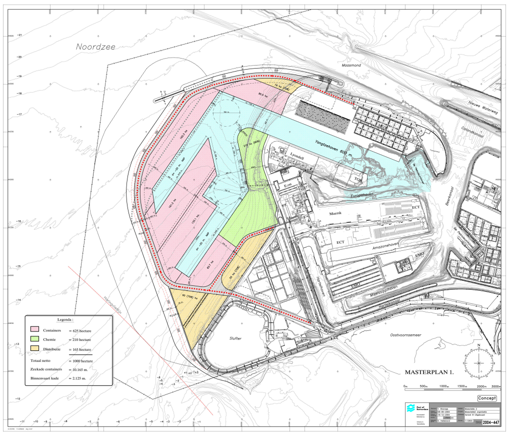

Impact of Maasvlakte 2 on the Wadden Sea and North Sea coastal zone

Effects in the context of the Birds and Habitats Directives

Port of Rotterdam & National Institute for Coastal and Marine Management

18 november 2005

Final Report

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HWE onderzoek en advies in waterbeheer en ecologie

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SUMMARY

Introduction

In January 2005 the Council of State (Raad van State) set aside the material policy decisions[1] taken by Government as part of the 'Key Planning Decision' (PKB-plus) on the Project 'Rotterdam Mainport Development' (PMR). The project foresees in the expansion of the current port and industrial zone by land reclamation adjacent to the present *Maasvlakte* area and the improvement of the living environment in the existing area. Due to the above mentioned Council decision, the implementation of the project has become less secure. The project partners[2] have therefore decided to 'rectify' the concerned material policy decisions commencing with Government's position (i.e. PKB-plus Part 3), in line with the Council of State's decision.

This report is a building block for the Appropriate Assessment of the impact of the foreseen land reclamation on the Wadden Sea Area[3]. It is not the Appropriate Assessment itself. The latter is being carried out by the National Institute for Coastal and Marine Management (RIKZ). RIKZ is currently drafting a separate document in which information from various sources, including this report, and results from recent model studies, are combined. This report should therefore only be considered as a contribution to the final conclusions of the Appropriate Assessment.

Assessment according to the Birds and Habitats Directives

To asses whether a project is in compliance with the Birds and Habitat Directives of the EC, a well defined procedure needs to be followed. This procedure has been laid down in Article 6 (3) and (4) of the Habitat Directive. The Appropriate Assessment is the second step in this procedure (see Diagram 1). This step specifically deals with the following question:

Will the project have a significant negative impact on the favourable conservation status in the concerned Natura 2000 area (Special Areas of Conservation, SAC)?

This question can be divided into a number of sub-questions:
1. Which aspects of the Project have a possible significant impact on the SAC?
2. How can the Project impact upon key species and habitats in the SAC?
3. Is there a possible negative impact of the Project on the conservation status of the SAC?
4. Are there possible negative, cumulative, effects as a result of other plans or projects?
5. Can negative effects be avoided by mitigating measures?

[1] Material policy decisions are part of the 'Key Planning Decision', or PKB-plus, taken by Government. Material policy decisions are components of planning decisions that have to be observed in further decision-making by lower public authorities, such as in the adoption of zoning plans.
[2] PMR partners are Central Government, Port of Rotterdam, Rotterdam Municipality, the greater urban area of Rotterdam and South-Holland Province.
[3] Appropriate Assessment = the assessment of the effects of a plan or project on areas included in the register of protected areas of the Birds and Habitat directives of the EC.

Consideration of a plan or project affecting a Natura 2000 site
(Article 6(3) and (4) of the Habitats Directive)

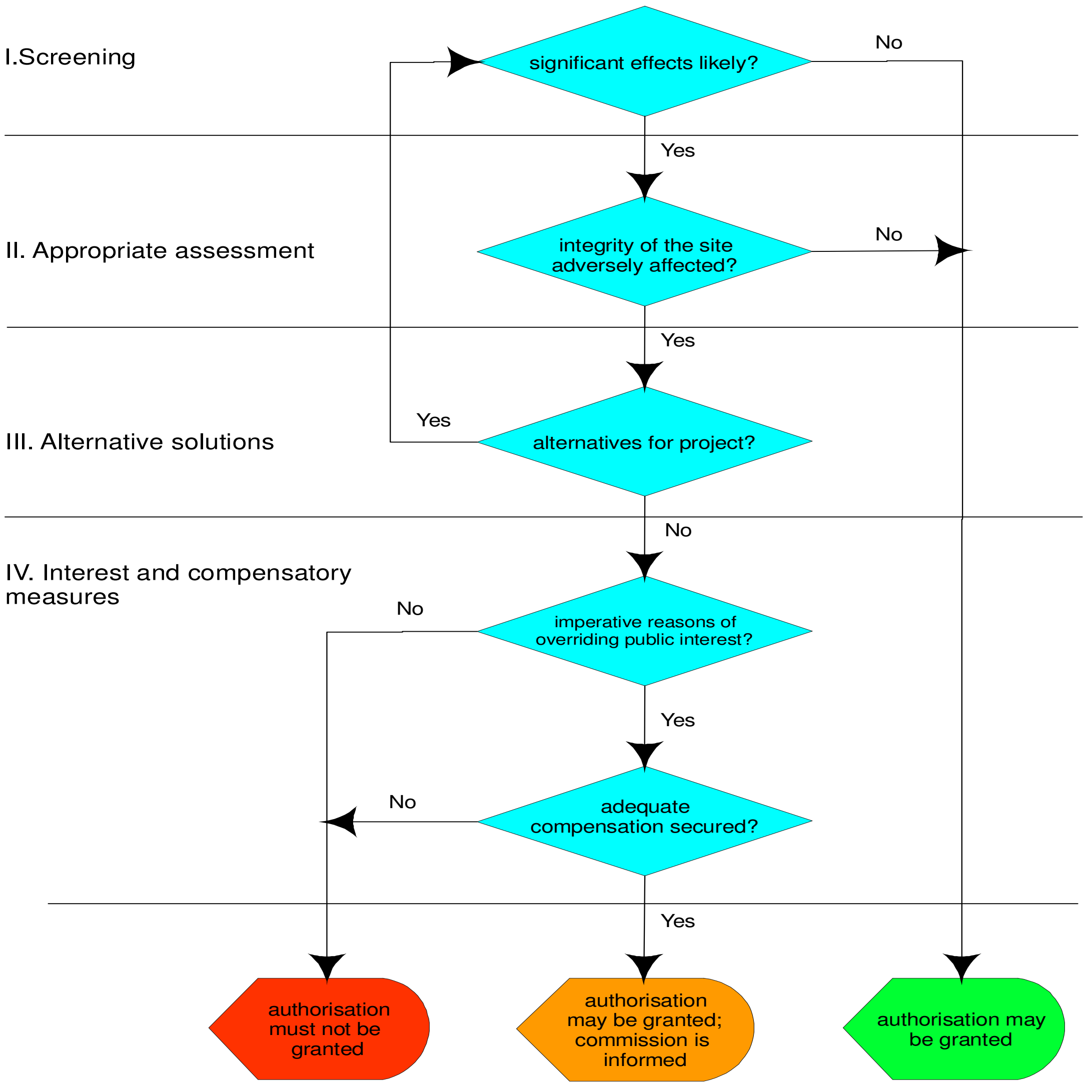


Diagram 1 Framework for Assessment of Projects or Plans according to Article 6 of the Habitat Directive

Approach

In this report, and the underlying research, use has been made of scientific literature, research reports (such as EVAII, soil subsidence studies), monitoring results (data collected by SOVON), results of earlier model studies (Maasvlakte 2, Flyland) and relevant documents of the Ministry of Agriculture, Nature and Food Quality. The information obtained and conclusions drawn were also subjected to expert review. Three expert consultation workshops were organised in which experts participated from Alterra, NIOZ, WL Delft Hydraulics, RIVO and RIKZ.

In addition, use was made of the 'box model EcoWasp' (Brinkman, Alterra) to evaluate the effect of different scenario's of nutrient and silt levels on primary and secondary production in the Western Wadden Sea Area. In parallel, model studies were carried out by WL Delft Hydraulics and RIVO into the effects of Maasvlakte 2 on sediment transport, nutrients and fish larvae. Insofar as these were available, results of these model studies were used to verify the assumptions made in this report.

A top-down approach was used to describe the impact of the Maasvlakte 2 on the Wadden Sea Area and the North Sea Coastal Zone. In this approach, the criteria that determine the favourable conservation status of the SAC's, are leading in the description of the impact. Evaluation of the relevant abiotic parameters that are possibly influenced by land reclamation, then takes place by means of a 'reverse cause-effect' analysis. As long as the conservation objectives have not yet been defined, the favourable conservation status is determined by the qualifying habitats and species, as mentioned in the designations (Birds Directive) and notifications (Habitats Directive).

Possible effects on suspended matter (silt), nutrients and fish larvae

The implementation of the Maasvlakte 2 consists of two main activities: 1) sand excavation in the North Sea and 2) land reclamation west of the current Maasvlakte. Sand excavation can lead to elevated concentrations of silt and as a result of the seaward expansion of the Maasvlakte the transport of silt, nutrients and fish larvae in the vicinity of the Maasvlakte and along the Dutch coast can be subject to changes. As a result, these activities may have an impact on the SAC's Wadden Sea Area and the North Sea Coastal Zone. Effects on the tidal range or sand transport in these SAC's are not anticipated. Relevant cause-effect relationships are illustrated in diagram 2 here below.

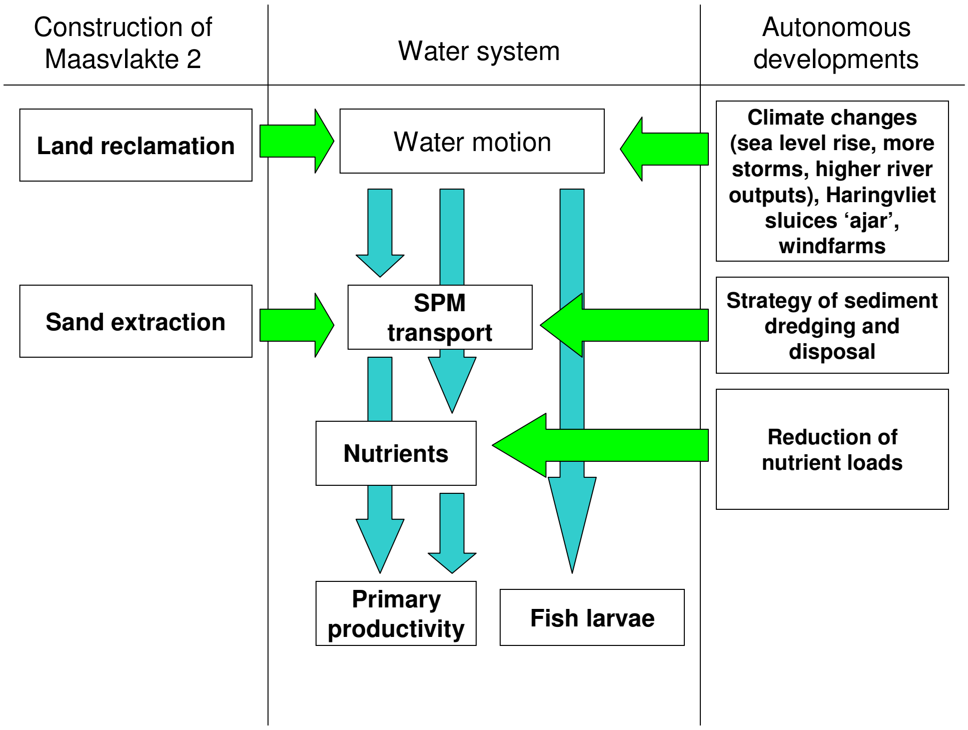


Diagram 2: Relationship between the Maasvlakte 2 intervention and the natural water system. Autonomous developments with an impact on the natural system are also indicated

Model studies show that, as a result of the presence of Maasvlakte 2, concentrations of silt and nutrients in the Wadden Sea Area will decline. Possible effects on the transport of fish larvae have not yet been quantified. It is safe to assume however, that the effect on fish larvae that do not display specific behaviour to reach nurseries (such as Herring and Sand Eel) will be less than the effect on species that do display such behaviour (such as larvae of Plaice).

As a result of the planned large-scale sand excavation needed for land reclamation, concentrations of silt will increase. This may have an impact on the North Sea Coastal Zone and the Wadden Sea Area. These effects are temporary and have an opposite impact as the presence of the Maasvlakte 2. Effects of sand excavation on transport of fish larvae are not anticipated as there are no expected changes in flow- or wave patterns.

The results of the latest model studies will not be available until the fall of 2005. The conclusions in this report are therefore based on earlier model studies. These earlier studies can be characterised as realistic to somewhat pessimistic. When the results of the latest model studies become available a final assessment of the effects can be made. In the meantime and in consultation with experts at NIOZ, Alterra and WL, a reduction of 15% of the sediment level and 10% of the nutrient supply has been assumed.

Impact on the food chain

In table 1 a qualitative overview is presented of the most important relationships between the factors that are influenced by Maasvlakte 2 and the effects on the biotic components of the ecosystem.

Table 1

Effect Maasvlakte 2	First order effect	Second and higher order effects
Nutrients	Primary productivity (phytoplankton and phytobenthos)	shellfish -> fishes, birds
		other primary consumers and detrivores -> birds
Suspended matter	transparency	period of phytoplankton bloom -> prim. consumers -> fishes -> birds, sea mammals
		visibility preys -> birds
Fish larvae	# young demersal fish species	demersal fish eating species
	# young pelagic fish species	species foraging near the water surface

The Ecowasp-simulations facilitate the insight into the possible impact on primary and secondary production in the Wadden Sea Area of changes in nutrient levels and suspended solids in the North Sea Coastal Zone. The most important results of the model studies are presented in table 2. Scenario 01 has been determined on the basis of the Flyland-calculations[4]. Pelagic primary production increases slightly in this scenario whilst the benthic primary production decreases. A striking result is that the filter feeder biomass shows an amplified response to changing nutrient loads. Comparison of the scenario's presented in table 2, also shows that productivity is primarily influenced by changes in nutrient levels and only marginally by changes in sediment levels.

Table 2 Model results Ecowasp; basic scenario in bold

Scenario	Forced parameter		Model results			
	N, P, Si	Silt	pelagic prim. prod.	Chlorophyll-a	benthic prim. prod.	maximum filter feeder biomass
00	0	0	100	100	100	100
07	-5%	-8%	101	104	98	92
01	-10%	-15%	102	110	94	80
04	-5%	-15%	102	104	100	92
06	-5%	-30%	104	106	106	95

[4] Most recent model results show that the impact of the presence of the Maasvlakte 2 PKB-variants is more comparable to scenario 4 than scenario 1 (the basic scenario).

Protected habitats

There are eight Habitat Directive areas in the Wadden Sea Area. Only the Wadden Sea and the North Sea Coastal Zone are potentially influenced by the presence of the Maasvlakte 2 project. The effects of changes in nutrient and silt concentrations in the Wadden Sea Area do not influence Lake IJssel (SAC Frisian Lake IJssel Coastal Zone) as there is no significant flow of water from the Wadden Sea into the IJssel Lake. There is no negative impact on the dune areas (proposed Habitat areas), despite the fact that these are connected to areas that are influenced by the Maasvlakte 2 project. The quality of the dune areas is not determined by (changes in) nutrients and silt present in the sea water. The same assessment can be made for the (dune) Habitat types 2110, 2120 and 2130 that are located within the SAC Wadden Sea.

The large scale morphology of the Wadden Sea and North Sea Coastal Zone is primarily determined by the supply and transport of sand and only to a minor extent by silt transport. Therefore, it is not expected that lower silt concentrations in the sea water will lead to changes in elevations and thus surface areas, of estuaries (1130), mudflats and sandflats not covered by seawater at low tide (1140) and sandbanks which are slightly covered by seawater all the time (1110). The sedimentation of silt on the various types of salt marshes (1310, 1320 and 1330) could be reduced, but with an insignificant impact on their sustainability.

Possible effects of the Maasvlakte 2 project on the quality of relevant habitat types have also been assessed. The main conclusions are:

- As there is no change in the exposure level, no change is expected in the pattern of silt-rich mudflats and silt-poor plates within habitat type 1140. It is possible however, that the silt concentrations will decrease slightly, in accordance with the lowered silt transport to the Wadden Sea. It is equally possible that silt levels will remain at their present level, as only a small portion of the present silt supply actually remains in the Wadden Sea.
- Assuming slightly lower silt levels in the adjacent tidal flats (worst case), the salt marshes will silt up at a slower pace. Along the main coast line, this is not considered a problem due to the fact that the present level of siltation is much higher than desirable from an ecological point of view. Moreover, the siltation rate along the main coast line is more than sufficient to keep up with the expected sea level rise. The salt marshes along the island coast line will not be able to keep up with the expected sea level rise. The effect is however minimal; submersion will take place in 120 as opposed to 125 years.
- The remaining criteria are either not influenced by the Maasvlakte 2 project or are examined in the impact description as intermediate variable (e.g. shellfish, deposit feeders).

- A reduced import of silt could lead to a maximum overall reduction of the anorganic silt fraction in the sediment of habitat types 1110 and 1140[5] of 15% (worst case). However, no major changes in the benthic fauna are expected. Within a particular range of silt concentrations, total organic matter and sediment shear stress appear to be more important factors determining benthic fauna composition and biomass than the anorganic silt content. As mentioned before, no change is expected in the hydrodynamics in the Wadden Sea, and therefore no effects in the pattern of relatively silt-rich and silt-poor areas (and sediment shear stress). It is expected that the total amount of (edible) organic matter will approximately remain at the same level.

Protected species

Demarcation of the study area

A large number of species in the Wadden Sea Area is protected under the Birds and Habitat Directives. The habitats of these species protected under the Habitat Directive have been listed in Table 3. As mentioned before, only the Wadden Sea and the North Sea Coastal Zone are potentially influenced by the presence of the Maasvlakte 2 project. For this reason, only the species will be considered for which these two areas have been proposed or designated as SAC[6]. Of the areas designated under the Birds Directive, i.e. the ‘Wadden Sea Islands, North Sea Coastal Zone and the polder Breebaart’ only the area ‘North Sea Coastal Zone’ is taken into consideration. 52 qualifying and otherwise relevant bird species, three fish species and three types of sea mammals occur in these areas.

Table 3 Designated (Birds Directive) and proposed (Habitats Directive) SACs in the Wadden Sea Area

Habitats Directive	Birds Directive
1. Wadden Sea	1. Wadden Sea
2. Frisian Coastal Zone of Lake IJssel	2. Frisian Coastal Zone of Lake IJssel
	3. Isles of Wadden Sea, North Sea Coastal Zone, polder Breebaart:
3. North Sea Coastal Zone	North Sea Coastal Zone [1]
4. Dunes of Texel	Dunes of Texel
5. Dunes of Vlieland	Dunes of Vlieland
6. Dunes of Terschelling	Dunes of Terschelling
7. Dunes of Ameland	Dunes of Ameland
8. Dunes of Schiermonnikoog	Dunes of Schiermonnikoog
	Polder Breebaart

[1] The SAC North Sea Coastal Zone has a wider boundary for the Birds Directive than for the Habitats Directive

[5] As HT 1130 is exclusively found in the most eastern part of the Wadden Sea area (part of the Dollard-estuary) it will not be affected.

[6] This means that species such as Fen orchid, Floating Water-plantain, Narrow-mouthed whorl snail and Root vole (ssp. *arenicola)* will not appear in the description of effects. The same applies to a number of bird species that are dependent upon dunes and higher salt marshes, and that do not utilise areas of the Wadden Sea that are possibly influenced by the Maasvlakte 2 project. The species concerned are: Little Grebe, Spotted Crake, Red-backed Shrike, Sedge Warbler, Whinchat, Common Stonechat and Northern Wheatear.

Approach towards quantifying effects on species

Possible effects of the changes in transport of silt, nutrients and fish larvae as a result of the Maasvlakte 2 project, were examined first on a generic and then on a detailed level. On a generic level, possible indirect effects of changes in transport were determined. Species that were not affected by these changes were characterised as 'not sensitive to changes caused by the Maasvlakte 2 project'. The remaining species were subsequently examined in more detail with respect to the impact on the food chain as a result of changes in transport processes. As a result, species were characterised as ´not sensitive´, ´moderately sensitive´, and ´sensitive´. Simulations with the EcoWasp model were subsequently used to determine whether certain effects on species could be further excluded. Finally, it was established insofar as effects were potentially significant.

Non-sensitive species

Fish. The three protected migrating fish species Twaite shad, River lamprey and Sea lamprey utilise the whole coastal area (including the Wadden Sea) as habitat. There are no sub-areas with a specific importance for these species. It is not expected that that there will be any effects on these species as the total quantity of nutrients (i.e. food) does not change as a result of the Maasvlakte 2 project, and due to the fact that neither transparency nor flow patterns in the coastal river are relevant to these species.

Birds. On the basis of their food habits, the bird species that occur in the SACs Wadden Sea and the North Sea Coastal Zone are classified into five main groups: 1) plant eaters, 2) birds of prey and owls, 3) fish eaters, 4) shellfish eaters and 5) other wadden birds with varied diets. The Maasvlakte 2 project will not have negative effects on the seven qualifying and five other relevant bird species with predominantly vegetarian food habitats as the project does not negatively affect these sources of food. Negative effects are also not expected on the qualifying species Peregrine Falcon, Hen Harrier, Marsh Harrier and Short-eared Owl. Even if the project has a possible (minor) effect, these species will not be hampered by food supply.
Within the group of fish eaters, eight species have been characterised as 'non-sensitive'. These species are either:

- Not, or only partially, dependent on the Wadden Sea or North Sea Coastal Zone (Black Tern, Lesser Black-backed Gull, Great Cormorant, Red-breasted Merganser, Great Crested Grebe, Smew)

or:

- The availability of animals of prey is not determined by conditions in the Wadden Sea, but rather by total fish production in the North Sea (Black-throated Diver, Red-throated Diver). The change in silt concentrations may however influence the possibility to hunt animals of prey due to the ensuing changes in transparency.

Within the group of Wadden birds, a further five species are characterised as 'non-sensitive'. For these species either the quantity of available food is not influenced by the Maasvlakte 2 project (Sanderling, Northern Pintail, Mallard, Turnstone) or the area concerned does not serve as foraging area (European Golden Plover).

Sea mammals. Seals and Harbour Porpoises travel great distances when foraging. The availability of food does not depend on the Maasvlakte 2 project. The sheer size of the foraging (seals) or distribution area (Harbour Porpoise) is such that significant effects are not expected as a result of a possible local increase or decrease in the totally available quantity of food.

Moderately sensitive and sensitive species

The construction of Maasvlakte 2 may affect bird species through changes in food availability in several ways. In most cases the presence of sufficient amount of food is the most important factor. For some species, such as Avocet and Common Shelduck, the availability of particular (micro)habitats is also important. These species depend on very soft (silty) sediments for the collection of their food.

The analysis of the relations between the possible sensitivity of bird species in the Wadden Sea and changes in the total food supply shows that 7 species are sensitive and 17 species are moderately sensitive to reductions and/or temporal shifts in food supply. A number of relevant ecological characteristics of these species are summarised in Table 4.

Table 4 Species sensitive or moderately sensitive to change/shift in food supply. WS = Wadden Sea, NSC = North Sea Coastal Zone.

Species	Type of food	Location	Period
Sensitive			
Common Eider	Cockles, Mussels, *Spisula* (in case of food shortage)	Sublittoral WS-NSC	Year
Greater Scaup	Zebra mussels, Mussels	Sublittoral WS West	Winter
Common Goldeneye	Zebra mussels, Mussels	Sublittoral WS West	Winter
Red Knot	Macoma	Littoral WS	Winter
Oystercatcher	Cockles, Mussels	Littoral WS	Year
Little Tern Common Tern	Sand Eels, small fish (young herring, sprat, etc.)	WS, tidal inlets	Breeding
Moderately sensitive			
Common Scoter	*Spisula*, possibly also *Ensis*	Sublittoral NSC	Winter
Avocet	Worms	Silty littoral WS	Breeding
Great Ringed Plover Dunlin Black-tailed Goldwit Northern Lapwing Krombekstrandloper Bar-tailed Goldwit Grey Plover	Worms	Littoral WS	August-May
Common Shelduck	Other diet, small organisms in the top layer of soft (silty) sediments	Silty littoral WS	Autumn
Eurasian Curlew Common Redshank	Mixed diet	Littoral WS	Year
Arctic Tern	Sand Eels, small fish (young herring, sprat, etc.), crabs, shrimps	WS	Breeding
Sandwich Tern	Young herring, Sand Eels	WS, NSC	Breeding
Eurasian Spoonbill	Gobies, other small animals	WS	Breeding
Spotted Redshank	Other diet, including shrimps	Silty littoral WS	July
Common Greenshank	Gobies, other small animals	Littoral WS	September

Further analysis of the effects on the 24 sensitive and moderately sensitive species shows that for 4 species adverse effects of the expected reduction of concentrations in nutrients as a result of Maasvlakte 2 cannot be excluded (no significant effects of reduction in silt are expected). The species concerned are Common Eider, Oystercatcher and Red Knot (shellfish eaters) and Little Tern (fish eater). The effects on these species have been assessed on the basis of the following criteria: the conservation state, the contribution of Wadden Sea population to the total Western Palearctic population and the expected influence of Maasvlakte 2 (large, average, limited). The EcoWasp modelling results of the ‘basic scenario’ (silt –15%, nutrients –10%) have been the starting point in the assessment of effects.

This implies a more than proportional relation between nutrient concentration and shellfish biomass and a less than proportional relation between nutrient concentration and other types of food. As indicated above, there is a lack of knowledge regarding the effects of Maasvlakte 2 on transparancy and hunting of prey by diving, fish eating birds.

Negative effects on species

Little Tern. The Little Tern predominantly forages in the tidal inlets of the Wadden Sea, in the direct vicinity of their breeding grounds. Their food mostly consists of sand eels and (young) herring, but includes other small fish (e.g. flat fish) as well. Due to their shallow diving habits, a (small) change in transparency will probably not have any effect. The supply of young herring, sprat and young flatfish however, probably will have an effect. A (limited) decrease in the supply of fish larvae to the Wadden Sea, possibly in combination with a diminished productivity (growth) of young fish, can have an impact on the quantity of food of the right size and subsequently on the numbers of Little Tern. Based on expert judgement, it is expected that the effect on sand eels and herring will be marginal. A possible effect on the Little Tern population cannot be discounted however, as long as it is not clear whether or not the quantity of appropriate animals of prey is affected by the Maasvlakte 2 project[7].

Red Knot. A decreased supply of nutrients to the Wadden Sea will probably have an impact on the shellfish stock and the related food availability for the Red Knot. The Red Knot travels large distances to find food in specific locations. It is safe to conclude therefore that food concentration is of importance. The effect on shellfish will therefore have an impact on the numbers of Red Knot.

Oystercatcher. A decreased supply of nutrients to the Wadden Sea will probably have an impact on the shell fish stock and, subsequently, on the numbers of Oystercatchers. Effects of a possibly decreased food supply due to Maasvlakte 2 cannot be discounted for this species, as the condition and survival of Oystercatchers (and thus their numbers) are verifiably limited by food availability in the Wadden Sea Area. Effects of Maasvlakte 2 can be discounted if it is made clear that the quantity of shellfish stock is not negatively affected by the project.

Common Eider. A decreased supply of nutrients to the Wadden Sea will probably have an impact on the shell fish stock and, subsequently on the numbers of Common Eider. Effects of a possibly decreased food supply (sublittoral cockles, mussels and *Spisula*) due to Maasvlakte 2 cannot be discounted for this species, as the condition and survival of Common Eiders (and thus their numbers) are verifiably limited by food availability on the Wadden Sea Area. Effects of Maasvlakte 2 can be discounted if it is made clear that the quantity of shellfish stock is not negatively affected by the project.

[7] Recent model results by WL and RIVO show that only marginal effects on the supply of young Plaice can be expected.

Diving fish-eating birds. This group consists of the various tern species as well as the Grebes and divers that forage along the Dutch coast. As a result of (the presence of) Maasvlakte 2, changes in the concentrations and spatial distribution of silt in the North Sea coastal zone and Wadden Sea can be expected: the North Sea will on average become slightly more transparent close to the coast (0-5 km) and the North Sea further away from the coast will become very slightly less transparent. Within the Wadden Sea the transparency will slightly increase. For the North Sea this will result in the narrowing of the entire transition zone between the cloudiness (surf) and further out at sea (5 km from the coast) by several hundred metres. The (average) impacts on the transparency will be more obvious in the winter than in the spring and summer because then the impact of a decrease in concentrations of suspended particles will be partially counteracted by an increase in primary production.
There is a lack of knowledge regarding the effects of a (possible) change in transparency on the ability of fish-eating birds to catch their preys. However, it seems unlikely that the changes in transparency will lead to adverse effects on fish-eating birds because (1) terns do not appear to be less successful in catching their prey with increasing transparency, and (2) the overall size of the potential foraging area with a particular transparency for the other fish-eating species (grebes and divers) – for which information like this is not available - does not appear to decrease substantially.

CONTENTS

1 INTRODUCTION

1.1 Background

1.1.1 Port of Rotterdam expansion: Maasvlakte 2

The Rotterdam Mainport Development Project provides for both the expansion of the current port and industrial zone and for an improvement of the living environment in the region (twin objectives). The planned expansion of the port of Rotterdam, Maasvlakte 2, is located on the sea side of the current Maasvlakte. Both the current Maasvlakte and the planned expansion of it are land reclamations in the coastal zone between the Hook of Holland and Voorne. The new port and industrial zone comprises a 1000-hectare net industrial zone for deep-sea related customers in the chemical, new industrial and container handling sectors, plus the accompanying distribution activities. In the current design the access to the land reclamation for sea and inland shipping is achieved by expanding and widening the present Yangtze dock in the Maasvlakte (Figure 1-1).

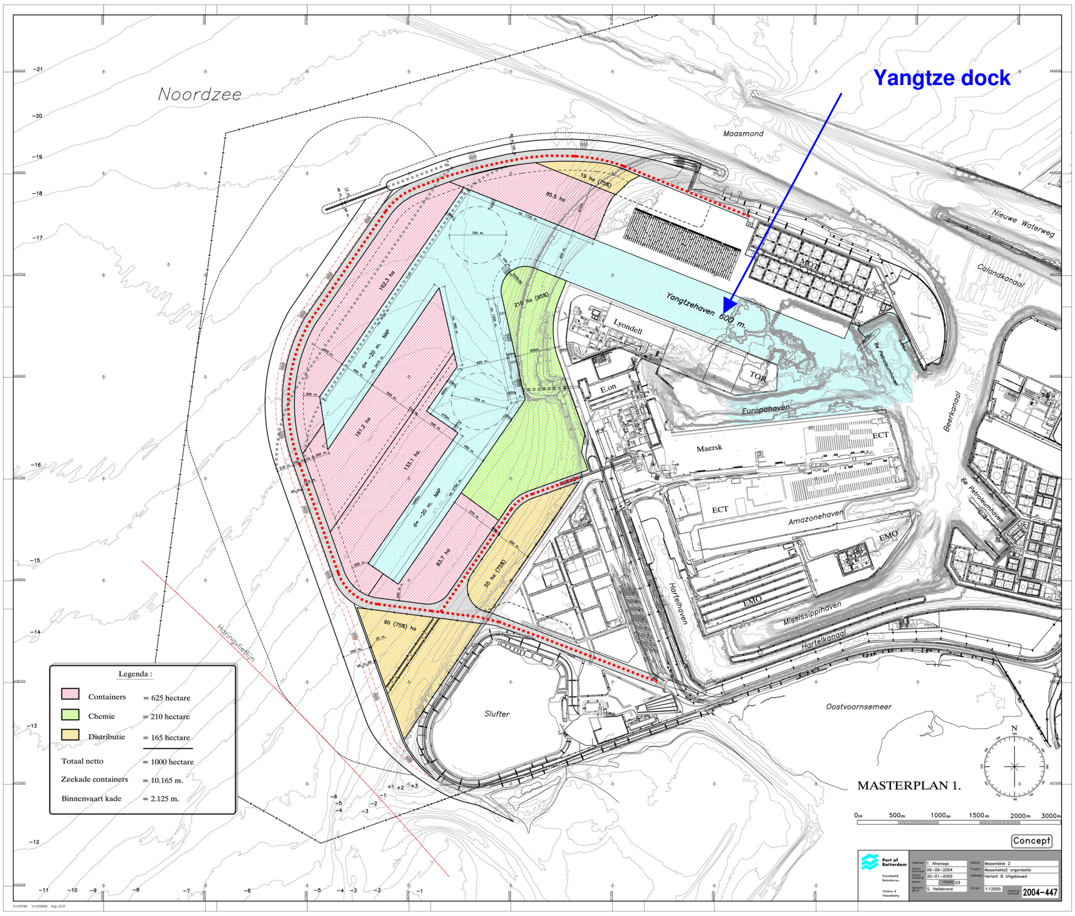


Figure 1-1 Design for Maasvlakte 2 ('cut-through alternative')

1.1.2 Amendment to the PKB-plus for the Rotterdam Mainport Development Project

In January 2005 the Council of State (Raad van State) set aside the material policy decisions (CBBs) in the PKB-plus[8] for the Rotterdam Mainport Development Project. The material policy decisions are parts of planning decisions that have to be observed in further decision-making by lower public authorities, such as the adoption of zoning plans. Although the PKB itself is not affected by the setting aside of the material policy decisions, and hence it represents government policy, the implementation of the various parts of the project has as a consequence become less certain.

In response to the statement by the Council of State, the PMR partners[9] decided to rectify the material policy decisions in the PKB-plus, which forms the starting point of the government's expressed position in PKB-plus part 3. The opportunity for discussion will be offered once again. The procedure is aimed at achieving better cohesion between the various PMR components and implementation as quickly as possible. There is considerable support for the rectification of the material policy decisions by the PMR partners and the civil society organizations consulted in the Rijnmond region. The unaltered point of departure is that the repair should be done carefully and as quickly as possible.

1.1.3 Wadden Sea Appropriate Assessment

One of the reasons for the Council of State to set aside the material policy decisions was that no satisfactory case had been made that the building of Maasvlakte 2 would have no impact on the ecological values of the Wadden Sea, a Natura 2000 area protected by the Birds and Habitat Directives. Part of the revision of PKB-plus is therefore the drawing up of an Appropriate Assessment, in other words an appraisal of the impact of the construction of Maasvlakte 2 on the Wadden Sea in terms of the Birds and Habitat Directives. A number of clearly specified steps must be taken for this research (see Chapter 2).

1.1.4 PKB-plus Reference alternatives and the Cut-through alternative

The opinion of the Council of State is based on the Reference designs for the land reclamation in the PKB-plus. In the interim, advances in understanding have meant that the design has been changed and the basis is now the so-called Cut-through variant[10]. This design is in a sense similar to Reference design 1 in the PKB-plus, in which the dock entrance also goes through the existing Yangtze dock. The difference is that the Cut-through variant protrudes less far out to sea and has a smaller surface area. Furthermore the shape of the coastline is designed in such a way that the flow pattern of the sea is affected as little as possible. Because of this the expectation is that the possible impact on the Wadden Sea will be considerably smaller than with the Reference alternatives.

[8] PKB = Key Planning Decision taken by the government. This decision makes the implementation of Maasvlakte 2 possible.

[9] The PMR partners are central government, the Port of Rotterdam Authority , the City of Rotterdam, the greater urban area of Rotterdam and the Province of South Holland.

[10] The term 'Cut-through' refers to the access to the new dock which goes through the existing Yangtze dock from the land side and protrudes through the sea defence (see Figure 1-1).

The Cut-through variant is being developed further by the Port of Rotterdam Authority, which is preparing the Maasvlakte 2 Environmental Impact Statement (EIS Construction) at this moment. This will contain a comparison between the Cut-through variant and the Reference designs in the PKB-plus.

1.1.5 Research into the impact of Maasvlakte 2 on the Wadden Sea

The government and the Rotterdam Port Authority are working together on the revision of the material policy decisions on the Wadden Sea in the PKB-plus and the research into the effects of Maasvlakte 2 on the Wadden Sea that this will necessitate. The results of the research not only serve for the reinstatement of the PKB-plus (with the help of the Appropriate Assessment), they also contribute to a satisfactory settlement of the EIS Maasvlakte 2 Construction and in this way to the procedures involved in granting the required concessions for land reclamation and sand extraction. The National Institute for Coastal and Marine Management (RIKZ) from the Ministry of Transport, Public Works and Water Management, represents the Government while the Maasvlakte 2 Project Organization (www.maasvlakte2.com) represents the Rotterdam Port Authority.

1.1.6 Consortium 3|MV2

In order to carry out the necessary research, the Rotterdam Port Authority and RWS / RIKZ have set up the 3|MV2 consortium. This consortium is lead by Royal Haskoning, who is also heads the Maasvlakte 2 EIS construction consortium. In this EIS, the work for which started in October 2004, the impact of Maasvlakte 2 on the coastal river and the Wadden Sea was already a subject for further study (planned for the spring of 2005), but much less detailed. As a result of the statement by the Council of State, the EIS consortium carried out research into this subject in February 2005. Among other things this has led to the research presented in this report.

1.2 Problem and aim

The expansion of the Maasvlakte has direct and possibly indirect implications for the physical and ecological system. In direct terms, the land reclamation will bring about changes to the flow and wave patterns around the expanded Maasvlakte. Given the proximity of the discharge of the Rhine into the North Sea, the land reclamation also has implications for the fresh water plume (hereafter referred to as the coastal river), which flows along the Dutch coast to the north. Changes in the coastal river also lead to changes in the transport of silt, nutrients and fish larvae around the Maasvlakte and along the Dutch coast, which can ultimately create impacts on the Wadden Sea and the North Sea coastal zone. Furthermore the expansion has possible impacts on the morphology of the area around the Maasvlakte.

The (large scale) sand extraction in the North Sea needed for the construction of Maasvlakte 2 also has implications for the system. Sand extraction releases silt that can be displaced by the currents over large distances. More silt in the water column has an impact on the transparency of the water and with it the primary production. The presence of pits can also have an impact on the currents and consequently on the transport of silt, nutrients and fish larvae along the coast. Possible changes in this do not stand in isolation but can have implications for the food chain in the ecosystem.

Indirectly changes in these parameters can have implications for birds and fish in the North Sea and the Wadden Sea.
The aim of the research is to answer the following questions:

- How do the primary abiotic factors, which are influenced by the land reclamation, relate to the natural values of the Wadden Sea and North Sea coastal zone that have to be protected under the terms of the Birds and Habitats Directives?
- Which of these values that have to be protected may be negatively affected by the land reclamation?

and finally:

- To what extent can it be expected that the land reclamation will have a (significant) negative impact on the favourable state of conservation of the Wadden Sea and North Sea Coastal Zone Natura 2000 areas??

1.3 Approach

1.3.1 Research along two tracks

The work on the research into the effects of the construction and existence of Maasvlakte 2 is being carried out along two tracks:

- Track 1[11], in which detailed research models are used to describe the primary effects of Maasvlakte 2 on the transport of silt, nutrients and fish larvae. The emphasis of the research is on quantifying the effects in the North Sea, North Sea coastal zone and the western Wadden Sea. Use is made in the research of the best available knowledge, updated results from earlier comparable studies (e.g. Flyland) and existing models, but new elements are also being developed for the set of models.
- Track 2, in which all the information for the actual appropriate assessment is collected. This is being done via a top-down approach in which, working on the basis of the criteria that are important in terms of the Birds and Habitats Directives (and therefore important for the appropriate assessment) are reasoned back to the primary factors, examined in track 1, which could possibly be influenced by the construction of the second Maasvlakte. In track 2 the emphasis lies on collecting and organizing information which is necessary to enable the assessment of any possible impact of Maasvlakte 2 on the favourable state of conservation of the Wadden Sea and North Sea Coastal Zone VHR areas.

The two tracks are closely related to each other and are variously cross connected, but do have different aims and plans. An initial ‘Draft Description of the Effects of Maasvlakte 2 on the Wadden Sea and the North Sea Coastal Zone’ was ready on 1 July 2005, based on the partly reanalyzed data (EIS-PKB MV2, Flyland, EVAII etc.). The first results from track 1 are expected during the summer of 2005. These can be used for a further quantification of the effects of various Maasvlakte 2 variants and fine-tuning of the conclusions in track 2 based on earlier research.

[11] Track 1, because this part of the research was started earlier than the actual appropriate assessment.

1.3.2 Experts' input

A fairly large group of experts in the field of the ecology and nature values of the Wadden Sea are involved in the research for the appropriate assessment (see Appendix 1a). They are consulted in three workshops, and when it was necessary, they were contacted on individual basis.
In addition to the above group of experts that was closely involved with the research, an appeal was made to a number of international experts for external quality assurance (see Appendix 1b). They were consulted at the start of the project (Comments Audit panel dated 03 06 2005) and will be commenting on the various end products.

To conclude, the client has created two support groups (one for each track), which support those carrying out the research in various ways (brainstorming, delineation, consultation). There have representatives from the RIKZ, the Rotterdam Port Authority and the Consortium in these groups (see Appendix 2c).

1.4 Status report

The research on which this report is based has led to the answers to the first two questions posed in 1.2. In addition the last question ' to what extent can negative impacts be expected from Maasvlakte 2 ' is also examined in this report. For the actual appropriate assessment the RIKZ is drawing up a separate document which will combine information from various sources, including the most recent results from 'track 1' and this report.

2 ASSESSMENT FRAMEWORK

2.1 Assessment framework of Article 6 of the Birds and Habitats Directives and Appropriate Assessment

2.1.1 Outlines

A number of precisely defined steps have to be taken when analyzing ecological factors in regard to writing up of a plan or project in which designated or proposed Birds and Habitats Directives areas are involved. They are defined in article 6, paragraphs 3 and 4 of the Birds and Habitats Directives (EC, 1992). An explanation of these steps and their implementation is given in EC (2001). It states that the following questions have to be answered in the following sequence (Figure 2-1 Assessment framework for a plan or project according to Article 6 of the Habitats Directive

1. *Screening:* Identifying possible impacts of the plan or project on Natura 2000 areas separately or in combination with other plans/projects (cumulative effects). Is it possible that the impacts are significant or not? If the answer is in the affirmative, an appropriate assessment must be carried out (step 2)
2. *Appropriate assessment*. Determining the implications of the impacts identified in the previous step on the integrity of the Natura 2000 area concerned, whereby account must be taken of the structure and functioning of the system and the conservation objectives in regard to the area concerned (favourable conservation status). If a negative impact can be expected, it must be determined whether this impact can be mitigated (softened). If this is found to be possible, one can approach the competent authorities, who may grant authorization for the project on the grounds of the detailed reporting that has been handed over. If this is not the case and if there is therefore a significant remaining impact, the next step comes into play.
3. *Investigation of alternatives*. Are there alternatives for achieving the goal of the plan or project that can avoid a negative impact on the Natura 2000 area? If no alternatives exist for the project, the competent authorities will not grant authorization for the project.
4. *Determining interest and compensatory measures*. Compensatory measures are defined in the event that significant impacts remain and there are imperative reasons of overriding public interest to carry out the project or plan. If this cannot be sufficiently substantiated or if it cannot be demonstrated that the proposed compensatory measures assure adequate and timely compensation for the harm, authorization for the project will not be granted. If this can be substantiated, the project may be granted authorization. The EC must be asked for advice during this step if key species or habitats are involved. In the other cases the EC has to be informed.

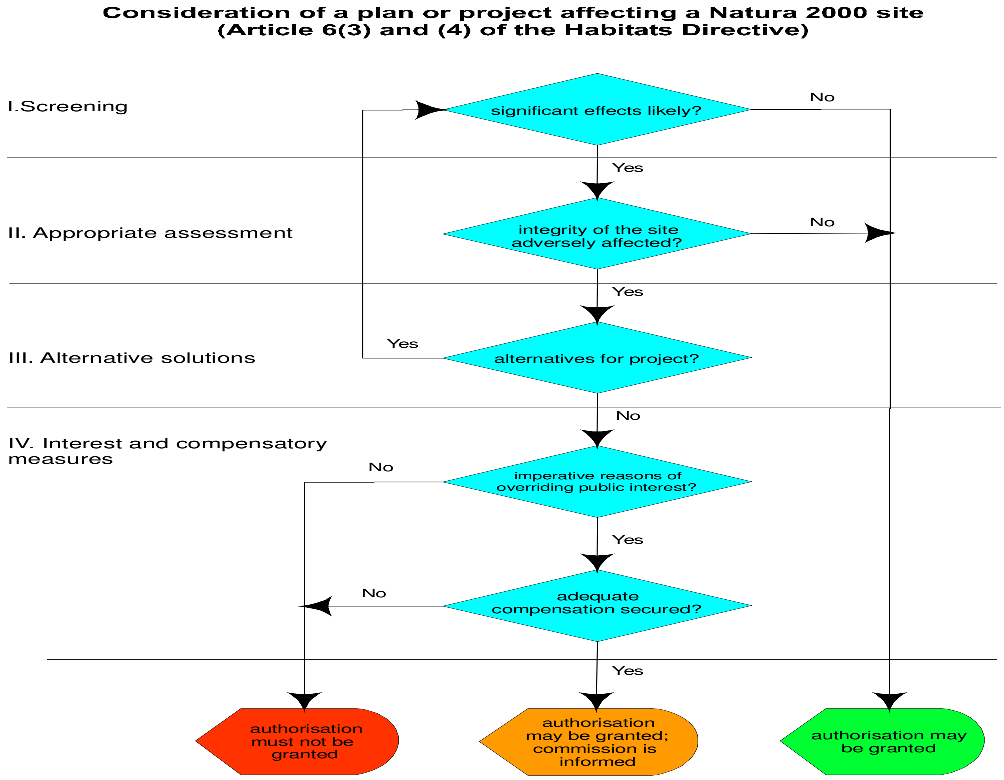


Figure 2-1 Assessment framework for a plan or project according to Article 6 of the Habitats Directive

2.1.2 Screening and identifying the possible significance of the impacts

The concept "significant" needs to be given an objective definition. EC (2001) explains how to determine the significance of an impact and how to report it. Illustration is provided in the form of examples, which make it clear that every area has its own characteristics. Something that is applicable to one area therefore does not necessarily apply to another area. EC (2000) quotes the following example: “The loss of 100 m^2 of habitat can be significant in the case of a small station occupied by rare orchids, but insignificant in the case of a vast steppe.”
There is a worked example in EC (2001) that describes which steps have been taken in substantiating whether or not the impact is significant (an appendix to the EC document contains an empty matrix for the screening and the determination of the possible significance of the impact).

1. Brief description of the project, the Natura 2000 area and the elements in the project through which the Natura 2000 area will be affected;
2. Description of the elements of the plan or project, separately or in combination with other projects or plans (cumulative effects)[12] that could have an effect on the Natura 2000 area;

[12] Use can be made of the step-by-step plan in EC (2001) (Box 2 on page 19) in order to determine whether cumulative effects of other plans or projects in combination with the plan or project that is the subject of study are to be expected. The essence of this is that account must be taken of other proposed plans or projects that have an impact in the Natura 2000 area concerned. If it cannot be excluded that any cumulative effects are significant, these effects must be incorporated in the next step (the appropriate assessment).

3. Direct and indirect (or secondary) abiotic effects of the project: take for example such aspects as changes in land use, emissions, land reclamation, dredging, and duration of the construction.
4. Description of the effects of these abiotic changes on biotic characteristics, such as loss of habitat, disturbance of key species, fragmentation, decrease in densities of species and some further general parameters such as water quality and climate.
5. Quantification of the effects and the definition of indicators in order to show the significance of the effects: examples are percentage loss of habitat, extent to which the population of certain species declines temporarily or permanently, and degree of fragmentation.
6. A determination can then be made of whether these effects are significant. The precautionary principle is used in the assessment. If it cannot be convincingly demonstrated that the impacts are not significant, it has to be assumed that they are significant ("Describe …where the above impacts are likely to be significant or where the scale of impacts is not known"). Establishing that a project may not be significant calls for a thorough investigation of its effects. An indication also has to be given of the reliability of the pronouncements. Consulting outside experts can give the pronouncement further underpinning.

There are no calculation rules available for determining whether an effect has to be considered as significant or not. However, a number of examples of criteria to be employed are described on the basis of the case studies (EC, 2001):

- Loss of or change in habitat: % loss within a Natura 2000 area compared with the total area of the habitat type concerned in the member state. In this case a loss of 1% was deemed to be significant because the area of the habitat type concerned was decreasing on a national scale. This case involved building a road.
- In another case, where no direct loss of habitat was created as a consequence of the project, an analysis was made of the relationships between species and habitats and in what periods of the year they were disrupted most.
- In the third example ('water resource developments in semi-arid land') there was an investigation into decreases in bird populations, the probability of species dying out and the disappearance of protected wetlands.

2.1.3 Appropriate assessment

If it has emerged in the previous step that significant impacts of the plan or project, in combination with other projects or plans (cumulative effects) or otherwise, can be expected or cannot be ruled out, an appropriate assessment must be carried out. (This is also referred to as the habitat test.) It is based on a sound prediction of the impact in which all direct and indirect effects are quantified. As is shown by the description of this step in EC (2001), in fact it calls for answering the same questions as in the screening phase, but tougher requirements are set in regard to the quality of the impact prediction. References are also made to the collection of supplementary information through, among other things, conducting field studies in the event that gaps in knowledge have been observed.

In addition to the results of direct measurements, great importance is attached in regard to actual impact prediction to setting up intervention impact chains in order to make it clear how the direct effects are the cause of indirect (secondary, tertiary etc.) effects. Model calculations play an important part in quantifying the effects. It is moreover recommended that use should be made of GIS (in order to clarify spatial relationships), information from comparable projects implemented in the past (in which predictions were verified on the basis of monitoring) and expert opinions.

The predicted impacts are then compared with the conservation objectives for the Natura 2000 area concerned. This involves:
- a description of the effects of the project or plan on species and habitats in the Natura 2000 area;
- a description of the way in which the conservation objectives and the structure and functioning of the area will be affected (for example on the basis of loss of habitat, disruption, damage, and chemical, hydrological and geological changes)[13];
- a description of mitigating measures as a result of which the negative impacts that have been described can be avoided or reduced.

Any uncertainties and gaps in knowledge must be identified in all three parts.

2.1.4 Compensation

Compensatory measures must be taken in the event that significant impacts remain despite the implementation of mitigating measures and there are imperative reasons of overriding public interest to carry out the project or plan.
Requirements are set in regard to the compensatory measures (EC, 2001):
- Damaged species and habitats must be restored in equal quantities in regard to what has been lost (1:1 compensation);
- Compensation must take place in the same biogeographical region where the damage occurs;
- Functions that are lost as a result of the plan/project must be restored through the compensation;
- There must be guarantees that the compensation plan will also really be put into effect (in a timely way) (implementation and management objectives) so that the conservation of the Natura 2000 network is assured.

2.2 Conservation objectives of the Wadden Sea area[14]

Currently the Dutch Ministry of Agriculture, Nature Management and Fisheries is working on the formal designation of the registered areas of conservation under the Habitats Directive by means of a designation Decree and to amend the Birds Directive. To this end a revised set of qualifying habitat types and qualities and qualifying bird species with the associated standards information were sent to the European Commission in the spring of 2004.

[13] The absence of conservation objectives can be a problem here. An interpretation of one's own can be given on the basis of the notification and instructional documentation in order not to impede the progress of a plan or project.

[14] The text of this section is based on the note of 24 May 2005 from the Ministry of Agriculture, Nature Management and Fisheries for the Interdepartemental Wadden Sea Committee (as a result of ministerial consultations on 22 April 2005).

This list of species and habitat types forms the basis for the conservation objectives for areas under the Birds and Habitats Directives in the Netherlands. It is expected that the final conservation objectives will be published in the course of 2006 after an extensive series of consultations.

The Ministry of Agriculture, Nature Management and Food Quality has drawn up provisional conservation objectives for the Wadden Sea for the purposes of the appropriate assessment of the key planning decision (PKB) Third Wadden Sea Policy Document part 3. The Ministers present from the Ministry of Agriculture, Nature Management and Food Quality, Ministry of Housing, Spatial Planning and the Environment, Ministry of Economic Affairs, Ministry of the Interior and Kingdom Relations and Ministry of Finance and the State Secretary of Transport, Public Works and Water Management agreed with these provisional conservation objectives in the ministerial consultations on 22 April 2005. The Ministry of Agriculture, Nature Management and Food Quality considers the risk that the final conservation objectives will depart from the provisional ones to be limited.

The text of the provisional conservation objectives for the Wadden Sea key planning decision (PKB) area is based on the designation Decrees of the Wadden Sea as a Birds Directive area and national nature reserve and on the main objective of the key planning decision (PKB) Third Wadden Sea Policy Document part 3. The text, a generally formulated, qualitative conservation objective, relates more specifically to maintaining a favourable status of the ecological requirements for the qualifying species of birds and qualifying habitat types and qualities that were listed in the information that was sent to the European Commission in the spring of 2004.

The following aspects apply to the Wadden Sea area as a general qualitative conservation objective arising out of the Birds and Habitats Directives:

"The policy and management with regard to the provisional conservation objectives with regard to the Wadden Sea are aimed at sustainable protection and development of the Wadden Sea as an area of natural beauty on which the influence of humans must be limited for maintaining or restoring a favourable conservation status for the structures, species, plants and animals that are qualified under the Birds and Habitats Directives for the Wadden Sea. The policy and management are also aimed at sustainable protection and the most natural possible development among other things, water movements and the associated geomorphological, soil and hydrological processes, the quality of the water, soil and air as well as the onshore and offshore flora and fauna, including the feeding, breeding and resting areas of birds."

The finalization of the general, qualitative main conservation objective given above has yet to take place. This also applies to the more concrete (quantitative) conservation objectives aimed at specific species and habitat types that arise out of it.

2.3 Assessment framework for Wadden Sea area Birds and Habitats Directives areas

Draft assessment frameworks for the Birds and Habitats Directives areas in the Wadden Sea have recently been drawn up. They also address in greater detail the qualitative conservation objective stated in 2.2 regarding to the relevant habitat types and species (Ministry of Agriculture, Nature Management and Fisheries DRZ-Noord, 2005a and b). The assessment framework consists of a number of parts:

- Assessment criteria for birds, habitat types and habitat species (see Table 2.1 Criteria for assessment in terms of conservation objectives in Birds and Habitats Directives areas)
- A table of scores for each species and habitat type with the results of the assessment in terms of the criteria (very unfavourable, unfavourable, moderately favourable or favourable)
- A significance standard for each species and habitat type. The scores attained determine how the significance of any damage will be assessed: the worse the scores, the harsher the assessment. In a 'harsh' assessment, for example, any decrease in the area of a habitat type or the population of a species in the Habitats Directive area concerned is assessed as being 'significant', whereas in the case of a 'generous' assessment a decrease is only deemed to be 'significant' if it is over 5% . The 'average' assessment is between the other two at 2%. It should be pointed out that there can be a departure from the designated significance standard in the assessment of a plan or project should the case arise.

Table 2.1 Criteria for assessment in terms of conservation objectives in Birds and Habitats Directives areas

assessment criterion	habitat types	habitat species	bird species
conservation status, determined by:	x	x	x
dispersion	x	x	x
surface area or population	x	x	x
typical species	x	NA	NA
structure and function	x	NA	NA
habitat	NA	x	x
future prospects or autonomous development	x	x	x
priority habitat type or priority species	x	x	x

In the meantime draft conservation objectives for all Natura 2000 areas in the Netherlands have been published together with documents for every species and habitat type (July 2005). The assessment criteria they contain agree in broad terms with the criteria of the assessment framework described above. However, the lists of qualifying and other relevant species and habitat types for the Wadden Sea and the North Sea somewhat differ from the lists used in earlier versions of this report, which were perused via www.lnv.nl. The final report is based on the lists used earlier, supplemented by a number of species from a later list that was distributed by the Ministry of Agriculture, Nature Management and Food Quality to the members of the Interdepartmental Wadden Sea Committee. A list of the species and habitat types taken into consideration is to be found in appendix 2.

3 POSSIBLE IMPACTS OF MV2 ON THE TRANSPORT OF SILT, NUTRIENTS AND FISH LARVAE

3.1 General

The construction of Maasvlakte 2 involves two main activities: the extraction of sand in the North Sea and land reclamation opposite the entrance to the Port of Rotterdam. As well as all kinds of autonomous developments (such as the sea level rise), these activities will have an impact on the surrounding water system (see Figure 3-1). The *land reclamation* alters the pattern of water flow in the vicinity of the land reclamed and in so doing also affects the transport of floating and dissolved substances such as silt, nutrients, phytoplankton and fish larvae. The *sand extraction* temporarily increases the silt content in the water as a result of the dredging process. The change to the seabed at the sand extraction location also alters the pattern of water flow, but this is such a local phenomenon that it is not relevant to the Wadden Sea. The expected effects on water levels as a result of land reclamation and sand extraction are less than a centimetre and play no further part; they will not cause any alteration in tidal amplitude. Similarly, the existence of Maasvlakte 2 is not expected to have the effect of causing changes in sand transport in the Wadden Sea area (van Ledden, 2005).

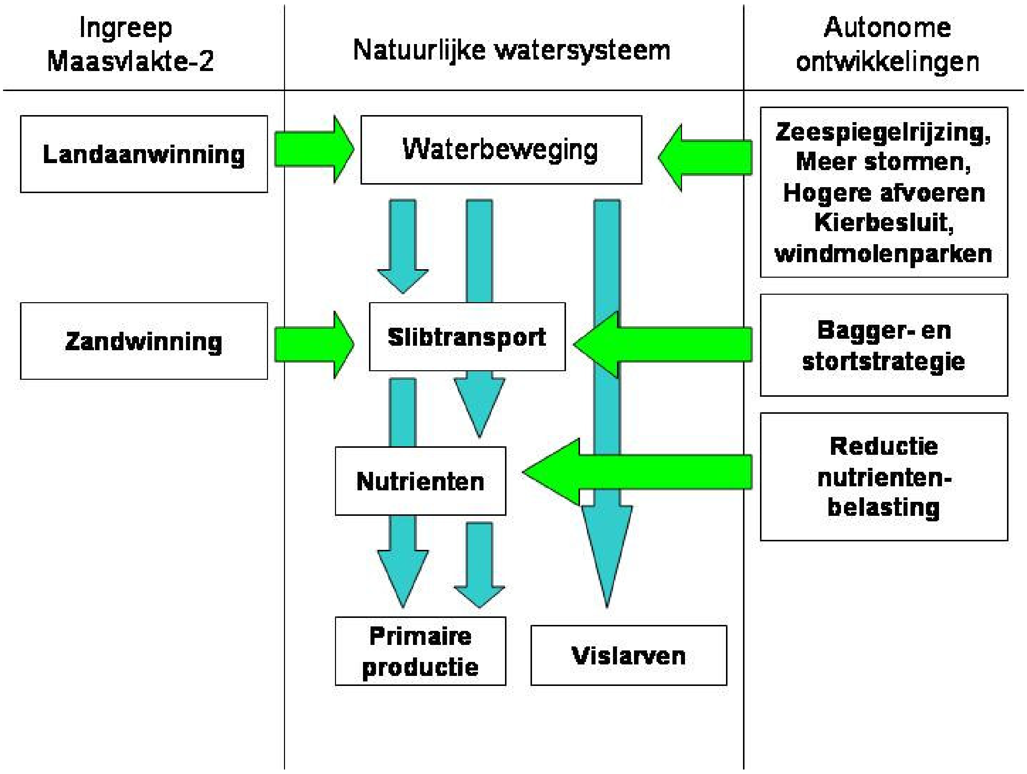


Figure 3-1 Relationships between the interference of Maasvlakte 2 and the natural water system. The autonomous developments that have an impact on the natural system are also shown.

The impact of the land reclamation on the flow, however, *is* important. The impact of the land reclamation on local pattern of water flow and particularly on local residual flows brings about a different distribution of the fresh water flowing from the New Waterway and the Haringvliet. This affects transport in a northerly direction but in a relatively narrow zone along the coast (the ‘coastal river’) in the direction of the Wadden Sea.

Because of this further impacts are created on a larger scale. The coastal river transports fresh water, silt, nutrients (dissolved and particulate), algae, contaminated substances and living organisms from the Rhine, part of which subsequently arrives in the Wadden Sea. The possible impacts will occur primarily in the western Wadden Sea. The eastern Wadden Sea is less affected by the coastal river, but more by the North Sea. As far as living organisms are concerned, these are organisms that are dependent on passive transport. This applies for the most part to fish larvae.

Changes in the quantity and transport of silt, nutrients and fish larvae along the Dutch coast in the direction of the Wadden Sea can have implications for certain habitats and species in the Wadden Sea. The quantification of these changes is therefore important in assessing their impacts on the protected habitats and species in the Wadden Sea.

This chapter summarizes the most important information for the track 2 research by van Ledden (2005). It contains an account of the results of earlier research on the transport of silt, nutrients and fish larvae along the Dutch coast (3.2) and a description of the current research, the results of which will be produced in the autumn of 2005 (0).

3.2 Results of earlier studies (including Flyland)

3.2.1 Introduction

Over the last few years detailed research has been carried out into the possible impacts of major infrastructural works on the surrounding coastal system and the coastal river in particular. This research has mainly been undertaken in the framework of the Key Planning Decision (PKB) for the Maasvlakte, but also in the framework of the research into the possibility of a new airport in the North Sea ('Flyland'). Furthermore in general terms research has been done into the behaviour of silt, nutrients and fish larvae along the Dutch coast and in the Wadden Sea. This includes several research projects at different universities, and research by the various institutes (WL|Delft Hydraulics, RIVO, Alterra, NIOZ, RIKZ) in the Netherlands.

This paragraph contains a brief survey of the results of earlier research on silt, nutrients and fish larvae moving in the direction of the Wadden Sea in relation to Maasvlakte 2. In view of the volume of the literature and the present constraints of space, it is not possible to give a full overview here. Only the most relevant issues, which are considered specific to the situation around Maasvlakte 2 in relation to the Wadden Sea, are dealt with in this report. This paragraph deals firstly with water levels, silt, nutrients and fish larvae individually. The concluding paragraph is in an overview and gives an indication of scenarios with expected impacts based on the current available knowledge.

3.2.2 Movement of water and the coastal river

The behaviour of the coastal river along the Dutch coast is referred to in literature as the 'river plume' (Van Alphen et al., 1988; McClimans, 1988; Simpson and Souza, 1995). This behaviour is caused by the interaction between the differences in density of fresh water and density of seawater and the rotation of the Earth. This is and is usually three-dimensional in nature. River plumes are divided into 'near-field' and 'far-field' zones in which different processes and time scales are of importance.

The near-field zone is limited to an area with a radius of about 10 km round the point of discharge of the fresh water from the Rhine and is distinguished by an almost permanent salt stratification. The far-field zone runs roughly from the top of Schouwen to beyond Den Helder and is characterized by the presence of cross-shore salinity gradients, which in conjunction with the rotation of the Earth, bring about a typical coast-related residual flow pattern (see de Kok, 1994 et al). The dimensions of the far-field zone are dependent on wind and the output of the Rhine and are 20 – 30 km for the width and 100 – 150 km for the length. The water from the Rhine and the Maas ultimately flows north, but sometimes moves temporarily to the southwest. In certain circumstances it can reach the mouth of the Westerschelde and be found off the Flemish coast.

An important feature of a river plume is the vertical difference in residual current direction in the water column. Close to the surface of the water the residual current is directed roughly northwards parallel to the coastline, but with a cross-coast component directed away from the coast. Close to the bottom the residual current has a crosswise component in the direction of the coast. This has significant consequences for the silt, which attains its highest concentration at the bottom. Because of this the silt is trapped in a relatively narrow band with high concentrations along the coast. Some of the nutrients are carried along with the silt. In addition some species of fish larvae make convenient use of the residual currents in the direction of the coast in order to enable them to reach suitable nursery areas.

In addition to the North Sea current, waves also have an effect on the behaviour of dissolved and floating substances moving in the direction of the Wadden Sea. The effect of waves is particularly important on the near coastal zone because of the relatively shallowness of the water. It shows itself in two ways, on the one hand there is increased shear stress on the seabed as a result of the waves, and on the other there is wave-driven transport of water in the near coastal zone, and with it the dissolved and floating substances as well.

In short, the impact of land reclamation on the behaviour of the water can be described as follows (see also Figure 3-1). The expansion of the Maasvlakte broadens the near-field zone of the river plume. The geometry of the estuary area means that this goes hand in hand with a stronger horizontal mixing with the surrounding seawater. Because of this the cross-shore salinity gradients decrease, in both the near-field and far-field zones, resulting in a decrease, in the entire Rhine plume, of residual currents close to the bottom and directed towards the coast. The residual current at the surface directed along the coast also becomes smaller, because this is in geostrophic equilibrium with the cross-shore density gradients. The effects described are in line with calculations from earlier impact studies for Maasvlakte 2.

3.1.3 Silt transport in the Dutch coastal zone

To a great degree the supply of silt along the Dutch coast is driven by the northward residual flow through the English Channel (yearly average 50,000 – 150,000 m^3/s), and the silt coming from the Channel zone and from the Flemish coast (De Kok, 2004). To a large extent the silt remains in the water column of the North Sea, and the net silt sedimentation in the southern North Sea is extremely limited on account of the relatively high rates of flow.

Net silt sedimentation only takes place in various ports along the North Sea coast (e.g. Zeebrugge, Rotterdam) and in the estuary areas of the former inlets of the Zeeland delta (Haringvliet, Grevelingen) and in the Wadden Sea. The silt from the ports is dredged out and, to a large extent, returned to the sea, as a result of which the silt in the system remains the same.

From direct measurements and satellite images it is shown that the silt concentration in the coastal river is high (approximately 50 – 100 mg/l), while further out to sea it is around 5-10 mg/l (Suijlen & Duin, 2002). This accumulation of silt in the coastal zone is caused by the residual flow pattern of the coastal river. Close to the surface of the water the residual current has a cross-coast component directed away from the coast. Near the bottom the residual current is mainly directed towards the coast. Because most of the silt is at or close to the bottom, net silt is therefore transported to the coast and creates a relatively narrow zone with high concentrations. Along the coast the residual current and therefore also the net silt transport is directed northwards. The yearly average net silt flux along the Dutch coast is estimated at 10 - 25 million tonnes / year (De Kok, 2004).

Satellite images also indicate that the concentration of silt is extremely dependent on the seasons: in the winter with relatively severe weather conditions the concentrations of silt are higher than in the summer with relatively calm weather. The measured variations are large and vary from a few milligrammes per litre in calm conditions to hundreds of milligrammes per litre in rough conditions.

It has been calculated for the Dutch coastal zone that the wave-driven transport of silt along the coast is around two to three times as large as the wave-driven transport of silt in the breakers zone (Torenga, 2002). For the total silt flux along the Dutch coast this means that the contribution of wave-driven transport amounts to at least 10%. It is possible that this contribution could be much greater since little is known about the silt concentrations and fluxes during storms. It is in precisely in this period that the contribution of the wave-driven transport is very large.

Various projects have looked at the impact of Reference design I (GAN) and II (GAB) of Maasvlakte 2 on the silt transport along the Dutch coast and in the direction of the Wadden Sea. The studies that have been carried out produce the following picture, in a qualitative sense, with regard to the impact of Maasvlakte 2 (De Kok, 1999; Thoolen et al., 2001; Boon et al., 2001):

- The impact of Maasvlakte 2 extends over a relatively large distance along the Dutch coast to beyond Callantsoog;
- The coastal river will become wider as a consequence of the construction of Maasvlakte 2. This will result in a lower silt concentration and silt flux off the coast near Callantsoog and somewhat higher concentrations at a greater distance from the coast.

The persistence of these conclusions in the studies is all the more striking in view of the great differences in the models, calculation grids, schematizations of forces and formulations used for the transport of the silt.

The above-mentioned impacts on the silt are understandable in the light of the impacts on the movement of water (see 0). The less strong residual current in the cross-coast direction causes a decrease in the net silt transport in the direction of the coast.

This causes a reduction in the concentration of silt in the vicinity of the coast and somewhat increases it further out to sea. The changes in the cross-coastal direction have an impact on the transport lengthwise. In the zone close to the coast the transport of silt decreases, and further out to sea there is an increase.

In a quantitative sense the results of the earlier studies show a large bandwidth in the decrease in the silt flux as a result of Maasvlakte 2. The calculated decrease in the net silt flux off Callantsoog varies from 5 – 25% in these studies. It should, though, be noted that the studies concerned have different starting points with regard to the calculation grids, layouts of Maasvlakte 2 and forces. In addition the net silt flux is very sensitive to the chosen forces and representative period. The net silt flux is the difference between the gross northerly and southerly silt transport, and amounts to less than 10% of the gross transport. The relative impacts of Maasvlakte 2 on the gross transport are less than on the net transport.

3.2.4 Nutrients and primary production

At the start of the study of the airport in the sea ('Flyland') Los (2000) gave an overview of the situation at the time with regard to floating matter, nutrients and primary production and the impact of possible autonomous developments. There was also a detailed overview of the research carried out by WL on nutrients and primary production in the North Sea over the last few decades. There are many references in this report to underlying research. In more recent years the results of the Flyland study have become available (Mare, 2001a, 2001b) and model research has been carried out into the impacts of an extra means of drainage in the Afsluitdijk (WL | Delft Hydraulics, 2003) and the response of primary production and phytoplankton in the North Sea to lower supplies of nutrients from the rivers (WL | Delft Hydraulics, 2004).

In brief—unlike the silt—the rivers are the most important source of nutrients for the Dutch coastal zone, especially for the Haringvliet and the New Waterway. Between 1950 and 1980 the supply of nutrients from the rivers increased, after which the level declined because of various environmental measures. The N/P ratio has increased since 1988, because of a greater decline in phosphate levels than in nitrogen levels. In terms of order of magnitude the flow of nutrients from the IJsselmeer for the western Wadden Sea is similar to the flow from the North Sea.

In the same way as with silt, the coastal river is an important means of transport for nutrients from the rivers flowing towards the Wadden Sea. The concentrations of nutrients are higher in a narrow band along the coast. The total nutrient concentrations are roughly inverse in proportion to the salinity and because of this are highly sensitive to the mixing of the river water in the North Sea.

The seabed plays an important role in nutrient dynamics, especially in the Wadden Sea, because the bottom functions as a permanent or temporary store of nutrients. The variation in space and time of the nutrient concentration is strongly related to the primary production, which varies in the North Sea from 45 to 572 $gC.m^{-2}.j^{-1}$. In the Dutch coastal zone primary production is predominantly affected by phosphate or by the availability of light. Further from the coast, nitrogen is often limiting. Because phosphate is released from the seabed in the summer, as a general rule the limitation of phosphate decreases in the summer.

Aside from nutrients, silt concentration is a very important factor in primary production. When there is a high concentration of silt there is too little light for primary production. Close to the Dutch coast where silt concentrations are at their highest, primary production is limited by light and is therefore lower than further out from the coast. A change in silt concentration will result directly in an altered spatial and time-dependant pattern of primary production. On average primary production will probably remain the same in the North Sea, but there will be more primary production in one area and less in another.

As a result of Maasvlakte 2 the flow pattern and the transport of silt along the Dutch coast will change. Both affect primary production either because of a change in the transport of nutrients or because of altered silt concentrations. A changed N/P ratio can moreover result in a change in the composition of algae including a change in the chance of an occurrence of algal blooms.

In the framework of the Rotterdam Mainport Development Project a study has been conducted in order to quantify the above-mentioned effects (WL | Delft Hydraulics, 1999). A summary of this model study has been taken from Los (2000) and is reproduced below:

Summary ' Large scale impacts of the second Maasvlakte on nutrient and chlorophyll contents in the coastal zone' (WL|Delft Hydraulics, 1999)
In order to quantify the impacts of the construction of Maasvlakte 2 on primary production, use was made of the Generic Estuaries Model (GEM). One GEM calculation was made for the situation without Maasvlakte 2 and one calculation was made for the situation with a northerly variant of Maasvlakte 2 protruding further into the sea by about 5.5 km than the existing Maasvlakte. Both calculations assumed a modified drainage programme from the Haringvliet locks; the so-called Getemd Getij (Tamed Tide) programme. The movement of the water and the silt patterns were calculated with a constant southwesterly wind of 7 m/s (4 on the Beaufort Scale). For each calculation a complete annual cycle was carried out, in which the temperature, amount of light, supply of nutrients and size of the silt concentration were varied. During the annual cycle the hydrodynamics were repeated unchanged in every tidal period and the horizontal silt concentration patterns remained constant.

It appears from this model study that, as a result of the changed flow regime, the silt and nutrients concentrations decrease in a strip approximately 15 km wide. Within a few kilometres of the coast the percentage decreases for the coast of South-Holland amount to more than 40 % for both silt and nutrients, and for the coast of North-Holland near Callantsoog around 30 % for silt and around 5 % for nutrients. Since the combined carriage of material from the New Waterway and the Haringvliet remains unaltered, a small increase in concentration takes place outside the 15 kilometre coastal strip, particularly for nutrients.

More recent calculations with the Flyland range of instruments gives a decrease of 0 – 15% of nutrients in the direction of the Wadden Sea if the Maasvlakte expansion goes ahead. This relates to Reference design II (GAB), which according to model studies from 2005 has a much greater impact than the Cut-through variant. The impact on nutrients is caused to an important degree by the change in silt percentages. This result shows that the construction of Maasvlakte 2 can have a considerable impact on the phytoplankton biomass and composition of species in the immediate coastal zone.

3.2.5 Fish larvae

Asjes et al. (2004) gave a detailed summary of the transport of fish larvae in the North Sea in general and the possible influence of Maasvlakte 2 in particular. There are many references to underlying research results in it, and a short summary is given below. For more information refer to Asjes et al. (2004) the references contained in it.

The coastal zone of the North Sea and the Wadden Sea are known for their essential roles as growing areas for flatfish such as sole and plaice. In these shallow areas there are large resources of food and a relatively protected environment. In some years the Dutch coastal zone also plays an important role as a growing area for young herring (Dickey-Collas, 2005). The spawning grounds of these species of fish are in the deeper parts of the North Sea and the Channel. The transport of eggs and larvae from the spawning grounds to the ‘nurseries’ takes place because of the current. The residual circulations in the North Sea as a result of the tide are crucial to this. Along the Dutch coast the coastal river not only plays an important role in the transport of silt and nutrients, but also especially for the transport of young flatfish in the direction of the Wadden Sea. Young specimens of these and other species of fish form an important source of food for several species of birds and marine mammals. A successful recruitment to the adult populations is important for commercial fishing.

In the framework of the model study for the purpose of the Appropriate Assessment, an extensive literature survey was conducted very recently into herring as the underpinning for the model for herring larvae (Dicky-Collas, 2005). The following text is taken from this report and gives a summary of this literature survey. It is true that a similar literature survey has been carried out for sole and plaice, but the final report has not yet been issued.

Summary ‘Desk study on the transport of larval herring in the Southern North Sea (Downs herring)’

The current knowledge about drift patterns and the behaviour of larval herring was examined, and the Channel herring (Downs herring) and the development of a model in order to describe larval drift patterns were looked at. The Downs herring is that part of the North Sea herring population which spawns in the southern part of the North Sea and the English Channel. As a general rule larval Downs herrings drift easterly in the direction of German Bight and the Skagerrak, but this depends on the sea currents. It is possible to model the general route covered by larval Downs herring, but annual variations in it are difficult to model. In some years the larvae and post-larvae come close to the Dutch coast (data taken from surveys). The annual class strength is determined during this phase of life (metamorphosis from larva to young herring). The larvae give evidence of vertical migration during growth and begin to assemble after metamorphosis. No proof has been found in the scientific literature to the effect that specific movements of larvae are brought about by particular behaviour as a result of environmental factors such as salt content or depth. At the moment there is no work available in the literature about changes in larval drift patterns because of human intervention and the consequences of this for the productivity of Downs herring and for fishing.

The thinking behind the impact of the construction of Maasvlakte 2 in relation to fish larvae is that the flow patterns (direction and speed) and the salt gradients in the North Sea in general and the coastal river in particular will change. A distinction is made between two different effects. One the one hand current direction and the coastward component in it can change.

These changes can impact on the *quantity* of fish larvae that can reach the Wadden Sea. On the other hand the residual current speed can alter the transport of fish larvae. The speed determines the *duration* of the transport phase to the Wadden Sea and because of that the moment ('timing') when the larvae are able to reach the Wadden Sea. Changes in the salt gradients can have an impact on both the size and the duration of the transport towards the Wadden Sea.

Changes in the quantity and duration of the transport of fish larvae can collectively affect the ultimate success of the transport of larvae to the nurseries. A reduced supply of larvae to the nurseries can subsequently affect recruitment to the adult populations. With herring and plaice it has been shown that the annual class strength is determined in the egg and larval stages (Brander & Houghton, 1982; Zijlstra et al., 1982; Van der Veer et al., 2000) and that transport to the nurseries can play a role in this (Van der Veer, 1998).

At the time it was concluded in the framework of the PKB for Maasvlakte 2 on the basis of (limited) literature surveys, estimates by experts and model calculations which only assume passive transport, that the impact of Maasvlakte 2 on the transport of fish larvae would be limited (Hoogeboom et al., 1999; Lanters and Jansen, 1999). The set of models used then still had many shortcomings, however, to such an extent that it must be concluded that the possible impacts of Maasvlakte 2 on the transport of fish larvae have not really been quantified as yet. At the moment, in the context of the research model for the Appropriate Assessment, these impacts are being mapped quantitatively with the help of 3-D water movement models in combination with behaviour models for fish larvae (plaice, sole and herring). The results of this study are expected in mid-September 2005 (see paragraph 3.3).

3.2.6 Scenarios

In the preceding paragraphs a brief summary of the current knowledge about silt, nutrients and fish larvae in the Dutch coastal zone in general has been given. At the same time we went into the question of what impacts are expected, based on the available knowledge and model studies for the Appropriate Assessment. On the basis of these paragraphs the following can be concluded with regard to the impacts of the land reclamation of Maasvlakte 2 on the Wadden Sea:

- **Silt:** The studies into the impacts of Maasvlakte 2 on silt transport towards the Wadden Sea all show a decrease varying from around 5 – 25%, depending, among other things, on the version selected (GAB or GAN). However the bandwidth of the results is large.
- **Nutrients:** An earlier model study shows a decrease in the total nutrient percentages in the first kilometres off the coast of North-Holland at Callantsoog of around 0 - 15%. Since the combined supply of material from the New Waterway and the Haringvliet remains unchanged, a small increase in concentration also takes place outside the 15 kilometre coastal strip.
- **Fish larvae:** The impact of the construction of Maasvlakte 2 on the transport of fish larvae was not quantified earlier with the help of calculation models. For the moment it appears probable that—in view of the limited disruption to the large-scale water movement and the residual transport in the southern North Sea by Maasvlakte 2—the impact is small.

The above-mentioned impacts for silt and nutrients are surrounded with a great deal of uncertainty. All kinds of assumptions were made in the model studies with regard to forces used and the processes modelled. For fish larvae, too, only a qualitative assessment was made and that—depending on the extent to which the movement of the water is affected—could also impact on the transport of larvae to the Wadden Sea. This particularly applies to flatfish (plaice, sole) which make use of a flow component directed towards the coast in order to reach the nurseries.

3.3 Model research (track 1)

3.3.1 Objective and demarcation of areas

The objective of track 1 is the quantification and explanation of changes in the transport of silt, nutrients and fish larvae to and from the Wadden Sea as a result of sand extraction and land reclamation in the context of Maasvlakte 2. From a practical point of view, only the western Wadden Sea to around the slack water of Ameland was looked at in the first instance. From earlier studies it follows that the impacts of the construction of Maasvlakte 2 around the slack water to the south of Ameland and in the eastern part of the Wadden Sea are negligible.

3.3.2 Approach

A number of models for quantifying the impacts on silt, nutrients, primary production and fish larvae are used in this research. In Figure 3-2 the ‘train models’ are summarized and the relationships between these models are also shown. The base is formed by the description of the water movement. The results of the flow are used as input for the fish larvae model and the silt transport model. The results of both the water behaviour and the silt transport make up the input data for modelling the nutrients and the primary production.

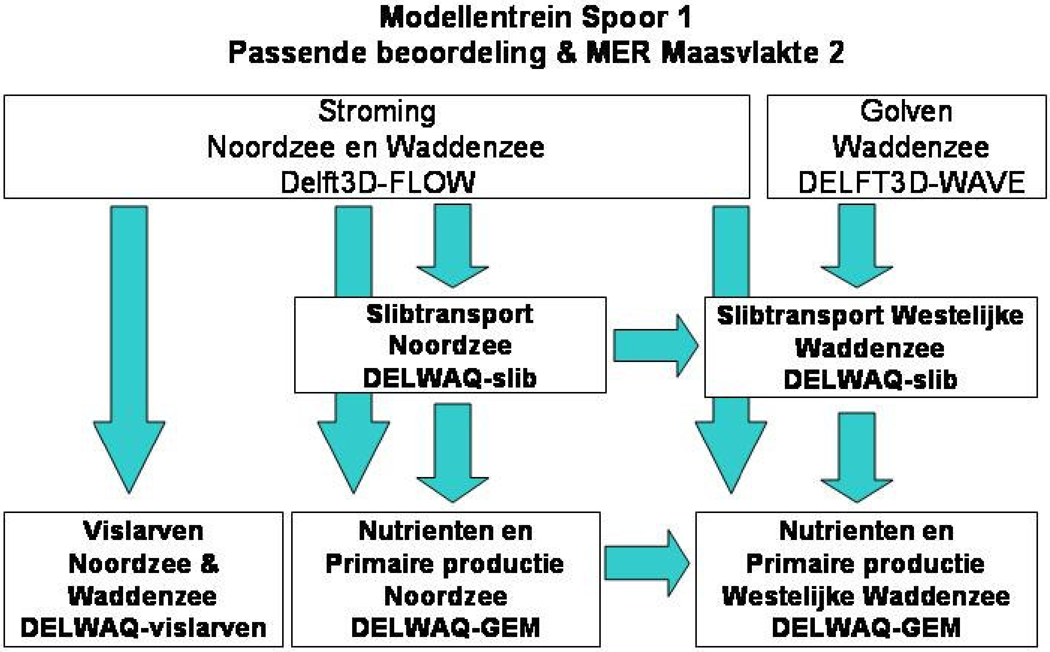


Figure 3-2 Overview and underlying relationships of the models used.

An important assumption in this research is that only the long-term impact of waves is taken into account for the North Sea by means of the values selected for the critical shear stresses of erosion and sedimentation. The short-term impact of silt on the bottom and re-suspension by (intermittent) wave action is not taken into account. The reason for this choice is that taking the waves into account for the whole of the North Sea is too complex a calculation, given the timetable of this project. It is known that waves play a (much) more limited role in the distribution of floating and dissolved matter than the current as a consequence of the tide, the wind and river discharge. However, the effect of waves in the North Sea is not negligible and attention will have to be paid to it when the results are interpreted. In the shallow western Wadden Sea, in contrast, wave action is crucial to the behaviour of silt and therefore also to nutrients and the primary production. Because of this it was decided to take wave action into account for this area.

Two different schematization models of the southern North Sea and the Wadden Sea are used in this research:

- **ZUNO-coarse:** This schematization model already existed and has been used on several occasions in earlier studies (Maasvlakte 2 and Flyland among others). Measurement comparisons have demonstrated that this model reproduces the large-scale water level fluctuations, current speeds and fresh and salt water patterns as a consequence of the tide, the wind and the river discharge into the North Sea well.

- **ZUNO-DD:** This schematization model was newly constructed because the grid resolution of ZUNO-coarse is not fine enough to effectively reproduce the local change in the geometry around Maasvlakte 2. To this end the model was cut up into various domains with varying resolutions. A relatively fine resolution was used around Maasvlakte 2, in the Dutch coastal zone and in the western Wadden Sea.

The ZUNO-coarse model was only used for a part of the fish larvae research. The ZUNO-DD model was used for silt, nutrients and primary production and for fish larvae.

In addition to the different schematization models two different simulation periods were used in this research: annual calculations and 14-day calculations, This was done because it proved unfeasible in practice to execute all the variants and alternatives using annual calculations with ZUNO-DD from the point of view of calculation times. These calculations were set up as follows:

- **Annual calculations:** For the annual calculations use was made of the current forces for the river discharge, the wind speed and direction and atmospheric pressure. Because the current forces are used the results of these model calculations can be compared with measurements. A similar calculation was made using ZUNO-DD for one year (November 1988 – November 1989), while similar calculations were made for nine years using ZUNO-coarse. Alongside measurements these calculations give an idea of the variability of the system.
- **14-day calculations:** Use was made in these calculations of average river discharges and a representative wind climate. This calculation was set up in such a way that the ‘long-term average’ situation was simulated.

Table 3.1 summary of the calculations used and for which aspect including the objective of these calculations.

Table 3.1 Review of the application of the schematization models in the research model

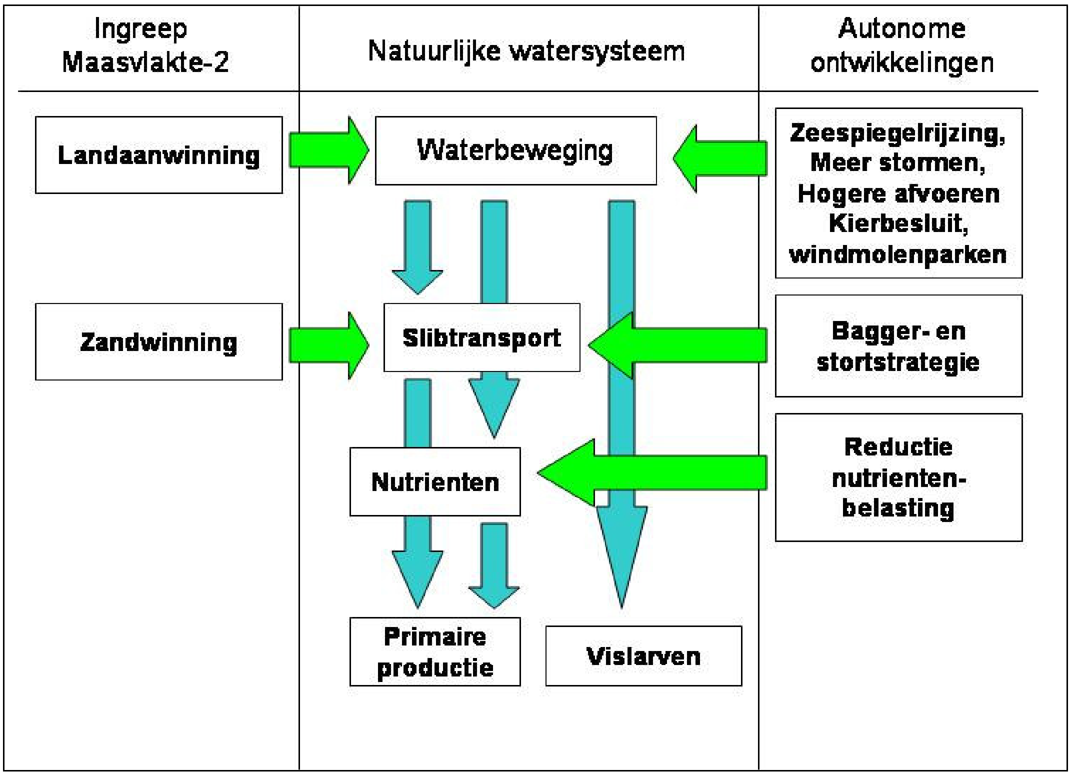
Schematization model	**ZUNO-coarse**	**ZUNO-DD**	
	Annual calculations (9 years)	Annual calculations (1988-1989)	14-day calculations (representative period)
Water movement	Variability	Control effects	Maasvlakte 2 effects
Silt	-	Variability and control effects	Maasvlakte 2 effects
Nutrients	-	Variability and control effects	Maasvlakte 2 effects
Fish larvae	Variability and sensitivity analyses	Maasvlakte 2 effects and comparison with ZUNO-coarse	-

3.3.3 Products

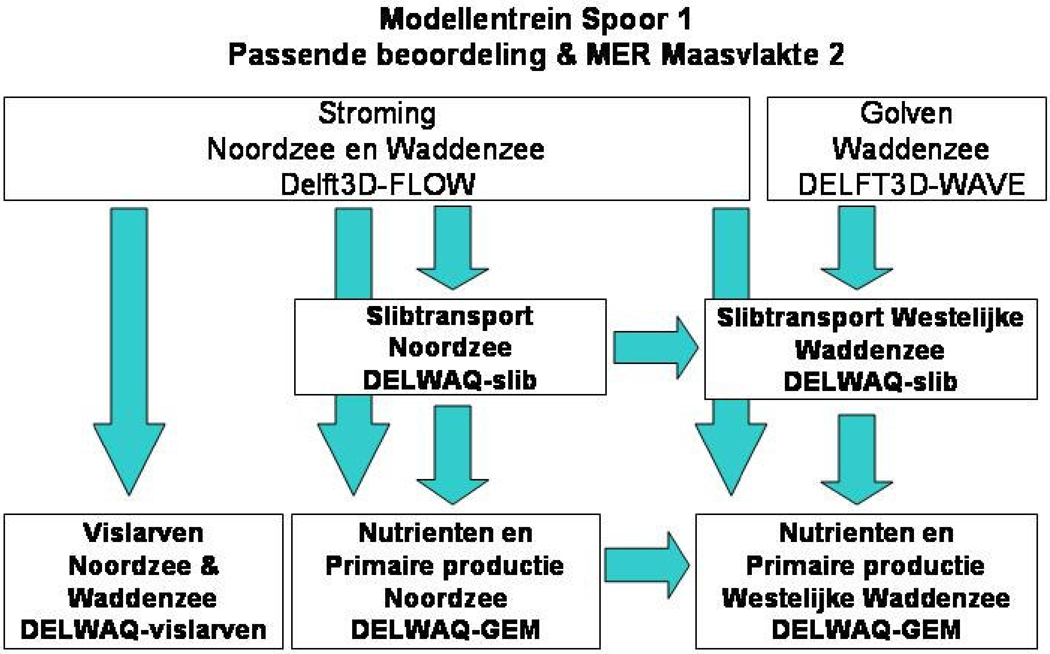
The track 1 research provides a quantitative insight into the impacts of the construction of Maasvlakte 2 on silt, nutrients and fish larvae in the direction of the Wadden Sea. It is not simply to do with the effects in themselves, but also with a good foundation of the observed impacts. Results are described in terms of changes along the Dutch coast and in the direction of the western Wadden Sea:

- In silt concentrations and (gross /net) fluxes
- In the transport of nutrients and primary production
- In the transport of larval herring, plaice and sole (quantity and timing)

In addition special attention will be devoted to the bandwidth of the results. This research model will be concluded on 1 November with a report of the impacts of the construction of Maasvlakte 2 on silt, nutrients and fish larvae in the direction of the Wadden Sea.



Impact Maasvlakte 2	Natural water system		Autonomous developments
Land reclamation	Water movement		Rise in sea levels More storms Higher drainage Kierbesluit Wind turbine parks
Sand excavation	Silt transport		Dredging and dumping strategy
	Nutrients Primary production	Fish larvae	Reduction in nutrient load



Train models Track 1
Appropriate assessment & EIS Maasvlakte 2

<table>
<tr><td colspan="2">Flow
North Sea and Wadden Sea
Delft 3-D FLOW</td><td>Waves
Wadden Sea
Delft 3-D WAVE</td></tr>
<tr><td></td><td>Silt transport
North Sea
DELWAQ-silt</td><td>Silt transport
Western Wadden Sea
DELWAQ-silt</td></tr>
<tr><td>North Sea and
Wadden Sea
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larvae</td><td>Nutrients and primary
production
North Sea
DELWAQ-GEM</td><td>Nutrients and primary
production
Western Wadden Sea
DELWAQ-GEM</td></tr>
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4. POSSIBLE EFFECTS OF MV2 ON THE WADDEN SEA/ NIORTH SEA COASTAL ZONE

4.1 Introduction

This chapter describes how possible changes in the transport of silt, nutrients and fish larvae *may* affect the Wadden Sea and North Sea Coastal Zone. These possible effects are described firstly using the results of a model study which is used to develop a number of scenarios for changes in nutrients and silt to determine the effects on primary and secondary production in the western part of the Wadden Sea (0). Secondly, the literature and expert opinion (from, among other things, two workshops) have been used to describe the most important relationships between the changes related to the intervention (= the construction of Maasvlakte 2) and the effects on habitats (0) and higher trophic levels (0).

4.2 Effects on primary and secondary production in the Wadden Sea (simulations)

This section summarizes a scenario study that was carried out using the EcoWasp model in the context of the ‘track 2’ investigation (Brinkman, 2005). This box model describes the dynamic behaviour of pelagic and benthic primary production, filter feeders and chlorophyll-a in the Western Wadden Sea as a function of various forcings along the boundaries (North Sea, IJsselmeer) and in the area itself (for example, wind). The model and the parameters used, as well as the system characteristics were set up in an earlier study. (See Brinkman & Smaal, 2003). Virtually all the parameters were set on the basis of a combination of literature data, process know-how, field data and monitoring results. Apart from some details, the model settings were left unchanged in comparison with the previous study mentioned above. The model shows patterns for the nutrients that are similar to hose shown by the monthly Rijkswaterstaat (the Directorate-General for Public Works & Water Management) monitoring data. Chlorophyll-a, however, is structurally underestimated, but that is inherent to the structure of the model because this calculates the maximum number of filter feeders rather than the current numbers.

For this study, a scenario approach was selected in view of the uncertainties in the previous studies for Maasvlakte-2 in relation to the effects on the slit and nutrients transport in the direction of the Wadden Sea (see section 3.2). In accordance with the results of the relevant studies, a series of scenarios were used with a *decrease* in silt and nutrients in the North Sea (see table 4.1). The basic scenario (1) assumes 15% less silt and 10% less nutrients available. These percentages were derived from results recalculated from model calculations that were performed in the context of the Flyland project (see 3.2) and adopted during a meeting of various experts in this field on 30 May 2005 (report by M. van Ledden). They were then varied by looking at increases and decreases of these effects in various combinations (scenarios 2 – 9) in order to gain insight into the sensitivity of the system to these parameters. Scenario 10 was added to see the consequences of a possible increase in the supply of nutrients. The changes in the silt were simulated by assuming a lowering of the silt content in the whole of the western part of the Wadden Sea; the changes in the nutrients were simulated by assuming different nutrient contents along the North Sea boundaries.

Table 4.1 Scenarios used in the EcoWasp model (Brinkman, 2005)

		Nutrients			
Scenario	**Silt**	**N**	**P**	**Si**	**Remarks**
0	-	-	-	-	Basic scenario present situation
1	-15%	-10%	-10%	-10%	Basic scenario for MV2
2	-30%	-10%	-10%	-10%	Reduction silt x 2
3	-15%	-20%	-20%	-20%	Reduction nutrients x 2
4	-15%	-5%	-5%	-5%	Reduction nutrients x ½
5	-30%	-20%	-20%	-20%	Reduction silt and nutrients x 2
6	-30%	-5%	-5%	-5%	Reduction silt x2 and nutrients x½
7	-8%	-5%	-5%	-5%	Reduction silt and nutrients x ½
8	-8%	-20%	-20%	-20%	Reduction silt x0.5 and nutrients x2
9	-8%	-10%	-10%	-10%	Reduction silt x ½
10	0%	+10%	+10%	+10%	Increase nutrients

The results of the EcoWasp simulations are summarized in Table 4.2. This table shows the sensitivity of a given variable (averaged over a period of five years) to a change in the silt in the Wadden Sea or nutrients in the North Sea. The table also shows the effects on the variable of the basic scenario and a scenario in which the silt and nutrients have been halved compared with the basic scenario.The results give the following picture:

- A lowering of the silt and nutrients results in a lowering of the *maximum filter feeder biomass*. This change is (almost) entirely caused by the changes in the nutrients; the filter feeders are not very sensitive to changes in the silt content. It is noticeable that, in the model, the maximum filter feeder biomass reacts strongly to changes in the amount of nutrients in the direction of the Western Wadden Sea, i.e. a 10% decrease in nutrients results in a 20% decrease in filter feeders.
- The model also shows that the *pelagic primary production* is much less sensitive to changes in the silt and nutrients supply than filter feeders. The influences of silt and nutrients are opposite to each other in the primary production. For benthic production, the reduction in nutrients is slightly more important, resulting in a fall in the basic scenario while, for pelagic production, it is the reduction in silt supply that is the deciding factor and leads to an increase in the basic scenario.
- Finally, the *algal content in the water column* increases and the *algal content at the sediment surface* decreases with a decreasing supply of nutrients. Just as for filter feeders, these values are not significantly influenced by variations in the silt content and are almost entirely governed by the changes in the supply of nutrients.

Table 4.2 Sensitivity to individual decreases in silt and nutrients (- : decrease, + : increase, 0 : (almost) no effect on the variable concerned) and the combined effect for the basic scenario in the EcoWasp model based on results from Brinkman (2005).

			Combined effect compared with scenarios	
Variable	Silt reduction	Nutrients reduction	Silt -15% and nutrients -10% (basic scenario)	Silt -15% and nutrients -5% (scenario based on 1st results from track 1)
Pelagic primary production	0	0	+3%	+2%
Benthic primary production	+	-	-5%	0%
Algal biomass in water column	0	+	+10%	+4%
Maximum filter feeder biomass	0	-	-20%	-8%

In some areas, the changes modelled with EcoWasp are consistent with general knowledge and observed trends in such systems. For example, a decrease in filter feeders as a result of a decrease in the nutrients is in line with the decrease in the amount of mussels landed in the Western Wadden Sea since the beginning of the eighties (Brinkman & Smaal, 2003). The amplified decrease in filter feeders as a result of a decrease in nutrients shown by the model is uncertain.

In a number of areas, the model deviates from the results expected on the basis of the literature and analysis of field data. This is partly because some processes are missing from the model. For example, the modelled response of benthic primary production is stronger than expected, while that of pelagic primary production is less than expected. This difference is attributed to the absence of grazing pressure on benthic diatoms in the model. There are also differences between the model results and the general expectations for which the explanation is much less clear. These lie, for example, more in the line of the expectation that with less nutrients the primary production will decrease and that the production of algae (analogous to the chlorophyll-a content) will remain more or less constant or will decrease slightly. The scenarios, however, show that the primary production remains more or less constant and the chlorophyll-a increases.

The detailed analysis of the exact causes of the surprising results lies outside the scope of the scenario study. It is however worth noting that the model contains a number of strongly dynamic components, which may explain the amplified decrease in filter feeders with a reduction in nutrients. Such reactions may well occur in practice (and in that sense, the model results can be seen as a sort of worst-case) but, at the same time, the room created (in terms of food) will be taken up by other organisms so that, net, a more or less proportional response will be found. The overall system reaction can be characterized as follows:

a) The silt content determines the light climate in the water column and hence, in the spring, the strength of the growth (the slope of the increase in the algal content), and hence the primary production in that spring period.
b) The nutrients content determines the algae production ceiling, and hence the primary production during the rest of the year, until the light conditions worsen in the autumn.

c) In the western part of the Wadden Sea, the second process is such more important than the first: the system behaviour is mainly determined by the nutrients.

d) The secondary producers (grazers or filter feeders) always continue growing until they regulate the algal content. This means that a change in nutrients is reflected in the filter feeder content, and not in the algal content. This does not entirely apply because the system is seasonally dynamic and a small response is found in the algal content and a large response in the filter feeders. The response of the primary production, as a product of the algal content and the nutrient conditions, lies somewhere in between.

e) Benthic organisms that live on detritus (including worms, these organisms are not included in the model) profit from the dead algae. Broadly speaking, the response of these organisms will follow that of the primary production. They will also profit from a situation in which there are fewer filter feeders than the maximum possible.

f) The conclusions under a, b and d apply equally well to the benthic primary production. No benthic grazer has been modelled but, in practice, it would have a similar function and show a similar reaction to that of the filter feeders.

We can conclude from the above that the results of the scenario study must be used with care. Assuming a decrease in the supply of both silt and nutrients abs a result of Maasvlakte 2, a decrease in the maximum amount of filter feeders is predicted and this is in line with earlier research and field data, though the amplified response that the model gives will, in practice, be more of a straight line response. The model calculates the *maximum* filter feeder populations. In practice, the populations will be lower than calculated due to irregular spatfall, extra mortality, predation or fishing, and will therefore be somewhere between almost 0 and this maximum number. The filter feeders are an important source of food for many bird species and so form the translation to higher trophic levels. For the remaining variables (benthic and pelagic primary production, and chlorophyll-a content) that play a role in the translation to higher trophic types, the predicted results are surrounded by many uncertainties. Further attention will therefore be paid to these in the model study for ‘track 1’ (see section 3.3).

4.3 Carry-over to habitats

4.3.1 Surface area and composition

The bed of the Wadden Sea is characterized by alternating deep channels and intertidal areas. The composition of the bed of the Wadden Sea is mainly sandy with a low percentage of silt (< 5 %). In the areas where the tidal currents meet (*wantijen*) the silt content can rise to around 10%, and in a narrow zone along the coats to 10 to 20% (Zwarts, 2004). In the Wadden Sea, the tidal movements and local wind waves are the primary physical processes that are responsible for stirring up and transporting sediment (sand and silt). Besides these physical processes, biological processes play a significant role in the behaviour of the silt in the Wadden Sea. A detailed description of the (silt) dynamics of the Wadden Sea is given by Oost (1995).

As stated in section 3.3 on the basis of model calculations, the expectation is that the **presence** of the second Maasvlakte will lead to a reduction in the transport of silt towards the Wadden Sea. The concentrations in part of the North Sea Coastal Zone will also decrease. At the moment it is not exactly clear how these decreases will affect the level and composition of the bed of the Wadden Sea, but a large number of model studies have shown that the large scale morphological developments in the Wadden Sea (and North Sea Coastal Zone) can be predicted with a model in which the silt is not explicitly included (see for example, Wang et al., 1995). Recent calculations with a combined sand-silt model point in the same direction, namely that the large scale morphology is determined by the supply and transport of sand rather than by silt (Van Ledden et al., 2003).

Based on the above, the expectation is that, for most of the Wadden Sea, a reduction in the supply of silt will not lead to changes in the *level* of the seabed and so will also not lead to changes in the surface areas of the various types of habitat. This also applies to the – strongly dynamic – North Sea Coastal Zone. The levels of the high seabed areas where the tidal currents meet and the high mud flats along the coast of the mainland may well decrease slightly. It is possible that, on the saltings, parts of the Wadden Sea where the currents are slow and where habitat development is mainly determined by the supply of silt, the further silting up and increase in levels will progress slightly more slowly. This is independent of the area development that is not affected by minor changes in the rate of silting up. This is dependant on the lee in the transition from flat to salting.

Large amounts of sand are needed for the **construction** of the second Maasvlakte and will be extracted from the North Sea. During this extraction, large amounts of silt will be stirred up, part of which will end up in the Wadden Sea as a result of the transport in a northerly direction. As opposed to the effects of the presence of Maasvlakte 2, the silt content will therefore increase (temporarily) due to its construction. Applying a similar argument to that used above, it is to be expected that the temporary increase in the silt content in the water will not lead to significant changes in the level of the sea bed.

In addition to the changes in the level and surface area of the seabed, changes in the *seabed composition* also play a significant role. The composition of the seabed is affected by many factors and, here again, it is not clear it will be affected by a change in the supply of silt. Indicative calculations with a sand-silt model show that the amount of silt in the seabed is affected on the one hand by the supply of silt and on the other hand by the local hydrodynamic conditions (Van Ledden & Wang, 2002). Depending on the influence of these factors, there appear to be two possible extremes for the Wadden Sea, given a reduction in the supply of silt:

- A *worst-case* scenario is formed by a direct translation of the decrease in silt supply into the seabed composition: in the long term, a lowering of the silt supply will result in the seabed also being less rich in silt over the whole of the Wadden Sea. This assumes that the silt supply determines the composition of the seabed.
- A *best-case* scenario is that the sediment composition in the Wadden Sea is insensitive to the supply of silt and is only determined by the local hydrodynamic conditions. This reasoning assumes that there is an adequate supply of silt in the Wadden Sea but that the local hydrodynamic conditions determine the amount of silt in the seabed.

At the moment, there is no consensus over the question as to which scenario is the most realistic. In view of these uncertainties, the *worst-case* scenario that is worked out in more detail in 0 will be used for the time being. It is important to mention in connection with this scenario that, because of the large amount of silt stored in the seabed, it will take dozens of years or longer before a new equilibrium is reached[15].

4.3.2 Quality: structure and function

The following factors are important for the structure and functioning of the Wadden Sea (LNV DRZ-Noord, 2005a):
Exchange between sandy and silt-rich intertidal areas (sandbanks and mud flats).
A varied level and presence of natural systems of channels in the littoral.
Presence of shellfish beds (littoral and sublittoral)[16].
Natural succession (salting types).
Zoning complete/salting zone not overrepresented (salting types).

With respect to 1 and 2. The large scale morphology of the Wadden Sea is mainly determined by the transport of sand and hardly at all by silt (see section 0). It is therefore not expected that (somewhat) lower silt concentrations will lead to changes in the large scale exchange of sandy (more dynamic) and silty (sheltered) areas. In the long term (decades) a reduced silt supply may well lead to a lowering of the silt content in the seabed (if we assume a *worst-case* scenario, see above). A temporary increase in the silt content as a result of sand extraction may, for the same reasons, possibly lead to changes that are opposed to those from a lowering of the silt content. The panel below, ‘Silt concentration in the seabed’ indicates the extent to which changes in the silt content of the seabed can work through into the food chain.

Silt concentration in the seabed
By: J. de Vlas

Silt can be subdivided into an inorganic fraction (clay particles) and an organic fraction that can again be split into a part with nutritional value (algae and dead remains of algae and small organisms) and a part with little or no nutritional value (peat particles). The changes that take place in the supply of silt only concern the inorganic, inedible fraction.

There is uncertainty about the effect of the reduced supply of inorganic silt on the silt contents in the seabed. This effect could remain limited to practically nil if the silt contents were determined almost entirely by the hydrodynamic conditions, independently of the accumulation by sedimentation that is possible mainly during the summer. If the concentrations in the water were indeed to work through in the composition of the seabed, a reduction of 15% could occur in the western part of the Wadden Sea. Even amplified effects could theoretically be possible, but only in areas with very high silt contents so that that possibility would have little effect on the total surface area.

[15] In this light, one might wonder, on the basis of this scenario, whether the seabed is in equilibrium at the moment, in view of the influence other projects and developments (see Dronkers, 2005).
[16] In (some) other countries in the European Union, including Germany, shellfish beds are considered to be a different habitat type, namely reefs (HT 1170). According to the Interpretation Manual, these can have either a dead (rocks) or living (mussels, Sabellaria etc.) substrate (EC, 1999).

> The occurrence of seabed fauna is correlated not only with the level of the seabed in the tidal zone but also with the silt content of the sediment, whereby the richest zone of the flat is found at a silt content between 3 and 8% with a maximum in the region of 5% (Dankers en Beukema,1984 and Zwarts, 1988). Translation of change to seabed fauna is not straightforward because there is normally a strong correlation between the sedimentation of inorganic and organic material. In this case, only the inorganic fraction of clay particles changes in the first instance.
>
> The production of organic (edible) material in the silt of the Wadden Sea will not change very much due to Maasvlakte 2, so that its distribution over the Wadden Sea will also not change much (if the hydrographic conditions remain unchanged). There are a number of complicating factors, namely the role that the inorganic fraction plays as a substrate, and the fact that the organic fraction may achieve a higher sedimentation rate by adsorption onto clay particles. There are no data to enable a quantitative calculation of the resulting effects. Looking at the situation as a whole, changes and shifts cannot be excluded, but they are still not expected that to be significant.
>
> There is another reason to assume that any shifts will not be substantial: The large changes in the silt content of the coastal waters that have occurred in recent decades, have also not led to the loss or sudden appearance of characteristic areas or birds. Only one shift has been properly documented, and that is the disappearance of seagrass from the western part of the Wadden Sea. The fact that it did not recover certainly has something to do with the construction of the IJsselmeer Dam but may also be related to the increased turbidity and increase in nutrient content. With respect to these aspects it is assumed that the effects of Maasvlakte 2 will be beneficial for the seagrass.

With respect to 3. The establishment of shellfish beds is determined by factors other than silt and/or nutrients. There may however be an indirect effect if the amount of suitable food changes, possibly in combination with the ratio between suitable (organic) and unsuitable (inorganic) food. The word ‘shellfish bed’ is often used for both cockle and mussel beds and sometimes also for clams. In the coastal zone, there is talk of ‘beds’ of razor clams and there are now also references to beds of Japanese oysters. Not all these ‘beds’ may be regarded as a habitat type in the sense of the Habitats Directive. Only concentrations of cockles with a density of more than 50 per m^2 are regarded as beds. There is however a continuous transition between concentrations of one or a few cockles per m^2 and more than 1000 per m^2 so that cockle beds also do not stand out due to changes in the morphology. The same also applies to concentrations of other shellfish, such as clams and razor shells; a wide range of densities is found, so without morphological consequences and without clear boundaries. In contrast, mussel beds do form clearly distinguishable ‘beds’, and so can be regarded as ‘beds’ in the sense of a habitat type. This does not apply to the Japanese Oyster, a species that may well form clear beds but that is not an indigenous species.

With respect to the structure parameter ‘shellfish banks’ we can only speak of an effect if the situation changes (worsens) such that the balance between the establishment of new beds and the from time to time loss of old beds changes. In as much as the establishment of new beds is determined by the supply of shellfish larvae (and hence by the size of the shellfish population) a direct effect of the reduction in support for shellfish can be expected. This is independent of the amount of silt in the water. Other factors however, in particular the numbers of crabs and shrimp in the spring (Beukema en Dekker, 2005) are just as important.

With respect to 4 and 5. There is a possible relationship between the silt concentrations in the water and the rate of silting up of the shallower parts of the Wadden Sea (see section 0): the more silt, the faster the silting up[17]. At the moment we are seeing a rapid rise in level and aging of the supralittoral habitat types along the mainland coast, where the high areas of saltings are becoming overrepresented. This is less so along the Wadden coast of the islands. A possible effect of Maasvlakte 2 will (certainly for the mainland saltings) have a not unfavourable effect on the succession/zoning (less rapid aging), though we should note that the difference will be very small (for more detail, see 0).
Any effects related to the increase in silt content (and possible nutrients) caused by the sand extraction will work in the opposite direction to those caused by the presence of the Maasvlakte. These effects will, however, be temporary. There have been very large fluctuations in the suspended material contents during the last thirty years, while the silting up of the saltings has continued steadily (Dijkema, 2005). It is therefore not likely that the increased silt contents associated with the sand extraction will lead to changes in the silting up of saltings and hence in the succession and/or zoning of types of saltings.

4.3.3 Quality: biota

Important and characteristic types and (groups of) species in the Wadden Sea are (LNV DRZ-Noord, 2005a):
1. Species of seagrass and Ruppia (littoral and sublittoral).
2. Filter feeders (mussels, cockles, clams).
3. Sediment eaters (worms, rag worms).
4. Fish.
5. Birds.
6. Sea mammals.
7. Characteristic (protected) species of higher plants and rare insects (on saltings).

With respect to 1. Reduced nutrients and silt concentrations are, in principle, favourable for the development of seagrasses. This applies to both the littoral zone, where seagrasses are found in a limited number of locations, and to the sublittoral zones, seagrass is now found nowhere in the Wadden Sea. Brackish conditions are needed for the development of Ruppia spp. Any increase in the salt content is therefore unfavourable for Ruppia. At the moment, Ruppia is only found in places where the salt contents are much lower than in the rest of the Wadden Sea (Balgzand). This is mainly due to the draining of fresh water from the North Holland Canal and the sluice near Den Oever. This situation will therefore not change significantly because of Maasvlakte 2.

[17] It is clear from developments over many years that there is no relationship between the import of silt in the Wadden Sea and the growth and erosion of saltings (cf. **0**): during the past thirty years there have been very large fluctuations in the suspended material content, while the area of the saltings has remained more or less constant (Dronkers, 2005).

With respect to 2. The growth of filter feeders (shellfish) depends mainly on the amount of edible phytoplankton, but also on the ratio of edible phytoplankton to inorganic particles (silt) that can be taken up. A decrease in the silt burden is, in principle, favourable for filter feeders (less inorganic material is taken up), while the decrease in nutrients is less favourable (because the primary production could fall). Since the growth of filter feeders is food limited, it is not expected that any positive effect of a fall in the silt concentrations will (anywhere near) balance the negative effects of a reduced primary production. This is also clear from the simulations with the EcoWasp model, in which the silt content had little or no effect on the maximum biomass of shellfish (see 0).

With respect to 3. The growth of sediment eaters is, besides depending on the remains of the pelagic primary production, mainly dependant on the primary production of the seabed algae (phytobenthos). In contrast to the phytoplankton, reduced nutrients concentrations in the water will not directly lead to a lowering of the phytobenthos production, because this depends mainly on the nutrients concentrations in the seabed. In the long term, concentrations in the seabed will however reach equilibrium with those in the water, because the raised concentrations in the seabed are due to the breakdown of organic material created by primary production with the aid of nutrients in the water. Any reduction of nutrients will therefore always work through into the phytobenthos production. The light conditions however also play a role. The EcoWasp simulations show that the benthic primary production exhibits a less than proportional response to a reduction in concentrations (see also 0).

A change in the silt concentration in the water may in the long term affect the concentration of silt on the seabed, which could affect the composition and biomass of seabed animals. This is however not expected as effects of the seabed shear and the total amount of organic material in and on the seabed are more important. As stated earlier, no changes are expected in the large scale hydrodynamics and so also not in the seabed shear and the pattern of relatively silt-rich and silt-poor regions.

With respect to 4 – 6. If the amount of food for fish, birds and sea mammals is limiting, any effects on primary production, the biomass of filter feeders (incl. zooplankton) and sediment feeders may also affect these groups.

With respect to 7. The silting up and aging of saltings may proceed slightly slower because of the lower silt concentrations. This could mean that the vegetation remains a bit longer on the lower and medium-height salt marshes but this is not a major effect, as already indicated above. It is the question whether lower nutrient concentrations will lead to effects on the salt marshes; after all, the saltings clay layer is very rich in nutrients. Any effect will however, in the end, be favourable because the expectation is that a reduced supply of nutrients will reduce the dominance by tick quackgrass (Rozema et al., 1991, Leendertse, 1991). Hear again, we should note that this effect will be limited. Any effects related to the increase in silt content (and possible nutrients) caused by the sand extraction will work in the opposite direction to those caused by the presence of the Maasvlakte. These effects will, however, be temporary. There have been very large fluctuations in the suspended material contents during the last thirty years (Dronkers, 2005), while the silting up of the saltings has continued steadily (Dijkema, 2005). It is therefore not likely that the increased silt contents associated with the sand extraction will lead to changes in the silting up of the saltings.

4.4 Translation to higher trophic levels

4.4.1 Primary production -> seabed animals

Maasvlakte 2 may influence the growth and development of seabed animals in the Wadden Sea indirectly as a result of changes in the following factors:

1. The availability of food for filter feeders (phytoplankton) and sediment feeders (phytobenthos and detritus);
2. The concentration of silt in the water (particularly important for filterers);
3. The sediment composition (relationship with species composition of seabed animals).

Besides these factors, the density of shellfish is determined to a large extent by the survival of larvae. These could also be influenced by the primary production and algae concentrations. The establishment in itself is mainly determined by the presence of predators (see 0). This makes the relationship with Maasvlakte 2 extremely indirect. In some years, cockles and mussels establish themselves in huge numbers. In the intervening periods, there is hardly any establishment of young animals. There was significant spatfall in the years 1975, 1979, 1987, 1992 (somewhat less) and 1997 (see, for example, Beukema 1982; Van Stralen and Kesteloo 1998; Kamermans et al. 2003a). The total biomass and its distribution over different class sizes are strongly dependent on the timing of the spatfall. This must be taken into account when assessing the effects of the second Maasvlakte on shellfish in the Wadden Sea.

With respect to 1. Phytoplankton and phytobenthos
The availability of food for seabed animals in the form of phytoplankton and phytobenthos is often linked to a decrease in the eutrophication of the rivers that are directly (Eems, IJssel) or indirectly (Waal, Meuse) connected to the Wadden Sea (see, for example, Leopold et al, 2003a, Prop 1998). The relationship between the P and N concentrations and the production of phytoplankton and shellfish was studied by the RIKZ in experimental ecosystems (Smaal et al., 1997 in Peeters et al., 1999; Prins et al., 1999). This study found no effects of a severely reduced P concentration on the growth of shellfish. The growth of Phaeocystis was limited but, because it is inedible, this (nuisance) alg does not contribute to the productivity of shellfish. The same study showed that only a very severe reduction of the nitrogen concentration leads to a fall in the productivity of shellfish: with a N reduction in the water column of 50%, there was (still) no difference in production to be seen at the end of the study period of 270 days. Only with an N reduction of 75% was a substantially reduced production of shellfish (50% of the control) measured at the end of the study period. In this last case, the concentration of inorganic nitrogen at the beginning of the experiment was around 75 µmol/l (1.05 mg/l) and fell rapidly over a period of 100 days. From 120 days to the end of the experiment, nitrogen was the limiting factor for the growth of phytoplankton (< 2 µmol/l).

We should bear in mind that the experiments referred to related to the East Schelt where the ratio between P and N is different from that in the Wadden Sea. The results are therefore not directly applicable to the situation in the Wadden Sea, though there can be summer periods in the Wadden Sea when either P or N appear to be the limiting factor for the primary production (GEM WL model, Alterra model). A reduction in the nutrients concentrations could therefore result in a sustained limitation of the primary production. Even if there were to be less growth of *Phaeocystis* in the early summer this would not be a problem for filter feeders, which do not feed on *Phaeocystis*. But this might well lead to less production of detritus. This then still indirectly works through into the food chains, through a reduced availability of food for worms and a reduced feedback of nutrients to seabed diatoms and (in deeper parts) to the water. For the rest, worms are mainly dependent on phytobenthos through direct take-up and, to a (much) lesser extent, indirectly on vegetable and animal plankton that end up on the seabed as detritus when they die. Shellfish and copepods mainly feed on phytoplankton. An increase in phytoplankton due to greater clarity can in principle encourage the growth of shellfish. The model calculations however show that the growth of phytoplankton (and hence of shellfish) is mainly determined by nutrients and less by the light conditions (see 4.2).

With respect to 2. Silt concentration
Cockles on higher, silt-richer beds on the Wadden Sea grow more slowly than animals that establish themselves in lower parts of the littoral (Kamermans et al., 2003a).This can be explained by the fact that the period during which the animals can feed is relatively short on the higher sandbanks. The silt content in itself also appears to be a determining factor in the growth of cockles (Wanink and Zwarts 1993). With respect to the growth of cockles, any decrease in the silt content in the seabed could therefore have a favourable effect.

With respect to 3. Sediment composition
The construction of the second Maasvlakte may lead to a reduction in the (inorganic) silt content of the Wadden Sea. This could also change the seabed composition, which could also lead to changes in the seabed fauna. Independently of the question as to whether a decrease in the silt content in the water will lead to a decrease in concentrations in the seabed, there is no unambiguous relationship between the silt content and the composition of the seabed animals (Groenewold and Dankers, 2002). This is probably more determined by the degree of ‘shelter’ and hence on the availability of sedimented dead organic material than by the silt content (see also the panel, ‘Silt concentration in the seabed’).
Cockles appear to have established themselves more in shallower parts of the Wadden Sea in recent decades than previously (RIZA, 2003). To a large extent, this effect appears to be a consequence of increased predation by shrimp in the deeper parts of the Wadden Sea (Beukema and Dekker, 2005) and so is independent of any changes in the silt content caused by Maasvlakte 2.

4.4.2 Primary production and transport of fish larvae -> fish

Various species of fish are important for the areas of the Wadden Sea and North Sea Coastal Zone covered by the Birds and Habitats Directives. In the first instance we are concerned with the fish species for which the area has been designated as a special area under the Habitats Directive. These are the Twaite Shad (*Alosa* fallax), River Lamprey (*Lampetra fluviatilis*) and Sea Lamprey (*Petromyzon marinus*). These species will not be negatively affected by Maasvlakte 2 (see 5.3).

There are also species that are not mentioned as such in the Directive but that form an important source of food for birds and sea mammals that are covered by the Directive. Of particular interest here are (young) sand eels (*Ammodytes sp.*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*) and flat fish (*Pleuronectes platessa, Solea solea*), so both seabed fish species and pelagic fish species. For example, the availability of prey fish of the right size in the vicinity of the breeding colonies of certain species of terns largely determines the success of the breeding.
The size of the fish populations (total biomass) in the North Sea and Wadden Sea is determined by:
- the production of new year classes (‘recruitment’);
- the survival;
- the individual growth rate.

Recruitment and survival
A number of fish species (including plaice, sole, herring, sand eels) follows a strategy whereby the spawning and development areas are geographically separated and whereby the larvae are transported by the hydrodynamic circulation and a specific behavioural component (for example, selective tidal transport of plaice) to, and concentrated in, special development areas, known as nursery areas. These nursery areas are different for each species but are mainly found in tidal areas such as the Wadden Sea and the shallow coastal zone. The construction of MV2 may influence the fish recruitment via effects on the transport of larvae along the Dutch coast:
1. if the water movements are substantially changed by the presence of MV2 (see 3.2.5) and
2. if MV2 is located between the spawning and nursery areas. This is in any case so for plaice, sole, herring and possibly also for sand eels.

The Wadden Sea forms an extremely important nursery area for plaice: it has been estimated that half of the plaice in the North Sea grow up in the Wadden Sea (Van Beek et al. 1989)**.** This is a very rough estimate that only relates to the production of the continental coast of the North Sea. The production of the coast of Great Britain is, however, small (around 10%). Besides in the Wadden Sea, the nursery areas of plaice and herring are also found in the Delta area, the North Sea Coastal Zone and the German Bight.
The supply of larvae to a nursery is partially determined by factors operating outside the nursery areas, such as the size of the spawning population and the fertility of the female animals, the location of the spawning grounds and the associated flow patterns, the meteorological conditions during the transport phase, and the death of eggs and larvae (Harding & Talbot, 1973: Harding et al., 1978; Jager, 1999).

It is thought that the strength of the year class for flat fish is largely determined during the larval phase (and hence by processes in the North Sea) and that 'fine-tuning' takes place in the nursery (Van der Veer & Bergman, 1986; van der Veer et al., 2000 ICES JMS). In some, exceptionally strong year classes (1963 and 1996 for plaice) it is possible that this adjustment did not occur in the Wadden Sea because the numbers of the primary predators (shrimp) had been reduced by the severe winters (Van der Veer et al., 2000). Recently (the nineties), there have been developments which have significantly reduced the numbers of young flat fish, mainly in the I and II groups in the Wadden Sea in favour of a distribution more along the coast (Vorberg et al. 2005: QSR Wadden Sea). There are a number of subtleties playing a role here: the supply of larvae, death and the dispersion/migration to deeper coastal waters. The autumn surveys showed that the plaice were migrating increasingly to deeper water (van Keeken et al 2004; Grift et al. 2004, Camphuysen et al. In preparation). NIOZ data show no decrease in the arrival of larvae but do show that the young plaice are leaving the Balgzand earlier (communication from H. van der Veer). Additionally, the growth rate of the 0 group has decreased (Teal et al. 2005, in preparation).
The most recent picture is that the plaice are leaving the Wadden area earlier for reasons that are not yet clear. The Wadden Sea is however still very important for flat fish at the earliest stages.

Besides overfishing, the collapse of the herring population in the eighties has been partially explained by poor recruitment resulting from hydrographic changes in the North Sea circulation which prevented the herring larvae from reaching the nursery areas (Corten, 2001).

Because of the strong dependence of plaice larvae on the Wadden Sea and coastal zone as nursery areas, plaice are in principle sensitive to any changes in larvae transport and/or another distribution over the Wadden Sea and coastal zone caused by Maasvlakte 2. A reduced supply of larvae to the Wadden Sea can in this way result in a lower recruitment. There may also be a shift in the time of arrival in the nursery areas. The time of arrival in the Wadden Sea varies naturally from mid March to the end of April/beginning of May (van der Veer et al. 2000).
It is not expected that there will be substantial effects on the recruitment of herring due to changes in water movements because herring use not only the Wadden Sea but the whole coastal zone as a nursery area. Effects are only to be expected if herring larvae no longer reach the relatively warm and food-rich coastal areas. Such drastic effects are not anticipated. At the moment, it appears that this also applies to sand eels (see the panel, 'The ecology of the sand eel').

Model results on fish larvae transport
(After: M. van Ledden, memorandum on track 1, dated 14 September 2005)

Model results have now shown that the effects of the construction and presence of Maasvlakte 2 (in all its variants) on the amount of fish larvae growing up in the North
Sea Coastal Zone and Wadden Sea and the moment these fish larvae arrive in these areas are negligible. For herring and sole, only a small proportion of the larvae reach
the Wadden Sea and the change as a result of the presence of Maasvlakte 2 is very small.
The success of the transport to the remaining nursery areas also appears to
the Wadden Sea and the change as a result of the presence of Maasvlakte 2 is very
small. The success of the transport to the remaining nursery areas also appears to be little affected by the construction of Maasvlakte 2. A relatively large proportion of the plaice larvae (17 – 24%) coming from the Southern Bight spawning population reach the Wadden Sea. Here again, the changes as a result of the construction of Maasvlakte 2 are however small. Only a small fraction of the plaice larvae coming from the English Channel spawning population (0.01-0.17%) reach the Wadden Sea. The success of the transport of these larvae to the Wadden Sea appears to decrease slightly due to the autonomous developments and slightly increase again due to the construction of Maasvlakte 2, but the significance of this is minor in view of the very small percentage that reaches the Wadden Sea.
The “timing” of the arrival in the Wadden Sea has been looked at in three locations (Marsdiep, Terschelling Gat & Borkum). In some cases, the height of the peak in the arrival of the larvae differs slightly, but the timing of the peak varies very little between the scenarios.
The above effects have also been calculated for the Cut-through Variant and so are comparable to the GAN (PKB Ref Reference design 1). No model results are available for the GAB (PKB Reference design II). In view of the effects on the large scale water movements and GAB residual flows, the expectation is that the effects for GAB will be slightly greater but will still be negligible. Sand extraction is also not expected to have any effect on fish larvae because the large scale water movements in the Southern North Sea are not influenced by this activity.

Growth

The presence of the second Maasvlakte may lead to a reduction in the nutrients concentrations, and hence in the primary production in the Wadden Sea and in (part of) the North Sea Coastal Zone. This fall in the primary production may (via a fall in the secondary production) work through into a reduced growth of fish (Peeters et al., 1999). It is not possible to say in advance whether or not the extent to which a reduction in the primary production can be directly interpreted into a reduction in the fish production. For example, not all species of algae are favoured for consumption by the secondary producers (zooplankton) and not all secondary producers are consumed to the same extent by fish.

The expectation is that any reduction in the nutrients concentrations will affect the growth and development of fish and that will in the first instance occur mainly in the Wadden Sea. Nutrients that do not end up in the Wadden Sea will are often distributed to other parts of the North Sea. The second Maasvlakte will after all, not affect the total amount of nutrients. Hence, no direct effect can be expected on fish in the North Sea. There may however be an indirect effect if fish that reach the North Sea after a period in the Wadden Sea are smaller or are fewer in numbers.

The growth of fish is determined by abiotic factors such as temperature and salt content and by the availability of food (zooplankton, worms, shellfish siphons). It is believed that the growth of young flatfish in the Wadden Sea is in general not food-limited (Van der Veer et al. 1993). Nevertheless, there are indications that plaice do not always grow at the same rate. Analyses of the growth zones of otoliths have shown that the growth rate of strong year classes is reduced during the first years of life (Rijnsdorp et al., 1996). The growth rate also fell from the end of the eighties compared with the previous period (the sixties and seventies). It is possible that these changes are correlated with changes in the productivity of the whole coastal ecosystem, among other things through the changes in eutrophication (Rijnsdorp et al., 2004).

The conclusion is that Maasvlakte 2:
- will have no substantial effects on the growth experienced by fish species that are not exclusively dependent on the Wadden Sea for their growth; after all, the total amount of nutrients will not change and so, indirectly, the total amount of food for fish will also not change;
- may have some effect on the growth of fish species that are dependent on the Wadden Sea (flat fish).

The ecology of sand eels
by: Z. Jager

Generally speaking, there are three species of sand eels in the North Sea:
- *Ammodytes marinus* (Raitt's sand eel)
- *Ammodytes tobianus* (lesser sand eel)
- *Hyperoplus lanceolatus* (greater sand eel; smelt).

A. marinus and *A. tobianus* look very similar but *A. tobianus* is found more inshore and *A. marinus* more offshore (Miller & Loates, 1997).

A. marinus represents >90% of commercial fishing catches (Wright et al., 2000), that recently fluctuated in size between 579,000 and 1,039,000 tons (Pedersen et al., 1999). During the night, sand eels live buried in the sediment and swim in schools in the pelagic zone during the day. They lay demersal eggs that stick to the substrate. In the period from 1983 to1985, the sand eel biomass in the North Sea was around 1,750,000 tons (Knijn et al., 1993), but has fallen sharply since then.

From September to March, the animals live mainly dug into the sediment and only come out to spawn in the period from December to January. During these months the animals live off their fat reserves (Winslade 1974). Only during April and July are the fish concentrations high enough to make fishing commercially viable. The hatching period is from mid March to the end of April with a peak at the beginning of April (Stenevik & Osland 2001).

The distribution maps for sand eels show a different distribution in the summer and winter; it looks as though the sand eels have a rather northern distribution; in other words they are not specially concentrated in the area where the second Maasvlakte will be constructed (Knijn et al. 1993). On the other hand, not much specific information has been found in the literature for the more coast-bound *A. tobianus*. Sand eels prefer a sandy environment, there may be ripples in the sand and currents up to 1 m/s are not a problem but the silt content may not be higher than 10% (Wright et al. 2000).

A further relevant fact is that the *A. marinus* larvae behave like herring larvae with regard to patterns of vertical migration (Jensen et al. 2003). For the project (appropriate assessment) this means that, if there were to be effects on herring larvae, effects on sand eels can also be expected.

4.4.3 Seabed animals -> birds

Many of the qualifying species in the Wadden Sea depend on seabed animals for their food. Some birds have a diet that consists mainly of shellfish; other birds live on worms or other seabed animals. There is also a group of birds that makes use of various sources of food. In the context of the EVA II study, an extensive analysis was made of the effects of changes in the seabed fauna on bird species. This analysis is an important source for the study on the possible effects of Maasvlakte 2 on the Wadden Sea and the North Sea Coastal Zone.

Leopold et al. (2003b) have classified birds living on intertidal mud flats into four groups in the basis of their diet (Figure 4-1):

– diet > 50 % shellfish (shellfish eaters);
– diet > 50 % worms (worm eaters);
– diet > 50 % other sources of food (birds with another diet);
– diet in which none of the three sources of food are > 50 % (birds with a mixed diet).

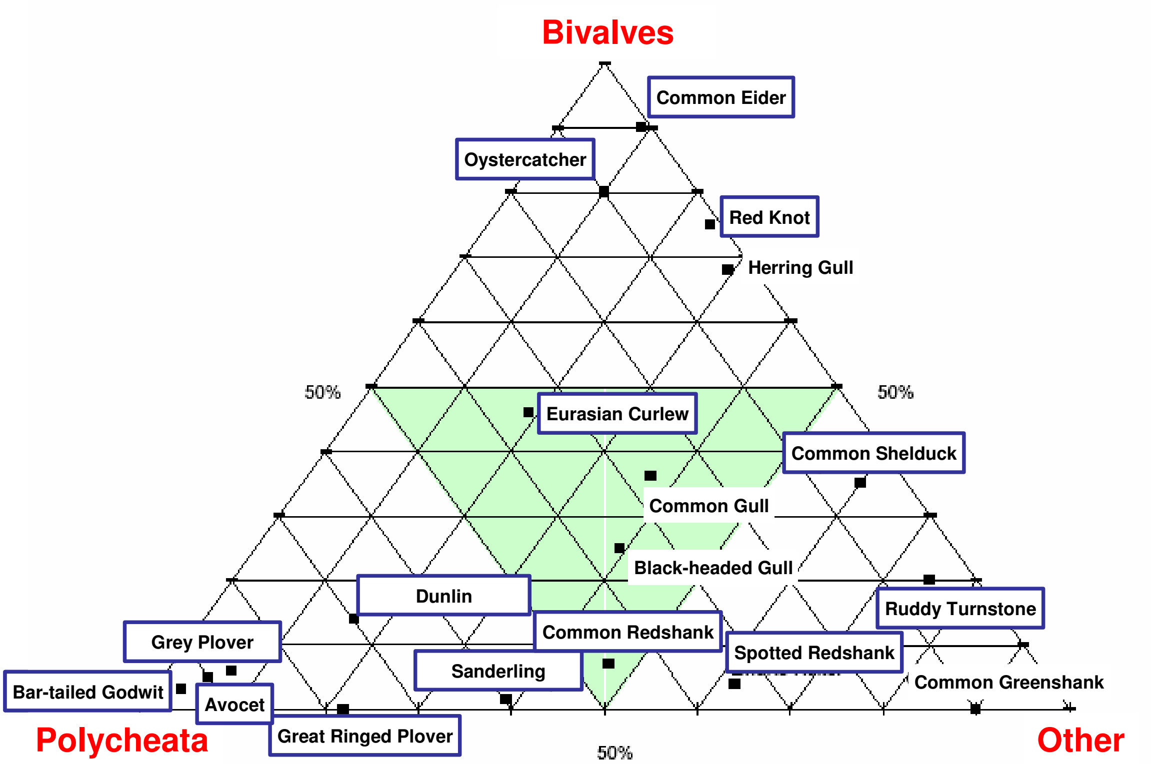

Figure 4-1 Classification of birds living on intertidal mud flats on the basis of their diet (from: Leopold et al., 2003b); blue borders added: qualifying and other relevant species.

Not all species that are important in the context of the Birds Directive appear in the classification by Leopold et al. (2003b). All the relevant bird species have been grouped on the basis of their diet in Table 4.3. The classification described above has been adopted for the birds living on intertidal mud flats. The Spotted Redshank and the Common Greenshank have not been included because they are classified as fish eaters (see 0). The Curlew Sandpiper is classified as a worm eater on the basis of the belief that its lifestyle is very similar to that of the Dunlin (van de Kam et al. 1999). The Black-tailed Godwit and the Northern Lapwing have been classified with the worm eaters on the basis of the belief that their diet in the Wadden area is comparable to the sort of prey found inland. The Golden Plover, which is increasingly using the Wadden area for feeding (thousands in the autumn, oral communication from C. Smit), has been classified as a worm eater.

Besides the diet of the birds living on intertidal mud flats, the period during which they are present in the Wadden area is important for assessing the possible effects of the construction of the second Maasvlakte on the species. Some birds breed in the area, other overwinter there. Yet other species use the Wadden area as an intermediate stop on their migratory route to build up their fat reserves. For a number of species, a distinction can be drawn between different subspecies and/or biogeographic populations. These differences are shown in table 4.3. The table includes indications from the literature on the extent to which the availability of food in the Wadden area determines their survival or breeding success. For the purpose of further analysis of effects, the substrate preferences of various birds have been included (after: Van de Kam et al., 1999).

Table 4.3 Classification of species living on intertidal mud flats that (almost) exclusively feed on seabed animals with remarks on the degree to which the occurrence of the animals is largely determined by the availability of food in the Wadden Sea

species	summer bird	migratory bird	winter visitor	food important?	substrate preference
Shellfish eaters ducks					
Common Eider	yes	yes	yes	yes, mass mortality due to reducing food stocks (Ens and Kats 2004, Camphuysen et al. 2002)	
Greater Scaup			yes	yes, especially mussel beds near the IJsselmeer Dam; relationship with occurrence in IJsselmeer	
Common Scoter			yes	Wadden Sea: possible, in sixties up to 40,000 (Swennen 1985), now very few; North Sea: no, stable population	
Shellfish eaters waders					
Red Knot		C.c. islandica	C.c. canutus	yes, decrease during nineties (Piersma and Koolhaas 1997; Piersma et al. 2001; Leopold et al. 2003a)	mixed
Oystercatcher	yes		yes	yes, possible deaths due to reducing food stocks (Rappolt et al. 2004, Camphuysen et al. 1996)	mixed
Worm eaters					
Ringed Plover	C.h. hiaticula	C.h. tundrea		not known	mixed
Dunlin		yes	yes	not known	mixed
Sanderling		yes	(yes)	no	hard

Golden Plover		yes	yes	no	hard
Black-tailed Godwit		L.l. islandica			mixed
Avocet	yes	yes		no	soft
Curlew Sandpiper		yes			soft
Bar-tailed Godwit		L.l. taimyrensis	L.l. lapponica	not known	mixed
Grey Plover		yes		now, comparable increase in Delta and British Isles (Berrevoets et al. 2002, Musgrove et al. 2001)	mixed
Mixed diet					
Northern Pintail			yes		
Mallard					
Northern Shoveller			yes		mixed
Common Redshank	T.t. britannica	T.t. totanus	T.t. robusta + small proportion britannica	no	soft
Eurasian Curlew		yes	yes	no; small increase since 75/76 (Leopold et al., 2003b)	hard
Other diet					
Common Shelduck	yes		yes	no	
Ruddy Turnstone		yes	yes	not known: decrease due to decrease in stable mussel beds or decrease due to moving further north / east because of climate change	

Shellfish eaters

For the birds living on tidal mud flats shown in Figure 4-1, Leopold *et al.* (2004b) have investigated whether there is a link between trends in the occurrence of the birds and the availability of the various food types. For four shellfish eaters (Common Eider, Oystercatcher, Red Knot and Herring Gull) that appears to be the case[18]. For these species a (not necessarily significant) break in the trend of the number of bird days per year was found around the year 1990, a year in which cockles and other shellfish were much rarer than they used to be.

Both the changes in the occurrence and the shifts in the geographic patterns of distribution point to a strong dependence of shellfish eaters on the food sources in the Wadden Sea. The availability of food therefore appears to be a limiting factor for the presence and numbers of these species.

The distribution of shellfish eating ducks in particular appears to be strongly related to the places with a (relatively) large supply of food. Common Eiders shifted from the Wadden Sea to the North Sea Coastal Zone when the stocks of shellfish in the Wadden Sea fell sharply (Ens and Kats 2004). The birds returned to the Wadden Sea however after a few years. The preference for the Wadden Sea can be explained by the fact that the birds can collect food much more efficiently in the shallower water. Ens and Kats (2004) show that the probability of survival of birds that only forage in the North Sea Coastal Zone fall sharply, because a negative balance is created between the energy used for foraging and the nutritional value of the prey found.

[18] The shellfish shortage at the beginning of the nineties probably also had a strongly negative effect on the numbers of Greater Scaup in the Wadden Sea. These birds then left for the IJsselmeer in large numbers (communication from C. Smit).

The distribution of the Greater Scaup exhibits a similar pattern: if there is sufficient food available and/or mild winters without ice, the birds prefer the IJsselmeer. If there is a shortage of food, they also forage on the Wadden, usually in the vicinity of the IJsselmeer Dam (van Roomen *et al.* 2004).

Worm eaters
Since 1990, the number of worm eating birds appears to be increasing (Leopold *et al.* 2004b). This may be linked to the hypothesis that, during the nineties, fishing for shellfish led to a far-reaching ‘shift towards worms’ of the mud flats. According to the ‘shift towards worms hypothesis’ (Piersma and Koolhaas 1997; Piersma *et al.* 2001) the proportion of worms in the seabed fauna of the Wadden Sea has increased in recent decades. This is thought to be a consequence of overfishing for shellfish, so that worms are able to colonize the undisturbed parts of the mud flats more quickly. This leads to the domination of a larger surface area by worms. In that case however, an increase in the number of worm eaters would not be limited to the nineties of the last century, since there was already bottom fishing in the previous decades. The counts from that period however point rather to a decrease in the numbers of worm eaters than an increase (Leopold *et al.* 2004b).

Mixed and other diet
For the species with other sources of food or a combination of food sources studied by Leopold *et al.* (2004b), the changes in the trend of their occurrence in the Wadden Sea were less significant. For many waders, however, there appears to be a positive correlation between the numbers of birds in the Wadden Sea and improved management of mussel beds (Leopold *et al.* 2004b). Mussel beds lead to a differentiated pattern of habitats. Bird species that can make use of many different sources of food appear to benefit from this.

4.4.4 Fish -> birds

Various birds in the Wadden area forage mainly for fish (including terns, divers, cormorants). The breeding success of these species is strongly dependent on the availability of prey. Relationships between the density of prey and the breeding success are known for various species (see, for example, Stienen and Brenninkmeijer 1998; Suddaby and Ratcliffe 1997). An example of this is shown in Figure 4-2.

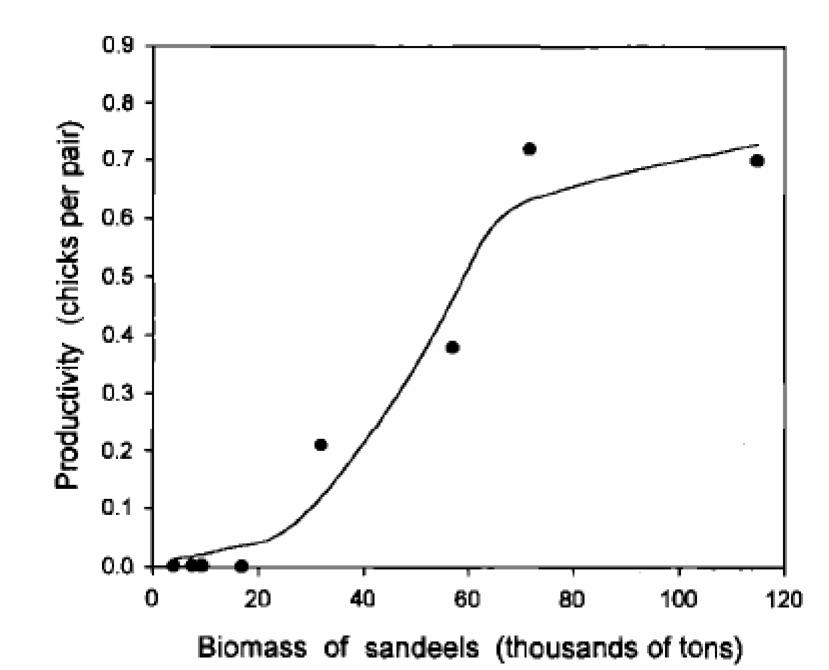

Figure 4-2 An example of the relationship between the availability of prey and the breeding success of Arctic Terns (from: Suddaby and Ratcliffe 1997).

A distinction can be drawn between species that forage mainly in the North Sea Coastal Zone or further into the North Sea and species that mainly limit their foraging to the Wadden Sea. Smaller terns cannot dive deep and forage in shallow water or close to the surface. Other species can dive deep to find fish. The action radius of the species also plays a role in the foraging behaviour (Figure 4-3). All these factors determine the choice of prey of the species, but also the sensitivity of the species to any changes as a result of Maasvlakte 2.

Table 4.4 contains an overview of the relevant factors for each species. The table was compiled following van Heinis (2005) and in consultation with Messrs C.J. Camphuysen (NIOZ) and J. Veen.

Table 4.4 Classification of bird species that (almost) exclusively live on fish; WS = Wadden Sea, NZ = North Sea Coastal Zone

Type	Period:	Foraging area*	Depth	Action radius**	Prey
Red-breasted Merganser	Winter	WS	Deep		includes smelt, shrimp and crustaceans
Common Merganser	Winter	WS	Deep		includes smelt, shrimp and crustaceans
Black-throated Diver	Winter	NZ	Deep		
Red-throated Diver	Winter	NZ	Deep		
Cormorant	Summer	NZ (and WS)	Deep	40	round fish and flat fish
Eurasian Spoonbill	Summer	WS	Shallow		includes gobies
Spotted Redshank	Migratory	WS	Shallow		gobies, shrimp, Nereis
Lesser Black-backed Gull	Summer	NZ	Surface	200	herrings and anchovies, swimming crabs, discards
Sandwich Tern	Summer	WS and NZ	Surface	50	sand eels, herrings and anchovies
Common Tern	Summer	WS and NZ	Surface	25	sand eels
Arctic Tern	Summer	WS and NZ	Surface	25	sand eels, crabs, etc.
Little Tern	Summer	WS	Surface	2,5	sand eels, young flat fish,
Black Tern	Roosting	WS	Surface		fish larvae

*: WS = Wadden Sea, NZ = North Sea Coastal Zone

**: In kilometres from location of colonies, only for summer visitors

Deep-water fish eaters

Species of birds that forage in deeper water hunt pelagic fish species. The nursery area of these fish lies either outside the Wadden Sea or the Wadden Sea represents only a relatively small part of it. Any effects that Maasvlakte 2 might have on the transport of fish larvae to the Wadden Sea will therefore be less important for these species. Only when changes in the transport of larvae or the nutrient concentrations lead to a change in the total fish populations may there be effects that affect the birds that hunt in deeper water.

Shallow water fish eaters

The shallow water fish eaters hunt on foot for small fish, including gobies, and all sorts of other animals in places where the water is no more than a centimetre or two deep. The Spotted Redshank is the least characteristic fish eater of this group. This species also eats a lot of worms, shrimp (Gerdes, 1995) and other prey (Leopold *et al.* 2004b). Mussel beds in particular provide excellent foraging for these species. At low water, small pools are created there containing small fish and other animals. This enables the birds to forage efficiently. Such pools are also found in the Wadden Sea mud flats. Eurasian Spoonbills arrive in the Wadden area in March and April. The first birds to arrive forage mainly in polder drainage ditches. From the beginning of May, when the water level in the polders is raised and the bank vegetation grows taller, the birds mainly forage on the mud flats (Van Wetten and Wintermans 1986).

To start with, the birds catch mainly shrimp on the mud flats. During the summer, the significance of the mussel beds increases. When the small fish (flat fish and gobies) increase in numbers, they prefer these (Van Wetten and Wintermans 1986).

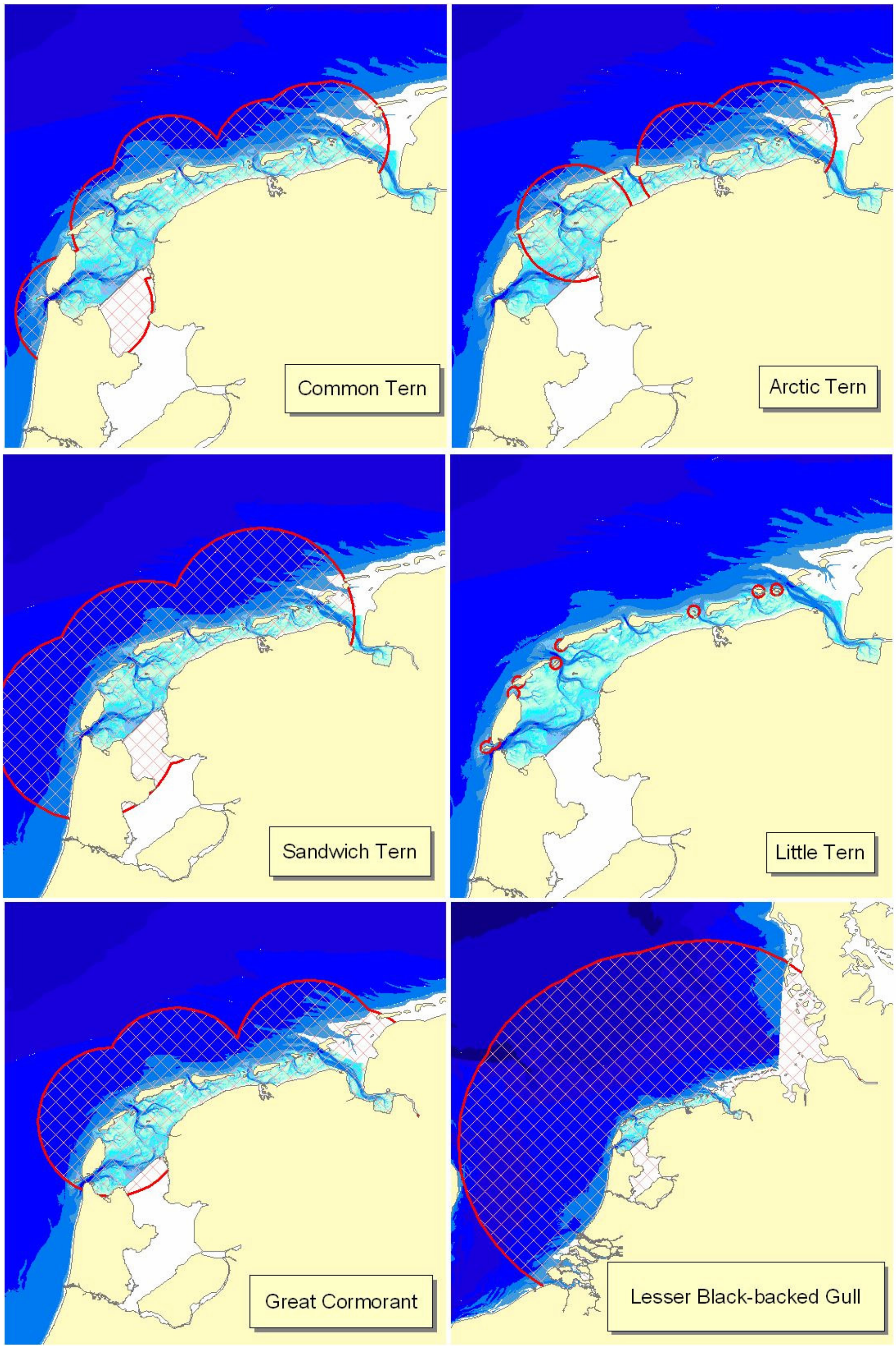

Figure 4.3 Foraging ranges of various fish eaters (source: experts meeting, 19 May 2005, Heinis 2005)

Surface hunters
The Wadden area is an important breeding area for various species of tern. These fish eaters that hunt at the surface of the water are directly dependent on the fish populations in the Wadden Sea. They usually have a limited action radius so there must be sufficient fish available close to the colonies, especially in the breeding period. Within the group of surface hunters (see Table 4-4) only the Lesser Black-backed Gull travels mush greater distances. The combination of undisturbed breeding places and an adequate supply of small fish for food in the immediate vicinity is particularly important for the Little Tern because this species has the smallest action radius. Figure 4-3 gives an indication of the range within which various species that breed in the Wadden area can find their food.

Terns eat mainly small round fish (see for example Common Tern: Stienen and Brenninkmeijer 1992 and Sandwich Tern: Brenninkmeijer and Stienen 1992, also Mr Jan Veen, oral communication). The Arctic Tern has a relatively wide choice of food and also catches many crabs, shrimp and worms. Most terns hunt in the Wadden Sea and a relatively narrow zone along the coast. Sandwich Terns have a larger action radius and use the North Sea Coastal Zone as a foraging area, but also fly further into the North Sea. Black Terns are rarely found in the Wadden area other than in August and use the Wadden Sea mainly as a place to sleep (Schobben *et al.* 1995, Van der Winden 2001). Large numbers of birds collect on the IJsselmeer and the adjacent part of the western Wadden Sea to build up their fat reserves before they fly to Africa (Van der Winden 2002). The IJsselmeer is probably more important to the Black Tern for building up reserves than the Wadden Sea.

If the transport of fish larvae is influenced by the Second Maasvlakte in such a way that fewer prey animals of the right size are available for foraging summer visitors, this might lead to a reduced breeding success. Species with a limited action radius and choice of food would be the most affected by this.

The birds in the surface hunter group can only make use of prey animals that swim just under the surface of the water. The availability of prey can therefore vary significantly in space and time. It is not known how important the clarity of the water is in the current situation. It is therefore impossible to predict whether any (local) increase in clarity as a result of a reduced silt contents will change the ‘catchability’ of prey. We should however note that the clarity is also partially determined by the amount of algae. A lowering of the silt content during the growing season will be associated with an increase in the primary production, so that effects of lower silt content on the clarity will be partially cancelled out.

4.4.5 Fish -> sea mammals

There are three sea mammals in the Wadden Sea and North Sea Coastal Zone that live mainly on fish: Porpoises, Harbour Seals and Grey Seals. Porpoises are found mainly in the autumn and winter in the coastal zone. Seals are found all year round. Grey Seals and Harbour Seals use the sand banks in the Wadden Sea and the tidal inlets between the islands as resting places (Figure 4-4).

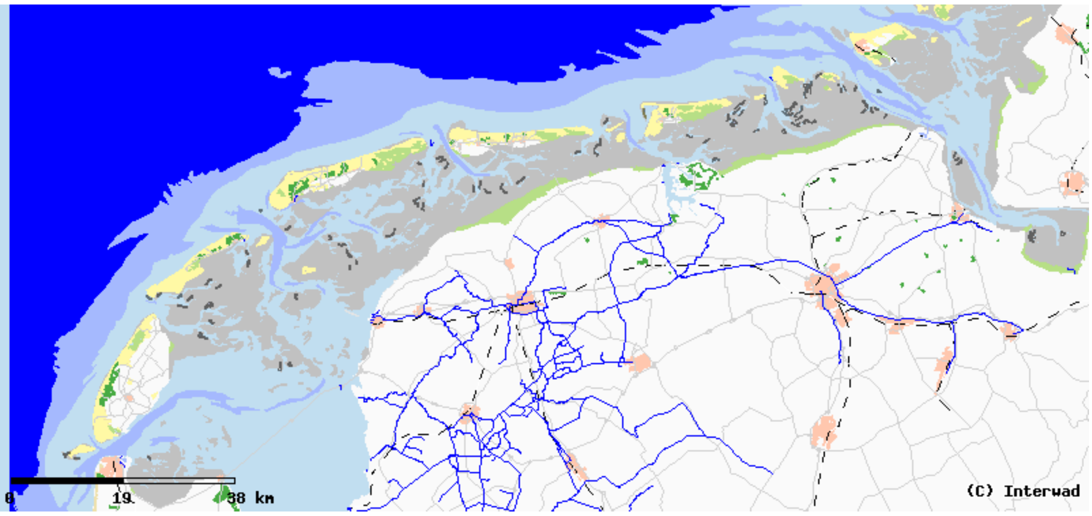

Figure 4-4 Seal colonies in the Wadden Sea (source: www.waddenzee.nl)

Brasseur *et al.* (2004a) have carried out field studies on the diet of the Harbour Seals resting in the Wadden Sea. In the same context a literature study was carried out on the diet of Grey Seals. An English study has shown that sand eels are an important prey species for the latter. We may assume that other species of round fish are also eaten. Less is known about the diet of Harbour Seals.

By following Harbour Seals with transmitters, Brasseur *et al.* (2004a) were able to establish that the animals travel up to 200 km from their colonies to forage (see, for example, figure 12A in Brasseur *et al.* 2004a). Seals are rarely seen at sea so it is difficult to say which parts of the North Sea are of specific importance for the animals.

Brasseur *et al.* (2004a) were unable to find a correlation between the densities of fish populations that were measured in the BTS and DMS surveys and the place where the seals forage. One explanation for this is that the fish populations are not limiting for the occurrence of seals. So the animals do not need to find the areas with the most fish in order to find sufficient food. The fact that the seal population has increased in recent decades, while prey species such as Cod have decreased significantly, supports this hypothesis. On the other hand, the absence of a correlation could indicate that the surveys do not register the fish populations that are most important for the seals.

Harbour seals are most strongly tied to the Wadden Sea during the nursing period (June – August). The pups are born here and nursed for around three weeks. During the nursing period, the mothers make much shorter foraging trips than normal. The take-up of food by nursing animals does not appear to be crucial for the condition of the mother or of the seal pups during this period. The take-up of food is however important in the period before the birth. Up to a few days before the birth of the young, pregnant seals can still travel large distances, for example from the Voordelta to the Wadden Sea (Reijnders *et al.* 2000, Brasseur and Reijnders 2001).

In some areas, Porpoises are concentrated in places where different types of water mix. For example, Teilmann (2003) makes a link between the ebb and flood currents in the Skagerrak and the frequency with which Porpoises are seen. Unpublished observations by Camphuysen in the Marsdiep show a similar pattern. It is possible that prey animals concentrate around the 'fronts' of different water types. The Porpoises look for these concentrations.
A study by Brasseur *et al.* (2004b) in the North Sea Coastal Zone near IJmuiden was not able to make a link between the occurrence of Porpoises and changes in temperature and salt content of the water because no significant differences in temperature and salt content were measured. It is possible that the measurements were taken at too great a depth (around 18 metres) to be able to register any changes.

For the rest, observations of Porpoises along the Dutch coast have increased significantly since 1990 (Camphuysen 2005). There may be large numbers. Leopold *et al.* (2004c) estimated the number of Porpoises between the coast and the 20 metre depth contour between IJmuiden and Texel to be some 3,000 in the winter of 2003/2004. Because the number of animals increases more rapidly than can expected from the growth rate of the population, Camphuysen (2005) suggests that they are animals from the population in the north western part of the North Sea, where the populations of prey animals have fallen sharply in the same period.

4 IMPACTS ON PROTECTED HABITATS IN THE AREA OF THE WADDEN SEA

4.1 Protected habitats

For the protection of natural habitats and habitats of protected species the EU member states propose areas where these species and habitats are found. At the beginning of July 2003 the European Commission approved a list of areas, which the Netherlands submitted for the Habitat Directive. In January 2005 the European Commission established the total European list (the so-called Community list).

In the area of the Wadden Sea there are eight designated areas for the Habitat Directive (see Appendix 3 for locations and boundaries):

1. Wadden Sea.
2. Frisian IJsselmeer coast.
3. North Sea coastal zone.
4. Texel dunes.
5. Vlieland dunes.
6. Terschelling dunes.
7. Ameland dunes.
8. Schiermonnikoog dunes.

Of these eight areas only the Wadden Sea and the North Sea coastal zone are found in the area that may be affected by the second Maasvlakte. Changes in the amounts of nutrients and silt in the Wadden Sea will not affect the IJsselmeer; after all, very little amount of water flows from the Wadden Sea to the Ijsselmeer. On the contrary, a lot of water flows from the Ijsselmeer to the Wadden Sea. Although the proposed dune areas do connect to areas that could be possibly affected, their surface area and quality are determined by factors other than the nutrient or silt content of the seawater. Attention is therefore focused exclusively on the Wadden Sea and North Sea coastal zone areas.

Table 5.1 contains a summary of the habitat types, which form the basis for the area selection. Information about the contribution in percentage terms of the habitat types to the total surface area of the reported areas is taken from LNV DRZ-Noord (2005a). A map giving the position of the various habitat types is shown in Appendix 4.

Table 5.1 Habitat types in the Wadden Sea and North Sea coastal zone

Area	EU habitat type	Nr.	Status	Share* (%)
Wadden Sea (259.214 ha)	**Sandbanks which are slightly covered by seawater all the time**	**1110**	**b**	**55**
	Estuaries	**1130**	**b**	**3**
	Mudflats and sandbars not covered by seawater at low tide	**1140**	**b**	**35**
	Salicornia and other annuals colonising mud and sand	**1310**		**1**
	Atlantic salt meadows (Glauco-Puccinellietalia maritimae)	**1330**	**b**	**2**
	Spartina swards (Spartinion maritimae)	**1320**	**o**	**0**
	Embryonic shifting dunes	**2110**	**b**	**1**
	Shifting dunes along the shorelines with Ammophila arenaria, (white dunes)	**2120**	**b**	**1**
	Fixed coastal dunes with herbaceous vegetation (grey dunes)	**2130***	**o**	**1**
North Sea coastal zone (24.838 ha)	**Sandbanks which are slightly covered by seawater all the time**	**1110**	**b**	**95**

b = most important area for habitat types concerned; o = also reported for habitat type

* indicative estimates (LNV DRZ-Noord 2005a)

5.2 Dune types (2110, 2120 en 2130)

The surface area and quality of the reported dune types are determined by factors (including large-scale hydrodynamic processes) other than the nutrient or silt content of the seawater. Because these habitatypes types lie above the high water mark, changes in the composition of the surrounding seawater will have no effect on them. Impacts from Maasvlakte 2 on habitat types 2110, 2120 and 2130 are therefore not to be expected.

5.3 Salt marsh types (1310, 1320[19] en 1330)

The main impact on habitats outside the dykes probably consists of a reduced supply of inorganic silt, as a result of which the siltation of salt marshes could happen somewhat less quickly than before. The supply of silt is not the factor that determines siltation on mainland salt marshes. Silt is present in abundance; it is the sedimentation conditions that determine the siltation. This siltation is very high in mainland salt marshes, 1-4 cm per year, with, as a result, a fairly quick succession to high salt marshes with Sea Couch. Some reduction in the rate of siltation would be an advantage rather than a disadvantage. It would also be able to keep pace easily with any acceleration in the rise in sea level, even in the event of a reduction of siltation in the order of 10-20% per year.

[19] Well developed forms of the type 1320 no longer occur in the Netherlands, because the principal typical species (Small spartina grass) has nearly all if not all disappeared from the country. The moderate form with the non-native English spartina grass covers a significant area only in the Eastern Scheldt and Western Scheldt (locally).

This is different for the island salt marshes. The supply of silt is a factor 10 lower and probably limiting. Close to the salt marsh edge and close to the salt marsh channels there is often a fair siltation (around 5-10 mm / year). Areas of salt marsh situated far from the edge of the mudflats and channels already receive relatively little silt now, albeit generally speaking enough to keep pace with the present rise in the sea level of 1.5 to 2 mm / year. A reduction of 10% in the rate of siltation would lead to a reduction of 0.2 mm per year.

The extent to which the reduction in siltation can lead to a substantial impact on the future area of island salt marshes is further elaborated below:

IMPACT OF REDUCED SILT SUPPLY TO THE SALT MARSHES IN THE WADDEN SEA

Basic assumptions:

- the silt supply decreases by 10%;
- translating this to the whole of the Wadden Sea is in proportion to this; where the seabed now contains 4% silt, it becomes (after at least a period of some decades) 3.6%, and so on; as stated in 3.5.1, the direct translation of 10% less silt supply to 10% less silt in the bottom and hence 10% less silt deposit is a worst case approach.. Because of the great uncertainties around the relationship between silt supply and the actual change in sedimentation and composition this scenario has been taken as a starting point.
- silt deposit on the salt marsh is also proportional (because the silt that is deposited on the salt marshes during storms to a large extent originates from the silt that is swirled up from the upper layer of the sediment); 10% less silt in the top layer of the seabed will thus also mean that 10% less silt will be deposited on the salt marshes.

Mainland salt marshes

There is no expectation of a shortage of silt for the mainland salt marshes. In general the siltation there amounts to more than 1 cm per year and if it reduces by 10% there is still so much that the mainland salt marshes will still silt up quickly. At the current (relative) increase in the sea level, around 1.5 to 2 mm per year is necessary there; in the event of an accelerated increase there is still a sufficient buffer to absorb this.

Island salt marshes

A silt deficit for the island salt marshes is a real possibility. Apart from the salt marsh edges and along the channels, the siltation in many places is just enough to keep pace with the current rise in sea level, in the order of 2 mm per year. It is assumed that 2 mm per year (allowing for a certain amount of compaction) is necessary to keep pace with the current rise in sea level. If this reduces by 10%, there is still 1.8 mm per year left. In 50 years that produces a reduction in siltation of 1 cm, and in 250 years of 5 cm. Taking into account a transitional phase in which there is still sufficient silt present at the bottom, it will be 250 - 300 years before this deficit is reached. From the subsidence study at Ameland it is known that even a much greater deficit (from 20 to 25 cm) is barely noticeable in the vegetation (Dijkema 2005). Much more important is the state of drainage; if this remains good, vegetation, once established, maintains itself well. Naturally there is a limit to this; there must be a difference in height between salt marsh and mudflats in order to maintain good drainage. But given the Ameland results it is very unlikely that 5 cm difference will be noticeable in the vegetation.

Sea level rise

In the reasoning for the island salt marshes, no account has yet been taken of the impact of an accelerated rise in sea level. Because of this a cumulative effect is created: both less siltation *and* a greater rise in sea level. A rise in sea level obviously results in more frequent flooding, and because of this a greater supply of silt, which can partly compensate for the effects of the rise in sea level.

In estimating the combined effect of an accelerated rise in sea level and a reduced supply of silt the following scenarios are assumed:

- scenario ‘constant siltation capacity, a rise in sea level of 6 mm / year (60 cm per century)’: at a certain point the salt marshes will drown, for example when they ‘lag behind’ by 50 cm. With a 10% reduction of the siltation capacity as a result of Maasvlakte 2, the point of great changes in vegetation will be brought back from 125 (= 50 / (0.6 – 0.2)) to around 120 (= 50 / (0.6 – 1.8)) years;
- scenario ‘increased siltation capacity through accelerated rise in sea level (as a result of increased duration of flooding) to 4 mm per year’. With a 10% reduction in the siltation capacity as a result of Maasvlakte 2 the point of great changes in vegetation will be advanced from 250 (= 50 / (0.6 – 0,4)) to 208 (= 50 / (0.6 – 0.36)) years.

CONCLUSIONS:
- if no account is taken of an accelerated rise in sea level there is an extremely small and probably no noticeable impact;
- the 1st scenario with a rise in sea level is pessimistic in terms of extra siltation, which creates changes in vegetation after around 100 years, but the impact of Maasvlakte 2 on the advancement of the ‘drowning point’ is then not great (advancement by 5 years);
- the 2nd scenario with a rise in sea level is optimistic in terms of siltation, where changes in vegetation only occur after more than 200 years; the impact of Maasvlakte 2 here is greater however, because the ‘drowning point’ is postponed for longer (advancement by 42 years).

Important quality characteristics of the salt marsh habitat types are (see also 0 and 0):
1. natural succession
2. zoning complete, specific salt marsh zones not over represented
3. birds
4. distinctive (attention) species of higher plants and rare insects.

1 and 2. No negative impact from Maasvlakte 2 (see 0)

3. Impacts on relevant bird species are discussed in 5.3.2 and 5.3.3

4. No negative impact from Maasvlakte 2 (see 0).

5.4 Estuaries (1130)

Estuaries are the downstream sections of river systems, which are affected by seawater and the working of the tides and strongly influenced by fresh river water. The mixing of fresh water with seawater creates a gradient of fresh to salt water, whereby the furthermost influence of salt water upstream forms the border of the estuary; the furthermost influence of fresh water downstream forms the border with the marine system. Within the Wadden area, the section in the extreme east, which is part of the Eemd-Dollard estuary, is considered to be this habitat type.
Neither the total surface area, nor the quality of this habitat type that is part of the Wadden Sea HR area will be affected by factors that might change because of MV2. Furthermore it is assumed that possible effects from Maasvlakte 2 itself will only take place in the western Wadden Sea and extend no further than the slack water of Ameland (see 0).

5.5 Mudflats and sandbars uncovered at low tide (1140)

A reduced (or temporarily increased) silt content in the great majority of the Wadden Sea will bring about few, if any, changes in the height or in the surface areas of various habitat types; the morphological developments are, after all, predominantly determined by the movement of the water and the associated transport of sand and not by the concentration of silt. A change in the surface area of habitat type 1140 is therefore not expected.

Important quality characteristics of this habitat type are (see also 0 and 0):
1. alternation of sandy and silt-rich parts (mudflats and sandbars)
2. presence of shellfish banks
3. sea grass and Ruppia species
4. concentration of filter feeders (mussels, cockles, clams)
5. concentration of sediment feeders (worms, sea centipedes)
6. typical species of fish
7. typical species of wading birds
8. typical species of marine mammals.

1. The alternation of relatively silt-rich and silt-poor (sandy) areas will not change as a consequence of Maasvlakte 2, because no changes in the morphology are expected and hence also not in the degree of exposure; dynamic areas remain dynamic and sheltered areas (where material sediments) remain sheltered (see also 0). Within these silt-rich and silt-poor areas however the silt percentage could somewhat decline.

2. There are no impacts expected from Maasvlakte 2 on the presence of shellfish banks (see 0).

3. No negative impact (see 0).

4 and 5. Effects on shellfish and sediment eaters are not treated as an independent criterion, but are included as interim variables for the definition of impacts on shellfish and worm-eating birds (see further 5.5 and ……)

6 to 8. See respectively 5.3 (fish), 5.5 (waders and water birds) and 5.3.4 (marine mammals).

5.6 Sandbanks permanently submerged by shallow seawater (1110)

The same reasons apply as mentioned above in respect of habitat type 1110 in both the Wadden Sea and the North Sea coastal zone; no change in the surface area is expected as a consequence of Maasvlakte 2.

Important quality characteristics of this habitat type are (see also 0 and 0):
In the littoral a varied height and presence of natural channel systems.
1. presence of shellfish banks
2. sea grass and Ruppia species
3. concentration of filter feeders (mussels, cockles)
4. concentration of other bottom organisms
5. typical species of fish

6. typical species of birds
7. typical species of marine mammals.

1. Maasvlakte 2 is not expected to have any effects on the establishment and presence of shellfish banks. (see 0).

2. No effect (see 0).

3 and 4. Effects on shellfish and other bottom animals are not treated as independent criteria, but are included as interim variables for the definition of impacts on birds that foragie on them (see further 5.5 and ……)

5 to 7. See respectively 5.3 (fish), 5.4 (fish-eating birds), 5.5 (waders and water birds) and 5.3.4 (marine mammals).

5.7 Conclusions: impacts on habitats

No effects are expected from the construction or the presence of Maasvlakte 2 on the surface area of EU habitat types. The quality of the habitat types will likewise not be reduced due to negative impact, in so far as this relates to criteria that do not recur (as interim variables) in the description on impacts on species (see chapter 4 for the underlying argumentation and chapters 6 and 7 for the description of effects on species).

5 IMPACTS ON PROTECTED SPECIES

5.1 Protected species

The Birds and Habitats Directives protect many species in the Wadden Sea area. The areas listed in Tabel 0.1 have been designated (Birds Directives) or proposed (Habitats Directive) for the protection of these species. As was substantiated in table 6.1 only the Wadden Sea and the North Sea coastal zone fall within the area affected by the Maasvlakte 2 project. Therefore only those species found in these two areas will be considered below. Only the sub-area 'North Sea coastal zone' of the Birds Directive area 'Wadden Sea islands, North Sea coastal zone and polder Breebaart' is considered (see Tabel 0.1) this means that such species as the Fen Orchid, Floating Water Plantain, Narrow-mouthed Whorl Snail and Root Vole do not appear in the further description of the effects. This also applies to a number of bird species that are dependent on dunes and higher salt marshes and that do not utilize areas of the Wadden Sea area that might possibly be influenced by the Maasvlakte 2 project. The species concerned are Little Grebe, Spotted Crake, Red-backed Shrike, Sedge Warbler, Whinchat, Common Stonechat and Northern Wheatear.

Table 6.1 Designated (Birds Directive) and proposed (Habitats Directive) areas SACs in the Wadden Sea area for the protection of birds and other species.

Habitat Directive	Birds Directive
1. Wadden Sea	1. Wadden Sea
2. Frisian coastal zone of Lake IJssel	2. Frisian coastal zone of Lake IJssel
	3. Wadden Sea islands, North Sea coastal zone, polder Breebaart
3. North Sea coastal zone	North Sea coastal zone[1]
4. Dunes of Texel	Dunes of Texel
5. Dunes of Vlieland	Dunes of Vlieland
6. Dunes of Terschelling	Dunes of Terschelling
7. Dunes of Ameland	Dunes of Ameland
8. Dunes of Schiermonnikoog	Dunes of Schiermonnikoog
	Polder Breebaart

1 The SAC North Sea coastal zone under the Birds Directive is much bigger than under the Habitats Directive (see Appendix 3).

Tabel 6.2 contains an overview of (parts of) the relevant Birds Directive and Habitats Directive areas of all the qualifying and other relevant bird species and all the species for which the areas concerned are important or for which the area has also been designated. The list was compiled using information available on www.minlnv.nl (April 2005), supplemented by a few species that were stated in the documentation that was distributed by the Ministry of Agriculture, Nature Management and Food Quality in the context of the Interdepartmental Wadden Sea Committee (of 24 May 2005)[20]. A more comprehensive overview of the sub-area is included in Appendix 2.

[20] This concerns the Goldeneye, Great Crested Grebe, Greenshank, Coot, Smew and Wild Duck.

Table 6.2 Qualifying and other relevant bird species (Birds Directive), important and proposed species (Habitats Directive) for the Wadden Sea and North Sea coastal zone. * = included in Appendix I of the Birds Directive.

Species	Status	
	Wadden Sea	North Sea coastal zone
Great Cormorant (breeding/not breeding)	o	o
Common Shelduck	q	o
Ringed Plover (breeding/not breeding)	o	o
Dunlin	q	q
Barnacle Goose*	q	
Common Goldeneye	o	
Marsh Harrier*	o	
Sanderling	q	q
Little Tern (breeding)*	q	
Common Eider (breeding/not breeding)	q	q
Great Crested Grebe	o	
European Golden Plover*	q	
Greylag Goose	q	
Common Greenshank	o	
Sandwich Tern*	q	
Goosander		o
Black-tailed Godwit	o	
Red Knot	q	q
Northern Lapwing	o	
Lesser Black-backed Gull (breeding)	q	
Bewick's Swan*	q	o
Pied Avocet* (breeding/not breeding)	q	o
White-fronted Goose	o	
Gadwall	o	
Curlew Sandpiper	o	
Eurasian Spoonbill* (breeding/not breeding)	q	
Eurasian Coot	o	
Red-breasted Merganser	o	o
Smew	o	
Artic Tern (breeding)	q	
Black-throated Loon		q
Northern Pintail	q	o
Red-throated Loon		q
Bar-tailed Godwit*	q	q
Brent Goose	q	
Eurasian Oystercatcher	q	o
Peregrine Falcon*	q	
Northern Shoveler	q	
Eurasian Wigeon	q	
Ruddy Turnstone	q	o
Tundra Bean Goose	o	
Greater Scaup	q	q
Common Redshank	q	

Species	Status	
	Wadden Sea	North Sea coastal zone
Short-eared Owl (breeding)*	o	
Common Tern (breeding)*	q	
Mallard	o	
Common Teal	q	
Eurasian Curlew	q	o
Grey Plover	q	q
Spotted Redshank	q	
Black Tern*	q	
Common Scoter		q
River Lamprey	a	a
Sea Lamprey	a	a
Twaite Shad	b	a
Porpoise		m
Grey Seal	m	m
Harbour Seal	m	m

q = qualifying; o = **o**ther relevant species
m = one of the 5 **m**ost important areas for…; a = **a**lso proposed for…
* included in Appendix I of the Birds Directive.

5.2 Impact description procedure

The impacts on species are addressed in two steps. First an analysis is made of the ecological characteristics of the species to find out whether the construction and presence of the Maasvlakte 2 will have little or no effect on that species.This is done on the basis of the description of first and higher order effects that the Maasvlakte 2 project can have via different intervention impact relationships defined in chapter 4. Diadromous fish, plant-eating birds, birds of prey and marine mammals are therefore discussed briefly in 5.3.

As far as the other species are concerned (fish-eating birds and shore birds), the impacts are described in greater detail on the basis of the intervention impact relationships described in chapter 4. A statement is made in regard to each species about the way in which it can be affected by the Maasvlakte 2 project. This includes determining whether or not a relationship exists between possible changes in the supply of silt to the Wadden Sea and/or with a possible reduction in the levels of nutrients in the Wadden Sea. A statement is also made about whether species can be affected by changes in the distribution patterns of clupeidae, sand eels and heterosomata.

This always includes determining whether the effects through these three routes in the intervention-impact chains can have more direct, direct or less direct impacts on the species. If one or more intervention impact routes have a directly proportional or more than directly proportional affect on the species, it has been characterized as ‘sensitive’ to changes as a result of the construction of Maasvlakte 2. If all routes have an effect that is less than direct, the species is ‘moderately sensitive’.

5.3 Delineation of impacts on species

5.3.1 Fish

The life cycle of the Twaite Shad, Sea Lamprey and River Lamprey consists of a breeding and rearing phase in fresh water (rivers) and a growth and maturity phase at sea. The location options and the lack of space associated with the sea phase play a role in the assessment of the possible impacts of the Maasvlakte 2 project. It is unlikely that the construction of Maasvlakte 2 will have an effect on the location options. Fish population studies show that Twaite Shad, Sea Lamprey and River Lamprey utilize the whole coastal area (including the Wadden Sea) as a habitat (Patberg *et al.* 2005). None of the sub-areas (coast of Holland, North Sea coastal zone, Wadden Sea) has specific significance in regard to these fish species and the total quantity of nutrients (and therefore food) does not change. It can therefore be concluded that it is improbable that the construction of Maasvlakte 2 will have a significant impact on these three fish species.

5.3.2 Plant-eating birds

In the Wadden Sea and North Sea coastal zone SACs there are 7 qualifying and 5 other relevant bird species with a predominantly vegetarian habits (Table 6.3 Qualifying and other relevant species with a vegetarian habit).

Table 6.3 Qualifying and other relevant species with a vegetarian habit

Qualifying	Other relevant species
Bewick's Swan	Bean Goose
Barnacle Goose	White-fronted Goose
Greylag Goose	Gadwall
Brent Goose	Mallard
Northern Shoveler	Coot
Eurasian Wigeon	
Common Teal	

The Barnacle Goose and the Greylag depend on (medium high) salt marshes for part of their food supply. These will not suffer a decline in quality as a result of the construction of Maasvlakte 2 (see 5.3). As a consequence of the virtual disappearance of sea grass from the Wadden Sea, the Brent Goose forages primarily in grasslands near the coast (autumn and winter) and in grasslands and salt marshes on the coast in the spring (van de Kam *et al.* 1999). The expectation is that the conditions for sea grass, which is currently virtually absent, will in any event not get worse and might even improve as a result of the expected increase in transparency (see 0). A negative impact on the Brent Goose is therefore not to be expected.

All other goose species use inland grasslands rich in food in the island polders or on the mainland. Bean Geese, White-fronted Geese and Bewick's Swans are found virtually exclusively in the island polders. As stated above (section 5.3) the quality of these will not decline as a result of the Maasvlakte 2 project. Wigeons also often forage in salt marshes (except in inland grasslands). No negative impacts the on salt marsh vegetation, and therefore on Wigeons, are to be expected.

Teals are found primarily in the Eems and Dollard (van Roomen *et al.* 2004). Here they find food that comes from salt marsh plants. Impacts on the Teal are therefore also not expected.

In recent decades the numbers of Gadwalls have increased sharply (van Roomen *et al.* 2004). They feed mainly on (fresh water) algae. The numbers in the Wadden Sea area are relatively modest and this species is nearly never found on the coast. An impact from the construction of Maasvlakte 2 is therefore also not expected.

Shovelers concentrate in the Dollard and Eems, near outlet sluices and elsewhere (Kleefstra *et al.* 2002). It is possible that they select these areas as resting places because of the lower salt content. In the Wadden Sea area shovelers live mainly off the seeds of salt marsh plants, but sometimes they also eat snails and other small creatures. However, the numbers in the Wadden Sea area are relatively modest. An impact from the construction of Maasvlakte 2 is therefore also not expected.

Coots frequently forage on the dykes around the Wadden Sea. The edges of the flats are used as resting places. The coast in the Wadden Sea area is of very limited importance to this species as a foraging area. The Wadden Sea area as a whole is also of limited significance in regard to this species. Of the 253,000 birds that remain in the Netherlands during the winter, during the period from 1998/1999 to 2003/2004 on average a maximum of 5270 were in the Wadden Sea area (2.1% of the Dutch population and 0.3% of the Northwest European population). The Maasvlakte 2 project is therefore not expected to have an impact on this species.

Summarizing, it can be concluded that no negative impacts as a result of the Maasvlakte 2 project are to be expected on any of the qualifying and other relevant plant-eating birds.

5.3.3 Birds of prey and owls

Outside the breeding season the qualifying Peregrine Falcon hunts for waders in the Wadden Sea area. This species has a preference for areas with abundant water and it overwinters, among other places, in the Wadden Sea area, where its prey consists largely of waders and (to a lesser extent) ducks (Bijlsma *et al.* 2001). During the 1999-2004 period the average annual maximum in the Wadden Sea areas was over 50 individual birds (SOVON data, 2005). The number of waders is therefore always many times greater than the food needs of the Peregrine Falcon. Impacts on this species are consequently not expected.

The Hen Harrier breeds in the dunes and salt marshes of several Wadden Sea islands. Harriers hunt young birds and small mammals on the islands. There is an excess of such food, also in the event that breeding populations were to decrease somewhat.

The Marsh Harrier breeds in the salt marshes in the dunes of the Wadden Sea area. Among other things, this species hunts the chicks of birds that breed in the salt marshes. There is an excess of such food, also in the event that breeding populations were to decrease somewhat.

Short-eared Owls also breed and hunt in the salt marshes. They live off a variety of small creatures, such as mice and chicks. The construction of Maasvlakte 2 will have no impact on the food supply of Short-eared Owls.

5.3.4 Marine mammals

The numbers of Harbour Seals and Porpoises along the Dutch coast are increasing (Reijnders *et al.* 2003; Camphuysen 2005). The population of the Grey Seal has also increased significantly. The increase in the numbers of Grey Seals is probably the effect of migration from other parts of the North Sea.

Seals and Porpoises cover large distances while foraging. The overall quantity of food will not be affected by the Maasvlakte 2 project. It is therefore not considered to be probable that a possible local decrease in the quantity of food available for Seals and Porpoises will represent a problem because the foraging area (Seals) or living area (Porpoises) is so large (see also 0).

5.4 Fish-eating birds

5.4.1 Fish eaters – surface hunters

Current situation and autonomous development
Table 6.4 Fish-eating birds that forage on the surface of the water contains an overview of the numbers of fish eaters in shallow waters in the Wadden Sea / North Sea coastal zone and the Netherlands, together with the size of the Northwest European population. The trend in the numbers for the Wadden Sea / North Sea coastal zone is also included.

Table 6.4 Fish-eating birds that forage on the surface of the water

	Normative period	Number of Wadden Sea (not breeding) birds (van Roomen et al. 2004)	Number of Wadden Sea breeding pairs (Dijksen & Koks 2003)	Total Dutch population (van Dijk *et al.* 2005)	NW European population (Delany & Scott 2002)	Trend	Range (km) (Heinis 2005)
Little Tern	Breeding		194	445*	3,400	0	2.5
Artic Tern	Breeding		1,478	1,423*	449,000	0	25
Common Tern	Breeding		6,390	16,804*	190,000	0	25
Sandwich Tern	Breeding		11,106	19,073*	170,000	f?	50
Black Tern	Aug	2,696*		?	400,000	-?*	NA
Lesser Black-backed Gull	Breeding		45,426	94,250*	530,000	+	200

Explanatory notes:

Number of birds: long-term average over a period of 5 years up to and including 2002/2003

– *: number of birds in August 2002, no integrated count

Total population in the Netherlands

– *estimated population size in 2003, on the grounds of indexing over the 1999-2003 period.

NW European population: number of birds on the basis of Delany & Scott 2002

– *: number of birds on the basis of Rasmussen *et al.* 2000

Trend: summer birds: Dijksen & Koks 2003, trend for the Wadden Sea area between 1991 and 2002

– *: overwintering birds (van Roomen *et al.* 2004), trend for the Wadden Sea from 1993/94 to 2002/03

Little Terns breed on various islands in the Wadden Sea. They always search out places near to deeper channels, i.e. Vliehors, Richel, Noordvaarder, Rif and Rottummerplaat and Rottumeroog (data from Dijksen & Koks 2003). The Little Tern is not very numerous in the Wadden Sea. Altogether there are approximately 190 breeding pairs (Dijksen & Koks 2003). The colonies are relatively small, a few dozen breeding pairs. The number of breeding pairs appears to be more or less stable (Dijksen & Koks 2003), although disruption caused by visitors can easily lead to poor breeding results (Rasmussen *et al.* 2000

The biggest colonies of the Artic Tern are on Griend, Schiermonnikoog, Rottumerplaat and Rottumeroog. The total number of birds has been dropping over the last few years after an initial increase at the beginning of the nineteen-nineties (Dijksen & Koks 2003). The breeding success of the birds is very variable. In 2002, for example, the colony on Griend reared no young to maturity (Lutterop & Kasemir 2002). Artic Terns have greater flexibility in their choice of food than Common Terns. They can switch more easily to sources of food like shrimps if the availability of fish is not adequate (Südbeck *et al.* 1998, Strienen & Brenninkmeijer 1998, Becker *et al.* 1997). Even so, in some years the local availability of sufficient food appears to be limiting, for example as reported by Dijksen (2004) in regard to birds on Griend (also applies to the Sandwich Terns and Common Terns breeding there).

The Common Tern is the most widely dispersed tern in the Wadden Sea area. There are altogether some 6400 breeding pairs. The biggest colonies are on Griend and Balgzand. Elsewhere in the Wadden Sea area there are colonies everywhere ranging in size from a couple of dozen to hundreds of birds, both on the islands and along the coast (Dijksen & Koks 2003). Despite unexplained shifts within the Wadden Sea area, the number of Common Terns is fairly stable. The availability of undisrupted nesting sites can be limiting for this species at the Wadden Sea level. The size of the population locally is probably determined by the availability of food (Strienen & Brenninkmeijer 1998, Dijksen 2004). Südbeck *et al.* (1998) and Thynen *et al.* (1998) expect that during periods of bad weather in the breeding season the availability of small fish can be a limiting factor for this species because they are then less easy to catch.

Black Terns do not breed in the Wadden Sea area. However, after the breeding season is it a place for birds to gather. The counts are not complete because the birds are often only present briefly (van Roomen *et al.* 2004). However, during some counts tens of thousands of birds have been observed at the same time (Winden & Schobben 2001). Van Roomen *et al.* (2004) do not refer to later descriptions of indications that the number of birds is decreasing. Developments outside the Wadden Sea area are the underlying reason for this.

Unlike the other terns in the Wadden Sea area, nearly all the Sandwich Terns breed together in one colony on Griend. In 2002 nearly 11,000 pairs bred there (Dijksen & Koks 2003). The number of pairs of birds breeding on all other Dutch Wadden Sea islands taken together is not more than 150 (whereas over 6000 breed in the Delta area). Sandwich Terns have a longer range than smaller terns (Camphuysen in Heinis 2005). As a rule they forage on the seaward side of the Wadden Sea islands (Garthe & Kubetzki 1998). Apparently Sandwich Terns prefer a longer distance to foraging locations rather than a dispersed breeding pattern.
Griend is one of the least disturbed colony sites in the Wadden Sea area. The colony on Griend represents more than 40% of the total population in the international Wadden Sea area (Rasmussen *et al.* 2000). After somewhat lower numbers in the middle of the nineteen-nineties, the number of breeding pairs seems to have been increasing over the last 10 years. Stienen & Brenninkmeijer (1998) and Van Tienen & Baarspul (1998) link this temporary decline half way through the nineteen-nineties to a reduced availability of sand eels. However, Stienen & Brenninkmeijer also refer to herring as an important source of food for the Sandwich Tern. On the other hand the catching of terns on the coast of Africa also appears to have an influence on the size of the population. Rasmussen et al (2000) expect that better protection of potential colony sites can also contribute to the sustainability of the population.

The Lesser Black-backed Gull breeds in large numbers on various islands. The largest colonies are on Noorderhaaks and Terschelling. Altogether more than 45,000 pairs breed in the Wadden Sea area (Dijksen en Koks 2003). The number of breeding pairs has increased steadily since the beginning of the nineteen-nineties, although there was a small drop in 2002 (van Roomen *et al.* 2004). The Black-backed Gulls leave in the winter. Recently an increase in the number of foraging Lesser Black-backed Gulls was observed in the polders on all Wadden Sea islands. Possibly the birds are searching for a new source of food as a result of the reduction in the number of discards by fishing vessels (verbal communication Cor Smit, Alterra).

Impacts
The Little Tern, Common Tern and Artic Tern all forage for small fish in the Wadden Sea. Changes in the availability of fish of the right size during the breeding season can affect the success of breeding. There are indeed indications of this for the Common Tern. Of the three species of tern being discussed, the Artic Tern is the least sensitive. Artic Terns can switch to other types of prey relatively easily. Furthermore, a rather small proportion of the Northwestern European population breeds in the Netherlands, i.e. some 0.3 % (compared with nearly 6% for the Little Tern and Common Tern).

It also needs to be borne in mind with regard to the Sandwich Tern that the availability of food can be determining for how successful breeding is, and consequently the size of the population of this species. The Sandwich Tern differs from the other terms because of its long range and the fact that it forages primarily on the seaward side of the Wadden Sea islands (for larger fish). An impact on this species will not occur until the stocks of prey in the North Sea as a whole decline.

Black Terns rarely forage in the Wadden Sea and never at all in the North Sea coastal zone. They will therefore not be affected by any changes in the supply of prey. The resting places for this species will not be harmed because no changes in the morphology of the Wadden Sea area are expected.

Lesser Black-backed Gulls find most of their food outside the Wadden Sea and North Sea coastal zone. A decrease in fish stocks inside the protected areas will therefore not result in an impact on this species.

Besides the presence of food, the ease with which prey can be caught also plays a role. This is probably affected by the transparency of the water. As a result of the widening of the coastal river through Maasvlakte 2, the water in the Wadden Sea and North Sea coastal zone could become more transparent. It is not known to what extent a change will affect the ease of catching fish. It could be affected positively or negatively. However, it should be pointed out that the quantity of algae also affects the transparency. A reduction in the silt content in the growing season will be accompanied by an increase in the primary production, as a result of which the impact of a reduced silt content on the transparency will in any event be partially counteracted.

Conclusions

During the breeding season the Little Tern and Common Tern are very much dependent on the nearby presence of sufficient food of the right format (such as sand eels, young herring and other small fish). If the construction of Maasvlakte 2 negatively impacts the numbers of prey of the right size in the Wadden Sea and North Sea coastal zone, it can lead to less successful breeding by the Little Tern and Common Tern. These species are therefore considered to be ‘sensitive’ in regard to changes.

The Artic Tern and Sandwich Tern are ‘moderately sensitive’. The Artic Tern is in this category because it can easily switch to other prey if the supply of fish is too small. The Sandwich Tern is moderately sensitive because it finds a large proportion of its food further out into the North Sea, where no changes in the availability of prey are expected.

Any change in the transparency is an uncertain factor in the assessment in regard to the species discussed above. Impacts can be positive or negative or they can offset one another (birds see fish more clearly, but fish see birds more clearly too).

No impact on the Black Tern is expected because the Wadden Sea is not an important foraging area for these birds. The Lesser Black-backed Gull is also not solely dependent on the Wadden Sea or North Sea coastal zone for its food supply. These two species are therefore ‘not sensitive’ to changes as a result of the Maasvlakte 2 project.

5.4.2 Deep water fish eaters

Current situation and autonomous development

Table 6.5 Fish-eating birds that forage in deep water contains an overview of the numbers of fish eaters in deep waters in the Wadden Sea / North Sea coastal zone and the Netherlands, together with the size of the Northwest European population. The trend in the numbers for the Wadden Sea / North Sea coastal zone is included.

Table 6.5 Fish-eating birds that forage in deep water

	Normative period	Number of (not breeding) birds Wadden Sea (van Roomen et al. 2004)	Number of Wadden Sea breeding pairs (Dijksen & Koks 2003)	Total population in the Netherlands	NW European population (Delany & Scott 2002)	Trend	Range (km) (Heinis 2005)
Black-throated Loon	Nov-Dec	1*		500***	1,000,000	?*	NA
Red-throated Loon	Jan	47*		10,000***	1,000,000	?*	NA
Great Crested Grebe	December	1,297*		20,500**	4,750,000	0	NA
Great Cormorant	Breeding		1,447	23,139*	310,000*	+	40
	Sept	9,194*		36,000**		+*	40
Smew	January	46*		6,800**	40,000		NA
Red-breasted Merganser	Jan	307*		Delta: 8,200	170,000	-*	NA

Explanatory notes:

Number of birds: long-term average over a period of 5 years up to and including 2002/2003

- *: number of birds in 2002/2003, no long-term average (van Roomen *et al.* 2004)

Total population in the Netherlands: long-term average over a period of 5 years up to and including 2002/2003

- *estimated population size in 2003, on the grounds of indexing over the 1999-2003 period (van Dijk *et al.* 2005)
- ** maximum number of birds counted in 2002/2003 (van Roomen *et al.* 2004)
- *** estimate for the Dutch part of the North Sea, Camphuysen & Leopold 1994

NW European population: number of birds on the basis of Delany & Scott 2002

- *: number of birds on the basis of Rasmussen *et al.* 2000)

Trend: summer birds: Dijksen & Koks 2003, trend for the Wadden Sea area between 1991 and 2002

- *: overwintering birds (van Roomen *et al.* 2004), trend for the Wadden Sea from 1993/94 to 2002/03

There is little known about the numbers of divers in the Netherlands. This is because most of the birds overwinter too far out to sea to be seen from dry land. According to Camphuysen & Leopold (1994), the number of overwintering Red-throated Divers in the Dutch part of the North Sea should be estimated at about 10,000. The number of Black-throated Divers in this area amounts to a few hundred (Camphuysen & Leopold 1994). No pronouncements can be made about trends in the size of the diver population on the basis of the available counts.

Great Crested Grebes are found primarily on water inside the dykes (fresh and salt). There are groups of Great Crested Grebes in the Wadden Sea area in the winter, primarily around the Lake IJssel Dam. However, the numbers are small compared with the total numbers of overwintering Great Crested Grebes in the Netherlands (2%) and essentially zero compared with the Northwest European population (< 0.1%). It can be assumed that the Great Crested Grebes use the Wadden Sea area primarily as a resting place and they forage inside the dykes.

In 2002 Cormorants bred in four places in the Wadden Sea area. The biggest colony is in Kroon's polder on Vlieland, where more than 1000 breeding pairs were found in 2002 (Dijksen & Koks 2003). There were also colonies on Texel, Rottumeroog and De Hond in the Eems. They have recently also established themselves on Terschelling, on the Boschplaat (Dijksen 2004). The number of Cormorants in the Wadden Sea area seems to be growing exponentially (Dijksen & Koks 2003). Few Cormorants remain in the Wadden Sea area in the winter (van Roomen *et al.* 2004).

Relatively few Red-breasted Mergansers remain in the Wadden Sea area during the winter. Around 300 were counted in 2002 (van Roomen *et al.* 2004). Much greater numbers overwinter in the Delta area, namely over 8000 a year. In the Lake IJssel area, which is a much less important area for this species, the numbers seem to have declined, possibly as a consequence of smaller stocks of smelt and eel, which are two important kinds of prey (Platteeuw 1985, Hartgers & Dekker 2000).

Smews seem to have the same foraging behaviour as Red-breasted Mergansers. However, they are more strongly tied to larger bodies of fresh water. Only small numbers remain in the Wadden Sea area in the winter. They represent only 1.6% of the overall numbers in the Netherlands and 0.13% of the European population.

Impacts

The populations of the Red-throated Diver and Black-throated Diver are stable. The North Sea coastal zone is of primary significance to these two species. The availability of prey is therefore not determined so much by the situation in the Wadden Sea, but rather by fish production in the North Sea and the fishing industry.
An impact on divers is only conceivable if the Maasvlakte 2 project were to negatively affect the fish stocks in the southern North Sea as a whole. This is not very likely because of the fact that the total quantity of nutrients will not change as a consequence of Maasvlakte 2. As far as the quantity of available food is concerned, no negative effects on these species are therefore expected. It is not known whether and, if so, how any changes in the transparency can affect the ease of catching prey.

In view of the growth of the Cormorant population and the limited importance of the North Sea coastal zone to the Red-breasted Merganser, no changes compared with the numbers of these species over the last 10 years are expected, even if there is a limited drop in the food supply. The Wadden Sea and North Sea coastal zone do not play a significant role as foraging areas for Great Crested Grebes and Smews. The Maasvlakte 2 project is therefore not expected to have an impact.

Conclusions

For a variety of reasons the Black-throated Diver, Red-throated Diver, Great Crested Grebe, Cormorant, Smew and Red-breasted Merganser are not sensitive to changes in the food supply as a consequence of Maasvlakte 2. However, the impacts of any change in the transparency cannot be assessed accurately at the moment.

5.4.3 Shallow water fish eaters

Current situation and autonomous development

Table 6.6 Fish-eating birds that forage in shallow water contains an overview of the numbers of (a significant proportion of) fish-eating species in shallow waters in the Wadden Sea / North Sea coastal zone and the Netherlands, together with the size of the Northwest European population. The trend in the numbers for the Wadden Sea / North Sea coastal zone is also included.

Table 6.6 Fish-eating birds that forage in shallow water

	Normative period	Number of Wadden Sea (not breeding) birds (van Roomen et al. 2004)	Number of Wadden Sea breeding pairs (Dijksen & Koks 2003)	Total population in the Netherlands	NW European population (Delany & Scott 2002)	Trend
Eurasian Spoonbill	Breeding		931	1,300*	10,000	+
Spotted Redshank	July	6,806		8,225**	100,000	0
Common Greenshank	September	4,616		5,492**	310,000	+

Total population in the Netherlands:

- *estimated population size in 2003, on the grounds of indexing over the 1999-2003 period (van Dijk *et al.* 2005)
- ** maximum number of birds counted in 2002/2003 (van Roomen *et al.* 2004)

In the 1990s Spoonbills left traditional colony sites on the mainland because of the significant predation pressure from foxes. They have established themselves on a number of islands. The colonies on Texel, Vlieland, Terschelling and Schiermonnikoog, with approximately 200 breeding pairs each, are the biggest ones (Dijksen & Koks 2003). Virtually the entire Northwest European population breeds in the Dutch part of the Wadden Sea. The numbers of Spoonbills still appear to be increasing. The birds forage on the flats, where they catch mainly shrimps and small flatfish (Van der Have & Osieck 1997). In so doing they fly from island colonies as far as the mainland.

The Spotted Redshank is found in the Wadden Sea area primarily in July. The largest groups remain in the Dollard and on the Balgzand (Van der Kam *et al.* 1999, van Roomen *et al.* 2004). Over the last few years the numbers of birds appear to have been stable (van Roomen *et al.* 2004), but Leopold *et al.* (2004b) detected a negative trend (not significant) in the nineteen-nineties. This trend is comparable to that of the Avocet. Both species are found in muddy / silty areas (Leopold et al 2004b).

The Greenshank is more widely dispersed over the Wadden Sea area than the Spotted Redshank (Van Roomen *et al.* 2004). Leopold *et al.* (2004b) reports that in around 1990 there was a change from a stable population to an increase in the number of birds in the Wadden Sea. After the growth around 1990 the population in the Wadden Sea has remained steady for the last 10 years (Van Roomen *et al.* 2004). The numbers of the species continue to increase in the salt Delta (Van Roomen *et al.* 2004).

Impacts
In regard to autonomous development, an effect can be expected on the size of the populations of all birds that forage for prey that is affected by turbidity or silt content and the supply of nutrients to the Wadden Sea. At the moment there are no indications that this will be the case for the Spoonbill, Spotted Redshank and Greenshank.

Spotted Redshanks appear to forage primarily in silty areas. Changes in the silt balance of the Wadden Sea could therefore result in impacts on this species. As far as birds in the Dollard and Eems are concerned, silt transport through the Eems is a much more important factor than transport from the North Sea. Any impacts of the Maasvlakte 2 project therefore play no role here. The Redshanks can moreover make use of many different types of food and will therefore be able to adapt relatively easily to shifts in the availability of sea bed creatures. This species is considered to be moderately sensitive to changes in the Wadden Sea as a consequence of the construction of Maasvlakte 2.

Greenshanks forage in shallow pools throughout the entire Wadden Sea. In this regard this species appears to be similar to the Spoonbill. The Greenshank can live off all sorts of different small creatures and therefore it can adapt relatively easily to shifts in the availability of small fauna on the flats.

Conclusion
The populations of Spoonbill and Greenshank are not expected to decline compared with the numbers that have been counted over the last 10 years. These two species are flexible as regards their choice of food, but they are dependent on the Wadden Sea for an important part of their food supply. They are therefore considered to be ‘moderately sensitive’ to any decrease in the overall amount of food as a result of the Maasvlakte 2 project. The Spotted Redshank is ‘moderately sensitive’ because changes in the silt balance of the Wadden Sea area can have a negative impact on this species.

5.5 Shore and water birds

5.5.1 Numbers and trends

The numbers of birds in the Wadden Sea area are monitored annually. This is done through measurement networks for summer birds and water birds. These programmes, both of which are coordinated by the SOVON, provide information about the numbers of birds and the changes in them. Use is made here of recent reports about trends in the numbers of summer birds (Dijksen & Koks 2003; van Dijk *et al.* 2005) and water birds (Van Roomen *et al.* 2004). Trends in the numbers of birds in the Wadden Sea area are discussed in the SOVON reports. In addition to this, in the context of the EVA II study by Leopold *et al.* (2004b), trends have been calculated for all kinds of shore birds in terms of the number of bird days per species. These data, summarized in table 6.7, provide the basis for the following discussion of the current situation and autonomous development in the occurrence of bird species in the Wadden Sea area.

Table 6.7 Shore and water birds

Species	Normative period	Number in Wadden Sea area	Total population in the Netherlands	NW European Union population	Trend van Roomen et al. 2004	Trend Leopold et al. 2004b
Shellfish eaters – ducks and scoters						
Eider Duck	January	86,070*	91,435*	1,030,000	f	-
	Breeding	6,900	7,000			
Scaup	December	13,000	66,600	310,000	-	
Goldeneye	January	413*	14,800*	400,000	0	
Common Scoter	Overwintering	1,200 flats* 48,000 coastal zone*	59,000*	1,600,000*	f	
Shellfish eaters – waders						
Knot	September	98,000	119,300		-	
C. c. islandica				*450,000*		
C. c. canutus				*340,000*		
Oystercatcher	September	171,380*	238,000*	1,020,000	-	-
	Breeding	?	95,000		-	
Worm eaters – waders						
Dunlin	September	290,000	329,000	1,330,000	0	+
Sanderling	May	7,700	10,500	120,000	+	+
Avocet	September	11,000	13,900	73,000	0	-
	Breeding	4,362	7500		0	
Bar-tailed Godwit	May	120,000	93,190		+	+
L. l. lapponica				*120,000*		
L. l. taimyrensis				*520,000*		
Grey Plover	May	41,000	44,500	250,000	0	+
Golden Plover	November	46,000	92,170	1,800,000	+	
Ringed Plover	September	8,000	8,500	210,000	f	+
Black-tailed Godwit	March	2,200	32,700	170,000	f	
Lapwing	November	34,000	253,900	3,900,000	f	
Curlew Sandpiper	September	412*	473*	740,000	?	
Mixed diet						
Redshank	September	26,345*	30,282*		0	
T. t. brittanica				*130,000*		
T. t. totanus				*65,000*		
Curlew	September	120,000	151,200	420,000	0	+
Mallard	January	51,000	434,500	4,500,000	0	
Pintail	November	9,600	22,600	60,000	f	

Species	Normative period	Number in Wadden Sea area	Total population in the Netherlands	NW European Union population	Trend van Roomen et al. 2004	Trend Leopold et al. 2004b
Other diet						
Turnstone	September	4,100	5,000	183,000	f	
Shelduck	November	56,000	65,000	300,000	0	

Number in Wadden Sea area:

- transitory and overwintering birds: average seasonal maximum during the 1977-2002 period (van Roomen *et al.* 2004)
- summer birds: Dijksen & Koks 2003, tables 3 - 7, number of breeding pairs in the Wadden Sea area in 2002
- * 2002/03 seasonal maximum (van Roomen *et al.* 2004)

Total population in the Netherlands:

- transitory and overwintering birds: average seasonal maximum during the 1997/98-2001/02 period (van Roomen *et al.* 2004); * seasonal maximum 2002/03 (van Roomen *et al.* 2004)
- summer birds: average number of breeding pairs during the 1999-2003 period (van Dijk *et al.* 2005)

NW European Union population: number of birds on the basis of Delany & Scott 2002 (*: number of birds on the basis of Rasmussen *et al.* (2000)).

SOVON trend

- overwintering birds: van Roomen *et al.* 2004, trend for the Wadden Sea from 1993/94 to 2002/03
- breeding pairs: Dijksen & Koks 2003, trend for the Wadden Sea area between 1991 and 2002 on the basis of the average maximum number of birds per season

Leopold *et al.*2004b: trend for the Wadden Sea area from the beginning of the nineteen-nineties (varying per species) to 2001/02 on the basis of bird days (number of birds times length of stay).

5.5.2 Shellfish eaters – ducks and scoters

Current situation and autonomous development

Table 6.7 shows the numbers of ducks and scoters that eat shellfish in the Wadden Sea / North Sea coastal zone and the Netherlands together with the Northwest European population. The trend in the numbers for the Wadden Sea is also included
Between 8,000 and 10,000 pairs of Eider Ducks breed in the Wadden Sea area (SOVON 2002). There have been substantial fluctuations in the population trends since the nineteen-nineties. The breeding population seems to have been declining (Dijksen & Koks 2001) or stabilizing (Oosterhuis & Van Dijk 2002) since the start of the 21st century.

The Wadden Sea area is important to Eider Ducks primarily as an overwintering area. The Eider Ducks that overwinter here are not just the ones breeding in the Netherlands. A large proportion of the Northwest European population that breeds in more northerly areas overwinters here too (Rose and Scott 1994). Since 1993 the RIKZ has conducted annual area-wide winter counts in the North Sea and Wadden Sea (among others Berrevoets & Arts 2003). The number of Eider Ducks decreased during the 1993 – 2003 period (De Jong et al. 2003). During the nineteen-nineties there was a shift from the Wadden Sea to the North Sea coastal zone, where few Eider Ducks had been seen previously (see Figure 6-1 Overwintering Eider Ducks in the Netherlands (from: Ens & Kats 2004)

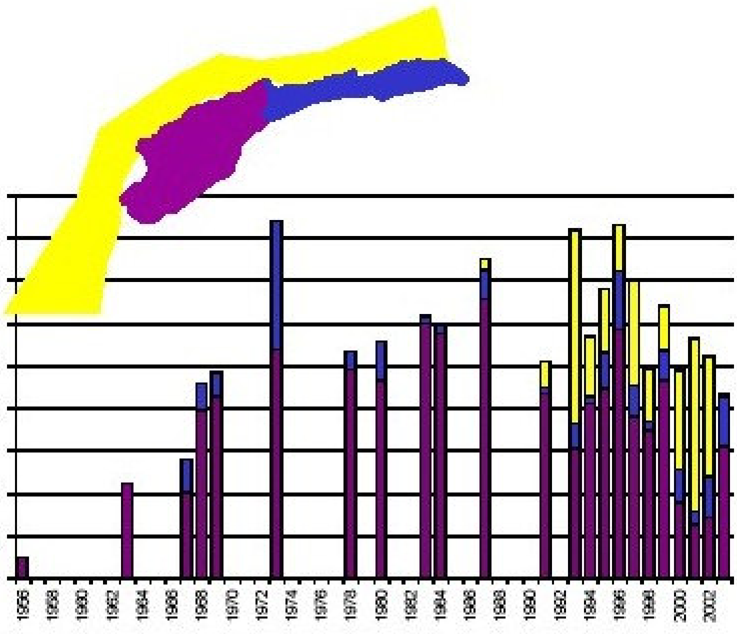

Figure 6-1 Overwintering Eider Ducks in the Netherlands (from: Ens & Kats 2004)

Camphuysen *et al.* (2002) report a connection between the massive mortality of Eider Ducks in 1999/2000 and limitations in the food stocks. Ens & Kats (2004) investigated this more comprehensively. They concluded that the mortality of Eider Ducks was linked to the decrease of sublittoral mussels. They explain the movement of large numbers of Eider Ducks to the North Sea coastal zone on the grounds of the scarcity of this source of food in the two subsequent years. In the North Sea coastal zone the birds feed on *Spisula*. However, the net intake of energy from this food source is too low for survival in the longer term (Ens & Kats 2004).

Common Scoters are also counted in the Wadden Sea, but much bigger numbers are to be found in the North Sea coastal zone. They live mainly off *Spisula* in the shallow parts of the coastal zone (Leopold 1996). Fluctuations in the number of Common Scoters might be explained by the fluctuations in the *Spisula* stocks (Bult *et al.* 2004 in De Jong *et al.* 2003). There are indications that *Ensis directus* (American razor shell, an exotic species that has in the meanwhile spread very widely in Dutch coastal waters) could be a new source of food for this bird species (Wolf & Meininger 2004).

Scaup are found primarily in Lake IJssel. There they live primarily off Zebra Mussels. In recent years the supply of Zebra Mussels has declined. The numbers of Scaup have therefore dropped sharply (Voslambert & Koffijberg 2002). However, large numbers are regularly counted in the western Wadden Sea, to the north of the Lake IJssel Dam. The birds live off the sublittoral mussel beds there (van Roomen *et al.* 2004). Bult *et al.* (2004) report that this area is also fished intensively by mussel fishing boats. This might therefore be a case of competition.

Most of the Goldeneyes, like the Scaup, are found mainly on the larger, relatively sheltered bodies of fresh and salt water (Lake IJssel, Oosterschelde, Grevelingenmeer and Volkerakmeer). The Wadden Sea is of limited significance for this species (Van Roomen *et al.* 2004).

Impacts

It can be assumed with regard to the Eider Duck and Common Scoter that the numbers of birds in the Wadden Sea (Eider Duck) and the North Sea coastal zone (both species) are limited sometimes by the available shellfish stocks. If the construction of Maasvlakte 2 results in a reduction or shift in the shellfish stocks as a result of changes in primary production and silt concentration, it can lead to a decline in the numbers of Eider Ducks and Common Scoters. This effect on Common Scoters might possibly be less because the stocks of *Spisula* in the coastal zone are not a permanent source of food. The level of the stocks always varies substantially, as a consequence of which the Common Scoters depend to an extent on stocks elsewhere. The presence of sufficient mussel beds in the Wadden Sea is very important to the Eider Duck. However, these are also important to the mussel fishing industry.

Scaup are dependent on Lake IJssel and the immediately adjacent part of the Wadden Sea. Changes in mussel stocks (western Wadden Sea) will therefore also partly determine the amount for the overwintering population. The intensive level of fishing in the area where Scaup are found might possibly mask any impact of the construction of Maasvlakte 2.

The impacts on Goldeneyes are comparable to those on Scaup, albeit that only a very small fraction of the Dutch population can be affected.

It is expected that changes in the flows of nutrients will result in a reduced secondary production of filter feeders (see 4.2). The model results relate to the maximum production by shellfish. However, the minimum levels in the availability of shellfish probably determine the size of the population of shellfish-eating ducks. The relationship between maximum production and minimum stock is not unambiguous, but the maximum stocks probably contribute to determining the levels in subsequent years. The size of the maximum stocks is determined by breeding results (not affected by Maasvlakte 2) and growth (possibly affected by Maasvlakte 2). In years when the breeding result is poor (or absent), mortality as a result of predation and fishing, among other things, is determining for the stocks. Although mussels are more important to Eider Ducks as a food source, it is possible that the recent cessation of mechanical cockle dredging in the Wadden Sea will also lead to a bigger population of Eider Ducks because it removes one of the mortality factors.

Conclusion

Decreases or shifts in shellfish stocks in the Wadden Sea as a result of the construction of Maasvlakte 2 can generate impacts on Eider Ducks, Scaup and Goldeneyes in the Wadden Sea. These species are therefore qualified as ‘sensitive’. Common Scoters are less directly affected. This species is therefore qualified as ‘moderately sensitive’.

5.5.3 Shellfish eaters – waders

Current situation and autonomous development
Table 6.7 shows the numbers of waders that eat mainly shellfish in the Wadden Sea and the Netherlands together with the size of the Northwest European population. The trend in the numbers for the Wadden Sea is also included.

Two waders in the Wadden Sea area specialize in shellfish, namely the Oystercatcher and the Knot. More than 20% of the total populations of both species stay in the Wadden Sea at the same time. Oystercatchers have specialized in larger mussels and cockles (Hulscher 1996). Knots primarily select marine molluscs (*Macoma*) and also cockle and mussel spawn (Dekinga & Piersma 1993, Zwarts & Blomert 1992, Zwarts *et al.* 1992, Piersma 1994). The waders eat shellfish in the littoral zone.

Oystercatchers are found all over the Wadden Sea area. Rappoldt *et al.* (2004) made an extensive analysis of the Oystercatcher population in the Wadden Sea in the context of the EVAII project. The analysis revealed a marked negative trend in the number of birds in the nineteen-nineties. A connection can be made to the availability of the most suitable prey, including cockles. In the absence of such prey, Oystercatchers can switch to other types of prey, but in the longer term it results in a decrease in the population (Rappoldt *et al.* 2004).
Two subspecies of the Knot use the Wadden Sea area. Birds from Greenland and Canada overwinter in the Wadden Sea area. Birds from Siberia stop briefly on their migration route to overwintering areas in African. In the late summer the birds are mainly in the eastern Wadden Sea, and in November in the western Wadden Sea (van Roomen *et al.* 2004).

Several authors (Piersma & Koolhaas 1997; Zwarts 2004; Van Gils 2004) point out that the dredging of the flats by the cockle fishing industry results in large scale changes in sediment and consequently in changes in the quantity and quality of the shellfish available for the Knot. The numbers of Knots show a sharp decline (van Roomen *et al.* 2004). Leopold *et al.* (2004b) report a change in the trend in the numbers of bird days for Knots at the beginning of the nineteen-nineties. After an increase in the nineteen-eighties, the species declined in the nineteen-nineties. This trend is matched by a significant decrease in the availability of prey, including young cockles (Leopold *et al.* 2004b).

Impacts
The EVAII studies revealed that Oystercatchers and Knots are sensitive to changes in the shellfish stocks in the Wadden Sea area. If the construction of Maasvlakte 2 results in a reduction or shift in the shellfish stocks as a result of changes in primary production and silt concentration, it can lead to a decline in the numbers of Oystercatchers and Knots.

Conclusion
Oystercatchers and Knots are sensitive to the impact of the Maasvlakte 2 project on shellfish in the Wadden Sea.

5.5.4 Worm eaters

Current situation and autonomous development
Table 6.7 gives the numbers of worm eaters in the Wadden Sea and the Netherlands together with the Northwest European population. The trend in the numbers for the Wadden Sea is also included.

There are counts available extending over several years for most species in the Wadden Sea. Over 1% of the Northwest European populations of all species can be found in the Wadden Sea area during some part of the year. There are very large parts of the populations of some species (Bar-tailed Godwit: virtually the entire population of the overwintering subspecies, *L.l. lapponica*; Dunlin: 22% of the overall population). Reliable annual series are only missing for the much less generally found Curlew Sandpiper.

Most worm eaters are distributed all over the Wadden Sea. Clear distribution patterns can be distinguished within the area for a few species. The Grey Plover, for example, is found primarily in the eastern part of the Wadden Sea and the largest numbers of Sanderlings are along the North Sea coast. The biggest numbers of breeding Avocets are found on the northern coast of Friesland and in the Dollard, particularly in the Breebaart nature conservation area. The birds are found spread all over the Wadden Sea area later in the year.

An analysis of the annual series reveals that the numbers of most species are stable or increasing. Leopold *et al.* (2004b) show in an analysis of the number of bird days that the numbers of various worm eaters increased in the nineteen-nineties, i.e. Dunlin, Sanderling, Bar-tailed Godwit, Grey Plover and Ringed Plover. An increase in the worm population (Piersma & Koolhaas 1996) of the flats may explain the increase in these species (Leopold *et al.* 2004b). Research into the impact of shellfish fishing revealed that the numbers of worms are increasing in the fished areas (Kraan *et al.* 2004, primarily *Nereis*: Leopold *et al.* 2004a). Worm eaters can benefit from this (Leopold *et al.* 2004b).

The numbers of transitory and overwintering Ringed Plovers, Black-tailed Godwits and Lapwings fluctuate in the SOVON counts (Van Roomen *et al.* 2004). However, looked at in the longer term (starting in the middle of the nineteen-seventies) the numbers of these species are still increasing in the Wadden Sea area (Van Roomen *et al.* 2004). The relatively marked fluctuations in the numbers of Black-tailed Godwits could be explained by the brief presence during March of large numbers of birds that are on their way to Iceland. Fluctuations in the numbers of Lapwings depend strongly on periods of frost. The trend in the number of bird days for Ringed Plovers is positive (Leopold *et al.* 2004b).

Golden Plovers use the flats primarily as somewhere to roost (Van de Kam et al. 1999). However, the birds forage primarily at night and so it is difficult to establish the extent to which they forage on the flats. Traditionally Golden Plovers were found mainly in inland grasslands and sometimes in salt marshes. Hulscher *et al.* (2001) and Hulscher & Bunskoeke (2003) suggest that the flats are becoming more important for Golden Plovers as the quality of the inland foraging areas declines. For the time being it is assumed that the flats are still relatively unimportant in regard to the food supply for this species.

The analysis by Leopold *et al.* (2004b) shows that the number of bird days for Avocets decreased in the nineteen-nineties. A recent unpublished analysis by SOVON paints the same picture. The population of breeding Avocets appears to be have been declining recently in the Friesian and Groningen salt marshes as a result of more extensive brush, predation and food problems (van Roomen *et al.* 2004). This trend is also being observed on ‘fox-free’ islands (Dijksen & Koks 2003). However, in 2002 the number of birds in the Dollard, in the Breebaart nature conservation area, increased markedly (Dijksen & Koks 2003). These developments are not visible in the trend calculations. Prop (1998) is able to establish a relationship for the 1975-1995 period between a decrease in the Avocet population in the Dollard and the driving back of eutrophication in the Westerwoldse Aa.

Regarding the Bar-tailed Godwit, Ringed Plover, Dunlin and Sanderling, Leopold *et al.* (2004b) report a switch from a negative to a positive trend around 1990. In combination with changes in the shellfish fishing industry, such trends in the bird days of worm eaters suggest that the occurrence of different species is limited by the food supply. The number of birds increases if more food is available.

Impacts
It is possible that the supply of silt to the Wadden Sea will decrease as a result of the Maasvlakte 2 project. As far as the Sanderling, a species found on sandy, hard substrates (beaches and exposed parts of the flats in the Wadden Sea), is concerned this can only amplify the positive trend that may be connected with the silting up of the flats. Negative effects are only expected if, as a result of a general reduction in the food supply, the numbers of its primary prey, the worm s*colelepis squamata*, decrease. This is not considered to be probable.

The increase in numbers of worm eaters found on a softer substrate appear to be linked for a number of species to trends in fishing techniques that disturb the sea bed. Possibly the cessation of mechanical cockle dredging will lead to a stabilization of this trend. The Maasvlakte 2 project can result in a deterioration of the system and consequently to an impact on the available worms in the Wadden Sea (see **0**). There can be a negative impact on these worm eaters, which would in fact mean a return, more or less, to the ‘old’ situation.

As regards the Avocet, a bird with a marked preference for silty substrates, the availability of food was one of the causes of the decline in this species in the past in the Dollard (Prop 1998). In the present situation it is above all the availability of suitable breeding sites that seems to be limiting for the species (see for example the mass settlement in the polder Breebaart). In so far as the Avocet searches for food using its bill to go through (very) soft mud, a reduction in the extent of silty areas would represent a disadvantage for the Avocet, as would any decline in sea bed fauna as a result of a reduction in nutrients.

No changes to the structure of the Wadden Sea area are expected as a consequence of the construction of Maasvlakte 2. The function of the Wadden Sea area as a resting place will therefore not be affected.

Conclusion
The Maasvlakte 2 project will not produce any negative impacts on the Sanderling and Golden Plover.

Worm eaters that are found on a mixed substrate (Ringed Plover, Dunlin, Black-tailed Godwit, Lapwing, Curlew Sandpiper, Bar-tailed Godwit and Grey Plover) are considered to be ‘moderately sensitive’ because of the possible impact of reduced nutrient contents on the availability of prey.

The size of the Avocet population appears to be determined primarily by the availability of food and other factors. This species is therefore also ‘moderately sensitive’ to the effects of the construction of Maasvlakte 2.

5.5.5 Mixed diet

Current situation and autonomous development
Redshank, Curlew and Pintail are classified as birds with a mixed diet that forage in the Wadden Sea area. According to Leopold *et al.* (2004b) the Lesser Black-backed Gull comes into the same category, but this was discussed in 5.4.

Table 6.7 shows the numbers of birds with a mixed diet in the Wadden Sea and the Netherlands together with the Northwest European population. The trend in the numbers for the Wadden Sea is also included.

Pintail and Mallard are to be found in the Wadden Sea area, particularly in the spring and winter (Van Roomen *et al.* 2004). Pintails feed mainly on seeds and small fauna (Van de Kam *et al.* 1999). The trend in the Wadden Sea area is fluctuating (Van Roomen *et al.* 2004). Mallard feed on the flats and eat mainly snails. Their concentrations in the Wadden Sea are along the Groningen coast and to a lesser extent along the Friesian coast, in the Dollard and on Texel.

Curlews remain on the flats for the whole year, but are scarce during the breeding season (van Roomen *et al.* 2004). In September nearly 30% of the total Curlew population can be found in the Wadden Sea area (van Roomen *et al.* 2004). They can utilize several sources of food (primarily worms but also small crabs etc.) and are therefore found all over the Wadden Sea area on silty and sandy areas (see Leopold *et al.* 2004b). The numbers of Curlews are stable (van Roomen *et al.* 2004). The bird days analysis by Leopold *et al.* (2004b) reveals that the species is increasing, whereby the growth in the nineteen-nineties appears to have been slightly larger than earlier.

Redshanks are found on the flats mainly in the summer. They eat a wide range of food, although on the flats worms and crustaceans appear to be the most important (Leopold *et al.* 2004b). The birds are to be found all over the Wadden Sea area. The numbers of birds in September are stable (van Roomen *et al.* 2004). Leopold *et al.* (2004b) report a slight positive trend in the number of bird days in the nineteen-nineties, but it is not significant.

Impacts
It also appears to be the case for species with a mixed diet that species found on a hard substrate have an advantage. Analogous to the reasoning for worm eaters, a deterioration of the Wadden Sea system can result in a reduction in the prey of Curlews.

Pintails appear to be largely dependent on seeds that come from the salt marshes. Impacts on the productivity of the Wadden Sea as a result of the construction of Maasvlakte 2 will consequently barely affect this species, if at all. The largest numbers of Mallard are found in the eastern part of the Wadden Sea. It is expected that any impacts caused by Maasvlakte 2 will be very limited or nonexistent. A relatively small part of the Northwest European population is found in the Wadden Sea. The impacts on the Pintail and Mallard therefore remain limited.

Kam *et al.* (1999) classified Redshanks as waders that prefer a soft substrate. It would appear from the distribution of the birds over the flats that this preference is much less marked than is the case for Avocets. A decline in silty substrates in the Wadden Sea will therefore have less effect on the size of the population of this species. They eat a wide variety of types of food and can therefore adapt to any shifts in the availability of fauna on the flats. There will only be negative impacts on Redshanks in the event that the overall productivity of the system drops.

Conclusion
There can only be impacts on the Curlew and Redshank if the overall productivity of the Wadden Sea system becomes substantially lower. Analogous to the worm eaters, these species are considered to be ‘moderately sensitive’. The Pintail and Mallard are not sensitive to the impacts of the Maasvlakte 2 project.

5.5.6 Other diet

Current situation and autonomous development
The choice of food by species with an ‘other’ diet has been less well studied than that of other species. Leopold *et al.* (2004b) compare different sources. Turnstones appear to search for all sorts of prey in mussel beds and other hard substrates. Shelducks forage primarily in shallow water in silty areas, where they eat large numbers of small snails (*Hydrobia*).

Table 6.7 shows the numbers of birds with an ‘other’ diet in the Wadden Sea and the Netherlands together with the size of the Northwest European population. The trend in the numbers for the Wadden Sea is also included.

Turnstones are found in the Wadden Sea area all year round, with the largest numbers being counted at the end of the summer. The long-term trend, from 75/76 to 02/03, is negative but in recent years appears to be levelling off (Van Roomen *et al.* 2004). It is possible that the birds continue to overwinter further to the north and east as a result of climate change (cf. Holloway *et al.* 1999). Incidentally, there are approximately ten times as many transitory Turnstones on the coasts of Britain (Van de Kam *et al.* 1999).

The largest numbers of Shelducks are found in the Wadden Sea area in the autumn (van Roomen *et al.* 2004). They go to the central parts of the flats in order to moult. They find most of their food in silty parts of the Wadden Sea. The population of Shelducks appears to be stable according to the trends analysis by Van Roomen *et al.* (2004) and Leopold *et al.* (2004b). Although reliable counts of moulting populations of Shelducks are not available (no counts on open water), in recent years the numbers would appear to be on the increase. It is possible that there is a link to the decrease in the numbers of birds in the German Bight as a result of disruption (verbal communication Norbert Dankers, Alterra). Shelducks are found closer to the coast and the islands during the breeding season.

Impacts
Turnstones have a wide variety of food options. They are therefore not sensitive to shifts in the availability of sea bed fauna, shrimps and small fish. The area of suitable habitats will probably increase as a result of the expected recovery of littoral mussel beds (because of the cessation of mechanical dredging for cockles). The Turnstone can therefore be considered to be not sensitive to changes in the Wadden Sea arising from the construction of Maasvlakte 2.

Shelducks are tied to the silty parts of the Wadden Sea. Changes in the silt balance can therefore have impact on this species. They are also sensitive to shifts in the availability of sea bed fauna because they are directly dependent on the productivity of the top layer of the flats.

Conclusion
The Shelduck is considered to be moderately sensitive to the impacts of the construction of Maasvlakte 2 because of its dependence on silty areas. Impacts on the Turnstone are not expected.

5.6 Summary of impacts on species

It emerges from the analysis made in this chapter of the relationships between the possible sensitivities of birds in the Wadden Sea to changes in the food supply that seven bird species are sensitive to this and that 17 species are moderately sensitive to a reduction or (temporal) shifts in the food supply.

Table 6.8 Species that are sensitive to a change/shift in food supply. WS = Wadden Sea, NSC = North Sea Coastal Zone. contains an overview of the most important ecological characteristics of these species. The following 13 species are not sensitive to any changes in the food supply as a consequence of the Maasvlakte 2 project: Black Tern, Lesser Black-backed Gull, Black-throated Diver, Red-throated Diver, Great Crested Grebe, Cormorant, Smew, Red-breasted Merganser, Sanderling, Golden Plover, Pintail, Mallard and Turnstone. It should be pointed out that in the assessment it has been assumed that any changes in the transparency do not negatively affect the ease with which fish-eating species that forage in deeper water can catch their prey. The species concerned are the Black-throated Diver, Red-throated Diver, Great Crested Grebe, Cormorant, Smew and Red-breasted Merganser.

Table 6.8 Species that are sensitive to a change/shift in food supply. WS = Wadden Sea, NSC = North Sea Coastal Zone.

Species	Type of food	Location	Period	Reaction to decrease in availability of food
Sensitive				
Common Eider	Cockles, mussels, *Spisula* (in case of food shortage)	Sublittoral WS-NSC	Year	Directly proportional
Greater Scaup	Zebra mussels, mussels	Sublittoral western WS	Winter	Directly proportional
Common Goldeneye	Zebra mussels, Mussels	Sublittoral western WS	Winter	Directly proportional
Red Knot	Macoma, cockles	Littoral WS	Winter	Directly proportional
Eurasian Oystercatcher	Cockles, mussels	Littoral WS	Year	Directly proportional
Little Tern Common Tern	Sand Eels, small fish (e.g. young herring)	WS, tidal inlets	Breeding	Directly proportional
Moderately sensitive				
Common Scoter	*Spisula*, possibly also *Ensis*	Sublittoral NSC	Winter	Less than directly proportional
Pied Avocet	Worms	Silty littoral WS	Breeding	Less than directly proportional, because of the strong influence of other factors
Ringed Plover Dunlin Black-tailed Godwit Northern Lapwing Curlew Sandpiper Bar-tailed Godwit Grey Plover	Worms	Littoral WS	August-May	Directly proportional
Common Shelduck	Other diet, small organisms in the top layer of soft (silty) sediments	Silty littoral WS	Autumn	Less than directly proportional
Eurasian Curlew Common Redshank	Mixed diet	Littoral WS	Year	Less than directly proportional
Artic Tern	Sand Eels, young fish, crabs, shrimps	WS	Breeding	Directly proportional
Sandwich Tern	Young herring, sand eels	WS, NSC	Breeding	More than directly proportional
Eurasian Spoonbill	Gobies, other small animals	Ws	Breeding	Less than directly proportional
Spotted Redshank	Other diet, including shrimps	Silty littoral WS	July	Less than directly proportional
Common Greenshank	Gobies, other small animals	Littoral WS	September	Less than directly proportional

7. IMPACTS IN REGARD TO CONSERVATION STATUS

7.1 Key factors

It is shown in chapter 6 that the Maasvlakte 2 project can result in impacts on bird species in several different ways. In all cases it is a matter of the degree to which the availability of food for these birds is affected. The presence of sufficient food is the most important factor. The presence of suitable places to search for that food is also an issue for a few species that prefer silty flats, including the Avocet and Shelduck. However, in addition to the impacts of the construction of Maasvlakte 2, there are also various other factors. These are autonomous developments and the impacts of other plans or projects (cumulative effects). Appendix 5 contains an overview.

This section contains a description of the most important key factors that determine the numbers of the species in the various groups of birds that might possibly be negatively affected by the Maasvlakte 2 project. The 'species documents' of the Draft Conservation Objectives (July 2005) represent a significant source of information for this description.

7.1.1 Shellfish eaters

The size of the population of shellfish eaters can depend strongly on the availability of shellfish (see also 6.5.2 and 6.5.3). The primary production has an effect on this because it is determining for the maximum shellfish biomass (see 4.2). However, the overall quantity of food available in the Wadden Sea is also determined by the breeding results of shellfish and the commercial fishing of the shellfish stocks (Ens & Kats 2004).

Breeding result

The breeding result of cockles, in particular, is very erratic as a result of which there are substantial fluctuations in the cockle stocks. The size of the population of birds that eat large numbers of cockles and mussels, such as the Oystercatcher and the Eider Duck, is determined by the changes in the overall quantities of the biomass of the different prey, whereby in bad years the birds can switch to alternative prey. The quantity of food is also not always limiting. Much less is known about the breeding result of *Spisula*, the staple food of the Common Scoter, and the breeding result of *Ensis*, a possible replacement food source for scoters. What is in any event known about the breeding result of *Spisula* is that it is not constant.

Commercial shellfish fishing

Besides the breeding result, commercial shellfish fishing is a very important factor in the availability of shellfish. The effects of mechanical cockle dredging on cockle stocks have proved to be so substantial that this type of commercial fishing is no longer permitted. This is probably not enough to ensure that there is sufficient food for shellfish eaters. This is because mussels are a significant source of food for these species. The availability of prey is very largely determined by the commercial fishing of seed mussels and mussel beds. The commercial fishing of seed mussels has a substantial impact on the establishment of littoral mussel beds. There is less food available for Oystercatchers and Knots as a result of their removal. The rearing of seed mussels in the sub littoral increases the sub littoral mussel stocks.

A large proportion of these stocks are fished, but over the course of many years the cultivation of mussels has nonetheless resulted in an increase in mussel stocks in the sub littoral. However, the birds that feed on mussels are often chased away from accumulations of mussels.

The commercial fishing of *Spisula* is a significant factor in the availability of food for the Common Scoter.

Knots eat mainly (littoral) cockles and marine molluscs (*Macoma*). The way in which the availability of these prey is affected by commercial shellfish fishing is different from the effect on littoral and sub littoral mussels. The regular dredging of the sea bed by the cockle fishermen inhibits the growth of shellfish, including non-cockles. The cessation of mechanical cockle dredging will probably result in a recovery of the (natural) availability of food for Knots. Unlike species that forage in the sub littoral and unlike the Oystercatcher, which also feeds extensively on littoral mussel beds, the availability of food for Knots is therefore determined primarily by the natural increase and growth of shellfish. Because the ‘competition’ with commercial shellfish fishing in the autonomous development of this species is largely disappearing, a reduction in productivity as a result of the Maasvlakte 2 project can have a greater effect than on the mussel-eating species. Of course the irregular breeding result of cockles remains a substantial limiting factor that is not impacted by Maasvlakte 2.

Eutrophication
The nutrient supply in the water that flows into the Wadden Sea via the Marsdiep appears to be a major factor in determining the maximum possible production of filter feeders in the western Wadden Sea (4.2). However, the dilution of the coastal river as a result of the construction of Maasvlakte 2 is not the only factor that determines this. The nutrient supply in the river water itself and the water that is sluiced into the Wadden Sea from Lake IJssel also play a part. If people succeed in reducing further the nutrient load in the major rivers in the coming decades, the impact on the primary production in the Wadden Sea can be greater than that of the dilution of the coastal river. The impacts of the Maasvlakte 2 project remain superposed on these other impacts of course.

Other factors
Some other factors that are limiting for shellfish eaters in the Wadden Sea area and North Sea coastal zone are:
- predation on Oystercatcher and Eider Duck eggs and/or chicks by birds of prey and seagulls (marginal effect; only weak chicks are taken).
- discharges of oil (relatively modest effect on the Common Scoter and Eider Duck; occurs rarely).
- cold winters and mortality during migration to and from the Wadden Sea area.

7.1.2 Other shore birds

The availability of sediment eaters (primarily worms) is much more steady than the availability of shellfish. There is no cyclical variation in the level of the stocks as a result of erratic recruitment. There is moreover little fishing for worms. Bait diggers visit a only a very small part of the flats.

Eutrophication
The eutrophication status of the Wadden Sea area appears to have a direct impact on the numbers of worms (Prop 1998). However, the Ecowasp model does not model the production of these creatures. Because the worms live primarily off phytobenthos and suspended organic material, it can be expected that there is a direct relationship between the primary production and the growth of worms. This means that a decline in the primary production as a result of a reduced nutrient load, as described in regard to shellfish eaters, also has an effect on worm eaters.

Silt concentrations
A decrease in the silt concentration may bring about a shift in the silt balance in the Wadden Sea. This can have a positive impact on shore birds that prefer sandy substrates, but the biggest bird densities are to be found on the more silty substrates. Some shore bird species, for example the Avocet and Shelduck, depend on even more silty substrates for collecting their food. These substrates are to be found primarily in the Eems and Dollard. No impacts of the Maasvlakte 2 project are to be expected here.

The coastal river is the primary source of inorganic silt for the Wadden Sea. The actual silt concentrations to be found in practice are largely the result of accumulation, whereby both inorganic and organic silt (detritus) play a role.

Nesting sites in salt marshes
Many shore birds are to be found in the Wadden Sea area largely outside the breeding season. A few species breed there in substantial numbers. The Wadden Sea area is an important nesting region for the Avocet in particular. There appears to be a shortage of good nesting sites inside the Wadden Sea area. The breeding success in the salt marshes on the mainland is suffering from predation by foxes and disturbance by people.

More extensive brush in the salt marshes also seems to be an obstacle for the birds. New nesting sites, such as the polder Breebaart a few years ago, become possible and are therefore colonized on a massive scale. However, within a few years the number of breeding pairs decreases again as a result of the development of vegetation.

7.1.3 Fish eaters

Fish eaters in the Wadden Sea area depend very much on the supply of small fish in the Wadden Sea area, and some species are dependent on the North Sea. The presence of fish is determined by the recruitment of young fish, the rate at which they grow up and the degree to which fishermen catch them. The disruption of the nesting sites is a limiting factor for some species.

Commercial fishing
The numbers of many fish species in the North Sea have been very severely reduced as a result of commercial fishing. Some species are or were virtually completely eradicated. It is not clear whether commercial fishing has a strong influence on the availability of food for terns and other fish-eaters. While there appears to have been a strong link in past years between commercial fishing of sand eels in the northern North Sea and the breeding success of terns, the sand eel species *Ammodytes tobianus*, which is more tied to the coast and is found in large numbers close to the Dutch coast, is barely fished.

Nesting sites
The number of safe nesting sites in the Wadden Sea is limited. A few small islands and sandbars are virtually free from predators so that birds that nest on the ground can breed without disturbance. Some birds, for example Little Terns, have to disperse to places that are close to suitable foraging locations in order to be able to rear their young. The heads of islands are suitable locations. However, here visitors subject the birds to severe disturbance.

7.2 Evaluation of impacts

The model study using the Ecowasp program provides an understanding of the effects of changes in nutrients and suspended silt in the North Sea coastal zone on the primary and secondary production in the western Wadden Sea (see 4.2). **Error! Reference source not found.**gives an overview of the most important results of the model study.

Scenario 01, which used assumptions based on Flyland calculations, describes the most probable changes[21]. In this scenario pelagic primary production increases slightly while the benthic primary production decreases. The maximum filter feeder biomass calculated by the model shows an amplified response to the limitation of nutrients.

Table 7.1 Ecowasp model results

Scenario	**Forced parameter**		**Model results**			
	N, P, Si	Silt	pelagic prim. prod.	Chlorophyll-a	benthic prim. prod.	maximum filter feeder biomass
00	0	0	100	100	100	100
07	-5%	-8%	101	104	98	92
01	-10%	-15%	102	110	94	80
04	-5%	-15%	102	104	100	92
06	-5%	-30%	104	106	106	95

Table 7.2 gives an overview of the extent to which the most important elements of the intervention – impact relationships have an effect on the availability of food for birds. This does not yet take into account key factors that are not affected by the construction of Maasvlakte 2.

[21] It can be concluded from the most recent model results from 'track 1' that the impacts of the presence of the Maasvlakte 2 PKB variants on the transport of silt and nutrients to the Wadden Sea are more comparable to the order of magnitude of scenario 4 than scenario 1 (the 'base case scenario').

Table 7.2 Primary impacts of Maasvlakte 2 and the availability of different types food types for birds.

Primary impact	Availability of food				
	Sub littoral shellfish	**Littoral shellfish**	**Worms**	**WS fish**	**NSC fish**
reduced supply of nutrients	(more than) directly proportional	(more than) directly proportional	less than directly proportional	directly proportional	less than directly proportional
reduced silt transport			less than directly proportional		
changes in distribution of fish larvae				directly proportional	less than directly proportional

7.3 Appraisal

The effects on species have to be appraised in order to evaluate whether the construction of Maasvlakte 2 results in significant impacts. The conservation status of the species, the proportions of the population that is affected and the extent to which this happens determine the seriousness of the effects.

The conservation status is described on the basis of the Wadden Sea Area Birds Directive Assessment Framework (LNV DRZ-Noord 2005b). Where necessary the project team has made an estimate[22]. The proportion of the population that is affected is determined by the proportion of the population that stays in the part of the Wadden Sea or North Sea coastal zone impacted by the Maasvlakte 2 project. In table 7.3 calculations were therefore made on a species by species basis of the proportion of the population that is found in the Wadden Sea and the North Sea coastal zone (average seasonal maximum / biogeographical population).

The extent of the impact is determined by the sensitivity as summarized in table 6.8. It is assumed in regard to sensitive species that the extent of the impact is average and that it is limited for moderately sensitive species. It is assumed that the extent of the impact on sensitive species is big if it is concluded on the basis of the EcoWasp simulations that a reduction in nutrient contents has an amplified effect.

The impact is determined on the basis of a combination of the conservation status of the species, the proportion of the biogeographical population that is affected and the extent to which the impact occurs (big, average, limited). The estimate of the impacts is derived from the results of the 'base case scenario' of the EcoWasp calculations (silt content: – 15%; nutrients: – 10%).

[22] These estimates were later compared with the species profiles of the draft conservation objectives (version of 23 June 2005) and corrected where necessary.

In other words a more than directly proportional relationship is assumed between a decrease in nutrients and shellfish and a less than directly proportional connection between nutrients and ‘other’ food.

Criteria for the appraisal ‘possible significant’ or ‘(probably) not’ significant are:
- the conservation status of the species is unfavorable or very unfavorable and
- more than 1% of the total biogeographical population stays in the area affected and
- the extent of the impact is big or average.

The impact is considered to be (probably) not significant if the conservation status is moderately unfavorable or favorable or if the numbers in the area affected compared with the total biogeographical population are relatively modest (<1%) or if the extent of the impact is limited.

The appraisal contained in table 7.3 reveals that under the ‘basic case scenario’ seven species are subject to possibly significant negative impacts from the reduction in nutrient contents associated with the presence of Maasvlakte 2 (the silt concentration has no effect, see Table 7.2. This concerns three shellfish eaters (Eider Duck, Oystercatcher, Knot) and one fish eater (Little Tern).

Table 7.3 Appraisal of MV2 impacts on relevant bird species: possible = possible significant impact; not = probably no significant impact; conservation status: - = unfavourable; +/- = moderately unfavourable; + = favourable

Species	Conservation status	Proportion of biogeographical population in study area (%)	Extent of impact	Significant impact?
Shellfish eaters				
Eider duck	-	8.4	big	possible
Common Scoter	+	3.0 (WS 0.08)	limited	not
Scaup	+/-	4.2	average	not
Goldeneye	+/-	0.1	average	not
Knot	-	12.4	big	possible
Oystercatcher	-	19.6	big	possible
Shore birds				
Avocet	+	15.1	limited	not
Ringed Plover	+	3.8	limited	not
Dunlin	+	21.8		not
Black-tailed Godwit	-	1.3		not
Lapwing	-	0.9		not
Curlew Sandpiper	+	0.06		not
Bar-tailed Godwit	+	18.8		not
Grey Plover	+	16.4		not
Shelduck	+	18.7	limited	not
Curlew	+	28.6	limited	not
Redshank	+	20.5		not
Fish eaters				
Little Tern	-	5.7	average	possible
Common Tern	+/-	3.4		not
Artic Tern	+/-	0.3	limited	not
Sandwich Tern	-	6.5	limited	not
Spoonbill	+	9.1	limited	not
Spotted Redshank	+	4.4	limited	not
Greenshank	+	3.2	limited	not

7.4 Further analysis of negative impacts on sp

7.4.1 Introduction

This section gives a detail analyzes of the impacts of the Maasvlakte 2 project on the species such as - shellfish eaters the Eider Duck, Oystercatcher and Knot and the fish eater the Little Tern. For these species it was concluded that they will possibly be significantly negatively impacted. This concerns the analysis builds on the conclusions in the previous chapters. Furthermore, the impacts are compared with the expected autonomous developments in the numbers of the species concerned and any cumulative effects from other plans or projects. These are the impacts of autonomous developments that have already become manifested, for example climate change, combating eutrophication, and commercial fishing, and also the expected (cumulative) effects of changed management of the Haringvliet locks, dredging, sand extraction, gas production and recreation. Appendix 5 contains an overview of the most important developments.

7.4.2 Little Tern

Occurrence and distribution

The Little Tern is a colonizing summer bird that prefers quiet and dynamic environments with little vegetation, such as sandbars, gravel banks, mussel beds, islands and areas that have had sand pumped onto them to raise the level. The Dutch summer birds are migratory and overwinter in Africa. Little Terns breed on various islands in the Wadden Sea. They always select spots close to deeper channels, namely Vliehors, Richel, Noordvaarder, Rif and Rottummerplaat and Rottumeroog Figure 7-1).

The Little Tern is not very numerous in the Wadden Sea. In 2003 there were on average 209 breeding pairs (7-1 Distribution and numbers of breeding pairs of Little Terns in the Wadden Sea area (averages during the 2000-2004 period)

This is approximately 47% of the total population in the Netherlands and 6% of the Northwest European population (7-1 Distribution and numbers of breeding pairs of Little Terns in the Wadden Sea area (averages during the 2000-2004 period)

The colonies are relatively small, a few dozen breeding pairs

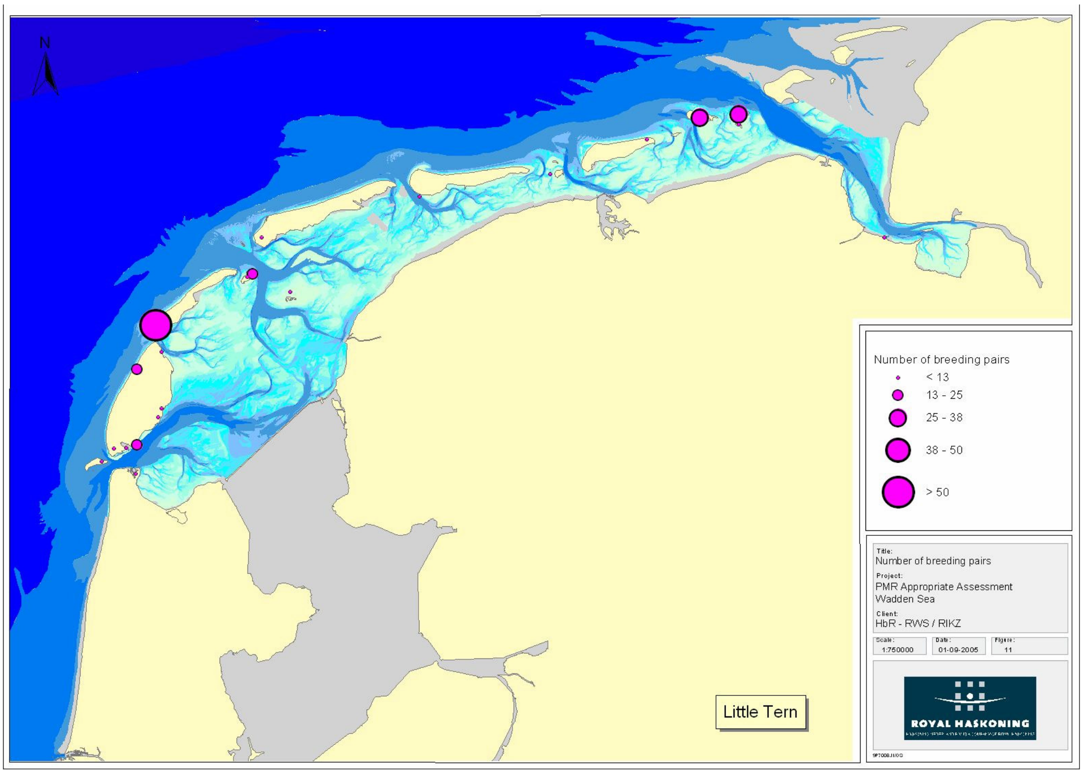

Figure 7-1 Distribution and numbers of breeding pairs of Little Terns in the Wadden Sea area (averages during the 2000-2004 period)

Table 7.4 Average number of breeding pairs of Little Terns in the Wadden Sea area (2000-2004 period) and the total number of breeding pairs in the Netherlands and Northwest Europe.

	Normative period	**Number of Wadden Sea breeding pairs** (data SOVON 2005)	**Total population in the Netherlands in 2003** (van Dijk *et al.* 2005)	**NW European population** (Delany & Scott 2002)	**Trend**
Little Tern	Breeding season	209	445	3,400	0

Conservation status

The conservation status of the Little Tern is considered to be unfavourable because the number of breeding pairs has declined sharply over the last 20 to 25 years. Furthermore, the continued existence of sufficient habitat (or nesting sites) is uncertain because the species have become significantly dependent on human intervention as a result of which temporary and new nesting sites are created.

Key factors
The breeding success of the Little Tern in the Wadden Sea area is determined by:
- Supply of sufficient fish of the right size in the immediate vicinity of the breeding colonies. The fish concerned are sand eels, young herring and other small fish. The Little Tern suffers in stormy weather conditions during the breeding season because water levels are then higher and the nesting locations, which are usually low lying, are submerged (Dijksen 2004);
- Degree of disruption. The number of potential nesting sites is limited because the birds have to breed close to tidal inlets in order to provide their young with sufficient food. The degree of disruption on the heads of the bigger Wadden Sea islands is relatively large despite measures to keep visitors away from the nesting sites;
- Dynamics in coastal areas, so that primary biotopes continue to exist, existing nesting sites can disappear because of vegetation succession; the traditional nesting biotope on beaches has virtually disappeared as a result of recreation;
- Predation of eggs and chicks by domestic and other mammals and birds (crows for instance).

Impacts of Maasvlakte 2
In view of the limited disruption of the large scale water movements and residue transport in the southern North Sea as a result of Maasvlakte 2, it seems reasonable for the time being to assume that the impact on the transport of young herring is negligible (see Chapter 3). In the meantime it has emerged that the impact on young flatfish is very modest. This also applies to the larvae of sand eels, which, like young herring, grow up in the coastal zone (P. Munk, by e-mail dated 31 August 2005).

It can be assumed that any impacts of a reduced supply of nutrients (and therefore indirectly of food for fish) in the Wadden Sea will not have an effect on herring and sand eels because their growth does not take place in the Wadden Sea. In view of the fact that the total quantity of nutrients does not change as a result of the Maasvlakte 2 project (only the distribution), it can be assumed in regard to the primary prey of Little Terns that the availability of food will not change and therefore neither will their growth. Any decrease in the numbers of young flatfish is similarly not to be expected. It cannot be excluded that flatfish in the Wadden Sea will grow slightly more slowly as a result of a reduced supply of nutrients and that therefore they will represent a more modest food value. It is unlikely that this will bring about negative impacts on the Little Tern because other sources of food will not be negatively affected.

Appraisal of impacts
The conclusion is that the total quantity of food for Little Terns as a consequence of Maasvlakte 2 will not change appreciably because no impacts are to be expected on the transport of the larvae and growth of the most important prey, namely herring and sand eels. Impacts of a reduction in the quantity of available food that may be associated with Maasvlakte 2 on the breeding success of this species can therefore be ruled out. It should moreover be pointed out that the breeding success is determined more by the weather conditions and the extent to which there is disturbance of the resting and nesting sites than by the availability of food.

7.4.3 Knot

Occurrence and distribution

The Knot is a wader from the tundra in arctic breeding areas in central and east Asia, Alaska, Canada and Greenland. Two sub-species of the Knot use the Wadden Sea area. Birds from Greenland and Canada over winter in the Wadden Sea area (from the late summer to May) and birds stop briefly to 'fatten up' on their migratory route from Siberia to African over wintering areas (Van Roomen *et al.* 2004). The total size of the Greenland population (*islandica*) is 450,000, and that of the nominate form *canutus* is 340,000 (Delany & Scott 2002). The Wadden Sea area is of great significance primarily to the Greenland subspecies of Knot. Approximately 25% of the total population over winters there regularly (Bijlsma *et al.* 2001).

Table 7.5 Knots in the Wadden Sea area and in Northwest Europe; average for the normative period (September)

Species	Average seasonal maximum (1977-2002)	Average Dutch seasonal maximum (1997-2002)	NW European Union population:	Trend van Roomen *et al.* 2004
Knot	98,000	119,300		-
C. c. islandica			450,000	
C. c. canutus			340,000	

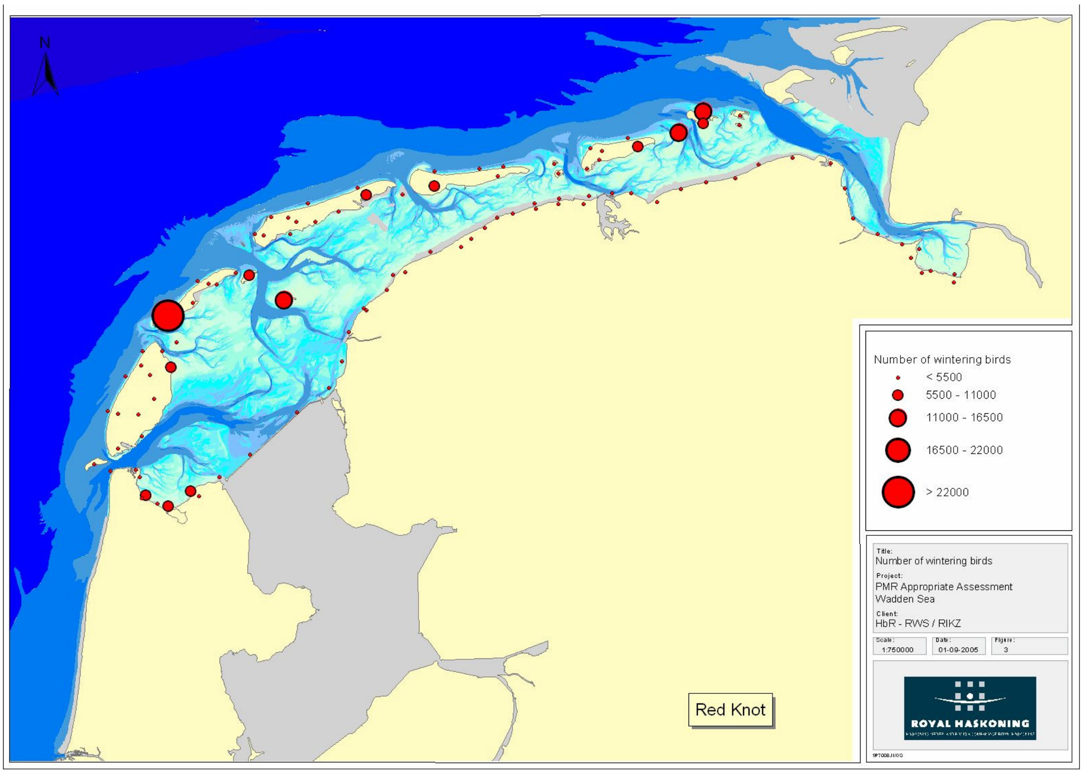

Figure 7-2 Distribution and numbers of Knots in the Wadden Sea area. Average seasonal maximums during the 1998-2004 period.

Conservation status

The Knot has declined markedly in recent years. Leopold *et al.* (2004b) report a change in the trend in the numbers of bird days in regard to Knots at the beginning of the nineteen-nineties. After an increase in the nineteen-eighties, the species decreased in the nineteen-nineties (see also Figure 7.3). This trend coincides with a severe drop in the availability of prey, including young cockles (Leopold *et al.* 2004b). The conservation status is judged to be ‘unfavorable’ because of the declining numbers in the nineteen-nineties. It should be pointed out that the numbers have not changed compared with the nineteen-eighties.

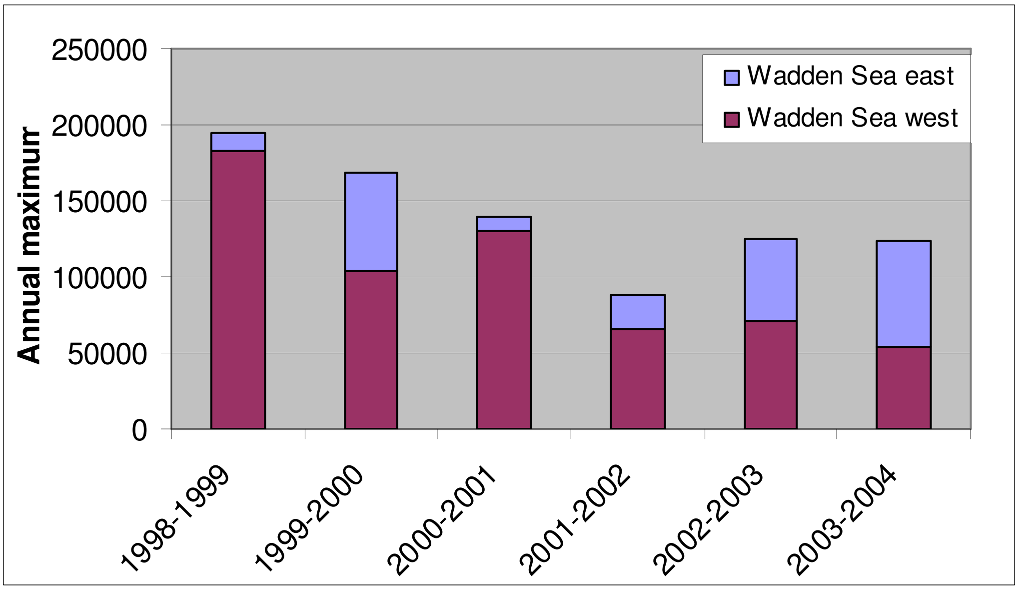

Figure 7-3 Variation in the maximum number of counted Knots (in September) in the Wadden Sea area in the period from 1998/99 to 2003/04

Key factors
The total number of Knots in the Wadden Sea area is determined by:
- Quantity of available food; Knots eat mainly smaller shellfish such as *Macoma*, young cockles and mussels; the available quantity of food is determined by
  - breeding result; this factor, which is not impacted by Maasvlakte 2, is very irregular for cockles in particular, as a result of which there are frequently periods with very low cockle stocks;
  - growth rate; dependent on primary production and consequently concentrations of nutrients (possibly affected by Maasvlakte 2, but also by possible autonomous decrease in concentrations);
  - commercial shellfish fishing; now that the mechanical dredging of cockles is no longer permitted, cockle stocks can rapidly recover in a year with a good breeding result and for several years thereafter a good level of cockle stocks will continue to exist (without removal as a result of fishing); however, Knots can probably not benefit from this because they only eat young cockles.
- Conditions in the nesting areas; there are indications that these have deteriorated primarily for the Greenland subspecies, as a result of which the size of the total population could decrease and therefore fewer birds will over winter in the Wadden Sea area;
- Disruption; Knots often stay in very large groups on high water refuge areas and are therefore prone to disruption by aircraft and recreation.

Impacts of Maasvlakte 2
The EVAII studies reveal that Knots are sensitive to changes in the shellfish stocks in the Wadden Sea area (see 6.5.3). The Knot is a species that covers large distances in order to search for food in specific places. It can be deduced from this that the concentration of food is important and the impacts on shellfish will probably have an effect on the numbers of Knots.
If the construction of Maasvlakte 2 results in a reduction in the shellfish stocks as a result of changes in primary production and silt concentration, it can lead to a decline in the numbers of Knots. It is concluded in 7.3 that significant negative impacts on Knots resulting from the presence of Maasvlakte 2 cannot be ruled out based on the assumptions of the base case scenario and a more than proportional effect of the reduction in nutrients on the shellfish biomass (nutrients –10% -> maximum shellfish biomass –20%). Impacts can also not be ruled out under a scenario in which the nutrients drop less sharply (-5% -> maximum shellfish biomass –8%).
The calculated impacts on food stocks are translated one for one in regard to species whereby it is implicitly assumed that the availability of food is the only factor that determines the numbers.

Appraisal of impacts
A reduction in the supply of nutrients to the Wadden Sea can have an effect on the shellfish stocks and therefore possibly also on the number of Knots. Impacts on the Knot can therefore not be ruled out because, as a consequence of the presence of Maasvlakte 2, the nutrient concentrations in the Wadden Sea will probably drop (slightly) in relation to autonomous development.

7.4.4 Oystercatcher

Occurrence and distribution

The Oystercatcher breeds mainly along the coasts of temperate and sub-arctic areas in Europe and Asia. Locally, brooding also takes place at greater distances from the coast. During the winter the species is found only along coasts, particularly in tidal areas and estuaries, but also along rocky coasts. During bad weather (extended periods of high water) it also forages in nearby inland grasslands (Bijlsma *et al*. 2001). Although a large proportion of the Dutch Oystercatcher population breeds in the Wadden Sea area (SOVON 2002), the area is important at a European level primarily in the autumn and winter when about 20% of the Northwest European population is to be found (**Error! Reference source not found.**), distributed over the whole area (7-4 Distribution and numbers of Oystercatchers in the Wadden Sea area. Average seasonal maximums in 1998-2004 period.

Table 7.6 Oystercatchers in the Wadden Sea area and in Northwest Europe

Species	2002/03 seasonal maximum (van Roomen *et al.* 2004)	Dutch 2002/03 seasonal maximum (van Roomen *et al.* 2004)	NW European Union population:	Trend Van Roomen et al. 2004
Oystercatcher – not breeding	171,380	238,300	1,020,000	-

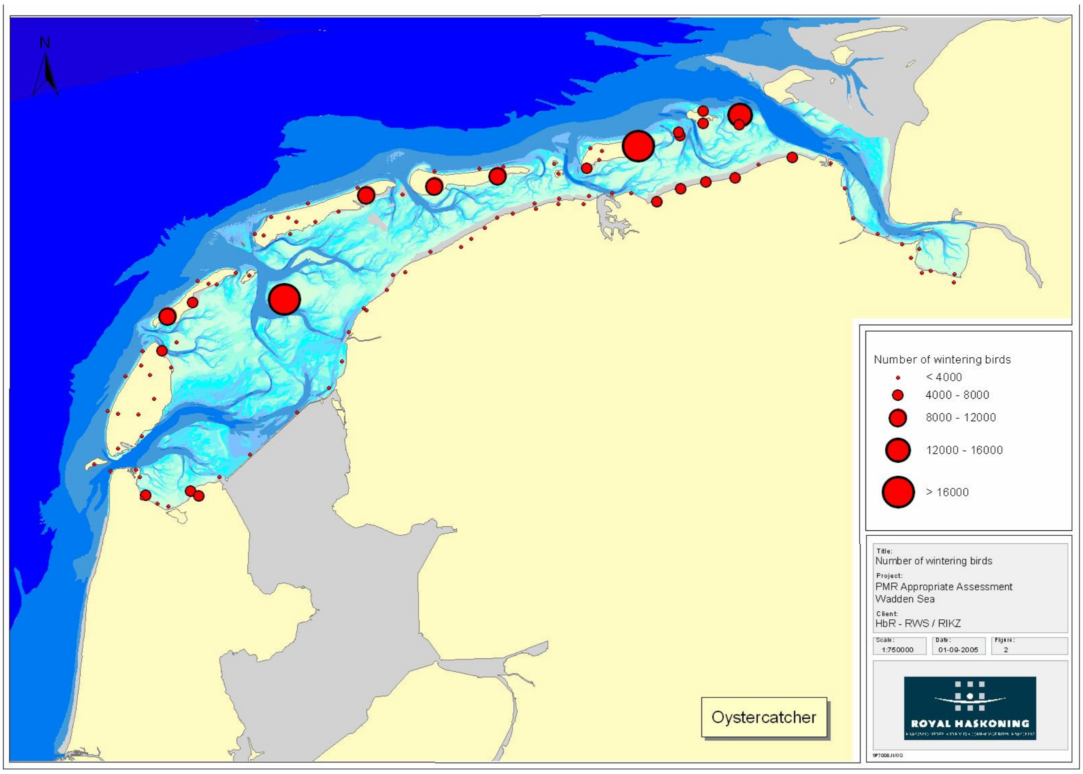

Figure 7-4 Distribution and numbers of Oystercatchers in the Wadden Sea area. Average seasonal maximums in 1998-2004 period.

Conservation status

The populations of overwintering Oystercatchers in the Dutch Wadden Sea and the Zeeland Delta have decreased significantly since the end of the nineteen-eighties. In the Wadden Sea there was a decline from 287,000 in the 1993-97 period to 190,000 during the 1998-2002 period (Van Roomen *et al.* 2004). The total population overwintering in the Netherlands fell from 350,000 in the middle of the nineteen-eighties to 238,300 in 2002. The Dutch summer bird population has also shrunk, particularly in suboptimal areas like the dunes. The international population did not decrease during this period (Delany & Scott 2002).

The conservation status of both summer and non-summer birds is considered to be ‘unfavourable’ because the numbers are dropping and are lower than in the nineteen-eighties.

Key factors
The following factors are important in regard to breeding success (summer birds) and the survival of overwintering birds:
- Quantity of available food; Oystercatchers eat mainly larger cockles and mussels in the littoral; the quantity of food available is dependent on
    - breeding result; this factor, which is not impacted by Maasvlakte 2, is very irregular for cockles, as a result of which there are frequently periods with very low cockle stocks;
    - growth rate; dependent on primary production and consequently concentrations of nutrients (possibly affected by Maasvlakte 2, but also by possible autonomous decrease in concentrations);
    - commercial shellfish fishing; now that the mechanical dredging of cockles is no longer permitted, cockle stocks can rapidly recover in a year with a good breeding result and for several years thereafter a good level of cockle stocks will continue to exist (without removal as a result of fishing);
- Conditions in the nesting areas, such as limited nesting opportunities as a result of brush covering salt marshes, the loss of nests and chicks because of earlier mowing etc.;
- Disruption by recreation in high water refuge areas.

Impacts of Maasvlakte 2
An extensive analysis of the trends in the Oystercatcher population in the Wadden Sea was made in the context of the EVAII project. A connection could be made in this analysis between the sharp downward trend in the number of birds in the nineteen-nineties and the availability of the most suitable prey, including cockles (Rappoldt *et al.* 2004). In the absence of such prey, Oystercatchers can shift to other prey, but in the longer term this leads to a reduction in the population (Rappoldt *et al.* 2004).

If the construction of Maasvlakte 2 results in a reduction or shift in the shellfish stocks as a result of changes in primary production and silt concentration, it can lead to a decline in the numbers of Oystercatchers. It is concluded in **Error! Reference source not found.** that significant negative impacts on Oystercatchers resulting from the presence of Maasvlakte 2 cannot be ruled out based on the assumptions of the base case scenario and a more than proportional effect of the reduction in nutrients on the shellfish biomass (nutrients –10% -> maximum shellfish biomass –20%). Impacts can also not be ruled out under a scenario in which the nutrients drop less sharply (-5% -> maximum shellfish biomass –8%).

Appraisal of impacts
A (limited) reduction in the supply of nutrients to the Wadden Sea has an effect on the stocks of shellfish and consequently possibly also on the numbers of Oystercatchers. A possible reduction in the food supply for this species as a result of the Maasvlakte 2 project cannot be excluded because:
- the condition and survival of Oystercatchers (and consequently the numbers) in some years in the Wadden Sea area are demonstrably limited by food (larger shellfish in the littoral);
- it cannot be ruled out that the expected recovery of the littoral cockle and mussel beds as a result of the termination of mechanical cockle dredging will be partially counteracted by the impacts of Maasvlakte 2;

- the drop in the numbers of Oystercatchers in the Wadden Sea area cannot be explained on the basis of international trends: the Northwest European population did not decrease during the period concerned.

Because of the clear relationship between food stocks and the numbers of Oystercatchers, impacts as a result of Maasvlakte 2 can be ruled out if it can be substantiated that the level of the shellfish stocks will not be negatively affected by Maasvlakte 2.

7.4.5 Eider Duck

Occurrence and distribution

The Wadden Sea is important to the Eider Duck primarily as an overwintering area (over 8% of the total Northwest European population) and to a lesser degree as a breeding area (see 7.7 Eider Ducks in the Wadden Sea area and in Northwest Europe; van Roomen et al. 2004, Dijksen en Koks 2003; van Dijk et al. 2005.). The Eider Ducks that overwinter here are not just the ones breeding in the Netherlands. A significant proportion of the Northwest European population that breeds in more northerly areas overwinters here too (Rose and Scott 1994). The overwintering birds are not evenly spread over the Wadden Sea area. They are found mainly in the western Wadden Sea (7-5 Distribution and numbers of overwintering Eider Ducks in the Wadden Sea area in November 2004 and February 2005 per 5 x 5 km. Taken from: de Jong et al. 2005.

Key factors

The number of Eider Ducks in the Wadden Sea depends on:

- Quantity of available food; Eider Ducks live mainly off sublittoral and littoral (when water levels are high) cockles and mussels; if there is insufficient food in the Wadden Sea they go to the North Sea coastal zone, where they eat *Spisula* (see figure 6.1); the quantity of food available is determined by
    - breeding result; this factor, which is not impacted by the Maasvlakte 2 project, is very irregular among cockles and *Spisula;*
    - growth rate; dependent on primary production and consequently concentrations of nutrients (possibly affected by Maasvlakte 2, but also by possible autonomous decreases in concentrations); no noteworthy impacts of Maasvlakte 2 are to be expected on the growth of *Spisula;*

  - o the ‘competition’ with commercial fishing plays a major role; both are dependent on sublittoral mussel beds. This is the case for Eider Ducks primarily during periods of low cockle densities and the absence of easily accessible (relatively shallow) *Spisula* beds.
- Disruption; Eider Ducks are sometimes chased away from important sublittoral mussel and cultivated mussel plots in the western part of the Wadden Sea by mussel farmers.

Effects van Maasvlakte 2
If the construction of Maasvlakte 2 results in a reduction or shift in the shellfish stocks as a result of changes in primary production and silt concentration, it can lead to a decline in the numbers of Eider Ducks just as it can for Oystercatchers. It is concluded in **Error! Reference source not found.** that significant negative impacts on Eider Ducks resulting from the presence of Maasvlakte 2 cannot be ruled out based on the assumptions of the base case scenario and a more than proportional effect of the reduction in nutrients on the shellfish biomass (nutrients –10% -> maximum shellfish biomass –20%). Impacts can also not be ruled out under a scenario in which the nutrients drop less sharply (-5% -> maximum shellfish biomass –8%). The calculated impacts on food stocks are translated one for one in regard to species whereby it is implicitly assumed that the availability of food is the only factor that determines the numbers.
Unlike the case for Oystercatchers, in the event of food shortages in the Wadden Sea, Eider Ducks can move to the *Spisula* that are found to the north of the Wadden Sea islands. However this source of food is not always available in sufficient quantities and it is a lesser source from an energy point of view because it is relatively deep.

Appraisal of impacts
A (limited) reduction in the supply of nutrients to the Wadden Sea has an effect on the stocks of shellfish and consequently possibly also on the numbers of Eider Ducks. A possible reduction in the food supply for this species as a result of the Maasvlakte 2 project cannot be excluded because:
- the numbers of Eider Ducks in the Wadden Sea area are demonstrably limited by food (sublittoral cockles , mussels and *Spisula);*
- it is possible that the cockle stocks will recover as a result of the termination of mechanical cockle dredging; however, these stocks are dependent on irregular breeding results and it cannot be ruled out that their growth will be limited as a result of Maasvlakte 2;
- any limitation in the productivity of mussels in the Wadden Sea as a result of the Maasvlakte 2 project can have a negative impact on Eider Ducks because of the competition with commercial mussel fishing.

Because of the clear relationship between food stocks and the numbers of Eider Ducks, impacts as a result of Maasvlakte 2 can be ruled out if it can be substantiated that the concentrations of nutrients will not decrease such that the level of the shellfish stocks will be impacted.

7.5 Dealing with uncertainty

It emerged during the investigation into and appraisal of the possible impacts arising from the presence of Maasvlakte 2 that when the direct effects on silt and nutrient concentrations are projected onto the ecological target variables, there is no general scientific consensus and/or significant uncertainties exist. This relates to the following subjects:

1. the effect of silt concentrations in the water on silt concentrations in the sea bed, with implications for the composition and sea bed fauna biomass (quantity of food for waders) and surface foraging areas for birds that prefer soft, very silty sea substrates (including Avocets and Shelducks);
2. effect of silt concentrations in the water on transparency and consequently on the ease with which fish-eating birds (terns, divers and grebes) can catch fish;
3. effects of nutrient concentrations on shellfish biomass (less than proportional, proportional or more than proportional relationship) with implications for birds that are dependent on shellfish (including Eider Ducks, Oystercatchers and Knots).

Below there is an explanation of how these uncertainties were dealt with in the impact prediction.

1. The quantity of silt on the sea bed depends on two factors, namely the supply of silt (concentration in the water) and the local hydrodynamic conditions. Maasvlakte 2 will cause changes in the silt supply. It will increase (temporarily) as a result of the sand extraction and it will drop slightly as a consequence of changes in the transport because of the presence of Maasvlakte 2. Neither the local hydrodynamic conditions in the Wadden Sea will change, nor the pattern of relatively silty and non-silty areas. There is currently no general consensus about how a change in silt supply will affect the composition of the seabed. The extreme scenarios are:

- A change in the concentration in the water has a proportional effect on the concentration in the sea bed; a drop of 15% in the water will therefore result in an overall decrease of the concentration in the sea bed of 15%;
- The composition of the seabed in the Wadden Sea is not sensitive to the silt supply (silt enters in excess) and is determined solely by the local hydrodynamic conditions.

The impacts were determined on the basis of the first scenario because it represents the worst-case situation. It is argued in 4.3.2 (box 'Silt concentration in the sea bed') that a reduction in silt concentration in the sea bed will result in no substantial impacts on the sea bed fauna biomass and composition because these are more dependent on factors that are influenced only barely or not at all by the Maasvlakte 2 project, such as the local hydrodynamic conditions (a variety of silty and non-silty areas) and the availability of organic material. This also means that no substantial negative impacts are to be expected from this higher up in the food chain (waders).

2. As a result of the construction and presence of Maasvlakte 2, temporary (because of sand extraction) or permanent changes in the concentrations and spatial distribution of silt in the North Sea (coastal zone) can be expected. There is uncertainty about whether changes in the transparency might possibly cause changes in the ease at which prey is caught by fish eaters (terns, divers and grebes). The impacts were appraised based on the assumption that these bird species sustain no substantial negative effects as a result of these changes. The arguments for this are:

- The model results from the track 1 investigation show that, as a consequence of the (possible) future distribution of suspended particles, the North Sea will on average become slightly more transparent close to the coast (0-5 km) and that the North Sea further away from the coast will become very slightly less transparent. In the zone between the surf and 5 km the current variation will remain. The (average) impacts on the transparency will be more obvious in the winter than in the spring and summer because then the impact of a decrease in concentrations of suspended particles will be partially counteracted by an increase in primary production. It is concluded on the grounds of the model results that the maximum permanent impact (in the winter) of the Maasvlakte 2 project is that the entire transition zone between the cloudiness (surf) and further out at sea (5 km from the coast) will become several hundred metres narrower. This therefore means in fact that the zone with a higher transparency will move closer to the coast.
- The scientific knowledge about the relationship between (increases in) the transparency and fishing success is limited. On the one hand it is possible that the hunting bird has greater success in catching fish because it can see its prey better as a result of higher transparency, but on the other hand the prey can also see the bird sooner and consequently it will swim away sooner, resulting in lower fishing success. Van Lieshout *et al.* (2003) report that Sandwich Terns are more successful at catching fish when the transparency improves. They also report that Common Terns and Little Terns (in the cloudy Westerschelde) appear to have no preference for clearer water. An increase in the transparency as a result of the Maasvlakte 2 project is not expected to have negative impacts on terns.
- There are similarly no substantial negative impacts to be expected on the other fish-eating species (grebes and divers) because the overall size of the potential foraging area with a particular transparency does not appear to decrease substantially.

3. The simulations produced by the EcoWasp model show a more than proportional relationship between changes in the nutrient concentrations and the maximum shellfish biomass. There was a great deal of discussion about these results in the workshops on 22/23 June and 20 September 2005. Although most of those present agreed that the relationship is more likely to be directly proportional than more than directly proportional, the impacts appraisal was based on the assumption that the relationship is more than directly proportional (worst case).

The Eider Duck is a summer bird that prefers salt marshes and dunes in the vicinity of extensive intertidal areas such as the Wadden Sea. Essentially the entire Dutch breeding population nests in the Wadden Sea islands (in particular Vlieland, Terschelling and Schiermonnikoog). Outside the breeding season most of the species remains in the Wadden Sea (where some of the Dutch summer birds overwinter, as do large numbers of birds from Scandinavia).

Table 7.7 Eider Ducks in the Wadden Sea area and in Northwest Europe; van Roomen et al. 2004, Dijksen en Koks 2003; van Dijk et al. 2005.

Species	2002/03 seasonal maximum; 2002 breeding population	Total population in the Netherlands	NW European Union population:	Trend van Roomen et al. 2004
Eider Duck – not breeding	86,070	91,435	1,030,000	f
Breeding pairs	6,900	7,000		

Conservation status
The conservation status of overwintering birds is considered by the Ministry of Agriculture, Nature Management and Food Quality to be unfavourable on the grounds of the recent (statistically significant) drop in the winter population and the high winter mortality that has occurred in a few recent winters. It should be pointed out that the numbers are still higher than in the nineteen-seventies.

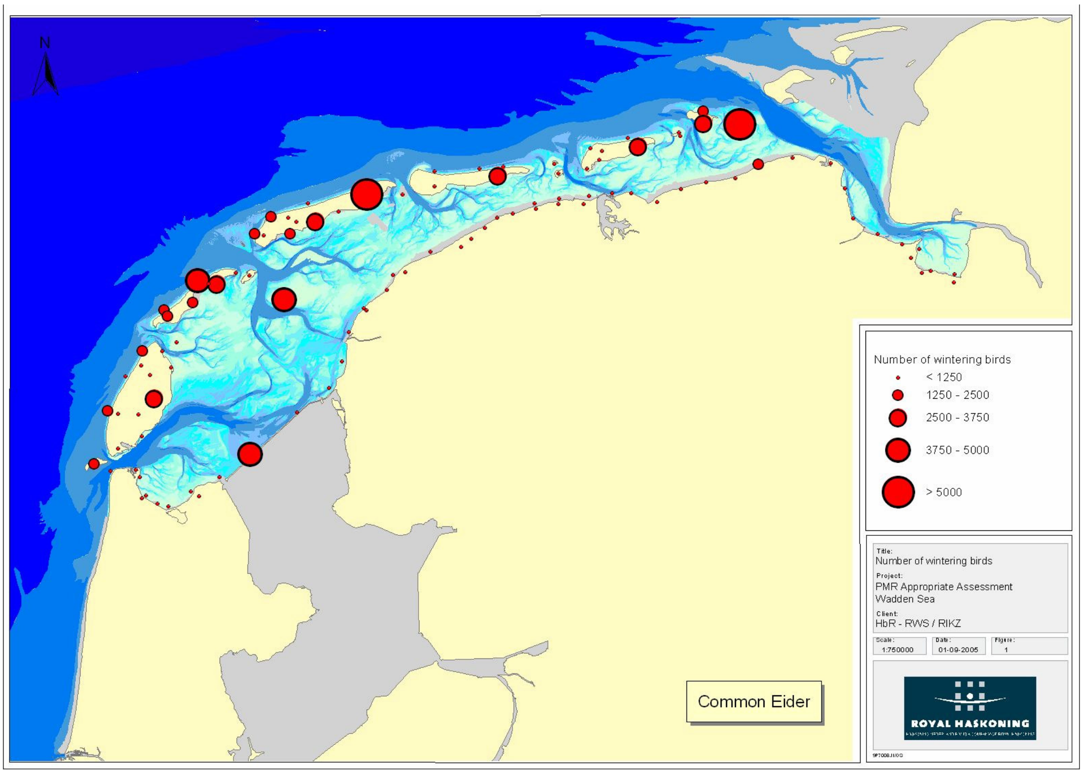

Figure 7-5 Distribution and numbers of overwintering Eider Ducks in the Wadden Sea area in November 2004 and February 2005 per 5 x 5 km. Taken from: de Jong et al. 2005.

Key factors
The number of Eider Ducks in the Wadden Sea depends on:
- Quantity of available food; Eider Ducks live mainly off sublittoral and littoral (when water levels are high) cockles and mussels; if there is insufficient food in the Wadden Sea they go to the North Sea coastal zone, where they eat *Spisula* (see figure 6.1); the quantity of food available is determined by
    - breeding result; this factor, which is not impacted by the Maasvlakte 2 project, is very irregular among cockles and *Spisula*;
    - growth rate; dependent on primary production and consequently concentrations of nutrients (possibly affected by Maasvlakte 2, but also by possible autonomous decreases in concentrations); no noteworthy impacts of Maasvlakte 2 are to be expected on the growth of *Spisula*;

  - o the ‘competition’ with commercial fishing plays a major role; both are dependent on sublittoral mussel beds. This is the case for Eider Ducks primarily during periods of low cockle densities and the absence of easily accessible (relatively shallow) *Spisula* beds.
- Disruption; Eider Ducks are sometimes chased away from important sublittoral mussel and cultivated mussel plots in the western part of the Wadden Sea by mussel farmers.

Effects van Maasvlakte 2
If the construction of Maasvlakte 2 results in a reduction or shift in the shellfish stocks as a result of changes in primary production and silt concentration, it can lead to a decline in the numbers of Eider Ducks just as it can for Oystercatchers. It is concluded in **Error! Reference source not found.** that significant negative impacts on Eider Ducks resulting from the presence of Maasvlakte 2 cannot be ruled out based on the assumptions of the base case scenario and a more than proportional effect of the reduction in nutrients on the shellfish biomass (nutrients –10% -> maximum shellfish biomass –20%). Impacts can also not be ruled out under a scenario in which the nutrients drop less sharply (-5% -> maximum shellfish biomass –8%). The calculated impacts on food stocks are translated one for one in regard to species whereby it is implicitly assumed that the availability of food is the only factor that determines the numbers.
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Appraisal of impacts
A (limited) reduction in the supply of nutrients to the Wadden Sea has an effect on the stocks of shellfish and consequently possibly also on the numbers of Eider Ducks. A possible reduction in the food supply for this species as a result of the Maasvlakte 2 project cannot be excluded because:
- the numbers of Eider Ducks in the Wadden Sea area are demonstrably limited by food (sublittoral cockles , mussels and *Spisula*);
- it is possible that the cockle stocks will recover as a result of the termination of mechanical cockle dredging; however, these stocks are dependent on irregular breeding results and it cannot be ruled out that their growth will be limited as a result of Maasvlakte 2;
- any limitation in the productivity of mussels in the Wadden Sea as a result of the Maasvlakte 2 project can have a negative impact on Eider Ducks because of the competition with commercial mussel fishing.

Because of the clear relationship between food stocks and the numbers of Eider Ducks, impacts as a result of Maasvlakte 2 can be ruled out if it can be substantiated that the concentrations of nutrients will not decrease such that the level of the shellfish stocks will be impacted.

7.5 Dealing with uncertainty

It emerged during the investigation into and appraisal of the possible impacts arising from the presence of Maasvlakte 2 that when the direct effects on silt and nutrient concentrations are projected onto the ecological target variables, there is no general scientific consensus and/or significant uncertainties exist. This relates to the following subjects:

4. the effect of silt concentrations in the water on silt concentrations in the sea bed, with implications for the composition and sea bed fauna biomass (quantity of food for waders) and surface foraging areas for birds that prefer soft, very silty sea substrates (including Avocets and Shelducks);
5. effect of silt concentrations in the water on transparency and consequently on the ease with which fish-eating birds (terns, divers and grebes) can catch fish;
6. effects of nutrient concentrations on shellfish biomass (less than proportional, proportional or more than proportional relationship) with implications for birds that are dependent on shellfish (including Eider Ducks, Oystercatchers and Knots).

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1. The quantity of silt on the sea bed depends on two factors, namely the supply of silt (concentration in the water) and the local hydrodynamic conditions. Maasvlakte 2 will cause changes in the silt supply. It will increase (temporarily) as a result of the sand extraction and it will drop slightly as a consequence of changes in the transport because of the presence of Maasvlakte 2. Neither the local hydrodynamic conditions in the Wadden Sea will change, nor the pattern of relatively silty and non-silty areas. There is currently no general consensus about how a change in silt supply will affect the composition of the seabed. The extreme scenarios are:

- A change in the concentration in the water has a proportional effect on the concentration in the sea bed; a drop of 15% in the water will therefore result in an overall decrease of the concentration in the sea bed of 15%;
- The composition of the seabed in the Wadden Sea is not sensitive to the silt supply (silt enters in excess) and is determined solely by the local hydrodynamic conditions.

The impacts were determined on the basis of the first scenario because it represents the worst-case situation. It is argued in 4.3.2 (box 'Silt concentration in the sea bed') that a reduction in silt concentration in the sea bed will result in no substantial impacts on the sea bed fauna biomass and composition because these are more dependent on factors that are influenced only barely or not at all by the Maasvlakte 2 project, such as the local hydrodynamic conditions (a variety of silty and non-silty areas) and the availability of organic material. This also means that no substantial negative impacts are to be expected from this higher up in the food chain (waders).

2. As a result of the construction and presence of Maasvlakte 2, temporary (because of sand extraction) or permanent changes in the concentrations and spatial distribution of silt in the North Sea (coastal zone) can be expected. There is uncertainty about whether changes in the transparency might possibly cause changes in the ease at which prey is caught by fish eaters (terns, divers and grebes). The impacts were appraised based on the assumption that these bird species sustain no substantial negative effects as a result of these changes. The arguments for this are:

- The model results from the track 1 investigation show that, as a consequence of the (possible) future distribution of suspended particles, the North Sea will on average become slightly more transparent close to the coast (0-5 km) and that the North Sea further away from the coast will become very slightly less transparent. In the zone between the surf and 5 km the current variation will remain. The (average) impacts on the transparency will be more obvious in the winter than in the spring and summer because then the impact of a decrease in concentrations of suspended particles will be partially counteracted by an increase in primary production. It is concluded on the grounds of the model results that the maximum permanent impact (in the winter) of the Maasvlakte 2 project is that the entire transition zone between the cloudiness (surf) and further out at sea (5 km from the coast) will become several hundred metres narrower. This therefore means in fact that the zone with a higher transparency will move closer to the coast.
- The scientific knowledge about the relationship between (increases in) the transparency and fishing success is limited. On the one hand it is possible that the hunting bird has greater success in catching fish because it can see its prey better as a result of higher transparency, but on the other hand the prey can also see the bird sooner and consequently it will swim away sooner, resulting in lower fishing success. Van Lieshout *et al.* (2003) report that Sandwich Terns are more successful at catching fish when the transparency improves. They also report that Common Terns and Little Terns (in the cloudy Westerschelde) appear to have no preference for clearer water. An increase in the transparency as a result of the Maasvlakte 2 project is not expected to have negative impacts on terns.
- There are similarly no substantial negative impacts to be expected on the other fish-eating species (grebes and divers) because the overall size of the potential foraging area with a particular transparency does not appear to decrease substantially.

3. The simulations produced by the EcoWasp model show a more than proportional relationship between changes in the nutrient concentrations and the maximum shellfish biomass. There was a great deal of discussion about these results in the workshops on 22/23 June and 20 September 2005. Although most of those present agreed that the relationship is more likely to be directly proportional than more than directly proportional, the impacts appraisal was based on the assumption that the relationship is more than directly proportional (worst case).

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Annex 1
Experts consulted and members of the steering group

Appendix 1a Participants in workshops and other experts consulted

Organisation	Name	Workshop 19 May 2005	30 May 2005	22/23 June 2005	20 Sept. 2005
Experts					
Alterra	Sophie Brasseur	+		written	
	Bert Brinkman	+		+	+
	Norbert Dankers			+	
	Bruno Ens			+	
	Mardik Leopold	+		written	+
	Han Lindeboom	+	+	+	+
	Cor Smit	+		+	+
NIOO-CEME	Peter Herman				+
NIOZ	Kees Camphuysen	+			+
	Rob Dekker	+			
	Jaap van de Meer	+			+
	Katja Philippart	+			
	Henk van der Veer	+		only 22 June	+
RIKZ	Cor Berrevoets		+		
	J. Baretta-Bekker		+		
	Jaap de Vlas	+	+	+	+
	Jaap Graveland		+		
	Job Dronkers				+
	Johan de Kok		+		+
	Lieke Berkenbosch	+	+	+	
	Marcel van de Tol		+		+
	Remi Laane				+
	Rene Bol				+
	Saskia Hommes			+	+
	Zwanette Jager	+	+	+	+

Organisation	Name	Workshop			
		19 May 2005	30 May 2005	22/23 June 2005	20 Sept. 2005
Project team					
Rotterdam Port Authority	Remco Hutter				+
	J. Konter		+		
	Tiedo Vellinga	morning		+	+
HWE	Floor Heinis	+	+	+	+
RIKZ	Mariska Harte		+		+
	Bianca Peters				+
	John de Ronde		+	+	+
	Rien van Zetten		at beginning		+
RIVO	Adriaan Rijnsdorp	+			
	Adriaan Rijnsdorp			only 22 June	+
	Tammo Bult			only 23 June	
Royal Haskoning	Claudia van Holsteijn		+		
	Jan Willem van de Vegte	+		+	+
	Mark van Zanten	morning		+	+
	Matthijs van Ledden	+	+	+	+
	Myriam de Jong	+	+	+	+
WL | Delft Hydraulics	Han Winterwerp			+	
	Hans Los			+	+
	Johan Boon		+		+

Appendix 1b Members of the Audit Panel

Name	Expert in
Prof. Colin Bannister	fish population dynamics
Prof. Keith Dyer	sediment dynamics
Prof. Mike Elliot	ecosystem dynamics in tidal basins
Prof. Jürgen Sündermann	hydrodynamics of shelf seas
Prof. Carlo Heip (chairman)	ecology of coastal marine systems

Appendix 1c Members of the steering group

Institute	Name
RIKZ	R. van Zetten
	J. de Vlas
	M. Harte
N.V. Havenbedrijf Rotterdam	T. Vellinga
	P. van der Zee

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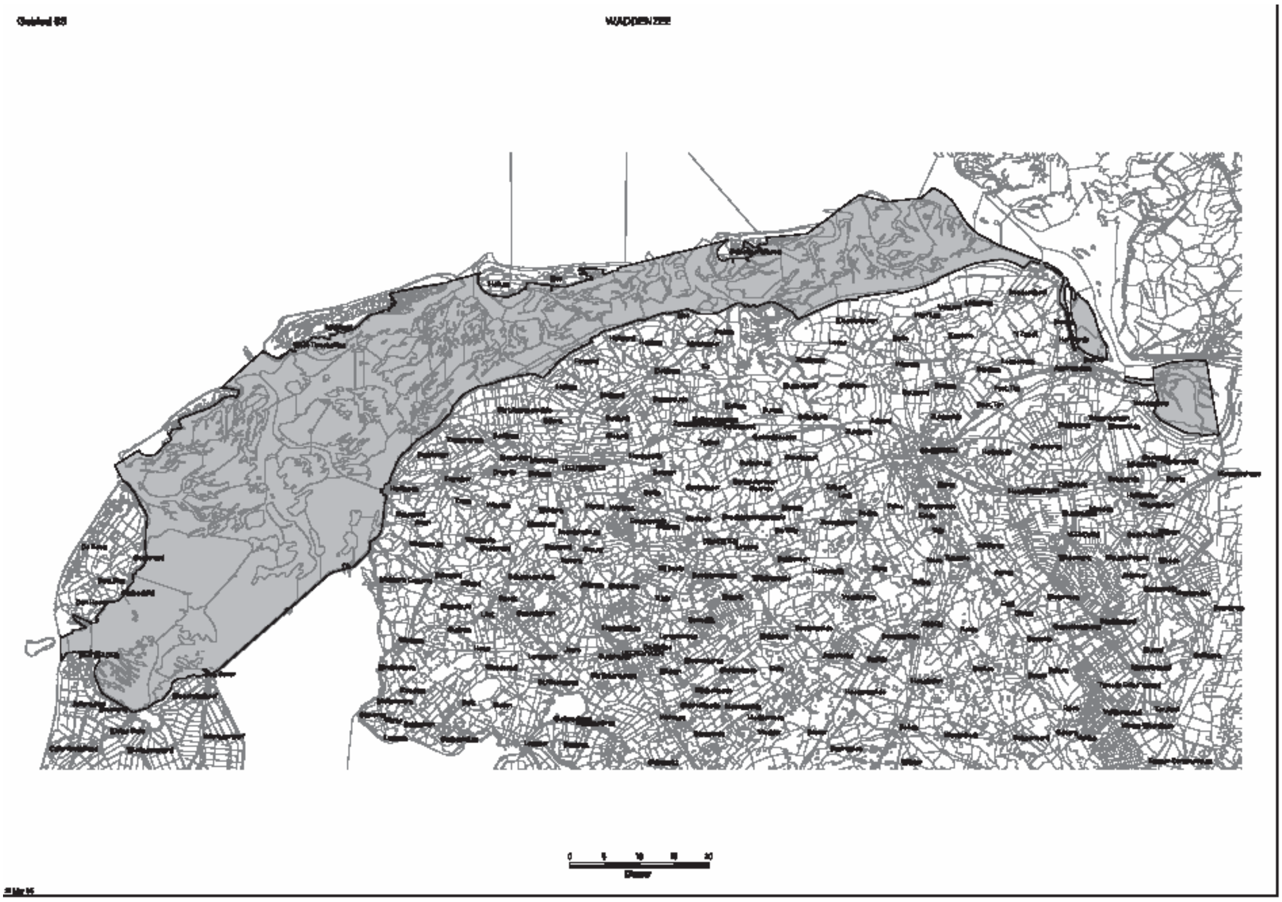
Annex 2
Assesment criteria

Vogelrichtlijngebied:	Aanwijzingscriteria Waddenzee Oppervlakte: 250.000 ha																		Aanwijzingscriteria Waddeneilanden/Noordzeekust-zone/Breebaart Oppervlakte: 272.027 ha						
Soort	Open water	Balgzand	Texel-De Schorren	Kust Wieringen	Vlieland-wadden	Richel	Terschelling-De Boschplaat	Griend	Friese Waddenkust	Ameland-wadden	Engelsmanplaat	Schiermonnikoog-wadden	Groninger Waddenkust	Rottumerplaat	Rottumeroog	Simonszand	Dollard	**Totaal**	Noordzeekustzone	Duinen van Texel	Duinen van Vlieland	Duinen van Terschelling	Duinen van Ameland	Duinen van Schiermonnikoog	**Totaal**
Aalscholver		o	o	o		o	o	o	o			o	o		o			o	o						o
Aalscholver (broedend)																					o				o
Bergeend		k	o	k	k		k	k	k	k	o	k	k	o	o	o	o	k	o						o
Blauwe kiekendief (broedend)							o					o						o		k	o	k	k	k	k
Bontbekplevier		o		o	o		o		o			o	o	o	o		o	o	o						o
Bontbekplevier (broedend)																						o			o
Bonte strandloper		k		o	k	k	k	k	k	k	k	k/o	k	k	k	o	k	k	k						k
Brandgans							o		k	o		k	k		o		k	k							
Brilduiker																		o							
Bruine kiekendief																	o	o		o	o	k	k	o	k
Dodaars (broedend)																						o			o
Drieteenstrandloper					o	k	o	o		o	k	o		k	o	o		k	k						k
Dwergstern (broedend)														k	k			k		o					o
Eidereend	k			o	o		o	o	o	o		o		o	o			k	k						k
Eidereend (broedend)																				o	o		o	o	o
Fuut																									
Goudplevier		o		k					k				o	o			k	k							
Grauwe gans		o					o		o			o	k				k	k							
Grauwe klauwier																							k		k
Groenpootruiter																									
Grote stern (broedend)								k				k		k				k							
Grote zaagbek																			o						o
Grutto				o					o								o	o							
Kanoetstrandloper		k	k	k	k	k	k	k	k	o	o			k	o	o		k	k						k
Kievit																									
Kleine mantelmeeuw (broedend)							k			o		k		o	o			k		k	o				k
Kleine zwaan				o					k				k					k	o						o
Kluut		k	o	k	o		k	o	k	o	o	o	k	o	o		k	k	o		o				o
Kluut (broedend)		k		o					k				k				k	k							
Kolgans																	o	o							
Krakeend		o																o							
Krombekstrandloper									o									o							
Lepelaar		k	k	o	o		k		o	k		k	o	o			o	k			k				k
Lepelaar (broedend)			k				k					k						k		k	k				k
Meerkoet																									
Middelste zaagbek							o											o	o						o
Nonnetje																									
Noordse stern (broedend)					o			k	k	k		o	k	k	o			k							
Paapje (boedend)																						o			o
Parelduiker																			k						k
Pijlstaart		k		o	o		k	o	k	o		k	k	o			k	k	o		o				o
Porseleinhoen (broedend)																							o		o
Rietzanger (broedend)																						o	o		o
Roodborsttapuit (broedend)																				o					o
Roodkeelduiker																			k						k
Rosse grutto		k	o	o	k	k	k	k	k	k	o	k	k	o	o	o	k	k	k						k
Rotgans		o	o	o	o		k	o	k	o	o	o	k	o	o			k							
Scholekster		k	o	k	k		k	k	k	k	o	k	k	k	o	o		k	o						o
Slechtvalk					o		o		k			o	o					k							
Slobeend		k		k					o			o					o	k			o				o
Smient		o		o			o		k	o		o	o				k	k							
Steenloper		o		o	o		o	o	o	o	o	o	o	k	o			k	o						o
Strandplevier																					o	o		o	o
Tapuit (broedend)																				o	o	o	o		o
Toendrarietgans																		o							
Toppereend	k			o														k	k						k
Tureluur		k	o	o	o		k	o	k	o		o	k	o	o		k	k			o				o
Velduil (broedend)							o					o						o		k		k	k	o	k
Velduil																									
Visdief (broedend)		k		o				k	k			o	o	o				k							
Wilde eend																		o							
Wintertaling		o		o			o		o								k	k							
Wulp		k	o	o	k	o	k	k	k	k	k	k	k	k	k/o	o	o	k	o		o				o
Zilverplevier		k	o	o	k	o	k	k	k	k	k	k	k	k	k	o	k	k	k						k
Zwarte ruiter		k		o					o				o				k	k							
Zwarte stern (slaapplaats)		k		k														k							
Zwarte zee-eend																			k						k

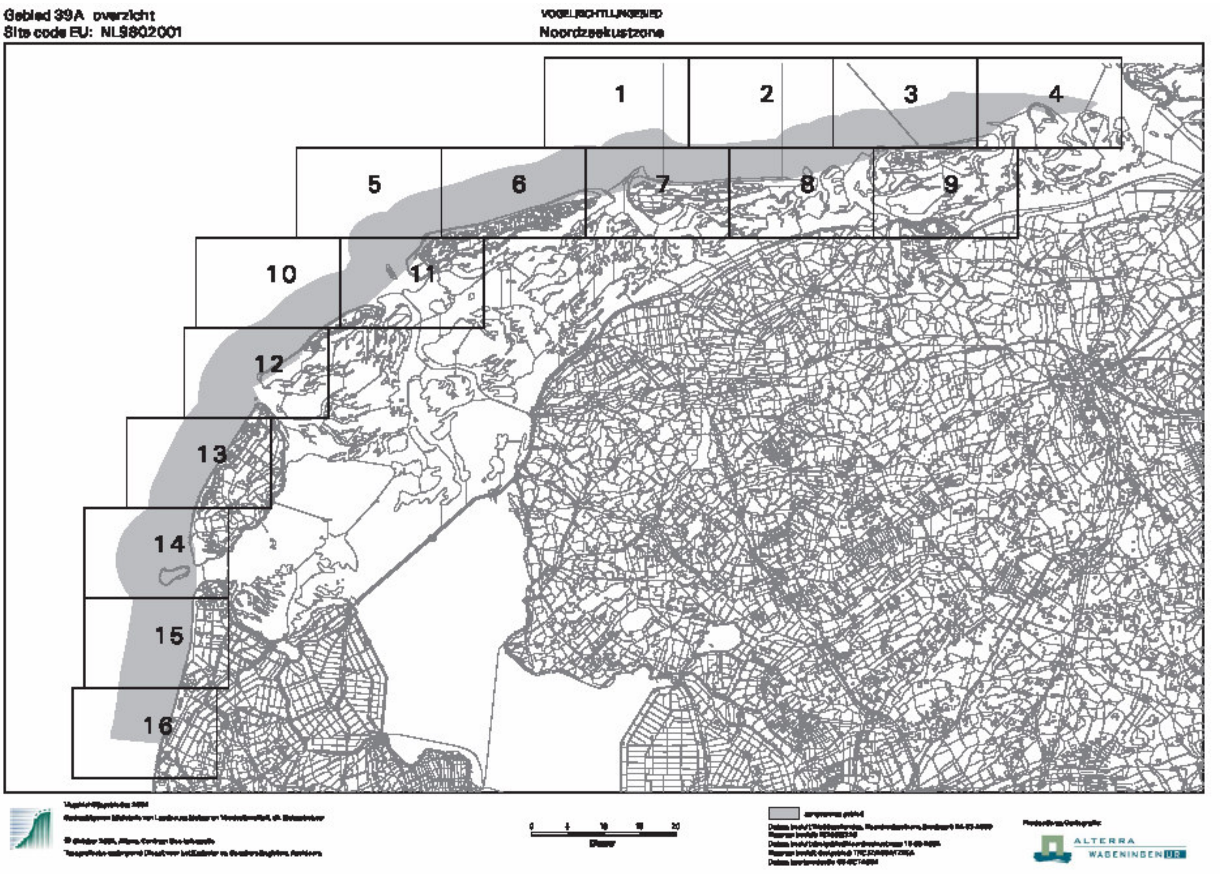
k: kwalificerende soort
o: overige relevante soort
k/o: vermeld als kwalificerende soort én als overige relevante soort

Annex 3
Overview of Birds and Habitats Directives Areas

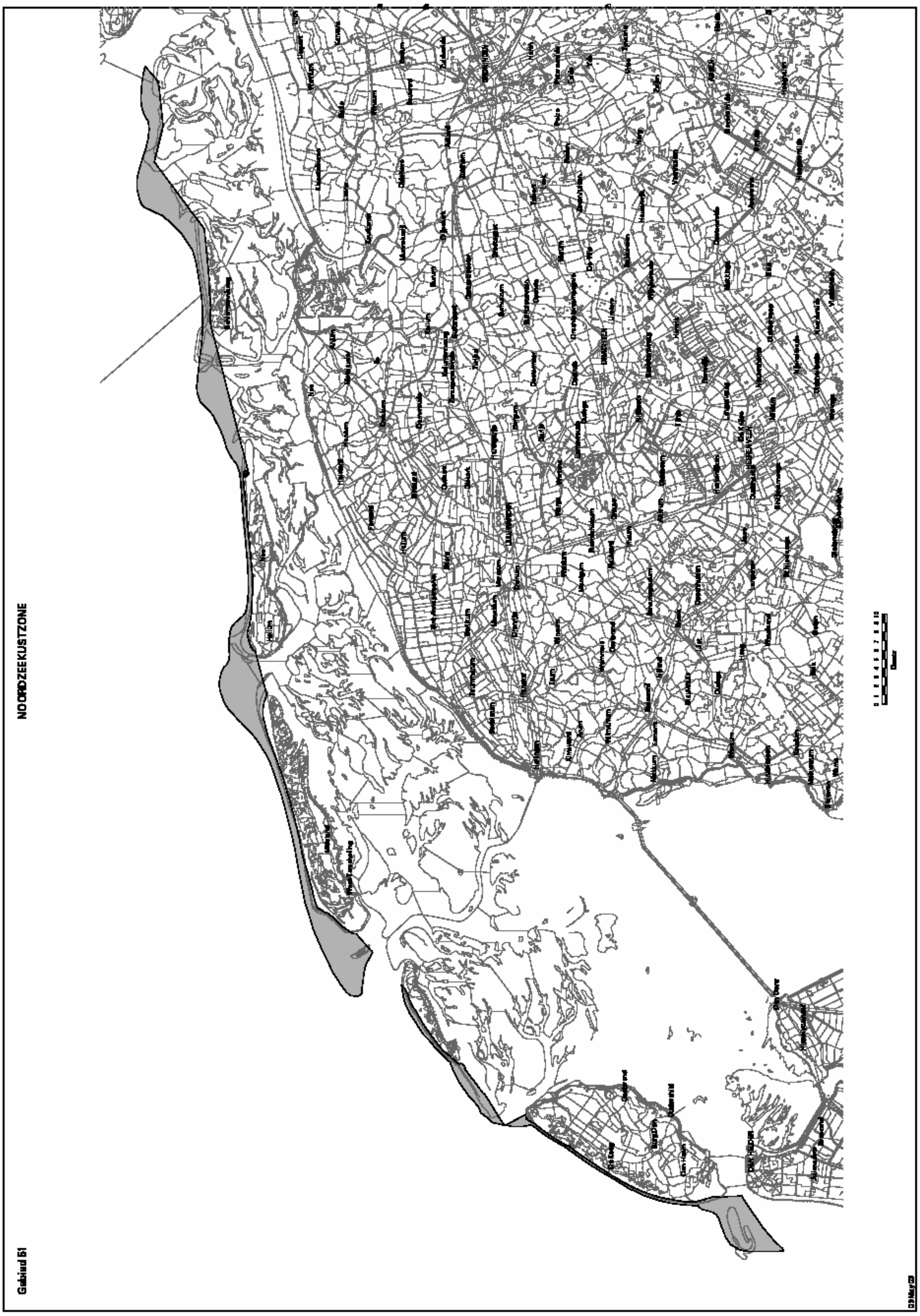
APPENDIX 3A: OVERVIEW OF THE WADDEN SEA HABITATS DIRECTIVE AREA



APPENDIX 3B: BIRDS DIRECTIVE AREA, WADDEN ISLANDS, NORTH SEA COASTAL ZONE AND BREEBAART



APPENDIX 3C. HABITATS DIRECTIVE AREA NORTH SEA COASTAL ZONE



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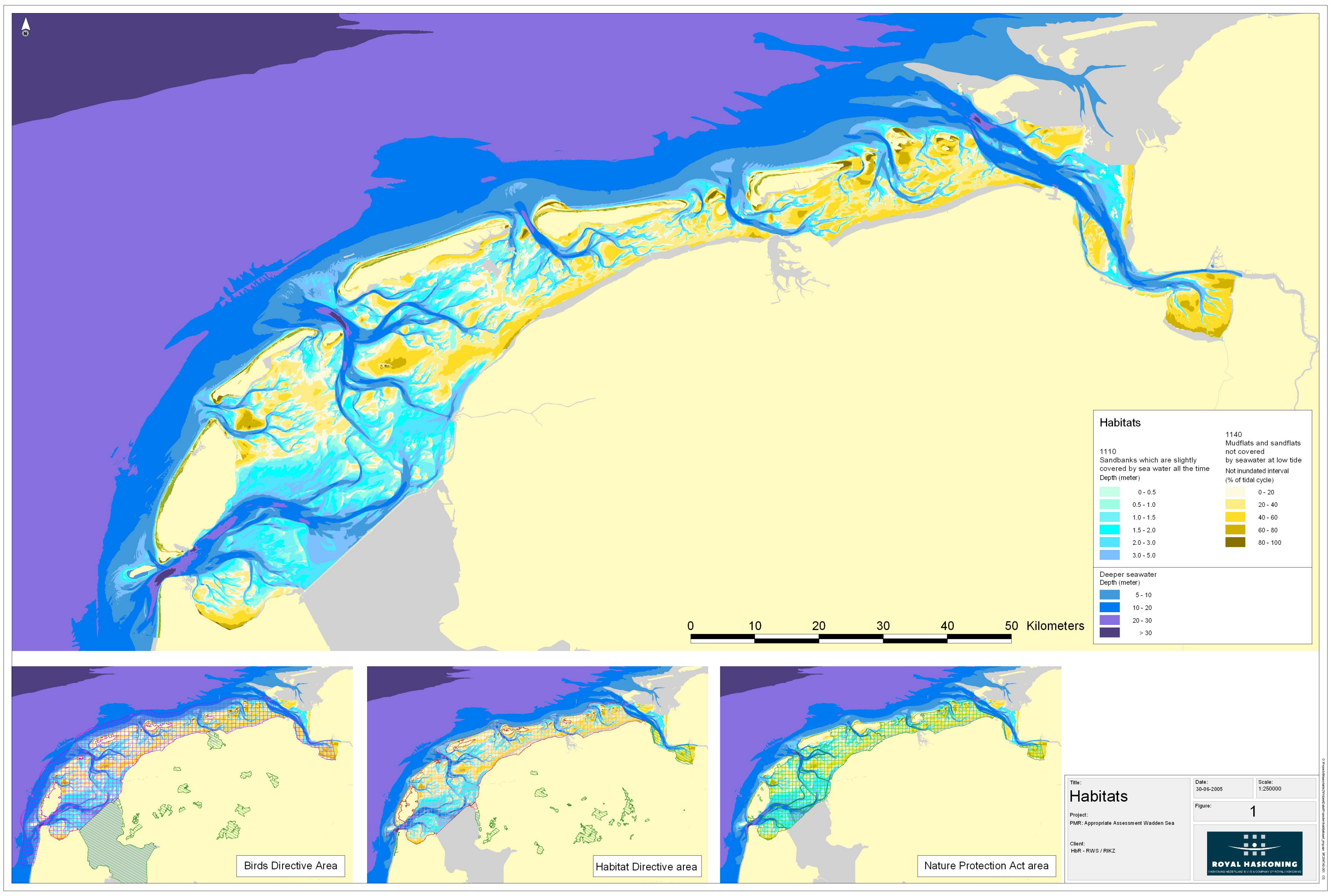
Annex 4
Habitats Map


0
10
20
30
40
50
Kilometers
Habitats
1110
Sandbanks which are slightly covered by sea water all the time
Depth (meter)
0 - 0.5
0.5 - 1.0
1.0 - 1.5
1.5 - 2.0
2.0 - 3.0
3.0 - 5.0
1140
Mudflats and sandflats not covered by seawater at low tide
Not inundated interval (% of tidal cycle)
0 - 20
20 - 40
40 - 60
60 - 80
80 - 100
Deeper seawater
Depth (meter)
5 - 10
10 - 20
20 - 30
> 30
Birds Directive Area
Habitat Directive area
Nature Protection Act area
Title:
Habitats
Project:
PMR: Appropriate Assessment Wadden Sea
Client:
HbR - RWS / RIKZ
Date:
30-06-2005
Scale:
1:250000
Figure:
1
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Annex 5
Autonomous development and cumulation

Natural variation
The variability of the Wadden Sea ecosystem is partially the result of annual variations in temperature and wind. At the same time there are climate oscillations with periods of decades or centuries. There are also long term developments such as the current global warming. Because of the interaction of cycles, current weather events and interaction between all the species of plants and animals present, the Wadden Sea can never be predicted exactly.

The construction of the second Maasvlakte will have no effect on the variability. As we have said, the variations are determined by climatological and other large scale factors.

Climate change
Changes in the climate, such as the current global warming, can sometimes lead to changes in ocean currents which may cause a step change that is noticeable in a process of continuous change. Because of the change in temperature, some species may extend their habitats in a northerly direction or there may be changes in the availability of food. These effects are very difficult to predict.

As a result of higher seawater temperatures, Baltic Clams now breed earlier in the year. The primary production (bloom of algae that serve as food for the Baltic Clam larvae) has however not changed. Consequently, the foraging circumstances for the Baltic Clam larvae have worsened and, in the longer term, the population of Baltic Clams in the Wadden Sea is expected to decline (Philippart *et al.* 2003, from LNV). Cockles breed irregularly, while the survival chance of the larvae is determined to a significant extent by the presence of shrimps that are predators for shellfish larvae. Due to the warmer water in the Wadden Sea, and possibly due to improved survival; rates of shrimp as a result of the small populations of some fish species that eat large quantities of shrimp (such as cod), the shrimp population is higher in the early spring than it use to be. As a result of this, there is more predation on cockle larvae, particularly in the deeper parts of the Wadden Sea (Beukema & Dekker in press), (LNV).

Because the effects of climate change take place at a much larger space and time scale than the effects of the second Maasvlakte on the Wadden Sea, climate change has not been included in the analysis of autonomous developments and cumulative effects.

Water quality change/ eutrophication
One of the most important policy objectives for the water quality in the Wadden Sea is combating eutrophication. Smaller quantities of nutrients from agriculture must be discharged to the Wadden Sea via the big rivers and drainage. The policy will also lead to less atmospheric deposition of nitrogen in the coming years. This autonomous development should lead to lower nutrients contents in the Wadden Sea, which will reduce the food stocks. This applies to the primary production and will work through into the food chain for shellfish, seabed animals, fish, birds and sea mammals. It is not known much this will decrease the capacity of the system. For the time being, however, it is not expected that the nutrients contents will (further) decrease in the short term.

Coastline and seabed of North Holland, South Holland and Zeeland
Over the years there have been various interventions along the coast of North Holland, South Holland and Zeeland. In the past, these interventions have led to changes in the transport of silt (the erosion of the Flemish Banks, the first Maasvlakte, the Dam near the Hook of Holland, sand extraction off the coast). The construction of the Delta Works and sea defences has had morphological consequences which have reduced the nursery areas for fish in particular (fresh-salt transitions). These changes are permanent. These interventions have therefore been included as an integral part of the modelling for calculating the effects.

Management of the Haringvliet Sluices
The decision to partially open the Haringvliet sluices is regarded as established policy. The changes in flow patterns and water quality around the mouth of the Haringvliet have therefore been included as an integral part of the model studies.

Coastline and seabed of the Wadden area
There have also been interventions in the Wadden area in the past. The most important of these were the construction of the IJsselmeer dam, the closing off of the Lauwersmeer, the work on saltings and the construction of dikes on the Wadden coast and the Wadden islands. These changes are permanent. They have therefore been included in the effects assessment as established facts; the effects of these interventions will not change in the future.
The planned removal of the bar in the Harlingen channel will have a very limited effect on the morphology and sedimentation in the Wadden Sea. Significant negative effects on qualifying species and habitats are not expected.

Gas production in the Wadden Sea causes subsidence, which leads to changes in the transport of silt and decreases the intertidal area. However, this has no effect on the transport of silt and nutrients (and fish larvae) from the North Sea Coastal Zone to the Wadden Sea).

Shell extraction reduces the hard substrate in the sublittoral. At the same time, silt is introduced into the water column. The intensity of shell extraction will stay the same. The model calculations implicitly take this activity into account.

Maintenance of coast and ports
Sand is regularly added to the coasts of North Holland, South Holland and some of the islands in order to protect the coastline. Dredging is carried out to maintain the accessibly of the ports for shipping. These dredgings are dumped off the Dutch coast and some of this material is transported to the Wadden Sea by coastal currents. Dredgings also come from inland sites and are dumped in the sea off the coast. These developments lead to an increase in the silt content in the Wadden Sea and the North Sea Coastal Zone. Maintenance is a temporary activity that is regularly repeated. The intensity with which sand is added to the coast and dredging is carried out will remain the same. The model calculations take this activity into account.

The establishment of the Japanese oyster
Since 1990, the exotic Japanese oyster has established itself in the Wadden Sea. Just like other shellfish, the Japanese oyster filters the water, so that the nutrients and silt contents fall. This means competition for food with native species, while the Japanese oyster is not edible for most species of birds living on the mud flats. The effect of the advance of the Japanese oyster is currently under investigation.

Fishing
Bottom fishing stirs up the seabed. This limits the availability of shellfish. Bottom fishing and pelagic fishing in the North Sea mean that larger fish are removed. This reduces the number of fish larvae so that the number of fish larvae available as food for fish eaters in the Wadden Sea decreases. Pelagic fishing in the Wadden Sea has the same effect.

Mussel fishing and cockle fishing in the Wadden Sea result in the removal of food for shellfish eaters. Shellfish also have a filtering effect because they take in silt; this will also increase.

The fishing intensity in the Wadden area and the North Sea Coastal Zone is developing independently of the construction of the second Maasvlakte. In this study we have therefore assumed that fishing activity will remain constant. Cockle fishing is an exception to this. It has recently been forbidden so that the number of cockles and hence their availability as food for birds will increase.

Recreation
Recreation in the Wadden Sea disturbs the birds and sea mammals. In view of the basic principles of Wadden Sea Key Planning Decision, recreation will remain at the same level as now. Recreation has been included in the effects assessment as an established fact. The effects of recreation will not change in the future unless specific measures are implemented.

Wind turbines
The siting of wind turbines in the sea results in a roughening of the seabed. This is not expected to affect the Wadden Sea. The siting of wind turbines along the Wadden coast or Eems-Dollard, with disturb birds breaking their journeys.