Measures for the Marine Strategy Framework Directive

First overview of potential measures, related costs and effects of implementing the Marine strategy

WaterDienst

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1 INTRODUCTION

1.1 General

The European Union's Marine Strategy Framework Directive (MSFD) was adopted in June 2008. This directive constitutes legislation directed at safeguarding the ecological status of the North Sea and to protect it as a resource for economic and social activities. It sets environmental goals by using a set of 11 descriptors that together form a comprehensive body of related objectives (see table 1.1). Targets are set in terms of Good Environmental Status (GES), to be reached in 2020.

Table 1.1.descriptors

1	Biodiversity
2	Exotic species
3	Fish populations
4	Food webs
5	Eutrophication
6	Sea bottom integrity
7	Hydrographical characteristics
8	Priority substances
9	Priority substances in fish
10	Marine litter
11	Under water noise

The implementation of the MSFD requires an economic analysis of the costs of degradation. These costs are very difficult to calculate. At present the costs of ongoing and proposed measures haven been inventoried by LEI (Walker et al 2010). Furthermore the selection of additional measures will be governed also by economic indicators, such as cost-effectiveness and disproportionality.

There are strong relations between the MSFD and the Water Framework Directive (WFD) and the measures that are formulated and implemented under the OSPAR Convention. The WFD primarily targets freshwater systems, while the emphasis of OSPAR is on reducing the impacts of various forms of pollution and disturbances on the marine life and biodiversity from both marine and land-based activities. OSPAR does not target fisheries and shipping.

Ongoing studies

Several studies have been carried out or are still ongoing that generate information that is also relevant to this overview of potential measures:

- *Initial assessment (by Imares and Deltares)*: this is at present a still ongoing study that will give an overview of the present status of the North Sea in terms of the descriptors of the Marine Strategy Framework Directive. It formulates criteria and parameters to assess this status and gives an overview of the present status. It does however not formulate the desired status of all the descriptors, nor will it formulate measures.
- *Analysis of the cost of avoiding degradation of the Dutch North Sea Environment* (Walker et al 2010): this study was completed recently. It gives an overview of all the measures already taken and related environmental costs. Measures are often grouped and not distinguished as individual measures. The measures under the WFD are represented, but not the measures needed to

implement Natura2000 in the North Sea. The latter are still subject to discussion but nevertheless will be important to the autonomous development of the North Sea.

- *Baseline Scenario Marine Strategy Framework Directive* (by ECORYS, 2010*)*; this study defines scenarios for relevant economic sectors (drivers) and related pressures to the North Sea. The formulated scenarios take into account the recent financial and economic crises. It is expected that these will only lead to a temporary dip in ongoing upward trends as shown by most of the drivers.
- *Initial assessment MSFD*: costs and effects (ECORYS, 2007). Prior to the adoption of the European Union's Marine Strategy Framework Directive (MSFD) in June 2008 a first Economic Impact Assessment (EIA) was conducted to understand the costs and effects in an early stage. A description of the EIA is included in this study ECORYS. The study gives an overview of the measures already taken, proposed measures and related environmental costs and possible scenario and measures for implementation of MSFD with related costs.
- *Natura 2000 sites North Sea;* As part of the designation process a number of studies have been conducted that focus on the present status of these areas and management objectives. There are to this date no formal objectives and related measures formulated for these sites.

1.2 Objective of this study

This study is complementary to the other ongoing studies. Its major focus is to define measures that need to be considered for the implementation of the directive. It describes a long list of possible measures directed at various drivers. Out of this list a shortlist of 40 measures has been selected, and for the selected measures costs and effects are described on the basis of existing information.

This initial overview of measures and related costs and effects, will help to define the need for additional assessments and studies and it will point out additional measures that may be relevant for the implementation of the directive.

Since there are no clear objectives for neither of the Descriptors or Natura 2000 sites, the effects and also cost-effectiveness of measures can only be roughly indicated. It is a first indication of potential relevant measures, it is not a recommendation for implementation. Based on new insights and knowledge the list can be further supplemented and extended in the future.

1.3 Structure of this report

This report consist of 4 parts:

- *The report* that gives general background on the approach followed, some relevant pressures and associated measures, a discussion on the potential measures for additional consideration and conclusions and recommendations.
- *A long-list of possible measures*, that is based on various sources, amongst them recent workshops, discussions but also information from other countries and policies and measures adapted by them or in preparation.
- *A shortlist of possible measures*, in the form of an excel sheet that gives a rough indication of the effects of measures and their cost-effectiveness and possible relevancy.
- *A list of measures*, describing the shortlist in more detail.

The report contains the following chapters:

- *Approach (chapter 2)*, which describes the assembly of the long list and the selection of measures for the short list and the way in which cost-effectiveness is assessed.
- *Major aspects (chapter 3)*, which describes some major groups of pressures and related measures, notably the existing and possible measures in the form of zoning, the implementation of Natura2000 and how to deal with marine litter.
- *Pressures and measures (chapter 4),* which gives an overview of pressures and related selected measures and discusses their cost-effectiveness and perspective for implementation and need for further study.
- *Conclusions and recommendations (chapter 5)* which indicates further steps related to potentially relevant measures.

2 APPROACH

This study generates a first overview of possible additional measures for implementing the MSFD. It describes possible measures, the expected effects of these measures on the environment, mainly in terms of pressures, and the expected costs of implementing these measures to the extent which is possible at this stage. There are many potential measures, but for this study it was decided to focus on (start with) a first selection of 40 measures for which costs and effects are presented in some detail. Annex I includes a long-list of identified measures.

2.1 Assembly of the long list of measures

2.1.1 General

The long-list has been formed on the basis of various sources, without any additional selection or filtering. It should be noted that there are many measures related to OSPAR that are directed at individual pollutants and industries. Most pollutants are however targeted by specific EU-regulations. The EU-Water Framework Directive is expected to have the largest positive impact on water quality. All these individual measures have not been included in the long list. Most of them are clustered in one of the ongoing measures as were identified by the study that was conducted by LEI (Walker et al.2010).

The measures are structured according to drivers and related pressures and descriptors. This structure has been used for the long list and the short list. It follows the structure of the studies of LEI (2010) and ECORYS (2007) but added marine tourism, Natura 2000 and coastal defense as drivers. Although there are many measures directed at safeguarding and improving the marine environment, the implementation of Natura 2000 can be seen as a separate set of measures, which are still in discussion. It is also a matter of discussion whether to include the Delta Programme as a driver as well. There are several measures within this program which will have an impact on the marine environment. The most important are:

- The allocation of water from the river Rhine to the river IJssel, which will reduce the outflow and reduce the volume and intensity of the coastal river.
- The proposed seaward advance of the coastline on top what is needed for long-term safety at present standards, which will significantly increase nourishment needs and related sand mining activities.

2.1.2 Present measures and autonomous measures

Many measures have already been taken to safeguard the North Sea environment. The table below, is taken from the LEI-study (Walker et al 2010) and gives an overview of existing measures and related costs.

The land-based costs are by far the largest. The true costs of land-based water quality management is even much higher. Only a percentage was attributed to the protection of the marine environment, following an earlier suggestion of the ECORYS (2007) study. For all costs 50% was attributed to the marine environment with the exception of sewers, for which a percentage of 25% was used, because sewers have also a major role in draining and not all costs can be considered as environmental costs. The LEI study also included the programme of WFD measures. Most WFD measures still need to be implemented.

Table 2.1. Indication of the current annual costs and current measures to avoid degradation of the Dutch North Sea environment (Walker et al. 2010).

Table S.1	**The annual costs and measures of avoiding degradation of the Dutch North Sea environment.**
Cost category	**Annual costs: €000**
Sea-based costs	
Sand and shell mining: • restrictions on site locations.	2,500
Oil and gas production: • measures regarding discharges of polluted production water.	12,500
Fisheries and aquaculture; • more sustainable fishing methods (i.e. gear change), • ban on dumping of marine debris from aquaculture, • limitations on cockle fisheries.	8,121
Shipping; • insurance costs, • contributions to the International Oil Pollution Compensation (IOPC) Fund, • TBT-free anti-fouling materials, • ballast water treatment facilities, • port receptions facilities for waste, • beach cleaning.	17,234
Recreation • Beach Cleaning	1,260
Wind farms: • Environmental Impact Assessments (EIA).	3,666
Ministry of Defense (Royal Dutch Navy); • research into underwater noise, • technical measures on board ships.	412
Dredging: • restrictions on sea based dumping of dredged material.	30,000
Land reclamation: Maasvlakte II; • EIA reporting, • habitat compensation, • monitoring of environmental effects, • restricted fishing areas, • enforcing and management of these measures.	20,595
Government; • policy work, • management, • monitoring of the North Sea environment and economic activities, • improvement of the knowledge about- the North Sea environment.	35,400
Subtotal sea-based costs	**131,688**
Land-based costs	
Waste water treatment plants	402,094
Sewers	458,154
Agriculture	364,037
Industry	188,026
River and lake beds	33,324

Other measures	250
Inland shipping	3,700
Subtotal land-based costs	**1,449,585**
TOTAL	**1,581,273**

As indicated many measures have already been taken to safeguard the environment of the North Sea. The present set of measures is taken from the LEI study. This study focuses on additional measures to be taken. However, it is vital that we have a complete overview of existing measures. This information is enriched with respect to:

1) *Making relevant distinctions in individual measures*; often measures are taken together in one group, so individual measures are no longer distinguishable. If there is a need to intensify or alter ongoing measures, it was tried to make this subdivision, since it enables us to underpin costs and effects of additional measures on the basis of present costs and effects.
2) *Adding existing relevant measures*. Some existing measures have been added, for the sake of constructing a complete overview, such as various zones with restrictions that are already operational (e.g. the Plaice box).
3) *Adding effects to existing measures*. The LEI study on the initial costs does not describe effects to the environment. Where possible, at this stage, also the effects have been indicated. Emphasis was on those existing measures that would furnish also information for proposed additional measures.

2.1.3 Adding new measures

Types of measures

Generally 5 basic types of measures have been distinguished:

- *Environmental licensing, monitoring and compliance*. Most larger interventions in the North Sea are subject to an Environmental Impact Assessment and to licensing. There is still scope to apply this instrument to more interventions and to increase monitoring. An example is sand mining. The requirement of an EIA is coupled to the volume and surface area for sand mining but not to its potential ecological effect, which depends mainly on location-specific conditions. So smaller but potentially harmful sand mining activities go without adequate assessments of the effects. An additional measure can be to subject also small and potentially harmful sand mining to an EIA. ECORYS (2007) estimated that the implementation of the MSFD may cost annually between 5 and 15 million Euros for policy making and licensing and related research activities. The same cost estimate was used for the LEI-study (Walker et al. 2010).
- *Reducing the volume of current activities,* such as reducing the trawling fleet capacity, the total volume of sand mined, or the number of shipping passages. Reducing the volume of an activity may be difficult since it is often related with large economic effects. The volume of shipping can not (or only with great effort and costs) be reduced, but it may be possible to steer shipping lanes away from vulnerable areas (see zoning). It is difficult to reduce the volume of sand that is mined at present. It is very difficult for coastal maintenance because this is vital to coastal protection, which relies on the maintenance of the Basic Coast Line (BKL) in addition with the strong preference for using sand instead of marine structures ("zacht waar het kan, hard waar het moet"). However, there are possibilities to scope for more sand-efficient ways of coastal maintenance and protection. Furthermore part of the discussion is whether the North Sea would be the preferred source for building materials, or if in combination with the ecological restoration of Lake Markermeer, more sand could be taken from the IJsselmeer Area. Also oil and gas

exploration and exploitation and the related infrastructure as well as wind farms can not be limited in volume. However, oil and gas exploitation is expected to be phased out in the coming decades (ECORYS 2010). Wind farms will increase in capacity and surface area. Mitigating the effects of these activities has to rely on technical measures or zoning (see below). Already for decades the fishing of commercially important species is subject to quota and these can be further reduced. There is also scope to reduce the quota on shell mining.

- *Mitigating effects by technical measures*. This is an important category. Nearly all pressures can be mitigated by applying best available technologies (BAT). OSPAR often uses BAT as a baseline for reducing harmful contaminants. Much can be expected from new fishing techniques, new techniques to reduce underwater noise or the ecological landscaping of mining burrows.
- *Zoning the activity to less vulnerable areas*. Zoning is an ongoing management tool and can be very effective to mitigate location-specific pressures, such as the physical and biological disturbance of the sea bottom. Zoning has however limited possibilities for improving water quality, decreasing marine litter and improving most fish populations. In relation to zoning the very intensive use of the North Sea must also take into account (see also chapter 3).
- *Research needed to support policy making*. Research can be seen as a separate measure. The more we know the more cost-effective measures can be designed and implemented.

Other categories are possible, but these 5 categories align well with the different pressures.

Table 2.2. Possible courses of action with respect to major drivers

Major drivers	*Policy and licensing*	*Volume reduction*	*Technical mitigation*	*Zoning with restrictions*	*Research needed*
Shipping	*X*		*X*		*x*
Sand mining for coastal protection	*X*		*X*	*X*	*x*
Sand mining for coastal management	*X*	*X*	*X*	*X*	*x*
Sand mining for construction	*X*	*X*	*X*	*X*	*x*
Shell mining	*X*	*X*	*X*	*X*	*x*
Bottom trawlers	*X*	*X*	*X*	*X*	*x*
Shrimp fishing	*X*		*X*	*X*	*x*
Open sea fishing	*X*	*X*	*X*		*x*
Offshore oil and gas	*X*		*X*		*x*
Offshore windfarms	*X*		*X*	*X*	*x*
Cables and pipelines	*X*		*X*		*x*
Military zones and activities	*X*		*X*	*X*	*x*

2.2 Selection of the shortlist

Using a gross list that was based on various sources a selection of potentially relevant measures was made. Focus was on the following types of measures:

- *Measures related to Natura 2000 sites.* Several parts of the North Sea have been indicated as Natura 2000 sites. Objectives and measures are still being discussed. Measures will likely be zoning instruments, or restrict specific uses or prescribe best available technology within the Natura 2000 sites. Since Natura 2000 covers nearly 1/5 of the Dutch North Sea, it is important to have a better description of related measures. Since management is still in discussion it is best to assume a range of possible restrictions to existing uses (see chapter 3.2 Natura 2000).

- *Measures that are already in discussion*, such as mitigation of noise pollution by alternative building methods for wind farms, using quiet propellers and refraining from the use of sonar. Also in discussion is an allocation of water between Rhine and Ijssel with implications for the coastal river and the use of electric pulse fishing, which is currently not allowed according to EU-regulations.
- *Measures that will be implemented shortly, as part of ongoing programs* such as WFD measures into emission and water quality and other international agreements and conventions like OSPAR and IMO. WFD measures have been included in the LEI (2010) overview, but most still have to be implemented and the effects on the North Sea have to be estimated. It is also important to indicate what effects may be expected from these measures, notably in terms of eutrophication and contaminants.
- *Measures that have great potential*, such as various types of proposals for zoning or measures that are directed to specific pressures that have so far not been considered.

2.3 The effects of measures

2.3.1 General

The goals of the MSFD are defined as 11 descriptors (see chapter 1.1). The state of these descriptors depends on a wide array of pressures. The effects of measures can be predicted mainly in terms of changes in relevant pressures, but it is difficult to define their effect on the level of descriptors. Even for most existing measures no concrete functional relations can be drawn between a measure and its effect on a pressure and on to the environment. Most measures are part of very complex intervention-effect chains that involve many measures as well as external factors. This implies that cost-effectiveness can not be defined in detail and with certainty. It is not possible to improve the level of knowledge on intervention-effects chains to a level to make this possible and certainly not in the coming years. The absence of detailed knowledge does not mean that it is not possible to set priorities and further courses of action for the implementation of the MSFD. A parallel may be drawn with OSPAR, a program that has generated many effective measures directed at safeguarding the marine environment. It focuses on potential harmful activities and sets objectives in terms of Best Available Technologies or Best Environmental Practices without detailed knowledge about related effects. OSPAR and also IMO focus on priority substances and the precautionary principle. OSPAR works according to the principles of the ecosystem approach and applies amongst others, also the precautionary principle. This principle is an important motive to move ahead in the right direction while constantly monitoring the results. A parallel can also be drawn with Quota set for fisheries. They give direction and are constantly monitored for their effects.

With the implementation of the MSFD a similar strategy can be followed. Because of lack of data and understanding a detailed cost-benefit analysis is not possible, but is will be possible to rank potential measures on the basis of the expected reduction and mitigation of pressures. Precautionary principles help in ranking such potentially harmful but not well understood pressures such as underwater noise by sonar and marine litter. BAT and BEP that do not lead to disproportional high costs to a sector will be ranked high, as well as all types of possible measures that do have substantial benefits to the sector as well (e.g. pulse fishing that reduces fuel consumption). The possibility for incremental implementation in combination with monitoring may also lead to a higher ranking. Zoning is an example of this. If proven successful the area that is zoned can be extended.

In this study expert judgment the relevancy of the relations between drivers and pressures have been indicated, showing how relevant a specific economic activity is to a specific kind of pressure. Similarly, also

on the basis of expert judgment the functional relation between a pressure and a descriptor has been indicated. This allows us to construct a ranking of possible cost-effective measures on the level of pressures.

It should be noted that for the ranking of measures on the basis of cost-effectiveness the following needs to be known with respect to effects:

- *The functional relation between a driver and a pressure*, for which we have an expert opinion (see table 2.4). Implicitly, this involves ranking the relative importance of all drivers that have similar pressures. **This is done in 4 classes: very large, large, medium and small.**
- *The functional relation between a pressure and a descriptor*, for which we have an expert opinion (see table 2.5). Implicitly, also this involves ranking the relative importance of a pressure with respect to a descriptor. **Also this is done in 4 classes: very large, large, medium and small.**
- *The relative importance to other descriptors*. This "weighing" is not done in this study. We assume all descriptors to be equally important. There is some expert opinion concerning the overall importance and related risks of drivers to the North Sea environment (see table 2. and figure 2.4).

Scores in tables 2.4 and 2.5 were used to assess the effects of measures.

2.3.2 Relative importance of drivers in relation to pressures

Table 2.4 is taken from the draft report on the initial status of the North Sea. Indicated are major drivers and related pressures.

It is noted that the impact of sand mining is of the same category as marine fisheries with respect to biological disturbance. The impact of sand mining may be somewhat overrated, since it takes place on less than 30-50km2/annually, while bottom trawlers operate on most of the North Sea. Over half (55%) of the Dutch part of the North Sea is fished more than once a year and only 14% less than once every four years (Lindeboom et al. 2005). When comparing the environmental impact of beam-trawling, the most important fishing technique in Dutch waters, Lindeboom (2005) estimates its effects to be 1000 times more severe than those of sand mining, and 100,000 times higher than those of oil and gas exploration (see also table 2.6).

Some drivers are strongly related such as sand mining and coastal defense, for which periodical foreshore nourishments but also beach nourishment takes place. The impact of these foreshore nourishments on water quality is small, since most siltation takes place during sand mining. Furthermore sand mining should be distinguished from shell mining, as these two are very different activities.

Dumping contributes significantly to the input of contaminants and nutrients. It should however be noted that dredging takes up small particles and attached contaminants that have settled previously into shipping channels and harbours. Without these deeper shipping channels and harbours these small particles would freely flow into the delta areas of the coastal North Sea. The primary driver is the input of contaminants by rivers and shore based activities. Dredging and related dumping does not increase the total amount of contaminants but temporarily buffers their release into the environment. Without any dredging and artificial sinks like shipping channels and harbours the total amount of silt particles and related contaminants would be roughly the same as now.

Table 2.4 taken from the draft initial assessment. An indication of links between human activities (drivers) and pressures. X indicates where links exist (Slijkerman et al., 2010). Colour codes indicate the relevance of the pressures for the Dutch part of the North Sea, adapted from Karman (2008): red=high; orange=high, but very local; yellow=moderate; = not relevant in the Dutch part of the North Sea.

Pressure	Physical loss		Physical damage			Other physical disturbance		Interference with hydrological		Contamination by hazardous substances			Nutrient and organic matter enrichment		Biological disturbance		
Driver	Smothering	Sealing	Changes in siltation	Abrasion	Selective extraction	Underwater noise	Marine litter.	Significant changes in thermal regime	Significant changes in salinity regime	Introduction of synthetic compounds	Introduction of non-synthetic substances and compounds	Introduction of radio-nuclides.	Inputs of fertilisers and other nitrogen- and phosphorus-rich substances	Inputs of organic matter	Introduction of microbial pathogens	Introduction of non-indigenous species and translocations	Selective extraction of species, incl. incidental non-target catches
Extraction of marine aggregates	X		X	X	X	X					X		X	X			X
Dredging for navigational purposes	X		X	X	X	X				X	X		X	X			X
Dumping of wastes and other material	X	X	X			X				X	X	X	X	X	X	X	
Exploration for oil and gas and placement of structures for the exploration of oil gas		X	X	X		X		X	X	X	X	X					
Placement and maintenance of cables and pipelines		X		X		X		X									
Construction and placement of artificial reefs		X		X		X											
Maritime transportation				X		X	X			X	X		X		X	X	
Renewable energy (wind farms)		X		X		X										X	
Land reclamation	X	X				X		X	X								
Coastal defense	X		X		X	X			X								
Maritime tourism				X		X	X			X	X		X	X	X	X	
Mariculture *	X	X		X		X	X			X			X	X	X	X	
Marine commercial fisheries				X		X	X			X	X						X
Land-based emissions (river discharges, atmospheric deposition)																	
Military activities																	

2.3.3 Relative importance of pressures to descriptors

Most GES descriptors are subject to several pressures. It is noted that several descriptors are related to only one (D2, D3, D10), two (D7, D11) or three pressures (D5, D8 and D9). The descriptors D1, D4 and D6 depend on many more pressures. The descriptor D2, exotic species is mainly related to ballast water by shipping. Fish populations (D3) is assumed to be only dependent on selective extraction by fisheries. This is the most important pressure, but other pressures such as the input of fertiliser and organic matter that increase eutrophication (D5), algae growth, biomass production and hence also the balance between fish populations through changes in the food web (D4) play a role as well. This shows the complex interrelations between descriptors, pressures and consequently also drivers. Most of these interrelations are not well understood and dynamic and all depend upon external variables such as climate change. It is therefore very difficult to draw robust intervention-effect chains that allow the quantification of the link between measures and descriptors. The emphasis in this study is on the relation between measures and pressures.

Table 2.5 (taken from the draft initial assessment). An indication of links between pressures and impacts on the GES descriptors (indicated by D1-D11). X indicates pressure of primary importance; (X) indicates pressure of secondary importance, X energy input described in Tasforce Group 11 report, but no indicator provided (Cardoso et al., 2010).**

Pressures and impacts		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11
Physical loss	Smothering	X			X		X					
	Sealing	X			X		X					
Physical damage	Siltation	X			X		X					
	Abrasion	X			X		X					
	Extraction	(X)			X		X					
Other physical disturbance	Noise	(X)			(X)							X
	Marine litter	(X)					(X)				X	
Interference with hydrology	Change in thermal regime	(X)			X		(X)	X				X**
	Changes in salinity	(X)			X		(X)	X				
Contamination	Synthetic substances	(X)			X		X		X	X		
	Non-synthetic substances	(X)			X		X		X	X		
	Radionuclides	(X)			X		(X)		X	X		
Systematic release of substances	Introduction of other substances	(X)			X		X		X			
Nutrient and organic matter enrichment	Input of fertilizer	(X)			X	X	X					
	Input of organic matter	(X)			X		X					
Biological disturbance	Microbial pathogens	X			X	X	(X)					
	Non-indigenous species	(X)	X		X		X					
	Selective extraction	(X)		X	X	X	(X)					

D1=Biodiversity; D2= Exotic species; D3=Fish populations; D4=Food webs; D5=Eutrophication; D6= Sea bottom integrity; D7=Hydrographical characteristics; D8=Priority substances; D9=Priority substances in fish; D10=Marine litter; D11=Under water noise.

2.3.4 Relative importance of drivers to overall North Sea environment

Karman et al. (2008) have indicated the relative importance of various drivers to the North Sea (see also Initial Assessment by Imares and Deltares). This may be used as a first assessment of the comparative importance of various drivers with respect to overall Descriptors, such as descriptor 1. It is noted that many activities fall into a similar category of importance. If one were to apply four categories than a following subdivision may be made:

1) Limited: cables and pipelines and energy production on land
2) Moderate: tourism and recreation, infrastructure for wind turbines
3) High: energy production at sea (wind turbines), infrastructure offshore oil and gas platforms, extraction of sand and gravel,
4) Very high: extraction of oil and gas, extraction for navigational dredging, beach replenishment, pollution land based sources and fishing including bottom trawling.

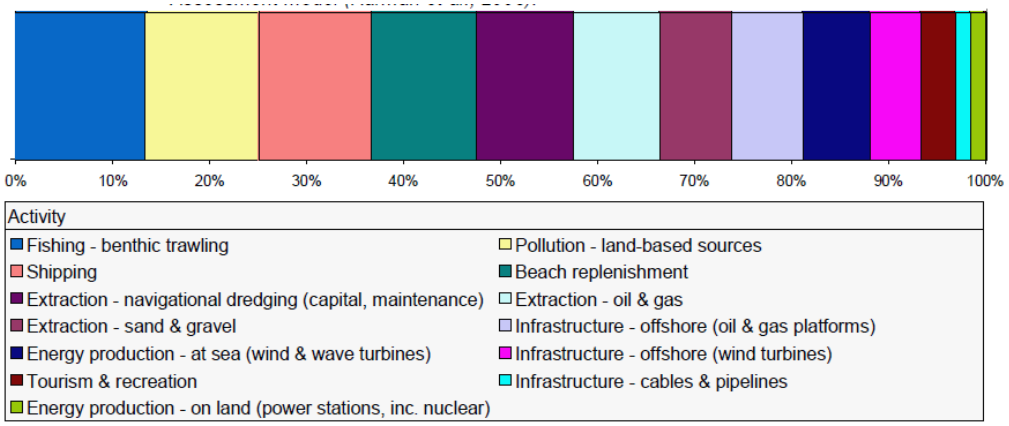

Figure 2.4 Relative ecological risks of various human activities in the Dutch part of the North Sea (Karman et al., 2008).

It is noted that navigational dredging, sand and gravel extraction and beach replenishment are considered to contribute together almost 27-28% of the total risks. As has been indicated these activities take place on only a very limited surface area of the North Sea.

Other measurements of relative importance of drivers have also been proposed, e.g. Lindeboom (2005) proposed a relative benthos damaging index for different human activities at sea:

Table 2.6 The relative impacts of various drivers on benthos (Lindeboom .2005).

Activity	Index
Fisheries	12,240-20,800
Sand extraction (after 2005)	160-172
Gas and oil (prior to 1993)	70
Sand mining (prior to 2005)	12
Pipelines and cables	<1
Gas and oil (after 1993)	<0.14
Shipping	<<1
Military activities	<<1
Gravel mining	0

Although this index solely considers benthic life and thus ignores pressures related to visual, acoustic or chemical disturbance of the environment, it might be more suitable than the one proposed by Karman et al. (2008) for some Descriptors, e.g. (1) Biodiversity or (4) Food webs or (6) Sea bottom integrity that are intimately linked to benthic life. It is noted that both reports come up with different estimations considering the importance of specific drivers.

2.3.5 Time-frame for 2015 and 2030

The tables that state the functional relations between drivers, pressures and descriptors correspond more or less to the present status. Many measures are already scheduled to be taken in the coming years, notably under the Water Framework Directive and Natura 2000. This implies that these relational matrices will change in 2015, only slightly, and perhaps more so in the years thereafter, for example in 2020. A pressure that is important now may become less important over time and the best option may be to phase it out instead of investing heavily in mitigating measures. Similarly, some drivers tend to increase and their related pressure may become very important in the future. With respect to these drivers it is best to take action now, anticipating future developments, in order to prevent pressures becoming very important.

There are also developments in the drivers themselves, e.g. in sand mining, shipping. Also changes in drivers will lead to changes in these relational matrixes. These latter changes are taken from the study of ECORYS (2010) on the economic baseline scenario.

In the study of ECORYS the following economic uses are analysed: fishing, shipping, oil and gas exploration, surface mining and quarrying, dredging spread, wind power, cables and pipelines, defence, recreation and tourism. For these human uses there is a potential conflict with the marine environment of the North Sea. The following table provides a summary of the expected developments for the mentioned (sea based) users in the coming years in terms of value added and employment.

Tabel 2.7 Summary of current economic significance (2007) and future projections 2015, 2020 and 2040 (from: ECORYS 2010).

Part a) Value added (€ million, nominal values)

	2007	2015				2020	2040
	2007	GE	TM	SE	RC		
Oil and natural gas	5,867	4,594	4,817	5,034*	5,034	3,943 - 4,574	1,262 - 2,050
Sand extraction	17	15				27	27 - 40
Shipping	1,208	1,368	1,291	1,179*	1,034	938 - 1,478	853 - 2,201
Fishery	45	32	38	38*	38	26 - 34	17 - 26
Wind energy	4,7	36				43 - 130	0 - 433
Piping and cable	N/A	N/A				N/A	N/A

Part b) Employment (fulltime jobs)

	2007	2015				2020	2040
	2007	GE	TM	SE	RC		
Oil and natural gas	800	531	565	609*	624	410 - 534	87 - 150
Sand extraction	154	138				247	247 - 370
Shipping	7,635	7,321	7,019	6,615*	5.941	5.079 - 7.132	3.636 - 7.006
Fishery	594	442	480	495*	507	399 - 478	263 - 377
Wind energy	36	273				330 - 990	0 - 3,300
Piping and cable	N/A	N/A				N/A	N/A

Notes:

* = most likely value 2015, based on recent economic outlook 2011-2015 CPB (CPB, 2010a)

N/A = not available

GE = Global Economy, TM = Transatlantic Market, SE = Strong Europe, RC = Regional Communities

Oil and gas

The economic crisis did have a small impact on the production of oil and gas. In 2009 the production of gas was approximately 7% less than the year before. Due to high energy prices, however, production value was comparable to pre-crisis levels (2006 and 2007). Both gas and oil prices are likely to increase the coming years, where a tight market will result in higher demand and higher prices. Taking into account the most recent economic outlook for the Dutch economy to the year 2015, until 2015 the SE and RC scenario are considered as most likely (all other things being equal).

Sand extraction

The economic crisis does not have any reported impact on the extraction of sand for suppletion purposes. For commercial sand, the economic crisis has led to a drop in demand. Construction projects are delayed or being postponed, so overall less fill sand is needed. Based on recent socio-economic scenarios, however, the volume of fill sand extracted is expected to return to the pre-crisis level by 2015.

Shipping

By the end of 2008, as result of the global crisis, cargo volumes began dropping and dropped even further in the course of 2009. This has also affected the Dutch sea shipping sector. Most Dutch traders ended in red numbers at the end of 2009. In 2010, however, freight volumes are again rising. The total handling is now almost at the level of the record year 2008, just before the outbreak of the global recession. Taking into account the most recent economic outlook for the Dutch economy to the year 2015, until 2015 the SE and RC scenario are considered as most likely (all other things being equal).

Fishery

For fisheries, fuel costs have an important impact on the performance of the sector. Although lower fuel prices, also revenues have declined due to a drop in demand and the price of fish. For the short term (2015), economic recovery will restore demand and price. As fresh fish is a luxury good, the return to pre-crisis levels is expected to be somewhat slower than for other products.

Wind energy

The future economic significance depends on the installed capacity. For the short term (2010-2015), the estimate is based on the existing wind power capacity and the construction of two new facilities (600 MW). Recently, under the Crisis and Recovery Law, € 2.4 billion has been allocated to the realisation of an extra 500 MW. In this way, the economic crisis thus stimulates the development of offshore wind energy.

Piping and cable

For piping and cable, the economic importance has been detailed only in qualitative terms. The economic significance of piping and cable is rising especially due to globalization of the markets for telecom and electricity and a rising demand for telecom and electricity facilities. The financial and economic crisis did not seem to have influenced the pipeline and cable sector.

Water Framework Directive

Implementation of WFD-measures will lead to an expected reduction in N-loading on the river Rhine of 10 to 15% and of the coastal river of 5% in 2015 and 7% in 2027. So a 6% reduction of N-loading may be assumed in 2020. The expected reduction in P-loading is similar (www.krwverkenner.nl). So in spite of the large costs only a limited reduction in P and N-loads to the North Sea is expected. It is noted that these investments were mainly directed at improving the water quality of inland water bodies. Nevertheless LEI (2010), based on ECORYS (2007), attributes 50% of these costs to the North Sea. Reduction rates in summer are somewhat higher. In the past 20 years P and N loads from WTP have been reduced by 50% and treatment efficiency has already reached on average 80% (www.compendiumvoordeleefomgeving.nl).

Changes in pressures

The (economic) development in all major drivers will lead to changes in the relational matrices between drivers and pressures. The major difference between table 2.4 and table 2.6 are:

- *The impact of sand mining* is less with respect to physical damage and biological disturbance, mainly because it is expected that mining areas will be deeper and will cover a smaller surface area. For 2020 a reduction in sand mining areas is expected. After 2020 sand mining volumes may rise again to the present levels, but the physically disturbed surface area will never be as large as at present. Underwater noise will not be less, since similar or even greater volumes of sand will be extracted.
- *Dumping of waste and other materials* is expected to decrease mainly because of ongoing policies.
- *Exploration for gas and oil* will slowly diminish as will be the related effects to the environment.
- *Maritime tourism* will lead to less physical disturbance because it is expected that large parts of the coastal zone will be zoned for tourism in the Natura 2000 sites, in order to minimize the effects on birds and marine mammals.
- *Marine commercial fisheries* is expected to use environmentally friendly alternatives to beam trawlers so the related physical disturbance will reduce significantly. The biological disturbance will be only a little less.

Although there are many positive changes the remaining pressures will still require additional measures.

Table 2.8 extrapolated from table 2.4 on the basis of expected development till 2020. X indicates where links exist (Slijkerman et al., 2010). Colour codes indicate the relevance of the pressures for the Dutch part of the North Sea, adapted from Karman (2008): red=high; orange=high, but very local; yellow=moderate; =not relevant in the Dutch part of the North Sea.

Pressure	Physical loss		Physical damage			Other physical disturbance		Interference with hydrological		Contamination by hazardous substances			Nutrient and organic matter enrichment		Biological disturbance		
Driver	Smothering	Sealing	Changes in siltation	Abrasion	Selective extraction	Underwater noise	Marine litter.	Significant changes in thermal regime	Significant changes in salinity regime	Introduction of synthetic compounds	Introduction of non-synthetic substances and compounds	Introduction of radio-nuclides.	Inputs of fertilisers and other nitrogen- and phosphorus-rich substances	Inputs of organic matter	Introduction of microbial pathogens	Introduction of non-indigenous species and translocations	Selective extraction of species, incl. incidental non-target catches
Extraction of marine aggregates	X		X	X	X	X					X		X	X			X
Dredging for navigational purposes	X		X	X	X	X				X	X		X	X			X
Dumping of wastes and other material	X	X	X			X				X	X	X	X	X	X	X	
Exploration for oil and gas and placement of structures for the exploration of oil gas		X	X	X		X		X	X	X	X	X					
Placement and maintenance of cables and pipelines		X		X		X		X									
Construction and placement of artificial reefs		X		X		X											
Maritime transportation				X		X	X			X	X		X		X	X	
Renewable energy (wind farms)		X		X		X										X	
Land reclamation	X	X				X		X	X								
Coastal defense	X		X		X	X			X								
Maritime tourism				X		X	X			X	X		X	X	X	X	
Mariculture *	X	X		X		X	X			X			X	X	X	X	
Marine commercial fisheries				X		X	X			X	X						X
Land-based emissions (river discharges, atmospheric deposition)																	
Military activities																	

2.4 The costs of measures

Costs are indicated as annual costs, including capital costs, costs for operation and maintenance as well as for control and monitoring.

For the ongoing activities costs estimates are mainly based on the recently concluded LEI study (2010) and earlier ECORYS study (2007). For new measures the following approach was used:

- Additional measures of similar character that are in essence intensifying existing measures are mainly based on the actual costs figures for these activities.
- Additional measures that are entirely new have been costed on the basis of the information available.

Given the stage of planning of MSFD cost estimate of possible measures is still rough. Moreover, at present it is not clear what specific measures are needed to achieve the desired ecological status and how these measures will ultimately be completed. If there is more clarity about the completion of the required measures a more accurate estimation of the costs can be made at a later stage. For this time however, the estimated costs do provide sufficient basis for a preliminary assessment.

2.5 Indication of cost-effectiveness and disproportionality

2.5.1 General

It is expected that the selection of measures for the implementation of the MSFD will depend upon the cost-effectiveness and disproportionality of measures. The cost-effectiveness is indicated on the basis of effects and costs. It is best to compare only measures directed at the same pressure, when comparing cost-effectiveness.

Effects were rated in two steps:

Step1: On site effect

For each measure the expected reduction on various pressures is indicated, using as classes:

- 1: Low = less than 5% in intensity
- 2: Moderate = between 5 and 15% in intensity
- 3: High = between 15 and 30% in intensity
- 4: Very high = more than30% in intensity

For each pressure its importance to an individual descriptor is indicated as well. For several descriptors, such as marine litter, a 1 on 1 relation is assumed.

Most descriptors are directly related to pressures, especially the following descriptors:

- D2. Exotic species: the man-induced part is strongly related to the release of ballast water. We assumed a 1 on 1 relation.
- D3. Fish populations are directly and mainly influenced by fisheries. The influence of beam trawlers on flatfish is assumed to be 1 on 1.
- D5. Eutrophication mainly depends upon the input of nitrogen and phosphorus from land based sources.

- D6. Sea bottom integrity relates to sand mining and nourishment, dredging and dumping and bottom fisheries. The relative importance relates mainly to the surface area these activities physically disturb (see step 2).
- D8. Priority substances relate to land based sources and what is released by ships, oil and gas rigs and by dredging activities.
- D9. Priority substances in fish. This strongly correlates with D8.
- D10. Marine litter. This depends mainly on fisheries, beach tourism and other mainly land based sources. Relative contributions of 15%, 25% and 55% on the descriptor are assumed. The impact of lost fishing nets on biodiversity is however very important.
- D11. Underwater noise is mainly related to the use of sonar especially by the military, shipping noises, construction noises of off shore windmill parks and exploration noises of the oil and gas industry. Of these especially sonar use by the military rates highest, followed by exploration and construction noises. Underwater noise also has a strong geographical dimension (see step 2).

The product of reduction and importance gives the effect on site.

Step 2. Extension to the North Sea

In the next step pressures are scored in their geographical dimension, using the following classes:

1. Low = less than 500 km2, roughly 1 % of the North Sea, examples are sand mining, dredging and dumping.
2. Moderate = between 500 and 5000 km2, roughly 1 to 10% of the North Sea. Examples are off shore wind parks, the existing Sea Bottom Reserve.
3. High = between 5000 and 15000 km2, roughly between 10 and 30% of the North Sea. Examples are the combined Natura 2000 sites, underwater noise by shipping.
4. Very high over 15.000 km2, roughly more than 30% of the north sea. Examples are most forms of fishing, water quality related issues and military sonar.

Indication of costs

In the list of measures there is more information on annual costs. Costs are rated in four classes:

1) Low = less than 1 million Euro/year
2) Moderate = between 1 and 5 million Euro/year
3) High = between 5 and 15 million Euro/ year
4) Very high = more than 15 million Euro/year

There are measures that do not involve additional costs. They have been scored 0.2 in the excel sheets, so their overall score is raised by a factor 5.

2.5.2 Cost-effectiveness per pressure

On the basis of the information available an indication can be given that allows the ranking of measures using cost-effectiveness. Cost-effectiveness is the quotient of effects divided by costs. This is represented by indicator CE1.

The importance of the overall descriptor of biodiversity is made more explicit by expressing cost-effectiveness also by adding the product of the importance of a pressure to D1 biodiversity times the effect. This is represented by indicator CE2.

Cost-effectiveness is ranked as follows, for CE1:

1) Low = less than 5
2) Moderate = between 5 and 15
3) High = between 15 and 30
4) Very high = more than 30

Ranking can be higher if more points are scored for CE2, according to the following classes:

1) Low = less than 10
2) Moderate = between 10 and 30
3) High = between 30 and 60
4) Very high = more than 60

2.5.3 Disproportionality per sector

Disproportionality is indicated per driver/sector. As far as information is available the costs of measures are compared to either the total turn over or preferably the total costs and profit made. Costs are expected to be not disproportionally large in the following cases:

1) Additional costs do not lead to different competing conditions, so it is expected that they will lead to a general rise in costs to the whole sector;
2) Additional costs can be fully integrated and allocated to clients and consumers.
3) Additional costs are expected to be small compared to ongoing costs.
4) It is expected that there are no additional costs, but mainly benefits, or reasonable returns on investments.

This scoring procedure is illustrated by looking at the measure deeper sand burrows. The effect of sand mining is large and deeper sand burrows will decrease the surface area of physical disturbance significantly (>60%), hence a score high (3) on D6 integrity of the sea bottom. But looking at the on-site effects also biological disturbance becomes less which has a positive impact on benthic fish communities, food webs and biodiversity as well. The relevance of physical disturbance to various descriptors is also scored. Since sand mining is not the only activity that impacts the sea bottom, it is scored only moderate on D6 integrity of the sea bottom. Sand mining is an incident with effects lasting several years. Beam trawlers frequent the same area nearly once a year, so their overall impact is much larger. A deeper burrow may even attract more flatfish and with restrictions it may also be visited more frequent by fisherman. On site sand mining is also important to other descriptors that are closely linked to biological disturbance. The onsite effects score moderate. The area with sand mining is small, so the overall effects are small to moderate. The cost are however very small. There are even benefits, a reason why the costs were scored with a 0.2. The cost-effectiveness is therefore still very high.

Table 2.9 Example score card

Measure	Pressure	Effect on pressure 1=small 2=moderate 3=large 4=very large											Relevance of pressure to descriptor 1=small 2=moderate 3=large 4=very large											Effects			Costs
		D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	Onsite	Scale	Overall	
Deeper sand burrows	Physical disturbance	2	0	0	1	1	3	0	0	0	0	0	2	0	0	1	1	2	0	0	0	0	0	12	1	12	0.2

3 MAJOR CLUSTERS OF MEASURES

3.1 General

There are many ongoing and potential additional measures to bring about the implementation of the MSFD. Some pressures are of a complex nature, because they originate from a multitude of sources, have complex interrelations and also involve different mitigating measures. In this chapter several aspects are described that merit more information. The implementation of Natura 2000 (par. 3.2) is an ongoing process, involving many different substantial areas, possible measures and also an ongoing discussion on management objectives. Most measures will have the form of restrictions within designated areas. But there are many more existing and possible forms of zoning and restriction specific activities within these zones (par.3.2.). The existing zones give insight in the possible effects and related costs and can be used as references. Marine litter is also a complex issue, since it has many different sources (e.g. fisheries, tourism, land-based) and source or effect-oriented measures (par.3.3). There are many different forms of underwater noise and a distinction needs to made between them, because they have different effects and require different measures (par.3.4).

3.2 Natura 2000

Two of the six intended Natura 2000 sites in the Dutch part of the North Sea have already been formally designated (see also www.natura2000noordzee.nl and figure 3.1). The six areas together amount to a total surface area of 10.250 km2, which amounts to 19% of the Dutch part of the North Sea. The areas are:

- *Voordelta* (designated area 900 km2): an area that consists of the coastal zone south of Rotterdam down to the Westerschelde, comprising mainly permanently inundated shallow sandbanks. For the integrity of this area it is vital that the physical disturbance of the sea bottom is decreased, so that shellfish beds can be regenerated. The construction of Maasvlakte 2 takes place in this area and hence has led to compensating measures, such as the designation of a sea (bottom) reserve of 25.000 ha with restrictions on fisheries and also other uses (notably recreation). Cockle fishery is banned completely from this area at an estimated annual loss in the order of 0,5 million Euro (Holstein, 2010). Management measures are therefore already in place and possibly no additional measures are needed in this area. The Voordelta is part of the Sea bottom reserve.
- *Noordzeekustzone* (partly designated between Petten and Rottemeroog). It is delineated at -20 meter depth contour, which coincides largely with the southern limit of the shipping lane. It surface area amounts to 1240 km2, of which 981 km2 has been designated only under the Birds Directive. (Gebiedendocument Noordzeekustzone maart 2007). This is a shallow zone that is already exempted from sand mining. Shell mining occurs in the tidal channels between the Wadden islands. Additional measures might target this activity. Part of this area is within the Plaice box, a zone in which bottom trawlers are restricted to less than 300 HP. This limitation has led to a sharp increase of the numbers of smaller boats that fish in this area. Probably more restrictive measures may be proposed in this zone in order to safeguard the integrity of the sea bottom in this zone.
- *Vlakte van de Raan* (area 190 km2): between Voordelta and the Belgium coastal zone, comprising of the mouth of the Westerschelde. Also permanently inundated shallow sand banks.
- *Dogger Bank* (area 4715 km2), situated about 275 km north of Den Helder. It is shallow and consists mainly of permanently inundated shallow sandbanks at depths between 24 and 40 meter.

- *Klaverbank* (area 1235 km2) situated about 160 km northwest of Den Helder. The sea bottom is formed by gravely and glacial deposits. It is therefore unique to the Dutch North Sea zone.
- *Frisian Front* (area 2889 km2) situated about 75 km north of Den Helder. This is the only Natura area that is only assigned under the Bird Directive.

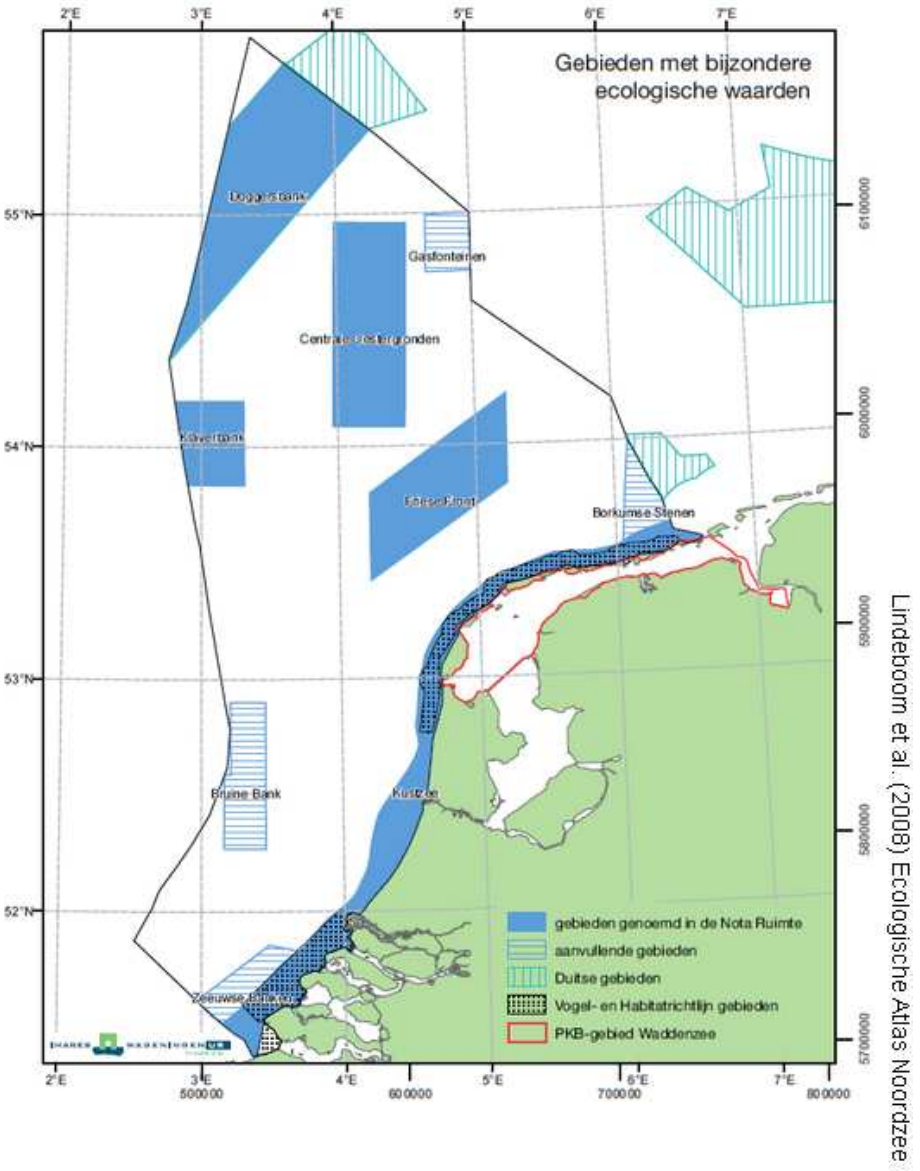

Figure 3.1. Natura 2000 sites and potential sites (taken from LIndeboom et al (2008) Ecologische Atlas Noordzee. *(Areas in the Nota Ruimte. Indicated are the following areas: Areas indicated in the Nota Ruimte, Additional Areas, German areas, existing Habitat- and Bird Directive sites and PKB-area Wadden Sea).*

Most areas are shallow. There are no final management plans and related measures yet. But in the shallow zones also brought under the protection of the Habitat Directive, the regeneration of the sea bottom has high priority. This can only be achieved by limiting the physical disturbance in these areas. An

exception is the Frisian front that is only designated under the Birds directive. This area has been designated because of the large numbers of the Guillemot (Zeekoet). Important to this bird is clean water (no oil spills) and limited disturbance. The area is also important to the Lesser and greater Black-backed gull (Kleine en Grote Mantelmeeuw) and the Skua (Grote Jager). These birds depend in part on (the discards) of fisheries. Their numbers will probably decrease if fishing intensity is reduced (Furness 2003). It is not expected that fisheries will be banned from this Natura2000 site.

For other ecologically valuable areas (*Borkumse Stenen*, *Bruine Bank*, *Gasfonteinen, Zeeuwse Banken),* a research project is being carried out to study whether these areas qualify for a protected status. Results are expected to be available in 2012. Of these areas the 'Borkumse Stenen' and de 'Bruine Bank' have the highest potential to be designated.

3.3 Existing and possible forms of zoning

3.3.1 Environmental zones imposing restrictions

Sea bottom reserve
This is a 2500 km2 large area that has been designated in 2008 as compensation for the loss of sea bottom due to the construction of Maasvlakte 2. Cockle fisheries and other activities leading to physical disturbance of the sea bottom have been completely banned from this area. (http://www.rijksoverheid.nl/onderwerpen/zeevaart-en-zeehavens/mainportontwikkeling-rotterdam/maasvlakte-2-en-natuurcompensatie).

Living Shellfish beds
Shellfishing is not allowed within the -5 meter depth contour line (Landelijke beleidsnota Schelpenwinning). This zone coincides with the Natura2000 area in the coastal zone in the northern part of the Netherlands.

Other existing zones
The Plaice Box (Schol Box) was designated in 1989 in order to protect young flounders. It comprises of an area of 40.000 km2 and is situated in Dutch, German and Danish coastal waters. It is restricted to trawlers with more than 300 HP. The effects of these restrictions are complex. Generally a decrease in young flounders could be observed. There is some discussion on the reasons for this. The fishermen argue that this is due to less fishing, which is believed to increase biomass production especially of food organisms favored by flounders. An additional study showed that other factors play a role as well, such as a general increase in water temperature, less available food and therefore lower growth rates. There may be other complex factors as well that relate to the functioning of the coastal river, that functions as transport mechanisms for young larvae between the spawning areas in the southern part of the North Sea and the Dutch coastal zone. But there are external factors as well, since the fishing fleet diminished as well as the input of nutrients. Recently the flounder population has increased. This already shows that it is difficult to predict the effects of measures on the ecosystem.

12-mile zone
This is a territorial zone. Within this zone there are restrictions on the dumping of garbage and ballast water by shipping. There are limitations to fisheries, since it is restricted to trawlers with more than 300HP. A large part coincides with the zone that is closed to sand mining (see below)

Coastal foundation/minus 20 meter depth zone
Within this zone sand mining is prohibited. Dumping of dredged materials occurs in this zone.

Tabel 3.1 Overview of existing zones and related restrictions present situation. Only in the Sea reserve there are restrictions on the recreational use as well.

	Fisheries				Sand mining	Shell mining	Wind parks
Area	**Bottom**	**Flounders**	**Shrimps**	**Shellfish**			
Natura 2000 areas							
Coastal zone: Voordelta	PR?	PR?	PR?	PR?	ZR	ZQ	0
Coastal zone: North	PR?	PR?	NR?	PR?	ZR	ZQ	0
Coastal zone: Middle	PR?	PR?	NR?	PR?	ZR	ZQ	0
Coastal zone: Vlakte van Raan	PR?	PR?	NR?	PR?	ZR	ZQ	0
High Sea:Doggersbank	NR	NR	NR	NR	0	0	NR?
High Sea:Klaverbank	NR	NR	NR	NR	0	0	NR?
High Sea:Fries Front	NR	NR	NR	NR	0	0	NR?
Potential Natura 2000 areas							
High Sea: Borkumse Stenen	?	?	?	?	NR	NR	?
High Sea: Bruine Bank	?	?	?	?	NR	NR	?
High Sea: Gasfonteinen	?	?	?	?	NR	NR	?
High Sea: Zeeuwse Banken	?	?	?	?	NR	NR	?
Other Environmental zones							
Inside -20 meter depth zone (coastal foundation)	0	0	0	0	FR	0	0
Sea (bottom) reserve	FR	FR	FR	FR	FR	FR	FR
Living shell fish banks	?	?	?	?	FR	FR?	?
12 mile zone	NR	NR	NR	NR	NR	NR	0
Plaicebox	NR	<300Hp is allowed	NR	NR	NR	NR	NR
Use related zones and restrictions							
Cables/pipelines	NR	NR	NR	NR	>500m	?	?
Shipping lanes	NR	NR	NR	NR	FR	FR	FR
Off shore Windfarms	FR	FR	FR	FR?	FR	FR	-
Archeological sites	?	?	?	?	FR	?	0
Defense	PR	PR	PR	PR	0	0	0

0 = not relevant/ not present
FR = fully restricted
PR =partly restricted
NR= no restrictions
ZR = restricted with respect to living shellfish banks, outside -20 depth contour, >500 meter outside cables and pipelines and outside of silt-rich sediments
ZQ = restricted to specific area and with quotation

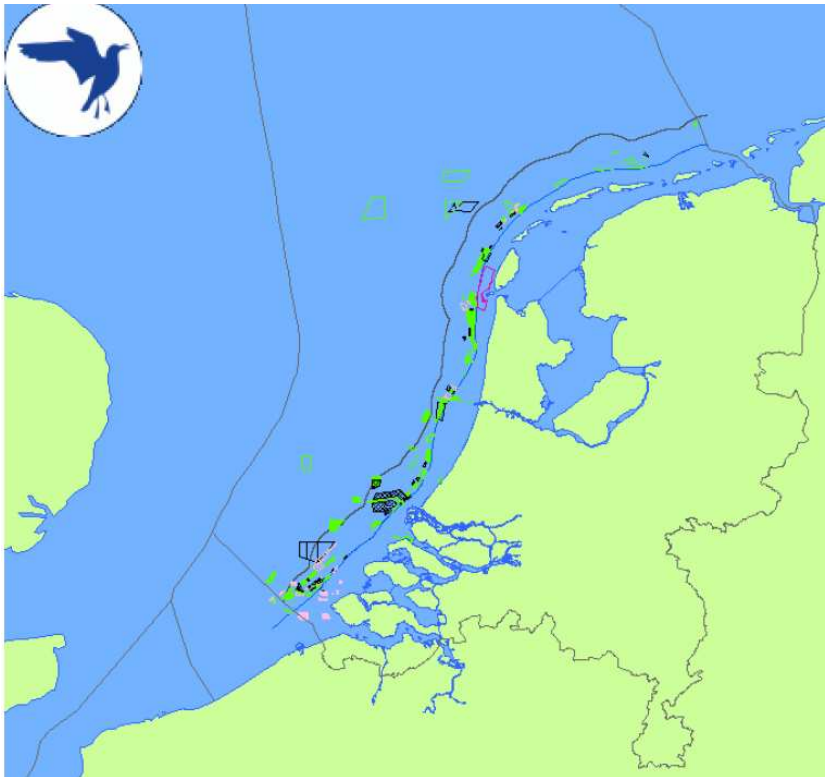

Figure 3.2 Map showing areas used for sand and shell extraction (www.noordzeeatlas.nl). Sand extraction is indicated in green, shell in red colors.

3.3.2 Economic zones imposing restriction to other economic activities.

Beam trawlers

The surface area fished annually within the 12 mile zone is estimated to be in the order of 6000 km2. As a consequence the whole 12 mile zone (in the order of 10.000 km2) is fished with a frequency of 0,6 times per year. This is a huge surface, but beam trawlers also operate outside the coastal zone, but no data are available yet. The physical disturbance is not as intense as with sand mining, but within the 12 mile zone, the area fished is more than 500 times as large as the area that is mined. Also its impact on silt concentrations can therefore be substantial but is not recognizable as a silt plume.

Offshore Wind Farms

Offshore wind farms represent areas with restriction to shipping and fishing. The first Dutch offshore wind farm, "Offshore Wind farm Egmond aan Zee" (OWEZ), has a surface area of some 27 km2 (108 MW); the second wind farm, “Prinses Amalia Wind park” has a surface area of about 14 km2 (228MW). The ecological effects are being studied and indicate positive impacts on bottom dwelling communities and some fishes. However, time since their completion is short so there is as yet no good insight into medium and long-term effects. More parks are planned in the order of 6000 MW, amounting to a potential surface area in the order of 1000 km2 (Anonymous, 2009). Although this is a substantial area, it is still relatively small, in the order of 10%, of the total surface area of the Natura 2000 areas.

Off shore wind farms introduce rocky substrates in a sandy substrate environment. The foundations are populated by shrimps that form the food source for fish. A Belgian study showed that over 29.000 individuals of pouting, representing 3,5 tons wet weight were present around just one foundation (monitoringrapport 2010: www.mumm.ac.be/downloads/mumm_report_mon_win2010.pdf, see also Degraer S, R.Brabant and B.Rumes (eds.) (2010).
The effects of offshore wind parks can not be compared with zones were fishing is banned, because of the presence of rocky substrates.

Sand mining and sand nourishment (see figure 3.2)
Roughly half of the sand mined is used in coastal protection and management. Assuming that most nourishment takes places in the form of foreshore nourishment, the related area of physical disturbance is in the order of several km2 yearly, a small area when considering the whole coastal zone of the Dutch North Sea of which the protected part under Natura 2000 amounts already to 1240 km2 (Baptist & Leopold 2009).

With on average 25 million m3 mined annually and an extraction depth up to 2 meters, sand mining leads to the physical disturbance of at least 12 km2 of sea bottom each year. This is a relatively small area, but recovery takes several years. So in the order of 30-50 km2 will be physically disturbed at any time and for that period the area is less suitable as a feeding area. Full regeneration takes even more time.
The upper limit in sand mining in future may be in the order of 5 times as large. But assuming that the average extraction depth will be increased to 10 or even 20 meters, the surface area disturbed annually will not increase, but is even expected to diminish in the first decades. Regeneration will take substantially longer, but deep-dredging might be used to create “new nature”.
The coastal zone up to the -20 meter depth contour is exempted from sand mining. This is a substantial area, even substantially larger than the surface area of the Natura 2000 areas in the North Sea coastal zone.

Sand mining is not allowed within the minus 20 meter depth contour, within 500 meters of cables, pipelines, offshore installations and windmill parks. RON2 (Regionaal Ontgrondingenplan Noordzee; 2004) states that the minus 20 meter depth contour is restricted for reasons of safety (coastal foundation) and ecology. So some of the transport costs may be attributed as environmental costs. It should be noted that sand mining is restricted in Belgium within the -10 meter depth contour line. Sand mining is not allowed were living shell fish beds are present and in areas that are very rich in silt.

ECORYS (2007) estimated a 5% increase in environmental costs as a minimum and up to 50% additional costs if sand mining would be fully restricted to specific zones and would need to limit the loss of silt during dredging operations (may account for 15 to 30% additional costs).

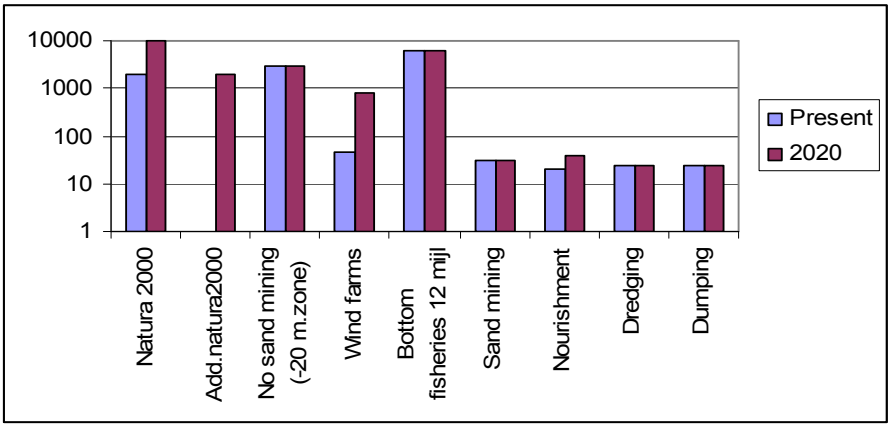

Figure 3.3 The surface area of zones with restrictions (Natura2000, No sand mining, Wind farms) and with physical disturbance (beam trawling, sand mining, nourishment, dredging and dumping). Note that the vertical axis is logarithmic and that the total surface area of the North Sea is in the order of 50.000 km2.

Cables and pipelines and archeological artifacts

There are more than 3700 kilometer of pipelines and 4000 kilometer of cables on the Dutch part of the North sea. Sand mining close to these lines is prohibited (at least 500 meter, or even 1000 meters). So theoretically this zone amounts to a restricted areas in the order of 3850 to 7700 km2. However, a part of the pipelines is situated in the coastal area within the -20 meter depth contour that is already exempted from sand mining. Another part is situated too far from the coast to be of interest to sand mining.

An owner of the cable or pipeline can restrict other uses within a 500 meter zone as well. It is not clear whether this is applied to fisheries. Sand mining is also prohibited within 500 meter of archeological artifacts. Some of these artifacts are situated outside of the minus 20 meter depth contour line.

Dredging and dumping

The major harbor approach shipping line is the Eurogeul that gives access to the harbour of Rotterdam. It extents up to 57 km in sea with an average width of 600 meters, so the total surface area is the order of 34 km2. The larger part of this shipping channel is dredged annually. So the physical and biological disturbed area is in the order of 34 km2. The deposition of the dredged material takes place on a similar area, also in the order of 30-35km2. Several smaller harbour approaches are also maintained, such as the IJ Geul (IJmuiden approach) the Schulpengat (Den Helder) with possible effects on the North Sea. Dredged material has been deposited for many years in designated dumping areas (such as Loswal Noord). At present dumping areas are under discussion as are new rules and guidelines. Dredged material rich in sand will preferably be distributed close to the coast so it has a function in coastal management. It is however not certain if it may limit the volumes for nourishment.

Shipping lanes (see figure 3.4)

Also the shipping lanes are exempted from sand mining. Fishing is permitted but not favored.

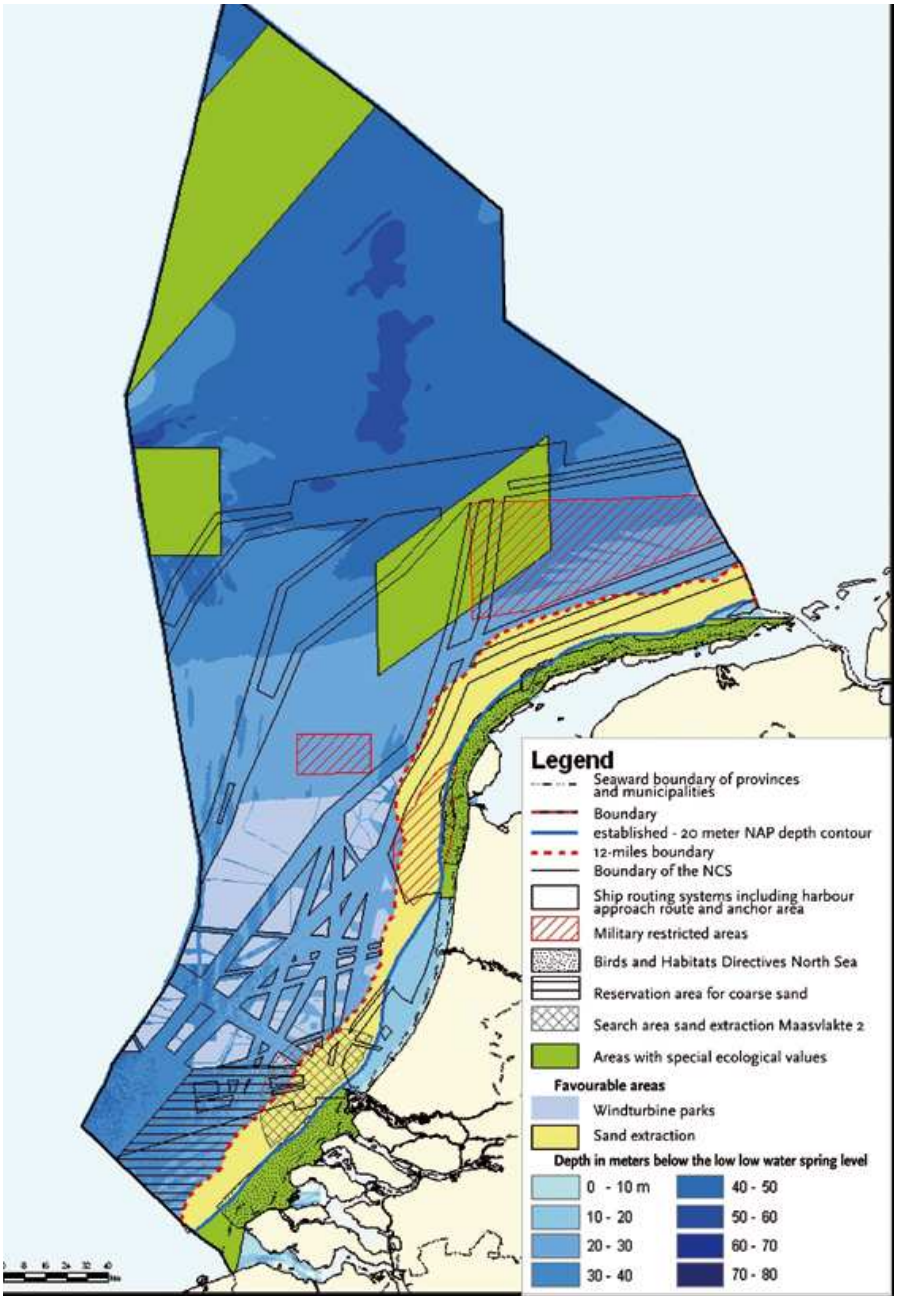

Figure 3.4 Map showing major zones and activities on the Dutch North Sea (www.noordzeeloket.nl). Dark green are the areas with ecological values. Also the minus 20 meter depth contour is indicated and outside this zone in yellow the sand mining areas.

Military zones.
A total of 7% of the Dutch North Sea (4.200 km2) is designated as a military zone. Within this zone there are temporary restrictions with respect to fisheries, especially when there is a risk of explosives. Sand mining is banned from military dump sites. Most military areas are situated far from the coastline with the exception of areas west of Den Helder. An area North of Den Helder partly overlaps with an ecologically important area.

3.3.3 Ecological and economic effects of different zoning options

3.3.3.1 Ecological effects of fisheries

Several forms of zoning already exist in the North Sea, such as offshore wind farms and oil and gas installation (closed for all other activities); the Plaice Box (closed for large beam trawlers); the Voordelta Sea Reserve (closed to beam trawling, recreation regulated) and shipping lanes (shipping regulated; exclusion zones for wind farms and oil and gas installations). With the designation of Natura 2000 sites, zoning becomes an even more important instrument in regulating pressures. Both offshore (Dogger Bank, Cleaver Bank, Frisian Front) and near shore (North Sea Coastal Zone and Voordelta) Natura 2000 sited have been designated. Pressures vary between sites

- In the offshore areas, the main fishery pressure stems from large beam trawlers while in near shore areas several fisheries interact with benthic life small beam trawlers (Euro cutters), shrimpers and shell fisheries.
- Near shore sites are subject to more land based pollution and eutrofication than offshore sites
- Nearshore sites are subject to more disturbance from recreation such as swimming, boating, sailing, kite- and windsurfing and jet-skiing,

Ecological effects observed in areas that are already zoned
The Sea Reserve (situated in the Voordelta) and also the offshore wind farms are monitored. There are marked differences between the two areas. The Sea Reserve is a near shore area that is only closed for beam trawlers. Disturbance from other forms of fishing and recreation continue. The offshore wind farms are situated in deeper water and completely closed to fisheries and recreation, but the turbines and the regular maintenance pose new sources of disturbance. In all areas however, benthic life is supposed to develop undisturbed and biomass and biodiversity are supposed to increase over time.

The Plaice Box comprises coastal waters off the Wadden Sea and is closed to trawlers > 300HP. As a consequence more smaller trawlers were built and the expected reduction in physical and biological disturbance is less than wished for. Plaice, the target species of this zoning measure did not increase in numbers in the area, probably due to a range shift unrelated to the fishing pressure (van Keeken et al. 2007).

Ecological effects related to different kinds of fisheries
A distinction is needed between various types of fisheries since there have different effects on the integrity of the sea bottom, food webs and fishing populations. These also influence the presence of birds, through discards, shellfish extraction and disturbance. Trawling has important effects of the North Sea ecosystem because trawlers remove a large proportion of the biomass of target and by-catch species and because trawl gears have direct impacts on the substratum and associated biota. Trawls cause disturbance to the substratum because they are in direct contact with the seabed. The magnitude of the impact is determined by the speed of towing, physical dimensions and weight of the gear, type of substratum and strength of currents or tides in the area fished. The effects may persist for a few hours in shallow areas with strong tides or for months in deeper areas subject to less natural disturbance from waves and tides.

- *Beam trawling* is done by using heavy equipment that leads to profound disturbance of the sea bottom. Studies indicate that many benthic organisms are killed, such as shellfish and crabs, with the passing of a beam trawler (Bergman & Hup 1992; de Groot & Lindeboom 1995; Bergman & van Santbrink 2000; Lengkeek & Bouma 2010) Long-lived, slow-growing species (such as large bivalves like *Arctica islandica*; Witbaard 1997 or gastropods like whelks*;* Mensink et al. 2000) are most negatively affected by beam trawling activities. Ecosystem changes occur as a result of beam trawling activities through alteration of production levels, food chains or population structures. Beam trawling activities lead to loss of benthic biodiversity (Philippart 1998), but also to temporarily increase of the food availability for scavengers, ranging from invertebrates, to fish, to birds (Camphuyen et al. 1993; Groenewold & Fonds 2000). In many areas recovery times take longer than between-trawling intervals. Beam trawling activities cause direct mortality of certain species (fishing mortalities are often in the order of 50% for target species; Bergman & van Santbrink 2000). Impacts of beam trawling on benthic communities differ between habitats. In sandy areas impacts are lower than in muddy areas or areas with coarse gravel (Kaiser et al. 2000). Beam trawling activities can cause an increase in the abundance of smaller sized fish and can increase the growth rate of some fish species (e.g. plaice) as a result of higher food abundance, a shift from a shellfish-dominated to a worms-dominated benthic food base, removed competition and/ or less predation by large fish. On the other hand, a large by catch percentage of the juvenile fish substantially increases juvenile mortality. Also the related underwater noise is substantial.
- *Shrimp trawling* uses lighter equipment and has smaller (but yet un-quantified) effects on the sea bottom. The physical disturbance is supposedly relatively small, a reason why it was not banned from the Sea (Bottom) Reserve that was created as a compensation measure for the Maasvlakte 2. Fishing is rather frequent so shrimp fishing generates substantial underwater noise and visual disturbance. Although shrimp fishery is known to have relatively large amounts of discards periodically, the data for the Dutch fleet are as yet insufficient to be able to quantify the discards. Management measures are taken to reduce discards and to increase survival of discarded non-target animals, particularly juvenile flatfish.*Otter trawl* uses large nets that are mostly freely floating; only the ground-rope glides over the seabed. The physical disturbance of the sea bottom is thus much smaller than in beam trawling (Philippart 1998). Also, fishing efficiency is lower, but otter trawls still do influence food webs and fish populations. The latter effect is regulated and management by a quota system. Discards do influence food webs/sea birds, notably gull species.
- *Fixed gears* use amongst others large standing nets. The have an impact on fish populations and form a risk to sea mammals (Camphuysen & Haelters 2009). Because of the limited ship movement, there impact on underwater noise is moderateAlso, sediment disturbance and bycatch of benthic invertebrates is negligible.
- *Mollusc dredge*. This is a group of specialized forms of fisheries that also uses trawls and specialised suction pipes and pumps that impact the sea bottom. A distinction can be made in:
- Cockle fisheries: also this fisheries was banned from the Wadden Sea, mainly because cockles form an important staple food to protected birds (Eider, Oystercatcher) and because this fishery was highly detrimental to sea bottom integrity (Piersma et al. 2001; Ens et al. 2004); . Recently small scale cockle fishery in the Voordelta zone is started again.
- Spisula fisheries: the presence of Spisula beds varies greatly between years. Spisula forms an important source of food to seaducks. The effects on seabed integrity are substantial but less severe than in cockle fisheries, as Spisula is only fished in highly dynamic sandy substrates

- Ensis fisheries: this is a comparatively new and still rather small fishery, with only 5 active boats. There is some potential for further growth. The smaller Ensis form a food source to seabirds. The effects on benthos and birds are small as only small surface areas are fished and because only sizes of Ensis are targeted that are too large for the birds to feed on (Leopold et al. 2008). Underwater noise is small as are the effects on marine mammals.
- Mussel seed fisheries: traditionally mussel seeds would be fished in areas where mussels are newly developing. Mussel seed fishery is to be banned from the Wadden Seaand be replace by new techniques such as mussel harvest installations. Fishing for seed mussels still is an important activity in the Voordelta.

Zoning is especially suitable in order to safeguard the integrity of the sea bottom, including shell fish beds. Under water noise, effects by discards as well as risks to sea mammals are best handled with an improvement in fishing techniques.

Tabel 3.1. Indication of the effects of various forms of fisheries

Fishery type	Effects							
	Sea bottom integrity	Fish populations	Food Webs	Under water noise	Biodiversity			
					Benthos	Fish	Birds	Mammals
Fisheries								
Beam trawling	Large	Large	Large	Large	Large	Large	Large	Small
Shrimp trawling	Medium	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderatel
Local fisheries	Small	Small	Small	Moderate	Small	Small	Small	Small
Fixed gears	None	Moderate	Moderate	Small	Small	Small	Small	unknown (risk)
Mollusc dredge								
Cockle	Large	Small	Large	Moderate	Large	Small	Large	Small
Spisula	Medium	Small	Moderate	Moderate	Large	Small	Large	Small
Ensis	Small	Small	Small	Moderate	Small	Small	Small	Small
Mussel seed	Large	Small	Large	Moderate	Large	Small	Moderate	Small

3.3.3.2 Ecological effects related to recreation and tourism

The coastal zones in the Netherlands are intensively used for recreation and tourism. Most tourists do not venture further than the dunes and beaches and do not disturb the offshore marine environment. However there is a number of activities that do cause disturbances, through underwater noise. The high recreation pressure at the beach has a huge impact on the number of coastal breeding birds and use of the beach by seals. Especially sand banks with a function for breeding and molting seals are very vulnerable to human visits. Also simply by trampling, mass tourism has an impact on coastal vegetation and dunes.

ECORYS (2006) studied the economic effects of the Sea Reserve also to recreation and tourism. In this study a distinction is made between:

- *Sea kayaking*; this is a small activity that may lead to disturbance. In the Sea Reserve it is still possible to kayak, but it needs to be well managed. No relevant economic effects are related to this economic activity.
- *Sport fishing*: a distinction can be made between 3 types of fisheries:
    - From the shore: an important activity but with little impact on the marine environment. Still especially angling leads to discarded lines, sinkers and hooks that pose risks of entanglements, ingestion, suffering and death of some seabirds and mammals This activity is not restricted in the Sea Reserve. So there are no economic effects expected related to this activity. Non-commercial gill-net fishery, set from the beach, is rapidly increasing and may impact local fish populations as well as marine mammals (by-catch harbour porpoise).
    - From small boats: these are usually privately owned. These boats go far into the area and come close to vulnerable areas only to pass through shipping channels. These small boats do not generate relevant forms of disturbance within the Sea Reserve once out in the open. Seals may suffer from high disturbance rates from boating (Brasseur & Reijnders 1996). Restrictions will have no impact on these activities.
    - From charters: these are larger boats that take tourists on board for fishing trips or seal watching. Also these boats usually fish outside the area of the Sea Reserve. Restrictions will have no impact on these activities.
- *Diving:* to divers the coastal zone of Zeeland is an important destination. Most dive in the large enclosed waters, mostly (former) estuaries. There is only limited diving in the North Sea itself, mostly associated with ship wrecks. Restrictions on diving will impact at the most only 1% of diving trips, representing an economic effect in the order of 0,135 million/Euro/year.
- *Visits to sand bars*: during low tide sand bars are visited by those who fish or kayak or windsurf in the area. Restrictions on this kind of visit align with the restrictions on the activities sport fishing, windsurfing, kite-surfing and kayaking. So no additional economic effects can be attributed to restrictions on these visits.
- *Windsurfing*: windsurfing has seen a large drop, since many windsurfers switched to other kind of sports such as kite-surfing. In Zeeland most surf on the large inland waters, but there are several important surfing spots in the area of the Sea Reserve. Areas up to 4,5 km from major wind-surfing spots are not restricted. The expected economic effects relate to only 15% of the present activity.
- *Kite-surfing:* this group surfs closer to the beach and uses mainly the same spots as the windsurfers. No effect on the number of users is expected, since the open zones around the major spots are large enough.
- *Wave-surfing:* in the Sea Reserve there will be restrictions related to the Bollen van de Ooster, which is a destination for wave-surfers. However the number of participants if small and there are alternatives. No relevant economic effects are expected.
- *Sailing and motor boating*: this is a very important activity in the area with over 12.000 berths in more than 80 harbors. There are strong seasonal trends in the intensity of boating and sailing that have to be taken into account. There are restrictions in order to limit the disturbance related to boating and sailing close to the most vulnerable areas within the Sea Reserve. Since most boats do have berths in the area it is expected that the local restrictions will mainly lead to a reallocation of favorite routes.

For management and compliance monitoring at least three ships with two crew-members, year round is preferred. Total cost 500-1000 k€ is needed.

3.3.3.3 *Economic effects of zoning to recreation and tourism*

Overall the economic effects of the Sea Reserve have been estimated to be 2 to 6 million Euro (Gross Added Value) annually (ECORYS, 2006). These are losses to the area itself. It is possible that some reallocation of activities along the Dutch coast may occur, so on a national scale the effects are smaller. However if similar restrictions as in the Sea Reserve would be part of all Natura 2000 sites, only limited substitution will be possible.

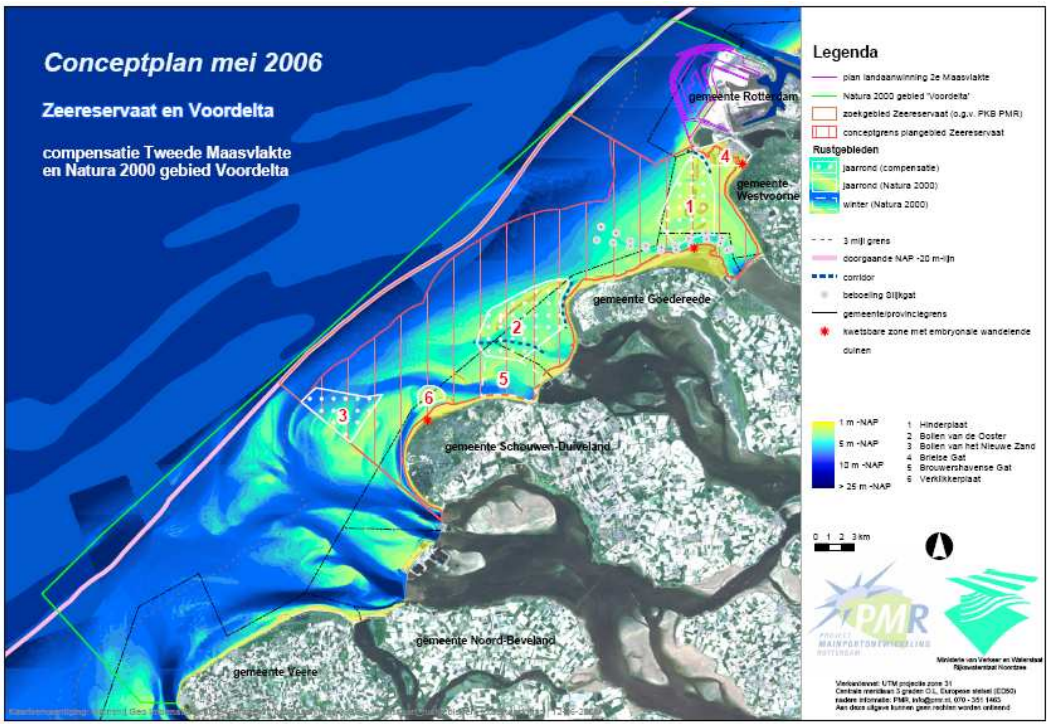

Figure 3.4 The location of the Sea Reserve (crossed lines). The figure 1 to 6 indicate areas with restriction to recreation.

The Sea Reserve is not representative for the coastal areas in the Netherlands. The number of tourists is large compared to the recreational use from people living in the areas. There are relatively more vulnerable locations present where more restrictions are needed because of the presence of birds and seals. There is much more boating and sailing because of the large number of berths in the neighborhood.

The negative economic effects of zoning on recreation and tourism are in the order of 1 to 2 million/annually/1000 m2 for the Sea Reserve. It is probably not more than 0.25 to 0.5 million Euro's/1000 mk2 for other coastal areas in terms of Gross Added Value.

3.3.3.4 *Economic effects of zoning to fishing*

The economic effects on fisheries of designating the Sea Reserve for Maasvlakte 2 has been studied in depth in order to underpin the discussion for financial compensation. The Sea Reserve is situated in the Voordelta. The Voordelta is part of the coastal zone, and may to some extent be considered as a reference for shallow coastal areas also further north along the coast. There are however differences in fishing activities and especially in the intensity of these activities. However, the intensity of various forms of

fisheries varies often greatly between years as well. So, only a global assessment is possible, especially on the long-term.

The effects of closure depend on various factors. Closure may cause additional shipping costs because boats that have their harbors close-by will need to travel more to reach alternative fishing sites. This will lead to additional transport costs and also there will be less time left to actually fish, so fishing days become less efficient. It is also possible that the alternative fishing areas are less productive, but this is less certain.

With respect to coastal fisheries a distinction needs to be made between the following kinds of fisheries:

Table 3.3: Estimated costs to the fishery sector of the potential area for designation of the Sea reserve.

	Areal dependency (no.boats)		**Displacement costs and lower efficiency (* 1000 Euro/annually)**	**Tie up of the fleer (*1000 Euro/annually)**	
Primary effect to fisheries					
	<10%	>50%		Reduction Gross earnings	Lower Gross Added Value
Beam trawl	50	3	217	1346	652
Shrimp trawl	141	17	179	1060	542
Local fishery	2	26	34	186	72
Otter trawl	42	35	54	317	135
Fixed gear	57	28	24	123	62
Molluscs dredge	23	2	0	921	658
Total	315	71	485	3963	2121
Secondary effects to industry					
Total			0		2741

Direct costs to fisheries
The table shows that there are large differences between additional costs related to displacement and lower efficiency of shipping days and the tie up of the fleet. The search area is a slightly larger than the proposed boundaries of the sea reserve, and follow more closely the proposed boundaries of the Natura 2000 area.

A very rough estimate of the costs of completely closing the sea reserve of 2,500 km2 would therefore be in the order of 2 million Euro to fisheries. It was however proposed that only banning of beam trawls would be sufficient in order to limit physical disturbance. The displacement costs of this type of fisheries amount to only 0,2 million Euro a year, or only 10% of the overall total. In the years considered the costs of trawling increased, also due to a rise in fuel costs. Value added dropped as a consequence, since costs rose from 50% to 60% of the gross earnings. The displacements costs may be too high to individual fishermen that strongly depend on this area. The designation of the sea reserve therefore included the financial compensation of the displacement costs.

Indirect costs to the industry
The estimated effects to the industry are expected to be very small in the case only displacement costs are taken into account, since no relevant reduction in landed volumes of fish is expected. An equivalent tie up of the fleet would however result in costs larger than the direct costs to the fishery it self.

Indirect effect related costs
We do not know what the effects of stopping beam trawl fisheries are on the other types of fisheries, since the frequent physical disturbance of the sea bottom has profound effects on the food web as well. The possible effects may be increased production of some, but also a decrease may be possible. This has not been considered in the study.

It should be noted that displacement costs vary widely depending upon the location that would be banned from fisheries. The proposed Natura 2000 areas comprise the whole coastal zone of the Netherlands roughly up to several kilometers from the coast. Fishing outside this zone would still be possible and the map of the ongoing fisheries shows that with the exception of shrimp trawls, the coastal zone is only a small part of the total area that is fished.

3.3.3.5 Relevant options for zoning and related restrictions

The following types of zoning can be considered with respect to fisheries:

- **Total ban of all activities**, such as found in relation to offshore wind farms. This will enhance benthos and related food webs. The foundations increase local biomass production, but lead also to a small shift in food webs. There are probably no reasons to specify requirements to prevent settlement of these foundations by organisms. The costs depend on the location but amount in the order of 2 million Euro/year per 1000 km2 for the coastal zone if a tie up of ships would be considered and if also the indirect costs are considered. This may probably only be needed for shrimp trawling since the coastal zone constitutes a very large part of their fishing area. Assuming only a tie up for shrimp trawlers the costs would amount in the order of 0.7 million Euro per year/1000 km2. It is not expected to be a measure for the Natura 2000 areas in open sea.
- **Ban on beam trawlers**, such as in the present sea reserve. Also this enhances the development and richness of the benthos communities. If applied only locally, displacement costs would be in the order of 0.1 million Euro/year/1000km2. In the case larger areas are banned additional costs may have to be considered.
- **Ban on beam trawlers and shell fisheries**, such as present in most of the Wadden Sea. This may be an option to increase the food source for specific bird species. Costs are in the order of 0,2 million Euro/year/1000 km2.
- **Ban on the use of fixed gear,** for example in areas with high concentrations of sea mammals. This ban of fixed gear need only to be considered in the case not sufficient mitigation of the risks to sea mammals would be possible. The costs involved are in the order of 0.01 million Euro/year/1000 km2.
- **Temporary ban on bottom fisheries,** such as allowing fishing only every 4 to 6 years allowing sufficient time in between for restoration. It may be assumed that every time fishing is allowed that the harvest will be bountiful. Temporary bans will perhaps not lead to a reduction in volume if only a small proportion of the North Sea is zoned in this way. If the whole of the North Sea would be temporarily closed there will also be an effect on volumes and to additional displacement costs. We assume that the costs will be 50% of a complete ban, so in the order of 0.1 million Euro/1000km2/year assuming that there is no reduction in the volume of the fish landed. If a tie up of the fleet would be necessary, 50% of the Gross Added Value might need to be considered as an economic effect, which would be in the order of 0.4 million Euro/1000 km2, including indirect effects.

Tabel 3.4. Overview of zoning options and related costs and effects.

Zoning restrictions	Effects	D 1	D 3	D 4	D 6	D 11	Costs Million Euro /1000km2/year
Coastal zones							
Total ban of all fisheries with restrictions to recreation	Effects: full regeneration of benthos, some spinoff to biodiversity and food webs: Additional less disturbance of birds and sea mammals	4	3	3	4	4	0,7+0,5=1,2 and 0,5 for administration= 1,7
Ban on beam trawlers with restrictions to recreation	Effects: full regeneration of benthos and related fish population, food webs and biodiversity. Additional less disturbance of birds and sea mammals	4	3	2	4	2	0,1+0,5=0,6 and 0,5 for administration = 1,1
Temporary ban on beam trawlers with restrictions to recreation	Effects: nearly complete regeneration of benthos and related fish population, food webs and biodiversity	4	3	2	4	2	0,1+0,5=0,6 and 0,5 for administration 1,1
Ban on beam trawlers and shell fisheries with restriction to recreation	Effects: nearly complete regeneration of benthos and related fish population, food webs and biodiversity	4	3	2	4	2	0,2+0,5=0,7 and 0,5 for administration 1,2
Ban on the use of fixed gear with restrictions to recreation	Effects: improved biodiversity	3	1	1	1	1	0,01+0,5 and 0,5 for administration = 1,01
Open Sea							
Ban on beam trawlers	Effects: full regeneration of benthos and related fish population, food webs and biodiversity	3	3	2	4	2	0,1 - 1,3
Temporary ban on beam trawlers	Effects: nearly complete regeneration of benthos and related fish population, food webs and biodiversity	3	3	2	4	2	0,05 - 0,4
Ban on beam trawlers and shell fisheries	Effects: nearly complete regeneration of benthos and related fish population, food webs and biodiversity	3	3	2	4	2	0,2 - 2
Ban on the use of fixed gear	Effects: improved biodiversity	2	1	1	1	1	0,01-0,03

Effects of scaling up

Scaling up and costs

The restrictions in the coastal zone will mainly lead to displacement costs but additional costs are related to restriction to recreation. Restriction on open sea may also lead to volume reductions and tie up of the fleet. This is perhaps not yet to be expected within the Natura 2000 sites, but if substantial parts of the North Sea would be closed the economic effects will increase.

Scaling up and effects

The indicated effects relate to effects on site within the zones themselves. Especially benthic organisms and related food webs and fish populations will improve and biodiversity will improve. Zoning will not greatly affect the pelagic fish populations. Depending upon their size sea mammals and birds may also benefit substantially from zones. This is also the reason why zoning with restrictions on recreational use leading to fewer disturbances have been scored higher than zoning without these restrictions.

Other forms of restrictions within zones
It should be noted that many restrictions focus on reducing the effects of beam trawlers. There are however also possibilities to reduce the effect by using electric pulse fishing. In this case already a substantial mitigation of effects may be possible, without substantial costs to the sector. It may be possible to use restrictions within a zone as an economic incentive to applying technical measures that reduce pressures. Examples are:

- Allowing only specific fishing techniques in designated areas: Examples could be the use of electric pulse fishing for example if the effects are small, one may consider that electric pulse fishing is allowed were traditional forms of beam trawlers are banned.
- Allowing only more silent ships in designated areas: ships that are better isolated and produce less underwater noise may be allowed into specific areas that remain closed to ships that produce more sound. Also the use of sonar may be restricted in this way.

3.4 Marine litter

3.4.1 General

Ecological and economic effects of marine litter
(see also www.parliament.uk/briefingpapers/commons/, and www.oceancommission.gov and MARPOL – documents.

Marine litter is a persisting problem. Most plastic bottles may last for more than 450 years. Plastic and polystyrene make up 75% of the marine litter. Marine litter is a problem at present but it will increase with time. Only a nearly complete reduction of the major sources may bring the rising tide of plastics to a halt. Immediate action is important since marine litter is a major environmental problem.

One of the most important sources for marine litter is beach tourism (in the order of 35%) followed by fisheries (in the order of 14%) while marine shipping but also land-based sources, such as open land fills, debris that is flushed out with storm sewers, plastics originating from agricultural use account for the rest.

Different sources account for different forms of marine litter. Beach tourism accounts for many plastic bags and plastic bottles. Fishing leads to abandoned and lost fishing gear, which poses serious risks to sea mammals, birds, fish and lobsters.

All sources together amount to a production of 20.000 tons that is deposited annually into the North Sea environment. Of this 15% washes up on beaches, 70% sinks and 15% floats. This means that even vigorous beach cleaning will never help to clean the sea completely.
Over the past years the presence of litter as could be detected in the stomachs of birds has remained more or less constant. But there are large variations over the years. Floating debris tends to accumulate in distinct areas. Recently also a large garbage patch was described in the North Atlantic.

Especially nets, ropes and plastic bags may lead to the entanglement of animals and leading to their death. It is very difficult to estimate the numbers of dead animals that can be attributed to the entanglement in marine litter. A reported study showed that about 12% of all gannet corpses on Dutch and German beaches were entangled in plastic (Camphuysen 1994). Plastic presence in the marine environment is monitored by a yearly examination of seabird stomachs, around the North Sea (Ryan et al. 2009; van Franeker et al. 2009).

Plastics degrade into small particles that are ingested by marine animals. Reports show that the number of microscopic small plastic particles may be over 10.000/liter of sand on some UK beaches (Marine Pollution Monitoring Management Group, 2002). Situations may be similar for Dutch beaches. It is not known to what extent these microscopic particles influence individuals, populations and food webs.

Marine litter has also economic effects because of the loss of commercially important wildlife, a decrease in biomass production, damages to boats from propeller fouling, contamination of beaches that need cleaning, injuries to swimmers and divers, the need for rescue operations because of malfunctioning boats, blocking and damage to water intake and damage to tourism. Especially costs to fisheries are substantial and reported to be in the order of 0.5 tot 2.5 million Euro annual for the fishing fleet of the Shetlands (www.kimointernational.org/MarineLitter.aspx). Other sources estimate the costs to be over 10.000 Euro annually for each fishing vessel.

3.4.2 Remedial measures

Regarding possible measures a distinction can be made between prevention at the source and remedial actions. Much action has already been taken. Some additional specific measures that are of a remedial nature are:

- "Fishing for litter" (see www.fishingforlitter.org). This is a measure taken in Scotland and recently also in south west England. The measure in Scotland has been successful for over 3 years now, accounting for 120 ton of litter, so about 40 tons per year. Assuming that 15% of the 20.000 tons discharged floats, 40 tons accounts for 1,3% percent of the total. If the measure is extended to more fishermen its contribution will surely increase. First steps to introduce this system also in the Netherlands were made in 2008 and 2009. In the Netherlands "fishing for litter" was introduced nearly 10 years ago.
- Plastic on Deposit. Often plastic bottles are already on a deposit which encourages recycling. This measure can be extended for example to plastic containers used in the fishing industry but also to plastic bags. The latter was successfully introduced in Ireland, but it is also common practice in for example California. One should note that there are many kinds of plastic bottles still outside of a deposit system. One could start introducing a deposit on all plastic bottles, or to include deposits in specific areas, such as for example supermarkets close to beaches. If high enough it will work also as an incentive to collect plastic bottles.
- Deposit and name tagging on fishing nets: this will help to reduce the number of abandoned nets and generate also money for their retrieval.
- Collecting lost fishing gear. The loss of fishing gear is one of the most important reasons for the large contribution of fisheries to marine litter. Norway recovers up to 500 nets per year, which is still far less than the number that is annually lost. There is an EU-funded project DeepClean that looks into this as well. There is discussion on the use of deposits also for fishing gear and tagging nets with the name of the owner.
- Improving waste disposal at harbors. Facilities are existing (HOI=haven ontvangst installaties) but could be improved further. Also a further refinement of the EU Directive on Port Reception Facilities (EU Directive 2000/59/EC) would be needed. This could be combined with an upfront charge for waste disposal in harbors. The idea is to charge ships for taking care of their waste regardless of the fact if they do bring waste in.
- Imposing a ban on waste disposal in the whole of the North Sea, similar to the ban on the Mediterranean. Domestic waste produced by the crew and waste containing oil, mainly the rest product of burning heavy fuels (e.g. sludge) have to be deposited at the harbour. Sanitary waste can at present be dumped outside the 12 mile zone.

3.4.3 Prevention at the source

The following measures are directed at the source:

- Reduction in the use of plastic non-degradable packaging materials using non degradable plastic and stimulating the use of biodegradable packing materials. The latter are in fact already available but need further stimulation or even licensing. There are different kinds of biodegradable plastics which can be based on renewable organic sources or synthetic with a petroleum base. Also over-packaging should be discouraged.
- Stimulating bio-degradables, also for fishing gear. An estimated 640.000 tons of fishing equipment is lost every year, making up 10% of the total. New developments in the packaging industry have already led to the development of biodegradable nets on the bases of the Double-Twist Technology and the development of biodegradable fishing gear is under way. Systems already exist that are partly biodegradable.
- Improving water treatment storage capacity and of combined sewer overflows in order to reduce the discharge of untreated sewage and related litter. Increasing the hydraulic capacity of waste water treatment plants and sewers is very expensive, but it will have additional benefits also to inland waters.
- Appropriately label all bathroom and sanitary products, with plastic as non flushable.
- Tighten packing, transport and shipping procedures to reduce the loss of plastic pellets to the marine environment.

3.5 Underwater noise

3.5.1 General type of underwater noise

Underwater noise is an important pressure with various sources, character and possible mitigating measures. A distinction can be made between:

- Sonar used by the military. This has an enormous range and may produce up to 140dB at distances up to 300 miles from it source. Low Frequency Active Sonar (LFAS) is a military sonar technology designed to detect and track quiet submarines. This type of sonar is the most damaging to marine mammals but mainly applied in deeper waters, outside the North Sea. Passive sonar is less intense and has far less impact.
- Sonar used by ships, in order to monitor depth under the hull. Has limited direct impact on fishes but may disorientate; forms a constant source of noise to marine mammals.
- Echoloding; used by fishing vessels to locate schools of fish. Has limited impact on fishes.
- Ping installations, used by fishermen in order to deter marine mammals away from their nets. The measure is meant to reduce the risk of entanglement, but may also deter animals from preferred feeding areas.
- Shipping noises produced by engine, hull and propeller. The higher tones deter fish. Adds to the general level of noise that may impact especially animals that detect their prey with natural sonar.
- Explosions used in exploration for oil and gas (seismic surveys). These noises are severe and have a wide range as well.
- Explosions used in military maneuvers and testing. Locally important.
- Construction noises especially of pile drivers, such are used to set the foundations for off shore wind mills. Extremely high sound levels, considered to be lethal for marine mammals at close range and audible over many tens of kilometers.

3.5.2 Measures differ depending on the source of sound

Possible measures include:

- Sonar used by military; often these can only be zoned away from vulnerable areas, training can be limited to less vulnerable zones and be confined to areas with less sensitive animals . There are only limited technical alternatives, such as passive sonar and satellite detection. A watch can be kept for the presence of animals in the vicinity during employment and the equipment can be temporarily switched off (van der Ent 2005).
- Sonar used by ships. A possible measure is the re-allocation of shipping lanes to less sensitive areas but given the intensive shipping in the North Sea and the lack of knowledge of marine mammal hotspots along major shipping lines, this does not seem very feasible.
- Echo-loding. Is less important, but training may help to reduce the intensity of use.
- Ping installations. Proper evaluation of all pro's and cons is still lacking.
- Shipping noises. Engine rooms can be isolated, hulls can be adjusted and new propellers can be installed that reduce shipping noises. Especially the use of new noise-poor propellers is promising, since it often leads to a reduction in fuel consumption so there is a net economic benefit from refitting.
- Exploration for gas and oil depends on seismic research. It is difficult to find alternatives. Pinging may help to deter animals before major explosives are detonated.
- Explosions of the military can be confined to limited testing areas. For training purposes also alternative munitions may be used with less explosive force.
- Construction noises can be reduced by a number of techniques (source:http://www.knikarmbridge.com/Tech_Reports/NewReports/Constructability%20Discussion%20for%20Sound%20Attenuation%20Techniques.pdf). The use of ping installations to scare away marine mammals is already common practice. Air bubble screens can be used to soften the blow as can hydraulic dampers. There are alternative foundation techniques available but they are far more costly. Possible alternatives include heavy foundations that do not require a set of piles and jetting in piles instead of pile driving techniques applicable to most of the North Sea bottom.

OSPAR is working with other international organizations (e.g. the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas, ASCOBANS) to investigate the problems and identify future actions to address underwater noise. Guidelines and regulatory controls are already used in several OSPAR countries, such as noise reduction measures during pile driving (UK), a ban on pile driving during key reproductive periods for particular species (Netherlands) or the mandatory use of thresholds to limit man-made emissions with certain acoustic characteristics (Germany) (source: http://qsr2010.ospar.org/en/ch09_11.html).

4 PRESSURES AND MEASURES

4.1 General

In chapter 2 the selection procedure was described. All selected measures have been described according to a standard format (see annex). The preferred measures are discussed for various major pressures.

4.1.1 Groups of pressures and measures

It is possible to distinguish several groups of strongly related pressures:

- *General water quality*: the water quality of the North Sea depends on a number of sources. Most of them are land based (rivers/urban and industrial emissions), harbours/industrial and other activities (sea shores/tourism) and some are sea-based (shipping, fishing, oil and gas exploration). A distinction can be made between sources and related water quality issues because of nutrients, silt and priority pollutants. Sand mining, dredging and dumping are the main sources for (man-made) silt plumes. Nearly all nutrients (from human sources) are related to land-based sources. Also most priority substances are land-based but some come from sea-based activities.
- *General disturbance:* this includes noise and other forms of disturbance due to shipping (constantly and wide-spread), dredging and construction (temporarily and localized) as well as coastal tourism (temporarily and localized). Shipping has a far wider area of impact than the other activities. But the loudest are construction and military activities.
- *General disturbance of fish populations and food webs.* The major factor here is fisheries (frequent and widespread). The importance of sport fishing is not relevant.
- *Physical and biological disturbance of the bottom.* The major factor is fisheries by beam trawlers (frequent and widespread) followed by sand mining, dredging and dumping and shell-mining.
- *Physical alteration of the bottom.* This is mainly due to sand-mining, dredging and dumping (localized and permanent) and to a limited extent by shell-mining, which temporarily limits the availability of shells also as substrate to shell-fish.

4.1.2 Perspective of potential measures

General

Table 4.1 shows the intermediate results. For all measures costs and effects have been scored in classes, resulting in a first indication of the cost-effectiveness of the measures and an indication of its disproportionality. This table is based on annex 2 and 3.

It should be noted that at present no Good Ecological Status has been formulated for any of the descriptors and related pressures. All indicators are still very much debated, since it is obvious that zero pressure can never be attained. The method used to determine the cost-effectivity of measures needs further validation with respect to the scores applied and the way scores and effects are defined. A change in method may lead to a shift in cost-effectivity rating and therefore in a shift in focus regarding priority measures.

For each measure its potential relevance for implementation (indicated as the perspective of the measure) is indicated. In the table the following information is used (see also par.2.5.1):

- *Effects*: this is a score based on the excepted reduction of a pressure, its relevance for specific descriptors and its geographical extension.
- *Costs:* are indicated in classes.
- *Cost-effectiveness*: this is indicated with a bandwidth, the lower indication is the quotient of effects divided by costs; the higher indication is inclusive of additional points in case a pressure is relevant to D1 biodiversity.
- *Disproportionality*: indicates whether the costs involved may be too to the sector.
- *Precautionary principle*: indicates if a pressure may have important but yet unknown effects, which would imply that reducing of the pressure has high priority.
- *Incremental implementation*: indicates if it is possible to implement a measure step by step, increasing its intensity (e.g. lowering standards, stronger restrictions) or enlarging surface area.

Table 4.1. First overview of effects and costs of selected measures

Measure	Pressure	Effects	Cost-effect.	Disprop. Costs	Pre.. Pr..	Incremen.-Impl.	Persp. implem.
Governance							
More calamity control							
Public campaigns on litter							
Restrictions on the use of plastics							
Oil and gas exploration							
Cleaning production mud	Contamination	32	12-24	No	Yes	No	Moderate
Green light for bird migration	Disorientation of migratory birds by light	16	60-180	No	No	No	Very high
Sand mining							
Deeper sand burrows	Physical disturbance	16	80-240	No	No	Yes	Very high
Ecological landscaping burrow pits	Physical disturbance	16	8-24	No	No	Yes	Moderate
Limiting silt plumes by limiting silt overflow	Water quality, smothering	6	1,5-3	No	No	Yes	Low
Zoning outside the -20 depth contour	Physical disturbance	8	2-6	No	No	No	Existing
Shell mining							
Reduction of quota	Physical disturbance and loss of substrate	16	8-24	Yes	No	Yes	Moderate
Zoning of shell mining	Physical disturbance and loss of substrate	16	8-24	Possibly	No	Yes	Moderate
Dredging and dumping							
Stricter standards for dumping	Contamination	14	5-14	Possibly	Yes	No	Low to moderate
Zoning dumping areas/reuse	Physical disturbance	8	4-12	No	No	Yes	Low to moderate
Shipping							
Harbor facilities for the	Marine litter	12	6-12	Possibly	Yes	No	Moderate

collection of wastes							
Ballast water treatment	Contaminants	40	13-27	Possibly	Yes	No	Moderate
Noise reduction of shipping	Under water noise	24	120-360	No	No	Yes, loud and new ships first	Very high
Reduction in the use of sonar	Under water noise	18	9-27	No	Yes	Yes	Moderate
Natura 2000 sites							
Natura 2000 coastal zones; ban on beamtrawling and recreational zoning	Physical disturbance, food web, fish population	26	26-104	Possibly	No	Yes, stricter with time	Very high
Natura 2000 sites open sea	Physical disturbance, food web, fish population	25	25-100	Possibly	No	Yes, stricter with time	Very high
Fisheries							
Innovation of selective fishing methods	Notably physical and biological disturbance also by discards	?	?	No	No	Yes, continuous development	?
Certification of the fisheries chain				No	No	Yes, continuous development	
Electric pulse fishing	Physical and biological disturbance	57	570-1710	No	No	Yes	Very high
SumWing	Physical and biological disturbance	48	240-480	No	No	Yes	Very high
Plaice box, limited to <300HP	Notably population of Plaice	18	9-18	No	No	No, existing	Existing, extension not likely
12 mile zone, limited to <300HP	Notably overfishing			No	No	No	
Sea reserve Maasvlakte 2	Physical and biological disturbance	64	32-128	Yes	No	No	Very high, extension with Natura2000
Closed areas offshore wind parks	Physical and biological disturbance	36	36-180	No	No	No, always complete ban	Very high, extension in new wind parks
Zones with reduced frequency of beam trawling	Physical and biological disturbance	69	35-104	Possibly	No	Yes, first pilot stage and later extension	Very high, potential outside Natura2000

Fishing for litter	Marine litter	28	28-56	No	Yes	No, existing	Existing, extension not possible
Biodegradable nets	Marine litter	52	52-156	No	Yes	No, needs to apply to all nets	Very high
Deposits and name tags on nets	Marine litter	32	32-64	No	Yes	No, needs to apply to all nets	Very high
Reduction shipping noise trawlers	Underwater noise	28	240-240	Possibly	No	Yes, loud ships first	Very high
Off shore wind parks							
Silent construction methods	Noise pollution	10	3-7	Possibly	Yes	No, but further tests on effects can	Low
Coastal defense							
Meganourishments in the active zone	Physical disturbance	8	4-12	No	No	Yes, one pilot now	Moderate
Sand-efficient coastal strategies	Physical disturbance also in sand mining areas	8	40-110	No	No	Yes	Very high
Maritime tourism							
Zoning tourism	Noise pollution	12	6-18	Possibly	No	Yes, monitoring shows effects	Moderate
Additional Beach cleaning	Marine litter	9	5-9	No	No	No	Moderate
Deposits on all plastics	Marine litter	9	9-18	No	No	Yes, first most harmful plastics	Moderate
Additional reduction land based pollution							
Additional P-reduction land based communal WTP	Euthrophication	12	3-6	No	No	No, difficult, effects will show late	Low
Additional N-reduction Land base communal WTP	Euthrophication	12	3-6	No	No	No, difficult, effects will show late	Low
Additional reduction contaminants land based communal WTP	Contaminants	12	3-6	No	Yes	Yes, follow BAT	Low

4.2 Overview of pressures and potential measures

4.2.1 Expected developments general water quality

Generally the input of nutrients, priority substances and marine litter is expected to diminish due to ongoing policies and measures. This is in spite of the general economic growth and related growth in shipping and industry.

The occurrence of silt-related effects is expected to show an upward trend, but probably will not reach the present level, due to the very high extraction rates because of the combination of sand extraction for the ongoing program for coastal protection (Prioritaire Zwakke Schakels) and the construction of Maasvlakte 2.

1)Nutrients/eutrophication (descriptor 5: eutrophication):
Excessive inputs of nutrients have led to algae blooms, amongst them also toxic algae blooms. In general eutrophication also leads to enhanced biomass production and favors some organisms over others. In the past the input of nutrients has been halved since its peak at the end of the 1970ies. There is discussion to what extent the reduction in fish population may be due to a reduction of nutrients.

Due to the Water Framework Directive especially the input of land-based nutrients will diminish further. Original, former levels of nutrients will not be reached, but it is debated whether a further reduction is in fact needed or even desired. Probably more important than the absolute inputs of different nutrients, is the ratio between important nutrients and the impact that this ratio has on the phytoplankton community (Philippart et al. 2007). Marine communities may not respond linearly to changes in e.g. the N/P ratio and further changes in relative availabilities of key-nutrients may have severe, but yet not understood ramifications on biodiversity. Overall measures directed at a further reduction of nutrients are costly, and may contribute to a favorable ecological status, but may as well upset this status.

There is however no concrete GES for nutrients and eutrophication yet.

(tentative conclusions: eutrophication is a difficult issue not well understood so some precautionary principle should be applied. A further reduction is still needed but only possible at very high costs; it is not expected that additional measures to reduce nutrients on top of the measures already proposed under the water framework directive will have high priority before 2020).

2)Priority substances/contaminants (descriptor 8 priority substances and 9 priority substances in fish).
Contaminants such as heavy metals are detrimental to most aquatic organisms and bioaccumulate along the food chain. Top predators, such as birds and sea mammals, are most at risk. Since many contaminants bioaccumulate in fat tissue, contaminants lead also to a health risk.

Most priority substances have already been greatly reduced by a number of measures, mainly under OSPAR and based on EU regulations !but also due to increased treatment of urban waste water. It is difficult to indicate whether specific current priority substances still form a major obstacle to reaching good ecological status of the North Sea. One of the major drivers has been health-related standards for fish and shell-fish. It is expected that priority substances will slowly diminish with the application and development of Best Available Technologies that are already required in the case of industry. Urban WTP's do not yet apply best available technology. Note, however, that new toxic substances are becoming available in rapid succession and that effects are as yet unknown.

OSPAR has formulated additional requirements for the Oil/gas industry, such as limiting the discharge of drilling mud. This may lead to additional treatment costs. Most objectives are in line with best technologies available, but the interpretation of requirements is often subject to discussion.

Dredging sludge still accounts for a large part of the input of contaminants, especially locally. Part of the sludge dredged from harbors is subject to controlled dumping in special facilities. Applying stricter standards would require more controlled dumping and a additional reduction of he input of contaminants.

(tentative conclusions: additional measures to reduce priority substances on top of the ongoing policies, will be very expensive, better to phase out as far as the landbased measures are concerned; attention should be paid also to new contaminants; OSPAR requirements could be interpreted stricter with respect to offshore activities leading to additional cleaning of drilling mud; stricter standards for dredging sludge would also diminish the input of contaminants into the environment)

3)Marine litter (descriptor 9: marine litter)
Marine litter is a problem to fish and especially birds. It hinders digestion and leads to less energy efficient foraging.

Various measures are taken with respect to marine litter. Some of these are source-oriented, such as the general trends towards the use of biodegradable plastics. Other measures relate for example to the collection of waste from ships. There is however still room for improvement. Promising are measures directed at the abandoned and lost fishing nets that pose major problems to marine mammals.

(tentative conclusion: although the impact of marine litter on marine organisms is not clear, there are several additional measures that can contribute to a reduction on both the source and effect-side).

4) Silt plumes (descriptor 4: food webs).
Silt plumes reduce light penetration and inhibit algae growth. The general effect is that the position of algae growth and also algae blooms shifts down current. High turbidity may hinder birds and fish that hunt on eye-sight. The information is however not conclusive.

An increase in sand mining is expected for coastal maintenance and possible for coastal development. There has been a peak in sand mining due to the construction of Maasvlakte 2. Annually on average 25 million m3 of sand are mined each year for coastal maintenance (in the order of 12 million m3) and construction (in the order of 13 million m3). The construction of Maasvlakte 2 requires in the other of 365 million m3 over 3 years. Together with major works on coastal protection sand mining amounted to over 100-120 million m3/year. Even if sand mining for coastal maintenance would triple, these high rates of sand mining will not be reached in future, unless new activities are developed. Coastal maintenance may increase up to 85 million m3 a year in a worst case scenario of a sea level rise of 130 cm by 2100 and complete replenishment of the coastal foundation. The amount of construction sand may double. In future the maximum expected rate of sand mining is in the same order as at present, due to the large extraction rates for the Maasvlakte 2.

The sand mining for Maasvlakte 2 is not expected to have significant adverse effects. In order to mitigate negative effects only silt-poor areas have been licensed for sand extraction. This has more or less become already standard policy.

At present sand mining is subject to EIA and is restricted with respect to living shell fish beds and silt-rich sediments. It is possible to take additional technical measures that reduce the overflow of silt, but these are very expensive and its benefits are probably small.

(tentative conclusion: additional measures to reduce silt plumes due to sand mining, such as confining the extraction to zones low in silt content, on top of the existing requirements set by licensing do not have a high priority, there are two ongoing pilots one for nourishment (sand engine) and one for ecological landscaping; the need to upgrade the annual nourishment volumes up 5 times as high should be assessed, a coastal protection and management strategy on the basis of limited sand nourishment should be studied.).

4.2.2 Expected development disturbance

Figure 4.1 shows the presence of the existing shipping lanes. The map shows that there is intense shipping in nearly half of the Dutch part of the North Sea. Traffic is intense in the coastal zone. Figure 3.2. shows fishing intensity. It gives a similar picture: most intensely fished areas cover nearly 2/3 of the Dutch part of the North Sea. Not mapped is the intensity of marine tourism. This is mainly found close to shore. Marine shipping is expected to increase only slightly, so also related disturbance may increase if no additional measures are taken.

1) *Noise pollution due to shipping (descriptor 11 under water noise)*. (So far it is uncertain what effects are to be expected as well as what costs, perhaps this should be mainly proposed for additional investigation). Mitigating techniques are available and are easily applied to new ship building. For older vessels limiting noise production is far more difficult to achieve. There is no clear picture of the costs involved but there are indication that their can be a considerable reduction in fuel consumption, making refitting a cost-beneficial measure with high potential.
2) *Noise pollution due to sonar (descriptor 11 under water noise)*. The impact of sonar has been intensely studies in the past years and well documented. Especially military low frequency active sonar is very harmful. A re-allocation of the existing areas may be considered since they overlap with Natura 2000 areas or are situated close-by. There is no clear picture of possible alternatives and what may be the effects for example to fishing efficiency if multibeam sonar would not be allowed any more. To a certain extent is would be possible to ban loud ships from protected areas. The reallocation of shipping lanes is probably no option in the crowded North Sea.
3) *Noise pollution due to the construction of wind farms*. *(descriptor 11: underwater noise)* (idem). Several measures are already in place such as a ramp-up procedure, which is a sort of warning before full impact pile driving starts. Nevertheless better technology is available that can be used to reduce noise production during the pile driving itself. The cost for the foundation may double in case new techniques are used. It looks not very promising.
4) *Light pollution (is this a descriptor, perhaps descriptor 1 biodiversity and descriptor 4 food webs?)*. This is mainly related to wind parks and offshore industry. Recently Phillips Light has developed new green LED lights that does no longer attract or disorient sea birds. It is presently piloted at NAM installations. There are ongoing studies by OSPAR regarding the need to reduce lights on platforms. Certainly in the long term the additional costs of implementing green LED light are expected to be negligible. The new green LED lights are more expensive to buy but contribute also to a reduction of energy consumption and therefore energy costs.

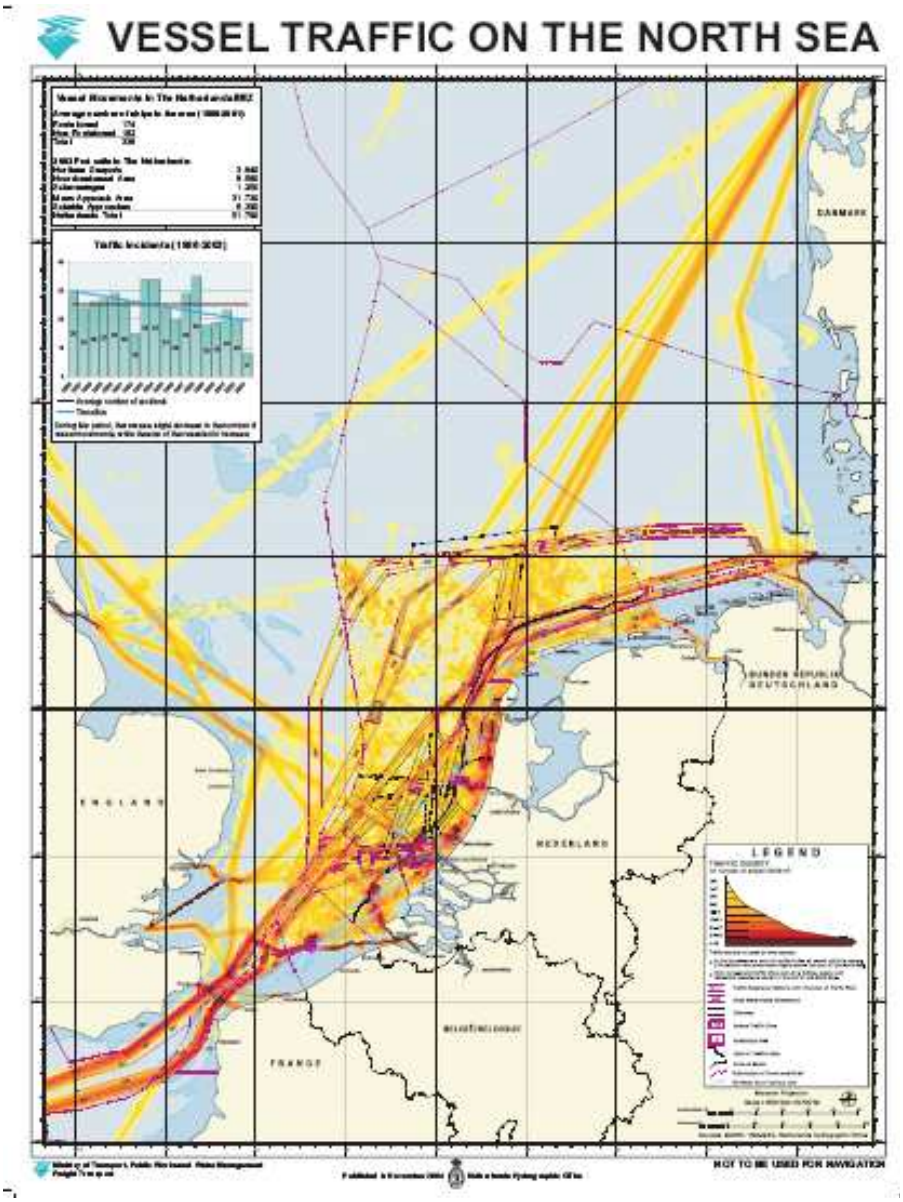

Figure 4.1. Map of vessel traffic routes and traffic intensity in number of ships/1000km^2. oranje colours correspond with a density of 9-15 ships/1000 km2. (VenW, 2009; http://www.noordzeeloket.nl/Images/VesselTraffic_tcm14-2878.pdf).

4.2.3 Expected development physical and biological disturbance sea bottom

The integrity of the sea bottom is an important environmental indicator and ecological objective. Goals related are allowing the development of well-balanced and complete bottom dwelling communities also as a basic food source to other organisms, such as fish, birds and marine mammals. Safeguarding integrity comprises of limiting the physical and biological disturbance, prevention of pollution and anoxic conditions.

Beam Trawling (descriptor 1 biodiversity, 3 fish populations and 6 integrity sea bottom).
Fishing is the largest driver behind the physical and biological disturbance of the sea bottom. This disturbance is so frequent that vulnerable juveniles of various bottom dwelling organisms have no time to develop, while adult individuals of long-lived animals are being fished-out. Hence the living communities are poor in species, poor in mature and older specimens. There is discussion whether frequent fishing enhanced bioproduction of a small group of opportunistic organisms that may be beneficial to the group of organism that feeds on them, e.g. commercially important flatfish species, the driver of the main fishery.

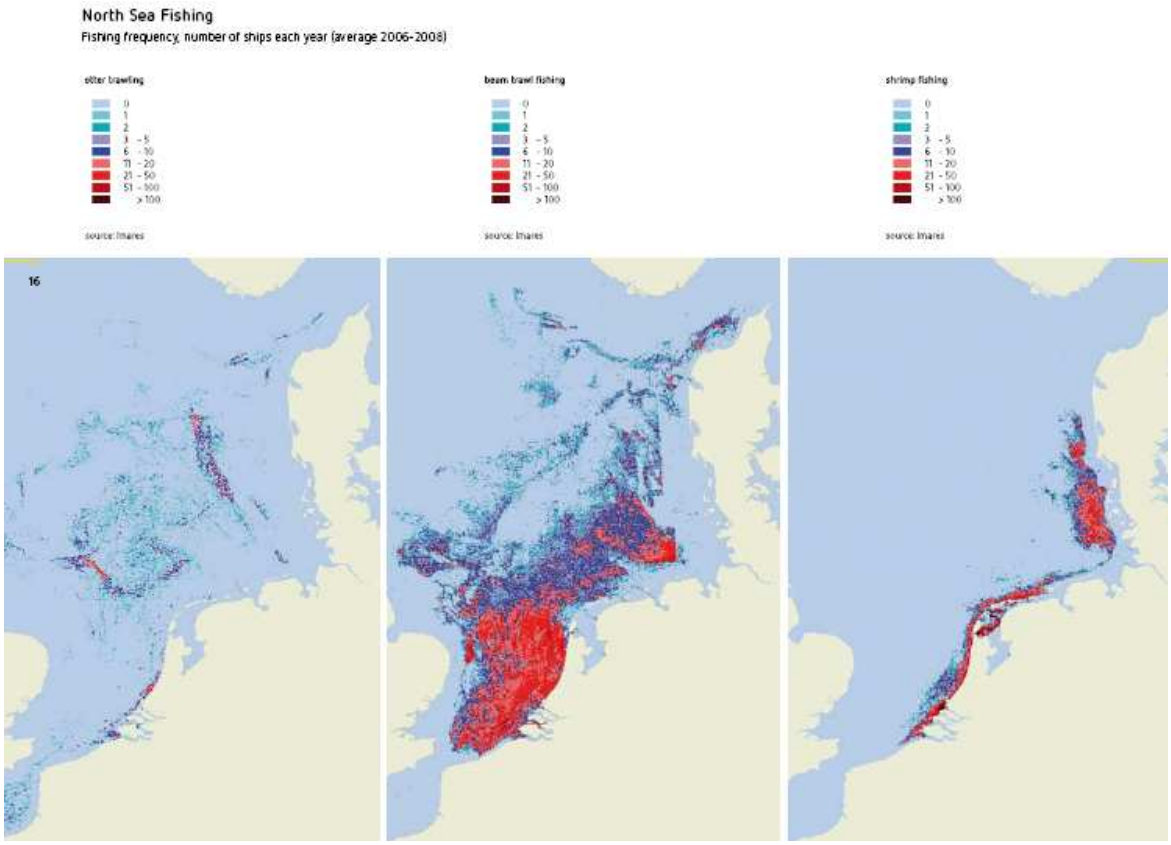

Figure 4.2 Fishing frequency, number of ships each year (average 2006-2008) (VenW, 2009)

Generally there is already a tendency to reduce the physical impact of *beam trawlers*. There are ongoing innovations, some of them triggered by ongoing policies, but mainly driven by the urge to reduce fuel consumption, by introducing more light-weight alternatives such as: SumWings and electric pulse fishing. However, it is not certain if the use of electric shocks will be permissible on the basis of EU-regulations. Furthermore all forms of bottom trawlers will still lead to biological disturbance.

There are various zoning measures that will lead to large ecological benefits, while the impact on the fishery industry may be limited if protected zones will eventually lead to greater fish densities in adjacent areas. However, much research is needed to underpin the long-term effects of partly and completely

closed zones and also to define criteria and zones where specific zoning measures may best be introduced.

One should note that the construction of offshore wind farms and also the designated Natura 2000 will lead to substantial areas with restrictions on beam trawling.

(tentative conclusion: zoning of beam trawling is recommended, research into the spin-off of sea reserves is recommended in order to quantity true costs and effects, but also to clarify the optimal balance between open and closed areas: innovations like pulse trawling and SumWing appear to be promising and should be stimulated).

Sand mining (descriptor 6: integrity sea bottom)
Sand mining (see also silt-plumes) is at present at an all-time high because of the construction of Maasvlakte 2. Nevertheless sand needed for coastal management is expected to increase. At present its contribution to the physical and biological disturbance is very small. Impacts related to the physical alteration of the sea bottom are more important.
(tentative conclusion: it is expected that sand mining will use deeper sand burrows in future, so limiting the surface area that is disturbed; the long-term alternation of the sea bottom becomes at the same time more important, as are measures such as ecological landscaping; furthermore the expected increase in nourishment is strongly related to the advice of the commission Veerman and traditional views on the coastal zone; it is very important to scope for more sand- and also cost-efficient scenario's, with less emphasis on principles and more on the goals of coastal management and protection).

Dredging and dumping(descriptor 6: integrity sea bottom)
Dredging and dumping of sludge is an ongoing activity. It is not expected to increase much in the near future. There are no plans to increase the nautical depth of the channels on the Dutch North Sea. New developments, such as the construction of an "energy island" on the Dogger Bank, or the construction of islands in from of the Dutch mainland coast, would alter this scenario.
Dredging is confined to the fixed area of the shipping channels. Dredging leads to large physical and biological disturbance, but there are no possible measures to mitigate these effects. Moreover, dredging recurrently occurs in the same places (no cumulative effects in space over time) and differs in this respect from mining. Dumping of dredged materials is subject to various laws and regulations. There is an ongoing discussion to use dredged material more efficiently in coastal management and to indicate zones where dumping is possible, outside ecologically vulnerable areas. Focus is on the dredging materials coming out of the Eurogeul. Probably an area north-west of Hoek van Holland may be formally designated for this material.
Dumping is officially called spreading ("spreiden") but in practice several meters are dumped by opening the bottom doors of the dumper. Spreading this material in a way that it limits the physical and ecological disturbance is not possible with current technology.
(tentative conclusion: specific areas should be designated for dumping dredged materials, in order to limit the impact of this annual activity and to use the material to restore sand dynamics and balances in the coastal zone).

Shell-mining. (descriptor 6: integrity sea bottom)
Shell-mining is an ongoing activity. It is not clear if it may increase in future. There are always applicants for more licenses, but the volume that can be mined is limited. A substantial amount of shell mining is currently done in highly sensitive Natura 2000 sites (Wadden Sea and Eastern Scheldt). Zoning may result

in phasing out these activities here, which would increase the demand for similar materials from the coastal North Sea.
Shell-mining may limit the availability of substrate suitable for mussels and oysters.
(tentative conclusion: the ongoing zoning in the Wadden Sea might increase the intensity of shell mining in the North Sea coastal zone, so it is necessary to protect vulnerable areas).

4.2.4 Permanent physical alteration of the sea bottom/hydrodynamic conditions

Dredging and dumping. (descriptor 7: hydrographical characteristics)
Dredging mainly maintains the depth of shipping channels, so over time no increase in altered area is expected. No additional measures are needed or even possible.
Dumping lead to the gradually upheaveling of the sea bottom. Over the years the dumping area may even become too high for deeper going ships. Dumping areas may be changed over time, so upheaveling remains limited as will be the effects of dumping.
(tentative conclusion: dumping should be limited to areas that are limited in size, if possible dumping should contribute to the sand balance of coastal processes; dumping can to a certain extent replace the need for coastal nourishment and related mining and pressures. If more sand is dumped than required these areas could also function as a sand burrow.

Sand mining. (descriptor 7: hydrographical characteristics)
Sand mining leads to a gradual increase in the physically altered sea bottom. This increase can be reduced significantly by allowing for deeper sand burrows, which is since Maasvlakte 2 already present policy (see above). Depths up to 20 meters can be allowed without risks for anoxic conditions. The sand pits for the construction of the Maasvlakte 2 have already been licensed to a depth of 10 meters. At present a pilot is started that looks at the possibilities for ecological landscaping in a 10 meter deep burrow area, part of the sand extraction for Maasvlakte 2. Creating artificial sand waves did lead to some additional “construction” costs.
However it is very cost-effective to allow for deeper sand burrow so limiting the area of impact.
(tentative conclusion: the use of deeper sand burrows is a cost-effective means of to reduce the area of impact by sand mining. Deeper sand burrows may allow for higher cost-efficiency and should preferably be combined with requirements for ecological landscaping.

Land reclamation (descriptor 7: hydrographical characteristics)
There are in addition to the construction of Maasvlakte 2 no large scale reclamation works expected that may lead to a change in hydrodynamic conditions. Even if coastal protection and management would lead to a seaward extension of the coastline, this would hardly matter to general patterns in flow conditions and wave energy.

Change in hydrological regime of rivers (descriptor 7: hydrographical characteristics)
Climatic change will lead to a change in the hydrologic regime of European rivers, including the Rhine and Meuse. It is generally expected that the summer base flow will be substantially lower for a longer period. This will lead to changes in salinity gradients and a slight shift in the coastal river which is powered by the volume of fresh water that enters the North Sea. Changes in hydrologic regime caused by shifting patterns in rainfall may be considered a scenario variable.

Part of the discussions within the Deltaprogramme is a possible shift in the allocation of water between the major tributaries, notably the rivers IJssel and Rhine. The objective is to have more water available to land based functions and water management. Consequently less water will reach the North Sea, so reducing in a manmade way the base flow that reaches the sea.

(Tentative conclusion: a change in hydrological regime, and notably of the base flow may have consequences for the ecological functioning of the coastal river. This should be studied in depth with respect to discussions that may imply a change in the allocation of water between Rhine and Meuse)

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Conclusions are tentative

This study looked at a first set of possible measures for implementation of the MSFD. It is not a complete assessment of all possible options for each individual pressure. Cost-effectiveness was assessed on the basis of a very rough expert judgment lacking concrete targets for the individual descriptors, most of which are still under study and discussion. With respect to costs often only limited information was available and most cost estimates are made on the basis of expert judgment. Especially with respect to the most promising measures but also measures with respect to the most important pressure additional studies are needed to assess their true potential and cost-effectiveness.

It should be noted that at present no Good Ecological Status has been formulated for any of the descriptors and related pressures. All indicators are still very much debated, since it is obvious that zero pressure can never be attained. The method used to determine the cost-effectivity of measures needs further validation with respect to the scores applied and the way scores and effects are defined. A change in method may lead to a shift in cost-effectivity rating and therefore in a shift in focus regarding priority measures.

Much action will be taken

There is a wealth of new policies and measures under way that will significantly reduce the existing pressures on the North Sea Environment. Amongst the most important are:

- The implementation of the WFD, which will lead to a further reduction in the input of nutrients and contaminants and will create more spawning areas reachable by more ecological infrastructure. The reduction in nutrients and pollutants is by itself not enough to significantly reduce eutrophication in the coastal zone. An additional reduction of the input of nutrients is very costly. It is however a matter of debate how much further reduction will be needed to attain GES, so the first step would be further studies.
- The implementation of Natura2000 will lead to the protection of at least 20% of the Dutch part of the North Sea and several potential sites are still under study. Especially in vulnerable and ecologically important areas such as the coastal zone a significant reduction in physical disturbance and to some extent also biological disturbance is expected, due to zoning of recreation and fisheries and more environmentally benign fishing techniques. It may be a matter of optimization to see whether banning some uses will be more appropriate than restrictions that only allow use on the basis of environmentally friendly techniques.
- The development and application of new fishing methods will significantly reduce related pressures also outside the Natura 2000 areas. Especially alternatives such as pulse trawling and SumWing will lead to a significant reduction in physical disturbance by beam trawlers. It is expected that several of these techniques will have a positive rate of return and do not require economic incentives. However, bottom fisheries will still have an impact on benthic communities. Other techniques will lead to less adverse impacts on marine mammals, but fishing without any casualties will not be possible and fishing should possibly be limited near important habitats of these animals.
- There are policies under way to reduce the volume of marine litter, and also more and more biodegradable packaging and even biodegradable fish nets become available. The successful Fishing for Litter, introduced 10 years ago in The Netherlands and now in full swing with the

participation of the whole fishing fleet, helps to reduce larger man-made litter. Most ports also have a reception facility to collect waste from ships. Nevertheless, the transition towards biodegradable plastic is slow. Especially lost and abandoned fishing nets remain a risk to marine mammals and birds. A system of deposits and nametags and also active retrieval of lost and abandoned nets may help to reduce this risk to acceptable levels.

- Underwater noise is on the agenda but reducing underwater noise is difficult and costly. It may be easier to use building requirements leading to noise poor ships and retrofitting existing ships. Some older boats produce noise levels above what is regulated and acceptable for the crew itself. Here stricter enforcement on health regulations may already be helpful. In principle it would also be possible to steer shipping away from the most vulnerable areas, such as resting places for seals. Especially military sonar is particularly damaging and needs further attention, since there are at present no technical alternatives, besides additional satellite detection. Mitigation is often sought in zoning the active use of sonar outside of vulnerable areas.
- There are technical measures and policies under way to adequately manage ballast water, which could be done by small scale treatment facilities. Management measures are required by the Ballast Water Convention (once ratified). Available prototypes have already been tested. The aim is that by 2016 on the big ships ballast water is treated by on-board facilities. However these measures are costly and need sufficient control, and receiving facilities are needed in harbors.
- The recent adopted policy to allow for deeper sand burrows will significantly reduce the surface area of sand mining in spite of an expected rise in nourishment volumes. This is a measure with no additional costs. There is also a tendency to use dredged materials as an alternative source for nourishment that will reduce sand mining. Research is under way to reduce the impact of nourishment itself, e.g. by using less frequent mega nourishments and to speed up the ecological rehabilitation of burrow by means of ecological landscaping. It is however important to study alternatives to coastal management that are more sand-efficient. Soft defenses make sense, but using less sand also.
- OSPAR and IMO regulations will lead to more measures to contain the volumes and risks related to contaminants released by oil and gas exploration and industry.

5.2 Recommendations

5.2.1 General

There are three distinct groups of recommendations:

1) *Present state, autonomous development and future goals; studies* are ongoing as part of the initial assessment but more insight may be needed in the relative importance of pressures and therefore the need to address specific activities.
2) *Potentially important measures, costs, effects but also instrumentation and implementation.* This study gives an initial overview but more in depth analyses will be needed with respect to the most relevant pressures and possible measures.
3) *Ranking, uncertainty, disproportionality and precautionary principles.* Also because of large uncertainties, especially with respect to the effects of measures, the ranking of measures can not only be based on cost-effectivity, other arguments are important as well and need to be made more explicit.

5.2.2 Present status, autonomous development and future goals

The most important recommendation is to develop a better overview of pressures and related effects on the North Sea. At present the geographical extension and ecologically relevancy of many pressures is not well known. Many measures will be taken that will have a significant influence on most pressures. These autonomous developments should be closely monitored in order to define the related reduction in pressures.

In addition to this a more precise definition of the environmental goals for each descriptor is needed. At present it is not known to what extent present or future specific pressures need to be reduced in order to attain acceptable levels that no longer hamper achieving important goals. One may note that for only parameters that can be linked to a pressure and a measure will help to rank and program measures needed.

More research is needed with respect to:

- The possible consequences of reducing the base flow of the Nieuwe Waterweg and its effects on the coastal river.
- The various forms of zoning that could be used to safeguard the integrity of the sea bottom, their effects and the zones for the preferred designation of these zones.
- The required additional reduction in nutrients to reduce eutrophication.
- More cost-effective forms of coastal management.
- Operational options to limit the loss and abandonment of fishing nets, the retrieval of lost nets and gradually use of biodegradable nets.

These aspects are described briefly below.

Reduction of base flow conditions
Young plaice reach the coastal waters of the Netherland by means of the coastal river. Due to the outflow of fresh water there is a return flow along the bottom in direction of the coast. The flow is used by larvae which at that time are freely floating. The effects of Maasvlakte 2 on this larvae transport mechanism have been extensively studied. However also a potential allocation of fresh water from the river Rhine to the River Ijssel will lead to a reduction in the inflow of water.

Aspects are:

- The expected reduction in summerly baseflow in the case of allocation.
- The subsequent effects on salinity gradients and related water transport.
- The ecological effects on larvae and ultimately the potential effects on specific fish populations.

Sand mining:
There are two ongoing pilots that study the possibilities and effects of ecological sand mining and of putting more sand into the active zone by means of a sand engine. Both projects will be closely monitored and will generate additional knowledge on what may be the most environmentally benign courses of action.

In addition to these pilots the proposals of the Delta Commission are presently studied. It is vital that also scenario's are studied that limit the total volume needed to safeguard and maintain the present coast. Elements can be:

- A limited sea ward advance, for example only for the purpose of protection,
- Re-use of dredged materials in coastal protection.

- Re-allocation of sand losses within the coastal zone, e.g. mining of sedimentation zones, which is common practice in other countries where the availability of sand is limited;
- Nourishment strategies that are more effective, notably higher in the active zone, and probably would also allow stable but on average steeper foreshore gradients.
- Foreshore nourishment on the basis of coarser materials, which will limit the erosional tendency.

Required additional reduction in nutrients
In the 70ies the input of nutrients into the North Sea was at its maximum, leading to frequent algae blooms and related problems, but no fundamental disrupture of food webs and ecosystem functioning. At present water quality has improved but occasional algae blooms still occur. It is difficult to estimate the additional reduction needed to prevent any algae blooms in future. It is not possible to reach pre-1950ies situations, before the large scale introduction of artificial fertilizers in agriculture and the later development of bioindustry. Especially the leaching of phosphate out of P-saturated soils is a slow process and will for many years still lead to increased inputs of phosphorus. Questions relate to:

- Acceptable nutrient levels, taking into account the acceptable level of algae blooms and reduction of biomass production, the possible limiting concentrations and inputs of both P- and N.
- The expected reduction in P- and N input due to ongoing measures, such as the WFD and required additional reduction.

Managing the ultimate disposal of fish nets
Abandoned and lost fish pose serious risks to marine life. Tackling these issues may require a combination of measures, such as incentives and controls.

5.2.3 Ranking, uncertainty, disproportionality and precautionary principles

In this study cost-effectiveness was handled by looking at the possible effect of measures on pressure and different descriptors. Special attention was paid to D1 biodiversity as the overall goal of the MSFD. There are however other ways to express cost-effectiveness, especially when scoring effects. Now all descriptors had the same weight, but in practice this will not be the case. Some are more important than others but there is at present no clear picture what weight may be attached to different descriptors.

Similarly, not all pressures are equally important. Expert judgments appear to vary widely when ranking the importance of the various drivers with respect to the ecological status of the North Sea. Weighing the relative importance of pressures and descriptors has probably a larger influence on ranking on the basis of cost-effectiveness than the precise indication of effects or the calculation of costs.

Cost-effectiveness is by itself not the only factor that should govern the ranking of possible measures. There are other factors that need to be taken into consideration, especially when cost-effectiveness is difficult to calculate because of lack of data. Important are:

- *Risks and precautionary principle.* It will not be possible to clearly define the relation between pressures and parameters. Much uncertainty will remain. But some uncertainties entails higher risks to the environment than others. Especially uncertainties with respect to priority pollutants need special attention as do interventions that may have non-remedial and irreversible effects. Regarding possible environmental risks involved also a ranking in measures is possible. Those ranking high should have priority even if cost-effectiveness is low.
- *Cost-effectiveness and disproportionality.* Some measures can be cost-effective but too costly to as sector to be taken without serious economic consequences. These measures may be implemented by using also economic incentives or financial compensation. There are also

measures that are perhaps not very cost-effective but do not lay a heavy burden on the sector. In this case these measures may be ranked high in spite of a lower cost-effectiveness.

- *Uncertainty and incremental development*. Of some measures it may not be certain if they will lead to the desired effects. But the implementation of many measures can be done step by step.

A clear method should be developed to rank potential measures appropriately.

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7 COLOPHON

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