

## 15. Target Assessment and Recommendations

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### 15.1 Introduction

In this final chapter, a general evaluation and assessment is given, mainly based on the material presented in chapters 4 to 13. As in the 1999 QSR, this chapter is structured according to the habitats as entailed in the Wadden Sea Plan with added sections on chemical quality of the Wadden Sea system, on introduced species, birds and on marine mammals.

In each of the sections below, the main findings presented in this report are summarized. This is followed by one or more conclusions, which also give information regarding the status of the various trilateral Targets formulated in the Wadden Sea Plan. Finally, recommendations are formulated, relating to policy and management, monitoring and the need for further research.

An assessment of the status and development of the Wadden Sea ecosystem and the trilateral targets would not have been possible without the Trilateral Assessment and Monitoring Program (TMAP) and additional national and international programs. Therefore, no recommendations are presented regarding the necessity of continuation of the TMAP as it is.

The TMAP covers the entire Wadden Sea area including islands and offshore areas and spans a broad range from physiological processes through population development to changes in landscape and geomorphology. Furthermore, the TMAP considers the EC Birds and Habitats Directives, as well as other international obligations, such as the Ramsar Convention, the Bonn Convention, and the OSPAR Convention, and contributes to a great extent to the monitoring obligations of the EC Water Framework Directive.

The TMAP consists of a 'Common Package' of parameters which provides an appropriate basis of information concerning the most important questions to be addressed in the protection and management of the Wadden Sea. A process to optimize the TMAP and further tune it to the re-

quirements of the EC Water Framework, Birds and Habitats Directives is presently ongoing.

For the compilation of this QSR, for the first time an operational common TMAP data exchange system was used.

### 15.2 Quality of water, sediment and biota

#### 15.2.1 Nutrients and eutrophication

A study on Wadden Sea specific eutrophication criteria carried out in 2001 and based on data up to 1996 suggested that the Wadden Sea is nitrogen limited and not phosphorus limited. Based on the OSPAR Comprehensive Procedure, the study suggested that autumn concentrations of ammonia and nitrite were suitable indicators of the eutrophication status of the Wadden Sea.

Up to 2002, riverine input of nutrients continued to decrease. In the Wadden Sea, this led to further decreasing phosphate concentrations in winter. Although the winter concentrations of nitrate and nitrite decreased in the German Bight, no consistent trend is discernable yet inside the Wadden Sea. This may indicate that the evaluation procedure as used in this and previous QSRs is not able to resolve the decreasing trend. The decrease in riverine nutrient input caused a similar trend in phytoplankton chlorophyll levels in summer in most of the southern Wadden Sea and in the Sylt/Rømø area. Chlorophyll levels show spatial differences, with the southern Wadden Sea having levels about twice as high as the northern Wadden Sea. Also near the major nutrient sources (Rhine-Lake IJssel, Elbe) higher levels occur.

Blooms of toxic and nuisance algae continued to occur, but did not increase. Dutch monitoring of the Marsdiep tidal inlet revealed a decrease in the duration of *Phaeocystis* blooms. Severe negative effects of toxic blooms were not observed, although the harvest of shellfish fishery was affected to some extent and some fish kills occurred along the Danish coasts.

Green macroalgae, consisting of several systematic groups, showed a general decline. In the summer of 2004, coverage of tidal flats went back to low values as observed prior to about 1980. Although massive development of green macroalgae is often related to coastal eutrophication, the developments in the Wadden Sea cannot be clearly linked to changes in nutrient input, remineralization rates or other environmental conditions.

The results of the 2001 study, that autumn concentrations of ammonia and nitrite are suitable indicators for organic matter turnover and eutrophication, were confirmed for the southern Wadden Sea (Netherlands, Norderney area). In the northern Wadden Sea, the ammonia and nitrite levels are about twice as low as in the southern part and are in line with a lower eutrophication status of the northern Wadden Sea as indicated by the summer chlorophyll levels.

#### Target

A Wadden Sea which can be regarded as a eutrophication non-problem area.

#### Target evaluation

- Though nutrient concentrations have decreased, the entire Wadden Sea still has to be considered a eutrophication problem area, meaning that the target has not yet been met.

#### Conclusions

- Riverine nutrient inputs have decreased gradually, resulting in decreasing phosphate concentrations. The Wadden Sea ecosystem, at least some parts of it, showed its response: decreased chlorophyll levels and lower organic matter turnover. No significant decrease, however, was observed of nitrogen concentrations inside the Wadden Sea in winter;
- Riverine nitrogen concentrations are still 7-8 times higher than riverine background concentrations for total nitrogen;
- The present organic matter turnover, as indicated by the concentrations of ammonia and nitrite, is about 3 to 5 times higher than under eutrophication non-problem conditions;
- Regional differences observed indicate a more intense eutrophication in the southern as compared to the northern Wadden Sea.

#### Recommendations

- In order to meet the target, continued effort is necessary to effectively implement current policies to reduce nutrient inputs; special ef-

fort is necessary with regard to nitrogen compounds;

- The temporal and spatial resolution of monitoring should be adapted to better cover the algal growth season and the whole annual cycle;
- Development of a harmonized approach for determining water residence time in different parts of the Wadden Sea to enable proper assessment of observed nutrient concentrations;
- Research should be done with priority into 1) the causes of the observed differences in eutrophication status between different parts of the Wadden Sea, and 2) the role of suspension feeders, including the Pacific oyster and the American jack-knife clam in the chlorophyll dynamics when using chlorophyll as indicator of eutrophication;
- Further research is necessary to assess how fundamental processes, e.g. nutrient regeneration from organic matter in the sediment, oxygen dynamics and food-chain effects respond to decreasing nutrient input.

#### 15.2.2 Hazardous substances

Riverine inputs, as well as concentrations in sediment, blue mussels, flounder and bird eggs of metals and xenobiotics were presented and analyzed for the period 1985 to 2002 inclusive. Input from the River Rhine was included because of its impact on the Wadden Sea system. Data about polyaromatic hydrocarbons (PAHs) was not part of the TMAP Common Package. Evaluations were made for different subareas of the Wadden Sea as in the 1999 QSR.

##### 15.2.2.1 Natural micropollutants (metals, PAHs)

The general picture is that in the period 1996-2002 metal input via rivers and concentrations of metals (Cd, Cu, Hg, Pb, Zn) in the Wadden Sea remained at more or less the same level as in 1995 or continued to decrease at a moderate rate. Significantly higher river loads in 2002, however, were recorded in the Elbe for cadmium, copper, and zinc, this being related to a significantly higher water discharge. A similarly enhanced river load in 2002 in the Weser was recorded for mercury and zinc. In decreasing order of importance, Elbe, Weser and Lake IJssel, still are the three quantitatively most important contributors of metals to the Wadden Sea. Atmospheric input of metals amounts to no more than a few percent of the summed riverine input.

Riverine input of polyaromatic hydrocarbons (PAHs) is not well known. Atmospheric deposition in the Dutch Wadden Sea in 2000-2001 was estimated at about 800 kg per year. Concentrations in sediment were taken from the OSPAR Joint Assessment and Monitoring Program (JAMP).

In sediment, concentrations of the 6 PAHs of Borneff did not show any trend in the Dutch Wadden Sea since 1988. The same applies to the little available German and Danish data.

Concentrations of mercury and lead exceeded proposed background concentrations. For zinc this was the case only in subarea DK1. Concentrations of mercury, copper and cadmium did not exceed the ecotoxicological assessment criteria developed by OSPAR (2004). Zinc concentrations equalled the higher limit, and lead concentrations even surpassed the limit of the OSPAR ecotoxicological assessment criteria.

In blue mussels, concentrations of cadmium, copper, mercury and lead exceed the proposed background values

In flounder, elevated concentrations of cadmium and mercury in subarea SH1 are considered indicative of the extreme River Elbe flood in 2002.

In eggs of oystercatcher and common tern, mercury levels generally decreased further. Exceptions, however, are recently increased mercury levels in the western Dutch Wadden Sea and Elbe estuary, indicating local sources.

### Target

Background concentrations of natural micropollutants in water, sediment and indicator species.

### Target evaluation

- For metals in sediment, the target has not yet been reached in all subareas of the Wadden Sea; enhanced concentrations occur in areas influenced by river discharge;
- For four metals, concentrations in blue mussels do not yet meet target levels;
- Mercury in bird eggs does not yet meet target levels;
- Regarding ecotoxicological assessment criteria accepted by OSPAR, concentrations in the Wadden Sea of mercury, copper, cadmium and PAHs do not pose a risk to the ecosystem, but zinc and lead still do;
- For PAHs in sediment, no natural background level has been documented. Concentrations are lower than in the Skagerrak, and higher than in Barents Sea sediments.

### Conclusions

- For metals, riverine input is quantitatively the most important input to the Wadden Sea;
- Input of metals continued to decrease or remained unchanged. In some years enhanced loads were due to high river discharge; for organic micropollutants no trend was evident;
- The River Elbe flood of August 2002 caused only a short-term and regional (SH1) increase of cadmium and mercury levels in flounder;
- Anomalous metal concentrations in sediment were found at two locations in subareas SH3 and DK2;
- Little progress has been made, either in JAMP or in TMAP, regarding harmonization of methodology of standardization and data quality control allowing reliable comparison of data.

### Recommendations

- Continued attention on reduction of metal discharges through rivers debouching into the Wadden Sea;
- Continued effort regarding harmonization of methods of analysis and of standardization, both being necessary to enable reliable comparisons at a geographical scale;
- Investigate the reason of anomalous metal concentrations in sediment found at two locations in subareas SH3 and DK2;
- Nickel, being a high priority compound in both OSPAR and EC WFD, to be included in the TMAP Common Package and data units.

### 15.2.2.2 Man-made substances (xenobiotics)

Among the xenobiotics monitored in the TMAP are PCBs (polychlorinated biphenyls), organotin compounds (e.g. TBT, TPT), hexachlorobenzene (HCB), Lindane ( $\gamma$ -HCH) and other pesticides. Organotin compounds in water of Dutch marinas decreased by ~60% between 1990 and 2002.

Riverine input of the above mentioned xenobiotic compounds generally continued to decrease. An exception is the increase of Lindane concentrations due to temporarily (1996 till 2000) increased input by the Elbe, the source of which is not known. One new element is the observation of relatively high concentrations of the biocide triphenyltin (TPT) which is known to be used for potato crops.

The persistency of most xenobiotics still constitutes an environmental problem as old deposits may be remobilized and transported to the Wadden Sea. The Elbe flood of August 2002 caused

an increase of DDT and DDE levels in blue mussels in subarea SH1.

Contents in sediment of PCBs had decreased in subarea NL1, as a result of which the gradient of decreasing concentrations from west to east had disappeared. Also for HCB, sediment concentrations decreased in the Dutch Wadden Sea, the lower values being at comparable level with concentrations in the Danish Wadden Sea. Organotin contents in the Dutch Wadden Sea decreased, but the high OSPAR ecotoxicological assessment criteria were still exceeded in 2002.

In blue mussels, contents of total PCBs, though highly variable, suggest a downward trend. In the northern Wadden Sea this decreasing trend was significant. Concentrations do, however, exceed the OSPAR background range. Ecotoxicological assessment criteria (OSPAR) are met only in Denmark. Lindane concentrations have decreased, now being at the same low level everywhere in the Wadden Sea. DDT/DDE concentrations also decreased. The Elbe flood of 2002 caused an increase in subarea SH1. For HCB, former 'hot spots' in subareas NL3 and SH1 have disappeared. Locally, enhanced concentrations are still found. TBT and TPT are dominant organotin compounds. In 2002 the OSPAR ecotoxicological assessment criteria were exceeded in the Dutch Wadden Sea.

In flounder, concentrations of PCBs have not really continued to decrease in the last 5 years. Highest levels were recorded in subareas NL1 to SH1. Adult flounders exceeded the OSPAR ecotoxicological assessment criteria. Lindane concentrations were very variable, showing a clear decrease only in subarea SH1. In 2002, highest concentrations were recorded in subareas NL1 to NDS3; here also the OSPAR ecotoxicological assessment criteria were exceeded. DDT and metabolites were variable, but high in subareas NDS2 and SH1. Former 'hot spots' of HCB contaminations in flounders in subareas NL3 and SH1 had disappeared. Increased concentrations due to the Elbe flood of 2002 were noted. The geographical variation of concentration levels, with the lowest present in subarea DK3, suggests that historical and local contamination exists mainly in the central and western part of the Wadden Sea.

In harbour seals found dead during the PDV-epizootic in 2002, and in common eider found dead during the winters of 1999 and 2000, very high organotin concentrations were found, indicating strong biomagnification. The effects of these compounds are largely unknown.

In eggs of oystercatcher and common tern, levels of PCBs and organochlorines have further de-

creased, especially in the Elbe area. Local sources of contaminants, however, can still be discerned through elevated levels in the vicinity of Rhine/Lake IJssel, Ems and Elbe.

Newly emerging xenobiotics, such as brominated flame retardants, perfluorinated octane sulfonates (e.g. PFOS), Irgarol (anti-fouling agent), alkylphenoles, Bisphenol-A and phthalates, none of which are part of the TMAP Common Package, were found to occur in various compartments of the Wadden Sea ecosystem. The ecotoxicological effects of some of these compounds are not well known.

In addition to PCBs and tributyltin (TBT), many other compounds have proven to be or are suspected of causing disruption of hormone-regulated endocrine processes in marine animals. Many of these hormone disruptors have been demonstrated to occur in the Wadden Sea, but so far there is little indication of hormonal disruption among fish and invertebrates, in contrast to findings in estuarine and coastal waters in the UK and the southern Baltic Sea.

Bioassays, Effect Directed Analysis (EDA) and Toxicity Identification Evaluation (TIE) have been developed as biological effect assessment techniques to assist the management of various discharges into the environment and the identification of culprit chemicals. These techniques are not yet commonly used in the Wadden Sea.

### Target

Concentrations of man-made substances as resulting from zero discharges.

### Target evaluation

- Although for a number of xenobiotic compounds discharges to and concentrations in the Wadden Sea have decreased, the target has not yet been reached;
- For some substances, e.g. TPT and Lindane, a significant deviation from the target is apparent;
- For PCBs, Lindane and TBT, the OSPAR ecological assessment criteria are exceeded in various Wadden Sea subareas;
- Of many newly developed xenobiotics, including hormone disruptors, concentrations have been found in the Wadden Sea, which is a deviation from the target;

### Conclusions

- Further reduction has occurred of riverine discharges and of environmental concentrations,

however, with exceptions for certain compounds and localities;

- The ban on the use of anti-fouling paints containing organotin for pleasure craft showed its effect in decreasing contamination of Dutch marinas;
- PCB-levels still exceed agreed background levels;
- Many newly developed xenobiotics, including hormone disruptors, have a wide occurrence in the Wadden Sea ecosystem, but are not included in the TMAP Common Package;
- Progress has been made in the development of biological effects assessment techniques.

#### Recommendations

- Extra attention to be paid to some recently and locally increased contaminant concentrations and to the sources of triphenyltin;
- Ecotoxicological research into the effects of organotin accumulation in common eider and harbour seal;
- Inclusion in TMAP of priority substances among the newly developed xenobiotics and hormone disruptors in connection with the requirements of the EC Water Framework Directive;
- Trilateral application of biological effects assessment techniques (e.g., bioassays, EDA, TIE) as a management and monitoring tool.

### 15.2.3 Oil pollution and seabirds

The main source of oil pollution at sea is illegal discharges with fuel oil residues due to operational processes on board ship, causing a clustering of oil slicks around the major shipping lanes. The number of oil spills reported along the Dutch and German coasts have decreased as compared to the 1990s. This kind of chronic oil pollution is a constant threat to seabirds. Surveys of birds found dead on the beaches, and an assessment of the proportion of these birds contaminated with oil, has been used as an indicator of oil pollution from shipping in the Wadden Sea and in the coastal waters of the North Sea. A large proportion, sometimes even 90%, of birds washed onto the beaches have been contaminated with oil.

In 1997, the North Sea was designated as 'Special Area' under the MARPOL Convention Annex I. The designation in 2002 of the Wadden Sea as a Particularly Sensitive Sea Area (PSSA) by the International Maritime Organization (IMO) was a further step to increasing awareness of the particular sensitivity of the Wadden Sea Area to impacts from shipping, such as oil pollution.

In the 1999 QSR, declining oil rates among beached birds were seen as a clear signal that the situation was improving. Since then, rates have declined further, but are still high. Oil rates among birds found inside the Wadden Sea are lower than those among birds found stranded on the North Sea beaches of the Wadden Sea islands. Increased oil rates, however, were established in The Netherlands in the winters 2002/03 and 2003/04, probably due to ship accidents such as those of the 'Tricolor' and 'Assie Eurolink'. It is too early yet to observe any effect of the designation of the PSSA 'Wadden Sea'.

Within OSPAR, an Ecological Quality Objective (EcoQO) regarding oil pollution at sea was developed for the common guillemot, a common seabird of the North Sea. In the Wadden Sea area, an oil rate of 10%, which is the EcoQO for the common guillemot, has still not been reached, despite an overall decline in oil rates since the mid-1980s. Shelduck, common eider, and herring gull, species more representative for the Wadden Sea area than the common guillemot, showed lower oil rates in 1999–2003 as compared with earlier periods.

#### Target

No specific target was formulated with respect to the effect of oil pollution on seabirds. As an alternative, the Ecological Quality Objective (EcoQO) developed by OSPAR was applied:

The proportion of oiled common guillemots among those found dead or dying on beaches should be 10% or less.

#### Target evaluation

- For common guillemot, the OSPAR Ecological Quality Objective (EcoQO) of 10% oil rate has not been met.

#### Conclusions

- Reported oil spills off the German and Dutch coast declined in comparison to the 1990s;
- Oil rates among beached birds have generally decreased further, but are still high. In the last few years, however, oil rates were found to have increased again in the Netherlands;
- Oil rates among birds inside the Wadden Sea are lower than on the North Sea beaches of the Wadden Sea islands.

#### Recommendations

- Continuation and further implementation of policies and measures to prevent oil pollution, including education programs for seafarers;

- Continued and well coordinated trilateral monitoring of beached birds is required to be able to assess the effect of the PSSA designation, and of North Sea wide oil pollution control policy;
- Analysis of oil residues on beaches and oiled birds washed ashore to be used to monitor the effectiveness of pollution control measures aimed at reduction of oil pollution from different sources.

### 15.3 Salt marshes

For salt marshes, three different targets apply, relating to (a) total area, (b) natural geomorphology and dynamics and (c) natural vegetation structure.

A fourth salt-marsh target 'Favorable conditions for migrating and breeding birds' will be addressed in section 15.8.

#### 15.3.1 Area of natural salt marshes

Natural salt marshes with an undisturbed geomorphology, vegetation and dynamics are characterized by the presence of meandering creeks, a diverse vegetation reflecting a diversity in sediment type and elevation, and no impact from human use and erosion protection measures.

Natural salt marshes occur mainly in sandy back-barrier conditions (e.g. on the barrier islands) whereas most of the mainland salt marshes are artificial because geomorphology is strongly affected by humans. Semi-natural salt marshes have developed within man-made sedimentation fields with a man-made drainage system or are affected by grazing or cutting.

In The Netherlands and Germany, roughly 57% of the salt marshes on the islands, and roughly 7% of the salt marshes on the mainland, have never been artificially drained and are not grazed by livestock and thus can be regarded as natural. For Danish salt marshes detailed figures on drainage and grazing were not available for GIS analysis.

A general increase of the total salt marsh area has been observed in most parts of the Wadden Sea during the past decades. This, however, includes all types of salt marshes. A more precise statement regarding the increase of area of natural salt marshes is hampered by the fact that accurate data about geomorphology, vegetation, drainage and grazing has become available only in the last few years. A direct comparison with data presented in the 1999 QSR cannot be made because this data did not include the pioneer zone or consisted of estimations and therefore did not comply with the recently developed standard methods.

An increase of the area of (semi-)natural salt marshes may take place through de-embankment of summer polder. Currently, a total of about 620 ha (240 in Niedersachsen, 40 Hamburg, 340 in the Netherlands) has been or will be de-embanked. The results of recent de-embankment projects showed that restoration of a natural salt marsh situation may take several years or decades depending on the geomorphological and hydrological conditions.

#### Target

An increased area of natural salt marshes.

#### Target evaluation

- In most parts of the Wadden Sea, an increase in area of natural and semi-natural salt marshes could be observed. An evaluation of the target in quantitative terms is, however, not possible for the entire area because of insufficiently detailed older data.

#### Conclusions

- About 56% of the island salt marshes in The Netherlands and Germany can be regarded as natural salt marshes;
- In those areas of the Wadden Sea where long-term data is available, an increase in salt marsh area (natural as well as semi-natural salt marshes) has been observed over the past decades. Locally, mainly at non-sheltered places along the mainland, losses have occurred due to erosion;
- An increase of the area of salt marshes could be achieved by de-embankment of summer polders. In due course, these marshes will develop to salt marshes with a more natural vegetation structure.

#### Recommendations

- Further development of naturally growing salt marshes is best helped by leaving geomorphology of neighboring mudflats undisturbed;
- Further increase of area of (semi-)natural salt marshes can be achieved by breaching protecting summer dikes or sand dikes;
- For vegetation mapping of de-embanked polders and other study sites, a frequency should be chosen tuned to the velocity of the salt-marsh development process.

#### 15.3.2 Increased natural morphology and dynamics of artificial salt marshes

In artificial (i.e. man-made through land reclamation) salt marshes mainly located along the main-

land coast artificial drainage systems have been used extensively in the past. During the last two decades the use of artificial draining has been significantly reduced, which has resulted in a more natural situation.

In about 34 % of the mainland salt marshes, no drainage measures have been taken during the past 10 years and 16% have never been drained artificially. In about 54% of the island salt marshes there were no drainage measures at all, and in an additional 34% of the island salt marshes no artificial drainage measures have been carried out during the past 10 years

Long-term monitoring revealed that the artificial ditch systems were very persistent. The development of remaining ditch systems into natural-like creeks will probably take several decades.

#### Target

An increased natural morphology and dynamics, including natural drainage patterns, of artificial salt marshes, under the condition that the present surface is not reduced.

#### Target evaluation

- Artificial draining in salt marshes has been reduced. The remaining ditch systems, however, have not yet developed into natural-like creek systems.

#### Conclusion

- Reduction or cessation of artificial drainage has increased the natural geomorphology and dynamics of artificial salt marshes,
- The maintenance of artificial drainage systems in salt marshes has decreased significantly during the last two decades. In 34% of the mainland salt marshes no drainage measures have been carried out during the last 10 years, in addition to about 16% of salt marshes which have never been drained artificially.
- Development of artificial drainage systems into a natural-like creek system is a slow process which will probably take several decades.

#### Recommendation

- Cessation of artificial drainage in all salt marshes without any agricultural use, taking care of prevention of water logging of dike foots,
- Further study and experiments into effective ways of facilitating the development of natural-like drainage creeks.

### 15.3.3 Improved natural vegetation structure of artificial salt marshes

The 'naturalness' of the vegetation structure of artificial salt marshes strongly depends on the local geomorphological conditions, including existing sea dikes. A precise description of the vegetation that can develop, and that can serve as an evaluation criterion, could therefore not be formulated. In those salt marshes, a more diverse vegetation structure reflecting the geomorphological conditions can be reached by reduction of artificial drainage and livestock grazing.

In some areas, grazing has continued as a management tool for nature conservation aimed at maintaining short vegetation attractive to migrating geese and to creating heterogeneity of vegetation structure. In areas where salt marsh dynamics are hampered, for example because of the stabilization of sedimentation fields, mid and high-marsh communities may extend and vegetation may develop towards a dominance of few species. This ageing of salt marshes is a recent focus in research. In such salt marshes, moderate livestock grazing may result in high variation of the vegetation structure if this is aimed at.

Since the 1980s, livestock grazing has generally decreased in the entire Wadden Sea area. The reduction of 50% of areas with intensive grazing took place on the mainland salt marshes in the Netherlands and Germany. In Denmark, the situation has not changed much compared to about 75% intensive grazing on the mainland, and 10% on the island marshes in 1987. In the Northern Danish Wadden Sea, the proportion of intensively grazed areas increased from 30% (in 1989) to 40% (in 2000).

The development of the vegetation structure, also with regard to ageing of salt marshes, can now be better monitored in the entire Wadden Sea by using a newly developed common TMAP typology for salt-marsh zones and vegetation types.

#### Target

An improved natural vegetation structure, including the pioneer zone, of artificial salt marshes.

#### Target evaluation

- A precise evaluation of the target cannot be given, because long-term data is only available for some regions and the developed common typology could not be applied to older data. Significant reductions of livestock graz-

ing intensity in The Netherlands and Germany contributed to a more natural vegetation structure of artificial mainland salt marshes. In Denmark, the proportion of intensively grazed salt marshes did not really change.

#### Conclusions

- Human use (livestock grazing, cutting) of salt marshes has generally decreased; this has resulted in a more natural vegetation structure of artificial salt marshes;
- Livestock grazing is still used as a management tool aimed at making salt marshes attractive to specific birds species, and to creating heterogeneity of the vegetation structure;
- Natural development of salt marshes is limited by existing sea dikes and reduced natural sedimentation areas;
- In some areas, ageing of salt-marsh vegetation could be observed, characterized by mid and high-marsh communities. This ageing of vegetation will be retarded by livestock-grazing;
- The within TMAP developed common vegetation typology will facilitate a Wadden Sea wide harmonized assessment of salt-marsh development.

#### Recommendations

- To prepare a Wadden Sea wide assessment of salt-marsh vegetation development, based on the now available common vegetation typology, which also can be used for the requirements of the EC Habitats Directive;
- Study of the possible interrelationship between ageing towards climax vegetation, rate of sedimentation and cessation of grazing;
- Continuation of long-term study sites and incorporation of these sites into the International Long-Term Ecological Research sites (ILTER).

### 15.4 Tidal area

The trilateral Targets related to the Tidal Area of the Wadden Sea have a physical as well as a biological dimension.

#### 15.4.1 Hydrology/geomorphology

A natural dynamic situation with respect to hydrology and geomorphology would imply no human interference in the shape and depth of tidal channels, as done by maintenance dredging of shipping channels, no artificial fixing of heads of islands to combat unwanted erosion, no sand nourishments of beaches and foreshore, and no

sediment disturbance by suction dredging cockle fishery. This would also imply the absence of disturbance of habitat forming biota, such as eel-grass beds and mussel beds (both intertidal and subtidal).

Tidal inlets and outer deltas are characterized by great natural dynamics. Positions of tidal channels, shoals and emerging sand banks are changing continuously.

For economic reasons, access to harbors in the Wadden Sea and its estuaries needs to be maintained. Keeping tidal channels and other shallow areas to a minimum depth required for safe shipping causes a continuous or periodic deviation of the natural and dynamic hydro-morphological equilibrium of the Wadden Sea system. Sedimentation-erosion processes make the system return to its equilibrium, causing renewed human intervention.

In the estuaries, an increase of the minimum depth in shipping lanes has led to an increased tidal regime causing higher high water levels, lower low water levels and higher tidal current velocities. It is not well known to what extent this has caused changes in the amount and nature of tidal flats and subtidal areas, although basic data may be available, for example, in the form of periodic sounding charts. Hypsometric curves, and temporal changes therein, might be useful as indicators of the geomorphological dynamics of estuaries and tidal basins.

Sea level rise due to climate change and progressive endikement and land reclamation have made the Wadden Sea narrower at many places. This, through increased wave energy, has led to a general depletion of fine-grained material and to a significant decrease of high mud flats bordering the mainland which constitute the preferred settling space for juvenile bivalves. These high mud flats are important as a settling habitat for juvenile bivalves. It is plausible that the intensive fishery for cockles and seed mussels in the Dutch Wadden Sea has contributed to a reduction of such high intertidal mud flats.

#### Target

1. A natural dynamic situation in the Tidal Area;
2. An increased area of geomorphologically [and biologically] undisturbed tidal flats and subtidal areas.

#### Target evaluation

1. The Tidal Area of the Wadden Sea is still characterized by a high degree of natural dynamics. There is no significant increase of construc-

tions for coastal defense. Deviations from Target 1 are existing coastal defense structures and deepening of channels for shipping;

- 2. Target 2 cannot be evaluated due to absence of proper information.

**Conclusions**

- Estuaries giving access to major sea ports (Elbe, Weser, Ems) experience progressive deepening causing hydrological changes. Also shipping channels adjacent to intertidal flats are deepened, It is not well documented to what extent these changes affect the target of geomorphologically and biologically undisturbed intertidal flats and subtidal areas (see also 15.6);
- Long-term sea level rise and land reclamation have caused loss of area of high mud flats, important as a settling habitat for juvenile bivalves.

**Recommendations**

- For a better assessment of the targets, parameters need to be developed within the TMAP to properly monitor changes in hydro-morphological dynamics and in geomorphologically and biologically undisturbed tidal flats and subtidal areas;
- A study should be undertaken into the effect of increased deepening for shipping on estuarine geomorphology, especially regarding changes in the amount and nature of tidal flats and subtidal areas;
- The signaled loss of high mud flats essential for bivalve settlement should be given more attention, through either monitoring or directed research.

**15.4.2 Macrozoobenthos**

Over the last 15 years, bivalve recruitment success has declined. This was accompanied by a shoreward shift of their centers of distribution, which is attributed to increasing predation pressure on the newly settled post-larvae by shrimps and shore crabs, and coincides with the occurrence of mild winters. This indicates the power of climate factors in governing recruitment, and therefore population sizes, of bivalves in the Wadden Sea. Continued global warming may therefore cause bivalve stocks to decline.

On a more regional scale, deterioration of sedimentary conditions may play a role, especially at the sandier lower tidal flats. Possible causes are removal of mussel beds by fishery and sediment disturbance by cockle dredging.

In general, mechanized fishery for cockles in the Dutch Wadden Sea has had negative effects on recruitment of cockles and non-target species living in intertidal flats. There is an indication that worms have increased in abundance. Mechanized cockle fishery in the Dutch Wadden Sea ceased on 1 January 2005.

During the last two decades the Wadden Sea has been in an early stage of eutrophication, almost without occurrence of harmful anoxia except in local 'black spots' and under patches of green algae.

Isolated populations of benthic invertebrates in estuarine and brackish habitats may be endangered. These populations need further attention in order to elucidate their status.

**Target**

An increased area of [geomorphologically and] biologically undisturbed tidal flats and subtidal areas.

**Target evaluation**

- The observed decline in bivalve recruitment and shift in their centers of distribution indicates a loss of previously biologically undisturbed tidal flats, in other words: a deviation from the target.

**Conclusions**

- Bivalve recruitment has declined and their centers of distribution shifted, largely due to increased epibenthic predation as a result of a series of mild winters; deterioration of sediment conditions due to shellfish fisheries may have contributed;
- A continued overall increase of worms was observed, the underlying cause of which is not well understood;
- Isolated populations of benthic invertebrates in estuarine and brackish habitats may be endangered.

**Recommendations**

- Elucidation of the status of isolated populations of benthic invertebrates in estuarine and brackish habitats, and of the underlying cause of the long-term increase in polychaetous worms and of shifting centers of bivalve recruitment.

**15.4.3 Biogenic structures**

Three species occurring in the Tidal Area of the Wadden Sea, viz. the seagrass *Zostera* spp., the blue mussel *Mytilus edulis* and the polychaetous

worm *Sabellaria spinulosa*, are responsible for the formation of specific biogenic structures. For these species a target applies regarding area and distributions of these structures.

#### *Sabellaria* reefs

*Sabellaria*-reefs are still extremely rare in the Wadden Sea, with only three known occurrences, viz. two in the Jade near Wilhelmshaven and one south of the island Amrum. The size of these reefs and their development over time are not well documented. This is partly caused by absence of systematic monitoring of these reefs (not included in TMAP Common Package), and partly by apparent inadequacy of the different methods used to survey the reefs.

*Sabellaria* reefs are placed on the Red List of Biotores. Under the EC Habitats Directive (Annex I), conservation of reefs is required, and within the NATURA 2000 network *Sabellaria* reefs can be protected as Special Area of Conservation (SAC).

#### Target

An increased area of, and a more natural distribution and development of [natural mussel beds, *Sabellaria* reefs [and *Zostera* fields].

#### Target evaluation

- No increased area of *Sabellaria* reefs has been reported.

#### Conclusions

- The dramatic decline of *Sabellaria* reefs has not stopped. Information concerning existing reefs is unsatisfactory;
- Specific measures to better protect existing *Sabellaria* reefs have not been implemented.

#### Recommendations

- The *Sabellaria* reefs should be designated as Special Area of Conservation, where especially seabed disturbing activities (sand extraction, dredging, bottom trawling) are not allowed;
- Human interventions changing the water current conditions should be considered carefully as they may affect *Sabellaria* reefs;
- A program should be launched under the TMAP to properly monitor existing *Sabellaria* reefs, and to explore the occurrence of reef structures in potential reef areas in the Wadden Sea Area. New reefs found should be considered for monitoring.

#### Seagrass (*Zostera* sp.) fields

In the southern and central Wadden Sea, the decline of seagrasses as observed between the 1950s

and 1990s seems to have come to a halt, and some slow recovery is evident. At present (2002/2003), seagrass beds with a total area of ca. 73 km<sup>2</sup> are distributed rather unevenly. Approx. 82% of the beds occur in the northern Wadden Sea between Eiderstedt and Skallingen where no long-term decline of seagrasses was noted. The total area covered has increased in The Netherlands and in Niedersachsen.

Both species *Z. marina* and *Z. noltii* show considerable interannual fluctuations in size and shape of local beds. Salinity and nutrient loading, separately and in combination, are important environmental factors for seagrass development. Local runoff of freshwater is considered advantageous for seagrass growth; these runoff points have been diminished by sea dike strengthening. Eutrophication and hydrodynamics seem to be the major factors determining the distribution of seagrasses in the Wadden Sea, while shellfish fishery and land reclamation have negative effects on a more local scale. Reintroduction programs, as performed in the western Dutch Wadden Sea, may have success in supporting the start of a natural recovery provided that the optimal locations are chosen.

#### Target

An increased area of, and a more natural distribution and development of [natural mussel beds, *Sabellaria* reefs and] *Zostera* fields.

#### Target evaluation

- The target of increased area of *Zostera* fields has not yet been met in all sub-regions of the Wadden Sea.

#### Conclusions

- It is still not precisely known how much *Zostera* occurs in the entire Wadden Sea and general trends in development can hardly be separated from more local phenomena and fluctuations;
- Although the long-term decline of seagrasses in the southern and central Wadden Sea seems to have come to a halt, and some slow recovery is evident in The Netherlands and Niedersachsen; no overall increase in area and natural distribution of seagrass fields has occurred;
- Reintroduction programs, if carefully designed, may contribute to seagrass recovery, especially in areas poor in natural propagules.

#### Recommendations

- Given the diminished and, in some areas, still

endangered state of seagrasses, negative effects of shellfish fishery and land reclamation works at existing and potential sites of seagrass beds should be avoided;

- Further reductions in nutrient loads would strengthen the vitality of seagrass when growing at average salinities;
- Restoring of ebb-sluices with continuous freshwater runoffs to explore their positive effects on local seagrass development;
- Further study of the effectiveness of re-introduction programs of intertidal seagrass, as well as a study of the feasibility of re-introduction of the large morph of *Zostera marina*;
- Improved harmonization of monitoring of and research into seagrass in the Wadden Sea.

#### Blue mussel beds

##### Intertidal mussel beds

As a follow-up of recommendations in the 1999 QSR, a protocol was developed for harmonized description and area measurement of intertidal mussel beds. In addition, in The Netherlands a habitat model was developed which is able to indicate where intertidal mussel beds are likely to develop and persist ('stable sites').

Introduced species such as Pacific oyster and slipper limpet may form a threat to existing mussel beds because these are effective competitors for space and food.

During the last 8-12 years, direct impact by fishery on the natural development of mussel beds in The Netherlands and Schleswig-Holstein has been small or absent. Restrictive fishery regulation as applied in The Netherlands contributed to reaching more than 2,000 ha of more or less stable mussel beds; few beds, however, developed in the western Dutch Wadden Sea. In the Danish Wadden Sea fishery had only local effects because of large closed areas. In Niedersachsen, the actual total area of mussel beds is below the level present in the late 1980s despite the recovery after the spatfall of 1996. Continued fishery led to loss of mussel beds. In response, 29 mussel bed sites have been protected from fishery since 2004.

Spatfall is a crucial process, the determining factors of which are still not well understood, especially those responsible for regional differences.

##### Subtidal mussel beds

Considerable areas of subtidal mussel beds exist in The Netherlands and Schleswig-Holstein, serving as an essential food resource for the common eider. These subtidal mussel beds are ecologically different from the beds in the intertidal, although

only limited information has become available on this issue. Mussel beds temporarily present on sublittoral culture lots are much poorer. Subtidal mussel beds are intensely exploited by fishermen, mostly for obtaining seed mussels to stock the culture lots. Because of their high biodiversity of associated fauna, subtidal mussel beds need to be better protected.

#### Target evaluation

##### Target

An increased area of, and a more natural distribution and development of natural mussel beds [, *Sabellaria* reefs and *Zostera* fields].

- The target of an increased area of natural mussel beds in the intertidal area was reached in the mid and eastern Dutch Wadden Sea. In the Danish and western Dutch Wadden Sea, no development according to the target occurred. In Niedersachsen, the actual total area of mussel beds is below the level present in the late 1980s and in Schleswig-Holstein still below the level present in the early 1990s;
- With regard to the subtidal mussel beds, no evaluation of the target is possible yet.

#### Conclusions

- The new protocol for area measurement of intertidal mussel beds will enable a harmonized assessment of the target in future;
- The Dutch habitat model has proven to be a useful tool for the protection of intertidal mussel beds;
- Subtidal mussel beds may be heavily exploited by mussel farmers to obtain seed mussels for stocking their culture lots;
- Subtidal mussel beds may be characterized by a high biodiversity, but data is still scarce;
- Natural development of intertidal mussel beds occurred as a result of consecutive spatfalls and large areas having been without fishery for seed mussels; poor recruitment since 1999, however, has caused a decline;
- Progress was made with protection of young mussel beds at old (stable) sites of mussel beds.

#### Recommendations

- Research on the spatfall process in general, and on the cause of the regional differences in recruitment success;
- Because of their high biodiversity and ecological importance, a trilateral protection regime

should be designed for subtidal mussel beds; subtidal and intertidal beds should also be considered as a biological quality element in the relevant EC Directives;

- The proliferation of the Pacific oyster should be monitored, and its competitive mechanism leading to the taking over of mussel beds investigated, with a view of developing options for management;
- The management measure of protecting stable mussel beds or sites (intertidal as well as subtidal) is still valid;
- Extension - if possible - of the habitat model developed as a management tool for intertidal mussel beds in the Dutch Wadden Sea to the German and Danish Wadden Sea as well.

#### 15.4.4 Introduced species

Regarding introduced species no targets have been formulated. Introduction of species from elsewhere to the Wadden Sea can hardly be controlled, as these can reach the Wadden Sea using natural vectors (e.g. sea currents) as well as anthropogenic vectors, such as tanker ballast water and transport of aquaculture products. Control will never be 100% effective. Moreover, climatic change due to global warming will allow species with a more southerly (or warmer) geographic distribution to establish populations in the Wadden Sea.

So far, there are only few examples of introduced species in the Wadden Sea that have had a negative impact on resident populations. Cord grass (*Spartina anglica*) displaced seagrass locally and the Pacific oyster (*Crassostrea gigas* - also known as Japanese oyster) currently seems to be taking over blue mussel (*Mytilus edulis*) beds. In both instances one can argue that a new biocoenosis is formed, which in the case of the Pacific oyster may be of high biodiversity. A single introduced species, however, may be able to cause severe ecological change, economic damage or be a threat to human health. Therefore, adaptations of TMAP may be necessary in order to provide the data for evaluating the possible impact of introduced species.

#### Target

(With respect to introduced species, no target was formulated).

#### Target evaluation

- Not applicable.

#### Conclusion

- Once they are established in the Wadden Sea, it is not easily feasible to effectively prevent further spreading of species, or to control their population development. Any action to remove an introduced species from the Wadden Sea would inevitably do harm to other components of the ecosystem;
- Effects of introduced species on the Wadden Sea ecosystem are difficult to predict.

#### Recommendation

- The TMAP should be alert to discover new immigrant species, and may need to be adapted to provide data for impact assessment of introduced species;
- Consider appropriate precautionary measures to prevent further introduction of species that may constitute a risk to the Wadden Sea ecosystem;
- Study of the ecological function of the newly developing reefs of Pacific oysters.

#### 15.4.5 Fish and shrimps

No trilateral targets have been formulated with respect to the fish and shrimp fauna of the Wadden Sea and its estuaries. Neither have specific parameters been included in the TMAP Common Package.

Brown shrimps play an important role in the Wadden Sea food web. They are epibenthic predators of small and juvenile zoobenthos and in turn serve as food for birds, fish and young seals. There is a fishery for brown shrimp in the Wadden Sea and the adjacent coastal zone of the North Sea.

Fish species use the Wadden Sea for different purposes. Some species, called residents, live here all their life; for others, it is just for passing through during their migrations between breeding habitats in freshwater and adult habitat in the sea, or vice versa. For a number of North Sea fish, e.g., the flatfish species plaice and dab, the Wadden Sea is important as a nursery; larvae enter the Wadden Sea, recruit to benthic life and profit from the available food resources before rejoining their adult populations in the North Sea. Depending on their occurrence mainly near the bottom or higher in the water column information has become available from national demersal fish surveys and local pelagic sampling programs.

#### Target

No specific fish-related trilateral targets have been formulated. The following more general targets do have some relationship:

1. An increased area of geomorphologically and biologically undisturbed tidal flats and sub-tidal areas;
2. A favorable food availability [for migrating and breeding birds].

#### Target evaluation

1. The target of undisturbed tidal flats and sub-tidal areas for fish and shrimp cannot be evaluated. The possibility of the observed shift in juvenile flatfish being related to a decreased area of undisturbed tidal flats and subtidal areas needs to be investigated;
2. There is currently no evidence of food shortage among fish and shrimp eating birds.

#### Conclusions

- Though demersal fish surveys are being carried out in all three Wadden Sea countries the methodology used is not well harmonized. For pelagic fish, information is fragmentary due to the absence of appropriate monitoring;
- The numbers of juvenile flatfish using the Wadden Sea as a nursery are clearly declining. This is especially so for dab and plaice, and is due to an offshore shift in the distribution of these fish species along the North Sea coast;
- The abundance of diadromous fish species is still low.

#### Recommendations

- The formulation of trilateral targets regarding fish, tuned to the requirements of the relevant EC Directives, will structure and focus research and monitoring of this important faunal group in the Wadden Sea;
- The existing demersal fish survey programs should be trilaterally coordinated and harmonized to provide valuable information on the quality of the Wadden Sea as a habitat for demersal fish;
- Development of trilaterally coordinated pelagic fish monitoring program, especially aimed at obtaining data about fish species depending on upstream water quality and breeding habitat;
- Studies should be undertaken to improve the ecological knowledge of non-commercial species, to investigate the functional relationship between fish species and specific habitats such as mussel beds and other hard substrate, and to obtain insight in the factors underlying the shift in distribution in juvenile flatfish;

- For threatened diadromous fish species further conservation effort is required, e.g. sluice and dike passage facilities and upstream habitat restoration.

### 15.5 Beaches and dunes

With regard to beaches and dunes, targets apply regarding natural dynamics, natural vegetation succession and favorable conditions for migrating and breeding birds

#### Beaches

With respect to the beaches of the Wadden Sea islands, for the first time in the QSR information about their ecology is presented from national projects. No specific parameters have been made operational within the TMAP. The available information is limited and does not allow a complete assessment of the status of the Wadden Sea beaches. However, it was shown that different types of beaches (reflective vs. dissipative, eroding vs. accreting) each have their own characteristic meio- and macrobenthic fauna serving as food for fish and shore birds.

The natural dynamics of beaches are locally and periodically influenced by coastal protection measures, e.g. in the form of stony groynes and sand nourishment of the beach or foreshore. Coastal protection measures are expected to increase related to continued sea level rise. Dynamic upper parts of sandy beaches may provide an essential breeding habitat for birds like kentish plover and great ringed plover. The breeding success of these birds may suffer from human recreational activities unless proper protection measures are implemented (see under 15.8.2).

#### Dunes

Natural dynamics of beaches at head and tail ends of some islands have increased due to major reduction of coastal protection measures. In the dunes more centrally on the islands, however, dynamics have increased only locally. The area with embryonal dunes, white dunes and primary dune slacks has not increased. Remnant coastal defence structures such as sand dikes, act as limiting factor. Areas with free-blowing sand are still very limited. About two thirds of the Wadden Sea dunes consist of mid-successional type vegetations, in which eutrophication has caused dense grass vegetations to develop. The more open and species-rich grey dunes and secondary pioneer vegetations have further decreased.

On some of the islands, species-rich dune slack vegetations have degraded due to groundwater extraction, causing an accelerated succession to drier communities.

Accelerated succession in dune vegetations is presently being remedied in some areas by application of traditional-style management measures, restoring successional processes and species-rich habitats.

The Wadden Sea dunes qualify for the EC Birds Directive, especially as a breeding habitat for a number of species. Some species characteristic of open dune areas have strongly declined due to the development of dense grass-dominated vegetations, partly due to airborne eutrophication. Increased scrub vegetation has led to the decline in numbers of some characteristic birds of prey.

#### Target

1. Increased natural dynamics of beaches, primary dunes, beach plains and primary dune valleys in connection with the Offshore Zone;
2. An increased presence of a complete natural vegetation succession.
3. Favorable conditions for migrating and breeding birds.

#### Target evaluation

1. The target of increased natural dynamics of beaches and dunes cannot be fully evaluated due to absence of criteria and of comparable relevant data; natural dynamics has increased where coastal defense activities were stopped; remnant coastal defense structures still remaining restrict increased dynamics;
2. A complete natural vegetation succession is not present because about two-thirds of the dune areas consists of mid-successional dune type and important other types are not present or show further decline;
3. The target 'Favorable conditions for migrating and breeding birds' will be evaluated in section 15.8.

#### Conclusions

- Too little information is available to allow a complete assessment of the status of the Wadden Sea beaches;
- No parameters have been developed within the TMAP to enable an evaluation of the target of (increased) natural dynamics of beaches;
- A major reduction of coastal protection measures has caused increased dynamics in beaches and primary dunes. Areas with free-blowing sand, however, are still very limited;
- Eutrophication from atmospheric deposition has caused dense grass vegetations to devel-

op and on some of the islands, species-rich dune slack vegetations have degraded due to groundwater extraction;

- The use of traditional-style management measures can contribute to restoring successional processes and species-rich habitats.

#### Recommendations

- The trilateral targets with respect to beaches need to be reconsidered and redefined against the background of (1) sea level rise and concomitant intensification of coastal defense, and (2) increased recreational pressure on the coastline;
- A better exchange of information about how coastal protection measures and remnant sand dikes influence pioneer stages and the possibilities for restoring natural dynamics;
- An inventory of the differences in water extraction management and of their ecological consequences;
- Existing differences in dune management regimes make a case for exchange of information on this issue among managers involved;
- More fundamental studies of the speed and direction of natural succession under different conditions, with the aim of contributing to future policy and management questions concerning the Wadden Sea dunes;
- The use of the newly developed TMAP classification for dunes for trilateral assessment of dune development, and concurrent data collection concerning atmospheric deposition, coastal protection measures and water management.

### 15.6 Estuaries

With regard to estuaries, the targets relate to protection of valuable parts and to restoration of riverbanks.

No comprehensive overview could be given of developments of human pressures in estuaries, and of the related hydrological, geomorphological and ecological response. Water Framework Reports 2005, however, state that in transitional waters (= estuaries) of the Wadden Sea Area significant changes have occurred in hydrology and that there has also been a reduction of tidal flats and brackish marsh habitats.

In German estuaries, the Ems included, increased deepening through dredging to promote safe shipping access to ports has led to changes in the tidal regime. No geomorphological changes of any importance have been observed. In the Ems estuary continued siltation of one of the tid-

al channels raises the question of future policy: allowing the development of a 1-channel system or maintaining a 2-channel system as in the Western Scheldt (SW Netherlands)?

Monitoring of macrozoobenthic communities in German estuaries revealed that of the species found, only a minor part form a stable community. Nevertheless, these estuaries provide biotopes for a number of red list species, the extent of which is not well documented.

#### Target

Valuable parts of estuaries will be protected and river banks will remain and, as far as possible, be restored to their natural state.

#### Target evaluation

- According to Water Framework Directive Reports 2005, most estuaries in the Wadden Sea Cooperation Area fail to meet the target.

#### Conclusions

- Continued deepening of shipping channels in estuaries has led to changes in the tidal regime;
- Geomorphological changes in estuaries are not very clear, except for the continued siltation of the Bocht van Watum tidal channel in the Ems estuary;
- Progressive human impact has resulted in loss of tidal flats and brackish-water habitats.

#### Recommendations

- Ecological targets for estuaries need to be reformulated and tuned to the requirements of the relevant EC Directives in order to increase their operational value;
- The tidal freshwater reaches of estuaries should be integrated into the Leeuwarden definition of an estuary;
- Restoration of estuarine habitats (especially shallow areas and foreland) is necessary in all estuaries under consideration. Problems linked to the artificial increase of the tidal range have to be given special attention;
- Monitoring of long-term ecological changes in valuable parts of estuaries (to be specified!) is necessary;
- Consequences of further deepening, barriers and harbor extension should be evaluated carefully, taking into account the historical deterioration of the estuaries;
- For the Ems estuary, a long-term vision should be developed including the issue of a 2-channel or 1-channel system.

## 15.7 Offshore Area

The Offshore Area is positioned seaward of the Wadden Sea islands, extending to the 3 sea-mile limit, including the Conservation Area beyond this limit. This part of the Cooperation Area is in open connection with (a) the Wadden Sea and its estuaries, through a series of tidal inlets, and (b) the open North Sea. For the Offshore Area there are Targets with respect to natural geomorphology, favorable food availability for birds, and viability of stocks of marine mammals.

### 15.7.1 Geomorphology

The sediments of the seabed of the Offshore Area and of the channels and flats in the Tidal Area of the Wadden Sea form a coherent 'sand sharing' system. As a consequence of sea level rise, sand will be transported from the coast off the islands into the Wadden Sea.

Whereas coastal defense activities on the Wadden Sea islands have continued where necessary, no major changes in geomorphology or its dynamics can be reported since the 1999 QSR. One exception, the construction in 1995 of a 800 m long cross-shore dam at the northern tip of the island of Texel caused sand accretion at both sides of the dam extending the beach in seaward direction, and changes in the nearby ebb tidal delta.

#### Target

An increased natural morphology, including the outer deltas between the islands.

#### Target evaluation

- As far as available data shows, no major changes of natural morphology have taken place.

#### Conclusion

- Apart from coastal defense activities on the Wadden Sea islands (e.g., foreshore sand nourishments, cross-shore dam at Texel) no evidence has become available regarding any long-lasting negative development in natural dynamics of the geomorphology of the Offshore Area.

#### Recommendation

- Major coastal defense constructions should be accompanied by studies – both near field and far field – on their effects on seabed morphodynamics.

### 15.7.2 Biota

Regarding birds and marine mammals, more information has become available on the numbers

of individuals and proportion of their populations using the Offshore Area. One new insight is that common and grey seals from the Wadden Sea do use also the Offshore Area and open North Sea, covering great distances. The underlying cause has not yet been elucidated.

Harbour porpoises have become more numerous in the Offshore Area of The Netherlands and Niedersachsen, although the number of sightings is still low. In Schleswig-Holstein and Danish waters, the numbers remained more or less stable. There was an overall mean abundance of ca. 36,500 animals in the German Exclusive Economic Zone of the North Sea.

Repeated inventories have demonstrated the occurrence of important stocks of the bivalve *Spisula subtruncata* along the Dutch coast, and of *S. solida* along the coast of Schleswig-Holstein. These bivalves are a major food source for diving ducks such as common scoter and eider. Especially for the eider, these *Spisula* stocks are important for survival in the Wadden Sea when bivalve stocks are depleted either by severe winter conditions or by extensive shellfish fishery. In The Netherlands, there is a fishery for *Spisula*.

From the ICES North Sea Benthos Project 2000 it appears that the macrozoobenthos community in the Offshore Area is part of coastal communities along the Belgian-Dutch-German coast, characterized by low species numbers, but locally enhanced where complex substrate (sand, gravel, stones) is present, such as near Borkum Riff and in the outer Amrum Grounds.

#### Target

1. A favorable food availability for birds.
2. Viable stocks and a natural reproduction capacity of the common seal, grey seal and harbour porpoise.

#### Target evaluation

1. Stocks of the bivalve *Spisula* constitute a favorable food source for diving ducks, provided fishing pressure on these bivalve stocks is low;
2. (See section 15.9 for evaluation of Target 2.)

#### Conclusions

- The Offshore Area seems to play a more important role in the life cycle of the harbour seal, grey seal and harbour porpoise than reported in the 1999 QSR;
- Bivalve stocks in the Offshore Zone are important as a food resource for common scoter, eider and other diving ducks. For the eider,

*Spisula* stocks in the Offshore Area are an essential escape during adverse conditions in the Wadden Sea.

#### Recommendations

- Further research is needed to elucidate the specific role and importance of the Offshore Area in the life cycle of harbour porpoise, grey seal and common seal;
- A proper management of *Spisula* fishery needs to be developed to ensure compliance with the target 'favorable food availability for birds', especially for common scoter, common eider and velvet scoter.

### 15.8 Birds

Two major groups of birds have been considered, viz. breeding birds and migratory birds. For these birds, the Wadden Sea with its salt marshes, dunes, beaches and tidal flats constitutes a wetland of extreme high standard. It accommodates essential populations' requirements, such as moulting, wintering, roosting and staging during seasonal migrations as well as breeding. The availability of food and low level of disturbance are essential factors. For 43 species the Wadden Sea supports more than 1% of the flyway populations, being the criterion of the Ramsar Convention. Of these, 4 are breeding birds, 24 are breeding as well as migratory and 15 use the Wadden Sea only during their seasonal migrations. Of all migratory birds, 29 species occur with more than 10% of their flyway population.

For more than 30 birds species, the Wadden Sea area is important as breeding area. Breeding habitats are present in salt marshes, dunes, pastures and on beaches.

The trilateral targets regarding migratory and breeding birds relate to favorable food availability, natural flight distances, natural breeding success and undisturbed roosting and moulting areas.

#### 15.8.1 Breeding birds

Among the 31 bird species monitored are 6 species with more than 25% of the NW European populations breeding in the Wadden Sea area. Two species are very rare after a long-term decline, viz. ruff and dunlin. For four rare species too, the Wadden Sea is situated on the edge of their European breeding range.

Over the period 1990-2001 and considering the entire Wadden Sea, ten species increased significantly, mainly due to expansion of their geographical breeding range. For common eider and arctic tern, this trend changed into a decreasing one in 1996 and 1998, respectively.

### Breeding success

Significant declines in numbers occurred in nine species, although most recent counts showed a levelling off in three of these species. Only the great ringed plover and kentish plover, both breeding on beaches, showed an ongoing decline. More species have been declining in The Netherlands and Niedersachsen as compared to the other parts of the Wadden Sea, the underlying causes of which are only partly understood.

The ongoing decline in numbers of the great ringed plover and kentish plover is caused by increased recreational pressure on beaches and other breeding habitats. Meanwhile, protection measures taken at many breeding sites of the little tern have been successful, resulting in a trend towards recovery.

### Food availability

The breeding populations of common eider (>75% in the Dutch Wadden Sea), oystercatchers and probably also herring gull have declined mainly in the Dutch Wadden Sea. This is considered an effect of intense shellfish fisheries notwithstanding the management measure of reserving certain amounts of cockle and blue mussel stocks for birds.

### Predation pressure

In some species, a shift in breeding numbers from mainland coast to the islands was observed, caused by increasing predation pressure by mammalian predators, e.g. the red fox.

Among the species breeding in salt marshes (e.g., waders, passerines) various trends and fluctuations have been observed, however, without a clear relationship with changes in agricultural use or vegetation development of these areas. Too few studies attempting to provide explanations have been undertaken.

### Target

Favorable conditions for [migrating and] breeding birds:

- A favorable food availability,
- [- Natural flight distances],
- A natural breeding success,
- [- Sufficiently large undisturbed roosting and moulting areas.]

### Target evaluation

- The target 'A favorable food availability' has not been met, especially for bivalve eating species in the Dutch Wadden Sea due to shellfish fisheries;

- The target 'A natural breeding success' has still not been met for beach-breeding species due to recreational disturbance.

### Conclusions

- For eider and oystercatcher, food conditions in the Dutch Wadden Sea have not been favorable due to shellfish fisheries, causing a decline of the breeding population;
- Measures aimed at protection of breeding sites of the little tern have proven successful;
- Numbers of breeding great ringed plover and kentish plover have continued to decline. Here protection measures have not been successful;
- Increasing predation pressure, e.g. by the red fox, has caused a shift of some breeding birds from mainland coast to the islands;
- Changes in breeding bird numbers in salt marsh habitats could not be linked to either management regime or vegetation development, mainly due to the absence of proper studies. Protection of species seriously at risk may be improved by compiling a list of such species for the Wadden Sea to assist the execution of EC Birds and Habitats Directives.

### Recommendations

- Implementation with urgency of effective measures to protect beach-breeding birds such as great ringed plover and kentish plover;
- A more effective conservation of shellfish stocks in the Dutch Wadden Sea is necessary to ensure favorable food conditions for shellfish-eating birds. The new policy as of 1 January 2005 designed for reaching this goal needs to be monitored and evaluated after some years;
- Prevention of introduction to the islands of mammalian predators;
- Further studies into the underlying causes of changes in the abundance and occurrence of salt-marsh breeding birds, including studies on reproduction success;
- For more effective conservation a list of bird species seriously at risk in the Wadden Sea area should be drawn up.

### 15.8.2 Migratory birds

An analysis of trends of migratory waterbirds utilizing the Wadden Sea reveals that 22 out of 34 waterbird species experienced declines in 1992-2000, of which 15 are statistically significant. This

development is an alarming and new phenomenon since the 1999 QSR. Since declines of these species have not been observed elsewhere, the Wadden Sea may be the main bottleneck. For most of the declining species the Wadden Sea represents an indispensable stopover for 'fast refueling' during their long-distance migration to their breeding and wintering areas.

#### Food availability

Of the 22 species showing a decreasing trend, 19 were dependent on feeding on benthos, incl. bivalves, for 'fast refueling' during their migration to the breeding and wintering areas. This is an indication of non-favorable food availability, although other risk factors such as wintering in Africa and breeding in the (sub)arctic may play a role. For the bird species within this group and specializing in molluscs (e.g. eider, oystercatcher, knot and herring gull), food availability was impaired due to shellfish fishery. For herbivorous species (e.g., dark-bellied brent goose, Eurasian wigeon, barnacle goose) food availability seems not to be limited.

#### Roosting areas

High tide roosts are relatively well protected, with more than 80% of these roosts being located within Special Protection Areas. Despite this, disturbances occur due to outdoor recreation, hunting, civil air traffic and military training activities. Some species, such as dark-bellied brent goose, Eurasian golden plover, and Eurasian curlew, preferably use high tide roosts that are located at inland agricultural areas. These roosts are less protected, or not protected at all (e.g. in The Netherlands).

#### Moulting areas

For three species important moulting areas exist in the Wadden Sea and offshore zone. Practically the entire northwest European common shelduck population moults in the southern part of the Schleswig-Holstein Wadden Sea. The National Park Agency responsible has been successful in entering into effect voluntary agreements with different user groups aimed at avoidance of disturbance during the moulting season.

Moulting areas used by the common eider are more dispersed along the coast, as well as in the center of the German Bight, and situated preferably in areas with low disturbance.

For common scoter, moulting areas are in the offshore zone, decreasing in importance from north to south. A realistic estimate of the numbers moulting in the Wadden Sea area does not, however, exist. Moulting areas are chosen according to the presence of their favored food resource

(e.g., bivalves *Spisula* spp.) and low disturbance level. Common scoters are easily disturbed by ships and airplanes, and their food resources affected by shellfish fishery.

#### Flight distances

The knowledge of natural flight distances of bird species occurring in the Wadden Sea area is still poor. The common scoter is sensitive to disturbance, having a flight distance of up to 2,000 m from approaching ships. The successive steps in reducing hunting pressure in Denmark are considered to have had a positive effect on Eurasian curlew numbers in the Wadden Sea area. No information, however, has become available on any related decrease of flight distance in this bird species. For geese species, different flight distances have been reported from areas with and without hunting.

#### Target

Favorable conditions for migrating [and breeding] birds:

- A favorable food availability,
- Natural flight distances,
- [- A natural breeding success,]
- Sufficiently large undisturbed roosting and moulting areas.

#### Target evaluation

- For bird species feeding on benthos/bivalves the target 'favorable food conditions' has not been met; for herbivorous birds this target has been met;
- The target 'natural flight distances' cannot be evaluated due to absence of relevant data;
- The target 'sufficiently large undisturbed roosting and moulting areas' is still not satisfactorily met.

#### Conclusions

- Decreasing overall trends in migratory bird species indicate non-favorable conditions with respect to the availability of their food organisms bivalves and other benthos;
- Food availability seems no problem for herbivorous bird species;
- Protection of moulting shelduck has been improved through voluntary agreements with different user groups aimed at avoidance of disturbance during the moulting season;
- There are gaps in knowledge regarding specific habitat requirements and sensitivity to disturbance of moulting common scoter and

common eider, preventing an optimal protection of this species;

- Still little information is available on flight distances and their dependency on various types of disturbance. This hampers optimal measures for protection.

#### Recommendations

- Further research and monitoring is needed to elucidate the possible cause of the observed decreasing trends in migratory bird species, most of which are feeding on bivalves and other benthos;
- Continued attention for conservation of shellfish stocks to ensure favorable conditions for benthos-eating migratory birds;
- Measures to be taken to reduce the still existing conflicts between roosting birds and various sources of anthropogenic disturbance;
- Further research and monitoring effort is needed to fill the gaps in knowledge regarding moulting common scoter and common eider and their protection;
- Seek solutions for co-existence of geese and farmers through balanced management schemes, and further develop geese management on a flyway level;
- Further study of flight distances in relation to sources of disturbance.

### 15.9 Marine mammals

Regarding marine mammals two targets apply, one for the Offshore Area and one for the Tidal Area, which were agreed at the Leeuwarden Conference (1994). As in the 1999 QSR, for these mammals the combined target will be evaluated.

#### 15.9.1 Harbour (= common) seal

After the PDV-epizootic in 1988, the harbour seal population in the Wadden Sea recovered prosperously and increased to approx. 21,000 in 2002, at an almost exponential rate. In 2002, a second PDV-epizootic struck the population, reducing numbers by around 50%; mortality was higher in adult males than in adult females. As a result, a relatively high proportion of pups was observed in 2003, providing a quick start of recovery of the population.

There has been an improvement of the health condition of harbour seals in general.

Application of satellite transmitters has shown that harbour seals from the Wadden Sea use the North Sea to a much greater extent than realized before. The reason for this is yet not clear, but may be related to the population's exponential

growth and/or to decreased availability of food in the Wadden Sea and adjacent coastal waters.

#### Target

Viable stocks and a natural reproduction capacity of the common seal [, grey seal and harbour porpoise].

#### Target evaluation

- The population of harbour seals in the Wadden Sea can be considered viable with a satisfactorily reproduction capacity.

#### Conclusions

- The harbour seal population in the Wadden Sea increased to approx. 21,000 in 2002 until a second PDV-epizootic halved the population. In 2003 recovery started with a relatively high production of pups. The population seems to be viable with a satisfactorily reproduction capacity;
- Seals from the Wadden Sea use the North Sea to a much greater extent than realized before. The reason for this is not clearly known.

#### Recommendations

- For optimal conservation of the harbour seal population, the recommendations of the Seal Management Plan 2002-2006 should be implemented;
- Research on feeding ecology should be undertaken to further quantify and elucidate the reasons behind the widespread occurrence in the North Sea of harbour seals from the Wadden Sea;
- Further studies of the impact of expanding offshore activities on foraging and migratory behavior of harbour seals.

#### 15.9.2 Grey seal

Since the 1999 QSR, grey seal numbers in the Wadden Sea have increased. In The Netherlands, numbers have more than doubled; in Schleswig-Holstein an increase was also observed. Although pup production has increased, the increase rate of the population is for a significant proportion due to influx of animals from the east coast of the United Kingdom. Recently, signs of expansion to other parts of the Wadden Sea (Borkum Riff, Norderney) and inner German Bight (Helgoland) were observed, yet without any significant breeding. Conservation of grey seals in the Wadden Sea must involve effective protection of colony sites, particularly during the breeding and moulting sea-

sons. Such protection is currently implemented in Schleswig-Holstein, but not in The Netherlands, where major colonies fall outside the Conservation Area. Furthermore, there is lack of knowledge of basic biology of the species in the Wadden Sea area.

#### Target

Viable stocks and a natural reproduction capacity of the [common seal,] grey seal [and harbour porpoise].

#### Target evaluation

- The target regarding grey seals cannot be evaluated due to insufficient data and knowledge.

#### Conclusions

- The numbers of grey seal in the colonies in the Dutch and Schleswig-Holstein part of the Wadden Sea increased, to a large extent being caused by influx from elsewhere. In 2003, signs of population expansion to other areas were observed;
- Conservation of grey seals in the Dutch Wadden Sea does not involve effective protection of colony sites, particularly during the breeding and moulting seasons;
- There is insufficient data and knowledge to judge whether the population in the Wadden Sea is viable, or has a natural reproduction capacity.

#### Recommendations

- For optimal conservation of the grey seal population, the recommendations of the Seal Management Plan 2002-2006 should be implemented;
- Studies to be initiated of basic population biology of grey seal and their habitat use to provide essential information to formulate appropriate management;
- Improved protection of grey seal colonies in the Wadden Sea and the Offshore Area, including also newly developing colonies;
- Adaptation of spatial coverage of monitoring of grey seals in order to design adequate management.

### 15.9.3 Harbour porpoise

Within the Wadden Sea itself and the adjacent Offshore Area, dedicated trilateral surveys do not exist. In Danish waters, dedicated surveys started in 2000 in connection with the offshore wind farm on Horns Reef. In the German sector of the North Sea, aerial surveys started in 2002 as part of offshore wind farm studies. In 2002 and 2003 in highest densities of harbour porpoise within the German Bight were observed off Schleswig-Holstein. Offshore developments, such as wind farms, and North Sea fishery form a potential threat to the harbour porpoise population(s). The impacts of these human activities are still insufficiently known.

#### Target

Viable stocks and a natural reproduction capacity of the [common seal, grey seal and] harbour porpoise].

#### Target evaluation

- The target regarding harbour porpoise cannot be evaluated due to insufficient information.

#### Conclusions

- No statement regarding viability of stock or natural reproduction capacity can be made, due to insufficient information;
- The Offshore Area and adjacent North Sea, especially off Schleswig-Holstein, is important for harbour porpoise. Dedicated trilateral (TMAP) surveys, however, do not exist.

#### Recommendations

- Organization of cooperative effort for better surveying the occurrence of harbour porpoise inside and outside the Cooperation Area;
- The national regulations of the Whale Sanctuary off Sylt and Amrum should be embedded in EU law in order to make protection more effective;
- Further studies of the impact of fisheries (e.g. by-catch) and offshore wind farms on harbour porpoise.

## 15.10 Summary of Target evaluation

In the table below an overview is presented of the evaluation of the Targets of the Wadden Sea Plan. To assist a quick overview, colored symbols have been used. These symbols should be interpreted in combination with the text of the evaluation. The meaning of the symbols is as follows:

- ▼ target not reached; development negative,
- ▲ target not yet reached; positive development,
- ▲ target reached, positive development,
- ▼ target reached, negative development
- ? no target evaluation possible.

Issue	Target	Evaluation
<b>Nutrients &amp; Eutrophication</b>	A Wadden Sea which can be regarded as a eutrophication non-problem area.	▲ Though phosphate concentrations have decreased, the entire Wadden Sea still has to be considered a eutrophication problem area, meaning that the target has not yet been met.
<b>Hazardous substances</b>	Background concentrations of natural micropollutants in water, sediment and indicator species.	▲ For metals in sediment the target has not yet been reached in all subareas of the Wadden Sea. For four metals concentrations in blue mussel do not yet meet target levels. Mercury in bird eggs does not yet meet target levels. Regarding the OSPAR ecotoxicological assessment criteria, concentrations in the Wadden Sea of mercury, copper, cadmium and PAHs do not pose a risk to the ecosystem, but zinc and lead still do. For PAHs in sediment, no natural background level has been documented. Concentrations are lower than in the Skagerak, and higher than in Barents Sea sediments.
	Concentrations of man-made substances as resulting from zero discharges.	▲▼ Although for a number of xenobiotic compounds discharges to and concentrations in the Wadden Sea have decreased, the target has not yet been reached. For some substances, e.g. TPT and Lindane, a significant deviation from the target is apparent. For PCBs, Lindane and TBT, the OSPAR ecological assessment criteria are exceeded in various Wadden Sea subareas. Of many newly developed xenobiotics, including hormone disruptors, concentrations have been found in the Wadden Sea, which is a deviation from the target.
	OSPAR EcoQO: The proportion of oiled common guillemots among those found dead or dying on beaches should be 10% or less.	▲ For the common guillemot, the OSPAR Ecological Quality Objective (EcoQO) of 10% oil rate has not been met.
<b>Salt marshes</b>	An increased area of natural salt marshes.	? In most areas of the Wadden Sea, an increase in area of natural and semi-natural salt marshes could be observed. An evaluation, of the target in quantitative terms is, however, not possible for the entire area because of insufficiently detailed older data.
	An increased natural morphology and dynamics, including natural drainage patterns, of artificial salt marshes, under the condition that the present surface is not reduced.	▲? Artificial draining in salt marshes has been reduced. The remaining ditch systems, however, have not yet developed into natural-like creek systems.

Issue	Target	Evaluation
Salt marshes (cont.)	An improved natural vegetation structure, including the pioneer zone, of artificial salt marshes.	▲▼ A precise evaluation of the target cannot be given because long-term data is only available for some regions and the developed common typology could not be applied to older data. Significant reductions of livestock grazing intensity in The Netherlands and Germany contributed to a more natural vegetation structure of artificial mainland salt marshes. In Denmark, the proportion of intensively grazed salt marshes did not change considerably.
Tidal area – hydrology/ geomorphology and macro-zoobenthos	A natural dynamic situation in the Tidal Area.	▲ The Tidal Area of the Wadden Sea is still characterized by a high degree of natural dynamics. There is no significant increase of constructions for coastal defense. ▲ Deviations from the target are existing coastal defense structures and deepening of channels for shipping.
	An increased area of geomorphologically and biologically undisturbed tidal flats and subtidal areas.	?▼ The target cannot be evaluated due to absence of proper information. The observed decline in bivalve recruitment and shift in their centers of distribution indicates a loss of previously biologically undisturbed tidal flats, in other words: a deviation from the target.
Tidal area – biogenic structures	An increased area of, and a more natural distribution and development of natural mussel beds, <i>Sabellaria</i> reefs and <i>Zostera</i> fields.	▼ No increased area of <i>Sabellaria</i> reefs has been reported.
		▲ The target of increased area of <i>Zostera</i> fields has not yet been met in all sub-areas of the Wadden Sea.
		▲▲ The target of an increased area of natural mussel beds in the intertidal area was reached in the mid and eastern Dutch Wadden Sea. In the Danish and western Dutch Wadden Sea, no development according to the target occurred. In Niedersachsen, the actual area of mussel beds is the level present in the late 1980s, and in Schleswig-Holstein still below the level present in the early 1990s.
		▲ In areas where there was no fishing, a more natural distribution and development of intertidal mussel beds occurred. ? With regard to the subtidal mussel beds, no evaluation of the target is possible yet.
Tidal area – introduced species	- no target -	- not applicable -
Tidal area – fish and shrimps	- no specific target - An increased area of geomorphologically and biologically undisturbed tidal flats and subtidal areas.	? The target of undisturbed tidal flats and subtidal areas for fish and shrimps cannot be evaluated. The possibility of the observed shift in juvenile flatfish being related to a decreased area of undisturbed tidal flats and subtidal areas needs to be investigated.
	A favorable food availability [for migrating and breeding birds].	▲ There is currently no evidence of food shortage among fish and shrimp eating birds.
Beaches and Dunes	Increased natural dynamics of beaches, primary dunes, beach plains and primary dune valleys in connection with the Offshore Zone.	?▲ The target of increased natural dynamics of beaches and dunes cannot be fully evaluated due to absence of criteria and of comparable relevant data; natural dynamics have increased where coastal defense activities were stopped; remnant coastal defense structures still remaining restrict increased dynamics.
	An increased presence of a complete natural vegetation succession.	▲ A complete natural vegetation succession is not present because about two-thirds of the dune areas consists of mid-successional dune type and important other types are not present or show further decline.

Issue	Target	Evaluation
<b>Estuaries</b>	Valuable parts of estuaries will be protected and river-banks will remain and, as far as possible, be restored to their natural state.	▼ According to the Water Framework Directive Reports 2005, most estuaries in the Wadden Sea Cooperation Area fail to meet the target.
<b>Offshore Zone</b>	An increased natural morphology, including the outer deltas between the islands.	▲ As far as available data shows, no major changes of natural morphology have taken place.
	A favorable food availability for birds.	▲(▼) Stocks of the bivalve <i>Spisula</i> constitute a favorable food source for diving ducks, provided fishing pressure on these bivalve stocks is low.
	Viable stocks and a natural reproduction capacity of the common seal, grey seal and harbour porpoise.	- see under 'Marine mammals' -
<b>Breeding birds</b>	Favorable conditions for [migrating and] breeding birds: - A favorable food availability, - A natural breeding success.	▼ The target 'A favorable food availability' has not been met, especially for bivalve eating species in the Dutch Wadden Sea due to shellfish fisheries.  ▼ The target 'A natural breeding success' has still not been met for beach-breeding species due to recreational disturbance.
<b>Migratory birds</b>	Favorable conditions for migrating and breeding birds: - A favorable food availability, - Natural flight distances, - Sufficiently large undisturbed roosting and moulting areas.	▲▼ For bird species feeding on benthos/bivalves the target 'favorable food conditions' has not been met; for herbivorous birds this target has been met.  ? The target 'natural flight distances' cannot be evaluated due to absence of relevant data.  ▲ The target 'sufficiently large undisturbed roosting and moulting areas' has still not satisfactorily been met.
<b>Marine mammals</b>	Viable stocks and a natural reproduction capacity of the common seal, grey seal and harbour porpoise.	▲ The population of harbour seals in the Wadden Sea can be considered viable with a satisfactorily reproduction capacity.  ? The target regarding grey seal and harbour porpoise cannot be evaluated due to insufficient data and knowledge.

## 15.11 Summary of recommendations

Issue	Policy & Management	Monitoring & Research
<b>Nutrients &amp; Eutrophication</b>	<ul style="list-style-type: none"> <li>In order to meet the target, continued effort is necessary to effectively implement current policies to reduce nutrient inputs; special effort is necessary with regard to nitrogen compounds.</li> </ul>	<ul style="list-style-type: none"> <li>The temporal and spatial resolution of monitoring should be adapted to better cover the algal growth season and the whole annual cycle.</li> <li>Development of a harmonized approach for determining water residence time in different parts of the Wadden Sea to enable proper assessment of observed nutrient concentrations.</li> <li>Research should be done with priority into 1) the causes of the observed differences in eutrophication status between different parts of the Wadden Sea, and 2) the role of suspension feeders, including the Pacific oyster and the American jack-knife clam in the chlorophyll dynamics when using chlorophyll as indicator of eutrophication.</li> <li>Further research is necessary to assess how fundamental processes, e.g. nutrient regeneration from organic matter in the sediment, oxygen dynamics and food-chain effects respond to decreasing nutrient input.</li> </ul>
<b>Hazardous substances</b>	<ul style="list-style-type: none"> <li>Continued attention on reduction of metal discharges through rivers debouching into the Wadden Sea.</li> <li>Nickel, being a high priority compound both in OSPAR and WFD, to be included in the TMAP and data units.</li> <li>Inclusion in TMAP of priority substances among the newly developed xenobiotics and hormone disruptors in connection with the requirements of the Water Framework Directive.</li> <li>Trilateral application of biological effects assessment techniques (e.g., bioassays, EDA, TIE) as a management and monitoring tool.</li> <li>Continuation and further implementation of policies and measures to prevent oil pollution, including education programs for seafarers.</li> <li>Analysis of oil residues on beaches and oiled birds washed ashore to be used to monitor the effectiveness of pollution control measures aimed at reduction of oil pollution from different sources.</li> </ul>	<ul style="list-style-type: none"> <li>Continued effort regarding harmonization of methods of analysis and of standardization, both being necessary to make reliable comparisons at a geographical scale.</li> <li>Investigate the reason for anomalous metal concentrations in sediment found at two locations in subareas SH3 and DK2.</li> <li>Extra attention to be paid at some recently and locally increased contaminant concentrations and the sources of triphenyltin.</li> <li>Ecotoxicological research into the effects of organotin accumulation in common eider and harbour seal.</li> <li>Continued and well coordinated trilateral monitoring of beached birds is required to be able to assess the effect of the PSSA designation, and of North Sea wide oil pollution control policy.</li> </ul>
<b>Salt marshes</b>	<ul style="list-style-type: none"> <li>Further development of naturally growing salt marshes is best helped by leaving geomorphology of neighboring mudflats undisturbed.</li> <li>Further increase of area of (semi) natural salt marshes can be achieved by breaching protecting summer dikes or sand dikes.</li> </ul>	<ul style="list-style-type: none"> <li>For vegetation mapping of de-embanked polders and other study sites, a frequency should be chosen tuned to the velocity of the salt-marsh development process.</li> <li>Further study and experiments into effective ways of facilitating the development of natural-like drainage creeks.</li> </ul>

Issue	Policy & Management	Monitoring & Research
Salt marshes (cont.)	<ul style="list-style-type: none"> <li>• Cessation of artificial drainage in all salt marshes without any agricultural use, taking care of prevention of water logging of dike footings.</li> <li>• To prepare a Wadden Sea wide assessment of salt-marsh vegetation development, based on the now available common vegetation typology, which also can be used for the requirements of the Habitats Directive.</li> </ul>	<ul style="list-style-type: none"> <li>• Study of the possible interrelationship between ageing towards climax vegetation, rate of sedimentation and cessation of grazing.</li> <li>• Continuation of long-term study sites and incorporation of these sites into the International Long-Term Ecological Research sites (ILTER).</li> </ul>
Tidal area – hydrology/geomorphology		<ul style="list-style-type: none"> <li>• For a better assessment of the targets, parameters should be developed within the TMAP to properly monitor changes in hydro-morphological dynamics and in geomorphologically and biologically undisturbed tidal flats and subtidal areas.</li> <li>• A study should be undertaken into the effect of increased deepening for shipping on estuarine geomorphology, especially regarding changes in the amount and nature of tidal flats and subtidal areas.</li> <li>• The signaled loss of high mud flats essential for bivalve settlement should be given more attention, through either monitoring or directed research.</li> </ul>
Tidal area – macrozoobenthos	<ul style="list-style-type: none"> <li>• - see under blue mussel beds -</li> </ul>	<ul style="list-style-type: none"> <li>• Elucidation of the status of isolated populations of benthic invertebrates in estuarine and brackish habitats, and of the underlying cause of the long-term increase in polychaetous worms, and of shifting centers of bivalve recruitment.</li> </ul>
Tidal area – biogenic structures: <i>Sabellaria</i> reefs	<ul style="list-style-type: none"> <li>• The <i>Sabellaria</i> reefs should be designated as Special Area of Conservation, where especially seabed disturbing activities (sand extraction, dredging, bottom trawling) are not allowed.</li> <li>• Human interventions changing the water current conditions should be considered carefully as they may affect <i>Sabellaria</i> reefs.</li> </ul>	<ul style="list-style-type: none"> <li>• A program should be launched under the TMAP to properly monitor existing <i>Sabellaria</i> reefs, and to explore the occurrence of reef constructions in potential reef areas in the Wadden Sea Cooperation Area. New reefs found should be considered for monitoring.</li> </ul>
<i>Zostera</i> fields	<ul style="list-style-type: none"> <li>• Given the diminished and, in some areas, still endangered state of seagrasses, negative effects of shellfish fishery and land reclamation works at existing and potential sites of seagrass beds should be avoided.</li> <li>• Further reductions in nutrient loads would strengthen the vitality of seagrass when growing at average salinities.</li> <li>• Reintroductions of intertidal sea grass in the southern Wadden Sea should focus on optimal sites and employ founding populations of considerable size to achieve self maintenance.</li> </ul>	<ul style="list-style-type: none"> <li>• Restoring of ebb-slucies with continuous freshwater runoffs to explore their positive effects on local seagrass development.</li> <li>• Further study of the effectiveness of re-introduction programs of intertidal seagrass, as well as a study of the feasibility of re-introduction of the large morph of <i>Zostera marina</i>.</li> <li>• Improved harmonization of monitoring of and research into seagrass in the Wadden Sea.</li> </ul>

Issue	Policy Et Management	Monitoring Et Research
Blue mussel beds	<ul style="list-style-type: none"> <li>• Because of their high biodiversity and ecological importance, a protection regime should be designed for subtidal mussel beds; subtidal and intertidal beds should also be considered as a biological quality element in the relevant EC Directives.</li> <li>• The management measure of protecting stable mussel beds or sites (intertidal as well as subtidal) is still valid.</li> </ul>	<ul style="list-style-type: none"> <li>• Investigation into the cause of the failing recruitment of littoral mussels and mussel beds in Niedersachsen, Schleswig-Holstein and Denmark.</li> <li>• The proliferation of the Pacific oyster should be monitored, and its competitive mechanism leading to the taking over of mussel beds investigated, with a view of developing options for management.</li> <li>• Extension, if possible, of the habitat model developed as a management tool for intertidal mussel beds in the Dutch Wadden Sea to the German and Danish Wadden Sea as well.</li> </ul>
Tidal area – introduced species	<ul style="list-style-type: none"> <li>• Consider appropriate precautionary measures to prevent further introduction of species that may constitute a risk to the Wadden Sea ecosystem.</li> </ul>	<ul style="list-style-type: none"> <li>• The TMAP should be alert to discover new immigrant species, and may need to be adapted to provide data for impact assessment of introduced species;</li> <li>• Study of the ecological function of the newly developing reefs of Pacific oysters.</li> </ul>
Tidal area – fish and shrimps	<ul style="list-style-type: none"> <li>• The formulation of trilateral targets regarding fish, tuned to the requirements of the relevant Directives, will structure and focus research and monitoring of this important faunal group in the Wadden Sea.</li> <li>• For threatened diadromous fish species further conservation effort is required, e.g. sluice and dike passage facilities and upstream habitat restoration.</li> </ul>	<ul style="list-style-type: none"> <li>• The existing demersal fish survey programs should be trilaterally coordinated and harmonized to provide valuable information on the quality of the Wadden Sea as a habitat for demersal fish.</li> <li>• Development of trilaterally coordinated pelagic fish monitoring program, especially aimed at obtaining data about fish species depending on upstream water quality and breeding habitat.</li> <li>• Studies should be undertaken to improve the ecological knowledge of non-commercial species, to investigate the functional relationship between fish species and specific habitats such as mussel beds and other hard substrate, and to obtain insight in the factors underlying the shift in distribution in juvenile flatfish.</li> </ul>
Beaches and Dunes	<ul style="list-style-type: none"> <li>• The trilateral targets with respect to beaches need to be reconsidered and re-defined against the background of (1) sea level rise and concomitant intensification of coastal defense, and (2) increased recreational pressure on the coastline.</li> <li>• Existing differences in dune management regimes make a case for exchange of information on this issue among managers involved.</li> <li>• The use of the newly developed TMAP classification for dunes for trilateral assessment of dunes development, and concurrent data collection concerning atmospheric deposition, coastal protection measures and water management.</li> </ul>	<ul style="list-style-type: none"> <li>• A better exchange of information about how coastal protection measures and remnant sand dikes influence pioneer stages and possibilities for restoring natural dynamics.</li> <li>• An inventory of the differences in water extraction management and of their ecological consequences.</li> <li>• More fundamental studies of the speed and direction of natural succession under different conditions, with the aim of contributing to future policy and management questions concerning the Wadden Sea dunes.</li> </ul>

Issue	Policy & Management	Monitoring & Research
Estuaries	<ul style="list-style-type: none"> <li>Ecological targets for estuaries need to be reformulated and tuned to the requirements of the relevant EC Directives in order to increase their operational value.</li> <li>The tidal freshwater reaches should be integrated into the Leeuwarden definition of an estuary.</li> <li>Restoration of estuarine habitats (especially shallow areas and foreland) is necessary in all estuaries under consideration. Problems linked to the artificial increase of the tidal range have to be given special attention.</li> <li>For the Ems estuary, a long-term vision should be developed, including the issue of a 2-channel or 1-channel system.</li> </ul>	<ul style="list-style-type: none"> <li>Monitoring of long-term ecological changes in valuable parts (to be specified) of estuaries is necessary.</li> <li>Consequences of further deepening, barriers and harbor extension should be evaluated carefully, taking into account the historical deterioration of the estuaries.</li> </ul>
Offshore Area	<ul style="list-style-type: none"> <li>Major coastal defense constructions should be accompanied by studies – both near field and far field – on their effects on seabed morphodynamics.</li> <li>A proper management of <i>Spisula</i> fishery needs to be developed to ensure compliance with the target 'favorable food availability for birds', especially for common scoter, common eider and velvet scoter.</li> </ul>	<ul style="list-style-type: none"> <li>Further research is needed to elucidate the specific role and importance of the Offshore Area in the life cycle of harbour porpoise, grey and harbour seal.</li> </ul>
Breeding birds	<ul style="list-style-type: none"> <li>Implementation with urgency of effective measures to protect beach-breeding birds such as great ringed plover and kentish plover.</li> <li>Prevention of introduction to the islands of mammalian predators.</li> <li>For more effective conservation a list of bird species seriously at risk in the Wadden Sea area should be drawn up.</li> </ul>	<ul style="list-style-type: none"> <li>Further studies into the underlying causes of changes in abundance and occurrence of salt marsh breeding birds, including studies of reproduction success.</li> <li>A more effective conservation of shellfish stocks in the Dutch Wadden Sea is necessary to ensure favorable food conditions for shellfish-eating birds. The new policy as of 1 January 2005 designed for reaching this goal needs to be monitored and evaluated after some years.</li> </ul>
Migratory birds	<ul style="list-style-type: none"> <li>Continued attention for conservation of shellfish stocks to ensure favorable conditions for benthos-eating migratory birds;</li> <li>Measures to be taken to reduce the still existing conflicts between roosting birds and various sources of anthropogenic disturbance;</li> <li>Seek solutions for co-existence of geese and farmers through balanced management schemes, and further develop geese management on a flyway level.</li> </ul>	<ul style="list-style-type: none"> <li>Further research and monitoring is needed to elucidate the possible cause of the observed decreasing trends in migratory bird species, most of which are feeding on bivalves and other benthos;</li> <li>Further research and monitoring effort is needed to fill the gaps in knowledge regarding moulting common scoter and common eider and their protection;</li> <li>Further study of flight distances in relation to sources of disturbance.</li> </ul>
Marine mammals	<ul style="list-style-type: none"> <li>For optimal conservation of the populations of harbour seal and grey seal, the recommendations of the Seal Management Plan 2002-2006 should be implemented.</li> </ul>	<ul style="list-style-type: none"> <li>Research on feeding ecology should be undertaken to further quantify and elucidate the reasons behind the widespread occurrence in the North Sea of harbour seals from the Wadden Sea.</li> <li>Further studies of the impact of expanding offshore activities on foraging and migratory behavior of harbour seals.</li> </ul>

Issue	Policy & Management	Monitoring & Research
Marine mammals (cont.)	<ul style="list-style-type: none"> <li>Improved protection of grey seal colonies in the Wadden Sea and the Offshore Area, including also newly developing colonies.</li> <li>The national regulations of the Whale Sanctuary off Sylt and Amrum should be embedded in EU fishery legislation in order to make protection more effective.</li> </ul>	<ul style="list-style-type: none"> <li>Studies to be initiated of basic population biology of grey seals and their habitat use to provide essential information to formulate appropriate management.</li> <li>Adaptation of spatial coverage of monitoring of grey seals in order to design adequate management.</li> <li>Organization of cooperative effort for better surveying the occurrence of harbour porpoise inside and outside the Cooperation Area.</li> <li>Further studies of the impact of fisheries (e.g. by-catch) and offshore wind farms on harbour porpoise.</li> </ul>