DANISH SCIENTIFIC APPRAISAL OF HELCOM'S AND OSPAR'S INDICATORS IN RELATION TO THE MONITORING PROGRAMME UNDER THE MARINE STRATEGY FRAMEWORK DIRECTIVE

– status 2020

Technical Report from DCE – Danish Centre for Environment and Energy No. 168 2020

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Data sheet

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Abstract: DCE has been asked by the MFVM to conduct a road map of the currently existing indicators or indicators under development. This road map will function as a status review or appraisal of each indicator and serve as an update of the DCE contribution of the 2014 road map. It was requested, that the road map should include information on background and aims, list potential problems or reservations and provide suggestions for solutions. For indicators under development, the road map should focus on potential future challenges such as lack of data and determination of threshold values. Based on the request DCE developed a road map indicator template, which was approved by the MFVM on November 22nd 2019 and it has consequently been used for the review.

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Preface

As part of DCEs advisory work for the Ministry of Environment and Food (MFVM), scientists participate in several HELCOM and OSPAR expert groups and networks on the environment. Part of this work include either review and/or development of descriptor indicators under the Marine Strategy Framework Directive (MSFD).

DCE has been asked by the MFVM to conduct a road map of the currently existing indicators or indicators under development related to the expert groups and networks that they are involved in. This road map will function as a status review or appraisal of each indicator and serve as an update of the DCE contribution of the 2014 road map (https://portal.helcom.fi/meetings/CORESET%20II%202-2014%20joint/MeetingDocuments/4-4%20Danish%20scientific%20appraisal%20of%20HELCOM%E2%80%99s%20and%20OSPAR%E2%80%99s%20indicators.pdf).

It was requested, that the road map should include information on background and aims, list potential problems or reservations and provide suggestions for solutions. For indicators under development, the road map should focus on potential future challenges such as lack of data and determination of threshold values.

Based on the request, DCE developed a road map indicator template, which was approved by the MFVM on November 22nd 2019 and it has consequently been used for the review.

The assignment from MFVM also included completing an extensive excel sheet with the indicator status information. This excel sheet have been emailed to MFVM separately from this document.

MFVM has commented on this document two times. First draft was send to MVFM on the 02.12.2019 and returned to DCE on the 20.12.2019. In this first round all comments from MVFM concerned requests for further elaboration of the background or status of an indicator. No text was deleted as a result of the comments. A second draft was send to MVFM on the 19.01.2020 and returned on 06.03.2020. AU incorporated the comments and an internal scientific review was performed. The name of the scientific reviewer, which were all employed at Department of Bioscience, Aarhus University, is noted at the end of each indicator. The document was subsequently approved and published.

The road map includes the following indicators: Page number:

Indicator appraisals

D1 Biodiversity

D1 Biodiversity (Marine mammals)

Seven HELCOM and three OSPAR indicators use, or aim to use, marine mammal data. The three OSPAR indicators (M4-B: Abundance and Distribution of Cetaceans, M3: Seal abundance and distribution, M5: Grey seal pup production) and three of the HELCOM indicators (Population trends and abundance of seals, Distribution of Baltic seals, Harbour porpoise distribution and abundance) use survey data and/or passive acoustic monitoring data (PAM) to assess abundance, distribution and pup production. The two HELCOM indicators on seal abundance and distribution have been operational for several years and are not addressed further. The HELCOM and OSPAR porpoise and cetacean indicators are under development. The OSPAR indicators on distribution and abundance of seals have been used for the OSPAR Intermediate Assessment 2017 and will probably be used in a very similar format in future corresponding assessments. The aerial survey and PAM data used for evaluating these abundance and distribution indications derives from the NOVANA and supplementary MSFD-related programmes. The indicators (except OSPAR M5, Grey seal pup production) address the primary MSFD criteria abundance and distribution. The porpoise indicators are not operational yet, because funding is needed for the development of a porpoise population model that will allow for the determination of threshold levels.

Three HELCOM indicators rely on carcasses collected from hunted, bycaught and stranded marine mammals, namely Nutritional status of marine mammals, Reproductive status of seals and Marine Mammal Health. These indicators address the condition of the populations, a secondary criterion. None of these indicators are fully operational. For harbour porpoise (Belt Sea population) and harbour seal (Limfjord, Kattegat, Western Baltic), Danish waters hold the majority or the entirety of these population units. To make these indicators operational and to supply a reliable data flow, Denmark's participation is essential. As these indicators all rely on the same data pool (from carcasses), programmes dedicated to data collection should be synergistic. Collection of carcasses will also enable the elucidation of key life history parameters (e.g., age at sexual maturity, age specific survival rates) which are valuable in the evaluation of abundance trends. Denmark does not collect stranded marine mammals on a large scale (< 40 animals per year across the country) and input for these indicators are thus very limited and scattered in time and space.

The last indicator, HELCOM's Seal pup weight at weaning, concerns grey seal pups, of which very few presently are born in Denmark, thus the importance of Danish data for the development of this indicator is minor.

DCE were not requested to review the indicators on bycatch of marine mammals and this subject is thus not included here.

Indicator title: **Abundance and Distribution of Cetaceans M4-B**	
HELCOM () OSPAR (X)	Partially overlapping (X) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
OSPAR Marine Mammal Expert Group (OMMEG) with Germany as lead.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. For the indicator to be effective, population abundance data should be available at regular interval of every six years. At present, the SCANS surveys (aerial and ship surveys of cetaceans coordinated on a European level) have been conducted at an 11-year interval. The SCANS surveys are not part of the Danish NOVANA program. Continued support for future SCANS surveys are needed to provide data.

Is a national (or regional) database in place?
Since SCANS surveys are not part of the Danish NOVANA program, the data are stored at DCE.

Background for indicator:
This indicator has been divided in three:

- M4-A Abundance and distribution of killer whales (pilot assessment)
- M4-A1 Abundance and distribution of coastal bottlenose dolphins
- M4-B Abundance and distribution of cetaceans other than killer whales and coastal bottlenose dolphins

The M4-B covers not only harbour porpoise but all whales not covered by the other two indicators and is thus the most relevant for Danish waters.

CEMP guidelines (OSPAR's Coordinated Environmental Monitoring Programme) have been developed describing the methods for monitoring: https://www.ospar.org/documents?v=39019

Aim of Indicator:
To detect trends in harbour porpoise abundance and distribution to a level where conservation measures can be implemented in time to restore the status of the population in case of a decline.

Does the indicator match COM DEC 2017 criteria? (and which)
It is planned to match the criteria of D1C2 (Abundance) and D1C4 (Distribution)

Thresholds:
Have not been implemented yet, but the OMMEG made the following suggestion in 2020:

"To maintain the porpoise population size at or above baseline levels (using the earliest reliable population estimate (e.g. from SCANS I or II) as the baseline provided that it is reasonable to assume that this represents GES, which may not be the case for very small populations or those subject to important known pressures), with no absolute decrease of >30% and a rate of decrease no greater than 30% over three generations (for porpoises estimated as 22.5 years). The rate of decrease may be assessed over a shorter time period (e.g. matching the 6-year reporting cycle) if the projection of future decline is considered to be reliable and/or the absolute decline is so large that the population is considered to be "at risk"; the CEMP guidelines (OSPAR's Coordinated Environmental Monitoring Programme) define these as:

- Declining means a negative trend of ≥5% over 10 years (significance level $\alpha<0.05$)
- Increasing means an positive trend of ≥5% over 10 years (significance level $\alpha<0.05$)
- Stable means population changes of <5% over 10 years

In particular, OMMEG supports the EG MAMA (HELCOM Expert Group on Marine Mammals proposal to set the threshold of statistical significance to $\alpha = 0.20$ in order to increase statistical power. "… "Thus, for

harbour porpoise, a 30% decline over 3 generations corresponds to an annual decline of 1.77% or just over 9% over the 6 year reporting cycle".

Description of challenges and reservations:
Historical data on abundance and distribution are lacking, so it is impossible to base the favourable reference value on historic abundances. Thus the indicators must focus on current trends and as such AU supports the suggested threshold as described above. The possibility to detect trends should be improved by increasing the frequency of large-scale surveys to every 6th year. Furthermore, to date, large-scale surveys have been undertaken during summer, resulting in a lack of seasonal information at the large scale.

The abundance estimates should be produced on a regular 6-year interval in order to provide data for the EU reporting periods.

Suggestions for solutions and process forward:
Funding should be assigned for future participation in SCANS-surveys on a 6-year interval.

Appraised by (name of AU advisor):
Signe Sveegaard

Qualifications of appraiser with regard to this indicator:
Signe Sveegaard, senior advisor, PhD, is specialised in harbour porpoise distribution, abundance and ecology. She has been a member of the OSPAR Marine Mammal Ecology Group (OMMEG) since it was re-established in 2018 and has thus taken part in developing this indicator.

Internal scientific review by:
Line A. Kyhn, Special Consultant, Researcher, Section for Marine Mammal Research, BIOS, AU

Indicator title:

Abundance and distribution of harbour porpoises (candidate)

Key site density of harbour porpoises (candidate)

HELCOM (X) OSPAR ( )	Partially overlapping (X) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM harbour porpoise indicator working group with Germany as lead. Also involved is Sweden, Finland, Poland and Denmark.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. For the Belt Sea harbour porpoise population the Danish NOVANA program is sufficient, but could be optimized by combining the abundance estimates of MiniSCANS (only the Belt Sea population in Kattegat, Belt Seas and western Baltic) with the larger European SCANS surveys to be conducted every sixth year.

For the Baltic Proper harbour porpoise, only one total population abundance estimate from 2011-2013 is available (SAMBAH.org). This should be repeated on a regular basis to be able to provide an estimate of trend. At present, we only know that the population is extremely small but not whether it is increasing or decreasing.

With regard to distribution, several Baltic Sea countries (including Denmark) have deployed passive acoustic monitoring (PAM) stations on part of the SAMBAH stations on a permanent or sporadic interval.

Is a national (or regional) database in place?
Data for the Belt Sea population is gathered as part of the NOVANA monitoring program which includes both population abundance estimates (1 per 6th year) and intermediate PAM in Natura 2000 sites (1 year every 6th year). While some data are available in "Naturdatabasen" (https://naturdata.miljoeportal.dk/), the data is mainly hosted at AU since it remains to be determined how all of the acoustic data, should be stored nationally.

For the Baltic Proper population, one additional year have been monitored around Bornholm (2018-2019) following the SAMBAH project, but at present the future monitoring is not planned. Aarhus University and The Danish Environmental Protection Agency are in the progress of applying for funding for SAMBAH II together with all other Baltic countries (except Russia): Germany, Sweden. Finland, Poland, Estonia, Latvia and Lithuania. The application will be submitted to EU LIFE in June 2020, and the final decision will be taken in Spring 2021. Data can at the earliest by collected 2022-24.

Background for indicator:
It was decided in HELCOM to create a working group for this indicator in 2017. The work have been ongoing with 1-2 annual meetings. It is still being debated whether this indicator should be divided in two: one for population abundance and one for density at key sites (a measure of distribution). The group is in close collaboration with the newly formed OSPAR MMEG, to avoid double work.

Aim of Indicator:
To detect trends in harbour porpoise abundance and distribution to a level where conservation measures can be implemented in time to take action and restore the status of the population in case of a decline.

Does the indicator match COM DEC 2017 criteria? (and which)
It is planned to match the criteria of D1C2 (Abundance) and D1C4 (Distribution).

Thresholds:
Have not been determined yet. It is planned to develop a population model to determine a threshold, but funding is not yet available. The model is planned to be included in the SAMBAH II project for both the Baltic Proper and the Belt Sea harbour porpoise population.

Description of challenges and reservations:
For both populations: Historical data on abundance and distribution of both populations are lacking, so it is impossible to base the favourable reference value on historic abundances. Thus the indicators must focus on current trends. The possibility to detect trends should be improved by increasing the frequency of large-scale surveys to every 6th year. Furthermore, to date, large-scale surveys have been undertaken during summer, resulting in a lack of seasonal information at the large scale.

Belt Sea population: Abundance estimates on a regular 6th year interval. Development of protocol for comparing and utilising the different monitoring schemes in Germany, Sweden and Denmark to assess intermediate (between population abundance surveys) changes in distribution at key sites.

Baltic Proper population: Main challenge is lack of data.

Suggestions for solutions and process forward:
EG MAMA (HELCOM Expert Group on Marine Mammals) 2019 suggested that for the indicator 'harbour porpoise abundance and distribution' to be fully operational, 30,000 euros covering 3 months of total worktime was proposed sufficient for modelling Favourable Reference Values (FRV) and Good Environmental Status (GES) threshold value.

Resources for the compilation of harbour porpoise data are also needed. 80,000 covering 4 months of total worktime is necessary for trend analyses and optimal design of monitoring programmes for abundance and distribution.

Appraised by (name of AU advisor):
Signe Sveegaard

Qualifications of appraiser with regard to this indicator:
Signe Sveegaard, senior advisor, phd, is specialised in harbour porpoise distribution, abundance and ecology. She has been a member of the Jastarnia group under ASCOBANS since 2007 and is the Danish representative of the HELCOM harbour porpoise distribution and abundance indicator group since 2018 and is thus taken part in developing this indicator.

Internal scientific review by:
Line A. Kyhn, Special Consultant, Researcher, Section for Marine Mammal Research, BIOS, AU.

Indicator title: **Nutritional status of marine mammals**	
HELCOM (X) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM Marine Mammal Health Group
Lead: Sweden is lead

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Danish data are being collected for the HELCOM area, but small populations in some areas and heterogeneous material in terms of age group, season and sex in all areas means that these are not adequate for setting thresholds.

Is a national (or regional) database in place?
Danish data are collected as part of the Danish EPA project 'Blubber thickness of Danish Marine Mammals'. Blubber thickness data are collected from stranded, regulated and live caught animals. A national database is planned for 2020.

Background for indicator:
Although all Baltic grey seals are part of the same management unit, the established GES threshold values appear to be inappropriate for Danish waters, where the blubber thickness is generally smaller. The indicator is operational for 1-3 year old grey seals from northeastern Sweden and Finland. GES threshold values are determined for hunted grey seals to be 40 mm and 35 mm for by-caught seals. For a population of grey seals approaching carrying capacity of the ecosystem, the GES boundary is 25 mm, but this latter estimate is based on theory rather than relevant data. GES threshold have not been set for grey seals, harbour seals or harbour porpoises in Danish waters.

Aim of Indicator:
To assess the nutritional status of marine mammals at a population level.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C3.

Thresholds:
There are presently not enough data from Danish waters to set thresholds.

Threshold have been set for grey seals in the northern part of the HELCOM area.

Description of challenges and reservations:
It is expensive to catch marine mammals to measure blubber thickness. Therefore regulated, bycaught or stranded animals should be used. However, fishermen are not allowed to bring by-caught harbour porpoises to harbour if they catch them by mistake, which means that valuable information is lost.

It is expensive to collect dead marine mammals and few people know where to report them. A balance needs to be struck between responding to people who do report animals, and collecting the most useful animals possible within the budget available from the EPA. The heterogeneous material in terms of sex, reproductive status, age group and season makes it statistically challenging to normalize the samples for these variables, and thus, the effective sample size is decreased.

Suggestions for solutions and process forward:
Building and training a stranding network with volunteers measuring or collecting stranded marine mammals could save time and money and ensure adequate data, once the network is up and running. Obtaining permission for fishermen to land bycaught porpoises and seals for use in blubber thickness analyses. Providing permissions for regulating seals on the premise that they are salvaged and made available for subsequent investigations. Regulated and bycaught marine mammals are invaluable data for this indicator,

as well as for reproductive status and health, because they are generally representative for the population relative to stranded animals, which are biased towards diseased and nutritionally compromised specimens. Hopefully, the limitations of the Danish data can be countermanded by including data from neighbouring countries for the setting of thresholds and subsequent assessments of GES.

Appraised by (name of AU advisor):
Line A. Kyhn

Qualifications of appraiser with regard to this indicator:
Ph.D., biologist and special consultant at Aarhus University. Specialized in biology of seals and porpoises since 2006.

Internal scientific review by:
Anders Galatius, senior advisor, PhD, Section for Marine Mammal Research, BIOS, AU.

Indicator title: **Reproductive status of seals**	
HELCOM (X) OSPAR ( )	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM Marine Mammal Health Group

Sweden is lead country for indicator development.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
No.

Data on regulated harbour seals from Swedish Kattegat are available, and small samples of Danish specimens are potentially available from regulation and collection on the beach (the animals need to be healthy, adult females at the right time of year to be included).

This leaves only a very small fraction of the seals collected in Denmark. There is no Danish program dedicated to collect stranded, bycaught or regulated seals and thus, only few suitable animals are collected.

There is no direct investigation of reproductive status of seals under NOVANA in the sense used by the indicator (investigations of pregnancy rates/birth rates of bycaught and hunted seals). Pup production of harbour and grey seals is monitored by aerial surveys in Denmark, and these data could potentially be used in an indicator with the same aim as the current indicator, but as the data are very different, new thresholds and assessment methods would need to be developed.

Is a national (or regional) database in place?
There is no national or regional database in place.

Background for indicator:
The indicator ''Reproductive status in marine mammals'' is part of the HELCOM program ''Health status'' in the program ''Mammals'.

Pup production of seals is a very direct indication of their condition and particularly relevant for Baltic seals, which have been subjected to severe reproductive impairments caused by chemical pollutants.

Aim of Indicator:
The aim is to assess the reproductive status of seals at a population level.

Does the indicator match COM DEC 2017 criteria? (and which)
Primary link: D1C3 (secondary)

Secondary links: D1C2, D1C4, D4C4, D8C2

Thresholds:
Thresholds have been set by the lead countries and approved by HELCOM EG MAMA. The set threshold value is defined as min. 80% pregnancy/birth rate. It is calculated by a Bayesian analysis, where it is evaluated whether observed data support the determined threshold value of good status. In this process, 80% support for a pregnancy rate ≥ threshold value is required. However, thresholds for populations close to carrying capacity need to be determined as it may be intrinsically lower. The lead countries should initiate this process and communicate with HELCOM EG MAMA.

Description of challenges and reservations:
Data have only been processed for ringed seals and grey seals from Sweden and Finland. Under the current conditions, it is unlikely that sufficient data for robust assessments will be available for other areas or species.

Denmark are collecting very few seals per year and not enough to support implementation of this indicator in Danish waters. Further necropsies have hitherto not focused on reproductive aspects.

At the moment, seals are only necropsied under 'Faldvildtkontrakten', at a maximum of 25 + 5 seals per year. Ideally, these seals should be equally distributed among the management units. In reality, the annual target of 25 harbour seals and 5 grey seals is hardly ever reached.

Suggestions for solutions and process forward:
Currently, this indicator cannot be implemented for Danish MSFD monitoring purposes, as hunted and by-caught seals are only available in very limited quantities. If hunting of seals in Denmark is initiated, this should be reevaluated. Adaptation of the indicator to the use of aerial survey data of pupping haulouts could be considered to expand its use to Danish waters. It should be acknowledged that such data cannot be used to assess pupping rate with high confidence, but it is the best option for areas or species with low access to hunted specimens. Aerial monitoring of pupping haulouts of grey and harbour seals is already being conducted under the Danish MSFD monitoring program.

In order to collect data on seal reproduction, Denmark needs to build a stranding network of volunteers who can collect animals for further examinations.

Appraised by (name of AU advisor):
Anders Galatius and Line A. Kyhn

Qualifications of appraiser with regard to this indicator:
Anders Galatius, senior researcher, PhD, is specialized in seal distribution, abundance and ecology. He has been a member of the OSPAR Marine Mammal Ecology Group (OMMEG) since it was re-established in 2018 and has been member and chair of HELCOM EG MAMA since 2011.

Line A Kyhn, Ph.D., biologist and special consultant at Aarhus University. Specialized in biology of seals and porpoises.

Internal scientific review by:
Signe Sveegaard, senior advisor, PhD, Section for Marine Mammal Research, BIOS, AU.

Indicator title: **Seal pup weight at weaning**	
HELCOM (X) OSPAR ( )	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
No lead country yet. HELCOM EG MAMA provides input.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
No. There are no programmes to address this indicator in any country. Some data exist in Estonia and Finland.

Is a national (or regional) database in place?
No.

Background for indicator:
Pup weight at weaning is a reliable measure of the condition of seals, in that pup weight is a direct measure of the resources an adult female can allocate to maximize survival and fitness of her offspring. Pup weights at weaning is only readily available for grey seals who have their pups in colonies or spread out, but easily detected on the sea ice. Ringed seals have their pups in snow dens on the sea ice and harbour seal pups can swim and escape almost from the moment they are born.

Pup weight at weaning is not monitored under the Danish monitoring programme, NOVANA.

Aim of Indicator:
This indicator aims to assess the condition of breeding females, a key demo-graphic entity, by pup weight at weaning. The indicator has not been developed beyond the concept.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C3 (secondary).

Thresholds:
There are no thresholds for this indicator. A lead country needs to be appointed to initiate the process.

Description of challenges and reservations:
There is no consistent monitoring of pup weight in any country. The indicator is only useful for one species, the grey seal.

Suggestions for solutions and process forward:
Pup weight at weaning is a relevant measure and does not have the problematic issues of 'Nutritrional status of seals', where the metric blubber thickness necessitates normalization of data for age, season, sex and reproductive status of the individuals. However, it is only realistically applicable to grey seals. In Denmark, grey seals do not have more 5-14 pups annually in the HELCOM area, so potential Danish data contributions would be sparse at present, but would increase in the future. Monitoring would be relatively inexpensive, if some key breeding colonies are selected to be monitored on an annual basis.

Appraised by (name of AU advisor):
Anders Galatius

Qualifications of appraiser with regard to this indicator:
Anders Galatius, senior researcher, PhD, is specialised in seal distribution, abundance and ecology. He has been a member of the OSPAR Marine Mammal Ecology Group (OMMEG) since it was re-established in 2018 and has been member and chair of HELCOM EG MAMA since 2011.

Scientific review:
Line A. Kyhn, Special Consultant, Researcher, Section for Marine Mammal Research, BIOS, AU.

Indicator title:

Marine Mammal Health

HELCOM (X) OSPAR ( )	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM Marine Mammal Health Group.

Lead: Germany

Are Danish data available for the HELCOM and/or OSPAR regional seas?
No.

Is a national (or regional) database in place?
No – there are no data at present.

Background for indicator:
This indicator is not operational and its development is currently being discussed in the working group 'Marine Mammal Health' under EG MAMA. This group has its next meeting before summer 2020 (postponed from March due to Corona). Details on the target organs need general consensus. It is expected that the group will agree on defined indicators during 2020.

Aim of Indicator:
To assess marine mammal health at a population level by regularly examining and assessing presence of prevailing diseases. And also to allow for examination of whether negative future changes in abundance of a species is caused by a new disease, a change in parasite composition or similar.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C3.

Thresholds:
Not established as the indicator has not yet been defined.

Description of challenges and reservations:
Very few seals and porpoises are collected annually in Denmark, and these are too few to support this indicator meaningfully. Additionally, further investigations of the necropsied animals will be necessary to address the data requirements of this indicator.

Dissected animals

year	Grey seal	Harbour seal	Harbour porpoise
2008	0	10	1
2009	0	18	5
2010	2	6	1
2011	0	21	0
2012	2	20	4
2013	1	21	4
2014	10	44	5
2015	3	18	2
2016	4	22	5
2017	2	16	7

Currently, marine mammals are only necropsied under 'Faldvildtkontrakten', at a maximum of 25 harbour+ 5 greyseals + 25 porpoises per year, which ideally should be distributed equaly among the relevant management units. In reality, these figures are not reached (see below).

Suggestions for solutions and process forward:
In order to collect data on Marine Mammal Health, Denmark can build a stranding network of volunteers who can collect animals for further examination. If further permissions to regulate seals are issued, it should be under the premise of salvaging the carcasses and making them available for necropsies. Also, fishermen should be permitted to bring bycaught harbour porpoises to harbour for necropsies. Bycaught and regulated marine mammals represent invaluable data for the indicators nutritional status, reproduction and health as they represent healthy animals.

Appraised by (name of AU advisor):
Line A. Kyhn

Qualifications of appraiser with regard to this indicator:
Line A Kyhn, PhD., biologist and special consultant at Aarhus University. Specialized in biology of seals and porpoises.

Internal scientific review by:
Anders Galatius, senior researcher, PhD, Section for Marine Mammal Research, BIOS, AU

D1 Biodiversity (Birds)

Six OSPAR and four HELCOM indicators relate to marine birds (OSPAR) or waterbirds (HELCOM), a category that in this context includes all bird species which for at least part of their annual cycle rely on marine or intertidal food resources and / or habitats. More than 50 species fall under this category, and they are subdivided into five categories by foraging ecology: benthic feeders, pelagic feeders, surface feeders, wading feeders and grazing feeders.

There is substantial overlap between the OSPAR and HELCOM indicators, with the HELCOM indicators to a large extent being adapted from pre-existing OSPAR indicators (previously Ecological Quality Objectives). Most of the indicators have been suggested and to some extent developed by the ICES / OSPAR / HELCOM Joint Working Group on Marine Birds (JWGBIRD) or its predecessor (ICES WGSE).

The indicators of bird abundance (one in OSPAR (here split into breeding and non-breeding), two in HELCOM) are relatively well-established and have been used in the most recent status assessments (OSPAR IA2017 and HELCOM HOLAS II). These indicators address the primary MSFD criterion D1C2. The other primary criterion D1C1 (bycatch in fishing gear) is so far not covered by an operational indicator, mainly due to lack of data. OSPAR has an operational indicator (used in IA2017) for breeding success under the secondary criterion D1C3, which is currently being revised. Both OSPAR and HELCOM aim to develop an indicator for D1C4 (distribution) although this is at an early stage. In addition, OSPAR has two indicators for D1C5 (habitat quality) at various stages of development: presence of non-native (predatory) mammals, and habitat disturbance.

Denmark currently only contributes data to the indicators of bird abundance. For breeding birds these data are incomplete with several species not being monitored. Breeding success of marine birds is currently not monitored in Denmark. For bycatch in fishing gear, methods for data collection are under development, but the current coverage is insufficient for the indicator (this also applies to other countries). The indicator for distribution will probably use the same data as the abundance indicators. The indicator for non-native mammals is not considered realistic to use in Denmark, while the data needs for the proposed habitat disturbance indicator are unclear at present.

Indicator title: **Number of drowned waterbirds in fishing gear / Marine bird bycatch**	
HELCOM (x) OSPAR (x)	Partially overlapping ( ) Complete overlap (x)

The indicator is being developed by (name of working group/s and lead country):
The ICES working group on bycatch (WGBYC) and JWGBIRD are involved, but there is no lead. However, UK and Germany have proposed a generic threshold (see below) for OSPAR, to be discussed at the Biodiversity data centre meeting in late March 2020.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
No.

No systematic data collection is in place. A current pilot project by DTU Aqua assesses the use of remote electronic monitoring (on-board video recording) to quantify bycatch.

Is a national (or regional) database in place?
No.

Background for indicator:
Bycatch in fishery gear is one of the main threats to seabird populations, and the EU's 'Action Plan for reducing incidental catches of seabirds in fishing gears' from 2012 requires that the problem is monitored and addressed.

Aim of Indicator:
To assess the extent and ideally impact of bycatch of seabirds in fishery gear.

Does the indicator match COM DEC 2017 criteria? (and which):
D1C1. This indicator is primary under the MSFD.

Thresholds:
No threshold defined, so far. 1% of total annual mortality has been suggested as threshold (see below).

Description of challenges and reservations:
The main current challenge for this indicator is the lack of available data. Limited data exist for gillnet fisheries (which are most important in relation to bycatch), but a systematic monitoring programme is not in place, and it is currently not possible to estimate total bird bycatch in Danish fisheries. DTU Aqua are developing an electronic monitoring programme, which attempts to address this. A secondary challenge is the development of threshold values. These should be developed and assessed at the regional scale, and at a species level. It is not meaningful for each country to develop its own threshold, because the impact on bird populations will depend on the total bycatch within the flyway. OSPAR and HELCOM thresholds will therefore be relevant for Denmark, but only as a part of a regional assessment.

Suggestions for solutions and process forward:
Further development of monitoring is necessary, particularly for the smaller fishing vessels that are currently not included in the program. The electronic monitoring being developed by DTU Aqua is central to this effort. Member states should collaborate to develop threshold values at the regional scale. Approaches for how to achieve this were discussed at an OSPAR-HELCOM workshop held in Copenhagen in September 2019. One suggestion made by JWGBIRD is to set the threshold as 1% of total mortality (which then would need to be estimated). Such a threshold would be precautionary, and would reflect the commitment in the EU Plan of Action 'to minimise seabird bycatch to as low levels as are practically possible'. UK and Germany are proposing this generic threshold for discussion at the OSPAR BDC meeting in March 2020.

Appraised by (name of AU advisor):
Morten Frederiksen & Ib Krag Petersen

Qualifications of appraiser with regard to this indicator:
Morten Frederiksen has been a member of JWGBIRD and its predecessor WGSE since 2004. Ib Krag Petersen is a member of JWGBIRD and has worked on bycatch of marine birds.

Internal scientific review by:
Thomas Bregnballe, senior researcher, Section for Wildlife Ecology, BIOS, AU coordinates monitoring of breeding waterbirds in Denmark.

Indicator title: **Abundance of waterbirds in the breeding season / Marine bird abundance (breeding)**	
HELCOM (x) OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
JWGBIRD, lead Germany (HELCOM), UK (OSPAR).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly, see below.

Is a national (or regional) database in place?
No.

Background for indicator:
Seabirds are a major component of marine ecosystems, and abundance is the most direct measure of population status.

Aim of Indicator:
To assess the abundance of breeding seabirds.

Does the indicator match COM DEC 2017 criteria? (and which):
D1C2. This indicator is primary under the MSFD.

Thresholds:
A quantitative baseline is agreed in OSPAR and HELCOM. Abundance of each species should be above 80% of a historical baseline for species laying one egg, and above 70% for species laying more than one egg. These levels are sensible and scientifically justified. The current baseline is simply abundance at the start of the available time series, which may not be the most sensible. A more objective baseline reflecting ecological carrying capacity or abundance without human intervention would be useful, but also difficult to construct.

Description of challenges and reservations:
This indicator is fairly unproblematic. However, not all species are covered by existing monitoring schemes (NOVANA), and there is no national database of breeding waterbird counts, which could be used to store and extract data. This means that Danish reporting of data for this indicator is unnecessarily complex and onerous.

Suggestions for solutions and process forward:
A national database to hold counts of colonially breeding seabirds would greatly improve the efficiency of reporting. The database will need regular updating. In particular there is a need for regular counts of breeding common eiders, mute swans, gulls and auks at all relevant sites or at selected sites. The current Danish monitoring programme NOVANA does not include any monitoring of gull colonies, except for the Wadden Sea.

The breeding populations of the following species included OSPAR IA2017 are not monitored in Denmark: mute swan, mallard, shelduck, common eider, common merganser, razorbill (though see below), common guillemot (though see below), ringed plover, oystercatcher, black-headed gull, herring gull, lesser black-backed gull, great black-backed gull, common gull.

Under the NOVANA programme, there are plans to initiate some monitoring of razorbill and common guillemot at the most important breeding site in Denmark.

Appraised by (name of AU advisor):
Morten Frederiksen & Thomas Bregnballe

Qualifications of appraiser with regard to this indicator:
Morten Frederiksen has been a member of JWGBIRD and its predecessor WGSE since 2004. Thomas Bregnballe coordinates monitoring of breeding waterbirds in Denmark.

Internal scientific review by:
Ib Krag Petersen, senior advisor, Section for Wildlife Ecology, BIOS, AU is a member of JWGBIRD and coordinates monitoring of non-breeding marine birds in Denmark.

Indicator title: **Abundance of waterbirds in the wintering season / Marine bird abundance (non-breeding)**	
HELCOM (x) OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
JWGBIRD, lead Germany (HELCOM), UK (OSPAR).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, although some offshore areas and species are not well covered (see below).

Is a national (or regional) database in place?
Yes. Data from NOVANA, national counts of wintering waterbirds every 3 years, and counts of moulting waterbirds in summer every 6 years.

Background for indicator:
Seabirds are a major component of marine ecosystems, and abundance is the most direct measure of population status.

Aim of Indicator:
To assess the geographically specific abundance of non-breeding seabirds.

Does the indicator match COM DEC 2017 criteria? (and which):
D1C2. This indicator is primary under the MSFD.

Thresholds:
Yes, a quantitative baseline is agreed in OSPAR and HELCOM. Abundance of each species should be above 80% of a historical baseline for species laying one egg, and above 70% for species laying more than one egg. These levels are sensible and scientifically justified. The current baseline is simply abundance at the start of the available time series, which may not be the most sensible. A more objective baseline reflecting ecological carrying capacity or abundance without human intervention would be useful, but also difficult to construct.

Description of challenges and reservations:
This indicator is fairly unproblematic for the coastal marine bird species. However, some offshore areas and offshore bird species are not sufficiently covered, and data from offshore surveys are not yet fully incorporated into the indicator. This means that important species as for instance common eider, common scoter, velvet scoter, long-tailed duck, red-throated diver, black-throated diver and little gull have insufficient data for the indicator.

Suggestions for solutions and process forward:
A collaboration between countries around the Baltic Sea in winter of 2016 demonstrated that coordinated offshore surveys can be conducted. This needs further development to also include areas outside of the Baltic Sea. In particular, it requires a coordinated plan for analysis of the combined data set, including financial support for the task. JWGBIRD is developing methods for incorporating data from offshore surveys into the indicator. Future plans for coordinated surveys should encompass the need for a wide geographical coverage in order to enable inclusion of shifts in the distribution of wintering waterbirds.

Appraised by (name of AU advisor):
Morten Frederiksen & Ib Krag Petersen

Qualifications of appraiser with regard to this indicator:
Morten Frederiksen has been a member of JWGBIRD and its predecessor WGSE since 2004. Ib Krag Petersen is a member of JWGBIRD and coordinates monitoring of non-breeding marine birds in Denmark.

Internal scientific review by:
Thomas Bregnballe, senior researcher, Section for Wildlife Ecology, BIOS, AU coordinates monitoring of breeding waterbirds in Denmark.

Indicator title: **Distribution marine birds/seabirds**	
HELCOM (x) OSPAR (x)	Partially overlapping ( ) Complete overlap (x)
The indicator is being developed by (name of working group/s and lead country): No current development, no lead. UK national indicator could be adapted for a pilot assessment.	
Are Danish data available for the HELCOM and/or OSPAR regional seas? Yes, same data as for abundance.	
Is a national (or regional) database in place? Yes. Data from NOVANA, national counts of wintering waterbirds every 3 years, and counts of moulting waterbirds in summer every 6 years.	
Background for indicator: Distribution is one measure of population status.	
Aim of Indicator: To assess the extent of the distribution (or range) of seabird species.	
Does the indicator match COM DEC 2017 criteria? (and which): D1C4. This indicator is secondary under the MSFD.	
Thresholds: None, and no current development of thresholds. Developing a threshold for this indicator would be particularly challenging, as the importance of changes in distribution will be difficult to assess.	
Description of challenges and reservations: It is unclear what an indicator of distribution could add to the existing indicator of abundance. Seabird distribution at sea is highly dynamic on a very short timescale in response to environmental conditions, while the breeding distribution on land changes very slowly for most species. The indicator is used by the UK for breeding and non-breeding coastal birds, mainly waders, and could potentially be adapted for similar use in OSPAR and HELCOM. However, there is no current lead.	
Suggestions for solutions and process forward: No further development recommended.	
Appraised by (name of AU advisor): Morten Frederiksen **Qualifications of appraiser with regard to this indicator:** Morten Frederiksen has been a member of JWGBIRD and its predecessor WGSE since 2004.	
Internal scientific review by: Thomas Bregnballe, senior researcher, Section for Wildlife Ecology, BIOS, AU coordinates monitoring of breeding waterbirds in Denmark.	

Indicator title: **Non-native/invasive mammal presence on island seabird colonies**	
HELCOM ( ) OSPAR (x)	Partially overlapping ( ) Complete overlap ( )
The indicator is being developed by (name of working group/s and lead country): UK only at present.	
Are Danish data available for the HELCOM and/or OSPAR regional seas? No.	
Is a national (or regional) database in place? No.	
Background for indicator: Predation from mammals is one of the main threats to ground-nesting seabirds. Such mammals are typically absent from small islands, which is the main reason that these islands are the preferred nesting habitat of seabirds. However, invasive/non-native species like rats and American mink are able to disperse to many small islands, with or without human assistance. If and when they are present on such islands, they constitute a major threat to the locally breeding birds.	
Aim of Indicator: To assess the presence/absence of mammals on islands important for nesting seabirds.	
Does the indicator match COM DEC 2017 criteria? (and which): D1C5 (partly). This indicator is secondary under the MSFD.	
Thresholds: None, to our knowledge.	
Description of challenges and reservations: This indicator is developed and used in the UK, where most important seabird islands are situated some way offshore, and where new dispersal of mammals therefore is rare. However, other countries such as Germany, the Netherlands, Finland and Sweden have considered the indicator impractical, either because the number of islands involved is extremely large or because islands are situated close inshore where dispersal of mammals is common. In either case, monitoring the presence of mammals in a representative way is considered very difficult, and the countries have not been interested in applying this indicator. The same reservations hold for Denmark.	
Suggestions for solutions and process forward: Application of this indicator will probably remain limited to the UK.	
Appraised by (name of AU advisor): Morten Frederiksen & Thomas Bregnballe **Qualifications of appraiser with regard to this indicator:** Morten Frederiksen has been a member of JWGBIRD and its predecessor WGSE since 2004. Thomas Bregnballe coordinates monitoring of breeding waterbirds in Denmark.	
Internal scientific review by: Ib Krag Petersen, senior advisor, Section for Wildlife Ecology, BIOS, AU is a member of JWGBIRD and coordinates monitoring of non-breeding marine birds in Denmark.	

Indicator title: **Marine bird habitat disturbance**	
HELCOM ( ) OSPAR (x)	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
JWGBIRD, lead Germany.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Possibly, depends on final design of the indicator. Data from national NOVANA counts of wintering sea-birds every 3 years may be useful here.

Is a national (or regional) database in place?
Yes, for NOVANA data.

Background for indicator:
One of the main human impacts on seabirds in shallow coastal areas is disturbance, where marine habitat becomes temporarily or permanently unavailable to foraging seabirds due to e.g. shipping or construction of offshore wind farms or other infrastructure. Food availability may remain unchanged in such habitat, but some bird species do not tolerate disturbance well and will avoid areas with regular human traffic, or even near static infrastructure such as wind turbines.

Aim of Indicator:
To assess the extent to which habitat has become or regularly becomes unavailable for specific species of seabirds due to disturbance .

Does the indicator match COM DEC 2017 criteria? (and which):
D1C5. This indicator is secondary under the MSFD.

Thresholds:
None yet, presumably JWGBIRD/Germany will work on this.

Description of challenges and reservations:
While such an indicator could be highly relevant, it requires substantial further development before it can be applied. For example, it is necessary to develop methods to decide on a baseline to compare against. Either data from both before and after construction of specific infrastructure need to be available, or habitat availability before disturbance must be assessed using some kind of modelling based on birds' habitat preference. The latter may be necessary in the case of e.g. shipping, where no 'before'-data exist.

Suggestions for solutions and process forward:
JWGBIRD has suggested this indicator. Germany are interested in developing it and carrying out a pilot study in the North Sea, but the development will need thorough input from other member states.

Appraised by (name of AU advisor):
Morten Frederiksen & Ib Krag Petersen

Qualifications of appraiser with regard to this indicator:
Morten Frederiksen has been a member of JWGBIRD and its predecessor WGSE since 2004. Ib Krag Petersen is a member of JWGBIRD and coordinates monitoring of non-breeding marine birds in Denmark.

Internal scientific review by:
Thomas Bregnballe, senior researcher, Section for Wildlife Ecology, BIOS, AU coordinates monitoring of breeding waterbirds in Denmark.

Indicator title: **Waterbird breeding success/failure**	
HELCOM ( ) OSPAR (x)	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
JWGBIRD, lead UK.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
No.

Is a national (or regional) database in place?
No.

Background for indicator:
Breeding success is both a sensitive measure of the ecological quality of marine areas in terms of their ability to support seabird populations, and an early signal of potential future changes in population size (young birds recruit to the breeding population when they are several years old). This indicator has been in place in OSPAR for several years, but the way the data are being used at present has been regarded as sub-optimal by JWGBIRD. A revised indicator, which uses the same data in a different way, has been suggested by JWGBIRD and has been discussed at the OSPAR BDC meeting in March 2020. In conjunction with the indicator of breeding abundance, this indicator provides a detailed picture of changes in population size and the mechanisms behind such changes.

Aim of Indicator:
To assess the breeding success (number of chicks produced per breeding pair) of breeding seabirds, and the impact on changes in population size.

Does the indicator match COM DEC 2017 criteria? (and which):
D1C3. This indicator is secondary under the MSFD.

Thresholds:
OSPAR has approved thresholds for the current indicator. Thresholds for the revised indicator are not yet developed, JWGBIRD will lead on this.

Description of challenges and reservations:
This is potentially a very relevant and useful indicator, particularly if the changes suggested by JWGBIRD are accepted by OSPAR. At present, the indicator measures the proportion of all monitored colonies where breeding failure occurs. This is a simplistic measure and difficult to interpret. The proposed revised indicator will quantify mean breeding success, and use a population model to assess the impact this level of breeding success would have on the population growth rate in the long term. It would thus directly integrate criteria D1C1 and D1C3.

At present, the indicator only exists for the OSPAR area, as very few data on breeding success are collected in the Baltic region. A suggestion has been made to use data collected on breeding common guillemots on Stora Karlsö (Sweden) as a starting point for a HELCOM indicator of breeding success, and if this is approved, similar data could be collected in the Danish colony at Ertholmene (Græsholmen). However, at present no systematic collection of data on seabird breeding success occurs in Denmark (it is not part of NOVANA), and the current OSPAR indicator does not use Danish data. Such data collection would require additional resources.

Suggestions for solutions and process forward:
The changes suggested by JWGBIRD will lead to an improved indicator. If Denmark should contribute to the existing OSPAR indicator (potentially the new version) or the potential future HELCOM indicator, additional resources are needed to support data collection. One possibility: As a start it would be relevant to

initiate studies of breeding success for selected species in the Danish part of the Wadden Sea. A programme for this is running in the Dutch and German part of the Wadden Sea, and a 'wish' from Germany and the Netherlands has been expressed for Denmark to join this part of the trilateral monitoring programme. This could probably be carried out for 65-100,000 DKK per year. More time is needed to develop a proposal for monitoring selected species outside the Wadden Sea (which species, selection of study sites, resources required etc.).

Appraised by (name of AU advisor):
Morten Frederiksen & Thomas Bregnballe

Qualifications of appraiser with regard to this indicator:
Morten Frederiksen has been a member of JWGBIRD and its predecessor WGSE since 2004, and has developed the proposed revised version of this indicator. Thomas Bregnballe coordinates monitoring of breeding waterbirds in Denmark.

Internal scientific review by:
Ib Krag Petersen, senior advisor, Section for Wildlife Ecology, BIOS, AU is a member of JWGBIRD and coordinates monitoring of non-breeding marine birds in Denmark.

D1C6 Pelagic habitats

There are multiple overlaps in the pelagic indicators proposed by HELCOM and OSPAR, and a shared feature of most of them is that the indicators are not mature. The table below includes the indicators that are relevant for work conducted at DCE. The data needed to estimate the indicators are described in the column "Data type", and includes phytoplankton, zooplankton, pH and alkalinity, and C14 labelling data. The indicators are then further divided into biomass ratios or life pairs, alpha diversity, chemical measurement and C14 labelling. The reason behind pairing of the indicators is the shared methodologies, such as biomass ratio / life pair and alpha diversity share some methodological commonalities, allowing them to be addressed together. Furthermore, overlapping indicators are not required for a thorough MSFD survey. The overlapping pattern in indicators arises from the fact that many of the indicators are proposed by individual countries, although not agreed or evaluated across national EPAs´. DCE has made a proposed order of prioritization for evaluation, but not necessarily the final implementation. The prioritizations are made such that each data type is represented.

Denmark has +30 year's long data series on plankton (phyto- and zooplankton) from many parts of the Danish waters These data can most likely become a powerful asset in the future environmental monitoring of these key environmental species. Yet, for most of the pelagic indicators, the question about data availability arises. A process has been initiated with the aim of reformatting and recalculating the NOVANA plankton database. However, this process currently is on "standby" mode, and as a result, data are not openly available yet. If it's decided to move forward with the validation of the pelagic indicators, AU suggests to extract the data directly from the national STOQ database, and correct the faulty coding in the analysis process. From DCE's perspective, the recalculation of carbon biomass affects carbon biomass calculation, whereas bio volumes will be unaffected. This will provide a data set in terms of numbers / concentration and biovolume, through which the indicator validation could be performed.

Table of pelagic indicators and their prioritization for review. The list suggests which indicators within each group (marked by a capital letter indicating one of the four overall method approaches) should be reviewed first (with a number n (Xn) indicating the order).

Data type	Indicator	Overall method	Priority
Phytoplankton	Diatom / Dinoflagellate index	biomass ratio/life pair(A)	A1
*Phytoplankton	Seasonal succession of dominating phytoplankton groups	biomass ratio/life pair(A)	A1
Phytoplankton	Phytoplankton community composition as a food web indicator	alpha diversity(B)	B3
Phytoplankton	Phytoplankton species assemblage clusters based on environmental factors	biomass ratio/life pair(C)	C3
Phytoplankton	Phytoplankton taxonomic diversity	alpha diversity(B)	B1
Phytoplankton	Changes in Plankton Diversity	alpha diversity(B)	B2
Zooplankton/ phytoplankton	Changes of plankton functional types (life form) index Ratio	trait(D)	D1
Zooplankton/ phytoplankton	Changes in Phytoplankton Biomass and zooplankton Abundance	biomass ratio/life pair(A)	A2
*Zooplankton/ phytoplankton	Changes in Phytoplankton and Zooplankton Communities	biomass ratio/life pair(A)	A3
*Zooplankton	Zooplankton mean size and total stock (MSTS)	biomass ratio/life pair(A)	A1
**pH and alkalinity	Chemical ocean acidification indicator	chemical measurements(C)	C1
**C14 data	Production of phytoplankton	C^{14} labelling (D)	D1

*Partly reported until NOVANA plankton data was withheld. **already reported for DK waters.

Indicator type: **Diatom / Dinoflagellate index**	
HELCOM (x) OSPAR ( )	Partially overlapping () Complete overlap (x)

The indicator is being developed by (name of working group/s and lead country):
The indicator was originally developed by Germany, but besides OIW in Warnemünde, also CEFAS in the UK have worked with this indicator under the auspice of OSPAR. Thus, both HELCOM PEG and the OSPAR PELAGIC working groups have been involved.

Status: Pre-core indicator and under implementation as a national indicator in several countries around the Baltic Sea.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring in these waters resulting to a weak historical record. After database revision, Danish data will be submitted yearly to ICES.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring in these waters resulting to a weak historical record. After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:
The indicator assumes that increase loading of nitrogen shifts the balance between diatoms and dinoflagellates in favour of dinoflagellates.

Aim of Indicator:
To identify changes in the ratio between diatom and dinoflagellates as indicator of food web perturbations.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6. Applicable to descriptor 4 of MSFD: “food web and descriptor 5 of MSFD: “eutrophication”.

Thresholds:
Thresholds are established by Germany in their part of the Baltic Sea, but the reference data is questionable due to age and the methods available at the time.

Description of challenges and reservations:
The indicator for GES, as presented in HELCOM, is determined relative to the baseline level around 1900 as the reference year. The 1900 level is determined for individual stations, where the ratio is determined qualitatively and with methods that were used approx. 100 years ago thus not aimed at quantitative analysis. The indicator claims that the relationship between the two taxonomic groups, diatoms and dinoflagellates is governed by anthropogenic and climatic influences. From AUs perspective, this is questionable as it is neither funded on solid scientific experimental evidence nor on solid theoretical hypothesis. As an example, the ratio may as well be governed by wind-driven turbulent mixing of the water column and natural climatic fluctuations. This applies to the present as well as in 1900. Besides, there are no Danish data that allows the calculation of the Diatom-Dinoflagellate index until around 1980 and are solid. The reliable Danish data only appeared around 1988-1990, and it is therefore not directly possible to use empirical values as references. Furthermore, the interpretation is questionable, since the index is founded on the assumption that diatoms represent high GES values, whereas dinoflagellates represent low GES values. There is, as far as AU recognises, no reasons to assume that dinoflagellates per se represent low GES.

Suggestions for solutions and process forward:
Since Diatom/Dinoflagellate index is a pre-core indicator, DCE recommends that its application is prioritised. However, to validate the applicability of this indicator, it is necessary to apply Danish NOVANA data, which, as highlighted earlier, is in the 'held back' currently, since the STOQ database in the process of being updated. AU suggests a way forward in the introduction to this indicator. It is also necessary to investigate possible solid links to human and climatic pressures, to further accept or reject the indicator. If changes due to prevailing conditions (such as natural variability and climate change) can be separated from those caused by human pressures in each region, this will help to inform management GES based decision-making process by allowing the application of regionally targeted management measures, where needed.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG meeting since 2016. Besides, he has worked with phytoplankton ecology, both in the field and in various laboratory assays, for the past 20 years, including responses to nutrients and climate changes. He has not been involved in the indicator development process and has raised concerns.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Seasonal succession of dominating phytoplankton groups**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM PEG / Estonia.

Status: HELCOM core indicator under implementation as a national indicator in several countries around the Baltic Sea

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. There are very limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After the completion of the database revision process, Danish data will be submitted yearly to ICES.

Background for indicator:
The indicator assumes that nutrient changes the contribution of specific phytoplankton groups or the timing of when the group(s) dominate and becomes abundant, thereby influencing ecosystem function. The consequence of altered timing of food and carbon availability for other higher trophic levels (e.g. zooplankton) can have wider food web impacts, and on the sedimentation of detritus (e.g. dead phytoplankton), which can influence the microbial food web and ecosystem balance (e.g. heterotrophy/autotrophy), together with the impact on the physicochemical state of the ecosystem (e.g. oxygen concentration). A deviation from the normal seasonal cycle (such as too high or too low biomass, or absence of some dominating phytoplankton group(s)) is indicative of an impairment of environmental status. Phytoplankton species composition changes if the amount of nutrients or the ratios of important nutrients (e.g. nitrogen and phosphorus) change, with eutrophication resulting in more intense and frequent phytoplankton blooms in the summer.

Aim of Indicator:
To gauge how eutrophication impact seasonal changes in major phytoplankton groups.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
The threshold needs to be established at the scale of the salinity of the individual station. As per HELCOM PEG decision of 2016, it is suggested to develop it into a trend based indicator. References period can be established flexible and GES levels can be gauged accordingly to the reference period.

Description of challenges and reservations:
A good number of Danish time series allow calculation of the seasonal succession of dominating phytoplankton groups from the early eighties, while solid, credible Danish data exist around 1988-1990 and onwards. These phytoplankton data series coincides temporally with high eutrophication. This opens the question: how is the anthropogenic and natural succession separated when the original state is unknown? Besides, the salinity of the Danish monitoring stations varies between 7 and almost 30 ‰, which has a strong influence on the species composition and the annual/monthly dynamics. Preliminary studies of indicator values, estimated at the station level with Danish data, show that a large part of the estimated monthly indicator values fall outside the GES values due to a very dynamic ecosystem. Merging data

across stations is an option, but due to the large community variation driven by salinity, the chance of losing spatial and biological resolution is high, if data are pooled. However, the pooling of data may be possible, but great care has to be taken.

Suggestions for solutions and process forward:
Since seasonal succession of dominating phytoplankton groups is a HELCOM core indicator, DCE recommends its application is prioritised. AU has been presented the indicator as an example in an EXCEL file, together with an R-script of unknown origin aimed at estimating this indicator. These examples are estimated on monthly and yearly averages of non-balanced sampling data, without paying attention to the spatial and temporal data structure. As an example, in one year a few samples have been collected, whereas in other years multiple samples are collected but only within few months etc. Therefore simple arithmetic averages cannot be used, and other means using appropriate statistical methods such as general linear models must be used. This needs to be addressed in the future if the indicator should be used. There is no doubt that this approach has potential, and thereby the method deserves to be further developed by applying Danish data.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG meeting since 2016. Besides, he has worked with phytoplankton ecology, both in the field and in various laboratory assays, for the past 20 years, including work on responses to nutrients and climate changes. He has not been involved in the indicator development process and has raised concerns.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Phytoplankton community composition as a food web indicator**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap ( )
The indicator is being developed by (name of working group/s and lead country): HELCOM PEG / SYKE Finland. AU has not been involved in the development Status: test indicator	
Are Danish data available for the HELCOM and/or OSPAR regional seas? Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters.	
Is a national (or regional) database in place? Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After the completion of the database revision process, Danish data will be submitted yearly to ICES.	
Background for the indicator: A healthy phytoplankton community forms the basis for effective micro- and mesozooplankton communities, and further for healthy fish communities. Being the primary producing component of the pelagic food webs, phytoplankton is the first trophic level responding to changes in nutrient availability. In addition to external nutrient loading, phytoplankton composition responds to internal nutrient loading, physical conditions, climate changes, and food web interactions.	
Aim of Indicator: To identify the effects of increased loading of nitrogen and potential decay of the pelagic food web.	
Does the indicator match COM DEC 2017 criteria? (and which) D1C6.	
Thresholds: Thresholds are so far not established and instead, the indicator is used as trend “gauge”.	
Description of challenges and reservations: Since different consultants/taxonomists work up Danish data, it is essential to review comparability of data at the level of consultants/taxonomists.	
Suggestions for solutions and process forward: As a test indicator, it is possible to take part in the indicator development process, and DCE recommends that initiatives to contribute to further development is taken. Firstly, it is essential to apply Danish data to the indicator. Further, scientific research is needed to examine the magnitude and direction of change, with the potential changes at the basin and/or the monitoring station scales. It is also necessary to investigate possible links to human and climatic pressures. If changes due to prevailing conditions (such as natural variability and climate change) can be separated from those caused by human pressures in each region, this will help to inform management about the direction the pelagic system is heading, thereby following past, present and future mitigation initiatives.	
Appraised by (name of AU advisor): Hans Henrik Jakobsen	

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG meeting since 2016. Besides, he has worked with phytoplankton ecology, both in the field and in various laboratory assays, for the past 20 years. This also includes responses to nutrients and climate changes. He has not been involved in the indicator development process, and has raised concerns.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Phytoplankton species assemblage clusters based on environmental factors**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s):
HELCOM PEG (Latvia)

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. Strong data coverage for the inner part for the Danish waters. There are very limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After the completion of the database revision process, Danish data will be submitted yearly to ICES.

Background for indicator:
The indicator is proposed with the implicit assumption that the abundance of some groups changes relatively to others during increased nutrient loadings.

Aim of Indicator:
To investigate how phytoplankton cluster behaves to nutrient loads, and to understand how nutrient loads affect biodiversity.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
Not as far as DCE is aware of.

Description of challenges and reservations:
There is no *peer reviewed* scientific report on the modus operandi in the primary literature. DCE is not aware of this indicator. The available reports are not transparent, and the available ones in its current state are not recommended. This may be solved by a thorough application to Danish data. Since different consultants/taxonomists work up Danish data, it is essential to review the comparability of data at the level of consultants/taxonomists.

Suggestions for solutions and process forward:
Since some uncertainty exists on the indicator applicability, DCE proposes a standby position in terms of further work on this indicator. Firstly, Danish data needs to be applied to the indicator. Further scientific research is needed to examine the magnitude and direction of the change of the indicator, with the potential changes at the basin and/or the monitoring station scales. It is also necessary to investigate possible solid links to human and climatic pressures. If changes due to prevailing conditions (such as natural variability and climate change) can be separated from those caused by human pressures in each region, this will help to inform management GES based decision-making by allowing the application of regionally targeted management measures, where needed.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG meeting since 2016. Besides, he has worked with phytoplankton ecology, both in the field and in various laboratory assays, for the past 20 years, including responses to nutrients and climate changes. He has not been involved in the indicator development process, and thereby has raised concerns.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Phytoplankton taxonomic diversity**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM PEG.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. Strong data coverage for the inner part for the Danish waters. There are very limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea and only one near-shore station in Skagerrak. Beyond that, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After the completion of the database revision process, Danish data will be submitted yearly to ICES.

Background for indicator:
It has been suggested that the more diverse the phytoplankton community, the more resistant it is to the changes caused by external pressures. The indicator utilises the alpha (Shannon – Weaver index) of phytoplankton to gauge diversity. The biodiversity of phytoplankton, the key primary producers in the marine ecosystem, is often very difficult to estimate, since the phytoplankton assemblage includes a vast number of taxa, many of which occur in such small quantities that they may not be recorded in routine sampling. Moreover, even a skilled taxonomist cannot identify all taxa to species level by the methods available within routine phytoplankton monitoring, i.e. light microscopy of preserved samples. That is, routine phytoplankton monitoring methods does not provide a complete list of phytoplankton species in the ecosystem at any given point in time. The introduced Shannon95 method circumvents the problem of rare (and thus unreliably recorded) taxa by computing the Shannon biodiversity index from the taxa that cumulatively constitute 95% of the total phytoplankton biomass. The Shannon95 metric responds to the extent by which the community is dominated by just one or few taxa. The metric was originally developed for the open Gulf of Finland, and its applicability for other sea areas should be tested.

Aim of Indicator:
To assess the taxonomic diversity of the phytoplankton community in relation to external pressures, such as nutrient loadings.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
Unknown by AU but presumably not.

Description of challenges and reservations:
Danish monitoring data includes +30 years of phytoplankton monitoring data, and therefore is as such a potentially strong tool for using this indicator. DCE therefor supports its development and that this indicator should be prioritised. Some of the issues that need to be addressed are establishing reference/baseline values because reference data representing phytoplankton communities unaffected by anthropogenic influence does not exist. Potential deviation from an agreed reference period may be used instead, to tease out possible trending from a previous state. The salinity of the Danish monitoring stations varies between 7 and almost 30 ‰, which has a strong influence on the composition of species community, and the open

question is how species composition is separated from the role of salinity? Besides, since different consultants/taxonomists work up Danish data, it is essential to review and compare data are at the consultants/taxonomists level.

Suggestions for solutions and process forward:
A thorough assessment of Danish phytoplankton data is needed before more decision can be made. During the past two phytoplankton inter-calibrations, large variability in taxonomist species identification was found, and therefore a method to separate the "human" factor from natural variability needs to be established.

This indicator resembles the "Changes in Pankton Diversity" developed in OSPAR.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG meeting since 2016. Besides, he has worked with phytoplankton ecology, both in the field and in various laboratory assays, for the past 20 years, also including the work on responses to nutrients and climate changes. He has not been involved in the indicator development, and thereby has raised concerns.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Zooplankton mean size and total stock (MSTS)**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM ZEN ZIM / Sweden.

Status: Core indicator.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. Strong data coverage for the inner part for the Danish waters. There are very limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring i with a weak historical record for these waters. Furthermore, the indicator requires quite accurate quantitative and qualitative monitoring data.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:
This plankton indicator links the relationship between functional groups in the marine food chain.

Aim of Indicator:
To assess the connection of primary producers with the upper trophic links in the food chain by their ability to pass on food to fish and other top predators.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
The threshold needs to establish at the scale of the station. As far as DCE are aware, no agreed GES threshold has been agreed.

Description of challenges and reservations:
AU believes that this is potentially a strong indicator and supports its development.

Suggestions for solutions and process forward:
This is a core indicator, and DCE therefore, suggests that this indicator is further developed and tested against Danish NOVANA data. AU recognizes that there are large differences between basins and there's a need for applying NOVANA data before final acceptance.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in on HELCOM ZEN SIM meetings since when the indicator was presented. He has not been involved in the indicator development process. He has worked with zooplankton ecology, both in the field and with copepods in various laboratory assays, for the past 20 years.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Changes in Phytoplankton and Zooplankton Communities**	
HELCOM ( ) OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
OSPAR. Presumably France but AU has not been involved in the development.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. Strong data coverage for the inner part for the Danish waters. There are very limited data for the North Sea, and no data for Danish Skagerrak because there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:
Plankton lifeform pairs can be used, in some hydrographic conditions, to assess community response to sewage pollution, anoxia, fishing, eutrophication and climate change.

Changes in plankton communities can affect higher food web levels, such as shellfish, fish and seabirds, since these organisms are supported either directly or indirectly by plankton. Indicators based on plankton lifeforms (i.e. organisms with the same functional traits) can be used to reveal plankton community responses to external factors, such as nutrient loading from human activities and climate-driven changes. When examined in pairs with an ecologically-relevant relationship, changes in the relative abundance of a lifeform pair can indicate a change in key aspects of ecosystem function, including links between pelagic and benthic communities, energy flows and pathways, and food web interactions.

Changes between the proportions in the 'small copepod and large copepod' lifeform pair could indicate possible alterations in the food web structure and energy flows. Yet, direct scientific interpretations thus may be difficult.

Aim of Indicator:
The indicator aims at teasing out changes or shifts in ecosystem functionality. As an example, if the "holoplankton and meroplankton" lifeform pair changes, this will suggest changes in the linkage between the benthic and pelagic components of the ecosystem.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
Unknown by AU.

Description of challenges and reservations:
Since different consultants/taxonomists work up Danish data, it is essential to review comparability at the consultants/taxonomists level.

Suggestions for solutions and process forward:
The indicator is relevant and will most likely be adopted by OSPAR. DCE, therefore, support its further development. Firstly, it is essential to apply Danish data to the indicator. Further scientific research is needed to examine the magnitude and direction of the change of the indicator, with the potential changes at the basin and/or the monitoring station scales. It is also necessary to investigate links between change in zooplankton and phytoplankton groups and the human and climatic pressures affecting these. If changes due

to prevailing conditions (such as natural variability and climate change) can be separated from those caused by human pressures in each region, this will help to inform management decision-making process by allowing the application of regionally targeted management measures, where needed.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG and in relevant OSPAR meetings meeting since 2016/2018. Besides, he has worked with phytoplankton and zooplankton ecology, both in the field and in various laboratory assays, for the past 20 years, also including the work on responses to nutrients and climate changes. He has not been involved in the indicator development process.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Changes in Plankton Diversity**	
HELCOM () OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
OSPAR. Presumably France but AU has not been involved in the development.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. Strong data coverage for the inner part for the Danish waters. There are very limited data for the North Sea, and no data for Danish Skagerrak because there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:
Species composition and abundance are influenced by changes in physical and chemical environmental conditions. As a result, phytoplankton communities can fluctuate in space and time. Human-induced disturbances such as pollution and excessive nutrients can drive marked changes in community composition because only some species can cope with the changed habitat conditions. Consequently, the dynamics of the phytoplankton community, and thus its structural attributes (e.g. diversity, dominance or size structure), will differ from those of natural (undisturbed) communities. To help assess dominance, an analysis of community variance is made over time. Low community variation characterizes a site with average species composition over time (little change over time), whereas large community variance may indicate sites that have shifted to a species-poor state.

Aim of Indicator:
To link pollution and excessive nutrients to changes in the structure of the primary producing community. However, phytoplankton communities can fluctuate in space and time. Human-induced disturbances such as pollution and / or eutrophication (i.e. excessive nutrients) can drive marked changes in community composition because only some species can cope with the changed habitat conditions. Consequently, the dynamics of the phytoplankton community, and thus its structural attributes (e.g. diversity, dominance or size structure), will differ from those of natural (undisturbed) communities.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
Unknown by AU. However, doubtful that thresholds can be established.

Description of challenges and reservations:
Since different consultants/taxonomists work up Danish data, and it is essential to review comparability at the consultants/taxonomists and AU level, which can affect the taxonomical resolution of Danish zooplankton data. For this indicator in particular, this is an important step, and it needs to be addressed before applying the data.

Suggestions for solutions and process forward:
OSPAR status of this indicator is unknown by DCE, as DCE has not been involved. A similar indicator (Phytoplankton taxonomic diversity) is developed in HELCOM using the same theoretical approach. It is therefore suggested to focus on the HELCOM indicator, since transfer between the two approaches most likely is uncomplicated. Firstly, it is needed to apply Danish data to the indicator. Further scientific research

is needed to examine the magnitude and direction of the change of the indicator, with the potential changes at the basin and/or the monitoring station scales. It is also necessary to explore methodologies that separate human and climatic change pressures.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG and in relevant OSPAR meetings meeting since 2016/2018. Besides, he has a worked with phytoplankton and zooplankton ecology, both in the field and in various laboratory assays, for the past 20 years. This also include work on the responses to nutrients and climate changes. He has not been involved in the indicator development process.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title:

Changes of plankton functional types (life form) index Ratio

HELCOM () OSPAR (x)	Partially overlapping (x) Complete overlap ( )

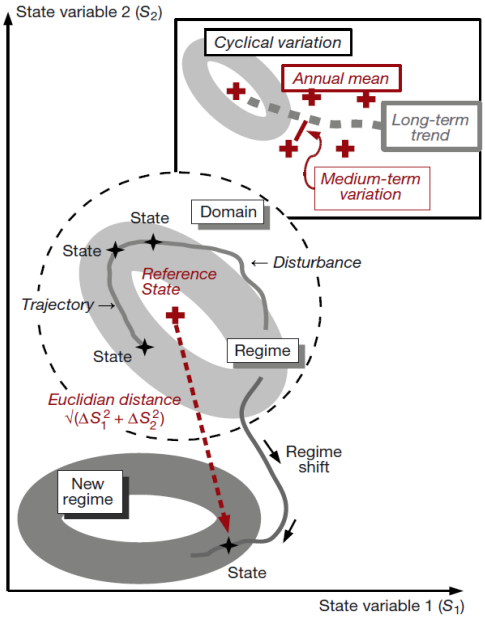
The indicator is being developed by (name of working group/s and lead country):
OSPAR. Presumably, France but AU has not been involved in the development. Status unknown.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Is a national (or regional) database in place?
Revision of database named STOQ is pending since 2009 and no work on Danish data can be executed until this is finished. After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:

Conceptual model of *modus operandi* of Changes of plankton functional types (life form) index Ratio following Tett, P. et al. 2013. Framework for understanding marine ecosystem health. Mar Ecol Prog Ser 494: 1-27



Use lifeform pairs such as "Gelatinous zooplankton vs. fish larvae", "copepods vs. phytoplankton" or "holoplankton vs. meroplankton". The abundance of species as grouped by lifeform/functional role is presented on a diagram for the study period, which is then compared with dynamics of species assemblages representative for the standard period. Several kinds of plankton characterise specific hydrodynamic regimes, and lifeform pair assemblages can be viewed graphically to characterise habitats.

This indicator reflects changes from a starting point (reference situation) to the current one, i. e. proportion of points out of the reference scatter plot. 3 diagrams are suggested. Each ratio gives a value between 0 and 1 and can be averaged with other ratios to give a final metric.

Aim of Indicator:
To describe how food web dynamics changes, and may also be used to follow the direction of a food web structure under, for e.g. anthropogenic pressures.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
Unknown by AU.

Description of challenges and reservations:
From the collegial discussions in the OSPAR group, it appears that establishing the index is challenging, and the work forward may rely on the use of single indices, rather than the use of one single “multi-lifeform-pair index”.

Since different consultants/taxonomists work up Danish data, it is essential to review how comparable data are at the consultants/taxonomists level.

Suggestions for solutions and process forward:
This indicator is build on solid scientific evidence, and it could be further developed. Firstly, it is essential to apply Danish data to the indicator. Further scientific research is needed to examine the magnitude and direction of the change of the indicator. This assessment must be executed at the basin and/or the monitoring station scales. It is also necessary to investigate link between life pairs and human and climatic pressures. If changes due to prevailing conditions (such as natural variability and climate change) can be separated from those caused by human pressures in each region, this will help to inform management decision-making process by allowing the application of regionally targeted management measures, where needed. It is also noteworthy to mention that the indicator is discussed to be included in the descriptor “Food Webs” as FW5.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG and in relevant OSPAR meetings meeting since 2016/2018. Besides, he has worked with phytoplankton and zooplankton ecology, both in the field and in various laboratory assays, for the past 20 years. This also include responses to nutrients and climate changes. He has not been involved in the indicator development.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Changes in Phytoplankton Biomass and zooplankton Abundance**	
HELCOM () OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
OSPAR.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Is a national (or regional) database in place?
Revision of database named STOQ is pending since 2009 and no work on Danish data can be executed until this is finished. Danish data is projected submitted yearly to ICES after revision.

Background for the indicator:
OSPAR current status of this indicator is unknown by DCE, and DCE has not been involved. This indicator based on phytoplankton biomass and zooplankton abundance provides means to identify changes (anomalies) in key groups within the plankton community; changes which represent deviations from the assumed natural variability in the plankton time series. These are identified as small, important or extreme changes. This indicator can also help to understand changes in other parts of the marine food web. Because of the local differences between monitoring station, the indicator should be calculated by the monitoring station.

Aim of Indicator:
This indicator shows the variation in phytoplankton biomass and zooplankton abundance. The indicator identifies changes calculated through time-series anomalies of phytoplankton biomass (chlorophyll-a and Plankton Colour Index) and zooplankton abundance (total copepod abundance).

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
The threshold in this indicator is defined as a deviation from normality and it most likely needs to be estimated at the scale of monitoring station due to the large spatial and temporal dynamics that typify each monitoring station.

Description of challenges and reservations:
Since different consultants/taxonomists work up Danish data, and it is essential to review comparability at the level of consultants/taxonomists. Moreover, zooplankton data for the North Sea and Skagerrak are virtually not existent. The indicator focuses on numbers and does not take into account subtle, yet important changes in mean size and species composition.

Suggestions for solutions and process forward:
Firstly, it is essential to apply Danish data to the indicator. Secondly, interpretation of the results in detail is required, considering monthly anomalies at the monitoring stations and basin scales. Furthermore, it is needed to link environmental and anthropogenic pressures to interpret the observations.

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the OSPAR COBAM meetings since 2018. He has not been involved in the indicator development process.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG and in relevant OSPAR meetings meeting since 2016/2018. Besides, he has a worked with phytoplankton and zooplankton ecology, both in the field and in various laboratory assays, for the past 20 years, also including responses to nutrients and climate changes. He has not been involved in the indicator development process.

Internal scientific review by:
Sanjina Upadhyay. PhD, Section of Marine Diversity and Experimental Ecology, BIOS, AU.

Indicator title: **Chemical ocean acidification indicator**	
HELCOM ( ) OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
The working group is called: Intersessional Correspondence Group on ocean acidification (ICG-OA).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Data on pH and total alkalinity are available in the ODA database maintained by DCE, AU. Preferably the data for the OSPAR region should also be available in the ICES database.

Is a national (or regional) database in place?
See answer above.

Data are collected within the NOVANA programme.

Background for indicator:
"Ocean acidification (OA) is the increase in seawater acidity primarily driven by rising atmospheric carbon dioxide. There is now incontrovertible evidence that OA is occurring on a global scale, affecting other important aspects of marine chemistry and with potentially significant adverse consequences on marine life and human society. However, many uncertainties remain relating to the current status and future development of OA at the regional and local scale, and its interactions with other marine environmental stresses such as warming and de-oxygenation…." More background info can be found here https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/730461/defra-sac-oa-report-2018.pdf and here http://ices.dk/sites/pub/Publication%20Reports/Expert%20Group%20Report/acom/2014/SGOA/sgoa_finalOSPAR_2015.pdf

Aim of Indicator:
Quantify the rate of change in pH in the OSPAR regions.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
So far, there is no threshold for the indicator. It has been discussed in the working group what the threshold could be, but the conclusion is that inconsistencies remain in the knowledge of biological effects (at least in the group) to set a threshold. It is a general understanding that there should be at least two different thresholds, one for offshore areas and one or more for coastal areas (probably more likely, for pelagic and benthic habitats).

Description of challenges and reservations:
pH is monitored regularly in Danish waters, but mostly in coastal areas. Total alkalinity is only sparsely measured as a part of primary production measurements. To get most out of the pH measurements, they should be supplemented with total alkalinity measurements. Currently most of the monitoring stations are placed in the coastal areas. This makes sense when you consider that the most significant changes take place in coastal areas. On the other hand, monitoring is limited in the North Sea, and it is therefore not possible to assess the state or development, based on available data. A biological indicator has been discussed in the working group, but so far, the development of such an indicator has been postponed. This is due to a range of challenges. Many species can adapt to moderate changes in pH, and therefore it is a challenge, if not impossible, to find a biological indicator that is sensitive to changes in pH and applicable to all OSPAR region. Still acidification threatens vulnerable habitats, such as cold-water coral reefs, and it has also been shown to have a negative synergistic effect in combination with hypoxia.

Note that all the pH measurements from the Danish monitoring program are currently quality assessed as a part of an acidification project!
Suggestions for solutions and process forward: Stay on the chemical indicator track at this point. Denmark should endeavour to take more alkalinity samples, preferably every time pH is measured. Furthermore, the monitoring of the Danish offshore areas should increase. The chemical indicator is currently the best measure of OA. Thresholds for GES has not been determined yet.
Appraised by (name of AU advisor): Jesper Philip Aagaard Christensen **Qualification with regard to this indicator:** Jesper PA Christensen has participated in OA working groups in OSPAR and HELCOM since 2019 and has several years of experience with pH and alkalinity research from his Ph.D. and as first-author in high-ranking scientific and popular science publications.
Internal scientific review by: Dr. Jacob Carstensen, Professor at Department of Bioscience, AU - Applied Marine Ecology and Modelling

Indicator title: **Production of phytoplankton [Candidate]**	
HELCOM (x) OSPAR (x)	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
Foodweb (OSPAR) and pelagic habitats (HELCOM). Lead unknown.

Not at the moment, but we participate in the relevant working groups for eutrophication and food webs.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, from the NOVANA programme.

Is a national (or regional) database in place?
Yes in ODA (The Surface waters database of DCE).

Background for indicator:
Primary production by phytoplankton is the basis for all other level in the food chain. We know that all levels, including fish stock and birds, e.g. eider ducks, are affected by changes in phytoplankton productivity. The process is also the process that initiate the cascade of processes in eutrophication. However, according to the MSFD, the indicator belong to the D4-Food web descriptor.

Aim of Indicator:
To quantify the input of organic matter to the food web and to the entire marine system.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C4 / D1C6.

Thresholds:
No, not now, it will require and assessment of reference conditions.

Description of challenges and reservations:
Primary production is a rate, in contrast to a state variable as e.g. concentrations or population numbers. Rates are considerably more difficult to measure. However, it is also the only way to calibrate and validate dynamic ecosystem models.

DCE supports of this indicator.

Suggestions for solutions and process forward:
There is no development at present. We suggest that DK initiate such a process e.g. a working group with experts from contracting parties.

Appraised by (name of AU advisor):
Professor Stiig Markager

Qualification with regard to this indicator:
Stiig Markager has published scientific papers within this field since 1989 and has been responsible for the indicator in the Danish monitoring since 1997.

Internal scientific review by:
Jens Würgler Hansen, senior advisor, Section for Marine Ecology, BIOS, AU.

D2 Non-indigenous species

DCE has several years of research expertise on invasive, and non-indigenous marine species (NIS). DCE participates in the OSPAR NIS-EG and have contributed to the development of the D2C1 indicator providing advice for the Danish EPA and ministry on monitoring of NIS and data management. D2C1 is considered ready for implementation within OSPAR. We await decisions from the HELCOM expert group dealing with this indicator.

Indicator title: **Trends in arrival of new non-indigenous species (D2C1)**	
HELCOM (X) OSPAR (X)	Partially overlapping (X) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
OSPAR (Non-Indigenous Species - Expert Group (NIS-EG)/GB/CEFAS)

HELCOM (TG ballast/Finland).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes.

Is a national (or regional) database in place?
YES data are available from a combination of data from the Danish marine monitoring program (NOVANA) and reports from species experts. NOVANA data are updated annually. Expert reports are updated upon request. There is currently no national NIS database. Data have until now been updated upon request from the Danish EPA.

Background for indicator:
NIS have been recognized as a potential threat to the marine waters as some NIS become invasive and may have an adverse impact on the receiving regions. As a first step a NIS indicator (D2C1) has been developed. It concerns the number of novel NIS introduced into a region per annum per reporting period (6 years). Data needed for the indicator are number of NIS. Information on their abundance is not taken into account. The reason being that many HELCOM and OSPAR countries does not collect abundance data, or have very different levels of monitoring making it difficult to compare abundance data (e.g. number of individuals or biomass per area or volume) between countries and regions.

Although there are also plans to reduce the impact of specific invasive marine species, it is recognized that this is very difficult if not impossible. The best thing is therefore to simply prevent the introduction of new species.

Aim of Indicator:
The aim is to have simple index such as an absolute or a relative number of new NIS per year per region. The hope is that countries through various evasive measures can reduce the number of new NIS below the chosen threshold.

Does the indicator match COM DEC 2017 criteria? (and which)
D2C1.

Thresholds:
There are subtle differences in the OSPAR and HELCOM D2C1 indicator. In OSPAR the expert group has agreed to use an indicator based on a trend in %NIS over time. To our knowledge HELCOM uses a fixed number of NIS per region per reporting period.

Description of challenges and reservations:
A national NIS database should be set in place. This needs to be updated annually and include data not only from the national NOVANA program. In addition, data that are systematically reported to and quality checked by experts should be included. There is currently no systematic monitoring of jellyfish and monitoring of non-commercial fish in the near coastal zone. The Danish EPA is currently emphasizing the use of eDNA as a supplementary method to monitor NIS. While this holds some promising future developments and tests of the eDNA technique therefor should include screening techniques. These techniques should include approaches such as meta barcoding which allows a full picture of the species list and not just a pre-selected list of NIS.

It is important that OSPAR and HELCOM agree on the list of species which belongs to the European NIS list. Currently OSPAR uses the EASIN list while HELCOM applies the AquaNIS list. The lists are not fully complementary and the validation and quality assurance procedures involved in making these lists appear to be dissimilar.

It is finally challenging to develop and agree upon the more advanced impact indicators (D2C2 and D2C3).

Suggestions for solutions and process forward:
Within the DCE we suggest that a system is setup by which conventional monitoring data, eDNA monitoring data along with data from marine species experts are assessed on an annual basis. The outcome should be an annually updated Danish NIS database.

For the development of future indicators (D2C2 and D2C3) Denmark should take a lead role as we possess some of the best data sets within OSPAR and HELCOM to develop and access these.

Appraised by (name of AU advisor):
Peter A. Stæhr

Qualification with regard to this indicator:
Peter A Stæhr has participated in the OSPAR COBAM meetings since 2019. To that end, Peter has contributed to the development of “tekniske anvisninger” related to NIS and Peter has also published several papers in high ranking papers over the past 20 years. Peter is also serving as responsible of the indicator D2.

Internal scientific review by:
Hans Henrik Jakobsen, Senior researcher, BIOS, AU.

D4 Food webs

The food web descriptor seems to be one of the most challenging descriptors proposed under the MFSD. A number of food web indicators have so far been proposed under the OSPAR auspice, namely "Production of phytoplankton" (See under D1C6 Pelagic habitats), "Size Composition in Fish Communities (Typical Length indicator, FW3)" and "Change in Average Trophic Level of Marine Predators in the Bay of Biscay (FW4)", Changes of plankton functional types (life form) index Ratio FW5, Biomass, species composition and spatial distribution of zooplankton FW6, Biomass trophic Spectrum (BST)(FW8), and Ecological network analysis (FW9). DCE is not aware of any similar activities within the HELCOM region, but it is assumable that the D4 covers the entire marine waters bodies related to the EU. DCE has not been involved in the development of any food web indicators under the MFSD.

DCE has not been asked to advice on the indicators FW3 and FW4 and these are therefore not included in the review. FW5 is a complex indicator that deserved attention and should be considered as an indicator. It is already under development under the pelagic indicators as the pelagic indicator "changes of plankton functional types (life form) index Ratio" and it is therefore included in the review. FW6 is an exploratory indicator on zooplankton biomass with strong similarities with the HELCOM indicator Zooplankton mean size and stock (MST) and crossover is also possible. FW9 is a model-derived indicator that represents the whole ecosystem / food web including all compartments and trophic interactions (direct and indirect) within an ecosystem. The applicability of this indicator has not been tested.

In some cases, indicators developed for pelagic habitats are also considered part of the food web descriptor. These are FW2, FW5 and FW6. The indicator FW2 examines how the primary production of phytoplankton changes over time and is new to OSPAR. This is not the case for DK, which already reports the indicator yearly and scientists from DCE has published several competent papers in high ranking scientific journals. The same applies to FW6 which has been reported annually in the past by DCE. In the case of FW9, DCE is involved in the indicator development in order to identify pressure-state relationships and further development of the indicator (R scripts). Testing of this indicator is ongoing inside and outside OSPAR regions aiming to test assessment of this indicator on a wider spatial scale.

Table of prioritisation food web indicators at DCE, ranked in the order of prioritisation.

Data type	Indicator	Overall method	prioritise
**C14 data	Production of phytoplankton	C^{14} labelling	1
Zooplankton/ phytoplankton	Changes of plankton functional types (life form) index Ratio FW5	biomass ratio/ life form pair	1
*Zooplankton/ hytoplankton	Biomass, species composition and spatial distribution of zooplankton FW6	biomass ratio/ life form pair	2
Fish catches, All NOVANA data and additional data sources reported to ICES	Biomass trophic Spectrum (BST)FW8	Fish catch	3
All NOVANA data and additional data sources	Ecological network analysis (FW9)	modelling of data	1

*already reported for DK waters until NOVANA plankton data was sat on hold. **already reported for DK waters.

Indicator title:

Changes of plankton functional types (life form) index Ratio FW5

HELCOM () OSPAR (x)	Partially overlapping () Complete overlap (x)

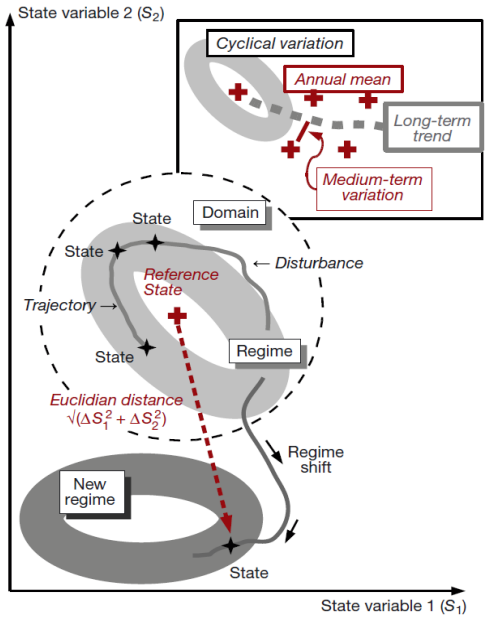
The indicator is being developed by (name of working group/s and lead country):
OSPAR. Presumably, France but AU has not been involved in the development. Status unknown.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Strong data coverage for the inner part for the Danish waters. However, more limited data for the North Sea, and only one near-shore station in Skagerrak. Besides, there are limited phytoplankton or zooplankton monitoring with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Is a national (or regional) database in place?
Revision of database named STOQ is pending since 2009 and no work on Danish data can be executed until this is finished. After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:

Conceptual model of *modus operandi* of Changes of plankton functional types (life form) index Ratio following Tett, P. et al .2013. Framework for understanding marine ecosystem health. Mar Ecol Prog Ser 494: 1-27.



Use lifeform pairs such as "Gelatinous zooplankton vs. fish larvae", "copepods vs. phytoplankton" or "holoplankton vs. meroplankton". The abundance of species as grouped by lifeform/functional role is presented on a diagram for the study period, which is then compared with dynamics of species assemblages representative for the standard period. Several kinds of plankton characterise specific hydrodynamic regimes, and lifeform pair assemblages can be viewed graphically to characterise habitats.

This indicator reflects changes from a starting point (reference situation) to the current one, i. e. proportion of points out of the reference scatter plot. 3 diagrams are suggested. Each ratio gives a value between 0 and 1 and can be averaged with other ratios to give a final metric.

Aim of Indicator:
To describe how food web dynamics changes, and may also be used to follow the direction of a food web structure under, for e.g. anthropogenic pressures.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6.

Thresholds:
Unknown by AU.

Description of challenges and reservations:
From the collegial discussions in the OSPAR group, it appears that establishing the index is challenging, and the work forward may rely on the use of single indices, rather than the use of one single “multi-lifeform-pair index”

Since different consultants/taxonomists work up Danish data, it is essential to review how comparable data are at the consultants/taxonomists level.

Suggestions for solutions and process forward:
This indicator is build on solid scientific evidence, it could be further developed. Firstly, it is essential to apply Danish data to the indicator. Further scientific research is needed to examine the magnitude and direction of the change of the indicator. This assessment must be executed at the basin and/or the monitoring station scales. It is also necessary to investigate link between life pairs and human and climatic pressures. If changes due to prevailing conditions (such as natural variability and climate change) can be separated from those caused by human pressures in each region, this will help to inform management decision-making process by allowing the application of regionally targeted management measures, where needed. It is also noteworthy to mention that the indicator is discussed to be included in the descriptor “Food Webs” as FW5.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the HELCOM PEG and in relevant OSPAR meetings meeting since 2016/2018. Besides, he has worked with phytoplankton and zooplankton ecology, both in the field and in various laboratory assays, for the past 20 years. This also include responses to nutrients and climate changes. He has not been involved in the indicator development.

Internal scientific review by:
Eva Friis Møller, Section leader of Applied Marine Ecology and Modelling, BIOS, AU.

Indicator title: **Biomass, species composition and spatial distribution of zooplankton FW6**	
HELCOM () OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
Unknown to AU.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Partly. Strong data coverage for the inner part for the Danish waters. There are very limited data for the North Sea and no data for Danish Skagerrak because there are limited phytoplankton or zooplankton monitoring in these waters with a weak historical record for these waters.

Is a national (or regional) database in place?
Strong data coverage for the inner part for the Danish waters. But more limited data for the North Sea and only one near-shore station in Skagerrak. Beyond that, there are limited phytoplankton or zooplankton monitoring in these waters with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:
Zooplankton is an important link between primary producers and higher trophic levels, and they play an important role in energy transfer. In many coastal areas, such as Bay of Biscay where it has been tested, phytoplankton and zooplankton are responsible for an important bottom-up process. This process controls the dynamics and structure of higher trophic levels. Most likely, this is an inherent feature and relevant for DK.

Aim of Indicator:
To identify long term changes in biomass, species composition and communities structure can be used as representative of environmental changes in the pelagic compartment and of potential impacts related to anthropogenic pressures, such as nutrients enrichment or oil spill.

Does the indicator match COM DEC 2017 criteria? (and which)
D1C6, FW6

Thresholds:
Thresholds need to be established at the scale of the station.

Description of challenges and reservations:
Its OSPAR status is unknown by DCE and DCE has not been involved in its development. DCE propose to maintain a standby position on this indicator and suggest that resources for a zooplankton indicator instead is applied to the mean size and standing stock indicator developed under HELCOM. Since different consultants/taxonomists work up Danish data, and it is needed to review comparability at the level of consultants/taxonomists. Moreover, zooplankton data for the North Sea and Skagerrak are virtually non-existing.

Suggestions for solutions and process forward:
Firstly, it is needed to apply Danish data to the indicator. In addition, more work is needed to draw conclusions on the magnitude, direction and the key pressures or environmental factors driving potential changes.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the OSPAR COBAM meetings since 2018. Has not been involved in the indicator development. To that end, he has a worked with zooplankton ecology in the field and with copepods in various laboratory assays for the past 20 years.

Internal scientific review by:
Eva Friis Møller, Section leader of Applied Marine Ecology and Modelling, BIOS, AU.

Indicator title:

Biomass trophic Spectrum (BTS) FW8

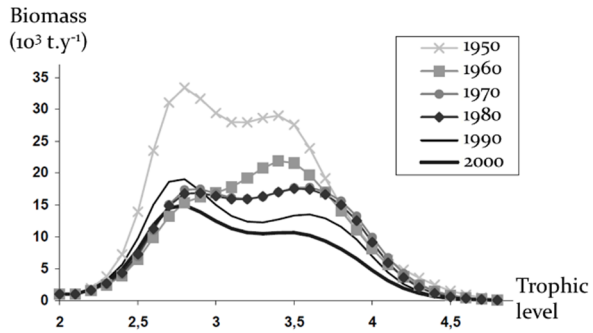
HELCOM () OSPAR (x)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by:
OSPAR. Presumably France but AU has not been involved in the development.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Presumably yes. In its current stage, only commercially available data is used and these are obtainable from ICES. Strong data coverage for the inner part for the Danish waters, but more limited data for the North Sea and only one near-shore station in Skagerrak. Beyond that, there are limited phytoplankton or zooplankton monitoring in these waters with a weak historical record for these waters.

Is a national (or regional) database in place?
Presumably are fish data available at the possession of DTU and ICES but AU is unaware about data quality and structure of fish data bases in general. As for the potential data not applied to the indicator, are size distributions of phytoplankton, micro and zooplankton available from NOVANA. Revision of database STOQ is pending since 2009 and no work on Danish data can be executed until this is finished. Danish data is submitted yearly to ICES

Background for indicator:



BTS give a detailed picture of biomass spectrum per trophic level (with step size 0.1 –see inserted picture). BTS aims to classify the trophic functioning of an ecosystem and its dynamic at the scale of the entire food webs, although it in its current version only gauge fishery. BTS provides diagnosis on the status of a given ecosystem. They are proposed as a complement of the indicator 4.3.1 under MSFD (Abundance trends of functionally important selected groups/species), since they provide a more holistic view of ecosystems structure. BTS show a better sensitivity to fishing pressure in several ecosystems. To build BTS, mean trophic levels and biomass of species will need to be estimated. Usually, empirical approaches (biomass) are coupled with modelling (trophic levels). Currently, BTS is used with landings from the commercial fishery, however, it would be preferable to use them with data from surveys (available and accurate data for calculation).

Aim of Indicator:
To quantify changes in the pelagic food web from a top – down point of view.

Does the indicator match COM DEC 2017 criteria? (and which)
D4C1, D4C2

Thresholds:
Unknown by AU although doubtful that thresholds can be established.

Description of challenges and reservations:
This indicator is not an environmental indicator but does instead gauge the effect of the fishery. Commercial fish data are collected at the deeper parts whereas phytoplankton are collected at the more closed waters where there is no fishery. This is, in particular, evident in the North Sea / Skagerrak region where there are limited phyto- and zooplankton data. The link between fishery and the lower trophic levels is not clear and

combining a mainly fishery driven indicator (landing) with phytoplankton and zooplankton (climate and environmental drive), present some challenging unresolved scientific issues. To that end, it is unclear how birds will fit into the scheme DCE, therefore, recommend to not move forward with this indicator at the moment.

Suggestions for solutions and process forward:
Firstly, it is needed to apply Danish data to the indicator. Further scientific research is needed to examine the magnitude and direction of change in the potential changes at the scale of the basin or at the scale of the monitoring station. It is also necessary to invent methodologies that separate human and climatic change pressures from the fishery. Data from commercial fish stock is well available,

In its current stage, the BTS model is not representing a full food web, and the BST should not be limited to data from commercial fished fisheries. That is, for the model to be fully operational, it is needed to apply data from the level of phyto- and zooplankton, fish (also non-commercial fished fish), and mammals, to gain the full benefit providing a full spectrum at the scale of the entire marine food webs.

Appraised by (name of AU advisor):
Hans Henrik Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has participated in the OSPAR COBAM meetings since 2018. Has not been involved in the indicator development.

Internal scientific review by:
Eva Friis Møller, Section leader of Applied Marine Ecology and Modelling, BIOS, AU.

Indicator title: **Ecological network analysis (Foodwebs FW9)**	
HELCOM ( ) OSPAR (x)	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
The indication is in its early development phase where Germany is now leading the initiative (originally it was FR and UK).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
In principle this indicator uses data for all trophic levels and important food web elements present in the area/ecosystem of study. Some of the relevant data are in place. The present initiative is building on a ENA model approach and data coverage is depending on the final model setup for Kattegat test case (not yet approved/decided!).

Is a national (or regional) database in place?
No! Data have to be gathered from various sources and databases. It I currently unknown how many state variables and process variables which needs to be parametrized initial test will depend on data availability.

Background for indicator:
The indicator is one among 9 different proposed indicators under the descriptor “food webs”. The ecological network analyses uses the ENA model approach which integrates various elements in foodweb of the marine ecosystems and analyse the structure and function using literature constants to model trophic interactions. Thereby the aim is to assess if the foodweb structure is adversely affected by anthropogenic pressures.

Aim of Indicator:
The overall aim of the descriptor D4 “food webs” should be seen as an indicator of the overall functioning of the marine ecosystem in relation to anthropogenic pressures. However, some of the proposed indicators under this descriptor have clear overlap with indicators under other descriptors as for example biodiversity (D1, D5, D6, D2 and D3). Clarification of the overall aim with D4 in relation to other Descriptor should be urged. The FW9 indicator could help distinguish by focusing on the relation between different ecosystem elements (e.g. phytoplankton, zooplankton, benthos birds etc.) as shaped by the various anthropogenic pressures on the ecosystem. Furthermore distinguishing from effects of eutrophication could benefit if it was decided to focus on top-down effect in the food chain.

Does the indicator match COM DEC 2017 criteria? (and which):
D4C1.

Thresholds:
No.

Description of challenges and reservations:
DCE recommended to initiate test of the ENA model and this test will possibly identify challenges that could lead to reservations.

Suggestions for solutions and process forward:
Denmark together with Sweden probably holds the most relevant input data resulting from monitoring of a suite of different element in the Kattegat and Western Baltic Sea ecosystems, and it is recommended to participate in an initial test of the ENA model based on Kattegat data.

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen is currently participation in the work in the OSPAR COBAM Food web working group, conduction a test model of the North Sea and the Kattegat.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU

D5 Eutrophication

This descriptor is addressing the effects of excess nutrients loadings to marine systems. The link to the press factors, inputs of nutrients, is well defined and the problem has been known and assessed for decades, so large amounts of data are available. Abatement measures are costly and have significant consequences for the society, so it is important for indicators to be very well documented. Due to the long history, many approaches for data collection and indictor definition exists, sometimes with inconsistent use. Moreover, new challenges emerge, i.e. focus on interactions with effects of climate change and changes in top-down control from fisheries and relationships to biodiversity.

It is recommended to have focus on three issues: 1) Clarifying and improving the definitions of existing indicators for nutrients, chlorophyll, light attenuation and oxygen, and insuring that new techniques for data collection, e.g. remote sensing for chlorophyll, are incorporated in a scientifically sound way. 2) Better definitions of thresholds, particular address the natural variability – this is closely related to (1). 3) Ensuring that indicators are used in an optimal way across the descriptors. i.e. that indicators for pH, primary production or biodiversity under descriptor D1 and D4 are used to support descriptor D5 and *vice versa.*

Indicator title: **Nutrient concentrations**	
HELCOM (X) OSPAR (X)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM and OSPAR. All countries.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, Denmark have data going back to the late 1970'ties and currently samples are collected in surface water (1m) and in bottom water if pycnocline and at standard depths (1, 5, 10, 15 …meter) at certain open water stations. Denmark has experienced some problems with the analysis of total nitrogen, and to a lesser extent, total phosphorous, in recent years, but data is there and for concentrations of total nitrogen data can be corrected and used.

Is a national (or regional) database in place?
Yes in ODA.

Background for indicator:
Nutrient concentrations is a primary (core) indicator (D5C1). Particularly data for total nutrient concentrations is considered to be among the best indicators for eutrophication as they reflect the total pool of nutrients circulating in the marine systems and not sensitive to the definition of periods as inorganic nutrient concentrations.

Different indicators for nutrient concentrations have been used during the years and these indicators are probably the most basic indicators for eutrophication assessments. Currently, four indicators are used: values for total nitrogen and total phosphorous and winter concentrations for inorganic nutrients. In addition, other indicators are in use in Denmark, e.g. number of days with inorganic nutrient concentrations below concentrations considered to be limiting for phytoplankton growth (2 µM for DIN and 0.2 µM for DIP) or other derived indicators assessing nutrient limitation - see Timmermann et al. 2015 (Timmermann, K., J. Christensen, C. Murray & S. *Markager (*2015) Modeller for Danske Fjorde og Kystnære Havområder – del 3) and other reports about eutrophication assessment.

Aim of Indicator:
The aim of indicator for total nutrient concentrations is to assess the total amount of nutrients present in the systems and the changes over years. For winter concentrations of inorganic nutrients, the aim is to assess the amount of nutrients available for phytoplankton growth in the following growing season.

Does the indicator match COM DEC 2017 criteria? (and which)
Yes, D5C1.

Thresholds:
Thresholds are described for different areas. It is necessary to update these thresholds and include new data and new knowledge. In addition, the relationship between natural variability and level of concentrations need to be evaluated in order to develop the correct scaling for different classes in the WFD and insure correspondence between thresholds for WFD and MSFD.

Description of challenges and reservations:
Nutrients concentrations in marine systems vary in time and space. It is therefore essential to define periods (annual or specific months) and depth intervals for an indicator. Presently, this is not always done in a systematic way. E.g. a description of the growing season is essential for indicators for winter nutrient concentrations. Likewise, a definition of the surface mixed layer is important for indicators for nutrient concentrations as concentrations are typically higher below a pycnocline.

Suggestions for solutions and process forward:
It is recommended that Denmark initiate a process to precisely define indicators for nutrients and further develop the scientific background for thresholds.

Appraised by (name of AU advisor):
Professor Stiig Markager

Qualification with regard to this indicator:
Stiig Markager has published scientific papers within this field since 2001 and de-veloped the methods used today in the Danish management of marine systems. Moreover, Stiig Markager has participated regularly in the relevant HELCOM and OSPAR expert groups the last five years, where these indicators are used.

Internal scientific review by:
Jens Würgler Hansen, senior advisor, Section for Marine Ecology, Bioscience, AU

Indicator title: **Chlorophyll concentration**	
HELCOM (X) OSPAR (X)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM and OSPAR. All countries.

Are Danish data available for the HELCOM and/or OSPAR regional seas?

Yes, Denmark have data going back to the late 1970'ties and currently data are collected in surface water (1m) and at standard depths (1, 5, 10, 15 …meter). Several countries, e.g. Denmark, are currently working on new techniques like satellite observations and the use of Ferryboxes (see Markager et al. 2019). Aarhus University is currently working on the use of satellite observations in a Danish context.

Markager, S., S. Upadhyay, P. Stæhr, H. Parner, H. Jakobsen, P. Walsham, K. Wesslander, D. Van der Zande & L. Enserink (2019). Towards a joint monitoring and assessment programme for eutrophication in the North Sea. Activity 3 Report. 52pp.

Is a national (or regional) database in place?
Yes in ODA.

Background for indicator:
Chlorophyll concentrations is a primary (core) indicator (D5C2). It is a proxy for phytoplankton biomass that increases during eutrophication and. Increase in phytoplankton biomass and hence primary production is one of the most fundamental effects on the ecosystem from eutrophication. Moreover, chlorophyll concentrations are inter calibrated among the member states under WFD.

Aim of Indicator:
The aim is to quantify the phytoplankton biomass and in particular the changes over time (years).

Does the indicator match COM DEC 2017 criteria? (and which)
D5C2.

Thresholds:
Thresholds are described for different areas. These thresholds are based on estimated historic or pristine loads of nutrients and modelled corresponding chlorophyll concentrations. This approach is questionable from a scientific perspective, but at present, it is the only available technique.

Description of challenges and reservations:
Like nutrients concentrations, concentrations of chlorophyll in marine systems will vary in time and space. The same needs for precise definitions of periods and depth intervals therefore apply to chlorophyll concentrations. In addition, there is a need for clarification of the statistical definition of indicator value as some regions (OSPAR) use a 90% percentile where other (HELCOM) use the mean value.

In the future, it is foreseen that new data sources for chlorophyll estimates will be used (see above). These have a very different coverage in time and space compared to *in situ* sampling, and the values for the chlorophyll indicators will not be comparable across data sources without a considerable effort to inter calibrate the different approaches.

Suggestions for solutions and process forward:
It is recommended that Denmark initiate a process the can help to precisely define indicators and incorporate new data sources.

Appraised by (name of AU advisor):
Professor Stiig Markager

Qualification with regard to this indicator:
Stiig Markager has published scientific papers within this field since 2001 and developed the methods used today in the Danish management of marine systems. Moreover, Stiig Markager has participated regularly in the relevant HELCOM and OSPAR expert groups the last five years, where these indicators are used.

Internal scientific review by:
Jens Wurgler Hansen, senior advisor, Section for Marine Ecology, Bioscience, AU

Indicator title: **Water clarity**	
HELCOM (X) OSPAR (X)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM and OSPAR. All countries.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, Denmark have data for Secchi depth going back to the 1970'ties and from 1998 Denmark have measured both Secchi depth and light attenuation of PAR (photosynthetic active radiation) based on irradiance data from CTD-casts

Is a national (or regional) database in place?
Yes in ODA.

Background for indicator:
An increase in light attenuation is, together with anoxia, the most devastating effect of eutrophication on marine ecosystems. The light attenuation is primarily due to an accumulation of organic matter, both dissolved and as detritus, over time due to a high primary production. Secondly, a higher phytoplankton biomass also contribute. The negative effect on the ecosystem is due to the limitation of plant deep in the water column and at the sea floor. The light level at the sea floor is crucial for growth and depth distribution of macrophytes and in a Danish WFD context particularly for eelgrass. Light attenuation is also important in the pelagic ecosystem as the occurrence and productivity of phytoplankton situated in the pycnocline is affecting the pelagic food web and oxygen condition in the deep layer.

Aim of Indicator:
The aim of the indicator is to follow changes of water clarity with time and to estimate light level for primary production at the sea floor and in the water column.

Does the indicator match COM DEC 2017 criteria? (and which)
D5C4.

Thresholds:
Thresholds are described for different areas.

Description of challenges and reservations:
Light attenuation was traditionally measured as Secchi depth and due to the long time series and historical data it is important to develop and maintain a transfer function between Secchi depth and the diffuse light attenuation coefficient for PAR (Kd), which is the preferred indicator today. However, K_d can be calculated in different ways. There is, therefore, a need for calibration and inter comparison of methods and to define the optimal seasonal period for light attenuation to be used as indicator for eutrophication.

Suggestions for solutions and process forward:
It is recommended that Denmark initiate a process for inter calibration and for definition of the indicator.

Appraised by (name of AU advisor):
Professor Stiig Markager

Qualification with regard to this indicator:
Stiig Markager has published scientific papers within this field since 2001 and developed the methods used today in the Danish management of marine systems. Moreover, Stiig Markager has participated regularly in the relevant HELCOM and OSPAR expert groups the last five years, where these indicators are used.

Internal scientific review by:
Jens Wurgler Hansen, senior advisor, Section for Marine Ecology, BIOS, AU

Indicator title: **Cyanobacteria bloom index**	
HELCOM (X) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
This indicator is developed by the intersessional network on eutrophication working group HELCOM IN-Eutrophication with Finland as lead country. This HELCOM indicator corresponds in many ways to OSPAR's indicator 'Trends in Blooms of the Nuisance Phytoplankton Species Phaeocystis in Belgian, Dutch and German Waters'. However, this indicator does not cover Danish areas. This indicator is developed in the working group OSPAR ICG-EUT.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, data from stations in the areas where this indicator is relevant are available. Relevant areas are in the eastern part of Denmark where the salinity is lower than 12 PSU.

Is a national (or regional) database in place?
After database revision, Danish data will be submitted yearly to ICES.

Background for indicator:
Cyanobacteria are mainly observed at low salinity and in areas with a surplus of phosphorus compared to nitrogen as cyanobacteria fixate nitrogen from the atmosphere. Cyanobacteria can be toxic for human and animals, and is, therefore, relevant to monitor. Further, a high abundance of cyanobacteria can negatively affect biodiversity.

Cyanobacteria blooms can be toxic and can reflect eutrophication with an excess of phosphorus.

The indicator is developed to cover criteria D5C3 in the GES-decision.

Aim of Indicator:
The aim of the indicator is to assess the cyanobacterial biomass and surface accumulation during summer.

Does the indicator match COM DEC 2017 criteria? (and which)
D5.

Thresholds:
Bay of Mecklenburg: 0.92 (value normalized to 0-1 with 1 as good status)

Arkona Sea: 0.90

Bornholm Sea: 0.87

All three area which includes Danish areas fail to achieve good status.

It is important to notice that the reference values do not reflect unaffected conditions.

The thresholds are pragmatic, operational and quantifiable.

Description of challenges and reservations:
The indicator is a HELCOM pre-core indicator and is included in the latest assessment of the Baltic Sea as a test-indicator with results to be considered as intermediate. The assessment includes Danish areas in Bay of Mecklenburg, Arkona Sea and Bornholm Sea, but Denmark have had a study reservation on this indicator.

Suggestions for solutions and process forward:
According to a note from DCE on consultation related to this indicator, DCE recommends to remove the Danish study reservation.

DCE recommends to ensure sufficient data i.e. number of stations and monitoring frequency to be used in this indicator.
Appraised by (name of AU advisor): Hans H Jakobsen **Qualification with regard to this indicator:** Hans Henrik Jakobsen has not been involved in the indicator development or participated in the HELCOM IN-Eutrophication group meeting. However, he has participated in HELCOM PEG meetings since 2016, and he is well experienced in phytoplankton dynamic. Besides, he has worked with phytoplankton for the past 20 years. This also includes responses to nutrients and climate changes.
Internal scientific review by: Jens Wüurgler Hansen, senior advisor, Section for Marine Ecology, BIOS, AU

Indicator title:

Trends in Blooms of the Nuisance Phytoplankton Species Phaeocytis in Belgian, Dutch and German Waters

HELCOM ( ) OSPAR (X)	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
The indicator is being developed in OSPAR ICG-EUT. Lead country is unknown.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
A few data is available from one station on the West coast (coastal North Sea, Vesterhavet).

Is a national (or regional) database in place?
Reliable data coverage for the inner part for the Danish waters. But more limited data for the North Sea and only one near-shore station in Skagerrak. Beyond that, there are limited phytoplankton or zooplankton monitoring in these waters with a weak historical record for these waters. After database revision, Danish data will be submitted yearly to ICES.

Background for the indicator:
Trends in blooms of nuisance Phaeocystis can cause a change in the balance of the ecosystem and can occur in response to high nutrient concentrations and may be indicative of eutrophication.

Aim of Indicator:
The aim of this indicator is to assess the concentration and blooms of Phaeocystis during April - August.

Does the indicator match COM DEC 2017 criteria? (and which)
D5.

Thresholds:
The indicator cover the North Sea. However, the current NOVANA monitoring is not targeted towards a method suitable to detect data Phaoocystis consistently.

Description of challenges and reservations:
Denmark only have a very few data relevant for this indicator and the indicator is only relevant in some Danish areas. Bloom of Phaeocystis in Danish area does not occur often, which is also the reason for the low monitoring activity, and it may be difficult to correlate changes in Phaeocystis concentrations or frequency of blooms to e.g. eutrophication. Most likely, the distribution of Phaeocysti is governed by salinity and the indicator is therefore relevant in the North Sea only.

High Phaeocystis concentrations can be affected by a combination of different factors, such as light, temperature, salinity, other hydrodynamic influences and nutrient availability.

Suggestions for solutions and process forward:
As this indicator only have little relevance in Danish areas, development of this indicator is recommended to have low priority.

Further research is needed to identify the reasons for high variability in data for this indicator.

Appraised by (name of AU advisor):
Hans H Jakobsen

Qualification with regard to this indicator:
Hans Henrik Jakobsen has taken part in a few relevant OSPAR meetings since 2018. Besides, he has worked with phytoplankton and zooplankton ecology for the past 20 years. This include a number of studies involving the ecological dynamics and metabolomic chemistry of Phaeocystis.

Internal scientific review by:
Jens Würgler Hansen, senior advisor, Section for Marine Ecology, BIOS, AU

Indicator title: **Shallow water bottom oxygen**	
HELCOM (X) OSPAR (X)	Partially overlapping (X) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
HELCOM IN-Eutrophication with Germany as lead country. This indicator is similar to the indicator 'Concentrations of dissolved oxygen near the seafloor' in OSPAR, which is developed in the group OSPAR ICG-EUT.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes.

Is a national (or regional) database in place?
Yes in ODA.

Background for indicator:
In HELCOM, the only indicator concerning oxygen has been the indicator 'Oxygen debt'. This indicator is only relevant in the deep areas of the Baltic Sea, and, therefore, do not include the major parts of the Danish areas. These areas will be included in this new indicator. In Denmark, the oxygen concentration is already assessed four times or more a year in the period July to November.

The oxygen concentration near the sediment is an important parameter for the marine ecosystem.

Aim of Indicator:
The aim of the indicator is to assess the oxygen concentration in the Baltic Sea and not just in the deep areas.

Does the indicator match COM DEC 2017 criteria? (and which)
D5C5.

Thresholds:
Denmark use 2 and 4 mg O_2 l^{-1}, other countries use other levels and in particular, other periods and statistical approaches.

No thresholds are agreed on yet. A separate project would be needed to determine this.

Description of challenges and reservations:
Different methods to calculate the oxygen concentration in bottom waters have been suggested. Which method to continue with is not yet decided. The optimal for Denmark is if the method for this HELCOM indicator correspond to how oxygen deficiency is estimated nationally. For some countries, a lack of data might be possible.

The challenges is similar to the challenges for concentrations of nutrients and chlorophyll, i.e. a need for precise definitions of time periods, depths intervals and the statistical variable used as indicator.

Suggestions for solutions and process forward:
It is important to involve Danish experts in the development of this indicator, so the indicator will be consistent to what is already done in Denmark.

Appraised by (name of AU advisor):
Professor Stiig Markager

Qualification with regard to this indicator:
Stiig Markager has published scientific papers within this field since 2001 and developed the methods used today in the Danish management of marine systems. Moreover, Stiig Markager has participated regularly in the relevant HELCOM and OSPAR expert groups the last five years, where these indicators are used.

Internal scientific review by:
Jens Würgler Hansen, senior advisor, Section for Marine Ecology, BIOS, AU

Indicator title: **Phytoplankton spring bloom intensity based on chlorophyll a**	
HELCOM (X) OSPAR (X)	Partially overlapping ( ) Complete overlap (X)

The indicator is being developed by (name of working group/s and lead country):
The indicator is relevant for the groups HELCOM IN-Eutrophication and OSPAR ICG-EUT. In HELCOM, Finland have agreed to initiate the collection and comparison of data.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes in both areas, though with different spatial monitoring scale.

Is a national (or regional) database in place?
Yes, the ICES database.

Background for indicator:
The current OSPAR indicator 'Concentrations of chlorophyll a in the Greater North Sea and Celtic Sea' covers the month March to September and the similar HELCOM indicator 'Chlorophyll-a' covers June to September. The latter does not cover the phytoplankton spring bloom, which in Denmark, typically, is from March to May. Phosphorous concentrations can be important during spring as the growth of phytoplankton can be limited by phosphorous during the spring bloom. This indicator will give a better assessment of the correspondence between chlorophyll a and concentrations of phosphorous, i.e. the effect of implementing measures to reduce phosphorous loads to the sea, as the current indicators mainly assess the effects of measures related to nitrogen.

Aim of Indicator:
To assess the effect of implementing measures to reduce phosphorous loads to the sea.

Does the indicator match COM DEC 2017 criteria? (and which)
D5C2.

Thresholds:
No thresholds are suggested yet. A separate project would be required to determine this.

Description of challenges and reservations:
To increase the confidence of the assessment, it is relevant to achieve data from other sources than *in situ* measurements (bottle/ship samples). Data from other sources as e.g. satellite data (EO data) and/or data from ferryboxes should be combined with in situ measurement. To combine these data is challenging, as it requires validation with *in situ* samples.

Suggestions for solutions and process forward:
Some resources are needed to combine the different data types with sufficient quality and confidence.

Appraised by (name of AU advisor):
Professor Stiig Markager

Qualification with regard to this indicator:
Stiig Markager has published scientific papers within this field since 2001 and developed the methods used today in the Danish management of marine systems. Moreover, Stiig Markager has participated regularly in the relevant HELCOM and OSPAR expert groups the last five years, where these indicators are used.

Internal scientific review by:
Jens Würgler Hansen, senior advisor, Section for Marine Ecology, BIOS. AU

Indicator title: **Biomass ratio of opportunistic and perennial macroalgae D5C6 (eutrophication)**	
HELCOM (x) OSPAR ( )	Partially overlapping ( ) Complete overlap ( )
The indicator is being developed by (name of working group/s and lead country): Unknown.	
Are Danish data available for the HELCOM and/or OSPAR regional seas? Yes. In a slightly different format.	
Is a national (or regional) database in place? Yes.	
Background for indicator: The indicator is related to water transparency and nutrient concentrations and follow the rationale that opportunistic macroalgae are favored over the perennial species with increasing eutrophication. Thus, assessing the ration between the two life forms gives an indication of the integrated nutrient level and water transparency. Denmark uses a similar indicator which builds on macroalgae coverage instead of biomass, and it also takes into account the depth distribution of the macroalgae vegetation.	
Aim of Indicator: The aim of the indicator is to assess if the abundance of opportunistic macroalgae is at levels that indicate adverse effects of nutrient enrichment of the system.	
Does the indicator match COM DEC 2017 criteria? (and which) D5C6.	
Thresholds: No agreed thresholds.	
Description of challenges and reservations: The Danish version of this indicator is under development and it unknown what will be the outcome of the indicator at HELCOM level.	
Suggestions for solutions and process forward: To proceed with the Danish indicator development (se also comment to “state of the hard bottom communities” under D6C5).	
Appraised by (name of AU advisor): Jørgen L. S. Hansen, BIOS, AU. **Qualifications of appraiser with regard to this indicator:** Jørgen L.S. Hansen has +25 years of experience working with benthic ecology. He has not been involved in the development of the indicator.	
Internal scientific review by: Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU	

D6 Seafloor integrity

Seafloor integrity is a descriptor that considers the overall environmental status of the seafloor habitats, their associated biological communities, ecological functions and resulting ecosystem services. These properties are assessed through a number of physical and biological indicators under D6 describing states and pressures on the seafloor. The descriptor thereby aiming to provide a holistic view of the seafloor where “the integrity” prescribes that neither habitats, biota nor ecological functionality is lost nor adversely affected. The criteria for good environmental status (GES) consider physical and community loss and disturbance from an area-based perspective where thresholds should be defined, and agreed upon, as maximal acceptable lost and disturbed area within each broad habitat type. All indicators, so far developed, under this descriptor implicitly assume spatial overlap of state and pressure variables used to assess impact (e.g. that poor conditions in one place do not result from pressures at another location). The GES-definitions also implicitly assume that the overall impact within a habitat type scales linearly with the area such that cumulative effects of pressures that do not overlap is not considered. The various indicators under this descriptor need input data from seabed mapping to decide the habitat typology, monitoring data of the benthos to assess state as well as input data of loss of seafloor and disturbance of seafloor in order assess pressure state relationships and impact. Assessments under D6 are typically challenged by lack of representativeness of the benthos data in relation to habitat type, accuracy of seafloor mapping and confidentiality of fishing pressure data. On top of these data gaps, the individual indicators may be challenged by lack of knowledge of pressure-state relationships. Some of these challenges are described in the below roadmap of D6 indicators. However, more extensive review of scientific literature may prove to fill in these knowledge gaps.

Indicator title: **Condition of the Benthic habitat D6C4 - HELCOM**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
Estonia has been leading this indicator work. Status and possible progress in development unknown. The indicator addresses/have relevance for both D6C3, D6C4 and D6C5. Unknown if the indicator primarily was developed for D6C4 as indicated in the Excel-worksheet (MVFM-Excel roadmap).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes. However, Danish data have another format than the Estonian data, which was used in preliminary tests. The indicator is tested on typical biotopes of the central Baltic Sea which is well defined due to a few habitat-forming species but different from corresponding Danish habitats.

Is a national (or regional) database in place?
Yes. However, Danish data are not classified according to the same habitat types (biotopes) used in the initial Estonian tests.

Background for indicator:
In principle this indicator builds on the same rationales as BH4 (OSPAR) where the habitat are classified by a number of biotopes. The area extent is then used to classified area loss and area with adverse affected habitats (biotopes). The Approach differs from BH4 as the final assessment in the Estonian test case is actually based on monitoring data and not an extrapolation combining habitat sensitivity with pressures (impact).

Aim of Indicator:
The aim of the indicator is to assess the if: “Spatial extent of each habitat type which is adversely affected, through change in its biotic and abiotic structure and its functions (e.g. through changes in species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), by physical disturbance” (cited from the Estonian report).

Does the indicator match COM DEC 2017 criteria? (and which):
D6C4.

In principle, it follows the COM DEC 2017 as the indicator describes the area extent of loss and disturbance. However, it is not certain if thresholds in the test report are (national Estonian? or just examples?) and if they have been agree on.

Thresholds:
No agreed thresholds.

Description of challenges and reservations:
1) The habitat and biotope classification is dominated by vegetated habitats/biotopes and only a few habitats are defined by fauna components. This together with the fact that 2) the biotopes are not dominating in Danish Seas and 3) that the Danish monitoring design for vegetation is different suggests that the approach cannot be transferred to Danish water without major adjustments.

Suggestions for solutions and process forward:
1) As describe for BH4 (OSPAR) with respect to D6C4, to follow COM DEC 2017 e.g. to use the distribution of physical loss (D6C1) of the seabed among habitat types to define habitat losses. For the soft bottom the state of the community and the state of the habitat could be assessed using a single indicator.

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. However, he has not been involved in the development of this specific indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU

Indicator title*:* **Population structure of long lived macrofauna communities (under D6C3)**	
HELCOM (X) OSPAR ( )	Partially overlapping (x) Complete overlap ( )
The indicator is being developed by (name of working group/s and lead country): Unknown to DCE.	
Are Danish data available for the HELCOM and/or OSPAR regional seas? There are Danish data available for both the HELCOM and the OSPAR regional seas. However, it is uncertain to which extent the indicator development have been based upon monitoring data, and what are the recommended data format. It is suspected that the Danish data format does not fit to the indicator as it gives a poor representation of species-specific population size/age structure.	
Is a national (or regional) database in place? National and regional databases are in place. Danish data at collected with frequencies from 1 to 6 years. However, it is uncertain if the Danish data fit the indicator. DCE is not aware that there have been any testing of the on Danish data format.	
Background for indicator: The indicator builds on the concepts of using biological traits to assess the environmental quality of the seafloor. Among, many different biological traits used for a variety of environmental assessments, the species-specific longevity of the bottom fauna has received most attention in the context of seafloor disturbance. The rationale is that the long-lived animals (this trait is closely linked to the trait late maturity) will be more susceptible to disturbance since they will be exposed for a longer time before they can reproduce. The indicator uses the species-specific longevity which means that the indicator does not explicit take the age of an individual into account when a "longevity-class" is assigned to a species. Instead, the indicator uses the weight as a proxy for age and assume logistic growth patterns.	
Aim of Indicator: The aim of the indicator is to determine the disturbance level from the distribution of size of long-lived animals within the benthic community.	
Does the indicator match COM DEC 2017 criteria? (and which): D6C3 Unknown if the indicator match the criteria. It is also unknown if there have been relevant tests of this, and whether such tests have included monitoring data!	
Thresholds: Unknown if any thresholds have been suggested.	
Description of challenges and reservations: There are implicit assumptions that are problematic when applying the indicator to the typical data format of monitoring data. These concerns is: 1) Is longevity a proxy for sensitivity to disturbance? (as many species change the vulnerability toward physical disturbance during their life cycle). 2) To what extent does biomass reflect age when the indicator is applied to monitoring data where the data format is average biomass of a specific species in a sample? In particular it is challenging to apply the indicator to the Danish monitoring data where the sample size is small and the chances of encounter the larger and rare animal smaller. A preliminary test of the indicator using a) the longevity classification from Bolam et al. 2017 on Danish soft-bottom monitoring data of species specific abundance data instead of biomass gave a counter-intuitive result showing a larger proportion of long-lived animals with increasing disturbance.	

Suggestions for solutions and process forward:
No suggested way forward – DCE recommend not implementing the indicator as more well-tested and simple indicators are available to describe the state of the sea floor. HELCOM have been considering not to go forward with this indicator, but their final decision is unknown.

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has performed test of the indicator but has not been involved in the development of this specific indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU.

Indicator title: **State of the soft-bottom macrofauna community (Eutrophication D5C8)**	
HELCOM (x) OSPAR ( )	Partially overlapping (X with use of indicators under descriptors D1 and D6) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
Finland and Sweden – status unknown.

The indicator is a general indicator which also occur under descriptor 6 to assess seafloor integrity. It also shares similarities with the Danish soft bottom macrofauna indicator used under the Water Frame Directive.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes. However data format is different (se roadmaps for D6-indicators).

Is a national (or regional) database in place?
Yes.

Background for indicator:
According to the COM DEC 2017 this is a secondary indicator D5C8 —except when it is used as a substitute for bottom oxygen conditions D5C5. It has a strong overlap with indicators under D1 and D6. In the COM DEC 2017 it is furthermore stated that this indicator should link areas under the Water Frame Directive with Offshore areas (MSFD-areas) by using consistent methods (indicators) to ensure that there is:

"no adverse effect due to nutrient and organic enrichment, as follows: (a) in coastal waters, the values for benthic biological quality elements set in accordance with Directive 2000/60/EC; (b) beyond coastal waters, values consistent with those for coastal waters under Directive 2000/60/EC. Member States shall establish those values through regional or sub-regional cooperation".

Aim of Indicator:
Assess whether achieved values of the species composition and relative abundance of macrofaunal communities, indicate that there is no adverse effect due to nutrient and organic enrichment.

Does the indicator match COM DEC 2017 criteria?
D5C8.

However it is unknown if present status of the indicator development conforms to COM DEC 2017.

Thresholds:
No Danish thresholds.

Description of challenges and reservations:
Denmark has developed an index/indicator, DKI, that have proven to be sensitive to (and thereby can decide if the benthic community is adversely affected by nutrient…) and applicable to eutrophication in WFD-areas. This indicator has been intercalibrated to other similar indices used in other EU countries and could be extended to the MSFD-areas. This, however, would require new intercalibration for areas bordering Swedish and German waters. Possibly it also necessary to set habitat-specific thresholds.

Suggestions for solutions and process forward:
To use the DKI-indicator which has been developed for a similar purpose under the WFD or to use an equivalent multi-metric index, and to proceed with intercalibration taking differences in sampling area between DK and other countries into account.

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has worked with correspondent indicators under WFD but has not been involved in the development of this indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU.

Indicator title: **Condition of the benthic habitat- Chronic effect on bivalves (BH5)**	
HELCOM ( ) OSPAR (X)	Partially overlapping ( ) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
OBHEG, Spain. Spain has taken up the initiative on testing BH5. The work is in its initial phase and there is no test results yet.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
In principle data can be extracted from the national monitoring program, NOVANA. However, the Danish monitoring program uses a smaller sampling area and the data format has not yet been calibrated against the other countries. The indicator probably needs larger sampling area in order to be implementable and therefore requires modification of the Danish NOVANA program. Currently the indicator does not seem relevant in the national Danish monitoring program or national reporting.

Is a national (or regional) database in place?
Yes! However, as described above the data format will not fit the indicator.

Background for indicator:
Background for this indicator is unknown.

Aim of Indicator:
To assess to assess the quality of the benthic habitat by using size distribution of selected species.

Does the indicator match COM DEC 2017 criteria? (and which)
D6C5.

Presently the indicator does not match the criteria. The indicator is not developed and tested and its relevance for describing the condition of the benthic habitat is unknown as is its sensitivity toward specific pressures. The indicator may be more relevant for “foodwebs (D5)” than for the seafloor integrity at least in Danish Seas.

Thresholds:
No thresholds.

Description of challenges and reservations:
The main challenges is lack of relevant Danish monitoring data and there is currently no test results to evaluate if the indicators works.

Suggestions for solutions and process forward:
As the indicator is not fully developed, it is uncertain whether it can be implemented in the Danish Monitoring program. Therefore, the indicator cannot be recommended without further testing, and this should include explicit tests on Danish fauna data. Furthermore, as the indicator uses sizes or size distributions it is believed, that Danish input data will not fit well with the indicator because the Danish data uses a small sampling area, and the data do not describe species specific size distributions.

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has not been involved in the development of this indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU.

Indicator title: **Condition of the benthic Habitat communities BH2**	
HELCOM ( ) OSPAR (x)	Partially overlapping (x) Complete overlap (x)

The indicator is being developed by (name of working group/s and lead country):
OBHEG (Lead France).

The indicator was used in the intermediate assessment of the Southern North Sea 2017. Hereafter it is unknown whether it has been further developed. Denmark did not participate in the intermediate assessment of the southern North sea.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Relevant data are available from the National Danish database as well as from HELCOM and OSPAR regional seas. The national Danish database holds >40 years of relevant soft-bottom fauna data from the North Sea, Kattegat, Belt Seas and Western Baltic. These data are also reported to ICES annually. Currently the Danish data coverage is relatively low in the North Sea area and in particular in the Skagerrak. Furthermore, the distributions of Danish monitoring stations in relation to the Broad habitat types has not been synthesized (prerequisite in order to match the COM DEC 2017) and certain habitat types may be underrepresented.

Is a national (or regional) database in place?
Yes.

Background for indicator:
The indicator BH2 "Condition of the Benthic habitat community" uses a normalization of the Margalefs biodiversity index to describe the condition of the benthic habitat. The development of the indicator is based on the same principles and rationales as used in the development of the national Danish indicator, DKI, used under the WFD. This implies that the sensitivity of several multi-metric indices were initially tested in gradients of environmental pressures before Margalefs index was finally selected as the indicator of benthic community quality. The Margalefs index correlates fairly well with the Danish DKI.

Aim of Indicator:
To assess the conditions of the benthic habitat communities (D6C5) by using the Margalefs biodiversity index as a quality measure.

Does the indicator match COM DEC 2017 criteria? (and which).
The indicator matches D6C5. However, the indicator needs to be tested on the level of broad habitat types.

Thresholds:
No agreed national thresholds. DKI is currently used (the usage include minor modifications) in annual assessments of the conditions of the benthic habitat in the open Danish Seas (MSFD – areas). However, no national (or OSPAR) thresholds have been agreed upon.

Description of challenges and reservations:
The indicator has been tested in the intermediate assessment of the southern North Sea covering Denmark, Germany, Netherlands, Belgium and UK waters. However, Denmark did not provide data for this assessment, and it should be noted, that the Danish data format deviates from those of the other four countries, which need to be solved before implementation on Danish data. The indicator builds upon concepts (quantitative measures of biodiversity) which is relevant for MSFD reporting of Danish waters in relation to both OSPAR and HELCOM. However, currently there are no limits or thresholds that can be transferred to Danish data.

Suggestions for solutions and process forward:
It is believed that this indicator (with modifications) as well as related indicators (DKI or HELCOM) can be implemented on Danish soft bottom monitoring data and reported under D6C5. This, however, requires a thorough inter-calibration and test using Danish North Sea and Kattegat data. These further developments and tests also need to address the challenges associated with the Danish data format (sample size).

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has worked with similar indicators under WFD but has not been involved in the development of this indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU.

Indicator title: **Habitat loss BH4-OSPAR**	
HELCOM ( ) OSPAR (x)	Partially overlapping (x) Complete overlap (x)

The indicator is being developed by (name of working group/s and lead country):
UK and DE were leading together during the EcApRHA project (this project ended 2016/2017). UK and DE is still lead on this but progress is unknown.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Unknown if Denmark have gathered the relevant physical GIS data per habitat and per biotope such that they are ready for analysis within the regional seas. Biotic data have not been compiled in relation to original indicator work by the EcApRHA project. Biotic raw data are in principle in place but has another format than tested in the EcApRHA project.

Is a national (or regional) database in place?
Relevant national data of offshore constructions and other activities that could result in habitat losses is maybe available from "Geodatastyrelsen" and "Søfartsstyrelsen". Information on sand and gravel extraction sites are available. There could be overlap and synergies with the work in relation to marine spatial planning. Biotic data are stored in the National database.

Background for indicator:
It should be noted that the OSPAR BH4 indicator (under D6C1) is closely related to "physical loss of seafloor" (D6C1) such that (according to COM DEC 2017) assessment of the extent of physical loss of seafloor is used in D6C4 to define loss per habitat type. Definition of loss seems still pending. Originally, it was defined as habitat that would not recover within 12 year or equal to 2 reporting cycles. The proposed indicator uses a combination of pressures (physical disturbance) and habitat sensitivity (biotic data) to define habitat loss.

Aim of Indicator:
The aim of the indicator is to identify the percentage (per habitat type) where the original habitat is lost such that recovery is not expected even though all anthropogenic pressures stops.

Does the indicator match COM DEC 2017 criteria? (and which):

It is unknown if the indicator as it is now matches the criteria due to limited test results. The new COM DEC 2017 seems logical with respect to BH4. However, it seems that the original EcApRHA – approach to BH4 was based on a combination of seafloor pressures per habitat combined with habitat sensitivity such that "loss of habitat" is basically defined as areas where the anthropogenic pressure is highest and sensitivity of the habitat is highest. The sensitivity of the habitat is defined by its "typical species" where presence of typical species implies some kind of reference condition. It is unclear how this indicator should be ground truth e.g. how much the species composition, as encountered by monitoring, should deviates from the typical species composition in the reference condition, before this is taken as an indication that the habitat is lost. It is also unclear how recoverability is taken into account sensu the new COM DEC 2017 setting 12 years a threshold for recoverability.

Thresholds:
No agreed thresholds!

Description of challenges and reservations:
The original BH4 approach builds on typical species/habitat sensitivity, which will need to be revised in order for the indicator to be applied to Danish Seas and this, is probably not feasible for most of the soft bottom communities in Danish waters. The overlap/distinction between the criteria D6C3 and D6C5 are also unclear.

Suggestions for solutions and process forward:
To follow the COM DEC 2017 more strictly and start with the physical loss of seabed (D6C1), and then move on to assess how this areal loss of seabed are distributed among habitat types. Finally, next step could be to decide if the habitat specific sensitivities are relevant or not (that is sensitivity according to a temporal definition of loss – recoverable/not recoverable e.g. what are the minimum requirements to recoverability in elapsed time after pressures ceases). This would maybe also help to distinguishing between loss vs disturbance (D6C4 and D6C5).

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has worked with disturbance and loss of the seafloor but has not been involved in the development of this indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU.

Indicator title: **Cumulative impact on benthic biotopes**	
HELCOM (X) OSPAR ( )	Partially overlapping (x) Complete overlap ( )
The indicator is being developed by (name of working group/s and lead country): The indicator are being currently developed by "EN BENTHIC" (HELCOM) with German and Swedish leads.	
Are Danish data available for the HELCOM and/or OSPAR regional seas? There exist relevant Danish pressure data for both the HELCOM and OSPAR regional sea areas. Their availability is unknown to DCE.	
Is a national (or regional) database in place? Unknown! The relevant data is stored in databases at different authorities and AU only hosts relevant data from the NOVANA program. Data coverage, quality and accessibility unknown.	
Background for indicator: The indicator describe the multi-pressure cumulative impact on the seafloor such that e.g. abrasion from bottom trawling, extraction of raw materials, dredging etc. are overlaid to describe the total pressure on the seabed biotope by biotope.	
Aim of Indicator: The overall aim is to describe the total impact on the seafloor from all relevant activities and pressures. These pressure maps can then subsequently be combined with sensitivity maps to evaluate the "state" at the level of biotopes or habitats (see also suggested procedures for habitat loss classification under BH4).	
Does the indicator match COM DEC 2017 criteria? (and which). From initial test result presented by German/Swedish lead (EN BENTHIC second meeting) for the Western Baltic Sea it seems that the indicator follows COM DEC 2017.	
Thresholds: German lead suggests a GES-limit of max 25% of the seafloor are affected and max 10 % are lost. These thresholds have not yet been agreed upon. Whereas the German approach is consistent with regard to integration rules of pressures, there could be a dependency of the spatial resolution of the individual pressures on these GES estimates. This is particularly relevant for fishery pressures, which may typically be aggregated before they are combined with other pressure data.	
Description of challenges and reservations: As in most of the HELCOM and regional sea areas, fishery (bottom trawling) dominates the estimated cumulative impact on the seafloor in the Danish offshore seas. The available fishing pressure data have a very low spatial resolution and this gives a low confidence if/when combined with benthos data to assess the state of the environment.	
Suggestions for solutions and process forward: Integration rules suggested by the working group should be adopted (endorsed) and the work should proceed for better and common agreed spatial and temporal resolution of fishery data, which is the dominating pressure. A minimum of 2 * 2 nautical miles and a temporal resolution of quarters are strongly recommended. Furthermore, available time series should be updated yearly. It is also strongly recommended to further validate the VMS-based estimated with for example AIS-data, and the potentials of using modelling tools such as e.g. down-scaling to extrapolate fishery impact should also be consulted.	
Appraised by (name of AU advisor): Jørgen L. S. Hansen, AU, DCE	

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has worked with disturbance and loss of the seafloor but has not been involved in the development of this indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU

Indicator title: **State of the hard bottom communities**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap ( )

The indicator is being developed by (name of working group/s and lead country):
It is not known who is lead and if the work is progressing.

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Data are available from monitoring of Danish stone reefs in the Kattegat (OSPAR/HELCOM), Belt Seas and Western Baltic Sea (HELCOM). Possibly, there exists data from a few areas of the North Sea and the Skagerrak but the data format is unknown.

Is a national (or regional) database in place?
Data are stored in a national database hosted by Aarhus University. Data are sampled with frequencies of 1 – 6 years.

Background for indicator:
The indicator are a pendant to the indicator "state of the soft bottom communities and concerns benthos (macro-algae and macro-zoobenthos) on hard substratum. In the Danish MSFD-areas, this mostly concerns stone reefs in the Kattegat, Belt Seas and Western Baltic Sea. It is unknown if there is other initiatives within the HELCOM regional seas that should be coordinated with.

Aim of indicator:
To describe the state of the hard bottom communities in relation to the relevant pressures of the seabed to ensure that the communities are not adversely affected.

Does the indicator match COM DEC 2017 criteria? (and which).
D6C5.

The indicator development based on Danish vegetation data has been tested but not inter-calibrated. The fauna part is in its initial development phase and this has not been tested or inter-calibrated. Furthermore, it should be noted that the indicator explicit takes water into account such that only hard substrates in the photic zone are assessed.

Thresholds:
Thresholds have been suggested for vegetation however only in the photic zone.. Whereas these thresholds primarily concerns the eutrophication (D5) these principles could be extended to address D6 seafloor integrity.

Description of challenges and reservations:
The Danish initiative has mostly been focused on the vegetation coverage in relation to eutrophication. To make the indicator more general applicable to hard bottoms it needs to be extended to below the photic zone and to include the fauna.

Suggestions for solutions and process forward:
Presently this national indicator is based on the relation between the coverage of the vegetation and water depth (which is a proxy for light availability, and thereby water transparency). This has the advantages that it is easy to extrapolate the "state of the hard bottom communities" in space according to bottom topography and substrate. However, it is needed to have a better understanding of the distribution of hard bottom fauna communities, their sensitivity and how this relates to the vegetation and other pressures than eutrophication.

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has not been involved in the development of this indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU

Indicator title: **State of soft-bottom macrofauna communities D6C5**	
HELCOM (x) OSPAR ( )	Partially overlapping (x) Complete overlap (x)

The indicator is being developed by (name of working group/s and lead country):
EN BENTHIC, Finland and Sweden (unknown if the lead is still operating or if it ended after HOLAS II).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes! Data format is slightly different and needs to be inter-calibrated with Germany and Sweden.

Is a national (or regional) database in place?
Yes. Data are reported annually to ICES. Part of the Danish data have also been synthesized in the "Gogina data set" used in the Holas II assessment. A comprehensive overview of the data compilation can be found in Gogina et al. (2016) ICES J. Mar. Sci. 73 and Schiele KS, (2016). Ecological indicators 61:447-455.

Background for indicator:
The indicator builds on a long tradition of assessing the quality of the benthic infauna community from its community composition. The present indicator uses the same conceptual approach as in the Water Frame Directive, however, with updated and a new version of the multi-metric index BQI. The indicator is related to the OSPAR BH2 indicator.

According to COM DEC the indicator should assess if "the extent of adverse effects from anthropogenic pressures on the condition of the habitat type, including alteration to its biotic and abiotic structure and its functions (e.g. its typical species composition and their relative abundance, absence of particularly sensitive or fragile species or species providing a key function, size structure of species), does not exceed a specified proportion of the natural extent of the habitat type in the assessment area."

Aim of Indicator:
To assess the overall quality of the soft-bottom macrofauna community. To be used on quantitative soft-bottom fauna samples to assess the overall quality of the soft-bottom macrofauna communities.

Does the indicator match COM DEC 2017 criteria (and which)?
D6C5.

It is unknown if any attempts have been made to test the indicator at the "broad habitat type" – level. It´s also unknown if the indicator have been used to assess the areal extent of macrofauna communities being in GES respective sub-GES.

Thresholds:
No agreed thresholds for Danish Waters.

Description of challenges and reservations:
The indicator is currently not well designed to be applied to broad habitat types in the Danish Waters as these are intersected with strong salinity gradients. The Danish indicator used in WFD explicitly takes into account the salinity which have stronger influence on the community composition than do some of the habitat types. This normalization is not included in indices used in our neighbouring countries. These problems should however be manageable.

Suggestions for solutions and process forward:
1) To agree on national principles for GES-thresholds setting. This means to decide whether thresholds should refer to some kinds of reference conditions (either known or extrapolated) or if the same threshold used in the WFD could be used.

2) To test the indicator as it is on Danish data,

3) To test alternatives (e.g. OSPAR – indicators, National WFD- and other indicators).

4) To launch inter-calibration with Germany and Sweden on the significance of sample size.

5) Use lessons learned from German and Swedish inter-calibration to guide potential future modification of the DK MSFD- soft-bottom monitoring program.

Appraised by (name of AU advisor):
Jørgen L. S. Hansen, AU, DCE

Qualifications of appraiser with regard to this indicator:
Jørgen LS Hansen has 22 years of experience working with benthic ecology, benthic monitoring, assessments and development of benthic indicators. Jørgen LS Hansen participate in OBHEG (OSPAR Benthic Habitat Ecology Group) since 2017 and HELCOM EN BENTHIC since 2018. Jørgen L. S. Hansen has worked similar indicator development under WFD and reported national test of similar indicators but but has not been involved in the development of this indicator.

Internal scientific review by:
Karsten Dahl, Senior Advisor and Section Leader, PhD, Section for Marine Biodiversity and Experimental Ecology, BIOS, AU

D10 Marine litter

D10 is in COM DEC 2017 described as "Properties and quantities of marine litter do not cause harm to the coastal and marine environment". Marine litter is in this context any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment. This includes litter items of following general material categories: synthetic polymer materials / plastics, rubbers, cloth / textile, metals, paper / cardboard, processed / worked wood, glass / ceramics, solid chemicals, others.

Following D10 indicators have been specified under these four criteria (C1-C4):

D10C1 – Primary: The composition, amount and spatial distribution of litter on the coastline, in the surface layer of the water column, and on the seabed.

D10C2 – Primary: The composition, amount and spatial distribution of micro-litter on the coastline, in the surface layer of the water column, and in seabed sediment.

D10C3 – Secondary: The amount of litter and micro-litter ingested by marine animals.

D10C4 – Secondary: The number of individuals of each species which are adversely affected due to litter, such as by entanglement, other types of injury or mortality, or health effects.

Denmark has since 2016 initiated national monitoring activities on following marine litter indicators:

- Beach litter on coastlines
- Seabed litter
- Microplastic in sediments and fish
- Ingestion of plastic by northern fulmars.

DCE has mainly been involved in coordination, conducting, assessing and / or giving advices on the indicators for beach litter and microplastic in sediment. Therefore only the status and challenges for these two indicators are described below.

The main challenges identified for these indicators concern size limited datasets for spatial and temporal assessments, development of internationally harmonised monitoring protocols, development of adequate QA / QC procedures, establishment of databases that can secure datasets, baseline settings and deriving thresholds values for harmful impacts.

Indicator title: **Beach litter - Amounts and composition on reference beaches**	
HELCOM (x) OSPAR (x)	Partially overlapping () Complete overlap (X)

The indicator is being developed by (name of working group/s and lead country):
HELCOM EN-LITTER (Polen) and OSPAR ICG-ML (Germany) as well as EU TG-ML (JRC).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
The Danish monitoring program on beach litter on rural reference beaches includes currently 2 monitoring stations in the Baltic Sea (Arkona basin), 2 stations in Kattegat (Roskilde fjord and Langerak) and 2 stations in North Sea/Skagerrak.

The monitoring records systematically the amounts and composition of beach litter on 100 m stretches with 3 seasonal surveys per beach location per year. The Danish beach litter monitoring was initiated in 2015.

Is a national (or regional) database in place?
The Danish data relevant for OSPAR are available from OSPAR database on beach litter.

The Danish data relevant for HELCOM are available from EEA database Marine Litter Watch on beach litter.

In addition, DCE is considering further to develop the national database ODA to include monitoring data for beach litter.

Background for indicator:
MSFD D10 mandates member states to monitor composition, amounts and spatial distribution and set thresholds for marine litter on coastlines.

The Danish MSFD oriented monitoring is performed according to recommendations in international guidelines described in OSPAR, HELCOM and JRC protocols. Data is reported to the EEA database according to the extended JRC joint list for marine litter items that can be translated into corresponding OSPAR codes for marine litter items, so comparative data sets also can be reported into an OSPAR format.

Aim of Indicator:
To assess amounts and composition of marine litter deposited on coastlines, which can be used for spatial and temporal assessments of sources, environmental state and impact from different land- and sea-based activities.

Does the indicator match COM DEC 2017 criteria? (and which).
This indicator covers partly D10C1, i.e. the coastline part of D10C1 (Primary): “Marine litter shall be monitored on the coastline and may additionally be monitored in the surface layer of the water column and on the seabed. Information on the source and pathway of the litter shall be collected, where feasible”.

Thresholds:
A threshold value on 20 items per 100 m (based on 10th percentile of EU dataset from 2015-2016) have been proposed as European wide threshold value for assessing GES and presented for WG GES.

Threshold values from risk assessments that link environmental levels to harm are still missing. Both environmental harm and socio-economic harm can be of concern.

Description of challenges and reservations:
The Danish MSFD oriented monitoring programme consists currently of a limited number of beach locations that will affect the uncertainties on e.g. national and subregional baseline settings and spatial and temporal trend assessments. Therefore the Danish monitoring data can better contribute to assessment based on e.g. HELCOM Assessment Units for sub-basins (scale 2) but not as detailed as to scale 3.

More focus is needed internationally on including hierarchically analyses of data, e.g. by splitting data from different types of urban, peri-urban and rural beaches instead of just aggregating all data to be able to discriminate between amounts and composition of marine litter dominantly washed ashore from the sea and litter that originate from local activities on or nearby the beaches. This is relevant in relation to both (sub-)regional source characterisations, baseline settings, trend-analyses and use of threshold levels.

HELCOM wide assessments are still challenged by the fact that not all countries are following the same monitoring protocol, because some countries are using the UNEP/MARLIN monitoring protocol, whereas others are using the OSPAR protocol or nationally adaptation to also include other types of litter items on the JRC joint Litter Category list like in DK.

A regional database for the Baltic Sea hosting all HELCOM relevant data is missing, whereas OSPAR has a functional database for storing and securing beach litter data instead of relying only on availability from national data providers. An alternative can also be the EU project financed EMODnet database that is able to harvest data directly from other databases including the OSPAR, EEA and ICES databases.

Suggestions for solutions and process forward:
The inclusion of more beach locations in the national monitoring program could be considered to increase the size of the dataset, especially in the Baltic sea area, but also a location in the Wadden Sea can be relevant for e.g. TMAP assessments. In addition, the survey number can be increased from 3 to 4 yearly surveys per beach, i.e. also to include a survey in January.

Regarding GES-value, the need of development of some sub-regional intermediate target values might be considered to be used for the coming assessment period, e.g. for high accumulation areas like the Skagerrak.

Hydrodynamic modelling has also potential to contribute with information for how transboundary pollution may be accounted for in the reporting of beach litter pollution nationally, to the RSCs and to the EU.

Regarding not fully harmonised HELCOM wide monitoring, it might be beneficial if there can be agreed on so-called “B-codes” that can be used to aggregate UNEP, OSPAR and TG-ML codes for specific types of litter items, or alternatively a common agreement on using same monitoring protocol by all member states are needed. Minor modifications in applied monitoring protocols should also be considered, so the list of monitored types of litter items better can support the assessment of effectiveness of specific actions on certain litter types in e.g. HELCOM and OSPAR RAPs.

Regarding the considerations of beach types used for assessments, more efforts are needed to identify and describe the differences in the nature of data from beaches with predominantly local impacts and beaches that mainly derive litter from diffuse sources washed ashore from the sea. It should be further investigated to what extent they can be used for more general assessments of the environmental conditions and characterisations of sources to marine litter in regional sea areas.

Development of a regional database for the Baltic Sea hosting HELCOM relevant data can also be a solution, or alternatively Baltic sea member states could agree on another common database framework, e.g. within the international databases EMODnet, EEA’s Marine Litter Watch or alternatively ICES DOME.

Appraised by (name of AU advisor):
Jakob Strand, BIOS, AU

Qualifications of appraiser with regard to this indicator:
Jakob Strand is member of several international expert groups on monitoring and assessment of marine litter. Jakob is co-chair on the beach litter in HELCOM EN-LITTER since 2017 and member of the beach litter subgroup in OSPAR ICG-ML since 2016, Member of EU-TG-ML since 2017 and Member of AMAP LMEG since 2019.

Internal scientific review by:
Louise Feld, academic staff, Section for Marine Diversity and Experimental Ecology, BIOS, AU

Indicator title: **Microlitter in water column and sediments**	
HELCOM (x) OSPAR (x)	Partially overlapping () Complete overlap (x)

The indicator is being developed by (name of working group/s and lead country):
HELCOM EN-LITTER (Sweden) and OSPAR ICG-ML (UK), ICES WGML (UK, F) as well as EU TG-ML (JRC).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Some data are available from MSFD oriented monitoring program for microlitter/microplastic in sediments from the Danish part of the North Sea and the Inner Danish waters from 2015. New sediment samples from 2018 are scheduled to be analysed in 2019-2020, mainly from coastal and open waters. Monitoring data from 2015 was performed according to international recommendations from JRC to MSFD-oriented monitoring (JRC, 2013) for microlitter particles > 100 µm (i.e. size fractions, shape/types and colours), but without specific polymer assignments on identified microplastic-like particles. However, the Danish data from 2018 are expected also to include polymer assignments.

In addition, some new project data exists for microlitter in water columns from Danish waters or are going to be reported in the near future. However, it is currently not clear to what extent these data (e.g. if generated with ferry box) are in line with HELCOM or OSPAR technical recommendations for microplastic monitoring, and if they fit into relevant reporting formats for QA/QC and international databases.

OSPAR (ICG-ML) has currently decided that microplastic in sediment is their recommended candidate indicator for microlitter, whereas HELCOM (EN-Litter) recommend a microplastic indicator for water column and/or sediment.

Is a national (or regional) database in place?
The 2015 data for microlitter in sediment are reported to the ODA database and will also be submitted to EMODnet database.

Background for indicator:
Microlitter particles (size fractions <5mm) can origin as both so-called primary microplastic (i.e. directly released into the environment in the form of microsized fractions) or as secondary microplastic (originating from the fragmentation of larger plastic items or from other relevant items of synthetic materials (e.g. rubber, paint flakes etc). Once they have entered into the marine environment, they can either float and be transported with ocean currents, sink to the sediment, wash ashore on coasts or accumulate in the food webs.

Sediment is generally regarded as a sample matrix with relatively higher particle densities that provide a more time-integrated measure while microplastic in water column provide more variable “snap shot” data with generally lower particle densities.

Aim of Indicator:
To assess amounts and composition of microlitter in sediments (and water column).

Does the indicator match COM DEC 2017 criteria? (and which).
This indicator cover partly D10C2, i.e. mainly the sediment part of D10C2 (Primary): “micro-litter shall be monitored in the surface layer of the water column and in the seabed sediment and may additionally be monitored on the coastline. Micro-litter shall be monitored in a manner that can be related to point-sources for inputs (such as harbours, marinas, waste-water treatment plants, storm-water effluents), where feasible.”

Thresholds:
No threshold value has been proposed yet for sediment, surface waters or coastlines. Threshold values from risk assessments that link environmental levels to harm are still missing.

Description of challenges and reservations:
Final recommendations on method requirements, particle size fraction intervals and specific parameters to be reported for microliter monitoring incl. QA/QC are not yet in place. Subsequently it is difficult to compare different data sets from different countries/laboratories.

Regionally recommended databases for storing HELCOM and OSPAR relevant monitoring data are missing and are currently relying on availability from national data providers or if any relevant data are available from the international databases EMODnet or ICES DOME.

The design of monitoring strategy including number of samples to be analysed needs to be evaluated with focus on performing adequate statistically spatial and temporal trend assessments for microplastic in sediments and/or water column.

Some focus should also be given on how a monitoring strategy can be developed in a manner that data can be related to inputs (pressure) from different types of point sources (e.g. harbours, WWTP effluents, storm water etc).

International agreements are still needed on how to best fulfil the COM DEC 2017 requirements on that data for amounts of micro-litter per category should report also on weight-based units and not only be based on counted numbers.

Suggestions for solutions and process forward:
Continuing to support the process on development of internationally harmonised guidelines, QA/QC frameworks and national databases and data transfer to international databases (e.g. EMODnet or alternatively ICES DOME). Development of a regional database for the Baltic Sea for storing HELCOM and/or OSPAR relevant data can also be a solution.

Appraised by (name of AU advisor):
Jakob Strand, BIOS, AU

Qualifications of appraiser with regard to this indicator:
Jakob Strand is member of several international expert groups on monitoring and assessment of microplastic. Jakob is co-chair on the microplastic indicator in HELCOM EN-LITTER since 2017 and in OSPAR ICG-ML since 2019, Member of EU-TG-ML since 2017 and Member of AMAP LMEG since 2019.

Internal scientific review by:
Louise Feld, academic staff, Section for Marine Diversity and Experimental Ecology, BIOS, AU.

D11 Underwater Noise

D11 relates to emission of energy into the marine environment, specifically mention-ing underwater noise, but the descriptor also covers heat (cooling water) and electromagnetic radiation (magnetic and electric fields). The two latter categories have not been dealt with so far and is awaiting initial guidance from the technical group (TG-Noise).

Underwater noise is divided into two categories (criteria) in the guidance from TG-Noise: Impulsive noise and continuous noise. The most significant impulsive noise sources are (not listed in any particular order): explosions, seismic surveys, pile driving and certain sonars, particularly with military purposes. A number of lesser sources are covered by this criterion as well, in particular seal scarers and equipment for subbottom profiling.

Primary sources of continuous noise are ships and leisure boats, but other activities and installations may contribute as well, especially to the local environment, such as dredging, offshore construction, oil and gas installations, offshore wind farms, and bridges.

Priorities in Denmark has been to follow recommendations from OSPAR and HELCOM, which includes delivery of data to the joint HELCOM / OSPAR impulsive noise register, hosted by ICES, and establishment of a continuous noise monitoring system, through currently 4 noise monitoring stations in the Inner Danish Waters and one station in the North Sea. This monitoring follows recommendations of the HELCOM monitoring program for continuous noise and will supply data to the newly established HELCOM continuous noise database, also hosted by ICES.

In addition to the monitoring activities Denmark is prioritising participation in development of indicators in HELCOM and OSPAR and establishing of common criteria and thresholds for good environmental status in TG-Noise.

Indicator title: **Continuous low frequency anthropogenic sound (HELCOM)** **Ambient noise (OSPAR)**	
HELCOM (X) OSPAR (X)	Partially overlapping ( ) Complete overlap (X)

The indicator is being developed by (name of working group/s and lead country):
ICG-Noise (OSPAR).

EN-NOISE (HELCOM). Lead (HELCOM) Poland, Co-lead Denmark, Finland, Ger-many and Sweden.

TG-Noise (European Union).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, from the BIAS project in 2014 and national monitoring 2016 and onwards, as well as the JOMOPANS project in 2019.

Is a national (or regional) database in place?
National data is stored at Aarhus University (AU), but no database is yet in place.

HELCOM decision by HOD-55 2018 to establish a HELCOM database hosted by ICES. This decision is under implementation and the database is expected to be operational in 2020.

ICG-Noise on their meeting in October 2019 agreed to prepare and submit a proposal to EIHA in spring 2020 to join the HELCOM database.

OSPAR data for area II (North Sea) for 2019 is currently hosted by BSH, Germany, as part of the JOMO-PANS project.

Background for indicator:
MSFD Descriptor 11, which mandates member states to monitor and set thresholds for low frequency continuous noise in the 63 Hz and 125 Hz third-octave bands. In most areas the primary source of anthropogenic noise in this frequency range is shipping.

Aim of Indicator:
To capture the pressure on the ecosystem from emission of low frequency noise, primarily from ships and boats, secondarily from infrastructure such as oil rigs, offshore wind farms and bridges.

Does the indicator match COM DEC 2017 criteria? (and which).
D11C1.

Coordination at regional level implemented through HELCOM and OSPAR.

Thresholds:
No thresholds for GES have been established. Work progressing on this issue in TG-Noise, EN-Noise and ICG-Noise. It is expected that TG-Noise will work towards proposing thresholds by the end of 2021.

Description of challenges and reservations:
A key concern at present is the focus on larger ships in the assessments. This focus is for technical reasons as the current modelling is based on AIS data to inform models about shipping densities. This approach fails to include the contribution from smaller boats, primarily leisure boats that typically do not carry AIS transmitters. The contribution of noise from these boats can be significant, especially in coastal waters, and is thus a particularly important aspect in Inner Danish Waters.

Suggestions for solutions and process forward:
Work on development of the indicator and establishment of thresholds must be supported by resources in the coming years, both in form of research on effect and participation in working groups etc. It is generally

accepted that it may be relevant to operate with different threshold values for different regional seas. Coordination between HELCOM and OSPAR is essential on this issue because of the overlap in Kattegat (common decision between HELCOM and OSPAR, i.e. Sweden and Denmark on which threshold to apply to Kattegat).

Development of methods to include leisure boats in assessments should be given high priority.

Appraised by (name of AU advisor):
Jakob Tougaard

Qualifications of appraiser with regard to this indicator:
Senior researcher, PhD. Bioacoustician by training. More than 20 years of experience with studies of effects of noise on marine organisms. Chair of HELCOM EN-Noise, member of OSPAR ICG-Noise and EU TG-Noise.

Internal scientific review by:
Line Hermansen, PhD, Section of Marine Mammal Research, BIOS, AU.

Indicator title:

Distribution in time and space of loud low- and mid- frequency impulsive sounds (HELCOM)

Distribution of Reported Impulsive Sounds (OSPAR)

HELCOM (X) OSPAR (X)	Partially overlapping ( ) Complete overlap (X)

The indicator is being developed by (name of working group/s and lead country):
ICG-Noise (OSPAR).

EN-NOISE (HELCOM). Lead (HELCOM) Germany

TG-Noise (European Union).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, as reported to the ICES impulsive noise register.

Is a national (or regional) database in place?
A joint HELCOM/OSPAR database is available and hosted by ICES. Reporting is annual. Data is collected by ministries and agencies responsible for permitting of activities generating impulsive underwater noise.

Background for indicator:
MSFD descriptor 11, which mandates member states to monitor and set thresholds for impulsive noise sufficiently loud to affect the marine ecosystem. Main sources are military antisubmarine sonars, underwater explosions, impact pile driving and seismic air guns. Additional sources include seal scarers and various transmitters used for sub-bottom profiling.

It is known from empirical studies that these sources are able to affect marine mammals and fish over extensive distances, up to several tens of km from the source and thus can affect very large areas.

Aim of Indicator:
To capture the pressure on the ecosystem from the sources mentioned under “Background for indicator”. It is expressed as an assessment of the size of the exposed area, evaluated day by day.

Does the indicator match COM DEC 2017 criteria? (and which).
D11C2.

Coordination at regional level implemented through HELCOM and OSPAR.

Thresholds:
No thresholds for GES have been established. Work progressing on this issue in TG-Noise, EN-Noise and ICG-Noise. It is expected that TG-Noise will work towards proposing thresholds by the end of 2021.

Danish thresholds for damage to hearing in seals and porpoises is established, but these do not directly relate to the indicator for the COM DEC 2017 requirement, as they relate to impact on individuals and not impacts on the population/habitat. The same goes for German thresholds for emissions from impact pile driving, i.e. they do not relate directly to GES, although they may be a means to achieve GES.3

Description of challenges and reservations:
The primary challenge is missing data in the reporting from member states. The existing data in the register is known to have significant gaps, relating to difficulties in obtaining data from the permitting agencies and ultimately from the operators, which generated the impulsive sound. For Denmark the largest issue is the absence of reporting of use of military sonars. Navies are not obliged to report their activities, as they have an exemption in the MSFD text, but a trustworthy assessment cannot be made without at least some knowledge on these activities.

There are ongoing discussions on how to combine and compare different sources, i.e. how to weigh very loud sources against less loud ones and how to compare different types of sources. These discussions are important, but largely technical and do not prevent progress.

Suggestions for solutions and process forward:
It should be a high priority to secure that all countries report activities and that reporting is as complete as possible. Pragmatic solutions to the issue of military sonars must be found at levels above the expert networks.

Appraised by (name of AU advisor):
Jakob Tougaard

Qualifications of appraiser with regard to this indicator:
Senior researcher, PhD. Bioacoustician by training. More than 20 years of experi-ence with studies of effects of noise on marine organisms. Chair of HELCOM EN-Noise, member of OSPAR ICG-Noise and EU TG-Noise.

Internal scientific review by:
Line Hermansen, PhD, Section of Marine Mammal Research, BIOS, AU.

Indicator title: **Impulsive noise impacts (OSPAR)**	
HELCOM ( ) OSPAR (X)	Partially overlapping ( ) Complete overlap ()

The indicator is being developed by (name of working group/s and lead country):
ICG-Noise (OSPAR). Lead by UK (CEFAS).

Are Danish data available for the HELCOM and/or OSPAR regional seas?
Yes, reported to the ICES impulsive noise register.

Is a national (or regional) database in place?
The indicator relies on the ICES register for impulsive noise. Information about distribution of sensitive marine species must be obtained from national and international monitoring programs.

Background for indicator:
MSFD Descriptor 11, which mandates that member states shall establish GES with respect to impulsive noise. As the already established indicator (Distribution of Reported Impulsive Sounds) is a pressure indicator only, it does not allow for a genuine assessment of the impact of the sound on the ecosystem. This indicator combines the existing pressure indicator with information about species habitat range and/or abundance to create a risk indicator, better suited for assessment purposes.

Aim of Indicator:
To assess risk of impact from impulsive sources in areas and/or at times where there are many sensitive species/individuals present. This is obtained by inclusion of information about abundance or presence/absence of selected indicator species, when assessing the pressure indicator and information about sensitive time periods and/or areas.

Does the indicator match COM DEC 2017 criteria? (and which).
D11C1.

No thresholds for GES have been established. Work progressing on this issue in TG-Noise, EN-Noise and ICG-Noise.

Thresholds:
No thresholds for GES have been established. Work progressing on this issue in ICG-Noise. Parallel (and coordinated) efforts are taking place in TG-Noise and EN-Noise, with a common understanding (for the time being) that one should await the development in OSPAR.

Description of challenges and reservations:
As the indicator relies on the pressure indicator (Distribution of Reported Impulsive Sounds) all issues related to the pressure indicator applies equally to the impact indicator.

A critical requirement for the indicator is that good information is available about distribution ranges and/or abundance of the selected indicator species. Such information is currently only available for some species and often not for the entire year.

Suggestions for solutions and process forward:
Procedures for deciding what species distribution maps to use in assessments must be in place, as the outcome of assessments relies critically on this input. This work should be extended beyond the noise expert networks, as the real expertise on these questions should be found in other expert networks, such as EN-MAMA, ICES-WGMEE, ASCOBANS etc.

Appraised by (name of AU advisor):
Jakob Tougaard

Qualifications of appraiser with regard to this indicator: Senior Researcher, PhD. Bioacoustician by training. More than 20 years of experience with studies of effects of noise on marine organisms. Chair of HELCOM EN-Noise, member of OSPAR ICG-Noise and EU TG-Noise.
Internal scientific review by: Line Hermansen, PhD, Section of Marine Mammal Research, BIOS, AU

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DANISH SCIENTIFIC APPRAISAL OF HELCOM'S AND OSPAR'S INDICATORS IN RELATION TO THE MONITORING PROGRAMME UNDER THE MARINE STRATEGY FRAMEWORK DIRECTIVE

DCE has been asked by the MFVM to conduct a road map of the currently existing indicators or indicators under development. This road map will function as a status review or appraisal of each indicator and serve as an update of the DCE contribution of the 2014 road map. It was requested, that the road map should include information on background and aims, list potential problems or reservations and provide suggestions for solutions. For indicators under development, the road map should focus on potential future challenges such as lack of data and determination of threshold values. Based on the request DCE developed a road map indicator template, which was approved by the MFVM on November 22nd 2019 and it has consequently been used for the review.

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