

## TMAP Issues of Concern and Parameters

### I Climate change

Change in climate includes rise in temperature and change in gale force and frequency.

#### I.1 Influence of changes in climate on physical conditions, rise in sea level, and on the stability and abiotic environment of plant, animal and man

The change in climate can influence physical boundary conditions and may cause a rise in sea level. It affects the stability of the environment of plant, animal and man.

##### Hypotheses:

Changes in climate can affect the water temperature, weather conditions, hydrological regime, flooding frequency, geomorphology and the geographical boundaries of the Wadden Sea.

Erosion processes and coastal protection will lead to changes in the zonation of the salt marsh vegetation.

Parameter	Compartment/Area
Coastline	whole area
Coastal protection measures	whole area
Geomorphology (height, coastline, drainage)	
Weather condition	
Hydrology (e.g. wave energy)	
Water temperature	
Salinity	
Flooding frequency	
Flooding level	
Net sedimentation	
Breeding Birds:	
Number and distribution for selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>
Salt marshes:	
salt marsh zonation	selected areas

### II Input of pollutants

Pollutants are nutrients, heavy metals and organic micro-pollutants, and solid wastes. Inputs via all possible routes are to be taken into account. Pollutant inputs are considered to affect the chemistry of soils, sediments and the water column, the natural biological processes, the individual species and the communities of the ecosystem Wadden Sea. The efficiency of policy targets on the reduction of pollutants in water, sediment and biota has to be documented. How are reduction measures and changes in inputs of chemicals connected? Have the changes in inputs effects on the concentrations in sediment and water? Do changes in chemical processes result in changes in the distribution of substances?

#### II.1 The changes in the chemistry of soils, sediments and the water column due to the input of pollutants

Input of pollutants may cause changes in the chemistry of soils, sediments and the water column.

##### Hypotheses:

Changes in input of nutrients and contaminants cause changes in the chemistry of the soil, sediments and the water column. Changes in levels of nutrients and contaminants will affect bioavailability, fluxes and effects of nutrients and contaminants.

Parameter	Compartment/Area	Parameter	Compartment/Area
precipitation	atmosphere	O <sub>2</sub>	water column / sediment
NO <sub>x</sub>	atmosphere	pH	water column
SO <sub>x</sub>	atmosphere	Seston	water column
NH <sub>4</sub> -N	atmosphere	Turbidity	water column
NH <sub>3</sub> -N	atmosphere	Temperature	water column
Net sedimentation	sediment	Salinity	water column
Grain size distribution	sediment	Residence time	water column
NH <sub>4</sub> -N (dissol. + part.)	pore water, water column / input areas and selected areas	Flushing time	water column
NO <sub>2</sub> -N (dissol. + part.)		Redox potential	sediment
NO <sub>3</sub> -N (dissol. + part.)		Thickness oxic layer	sediment
Total N		Gas production (methane)	sediment
SiO <sub>4</sub> (dissol. + part.)		Free sulfide conc.	sediment
PO <sub>4</sub> - (dissol. + part.)		Denitrification capacity	sediment
Total P		Metals (see JAMP)	sediment/ suspended matter
Organic P		PCB (see JAMP)	sediment/ suspended matter
Dissolved org. carbon		Lindane	water column
Total organic carbon		Triazines	water column
Particulate org. carbon		TBT	water column
		PAH (see JAMP)	sediment/ suspended matter

**II.2 The response of natural processes in the ecosystem to changes in the pollutant level: Primary production, food chain fluxes, reproduction and decomposition**

Changes in the status of the ecosystem (through the food chain accumulation of contaminants) may represent a threat to predators and their consumers, e.g. man.

Hypotheses:

Changes in concentrations of nutrients and contaminants affect the biological processes (primary and secondary production in the different food web levels, decomposition, reproduction and recruitment of key species). An increase of contaminants in the water column and sediment may lead to increased concentrations in biological tissues at the various food web levels.

Parameter	Compartment/Area	Parameter	Compartment/Area
<b>Phytoplankton:</b>		<b>Fish: Eelpout, Flounder</b>	
Species composition	water column / selected areas	Heavy metals	muscle, liver / selected areas
C <sup>14</sup> uptake		Organic micro-pollutants	
Chlorophyll a		<b>Eelpout, Flounder, Plaice</b>	
Phytoplankton C		Relative abundance	
Global radiation		Biomass	
Secchi disk (if possible PAR 400 - 700 nm)	water column / selected areas	Fecundity	
UV-B		Maturity	
<b>Benthic microalgae:</b>		Number of larvae	
Chlorophyll -a	sed. surface (acc. zoo-benthos)	Recruitment	
Primary production		<b>Pollutants in Bird Eggs:</b>	
<b>Salt marshes (all types):</b>		Heavy metals <sup>6)</sup>	eggs / selected areas <sup>8)</sup>
Biomass (vegetation)	selected areas	Organic micro-pollutants <sup>6)</sup>	
<b>Macro-algae:</b>		<b>Breeding Birds:</b>	
Areal coverage	surface / whole area	Number and distribution for selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>
<b>Zooplankton:</b>		<b>Breeding Success:</b>	
Number of all species	water column (acc. phytoplankton)	Juvenile <sup>7)</sup> mortality	selected areas <sup>8)</sup>
Biomass		Egg mortality <sup>7)</sup>	
Egg production copepods		Growth rate <sup>7)</sup>	
Number of copepodites		Recruitment <sup>7)</sup>	
Particle size distribution		Mortality outside the breeding season <sup>7)</sup>	
Heavy metals		<b>Seals:</b>	
Organic micro-pollutants		Heavy metals	kidney, liver
<b>Mussel: Mytilus</b>		Organic micro-pollutants	blood, blubber
Heavy metals	tissue /selected areas	Number and distribution of seals (population size, breeding success, recruitment, survival)	whole area
Organic micro-pollutants			
<b>Mytilus edulis:</b>		<b>Decomposition:</b>	
Primary settlement	eu- and sub littoral / unfished + fished beds	Bacterial cell number (biomass to be calculated)	water, sediment / selected areas
Length distribution (recruitment, age structure)		Microbial biomass	
Condition index		Bacterial production	
Stress indices		N, P, Corg (dissolved, particulate, organic, inorganic)	
Histological changes (TBT)		Bacterial oxygen demand	water, sediment
<b>Crangon crangon:</b>		Enzyme activity	water, sediment
Heavy metals	tissue	H <sub>2</sub> S, FeS	sediment
Organic micro-pollutants	tissue	Sulfate reduction	sediment
Stock size (relative abundance and biomass)		Gas production (methane)	sediment
Recruitment		Denitrification rate	sediment
<b>Polychaetes: Nereis diversicolor, Arenicola marina</b>			
Heavy metals	tissue		
Organic micropollut-	tissue		

ants				
	Parameter	Compartment/Area	Parameter	Compartment/Area
<p><b>II.3 Responses of functional processes which affect the species-species relationship</b></p> <p>Pollutants may affect the abundance and physiological functioning of species, leading to structural changes of the ecosystem. Effects on commercial species may occur.</p> <p><u>Hypotheses:</u></p> <p>Changes in concentrations of nutrients and contaminants may affect the physiological functioning, growth and reproduction, recruitment and natural mortality of species leading to changes in the abundance and distribution of species. This has an effect on the different organizational level, e.g. cellular, organism, species and community.</p>	<b>Zooplankton:</b>		<b>Eelpout, Flounder, Plaice</b>	
	Heavy metals		Relative abundance	
	Organic micropollutants		Biomass	
	Number of all species	water column (according phytoplankton)	Pathology (diseases, bilateral asymmetry)	
	Biomass		Growth	
	Age structure <sup>4)</sup>		Age structure	
	Egg production copepods		Recruitment	
	Number of copepodites		Fecundity	
	<b>Mussel: Mytilus, Cerastoderma</b>		Maturity	
	Heavy metals	tissue / selected areas	Number of larvae	
	Organic micropollutants		<b>Breeding Birds:</b>	
	Length distribution (recruitment, age structure)	eu- and sublitoral / fished + unfished areas	Heavy metals <sup>6)</sup>	eggs / selected areas <sup>8)</sup>
	Primary settlement		Organic micropollutants <sup>6)</sup>	
	Condition index	eulitoral / unfished areas	Number and distribution for selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>
	<b>Cockle beds:</b>		<b>Breeding Success:</b>	
	Shell anomaly	exploited and reference beds	Juvenile <sup>7)</sup> mortality	selected areas <sup>8)</sup>
	<b>Macro-algae: Entromorpha, Ulva</b>		Egg mortality <sup>7)</sup>	
	Area covered	intertidal / whole area	Growth rate <sup>7)</sup>	
	<b>Eelgrass:</b>		Recruitment <sup>7)</sup>	
	Coverage of eelgrass	intertidal / whole area	Mortality outside the breeding season <sup>7)</sup>	
	<b>Crangon crangon:</b>		<b>Migratory Birds:</b>	
	Heavy metals	tissue	Numbers of waterbirds in counting units according the time of season <sup>5)</sup>	counting units <sup>9)</sup>
	Organic micropollutants	tissue		
Stock size (relative abundance and biomass)				
Size structure		<b>Beached Bird Survey:</b>		
Black spot disease		No. of dead birds (all species)	beach/selected area <sup>10)</sup>	
Recruitment		No. of contaminated birds		
<b>Polychaetes: Nereis diversicolor, Arenicola marina</b>		Kind of contaminating oil	contaminated feathers	
<b>Seals:</b>				
Heavy metals	tissue	Heavy metals	kidney, liver	
Organic micropollutants	tissue	Organic micropollutants	blood, blubber	
<b>Fish: Eelpout, Flounder</b>		Number and distribution of seals (population size, breeding success, recruitment, survival)	whole area	
Heavy metals	muscle, liver			
Organic micropollutants	muscle, liver			



#### II.4 The response of community occurrence and structure to pollutant inputs

Changes in the occurrence, dominance structure and distribution patterns of ecological communities are sensitive indicators of changes in the environmental conditions.

##### Hypotheses:

Changes in the nutrient and contaminant levels and in nutrient ratio cause changes in the occurrence, dominance structure and distribution patterns of ecological communities.

Parameter	Compartment/Area	Parameter	Compartment/Area
<b>Phytoplankton:</b>		<b>Salt marsh fauna (all types):</b>	
Species composition	selected areas	Species composition	selected species groups/ selected areas (see vegetation)
Biomass (cell numbers, Chl-a, phytopl.-C)		Biomass	
Species richness		Species richness	
Dominance structure		Dominance structure	
<b>Zooplankton:</b>		Zonation	
Species composition	see phytoplankton	<b>Zoobenthos community</b> (tidal flats)	
Biomass			
Species richness			
Dominance structure		Location and area of biotopes	selected areas
<b>Blue mussel beds:</b>		Biomass + abundance	
Location and area	intertidal / unfished	Species composition	
Location	subtidal / unfished	Dominance structure	
Biomass + abundance (fauna + flora)	intertidal / unfished	Species:distribution pattern	
Species richness		<b>Benthic Macro-algae</b>	
Dominance structure		Area covered	intertidal / whole area
<b>Eelgrass:</b>		<b>Fish community:</b>	
Location and coverage	intertidal / whole area	Species composition	fished + unfished areas
Location and area of habitats		Biomass + abundance	
Biomass of eelgrass		Species richness	
Coverage of eelgrass	intertidal / whole area	Dominance structure	
<b>Salt marsh vegetation (all types):</b>		<b>Breeding birds:</b>	
Location and area	whole area	Number and distribu- tion for selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>
Vegetation types			
Species richness	selected areas	<b>Migratory birds:</b>	
Dominance structure		Number of waterbirds in counting units according to the time of season <sup>5)</sup>	counting areas <sup>9)</sup>
Vegetation height		Percentage of young birds of staging water- birds <sup>5)</sup>	
Biomass (above- ground)			
Zonation			
Nutrient inputs			

### III Commercial fisheries

#### III.1 The response of species to fisheries in the Wadden Sea

Fishing can affect the abundance of commercial species (brown shrimps, cockles, blue mussels). Fishing activities can also affect the bottom fauna species and food availability for birds.

##### Hypotheses:

The cockle and mussel fishery on natural beds and establishment of blue mussel culture lots changes the benthic habitat and affects the occurrence and abundance of individual species, and especially top predators (e.g. birds).

Parameter	Compartment/Area	Parameter	Compartment/Area
<b>General fishery parameters</b>		<b>Fish: Eelpout, Flounder, Plaice</b>	
<b>Mussel/Cockle/Shrimp fishery:</b>		Pathology (diseases, bilateral asymmetry)	
Fishery statistics (total, CPUE)		<b>Cockles</b> (same parameters as for zoobenthos community)	exploited beds
Fishing amount per km <sup>2</sup>	each tidal inlet or channel	Abundance	
No. of licenses		Biomass	
No. of vessels		<b>Cockles</b> (same parameters as for zoobenthos community)	unexploited beds
Hours of fishing		Abundance	
Horse power of vessels		Biomass	
Size of vessels		<b>Crangon crangon:</b>	
Range of vessels		Stock size (relative abundance + biomass)	
Crew of vessels		Size structure	
No. of gears		Recruitment	
Gear type		<b>Breeding birds:</b>	
Fishing areas	whole area	Number and distribution for selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>
Fishing periods		<b>Breeding Success:</b>	
Shrimping by-catch composition and discard	fishing areas	Juvenile <sup>7)</sup> mortality	selected areas <sup>8)</sup>
<b>Mytilus edulis:</b>	fished beds	Egg mortality <sup>7)</sup>	
Abundance	intertidal / fished beds	Growth rate <sup>7)</sup>	
Biomass		Recruitment <sup>7)</sup>	
Length distribution (recruitment + age structure)	intertidal + subtidal / fished beds	Mortality outside the breeding season <sup>7)</sup>	
Stress indices	intertidal / fished beds		
<b>Mytilus edulis:</b>	unfished beds		
Abundance	intertidal / unfished beds		
Biomass			
Length distribution (recruitment + age structure)	intertidal + subtidal / unfished beds		
Stress indices	intertidal / unfished beds		
<b>Mytilus edulis:</b>	cultured beds		
Abundance			
Biomass			
Length distribution (recruitment + age structure)			

### III.2 The response of community occurrence and structure to the fisheries in the Wadden Sea

Sedimentation or erosion of intertidal areas can be initiated or increased, thus indirectly affecting the community.

#### Hypotheses:

Fisheries can affect the occurrence and structure of communities. This includes indirect effects through gear activity (sediments, disturbance) as well as resource depletion (food web links).

Parameter	Compartment/Area	Parameter	Compartment/Area
<b>Mussel fishery:</b>		<b>Zoobenthos:</b>	
<b>Blue mussel beds:</b>		Biomass and abundance (fauna)	subtidal / selected areas / with and without shrimping
Location and area	intertidal/fished beds	Species composition	
Location	subtidal/fished beds	Dominance structure	
Biomass (fauna)	intertidal/fished beds	Species: distribution pattern	
Species composition		<b>Sabellaria:</b>	
Dominance structure		Location + development	
Mussel bed structure		<b>Fish community:</b>	
<b>Blue mussel beds:</b>		Biomass + abundance	fished + unfished areas
Location and area	intertidal/unfished beds	Species composition	
Location	subtidal/unfished beds	Species richness	
Biomass (fauna + flora)	intertidal	Dominance structure	
Species composition	intertidal/unfished beds	<b>Breeding birds:</b>	
Dominance structure		Number and distribution of selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>
Mussel bed structure		<b>Migratory birds:</b>	
<b>Blue mussel beds:</b>			
Location and area	intertidal + subtidal/cultured beds	Number of waterbirds in counting units according to the time of season <sup>5)</sup>	counting areas <sup>9)</sup>
Location	subtidal/cultured beds		
Biomass estimation	intertidal + subtidal/cultured beds	Percentage of young birds of staging waterbirds <sup>5)</sup>	
<b>Cockle areas:</b> (see zoobenthos community)			
Location and area of habitat	fished and unfished areas		
Biomass			
Species composition			
Dominance structure			
Species: distribution pattern			

#### IV Recreation

Recreational activities include all tourist or leisure-oriented activities in the entire Wadden Sea (e.g., non-commercial shipping, wind-surfing, hunting, game fishing, bird watching, tourism, sight-seeing and individual aircraft traffic). The main impact of recreational activities is disturbance.

##### IV.1 The response of species to recreational activities in the Wadden Sea

The recreational activities can affect the quality of the ecosystem, especially for birds and mammals, and the scenic quality for man. The recreational value of the Wadden Sea can be reduced by over-exploitation by recreational activities.

##### Hypotheses:

Recreational activities can affect the occurrence and abundance of species. This includes the population size, growth and reproduction of species. The main impact of recreational activities may be related to the presence of visitors in the Wadden Sea area and their activities. Natural fluctuations have to be taken into account.

Parameter	Compartment/Area	Parameter	Compartment/Area
<b>Tourism (general):</b>		<b>Breeding birds:</b>	
No. of visitors	communities, provinces	Number and distribution for selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>
Length of stay		<b>Breeding Success:</b>	
Socioeconomic data		Juvenile <sup>7)</sup> mortality	selected areas <sup>8)</sup>
No. of overnight stay (• 9 beds and <9 beds)	islands + coastal communities	Egg mortality <sup>7)</sup>	
Bed capacity (• 9 beds and <9 beds)		Growth rate <sup>7)</sup>	
Official harbor capacity		Recruitment <sup>7)</sup>	
<b>Recreational Activities:</b>		Mortality outside the breeding season <sup>7)</sup>	
No. of boats at sea (list different boat types)	selected areas	<b>Migratory Birds:</b>	
Human activities (tidal flats, beaches, dunes, salt marshes)	selected areas	Number of waterbirds in counting units according to the time of season <sup>5)</sup>	counting areas <sup>9)</sup>
No. of flat walkers	per routes	Percentage of young birds of staging waterbirds <sup>5)</sup>	
<b>Shipping:</b>			
Total no. of ships (different types, overnight stays, in- and outgoing)	harbors		
Passage of sluice ships	NL		
<b>Air traffic:</b>			
Landings/take offs	all islands, coastal areas		
<b>Groundwater level</b>	islands		

## V Agricultural practice

### V.1 The response of salt marsh communities to agricultural utilization

The grazing of cattle on salt marshes has changed the structure of the flora and fauna and has reduced the ecological and recreational value of salt marshes.

#### Hypotheses:

Cattle grazing on salt marshes directly affects the natural occurrence and structure of plant and animal communities. It also affects the natural breeding and roosting habitats of birds. A reduction of cattle grazing in conjunction with the restoration of tidal processes on salt marshes will lead to the reestablishment of the natural biotic communities. Natural salt marshes exposed to the tides function as natural filters of suspended solids and hence as a sink for adsorbed pollutants.

Parameter	Compartment/Area	Parameter	Compartment/Area
<b>Salt marshes (utilized)</b>		<b>Salt marshes (unutilized)</b>	
Location and area	whole area	Location and area	whole area
No. of domestic animals per area and time <sup>1)</sup>		Species richness (vegetation)	selected areas
Hay making (location)		Biomass (aboveground vegetation)	
Species richness (vegetation)	selected areas	Dominance structure (vegetation)	
Biomass (aboveground vegetation)		Species richness (fauna)	
Dominance structure (vegetation)		Dominance structure (fauna)	
Vegetation height		Zonation (flora, fauna)	
Zonation (flora)		Soil parameters (net sedimentation, grain size distribution, C/N ratio, organic matter thickness oxic layer)	
Species richness (fauna)		Flooding (flooding frequency, inundation, elevation, flooding level)	
Dominance structure (fauna)			
Biomass (fauna)			
Zonation (fauna)			
Flooding (flooding frequency, inundation, elevation, flooding level)			
<b>Land use:</b>			
List of utilization	whole area		
<b>Breeding Birds:</b>			
Number and distribution for selected breeding birds <sup>5)</sup>	total area / census areas <sup>8)</sup>		
<b>Migratory Birds:</b>			
Number of waterbirds in counting units according to the time of season <sup>5)</sup>	counting areas <sup>9)</sup>		
Percentage of young birds of staging waterbirds <sup>5)</sup>			

- 1) All heavy metals to be measured in the sediments (<20µm, <63µm fractions) and in the water column (adsorbed to suspended solids).
- 2) Congeners 28, 52, 101, 118, 138, 153, 180.
- 3) All organic micro-pollutants to be measured in the sediments, Lindane in the water column.
- 4) Age structure may also refer to meristic parameters indicating the age distribution of a sample.
- 5) Species according to the Trilateral Monitoring Breeding Bird Program (JMBB)/ Trilateral Monitoring Migrating Bird Program (JMMB)
- 6) Eggs, common tern and oystercatcher only.
- 7) Selected species according to the National Coordinator Group of Trilateral Breeding Bird Monitoring Program (JMBB).
- 8) Selected areas for according to the National Coordinator Group of Trilateral Breeding Bird Monitoring Program (JMBB).
- 9) Counting units according to the National Coordinator Group of Trilateral Migratory Bird Monitoring Program (JMBB).
- 10) Selected areas according to the National Coordinator Group of Trilateral Beached Bird Surveys (TBBS).
- 11) To be specified by kind of cattle (sheep, cows).
- 12) Areas to be selected by their vicinity to eulitoral reference areas

**General note.** The assessment of heavy metals and organic micro-pollutants to be carried out in all relevant compartments: mussel bed, eelgrass, tidal flat sediments (including gullies) and salt marsh soils. The additional consideration of data for the input loads (riverine, diffuse, wet deposition) from external sources of information is highly recommended.