ILVO
Instituut voor Landbouw- en Visserijonderzoek

STUDY RELATED TO THE REALIZATION OF THE WATER FRAMEWORK DIRECTIVE INTERCALIBRATION FOR THE BELGIAN COASTAL WATERS, TO DESIGN THE DESCRIPTIVE ELEMENTS 1 AND 6 OF THE MARINE STRATEGY FRAMEWORK DIRECTIVE AND THE NATURE OBJECTIVES OF THE HABITAT DIRECTIVE FOR INVERTEBRATE BOTTOM FAUNA OF SOFT SUBSTRATES

BESTEK NR. DG5/MM/WB-SVG/13013

ILVO MEDEDELING nr 170
augustus 2014

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Landbouw en Visserij

Study related to the realization of the Water Framework Directive intercalibration for the Belgian Coastal waters, to design the descriptive elements 1 and 6 of the Marine Strategy Framework Directive and the nature objectives of the Habitat Directive for invertebrate bottom fauna of soft substrates

Bestek nr. DG5/MM/WB-SVG/13013

Opdrachtgever: DE FEDERALE STAAT, VERTEGENWOORDIGD DOOR DE FEDERALE OVERHEIDSDIENST VOLKSGEZONDHEID, VEILIGHEID VAN DE VOEDSELKETEN EN LEEFMILIEU (FOD VVVL), Dienst Marien Milieu

ILVO MEDEDELING nr 170

augustus 2014

ISSN 1784-3197

Wettelijk Depot: D/2014/10.970/170

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ILVO document control

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SUMMARY

This study relates to three European directives: the Water Framework Directive (WFD) with relation to the coastal waters (<1 nautical mile), the Marine Strategy Framework Directive (MSFD) and the Habitat Directive (HR) as they relate to the marine waters of Belgium. The tasks performed in this study fulfill the requirements for the further implementation of the indicator Benthic Ecosystem Quality Index (BEQI) regarding the evaluation of the ecological/environmental status of soft-sediment benthic habitats under the three abovementioned European Marine directives.

The main goals of this study were to:

- Evaluate whether the current calculation methods of the BEQI values for the different benthic parameters need to be adapted;
- Intercalibrate the BEQI with the other benthic indicators within the Northeast Atlantic region based on the available WFD monitoring data of the Belgian Coast;
- Determine the habitat and reference aspects of the assessment protocol for application of the BEQI under the WFD, MSFD and HR.

This report contains a summary of the analyses done to answer the questions related to the abovementioned goals. Those analyses were presented to the client and to two experts (Steven Degraer, KBIN; Jan Vanaverbeke, Ghent University (UGent)) to obtain agreement about how to shape the assessment procedure for the BEQI under the three EU Directives (WFD, MSFD, HR).

BEQI design

The BEQI indicator tool was developed during a project in the Netherlands in 2007 (Van Hoey et al., 2007) and was adopted by Belgium as an indicator tool for the evaluation of benthos in soft sediment substrates for the WFD and MSFD. To evaluate if the design of the BEQI tool needed adaptation, we tested different configurations (selection of other percentile values as boundary values; weighing of parameters in the average BEQI score) of the BEQI calculations based on the WFD monitoring dataset (2007-2009). Based on the analyses, the following conclusions were made:

- Changes in the boundary class value for the good/moderate boundary by selecting other percentile values leads to minor changes in the BEQI scores for each parameter and the BEQI average.
- More obvious changes to the assessment results of the parameter species composition (similarity) could be obtained by selecting other percentile values to some boundary classes (high/good or reference).
- Weighing certain parameters by determining the BEQI average is not advisable.

Therefore, we propose only to change the boundary class determination for the parameter species composition (similarity) compared to the original design.

BEQI intercalibration

According to the WFD, the intercalibration process for benthic indicators between the different member states within a region has lasted for some time. This process has been delayed in the third phase because the intercalibration of benthic indicators in the Northeast Atlantic geographical intercalibration group (NEA-GIG) has not yet been accepted at the time of this writing. One of the obstacles in the NEA-GIG intercalibration exercise was to define the same level of impairment on the common dataset, the so-called benchmarking. In the absence of a clear work plan for phase 3, we have tested the comparability of the BEQI with some common benthic indicators on the Belgian WFD coastal monitoring data according to the intercalibration guidance. To overcome the benchmarking problem, we have used a local reference value for each indicator extracted from the same ‘reference’ dataset and defined based on similar criteria.

The intercalibration test on the WFD monitoring data in the Belgian Coast revealed no harmonised results. Methods including different parameters (BEQI and BQI) or a different algorithm (BEQI) show a low comparability compared to methods constructed with rather similar parameters (AMBI, number of species and diversity index).

Reference dataset for WFD, MSFD and HR

An appropriate choice of a reference is a necessary step in the assessment procedure for assessing the ecological quality of an ecosystem component (Van Hoey et al., 2013). Additionally, the benthic samples (reference and assessment) need to be correctly assigned to a certain habitat type to avoid the comparison of proverbial apples and oranges during the assessment. This chapter presents an investigation of both aspects (reference, habitat type) in function of the WFD, MSFD and HR.

Data availability

For soft sediment benthic habitats (benthos) within the Belgian Part of the North Sea (BPNS), data were collected in 1977 - 2012 by two institutes (Marine Biology group of Ghent University [Marbiol] and the Bio-environmental Research group of the Institute of Agricultural and Fisheries Research (ILVO) [Biomon]). The databases were merged and an intensive quality control was done (taxonomic discrepancies, sample validation). A protocol was outlined for selecting and standardizing the taxon list for the assessment of soft-sediment benthic habitats under the three Directives (Annex 1 and 2). The history of sampling in the BPNS was described, to improve selection of the reference conditions. The sampling intensity increased over the last 35 years, and the best spatial coverage for most habitats is seen in the last 10 years.

The merged dataset (Marbiol-Biomon) contains 8447 benthic samples (Van Veen grabs) with 102274 taxon records. This dataset was used within this project to determine the mean individual biomass of each taxon and to explore the applicability of the data for reference selection.

Mean individual biomass

The BEQI parameter biomass was left out for most applications, owing to the absence of consistent biomass data within the available datasets. However, we calculated mean individual biomass values for each taxon and used those values to calculate the biomass values when they were missing in the dataset. Based on the Marbiol-Biomon database, the mean individual ash free dry weight and wet weight was determined for most benthic taxa in the soft sediments in the BPNS.

Habitat approach

Two major approaches to assign benthic samples to a certain habitat type were tested: (1) a regular multivariate community analysis based on an abundance species dataset (Biological model approach), complemented with physical data (e.g. sedimentology, depth) and (2) plotting reference and assessment samples on a habitat suitability map (Habitat suitability model approach) (Van Hoey et al., 2013). Both habitat approaches seemed to be appropriate in the case of the habitat classification on the BPNS scale, especially because of the data availability and the good spatial coverage. But neither of them were ideal (Van Hoey et al., 2013). Based on this study, the best approach to catalogue the reference and assessment samples for the three EU Directives was the one based on the sedimentological information per sample and on a discriminant function analysis of the habitat suitability model (Degraer et al., 2008). The protocol used in Degraer et al. (2008) needs to be executed to make the final catalogue of the samples to each habitat type for the samples used in the EU Directive assessment of soft-sediment substrates.

For the assessment of the ecological/environmental status of soft-sediment substrates in the BPNS, we decided to determine the status of the three main benthic habitats: (1) *Macoma balthica* habitat: muddy substrate (EUNIS: sandy mud to mud); (2) *Abra alba* habitat: fine muddy sand (EUNIS: muddy sands to sands); (3) *Ophelia borealis* habitat: medium to coarse sand (EUNIS: coarse grained sediments). The *Nephtys cirrosa* habitat was not assessed because it shows a high overlap in characteristics with the three other habitat types.

Reference approach

In the case of the WFD, a reference dataset is ideally a dataset from an area under pristine conditions (undisturbed). Centuries of human activity in this region make such data impossible to find. However, the MSFD strives for a good environmental status, corresponding with a status under sustainable human activities. Hence, Belgium will use the concept of the MSFD to define the ecological characteristics for the marine habitats under “sustainable” conditions as reference setting. According to Van Hoey et al. (2013), the selection of an appropriate benthic reference dataset should be based on benthic data with a good spatial and temporal coverage. However, data of the most intensively used areas should be avoided. In combination with best professional judgment, this should lead to a confident, scientifically based identification of reference values for soft-sediment benthic habitats.

We thus selected the most appropriate data for each benthic habitat of the BPNS as reference for the three EU Directives based on the following selection criteria:

- The data must be collected in the period 1994-2012 on the BPNS.
- No geographical sub-datasets for certain habitats or in the light of certain Directives needs to be defined.
- Data collected in areas where a certain human activity (dredge disposal, sand extraction, wind-farm construction) can disturb the natural variability of the benthic characteristics were excluded.
- To have a good temporal and spatial coverage of samples within the reference dataset, we tried to have a balanced sampling (similar number of samples) over the years and within the areas of the BPNS.

The dataset that meets these criteria will be a good dataset that reflects the temporal and spatial characteristics of our soft-sediment bottom fauna under relatively good conditions.

SAMENVATTING

Deze studie past binnen de verplichtingen die uit drie Europese richtlijnen voortvloeien: de Kaderrichtlijn Water (KRW) met betrekking tot de kustwateren (<1 nautische mijl), de Kaderrichtlijn Mariene Strategie (KRM) en de Habitatrichtlijn (HR) met betrekking tot de mariene wateren van België. Deze studie groepeert bepaalde taken die vervuld dienen te worden met betrekking tot de verdere implementatie van de indicator Benthic Ecosystem Quality Index (BEQI) voor de evaluatie van de milieu toestand van de zachte substraten onder de drie Europese Marine richtlijnen. De belangrijkste doelstellingen van dit onderzoek waren:

- Het evalueren of de huidige berekeningsmethoden van de BEQI waarden voor de verschillende benthische parameters moeten worden aangepast
- Het intercalibreren van de BEQI met de andere benthische indicatoren binnen de Noord-Oost Atlantische regio op basis van de beschikbare KRW monitoringsdata van de Belgische kust.
- Het bepalen van de habitat en referentie aspecten van het beoordelingskader voor de toepassing van de BEQI onder de KRW, KRM en HR .

In dit rapport wordt een samenvatting gegeven van de analyses gedaan om vragen met betrekking tot de bovengenoemde doelstellingen te beantwoorden. Die analyses werden gepresenteerd aan de opdrachtgever en een aantal deskundigen (Steven Degraer , KBIN , Jan Vanaverbeke, UGent) om zodanig een aantal afspraken te maken in de manier van het invullen van het beoordelingskader voor de BEQI onder de drie EU-richtlijnen (KRW , KRM , HR).

BEQI design

De BEQI indicator werd ontwikkeld tijdens een project in Nederland in 2007 (Van Hoey et al., 2007) en werd door België aangenomen als indicator voor de evaluatie van de bodemdieren in zacht substraten voor de KRW en KRM. Om te evalueren of de configuratie van de BEQI indicator dient verandert te worden, hebben we verschillende configuraties (de selectie van andere percentiel waarden voor de grenswaarden; weging van de parameters bij het bepalen van de gemiddelde BEQI score) van het BEQI algoritme getest op basis van de KRW monitoring dataset (2007-2009). Op basis van de analyses konden volgende conclusie genomen worden:

- Veranderingen in de grens klasse waarde voor de goede/matige grens door het selecteren van andere percentielwaarden leidt tot kleine veranderingen in de BEQI scores voor elke parameter en het BEQI gemiddelde.
- Duidelijkere veranderingen in de beoordelingsresultaten van de parameter soortensamenstelling (similarity) kon worden verkregen door het selecteren van andere percentielwaarden voor sommige grens klassen (hoog/goed of referentie) .
- Weging van bepaalde parameters bij het bepalen van het BEQI gemiddelde wordt afgeraden.

Daarom stellen wij voor alleen de grens klasse bepaling voor de parameter soortensamenstelling (similarity) te wijzigen ten opzichte van het oorspronkelijke algoritme.

BEQI intercalibratie

Het KRW intercalibratieproces voor benthische indicatoren tussen de verschillende lidstaten binnen een regio is al voor een tijdje aan de gang. Dit proces wordt opgehouden in de 3^de^ fase, te wijten aan het feit dat de onderlinge intercalibratie van de benthische indicatoren in de Noordoost-Atlantische geografische intercalibratiegroep (NE -GIG) nog niet werd geaccepteerd. Eén van de obstakels in de NEA-GIG intercalibratie was om hetzelfde niveau van ‘referentie’ binnen de gemeenschappelijke dataset, de zogenaamde benchmarking, te definiëren. Doordat het werkplan voor fase 3 nog niet duidelijk is, testten we binnen dit project de vergelijkbaarheid van de BEQI met een aantal algemen benthische indicatoren op de Belgische KRW monitoringgegevens, volgens de intercalibratie richtlijn. Om de benchmarking te overwinnen, hebben we voor elke indicator een lokale referentie waarde gebruikt, welke bepaald werd uit dezelfde 'referentie' dataset en gedefinieerd op vergelijkbare criteria.
De intercalibratie test op de KRW monitoringgegevens van de Belgische Kust onthult geen geharmoniseerde resultaten. Methoden welke verschillende parameters (BEQI en BQI) of een ander algoritme (BEQI) bevatten, tonen een lagere vergelijkbaarheid, in vergelijking met methoden gebouwd uit min of meer dezelfde parameters (AMBI, aantal soorten en diversiteit index).

Referentie dataset voor KRW, KRM en HR

Een juiste keuze van een referentie is een noodzakelijke stap in de beoordelingsprocedure voor het bepalen van de ecologische kwaliteit van een ecosysteem component (Van Hoey et al., 2013). Daarnaast, dienen de benthische stalen (referentie en evaluatie) correct toegewezen te worden aan een bepaald habitattype om een vergelijking tussen appels en peren in de beoordelingen te vermijden. In dit hoofdstuk zullen beide aspecten worden onderzocht in functie van de KRW, KRM en HR.

Beschikbaarheid van gegevens

Voor de zachte substraten (benthos) binnen het Belgische deel van de Noordzee (BDNZ), werden gegevens verzameld in 1977-2012 door twee instituten (Mariene Biologie groep van de Universiteit Gent [MARBIOL] en de Biologische milieugroep van het Instituut voor Landbouw- en Visserijonderzoek [BIOMON]). Databases werden samengevoegd en een intensieve kwaliteitscontrole werd gedaan (taxonomische verschillen, stalen validatie) . Een protocol werd geschetst voor het selecteren en het standaardiseren van de taxon lijst voor de beoordeling van de zachte substraten onder de drie richtlijnen (bijlage 1 en 2). De geschiedenis van de bemonstering in het BDNZ werd beschreven, omdat dit waardevolle informatie is voor het selecteren van de referentie. De bemonstering intensiteit nam in de afgelopen 35 jaar toe, en de beste ruimtelijke dekking voor de meeste habitats werd bereikt in de afgelopen 10 jaar. De samengevoegde dataset (MARBIOL - BIOMON) bevat 8447 benthische stalen (Van Veen grijper) met 102.274 taxon records. Deze dataset werd binnen dit project gebruikt om de gemiddelde individuele biomassa van elk taxon te bepalen en de toepasbaarheid van de gegevens te onderzoeken voor de referentie selectie.

Gemiddelde Individuele biomassa

De BEQI parameter biomassa werd weggelaten voor de meeste toepassingen, door het ontbreken van consistente biomassa gegevens binnen de beschikbare datasets. Omdat het een waardevolle parameter is, berekende we de gemiddelde individuele biomassa waarde voor elk taxon en gebruikt deze waarde om de biomassa te berekenen wanneer ze ontbrak in de dataset. Op basis van de MARBIOL - BIOMON databank, werd het gemiddelde individuele as vrij drooggewicht en nat gewicht bepaald voor de meeste benthische taxa in de zachte sedimenten op het BDNZ.

Habitat approach

Twee belangrijke benaderingen om benthische stalen toe te wijzen aan een bepaald habitattype werden getest: (1) de klassieke multivariate gemeenschapsanalyse op basis van een densiteit-soort dataset (Biological model aanpak), aangevuld met fysische gegevens (bv. sedimentologie, diepte) en (2) het plotten van referentie en evaluatie stalen op een habitatgeschiktheidsmodel kaart (Habitat geschiktheid model benadering) (Van Hoey et al., 2013). Beide habitat benaderingen leek passend zijn in het geval van het bepalen van de habitat indeling op BDNZ schaal, vooral als gevolg van de beschikbaarheid van gegevens en de goede ruimtelijke dekking, maar geen van hen waren ideaal (Van Hoey et al., 2013). Op basis van deze studie hebben we besloten dat de beste benadering voor het catalogeren van de referentie en evaluatie stalen voor de drie EU-richtlijnen tot een bepaald habitat is om gebruik te maken van de sedimentologische informatie per staal en op de discriminant functie analyse van het habitatgeschiktsheidsmodel (Degraer et al., 2008). Het protocol van in Degraer et al. (2008) moet worden uitgevoerd om de definitieve lijst van de stalen voor elk habitattype te maken voor de stalen gebruikt in de EU-richtlijn beoordeling voor zachte substraten. Voor de beoordeling van de milieutoestand van zachte substraten op het BDNZ, hebben we besloten om de status van de drie belangrijkste benthische habitats te bepalen: (1) *Macoma balthica* habitat: slib (EUNIS: zanderig slib tot slib); (2) *Abra alba* habitat: fijn slibrijk zand (EUNIS: slibrijk zand tot zand); (3) *Ophelia borealis* habitat: medium tot grof zand (EUNIS: grof zanderig sedimente). Het *Nephtys cirrosa* habitat wordt niet beoordeeld omdat het een hoge overlap in kenmerken met de drie andere habitattypen vertoont.

Referentie approach

In het geval van de KRW, een referentie dataset is bij uitstek een dataset uit een gebied in pristine omstandigheden (onverstoorde staat). Deze gegevens bestaan niet in onze regio, omdat een hoge intensiteit van menselijke activiteiten in onze wateren al eeuwen aanwezig is. Echter, de KRM streeft naar een goede milieutoestand, wat overeenkomt met een status die bereikt wordt bij een duurzame uitvoering van de menselijke activiteiten. Daarom zal België het concept van de KRM gebruiken om de ecologische kenmerken van de mariene habitats onder 'duurzaam' voorwaarden als de referentie te definiëren. Volgens Van Hoey et al. (2013), moet de keuze van een geschikt benthische referentie dataset worden gebaseerd op gegevens met een goede ruimtelijke en temporele dekking. Echter, gegevens verzameld in gebieden onderworpen aan intensieve menselijke activiteit dien te worden vermeden. In combinatie met beste professionele oordeel, moet dit leiden tot een betrouwbare, wetenschappelijk gebaseerde identificatie van referentiewaarden voor zachte substraat habitats.
Dus hebben we de meest geschikte referentie gegevens voor elk benthische habitat van het BDNZ voor de drie EU-richtlijnen gekozen op basis van volgende selectiecriteria:

- De gegevens moesten verzameld zijn in de periode 1994-2012 op het BDNZ.
- Geen geografische sub-datasets voor bepaalde habitats of in het licht van bepaalde richtlijnen moet worden gedefinieerd.
- Gegevens verzameld in gebieden waar een bepaalde menselijke activiteit (baggerstort, zandwinning, windmolenparken) de natuurlijke variabiliteit van de benthische kenmerken kan verstoren worden uitgesloten.
- Om een goede temporele en ruimtelijke dekking van de stalen binnen de referentie dataset te hebben, probeerden we om een evenwichtige steekproef (vergelijkbaar aantal stalen) over de jaren en binnen de gebieden op het BDNZ te hebben.

De dataset die aan deze criteria voldoet zal een goede dataset zijn dat de temporele en ruimtelijke karakteristieken van onze zacht substraat bodemfauna onder relatief goede omstandigheden weerspiegelt.

RESUME

Cette étude s'inscrit dans le cadre des obligations provenant de trois directives européennes : la directive-cadre sur l'eau (DCE) en relation avec les eaux côtières (< 1 mille nautique), la directive cadre stratégie pour le milieu marin (DCSMM) et la directive Habitat (DH) concernant les eaux marines belges. Cette d'étude regroupe certaines tâches à remplir pour garantir la continuité de la mise-en-oeuvre de l'indicateur « Indice de qualité des écosystèmes benthiques » (BEQI) pour l'évaluation de l'état écologique/environnemental des habitats benthiques dans les sédiments mous dans le cadre des trois directives marines européennes.
Les principaux objectifs de l'étude étaient:

- Évaluer si les méthodes de calcul actuelles des valeurs BEQI pour les différents paramètres benthiques doivent être adaptées

- Intercalibrage de l’indicateur BEQI avec les autres indicateurs benthiques utilisés dans la région de l'Atlantique du Nord-Est sur base des données de surveillance DCE disponibles pour la côte belge.
- Déterminer les critères des habitats et des références du protocole d'évaluation pour l'application du BEQI dans le cadre de la DCE, DCSMM et DH.

Dans ce rapport, nous résumons les analyses effectuées pour répondre aux questions relatives aux objectifs mentionnés ci-dessus. Ces analyses ont été présentées au client et à certains experts (Steven Degraer, IRBSN; Jan Vanaverbeke, UGent) pour aboutir à un accord dans la façon d’effectuer la procédure d'évaluation du BEQI dans le cadre des trois directives européennes (DCE, DCSMM, DH).

Conception BEQI

L’indicateur BEQI a été développé durant un projet aux Pays-Bas en 2007 (Van Hoey et al, 2007) et a été adopté par la Belgique comme indicateur pour l’évaluation du benthos dans les substrats à sédiment mou pour le DCE et le DCSMM. Pour évaluer si la conception de l’outil BEQI doit être adaptée, nous avons testé différentes configurations (sélection d’autres valeurs percentile comme valeurs limites, pesée des différents paramètres dans le score moyen BEQI) des calculs BEQI avec les données (2007-2009) provenant du programme de surveillance WFD. Ces analyses ont menées aux conclusions suivantes :

- Varier la valeur limite de classe pour la limite « bien/modéré » en sélectionnant d'autres valeurs de percentile conduit à des changements mineurs dans les scores BEQI pour chaque paramètre et pour la moyenne BEQI.
- Des changements plus manifestes dans les résultats du paramètre « composition des espèces » (similitude) ont été obtenus en sélectionnant d'autres valeurs de percentile pour certaines classes (« haut/bien » ou référence).
- Il n’est pas conseillé de peser certains paramètres en déterminant la moyenne du BEQI.

Par conséquent, nous proposons de simplement changer la détermination de la valeur limite pour le paramètre «composition des espèces » (similarité) par rapport à la conception originale.

BEQI intercalibration

Suivant la DCE, le processus d’intercalibration des indicateurs benthiques entre les différents Etats Membres dans une certaine région a débuté il y a un certain temps. Ce processus se trouve momentanément à l’arrêt dans sa troisième phase, parce qu’il n’y a pas encore d’accord sur l'inter-calibration des indicateurs benthiques au sein du Groupe d’intercalibration de la zone géographique du Nord-Est de l’Atlantique (NEA-GIG). L'un des obstacles à l’exercice d’intercalibration du NEA-GIG a été de définir le même niveau de référence sur l'ensemble des données communes, c’est-à-dire l'analyse comparative. Vu que le plan de travail pour la phase 3 n'a pas encore été élaboré, nous avons comparé le BEQI avec certains indicateurs benthiques communs sur base des données de surveillance WFD belges des zones côtières, suivant les directives d’inter-calibration. Pour surmonter l’obstacle de l'analyse comparative, nous avons utilisé une valeur de référence locale pour chaque indicateur. Cette valeur a été extraite du même ensemble de données de ‘référence’ et définie selon des critères similaires.
Le test d’intercalibration des données de surveillance de la DCE sur la côte belge ne révèle aucun résultat harmonisé. Les méthodes, qui comprennent des paramètres différents (BEQI et BQI) ou un algorithme différent (BEQI) montrent une faible comparabilité par rapport aux méthodes construites avec des paramètres relativement similaires (AMBI, nombre d'espèces et indice de diversité).

Base de données de référence pour la DCE, DCSMM et DH

Une étape nécessaire dans la procédure d'évaluation de la qualité écologique d'un élément de l'écosystème est le choix d’une référence appropriée (Van Hoey et al., 2013). En outre, les échantillons benthiques (de référence et d'évaluation) doivent être correctement attribués à un certain type d'habitat pour éviter de comparer des pommes et des poires lors de l'évaluation. Dans ce chapitre, les deux aspects seront étudiés en fonction de la DCE, DCSMM et DH.

La disponibilité des données

Pour les habitats à sédiment mou (benthos) dans la partie belge de la mer du Nord (PBMN), les données ont été recueillies en 1977-2012 par deux instituts (groupe de biologie marine de l'Université de Gand [Marbiol] et le groupe de recherche Bio-environnementale de l'Institut de Recherche Agricole et de la Pêche [BioMon]). Les bases de données ont été fusionnées et un contrôle intensif de qualité a été fait (divergences taxonomiques, validation des échantillons). Un protocole a été décrit pour la sélection et la standardisation de la liste des taxons pour l'évaluation des habitats benthiques à sédiments mous dans les trois directives (annexe 1 et 2). L'histoire de l'échantillonnage dans la PBMN a été décrit, car il s'agit d'informations précieuses pour le choix des conditions des références. L'intensité d'échantillonnage a augmenté au cours des 35 dernières années, et la meilleure couverture spatiale pour la plupart des habitats a été réalisée durant les 10 dernières années.

L'ensemble de données fusionné (Marbiol - BioMon) contient 8447 échantillons benthiques (benne preneuse «Van Veen ») avec 102 274 entrées de taxons. Cette base de données a été utilisée dans ce projet pour déterminer la biomasse individuelle moyenne de chaque taxon et d'explorer l'applicabilité des données pour la sélection des références.

Biomasse individuelle moyenne

Le paramètre BEQI biomasse a été exclu pour la plupart des applications, en raison de l'absence de données cohérentes sur la biomasse au sein de l'ensemble des données disponibles. Cependant, puisqu'il s'agit d'un paramètre important, nous avons calculé les valeurs moyennes de la biomasse individuelle pour chaque taxon et nous avons utilisé ces valeurs pour calculer les valeurs de biomasse qui étaient absents dans la base de données. Sur base des données Marbiol-BioMon, la moyenne individuelle pour le poids sec sans cendres et le poids humide a été déterminée pour la plupart des taxons benthiques dans les sédiments mous sur la PBMN.

Approche d'habitat

Deux approches importantes ont été testées pour attribuer les échantillons benthiques à un certain type d'habitat: (1) l'analyse multivariée régulière de la communauté basée sur un ensemble de données sur l'abondance des espèces (approche de modèle biologique), complétée par des données physiques (par exemple la sédimentologie et la profondeur) et (2) le dessin des échantillons de référence et d'évaluation sur une carte d'aptitude de l'habitat (approche dite du modèle d'aptitude de l'habitat) (Van Hoey et al., 2013). Les deux approches d'habitat semblent être appropriées dans le cas de la classification de l'habitat à l'échelle du PBMN, notamment en raison de la disponibilité des données et la bonne couverture spatiale, mais aucune des deux n'était vraiment idéale (Van Hoey et al., 2013). Sur base de cette étude, nous avons décidé que la meilleure approche pour cataloguer les échantillons de référence et d'évaluation pour les trois directives européennes, est l'approche basée sur l'information sédimentologique pour chaque échantillon et sur l'analyse de fonction discriminante du modèle d'aptitude de l'habitat (Degraer et al., 2008). Le protocole utilisé par Degraer et al. (2008) doit être exécuté pour cataloguer les échantillons dans chaque type d'habitat pour les échantillons utilisés dans l'évaluation de la directive de l'UE sur les substrats à sédiment mou.

Pour l'évaluation de l'état écologique/environnemental des substrats à sédiment mou sur la PBMN, nous avons décidé de déterminer l'état des trois principaux habitats benthiques: (1) l'habitat *Macoma balthica*: substrat vaseux (EUNIS: de boue sableuse à boue); (2) l'habitat *Abra alba*: sable fin vaseux (EUNIS: de sables vaseux à sable);(3) Habitat *Ophelia borealis*: de sable moyen à gros grains (sable EUNIS: de sédiments à gros grains). L'habitat *Nephtys cirrosa* n'a pas été évalué, car il montre un chevauchement important des caractéristiques des trois autres types d'habitats.

Approche de référence

Dans le cas de la DCE, un ensemble de données de référence est idéalement construit à partir d'une zone où les conditions sont parfaites (conditions non perturbées). Ce genre de données n'existe pas dans notre région, car de nombreuses activités humaines ont eu lieu dans nos eaux depuis des siècles. Cependant, la DCSMM aspire à un bon état écologique, correspondant à un état en vertu d'activités humaines durables. Ainsi, la Belgique utilisera le concept de la DCSMM pour définir les caractéristiques écologiques pour les habitats marins dans des conditions «durables» comme cadre de référence. Selon Van Hoey et al. (2013), la sélection d'un ensemble de données de référence benthique doit être basée sur des données benthiques qui représentent une bonne couverture spatiale et temporelle. Toutefois, les données des zones les plus intensément exploités doivent être évitées. En combinaison avec le meilleur jugement professionnel, cela devrait conduire à une identification fondée des valeurs de référence pour les habitats benthiques à sédiments mous.

Ainsi, nous avons sélectionné les données les plus appropriées pour chaque habitat benthique de la PBMN qui pourront servir de référence pour les trois directives de l'UE sur base des critères de sélection suivants:

- Les données doivent être collectées dans la période 1994-2012 sur la PBMN.
- Il n'y a pas de nécessité de définir des sous-ensembles de données géographiques pour certains habitats ou pour certaines Directives
- Les données collectées dans les zones où une certaine activité humaine (décharge de matériel de dragage, extraction de sable, construction d'éoliennes) peut perturber la variabilité naturelle des caractéristiques benthiques ont été exclues.
- Pour avoir une bonne couverture spatiale et temporelle des échantillons dans la base de données de référence, nous avons essayé d'avoir un échantillonnage équilibré (nombre similaire d'échantillons) au fil des ans et dans les différentes zones de la PBMN.

La base de données qui répond à ces critères sera une bonne base de données qui reflète les caractéristiques spatiales et temporelles de notre faune benthique sur sédiment mou sous des conditions relativement bonnes.

1 Introduction

This study relates to the obligations stated in three European Directives: the Water Framework Directive (WFD) with relation to the coastal waters (<1 nautical mile from the coastline), the Marine Strategy Framework Directive (MSFD) and the Habitat Directive (HR) with relation to the marine waters of Belgium. All three Directives require an evaluation of the ecological (WFD) or environmental (MSFD) quality of the marine invertebrate bottom fauna (benthos). For the WFD, this fauna is included as the biological quality element 'invertebrate bottom fauna'. By 2015, this quality element must be monitored and determined to have reached a good ecological status. The Belgian government decided to evaluate the ecological status of invertebrate bottom fauna using the benthic indicator BEQI (Benthic Ecosystem Quality Index, www.beqi.eu). One aim of the MSFD is to reach good environmental status of the marine waters of the EU in 2020. This status needs to be evaluated based on indicators defined for eleven descriptors. For the MSFD, the invertebrate bottom fauna is part of descriptor 1 (Biodiversity) and 6 (Seafloor integrity), and the BEQI was chosen as one of the indicators (*Belgische staat*, 2012). Under the HR, the conservation objectives for habitat 1110 (sandbanks slightly covered by sea water all the time) must be evaluated. The BEQI will be proposed as one of the indicators for that as well.

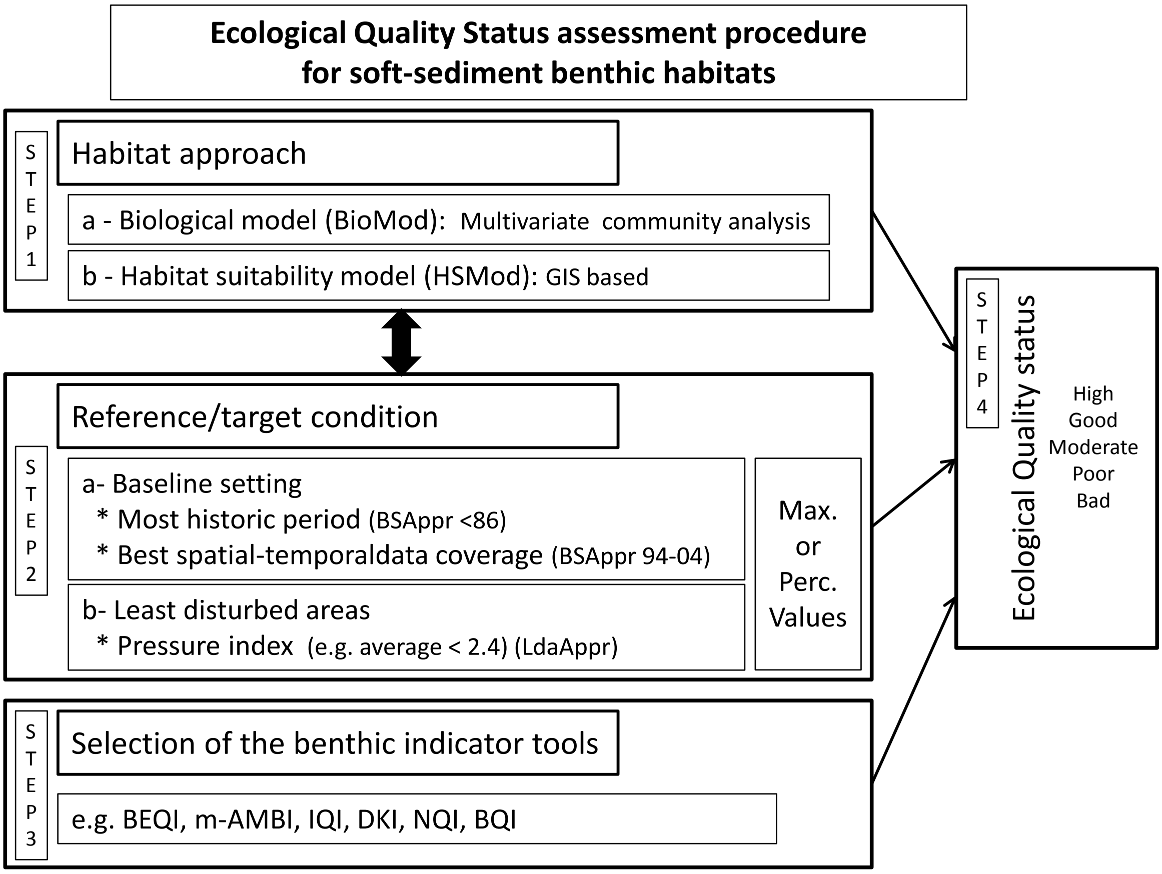

Figure 1. Flow chart of the ecological/environmental quality status assessment procedure for soft-sediment benthic habitats and their relationships.

The BEQI is a benthic indicator tool. It was initially developed to assess the ecological status of benthic habitats in various water systems in function of the WFD (Van Hoey et al., 2007). The goal of the indicator is to assess the difference in four benthic characteristics (number of species, species composition, density and biomass) between an assessment and a reference dataset. This differs from regular benthic indicators in that these four parameters are calculated and evaluated per habitat within a water system, instead of per sample within a water system. The applicability of this

indicator is wider than the scope of the WFD and can be used to assess impacts of human activities (Van Hoey et al, 2012; Coates et al., 2013) and as indicator for the MSFD (Van Hoey et al., 2013).
To assess the ecological (WFD) or environmental (MSFD) status of soft-sediment benthic habitats, the following aspects must be considered: (1) habitat assignation of the samples (habitat approach), (2) reference or target conditions for the benthic parameters (reference approach), and (3) the selection of indicator tools to assess the relative quality status (indicator approach) (Van Hoey et al., 2013) (Figure 1). It is possible to use the same assessment procedure for all three of the abovementioned European Directives. Therefore, it is appropriate to determine and record the required details of this assessment procedure for the evaluation of soft-sediment benthic habitats in the BPNS and to apply it for all three Directives. For the WFD, such an assessment protocol has been more or less defined (Van Hoey et al., 2008, 2009, 2010), but it needs to be optimised for application under the MSFD and HR. These directives apply to a much larger area within the BPNS than the WFD – the WFD only applies to the 1 nautical mile zone. Furthermore, the WFD requires the existing methodologies within a region (the Northeast Atlantic for Belgium) to be intercalibrated to illustrate the level of agreement between nations. Unfortunately, for the WFD, the intercalibration in the Northeast Atlantic still needs to be finalised for benthos in coastal and transitional waters (see Annex 2 in Commission Decision 2013/480/EU).

For Belgium, the Department of the Marine Environment is responsible for coordinating and organizing the national implementation of those three EU directives (WFD, MSFD and HR). In the present study, a number of tasks were done to support further implementation of the indicator 'Benthic Ecosystem Quality Index (BEQI)' for evaluation of the ecological/environmental status of soft-sediment benthic habitats under the three European Marine Directives.

The main goals of this study were to:

- Evaluate whether the current calculation methods of the BEQI values for the different benthic parameters need to be adapted
- Intercalibrate the BEQI with the other benthic indicators within the Northeast Atlantic region based on the available WFD monitoring data for the Belgian Coast.
- Determining the habitat and reference aspects of the assessment protocol for applying the BEQI under the WFD, MSFD and HR.

This report contains a summary of the analyses done to answer the questions related to the abovementioned goals. Those analyses were presented to the client and to two experts (Steven Degraer, KBIN; Jan Vanaverbeke, Ghent University (UGent)) to obtain agreement about how to give shape to the assessment procedure for the BEQI under the three EU Directives (WFD, MSFD, HR). The resulting agreements are outlined in the conclusion section of each chapter. This study will also deliver the reference datasets for the benthic habitats on the BPNS based on those agreements, which are needed to assess the status of the soft-sediment benthic habitats at regular time intervals under each Directive.

2 BEQI design

The BEQI indicator tool was developed in 2007 (Van Hoey et al., 2007). Belgium adopted the BEQI as an indicator tool for the evaluation of benthos in soft sediment substrates for the WFD and MSFD (*Belgische staat*, 2012). The concept of the indicator (level 3) is outlined in box 1. This tool is now used when evaluating the status of benthos within the 1 nautical mile in function of the WFD, based on the monitoring data collected in the period 2007-2009 (Van Hoey et al., 2008, 2009, 2010). Several points of potential improvement were identified as a result of these evaluations, the intercalibration activities in phase I and II, and the experience gained while using the BEQI for other purposes (e.g. dredge disposal evaluation [Van Hoey et al., 2012] and impact evaluation of wind farms [Coates et al., 2013]). Points to consider:

1) The Bray-Curtis similarity index, which is a measure for the evaluation of the species composition, is not sensitive enough. This parameter usually scored “moderate” in various assessments. The researchers thus intuit that the probability curve for similarity after randomisation is too narrow and therefore the demands for falling above the good/moderate boundary is too high.
2) The biomass parameter could not be assessed in most assessments due to the lack of consistent biomass measurements for the reference data. Therefore, it is advisable to work in the future with a proxy (average individual biomass per taxon) for records lacking biomass values in the reference data (see chapter 5.2 below).
3) Meetings with benthic experts included discussion of the possible high correlation between density and biomass. Incorporating both parameters in the ecological evaluation would be useful because biomass tells something about food availability and productivity of the system. Those parameters do not need to have the same weight as the others in the assessment, however.

This chapter presents testing of different configurations of the BEQI calculations based on the WFD dataset (2007-2009). The aim was to optimise the design of the BEQI tool. First, we tested the influence of the selection of different percentile values out of the randomisation distribution for the different boundary classes (bad, poor, moderate, good and high) on the BEQI scores (per parameter and for the average). Second, we tested the influence of the weighing of the parameters during the calculation of the average BEQI score. Based on these analyses, we propose a final design for the BEQI tool.

Box 1: Benthic Ecosystem Quality Index (BEQI)

BEQI analyses and evaluates the benthic macrofauna community per habitat. The term habitat is defined by the user, but should essentially be an ecologically distinct landscape feature within a water system (Van Hoey et al., 2004; Van Hoey et al., 2007).

BEQI calculation - The BEQI level 3 uses four biological parameters: number of species, total density (ind.m-2), total biomass (g AFDW.m-2), and similarity (Bray-Curtis similarity based on 4th root transformed density data). The similarity index compares the assessed species composition (species and their densities) with a reference species composition. Each parameter provides information about the structure and functioning of the benthic community. The BEQI evaluates the benthic community at the level of a habitat or ecotope, rather than the evaluation of a single sample. This requires a certain number of reference and assessment samples and a minimum sampling area per habitat. This approach allows for the incorporation of natural variability (spatial and temporal). The BEQI takes into account the total sampling surface within a certain habitat, as the parameter results will strongly depend on the sediment surface sampled. Therefore, the expected reference values for the BEQI parameters are calculated per habitat from permutations executed over increased sampling surfaces. An algorithm was used that computed rarefaction curves using a random resampling procedure with replacement (i.e. bootstrapping, using 2000 random samples**).** This allows to estimate, for any given sampling surface, the reference value that can be expected. Then this value can be compared with a similar sampling surface used to evaluate the current ecological status. For the parameters ‘number of species’ and ‘similarity’, a one-sided evaluation approach (only values lower than the reference are evaluated in the high-bad gradient) is used, whereas for the parameters density and biomass a two-sided evaluation approach (values lower or higher than the reference are evaluated in the high-bad gradient) is used (Figure 2). Additionally, the BEQI produces a list of species that are responsible for observed deviations from the reference state (a list of species which contributes mostly to the dissimilarity between reference and assessment: SIMPER analysis). This gives additional insight into how the current state has changed. This is done for the parameters ‘density’, ‘biomass’ and ‘similarity’.

Ecological quality status classes – For each parameter, reference values were determined for each ecological status class boundary of the WFD: high (1 - 0.8), good (0.6-0.8), moderate (0.4-0.6), poor (0.2-0.4), bad (0 - 0.2). At level 3, the reference value of the good/moderate boundary is determined based on the 5th percentile (number of species, similarity) or on the 2.5th and 97.5th percentile (density, biomass) out of the permutation distribution of each parameter (Figure 2). The moderate/poor and poor/bad reference values were determined by equal scaling (respectively 2/3 and 1/3 of the good/moderate reference value), whereas the median value (number of species, similarity) or the 25th and 75th percentile (density, biomass) out of the permutation distribution was used as the reference value of the high/good boundary.

Overall BEQI score – For the WFD, the different parameter assessments of the BEQI need to be summarised and integrated into one overall Ecological Quality ratio (EQR) and ecological status class. In the BEQI method priority is given to both transparency and simplicity. Each step of the integration remains visible and interpretable. The overall EQR value of a habitat or water system is obtained by averaging. Within level 3, first the habitat is evaluated based on the average outcome of the four biological parameters, after which the outcomes of the different habitats are averaged to get an average estimate at level 3.

The BEQI index can be calculated with a web-application tool, developed by the Flanders Marine Institute VLIZ (http://www.beqi.eu).

2.1 Test of other percentile boundaries

2.1.1 Design

In first instance, we examined the effect of the selection of other percentile boundaries for the 5 boundary classes (reference [1], good/high[0.8], moderate/good[0.6], poor/moderate[0.4], bad/poor[0.2]) on the BEQI outcome. The reference values for each boundary class is determined based on permutations executed over increased sampling surfaces. An algorithm was used that computed rarefaction curves using a random resampling procedure with replacement (i.e. bootstrapping, using 2000 random samples). From these rarefaction curves, a set of percentile values (1; 2.5; 5; 10; 25; 50; 75; 90; 95; 97.5; 99 percentiles) per sampling surface were determined, which were used as boundary class values (Figure 2).

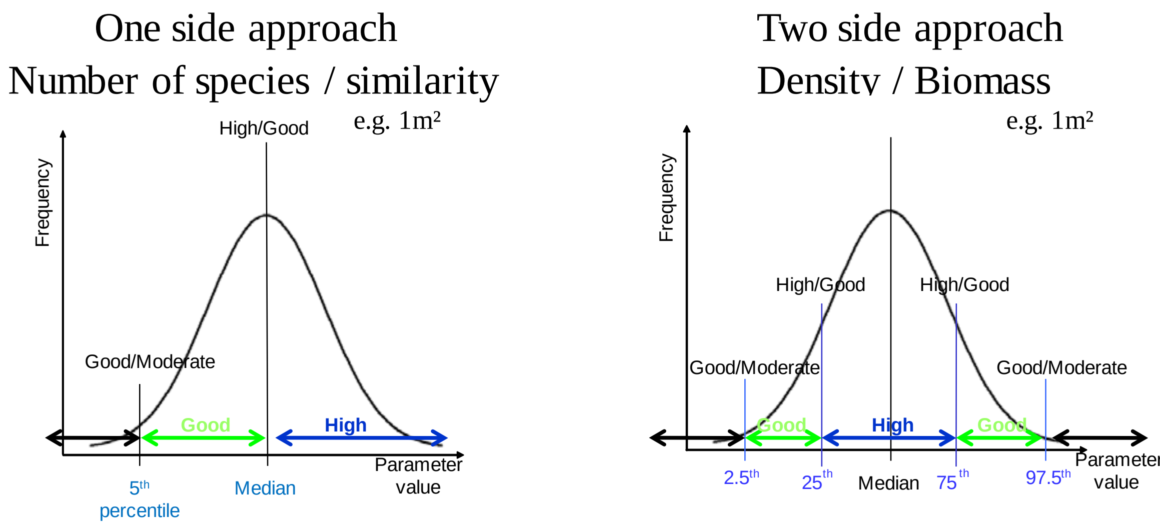

Figure 2. Overview of the determination of the reference values per boundary class

The current configuration of the BEQI includes (Figure 2, Figure 3):

- Number of species / species composition: One side evaluation, 5th percentile as boundary between good and moderate. Median as good/high boundary. Reference value is maximum. Other boundary class values at equal distance from good/moderate.
- Density/ biomass: Two side evaluation, 2.5th and 97.5th percentile as the boundary between good and moderate. 25th and 75th as good/high boundary. Median as reference value. Other boundary class values at equal distance from good/moderate.

Following alternative configurations (other percentile values for the boundary classes) were tested (Figure 3):

1) Config 1 (low stringency reference values):
    a. Number of species / species composition: percentile value 2.5 as good/moderate
    b. Density/ biomass: percentile value 1 and 99 as good/moderate.
2) Config 2 (least stringent reference values):
    a. Number of species / species composition: percentile value 1 as good/moderate
    b. Density/ biomass: percentile value 1 and 99 as good/moderate.
3) Config 3 (more strict reference values):
    a. Number of species / species composition: percentile value 10 as good/moderate
    b. Density/ biomass: percentile value 5 and 95 as good/moderate.
4) Config Sim: current configuration, except for the parameter species composition:
    a. Sim 1: 5th percentile as high/good, other boundaries equal classes
    b. Sim 2: Median as high/good, other boundaries equal classes
    c. Sim 3: Median as reference value, other boundaries equal classes

The BEQI values (EQR values) for each parameter obtained by analysing the WFD dataset per zone (west, middle and east coastal zone), habitat (*Abra alba*, *Nephtys cirrosa*, *Macoma balthica*) and year (2007, 2008, 2009 and 2007-2009) were compared to test the differences in configuration of the BEQI calculations. This delivered 25 different assessments, with which we can test the changes of the BEQI outcome for the different configurations.

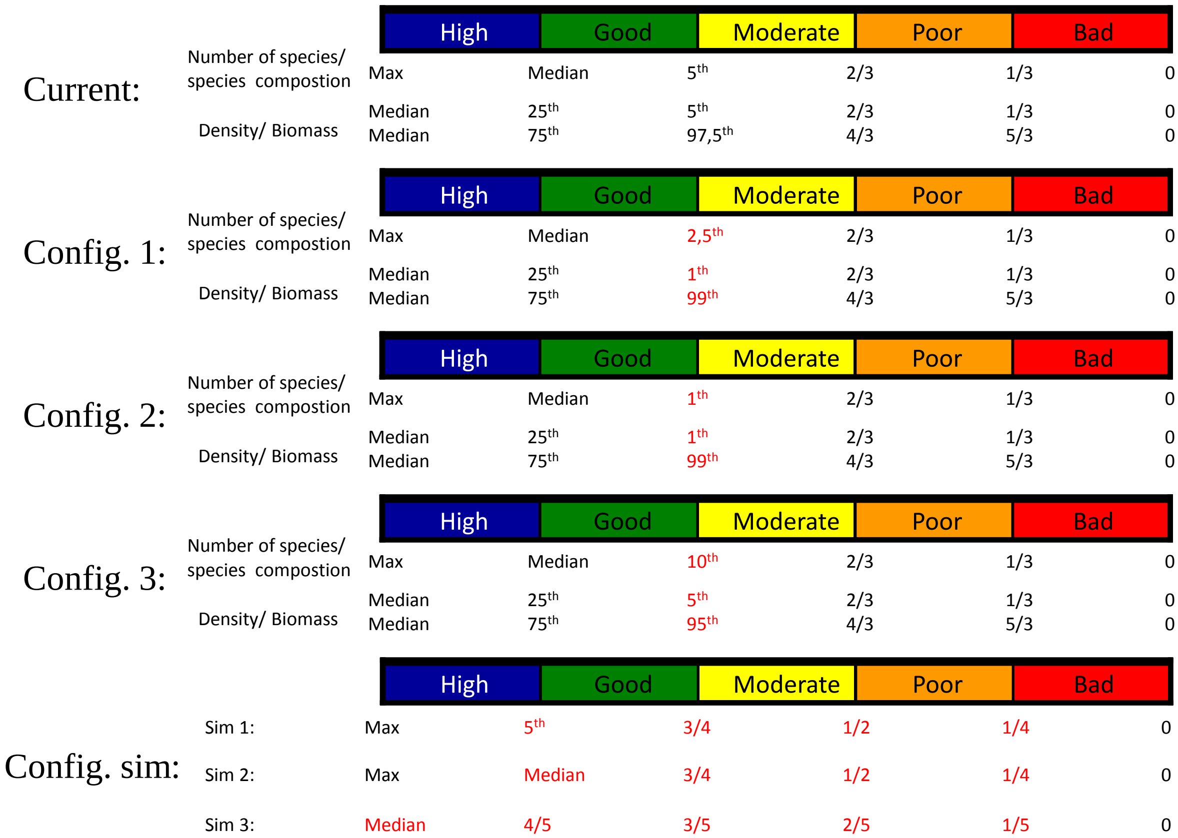

Figure 3. Visualisation of the determination of the boundary values based on the percentile values. The fractions (2/3, 1/3, 4/3, 5/3) in config 1 to 3 are calculated on the good/moderate value. In config sim, the fractions are determined on the high/good (sim 2) or ref value (sim 3).

2.1.2 Results

Table 1. Average changes ± standard deviation in the BEQI EQR values of each parameter and the average BEQI.

Configuration	Number of species	Density	Similarity	Average BEQI
Config 1	+ 0.015 ± 0.012	+ 0.020 ± 0.020	+ 0.013 ± 0.010	+ 0.016 ± 0.007
Config 2	+ 0.032 ± 0.026		+ 0.032 ± 0.026	+ 0.027 ± 0.011
Config 3	- 0.015 ± 0.013	- 0.023 ± 0.025	- 0.015 ± 0.013	- 0.017 ± 0.009
Sim 1			+ 0,164 ± 0,011	+ 0,055 ± 0,004
Sim 2			+ 0,099 ± 0,033	+ 0,033 ± 0,0011
Sim 3			+ 0,178 ± 0,106	+ 0,082 ± 0,0013

The changes in the selection of percentile values for the boundary good/moderate in configuration 1, 2 and 3 had of course no effect on the high status records, because this boundary value was not changed in any of those configurations.
Less confident assessments (lowest power due to lower sampling effort) were more sensitive to the boundary changes. This is due to the fact that the percentile values out of the rarefaction curves for each parameter were more variable by low sampling effort compared to higher sampling effort. Or in other words, when two samples in a habitat are considered and one extra sample is added, it is more likely to add a new species to the species pool. On the other hand, when 20 samples are considered and 1 extra sample is added, the chance of adding a new species to the species pool is lower. In this case, the percentile values reach a certain asymptotic value with increasing sampling effort.
The changes in percentile values resulted in minor changes in the BEQI EQR values (Table 1) and only in a few cases to changes in a status class (Figure 4). Configuration 1 resulted in a slight increase of the EQR values for each parameter, due to the fact that the boundary values were less stringent compared to the basic configuration. The least stringent configuration method was the second one, which logically resulted in a stronger increase of the EQR values.

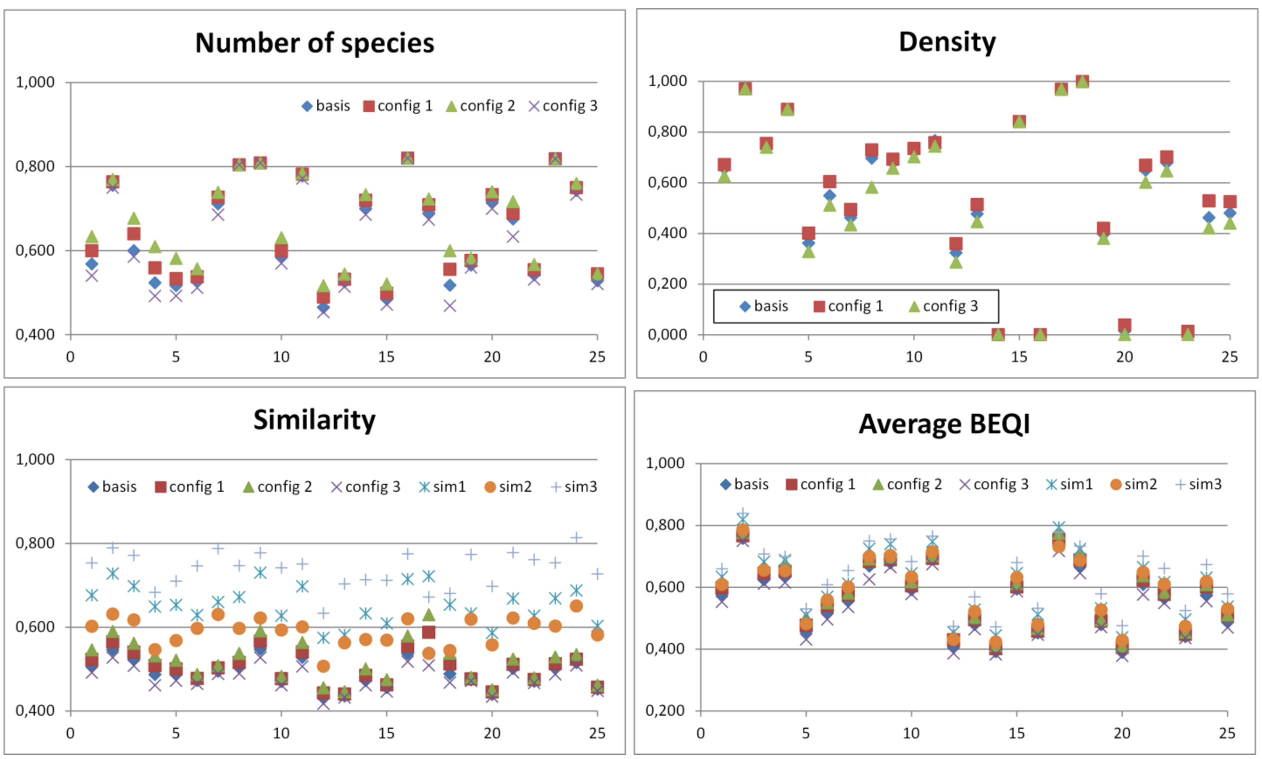

Figure 4. The BEQI EQR values for the different assessment cases for the different BEQI configurations.

As outlined in the introduction of this chapter, the parameter similarity does not seem to be sensitive enough. The changes in percentile values for similarity for certain boundary classes (config 1 to 3) did not have the expected result, because the EQR value changes were minor and did not result in a change of status class.
An EQR value of 1 means that the species composition and the densities were exactly the same between the reference and assessment dataset. This situation is very rare in marine ecology, due to the large spatial and temporal variability in the occurrence of species and their densities. Therefore, we rescaled the boundary settings for the parameter species composition (Figure 3)

assuming that the species composition of the assessment data is in high status when it falls above the 5^{th} percentile value. This means that the evaluation of the species composition is made less stringent. Of the three tested similarity configurations , the 3^{rd} one was least stringent, whereas the 2^{nd} one was most stringent. The effect of adapting the similarity calculations had a more pronounced effect on the average BEQI results with configurations 1 to 3, but this effect was rather small (e.g. sim 1: + 0,055 $\pm$ 0,004; Table 1).
We tested the comparability of several configurations of the BEQI with the m-AMBI (most common benthic indicator within WFD) (Table 2). We saw that the BEQI (sim3) configuration showed the highest comparability, followed by BEQI (sim1).

Table 2. Intercalibration test of some BEQI configurations with m-AMBI. M-AMBI max is m-AMBI calculated with maximum values and m-AMBI ref95 is with the 95 percentile values as reference values out of the WFD reference dataset. K= Kappa value; %= percentage of class disagreement and r= correlation factor. Green: best option; yellow=2^{nd} best option

	BEQI (basis)			BEQI (config1)			BEQI(config2)			BEQI(sim1)			BEQI(sim3)		
	k	%	r	k	%	r	k	%	r	k	%	r	k	%	r
M-ambi max															
M-AMBI ref95															

Based on these results and the expert discussion, we decided that the BEQI tool assessment can improve by changing the similarity calculations to the sim 1 configuration, because:

- By moving the 5^{th} percentile boundary to the high/good boundary class, we keep the BEQI calculation philosophy (the 5^{th} percentile is a statistically accepted level and appropriate for defining class boundaries) (Van Hoey et al., 2007).
- This is also better from an ecological point of view, because this configuration is less stringent for species composition assessments. In the current version, the species composition between assessment and reference needs to be very similar to fall within good or high status, which was seldom found in the WFD assessments. Based on our best professional judgement, we can say that those differences were not related to different species, but mainly to different densities. This does not to mean that the status of the species composition is bad.
- When this configuration was intercalibrated with the m-AMBI (most common WFD benthic indicator), it leads to a higher comparability, compared to the basic configuration (Table 2).

2.2 Application of weighing in determing the average BEQI score

2.2.1 Design

Other than an adaptation of the percentile values, which influences the individual EQR values, we can test if the average BEQI score can be calculated differently. We tested two ways of weighing to determine the average BEQI EQR value:

1) The parameter species composition (similarity) only counts for half compared to the other parameters in calculating the average BEQI value. This option is tested on the WFD assessment dataset (2007-2009) of the Belgian coast.
2) The parameters ‘density’ and ‘biomass’, which are considered to be similar evaluation parameters, were counted for 1/3 within the BEQI average. This option was tested on the assessment results (BEQI scores) of the Dutch water bodies described in Van Hoey et al., 2007. In that report, a description of the assessment of different water body types was given by using the four BEQI parameters (biomass, density, species composition and number of species).

2.2.2 Results

If the parameter species composition (similarity) would only count for half (1/2) in the calculation of the average BEQI score, the score would change only slightly (+0.013 ± 0.017) (Figure 5).
If the parameters density and biomass would only count for 1/3 within the average BEQI score, the score would again change slightly (+0.008 ± 0.033) (Figure 5). The average BEQI increased in some cases (11 cases) but decreased in others (10 cases), revealing no straightforward pattern. Additionally, the correlation between the BEQI parameters was low, indicating that they visualise different aspects within the assessment. Especially the correlation between the biomass and density assessment was not higher compared to the correlation factors between the other parameters.

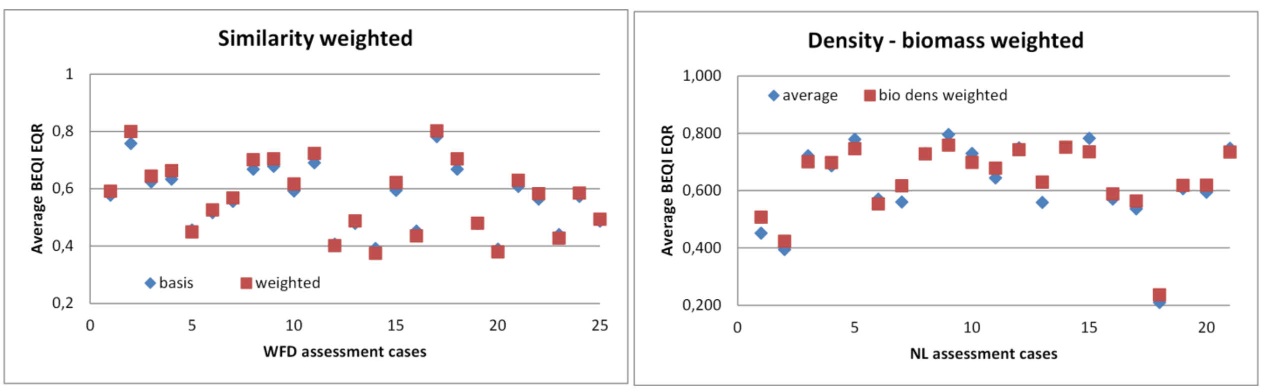

Figure 5. Left: Difference between basic and weighted average BEQI value when the parameter similarity is weighted. Right: Difference between basic and weighted BEQI value when the parameters density and biomass are weighted.

Table 3. Correlation factors between the BEQI parameters based on draftsman plot analyses (PRIMER).

	Biomass	Density	Similarity	Number of species
Biomass				
Density	0.48			
Similarity	0.56	0.47		
Number of species	0.35	0.27	0.47	

Based on the results and the expert discussion, we decided that the BEQI tool would not benefit from weighing parameters in determining the final assessment (average BEQI value). One of the philosophies of the BEQI tool is to be transparent and to interpret the parameter’s results individually. When the average BEQI score is moderate, poor or bad, it should be interpreted as a warning to trigger more detailed investigations, for example by developing an investigative monitoring programme. But even when the average BEQI score is good or high, but one or more EQR values of the parameters are evaluated as moderate, poor or bad, it should be interpreted as first warning of possible changes. The data then needs a closer, detailed examination to discover the reason for deviation.

2.3 Conclusion: final design of the BEQI tool

During the project meeting, the results of the different configurations were visualised and discussed. Afterwards the following conclusions about the design of the BEQI tool could be made:

- Changes in the boundary class value for the good/moderate boundary by selecting other percentile values leads to minor changes in the BEQI scores for each parameter and the BEQI average.
- More obvious changes to the assessment results of the parameter species composition (similarity) could be obtained by selecting other percentile values to some boundary classes (high/good or reference).
- Weighing certain parameters when calculating the BEQI average is not advised.

Based on these conclusions, we propose to set the boundary class values within the BEQI tool as follows (Figure 6):

- Number of species: one side evaluation, 5th percentile as good/moderate boundary value and median as high/good boundary value, other boundary class values at equal distance.
- Species composition (similarity): one side evaluation, 5th percentile as high/good boundary value, other boundary class values at equal distance.
- Density and biomass: two side evaluation, 2.5th and 97.5th percentile as good/moderate boundary value and 25th and 75th percentile as high/good boundary value, other boundary class values at equal distance.

Proposed design:		High	Good	Moderate	Poor	Bad
Number of species	Max	Median	5th	2/3	1/3	0
Species composition	Max	5th	3/4	1/2	1/4	0
Density/ Biomass	Median	25th	5th	2/3	1/3	0
	Median	75th	97,5th	4/3	5/3	0

Figure 6. Proposed design of the determination of the boundary class values within the BEQI tool.

3 BEQI intercalibration

3.1 Context setting

The WFD has a long history in the intercalibration process for benthic indicators among Member States within a region. The intercalibration process for the benthic indicator of the Belgian coast and transitional waters is executed in different phases within the Northeast Atlantic Region Intercalibration group (NEA-GIG).
The first phase (2004-2008) focused on the intercalibration of benthic indicators in the coastal waters. After the first phase, the BEQI was included in the EU Commission Decision, after a separate intercalibration and the delivery of an extra document with technical explanation. This separate intercalibration between BEQI and other indicators was needed because the BEQI scores were determined at habitat level instead of sample level. The EQR values of the other indicators for the habitats is determined by the average EQR value of the samples.
In the 2nd phase (2008-2012), the NEA-GIG benthic intercalibration group focused on the intercalibration of benthic indicators in transitional waters, which had not been done in the first phase. In this phase, JRC developed guidelines for the intercalibration (Guidance document No. 14), which determines the analysis procedure (benchmarking, statistical analyses, etc.). These guidelines were not yet available in the first phase, so each intercalibration group used its own statistical techniques. The full application of these guidelines in the second phase failed, mainly due to problems of benchmarking. Therefore, the intercalibration results of the NEA-GIG benthic group has not been accepted in the 2nd EU Commission Decision (see Annex 2 in Commission decision 2013/480/EU).
Now, the third phase of the intercalibration (2013 – 2015) has started, and the working plan is still being developed (as of the beginning of 2014). The Belgian government has decided to already do some preparatory work, which is outlined in this chapter. We will apply the WFD intercalibration protocol on the 3-year WFD monitoring data using Northeast Atlantic benthic indicators (Table 4). The problem within this intercalibration protocol is the benchmarking (alternative reference). If natural or near-natural reference conditions are not available or cannot be reliably derived for a certain type, intercalibration needs to be carried out against an alternative reference / alternative benchmark (e.g. good ecological status for that surface water type). Therefore, sites have to be found which were impacted by similar levels of impairment, and this needs to be defined by quantitative pressure data. The obstacle in the NEA-GIG international intercalibration exercise was to define the same level of impairment on the common dataset. However, coastal and transitional waters are subject to multiple pressures which makes them difficult to quantify.
One way to skirt the requirement of using pressure data in the benchmarking process is to use, for each indicator, a local reference value extracted from the same ‘reference’ dataset and defined using similar criteria (e.g. 95th or 99th percentile). This way, the intercalibrated benthic indicators will start from the same level of impairment (benchmark) and the comparability of the boundary settings of each indicator can be tested, which is the main goal of the intercalibration. The disadvantage of this method is that the deviation of this ‘reference’ dataset to the pristine or undisturbed conditions is unknown.

This chapter describes an intercalibration test of the BEQI with some common benthic indicators done on the Belgian WFD coastal monitoring data.

3.2 Methods and data

The intercalibration between the BEQI and some other NEA-GIG indicators for coastal waters (m-AMBI, IQI, DKI, NQI, BAT, BEQI2, QSB, BO2A) was done according to options 2 or 3 of the intercalibration guidelines. The intercalibration with the BQI, DKI, IQI, m-AMBI, and NKI is feasible due to their clear mathematical procedure (Van Hoey et al., 2013). The reference values for the parameters of those benthic indicators is the 95th percentile value (not the maximum value, because it can be an outlier within the dataset) out of the Belgian reference dataset (Van Hoey et al., 2013). This dataset consider all data from the period 1994-2004 in the Belgian Part of the North Sea for each habitat.

Table 4. Overview of the NEA-GIG indicators for intercalibration.

	MULTIMETRIC	
BQI (Sweden)	$\sum_{i=1}^{n}((\frac{Ni}{N}+ES50_{0.05i}))*10\log(S+1)/\text{BQI}ref$	(Rosenberg et al., 2004)
BEQI (Belgium)	EQR=average (EQR species+ EQR density+ EQR similarity)	(Van Hoey et al., 2007) http://www.beqi.eu
DKI (Denmark)	$\left(\frac{1-\frac{AMBI}{7}+\left(\frac{H'}{Hmax}\right)}{2}\right)*\left(\frac{\left(1-\frac{1}{N}\right)+\left(1-\frac{1}{S}\right)}{2}\right)$	(Borja et al., 2007)
NQI (Norwegian)	$(0.5*\left(1-\frac{AMBI}{7}\right)+\left(0.5\frac{SN}{2.7}*\frac{N}{N+5}N\right))/NQIref$	(Rygg, 1985 and 2002)
IQI (UK, Ireland)	$\frac{(((0.38*\left(\frac{1-(\frac{AMBI}{7}}{1-(\frac{AMBIref}{7}}\right))+\left(0.08\left(\frac{1-\lambda'}{1-\lambda ref}\right)\right)+(0.54*\left(\frac{S}{Sref}\right)))-0.4)}{0.6}$	
BEQI2 (The Netherlands)	EQR (ecotope) = 1/3 * [Sass / Sref] + 1/3 * [H'ass / H'ref] + 1/3 * [(6 - AMBIass) / 6]	Van Loon et al., 2011
QSB (Cantabria [Spain])	Average of Richness, Bray-Curtis similarity index (comparing to a predefined community type), percentage of opportunistic species (Ecological groups IV and V of AMBI index) and total abundance.	
BOPA (Andalusia [Spain])	BOPA = log((opportunistic polychaete frequency / (amphipod frequency + 1))+1)	Dauvin et al., 2007
	MULTIVARIATE	
M-AMBI (Basque [Spain], France, Germany)	Factor analysis: S, AMBI, Shannon diversity index	(Borja et al., 2004 and Muxika et al., 2007) http://ambi.azti.es
BAT (Portugal)	Factor analysis: S, AMBI, Margaleff diversity index	

A confident intercalibration analysis requires an appropriate number of data points. The most appropriate dataset consists of the WFD monitoring data collected in 2007-2009 in the Belgian coastal waters (Table 5). The possible cases (data points) are outlined in Table 5, which contain enough samples per case to execute a more or less confident assessment. This cases are obtained by different evaluation options, considering years or zones separately or joined per habitat type. The BEQI is determined on the pooled dataset per case, whereas the status by the other indicators for each case are determined by the average of the sample EQRs.

Table 5. Overview of the available data (sampling surface as m²) in each period, zone and habitat.

	2007	2008	2009	2007-2009
Zone 1, *Abra alba*	0.9	2.7	3.8	7.4
Zone 1, *Nephtys cirrosa*	1.4	1.8	2.1	5.3
Zone 1, *Macoma balthica*	2.1	1.5		3.7
Zone 2, *Abra alba*	0.6	2.3	1.8	4.7
Zone 2, *Macoma balthica*	1.8	1.6		4.8
Zone 2, *Nephtys cirrosa*			1.4	2.1
Zone 3, *Macoma balthica*	6	2.0	1.2	9.2
Abra alba	1.5	5	5.8	12.3
Nephtys cirrosa	1.4	1.8	4	7.2
Macoma balthica	9.9	5.1	2.2	17.2

The intercalibration is done with the protocol developed during phase 2 of the intercalibration, for which a calculation file is available. The calculated EQR values of each indicator for each case is filled in in this calculation file. The EQR values corresponding with each boundary are those for the NEA-GIG coastal waters.

3.3 Results

The intercalibration test on the WFD monitoring data in the Belgian Coast reveals no harmonised results (Table 6, Figure 7). The Belgian method, BEQI, shows no clear regression with the other methods; nor does the Swedish method (BQI). The methods constructed with rather similar parameters shows a higher comparability as compared to the BEQI and BQI. The latter two indicators differed rather widely in algorithm or parameters included.

Table 6. The regression and class boundary bias values of the intercalibration between the benthic indicators.

MS	DK	UK	SP	NO	BE	SE
No of subtypes	1	1	1	1	1	1
Subtype	NEA-1	NEA-1	NEA-1	NEA-1	NEA-1	NEA-1
intercept (c)	0.357	0.334	0.400	0.256	0.823	0.421
slope (m)	0.593	0.488	0.477	0.520	-0.178	0.324
Pearson's r	0.825	0.823	0.826	0.821	-0.251	0.334
WARNING! Min R^2< 1/2 * Max R^2	0.680	0.678	0.683	0.675	0.063	0.112

	DK	UK	SP	NO	BE	SE
H/G	0.670	0.750	0.770	0.720	0.800	0.890
G/M	0.530	0.640	0.530	0.630	0.600	0.680
H/G bias_CW	0.5723	-0.0583	0.5324	-0.5174	0.7513	0.0284
G/M bias_CW	0.1570	-0.1063	0.0240	-1.4535	-1.7959	-0.1611

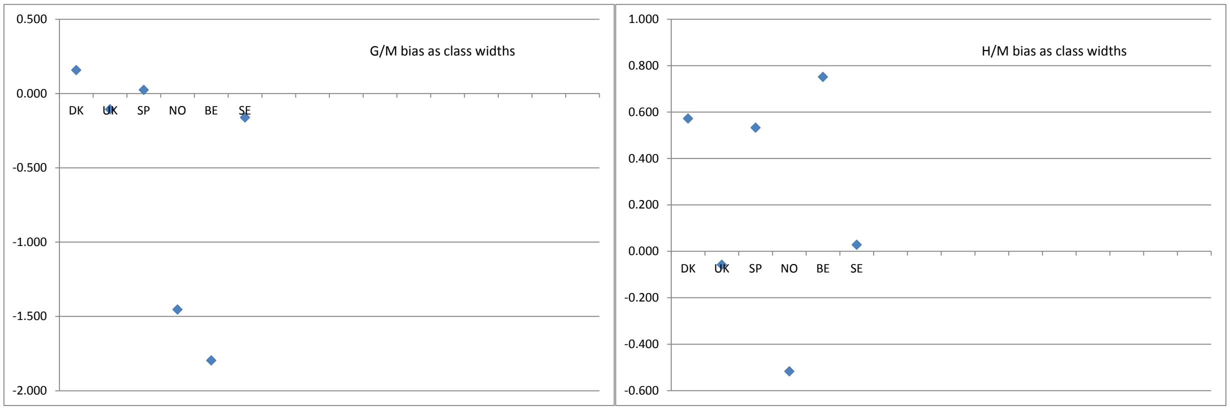

Figure 7. Left: The class width differences for the good/moderate boundary; Right: The class width differences for the high/good boundary.

The cases leading to a difference in assessment between the different indicators is related to certain aspects, such as:

- When using the BEQI, *Nephtys cirrosa* habitat assessments that include 2009 data (with high densities of *Ensis directus*) lead to low EQR scores, but this has no effect on the EQR of the other indicators.
- *Abra alba* habitat and *Macoma balthica* habitat in certain periods and zones shows a higher EQR value with the BEQI compared to the other indicators.

When the cases leading to a high mismatch were excluded from the comparison, the harmonisation results are logically much better, especially for the BEQI (Table 7).

Table 7. The regression and class boundary bias values of the intercalibration between the benthic indicators after excluding the highest mismatches.

MS	DK	UK	SP	NO	BE	SE
No of subtypes	1	1	1	1	1	1
Subtype	NEA-1	NEA-1	NEA-1	NEA-1	NEA-1	NEA-1
intercept (c)	0.292	0.273	0.386	0.136	0.257	0.410
slope (m)	0.693	0.584	0.506	0.679	0.738	0.360
Pearson's r	0.846	0.911	0.868	0.905	0.540	0.282
WARNING! Min R^2< 1/2 * Max R^2	0.715	0.830	0.753	0.819	0.291	0.080

	DK	UK	SP	NO	BE	SE
H/G	0.670	0.750	0.770	0.720	0.800	0.890
G/M	0.530	0.640	0.530	0.630	0.600	0.680
H/G bias_CW	0.154325	-0.20301	0.286896	-0.60364	0.720871	-0.26127
G/M bias_CW	0.085971	0.004752	0.107469	-1.3534	0.361074	0.10368

4 Reference setting for WFD, MSFD and HR

An appropriate choice of reference is a necessary step in the assessment procedure for determining the ecological quality of an ecosystem component (Figure 1). Additionally, the benthic samples (reference and assessment) need to be correctly assigned to a certain habitat type to avoid “comparing apples and oranges” during the assessment. In this chapter, both aspects are investigated in function of the MSFD and HR, based on the experience of the WFD (Van Hoey et al., 2008) and the formulation of the assessment procedure for benthos (Van Hoey et al., 2013). Currently, a reference dataset for each relevant habitat type was defined only for the WFD, based on the benthic data within the 6-nautical-mile zone in the period 1994-2004 (Van Hoey et al., 2008).

4.1 Available data

4.1.1 General

For soft sediment benthic habitats (benthos) within the BPNS, data were collected since 1977 until now (2012) by two institutes (Marine Biology Section of Ghent University [Marbiol] and the Bio-environmental research group of the Institute for Agricultural and Fisheries Research [Biomon]). Both institutes have their own databases:

- Macrodat (Marbiol): 56807 records, with 42415 quality controlled benthic records
- IMERS (Biomon): 66085 records, with 59859 quality controlled benthic records

The three main data sources for these databases are:

- Long term monitoring at fixed locations
- Spatially and temporally limited project monitoring
- Monitoring in function of the evaluation of the impact of human activities (sand extraction, disposal of dredged material, sand suppletion activities for coastal defense, wind farms)

The databases were fed by different persons with different levels of experience (Master’s students, PhD students, employees). Consequently, an intensive quality control on the suitability of all records in the database was performed, including:

- Identification level: appropriate taxonomy, spelling errors, ecosystem component, …
- Sample level: duplicates, partly analysed samples, …

After quality control, we compiled a dataset (Marbiol-Biomon) of 8447 benthic samples (Van Veen grabs) with 102274 taxon records. This dataset was then used within this project to determine the mean individual biomass of each taxon and to explore the applicability of the data for reference setting.

4.1.2 Taxon characteristics

Because data were generated by different persons, the species identifications were not always done at the same level, and did not always have the appropriate taxonomic nomenclature. Consequently, the taxonomic levels and nomenclature had to be made uniform. The applied rules are described in Annex 1.

In the databases of Marbiol and Biomon, 1445 and 927 different taxa were listed, respectively. After applying the rules (Annex 1), the combined taxon list holds 518 valid taxa (including different stages of certain taxa) or 433 taxa (without different stages). This taxon list includes many rare species (taxa which were present in less than 1% of the samples and with a maximum of 3 individuals). These were excluded for the reference and assessment data sets for determining the ecological status under the three EU Directives (WFD, MSFD, HR).
The taxon list used for the EU Directives is given in Annex 2. All data collected in soft sediment substrates on the BPNS need to use at minimum the same level of identification as listed in Annex 2.

4.1.3 Sample characteristics

During the last 35 years, many benthic samples have been collected in the BPNS. The sampling intensity, however, has differed substantially between years and between seasons (Figure 8). Autumn and spring were the seasons with the highest sampling effort over the years.

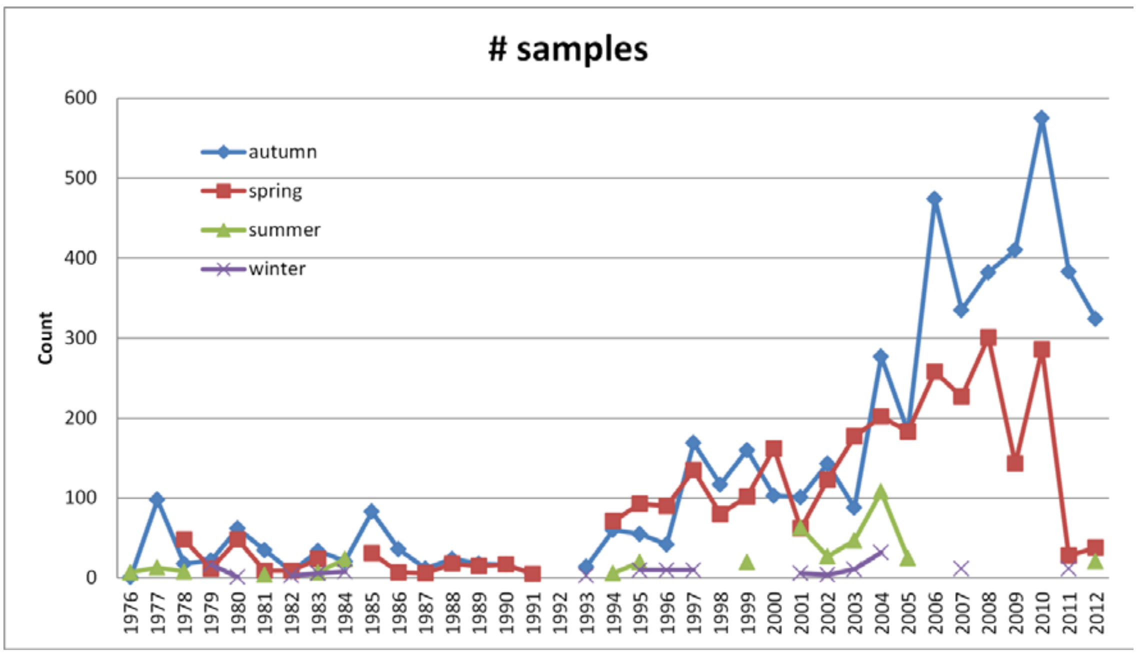

Figure 8. Number of samples in the Marbiol-Biomon benthos database collected over the years and in the different seasons.

There was only 1 year (1992) without newly collected benthic data. In the period 1976-1986, samples were collected regularly in the BPNS, but only at some fixed stations. The period 1987-1993 was a period with only a few samples per year, collected at some fixed stations. From 1994 onwards, the amount of collected samples started to increase. In the period 1994-2004, most data originated from the work of Steven Degraer (western coastal area), grid sampling in certain areas of the BPNS (e.g. Flemish banks), detailed mapping of the coastal area (HABITAT project) and the long term monitoring at fixed stations. A second increase of the amount of collected samples started in 2004, due to changes in the monitoring programmes for dredge disposal and sand extraction at ILVO. The data collected in the period 2004-2010 originate mostly from the monitoring of human activities (sand extraction, dredge disposal, sand suppletion, wind farms). These monitoring programmes consist of T0 monitoring and detailed control/impact monitoring

for specific activities. Especially those of sand extraction and dredge disposal were optimised to be cost- and time effective during the long term (only autumn sampling), due to the increased spatial area up taken by those activities. The sampling in 2004-2012 covered the entire BPNS area: samples were taken in both the coastal area as in the offshore area (Hinderbanken), and both in the western part (Flemish banks) as in the eastern part (Zeeland banks).
This history of sampling in the BPNS is important in the light of the selection of a reference dataset for soft-sediment benthic habitats.

4.2 Mean individual biomass determination

The parameter biomass is usually left out of BEQI calculations, due to the absence of consistent biomass data within the available datasets. To be able to implement this parameter anyway, we calculated mean individual biomass values for each taxon and used these to calculate missing biomass values. In the Marbiol-Biomon database, biomass data were present in a part of the samples. Biomass values were given as ash-free dry weights in the Marbiol database, whereas in the Biomon database, the biomass values were given as wet weights. Ash-free dry weight represents the organic content of the specimen (inorganic content removed) and is a proxy for the consumable part of a specimen. Ash-free dry weight measurements are time and cost intensive, because the procedure requires a period of drying and incinerating. This procedure requires destruction of the specimen. Wet weight measurements, on the other hand, are simple and not destructive. The wet weight is the weight of a specimen with all fluids topped off and can directly be determined during the sample handling. The disadvantage of wet weight is that it is a less robust, more variable measurement of biomass of a species, compared to ash-free dry weight.
For the 518 valid taxa, 41949 wet weight and 11857 ash-free dry weight measurements were available when taken together. The stage of the taxon records (juvenile, spat, …) was taken into account if possible. For each valid taxon, the mean individual biomass was determined by summing the counts and biomass for each taxon record and by dividing this total biomass by the total counts for each taxon.
Because the mean individual biomass value is more confident when a large number of measurements are available, the obtained values were scored in three confidence classes.

- Code 0: No mean individual biomass (ash free dry weight or wet weight) can be determined
- Code 1: The confidence of the obtained value is low, because it is based on only one measurement or because it was derived from values of a related taxon. These values need to be updated in the future.
- Code 2: The mean individual biomass value is reliable; it was based on a high number of measurements (exact numbers given in the biomass file)

Table 8 indicates that mean individual wet weight was calculated for common species, except for 10 taxa (certain stage of a common species). For 46 regularly recorded taxa, it is advisable to update the mean individual wet weight value in the future. The absence of biomass values (wet weight and ash-free dry weights) for rare species is not a major problem, because those taxa will not be assessed under the EU Directives (see 5.1.2). More common taxa records have no individual ash-free dry weight value, which is for 33% certain stages of a taxon. For the most common and abundant species in the soft sediments on the BPNS, mean individual ash-free dry weight and wet weight were now determined.

Table 8. Overview of taxa for which individual biomass values were obtained (code 1=low confidence; code 2=reliable value) or not (code 0). Rare species are species which were found in less than 4 samples. Common species are species which were found in more than 3 samples.

	I AFDW		I WW	
	Rare spp	Common spp	Rare spp	Common spp
0	113	136	62	10
1	11	15	47	46
2	11	233	26	328

Table 9. List of taxa, where for the individual wet weight (WW) is adapted or selected from a related taxon.

Taxon	Stage code	REMARK
Anapagurus	Not specified	AFDW > WW
Bathyporeia pelagica	Not specified	AFDW adapted, 2 highest Individuel records not taken into account
Abra prismatica	Not specified	AFDW same as Abra alba
Acrocnida brachiata	Not specified	AFDW same as Amphiura
Cerastoderma edule	not specified	biomass from Macom balthica, similar size
Scoloplos armiger	juvenile	Biomass of adult, little overestimation
Ensis directus	Not specified	Only records with >1g WW used, others are Ensis spat
Modiolula phaseolina	Not specified	IWW as Mytillus
Calliopius laeviusculus	Not specified	IWW from Amphipode (B. tenuipes) with same AFDW
Eunoe nodosa	Not specified	IWW from Harmothoe glabra
Eupolymnia nebulosa	Not specified	IWW from Lanice (Terebellidae)
Dorvillea	Not specified	IWW from Poecilochaetus, similar AFDW and type
Edwardsiella	Not specified	IWW same as Edwardsia
Arca tetragona	Not specified	IWW same as Goodallia triangularis
Portumnus latipes	larvae	IWW same as juvenile Portumnus
Neoamphitrite	Not specified	IWW same as Lanice
Leucothoe spinicarpa	Not specified	IWW same as Leucothoe incisa
Pisidia longicornis	juvenile	IWW same as Pisidia not specified
Pontocrates	juvenile	IWW same as P. altamarins, AFDW in same line
Pagurus forbesii	Not specified	IWW same as pagurus pubescens, smallest of pagurus in dataset
Urothoe pulchella	Not specified	IWW same as Urothoe brevicornis
Ampelisca tenuicornis	not specified	same as Ampelisca brevicornis
Pseudoparatanais batei	Not specified	same as Tanaissus
Tannaidacea	Not specified	same as Tanaissus
Tellimya ferruginosa	spat	same as Tellina spat, similar AFDW

Only for a few taxa, the individual wet weight value was adapted or selected from a related taxon (Table 9). The most important species in this list is *Ensis directus*, for which not all biomass records in the database were used to determine the individual wet weight because a part of the records were considered as *Ensis* spat (low biomass value).

4.3 Habitat classification of the benthic samples

On the BPNS, four benthic habitats were identified (Van Hoey et al., 2004; Degraer et al., 2008): 1) *Abra alba* habitat (fine sandy mud); 2) *Macoma balthica* habitat (mud); 3) *Nephtys cirrosa* habitat (well sorted medium sand) and 4) *Ophelia borealis* habitat (medium to coarse sand). These habitats are not strictly separated, but show a gradient in occurrence and characteristics (Van Hoey et al., 2004).

The habitat approach is an important step in the assessment procedure (Figure 1), but has sometimes been neglected (Van Hoey et al., 2013) because artifacts in ecological status assessment can be caused by natural fluctuations (spatial and temporal) (Chainho et al., 2007; Borja et al., 2008; Kroncke and Reiss, 2010; Van Hoey et al., 2010) or an inadequate assessment of reference conditions per habitat type (Borja et al., 2011). A different habitat assignation of samples can lead to differences in reference condition values and ecological quality status scores. The use of identical reference values for diversity within dynamic sandy areas or low-dynamic muddy sand areas leads to an inappropriate (too low) ecological quality value for the samples of the dynamic sandy area compared to what is naturally expected for that habitat type. A major problem, mainly in coastal soft-bottom systems, is to track the deviation lines within the data of the different benthic habitat types, given the gradual changes in sedimentological and biological conditions (Kunitzer et al., 1992; Van Hoey et al., 2004). This aspect of gradual changes in conditions is also difficult to take into account in the habitat classification maps of an area (Degraer et al., 2008).

4.3.1 Habitat approaches

Table 10. Percent correspondence in sample classification between the Habitat suitability model approach (HSmod) and the Biological model approach (Biomod). The % of correspondence between Biomod and HSMod is given in the right corner, whereas the % of correspondence between the HSMod and BioMod is given in the left corner.

		BioMod					
	%	*A. alba*	*M. balthica*	NA	*N. cirrosa*	*O. borealis*	
HSMod	*A. alba*	76 62	7 4	9 25	5 5	3 4	100 100
	M. balthica	13 18	52 51	35 29	0 2	0 0	100 100
	NA	43 23	15 33	12 23	21 6	9 15	100 100
	N. cirrosa	13 7	1 0	5 22	47 32	34 39	100 100
	O. borealis	7 5	0 0	7 10	35 24	51 61	100 100

Two major approaches to classify benthic samples to a certain habitat type were tested in Van Hoey et al. (2013): (1) a regular multivariate community analysis based on an abundance species dataset (Biological model approach, BMod), potentially complemented with physical data (e.g. sedimentology, depth) and (2) plotting reference and assessment samples on a habitat suitability map (Habitat suitability model approach, HMod). The results on a dataset of 6368 samples indicate a good agreement, following a weighted Cohen's Kappa analysis (0.684), between the sample classifications of both habitat approaches. Despite this, obvious differences are found between the percentage of (dis-)agreement between the approaches for the different habitat types (Table 10). It seems that the assignment of samples to the *N. cirrosa* habitat is the most difficult, with only 32 or 47% correspondence between both approaches. If there were

discrepancies between both approaches, most misclassified samples were linked to the most related habitat type, in correspondence to their sedimentology (Van Hoey et al., 2013). The BioMod approach has more "not assigned" samples compared to the HMod approach, due to the fact that samples in the BioMod approach belonging to transitional species groups (mixed characteristics of different habitats) are considered as not assignable.
Both approaches lead to different results regarding the sample classification, with a good agreement for the *A. alba* and *O. borealis* habitat and less agreement for *M. balthica* and *N. cirrosa* habitat. Different reasons for the mismatch between both approaches can be found (Van Hoey et al., 2013). First, in the BioMod, changes can be detected more readily, depending on the sample grid, because in the HSMod generalisations were made regarding spatial accuracy (250m (Degrear et al., 2008)). Second, the habitat boundaries within the HSMod approach do not strictly take the benthic species-sediment gradient into account, while the BioMod approach incorporates transitional species assemblages. The latter is more effective for defining reference values (optimal conditions, habitat characteristics *sensu strictu*). Third, the use of the BioMod approach can result in an incorrect classification of impoverished samples of a species-rich habitat type, which were mostly catalogued as part of the naturally poor benthic habitat type (e.g. *A. alba* and *M. balthica* habitat).The HSMod, which reflects habitat potential, based on the physical characteristics of an area, is less influenced by this aspect. Fourth, the BioMod approach has no full coverage whereas the HSMod emphasises the concept of benthic habitat as a 'preferred substrate' and offers a wide coverage and faster analysis, making it a feasible managing tool (if underlying maps are appropriate and confident).

4.3.2 Habitat data

Table 11. Amount of samples available per habitat type in each period and area in autumn. In yellow, an amount of samples (>50) enough to describe the 'reference' state.

	Abra alba habitat			*Macoma balthica* habitat			*Nephtys cirrosa* habitat			*Ophelia borealis* habitat		
	1977-1986	1994-2004	2005-2012	1977-1986	1994-2004	2005-2012	1977-1986	1994-2004	2005-2012	1977-1986	1994-2004	2005-2012
WFD(<6nM)	99	317	481	49	84	374	6	54	20	6	6	25
MSFD	130	455	655	49	90	414	70	141	433	102	372	642
Natura 2000	72	293	398	3	5	55	47	73	41	54	137	299

As outlined in 5.1.3 and in Table 11, the knowledge about the benthic characteristics of soft-bottom sediments in the BPNS is still increasing. In each area, the amount of collected samples was highest in the period 2005-2012.

This increasing amount of samples in each habitat over the years results in an increased chance of finding new species: the number of taxa found in each sampling year markedly increased over 35 years, with the highest numbers in 2008 and 2010 (Figure 9). There is a very clear relation between the number of samples and the number of taxa found (Figure 9).

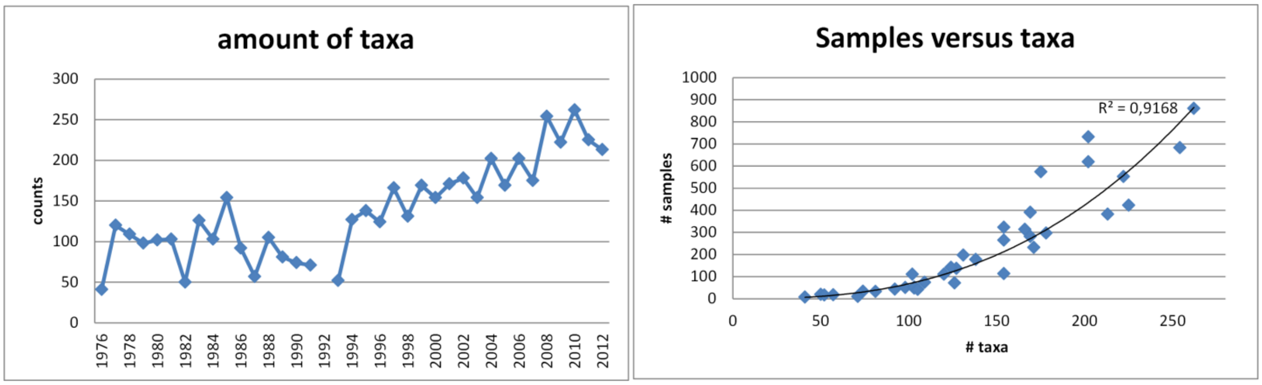

Figure 9. Amount of taxa found over the years (left graph) and the relation between amount of samples versus amount of taxa (right graph). Trend line is a power function.

If we consider the number of taxa found in each period for each specific habitat, we see that (Table 12):

- The number of taxa collected within the *A. alba* habitat was highest in the period 1994-2004. In this period, several research projects focused on this particular habitat.
- The number of taxa collected increased over the 35 years for the *O. borealis* and *N. cirrosa* habitat, with highest taxon records in the period 2005-2012. This was related to intensive sampling in these areas. Table 11 indicates that the amount of collected samples almost doubled for those habitats in this period.
- For the *M. balthica* habitat, the highest number of taxa were found in the period 2005-2012, due to the much more intensive sampling (factor 3 to 4 more) (Table 11).

Table 12. The number of taxa found in each habitat type in the different periods.

Period	*M. balthica*	*A. alba*	*N. cirrosa*	*O. borealis*	TOTAL
<1986	60	157	91	172	222
1986-1993	49	106	23	92	153
1994-2004	83	246	155	218	319
2005-2012	130	217	248	283	371
TOTAL	151	291	278	330	
Unique taxa	5	23	19	34	
Common to all	111				

There was of course a high overlap in species found in the different habitats (Table 12). Only a few taxa were found exclusively in a specific habitat, and that was highest for the *O. borealis* habitat (34 taxa). In total, 111 taxa were found at least once in the four habitats. The 10 most common species in all habitats still showed a clear preference to one of the habitat types (Table 13). Nevertheless, the taxa *Spio, Spiophanes bombyx, Nephtys cirrosa* and *Nephtys* juveniles were abundant in all habitat types.

Table 13. Top 10 of most common benthic species in autumn and their percentage of occurrence in the 4 habitat types.

unified taxa	% total	*Macoma balthica*	*Abra alba*	*Nephtys cirrosa*	*Ophelia limacina*
Nephtys juv	57,64	53,82	61,49	32,72	69,27
Nephtys cirrosa	54,75	7,64	34,55	93,98	78,82
Spio	50,79	21,18	56,29	56,64	56,16
Spiophanes bombyx	49,78	11,11	63,90	51,23	52,52
OLIGOCHAETA	40,75	43,58	46,27	10,19	50,35
Cirratulidae	33,13	69,97	51,86	4,63	9,81
Abra alba	31,58	30,56	69,41	4,78	4,86
Nephtys hombergii	29,75	42,19	62,97	1,85	2,08
Scoloplos armiger	28,17	8,51	50,16	16,51	19,97
Magelona	27,92	7,81	58,93	10,03	13,37

4.3.3 Conclusion.

Both habitat approaches (methods to classify samples to a habitat type) (Biomod and HSMod) seemed to be appropriate in the case of the habitat classification on the BPNS scale, especially because of the data availability and the good spatial coverage, but neither of them are ideal (Van Hoey et al., 2013).
Based on the analyses and the discussions at the experts' meeting, we decided that the best approach to catalogue the reference and assessment samples for the three EU Directives is by using the sedimentological information per sample and to rerun the discriminant function analysis of the habitat suitability modelling (Degraer et al., 2008). The protocol used in Degraer et al. (2008) needs to be executed to make the final catalogue of the samples to each habitat type for the samples used in the EU Directive assessment of soft-sediment substrates.

For the assessment of the ecological/environmental status of soft-sediment substrates on the BPNS, we decided to focus on the three main benthic habitats:

- *M. balthica* habitat: muddy substrate (EUNIS: sandy mud to mud)
- *A. alba* habitat: fine muddy sand (EUNIS: muddy sands to sands)
- *O. borealis* habitat: medium to coarse sand (EUNIS: coarse grained sediments)

The focus on these three main habitat types is also in line with the EUNIS habitat classification that was used to evaluate the environmental target of the MSFD. The spatial extent and distribution of the EUNIS level 3 habitats (sandy mud to mud, muddy sands to sands and coarse grained sediments), as well as that of gravel beds fluctuate - relative to the reference state as described in Initial Assessment - within a margin limited to the accuracy of the current distribution maps.

The *N. cirrosa* habitat will not be assessed because

- It shows the highest overlap in characteristics with the three other habitats (Van Hoey et al., 2004)

- it was not cataloged as a separate type, when analysed on North Sea scale (Reiss et al., 2010).
- based on the habitat approach analyses, it is difficult to catalogue samples to this type (Van Hoey et al., 2013).

4.4 Reference dataset determination for the benthic habitats on the BPNS

In the case of the WFD, a reference dataset is ideally a dataset from an area in pristine conditions (undisturbed conditions) (Muxika et al., 2007, Van Hoey et al., 2010; Borja et al., 2012). Such data do not exist within our region. The Belgian waters in the Southern Bight of the North sea have already undergone centuries of influence by humans, and the intensity of activities around and within this area has only increased over time. However, the MSFD strives towards environmental targets for a good status, which must correspond with a status under sustainable human activities. Therefore, Belgium will not and cannot define a reference state for the marine habitats as defined under the WFD (Van Hoey et al., 2008), but will use the concept of the MSFD to define the ecological characteristics for the marine habitats under "sustainable" conditions as reference setting. Optimally, such references are derived from data (1) acquired from multiple sites with similar physical characteristics, within an ecoregion and habitat type (see habitat approach); (2) that ideally represent minimally impaired or undisturbed conditions; and (3) that provide an estimate of the variability in biological communities due to natural physical and climatic factors (Borja et al., 2012). We will take this advice into account when defining the most optimal reference dataset for the benthic habitats on the BPNS under the three EU nature directives. There are of course different approaches to define a reference dataset (Figure 1), and that will be discussed in section 5.4.1.

4.4.1 Reference approaches

The main approaches identified in literature and in WFD guidelines for selecting reference settings were (1) comparison with an existing 'pristine'/undisturbed site (or a site with minor disturbance); (2) using historical data and information; (3) using models or (4) using best professional judgment (Van Hoey et al., 2010). Borja et al. (2012), upon scoring the approaches, showed that the one based on pristine conditions is the best approach. The other approaches were judged as adequate, but they should be combined with best professional judgment. The selection of an adequate reference setting approach depends mainly on the knowledge and availability of data within the research area.
In the case of the BPNS, pristine sites do not exist and most appropriate available 'historic' data go back to the end of the 1970s, when human activities had already intensified. The oldest available database is the "Gilson collection" (early 19th century), but due to differences in sampling techniques and standards used during collecting, this database was not fit for purpose (Houziaux et al., 2011). Therefore, we evaluate and analyse the use of certain data from the Marbiol-Biomon database of the last 35 years as potential use as reference datasets.

Table 14. An overview of the obtained reference or target values obtained for the different benthic parameters used in this study for the different habitat and reference setting approaches per habitat type. Max: Maximum value of the

dataset; 0.95: 95th percentile value of the dataset. *Nepthys cirrosa* habitat is not visualised in this table, compared to Van Hoey et al., 2013.

		Habitat suitability model approach (HSMod)						Biological model approach (BioMod)					
		BSAppr<86		BSAppr94-04		*LdaAppr*		BSAppr<86		BSAppr94-04		*LdaAppr*	
		Max	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*
Abra alba	*S (0.1m²)*	36	28	53	38	53	37	36	27	53	39	53	38
	d	3,93	3,58	5,08	4,29	5,08	4,19	3,93	3,52	5,08	4,44	5,08	4,49
	ES50	18,09	15,99	20,37	17,40	20,37	16,99	18,09	15,94	20,72	17,85	20,72	17,43
	Hlog2	4,21	3,85	4,54	4,13	4,54	4,04	4,21	3,84	4,54	4,18	4,54	4,11
	1-λ'	0,93	0,91	0,94	0,92	0,94	0,91	0,93	0,91	0,94	0,92	0,94	0,92
	NQI	0,70	0,68	0,77	0,74	0,77	0,74	0,70	0,68	0,77	0,74	0,77	0,75
	BQI	12,16	11,25	16,70	12,35	17,06	12,16	12,16	11,22	16,70	12,64	17,06	12,43
	AMBI	0,26	0,74	0,00	0,10	0,00	0,08	0,26	1,13	0,00	0,10	0,03	0,10
		Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M
	S (1m²)	89	65	99	73	101	75	84	59	99	75	99	75
	N (1m²)	2834	1039-6490	3999	1500-16835	4983	1822-19347	2655	985-6072	5140	2161-18344	6014	2351-20020
	Sim (1m²)	0,87	0,75	0,82	0,70	0,82	0,71	0,86	0,73	0,83	0,74	0,84	0,74
	# samples	93		393		345		99		357		302	
		Max	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*
Macoma balthica	*S*	18	15	42	24			12	11	13	11		
	d	2,28	1,81	4,69	2,91			1,36	1,34	2,09	1,65		
	ES50	11,81	10,14	16,42	12,72			7,84	7,06	11,77	9,15		
	Hlog2	3,10	2,87	3,95	3,17			2,56	2,34	3,30	2,86		
	1-λ'	0,85	0,82	0,90	0,86			0,83	0,79	0,88	0,85		
	NQI	0,68	0,66	0,71	0,66			0,68	0,67	0,66	0,60		
	BQI	9,74	8,70	13,31	9,37			8,20	7,74	8,28	7,56		
	AMBI	0,00	0,37	0,00	0,94			0,00	0,38	0,68	1,34		
		Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M
	S (1m²)	48	30	81	47			31	22	46	30		
	N (1m²)	1827	415-4745	1386	429-3002			735	212-1421	456	225-1285		
	Sim (1m²)	0,88	0,67	0,86	0,63			0,93	0,76	0,83	0,70		
	#	48		94		4		29		82		2	
		Max	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*	*Max*	*0,95*
Ophelia borealis	*S*	43,0	35,4	42	22	42	24	43	34	31	22	35	23
	d	4,22	3,76	4,55	2,94	4,61	3,15	4,22	4,03	3,79	2,89	4,61	3,14
	ES50	17,17	13,09	16,44	13,59	19,04	14,57	17,17	15,55	16,22	13,24	19,04	14,62
	Hlog2	4,04	3,56	4,00	3,47	4,26	3,67	4,04	3,76	3,89	3,47	4,26	3,68
	1-λ'	0,91	0,90	0,93	0,88	0,93	0,90	0,91	0,90	0,91	0,88	0,93	0,90
	NQI	0,68	0,67	0,75	0,70	0,75	0,71	0,73	0,71	0,75	0,71	0,75	0,71
	BQI	12,37	10,72	12,96	10,22	18,11	11,20	12,37	11,07	12,29	10,31	12,69	10,81
	AMBI	1,00	1,09	0,04	0,50	0,00	0,52	0,58	0,70	0,15	0,47	0,15	0,51
		Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M	Ref	G/M
	S (1m²)	75	43	96	56	108	68	96	63	81	57	96	67
	N (1m²)	1629	364-3968	658	432-1158	701	463-1195	1619	606-3697	672	480-924	726	488-1090
	Sim (1m²)	0,94	0,63	0,77	0,61	0,73	0,59	0,89	0,69	0,79	0,68	0,74	0,64
	#	30		212		387		47		190		336	

In Van Hoey et al. (2013), we tested two main approaches to define reference: the baseline setting approach and the least disturbed area approach (Figure 1). All approaches result in the selection of an appropriate reference dataset, from which the reference values per benthic characteristics (parameter) can be extracted (Table 14). For the selection of those reference values it is advisable to use a certain percentile value (e.g. 95th percentile) instead of the maximum value of the dataset. A percentile approach tends to give more demanding and balanced reference values, because there is a chance that the maximum value is an outlier value within the dataset and those can be repeated between approaches (Van Hoey et al., 2013).

The first approach, the BSAppr<86, tended to give lower reference values for the studied parameters compared to the other approaches (Table 14). This difference could be related to differences in anthropogenic pressures along the time scale. This is unlikely, however, due to the fact that this 'historic' period was already in a time period of intense human activity. This difference can also be related to the fact that this dataset contains fewer samples (see Table 14 and Figure 8), which are spatially and temporally less distributed over the area (period 1977-1986 is mostly data from fixed stations). Differences in methodology (handling, taxonomy) and sampling strategies (e.g. fixed, random) are common shortcomings in the use of 'historic' datasets (Van Hoey et al., 2013). The BSAppr (1994-2004) approach used data from a period with a good spatial and temporal coverage of the samples. This seems to be a more accurate way to report natural spatial and temporal variability within the different benthic habitats in our study area. The reference conditions obtained with this approach do not represent the pristine conditions mentioned in the WFD, but could rather reflect the sustainable conditions mentioned under the MSFD. The reference values obtained from this approach seem to be reliable and realistic in the light of the best professional judgment of the local benthic experts (Table 14). The only question is if this time period is representative enough for the benthic characteristics of our main benthic habitats in the BPNS (see further). The last approach is the LdaAppr, which grouped reference data from areas with lower disturbance. The least disturbed areas within the investigated area is determined based on a pressure index (Van Hoey et al., 2013). This index evaluated the amount of human activities and their relative intensity in a certain area and scored the average between 0 (least disturbed) and 3 (high disturbance). All sub-areas (sand bank areas) have great amounts of human activity, thus only data originating from areas with the highest pressure classification (PI>2.4) could be used in this LdaAppr. This approach mostly resulted in similar or slightly higher reference values compared to the BSAppr (94-04) (Table 14), indicating that the incorporation of data from more intensively used areas in the other approaches has a minor influence on the reference conditions setting.

4.4.2 Geographical scope

The geographical coverage of the dataset in function of the scope of the three directives also requires attention. The WFD is operational within 1 nautical mile of the coastline, whereas the MSFD emphasises the entire BPNS and the HR only applies to the Natura 2000 area 'Vlaamse banken'. Does this means that the geographical coverage of the reference data must follow these delimitations? We tested what the consequences were for the reference value of each benthic parameter and the BEQI values when it was limited to certain geographical scales. Gradients in benthic characteristics within the different habitats on the BPNS have been observed, such as the west-east and onshore-offshore gradients (Van Hoey et al., 2004, 2005).

Currently, a reference dataset for each relevant habitat type has been defined only for the WFD. This dataset was based on the benthic data within the 6-nautical-mile zone in the period 1994-2004 (Van Hoey et al., 2008), and gives a relatively good image of the spatial and temporal variation within the different habitats in the Belgian coastal zone.
For the analyses in this section, we used the reference period 1994-2004 at three geographical scales:

- MSFD: Data from the entire BPNS were selected
- WFD (<6nM): Only data from within the 6-nautical-mile zone were selected
- Natura 2000: Only data from the 'Vlaamse banken' zone were selected.

Selecting the reference dataset for certain habitat types would be simpler without geographical differentiation. The ideal situation would be one dataset for each habitat type that is appropriate for the three EU Directives together. Therefore, for instances where there are no essential differences in our analysis results we have selected such a dataset.

Abra alba habitat

For number of species, the highest reference value is found in the MSFD dataset (most data, widest spatial scale), but for the good/moderate boundary, the Natura 2000 reveals the most stringent value (Table 15). The same is true for similarity, density and biomass, which were most stringent for the Natura 2000 reference dataset. This pattern is also visible in the assessment, which reveals the lowest EQR values by using the Natura 2000 reference dataset. This pattern is related to the fact that the *Abra alba* habitat shows an east-west gradient in characteristics.
Although the community structure shows a high similarity across the full distribution range of the *A. alba* community, large-scale as well as small-scale changes in community composition were observed: the BPNS should be considered as a major transition area of the *A. alba* community, representing both rich distribution in the south to the poorer distribution in the north (Van Hoey et al., 2005). But for the small area represented by the Belgian coast, it is not advisable to set different goals for the *A. alba* habitat for the eastern or western distribution area in the light of assessing the ecological status under the different Directives. Therefore, a geographical differentiation in reference dataset for the *A. alba* habitat is not really necessary for MSFD and WFD, which apply to the entire coast.

Table 15. The reference values and good/moderate boundary values for the different BEQI parameters under the different geographical scales for two sampling efforts (10 [1m²] or 30 [3m²] Van Veen samples) for the *Abra alba* habitat.

REF: 94-04	1m²	Number of species		Similarity		density		Biomass	
		REF	G/M	REF	G/M	REF	G/M	REF	G/M
Abra alba (1m²)	MSFD	201	59	0,741	0,588	3587,4	1302,6-23664,9	1318,2	200,6-19027,1
	WFD (<6nM)	177	59	0,766	0,62	4511,1	1503,4-28740	2057,4	273,9-23848,9
	Natura 2000	177	64	0,779	0,644	4967,6	1723,2-28166,8	2383,9	350,4-23454,1
Abra alba (3m²)	MSFD	201	94	0,829	0,753	4228,3	2153,6-13849,4	2064,5	509,3-10372,9
	WFD (<6nM)	177	91	0,851	0,775	5849,1	2660,8-17363,03	3374,1	750,4-13781,9
	Natura 2000	177	95	0,859	0,789	6182,2	2850,1-17778,6	3679,5	868,2-14265,9

Table 16. The BEQI scores for a test assessment dataset (10 samples, 1m²) under the different geographical scales for the *Abra alba* habitat.

Abra alba	Similarity EQR	No. of species EQR	Density EQR	Biomass EQR	Final EQR Default
MSFD	0,522	0,529	0,52	0,681	0,563
WFD	0,504	0,529	0,451	0,634	0,53
Natura 2000	0,478	0,488	0,393	0,604	0,491

Macoma balthica habitat

For the *M. balthica* habitat, a geographical differentiation was not necessary because this habitat is mainly found within the 6 nautical mile limit and on the eastern part of the Belgian coast. This explains the inadequate number of samples in the period 1994-2004 for the *M. balthica* habitat in the Natura 2000 area 'Vlaamse banken'. The reference values and BEQI scores were very similar between the two geographical datasets (Table 17, Table 18). For the *M. balthica* habitat, a geographical differentiation is not necessary.

Table 17. The reference values and good/moderate boundary values for the different BEQI parameters under the different geographical scales for two sampling efforts (10 [1m²] or 30 [3m²] Van Veen samples) for the *Macoma balthica* habitat.

REF: 94-04	1m²	Number of species		Similarity		density		Biomass	
		REF	G/M	REF	G/M	REF	G/M	REF	G/M
Macoma balthica (1m²)	MSFD	71	21	0,717	0,53	393,1	163,1-1575	12,3	3,3-32,5
	WFD (<6nM)	67	21	0,726	0,54	426,1	175,5-1511,1	13	3,3-33,5
	Natura 2000	NA	NA	NA	NA	NA	NA	NA	NA
Macoma balthica (3m²)	MSFD	71	34	0,851	0,742	459	254,4-1051,7	13,7	6,8-24,5
	WFD (<6nM)	67	38	0,856	0,751	480,5	262,1-1076,9	14	7,1-25,1
	Natura 2000	NA	NA	NA	NA	NA	NA	NA	NA

Table 18. The BEQI scores for a test assessment dataset (10 samples, 1m²) under the different geographical scales for the *Macoma balthica* habitat.

Macoma balthica	Similarity EQR	No. of species EQR	Density EQR	Biomass EQR	Final EQR Default
MSFD	0,468	0,514	0,608	0,667	0,564
WFD	0,469	0,514	0,574	0,68	0,559
Natura 2000	NA	NA	NA	NA	NA

Ophelia borealis habitat

The geographical dataset MSFD delivered clearly higher reference values for number of species and density, but lower biomass values (Table 19). For the good/moderate boundary, the demand for number of species was higher in the MSFD dataset, because the Natura 2000 area 'Vlaamse banken' comprehends only a part of the distribution area of the *O. borealis* habitat. The demands for similarity were lower, due to the fact that the MSFD dataset better represents the variability of the benthic characteristics of the *O. borealis* habitat. The BEQI scores were lower for number of species, density and the average when using the MSFD dataset (Table 20). Similarity and biomass BEQI scores were higher when using the MSFD dataset.

Table 19. The reference values and good/moderate boundary values for the different BEQI parameters under the different geographical scales for two different sampling effort (10 [1m²] or 30 [3m²] Van Veen samples) for the *Ophelia borealis* habitat.

REF: 94-04	1m²	Number of species		Similarity		density		Biomass	
		REF	G/M	REF	G/M	REF	G/M	REF	G/M
Ophelia borealis (1m²)	MSFD	181	38	0,648	0,481	592,1	312,8-1332,8	119,8	6,3-485,6
	WFD (<6nM)	NA	NA	NA	NA	NA	NA	NA	NA
	Natura 2000	127	34	0,702	0,523	422	237,5-716,1	199	7,8-540
Ophelia borealis (3m²)	MSFD	181	70	0,764	0,662	606,6	421,3-927,4	138,6	44,2-2973,2
	WFD (<6nM)	NA	NA	NA	NA	NA	NA	NA	NA
	Natura 2000	127	60	0,824	0,708	432,2	315,2-579,9	201,3	71,4-385,3

Table 20. The BEQI scores for a test assessment dataset (10 samples, 1m²) under the different geographical scales for the *Ophelia borealis* habitat.

Ophelia borealis	Similarity EQR	No. of species EQR	Density EQR	Biomass EQR	Final EQR Default
MSFD	0,531	0,7	0,679	0,664	0,644
WFD	NA	NA	NA	NA	NA
Natura 2000	0,524	0,782	0,814	0,63	0,688

4.4.3 Conclusion

The conclusion made in Van Hoey et al. (2013) also applies to the present study. Selection of an appropriate benthic reference dataset should be based on the following two criteria: (1) benthic data with a good spatial and temporal coverage; (2) benthic data of the most intensively used areas, ideally determined by a pressure index, should be avoided. In combination with best professional judgment, this should lead to a confident, scientifically based identification of reference values for soft-sediment benthic habitats.

In practice, this means that we select the most appropriate data for each benthic habitat of the BPNS as reference for the three EU Directives based on following selection criteria:

- The data is collected in the period 1994-2012 on the BPNS. The data originating prior to 1994 are not suitable for this purpose due to the low spatial coverage of the samples, differences in sample handling and the overall lower number of collected samples.
- Geographical sub-datasets for certain habitats in the light of the different Directives are not required.
- Data collected in areas where a certain human activity (dredge disposal, sand extraction, wind farm construction) can disturb the natural variability of the benthic characteristics were excluded.
- To have a good temporal coverage of samples within the reference dataset, we try to have a balanced sampling over the years within the period 1994-2012. By doing so, we avoid that years with high sampling effort in a certain habitat will have a higher influence on the reference values. Therefore, we attempt to have an equal amount of samples per year over the reference period. For years with more data, we randomly select a set of samples for the reference dataset.
- To have a good spatial coverage of samples within the reference dataset, we strive for balanced sampling across the BPNS within the period 1994-2012. We thus avoid a situation where certain areas with high sampling effort in a certain habitat will skew the reference values. Therefore, we aim for a balanced number of samples across the BPNS for each habitat type within the reference period. For areas with much more data, we randomly select a set of samples for the reference dataset.

The dataset that meets these criteria reflects the temporal and spatial characteristics of our soft-sediment bottom fauna under relatively good conditions (Figure 10). The only question we cannot answer is if these relatively good conditions are sustainable conditions or even real references. The BEQI assessment for soft-sediment habitats in the BPNS will determine if we are more or less in the same situation as defined by the ‘reference’ dataset or not. If the BEQI assessment signals a deviation (moderate or lower score), policymakers and scientists should then be triggered to start investigative research to define the source.

Figure 10. The diversity in soft-sediment fauna within the Belgian Part of the North Sea (photo credit: Hans Hillewaert, ILVO)

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6 Annex 1: Rules for harmonisation of taxa list for EU Directive assessment

Taxa = species + stage code (juvenie, spat, larvae, …) + gender code (male/female) Species and stage code are standardised.

1) WORMS list *(*www.marine**species**.org) as standard for the taxonomy and species name validation.
2) Exclusion of the following taxa:
    a. non-benthic phyla: e.g. fish, birds, insects
    b. species groups not representative of subtidal soft-sediment benthos on the BPNS

Cirrepedia	Hydrozoa	Porifera
Copepoda	Cnidaria	Cladocera
Ostracoda	Gastrotricha	
Bryozoa	Cephalopoda	
Chaetognatha	Nematoda	

    c. Exclusion of taxa and their records for which the identification level was too low (order, class, family), in the case that the majority of the individuals are identified on a lower taxonomical level (genus, species). Such type of species were mostly in bad shape, only a certain stage (juvenile, larvae, bivalvia spat) or in other words difficult to identify.

Polychaeta	Isopoda	Glyceridae
Amphipoda	Mysidacea	Melitidae
Cumacea	Crustacea	Oedicerotidae
Decapoda	Bivalvia	Pycnogonidae
Natantia	Gastropoda	Echinoidea
Caprellidae	Brachyura	Archiannelida?
Tannaidacea	Holothuroidea	Tubularidae

    d. Benthic taxa for which it is difficult to determine the density (e.g. fragmentation of specimen during sampling): e.g. *Nemertea*
    e. Taxa which were rare within the entire dataset of 35 years. Rare taxa were taxa which were present in less than 1% of the samples and with a maximum of 3 individuals. This last rule is only applied when selecting the final taxa dataset for the EU Directives and not for the analyses within this report.
3) The following rules are applied to harmonise the identification (e.g. lumping of taxa)
    a. Exclusion of spelling errors
    b. Synonymy (WORMS)
    c. Taxa which are always determined on a higher taxonmical level
        i. Oligochaeta, Cirratulidae
        ii. Anthozoa (Actinaria, Sagartia, + all others [except Edwardsidae]

d. Juveniles of certain taxa are discriminated as separate taxa. Juvenile taxa are excluded for the ecological status assessments of the three directives, but need to be discriminated in the regular sample handling

Glycera	*Bathyporeia*	*Ophiura*
Nephtys	*Urothoe*	*Ophiuroidea*
Nereis	*Diastylis*	*Spisula*
Phyllodoce	Crangonidae	
Scolelepis	Paguroidea	
	Liocarcinus	

e. Taxa for which the identification on species or genus level changed over the years, or between the projects are grouped on a higher taxonomical level. Identification to this level is minimally required in the regular sample handling.

Lumbrineris	*Atylus (behalve A. swam en N. falcatus)*	*Gastrosaccus*
Microphthalmus	*Apherusa*	*Schistomysis*
Pholoe	*Corophium*	*Praunus*
Eulalia	*Gammarus*	*Amphiura*
Eumida	*Jassa*	*Edwardsia*
Myrianida	*Melita*	*Edwardsiella*
Exogone	*Synchelidium*	*Thracia*
Syllis (Syllis + Typosyllis)	*Stenothoe*	*Astarte*
Pomatoceros	*Iphinoe*	*Mactra*
Magelona	*Pseudocuma*	*Venerupis*
Polydora	*Pestarella*	*Euspira*
Malacoceros	*Macropodia*	*Nudibranchia*
Ampharete	*Processa*	
Polycirrus	*Upogebia*	
Capitella		
Maldanidae		
Orbinia		
Aricidea		
Polygordius		

f. In some general taxa (*Urothoe, Bathyporeia, Nephtys*), many rare taxa were found next to the regular species. In these cases, a new taxon was created (e.g. *Urothoe other*). This taxon groups rare species within the common genera.

g. Certain taxa forms a species complex
    i. Glycera alba = Glycera alba + Glycera tridactyla
    ii. Eteone longa-flava
    iii. Phyllodoce mac/muc: Phyllodoce maculate + Phyllodoce mucosa
    iv. Mediomastus- Heteromastus: Mediomastus fragilis + Heteromastus filiformis

h. Some species appeared in the dataset at a certain time due to improved identification, but have probably already been present for a long time.
    i. *Mediomastus fragilis* (sinds 2010) (complex with *Heteromastus filiformis*), Phoronida, Protodriloides, *Streblospio benedicti*
    ii. *Nephtys assimilis* (end of the 1990s)

7 List of taxa considered in the assessment under the EU Directives (MSFD, WFD, HR).

Phylum	Class	Order	Family	Unified taxon name	AphialD	Authority_accepted
Annelida	Clitellata			Oligochaeta	2036	
Annelida	Polychaeta	Eunicida	Dorvilleidae	Dorvillea	129261	Parfitt, 1866
Annelida	Polychaeta	Eunicida	Dorvilleidae	Parougia eliasoni	130037	(Oug, 1978)
Annelida	Polychaeta	Eunicida	Dorvilleidae	Protodorvillea kefersteini	130041	(McIntosh, 1869)
Annelida	Polychaeta	Eunicida	Lumbrineridae	Lumbrineris	129337	Blainville, 1828
Annelida	Polychaeta	Phyllodocida	Aphroditidae	Aphrodita aculeata	129840	Linnaeus, 1758
Annelida	Polychaeta	Phyllodocida	Glyceridae	Glycera alba	130116	(O.F. Müller, 1776)
Annelida	Polychaeta	Phyllodocida	Glyceridae	Glycera lapidum	130123	Quatrefages, 1866
Annelida	Polychaeta	Phyllodocida	Glyceridae	Glycera unicornis	130131	Savigny in Lamarck, 1818
Annelida	Polychaeta	Phyllodocida	Goniadidae	Goniada maculata	130140	Örsted, 1843
Annelida	Polychaeta	Phyllodocida	Goniadidae	Goniadella bobretzkii	147475	(Annenkova, 1929)
Annelida	Polychaeta	Phyllodocida	Hesionidae	Microphthalmus	129313	Mecznikow, 1865
Annelida	Polychaeta	Phyllodocida	Hesionidae	Podarkeopsis capensis	130195	(Day, 1963)
Annelida	Polychaeta	Phyllodocida	Nephtyidae	Nephtys assimilis	130353	Örsted, 1843
Annelida	Polychaeta	Phyllodocida	Nephtyidae	Nephtys caeca	130355	(Fabricius, 1780)
Annelida	Polychaeta	Phyllodocida	Nephtyidae	Nephtys cirrosa	130357	(Ehlers, 1868)
Annelida	Polychaeta	Phyllodocida	Nephtyidae	Nephtys hombergii	130359	Savigny in Lamarck, 1818
Annelida	Polychaeta	Phyllodocida	Nephtyidae	Nephtys longosetosa	130364	Örsted, 1842
Annelida	Polychaeta	Phyllodocida	Nereididae	Alitta succinea	234850	(Leuckart, 1847)
Annelida	Polychaeta	Phyllodocida	Nereididae	Eunereis longissima	130375	Johnston, 1840
Annelida	Polychaeta	Phyllodocida	Nereididae	Neanthes irrorata	130389	(Malmgren, 1867)
Annelida	Polychaeta	Phyllodocida	Pholoidae	Pholoe	129439	Johnston, 1839
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Eulalia	129445	Savigny, 1818
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Eumida	129446	Malmgren, 1865
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Hesionura elongata	130649	(Southern, 1914)
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Hypereteone foliosa	152250	(Quatrefages, 1865)
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce groenlandica	334506	Örsted, 1842
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce lineata	334508	(Claparède, 1870)
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce mac/muc	129455	Lamarck, 1818
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Phyllodoce rosea	334514	(McIntosh, 1877)
Annelida	Polychaeta	Phyllodocida	Phyllodocidae	Eteone longa-flava		
Annelida	Polychaeta	Phyllodocida	Polynoidae	Polynoidae	939	Malmgren, 1867

Phylum	Class	Order	Family	Unified taxon name	AphiaID	Authority_accepted
Annelida	Polychaeta	Phyllodocida	Sigalionidae	Pisione remota	130707	(Southern, 1914)
Annelida	Polychaeta	Phyllodocida	Sigalionidae	Sigalion mathildae	131072	Audouin & Milne Edwards in Cuvier, 1830
Annelida	Polychaeta	Phyllodocida	Sigalionidae	Sthenelais boa	131074	(Johnston, 1833)
Annelida	Polychaeta	Phyllodocida	Syllidae	Eusyllis	129653	Malmgren, 1867
Annelida	Polychaeta	Phyllodocida	Syllidae	Exogone	129654	Örsted, 1845
Annelida	Polychaeta	Phyllodocida	Syllidae	Myrianida	129659	Milne Edwards, 1845
Annelida	Polychaeta	Phyllodocida	Syllidae	Odontosyllis	129660	Claparède, 1863
Annelida	Polychaeta	Phyllodocida	Syllidae	Sphaerosyllis	129677	Claparède, 1863
Annelida	Polychaeta	Phyllodocida	Syllidae	Streptodonta pterochaeta	238207	(Southern, 1914)
Annelida	Polychaeta	Phyllodocida	Syllidae	Streptosyllis websteri	131402	Southern, 1914
Annelida	Polychaeta	Phyllodocida	Syllidae	Syllinae	152223	Rioja, 1925
Annelida	Polychaeta	Sabellida	Fabriciidae	Fabriciidae	154918	Rioja, 1923
Annelida	Polychaeta	Sabellida	Fabriciidae	Manayunkia	129535	Leidy, 1859
Annelida	Polychaeta	Sabellida	Oweniidae	Owenia fusiformis	130544	Delle Chiaje, 1844
Annelida	Polychaeta	Sabellida	Sabellariidae	Sabellariidae	979	Johnston, 1865
Annelida	Polychaeta	Sabellida	Sabellidae	Sabellidae	985	Latreille, 1825
Annelida	Polychaeta	Sabellida	Serpulidae	Spirobranchus	129582	Blainville, 1818
Annelida	Polychaeta	Spionida	Magelonidae	Magelona	129341	F. Müller, 1858
Annelida	Polychaeta	Spionida	Poecilochaetidae	Poecilochaetus serpens	130711	Allen, 1904
Annelida	Polychaeta	Spionida	Spionidae	Aonides oxycephala	131106	(Sars, 1862)
Annelida	Polychaeta	Spionida	Spionidae	Aonides paucibranchiata	131107	Southern, 1914
Annelida	Polychaeta	Spionida	Spionidae	Malacoceros	129614	Quatrefages, 1843
Annelida	Polychaeta	Spionida	Spionidae	Polydora	129619	Bosc, 1802
Annelida	Polychaeta	Spionida	Spionidae	Pygospio elegans	131170	Claparède, 1863
Annelida	Polychaeta	Spionida	Spionidae	Scolelepis bonnieri	131171	(Mesnil, 1896)
Annelida	Polychaeta	Spionida	Spionidae	Scolelepis squamata	157566	(O.F. Muller, 1806)
Annelida	Polychaeta	Spionida	Spionidae	Spio	129625	Fabricius, 1785
Annelida	Polychaeta	Spionida	Spionidae	Spiophanes bombyx	131187	(Claparède, 1870)
Annelida	Polychaeta	Spionida	Spionidae	Streblospio benedicti	131191	Webster, 1879
Annelida	Polychaeta	Terebellida	Acrocirridae	Macrochaeta helgolandica	129746	Friedrich, 1936
Annelida	Polychaeta	Terebellida	Ampharetidae	Ampharete	129155	Malmgren, 1866
Annelida	Polychaeta	Terebellida	Cirratulidae	Cirratulidae	919	Carus, 1863

Phylum	Class	Order	Family	Unified taxon name	AphiaID	Authority_accepted
Annelida	Polychaeta	Terebellida	Pectinariidae	Lagis koreni	152367	Malmgren, 1866
Annelida	Polychaeta	Terebellida	Terebellidae	Eupolymnia nebulosa	131489	(Montagu, 1818)
Annelida	Polychaeta	Terebellida	Terebellidae	Lanice conchilega	131495	(Pallas, 1766)
Annelida	Polychaeta	Terebellida	Terebellidae	Polycirrus	129710	Grube, 1850
Annelida	Polychaeta	Terebellida	Terebellidae	Thelepus cincinnatus	131543	(Fabricius, 1780)
Annelida	Polychaeta		Arenicolidae	Arenicola marina	129868	(Linnaeus, 1758)
Annelida	Polychaeta		Capitellidae	Capitella	129211	Blainville, 1828
Annelida	Polychaeta		Capitellidae	Notomastus latericeus	129898	Sars, 1851
Annelida	Polychaeta		Capitellidae	Heteromastus-Mediomastus		
Annelida	Polychaeta		Maldanidae	Maldanidae	923	Malmgren, 1867
Annelida	Polychaeta		Opheliidae	Ophelia borealis	130491	Quatrefages, 1866
Annelida	Polychaeta		Opheliidae	Travisia forbesii	130512	Johnston, 1840
Annelida	Polychaeta		Opheliidae	Thoracophelia flabellifera	339492	Ziegelmeier, 1955
Annelida	Polychaeta		Orbiniidae	Orbinia	129420	Quatrefages, 1865
Annelida	Polychaeta		Orbiniidae	Scoloplos armiger	334772	(Müller, 1776)
Annelida	Polychaeta		Paraonidae	Aricidea	129430	Webster, 1879
Annelida	Polychaeta		Paraonidae	Paraonis fulgens	146932	(Levinsen, 1884)
Annelida	Polychaeta		Polygordiidae	Polygordius	129472	Schneider, 1868
Annelida	Polychaeta		Protodrilidae	Protodrilus	129514	Hatschek, 1881
Annelida	Polychaeta		Protodriloididae	Protodriloides	129513	Jouin, 1966
Annelida	Polychaeta		Psammodrilidae	Psammodrilus balanoglossoides	130859	Swedmark, 1952
Echinodermata	Asteroidea	Forcipulatida	Asteriidae	Asterias rubens	123776	Linnaeus, 1758
Echinodermata	Echinoidea	Clypeasteroida	Echinocyamidae	Echinocyamus pusillus	124273	(O.F. Müller, 1776)
Echinodermata	Echinoidea	Spatangoida	Loveniidae	Echinocardium cordatum	124392	(Pennant, 1777)
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	Acrocnida brachiata	236130	(Montagu, 1804)
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	Amphipholis squamata	125064	(Delle Chiaje, 1828)
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	Amphiura	123613	Forbes, 1843
Echinodermata	Ophiuroidea	Ophiurida	Ophiotrichidae	Ophiothrix fragilis	125131	(Abildgaard, in O.F. Müller, 1789)
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	Ophiocten affinis	124850	(Lütken, 1858)
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	Ophiura albida	124913	Forbes, 1839
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	Ophiura ophiura	124929	(Linnaeus, 1758)

Phylum	Class	Order	Family	Unified taxon name	AphiaID	Authority_accepted
Arthropoda	Malacostraca	Amphipoda	Ampeliscidae	Ampelisca brevicornis	101891	(Costa, 1853)
Arthropoda	Malacostraca	Amphipoda	Amphilochidae	Amphilochus	101450	Bate, 1862
Arthropoda	Malacostraca	Amphipoda	Aoridae	Aora gracilis	102012	(Bate, 1857)
Arthropoda	Malacostraca	Amphipoda	Atylidae	Atylus	101497	Leach, 1815
Arthropoda	Malacostraca	Amphipoda	Bathyporeiidae	Bathyporeia elegans	103058	Watkin, 1938
Arthropoda	Malacostraca	Amphipoda	Bathyporeiidae	Bathyporeia guilliamsoniana	103060	(Bate, 1857)
Arthropoda	Malacostraca	Amphipoda	Bathyporeiidae	Bathyporeia pelagica	103066	(Bate, 1856)
Arthropoda	Malacostraca	Amphipoda	Bathyporeiidae	Bathyporeia pilosa	103068	Lindström, 1855
Arthropoda	Malacostraca	Amphipoda	Bathyporeiidae	Bathyporeia sarsi	103073	Watkin, 1938
Arthropoda	Malacostraca	Amphipoda	Bathyporeiidae	Bathyporeia other		
Arthropoda	Malacostraca	Amphipoda	Calliopiidae	Apherusa	101509	Walker, 1891
Arthropoda	Malacostraca	Amphipoda	Caprellidae	Pariambus typicus	101857	(Krøyer, 1884)
Arthropoda	Malacostraca	Amphipoda	Caprellidae	Phtisica marina	101864	Slabber, 1769
Arthropoda	Malacostraca	Amphipoda	Cheirocratidae	Cheirocratus	101669	Norman, 1867
Arthropoda	Malacostraca	Amphipoda	Corophiidae	Corophium	101489	Latreille, 1806
Arthropoda	Malacostraca	Amphipoda	Gammaridae	Gammarus	101537	Fabricius, 1775
Arthropoda	Malacostraca	Amphipoda	Haustoriidae	Haustorius arenarius	102317	(Slabber, 1769)
Arthropoda	Malacostraca	Amphipoda	Ischyroceridae	Ericthonius punctatus	102408	(Bate, 1857)
Arthropoda	Malacostraca	Amphipoda	Ischyroceridae	Jassa	101571	Leach, 1814
Arthropoda	Malacostraca	Amphipoda	Leucothoidae	Leucothoe incisa	102460	(Robertson, 1892)
Arthropoda	Malacostraca	Amphipoda	Leucothoidae	Leucothoe lilljeborgi	102462	Boeck, 1861
Arthropoda	Malacostraca	Amphipoda	Lysianassidae	Orchomenella nana	102691	(Krøyer, 1846)
Arthropoda	Malacostraca	Amphipoda	Maeridae	Maerella tenuimana	102831	(Bate, 1862)
Arthropoda	Malacostraca	Amphipoda	Megaluropidae	Megaluropus agilis	102783	Hoeck, 1889
Arthropoda	Malacostraca	Amphipoda	Melitidae	Abludomelita obtusata	102788	(Montagu, 1813)
Arthropoda	Malacostraca	Amphipoda	Melitidae	Melita other		
Arthropoda	Malacostraca	Amphipoda	Microprotopidae	Microprotopus maculatus	102380	Norman, 1867
Arthropoda	Malacostraca	Amphipoda	Oedicerotidae	Perioculodes longimanus	102915	(Bate & Westwood, 1868)
Arthropoda	Malacostraca	Amphipoda	Oedicerotidae	Pontocrates altamarinus	102916	(Bate & Westwood, 1862)
Arthropoda	Malacostraca	Amphipoda	Oedicerotidae	Pontocrates arenarius	102918	(Bate, 1858)
Arthropoda	Malacostraca	Amphipoda	Oedicerotidae	Synchelidium	101704	Sars, 1895
Arthropoda	Malacostraca	Amphipoda	Photidae	Photis	101563	Krøyer, 1842

Phylum	Class	Order	Family	Unified taxon name	AphiaID	Authority_accepted
Arthropoda	Malacostraca	Amphipoda	Sophrosynidae	Sophrosyne robertsoni	102729	Stebbing & Robertson, 1891
Arthropoda	Malacostraca	Amphipoda	Stenothoidae	Stenothoe	101770	Dana, 1852
Arthropoda	Malacostraca	Amphipoda	Unciolidae	Unciola planipes	102061	Norman, 1867
Arthropoda	Malacostraca	Amphipoda	Urothoidae	Urothoe brevicornis	103226	Bate, 1862
Arthropoda	Malacostraca	Amphipoda	Urothoidae	Urothoe elegans	103228	(Bate, 1857)
Arthropoda	Malacostraca	Amphipoda	Urothoidae	Urothoe poseidonis	103235	Reibish, 1905
Arthropoda	Malacostraca	Amphipoda	Urothoidae	Urothoe other		
Arthropoda	Malacostraca	Cumacea	Bodotriidae	Bodotria	110387	Goodsir, 1843
Arthropoda	Malacostraca	Cumacea	Bodotriidae	Cumopsis	110393	G.O. Sars, 1865
Arthropoda	Malacostraca	Cumacea	Bodotriidae	Iphinoe	110391	Bate, 1856
Arthropoda	Malacostraca	Cumacea	Diastylidae	Diastylis bradyi	110472	Norman, 1879
Arthropoda	Malacostraca	Cumacea	Diastylidae	Diastylis rathkei	110487	(Krøyer, 1841)
Arthropoda	Malacostraca	Cumacea	Diastylidae	Diastylis rugosa	110488	Sars, 1865
Arthropoda	Malacostraca	Cumacea	Pseudocumatidae	Pseudocuma	110427	G.O. Sars, 1865
Arthropoda	Malacostraca	Decapoda	Callianassidae	Pestarella	147087	Ngoc-Ho, 2003
Arthropoda	Malacostraca	Decapoda	Corystidae	Corystes cassivelaunus	107277	(Pennant, 1777)
Arthropoda	Malacostraca	Decapoda	Crangonidae	Crangon crangon	107552	(Linnaeus, 1758)
Arthropoda	Malacostraca	Decapoda	Crangonidae	Philocheras trispinosus	107562	(Hailstone in Hailstone & Westwood, 1835)
Arthropoda	Malacostraca	Decapoda	Diogenidae	Diogenes pugilator	107199	(Roux, 1829)
Arthropoda	Malacostraca	Decapoda	Hippolytidae	Hippolyte varians	107518	Leach, 1814 [in Leach, 1813-1814]
Arthropoda	Malacostraca	Decapoda	Inachidae	Macropodia	205077	Leach, 1814
Arthropoda	Malacostraca	Decapoda	Leucosiidae	Ebalia	106889	Leach, 1817
Arthropoda	Malacostraca	Decapoda	Majidae	Majidae	106760	Samouelle, 1819
Arthropoda	Malacostraca	Decapoda	Paguridae	Pagurus bernhardus	107232	(Linnaeus, 1758)
Arthropoda	Malacostraca	Decapoda	Paguridae	Pagurus pubescens	107240	Krøyer, 1838
Arthropoda	Malacostraca	Decapoda	Pinnotheridae	Pinnotheres pisum	107473	(Linnaeus, 1767)
Arthropoda	Malacostraca	Decapoda	Polybiidae	Liocarcinus holsatus	107388	(Fabricius, 1798)
Arthropoda	Malacostraca	Decapoda	Polybiidae	Liocarcinus marmoreus	107390	(Leach, 1814)
Arthropoda	Malacostraca	Decapoda	Polybiidae	Liocarcinus navigator	107392	(Herbst, 1794)
Arthropoda	Malacostraca	Decapoda	Polybiidae	Liocarcinus pusillus	107393	(Leach, 1816)
Arthropoda	Malacostraca	Decapoda	Polybiidae	Liocarcinus vernalis	107394	(Risso, 1816)
Arthropoda	Malacostraca	Decapoda	Porcellanidae	Pisidia longicornis	107188	(Linnaeus, 1767)

Phylum	Class	Order	Family	Unified taxon name	AphiaID	Authority_accepted
Arthropoda	Malacostraca	Decapoda	Portunidae	Portumnus latipes	107400	(Pennant, 1777)
Arthropoda	Malacostraca	Decapoda	Processidae	Processa	107054	Leach, 1815 [in Leach, 1815-1875]
Arthropoda	Malacostraca	Decapoda	Thiidae	Thia scutellata	107281	(Fabricius, 1793)
Arthropoda	Malacostraca	Decapoda	Upogebiidae	Upogebia	107079	Leach, 1814
Arthropoda	Malacostraca	Isopoda	Cirolanidae	Eurydice pulchra	118852	Leach, 1815
Arthropoda	Malacostraca	Isopoda	Cirolanidae	Eurydice spinigera	148637	Hansen, 1890
Arthropoda	Malacostraca	Isopoda	Dajidae	Prodajus ostendensis	148638	Gilson, 1909
Arthropoda	Malacostraca	Isopoda	Idoteidae	Idotea linearis	119046	(Linnaeus, 1766)
Arthropoda	Malacostraca	Mysida	Mysidae	Gastrosaccus	119859	Norman, 1868
Arthropoda	Malacostraca	Tanaidacea	Paratanaoidea incertae sedis	Pseudoparatanais batei	136457	(Sars G.O., 1882)
Arthropoda	Malacostraca	Tanaidacea	Tanaissuidae	Tanaissus lilljeborgi	136486	(Stebbing, 1891)
Arthropoda	Pycnogonida	Pantopoda	Nymphonidae	Nymphon brevirostre	150520	Hodge, 1863
Arthropoda	Pycnogonida	Pantopoda	Phoxichilidiidae	Anoplodactylus petiolatus	134723	(Krøyer, 1844)
Mollusca	Bivalvia	[unassigned] Euheterodonta	Pharidae	Ensis directus	140732	(Conrad, 1843)
Mollusca	Bivalvia	[unassigned] Euheterodonta	Pharidae	Ensis magnus	160539	Schumacher, 1817
Mollusca	Bivalvia	[unassigned] Euheterodonta	Pharidae	Phaxas pellucidus	140737	(Pennant, 1777)
Mollusca	Bivalvia	Anomalodesmata	Thraciidae	Thracia	138549	Blainville, 1824
Mollusca	Bivalvia	Arcoida	Noetiidae	Striarca lactea	140571	(Linnaeus, 1758)
Mollusca	Bivalvia	Carditoida	Astartidae	Astarte	137683	J. de C. Sowerby, 1816
Mollusca	Bivalvia	Carditoida	Astartidae	Goodallia triangularis	138831	(Montagu, 1803)
Mollusca	Bivalvia	Myoida	Myidae	Mya	138211	Linnaeus, 1758
Mollusca	Bivalvia	Myoida	Myidae	Sphenia binghami	140432	Turton, 1822
Mollusca	Bivalvia	Myoida	Pholadidae	Barnea candida	140767	(Linnaeus, 1758)
Mollusca	Bivalvia	Pectinoida	Pectinidae	Aequipecten opercularis	140687	(Linnaeus, 1758)
Mollusca	Bivalvia	Veneroida	Cardiidae	Cerastoderma edule	138998	(Linnaeus, 1758)
Mollusca	Bivalvia	Veneroida	Donacidae	Donax vitatus	139604	(da Costa, 1778)
Mollusca	Bivalvia	Veneroida	Mactridae	Lutraria lutraria	140295	(Linnaeus, 1758)
Mollusca	Bivalvia	Veneroida	Mactridae	Mactra	138158	Linnaeus, 1767

Phylum	Class	Order	Family	Unified taxon name	AphiaID	Authority_accepted
Mollusca	Bivalvia	Veneroida	Mactridae	Spisula elliptica	140300	(Brown, 1827)
Mollusca	Bivalvia	Veneroida	Mactridae	Spisula solida	140301	(Linnaeus, 1758)
Mollusca	Bivalvia	Veneroida	Mactridae	Spisula subtruncata	140302	(da Costa, 1778)
Mollusca	Bivalvia	Veneroida	Montacutidae	Kurtiella bidentata	345281	(Montagu, 1803)
Mollusca	Bivalvia	Veneroida	Montacutidae	Tellimya ferruginosa	146952	(Montagu, 1808)
Mollusca	Bivalvia	Veneroida	Semelidae	Abra alba	141433	(W. Wood, 1802)
Mollusca	Bivalvia	Veneroida	Semelidae	Abra prismatica	141436	(Montagu, 1808)
Mollusca	Bivalvia	Veneroida	Tellinidae	Macoma balthica	141579	(Linnaeus, 1758)
Mollusca	Bivalvia	Veneroida	Tellinidae	Moerella donacina	147021	(Linnaeus, 1758)
Mollusca	Bivalvia	Veneroida	Tellinidae	Moerella pygmaea	147022	(Lovén, 1846)
Mollusca	Bivalvia	Veneroida	Tellinidae	Tellina fabula	141587	Gmelin, 1791
Mollusca	Bivalvia	Veneroida	Tellinidae	Tellina tenuis	141595	da Costa, 1778
Mollusca	Bivalvia	Veneroida	Ungulinidae	Diplodonta	138621	Bronn, 1831
Mollusca	Bivalvia	Veneroida	Veneridae	Petricolaria pholadiformis	156961	(Lamarck, 1818)
Mollusca	Bivalvia	Veneroida	Veneridae	Polititapes rhomboides	745846	(Pennant, 1777)
Mollusca	Bivalvia	Veneroida	Veneridae	Venerupis	138647	Lamarck, 1818
Mollusca	Gastropoda	[unassigned] Caenogastropoda	Epitoniidae	Epitonium clathrus	146905	(Linnaeus, 1758)
Mollusca	Gastropoda	Littorinimorpha	Caecidae	Caecum glabrum	138952	(Montagu, 1803)
Mollusca	Gastropoda	Littorinimorpha	Calyptraeidae	Crepidula fornicata	138963	(Linnaeus, 1758)
Mollusca	Gastropoda	Littorinimorpha	Naticidae	Euspira	138239	Agassiz in J. Sowerby, 1837
Mollusca	Gastropoda	Neogastropoda	Nassariidae	Nassarius reticulatus	140513	(Linnaeus, 1758)
Mollusca	Gastropoda	Nudibranchia		NUDIBRANCHIA	1762	Cuvier, 1817
Chordata	Ascidiacea			ASCIDIACEA	1839	Nielsen, 1995
Chordata	Leptocardii		Branchiostomatidae	Branchiostoma lanceolatum	104906	(Pallas, 1774)
Cnidaria	Anthozoa	Actiniaria	Edwardsiidae	Edwardsia	100730	Quatrefages, 1842
Cnidaria	Anthozoa			Anthozoa	1292	Ehrenberg, 1834
Phoronida				Phoronida	1789	Hatschek, 1888
Sipunculida				Sipuncula	1268	

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This publication is available upon request of Gert Van Hoey

Van Hoey Gert, Jan Vanaverbeke, Steven Degraer, 2014. Study related to the realization of the Water Framework Directive intercalibration for the Belgian Coastal waters, to design the descriptive elements 1 and 6 of the Marine Strategy Framework Directive and the nature objectives of the Habitat Directive for invertebrate bottom fauna of soft substrates. ILVO-mededeling 170, 56 pages

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