a set of points. Such trajectories reflect: (i) cyclic and medium term variability (the higher order consistencies in the plankton that result from seasonal cycles, species succession and inter-annual variability); (ii) long term variability that might result from environmental pressure. The seasonal nature of plankton production and the succession of species in seasonally stratifying seas, result in this trajectory tending in a certain direction (as plankton growth increases in the spring and declines during autumn), such that the trajectory tends towards its starting point. Given roughly constant external pressures, the data collected from a particular location over a period of years forms a cloud of points in state-space that can be referred to as a regime. Long-term variability may show a persistent trend of movement away from a starting point in state-space.

To define a regime, an envelope can be drawn about this group of points using a convex hull method. Because of theoretical arguments that the envelope should be doughnut-shaped with a central hole, bounding curves can be fitted outside and inside the cloud of points (**Figure 3**).

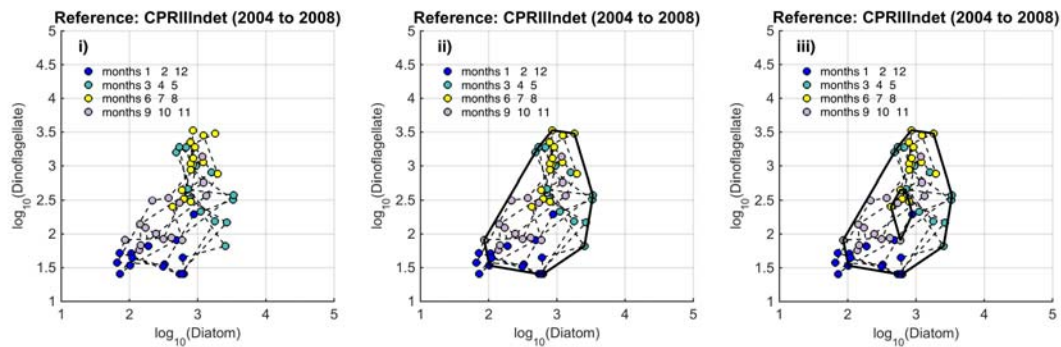


Figure 3. Creating the envelope in three steps, from left (i) to right (iii): An example of a regime defined by the envelope drawn by the convex hull method. The plot is displayed on a logarithmic scale because this is a common method of showing the full extent of seasonal variability. The data are from the ecohydrodynamic zone that represents the indeterminate area within the Greater North Sea (EHD II Indet, see figure Figure 1). The colour of each point corresponds to the season it was sampled within; winter months=blue, spring months =aqua, summer months =yellow, autumn months =purple.

The size and shape of the envelope are sensitive to sampling frequency and the total numbers of samples. Envelopes are made larger by including extreme outer or inner points, and the larger the envelope, the less sensitive it will be to change in the distribution of points in state-space and therefore to detect a change in condition. Conversely, if too many points are excluded the envelope will be small and even minor changes will result in a statistically significant difference. It is therefore desirable to exclude a proportion (p) of points, to eliminate these extremes, and so the 90th percentile was used. Envelopes are therefore drawn around the cloud of points to include a proportion ($p = 0.9$) of the points: with 5% of points that were most distant from the cloud's centre, and 5% of points that were closest to the centre excluded.

In order for a Plankton Index to be calculated, it is necessary to establish starting conditions as the basis for making comparisons. In the example shown in **Figure 3**, data collected from the indeterminate area within the Greater North Sea (see **Figure 5**) between 2004 and 2008, are used to create an envelope. The envelope, thus drawn (Figure 3i)) defines a domain in state-space that contains a set of trajectories of the diatom-dinoflagellate component on the marine pelagic ecosystem and thus represents the prevailing regime during the starting period.

The next step is to map a new set of data into the starting condition state space and compare these new data (at least a dozen points (**Figure 3ii**)). The value of the PI is the proportion of new points that fall inside the envelope (or to be precise, between the inner and outer envelopes). In the example shown in **Figure 4**, 24% or 17 of the 71 new points lie outside, and the PI is 0.76. A value of 1.0 would indicate no change, and a value of 0.0 would show complete change, with all new points plotting outside the starting condition envelope. The envelope was made by excluding 10% of points, so some new points are expected to fall outside: 7.1 (10% of 71), in the case of the example. The exact probability of getting 17 by chance alone when only 7.1 are expected, can be calculated using a binomial series expansion, or by a chi-square calculation (with 1 df and a 1-tail test). The conclusion is that the value of 0.76, is significantly less than the expected value of 0.9, and so the condition of the phytoplankton in this region, as determined by diatoms and dinoflagellates, was statistically significantly ($p < 0.01$) different between the two periods.

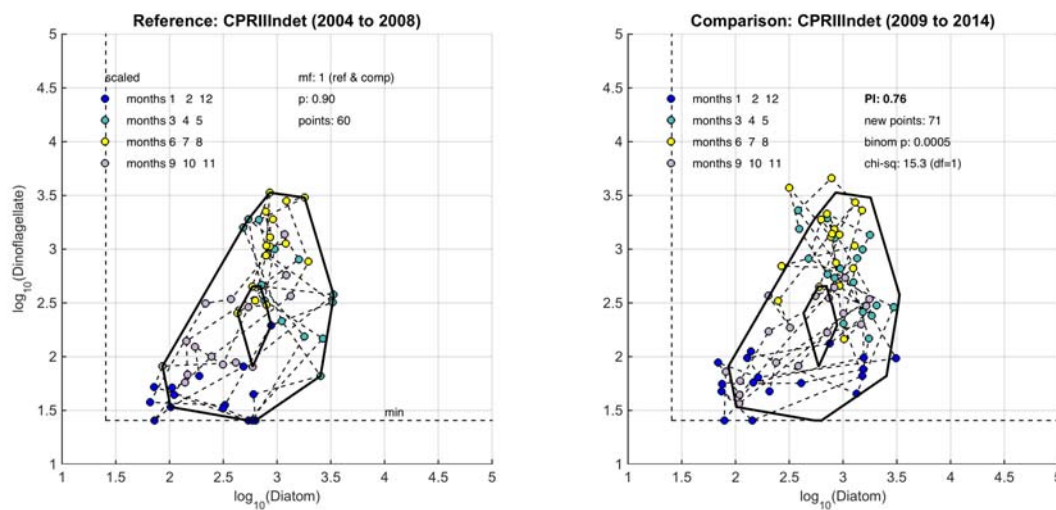


Figure 4 : An example for the comparison between two periods within the indeterminate area of region II (see Figure 1), i) is the reference period of 2004 to 2008, ii) is the comparison period of 2009 to 2014. The PI value of 0.76 shows a significant change between the two communities with a binomial p-value of 0.0005 (where significance = p-value < 0.01).

The time series of the index is produced by comparing the starting condition envelope with data collected from each subsequent year.

Two lifeforms will not be sufficient to describe all of the important characteristics of the plankton. In principle, there is no constraint to adding more lifeforms to the state-space plots (see Tett et al. 2013). The rule is that each additional lifeform has to be different from those already used and the axis for each new lifeform has to be drawn at right angles to all existing axes. The state-space map therefore has to be drawn in as many dimensions as there are state variables (lifeforms) but this becomes complicated when considering the number of lifeforms that we might want to use to fully represent the community structure of the plankton.

- ***Two dimensional state-space plots of specific pairs of plankton lifeforms can be used to investigate pelagic habitats and can be combined to provide a holistic plankton indicator to track changes in the condition of the planktonic component of the pelagic ecosystem.***
- ***Time series of the index will be used to track persistent changes in the condition of the plankton over time and relate any such trend to trends in anthropogenic and climate pressures.***

Starting conditions and analysis:

The period of 2004 to 2008 was selected for the starting conditions as each dataset used here (Continuous Plankton Recorder, Swedish Meteorological and Hydrological Institute, Plymouth Marine Lab L4) has adequate data during that period to construct a reliable starting condition envelope. Additional European datasets will be added in the future as resources become available. This envelope represents starting conditions and not reference conditions. The starting condition envelope was compared with data from the subsequent six-year period (2009 to 2014). The 2009 to 2014 period was chosen as it is the most recent period with data and it is the same temporal length as the MSFD assessment period.

- ***Starting conditions do not represent reference conditions***

Spatial scale:

Because plankton community composition, distribution, and dynamics are closely linked to their environment, the

analysis was performed at the scale of the “ecohydrodynamic” zones (EHD; Figure 5) (van Leeuwen et al. 2015). EHDs were determined through analysis of a 50-year hind cast using the General Estuarine Transport Model (GETM) physical model of North Sea hydrodynamics (the model is at lower resolution in the Celtic Seas and is not developed for the Bay of Biscay). EHDs are constructed using density stratification, the most important large-scale physical feature in shallow shelf seas (van Leeuwen et al. 2015). Density stratification occurs when the buoyancy of surface waters (influenced by fresh-water input or solar heating) is stronger than turbulence and vertical mixing, which limits vertical exchange across the pycnocline (van Leeuwen et al. 2015)). The predominant EHD zone types, based on water column structure, are:

- Permanently mixed throughout the year;
- Permanently stratified throughout the year;
- Regions of freshwater influence (ROFIs);
- Seasonally thermally stratified (for approximately half the year, including summer);
- Intermittently stratified;
- Indeterminate regions (inconsistently alternate between the above).

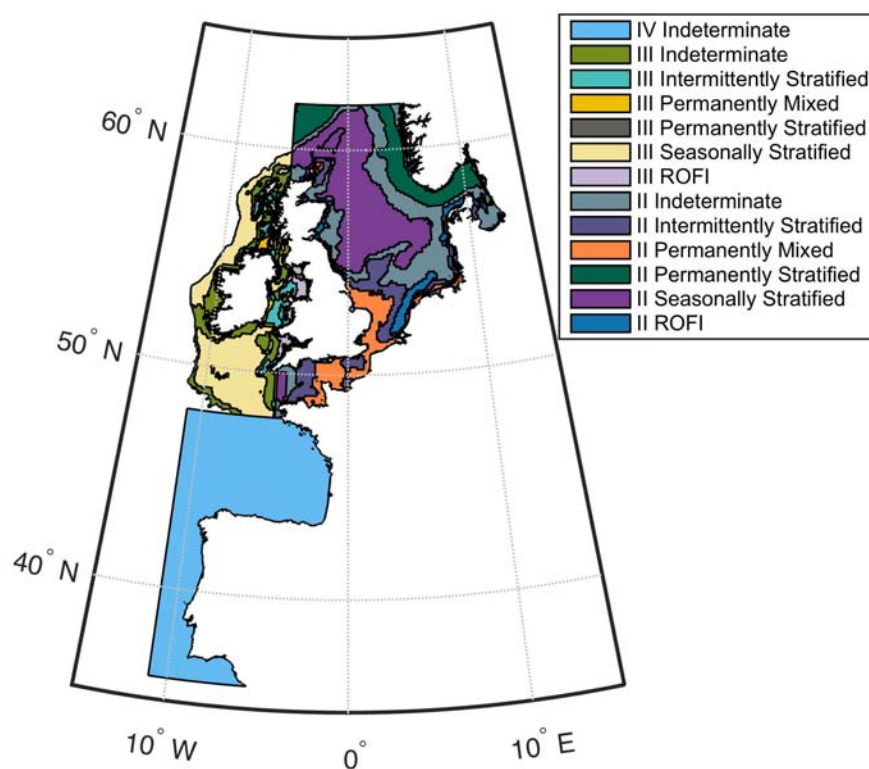


Figure 5: Map of ecohydrodynamic zones (EHDs) in the Greater North Sea, Celtic Seas and the Bay of Biscay and Iberian Coast, coloured by EHD type and region number.

EHDs are constructed based on key water column features, which are important to plankton community structure and dynamics. The predominant EHD area types, based on water column structure, are 1) Permanently mixed throughout the year, 2) Permanently stratified throughout the year, 3) Regions of freshwater influence (ROFIs), 4) Seasonally thermally stratified (for about half the year, including summer), 5) Intermittently stratified and 6) Indeterminate regions (inconsistently alternate between the above levels of stratification).

At the time of calculating this assessment (2016), the EHD model was more reliable and detailed for the Greater North Sea than for the Celtic Seas. The model had not been developed for the Bay of Biscay and Iberian Coast so that sub-region was considered as a single region of indeterminate status.

- ***Ecohydrodynamic zones (EHDs) are a geographical representation of the conditions which best suit plankton distribution, dynamics and community composition***
- ***EHD’s are constructed based on water column density stratification***

The plankton data:

The assessment has been carried out using phytoplankton and zooplankton data from three different sources (Figure 6). The data submitted by the Swedish Meteorological and Hydrological Institute (SMHI) and Plymouth Marine Laboratory (PML – United Kingdom) are fixed point time series. Four near-shore stations from SMHI were used in the analysis, which fall in to the EHD zone that describes the indeterminate regions of the Greater North Sea. Both zooplankton and phytoplankton are sampled one to two times per month all year around. The PML station (L4) is 13 km offshore from Plymouth and is sampled for zooplankton and phytoplankton and a suite of other variables on a weekly basis. Unlike the fixed point stations, data from the Continuous Plankton Recorder (CPR) survey is collected at a much broader spatial scale through the use of ships of opportunity. CPR data are collected offshore and in the open ocean and are best analysed at a monthly time scale. It should be noted that all other data for this assessment comes from the CPR data collection on major shipping lanes. The CPR survey is coordinated by the Sir Alister Hardy Foundation for Ocean Science (SAHFOS) in the UK. Data from the different providers were not combined for analysis due to differences in sampling, plankton analysis and enumeration methods. Instead, the datasets were analysed separately. Each dataset has internal QA/QC procedures to ensure consistency and accuracy of the data.

As the SMHI stations are located in the indeterminate EHD of the Greater North Sea their data were averaged for analysis. All CPR samples were averaged for each EHD type in each OSPAR sub-region. In the future, more datasets from other OSPAR Contracting Parties will be incorporated into the analysis.

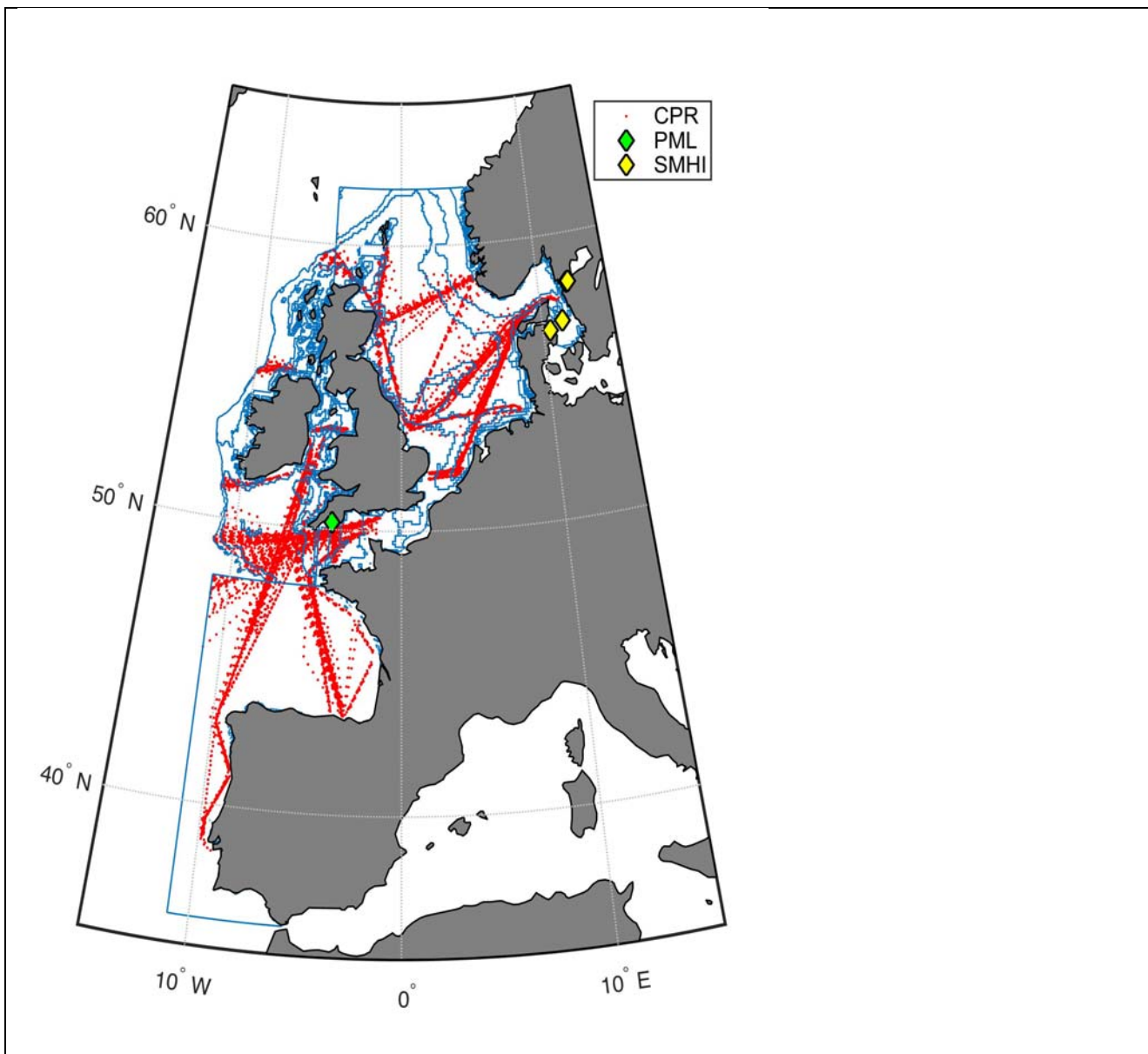


Figure 6: Map of sample locations. The data used for this assessment were obtained from the UK (CPR and PML L4) and Sweden (SMHI). Future work will expand the plankton database to include data from additional countries.

Lifeform construction:

Each lifeform pair consists of two ecologically relevant lifeforms, which contain common functional traits (**Table 2**). The rationale for selecting the lifeform pairs and additional criteria containing supplementary information on lifeforms is contained in **Table 2**.

The database master species list was built by assigning functional traits to each species for a dataset and then adding additional new datasets to expand the master species list (**Figure 7**). The species list for each new dataset was assigned a unique Aphia ID via the World Register of Marine Species (WoRMS) (**Figure 7**). The new dataset's species list was then compared with the plankton database's master species list via Aphia IDs and any new species were identified. This process ensures that each species is only entered in the database once. The new species were then manually assigned functional traits by searching the literature; fields were left blank where functional traits for species were unknown. Once traits were assigned, the new species were added to the master species list. Queries were constructed to build lifeforms from the functional trait information (**Table 3**).

A simple method of confidence assessment was used to determine the confidence in each lifeform (**Table 4**).

Using expert opinion, each lifeform was evaluated on two characteristics: the ability to ID and speciate organisms in that lifeform using light microscopy and the understanding of the accuracy of determining traits assigned to the lifeform. For example, low confidence is assigned to the lifeform pair ‘diatoms vs autotrophic and mixotrophic dinoflagellates’ as the mixotrophic and autotrophic mode of nutrition of many dinoflagellates species is currently uncertain. Thus the accuracy of assigning the lifeform category is low. Likewise, the lifeform pair ‘carnivorous zooplankton v non-carnivorous zooplankton’ has a low confidence designation since the feeding habits of many abundant and common zooplankton species remain unknown. Further investigation also must be conducted to decide if both nuisance and toxin-producing lifeform pairs are required. Only pairs with two high-confidence lifeforms were used in the OSPAR reporting.

- **Species are assigned functional traits and combinations of traits are used to construct lifeforms**
- **Lifeform pairs consist of ecologically-relevant lifeforms, with each pair having an ecological rationale for selection**
- **A simple confidence assessment method was used to evaluate the confidence in each lifeform. Only pairs containing two high-confidence lifeforms have been used for reporting**

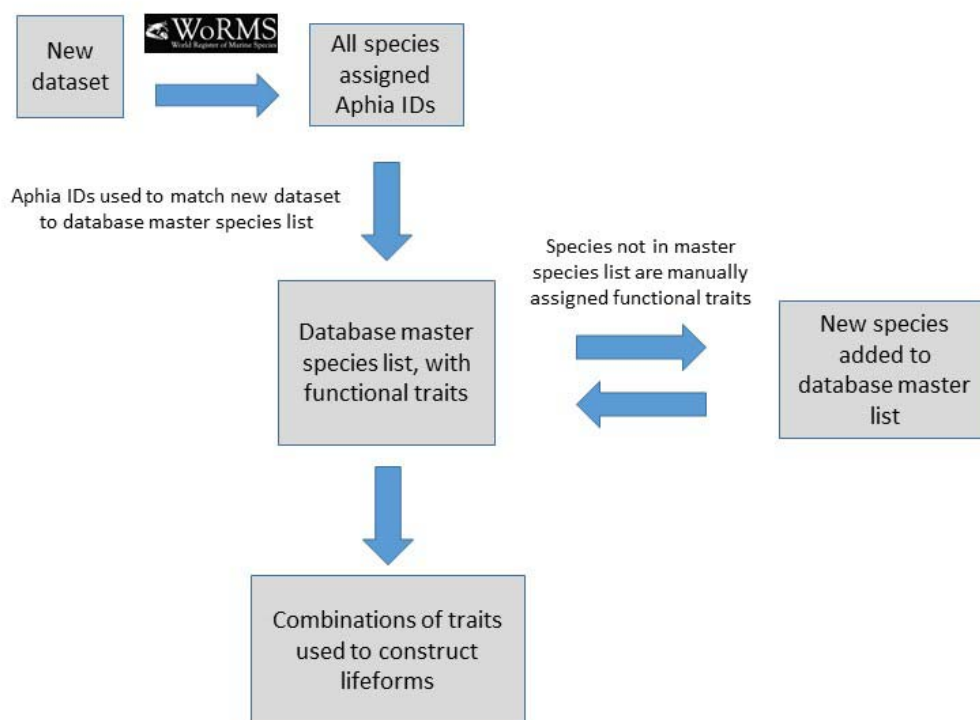


Figure 7: Schematic illustrating the process undertaken to assign traits to species, then species to lifeforms. Each species must first be assigned a unique Aphia ID to determine if it is already present in the master species list.

Table 2: Lifeform pairs consist of two ecologically-relevant lifeforms. The ‘Additional criteria’ column contains supplementary information regarding particular lifeforms. We have also included a simple confidence rating for each lifeform pair, as described in the text.

Lifeforms	Additional criteria	Confidence	Explanation
Diatoms vs dinoflagellates		High	Dominance by dinoflagellates may be an indicator of eutrophication or change in water column stability and may result in less desirable food webs.

Gelatinous zooplankton vs fish Larvae/eggs	Ctenophores and cnidaria	High	Indicator of energy flow and possible trophic pathways.
	Include fish eggs		
Small copepods vs large copepods	Adults <1.9mm (not nauplii or eggs)	High	Size based indicator of food web structure and energy flows.
	Adults >2mm		
Carnivorous zooplankton vs non-carnivorous zooplankton		Low	Indicator of energy flow and balance between primary consumers and secondary consumers.
Crustaceans vs gelatinous zooplankton		High	Indicator of energy flow and possible trophic pathways.
Large microphytoplankton vs small microphytoplankton	>20 um cells, not colonies.	High	Size-based indicator of the efficiency of energy flow to higher trophic levels.
	<20 um cells, not colonies.		
Microphytoplankton vs non-carnivorous zooplankton	Biomass (example Chl, PCI)	High	Indicator of energy flow and balance between primary producers and primary consumers.
	Abundance		
Diatoms vs autotrophic and mixotrophic dinoflagellates		Low	Shift in primary producers may indicate eutrophication.
Pelagic diatoms vs tychopelagic diatoms		High	Indicator of benthic disturbance and frequency of resuspension events.
Nuisance and/or toxin-producing diatoms vs diatoms Or Nuisance and/or toxin-producing dinos vs dinos		Low	Shift in algal community towards nuisance and/or toxic species which have the potential to impact other higher trophic level indicators.
Holoplankton vs meroplankton		High	Indicator of strength of benthic-pelagic coupling and reproductive output of benthic versus pelagic faunas.
Ciliates vs microflagellates	Including tintinnids	Low	Shift from primarily autotrophic to a more heterotrophic system.
	All species < 20 µm		

Table 3: Each lifeform is constructed of organisms with particular traits. A query is then used to assign lifeforms

to individual species.

Lifeform	Traits	Criteria
Diatoms	'Diatom' only	PhytoplanktonType=Diatom
Dinoflagellates	inoflagellate' only	PhytoplanktonType=Dinoflagellate
Gelatinous zooplankton	'Gelatinous' only	PlanktonType=Zooplankton AND Gelatinous=Y
Fish larvae/eggs	'Fish' only	ZooType=Fish
Carnivorous zooplankton	'Carnivore' only	PlanktonType=Zooplankton AND Diet=Carnivore
Non-carnivorous zooplankton	'Zooplankton' AND either 'Herbivore', 'Omnivore', OR 'Ambiguous'	PlanktonType=Zooplankton AND (Diet=Herbivore OR Omnivore OR Ambiguous)
Crustaceans	'Crustacean' only	Crustacean=Y
Large phytoplankton	'Phytoplankton' AND 'Lg'	PlanktonType=Phytoplankton AND PhytoplanktonSize=Lg
Small phytoplankton	'Phytoplankton' AND 'Sm'	PlanktonType=Phytoplankton AND PhytoplanktonSize=Sm
Phytoplankton	'Phytoplankton' only	PlanktonType=Phytoplankton
Autotrophic and mixotrophic dinoflagellates	'Dinoflagellate' AND either 'Auto' OR 'Auto/Mixo'	PhytoplanktonType=Dinoflagellate AND (FeedingMech=Auto OR Auto/Mixo)
Pelagic diatoms	'Diatom' AND 'Pelagic'	PhytoplanktonType=Diatom AND DiatomDepth=Pelagic
Tychopelagic diatoms	'Diatom' AND 'Tychopelagic'	PhytoplanktonType=Diatom AND DiatomDepth=Tychopelagic
Nuisance and toxin-producing diatoms	'Diatom' AND either 'Toxic' OR 'Nuisance'	PhytoplanktonType=Diatom AND (HAB = Toxic)
Nuisance and toxin-producing dinoflagellates	'Dinoflagellate' AND either 'Toxic' OR 'Nuisance'	PhytoplanktonType=Dinoflagellate AND (HAB = Toxic)
Holoplankton	'Holoplankton' only	Habitat=Holoplankton
Meroplankton	'Meroplankton' only	Habitat=Meroplankton
Large copepods	'Copepod' AND 'Lg'	Copepod=Y AND ZooSize=Lg
Small copepods	'Copepod' AND 'Sm'	Copepod=Y AND ZooSize=Sm
Ciliates	Ciliate'	PhytoplanktonType=Ciliate
Microflagellates	'Dinoflagellates' AND 'Sm'	PhytoplanktonType=Dinoflagellate AND PhytoplanktonSize=Sm

Table 4: A simple method of confidence valuation was used to determine the confidence in each lifeform. Only pairs with high confidence used in the OSPAR reporting.

	Easy to ID/speciate	Difficult to ID/speciate
Known traits	High	Low
Unknown traits	Low	Low

3.5 Presentation of assessment results

- *Consideration of target audience and appropriate communication style*
- *Assessment metadata schema (link to ODIMS)*

The common indicator assessment is published on the OSPAR Assessment Portal <https://oap.ospar.org/en/ospar-assessments/intermediate-assessment-2017/biodiversity-status/habitats/changes-phytoplankton-and-zooplankton-communities/>

4 Change Management

- *Responsibility for follow up of assessment (e.g. if the monitoring is not adequate)*
 - Pelagic subgroup of ICG-COBAM
 - BDC

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