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Follow-up on initiatives taken by the TMAP ad hoc working group fish in 2006.

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1. Background

Trilateral Cooperation

Since 1978, The Netherlands, Denmark and Germany have been working together on the protection and conservation of the Wadden Sea covering management, monitoring and research, and political matters. An important element of the Trilateral Cooperation with regards to monitoring and research is the Quality Status Report (QSR). This report is published every 5 years and it presents the results various ongoing monitoring programs in the Wadden Sea. Another important element of the Trilateral Cooperation is the Trilateral Monitoring and Assessment Program (TMAP) which aims at providing a scientific assessment of the status and changes in the ecosystem, and the effectiveness of implementing targets set by Trilateral Wadden Sea Plan. The results of these monitoring and assessment programs are presented in the QSR. Finally, the Trilateral Cooperation with regards to monitoring and research is facilitated and enhanced by means of the International Scientific Wadden Sea Symposia.

Fish play (both as predator as well as prey) an important role in the ecology of the Wadden Sea, and the Wadden Sea is an important habitat for (certain life stages of) various fish species. The importance of fish for the Wadden Sea and visa versa has not been recognized sufficiently within the Trilateral Cooperation. Although a chapter on fish was included in the Quality Status Reports of 1999 (De Jong et. al., 1999) and 2004 (Vorberg et. al., 2004), fish are not included in the TMAP, nor is fish mentioned (explicitly) in the Wadden Sea Plan. A closer international cooperation and more focus on fish monitoring and research was recommended by the QSR 2004 and the 11th International Scientific Wadden Sea Symposium (2005).

TMAP ad hoc working group fish

The recommendations in the QSR 2004 have led to the instigation of the TMAP ad hoc working group fish. The main objectives of this group are:

- 1) to support the TMAP Revision process (Monitoring for Wadden Sea Plan and EU Directives) and
- 2) to enhance the comparability and consistency of Wadden Sea monitoring methods and data based on the QSR 2004 experiences.

The group reports to the Trilateral Monitoring and Assessment Group (TMAG), through the Common Wadden Sea Secretariat (CWSS).

The group met for the first time in Hamburg on 29-30 March 2006. A large group of fish experts was invited, including scientists working in other areas than the Wadden Sea. The nature of the meeting was mainly informative; presentations were given about ongoing monitoring programs and the development of assessment methods and tools. The group also formulated a number of short term and longer term tasks and recommendations (TMAP, 2006a).

As insufficient time was available at the March meeting to draft a report to TMAG, a sub-group was invited in Wilhelmshaven on July 3rd, 2006. This sub-group identified 2 topics / recommendations which required further attention and needed follow-up work before submitting the report to TMAG:

- 1) The preparation of a list of typical/important Wadden Sea fish species and the selection of species for TMAP/QSR .
- 2) The evaluation of the applicability of the fish-assessment-tool approach that was developed for the Water Framework Directive (WFD) in transitional waters.

The follow-up work and the report were completed by correspondence. The report was submitted to TMAG in August (TMAP, 2006b).

The sub-group re-convened in Haren on November 20th, 2006 with the specific goal to jointly discuss the progress and directions taken with regards to the species list and selection (see Section 2) and the evaluation of the applicability of the WFD approach (see Section 3).

Work commissioned by RWS RIKZ

Part of the work that was carried out by IMARES for the TMAP ad hoc working group on fish was commissioned and financed by the National Institute for Coastal and Marine Management (RWS RIKZ). This work consisted of the following:

- 1) Participation in the working group meeting held in Haren in November 2007 (see above).
- 2) Further work on the fish species table after the November meeting (see Section 2 and Annex 1)
- 3) Develop a strategy of approach for follow-up work to be carried out in 2007 (see Section 4)

2. Fish species list

During the March meeting of the TMAP ad hoc working group fish it was recommended to prepare a list of typical/important Wadden Sea fish species.

During the July meeting it was decided that this list should consist of the species currently present in the Wadden Sea, based on the abundance and occurrence in the ongoing monitoring programs in the last 5 years. It was also decided that this list should serve as basis for a “bottom-up” selection of fish species for monitoring within TMAP/QSR context, by including selection criteria columns in the table.

After the meeting all participants who are responsible for monitoring programs supplied data on species composition, abundance and presence/absence in the last 5 years, and these data were compiled into one table by IMARES. Furthermore, the table was elaborated by IMARES: additional selection criteria were added and a scoring system was included.

During the November meeting the group elaborately discussed the relevancy and contents of the selection criteria columns, the scoring and weighting procedures for selecting priority species, and further elaboration of the table (e.g. life style description, fyke data). The table was updated accordingly after the meeting by IMARES.

The current status of the fish species table is presented in Annex 1: Wadden Sea Fish Fauna. An explanation of the table, the parameters and the scoring system is also presented in the Annex.

3. Applicability of the WFD approach

The evaluation of the applicability of the WFD approach was another recommendation done by the working group meeting in March, which was followed-up after the meeting in July. CWSS contracted Bioconsult to carry out “phase I” of the development of an assessment procedure comparable to the WFD approach for transitional waters. This phase consisted of a theoretical evaluation of the applicability (Bioconsult, 2006). It was concluded that “establishment of a formalized fish-based assessment procedure for the trilateral cooperation region orientated to the basic features of the procedure for the transitional waters seems possible in principle”. However, it was also pointed out that data analyses are required before a final judgment can be given on the applicability of the WFD approach. Bioconsult formulated a “phase II” in which literature research and data analyses are carried out. Based on these results it should be possible to conclude whether or not to continue with “phase III” in which an assessment procedure is developed.

The basic feature of the WFD approach is evaluating the present state of an ecosystem by comparing it to predefined targets, with the goal to develop management measures to achieve these targets. However, the feasibility of this approach for the Wadden Sea fish fauna evoked a great deal of discussion within the group. Two mayor points of concern were expressed by the group. Firstly, how to provide a scientific sound definition of the targets. The lack of (quantitative) historic data makes it impossible to describe a pristine situation which can be used as basis for the targets. And it was generally agreed that “more” is not necessarily “better”. Secondly, the complexity of the Wadden Sea ecosystem and the lack of fundamental scientific knowledge makes it extremely difficult

to identify the driving forces behind the observed changes, and hence to define management measures to achieve targets. Changes in the Wadden Sea fish fauna can be caused by human pressures, but also by natural variability. They can be a result of local processes (occurring within the Wadden Sea or part of the Wadden Sea) or of large scale processes (occurring in the connected marine or freshwater systems). Furthermore, it is difficult to disentangle direct effects and indirect effects caused by inter-specific interactions.

Despite the present inability to define absolute targets, it was generally agreed that monitoring is important. Population parameters such as abundance, biomass, age structure should be monitored to enable references to any identifiable changes in the fish fauna. Furthermore, more fundamental research is required to obtain a better understanding of the driving forces causing changes in the Wadden Sea ecosystem and fish assemblages.

Although the direct adoption of the WFD approach for transitional waters is clearly hampered by the present inability to define absolute targets for the Wadden Sea fish fauna, the group agreed that the methodology can be adapted and be put to use for the Wadden Sea fish fauna. An assessment tool consisting of indicator species and parameters can be developed. And, instead of comparing the observed values to an absolute target and assessing the status as “good” or “bad”, the observed values can be compared to the long term average, so changes in indicator species and parameters can be identified and if possible related to causal factors.

4. Strategy of approach for follow-up

The TMAP ad hoc working group fish agreed on 4 steps which are required to be able to prepare an assessment tool. The present document suggests an additional step, i.e. a literature study. Each of these steps is discussed in more detail in the following sections.

1. Reference species list
2. Selection of key species
3. Data analysis
4. Literature study
5. Recommendation TMAP assessment tool

Important note: All above mentioned steps can only take place in cooperation with the CWSS and the TMAP ad hoc working group fish. The available data from the various monitoring studies are exclusively used within the framework of the project.

4.1 Reference species list

Although quantitative historic data is lacking, anecdotal historic data exists on species composition in the Wadden Sea. It was decided to compile a reference list of all species ever encountered in the Wadden Sea. For this new Wadden Sea fish species list information presented in *Fishes and fisheries of the Wadden Sea* (Witte and Zijlstra, 1978; Zijlstra, 1978), the *Schleswig-Holstein Fish Atlas* (Vorberg & Breckling 1999) and the 30-year data set from DFS and DYFS will be used.

Mr Ralf Vorberg (Marine Science Service, Germany) offered to compile the list and screen the anecdotal data on reliability. IMARES (Netherlands) and Bundesforschungsanstalt für Fischerei (Germany) will supply species composition data for the full time series of the DFS (Netherlands) and the DYFS (Germany) surveys. The data extractions from the databases in the Netherlands and Germany will require thorough screening for input errors and consistency in species identifications, and may require inputting of data into the computer (as the historic data of non-commercial species has seldom been used).

Deliverable:

- *Reference species list for Wadden Sea fish fauna.*

4.2 Selection of key species

The TMAP ad hoc working group fish has already prepared a present-day species list (see Section 2 and Table 1 in Annex 1). However, this table is not necessarily final. Possibly, the monitoring data can be elaborated if the fyke data collected by the Royal Netherlands Institute for Sea Research are made available. Furthermore, the information presented in the selection criteria columns may need to be updated based on new insights due to ongoing research.

In principle, Table 1 in Annex 1 supplies all information required to be able to select key species. Although the scoring system attempts to provide an objective quantitative tool to select these key species, it is still necessary that all participants of the TMAP ad hoc working group fish, and if possible other experts in the field of fish ecology, review the quantitative and qualitative criteria and support a joint decision on the selection of species. The selected species will be included in the data analysis (step 3, Section 4.3), and depending on the results they may or may not be included in an assessment tool.

Deliverables:

- *Update of present-day species list for Wadden Sea fish fauna*
- *List of key species to be included in the data analysis*

4.3 Data analysis

Analysis of the monitoring data from different surveys is required to be able to judge which species, parameters and surveys are suitable to include in an assessment tool. Starting point for these analysis is the list of key species developed in step 2 (see Section 4.2). Furthermore, the survey data will probably form the basis for the definition of abundance reference values as historic data on abundance are absent.

The analysis will include:

- estimation of relative gear efficiency for the 2 beam trawl surveys
- qualitative evaluation of gear comparability for species composition and abundance estimates
- statistical analysis of temporal trends for stow-net and beam-trawl data
- statistical analysis of spatial trends for beam-trawl data
- if possible, statistical analysis of seasonal trends using incidental survey data
- if possible, statistical analysis will include potential causal factors
- testing of potential assessment parameters
- determination of long-term averages of proposed assessment parameters

A data analysis workshop will be organised by CWSS in the first half of 2007. Only a subgroup of the ad hoc working group fish (only those participants in charge of monitoring data?) will participate in the data analysis workshop to enhance the efficiency of the workshop. Prior to the workshop, the required statistical tests, programmes and data exchange formats will be discussed by correspondence. Furthermore, the data will be complete and checked for errors prior to the workshop.

Deliverables:

- *Report of the data analysis*
- *Proposal on which species, parameters and surveys are suitable for an assessment tool*

4.4 Literature study

Three aspects of the literature on fish fauna are relevant within the present context:

- Historic data Wadden Sea (relevant for reference situation)
- Ecological studies (relevant for identification of causal relationships)
- Development indicators (relevant for development of an assessment tool for the Wadden Sea)

The general opinion of the TMAP ad hoc working group fish is that all historical information on Wadden Sea fish fauna is confined to the references mentioned in Section 4.1. Therefore, it was

decided NOT to invest time in trying to find other historic data on species composition and/or abundance estimates of the Wadden Sea fish fauna.

All available knowledge on the ecology of the key species and the Wadden Sea ecosystem should be incorporated or taken into account in the process of analysing temporal and spatial trends and developing an assessment tool. Please note that it is doubtful whether the state of the art is sufficient to identify most of the causal factors underlying the observed changes, and that an understanding of the causal relationships is required in order to develop meaningful assessment tools and management targets. Nevertheless, a first step towards the development of an assessment tool will be undertaken based on the present knowledge. Although a thorough search of the peer-reviewed and grey literature may reduce the risk over overlooking relevant ecological studies, such a literature study will be time consuming and it is uncertain if it will be cost effective. Therefore it was decided NOT to include a literature study on ecological studies in the TMAP follow-up work.

In the development of a TMAP assessment tool, only the WFD approach for transitional waters has been considered. However, the Wadden Sea clearly is a more complex and larger system than the water-bodies addressed by the WFD approach for transitional waters. Therefore it would be worthwhile to examine the literature concerning development of indicators in marine ecosystems and evaluate the applicability of these indicators for the Wadden Sea. Examples are Daan (2000), INDECO (2005) and Jennings (2005).

Deliverables:

- *Working document (to the TMAP ad hoc working group fish) summarising the indicators developed for marine ecosystems and evaluating their applicability to the Wadden Sea*

4.5 Recommendation TMAP assessment tool

After steps 1 to 4 have been carried out (see Sections 4.1 - 4.4), it should be possible to reach consensus on the feasibility and the design of a TMAP assessment tool for the Wadden Sea fish fauna. The present-day species list and the data analysis will lead to conclusions on which species, parameters and survey records are suitable to be incorporated in an assessment tool. The evaluation of the WFD approach and the literature study on indicators used in marine ecosystems will allow a proposal on how to define an assessment tool. And finally, the data analysis and the reference species list may allow a proposal for the reference conditions.

Conclusions on the feasibility and a proposal for an assessment tool will be formulated by the entire working group based on the results and deliverables of steps 1-4. For this CWSS will organise a meeting for the full TMAP ad hoc working group fish in Wilhelmshaven in the second half of 2007.

Step 5 in the present document is the initiation of phase III as described by Bioconsult (2006). The goal of step 5 is to achieve consensus on the feasibility and approach of a TMAP assessment tool. The further development of the tool (phase III in Bioconsult, 2006) is not included in step 5 of the follow-up work to be carried out in 2007. If consensus is achieved the further development of the tool can be carried out in 2008.

Deliverables:

- *Evaluation of the feasibility of an assessment tool for the Wadden Sea fish fauna*
- *Proposal for an assessment tool for the Wadden Sea fish fauna*

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Signature:

Date:

May, 2007

Annex 1: Wadden Sea Fish Fauna

Table 1 presents a list of the fish fauna of the Wadden Sea. The decision on which species to include in this list was primarily based on the occurrence in the ongoing monitoring programs in recent years.

Three species were not caught during the ongoing monitoring programs in recent years, but were nevertheless considered relevant for the Wadden Sea. These species were houting (which is a Habitat Directive species) and the thick-lipped and thin-lipped grey mullets (both of which are expected to be abundant in fyke catches).

The ongoing monitoring programs included in the table are:

- The Demersal Fish Survey (DFS) carried out by Wageningen-IMARES (formerly known as RIVO, Netherlands) from 1970 onwards
- The Demersal Young Fish Survey (DYFS) carried out by the Bundesforschungsanstalt für Fischerei (Germany) from 1974 onwards
- The Schleswig-Holstein Survey (SHS) carried out by the Marine Science Service (Germany) from 1991 onwards

A survey which was included in the table despite the fact that it is not an ongoing monitoring program (i.e. it will probably not be continued after 2007)

- The Seabird-Fish-Interactions Survey (SFIS) carried out by the Institute of Avian Research (Germany) in the years 2005-2007

An ongoing monitoring program which is unfortunately not (yet) included in the table is

- The Fyke sampling 't Horntje (NIOZ) carried out by the Royal Netherlands Institute for Sea Research from 1960 onwards

The DFS and DYFS are beam trawl surveys, the SHS and SFIS are stownet surveys, and the NIOZ series is a fyke net survey. Both beam trawl surveys have a large spatial coverage, together these 2 surveys cover the entire Dutch and German Wadden Sea and the adjacent coastal waters. The spatial coverage of the stownet and fyke net surveys is limited. Further information on the surveys is given in Report of the TMAP ad hoc working group fish, August 2006.

The objective of Table 1 was not only to list the Wadden Sea fish species, but also to serve as a basis for the selection of a limited number of species as candidates for monitoring within TMAP.

The first part of the table (in shades of yellow to red, named selection criteria) provides information on the ecology of the species, its relevance to management and its sensitivity to important driving forces. These parameters are important criteria for the selection of species for TMAP monitoring. The second part of the table (in shades of blue, named monitoring) presents the occurrence and abundance of each species in recent years (2001-2005 for the ongoing surveys and 2005-2006 for the SFIS) and the catchability of each species with different gears. These parameters indicate the feasibility of currently monitoring the species within the ongoing monitoring programs.

For each fish species a total score was calculated for the selection criteria and for the monitoring parameters separately. For this, each column received a weighting factor indicating the relative importance of each '+' within the column. These weighting factors were based on expert judgement and elaborate discussions within the TMAP ad hoc working group fish. Both scores (i.e. one for the selection criteria and one for the monitoring parameters) are a simple addition of each '+' multiplied by the weighting factor which is listed at the top of the table.

Note that Table 1 is an update of the table presented in Annex 5 of the Report of the TMAP ad hoc working group fish, August 2006.

Table 1 has been sorted by scores, primarily the selection criteria scores and secondarily the monitoring result scores. Sixteen species have a high score (>2) for both selection criteria as well as monitoring results, these are the top 16 species in Table 1 and they are listed separately in Table 2. Four species have a high score (>2) for the selection criteria but a low score for the monitoring results, they are listed separately in Table 3.

Table 1: Continued

	Monitoring ⁽¹⁴⁾											Score (maximum=12) ⁽¹³⁾			
	Abundance ⁽¹⁵⁾						Occurrence ⁽¹⁶⁾						Catchability ⁽¹⁷⁾		
	NL: DFS outer area (beamtrawl, 2001-2005)	NL: DFS inner area (beamtrawl, 2001-2005)	DE: DYFS (beamtrawl, 2001-2005)	DE: SHS (stownet, 2001-2005)	DE: SFS (stownet, 2005-2006)	NL: NIOZ (fyke, -)	NL: DFS outer area (beamtrawl, 2001-2005)	NL: DFS inner area (beamtrawl, 2001-2005)	DE: DYFS (beamtrawl, 2001-2005)	DE: SHS (stownet, 2001-2005)	DE: SFS (stownet, 2005-2006)		NL: NIOZ (fyke, -)	Beamtrawl	Stownet
weight of each "+"	0.5	0.5	1	1	0	0	0.5	0.5	1	1	0	0	n.a.	n.a.	n.a.
Species caught in monitoring programmes in 2001-2005															
Pleuronectes platessa	Plaice	++	++	++	++	++	++	++	+	++	+	+	+	-	11
Alosa fallax	Twaite shad	+	+	+	++	++	-	-	-	++	+	-	-	+	6
Clupea harengus	Herring	++	++	++	++	++	+	+	++	++	++	-	-	+	10
Osmerus eperlanus	Smelt	+	++	++	++	++	+	+	+	++	++	-	-	+	9.5
Solea vulgaris	Sole	+	++	+	++	++	+	+	+	++	++	+	-	+	7.5
Zoarces viviparus	Eelpout	+	+	+	+	+	-	+	+	+	-	+	-	+	5.5
Liparis liparis	Sea-snail	+	+	+	+	+	+	+	+	+	+	+	-	+	5
Platichthys flesus	Flounder	++	++	++	++	++	+	+	++	++	+	+	-	+	9.5
Limanda limanda	Dab	++	++	++	+	+	++	+	+	-	-	+	-	+	7.5
Gadus morhua	Cod	+	++	+	+	+	+	+	+	+	+	+	+	+	6
Lampetra fluviatilis	River lamprey	+	+	+	+	+	-	-	-	+	+	-	+	+	4
Ammodytes sp.	Sand eel	+	+	+	+	+	+	+	-	-	+	-	-	+	4
Sprattus sprattus	Sprat	+	+	+	++	++	+	+	+	++	++	-	+	+	8
Merlangius merlangus	Whiting	++	+	++	++	++	+	+	+	+	+	+	+	+	7.5
Anguilla anguilla	Eel	+	+	+	+	+	-	-	-	+	-	-	-	+	4
Engraulis encrasicolus	Anchovy	-	-	+	+	+	-	-	-	+	+	-	-	+	3
Alosa alosa	Allis shad	-	-	+	-	-	-	-	-	-	-	-	-	+	1
Gymnocephalus cernuus	Ruffe	-	+	+	-	-	-	-	-	-	-	+	+	-	1.5
Petromyzon marinus	Sea lamprey	+	-	-	-	+	-	-	-	-	-	-	-	+	0.5
Myoxocephalus scorpius	Bull-rout	+	++	++	+	+	+	+	+	+	+	+	-	+	7.5
Pholis gunnellus	Butterfish	+	+	+	+	+	-	+	-	+	+	+	-	+	3.5
Cyclopterus lumpus	Lumpsucker	+	-	+	+	+	-	-	-	+	+	+	-	+	3.5
Liparis montagui	Montagu's sea snail	-	-	+	+	+	-	-	-	+	+	+	-	+	3
Syngnathus acus	Greater pipefish	+	+	+	-	-	+	-	-	-	-	+	-	+	2.5
Echiichthys vipera	Lesser weever	+	+	+	-	-	+	-	-	-	-	+	-	+	2.5
Syngnathus rostellatus	Nilsson's pipefish	++	++	++	++	++	+	+	++	++	++	+	-	+	10
Pomatoschistus minutus	Sand goby	++	++	++	++	++	+	+	+	++	++	+	-	+	9
Pomatoschistus microps	Common goby	(18)	(18)	+	+	++	(18)	(18)	-	-	++	+	-	+	(18)
Trachurus trachurus	Horse mackerel	+	+	+	++	++	+	+	+	+	+	+	-	+	5.5
Psetta maxima	Turbot	+	+	+	+	+	+	+	+	+	+	+	-	+	4.5
Scophthalmus rhombus	Brill	+	+	+	+	+	-	-	-	+	-	+	-	+	4
Belone belone	Garfish	+	+	-	+	+	-	-	-	+	+	+	-	+	3
Hyperoplus lanceolatus	Greater sand-eel	+	+	+	-	+	+	+	-	+	+	-	-	+	2.5
Agonus cataphractus	Hooknose	++	+	++	+	+	+	+	+	+	+	+	-	+	7.5
Ciliata mustela	Five-bearded rockling	+	++	+	+	+	+	+	+	+	+	+	-	+	6.5
Eutrigla gurnardus	Grey gurnard	+	+	+	+	+	-	-	-	+	-	+	-	+	4
Callionymus lyra	Dragonet	++	+	+	-	+	+	+	+	-	-	+	-	+	4
Scomber scombrus	Mackerel	+	+	-	+	+	-	-	-	+	-	+	-	+	3
Gasterosteus aculeatus	Stickleback	+	+	+	+	+	-	-	-	+	-	-	-	+	4
Trigla lucerna	Tub gurnard	+	+	+	+	+	+	-	+	-	-	+	-	+	4.5
Amoglossus laterna	Scaldfish	++	+	+	-	-	+	+	+	+	+	+	-	+	3
Buglossidium luteum	Solenette	++	+	+	-	+	+	+	+	+	+	+	-	+	3
Trisopterus luscus	Bib	+	+	+	-	-	-	+	+	+	+	+	-	+	2.5
Salmo salar	Salmon	-	-	-	+	-	-	-	+	+	+	-	-	+	2
Mullus surmuletus	Striped red mullet	+	+	+	-	-	-	-	-	+	-	+	-	+	2
Atherina presbyter	Sand-smelt	+	-	+	-	+	-	-	-	-	-	-	-	+	1.5
Callionymus reticulatus	Reticulated dragonet	+	-	+	-	-	-	-	-	-	-	+	-	+	1.5
Stizostedion lucioperca	Pikeperch	-	+	+	-	-	-	-	-	-	-	+	+	+	1.5
Dicentrarchus labrax	Bass	+	+	-	-	-	-	-	-	-	-	+	+	+	1
Perca fluviatilis	Perch	-	+	-	-	-	-	-	-	-	-	+	+	+	0.5
Entelurus aequoreus	Snake pipefish	+	+	+	-	+	-	-	-	+	-	+	-	+	2
Microstomus kitt	Lemon sole	+	+	+	-	+	-	-	-	-	-	+	-	+	2
Gaidropsarus vulgaris	Three-bearded rockling	+	-	+	-	-	-	-	-	-	-	+	-	+	1.5
Callionymus maculatus	Spotted dragonet	-	-	+	-	-	-	-	-	-	-	+	-	+	1
Galeorhinus galeus	Tope	+	-	-	-	-	-	-	-	-	-	+	+	+	0.5
Pollachius pollachius	Pollack	-	+	-	-	-	-	-	-	-	-	+	+	+	0.5
Nerophis ophidion	Straight-nosed pipefish	-	-	+	-	-	-	-	-	-	-	+	-	+	1
Enchelyopus cimbrius	Four-bearded rockling	+	-	-	-	-	+	-	-	-	-	+	-	+	1
Trisopterus minutus	Poor cod	+	+	-	-	-	+	-	-	-	-	+	+	+	1
Number of species		48	45	49	34	38	48	45	49	34	38				
Number of hauls		295	582	1185	53	19	295	582	1185	53	19				
Other species relevant for the Wadden Sea															
Coregonus oxyrinchus	Houting	-	-	-	-	-	-	-	-	-	-	-	+	-	0
Chelon labrosus	Thick-lipped grey mullet	-	-	-	-	-	-	-	-	-	-	-	+	-	0
Liza ramada	Thin-lipped grey mullet	-	-	-	-	-	-	-	-	-	-	-	+	-	0

Table 1: Continued (footnotes)

Footnotes

⁽¹⁾ Ecological guildes	⁽²⁾ Stratification	⁽³⁾ Benthic habitat
ER = estuarine resident	D = demersal	m = mud
MJ = marine juvenile	P = pelagic	s = sand
MS = marine seasonal migrant	DP = sand eels: pelagic or	g = gravel
MA = marine adventitious	buried in bottom	h = hard (rocks, musselbeds etc.)
CA = diadromous		p = plants
FW = fresh water		

⁽⁴⁾ Species included in the Habitats Directive - Annex 1 & 2. Fish species relevant for the Wadden Sea (species relevant for freshwater between brackets)

⁽⁵⁾ Species abundance monitoring proposed in relation to the Water Framework Directive in transitional waters (all transitional waters except Eider)

⁽⁶⁾ On any red list (Netherlands, Germany or Denmark)

⁽⁷⁾ Critical food source as indentified by expert judgement of current group and by Heinis et al., 2005

⁽⁸⁾ Publication(s) exist(s) indicating link between abundance/distribution of species and any climate change related factors

⁽⁹⁾ Publication(s) exist(s) indicating link between abundance/distribution of species and nutrient enrichment or turbidity

⁽¹⁰⁾ Publication(s) exist(s) indicating link between abundance/distribution of species and other sources of habitat degradation

⁽¹¹⁾ Species prone to direct fishing mortality (i.e. commercial species). Indirect mortality due to discarding or bottom-disturbance not included

⁽¹²⁾ Species with a limited dispersal in all life stages, hence suitable indicators of small-scale changes and contaminations

⁽¹³⁾ Score based on every "+" multiplied by weighting factor

⁽¹⁴⁾ Ongoing monitorings programmes and an example of a shorter running survey (SFIS)

code = name	gear	institute	country	years	in table
DFS = Demersal Fish Survey	beam trawl	Wageningen-IMARES (formerly known as RIVO)	The Netherlands	1970-	2001-2005
DYFS = Demersal Young Fish Survey	beam trawl	Bundesforschunganstalt für Fischerei	Germany	1974-	2001-2005
SHS = Schleswig-Holstein Survey	stownet	Marine Science Service	Germany	1991-	2001-2005
SFIS = Seabird-Fish-Interactions Survey	stownet	Institute of Avian Research	Germany	2005-2007	2005-2006
NIOZ = Flyke sampling 't Hornstje	fyke	Royal Netherlands Institute for Sea Research	The Netherlands	1960-	-

⁽¹⁵⁾ Abundance:

++ = top 10 in abundance

+ = present

- = absent

⁽¹⁶⁾ Occurrence:

++ = present in 90-100% of the hauls

+ = present in 10-90% of the hauls

- = present in <10% of the hauls

⁽¹⁷⁾ Suitability gear for quantitative abundance estimate

⁽¹⁸⁾ Identifications unreliable, *P. microps* and *P. minutes* pooled

Table 2: Species with a high score (>2) on both selection criteria as well as monitoring results.

Species		Ecological guild	Stratification	Benthic habitat
<i>Anguilla anguilla</i>	Eel	CA	D	m-s
<i>Alosa fallax</i>	Twaite shad	CA	P	
<i>Osmerus eperlanus</i>	Smelt	CA	P	
<i>Lampetra fluviatilis</i>	River lamprey	CA	P	
<i>Platichthys flesus</i>	Flounder	ER/CA	D	m-s
<i>Zoarcetes viviparus</i>	Eelpout	ER	D	m-p
<i>Liparis liparis</i>	Sea-snail	ER	D	m-h
<i>Ammodytes</i> sp.	Sand eel	ER	DP	s
<i>Pleuronectes platessa</i>	Plaice	MJ	D	m-s
<i>Solea vulgaris</i>	Sole	MJ	D	m-s
<i>Limanda limanda</i>	Dab	MJ	D	s
<i>Gadus morhua</i>	Cod	MJ	D	
<i>Merlangius merlangus</i>	Whiting	MJ	D	
<i>Clupea harengus</i>	Herring	MJ	P	
<i>Sprattus sprattus</i>	Sprat	MS	P	
<i>Engraulis encrasicolus</i>	Anchovy	MS	P	

Table 3: Species with a high score (>2) on selection criteria but a low score (<2) on monitoring results.

Species		Ecological guild	Stratification	Benthic habitat
<i>Alosa alosa</i>	Allis shad	CA	P	
<i>Petromyzon marinus</i>	Sea lamprey	CA	P	
<i>Coregonus oxyrinchus</i>	Houting	ER	P	
<i>Gymnocephalus cernuus</i>	Ruffe	FW	D	