

Evaluation of fundamental applicability of assessment approach for fish in transitional waters in the Wadden Sea in conformity with Water Framework Directive (WFD)



Common Wadden Sea Secretariat (CWSS)
Wilhelmshaven

August 2006

Client: **Common Wadden Sea Secretariat (CWSS)**
Wilhelmshaven

Title: **Evaluation of fundamental applicability of assessment approach for
fish in transitional waters in the Wadden Sea in conformity with WFD**

Contractor: **BIOCONSULT**
Schuchardt & Scholle GbR

Reeder-Bischoff-Str. 54
28757 Bremen
Tel.: +49 (0)421 - 6207108
Fax: +49 (0)421 - 6207109

Klenkendorf 5
27442 Gnarrenburg
Tel.: +49 (0)4764 - 921050
Fax: +49 (0)4764 - 921052

Internet www.bioconsult.de
e-mail info@bioconsult.de

Prepared by: **Dipl.-Biol. Jörg Scholle**
Dr. Bastian Schuchardt
Dr. Carmen-Pia Günther

Date: **August 2006**

1. Background

The established and long-term Trilateral Monitoring and Assessment Program (TMAP) is one of the major tools within the framework of international cooperation for protection of the Wadden Sea. Joint preservation goals and parameters for individual components of the Wadden Sea ecosystem were defined in the Trilateral Wadden Sea Plan of 1997.

After transposition of the EU Water Framework Directive (WFD) into national law a monitoring system for specific quality components is currently also being developed and established for coastal waters (incl. the Wadden Sea). Coordination with existing programmes, such as the TMAP, appears meaningful and is also targeted in some cases.

For the fish fauna the TMAP primarily utilizes the results from existing monitoring programmes in the three countries. Coordinated monitoring of the fish fauna is not carried out. In addition, no specific monitoring is planned for the coastal waters as a whole within the scope of transposition of the WFD. However, specific monitoring of the fish fauna is currently being established within the framework of the WFD for the so-called transitional waters (TW), which for the most part are located within the trilateral cooperation region.

It appears meaningful to create a more pronounced link between the ongoing and planned monitoring studies in the Wadden Sea as well as a connection to monitoring of fish fauna in the TW and also to target interlinkage with any future NATURA 2000 monitoring in the Wadden Sea, in the EEZ and in the estuaries (incl. the TW) in which Natura 2000 areas were recently registered. This applies all the more given the fact that the various habitats, i.e. open sea, Wadden Sea and estuaries (and/or transitional waters), are closely ecologically interlinked since they have a different functional significance for the lifecycle of many fish species.

Against this background the Common Wadden Sea Secretariat (CWSS) aims at creating closer links between the monitoring of fish fauna, among other things, in the various areas and also applying an assessment approach to the fish fauna in the Wadden Sea in accordance with the requirements of the Water Framework Directive, as appropriate.

2. Definition of tasks

The special significance of the Wadden Sea for fish fauna has been defined, for instance in the 2004 QSR Report, but yet fish are not given appropriate consideration within the framework of the TMAP. Fish-specific trilateral goals do not exist at present. To reduce this deficit in future, one the tasks of the *TMAP Ad hoc working group 'Fish'* is to coordinate the various national monitoring programmes in the trilateral cooperation region better. This shall contribute to optimizing the comparability of the data generated there and thus their usefulness in terms of defining fish-related TMAP goals as well as their future verification. Though it does not exist yet, a formalized fish-based assessment procedure for the trilateral cooperation region could also serve this purpose. Assessment procedures on the basis of fish fauna have recently been submitted for very different types of waterbodies, particularly in the course of transposition of the WFD. However, the WFD does not make consideration of fish fauna as a quality component mandatory for the 'coastal water' type so no specific assessment procedure that could be used within the scope of the TMAP has been developed for coastal waters.

In contrast to the situation for the coast, a fish-based assessment tool conforming to the WFD has been worked up for the transitional waters of the Wadden Sea estuaries of the Eider, Elbe, Weser and Ems Rivers (Bioconsult 2006). Because of the close interlacing of the two habitats estuary and Wadden Sea, its appeared meaningful to examine whether the assessment approach for the transitional waters can also be a suitable instrument for reviewing quality goals to be defined (in the future) within the framework of the trilateral cooperation. This task was assigned to BioConsult Schuchardt & Scholle GbR by CWSS in the form of a short study in July 2006.

The purpose of this report is to assess the fundamental applicability of this procedure to the Wadden Sea. This shall be done while also taking into account the potentially available fish fauna data from the various monitoring programmes that have been or will be carried out in the Wadden Sea.

The report encompasses the following aspects, which will be briefly described below and discussed against the background of the issue at hand:

- Fish monitoring in the Wadden Sea. Overview of the compilation of completed or planned monitoring programmes in the Wadden Sea drawn up by the *TMAP Ad hoc working group 'Fish'*, including the adjoining transitional waters as a potential database for the assessment.
- Consideration given to fish fauna within the framework of the TMAP to date.
- Description of the basic features of the procedure for transitional waters (TW) and requirements for application.
- Assessment of general suitability for application in the habitat coast/Wadden Sea.

3. Fish monitoring in the Wadden Sea – state of data

Table 1 shows an overview of various monitoring programmes in the area of the trilateral Wadden Sea (supplemented by studies in transitional waters), whose data are potentially useful as a basis for development or application of an assessment procedure.

Table 1: Overview of the fish-related monitoring studies in the area of the northern German coast. EEZ: Exclusive Economic Zone. GASEEZ: German Autumn Survey EEZ; BLMP: Bund Länder Messprogramm JAMP: Joint Monitoring and Assessment Programme; DYFS: Demersal Young Fish Survey; DFS: Demersal Fish Survey; WiKu: Brown Shrimp Coastal Winter Survey; WFD: Water Framework Directive. TW = Transitional waters, WS = Wadden Sea, NSEA = North Sea. Source: TMAP *Ad hoc working group fish*.

Project	Institution				annual		Hauls/a	Month												Gear	Comment		
		TW	WS	NSEA	Yes	No		J	F	M	A	M	J	J	A	S	O	N	D				
Fish Monitoring German EEZ	BfA-Fi			x	x		n.d.																since 1958
GASEEZ	BfA-Fi			x	x		n.d.																
BLMP/JAMP	Wassergütestelle Elbe			x	x		14														x		commercial beam trawl bis 2006, thereafter uncertain
DYFS	BfA-Fi		x		x							x*										x	3-m-shrimp-beam trawl without tickle chain since 1974
WiKu	BfA-Fi		x		x																	x	3-m-shrimp-beam trawl without tickle chain
Fish Monitoring East Frisian Wadden Sea	AWI		x		x																		1992-1997: 6 surv./a, since 1997 2/surv.a
Fish Monitoring Sylt/Römö	AWI		x																				new long time series
DFS	NL Institute for Fisheries Research		x		x																		3-m-shrimp-beam trawl with one tickler chain since 1969
NIOZ Fish long term Monitoring (Texel/Marsdiep)	NIOZ		x		x																		fyke net since 1960, daily data: April-June, September-October
Fish Monitoring S-H Wattenmeer	Vorberg, Nationalpark S-H Wattenmeer		x		x																		stow net (9 x 10 m) since 1991
Seabird-Fish Interaction in the Wadden Sea	Dänhard, Institute of avian research		x		x																		stow net (5 x 7 m) bis 2007, thereafter uncertain
Monitoring WFD - Eider	div., Landesamt für Naturschutz S-H	x				x	8																stow net (9 x 10 m) 2002/2003, from 2006 ff (1 surv./2 a)
Monitoring WFD - Ems	Bioconsult, LAVES	x					12																stow net (ca. 8 x 13 m) since 2006 ff (1 surv./2 a)
Monitoring WFD - Weser	Voigt-Consulting, LAVES	x					16																stow net (9 x 17 m) 2003, from 2007 ff (1 surv./2 a)
Monitoring WFD - Elbe	Wassergütestelle Elbe	x			x		16																stow net (9 x 10 m, ?) since 2000 ff (annual)

These are studies that differ methodologically to a varying extent depending on their respective purpose. The methodological differences are related to the fishing gear (e.g. beam trawl, stow net) as well as to the scope of the fishing (in terms of space and time, number of hauls). However, the evaluation of the catches with respect to taxonomic depth of focus, for example, and regarding the inclusion of parameters, such as determination of length and biomass, is extensively similar with few exceptions. In terms of quantitative aspects (e.g. fish frequencies), the catch results of the

various programmes are not directly comparable, or only to a limited extent, because of the above mentioned differences. Overall, however, a large number of data for many years are available for the trilateral Wadden Sea region.

4. Consideration of fish fauna within the framework of the TMAP – status quo

A brief outline of the consideration given to fish fauna within the framework of the trilateral cooperation to date is provided in the following. As mentioned above, in spite of their significant role in the Wadden Sea ecosystem, fish were not the focus of the concept for the 1995 Wadden Sea monitoring programme.

Some species, like eelpout (*Zoarces viviparus*), flounder (*Plathichthys flesus*) and plaice (*Pleuronectes platessa*), are listed as target organisms in the Wadden Sea in the TMAP Manual of 2000. However, monitoring is not part of the TMAP Common Package. For these species population parameters, such as abundance, biomass, age structure, etc., should be presented descriptively to enable references to any identifiable changes in the stock. The evaluations are primarily based on data from monitoring programmes of other organizations, like the 'Demersal Young Fish Survey (DYFS)' or the 'Demersal Fish Survey (DFS)'.

Besides an analysis of the development of stocks of selected species, fish are also studied within the framework of pollutant monitoring. The target species was initially the flounder, though recently the eelpout was also included in the study programme.

For methodological reasons the above mentioned long-term studies (DYFS, DFS), whose data are used within the scope of the TAAP, concentrate on the demersal fish species. The 'Quality Status Report' of 2004 (Essink et al. 2005) meets the need for information on pelagic fish species in the Wadden Sea. The results of long-term studies with the stow net in Schleswig-Holstein and of a project in the Ems estuary were presented and the increasing need of such data was set forth in the recommendations on fish monitoring. Overall data on stock development for a total of 20 selected species are presented in the current QSR 2004, without evaluating these data in detail, however. In the recommendations of the QSR 2004 concerning revision of the targets of the Wadden Sea plan no specific goals have been stated yet for the development of fish stocks in the Wadden Sea. A selection of significant Wadden Sea species ('TOP 15 target species') has been carried out as a first step for eliminating this deficit within the scope of the work of the *TMAP Ad hoc working group 'Fish'* on the basis of data from the monitoring studies (excluding TW) shown in Table 1 (see below). In future appropriate proposals on 'targets' shall be formulated for these species by the working group.

Current 'target species' of TMAP fish monitoring (the 'TOP 15+')

In the reporting period from 2001 – 2005 66 fish species were documented on the basis of the various studies for the entire Wadden Sea. Especially significant species in accordance with the TMAP were filtered out of this spectrum (see *Species Table* - Ad hoc working group Fish). Criteria such as protection status, sensitivity to selected factors as well as study-based frequency and constancy were used for the selection. The parameter groups 'conservation-related status' and 'sensitivity' were given greater weight than the parameters frequency and constancy in the classification of the species. Table 2 shows an overview of the species that achieve a high degree of significance according to the selection criteria and weighting. However, the data of all studies have not been

taken into account yet so the 'TOP 15 list' is provisional and further elaboration by the *TMAP Ad hoc working group 'Fish'* is currently in progress.

Table 2: Draft of selection criteria (worthiness of protection, sensitivity, ecology) of the 'top-priority' fish species, resulting from the data of the period 2001-2005. Footnote 2 (red crosses): data on WFD ('indicator species' - TW) – not taken into consideration for determination of the scores. Habitat: b = benthic, d = demersal, p = pelagic. Source: *TMAP Ad hoc working group fish. (status quo 18.8. - not updated)*

Footnotes

- ¹⁾ Species included in the Habitats Directive list of fish species relevant for the Wadden Sea
 - ²⁾ Species monitored in other programmes related to the Birds Directive and the Water Framework Directive in transitional waters
 - ³⁾ On any red list (Netherlands, Germany or Denmark)
 - ⁴⁾ Critical food source as identified in REF
 - ⁵⁾ Publication(s) exist(s) indicating link between abundance/distribution of species and any climate change related factors
 - ⁶⁾ Publication(s) exist(s) indicating link between abundance/distribution of species and nutrient enrichment or turbidity
 - ⁷⁾ Publication(s) exist(s) indicating link between abundance/distribution of species and other sources of habitat degradation (f.e. dredging, anox)
 - ⁸⁾ Species prone to direct fishing mortality (i.e. commercial species). Discard/bottom disturbance mortality not included (is generic)
 - ⁹⁾ Species with a limited dispersal in all life stages, hence suitable indicators of small-scale changes and contaminations
- ¹⁰⁾ Abundance:
 ++ = top 10 in abundance (in 2001-2005)
 + = present (in 2001-2005)
 - = absent (in 2001-2005)
- ¹¹⁾ Occurrence:
 ++ = present in 90-100% of the hauls (in 2001-2005)
 + = present in 10-90% of the hauls (in 2001-2005)
 - = present in <10% of the hauls (in 2001-2005)
- ¹²⁾ Suitability gear for quantitative abundance estimate
- ¹³⁾ Data only available for 2005
- ¹⁴⁾ Determinations unreliable, P. microps and P. minutes pooled

Abbreviations:

- HD Habitats Directive
- BD Birds Directive
- WFD Water Framework Directive (transitional waters)
- DYFS Demersal Young Fish Survey (beamtrawl), BFA Germany
- DFS-WS Demersal Fish Survey (beamtrawl) in the Wadden Sea, IMARES, Netherlands
- DFS-coast Demersal Fish Survey (beamtrawl) in coastal waters bordering the WSea, IMARES, NL
- SHS Schleswig-Holstein Survey (stownet), Marine Science Service, Germany
- SBS Sea Bird xxx Survey (stownet), Institut für Vogelforschung, Germany
- ER estuarine resident
- MJ marine juvenile
- MS marine seasonal migrant
- MA marine adventitious
- DD diadromous
- FW fresh water

Taxon	Selection criteria									Monitoring												Priority TMAP	Priority b.o. score	Score			
	Conservation goals			Sens. to driving forces			Ecology			Abundance (10)				Occurrence (11)				Catchability (12)									
	HD species (1)	WFD & BD species (2)	Endangered or vulnerable (3)	Food for birds or mammals (4)	Climate change (5)	Nutrient enrichment (6)	Habitat degradation (7)	Fishing mortality (8)	Local pressures (9)	Hard substrate	Ecological guild	Habitat	DYFS	DFS-WS	DFS-coast	SHS	SBS (13)	DYFS	DFS-WS	DFS-coast	SHS				SBS (13)	Beamtrawl	Stownet
<i>Pleuronectes platessa</i>				-	+	+	+	-	-	MJ	b	++	++	++	++	++	++	++	++	++	++	++	+	-	high	high	7,0
<i>Solea vulgaris</i>				+	+	+	+	-	-	MJ	b	++	+	++	++	++	++	+	+	+	+	+	+	-	high	high	6,8
<i>Clupea harengus</i>		+		+	+	-	+	-	-	MJ	p	++	++	++	++	++	++	+	+	++	++	++	-	+	high	high	6,5
<i>Osmerus eperlanus</i>		+		+	-	-	+	-	-	DD	p	++	+	++	++	++	++	+	+	++	++	++	-	+	high	high	6,3
<i>Alosa fallax</i>	+	+	+	+	-	-	-	-	-	DD	p	+	+	++	++	++	++	-	-	++	+	+	-	+	high	high	5,0
<i>Gadus morhua</i>				+	+	-	+	-	-	MJ	d	+	+	+	+	+	+	+	+	+	+	+	+	+	high	high	5,0
<i>Syngnathus rostellatus</i>				+	-	-	-	-	-	ER	b	++	++	++	++	++	++	+	+	++	++	++	+	-	high	high	4,5
<i>Merlangius merlangus</i>				+	-	-	+	-	-	MJ	d	+	++	++	++	++	++	+	+	+	+	+	+	+	high	high	4,3
<i>Myoxocephalus scorpius</i>				-	-	-	-	+	+	ER	b	++	+	++	++	++	++	+	+	+	+	+	+	-	high	high	4,3
<i>Limanda limanda</i>				-	+	-	+	-	-	MJ	b	++	++	++	++	++	++	+	++	-	-	+	-	high	high	4,0	
<i>Pomatoschistus</i> spp.				+	-	-	-	-	-	ER	b	++	++	++	++	++	++	+	+	+	+	+	+	high	high	4,0	
<i>Sprattus sprattus</i>				+	-	-	-	-	-	MS	p	+	+	++	++	++	++	+	+	++	++	++	-	+	high	high	4,0
<i>Trachurus trachurus</i>				+	-	-	+	-	-	MA	d	+	+	++	++	++	++	-	+	+	+	+	+	high	high	4,0	
<i>Ammodytes</i> sp.				+	-	-	+	-	-	ER	b	+	+	+	+	+	+	+	+	-	+	+	-	high	high	3,8	
<i>Liparis liparis</i>		+	+	-	-	-	-	-	+	ER	b	+	+	+	+	+	+	+	+	+	+	+	+	high	high	3,8	
<i>Platichthys flesus</i>		+		+	-	-	-	-	-	ER/DD	b	++	+	++	++	++	++	+	+	++	++	++	+	high	high	3,8	
<i>Zoarces viviparus</i>				-	-	-	-	+	+	ER	b	+	+	+	+	+	+	+	-	+	+	+	-	high	high	3,8	
<i>Lampetra fluviatilis</i>	+		+	-	-	-	-	-	-	DD	b	+	+	+	+	+	+	-	-	+	+	+	-	high	high	3,5	
<i>Salmo salar</i>	+		+	-	-	-	+	-	-	DD	p	-	-	+	+	+	+	-	-	+	-	-	+	high	high	3,5	

The species that should be given higher priority stem from several ecological guilds (Elliott & Dewailly 1995):

- Diadromous fish species
- Estuarine fish species

- Marine juvenile fish species
- Marine seasonal fish species
- 'Wadden Sea guests', purely marine species

The ecological guilds will be briefly characterized below.

Diadromous fish species

The more important species of the Wadden Sea according to the above ranking include the following diadromous species: river lamprey (*Lampetra fluviatilis*), twaite shad (*Alosa fallax*), Atlantic salmon (*Salmo salar*) and smelt (*Osmerus eperlanus*). The first three species mentioned above are found both in Annex II and V of the FFH Directive and on the Red List of Endangered Species for the Wadden Sea (Nordheim et al. 1996). With regard to the FFH Directive, however, the Atlantic salmon is only relevant in freshwater. In principle it can be assumed for all four fish species that live in the sea but spawn in rivers that they may react sensitively to habitat changes (e.g. weirs in rivers, substrate changes in the spawning grounds, noise during the migration phase). The extent to which habitat changes or fishing in the Wadden Sea has or had a detrimental effect cannot be determined with certainty. Of the four diadromous species, the smelt has the greatest abundance (= density of individuals) and highest frequency of occurrence. The stow net is the suitable fishing gear for three pelagic species, twaite shad, Atlantic salmon and smelt, of the group of predominantly diadromous fish species. Only the river lamprey is presumably caught better with a beam trawl.

Estuarine fish species

The higher-priority estuarine species of the Wadden Sea are the eelpout (*Zoarces viviparus*), the lesser pipefish (*Syngnathus rostellatus*), the short-spined bullhead (*Myoxocephalus scorpius*), the common sea snail (*Liparis liparis*) as well as the sand eel (*Ammodytes* spp.). Of these, only the common sea snail is a species on the Red List. The only commercially fished species is the sand eel (*Ammodytes* sp.). Since the eelpout and short-spined bullhead have only a small propagation capacity, which extensively limits their entire lifecycle in geographic terms, they appear particularly sensitive to local disturbances. Both species – like the common sea snail – depend on the occurrence of hard substrate. The species with the greatest abundance and most widespread occurrence of this ecological group is the lesser pipefish. All species can be caught better with a beam trawl than with a stow net. This is due to their way of life (on or in the seabed). Depending on the fishing conditions (in the case of ground contact of the stow net), the species may also be frequently caught in stow nets, however.

Juvenile marine, marine seasonal and purely marine fish species

Of temporarily selected target species of the Wadden Sea, some belong to the guild of marine species that as juveniles use the estuaries and coastal waters as maturing grounds. This group includes the pelagic Atlantic herring (*Clupea harengus*), the demersal round fish species Atlantic cod (*Gadus morhua*) and whiting (*Merlangius merlangus*) as well as the flatfish dab (*Limanda limanda*), plaice (*Pleuronectes platessa*) and sole (*Solea solea*). Furthermore, a 'marine seasonal'

species, i.e. the sprat (*Sprattus sprattus*), and a purely marine species, the horse mackerel (*Trachurus trachurus*), meet the selection criteria. None of the species of the marine guilds currently has protective status in accordance with the FFH Directive or according to the Red Lists. According to the TMP Ad hoc working group, the herring, cod as well as the plaice and sole have been classified as sensitive to climate changes. Moreover, all flatfish species are considered to be sensitive to increased nutrient concentrations. The fishing-related mortality of all marine juveniles is high. Based on the period 2001 – 2005, the plaice and herring are the two species with the highest abundance and greatest constancy in the trilateral Wadden Sea region. The herring and sprat are caught best with a stow net, while a beam trawl is more suitable for the three flatfish species dab, plaice and sole.

5. Fish-based assessment tool for TW

General

In the following the main characteristics of the fish-based assessment procedure developed by us for the transitional waters (TW) within the framework of the WFD will be described briefly. The method is initially applicable primarily for the transitional waters of the Rivers Elbe and Weser. Currently we are also examining the applicability of the method to the Rivers Eider and Ems as well within the scope of various projects. For the transitional waters of the latter rivers this will take place within the framework of a joint Dutch-German project 'KRW-LT', in which, among other things, applicability for Westerschelde will be examined.

As a work step, the Water Framework Directive (WFD) stipulates evaluation of the status quo of the water quality of the transitional waters, among other things, on the basis of various quality components. One of these quality components is the fish fauna. The transitional waters, by definition the sections of the estuaries that are located between the limnetic areas and the coastal areas and are characterized by pronounced salinity gradients, are distinguished by the dynamic convergence of limnetic and marine elements and are therefore habitats of a very unique type. This also applies to the fish fauna there. These features make a specific assessment approach necessary for the transitional waters with respect to fish fauna as a quality component. The concept for the multi-metric assessment procedure comprised the following work steps:

- Preparation of an assessment yardstick (here: historical reference)
- Definition of metrics relevant for the assessment (qualitative: spectrum of species; quantitative: frequency)
- Determination of natural variability of fish fauna by means of various statistical methods
- Development of a computer-aided assessment tool and definition of class boundaries for the determination of the ecological state and/or ecological potential in a 5-stage system in accordance with the Water Framework Directive
- Formulation of requirements for carrying out monitoring

One of the goals of the assessment procedure is to reflect on and identify the various impairments of the transitional waters (e.g. loss of habitat, river training and maintenance measures, water quality) by means of the fish fauna. This necessitates the use of several suitable variables. Another requirement was to design the assessment tool and assessment procedure as transparently and comprehensibly, i.e. as 'simply', as possible. A total of 9 qualitative and quantitative metrics were selected against this background, making it possible to map the ecological state of the transitional waters via the fish fauna.

Analogous to international assessment procedures for transitional waters (including Coates, UK, 2004/2005; Jager, Netherlands, 2004; Goethals et al., Belgium, 2004; Borja, Spain, 2004), a distinction is made between ecological type guilds of fish (see Elliot & Dewailly 1995) and they are

used as a relevant metric for the assessment in each case. It makes sense to take guilds into consideration since the corresponding species make different 'use demands' on the estuary in each case and are thus suitable for enabling an indication of specific impairments by virtue of their 'characteristics' (species diversity, frequency). Against the background of the WFD requirements the assessment procedure comprises 2 modules while a 3rd assessment parameter, 'age structure', is an integral part of the 'richness' module (frequency).

Module Community of species – ecological guilds (numbers of species)

Altogether 5 ecological guilds are used, each of which is assessed as a separate variable with respect to **qualitative** aspects (numbers of species). The historical reference numbers of species derived for each guild constitute the assessment yardstick.

Module Richness (abundance/frequency)

With regard to the **aspect of frequency**, the entire spectrum of species found in the region is not included in the assessment since it is very difficult to specify reference frequency values for each species. Therefore, this aspect focused on selected species. Species were selected that belong to major type guilds or different 'user groups' (diadromous-estuarine, estuarine residents, marine-juvenile) and, furthermore, also represent different habitat guilds (according to Elliot & Dewailly: benthic, demersal or pelagic way of life).

The following 6 species were selected as 'quantitative indicators':

- The 'diadromous-estuarine' species twaite shad (*Alosa fallax*) and smelt (*Osmerus eperlanus*). The latter species is of special significance in that it is also relevant in terms of the FFH Directive. 'Double use' of data for both European directives is thus made possible.
- The flounder (*Pleuronectes/Platichthys flesus*) as a benthic species and the common sea snail (*Liparis Liparis*) as a hard substrate species are selected from the guild of 'estuarine residents'.
- The Atlantic herring (*Clupea harengus*) is taken into account from the group of 'marine-juvenile'.
- The ruffe (*Gymnocephalus cernuus*) was included in the quantitative assessment as a limnetic euryhaline species.

The great (natural) variability of abundance was buffered by the allocation to frequency categories while at the same time the ranges of the classes take into account the species-specific variability of the catch figures and/or the variability in stocks of the species. The species-specific reference frequencies were derived for the most part from current catch data and to a lesser extent from historical data.

The **age structure** was included in the assessment as a further metric although this is not explicitly required in the WFD. It is meaningful to include this aspect in the assessment procedure because in our view it can provide information on whether the estuaries adequately perform their

function as reproduction and maturing grounds (among other things, a reflection of structural water conditions, water quality). This aspect is not included in the assessment procedure as a separate module, but is taken into consideration within the scope of the frequency analysis.

Assessment

The ecological state/potential is determined in the assessment procedure **as a deviation from the reference**. This is possible for the aspect of species diversity at the level of the respective ecological guilds as well as for the aspect of frequency at the level of the selected species.

The assessment is carried out in computer-aided form on the basis of a 'database' that encompasses the historical and species-specific characteristics (belonging to user, habitat or reproduction guilds, species-specific frequency, etc.). The currently recorded catch data can be inputted by means of an entry mask. The assessment procedure then takes place automatically, taking into consideration the above mentioned metrics through a comparison of actual state and reference. The overall result is a mean value from the results of all metrics that, in principle, all go into the final result on an equally weighted basis. The final (also automated) step is allocation of the result to an EQR (Ecological Quality Ratio), which has values between 0 and 1 according to a 5-stage system and has a corresponding state category (ecological state or ecological potential, 1 = very good to 0 = poor).

Requirements for data collection

Use of the above outlined fish-based assessment tool for transitional waters places specific demands on data collection. The procedure, including definition of the class boundaries for the related measured variables, is calibrated to the fishing method with stow nets and therefore requires this method for its application.

The great spatial and time-related variability of the estuarine fish communities plays an important role with respect to the design of a suitable monitoring system. To generate reliable assessment results in terms of the ecological state and/or ecological potential of the transitional waters, the following aspects should be taken into account:

Scope in year of study

- Measuring points along the salinity gradients (oligohaline, mesohaline and polyhaline range); the number of measuring points depends on the size of the estuary and in the case of the Eider should be at least 2, in the case of the other estuaries 3 – 4 measuring points.
- times of study in spring and autumn;
- catches over both tide phases (high and low tide);
- the spring study should take place in May as the best time for data acquisition on (adult) twaite shad and common sea snail. This means a certain loss of information can be expected with regard to the smelt, which usually reaches its maximum abundance before

May. However, it can also be expected that adequate information on the smelt can be obtained in May on the basis of the existing data;

- determination of 3 age categories in accordance with the existing practice of the Elbe working group (see stow net catches 2000 – 2004);
- not absolutely necessary: *survey and inclusion of information of third parties as verification of the sturgeon.*

Study frequency in 6-year WFD reporting period

The WFD requires a report on the current ecological state of the various waterbodies every 6 years. Because of the great spatial and time-related variability of the estuarine fish fauna mentioned above, at least a 2-time, possibly a 3-time study (for scope of an annual study see above) for a reporting period (6 years) is necessary for a reliable assessment of the type of waterbody.

6. Applicability of the TW assessment for the Wadden Sea

The main requirements for application of the existing assessment approach for transitional waters (fish fauna, Bioconsult 2006) to the Wadden Sea will be analyzed in the following.

Reference (valuation criterion)

Derivation or definition of a reference yardstick is a central aspect of the concept of any assessment procedure. For an assessment of the actual state of a waterbody the WFD stipulates orientation to the natural, non-anthropogenically influenced state of the waterbody. Since, as a rule, such uninfluenced reference habitats no longer exist today, historical data are used for reconstruction of such a reference state to the extent such data are available in suitable form. A reference time must be specified in such a way that at least the most important anthropogenic changes can be excluded. If historical data are not available, either in suitable form or in general, it is also possible to derive a reference state from current data and/or an 'expert judgement'.

The reference fish community for **transitional waters (TW)** was derived by us primarily from historical works predominantly dating from the period between around 1870 to 1920, i.e. a period before or at the beginning of the first large-scale river training measures. Since the estuaries were already subject to anthropogenic use at that time, the reference does not represent a pristine state, but in our view nevertheless represents a (very) good ecological state in terms of the fish fauna since the species diversity was very high and the main characteristic species of estuaries, such as sturgeon (*Acipenser sturio*), houting (*Coregonus oxyrinchus*), shad (*Alosa* spp.), Atlantic salmon (*Salmo salar*), etc., were still caught in large quantities.

- In our view orientation to a 'historical' state as an assessment yardstick also appears feasible for the **trilateral Wadden Sea region** in principle. Appropriate literature research will be necessary for this purpose in any second phase of the project that might have to be carried out. References to a relatively extensive state of data exist, for example, in works of Olsen (historical maps on fish distribution in the North Sea), Decker (1900), Redecke (1907), Schnackenberg (1928), Nolte (1976), Tiews (1983), Sarrazin (1987) and Vooy's et al. (1991). The reference period shall be defined on the basis of relevant research. A period around or before 1930 would be conceivable here (see, for instance, COLIJN 1989 - amoeba model) before the beginning of the pronounced eutrophication of the Wadden Sea.

Module 'Species composition' (number of species) – qualitative metrics

The WFD requires that consideration be given to the species community as an assessment parameter. Within the framework of the assessment procedure for **TW** we have been able to derive the historical species community as a qualitatively reliable assessment yardstick on the basis of the available data. In a further step the spectrum of species was differentiated according to ecological guilds that each have more or less specific requirements regarding their habitat, thus enabling more specific indication of certain impairments.

- In our view a similar approach seems possible for the **trilateral Wadden Sea region**. It appears realistic that the reference state can easily be derived in qualitative terms (spectrum of species) on the basis of the literature and available monitoring data. The species community should also be differentiated into ecological guilds with different habitat demands and the guilds should be used as variables. The question of which ecological guilds should be taken into consideration as metrics on a meaningful basis must be answered in coordination with the *TMAP Ad hoc working group 'Fish'* in project phase II. However, we assume that a similar differentiation (diadromous species, resident species, marine-juvenile, marine-seasonal) as for transitional waters is also meaningful for the Wadden Sea (see also section 4, 'Top 15 species').

Module 'Frequency' (incl. age structure) – quantitative metrics

Besides consideration of the numbers of species, the WFD also requires that the aspect 'abundance' be taken into account as an assessment parameter. Within the scope of development of the assessment procedure for **TW** it was not possible to derive reference frequencies for all historically verified species. For this reason we restricted the quantitative analysis there to selected 'indicator species' (see section 5, this also applies to consideration of age groups). The selection was carried out on the basis of various aspects: 1. significance in terms of nature conservation (in particular FFH species because of the synergy with Natura 2000), 2. different habitat demands (benthic, demersal, pelagic, hard substrate and soft substrate species), 3. commercial importance. The reference frequency was primarily defined on the basis of existing current data according to the 'best off' principle. However, there were also some methodologically comparably collected historical data that were able to be used. They provided valuable information for plausibilization of the derived reference frequency. The top 20% quantile of the standardized catch numbers was defined here as the highest frequency category that represents the top anchor point (= very good ecological state) for the parameter 'abundance'. Accordingly, the bottom 20% quantile corresponds to a 'poor' ecological state. The reference frequency was derived on the basis of a defined fishing method (stow net), i.e. the procedure is calibrated to this fishing method. As a result, therefore, application of this method is absolutely imperative with respect to future WFD monitoring in the TW.

- Whether this step is also feasible for the **trilateral Wadden Sea region** cannot be determined reliably without an analysis of the available data records. In principle, however, this appears possible. Limitation of the quantitative aspect to selected indicator species is presumably also necessary and possible. They could be taken from the 'TOP 15 species' listed in section 4, especially since 5 of these species can also be found in the assessment procedure for TW as quantitative variables and thus contribute to the targeted content-related link between Wadden Sea and estuaries and/or their respective monitoring tools. However, the procedure for definition of reference frequency for the selected 'indicator species' will not be trivial. Such a definition will presumably be able to be derived from the data of the existing monitoring studies using the 'best off' approach, extensively similar to the TW procedure. Two questions in particular are open here and cannot be evaluated within the framework of this short study: (1) To what extent are useful historical data available for plausibilization? (2) Are the available (current) data adequately comparable in methodological terms to be able to use them in a targeted manner? As already outlined above, the data of the various monitoring programmes are directly comparable qualitatively and above all quantitatively only to a restricted degree because of the differing study

design. When defining the reference frequency, therefore, it presumably makes sense to focus primarily on the extensive beam trawl data (DYSF, DSF). Since beam trawl fishing is also carried out differently in terms of method within certain limits (with and without 'chain'), comparability of the two methods should first be examined on the basis of quantitative aspects, however. Some indications of the varying effectiveness of beam trawl fishing with or without chains can be found in the relevant literature (Valdemarsen & Suuronen 2001, Jennings & Kaiser 1998, Jones 1992). This as well as the usefulness of historical data should be treated in the framework of the next project phase. In our view a reliable final judgement regarding the definition of reference frequencies as an assessment yardstick is possible only on the basis of data analyses.

Assessment

In the context of the assessment significant differences exist between the previous trilateral practice and the WFD. The assessment of the quality of a waterbody to be carried out within the scope of the WFD also has a formal function: it serves the purpose of determining the need for action necessary to achieve a 'good ecological state' of the waterbody. This is a binding goal of the WFD. The state is assessed by means of various quality components on the basis of specific agreed limits. In the case of deviations or deficits that are determined by means of the assessment procedures, implementation of suitable measures is usually necessary to achieve the target state ('good').

- For the **trilateral Wadden Sea region** development targets that require further operationalization are formulated in the Trilateral Wadden Sea Plan for most quality compartments. Within the framework of the TMAP an assessment is conducted on the extent to which these development targets were reached (see also QSR 1999, QSR 2004). The ascertained developments of the various compartments are evaluated in the form of an appraisal against the background of the corresponding targets, which indicate whether the state is approaching or moving away from the goals. In contrast to the case of the WFD, a formal need for action does not result from this, but appropriate agreements are made within the scope of the minister conferences and the trilateral Wadden Sea region. The application of the WFD assessment approach to fish fauna in the entire Wadden Sea examined here would be a contribution to operationalization of the politically agreed trilateral targets in that defined qualitative and quantitative assessment criteria are applied.

Requests regarding data and monitoring

The establishment of a formalized fish-based assessment procedure in the Wadden Sea requires a methodological stipulation for data collection (see TW, section 5). Since carrying out separate fish monitoring is not planned within the framework of the TMAP, the methodology of the existing long-term studies, which will also be conducted in the trilateral cooperation region in the future, is decisive for adjustment of an assessment procedure.

Furthermore, a joint assessment procedure will contribute to improvement of the comparability of the existing long-term studies as well as support coordination and cooperation within the Wadden Sea.

Table 3 shows a summarizing overview of the requirements for applicability of the fish-based TW assessment approach for the Wadden Sea. The major aspects of the procedure are listed here and evaluated in summary form with regard to their transferability to the Wadden Sea on the basis of the above analysis.

Table 3: Basic features of the fish-based assessment procedure for TW and evaluation of the applicability to the Wadden Sea region. Y = yes, p = possible, n = no, r = restricted, n.n. = not necessary, n.p. = not possible, ? = undetermined

	Transitional Waters	Wadden Sea
Reference - qualitative metrics		
historic	y	p
best-off'		
expert judgement		
Reference - quantitative metrics		
historic	r	n, r
best-off'	y	p
expert judgement		p
Module: Qualitative metrics		
species composition	y	p
ecological guilds	y	p
Module: Quantitative metrics		
choice of 'indicators'	y	p, (expedient)
abundance classes	y	r
rel. abundance	n.n.	p
age classes (indicator species)	y	p
Requests - data and monitoring		
specific WFD monitoring	y	n.p.
standardized surveys	y	n.p.
fishing gear	determinate	diverse
fishing dates - seasonal	determinate	+/- diverse
number sample sites/hauls	determinate	diverse
Assessment		
different waterbodies	n	?
subtypes within the waterbody	n	?
areas within the waterbody	n	?
whole waterbody	y	?

7. Conclusion

The purpose of this report is to evaluate the fundamental applicability of the existing fish-based WFD assessment tool for transitional waters in the Wadden Sea. Based on the report, establishment of a formalized fish-based assessment procedure for the trilateral cooperation region oriented to the basic features of the procedure for the transitional waters seems possible in principle. However, a final judgement is not possible at the observation level of this report.

Against this background it must be underlined that an analysis of the existing monitoring data for a number of aspects is necessary for clarification purposes. This applies in particular to an analysis of the available monitoring data in view of the following important points for the issue at hand:

- Does the variability of the fish communities (or of the data) permit reliable derivation of species-specific frequency classes for the necessary quantitative analysis of the fish community in accordance with the WFD? For this purpose it is necessary to determine the spatial and time-related variability of the fish communities on the basis of the existing monitoring data (possibly also of historical data).
- Which of the existing monitoring data can be placed how in relation to one another for use in an assessment system? For this purpose a targeted analysis of the comparability of the various monitoring data is necessary.
- Into what subsections can or must the trilateral cooperation region be subdivided for an assessment of the fish fauna? Are the waterbodies defined according to the WFD a meaningful subdivision in terms of fish fauna? What subsections would be covered by existing useful data (that can be related to one another)?
- Are there additionally any further special habitat features (subtypes) that have their own fish community and thus require specific reference?

It is also pointed out at this juncture that operationalization of the trilateral targets is enabled through the use of a formalized procedure in accordance with the WFD.

This short study indicates that it makes sense to answer the above formulated questions in the next project step by means of a statistical analysis of the existing data. On the basis of these results, a decision can then be made on development of an assessment procedure as a third step by the client and/or the *TMAP Ad hoc working group 'Fish'*.

8. Outlook and proposal for further procedure

If further work should be carried out on the basis of this short study, we propose the procedure briefly outlined below, which provides for another 2 phases. Furthermore, the following list provides a rough estimate of the required time and expense.

Project phase II: Literature research of historical data and analysis of the monitoring data

The following preliminary work is necessary:

- Literature research of historical data and their evaluation
- Compilation of existing monitoring data (will be carried out by the client)
- Processing of the data records for the statistical analyses

In the next step selected data records shall be analyzed in detail with regard to the following aspects:

- Analysis of qualitative and in particular quantitative comparability of the fishing methods applied within the scope of the respective monitoring studies
- Selection of suitable data records for further analysis
- Multivariate analysis (e.g. PRIMER, CANOCO, variance analyses) of the data against the background of spatial and time-related variability of the fish communities as the basis for evaluation of feasibility, development of an assessment procedure
- The results of the evaluations may serve as the basis for selection of variables relevant for the assessment (see PP III).
- Presentation and final assessment of the results in a report against the background of the issue in question.
- Participation in work meetings (in coordination with the client)

Note: All above mentioned steps take place in close cooperation with CWSS TMAP ad hoc working group 'Fish' and the data originators. The available data from the various monitoring studies are exclusively used within the framework of the project.

Cost and time frame – PP II

October – December 2006: Compilation of raw monitoring data (CWSS action), literature research 'historical data' on fish fauna of the Wadden Sea (BC action)

December 2006 – March 2007: Data processing, data analyses, report on results (BC action)

Rough estimate of work required:

Part 1: Literature research (incl. evaluated): approx. 10 –15 days / 80 – 120h

Part 2: Statistical analyses, preparation of report 20 – 25 days/ 160 - 200h (depending on availability / quality of the data)

Project phase III: Development of the assessment procedure

If a decision is made to continue on the basis of PP II, development of a formalized assessment procedure shall follow in a last processing phase and the individual steps shall be carried out in close coordination with TMAP ad hoc group 'Fish'. The following work steps will be performed within the scope of PP III:

- Derivation and coordination of the reference (assessment yardstick)
- Coordination and definition of qualitative and quantitative metrics relevant for the assessment
- Discussion, coordination and definition of class boundaries for the determination of ecological state categories (in accordance with WFD)
- Definition of requirements regarding data structure, data scope and data generation as a prerequisite for application of the assessment tool
- Development of concept for an automated assessment procedure (database-based)
- Preparation of a report, incl. instructions for application of the assessment procedure
- Participation in work meetings (in coordination with the client)

Cost and time frame PP III

March - July 2007

Rough estimate of work required: 25 days/ 200 h

9. Literature

- ARGE ELBE, 2000-2004: Ergebnisse der Hamenbefischungen in der Unterelbe aus den Jahren 2000-2004. Hamburg, Wassergütestelle Elbe.
- BIOCONSULT 2006: Fischbasiertes Bewertungswerkzeug für Übergangsgewässer der norddeutschen Ästuare. Bericht i. A. der Länder Niedersachsen und Schleswig-Holstein, pp. 85 pages + appendix.
- BORJA, A., FRANCO, J., VALENCIA, V., BALD, J., MUXIKA, I., BELZUNCE, M.J. & O. Solaun, 2004: Implementation of the European Water Framework Directive from the Basque country (northern Spain): a methodological approach. *Marine Pollution Bulletin* 48: 206-218.
- BREINE, J.J., MAES, J., QUATAERT, P., Van den BERGH, E., SIMOENS, I. Van THUYNE, I. & C. BELPAIRE, 2005 (in Bearb.): A fish-based assessment tool for the ecological quality of the brackish Schelde estuary in Flanders (Belgium).
- COATES, S.A., 2005 (written): Update Classification Scheme.
- COATES, S.A., COLCLOUGH, S.R., ROBSON, M. & T.D. HARRISON, 2004: Development of an Estuarine Classification Scheme for the Water Framework Directive. Phase 1&2 – Transitional Fish Component. R&D Technical Report E1-131. Environment Agency, Thames region.
- COLIJN, F., 1989: Gewässergütekriterien und naturbezogene Zielsetzungen in den marinen und brackigen niederländischen Gewässern. In: Gütekriterien für Küstengewässer – Niedersächsisches Umweltministerium: 36-42.
- DECKER, W. 1900: Der Garnelenfang und die Garnelenfanggeräte an der oldenburgischen, preussischen und holländischen Küste. – Berichte für die Jahre 1897 und 1898. *Abh. Dt. Seefischerei – Verh.* 5: 3-16.
- ELLIOTT, M. & F. DEWAILLY, 1995: The structure and components of European estuarine fish assemblages. - *Netherlands Journal of Aquatic Ecology* 29(3-4): 397-417.
- ESSINK, K., DETTMANN, C., FARKE, H., LAURSEN, K., LÜRBEN, G., MARENČIĆ, H. & W. WIERSINGA (Eds.), 2005: Wadden Sea Quality Status Report 2004. Wadden Sea Ecosystem No.19 Trilateral Monitoring and Assessment Group, Common Wadden Sea Secretariat, Wilhelmshaven, Ger, pp. 359.
- GOETHALS, P.L.M., ADRIAESSENS, V., MAES, J., ERCKEN, D., BREINE, J., SIMOENS, I., Van LIEFERINGE, C., VERHAEGEN, G., OLLEVIER, F., De PAUW, N. & C. BELPAIRE, 2002: Assessment of fish communities in the Scheldt estuary in Flanders (Belgium) by means of an Index of Biotic Integrity, in: MEIRE, P. et al. 2002. ECSA Local Meeting: Ecological structures and functions in the Scheldt Estuary: from past to future, Antwerp, Belgium October 7-10, 2002: Abstract Book, pp. 43.
- JAGER, Z., 2004: Implementatie KRW vis in overgangswateren. Rijksinstituut voor Kust en Zee/Rikz, pp. 44 + appendix.
- JENNINGS S. & M.J. KAISER, 1998: The effects of fishing on Marine Ecosystems. *Advances in Marine Biology*, 34, 201-302.

- JONES, J.B., 1992: Environmental impact of trawling on the seabed: a review. *New Zealand Journal of Marine and Freshwater Research*, 26, 59-67.
- NORDHEIM, H. von, ANDERSON, O. & THIESSEN, J. (Eds.) 1996. Red list of biotopes, flora and fauna of the trilateral Wadden Sea area.
- NOLTE, W. 1976: Die Küstenfischerei in Niedersachsen. Kommissionsverlag Göttinger Tageblatt, pp. 109. (*Zitat Schellfisch in hohen Massen*)
- OLSON, O.T. Historische Karten Fischverteilung in der Nordsee:
<http://www.antiquemaps.com/uk/olsen.htm>
- SCHNAKENBECK, W., 1928: Handbuch der Seefischerei Nordeuropas - Die Nordseefischerei. - Band 5 Heft 1, E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart: pp. 229.
- REDEKE, H. 1907: Zuiderzee-Rapport. Ministrie Landbow Nyverheid & Handel, Den Haag, pp. 90.
- SARRAZIN, J. 1987: Küstenfischerei in Ostfriesland 1890-1921. Ostfriesische Landschaft, Aurich:234 S
- TIEWS 1983: Über die Veränderungen im Auftreten von Fischen und Krebsen im Beifang der deutschen Garnelenfischerei während der Jahre 1954-1981. *Arch. Fisch. Wiss.* 34:1-156.
- VALDEMARSEN, J.W. & P. SUURONEN, 2001: Modifying fishing gear to achieve ecosystem objectives. Reykjavik Conference on Responsible Fisheries in the Marine Ecosystem. Reykjavik, Iceland, pp. 20.
- VOOYS, C.G.N. De, J.Y. WITTE, R. DAPPER, J.M. van der MEER & H.W. van der VEER 1991: Lange termijn veranderingen in zeldzame vissoorten op het Nederland continentaal plat van de Noordzee. *Neth. Inst. Sea Res., NIOZ-Rapp.* 1991-6:81S.