Colophon

Compilation and Layout
Common Wadden Sea Secretariat (CWSS), Wilhelmshaven, Germany

Cover
Mosaic of satellite images of the period 2000-2002
(Source: Eurimage, Common Wadden Sea Secretariat & Brockmann Consult)

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Besemann, Wittmund

Wilhelmshaven, January 2008

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We are pleased to submit to UNESCO the nomination of the Dutch-German Wadden Sea for inscription into the World Heritage List. The submission fills us with a great deal of pride. This nomination reflects 15 years of discussion with a wide range of stakeholders and local residents. These discussions have created a firm foundation of support and signify a shared responsibility for the future of the Wadden Sea as a World Heritage Site. Naturally, we are also proud to submit the nomination because the Wadden Sea is undeniably unique. It forms the largest unbroken system of tidal sand and mudflats world-wide, with dynamic processes proceeding in a largely unimpaired way, with spectacular biodiversity of global importance.

For more than a generation our countries have invested huge efforts to protect, conserve and wisely manage the Wadden Sea, both on the regional and national level, and in the context of our common cooperation. We are convinced that we have reached a stage of coordinated trans-boundary protection, management and monitoring that is unprecedented throughout Europe. The inscription into the World Heritage List would both recognise and reinforce the efforts which the people living, working and enjoying the area, together with us as governments, have made during the latter part of the last century to conserve this area for present and future generations. World Heritage status would also strengthen the regional identity and positively present the region globally.

By focusing on the many day to day challenges and pressures we sometimes overlook the sheer scale and beauty of such a majestic landscape. As has been stated in the nomination dossier walking across the Wadden Sea tidal flats where just a few hours before it was covered by meters of water, surrounded by an endless sky that meets the sea in a distant horizon is an unforgettable experience. Or to see in spring and autumn the huge flocks of birds passing through the Wadden Sea displaying their acrobatic flights like the thousands of knot; or the huge flocks of brent geese, dark against the clear sky, their babbling calls growing in intensity as they approach and dive into the salt marshes to feed in spring before they leave for the remote areas of Siberia. It is a truly magical place – somewhere people can enjoy life changing experiences of nature.

We hope that the nomination will result in a positive decision on the inscription of the Wadden Sea into the World Heritage List. This will signify an international recognition of the Wadden Sea and at the same time, we believe, it will contribute to the List by including a unique trans-boundary wetland ecosystem at the interface of land and sea.
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 2 Description of the Property
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ANNEXES


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Annex 05 List of Wadden Sea bird species Vol. 2, page 63

Annex 06 List of endemic saltmarsh species Vol. 2, page 69


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Annex 19 List of regional or sectoral management systems Vol. 2, page 361

Annex 20 Regional declarations supporting the nomination Vol. 2, page 367

Annex 21 37 topographical maps of the property, scale 1:50,000 Extra supplement

Annex 22 CD with GIS data, topographical maps and all documents Extra supplement

Annex 23 Image inventory list Extra supplement

Annex 24 DVD with photographs and a slideshow about the Wadden Sea Extra supplement
State Parties
The Netherlands and Germany.

State, Province or Region
The Netherlands: Provinces of Noord Holland, Fryslân, Groningen.

Name of Property
“THE WADDEN SEA”

Geographical coordinates to the nearest second
The geographical coordinates to the nearest second are in Table S1.

Textual description of the boundaries of the nominated property
The nominated property “The Wadden Sea” encompasses the Dutch Wadden Sea Conservation Area, subject to the Key Planning Decision (PKB) Third Policy Document on the Wadden Sea, and the German Wadden Sea National Parks of Niedersachsen and Schleswig-Holstein. In parts of the area the islands or major parts of the islands are not within the nominated property. The nominated property covers an area of 9,735.6 km². The underlying approach of the conservation and sustainable use of the nominated property is an ecosystem approach. All habitats which belong to the Wadden Sea – salt marshes, tidal areas including the tidal inlets, channels and gullies, beaches and dunes, estuaries and offshore areas – are encompassed by the conservation regime in order to protect the ecological processes that are fundamental to the conservation of the system and its flora and fauna. Within the overall comprehensive protection regime, the nominated property is comprised of different protection zones. The zones providing the strictest protection are e.g. the main haul-out sites for harbour and grey seals and high water roosts and breeding sites for birds. These areas are closed for access the whole or part of the year. Outside these strictly protected areas, admission and use of the area is allowed, basically on the condition that these activities do not adversely affect the area and its ecological and landscape values. In addition, several activities are regulated in time and space.

The Wadden Sea Plan, as outlined in chapter 5.e, is valid for the Trilateral Wadden Sea Cooperation Area, in short the Wadden Sea Area. The Wadden Sea Area includes the nominated property and is delimited by 3 nautical miles offshore, with the exception of areas off the East Friesian islands and off the islands of Sylt and Amrum, where the delimitation goes beyond the 3 nautical miles up

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<td>007</td>
<td>National Park Wadden Sea Schleswig-Holstein</td>
<td>54° 31’ 43’’ N 08° 33’ 22’’ E</td>
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<td>4,396.1</td>
<td>D19/19 – D10/19</td>
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<td><strong>Total Property</strong></td>
<td></td>
<td></td>
<td><strong>973,562</strong></td>
<td><strong>9,735.6</strong></td>
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1 Excluding the so called disputed area in the Ems-Dollard Estuary
to 12 nautical miles, the seawalls of the mainland or - where the main dike is absent - the spring high tide water line, the brackish water limits of the rivers Ems, Weser and Elbe and inland Ramsar and NATURA 2000 areas.

The purpose of the buffer zone according to paragraph 104 of the Operational Guidelines is to provide an extra layer of protection to the property. The size of the nominated property, the scope and span of the regulations in place and international agreements and regulations, both in space and scope, ensure the integrity of the nominated property and fully meet the intent of paragraph 104 of the Operational Guidelines. The EC Habitats Directive stipulates, for example, that any plan or project, either within or outside of the nominated property, likely to have a significant effect on it shall be subject to appropriate assessment of its implications for the site. Therefore, a buffer zone to the nominated property has not and will not be designated.

**Justification. Statement of Outstanding Universal Value**

The Wadden Sea forms the largest unbroken system of tidal sand and mud flats worldwide with natural dynamic processes proceeding in a widely unimpaired natural state. It is one of a kind on earth. The Wadden Sea ecosystem represents one of the most important international wetland habitats that provide the basis for exceptional high biological production, species diversity and a high degree of ecological specialization and potential for adaptation.

It is an outstanding example of the ongoing Holocene development of a sandy coast under conditions of rising sea level and is unique in that it is the largest extensive tidal flat and barrier island depositional system in the World. Its geological and geomorphological features are closely entwined with biophysical processes and provide an invaluable record of the ongoing dynamic adaptation of coastal environments to global change. The biogeomorphological interactions are notably strong and unique at all scales.

The high primary and secondary production in the Wadden Sea sustains species of birds, fish and crustaceans and seals well beyond its borders. The rich and diverse habitats are of outstanding international importance as an essential habitat for migratory water birds using the East Atlantic Flyway and other migration routes between South Africa, Northeast Canada, and northern Siberia. It is one of the few shallow seas in the Northern Hemisphere with a high production of fish and serves as an essential spawning, feeding and nursery area for species migrating between freshwater and saltwater.
The mosaic of natural phenomena including the complex geomorphological features and biologically diverse and rich habitats, the unparalleled vastness and expanse in terms of the spatial dimension and the millions of migratory birds passing through in spring and autumn together to form an exceptional and beautiful land and seascape.

The nominated property encompasses all the biophysical and ecosystem processes that characterise a natural and sustainable Wadden Sea. The standards of protection, management including coastal protection measures, and monitoring ensure that the natural Wadden ecosystem, with all its component parts, will continue to evolve naturally and to sustain human uses. Man’s use of the natural resources in a sustainable way including small-scale traditional uses is a key to help guarantee its integrity for generations to come.

Criteria under which the property is nominated

The Wadden Sea represents a natural system of outstanding universal value based on the following inscription criteria:

**Criterion viii:** “be outstanding examples representing major stages of earth’s history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features”

The Wadden Sea has evolved over the last 8,000 years being a very young ecosystem in geomorphological and evolutionary terms. It represents an outstanding example of the Holocene development of a temperate-climate sandy barrier coast under conditions of rising sea level. The Wadden Sea is unique in that it consists entirely of a sandy-muddy tidal system with only minor river influences on morphodynamics. The Wadden Sea ecosystem is characterised as tidal flats and barrier island system with extensive salt marshes. The Wadden Sea differs from other systems of this type in that it is the only tidal flat and barrier island depositional system of this scale and diversity in the World.

There are no systems in the World that compare to the Wadden Sea.

The Wadden Sea contains very fine examples of post-glacial coastal geomorphology and the dynamic interaction of physical and biological processes on a scale that is not found within one unified system anywhere else in the world. Despite man-made interventions the continuing presence of these dynamic natural processes ensures the development and rejuvenation of landforms including the whole range of habitats, and secures the maintenance of ecosystem functions. The Wadden Sea ecosystem will thus continue to serve as an important bio-physical reference for the study of the effect of sea level rise and it will be important to consider this function as a legitimate part of the World Heritage concept.

**Criterion ix:** “be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals”

The Wadden Sea is a unique coastal ecosystem with enormously productive marine biota and with linkages far beyond its narrow geographical boundaries. It is one of the last remaining natural large-scale inter-tidal ecosystems in Europe where natural processes continue to function in an undisturbed manner. Excellent and broad scale examples of biogeomorphological processes can be found in the coastal dunes, the salt marshes, and on the tidal flats on mussel beds and sea grass meadows. This transitional environment between land and sea is characterized by the constant change of flood and ebb tides, great fluctuations in salinity, high temperatures during summer and occasional ice cover in winter. These circumstances have created numerous ecological niches, colonized by species that are adapted to the extreme environmental conditions.

The Wadden Sea is an ecological transition zone between land and ocean. With its estuaries, marshes and particularly its wide intertidal zone intersected by deep gullies, the Wadden Sea functions as a gigantic coastal filter system. Freshwater and marine waters are mixed and flushed to and fro with the tides, transporting huge amounts of sediments, organic matter and nutrients. These riverine and marine imports of materials form the basis of the trophic system. Imported organic material is mineralized in the marshes, tidal flats sediment and shallow waters. The release of nutrients from this spacious purification plant, together with those nutrients supplied from the catchment area and the Atlantic waters, fuels outstanding primary production. Due to the active biota, this filter never clogs but is continuously renewed.

**Criterion x:** “contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation”

The tidal flats in the Wadden Sea form the largest unbroken stretch of sand and mudflats worldwide, accounting for 60% of all tidal areas...
in Europe and North Africa. As such it is ‘the only one of its kind’ and many textbooks refer to the Wadden Sea when describing inter-tidal habitats and the rich and diverse flora and fauna they sustain. The tidal flats and the salt marshes form the largest coherent habitat of this type in Europe and constitute an essential element of the Wadden Sea ecosystem.

The Wadden ecosystem represents one of the internationally most important wetlands. It is internationally recognised as a biologically highly productive ecosystem of great natural, scientific, economic and social importance.

The Wadden Sea is extremely rich in environmental gradients and transitional zones, yielding many different (micro) habitats that form the basis for ecological specialization under extreme conditions. The salt marshes host about 2,300 species of flora and fauna. The marine and brackish areas support a further 2,700 species. In total it is estimated that the Wadden Sea Area provides habitats for up to 10,000 species of unicellular organisms, plants, fungi and animals.

The large size of the Wadden Sea allows the diverse species to survive by spreading over several habitats, or by adopting a series of niches over the course of time. This constantly opens up territory for use by other individuals or species, and accounts for a high capacity to accommodate migratory species.

The rich and diverse habitats are of outstanding international importance for birds as staging, moulting and wintering areas. According to the 1% criterion of the Ramsar-Convention, which is an internationally recognized measure to identify wetlands of international importance, the Wadden Sea is of outstanding international importance as a staging, moulting and wintering area for at least 52 populations of 41 migratory waterbird species that use the East Atlantic flyway and originate from breeding populations as far away as northern Siberia or Northeast Canada. Numbers of 44 populations of 34 species are so high, that the Wadden Sea is indispensable and often main stepping stone during migration, or as their primary wintering or moulting habitat. Therefore the Wadden Sea is essential for the existence of these bird species. A severe deterioration of the Wadden Sea implies a biodiversity loss on a worldwide scale.
Name and contact information of official local institution/agency

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hubert.farke@nlpv-wattenmeer.niedersachsen.de
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An A3 overview map on the following page indicates the distribution of the 37 detailed topographical maps 1:50,000, which are in Annex 21 (for the further off-shore area topographical data is not always available).

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Chapter 1 Identification of the Property

1. Maps and plans, showing the boundaries of the nominated property

Figure 1.1 (left): The North Sea region with the Wadden Sea Area.

Figure 1.2 (right): The Wadden Sea.

Figure 1.3: Wadden Sea Area and nominated property.
### Chapter 2 Description of the Property

#### Site element

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<tr>
<th>Site element</th>
<th>Name</th>
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<td>Centre point 54° 31' 43'' 08° 33' 22''</td>
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</table>
the strictest protection are e.g. the main haul-out sites for harbour and grey seals and high water roosts and breeding sites for birds. These areas are closed for access the whole or part of the year. Outside these strictly protected areas, admission and use of the area is allowed, basically on the condition that these activities do not adversely affect the area and its ecological and landscape values. In addition, several activities are regulated in time and space, such as areas where mussel fishery is prohibited.

The Wadden Sea Plan, as outlined in chapter 5.e, is valid for the Trilateral Wadden Sea Cooperation Area, in short the Wadden Sea Area. The Wadden Sea Area includes the nominated property and is delimited by 3 nautical miles offshore, with the exception of areas off the East Friesian islands and off the islands of Sylt and Amrum, where the delimitation goes beyond the 3 nautical miles up to 12 nautical miles, the seawalls of the mainland or – where the main dike is absent – the spring high tide water line, the brackish water limits of the rivers Ems, Weser and Elbe and inland Ramsar and NATURA 2000 areas.

The purpose of the buffer zone according to paragraph 104 of the Operational Guidelines is to provide an extra layer of protection to the property. The size of the nominated property, the scope and span of the regulations in place and international agreements and regulations, both in space and scope, ensure the integrity of the nominated property and fully meet the intent of paragraph 104 of the Operational Guidelines. The EC Habitats Directive stipulates e.g. that any plan or project, either within or outside of the nominated property, likely to have a significant effect on it shall be subject to appropriate assessment of its implications for the site. Therefore, a buffer zone to the nominated property has not and will not be designated.

1.f Area of nominated property

The nominated property “The Wadden Sea” encompasses the Dutch Wadden Sea Key Planning Decision Area, the Niedersachsen Wadden Sea National Park and the Schleswig-Holstein Wadden Sea National Park.

The nominated property does not include the Danish part of the Wadden Sea Conservation. The Danish part of the Conservation Area is 1,250 km² which amounts to 12.7% of the total Wadden Sea Conservation Area.

In 2000-2001 the regional consultations on the nomination of the Danish part of the Wadden Sea Conservation Area for inscription in the World Heritage List took place in preparation of the 9th Wadden Sea Conference in Esbjerg on 31 October 2001. The result was that the adjacent county councils voted against a nomination. It was therefore agreed within the Trilateral Wadden Sea Cooperation at the 2001 Wadden Sea Conference to await the finalization of the consultations in all parts of the Wadden Sea Region. In 2003, the Danish Wadden Sea was chosen, as one of seven national pilot projects, for the exploration of the possibilities for establishing national parks in Denmark. The deliberations as to designating the Danish part of the Wadden Sea Conservation Area or an extended area as a national park have not yet been concluded, and further consultations on the World Heritage nomination have not been initiated pending the passing of legislation in the Danish parliament and the decision on whether to designate the Danish Wadden Sea as a national park.

It is to be acknowledged that the Danish part of the area is 12.7% of the total Wadden Sea Conservation Area, as indicated above. All typical features of the Wadden Sea ecosystem are repre-
sented within the nominated property. Moreover, Denmark remains a partner within the trilateral Wadden Sea cooperation and has signed up to the Wadden Sea Plan, which provides for the same level of protection and regulation of the Danish part of the Wadden Sea as for the nominated property.

Furthermore, the small Hamburg Wadden Sea National Park of 136 km² is not included in the nominated property. The state government of Hamburg decided to postpone the nomination of its part pending the decision on the deepening of the Elbe shipping lane in conjunction with an environmental impact assessment study. As outlined in chapter 4, the project is located outside the nominated property and the Hamburg National Park.

Taking account the extensive preparations already undertaken, the increased public support for the nomination in both countries and the uncertainty of whether and when further consultations on the World Heritage nomination will be re-initiated in the Danish Wadden Sea region, Germany and the Netherlands have decided to proceed with the Dutch-German nomination. This decision was made at the 10th Governmental Danish-German-Dutch Wadden Sea Conference on 3 November 2005 on the Dutch Wadden Sea island of Schiermonnikoog.
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 2 Description of the Property
2. DESCRIPTION

2.a Description of the property

The Wadden Sea is a coastal wetland of exceptional size, great beauty and richness in unique natural assets. It is one of the largest coastal wetlands in the world. Coastal wetlands are products of a post-glacial sea level rise by more than one hundred meters. These transitional zones between sea and land have been continuously shifting in size, shape and position over the last 16,000 years and will continue to do so. Although, in structure and function these wetlands resemble those of ancient coasts, they are in fact rather recent and highly dynamic features of the earth system. For this reason, existing coastal wetlands are not cradles of endemic organisms or refugees for relicts of the past.

Their biota has a long evolutionary history of adaptations to coastal dynamics, frequent natural cataclysms and to the environmental extremes of the coastal zone. The physical environment of coastal wetlands is a great challenge to life. Favoured are either versatile organisms or specialists with a wide dispersal. The latter is necessary in order to balance between frequent disappearances and new emergences elsewhere of their specific coastal habitat type. The net result of this evolutionary history is a rather small set of the world’s species that can thrive in coastal wetlands. However, those which can are of a very special kind.

On the other hand, the outstanding plenitude of resources in coastal wetlands has given rise to an extraordinary biotic production. Via migrating and drifting organisms there is even an outreach far beyond the confines of the wetlands proper. The Wadden Sea is an indispensable hub along the East Atlantic flyway of coastal birds between northern and southern hemispheres. Its shallow waters are a nursery for finfish and various invertebrates of the entire coastal sea and even beyond.

The richness and exceptional productivity of the biota in coastal wetlands has attracted people from early on, in spite of the environmental hostility. With advancing technology, more and more of these wetlands have been separated from the sea and transformed into dry land. Also, the Wadden Sea has been to some extent subject to attempts at coastal conversion. However, it still has maintained the largest coherent area in the world with marine tidal sediments. These appear to be drenched land when the tide is out and a shallow sea when the tide is in. The Wadden Sea is a coastal sea shallow enough to wade across. The unique character and the outstanding vastness of these tidal flats with fringing salt
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 2 Description of the Property

The Wadden Sea contains the largest coherent tidal flat area in the world. It is spread out along the southern edge of a stormy shelf sea. From the land side, large rivers enter, which drain a continental area of the cold and moist temperate climatic zone in the northern hemisphere. This coastal transition is extremely flat, with its deepest and highest parts all within 50 m below and above mean sea level. The Wadden Sea was formed after a rapid post-glacial transgression and has remained highly dynamic in size and shape due to changes in sea level, tides, waves and strong winds. It consists of a dynamic mosaic of habitats with fringing brackish and marine marshes, estuarine and open coastal tidal flats, beaches, dunes, sand bars and barrier islands, tidal streams, inshore shallows and offshore waters. These together sustain a specific and diverse coastal flora and fauna.

In this chapter, the “Wadden Sea” refers both to the nominated property as well as to the ecosystem in the broadest sense. In a few cases, it is necessary in the description of the geomorphology, hydrodynamics and habitats to make digressions beyond the confines of the nominated property, because natural processes and, in particular, migratory organisms do not respect administrative boundaries.

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Figure 2.1: Northeast Atlantic with the North Sea region.

marshes, beaches, dune islands and shoals and the spectacular abundance of wildlife is motivation for this proposal to have it designated as World Heritage Site.

Almost three decades ago, scientists of the Netherlands, Germany and Denmark provided a comprehensive review of existing knowledge on natural processes and human impacts in the Wadden Sea. This has provided a firm basis for environmental policies and management. The state of knowledge has been updated about every three years in proceedings of scientific symposia on the Wadden Sea environment. The ecological quality status has been regularly assessed in reports since 1991 based mainly on the results of the Trilateral Monitoring and Assessment Program (TMAP) referred to in chapter 6. Together with workshops on selected topics such as sustainable coastal protection, salt marshes or trends in bird populations, this strong scientific dedication to the Wadden Sea provides a broad and solid basis for the following description.

Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 2 Description of the Property

Physical environment

The nominated property is an extremely shallow and elongated coastal margin, without a clear boundary between land and sea. Land lies in water and the sea moves over land. This land has been formed by the sea, and this sea is in perpetual tidal motion and at times stirred up by violent storms. The coastal climate is mainly determined by oceanic forces.

Geography

The northern oceans of the world are fringed by extensive shelf seas. On the Atlantic shelf of Western Europe, the North Sea is with 520,000 km² the largest shelf area (Fig. 2.1). To the west, it is connected with the Atlantic shelf through the English Channel and shielded from the North Atlantic basin by the British Isles. To the east, the Skagerrak connects it with the enclosed Baltic Sea. To the north, there is a wide transition to the deep Norwegian Sea. In the south, the North Sea meets the European continent, and here the shallow Wadden Sea comprises most of the coastline. It is linked to the ocean but located in the innermost part of one of its marginal seas.

The North Sea shelf area is an ancient continental drift depression, overlain by sedimentary deposits several kilometres thick. These originated from the surrounding land masses, and some of their strata contain large amounts of liquid and gaseous hydrocarbons, which are intensively exploited. The depth of the North Sea increases

Wadden Sea area from the very beginning of this amphibious and dynamic landscape. Early settlers in the marshes built knolls (Terpen, Wierden, Wurten, Warften) to live upon. In a later phase, they claimed land by separating marshes from the sea with earthen walls (dikes). They affected flora and fauna by habitat transformations, the extraction of materials, and by hunting and fishing. However, the unique coastal landscape and seascape still resemble very much intact conditions, and the extraordinary flocks of coastal birds and the abundant seals are indicative of a thriving coastal ecosystem.

Figure 2.2: Bottom topography and catchment areas of the Greater North Sea (Source: OSPAR Commission).
towards the Atlantic Ocean to about 200 m at the edge of the continental shelf. In the middle of the North Sea lies the shallow area of the Dogger Bank, where depths can be less than 20 m. This bank has a significant impact on the circulation in the southern North Sea and is an important fishing area.

The southern half of the North Sea is very shallow, mostly less than 50 m in depth, and here several large rivers debouch: Humber, Thames, Schelde, Maas, Rhine, Ems, Weser and Elbe (Figure 2.2). These rivers cause oceanic salinity to be slightly depressed in the coastal waters and nutrient concentrations to be elevated. Many of these rivers developed inner deltas and outer estuarine funnels with extensive freshwater and brackish marshes which merge at the outer coast with salt marshes of marine origin.

The shallow southern North Sea meets an extremely flat marshland, only occasionally intersected by moderate elevations of glacial origin or of dunes on barrier islands. These elevations generally remain below 50 m in height. In the tidal inlets with strong scouring currents the depth rarely exceeds 50 m. Thus, over a length of 1000 km of coastline and an average width of 250 km, the profile remains within the narrow vertical confines of about 100 m. The central part of this coastal flatland and shallow sea has been named the Wadden Sea because here tidal flats – where one may wade through – show their widest extent.

As a seaward limit of the Wadden Sea the -15 m depth contour has been suggested which is parallel to but usually somewhat beyond the administrative boundary of the Wadden Sea. Selecting this depth contour is somewhat arbitrary anyway, but refers roughly to the boundary of an assumed coastal sediment exchange system, and coincides also with the seaward occurrence of some important seasonally migrating aquatic organisms of the tidal area. Coastal birds extend their feeding ranges rarely further offshore. Also, the landward limit of the Wadden Sea depends somewhat on the aspects in mind. Geomorphologically all the flat marshlands are included up to a maximum of 5 m above mean sea level. This is roughly equivalent to the widest transgression of the sea in the distant past and subsequent deposition of marine and fluvial sediments.

The long shore extent of the present Wadden Sea reaches to the Skallingen peninsula in Denmark and the Den Helder peninsula in the Netherlands. The coastline distance between these is roughly 500 km. The geomorphological width between seaward and landward boundaries may be up to 150 km in the estuaries but the average is only half of that. The Wadden Sea Area with its offshore parts is about 14,700 km², which comprises a maritime zone from flat land to shallow waters (Table 2.1).

The tidal area is smaller. The long shore limits are the same, but the seaward boundary is defined as the line connecting all barrier islands and sand bars, and the landward boundary is the dike line or, in a few cases, Pleistocene cliffs beyond which the sea does not extend. This area is about 8,400 km², and of this, intertidal sediment flats comprise nearly half of the area.

This area of the Wadden Sea may be divided into three sub-regions:

- **The Southern Wadden Sea** extends from the Marsdiep tidal inlet in the west to the Jade inlet in the east. Twelve main islands form a seaward sandy barrier some 5 to 15 km off the mainland coastline and provide shelter to the tidal area against waves generated by northwestern and northern winds. A large embayment, the former brackish Zuiderzee (3,600 km²), was once part of the Southern Wadden Sea but became separated by a causeway in 1932 and was turned into a freshwater lake and agricultural land. Another embayment, the Dollard in the Ems estuary, still exists.

- **The Central Wadden Sea** extends from the Jade inlet to the Eiderstedt peninsula, and has three major estuaries: Weser, Elbe and Eider. Across the Eider estuary a storm surge barrier has been built. Salinity is lower and more variable in the central sub-region than in the others, while tidal range is higher. A seaward chain of barrier islands is absent. With the Jadebusen a large embayment extends deep into the marshland.

<table>
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<th>Geomorphological region</th>
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<td>Salt marshes</td>
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<tr>
<td>Intertidal sand and mud flats</td>
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<tr>
<td>Subtidal flats and gullies</td>
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</tr>
<tr>
<td>Islands and dry sandy shoals</td>
<td>1,000</td>
</tr>
<tr>
<td>Offshore area (to about –15 m depth-line seaward of the islands)</td>
<td>4,900</td>
</tr>
<tr>
<td><strong>Total Wadden Sea Area</strong></td>
<td><strong>14,700</strong></td>
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</table>
Chapter 2 Description of the Property

The Northern Wadden Sea extends from the Eiderstedt peninsula in the south to the Skallingen peninsula in the north. Eight islands and high sand bars form a seaward barrier some 5 to 25 km off the mainland coastline, and provide shelter against waves generated by the prevailing westerly winds. Several marsh islands are scattered across the tidal area and are remnants of a coherent marshland which became drowned in medieval times. Only here also some Pleistocene cliffs occur. Large estuaries are absent.

Hydrology

A key feature of the hydrology of the southern shores of the North Sea is a continuous long-shore current from southwest to northeast (Fig. 2.3). It is supplied with Atlantic water passing southward along the British east coast and eastward through the English Channel. These water masses merge west of the Wadden Sea, then continue as continental coastal currents following the coastline just seaward of the tidal area and finally adding to the Norwegian Trench outflow back into the Atlantic. This coastal long-shore current takes up the river runoff of the Rhine and Elbe together with several smaller rivers. It is this mixed water body, which supplies the tidal area of the Wadden Sea and which is hydrologically a coherent part of the coastal long-shore current.

All rivers discharging directly into the waters of the Wadden Sea come from a catchment area of 230,000 km² with an annual discharge volume of 60 km³. Together with the Rhine and a few other rivers debouching adjacent to the Wadden Sea and affecting its waters, catchment area and freshwater discharge approximately double. These rivers cause fluctuations in salinity. Usually, slightly lower average values occur in winter and spring and higher values in summer. This reflects the precipitation pattern of north-western Europe. However, the riverine influence is not strong enough to categorize the entire Wadden Sea as an enlarged estuary. It is not an open oceanic coast either. The Wadden Sea holds a hydrologically unique intermediate position with three major hydrological characteristics:

- Salinity remains mostly between 20 to 30 psu, which is lower than oceanic waters (34) but higher and less variable than in most estuaries (0–20);
- Wave exposure is mitigated by a barrier of sandy islands, sand bars and shoals, while...
tides and frequent storms keep the waters in perpetual motion;

- Meso- to macrotidal (1.4 to 4.0 m mean tidal range) conditions in combination with an extremely gentle slope from land to sea expose the bottom of the sea over an average width of 15 km (range 5 to 25) and an area of 4000 km².

A further distinctive hydrological feature of the Wadden Sea is the continuous series of tidal basins which are analogues to riverine catchment areas. However, they differ from these by having alternating flow directions with the tides (Fig. 2.4). The existence of tidal basins is interrelated with the existence of barrier islands or high sands. Between adjacent islands, the tidal flow is compressed, forming tidal inlets up to 50 m in depth, scoured by strong currents. Behind the barrier islands most inlets furcate into major gullies (channels) and these branch into smaller and smaller tidal creeks or runnels in a recurrent fractal pattern. In the back-barrier area, flood waters of adjacent tidal inlets meet at tidal divides (watersheds). Seaward of tidal inlets, ebb deltas form with highly turbulent waters. Here ebb currents interfere with waves and the long-shore current. As a result, transported sand accumulates in the form of highly dynamic bars and shoals.

Altogether, a series of 33 such tidal inlets with their back-barrier basins and ebb deltas have been identified as recurrent features of the hydrography of the Wadden Sea. They are connected by some overflow across tidal divides in the back-barrier area and by the tidal flow and long-shore current seaward of the islands. Because of their lateral connections across watersheds, these tidal basins are different from coastal lagoons, which are a common feature of many other shores in the world. The regular pattern of tidal basins is interrupted by four major estuaries: Ems, Weser, Elbe and Eider. Their riverine runoffs add up with the ebb flow. The resulting strong currents tend to displace ebb deltas by wide open funnels. These estuaries provide habitats of highly fluctuating and low salinities, in rare cases even freshwater tidal areas.

Tides are semi-diurnal (two ebb and two flood phases per day). Mean vertical ranges increase from 1.4 m in the southwest to almost 4 m in the Central Wadden Sea and decrease from there again to 1.5 m in the north. Twice a day tides move an average volume of 15 km³ of sea water into the tidal back-barrier area, where roughly the same volume remains in the subtidal zone, thus swelling up to some 30 km³ at high tide. This high exchange rate of tidal water masses secures the dominance of marine conditions in the back-barrier area. Tidal waves progress counter-clockwise within six hours through the Wadden Sea: when the tide is high in the southwest, then it is low in the northeast.
Consequently, a single aerial image cannot show the full extent of tidal exposure. To show this, several images need to be combined.

The effects of full and new moon phases on tidal range is only about 20% in the Wadden Sea. Instead, strong onshore winds may increase high tides up to 4 m above normal high tide levels. Strong offshore winds may push low tides down to 1.5 m below normal low tide level. Corresponding to this asymmetry in modifying tidal heights, also the frequency of strong onshore winds is much higher than of strong offshore winds. Thus, tidal flats may often remain submerged over several days due to prevailing strong westerly winds, while continuous emergence over several tidal cycles caused by southern or eastern winds is rare. Because of this, it is easier for marine than for terrestrial organisms to persist in the tidal zone of the Wadden Sea.

Climate

With a latitude of 53° to 55° N, the Wadden Sea climate would resemble that of Hudson Bay, the Bering Sea or the Sea of Okhotsk in Siberia, if it were not for the warm water masses of the Gulf Stream that pass north-western Europe and also penetrate into the North Sea. Climatically, the Wadden Sea region is more akin to the Gulf of Maine, Vancouver Island, the Sea of Japan or the Yellow Sea, all between 40° and 50° N. The climatic conditions are characterized by the interaction of humid maritime air masses coming from westerly directions, and dry continental air masses coming from the east. The eastward moving depressions originating in the North Atlantic dominate with their westerly winds. This explains rather mild...
winters and cool summers. The mean annual air temperature is around 8.5°C. The mean annual water temperature is about 9°C, with a summer average of 15°C and a winter average of 4°C. Extreme water temperatures of the last six decades were +23°C and -2.3°C in the tidal area.

In the tidal area, at least some ice cover was observed on an average of 19 days per year in the last century. The tides prevent the development of a coherent ice sheet. They break it up and ice floes become piled upon each other, drifting to and fro, and being dragged across tidal flats, leaving trails and pits behind. Sediments in the high tidal zone may become frozen to a depth of a few centimetres. In recent times, however, winters with ice and frozen sediments in the Wadden Sea have become rare.

In summer, the regular tidal exchange of water masses rarely allows water temperature to exceed 20°C, although in residual waters on the tidal flats up to 32°C have been measured on sunny days. Important for many organisms is a seasonal reversal of temperature between the tidal area and offshore coastal waters (Fig. 2.6). The latter are colder in summer than the water above the tidal flats, while offshore waters remain warmer during winter than those further inshore. Particularly in spring, the early warming up of the shallow tidal waters facilitates reproduction and growth of tidal zone organisms. Conversely, cold spells in early winter initiate migrations from inshore to offshore.

In spite of humid air from the sea, precipitation in the Wadden Sea region is moderate, with some 700 to 800 mm per year or roughly 2 mm per day. Clouds often pass the Wadden Sea, and rain comes down further inland where the terrain reaches higher elevations. Rainwater has little direct effects on the salinity in the tidal area. Indirect effects by river runoff are stronger.

Of great importance for climate variation in the Wadden Sea are the North Atlantic oscillations between low air pressure in the north (Iceland) and high pressure in the south (Azores). This gradient in air pressure tends to be pronounced and is associated with strong westerly winds, cool summers and mild winters at the North Sea coast. However, this pressure gradient has shown an approximately decadal periodicity in the past. Periods with a steep pressure gradient and thus frequent storm surges, wet and mild winters alternate with periods of a weak gradient and thus continental climate with easterly winds and severe winters. These periodicities have been shown to affect abundances of marine organisms and migrations of birds.

The overall effect is a rather variable temperate climate. Moderate maritime conditions prevail and continental extremes are rare. Climate change scenarios predict the maritime dominance in winter to become even stronger, while summers may be subject to more continental influence. Thus, storminess and rain in winter may increase while freezing conditions may become exceedingly rare. Warming in spring may commence earlier and waters will attain higher temperatures in summer.
which then last longer in autumn. Sea level rise is expected to lag behind atmospheric warming but will eventually have more serious consequences for the shallow and flat Wadden Sea. With more than half a meter of sea level rise by the end of this century, the size of the tidal flats could decrease by 15% and the tidal basins will take the character of tidal lagoons if no mitigation measures are taken.

**Geology**

The Wadden Sea is a sedimentary region. Tectonic activities do not threaten this coast. Neither volcanic eruptions nor serious earthquakes are expected. Since the Tertiary, the region has been part of a descending basin, gradually filling up with Quaternary sediment of 1000 m thickness or even more. This pattern is only sporadically interrupted by uplifting domes of Permian salt. This phenomenon has given rise to a Triassic outcrop adjacent to the Wadden Sea, the rocky island of Helgoland. Similarly, on Sylt, one of the northern islands in the Wadden Sea, Tertiary layers have been lifted upwards.

Otherwise, the entire region of the Wadden Sea is composed of residues of the Quaternary glacial periods. Scandinavian glaciers have modulated and transported a variety of materials with origins spanning almost the entire history of the earth and deposited these mixed sands and stones in the Wadden Sea. Glaciers have passed over several times, carved valleys and left moraines as hills in the landscape, sometimes with large boulders ground by ice. Also, riverine sediments from Scandinavia have become deposited in the area.

The current landscape and submarine seascape is almost a complete product of the last three glaciation periods and their interglacial phases, including the present one. Presumably, the past interglacials have given rise to coastal environments similar to the present Wadden Sea. At least fossils indicate a marine fauna similar to the present one, and ancient cliffs and marine sediments show how far past interglacial seas have transgressed into the land.

The glacial front of the last glaciation, with its maximum 18,000 years ago, stopped just eastward of the present region of the Wadden Sea, which presumably was covered by tundra vegetation throughout that time. Sea level was down to 120 m below what it is now. With the onset of warming, sea level has risen rather fast and reached the present region of the Wadden Sea about 8,000 years ago. Then sea level rise began to slow down and the geomorphology of the Wadden Sea started to evolve.

**Morphodynamics**

The characteristic geomorphology of the Wadden Sea with mainland marshes, extensive tidal flats and a long chain of barrier islands developed gradually over the last 8,000 years and is still in motion. Its unique geomorphology is the product of a combination of five major past and ongoing processes: (1) Glaciations left a smooth relief of gentle valleys and hills where rivers found their course and which determined the general shape with a bend in the coastline at the mouth of the Elbe river from west-east to south-north in direction. (2) Post-glacial sea level rise entailed a progressively growing tidal range and gradually enlarged the tidal area. (3) The southern North Sea basin supplied sediments to the region of the Wadden Sea, transported by long-shore currents, tides and waves. (4) Strong onshore winds have caused episodic floods of up to 4 m above normal high tides. These floods left conspicuous and lasting effects on the landscape. Strong onshore winds have also given rise to massive dunes on the barrier islands. (5) Large rivers which debouch near to or directly into the Wadden Sea have added fine sediments to the coast.

Together, these processes have created a dynamic and amphibious coastal land- and seascape with an extent of tidal flats which is nowhere else to be found in the world. In the last millennium the episodically flooded higher part of this coastal landscape became more and more transformed by human activities, while the tidal area remained very much the product of a natural interplay between a shallow sea and a flat land.

The valleys and trenches formed by the glaciers affected the course of the rivers Ijssel, Ems, Weser, Elbe and Eider and the positions of the conspicuous estuaries. Glacial moraines form the core of the islands Texel, Föhr, Amrum and Sylt. Presumably there were some glacial relict islands seaward of the present Wadden Sea. Their erosion in the course of sea level rise probably served as an important source of sediment. Landward of the marshes, gentle moraines dominate the landscape. As remnants of past transgressions, some show former cliffs which provide magnificent platforms to view the marshes, the tidal area and islands.

Changes in sea level have been most influential and will continue to be so. It is assumed that when post-glacial sea level rise slowed down 8,000 years ago, a seaward barrier of sand bars and long spits developed. Between this barrier and the glacial moraines, a back-barrier area of lagoons and marshes came into existence. At the feet of moraines, raised bogs developed. Alongside
rivers, gallery forests grew up, while otherwise the landscape remained without trees because of episodic flooding by the sea.

With increasing tidal range, the outer sandy barrier broke up into a chain of barrier islands. Concomitantly, the tidal area grew larger at the expense of marshes. Sequences of preserved sediment layers indicate that the balance between marshes and tidal flats shifted back and forth as a result of variable sea level and sediment supply. The overall trend, however, was a rise in sea level. The chain of barrier islands gradually moved landwards and tidal inlets adjusted their cross sections to changing volumes of tidal waters. These dynamics are still ongoing and are expected to accelerate with more rapid sea level rise in the wake of global warming.

Long barrier spits are common at depositional coasts. They occur where average tidal ranges are less than 1.5 m. This is the case adjacent to the Wadden Sea along the Dutch coast and in northern Jutland. The peculiar chains of barrier islands in the southern and northern Wadden Sea are the consequence of tidal ranges between 1.5 to 3 m. Above 3 m no barrier systems persist. Maximum tidal current velocities in tidal inlets reach about 1.5 ms⁻¹ at spring tides. These currents are sufficient to keep channels open in spite of sediment supply. In the Central Wadden Sea, major rivers debouch and tidal ranges tend to be higher than 3 m. Therefore the central part lacks barrier islands. Only small ephemeral islands do occur around mean sea level, surrounded by extensive tidal flats.

As remnants of formerly more extensive marshes, some marshy islands are interspersed in the tidal back-barrier area in the Northern Wadden Sea. Altogether there are at present some fifty islands and high sand bars, some of which are episodically flooded during storm surges. Marshy islands flooded during storm surges are called Halligen. Their vegetation consists of salt marshes and they grow upwards layer by layer when new deposits are added during flooding. Often the surrounding tidal flats do not grow up at the same pace. Then edge instabilities arise and the Halligen become eroded or have been protected by brushwood groins or stone walls in response. Houses on Halligen have been built on mounds. They are the only parts which remain above the water during storm tides. These Halligen with their dwelling mounds are a unique feature of the northern Wadden Sea and find no parallel elsewhere in the world.

Through the tidal inlets, sediments are moved from the outer coast into the tidal area and back again. The balance of this sand-sharing system varies with shape and size of tidal basins. Large back-barrier tidal basins have extensive ebbtidal deltas and deep tidal inlets. Usually less than half of the basin area is occupied by tidal flats. Small basins have small ebb deltas, shallow inlets and the share of intertidal flats is more than half of the area.

These hydrological and geomorphological relations are highly sensitive to sea level and variations in storminess. Accordingly, the geomorphology remains very dynamic. Small islands emerge and others disappear in the course of the centuries such as the islands Bosch in the Dutch part and Buise in the German part of the Wadden Sea. This phenomenon is accessible to experience within human life spans. There is little local stability but a high resilience of the general coastal configuration, which has persisted through the last millennia. However, there never was and still is no morphological equilibrium. Permanent change is the consequence of trends in sea level, tidal range and climate.

A shallow sea and a flat land also meet at other coasts of the world; however, the Wadden Sea has developed a unique geomorphology with its specific combination of physical factors and their interactions with the regional biota. This will be further detailed in the following paragraph and in the chapter on habitats.

Soils and sediments

Natural rock formations do not occur in the Wadden Sea. Sediments prevail throughout the region; only some pebbles and a few boulders are scattered locally. The sand is of fluvial and glacial origin, redistributed by currents and waves in the southern North Sea. The fine clay fraction in the sediments is thought to be primarily derived from recent riverine sources.

Sediments display a progressively shoreward-finishing grain-size gradient. This gradient commences with shoals and sand flats in seaward sections, followed by mixed flats and, finally, mud flats fringing the mainland shore and sometimes occurring along tidal divides. Sandy tidal flats comprise 75%, mixed flats 18% and mud flats 7% of the back-barrier intertidal area. Almost all subtidal sediments are sandy. This dominance of sand is explained by the fact that the Wadden Sea is primarily created by relatively strong forces of the sea and a weak contribution by rivers.

Most of the supratidal marshes are composed of clay and peat of mainly terrestrial origin. The finer the sediments, the higher the biogenic share
in their formation. In the salt marshes the retention capacity of the vegetation for fine particles is high. On mud flats, a bio-film of microalgae retains fine deposits. Also seagrass beds retain fine sediments, at least seasonally. Biogenic reefs of suspension-feeding molluscs locally enhance the mud content of sediments with their bio-deposits. Conversely, the abundant lugworms on the tidal flats of the Wadden Sea bioturbate the sediment and prevent fine-particulate accretion. These marine worms also contribute to the dominance of sandy tidal flats. Similarly, as Darwin described the role of earthworms in the shaping of the landscape in England, lugworms shape the appearance of the tidal flats and the spatial relation between mud and sand flats in the Wadden Sea (see also under section tidal flats).

Extensive molluscan shell beds which occur alongside tidal channels are a further biogenic contribution. These shells are a token of the high benthic filter-feeder production in the Wadden Sea. Together with a few stones and boulders, these shell beds provide the only natural hard substrate in an otherwise soft sediment environment.

Soil formation on sandy barrier islands is a slow process, because in the dry dunes the vegetation is scarce and often dominated by very slow-growing dry grassland or heather. Developing soils often become soon buried under sand blown in by the wind. In dune slacks, highly acidic soils occur with beginning peat formation. However, this remains insignificant because of the ephemeral nature of most dune slacks.

Salt marshes, on the other hand, may form clay soils of considerable magnitude and duration. Marsh soils grow upwards layer by layer with each inundation during spring-tides or tides amplified by strong onshore winds. The topography of salt marshes often shows a bewildering pattern of meandering creeks, irregularly shaped ponds and puddles, and the marsh surface is further diversified by a mosaic of vegetation types.

Deposits are supplied with waves from the sea. The seaward edges of salt marshes tend to grow faster and higher than the landward parts, because coarse-grained sediments deposit faster than alluvial mud particles. This process often generates inverted wedge-shaped salt marsh profiles. In salt marsh depressions soils become anoxic under water-logged conditions and vegetation may die back. Salt marsh puddles and ponds arise. These may become connected by creeks, which gradually become deeper and wider towards the tidal flats. Where adjacent tidal flats do not keep up with sea level rise as the salt marshes do with their sediment accretion, waves may attack salt marsh edges and cause erosion. This leads to salt marsh retreat and a possible advance of the tidal flats. Under sheltered conditions, the reverse process is initiated by pioneer plants growing into the upper tidal zone and trapping sediments where vegetation is getting dense.

In estuaries and landwards, salt marshes grade
into brackish and freshwater reed marshes. The latter may also develop mangrove-like stands of willows, but this usually takes place outside the Wadden Sea upstream in the estuaries. At such sites peat formation commences. The most common peat is formed by the reed, Phragmites australis. It also dominates in clods of peat underlying tidal sediments or recent salt marshes. These have developed during a time of lower sea level, then became inundated, soaked with seawater and subsequently buried underneath marine deposits.

These fossil peat layers were excavated during medieval times on a large scale. The peat was dried, then burned and the salty ash was commercially exported. This provided a major income but also lowered the level of the terrain significantly. During storm tides much of these peat mining areas became inundated and then covered again with marine deposits. Particularly around the Haligen, traces of former peat mining are still visible and are now to be found in the tidal zone.

In the long term, much of the accumulated clay and peat became recycled. This is caused by the dynamic interplay between the advance of salt marshes into tidal flats by progressive salt marsh pioneer plants and by salt marsh retreat as an effect of wave erosion. The balance is sensitive to sea level, height of waves and the sediment supply. Hence, a shifting of shorelines back and forth in the course of centuries has been an inherent property of sheltered shores in the Wadden Sea.

At the more exposed shores, shifts in shorelines are driven entirely by physical forces. This is the case at the seaward beaches of the barrier islands. Here, however, the salt marsh clay that had developed on the sheltered leeward side of the islands and then became overtopped by migrant dunes is finally showing up again at eroding seaward beaches as circumstantial evidence of landscape dynamics in the Wadden Sea.

**Habitats**

Habitats in the transition zone between the land and the sea are the product of intricate interactions between physical properties and biological activities. The spectacular dunes on the barrier islands give evidence to the ongoing contest between aeolian mobilization of sand and biotic stabilization. Salt marshes grow out of the sea by a dense vegetation trapping deposits during inundation, while at the same time waves erode the edges. Mussels attach to each other, accumulate sediments over the years and successively provide habitat to more and more species until in a severe storm or a winter with floes of ice scours it all away. Less obvious are the habitat maintaining activities of lugworms, which by their continuous recycling of surface sediments keep a sand flat sandy and prevent it from becoming a mud flat. Without this secret work of worms, about 3,000 km² of rippled sand would be smooth and slippy.

The habitats of the Wadden Sea show in a fascinating way how in the biosphere an interplay between physical forces and biological activities generates conditions for life in a fragile balance. People can only grasp this in such a natural landscape, where the physical forces are strong, biological activities high, and the basic materials are soft sediments which readily change their configuration. This is strikingly exemplified in the Wadden Sea along an offshore-inshore gradient and from deep water up to the highest dunes (Fig. 2.7). The Wadden Sea provides a multitude of transitional habitats with tidal channels, sandy shoals, seagrass meadows, mussel beds, sandbars, mudflats, salt marshes, estuaries, beaches and dunes. In this chapter on habitats, the structure of the Wadden Sea Plan (see chapter 5) is adopted. According to that the ‘offshore area’ is not a habitat as such. However, there are characteristics which justify consideration as such in this chapter.

**Offshore belt**

The transition between the Wadden Sea and the North Sea may vary with regard to the aspect considered. In fact, there is a continuum between the characteristics of inshore and offshore areas, and the offshore part of the Wadden Sea is operationally defined here as the zone seaward of a line connecting the barrier islands and high sand bars, and extending into the North Sea down to the –15 m depth contour. This belt has no tidal flats and drops off rather smoothly towards the open North Sea but does not fully comply with it in terms of the biota present.

This offshore belt roughly comprises 6,000 km² and average water depth is around 10 m. Along the Southern Wadden Sea this zone varies between 10 and 25 km in width. In the Central and Northern Wadden Sea the offshore belt is wider and varies between 20 and 50 km. This transitional zone is only partially included in the nominated property, which particularly extends seaward off the Ems estuary and off the islands of Sylt and Amrum. This offshore belt has to be taken into account regardless of boundaries because physical processes and migrations of organisms reach across. The offshore zone is to a major extent within the Wadden Sea Area and hence also subject to protection and management in the context of the trilateral Wadden Sea Cooperation. Furthermore,
the larger part of the offshore zone is subject to protection under the EU Habitats and Birds Directives and other international conventions such as the Ramsar Convention.

Hydrologically the offshore belt is part of the coastal long-shore current and cannot be considered to constitute a distinct water body. Due to the tides it exchanges an average volume of 15 km³ of water twice daily with the tidal area. This exchange is presumably several times more intense than the exchange with the open North Sea and adjacent coastal areas to the west and north. In terms of sediment, the offshore belt is part of a sand-sharing system with the barrier islands and tidal area. It is assumed that almost no sand is transported across the 15 to 20 m depth contour. However, this may happen during exceptionally heavy storms with waves affecting the bottom of the sea as far down as 50 m. Traces of such disturbances have been observed in the benthic fauna at such a depth. The regular sand-sharing system between the offshore belt and the islands, the outer sand bars and the tidal area is a vital condition for the resilience of the coastal system when responding to changes in tidal area and sea level and to disturbances caused by heavy storm tides.

The ecology of the tidal area and the open North Sea is intimately linked through the offshore belt. Phytoplankton blooms often commence in this zone. Here, turbidity is low enough for sufficient light availability in the water column and nutrient concentrations sufficiently high for rapid uptake. Both together provide an optimum for the development of microalgae suspended in the upper layer of the water. Through the tidal inlets, this offshore primary production supplies the benthic suspension and deposit feeders in the shallow inshore zone. In other words, phytoplankton originating offshore feeds inshore zoobenthos.

The benthos of the offshore belt differs from that of the open North Sea by being particularly adapted to the instability of the substratum and the occasional disturbances when waves hit the...
ground. Macroalgae are absent except where boulders provide isolated firm substratum. Most invertebrate animals are highly mobile to cope with shifting sands. Nevertheless, also tube-building worms such as the sand mason (*Lanice conchilega*) take the chance of intermittent stability, settle in dense assemblages and then manage to stabilize the sand. This provides habitat for other benthos and diverse assemblages arise until scouring waves destroy this worm-based habitat after a year or more.

Particularly the ebbtidal deltas in front of the tidal inlets provide a habitat with continuously shifting sands. Few organisms are adapted to live there but those who can are highly specialized such as stout little worms (*genus Ophelia*) which coil up once disturbed. Sand grains stick to their skin and make them heavy enough to soon return to the bottom in turbulent waters. Tiny amphipods (*Haustoriidae*) have evolved shovel-like legs to dig through the sand but also swim quickly in the water by paddling with their broad legs.

Ecologically the most important function of the offshore belt for the tidal area may be its role as a spawning site for organisms the larvae of which become transported into the tidal area and grow up there under highly nutritious and warmer conditions in spring and summer. This applies in particular to brown shrimp (*Crangon crangon*). It is nowhere as abundant as in the Wadden Sea and functions as a key predator on small benthic invertebrates (see also section on population of sentinel species). The shrimp fishery focuses on the offshore belt, because this is where the large adults stay while the smaller shrimp populate the tidal area. In former times, the rough surf in the offshore belt confined shrimp fishery to beam-trawling in the more sheltered back-barrier area but this limitation has been overcome by larger and better motorized vessels.

What has been exemplified with the brown shrimp also applies to several species of flatfish, with the plaice (*Pleuronectes platessa*) being the most abundant and the sole (*Solea solea*) (see also section on population of sentinel species). With the exception of the flounder (*Platichthys flesus*), adult flatfish stay mostly offshore while their larvae drift inshore, metamorphose and then start feeding on benthic prey on muddy tidal flats. Before winter commences the young return offshore.

For many other fish and invertebrates, the offshore belt serves as a refuge during winter, when temperatures in the tidal area become too cold. Particularly during exceptionally severe winters, this refuge function becomes vital for populations to survive. Partly, survival is achieved by satellite populations in the offshore belt while the larger part of the population occurs in the tidal area. This is the case with the cockle (*Cerastoderma edule*) which is highly susceptible to freezing conditions. Following a severe winter, offshore satellite populations may supply the larvae for recolonizing the tidal area. More mobile organisms, including worms which usually stay in the bottom, have been observed to escape from freezing conditions in the tidal area with the ebb current and then resettle in the offshore belt from where they may return in the next spring.

Terns in summer and Eiders and Common Scoter in winter often feed in the offshore belt. For individual harbour seals (*Phoca vitulina*) tagged with transmitters it has recently been shown that most feeding trips of these seals occur in the offshore belt and even beyond. The same probably applies to the larger grey seals (*Halichoerus grypus*). Both species aggregate for resting on emerging sand bars in the ebbtidal delta. Most sightings of the native whale species in the Wadden Sea, the harbour porpoise (*Phocoena phocoena*), are made in the offshore belt, and these also bring up their young in this zone. A hot spot for harbour porpoise recruitment is off the islands of Sylt and Amrum, and therefore this offshore region has been included into the National Park of the Schleswig-Holstein Wadden Sea (see also section on population of sentinel species).

In conclusion, although geographically not obvious, the offshore belt adjacent to the tidal area is an essential habitat for the Wadden Sea ecosystem. Phytoplankton blooms are transported from the offshore belt into the tidal area. Also larvae of benthic fauna and fish take the same route. Shrimp, fish, diving birds and marine mammals readily commute between inshore and offshore parts depending on developmental stage or season. In severe winters the offshore belt provides an important refuge for the survival of populations otherwise confined to the tidal area. The offshore belt is also an important part of the coastal sand-sharing system.

**Tidal area**

The occurrence of tidal areas is confined to oceanic coasts with notable astronomical tides. Similar habitats arise where in extremely shallow waters on- and offshore winds cause windflats and marshes to be irregularly emerged and submerged. The general appearance of tidal areas greatly differs between climate zones, substrate
types and bio-geographic regions. The distinction made here between an offshore belt, tidal area, estuaries and salt marshes cannot be applied to other coastal regions where barrier islands are absent, where riverine influence is a key factor or where salt marshes or even mangroves in tropical and subtropical zones occupy to a large extent the tidal zone. The singularity and exceptional spatial extent of the Wadden Sea may justify habitat distinctions appropriate specifically for this coastal region.

The tidal area of the Wadden Sea comprises the tidal flats, subtidal shoals and gullies of the back-barrier region and in the Central Wadden Sea. The boundary at the North Sea side is determined by an artificial line between the tips of barrier islands and outer sand bars. The borders to the estuaries are determined by salinity, the average 10 psu isohaline at high water in the winter situation. The tidal area includes the most characteristic habitats of the Wadden Sea. Above all, the tidal flats up to the horizon are a phenomenon that cannot be found anywhere else on such a large scale. The tidal flats of the Wadden Sea form the largest unbroken stretch of mud and sand flats in the world. At low tide, the tidal flats are exposed over about half of the tidal area. The other half is subtidal shoals and deep gullies which branch into ever smaller creeks and runnels intersecting the tidal flats. Embedded in this topographic and sedimentary matrix are biogenic habitats such as seagrass meadows and mussel beds which will be given special attention.

Twice a day a spectacle happens. Land slowly rises from the sea and then is irresistibly engulfed again by the flooding waters. The bottom of the sea meets the horizon and invites the observer to take a long walk. However, the walker has to be cautious. Numerous runnels, some creeks and, finally, deep gullies may block the way and require swimming. Pushed by onshore winds the flood may return sooner than expected from the astronomical tide tables published for the various localities within the Wadden Sea Area. Therefore, guided tours are offered to the visitors, explaining not only the tides but also revealing the secrets of hidden life in the marine sediments under our feet.

The sediment surface is almost completely covered by microscopic algae, and often their photosynthetic activity can be seen by bubbles of oxygen in puddles of water. Small snails, in particular, graze on these algae. Snails can be so numerous that what first appears to be coarse grained sediment is actually one snail shell next to the other of the common mud snail (*Hydrobia ulvae*), reaching densities of up to 120,000 snails per m². These are at most a few millimetres long. With their rasping tongue they feed on diatom algae and bacteria films attached to sand grains or to the houses of their fellow snails. The snails in turn are hosts to a specific community of parasites, are prey to crabs, shrimp and fish, and some birds such as Shelduck (*Tadorna tadorna*) at times prefer to forage on this abundant food.
Chapter 2 Description of the Property

These little snails prefer the upper tidal zone where most of the diatom algae occur on muddy flats. Young snails, however, drift downshore to feed on diatoms attached to individual sand grains, which are hardly smaller than the young snails. Therefore predators find it difficult to separate snails from grains of sand. This helps the young snails to survive. In late summer, when grown up, snails drift back to the upper tidal zone where their parents have remained.

Most of the marine organisms in the tidal sediments are rather small. Up to one hundred nematodes can be found per cm³ of surface sediment. However, the tidal flats of the Wadden Sea also harbour large sediment fauna. Most notable is the lugworm (Arenicola marina, Polychaeta) which may be up to 20 cm long and as thick as a pen. This worm stays well below the sediment surface at the base of its U-shaped burrow, out of reach to most predators. Its food slides down a funnel from the sediment surface. The worm ingests sand, digests adhering microalgae and bacteria, and then egests a fecal string of clean sand back to the surface, coiled up like cooked spaghetti. The faecal mounds lie scattered all over the sediment surface, giving the tidal flats of the Wadden Sea a highly characteristic surface topography (see also under section soils and sediments).

Lugworms irrigate their burrows with water from above to supply their gills with oxygen and thus build up anoxic environment in an otherwise anoxic sediment with toxic sulphides. This creates a number of microoxic niches alongside burrows which are utilized by minute worms, copepods and amphipods. Some of these worms have never been found away from lugworms burrows (i.e., Typhlopolycystis rubra, Scoliopharyngia arenicola, Coelogygnopora faenofurca) and constitute a highly specialized faunal component.

The almost ubiquitous lugworms displace other fauna by destabilizing the sediment surface layer which is recycled 10-20 times per year through the guts of these worms. Even their own juveniles are relegated to marginal zones until big enough to join the adults. Another victim of the bioturbation activity of lugworms is the small mud shrimp (Corophium volutator, Amphipoda). It dwells in much smaller U-shaped burrows. The young ones are suspension feeders and the older ones collect sediment particles which are individually taken in between the mouth appendices to scrape off palatable bacteria and microalgae.

This amphipod is restricted to a belt in the upper tidal zone because here predation by fish and the brown shrimp (Crangon crangon) is rather limited. However, during low tide exposure there is a specialized predator in the form of the nemertine worm (Tetraestemna melanocephalum). This sneaks into burrows and captures the amphipods with a poisonous proboscis. This predator is only successful during low tide when the amphipods cannot escape by swimming. Also at low tide, the common redshank (Tringa totanus) prefers forage on Corophium. This is convenient to the wading bird because it breeds in adjacent salt marsh vegetation, just high enough to hide its nests and young from gulls and raptorial birds.

Almost all organisms living in the tidal sediments are of marine evolutionary origin. Those of terrestrial or limnic origin are an almost negligible minority on the tidal flats of the Wadden Sea. However, their adaptations to the hostile marine environment are striking. The small roof beetle (Bledius spectabilis) feeds in the upper tidal margin on biofilms composed of blue-green bacterial colonies (Cyanobacteria) and lives in vertical burrows which can be sealed during inundation. The beetle survives in a chamber filled with air. When inundations become too frequent during autumn and winter, beetles leave the tidal zone to hibernate in the upper salt marsh.

Waders and gulls also follow the ebbing tide down to the lowest level to forage for prey left behind in shallow puddles and prey hiding underneath the surface of the sediment. Evidently these tidal flats are so rich in resources that birds fly in from far away. However, birds do not forage evenly throughout the tidal zone. Their preferred prey may occur in distinct belts or patches, differs in sizes and abundance between mud and sand or is not everywhere easily accessible at all times. This is where the large coherent tidal area pays for the foraging birds. They are able to optimize their foraging strategy by selecting the most favourable sites at a given time.

A most graceful wading bird in black and white is the Avocet (Recurvirostra avosetta). It breeds with about 10,000 pairs in the Wadden Sea Area and 46,000 birds visit during autumn migration and then leave for wintering in West Africa by the end of October. The main feeding grounds are the mud flats along the mainland coast of the Wadden Sea. There they prey on worms and, in particular, on the mud shrimp (Corophium volutator) (see above).

Time is short for birds which rely on low tide exposure to catch sufficient prey. This is particularly the case when the Wadden Sea is visited for a stopover on the long flyway between southern wintering and northern breeding grounds. Refuel-
ling has to be accomplished in a short time. The Wadden Sea is ideal for that purpose. The vast extent of tidal flats and the hunting prohibition keep human disturbances at a minimum. Guided tours for visitors usually follow a fixed path, and birds are able to become accustomed to such predictable events.

The density and diversity of the tidal flat fauna in the Wadden Sea are higher than in most other coastal environments. The average biomass is about 50 g dry organic weight per m² and this is 10-20 times higher than in the offshore area. Of further importance is the fact that much of this biomass is rather easy to access for fish when the tide is in and birds when the tide is out. For example, preying on earthworms on dry grassland is much more difficult for a bird than feeding on ragworms, cockles or mud shrimp on a tidal flat.

The benthic biomass production on tidal flats is so high because there are two sources of food. One is the microbial and microalgal production on the sediment surface and the other is a phytoplankton import with the tides from offshore waters. Further, these benthic and pelagic unicellular microalgae are much easier for invertebrate fauna to consume than larger plants. Thus, food webs in the tidal area are highly efficient.

In contrast to many other habitats, all these interactions between organisms from microbes to birds, as well as between organisms and their habitat by adaptations and modulating effects are highly conspicuous and often directly observable on the tidal flats. A guided walk across tidal flats may take the place of many formal lectures and textbook chapters on basic and applied ecology. The tidal flat habitat reveals natural processes that are easily extended beyond the horizon to understand the earth system. Also, the consequences of climate change with the entailed sea level rise are readily apparent.

There are various specific types of tidal flats such as macroalgal mats, shell beds, soft mud, fine and coarse grained sand flats, seagrass meadows and mussel beds. The latter two are singled out for closer description.

Seagrass meadows

Seagrasses are submersed flowering plants which have their evolutionary origin in freshwater and from there have colonized shallow coastal waters with about 60 species world-wide. Typically for the harsh environment of the Wadden Sea, only two of these seagrass species have managed to become established in the area. However, due to its changeable environmental history, the Wadden Sea populations of both species have accumulated a much higher genetic diversity than other populations along the European Atlantic coast. This is an example where versatility of individual species has been favoured in the course of evolution over high species diversity.

The two species, *Zostera noltii* and *Z. marina*, often called dwarf seagrass and common seagrass, respectively, tend to occur in mixed stands on the tidal flats. The dwarf seagrass grows in very dense
patches which trap sediment particles transported by tides and waves. Consequently, this accretion of sediment causes dwarf seagrass to grow on slightly elevated hummocks, while the interspaces between hummocks are the preferred habitat of the common seagrass. This species grows more scattered as individual plants and this pattern does not facilitate sediment accretion but favours erosion. Physiological measurements have shown that the dwarf seagrass is more tolerant to low tide desiccation than the common seagrass. This is a striking example of how coexistence between potential competitors is mediated by their habitat modifications.

Zostera beds provide a substrate for fouling algae which, in turn, are grazed by snails and other invertebrates. Snails, in fact, are essential for keeping seagrass blades sufficiently clean from fouling algae. Otherwise, photosynthesis would be inhibited by shading the chloroplasts of the seagrass. The canopy and rhizomes offer protection for small animals such as juvenile bivalves, crustaceans and fishes, which utilize the beds as a nursery. It is peculiar to find marine invertebrates specializing on the inflorescence of seagrass as a microhabitat which remains filled with water throughout the tidal cycle. The polychaete worm, Polydora cornuta, has been encountered regularly in the inflorescences raising its larvae there.

In autumn, Zostera beds constitute a preferred food for brent geese (Branta bernicla) and widgeon (Anas penelope). Although these birds thin out blades and rhizomes, dwarf seagrass has been observed to grow more vigorously at sites where grazing took place in the preceding year as opposed to sites where grazing was inhibited. Grazing by these birds is apparently beneficial.

In the Wadden Sea, most beds are to be found in the mid to upper tidal zone along the leeside of islands and high sand bars, as well as along sheltered parts of the mainland coast. In addition to the protection offered by islands against waves created by the prevailing westerly gales, clay and peat of marsh soils submerged long ago provide a firm substrate for the roots. There, seagrass is safe from getting uprooted by wave erosion.

This is an example of how the remains of terrestrial habitats, long gone in the wake of sea level rise and storm tide devastations, influence the spatial pattern of a marine habitat centuries later. It may also explain why most seagrass meadows are found in that part of the Wadden Sea where in medieval times floods drowned an extensive marsh (Fig. 2.8). Probably, the prevailing high sediment dynamics in the Wadden Sea are a major limiting factor for seagrass occurrence, leaving most of the tidal flats bare of rooted plants.

Mussel beds

Mussel beds are generally known from rocky shores. However, in the Wadden Sea mussels have managed to develop persistent beds on sediments. Blue mussels (Mytilus edulis) occur in a belt from
slightly above to a few meters below low tide line. Mussels have the ability to attach to each other by byssal threads. This has the advantage that aggregates of interconnected mussels resist translocation by waves and currents. It allows them to live upon the sediment surface without digging into the sediment as other bivalves usually do.

On sedimentary flats mussels usually aggregate into coherent mats which completely cover the sediment. Some 1,000 to 4,000 mussels per m² may occur. They mostly form elongated beds perpendicular to the main flow of tidal waters. This minimizes intraspecific competition for the suspended food which they filter out of the tidal waters. It is the balance between the benefits of living tossed together and the disadvantage of competing for food that generates the rather specific fractal spatial pattern of mussel beds in the Wadden Sea.

Mussels cause the deposition of a large amount of suspended matter by their faeces and pseudofaeces as well as by creating a rough surface with sheltered interspaces. This causes mussel beds to rise above the ambient sediment surface up to half a meter or more. Sedimentation may be further enhanced by macroalgae which grow attached to the mussels. Sediment is partly deposited within the bed, partly in its surroundings or even, after storms, in land reclamation fields and on salt marshes. The importance of mussel beds for the sediment budget of the Wadden Sea has been stressed.

Mussel beds are very active in the breakdown of organic matter. While mussels contribute to a very rapid remineralisation and release significant amounts of ammonia and silicate, the main decomposition of organic matter is carried out by bacteria in the faecal material. One can conclude that mussel beds increase the turnover rate of organic matter through filtration, deposition and breakdown of organic matter and that they supply dissolved nutrients for primary production.

Mussel beds provide a natural hard substratum of considerable extent and this hosts a number of associated algae and invertebrates which otherwise would be absent from the Wadden Sea. A good example is the bladder wrack \( (Fucus vesiculosus) \). Thalli of this macroalga are fixed by mussels with their byssal threads. In this association the bladder wrack merely grows vegetatively and lacks the characteristic bladders. Presumably, bladders would cause uplifting together with the mussels underneath and thus would be detrimental. A small periwinkle \( (Littorina mariae) \) grazes specifically on this wrack and is never found outside the mussel beds. These snails have been shown to be genetically distinct from populations which dwell on rocky shores.

More than one hundred allied species are to be found in mussel beds. Barnacles grow on the shells and create a rough surface with numerous small niches. Although barnacles lower the rate of growth and survival of the mussels they have overgrown, they also provide ideal settlement
conditions for the recruits of the mussels. This is an interesting case of interactions between species, where disadvantages and benefits may alternate. In the short term and on the scale of an individual mussel, the negative effects of fouling prevail, while, in terms of the persistence of mussel beds and the mussel population as a whole, the positive effect of facilitating recruitment outweighs the negative one. Especially deposit feeding worms profit from the organic matter that accumulate underneath the layer of mussels, which also shields from predators above. Juvenile shore crabs (Carcinus maenas) prey on small mussels and find shelter underneath the big ones to keep away from their own predators.

Mussels in the Wadden Sea tend to be heavily infested by the shell-boring polychaete worm, Polydora ciliata. This weakens shell strength and facilitates predation by shell-crushing predators like crabs and Eider ducks. The biomass of mussel beds is 25 times higher than in adjacent bare sediment flats. This attracts wading birds and gulls to intertidal mussel beds and diving Eiders to subtidal beds. More than 200 birds per ha of mussel bed have been counted. This amounts to 25% of the wading birds in the Wadden Sea feeding on mussel beds that cover only 1% of the tidal area. The most important predators consuming mussels are eider ducks (Somateria mollissima) and oystercatchers (Ostralegus haematopus). These birds can shift their diet between mussels and cockles depending on availability. Herring-gulls (Larus argentatus) feed preferentially on young mussel beds.

Recently, introduced Pacific oysters (Crassostrea gigas) began to invade mussel beds. Oyster spat attach directly to individual mussels, grow larger and suffocate the mussels underneath. However, oysters, in turn, provide shelter to young mussels which thrive well in between the much bigger oysters. Thus, although mussel beds appear to be transformed into oyster reefs, mussels nevertheless manage to persist. Also, the species formerly associated with mussel beds continue to exist in the new association.

**Subtidal shoals and gullies**

The diversity of epibenthic organisms which live upon the sediment surface is higher in the subtidal zone than in the intertidal and also than in the wave-swapped offshore belt seaward of the barrier islands and sand bars. In the back-barrier subtidal zone, species which cannot endure low tide exposure but take advantage of the richness of food and the shelter from strong waves join species which have their main occurrence in the intertidal zone. Sponges, tunicates and colonial hydrozoan polyps which attach to shell beds are mostly confined to subtidal shoals. The most beautiful colonies are formed by polyps of the species Sertularia cupressina. In the past, these were dredged, dried and then stained in bright colours to use for decorative purposes, until substitutes made out of plastic replaced them on the market.

Reefs have been created by generations of worms which build their tubes out of sand grains and attach tubes to each other. The species Sabel-
**Salt marshes**

Salt marshes and mangroves are composed of upright vegetation. These plants are of terrestrial evolutionary origin but tolerate marine waters. Elsewhere in the world, they often manage to occupy the tidal zone down to about mid tide level and exhibit a vegetation height of more than one meter. This is not the case in the Wadden Sea. Mangroves are absent, because of low temperatures, and salt marshes are mostly confined to the supratidal zone not regularly flooded at each high tide. Only a few pioneer plants extend their range into the tidal zone down to about neap tide level, which is equivalent to three hours of submersion per tidal cycle on average (Fig. 2.9). Furthermore, Wadden Sea salt marshes rarely exhibit vegetation heights above one meter. Grasses and herbs or low shrubs of less than half a meter dominate. Trees do not occur in these salt marshes.

**Vegetation and topography**

Wadden Sea salt marshes are naturally open grasslands with habitat specific plants of great beauty and diversity. Salt marshes show a great variety of appearances. They can be rich in flowers, they can exhibit a rather diverse mixed assemblage of specialized plants and generalists adapted to disturbed regimes or they can be completely dominated by one or two grass species forming monotypic stands of vegetation. In general, diversity increases from the pioneer zone to the rarely submerged upper salt marsh belt. Highest diversity is found in sandy salt marshes and in the transition zone to dunes. Ranges of salt marsh plant populations are generally limited in the seaward direction by their ability to withstand marine...
inundations. In the landward direction they tend to be limited by competition, particularly shading by other plants.

Accordingly, the most specialized salt marsh plants are to be found in the lower zone, while the upper salt marsh also includes generalist plants of wide tolerance which may be common outside salt marshes as well. Plants in a salt marsh either adjust to salinity or regulate the salt content in their cells. Some of the salt marsh halophytes are succulents, compensating a high salt content by extending the vacuoles in their cells (i.e., *Salicornia* spp., *Suaeda maritima*). Others are capable of excreting salt through special glands (i.e., *Limonium vulgare, Spartina anglica*) or salt bladder cells which fill with salt, then die or burst, releasing salt from the plant (i.e., *Atriplex* spp.). Still others simply seem to accumulate salt in their leaves until they die at the end of the season (i.e., *Juncus gerardi*).

Under conditions of sea level rise, salt marshes will persist as a habitat by accretion. As the vegetation grows older, a gradual landward shift of the zonation may occur. Accretion is accomplished by inorganic sediments imported during inundations from the seaward tidal flats and by organic matter which is supplied by the marsh vegetation itself. Vertical accretion rates tend to decrease with increasing marsh elevation and with increasing distance from tidal flats or creeks meandering and branching across salt marshes (see also under section soil and sediments). Vegetation height and density also facilitate accretion rate. These variations generate a rather irregular topography and a complex mosaic-like vegetation pattern. Further, water-logged pans arise which are bare.
or with scarce vegetation. Instead of accretion, these pans may erode into salt marsh ponds, and these may eventually merge into a creek. It is basically the vegetation which generates this highly complex and irregular dynamic habitat mosaic of salt marshes.

While salinity may be high in salt marsh pans during dry periods, salinity is low at the upper end of salt marshes where these are bordered by dunes. Here, freshwater seepage is common, creating brackish water habitats. In the absence of grazing, often the reed (Phragmites australis) takes over as it also does in the inner parts of estuaries. For example, in the Elbe estuary, outside the nominated property, under macrotidal conditions the reed grows up to 4 m in height.

Depending on sediment supply and wave action, the seaward edge of salt marshes may show a variable width of pioneer zone composed mainly of glassword (Salicornia spp.) and the cordgrass (Spartina anglica). While the former are annuals and rather short, the latter grows in dense tussocks which extend laterally and, finally, may merge into continuous belts. At sites with low sediment supply at the seaward edge, salt marshes become cliffed and retreat, and no progressive pioneer zone develops into the tidal zone. On a larger scale, this edge instability may not be taken as a threat to the habitat, because the eroded material may accumulate elsewhere, allowing pioneer vegetation to colonize anew.

**Animals**

While the organisms occurring on tidal flats are predominantly of marine origin, in salt marshes those of terrestrial origin by far outnumber marine algae and marine invertebrates. However, an abundant marine snail, very similar to the abundant mud snail (Hydrobia ulvae) on the tidal flats, is Assiminea grayana. It grazes on microalgae in the moist microenvironment underneath dense vegetation. Interestingly, although the adults are confined to the supratidal salt marshes, their larval development is still planktonic in the tidal waters. This guarantees wide dispersal. This prosobranch marine snail with gills often shares the same habitat and feeding mode with a pulmonate snail of terrestrial origin (Ovatella myosotis), and as such is equipped with a lung to breathe air.

Aquatic species of the microfauna are particularly adapted to highly variable moisture and salinity in salt marshes. A study on turbellarian worms revealed that many species are of the specialized brackish water fauna. They thrive in salt marshes, where salinity fluctuates between inundations during storm tides and periods of heavy rain. When it gets too dry or otherwise adverse, some of these species even encyst and then wait in this dormant stage for more benign conditions to come.

Most invertebrates in the salt marshes are terrestrial arthropods. Many of them show morphological adaptations to prevent saltwater from intruding into their bodies. Some have a dense fur, like a hair coat, which ensures that an air film is trapped between the hairs when the organism is covered with water. Such films of air serve as physical gills. Tolerance to salinity, osmotic and ionic regulation as well as avoidance behaviour
During periods of inundation are also quite common. On the other hand, it is curious to find spiders such as *Erigone arctica* (Micryphantidae) and *Leptorrhoptrum robustum* (Linyphiidae) spinning nets under submerged conditions.

A common mode of life for terrestrial arthropods in order to become partially independent from the harshness of the physical environment is to adopt an endophagous or endoparasitic habit. A large proportion (ca. 60%) of coastal butterflies (mostly Microlepidoptera), as well as some beetle species, spend their larval stages inside roots, stems, shoots, leaves or flowers of saltmarsh plants. Endoparasitism by larval stages is found in more than 100 hymenopteran insect species encountered in the Wadden Sea salt marshes.

Salt marshes of the Wadden Sea make up about 20% of this habitat type along the European Atlantic and Baltic coasts. They represent an indispensable habitat for huge flocks of migratory waterfowl and breeding birds. Many just come for resting at high tide until the tidal flats become accessible for foraging again. However, salt marshes are also important breeding areas for various wading birds, terns and gulls, spoonbills and some passerines. The Oystercatcher (*Haematopus ostralegus*) is one of the most abundant breeding birds in the Wadden Sea. Highest densities are found on island salt marshes. Pairs are territorial, with an average of one pair per ha. Breeding close to the salt marsh edge in the vicinity of the tidal feeding grounds is most advantageous. Pairs have to queue for several years before finding a chance to occupy one of these superior territories. Other pairs decide on a breeding territory further away from the edge, starting earlier in life with raising young, but their overall reproductive success may be lower because they have to “leapfrog” over the territories of others in order to forage and feed their chicks. As a result, these often die of starvation.

Brent goose (*Branta bernicla*) and barnacle goose (*Branta leucopsis*) use salt marshes during spring migration to replenish their body reserves. This is essential in order to reach their distant breeding grounds. A study on salt marshes of the island of Schiermonnikoog revealed that grazing by barnacle geese improved the quality of vegetation for the birds. A positive feedback between increased grazing intensity and foraging efficiency on short-grazed lush vegetation has been revealed. This was the case for low-productive vegetation, while high-productive sites developed a dense and high vegetation unsuitable for herbivore consumption.

### Modified salt marshes

In the Wadden Sea, about one third of the salt marsh area shows the natural patterns of accretion, erosion and vegetative diversification described above. Entirely natural salt marshes prevail on the barrier islands and, in the Northern Wadden Sea, also behind sandy barriers of the mainland (Table 2.2). Along most of the mainland, however, salt marshes are man-made. At the seaward edge, accretion is facilitated by means of brushwood groins. These are set up in a rectangular pattern. Groins are often up to one meter in height, constructed with two parallel rows of wooden pilings and brushwood fixed in between. Such groins are permeable for water, mitigate wave action and enhance sedimentation.

### Table 2.2: Area of salt marsh types (ha) in the Wadden Sea, including the pioneer zone, except for Niedersachsen.

<table>
<thead>
<tr>
<th>Salt marsh type</th>
<th>The Netherlands</th>
<th>Niedersachsen</th>
<th>Schleswig-Holstein</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Barrier islands</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A barrier-connected (incl. foreland)</td>
<td>3,500</td>
<td>2,820</td>
<td>1,130</td>
<td>7,450</td>
</tr>
<tr>
<td>B green beaches</td>
<td>380</td>
<td>310</td>
<td>0</td>
<td>690</td>
</tr>
<tr>
<td>C1 summer polder</td>
<td>0</td>
<td>60</td>
<td>0</td>
<td>60</td>
</tr>
<tr>
<td>C2 de-embanked (summer) polder</td>
<td>45</td>
<td>150</td>
<td>0</td>
<td>195</td>
</tr>
<tr>
<td><strong>2. Mainland</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A barrier-connected</td>
<td>0</td>
<td>0</td>
<td>730</td>
<td>730</td>
</tr>
<tr>
<td>B foreland marsh</td>
<td>4,000</td>
<td>5,430</td>
<td>7,470</td>
<td>16,900</td>
</tr>
<tr>
<td>C1 summer polder</td>
<td>960</td>
<td>1,540</td>
<td>0</td>
<td>2,500</td>
</tr>
<tr>
<td>C2 de-embanked summer polder</td>
<td>295</td>
<td>90</td>
<td>0</td>
<td>385</td>
</tr>
<tr>
<td><strong>3. Halligen</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>45</td>
<td>2110</td>
<td>2,155</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>9,225</td>
<td>10,400</td>
<td>11,440</td>
<td>31,065</td>
</tr>
</tbody>
</table>

**Source:** QSR 2004.
In addition to groins, parallel ditches are dug to facilitate drainage and to enhance vegetation settlement and growth. Small ditches lead to larger ones which debouch drainage water into the tidal flats. Draining by numerous ditches prevents water-logging. The vegetation in such man-made salt marshes was grazed intensively by livestock to keep the vegetation short, often less than the length of a finger. Under these conditions, lower and upper marshes are dominated by the grasses *Puccinellia maritima* and *Festuca rubra*, respectively. To increase the natural value of those marshes, grazing and draining have been reduced or abandoned. Today, a large proportion of the man-made marshes are allowed to grow according to the geomorphological conditions of the habitat. The landward boundary of such groin-protected and drained salt marshes is almost always an earthen seawall (dike) to prevent inundations of the hinterland. The purpose of such a foreland in front of a dike is to dissipate wave energy during storm tides.

In the Southern Wadden Sea, the upper foreland is often protected by a summer dike, which is high enough to keep out inundations during summer, while storm tides in winter may overtop such a seawall. The marshes between the summer dike and the main dike are so-called summer polders. Here, the vegetation is no longer dominated by halophytes. Summer polders mainly serve to improve livestock farming. Some of these have been de-embanked in order to restore more diverse salt marsh vegetation (Table 2.2). On the *Halligen* in the Northern Wadden Sea, a salt marsh type prevails which resembles the upper foreland along the mainland. Shores of these *Halligen* have been supplied with stonewalls to stop cliff erosion at the salt marsh edge, which tends to be much higher than in ambient tidal flats. The vegetation on the *Halligen* is dominated by *Festuca rubra* and *Juncus geradii* vegetation.

Traditionally, salt marshes were used for livestock grazing, mostly cattle in the Southern Wadden Sea and sheep in the Northern Wadden Sea. On mainland salt marshes, the grazing intensity was kept high, because it was assumed that when vegetation remained short and dense, the resulting lawns were better than natural vegetation in preventing erosion on the foreland in front of seawalls. In the meantime, it has been demonstrated that higher vegetation can function likewise. Consequently, grazing intensity is now generally reduced to allow for higher plant diversity.

In conclusion, there is quite a diversity of distinctive salt marsh types in the Wadden Sea. Most consist of a species-rich dynamic mosaic of vegetation patches. A rather monotonous grassland prevails either as a result of intensive livestock grazing or of high nutrient supply in the absence of grazing. Barrier-connected salt marshes are often entirely natural while the others are mostly man-made and/or managed for coastal protection. The barrier-connected type constitutes a rare
natural heritage, and the latter is a rather distinctive cultural heritage documenting the contest between man and the sea. Both types together represent an area of 400 km\(^2\) in the Wadden Sea Area and about 300 km\(^2\) in the nominated Wadden Sea property.

Beaches and dunes
Beaches and coastal dunes together constitute one morphogenetic habitat system. Sand blown by wind in the landward direction from the dry parts of beaches becomes trapped by various pioneer plants. In the Wadden Sea, the main dune generating species is the marram grass *Ammophila arenaria*. This is able to grow upwards with the accumulating sand. Marram grass does not, however, fix the sand entirely. Aeolian transport of sand continues, albeit at a lower rate. It may happen that one dune overtops another. In this way, dune heights of 20 m are exceeded. Above that height, wind forces become too strong for marram grass to slow down sand transport, and bare migrant dunes arise. These usually travel from west to east in response to the prevailing wind direction. Migrant dunes may reach the lee side of barrier islands, supplying beaches and tidal flats there with new sand. Ecologically, beaches and dunes are linked to the other habitats, not only by sand transport but in particular by birds, which rely on beaches and dunes as important foraging, nesting and resting habitats.

Beaches and high sands
All beaches in the Wadden Sea are sandy and mostly situated on the North Sea sides of barrier islands. Mainland beaches occur in the Central Wadden Sea near Cuxhaven and at the tip of the Eiderstedt peninsula. While, in the past, these beaches were regarded as dreadful sites, mostly by sailors threatened with becoming beached in the surf, nowadays these beaches are regarded as the most attractive recreational sites and constitute a major basis for regional tourism. Sandy islands like Trischen, Memmert and Rottumerplaat and vast remote high sands, like the Northfrisian "Außensände", Blauort in Dithmarschen and Richel in the Dutch part, form another important part of the sandy habitats in the nominated property.

Sandy beaches are the most dynamic physical systems of the seashore. Wave energy associated with sediment particle size and tidal range are major structuring forces for beach morphology as well as for the composition of the biota dwelling in the sand (Fig. 2.10). The wave-shoaling zone of the beach system extends far into the North Sea, without a distinct seaward boundary. The surf zone begins with shore-parallel bars and is recognizable from the shore as the breakpoint of the approaching waves. Bars are followed by a wide trough until waves dissipate the rest of their energy in the swash zone. This is also called the beach face and is approximately equivalent to the intertidal zone. It often ends in a distinct berm or continues into an extended beach plain.
Beach organisms are almost all of marine evolutionary origin. Their distribution is largely physically controlled. Wave exposure has a strong adverse effect on the benthic macrofauna, which increases in abundance and diversity from reflective to dissipative shores. The smaller and highly diverse interstitial fauna of sandy beaches (micro- and meiofauna) thrives best at intermediate beaches. These organisms are somewhat buffered against the physical extremes of the beach environment by dwelling well below the surface during the entire tidal cycle.

The most common macrofaunal inhabitant of sandy beaches in the Wadden Sea is the polychaete worm, *Scolelepis squamata*. It looks greenish, gets up to 8 cm long and has two tentacles to feed on suspended as well as deposited food particles. Together with some amphipods, this worm is the principal prey of sanderlings (*Calidris alba*) which patrol the beaches. This small wading bird runs with an amazing speed in front of splashing waves and is very common from late summer to spring. Its plumage is then black and white, while it is brownish when in its Arctic breeding grounds. Gulls often assemble in huge flocks on beaches, particularly after storm tides, when bottom animals became whirled up in the breaker zone and washed onto the beach face. When the sea is calm, terns often patrol the surf zone in search of small fish.

Interestingly, the numerous interstitial fauna of sandy beaches is barely linked to larger organisms which only becomes part of the swash zone during heavy storms, when waves reach up to the foot of the dunes.

Three beach types are well represented in the Wadden Sea. Dissipative beaches represent the high energy end of the beach spectrum. They are a product of large waves moving over fine sand, resulting in a flat beach face and wide surf zone. Dissipative beaches tend to have relatively stable morphologies, and exhibit minimal shoreline change. They are the prevailing type in the Southern Wadden Sea. The low energy end of the spectrum is represented by reflective beaches. They develop under combinations of low waves and/or longer wave periods or coarse sand. Reflective beaches have a relatively narrow swash zone and a surf zone is absent. Waves move unbroken to the shore, where they collapse or surge up a steep beach face. Sand is transported shoreward under such conditions and often beach cusps arise. In the Wadden Sea, reflective beaches are not common and are found mostly at the bended tips of barrier islands.

Intermediate beaches represent a transition from high energy dissipative to low energy reflective beaches. They occur under a wide range of conditions, from moderate to high waves, fine to medium sand, and longer wave periods. There is a pronounced long-shore variability caused by alternating rip and bar topography. Intermediate beaches are the most mobile in terms of sediment exchange.
in the food web. At the base of their small food web are organic imports pumped into the permeable sand by the waves and also some microalgae attached to sand grains. These are exploited by interstitial scavengers and herbivores which in turn are predated by carnivores of similar small body size. Dominant among these is the turbellarian worm *Notocaryoplanella glandulosa* (Otoplanidae). It is a few millimetres long, transparent, and dashes through the interstices of sand. It is capable of adhering firmly to sand grains and also letting loose again very quickly. This helps it to stay within the turbulent zone at the lower beach face of exposed shores.

Several species of air-breathing sand hoppers (talitrid amphipod crustaceans) dwell in the dry sand above the reach of splashing waves near the drift line. They are often superabundant and scavenge mainly at night on organic debris washed ashore. On some beach plains, a very peculiar assemblage of microbiota has developed. This has been termed colored sand and shows four distinct layers, of which the upper three measure only a few millimetres in thickness. The sediment surface layer is brownish and contains diatoms (microalgae of the Bacillariophyceae). Below this is a layer of bluegreen "algae" (Cyanobacteria) followed by a layer of purple bacteria. All three perform photosynthesis, and the latter splits hydrogen sulfide as electron acceptor instead of water. These layers are on top of a deep black zone where sulfur bacteria abound. Such colored sands have been described from the beach plains of the islands of Amrum and Mellum and from mainland beaches at St. Peter Ording.

Two red-list bird species prefer to nest on plains of dissipative beaches and among cusps of reflective beaches: Kentish plover (*Charadrius alexandrinus*) and Little tern (*Sterna albifrons*). Their survival is threatened because they unfortunately prefer the same beaches as nesting sites that are most attractive for recreation. In winter, snow buntings (*Plectrophenax nivalis*) are common visitors of the upper washlines.

To conclude, there is a considerable extent and diversity of sandy beaches in the Wadden Sea area. The biota are distinctly different in composition from those of the offshore belt and the tidal area. Beaches considerably contribute to overall faunal diversity with rather unique forms of life. In contrast to tidal flats, organisms have little effects on their habitat. Physical factors select the forms of life, most of which are rather small.

### Dunes

Coastal dunes develop where sand is mobilized at dry beaches and blown landwards. The sand is trapped by plants, which give rise to a succession of dunes from embryonic to white, grey and brown dunes. This dry dune vegetation (*xerasere*) alternates with wet dune vegetation (*hygrosere*) in the dune valleys (slacks). With a few exceptions (e.g. Eiderstedt peninsula) the dune habitat is confined to the Wadden Sea barrier islands. Dry dune vegetation dominates with 85% over wet dune slack vegetation types (Table 2.3). The dunes included in the nominated property predominantly occur on the Eastfrisian islands and at some confined mainland sites.

Dune succession commences with embryonic dunes and occasionally even starts from a drift line on dry sandy soils. The salt-tolerant *Agropyron junceum* growing slightly above the wet beach face is the most frequent pioneer plant initiating dune formation. Salinity decreases as more sediment becomes accumulated in the shelter of the grass. This is a cumulative effect of rain in the absence of further marine inundations.

Once salinity is low, the vigorously growing marram grass (*Ammophila arenaria*) takes over. It grows upwards with progressive sand accretion and an extensive root system remains in contact with groundwater. Dunes dominated by marram grass are termed white dunes, because bare sand is still visible and is kept in motion by the wind. Vigor of marram grass wanes when dunes mature and lose nutrients. Often, nematodes attack roots and further weaken the marram grass. This allows a diverse group of other grasses, herbs and shrubs to move in. Humus accumulates, and the white sand turns grey (grey dunes) and in later succes-
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Dune grassland prevails in the southern Wadden Sea, while dune heath is more dominant in the north. The dune grassland is facilitated by an atmospheric supply of reactive nitrogen and maintained by rabbits and other grazers. Dune heath is adapted to nutrient-poor conditions. The boreal crowberry *Empetrum nigrum* is considered to represent an end-successional stage, because windy and salty conditions strongly hamper woodland development.

Scrubs often show up on the lee side of white dunes. In the southern Wadden Sea, *Hippophae rhamnoides* dominates where the sandy soils still contain small quantities of lime. This lime dependence is the reason that this scrub can hardly be found on the lime-poor northern islands of the Wadden Sea. Here, the sand willow (*Salix arenaria*) is common. The woodland in the dunes is almost always initiated by plantations, particularly of pine trees.

Between dune ridges, ground water may accumulate and cause moist soil in summer and prolonged inundations in winter. The vegetation in these dune slacks is highly diverse and ranges from pioneer plants, which include many extremely rare species, to fens dominated by grasses or reedbeds. Dune slack heath and willow shrubbery may also occur, as well as occasional dune slack woodlands with low-growing alder and birch.

Habitats in the dunes vary from extremely dry to permanent inundation, from alkaline to acidic, from pure sand to peaty soils, and, finally, from freshwater to rather saline conditions. Dunes dominate the landscape of the barrier islands and provide impressive scenery. However, dunes are also part of the coastal defence system, and for that purpose they have been stabilized in the vicinity of villages and towns. Cliff erosion is often countered by trapping sand with brushwood fences and planting marram grass. In combination with eutrophication, these human interferences have modified habitat proportions with a dominance of dune grassland and scrubs at the expense of embryonic and white dunes.

Besides a rich arthropod fauna, with ants in particular, amphibians and lizards, small mammals and birds populate dunes. Characteristic for moist dune areas are natterjack toads (*Bufo calamita*), which have a yellow vertical stripe on their back. At night, the natterjacks even climb up into the dry dunes to forage on insects there. On islands without foxes, gulls (*Larus argentatus*, *L. fuscus* and *L. canus*) maintain large breeding colonies in the dunes. Their import of nutrients from the sea has striking effects on the dune vegetation. Occasionally, eider ducks (*Somateria molissima*) also breed in the dunes. Other breeding birds often encountered in the dune areas are hen harrier (*Circus cyaneus*), short-eared owl (*Asio flammeus*) and passerines such as wheatear (*Oenanthe oe-
In late summer, whimbrel (Numenius phaeopus), gulls, and starlings forage on berries of the dune shrubs. Hares are widespread, and on some islands, rabbits have been introduced. Both modify the vegetation by grazing. Livestock grazing was once common in the dunes but has been phased out.

The lower plant production in dunes than in salt marshes entails less opportunities for animals, which are rather scarce in comparison. On the other hand, plant diversity exceeds that of salt marshes by a factor of ten, including a variety of rare and endangered species. Therefore, almost all of the dune areas in the Wadden Sea are under nature protection. Management measures have been taken to restore successional processes as well as typical species-rich habitats where, in the past, anthropogenic disturbances had modified the vegetation.

**Species and population size**

Coastal wetlands with their salt marshes, tidal areas, dunes, and beaches, belong to the most dynamic habitats on earth. They were tossed forth and back, squeezed and enlarged with the ups and downs of sea level in the past. Terrestrial and limnic organisms are challenged by seawater, while marine organisms are challenged by the vagaries of terrestrial climate. Accordingly, coastal wetlands are not sites where endemic and conservative species could survive and where relicts of the past would encounter a safe refuge.

A naturally high level of disturbances and frequent occurrences of extreme events may even lead to the expectation that biodiversity would be generally low. However, this is not the case in the Wadden Sea. The reason for a high number of species is the manifold opportunities to make a living, at least for some time within a cycle of life. This is because of (1) a high habitat diversity generated by the dynamic transitions between the land and the sea and (2) the rich spectrum of resources washed ashore from the production of the vast oceanic realm, discharged by the rivers from their large watersheds, and made available by the rapid biological turnover on site. In addition, the Wadden Sea is not isolated but in the midst of migration routes and accessible to dispersal along the coast and rivers as well as across the sea.

The following chapter will deal with patterns of species diversity and with populations of sentinel species in the Wadden Sea. It will be shown that incredibly high species numbers have been revealed where this was not expected. The Wadden Sea is a treasure box of extremely specialized species alongside with species of an astounding versatility in their adaptations. The combination of great naturalness with a large areal size offers opportunities for many a species which are endangered elsewhere along the world’s coasts (see Tab. 2.5). Particularly when considering the huge flocks of migratory birds in the tidal area, the essential role of the Wadden Sea for global biodiversity becomes obvious. Further, the Wadden Sea is a showcase to demonstrate how important a population of an individual species of organism can be in shaping an entire coast-scape.
Wadden Sea also constitutes a good example for the reversal of negative trends in populations and habitats brought about by stringent conservation and restoration programs.

Patterns of species diversity

Numbers of species tend to increase with the intensity of an inventory. In the Wadden Sea, there is a long tradition of research on the composition of the regional flora and fauna. Nevertheless, not all groups of very small organisms have been assessed. The Wadden Sea represents a critical habitat for about 2,700 species of marine origin in the intertidal and subtidal zones and at least 5,100 semi-terrestrial and terrestrial species, mostly the flora and fauna of salt marshes and dunes on the islands (Table 2.4). Considering various unicellular groups and small metazoans such as terrestrial nematodes not included in the surveys, we may estimate that the Wadden Sea Area is populated by up to 10,000 taxa of organisms living in the bottom and waters of the sea, in salt marshes, dunes and other habitats on the islands.

Phototrophic plants comprise about 2,300, macrofungi 1,300 and animals at least 4,200 species. With this species richness the Wadden Sea plays an important role in preserving biodiversity in temperate coastal zones in accordance with the requirements of the Convention on Biodiversity. The planktonic species and many of the fish and birds are not residents in the Wadden Sea. They either drift in and out or stay only for some phase of their life or for a particular season in the Wadden Sea. About 800 species belong to this temporary component of the biota. To these, one could add further species which have been observed as rare visitors, stragglers or stray migrants. Also, legions of rare fish and, particularly, birds have been observed. Altogether, these records comprise at least 300 more species not included in Table 2.4.

Complete surveys on species richness within habitats are extremely time consuming and require a wide spectrum of taxonomic expertise. Therefore, this has been rarely accomplished. However, one such an assessment has been performed at a sandy beach with a sand flat on the island of Sylt along a transect from high to low tide level, 115 m long. Altogether, about 50,000 sediment samples have been analyzed and more than one million individuals have been examined and identified to species level. Most species belonged to the interstitial fauna, metazoans small enough to move through the interstices of sand without having to push sand grains out of their way. In total, 652 species were recorded, and for 148 of them that beach is the type locality, because these species were described here for the first time. To these, roughly 200 taxonomic groups not included in the survey have to be added. Also not considered are the plants, of which about 150 unicellular benthic algae may occur at the site. Thus, walking from high to low tide line on that particular beach one trespasses territories of their life or for a particular season in the Wadden Sea.

Table 2.4: Overview on species richness in the Wadden Sea. In some groups numbers have been estimated. Due to taxonomic uncertainties not all species complexes have been analysed, and in terrestrial environments surveys on small soil fauna are incomplete. Rare visitors are left out. (Lists of species encountered in the Wadden Sea Area are compiled in: Wolff W.J. (ed) 1983. Ecology of the Wadden Sea. Balkema, Rotterdam, The Netherlands).

<table>
<thead>
<tr>
<th>Marine aquatic organisms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular plants (seagrass)</td>
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<tr>
<td>Macroalgae</td>
<td>80</td>
</tr>
<tr>
<td>Pelagic microalgae</td>
<td>380</td>
</tr>
<tr>
<td>Benthic microalgae</td>
<td>260</td>
</tr>
<tr>
<td>Zooplankton</td>
<td>260</td>
</tr>
<tr>
<td>Benthic microfauna</td>
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</tr>
<tr>
<td>Benthic macrofauna</td>
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</tr>
<tr>
<td>Fish</td>
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</tr>
<tr>
<td>Marine mammals</td>
<td>3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Terrestrial, semi-terrestrial and freshwater organisms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Macrofungi (islands)</td>
<td>1,300</td>
</tr>
<tr>
<td>Lichens (islands)</td>
<td>347</td>
</tr>
<tr>
<td>Mosses (islands)</td>
<td>338</td>
</tr>
<tr>
<td>Vascular plants</td>
<td>900</td>
</tr>
<tr>
<td>Molluscs</td>
<td>70</td>
</tr>
<tr>
<td>Arthropods</td>
<td>2,000</td>
</tr>
<tr>
<td>Birds1</td>
<td>106</td>
</tr>
<tr>
<td>Other vertebrates (mammals, reptiles, amphibians)</td>
<td>40</td>
</tr>
</tbody>
</table>

1. This number is listed by the trilateral experts groups Joint Monitoring of Migratory Birds (JMMB) and Joint Monitoring of Breeding Birds (JMBB) based on the EU Birds Directive. 176 species are listed in the framework of the trilateral cooperation, but in total there are many more.
almost 1,000 species. Macoinvertebrates tend to increase in diversity from high to low tide line and then further with depth of the sea bottom. This is not the case with the diverse interstitial fauna, which attained a maximum of species richness at a 10 m wide terrace just below the steep slope of the beach face. Here, an optimal balance occurs between the supply of organic materials, oxygen availability and water retention during low tide exposure. At this terrace, 350 species per meter interval were found along the transect. Contrary to most larger marine organisms, the hot spot of diversity of the interstitial fauna lies in the intertidal zone rather than at greater depths. The same applies to the benthic diatom algae.

In salt marshes there is an incredible richness of small arthropod species, mainly insects and spiders. The main primary producers, the vascular plants, comprise only 45 species. The microflora was not assessed. Directly feeding on these plants were 6 species of waterfowl and 400 insect species. Another 500 species have been found to feed on dead plant material, algae and fungi. Predaceous arthropods comprised 245 species and parasites 290. To this spectrum we may add about 100 species of birds feeding and resting in salt marshes. The sum of all these species is almost 1,600. Further, to these terrestrial or semi-terrestrial organisms some 500 species of aquatic, mostly marine, invertebrates of the meiofauna have to be added. Again, considering unicellular organisms not included in the surveys, the grand total is probably in the order of 2,300 taxa which dwell in the salt marshes of the Wadden Sea. This number compares well with the richness of species encountered in European temperate forests.

**Populations of sentinel species**

**Birds**

The Wadden Sea, with its diverse and often undisturbed habitats and vast tidal flats that serve as feeding grounds, is of an outstanding, international importance for birds breeding, staging, moulting and wintering in the area. A list of breeding, migratory and offshore birds is in Annex 05.

The availability of food and a low level of disturbance are essential factors. For 43 species, the Wadden Sea supports more than 1% of the flyway populations, which is the criterion of the Ramsar Convention as an internationally recognized measure for identifying wetlands of international importance. Of these, 4 are breeding birds, 24 are breeding as well as migratory species and 15 use the Wadden Sea only during their seasonal migrations. Of all migratory birds, 29 species occur with more than 10% of their flyway population in the Wadden Sea.

A regular census is carried out on 31 breeding bird species that are considered characteristic for the Wadden Sea and which are indicative of favourable food availability and natural breeding success. In 2001 the survey recorded an overall number of 469,000 breeding pairs or territories. Nearly 70% of the breeding bird population is represented by gulls, with Black-headed Gull
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Figure 2.11: Comparison of breeding bird populations in the Wadden Sea in 2001 with NW-European population sizes (from: Koffijberg et al. 2006).

Figure 2.12: Maximum estimated numbers of migratory birds between 1992–2000 given as proportion of flyway populations for the entire Wadden Sea (from: Blew & Südbeck 2005).
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**Larus ridibundus**, Lesser Black-backed Gull (**Larus fuscus**) and Herring Gull (**Larus argentatus**) being the most abundant species. Another 18% of the total population are coastal waders, notably Oystercatcher (**Haematopus ostralegus**), Avocet (**Recurvirostra avosetta**), Northern Lapwing (**Vanellus vanellus**) and Common Redshank (**Tringa totanus**). Among the rare breeding birds are Dunlin (**Calidris alpina schinzii**) and Ruff (**Philomachus pugnax**), which have been subject to long-term declines and currently balance at the verge of extinction in the Wadden Sea.

In five species, at least 25% of north-western European populations breed in the Wadden Sea. For 21 out of 31 species, the population in the Wadden Sea Area accounts for more than 1% of the NW-European population. In an international context, the Wadden Sea represents a core breeding area for Eurasian spoonbill (**Platalea leucorodia**), Avocet, Gull-billed Tern (**Gelochelidon nilotica**) and Sandwich Tern (**Sterna sandvicensis**), each supporting between 33 to 100% of the NW-European population.

Breeding habitats are present in salt marshes, dunes, pastures and on beaches. Many species (21 out of 30) prefer islands as breeding sites. This especially applies to colonial breeders like Great Cormorant (**Phalacrocorax carbo**), Eurasian spoonbills, gulls and terns as well as Hen Harrier (**Circus cyaneus**) and Short-eared Owl (**Asio flammeus**). Occurrence of the latter two species is mainly in the dune areas in the western Wadden Sea. Populations of Avocet, Great Ringed Plover (**Charadrius hiaticula**), Kentish Plover (**Charadrius alexandrinus**), Gull-billed Tern, Northern Lapwing and Black-tailed Godwit (**Limosa limosa**) mainly concentrate along the mainland coast. The Wadden Sea also constitutes a refuge for those species that have largely lost their inland habitats, e.g. Northern Lapwing, Redshank and Black-headed Gull.

Even more important than for breeding birds, is the role of the Wadden Sea as an outstanding internationally important staging, moulting and wintering area. Following the 1% criterion of the Ramsar-Convention, the Wadden Sea accommodates at least 52 such populations of 41 migratory waterbird species that use the East Atlantic flyway and originate from breeding populations as far away as northern Siberia or Northeast Canada. Some species comprise two or more populations which occupy separate breeding regions and also differ in flyways and their timing of migrations. In about 20 populations more than half of the individuals utilize the Wadden Sea at some stage of their annual life cycle. For about 10 species almost the entire populations occur in the Wadden Sea. Numbers of 44 populations of 34 species are so high that the Wadden Sea can be considered as their indispensable and often main stepping stone during migration, or as their primary wintering or moulting habitat. Therefore the Wadden Sea can be considered essential for the existence of these bird species. A severe deterioration of the Wadden Sea would cause a biodiversity loss on a worldwide scale.

Adding up the numbers from a survey in 2000, a maximum of some 6.1 million birds present in the Wadden Sea is obtained. Considering turnover, as many as 10-12 million birds pass through
the Wadden Sea Area each year. This is at least ten times as many as there are coastal breeding
birds in the area. Of all migratory birds, waders
comprise 55%, ducks and geese 27% and gulls
16%. Most species reach their highest numbers
during the autumn migration. Numbers of waders
are almost as high during spring, whereas ducks
and geese over-winter in high numbers. Only gulls
reach considerable numbers in summer. Almost
the entire population of the Dark-bellied Brent
Goose (Branta b. bernicla) and the entire West-
European population of Dunlin (Calidris alpina)
use the Wadden Sea during periods of the annual
cycle. Without the Wadden Sea, their populations
would suffer heavily. An additional seven species
are present with more than 50% and further
14 species with more than 10% of their flyway
population.

The Wadden Sea serves as a refuelling region
for birds either breeding in Arctic North America
or in Arctic Asia. Two subspecies of Knot (Calidris
canutus) probably split about 10,000 years ago.
One breeds in Greenland and Canada and winters
in the Wadden Sea. The birds leave for breeding
by the beginning of May. Adults begin to return
in July and are followed by their young in August
and September. This population comprises about
450,000 knots. The other subspecies, probably
comprising 340,000 knots, breeds in Siberia and
winters in West Africa. These birds only make short
stopovers in the Wadden Sea. In spring they arrive
after the other subspecies has left, while in late
summer and autumn both overlap in the Wadden
Sea. All feed on small bivalves buried in the sedi-
ments of the tidal flats.

Wadden Sea areas, including the coastal zone
of the adjacent North Sea, are used by high
numbers of moulting Shelduck (Tadorna tadorna)
and moulting and wintering Eider (Somateria
molissima). In summer, nearly 80% of the NW
European population of Shelduck gather in the
Dithmarschen Wadden Sea north of the mouth
of the River Elbe for moulting. They lose their
flight feathers, are completely flightless for some
weeks and are thus highly dependent on the vast
and undisturbed tidal flats.

Without the Wadden Sea, several European
bird populations would be endangered or even
lost. Although bird migration is a global natural
phenomenon that cannot be associated with
a single site, the Wadden Sea is a vital and ir-
replaceable stepping stone that is considered a
critically important ‘mega-site’ for bird migration.
It is not just one of several stopover sites on the
East-Atlantic flyway, but it is the essential and
indispensable stopover.

Marine mammals
Marine mammals regarded as indigenous species
in the Wadden Sea are the harbour seal (Phoca
vitulina), grey seal (Halichoerus grypus), and
harbour porpoise (Phocoena phocoena). After
centuries of hunting, protection measures have
fostered a striking comeback in the seal popula-
tions. At present, seals are so abundant in the
Wadden Sea and flight distance has decreased so
much since the ban of hunting in the 1970s that
all visitors to the Wadden Sea have a fair chance
observing these animals. Seal tours are announced
at every harbour and constitute one of the prime
attractions for tourists. Off the island of Sylt, also
the harbour porpoise became so frequent that encounters on arranged boat tours and regular ferry tours are almost certain when the sea is calm.

The Wadden Sea now sustains approximately 20% of the world-population of harbour seals that belong to the Northeast-Atlantic subspecies *Phoca vitulina vitulina*. Simultaneous counts are performed from the air during low tide in August (moulting season), when approximately two thirds of the seals lie on the exposed sand bars. In total, 15,426 were counted in 2006, compared to about 4,000 thirty years earlier. The increase since then was not an uninterrupted one. A virus disease strongly affected the entire population of the North Sea in 1988 and again in 2002 but recovery seems to have proceeded well. In the Wadden Sea, seals have adapted to the tidal conditions, which regularly submerge their resting and whelping sites. For whelping, females prefer sand flats in the sheltered inner part of the tidal area, while the main sites for resting are sand bars in the ebb tidal delta, from where seals may go hunting either way, into the tidal area or into the offshore belt and further out into the North Sea. Long-term field
and pathological investigations indicate that there has been an improvement in their health condition over the last twenty years.

Archaeological findings suggest that grey seals were the dominant species in the Wadden Sea until medieval times. Whelping in this larger seal species occurs in winter when storm surges are most frequent. Therefore, females often have their pups on the upper beaches of the islands. This habit probably made them so vulnerable to hunting that grey seals remained absent from the Wadden Sea for several centuries. Three decades ago, however, grey seals started to re-establish in the Wadden Sea. Thriving colonies are now found in the western Dutch Wadden Sea, in the southern Wadden Sea at the tips of the western Eastfriesian islands, in the northern Wadden Sea off the islands of Amrum and Sylt, and just outside the Wadden Sea a colony became established near the island of Helgoland. Simultaneous aerial counts carried out in March-April during moulting came up with 2,139 grey seals in the Wadden Sea Area. Results from a few recently satellite-tagged animals indicate migration of grey seals from the Wadden Sea to British coasts and vice-versa. Therefore, the rookeries in the Wadden Sea seem to belong to a population which occupies the entire North Sea region.

This also applies to the harbour porpoise. The total population in the North Sea may comprise about 230,000 individuals. Particularly females with small offspring are observed off the northern Wadden Sea. There, aerial surveys in May-August have spotted a mean density of 1–2 harbour porpoises per km². A whale sanctuary was established off Sylt and Amrum in 1999 and is part of the nominated property.

Fish

More than 140 species of fish have been recorded from the Wadden Sea. A list of fish species is in Annex 04. Most of them are North Sea or even oceanic species which visit the Wadden Sea but do not depend on this area. Whiting (Merlangius merlangus) and Cod (Gadus morrhua) have open sea nurseries but in late summer and autumn juveniles may invade the Wadden Sea in huge numbers. Their appearances are highly variable from year to year, and when they occur, they turn out to be very effective predators on Brown Shrimp (Crangon crangon), causing its population to crash intermittently. Almost all small fish are also victims of these occasional juvenile incursions.

Other species use the Wadden Sea only as a passage during their migration from the sea to the rivers. These are known as diadromous species. Of those which spawn upstream in the rivers, notable species are River Lamprey (Lampetra fluviatilis), Sea Lamprey (Petromyzon marinus), Allis Shad (Alosa alosa) and Houting (Coregonus oxyrinchus). Formerly important were also Sturgeon (Acipenser sturio) and Salmon (Salmo salar). These have been over-fished and their riverine habitat degraded, but reintroduction and recovery seems possible if their riverine habitats continue to improve. Twaid Shad (Alosa fallax), Smelt (Osmerus eperlanus) and Sea Trout (Salmo trutta) spawn in the rivers, but
juveniles and adults tend to live permanently in the Wadden Sea and not merely pass through. Eel (Anguilla anguilla) is also a diadromous fish, albeit the other way round. Eels spawn in oceanic waters, and the pelagic larvae are transported to the coast by Atlantic currents. The larvae metamorphose into transparent ‘glass eels’ and migrate into freshwater where they spend 6–20 years before the onset of maturation, at which they return to the sea as ‘silver eels’ and pass through the Wadden Sea in summer and autumn. Some juveniles do not migrate into freshwater but stay in the Wadden Sea until they mature.

For fish in the North Sea, the most important function of the tidal area of the Wadden Sea is that of a nursery. Some of these North Sea fish occur only as juveniles in the Wadden Sea, most notably the flatfish Plaice (Pleuronectes platessa), Sole (Solea solea), Herring (Clupea harengus) and Sprat (Sprattus sprattus). The two flatfish spawn in the North Sea and their pelagic eggs and larvae drift into the tidal area with the currents. After entering the Wadden Sea, the pelagic larvae undergo metamorphosis and settle on the mud flats. Here, they benefit from ample food and warm temperatures. They leave the Wadden Sea as juveniles before their first winter. A part of the juvenile population re-enters the Wadden Sea in its second year, while adults stay permanently in offshore waters. Herring and Sprat are the most abundant pelagic fish species in the Wadden Sea. Juveniles of both species occur side by side, measure 5 to 10 cm in length, and form big shoals particularly at night.

Opposite to the above, Flounder (Pleuronectes flesus), Five-bearded Rockling (Mustela ciliata) and Sand Goby (Pomatoschistus minutus) spawn in the North Sea and stay as adults in the Wadden Sea. About twenty species are residents in the Wadden Sea and may only leave the tidal area during exceptionally cold winters or, in the case of the Lumpsucker (Cyclopterus lumpus), also leave in summer. Eelpout (Zoarces viviparus) and Bull Rout (Myxocephalus scorpius) both are common demersal fish in the Wadden Sea and stay there during their whole life. Eelpout give birth to fully developed young and males of Bull Rout guard their eggs deposited under shelter at the bottom. The pelagic Garfish (Belone belone) attaches its eggs equipped with long sticky hairs to the blades of eelgrass.

Fish are sensitive indicators of a recent warming trend. Species once rare have become residents such as Mullet (Chelon labrosus), Anchovy (Engraulis encrasicolus), Sand-Smelt (Atherina presbyter) and Red Mullet (Mullus surmuletus). In general, the finfish fauna of the present Wadden Sea is strongly dominated by small-sized fish.

Macrozoobenthos

The benthic macrofauna of the Wadden Sea comprises about 400 species, of which some 150 occur in the intertidal zone. Benthic macrofauna is less diverse than benthic meiofauna, which counts about 1,200 species. The average biomass of benthic macrofauna on the tidal flats ranges between 38 and 65 g dry organic matter per m², whereas in the inner estuaries and in the North Sea average macrobenthic biomass is much lower (1 – 13 g per
Within the tidal area, biomass is low on deep and exposed sandy bottoms and high in mixed and muddy sediments. However, the absolute hot spot is observed in the mussel beds, where biomass ranges between 1,000 to 2,000 g per m². These biomass values are important, because benthic macrofauna is the main food source for most of the birds and fish in the Wadden Sea.

Dominant in biomass are usually the bivalves, cockles (Cerastoderma edule) and mussels (Mytilus edulis) in particular. Next in biomass are often the worms with the lugworm (Arenicola marina) contributing most. Extremely numerous but less important in terms of biomass are the mud snail (Hydrobia ulvae) and the mud shrimp (Corophium volutator).

The European cockle (Cerastoderma edule) ranges from Norway to Morocco, but its largest population is found in the Wadden Sea. The occurrence of cockles on the tidal flats is rather patchy. Dense patches develop only at times and sites where their main predators, shorecrabs (Carcinus maenas) and brown shrimp (Crangon crangon), have not encountered the spat in summer. In autumn, also flocks of knots (Calidris canutus) can eliminate patches of young cockles. Once reaching a large size, cockles may attain considerable longevity. Individuals up to 15 years of age have been found, and these old ones significantly contribute to the reproductive potential of the entire cockle population. A rare sister species, the lagoon cockle (Cerastoderma glaucum), occurs fairly isolated in salt marsh creeks of the Wadden Sea islands. Presumably, the young attach to birds for dispersal to creeks on other islands, which may explain their genetic homogeneity over wide distances.

The most popular creature for visitors participating on guided walks across the tidal flats are the ubiquitous lugworms because of their highly characteristic coiled faecal strings. These mounds are scattered all over the flats with about 20 to 40 per m². In total, there are roughly one billion lugworms in the entire Wadden Sea consuming sand and digesting adhering bacteria and microalgae. Worms themselves are prey to flatfish and waders. Because lugworms dwell deep in their burrows, predators only get them when worms approach the sediment surface with their rear end to defecate. Tail ends are then sacrificed to the predators and the worms subsequently regenerate.

Lugworms spawn in late summer. Their larvae develop in the mother burrow and then drift into the subtidal zone, where juveniles hibernate among shell debris. In spring, the little worms drift back into the tidal zone and tend to settle at the margins of the adult population, usually as a nursery belt in the uppermost intertidal zone. From there, juveniles gradually migrate in autumn into the area of the adults. This complicated pattern has probably evolved because the sediment turnover caused by a dense population of adult worms inhibits juvenile development. The population size of these lugworms is remarkably stable over the years, perhaps because of this density-dependent response of juveniles to the dominating adults.

Juveniles of brown shrimp (Crangon crangon) often take refuge in the feeding funnels of lugworm burrows during low tide exposure. When the tide is in, the shrimp feed on small zoobenthos of any kind and exert particularly high predation pressure on bivalve spat. In effect, successful recruitment in cockles is often confined to years with low shrimp abundance. For the Wadden Sea, it is even the rule that successful bivalve recruitment is limited to summers after a severe winter, because that retards the development of shrimp and crabs. Shrimp spawn in the offshore belt and their larvae are transported into the tidal area by the currents. Juveniles first stay on tidal flats but when their length exceeds one centimetre they begin migrating back and forth with the tides. Most adults stay in the subtidal zone and finally return to the offshore belt of the Wadden Sea.

Ecologically, the most important plants for the food web of the Wadden Sea are the unicellular algae on the sediment surface and in the tidal waters. More conspicuous, however, are the vascular or flowering plants. In the intertidal zone, two seagrass species, Zostera noltii and Z. marina, are the major habitat forming plants.

The most characteristic and peculiar plants of salt marsh pioneers in the upper intertidal and lower supratidal zones belong to the glasswort species complex (Salicornia spp.). This is a cosmopolitan genus in seashore environments. The succulent halophytes, with their segmented shoots, somewhat resemble a desert plant but are, in fact, growing where they become submerged by the tides twice daily. Seeds germinate at high salinities. In the Wadden Sea, the Salicornia species are annual herbs less than 20 cm tall. Most seaward on mud and sand flats grows the upright and slender Salicornia stricta (syn. S. dolichostachya). Seeds are not shed and remain on the decaying green plant in autumn. A pioneer on flat sandy beaches is the mostly low-growing Salicornia procumbens (syn. S. decumbens), which turns from green to yellow and orange in autumn. More within the salt marshes in between other vegetation grows...
Salicornia brachystachya (syn. S. ramosissima). Its seeds even germinate at shaded sites, which is not the case in the other species. This strongly branched plant tends to have rather short shoot segments and turns from green to dark red in autumn. Taxonomists disagree about the proper subdivision of this complex of species. Speciation is still ongoing in the Wadden Sea and has not yet become genetically entrenched, and each species exhibits a high plasticity in its growth form. There is a strong tendency to inbreed and distinctive local populations may occupy contrasting habitats. The Salicornia species have attracted much research, because glassworts were seen as useful pioneers for the purpose of converting tidal flats into salt marshes, which then could be claimed and transformed into arable land. This interest is gone but glassworts are still highly regarded as a tasty vegetable.

Glassworts were the only salt marsh pioneers on tidal flats in the Wadden Sea until eighty years ago. Then, cord grass was introduced to facilitate sediment accretion at the shore. It originated from a hybrid between the Afro-European Spartina maritima and the American S. alterniflora, accidentally introduced to southern England. The sterile hybrid converted by autogenic chromosome doubling into a fertile species, which has been named Spartina anglica. Coincidentally, that happened very close to the site and time of Darwin writing on the origin of species. This vigorous species now dominates in the pioneer zone of salt marshes in the Wadden Sea. With glassworts and cord grass, the species diversity in the pioneer zone is rather low but rapidly increases in a dynamic mosaic-like fashion further up in the supratidal zone. Here, the Wadden Sea salt marshes in summer display a picturesque sea of flowers which is one of the main attractors for people visiting this coast.

The low marsh, inundated by more than one hundred floods per year, is characterized by a low-growing grass, Puccinellia maritima, often in combination with the purple-flowering Limonium vulgare. On clayish or brackish ungrazed marshes, Aster tripolium can be present. On well-drained creek levees and terraces Halimione portulacoides is the dominant species. On the middle marsh, with less than 100 floods per year, a dense lawn of Festuca rubra and Juncus gerardii is developed, sometimes associated with Limonium vulgare and Artemisia maritima. Sandy salt marsh pastures often have a pink appearance in early summer, because Armeria maritima achieves dominance. It is avoided by livestock. When grazing by domestic animals is reduced or ceases, and depending on geomorphological conditions, clay content and elevation, Elymus athericus, Halimione portulacoides, Spartina anglica or Elymus repens can represent the dominant species within the salt marshes. Under brackish conditions, Phragmites australis will prevail.

Without the marram grass (Ammophila arenaria), the barrier islands of the Wadden Sea would presumably look very different. This can be inferred from observations made at the coast of
Oregon in Northwest America. After introduction there, the marram grass altered the dynamics of the dune system entirely. It quickly generated a high and permanent fore-dune barrier behind the beach where none had been before. Sand formerly blown further inland was now trapped, and on the leeside of the new dune ridge a wet deflation plain emerged with unstable 'quicksand'. Thus, a coastal landscape which had existed for 10,000 years was dramatically transformed within a few decades by the introduced marram grass.

In the Wadden Sea, however, marram grass is native. It can cope with sand accretion rates of up to one meter per year by extending its shoots. Sand accumulates because the tussocks substantially slow down the wind speed above ground level. The grass extends horizontally with its rhizomes and its roots penetrate the emerging dune to depths of two meters or even more. Leaf rolling and a thick cuticle on the outer side restrict transpiration losses and reduce damage by sand blasting. Although marram grass only dominates the vegetation on the white dunes, without its dune-building capacity all the later successional phases with the many rare and endangered plant species could not develop. This is a striking example of how the attributes of one particular species of plant have created an entire coastal landscape, and it is hard to imagine what the evolution of the Wadden Sea barrier islands would have been like without marram grass.

Endemic and threatened species
As a coastal wetland, the Wadden Sea is neither sufficiently isolated for the evolution of endemic species nor has it remained climatically stable enough over the past millennia to preserve relict species. In addition, there is a long list of unicellular algae and small-sized invertebrates which have been first described for science from type-localities in the Wadden Sea, and up to now have not or only rarely been recorded elsewhere. However, for these taxa, a lack of records from outside the Wadden Sea is most likely caused by a lack of studies rather than real endemism. A list of endemic saltmarsh species is in Annex 06.

The Wadden Sea has remained a coast-scape which still provides ample space and resources to all these populations, and many of the large animals once threatened by man have started to recover. As an example, the Harbour porpoise is now classified as Vulnerable (VU) with a reduced threat category (A1cd) for the Wadden Sea, indicating a significant reduction in threat and an increase in population size. Similarly, the Allis shad and Twait shad are also classified as Vulnerable (VU) with a reduced threat category (DD). The Houting (Coregonus oxyrinchus) is listed as Near Threatened (NT) with a reduced threat category (LR/nt), and the Black-tailed Godwit (Limosa limosa) is listed as Near Threatened (NT) with a reduced threat category (BD). Table 2.5 provides a list of threatened vertebrate animals on the IUCN Red List with survivors encountered in the Wadden Sea.

<table>
<thead>
<tr>
<th>Species</th>
<th>Common name</th>
<th>IUCN Red list status</th>
<th>EU Directive status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phocoena phocoena</td>
<td>Harbour porpoise</td>
<td>VU A1cd</td>
<td>HD Annex II, V</td>
</tr>
<tr>
<td>Alosa alosa</td>
<td>Allis shad</td>
<td>DD</td>
<td>HD Annex II, V</td>
</tr>
<tr>
<td>Alosa fallax</td>
<td>Twait shad</td>
<td>DD</td>
<td>HD Annex II, V</td>
</tr>
<tr>
<td>Coregonus oxyrinchus</td>
<td>Houting</td>
<td>DD</td>
<td>HD Annex II, IV (priority species)</td>
</tr>
<tr>
<td>Lampetra fluviatilis</td>
<td>River lamprey</td>
<td>LR/nt</td>
<td>HD Annex II, V</td>
</tr>
<tr>
<td>Limosa limosa</td>
<td>Black-tailed Godwit</td>
<td>NT</td>
<td>BD Annex II</td>
</tr>
</tbody>
</table>
to recover during recent decades. Some species threatened in general find refuge in the Wadden Sea to some extent (Table 2.5). However, all of these are migratory and cannot be rescued by measures confined to the Wadden Sea. Particularly, fish cannot take advantage of protection within the Wadden Sea as long as riverine habitats are not sufficient (e.g. for the sturgeon, Acipenser sturio) or fishery pressure continues further offshore (e.g. on thornback skate, Raja clavata).

The Wadden Sea as a gigantic coastal filter system

The Wadden Sea ecosystem represents one of the most important wetland habitats in the entire world. It provides a multitude of transitional zones between land, the sea and freshwater. All of its habitats together function as a gigantic coastal filter system. Water runoff from the land and water masses from the sea are mixed and flushed with the tides several times back and forth before being taken up by the long-shore current and eventually released to the Atlantic Ocean.

Riverine and marine imports of organic matter and dissolved compounds are retained. This clearance operation is mediated by the coastal biota. It begins with life in permeable sands in the offshore belt of the Wadden Sea and extends onto the sandy beaches and tidal flats. Waves push water into the interstices of the sand. These sand grains are highly bioactive, because they are overgrown by films of microorganisms. Some are photosynthetic and enrich the water with oxygen. Others utilize this oxygen to mineralize organic matter. In deeper layers of the sediment, this process proceeds more slowly in the absence of oxygen.

On the sandy tidal flats large burrowing infauna irrigates the sediments and enlarges the oxic remineralising zone by several orders of magnitude. Particularly the abundant lugworms pump down water into the underground, providing a unique habitat for microscopic organisms, with species which do not occur anywhere else. These large burrowers considerably facilitate the biogenic coastal filter function.

Cohesive mud is covered by a living slime full of microscopic algae and bacteria which trap particulate and dissolved matter. Their highly bioactive film further purifies incoming water which has already passed the permeable sands and lugworm flats further seaward. Even inside the salt marshes, films of microbiota cover the sediment surface and contribute to the mineralization of the organic imports from the land and the sea as well as from the bio-production within the salt marsh.

The many suspension feeders in the tidal area are a third component of the coastal filter system. Bivalve molluscs are the prominent members, but filter feeders of many other zoological phyla are involved, such as tentaculated worms or worms which construct a filter out of slime, small crustaceans with feathered setae on their legs, colonies of polyps which grow on shells and algae and many more. Most of these live at the bottom, but some also drift in the tidal waters while filter feeding. It has been calculated that the bivalves alone filter the entire water volume of the Wadden Sea once every two weeks.

Suspension feeders tend to aggregate. Mussels beds are particularly characteristic for the Wadden Sea and significantly reduce suspended matter in the passing water. In return, they release nutrients like ammonia and silicate at a much faster rate than sediment bottoms, thereby facilitating the growth of phytoplankton. This may then drift to other mussel beds, serving there as a renewed food supply. In addition to phytoplankton, resuspensions of bottom particles including benthic microalgae also may contribute considerably to the food of suspension feeders in the tidal area. Re-suspended matter may amount to almost half of the food supply.

A large part of the planktonic food for suspension feeders comes from the North Sea, where phytoplankton blooms arise in the coastal waters. There, transparency for unhampered phyto synthesis is higher than in the shallow turbid waters laden with re-suspensions from the bottom. Thus, a purification of North Sea waters takes place in the Wadden Sea, effected by the coastal filter system. This filter never clogs, because it is permanently renewed by the consumers within the food web of the Wadden Sea.

Considering birds and fish, the rich populations of benthic suspension and deposit feeding invertebrates in the tidal area constitute a large fuelling station from which birds fly to distant lands and fish swim up the rivers or across oceans. In this respect, the Wadden Sea serves not only as a gigantic filter system but as an equally gigantic import and export system between land and sea as well.

The exceptionality of the Wadden Sea resides in the following qualities:

- Its vast size as an amphibious transition between land and sea;
- A unique diversity and combination of dynamic aquatic, semi-aquatic and terrestrial habitats;
A diversity of resident organisms together with an extraordinary number of migrants;
Breathtaking numbers of birds assembling in flocks dancing through the sky;
Millions of aquatic nurslings exploiting food in comfortable shallow waters;
A bewildering diversity of tiny organisms specialized on changeable seashore conditions;
The mastery of outstanding species of plants and animals over the dynamics of their physical environment by creating solid reefs, permeable sediments, sticky mud, accreting salt marshes and high dunes.

Exploitation of natural resources
Gas and oil
All activities related to exploration and exploitation are subject to the strictest regulations probably world wide. They will be carried out in accordance with binding international and national mining and nature protection legislation, and in compliance with the Wadden Sea Plan (Stade Declaration 1997) and international regulations, for example PSSA, OSPAR, AEWA, MARPOL, and the Ramsar and Bonn Conventions.

In Schleswig-Holstein the Wadden Sea Plan is implemented by the National Park Act. Oil exploitation is confined to the existing exploitation site at Mittelplate in the Schleswig-Holstein Wadden Sea. In the Dutch Wadden Sea new exploration and exploitation of gas is only permitted from sites on land and from existing platforms in the North Sea coastal zone outside the nominated property.

An overview of oil and gas production sites and pipelines is given in Figure 2.13.

Gas exploitation in the Netherlands
In the Dutch Wadden Sea there is one site for the exploitation of natural gas: Zuidwal. All other production sites are located outside the nominated property, but the wells or reservoir may extend under it. Not all prospects and leads are yet explored or in production. However, it is agreed that new exploration drilling and new production installations will not be permitted in the future in the Dutch part of the nominated property. As a consequence, new production from under the Wadden Sea will have to be developed from the mainland, the islands or the North Sea coastal zone.

The exploitation of the ‘Zuidwal’ concession area (Vermilion) in the middle of the western part of the Dutch Wadden Sea near Harlingen concerns a deposit which has been estimated to encompass about 22 billion m³ of exploitable natural gas. Exploitation started in 1989. The natural gas is transported via pipeline to a treatment installation in Harlingen. All solid wastes from the exploitation site are transported to land and the produced water is returned to the reservoir. The production facility is a ‘zero emission unit’.

Adjacent to the nominated property, there is the production site ‘Blija Ferwerderadeld’ located on the mainland coast in the eastern part of the province of Fryslân and also producing from under the Wadden Sea. More to the east, permits were recently granted for three additional exploitation sites adjacent to the Wadden Sea, Moddergat, Vierhuizen and Lauwersoog, for production of gas under the nominated property. These permits were granted after a comprehensive decision-making process, including a full impact assessment procedure. Production is allowed within the limits of the resilience of the Wadden Sea to compensate sea level rise by natural sedimentation. Gas production within strict permit conditions will not deteriorate the qualities of the Wadden Sea. Both subsidence and the ecological development will be followed by a strict monitoring program. The exploitation has been permitted on the condition that the production will not adversely affect the nominated property.

The Groningen gas field extends slightly under the Wadden Sea and the Ems estuary. All production sites are on the mainland, and no production wells were drilled under the Wadden Sea. A monitoring well to register pressure is situated on a small artificial island in the estuary. The island is a breeding site for a colony of cormorants. New production facilities on the mainland behind the sea dike, are not expected, but cannot be excluded either.

The island of Terschelling is the most western island with a potential for gas development. The expected reserves are small and have not yet been developed. In the present energy situation, there are no plans to do so. The island of Ameland holds the third largest gas field of the Netherlands. On Ameland, three sites were constructed. The site with production was built in 1983 and is situated on the east cape of the island. The site is connected to two offshore platforms (2–3 km offshore at a water depth of 5–10 meters). The morphology and ecology in the area are influenced by the production (subsidence), and this has been monitored since 1987 under supervision of an independent commission. The technical reports are published
Figure 2.13: Gas and oil in the Wadden Sea (on the basis of the QSR 2004).

Gas and Oil in the Wadden Sea
Legend
- Nominated property
- Gas Exploitation Site
  - Gas Exploitation Site outside the nominated property
- Oil Exploitation Site
  - Oil Exploitation Site outside the nominated property
- Gas Pipe
- Oil Pipe
- Intertidal area
- National Boundary

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about every 5 years in the public domain. Reports are in Dutch, but a summary is available in English and in Russian. The monitoring will continue until the end production in 2020. On the west cape of Ameland near Hollum, an old well site is situated. Reserves have been assessed but have not been produced. On the south side of Ameland (Ballumer Bocht) a future well site was constructed to explore a small prospect partly under the island and partly under the nominated site. Exploration was postponed until a later date, in order not to interfere with the decision-making with respect to Moddergat and Lauwersoog production.

The island of Schiermonnikoog does not hold any reserves to our knowledge, but on the seaside development will continue. Between Ameland and Schiermonnikoog, a so-called monopole is situated, with wells that connect to offshore gas fields. These fields are not yet in production. All these sites and platforms are located outside the Wadden Sea, but the concession area extends over the mainland, the Wadden Sea and parts of the North Sea.

Gas and oil exploitation in Germany
In Germany all exploration and exploitation activities are subject to the Federal Mining Act and are carried out in accordance with the relevant mining regulations procedure. In the context of this licensing procedure, standard authorisation preconditions are required to be fulfilled. The relevant nature protection regulations of the National Park Acts, the State and Federal Nature Protection Acts, relevant EU directives and international regulations are to be complied with and followed.

There are two sites where natural gas is exploited in the Niedersachsen Wadden Sea Area. ‘Leybucht Z 1’ in the exploitation field ‘Juist-Leybucht I’ of the concession area ‘Juist’ is situated in the nominated property. Production started in 1977. ‘Manslagt Z 1’, in the exploitation field ‘Groothusen II’ of the concession area ‘Groothusen’, is situated in the Ems estuary outside the nominated property. Production started in 1993 and stopped in October 2000 because
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 2 Description of the Property

of an occlusion of the drill-hole. It is currently being investigated whether production can be resumed.

Oil production only occurs on one location in the nominated property, in the Dithmarschen part of the Wadden Sea near the island of Trischen. Concessions were already issued in the 1950s. The consortium "Mittelplate" started the construction of the exploitation site "Mittelplate A" before the National Park Schleswig-Holstein Wadden Sea was declared in 1985. Oil production started in 1987. In the 1999 amendment of the National Park Act, the permit for oil production within the nominated property was restricted to the existing exploitation site. According to current estimates, there are still more than 100 million tons of crude oil in several layers of oil-bearing sandstone at depths between 2,000 and 3,000 meters. Around 60 million tons are considered to be recoverable, this being the most important oil deposit in Germany.

In 1998, drilling operations started to exploit part of the oil from the eastern section of the 'Mittelplate' field from the mainland. In 2000, onshore production started at the Dieksand land station in Friedrichskoog in order to increase the exploitation and to limit the presence of the existing drilling site in the area. Formerly, the crude oil was transported to Brunsbüttel by three special double hull tankers. In 2003, plans for a pipeline were approved, which went into operation in 2005. Thus, disturbance of moulting Shelducks have been minimized and potential risks of oil spills have been virtually excluded.

Through the full operation period of the 'Mittelplate A', monitoring has been conducted in order to assess the ecological impact of the drilling site. Until now, no negative effects at the locality and its surroundings have been found. The production facility can be characterized as a 'zero emission unit'.

Fishery

The main fisheries in the Wadden Sea are for brown shrimps and blue mussels. There is one license for oyster (Crassostrea gigas) culture in Schleswig-Holstein. Additionally there is a local fishery on a limited scale with fixed nets and tow nets.

Shrimp fishery

The shrimp fishery focuses on the offshore belt and deeper subtidal creeks, because this is where the large adults stay while the smaller shrimp populate the tidal area. In former times, the rough surf in the offshore belt confined the shrimp fishery to beam-trawling in the more sheltered back-barrier area, but this limitation has been overcome by larger and better motorized vessels. The data about landings, recorded in each country, do not differentiate between the yield fished in or outside the Wadden Sea Area. The yearly average catch in the total landings of shrimp for the period 1994-2003 was about 21,000 t. Landings are mostly regulated by the capacity of the market. The scenic shrimping vessels with their beams uplifted, visible over a long distance, and followed by flocks of scavenging gulls have become almost an icon for
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 2 Description of the Property

Wadden Sea tourism in many parts of the Wadden Sea. Shrimps are a popular delicacy of the region and an economic factor for the coast.

In the Netherlands, 90 vessels are operating in the Wadden Sea. Of these 60 are exclusively fishing on shrimps. The total average annual catch in the Netherlands (including that from vessels outside the Wadden Sea) was about 10,000 t in the period 1994–2003. About half is fished in the Wadden Sea.

In the German part, the shrimp catch has been in average around 11,000 t/yr. In Schleswig-Holstein, 99 vessels (2003) are mainly involved in shrimp fishery. In Niedersachsen, shrimp fishery was carried out by 101 vessels, which were exclusively fishing for shrimps, and an additional 35 vessels, normally fishing flatfish, but which also fished for shrimps in 2003 (in total 136 vessels for shrimp and flatfish fishing in 2003). Shrimp fishery for animal consumption is of minor importance and only carried out in Niedersachsen in the second half of the year. The landings are around 600–1,200 t/yr., which is about 13% of the amount landed for human consumption in Niedersachsen.

Shrimp fishery is allowed in the nominated property with the exception of those areas designated as no-take zones or reference areas in the Schleswig-Holstein and Dutch part.

**Blue Mussel fishery**

In the Netherlands and Germany, blue mussel fisheries are mainly carried out on seed mussels from natural mussel beds. The seed mussels are then dispersed on culture lots where they grow to marketable size. In Niedersachsen, fishing of wild mussels for direct consumption is only allowed on sub-littoral banks, and only small amounts are being fished (about 200 t in 2002). In the Schleswig-Holstein and Dutch Wadden Sea, commercial fishery of wild mussels for direct consumption is not allowed. Major parts of the Wadden Sea (intertidal and subtidal areas) are closed for blue mussel fisheries. An overview of additional restrictions is given in Table 2.6.

In addition to the regulations already existing for culture lots, new regulations concerning the mussel fishery have been introduced gradually since the mid 1980s to ensure a sustainable mussel fishery in accordance with stated conservation objectives and the trilateral Targets. At the 1991 Wadden Sea Conference in Esbjerg, it was agreed to close substantial areas for mussel fishery. The Wadden Sea Plan continues the policy of closed areas, also with the aim to protect and enhance the growth of wild mussel beds and Zostera fields. Mussel fishery will, in principle, be limited to the subtidal area. Finally, the Wadden Sea Plan stipulates that the current area of mussel culture lots will not be enlarged.

The blue mussel fishery is strongly dependent on natural conditions and the availability of natural spat fall, which is highly variable. Therefore, the catches of mussels show strong fluctuations per year and region. In the last ten-year period, the years 1998 and 1999 allowed higher catches, whereas in 2001 and 2002 the lowest catches were reported. The average annual landings of mussels in the past 10 years (1994–2003) were

| Table 2.6: Overview of shellfish fishery and management (from Quality Status Report 2004), (adapted). |
|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
| | The Netherlands Wadden Sea | Niedersachsen Wadden Sea | Schleswig-Holstein Wadden Sea |
| Average annual mussel landings (metric tons gross) | 26,380 (2001-2005) (from culture lots) | 7,278 (94-03) (culture + wild) | 16,500 (95-05) (from culture lots) |
| Mussel culture in area (ha) | Designated: 7,800 used: 3,300 | 1,300 (maximum) | 2,000 |
| Number of licenses | 89 (seed fishing vessels), 82 mussel culture | 5 (vessels) | 8 |
| Quota | For seed mussels | None | None |
| Permanently closed area (ha) | 42,540 | 93,480 | 135,000 |
| Additional restrictions | Intertidal: Seed fishery on unstable mussel beds only if at least 2000 ha of 1-year old mussel beds are left. Additionally 17 sites closed in accordance with Management Plan (about 10% of intertidal mussel beds) | | None |

1**Average of 5 years (1999–2003). The closed area covers 33.8% of the National Park area.**
about 65,000 tons wet weight (including shells), of which most (about 39,000) was landed in the Netherlands. Table 2.6 provides an overview of shellfish fishery in the nominated property.

The majority of landings are traded in the Netherlands. A considerable part of the German landings are transported to the Netherlands for processing and sale.

Due to the lack of reasonable spatfall of blue mussels in the past years, recent experiments are being carried out with new collector methods, and seed mussels are being collected with the help of so-called smart farms. Finally, it should be noted that Spisula fishery (S. solida and S. subtruncata) is either prohibited or not taking place because of lack of stocks.

Cockle fishery
Since the closure of mechanical cockle fishery in the Dutch part of the nominated property, it is now prohibited in the entire nominated property. The cockle fishery has been phased out in the German part for almost 20 years. A manual cockle fishery is still allowed in the Dutch Wadden Sea, with a maximum yearly catch of 5% of the cockle stock. A maximum of 31 licenses for the manual cockle fishery may be granted. As yet, 17 licenses have been actively used. In 2005, 365 tons of meat were landed. For that year, a quota of 600 tons was fixed. Non-commercial, manual collection of shellfish is also allowed, if this does not exceed a catch of 10 kg a day. Commercial collecting of mussels is not allowed.

Extraction of sand and shells
Sand extraction has a long history as a traditional use of the area. The main purposes were the use of the material for building dikes, dwelling mounds and roads. During the past decades, this activity has steadily declined. Today, still a certain amount of sand is used only for purposes of coastal protection, e.g. beach nourishment, dike and dwelling mound (on the Halligen) reinforcement. In the Dutch part of the nominated property, sand extraction is only allowed as a side product of regular maintenance of shipping lanes, incidental deepening of main shipping lanes or clearance for the sake of construction. Sand extraction for commercial purposes is not allowed in the Niedersachsen Wadden Sea. Sand is only extracted for dredging of shipping lanes and coastal defence purposes. In the Schleswig-Holstein Wadden Sea, no sand is extracted for commercial purposes. In the period 1999-2003, an average of 1.1 million m³ was extracted per year for coastal defence purposes.

The extraction of shells is only carried out in the Dutch part and has also decreased in the past years. It is regulated by introduction of quotas on extraction and by limitation to three locations: Marsdiep, Vlie and Friese Zeegat, below normal 5 meters. The total allowable amount of shells to be extracted in the Wadden Sea and the adjacent North Sea coast is based on a long term average of the natural calcimass production, of which the extraction of 50% is allowed but with a maximum of 90,000 m³ in the Dutch Wadden Sea. The extraction of shells in the German Wadden Sea is not allowed.

Hunting
Hunting has been completely phased out within the nominated property with the exception of a restricted hunting on some waterbirds for 10 days and hunting of hare on parts of the inhabited islands in Niedersachsen.

Nonetheless, hunting has a long tradition in the Wadden Sea region. In former times, taking of seals and trapping of waterbirds – mostly geese and ducks – were traditional and integrated parts of the livelihood of the inhabitants of the Wadden Sea isles and the coastal areas. Waterbirds were also hunted to be sold to provide an additional income. Hunting of waterbirds included a selection of ducks, geese and waders, depending on the country involved. The many duck decoys, which still exist along the coast, bear witness to this. Some of these have been restored and serve, amongst others, as museums, whereas others are still functioning. However, methods, equipment and also the purpose changed with time, as has legislation and public opinion on hunting. Nowadays, hunting has changed into a mainly recreational activity, with the exception of hunting of rabbits on behalf of coastal protection. Seals are no longer hunted in the Wadden Sea (closing of the hunting season in the Netherlands in 1962, in Niedersachsen in 1973, in Schleswig-Holstein in 1974). Exemptions for hunting for wildlife management and pest control are possible.

Salt marshes – Land use and management
Mainland salt marshes have been embanked for centuries for land reclamation and coastal protection. Their extent today is only a fraction of the previously widespread transition zone between fresh, brackish and saline habitats. Land reclamation stopped in the 1950s of the last century and the last large embankment for coastal protection ended in the early 1980s. In connection with
coastal protection activities, salt marsh areas have been created in front of the new dikes to maintain their function as wave breakers. These ‘artificial’ salt marshes have developed since then as semi-natural salt marshes with an ecological function similar to natural salt marshes. Today, in some places in the Netherlands and Niedersachsen “outpoldering” projects are being carried out.

Coastal flooding defence and protection

Through maintenance of the drainage channels and brushwood groins along the mainland coast, almost all the area of foreland-type salt marshes has an oversized creek system and a reduced morphological variation. Salt marsh revetments, mainly as sedimentation fields (“Lahnungsfelder”, “landaanwinningswerken”) are being maintained to protect the salt marsh edges around the islands, Halligen and the mainland coast from erosion due to the extremely high wave energy. During the last 20 years the artificial drainage system also has been reduced, in many places to a size which is needed to guarantee a safe drainage of the dike after storm surges. In about 39% of the mainland salt marshes, no drainage measures have been taken during the past 10 years. This has enhanced natural sedimentation and erosion processes and the development of natural salt marsh vegetation. In order to gain sod for coastal defence, grazing of the sod areas is necessary.

Grazing

Grazing by domestic animals can interfere with the natural development of salt marshes. Too intensive grazing by cattle or sheep may lead to destruction of the top soil layer and a decrease of the perennial vegetation due to feeding and trampling. It results in a decrease in sedimentation and in reduced soil conditions and soil stability, both of which are harmful for coastal protection and nature conservation. It leads to a monotonous habitat structure and, in this way, to less attractive conditions for breeding birds. Low-rate grazing, on the other hand, can possibly increase the diversity of plant and animal species on sites with a clay layer thicker than 15-20 cm.

In former times, many sites were intensively used for agricultural purposes. Since the mid 1980s, a reduction of areas with intensive grazing by 50% could be observed on the mainland salt marshes in the Netherlands and Germany (Figure 4.3). In some case, moderate grazing is carried out for biodiversity purpose. Many areas with natural and semi-natural salt marshes have developed during these last two decades.

On the islands, the majority of the salt marshes can develop naturally, and they show various transition stages. Livestock grazing for agricultural purposes has generally decreased in all areas during the past 20 years. In about 60% of the salt marshes there were no drainage measures taken at all, and in an additional 31% no artificial drainage measures have been carried out during the past 10 years.

2.b History and development:
A Wadden Sea of change

Coastal wetlands all over the world changed considerably in position, size and shape in the wake of a postglacial sea level rise of more than one hundred meters over the last 16,000 years. Hunters and gatherers frequented these bountiful coasts from the beginning. Severe resource depletion commenced in Asian and Mediterranean regions 2,500 years ago. In the North Sea region, intensification of resource use began about a thousand years ago. Human impacts intensified with population growth and dominance of global markets but then slowed in some and reversed in a few coastal wetlands, including the Wadden Sea, by prudent environmental management. In this section, the geomorphological, human and ecological history of the North Sea region with the Wadden Sea at its centre is summarized, concluding with perspectives on future developments.

Early geomorphological development

Since the end of the last glaciation, sea level has risen by 120 m in the North Sea region (Fig. 2.14). During a fast rise until 7000 BP, tundra and boreal forest in the southern North Sea were inundated. When the shoreline approached the region of the present Wadden Sea, sea level rise decelerated. Some phases of stasis or fall occurred intermittently. A switch from transgression to 200 years of regression took place around the beginning of the Christian calendar. This interval was followed by a rise of roughly 2 m until today.

When sea level rise slowed down, barrier spits with sand dunes developed. These were eventually breached and cut into barrier islands as sea level continued to rise and tidal range increased. In the southern part, this happened between 7500 and 6000 BP and constituted the birth of a coastal configuration which resembled the present Wadden Sea. The tidal area behind barrier islands gradually enlarged with sea level rise. When this stopped intermittently, the tidal area decreased, and then increased again when sea level rise continued. Landward of the tidal area,
a marsh of a similar areal extent provided a wide episodically flooded plain, consisting of salt marsh vegetation and brackish to limnic reed marshes. Between these marshes and the Pleistocene elevations, extensive raised bogs developed. Along major rivers, gallery forests occurred at the levees. Otherwise, the marsh was a treeless plain kept open by episodic flooding.

Such a coastal landscape may be regarded as a pristine condition of the Wadden Sea, and it lasted until about a thousand years ago. The positions of shorelines at islands and between the tidal area and the salt marsh area were highly dynamic and shifted back and forth with sea level and sediment supply.

Human history
As far as we know, humans have always been present in the Wadden Sea region. Islands, tidal flats and marshes, with a diversity of fish, shellfish, fowl, mammals and wild plants must have offered ample opportunities for Neolithic and Mesolithic hunters and gatherers. The archaeological evidence is scarce, however, as traces have been destroyed by wave erosion or buried under massive layers of sediments. Permanent settlement was largely restricted to higher grounds. On the moraine islands of Sylt, Föhr and Amrum, outside the nominated property, as many as 77 megalithic graves and 1000 Bronze Age barrows have been located, and the adjoining tidal flats and sand dunes provided dozens of flint daggers and sickles.

Wetland settlements are known from the western part of the Wadden Sea from 5500 BP onwards. Fishing and fowling was combined with agriculture. About 3350 BP, relatively large numbers of colonists settled at a former salt marsh estuary on the Noord-Holland peninsula and, later, on the banks of the rivers Weser, Elbe and Ems. Settlements were abandoned when extending bogs and recurrent sea-breaches submerged the farmland. Settlers on the seaward salt marshes

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Figure 2.14: Transgression curve of the average tidal high water in the southern North Sea (source: K.-E. Behre, 2004).
were transhumant pastoralists who took their cattle to higher grounds during winter season. First salt marsh settlements were established on level terrain, but subsequently inhabitants began to raise their farmyards to keep them out of the water during storm tides. Collective raised mounds (terpen, wierden, wurten or warften) from sods and dung were built for safe housing in an otherwise amphibious marsh.

From the ninth to tenth century AD a great transformation of the coastal landscape set in. Swamps and bogs were systematically drained and converted into cultural land. Salt marshes came to be protected by earthen sea walls (dikes) repelling the floods and retaining fresh groundwater supplies. By the thirteenth century one to two meter high dikes surrounded most marshes. Valve sluices were used to discharge accumulating rainwater. The population increased and reached an unprecedented prosperity. Urban demands for cattle, cereals and dairy products boosted agriculture and commerce.

However, the dikes were feeble and major storm surges swept freely over their tops. The drainage of swamps and bogs had unforeseen repercussions, as it caused topsoil erosion and subsidence. Embanked marshes could no longer rise by regular deposition of fertile clay during inundations. In stagnant brackish waters mosquitoes multiplied. Malaria became endemic, leading to widespread health problems. Salt making was an important economy. To obtain salt, tidal peat banks were dug off, the peat dried and then burned. The salt was extracted from the ashes. This activity started in Roman times, and at the end of the Middle Ages most tidal bogs had disappeared. This reinforced erosion by an advancing sea. Apparently, human activities have contributed to the development of deep embayments such as Zuiderzee, Dollard and Jade Bay, and large parts of the Northfrisian area. Devastating floods caused the deaths of thousands of people and their livestock. Only part of the inundated land could be reclaimed in subsequent decades and centuries.

With the beginning of the Modern Age (1500 AD), dikes were reconstructed until they were strong enough to stand substantial storm surges. When the risk of flooding declined, a growing number of farmsteads were reallocated from knolls onto the flat ground. Extensive drainage guaranteed sufficient lowering of the water tables to intensify arable farming. Maritime trade also intensified, with islanders being particularly involved in shipping, trading and whaling.

From 1900 AD onwards, large-scale mechanisation of dike building, hydrological management, agriculture and fishing took place. The landscape was more and more redesigned to fulfil human needs. Many remaining bays were embanked, estuaries canalized and rivers dammed. On the islands, tourism developed into the major economic activity and entailed a sprawl of infrastructures. However, in the last third of the twentieth century a turning point was reached. The idea that a coastal landscape is something to be valued in itself has gained ground. Species and habitat protection and restoration efforts have been initiated on a large scale.
For centuries, the deep tidal inlets in the Wadden Sea area have formed the main shipping routes from the ‘Zuiderzee’ harbours to the open sea. Of these harbours, Amsterdam became the most important and developed into a central staple market within Europe. During the 16th century the focus of trade was directed toward the Baltic area, with the emphasis on grain trade. But from the 17th century onwards the trade with the East and West Indies in luxury commodities such as tea, coffee and tobacco rapidly gained importance. For this purpose, the Dutch East India Company (VOC) was founded in 1602. The large merchantmen used for the long distance trade were unable to pass the shallow waters of the ‘Zuiderzee’ to enter the Amsterdam harbour. Therefore, these ships were loaded and unloaded on the Texel roads in the western Wadden Sea. Protected from the northwestern winds by the Island of Texel, it was a relatively calm area. Relatively, because over the centuries thousands of these ships have been wrecked by storms. A notorious example is the Storm of Christmas Eve 1593, when more than 40 ships are said to have sunk in a single night. Until now, approximately 80 shipwrecks with archaeological significance have been located in this area.

The Wadden Sea is a high dynamic tidal area. Gullies cut deeply into the Pleistocene subsoil and are shifting constantly. Sediment is continuously eroded and redeposited. Ships that sank into such gullies deflected existing currents and, consequently, the course of these gullies. In a short period of time, these ships were covered and protected by a layer of sediment, which caused these wrecks and their (organic) content to stay extremely well preserved. This archaeological maritime heritage is of great importance on a national level. These shipwrecks reflect a period in the national history in which the Netherlands became an important maritime nation. But the significance of this heritage goes far beyond national meaning. The shipwrecks, which are of many different nationalities, form the physical testimony of the maritime exploration and trade of the 16th to 18th century that brought contact with distant parts of the world, sometimes for the first time. The number of wrecks and the extremely favourable preservation circumstances make the western Wadden Sea one of the richest archaeological resources of our common maritime heritage. That is why the western Wadden Sea is on the tentative list of the Netherlands as a cultural site (26/09/1995). However, the shipwrecks are not included in this nomination of the Wadden Sea. The reason for this is that at the moment, there is not a complete archaeological characterization of all the shipwrecks concerned. In addition, there is only little information on the number, the locations and the characterization of possible shipwrecks in the German part of the Wadden Sea. Therefore, much work still has to be done to establish a full inventory of the underwater cultural heritage of universal value for the Wadden Sea.

As the gullies keep shifting, the sedimentation–erosion process repeats itself. This situation can cause covered wrecks to be exposed again.
or it may lead to the discovery of a new wreck and sometimes even several wrecks at the same time. Exposition from the protective sediment may be a threat to the long-term preservation of these shipwrecks by erosion, the woodboring shipworm (*Teredo navalis*) or by human activities such as looting. Therefore, the wrecksites and sedimentation-erosion patterns within the area are monitored on a regular basis. In the last two decades techniques also have been developed to physically protect these wrecks by covering them with nets with fine meshes that catch the sand, resulting in artificial mounds or reefs.

The shipwrecks and their environment are subject to protection under the Monuments and Archaeological Sites Act 1988, the Nature Conservation Act 1998 and the PKB. The Malta Convention was ratified by the Netherlands in 1998 and implemented in the Monuments and Archaeological Sites Act 1988. According to the PKB, monitoring of the shipwrecks as well as investigation and recovery of shipwrecks that are exposed from the protective sediment as a consequence of natural physical processes is allowed under certain conditions. These activities may not adversely effect the natural values and features. Human activities in the Wadden Sea may not damage the archaeological values present in the bottom of the Wadden Sea.

When flying over the Wadden Sea area of North Frisia at low tide, traces of earlier land cultivation, farming and settlements can be seen on the eroded banks of tidal gullies lining the mudflats or in areas where the mudflat substratum has been worn away by the flow of water. The remains of ditches used for drainage and soil improvement are the most common traces which appear. However, it is also possible to find the remains of roads and dikes, mound bases, wells and cisterns constructed from dried bricks of peat or clay, pits and stakes used for various purposes as well as areas used for the mining of peat for fuel and salt.

Walking out onto the mudflats, it is possible to date some of these structures, known locally as "Kulturspuren" (traces left by cultural development), with the help of archaeological evidence. In this way, it is possible to reconstruct the course of earlier land development and settlement and to outline the general contours of the development of land cultivation in space and time. Archaeological and geographical research has shed light on the complicated interplay between human manipulation of the environment, a rising sea level, and the increasing frequency and severity of tidal flooding. At the same time, interdisciplinary cooperation has shown that the morphological development of this coastal landscape cannot be fully understood without knowledge of the composition of the geological subsoil and, in particular, the consistency and strength of the Holocene sediments.

The present protection and management of the nominated property will ensure that such features are also protected as part of the nomination and remains an integrated part of the heritage. Small-scale traditional uses are small-scale activities, mainly carried out by local inhabitants, in ac-
cordance with regional customs and traditions. They are part of local heritage and give islanders a sense both of belonging and of freedom. These feelings are intense and, as such, they play an important part in shaping the islanders’ identity. These uses enhance the involvement of local communities. These activities are only allowed if they do not cause significant damage to nature. The local authorities are responsible for supervising these uses. Examples are catching shrimp for own consumption (dragnet shrimp fishing), digging up lugworms and ragworms by hand, collecting shellfish by hand for own consumption, walking and strolling along the countryside.

Experiencing the scenic values
The complex and dynamic mosaic of the superlative natural phenomena formed by the geomorphological features and biologically rich and diverse habitats that constitute the Wadden Sea ecosystem forms one of the most dramatic and beautifully integrated landscapes and seascapes world wide. This can be experienced when walking on the “bottom of the sea” during low tide and crossing this vast expanse of interrelated land and seascape from the mainland to one of the many barrier islands. On the way one passes all the habitats characteristic of this system, including the salt marshes with their intricate gully systems and the mudflats near the coast, hard sandbanks and deep gullies where the water constantly moves in and out. Experiencing the marine environment on foot, where just a few hours before it was covered by some meters of water, surrounded by an endless sky where the sea meets the horizon deeply impresses most people visiting the Wadden Sea.

As far back as Antiquity, the vast area of the Wadden Sea and the dynamic transition between sea and land created a lasting impression on human observers. The earliest and most famous testimony is recorded in the ‘Historia Naturalis’ by Plinus Secundus (23–79 AD). Pliny’s amazement was caused by the ‘indistinctness’ of the coastal formation, of which one could not tell, “whether this region was part of the mainland or part of the sea.” It is not surprising therefore, that Pliny found the intimate link between the people in this region and this dynamic natural environment quite incomprehensible.

A fundamental re-interpretation of the visible world during the 17th – 18th centuries introduced the ‘aesthetics of the sublime’, which made it possible to ascribe a particular aesthetic quality to the elements of coastal landscapes. As a result, a new perception of ‘pleasure’ was derived from the stimulus to the human senses provided by the natural features of the Wadden Sea.

The completely open horizon with the apparently limitless sky above and the indistinct transition between the tidal flats and the sea creates an expansive experience and intense stimulation of the senses that cannot be equalled by any other comparable coastal formation. This creates a unique relationship between the high aesthetic qualities of the natural ensembles and of the extraordinary ecological features of the area. The extraordinary aesthetic importance of the Wad-
The serene beauty and peacefulness of the landscape and seascape are continually changing as a result of seasonal variations in climate and the rhythm of the tides. The onset of major winter storms can suddenly transform the placid waters into a wild and awesome setting of wild beauty that inspires great respect for the forces of nature. It is the intense tension between the human perception of the grandeur and beauty of the natural systems and their ability to instill awe that result in an exceptional attractiveness. The sheer scale and richness of the land and seascape in which anthropogenic features play an important role enhances the aesthetic value of the Wadden Sea. It has stimulated such famous novels as The Dyke Master by Theodor Storm and The Riddle of the Sands by Erskine Childers, as well as the world-known expressionist paintings by Emil Nolde. Childers and Nolde capture the very beauty of the “sands”, the extended tidal flats and the silence and the awe under storm.

History of ecological changes

Large terrestrial mammals (e.g. aurochs, elk, bear) and birds (pelican, flamingo) were hunted during the earliest human occupation in the Wadden Sea and elsewhere in Europe and finally disappeared. During medieval and modern times, a gradual decline of waterbirds (e.g. herons, cranes, spoonbills, cormorants, ducks and geese) and marine mammals (e.g. grey seals, large whales) is assumed to have been caused by hunting. Large diadromous fish (e.g. sturgeon, salmon), groundfish (e.g. haddock, cod, rays) and oysters declined because of intensive fishing. This trend culminated in the nineteenth and twentieth centuries. The commercialization and intensification of exploitation inside and outside the Wadden Sea Area was a major driver for declines. This became obvious with the onset of protection programs for birds and seals in the twentieth century, which have resulted in a striking increase of populations.

For species depending on wetlands, river or estuarine habitats, habitat loss, destruction and degradation also played a significant role in declines. At the end of the twentieth century, 144 species (~20% of total macrobiota) were listed on the Trilateral Red List of threatened species for the Wadden Sea Area. Of these, 21 species were considered extinct in the twentieth century, while another four species had become extinct in earlier centuries. Habitat loss was considered to be the most important factor, particularly in extinctions of invertebrates and plants. Exploitation is assumed to be second in importance and has mostly affected vertebrates.

Dune areas on the barrier islands have been affected by stabilization for coastal defence purposes and by eutrophication. Some wet dune slack became affected by groundwater extraction. More significant have been livestock grazing, pine plantations and the spread of introduced non-native species. Most notably are Pinus spp. and Rosa rugosa in grey and white dunes. The American cranberry Oxycoccus macrocarpus dominates in some dune slacks. In dry dunes with scarce vegetation a southern-hemisphere moss Campylopus introflexus is taking over. The cranberry and the moss seem to be competitively superior to native vegetation, while the Asian rose and various alien shrubs and trees took benefit from anthropogenic alterations in the dune environment. Also, the introduction of rabbits affected dune vegetation as has their recent population decline. Management attempts are underway to reverse some of these developments and to restore previous dynamics.
In the course of eutrophication, developments in phytoplankton, green macroalgae, and benthic macrofauna have been attributed to changes in nutrient and food supply to the coastal waters. A decline in intertidal seagrass beds may have been indirectly caused by reactive nitrogen enhancing epiphytic algae. In recent decades, riverine loads of nutrients have been declining but are still above pre-industrial levels. Respective changes have been observed in phytoplankton, but this may have been confounded by effects of climate change.

In the 1930s, seagrass became infected by an epidemic disease and the subtidal meadows never recovered. Up to now, 52 aquatic plants and invertebrates, brought from overseas with shipping and aquaculture, have become established in the Wadden Sea Area. This has not yet caused any extinctions of native species. However, most notably the cordgrass (Spartina anglica), which was planted into the Wadden Sea Area in the 1920s, and the Pacific oyster (Crassostrea gigas), introduced in the 1980s, do replace native species and have generated novel habitat structures in the Wadden Sea. Other exotic species also have become highly abundant, sometimes only intermittently and in other cases facilitated by climate change, i.e. warmer summers and milder winters since 1996. Apparently, each is filling an open opportunity which was available to their mode of life, e.g. the Japanese seaweed (Sargassum muticum), a bristle worm (Marenzelleria viridis), the American razor clam (Ensis americanus), the American slipper limpet (Crepidula fornicata) and the Australasian barnacle (Elminius modestus) among others. In contrast to oceanic islands, isolated mountain tops and lakes, coastal environments along continental margins such as the Wadden Sea are inhabited by biota which have had a long history of contest with immigrants and thus are less likely to be strongly affected by introduced species.

The overall effect of ecological long-term change on ecosystem structure and functioning has led to a simplification and homogenization. Conservation efforts have reversed negative trends by enabling some birds and mammals to recover. Many salt marshes have been relieved of heavy livestock grazing, and drainage furrows are restricted to areas necessary for protection and against flooding and maintenance of dikes. This has significantly diversified the vegetation. Still, the present extent of salt marshes is only a shadow of its past. Also, many dunes and shorelines have been strongly modified, and the invasions of exotic species cannot be reversed.

Protocols and managing the ecosystem

Since the beginning of the last century, smaller nature reserves have been established in practically all parts of the Wadden Sea, primarily to protect breeding birds. Though the importance of the Wadden Sea for birds had already been established, it was only after the Second World War that scientists from the three Wadden Sea countries documented the significance of the Wadden Sea as one of the important ecosystems world-wide. In the 1960s–70s, major projects and developments such as large scale embankments, harbour and industrial developments as well substantial increases in tourism and pollution constituted significant impacts on the Wadden Sea ecosystem. Scientists and non-governmental organizations, such as the WWF, the German “Schutzstation Wattenmeer” and the Dutch Wadden Society, which had been established in 1965 in protest of a Dutch dam project, strongly advocated a comprehensive protection and conservation of the entire ecosystem which could effectively tackle the negative impacts both from inside and outside the Wadden Sea. The small scale nature reserves were too limited in their scope and inadequate instruments to protect an entire ecosystem, they contended.

The Wadden Sea environmental movement was the major force which resulted in the designation of comprehensive protection schemes by the responsible authorities in the countries and in the establishment of a trilateral Wadden Sea cooperation to protect the Wadden Sea as an ecological entity. It all started in the 1970s with designation of considerable parts of the Wadden Sea as nature reserves. Around 1980, major conservation schemes were introduced in all three countries, leading to a comprehensive protection of the Wadden Sea. The Dutch part was made subject to a planning decree in 1980, setting out the conservation objectives and regulating human activities. In 1985/86, the two German states Schleswig-Holstein and Niedersachsen declared their parts of the Wadden Sea national parks. The designations have since been amended and extended but the main traits of the conservation schemes introduced a generation ago have been maintained.

The Wadden Sea is further subject to a multitude of international designations. Most of the Wadden Sea Area has been designated Special Protection Areas under the Birds Directive and designated as habitat areas under the Habitats
Directive, which forms the Natura 2000 for the Wadden Sea. Further, most of the area has been designated as wetlands of international importance under the Ramsar Convention and Particularly Sensitive Sea Area by the International Maritime Organization.

In parallel, the three governments started a cooperation, with the aim of ensuring a coordinated protection of the Wadden Sea. The first trilateral Danish–German–Dutch Governmental Conference on the Protection of the Wadden Sea was held in 1978 in The Hague. The 10th Ministerial Conference was held on the Dutch island of Schiermonnikoog on 3 November 2005.

The formal basis of the Cooperation is the “Joint Declaration on the Protection of the Wadden Sea” signed at the Third Wadden Sea Conference in Copenhagen in 1982. The Joint Declaration is a declaration of intent of the three Wadden Sea countries to consult each other in order to coordinate their activities and measures to implement a number of legal instruments with regard to the comprehensive protection of the Wadden Sea region as a whole including its fauna and flora. In 1987, the Common Wadden Sea Secretariat was established to facilitate and support the Cooperation.

It is important to acknowledge that the trilateral cooperation is a political cooperation which aims at a coordinated implementation of relevant international legal instruments such as the European Union directives and strategies, the Ramsar Convention and the Convention on Migratory Species (Bonn Convention) in the field of nature and environmental protection for a comprehensive protection of the Wadden Sea. The ministerial conferences, which are held as a rule every 3-4 years, are the central decision making bodies for the cooperation.

Since 1997, the arrangements of the Wadden Sea Cooperation have been embedded in the framework of the Trilateral Wadden Sea Plan, which entails policies, measures, projects and actions agreed upon by the three countries. The Plan is a statement of how the three countries envisage the future coordination and integration of management of the Wadden Sea Area and of the projects and actions that must be carried out to achieve the commonly agreed Targets.

**Perspectives**

The economy of the Wadden Sea Area is likely to shift further from agriculture and fisheries towards tourism and, perhaps, to alternative energy in the form of wind, water and photovoltaic power, as well as biomass. Pollution and eutrophication is expected to decrease strongly as a consequence of European policy. Stemming the tide of unintentionally introduced species in the wake of globalization will be difficult.

Like all other coastal wetlands in the world, the Wadden Sea will be increasingly affected by global warming with a slow but inevitable rise in sea level. New species from southern regions will immigrate, some resident species will retreat towards northern regions, and introduced species adapted to warmer conditions will proliferate. Nevertheless, the Wadden Sea ecosystem may be expected to retain most of its unique composition and functioning, because coastal species are adapted to a wide range of temperature variation. A more serious threat is the long-term prospect of a rise in sea level on the order of one to two meters.
3. Justification for Inscriptio

Sediment ripples on the Wadden Sea mudflats (Photo: Jan van de Kam).

The Wadden Sea forms an interface between a continental riverine catchment area of about 400,000 km² on the landward side, and the North Sea and an Atlantic shelf to the west. The Wadden Sea contains a complex mosaic of sand and mudflats, tidal channels, salt marshes, seagrass meadows, mussel banks, sandbars and barrier islands extending over an area of some 14,000 km² where natural processes proceed in a relatively undisturbed manner.

The complex and dynamic mosaic of the natural phenomena formed by the geomorphological features and biologically rich and diverse habitats that constitute the Wadden Sea ecosystem forms one of the most dramatic and beautifully integrated landscapes and seascapes world wide.

3. a Criteria under which inscription is proposed

The Wadden Sea represents a natural system of outstanding universal value based on the following inscription criteria:

**Criterion viii:** “be outstanding examples representing major stages of earth’s history, including the record of life, significant on-going geological processes in the development of landforms, or significant geomorphic or physiographic features”

The Wadden Sea has evolved over the last 8,000 years being a very young ecosystem in geomorphological and evolutionary terms. It represents an outstanding example of the Holocene development of a temperate-climate sandy barrier coast under conditions of rising sea level. The Wadden Sea is unique in that it consists entirely of a sandy-muddy tidal system with only minor river influences on morphodynamics. The Wadden Sea ecosystem is characterised as tidal flats and barrier island system with extensive salt marshes. The Wadden Sea differs from other systems of this type in that it is the only tidal flat and barrier island depositional system of this scale and diversity in the World. There are no systems in the world that compare to the Wadden Sea.

An inherent feature of the system is the continuous change of the flats, the deeps and the gullies from the largest to the smallest fraction. The tidal-channel systems can be regarded as ‘statistical self-similar fractal’, i.e. the whole has the same shape as one or more of the parts networks and the similarity of the channel systems points to a self-organising nature. On smaller scales, fractal patterns are also found in the muddy deposits. These morphological variations are in the aesthetic perception compounded by the infinite tidal rhythm. Nowhere else can the dynamic interplay between the sea and land...
be experienced on such a scale and richness in forms. Nowhere else is there such a variety of natural features in a coastal area: the hugeness of the area; barrier islands with large differences in land and seaside; tidal area with an enormous differentiation, uninterrupted over many hundreds of kilometres with a highly dynamic system of deeps and gullies constantly changing; estuaries and tributaries debouching into the area; and large areas of salt marsh area along the coast with islands and Halligen. These natural features dominate the land and seascape and are accentuated by humanity’s constant struggle with the area for over a thousand year. It is this complexity of habitats and biotopes so intricately linked in an elaborate ecosystem that stimulates the observer with its superlative intricacy.

The Wadden Sea contains very fine examples of post-glacial coastal geomorphology and the dynamic interaction of physical and biological processes on a scale that is not found within one unified system anywhere else in the world. Despite man-made interventions the continuing presence of these dynamic natural processes ensures the development and rejuvenation of landforms including the whole range of habitats, and secures the maintenance of ecosystem functions. The Wadden Sea ecosystem will thus continue to serve as an important bio-physical reference for the study of the effect of sea level rise and it will be important to consider this function as a legitimate part of the World Heritage concept.

Although tides with lower mesotidal to macrotidal amplitudes dominate the morphological evolution of the Wadden Sea ecosystem, wind stresses and waves also play a major role in the morphology of the Wadden Sea ecosystem. The morphological succession of the wetland system commences with sand flats in the seaward sections, followed by mixed flats and finally mud flats along the mainland shore and in embayments. In contrast to other parts of the world, the tidal flats of similar systems are merely occupied by eelgrass meadows or Spartina here and there. The mobility of sediments has prevented basin-wide encroachments by upright growing vegetation in the case of the Wadden Sea. This has created the unique character of its seascape of mainly unvegetated shoals divided by an intricate fractal-channel pattern. This unique feature of the Wadden Sea is mentioned in many international textbooks as the example, par excellence, of extensive post-glacial meso to macro-tidal flat development.

There are also sedimentary features, such as naturally open barrier coasts consisting of dunes intersected by small overwash areas that are unique to NW-Europe. Another example is the unique sawtooth-shaped and swale topography along the barrier island coastline that is thought to be the result of near-shore wave/current generated resonance phenomena that form incised rip-current channels.

Excellent and broad scale examples of bio-geomorphological processes can be found in the coastal dunes, the channels, the tidal flats and the salt marshes. Because the Wadden Sea contains many different types of islands, sheltered and exposed dunes and subsequent sheltered and exposed types of salt marsh and green beaches there also is a great variety in vegetation types and communities.

The significant ongoing geological and geomorphological processes driving the development of landforms are continuously renewing the geomorphic features of the landscape and seascape within the lifespan of man. The Wadden Sea’s outstanding universal value is maintained through the strong hydraulic and aeolian dynamics that form the prominent morphological changes on a variety of spatial and temporal scales, from whole groups of inlet systems that influence each other over many centuries, down to the shifting of a sand ripple in the order of minutes. These morphodynamic adjustments are possible due to the fact that the Wadden Sea system can still react in a natural way to human influences, allowing it to evolve freely to a large degree.

The Wadden Sea attracted the interest of scientists from an early stage of scientific endeavour and is one of the earliest and best-studied depositional systems. As such it is an important international reference area for tidal flat system studies. Long-term depositional processes have led to the formation of a series of Holocene sedimentary deposits, which provide details of the development of the Wadden Sea and the regional climate in great detail. This has allowed geoscientists to establish comprehensive archives of documentary evidence of tidal processes, stratigraphy, sedimentary structures and sediment distribution patterns.

The biological systems and their interactions with geological and geomorphological processes in the Wadden Sea have also been studied in great detail over a similar long time. The comprehensive archives of bio-geophysical data form an historical record of the response of the Wadden system to sea level rise. These archives illustrate the ongoing processes and have formed the basis for numerous publications, maps, drawings, and other materials of immense value to the natural sciences and the
sustainable use of the Wadden Sea ecosystem, and form an international reference for comparative studies with other tidal wetland ecosystems and their response to global change.

The unique geomorphological character of the Wadden Sea also has direct links to other World Heritage themes such as “stratigraphic sites”. The Holocene stratigraphic records of the Wadden Sea form part of the overall geological inventory accumulated in the archives of numerous coastal research institutions. These invaluable and unique materials documenting the genesis of the Wadden Sea are unparalleled and form a universally important archive of the Holocene history of sea-level rise, climate, and depositional response.

The Wadden Sea is subject to sea level rise as a result of climate change and tilting of the earth’s surface. It has always been able to react in a natural way to relative rise of the sea level. Scientific opinion is that it will be able to respond to increased sea levels in the foreseeable future because the morphodynamic and biological processes that maintain the health and productivity of the ecosystem have the freedom to adapt. There are only very few areas worldwide where it is possible to experience the dynamic adaptation of bio-geomorphological processes within a generation.

An expert statement “The Outstanding Universal Value of the „Wadden Sea“: A Geological Perspective”, which in further detail substantiate the inscription under this criterion, is in Annex 01.

**Criterion ix:** “be outstanding examples representing significant on-going ecological and biological processes in the evolution and development of terrestrial, fresh water, coastal and marine ecosystems and communities of plants and animals”

The Wadden Sea is a unique coastal ecosystem with enormously productive marine biota and with linkages far beyond its narrow geographical boundaries. It is one of the last remaining natural large-scale inter-tidal ecosystems in Europe where natural processes continue to function in an undisturbed manner. Excellent and broad scale examples of biogeomorphological processes can be found in the coastal dunes, the salt marshes, and on the tidal flats on mussel beds and sea grass meadows. This transitional environment between land and sea is characterized by the constant change of flood and ebb tides, great fluctuations in salinity, high temperatures during summer and occasional ice cover in winter. These circumstances have created numerous ecological niches, colonized by species that are adapted to the extreme environmental conditions.

The Wadden Sea is an ecological transition zone between land and ocean. With its estuaries, marshes and particularly its wide intertidal zone intersected by deep gullies, the Wadden Sea functions as a gigantic coastal filter system. Freshwater and marine waters are mixed and flushed to and fro with the tides, transporting huge amounts of
sediments, organic matter and nutrients. These riverine and marine imports of materials form the basis of the trophic system. Imported organic material is mineralized in the marshes, tidal flats sediment and shallow waters. The release of nutrients from this spacious purification plant, together with those nutrients supplied from the catchment area and the Atlantic waters, fuels outstanding primary production. Due to the active biota, this filter never clogs but is continuously renewed.

Natural processes such as tides, wind, currents, waves and a series of biological processes occurring in a large area have resulted in the richness of geomorphological and biogenic structures. Due to the undisturbed presence of these processes, structures are not only conserved, but there are also rejuvenation cycles, creating new structures and breaking down old structures representing all stages of succession. Examples are the dunes and salt marshes that can be found in various stages of succession, and structured mussel banks, which are formed by a combination of growth and food depletion from the overlying water.

From a physical point of view, the Wadden Sea combines two extremes. The stability and rather dampened fluctuations in the physical properties of oceanic waters with their high heat capacity meets in the Wadden Sea the strong and rapid physical fluctuations of the terrestrial environment. The mix of these two regimes gives rise to the unique ecological character of the Wadden Sea when projected on the large expanses of the shallows and the flat land.

Due to the shallowness of the area and the transitional boundaries between land and sea, there is a strong interaction between biota and geomorphological processes, i.e. bio-geomorphology. The Wadden Sea morphology and geomorphological processes contain gradients between high and low, wet and dry, and sedimentation and erosion. These gradients and the processes that cause them, have a direct influence on gradients in grain size of the sediment, nutrient levels, organic matter levels and moisture. Plants and animals are tuned to specific conditions and will therefore be abundant in specific locations. The geomorphological influence on biota is most direct in respect to inter-tidal habitats and their flora and fauna. Conversely, the biological influence of biota on geomorphological processes creates, maintains, or transforms their own geomorphological surroundings. This is demonstrated by the influence of vegetation on the hydraulic resistance, erodibility and sedimentation, or by the influence of fauna on sediment characteristics through bioturbation and bio-stabilization.

The Wadden Sea forms an outstanding example in which biogeomorphological interactions are clearly demonstrated in the shallow, productive waters and various sedimentary environments. Important in this respect is that the Wadden Sea has many examples in which the timescale for geomorphological changes coincides with the timescale for biological changes. This results in mutually interacting processes. Unlike other areas in the world, landscape processes are not domi-
nated by geological timescales nor do biological processes dominate landscape features. This means that the constantly changing landscape requires adaptation of organisms and at the same time that organisms affect their environment as ‘ecosystem engineers’. Excellent and broad scale examples of these biogeomorphological processes interactions can be found in the coastal dunes, the tidal flats and the saltmarshes. Of particular interest are for example the intertidal mussel beds. These form a biogenic structure that has considerable influence on the morphology of the tidal flats; they stabilize the sediment, preventing it from erosion and actively accrete silt. The numerous macrobenthic species can have an opposite effect. Their constant reworking of the sediment (bioturbation) makes the seabed more susceptible to erosion. Saltmarshes form another example in which the capturing of sediment increases the bed level, which leads to changes in vegetation composition and subsequent changes in sedimentation rates.

The Wadden Sea provides a multitude of transitional zones between land, the sea and freshwater environment, which is the basis for species richness. Among these organisms, there is a high degree of ecological specialization. On the tidal flats, the microbiota is highly diverse too, while only a few species of macroflora and macrofauna are adapted to the extreme environment. Of these, however, exceptionally high numbers and biomass can be found. The high productivity is most significantly demonstrated with respect to fish, shellfish, and birds.

The productivity of the Wadden Sea in terms of biomass is one of the highest in the world. A special feature of the Wadden Sea is that primary production is dominated by microscopic algae that cover the sediment surface of the tidal flats as microphytobenthos and drift in the shallow coastal waters as microphytoplankton. In spite of turbid waters, the periodic tidal exposure and shallowness guarantees sufficient light for photosynthesis. The gross primary production by microphytobenthos is the highest in the world for locations north of 42° latitude. The contribution of microphytobenthos to the primary production is about as high as the local primary production by planktonic algae.

The very fact that most photosynthetic production is generated in the form of unicellular algae allows for highly effective consumption. These miniature plants are more readily consumed by invertebrate herbivores than larger plants. As a result of this high production of easily consumable benthic and planktonic food, the biomass of marine invertebrates on the tidal flats is on average 20 times higher than offshore benthic systems in the North Sea. This is what makes the Wadden Sea tidal zone so attractive to secondary consumers from outside, and explains the dense swarms of shrimp and small fish and the spectacular flocks of birds that congregate there.

The Wadden Sea is an integral part of the North Sea, one of the few shallow and relatively sheltered seas in the Northern Hemisphere and one of the most highly productive fish grounds world-wide. The Wadden Sea plays an important role in this high productivity. As a shallow sea, the benthic-pelagic coupling is notably strong, and the primary production and secondary production are high. This production forms a foundation to the intricate food web that ultimately results in an important nursery area for fish, a foraging and resting habitat for seals, and a foraging habitat for waders and other waterfowl, which are of international importance. For aquatic consumers, the shallow waters of the Wadden Sea serve as a vast nursery. Plenty of food, benign higher temperatures in the shallows than further offshore in spring, and the absence of large predaceous fish where the water level fluctuates with the tides, all of these contribute to a high turnover of nurseries. The Wadden Sea is an important nursery area for sole (Solea solea), plaice (Pleuronectes platessa) and dab (Limanda limanda). They grow up rapidly in spring and summer, and leave the Wadden Sea towards offshore waters when the cold seasons commence. For some fish that commute between inland waters and the open sea in the course of their life cycle, the rich food sources of the Wadden Sea constitute an important intermediate staging area. Good examples of diadromous fish species are flounder (Platichthys flesus), smelt (Osmerus eperlanus) and eel (Anguilla anguilla). Marine organisms manage to dominate the entire tidal zone. The plentiful supply of materials from land and ocean allows the marine food web to provide ample food for the waders, gulls and ducks. Migrants support or exploit distant ecosystems along the East-Atlantic flyway. In addition, there are birds that exploit the Wadden Sea in winter. Similar long-distance links apply to fish and some crustaceans.

The birds feed primarily on the extensive sediment flats during low tide exposure. Some species also exploit the marshes and other dive in the gullies for food. Although the availability of the food is crucial, it is more than just high benthic biomass that supports the enormous number of...
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birds. Food availability may be highly variable at a particular site, depending on weather, disturbances and competitors, however the vast size of the continuous tidal area secures sufficient alternatives if one site fails. Another important factor that is sustaining the large populations of birds are abundant nearby resting and moulting areas, usually on sand bars and islets remote from any human disturbance. This aspect is also of primary importance for the seals, using the Wadden Sea as a nursery and resting area.

The present form of the Wadden Sea is mainly the result of natural forces. There may be other coastal areas with similar ecosystem functions, but none comes close to the Wadden in terms of such a large and coherent area of inter-tidal habitats of such high diversity.

An expert statement “The Outstanding Universal Value of the “Wadden Sea”: An Ecological Perspective”, which in further detail substance the inscription under this criterion, is in Annex 02.

Criterion x: “contain the most important and significant natural habitats for in-situ conservation of biological diversity, including those containing threatened species of outstanding universal value from the point of view of science or conservation”

The tidal flats in the Wadden Sea form the largest unbroken stretch of sand and mudflats worldwide, accounting for 60% of all tidal areas in Europe and North Africa. As such it is ‘the only one of its kind’ and many textbooks refer to the Wadden Sea when describing inter-tidal habitats and the rich and diverse flora and fauna they sustain. The tidal flats and the salt marshes form the largest coherent habitat of this type in Europe and constitute an essential element of the Wadden Sea ecosystem.

The Wadden ecosystem represents one of the internationally most important wetlands. It is internationally recognised as a biologically highly productive ecosystem of great natural, scientific, economic and social importance.

The Wadden Sea is extremely rich in environmental gradients and transitional zones, yielding many different (micro) habitats that form the basis for ecological specialization under extreme conditions. The salt marshes host about 2,300 species of flora and fauna. The marine and brackish areas support a further 2,700 species. In total it is estimated that the Wadden Sea Area provides habitats for up to 10,000 species of unicellular organisms, plants, fungi and animals.

The large size of the Wadden Sea allows the diverse species to survive by spreading over several habitats, or by adopting a series of niches over the course of time. This constantly opens up territory for use by other individuals or species, and accounts for a high capacity to accommodate migratory species.

The marine deposits remain permanently flooded (subtidal) or are either periodically (intertidal) or episodically (supratidal) flooded by marine and brackish waters or in some cases even freshwater. Terrestrial soils range from very wet to extremely dry in the coastal dunes. High temperatures during summer and occasional ice cover in winter, and above all powerful storms with heavy rainfalls create these highly variable ecological niches for life. Under such circumstances, most species have adopted an extreme versatility. Others have evolved a high degree of specialization to survive the extreme environmental conditions. A high degree of endemism is not a characteristic of coastal wetlands. They are all relatively young and are interconnected by the flow of water which prevents the genetic isolation of populations. The outstanding feature of the Wadden Sea is the complex mixture of species from a wide array of regions and habitats as well as a mixture of residents, migrants and casual visitors, as well as high abundance of individuals instead of high biodiversity at least in the tidal flats.

The rich and diverse habitats are of outstanding international importance for birds as staging,
moulting and wintering areas. According to the 1% criterion of the Ramsar-Convention, which is an internationally recognized measure to identify wetlands of international importance, the Wadden Sea is of outstanding international importance as a staging, moulting and wintering area for at least 52 populations of 41 migratory waterbird species that use the East Atlantic flyway and originate from breeding populations as far away as northern Siberia or Northeast Canada. Numbers of 44 populations of 34 species are so high, that the Wadden Sea is indispensable and often main stepping stone during migration, or as their primary wintering or moulting habitat. Therefore the Wadden Sea is essential for the existence of these bird species. A severe deterioration of the Wadden Sea implies a biodiversity loss on a worldwide scale.

Adding up the numbers, results in a maximum of some 6.1 million birds present at the same time in the Wadden Sea. Each year on average 10 to 12 million birds migrate back and forth between their breeding grounds in Siberia, Scandinavia, Greenland and Northeast Canada and their wintering grounds in Europe, Africa and even further South. Most species reach highest numbers during autumn migration; numbers of waders are almost as high during spring, whereas ducks and geese over-winter in high numbers; only gulls reach considerable numbers in summer. Almost the entire population of the dark-bellied brent goose (Branta b. bernicla) and the entire West-European population of dunlin (Calidris alpina) use the Wadden Sea during several periods of the annual cycle. Without the Wadden Sea their populations would suffer heavily. Additional seven species are present with more than 50% and further 14 species with more than 10% of their flyway population. Wadden Sea areas including the coastal zone of the adjacent North Sea are used by high numbers of moulting Shelduck (Tadorna tadorna) and moulting and wintering eider (Somateria mollissima).

Although bird migration is a global natural phenomenon that cannot be associated to a single site, the Wadden Sea is a vital and irreplaceable stepping stone that is considered a critically important ‘mega-site’ for bird migration. It is not just one of several stopover sites on the East-Atlantic flyway, but it is the essential stopover.

The millions of migratory birds, which pass through the area in spring and autumn and in huge flocks convey a scenic depth to the area which can be seen nowhere else on this scale, enhance the exceptional beauty and perceptive value of the area. This reinforces the unique relationship between the high aesthetic qualities of the land and seascapes and the extraordinary ecological features of the area.

The Wadden Sea is an important reproduction area for more than 30 species of breeding birds. For 5 species, at least 25% of northwestern European populations breed in the Wadden Sea. The ecological support for resident and migratory birds is of outstanding universal scientific value because the study of migration can only be executed on this large scale in the Wadden Sea.

The Wadden Sea may be considered of lesser importance as a permanent home for rare or endangered species. However, when the large population and variety of different mammals, birds, fish, crustaceans, molluscs and other animals as well as plants that are sustained by the Wadden Sea’s ecosystems are considered, the Wadden Sea plays a very important role as a habitat of great international significance.
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The Wadden Sea also constitutes a refuge in the life cycle for those species that have lost their inland habitats e.g. northern lapwing, redshank and black-headed gull. Without the Wadden Sea, several European bird populations would be endangered or even lost. The Wadden Sea is also an essential staging area for fish migrating between rivers for spawning and the oceans for feeding or vice versa. These fish could not complete their life cycles without the nutritious habitats of the shallow Wadden Sea. This also applies to many fish and invertebrates that rely on the tidal zone as a nursery and spend their adult life further offshore.

A unique feature of the Wadden Sea harbour seals is that they rely on the Wadden Sea tidal sandflats for resting and whelping. Their resting habitat disappears during high tide and, therefore, their behaviour is completely adapted to these conditions. The Wadden Sea sustains approximately 20% of the world-population of harbour seals (some 15,000 individuals in 2006) that belong to a sub-species (Phoca vitulina vitulina), which is found mainly in UK, Icelandic, Norwegian and Wadden Sea waters. In recent years, grey seals started to re-establish themselves in the Wadden Sea, first a haul-out rookery off the German Island of Amrum, followed later by a few rookeries in the western part of the Dutch Wadden Sea. The most important calving and nursing site for the harbour porpoise (Phocoena phocoena) population of the central North Sea is off the coast of the Wadden islands Sylt and Amrum.

Overall, after centuries of extensive exploitation in the Wadden Sea, protection measures have triggered a striking comeback in many of the resident bird species and also of seals, which have shown a very good recovery within the last three decades, and also after the two virus epizootics in 1988 and 2002. Hunting of seals was stopped in the seventies and essential habitats are kept free from human disturbance.

The expert statement in Annex 02 also in further detail substances this criterion.

3.b Proposed statement of outstanding universal value

The Wadden Sea forms the largest unbroken system of tidal sand and mud flats worldwide with natural dynamic processes proceeding in a widely unimpaired natural state. It is one of a kind on earth. The Wadden Sea ecosystem represents one of the most important international wetland habitats that provide the basis for exceptional high biological production, species diversity and a high degree of ecological specialization and potential for adaptation.

It is an outstanding example of the ongoing Holocene development of a sandy coast under conditions of rising sea level and is unique in that it is the largest extensive tidal flat and barrier island depositional system in the World. Its geological and geomorphological features are closely entwined with biophysical processes and provide an invaluable record of the ongoing dynamic adaptation of coastal environments to global change. The biogeomorphological interactions are notably strong and unique at all scales.

The high primary and secondary production in the Wadden Sea sustains species of birds, fish and crustaceans and seals well beyond its borders. The rich and diverse habitats are of outstanding international importance as an essential habitat for migratory water birds using the East Atlantic Flyway and other migration routes between South Africa, Northeast Canada, and northern Siberia. It is one of the few shallow seas in the Northern Hemisphere with a high production of fish and serves as an essential spawning, feeding and nursery area for species migrating between freshwater and saltwater.

The mosaic of natural phenomena including the complex geomorphological features and biologically diverse and rich habitats, the unparalleled vastness and expanse in terms of the spatial dimension and the millions of migratory birds passing through in spring and autumn combine to form an exceptional and beautiful land and seascape.

The nominated property encompasses all the biophysical and ecosystem processes that characterise a natural and sustainable Wadden Sea. The standards of protection, management (including coastal protection measures) and monitoring ensure that the natural Wadden ecosystem, with all its component parts, will continue to evolve naturally and to sustain human uses. Man’s use of the natural resources in a sustainable way including small-scale traditional uses is a key to help guarantee its integrity for generations to come.
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3.c Comparative analysis (including state of conservation of similar properties)

As outlined in the previous chapters, the Wadden Sea is an extensive coastal tidal and mudflat system. The Wadden Sea mudflats are characterised by their location in tidal inlets of barrier islands. They contain a sequence of large and small ebb and flood gullies and their energy gradients follow from the morphology. The Wadden Sea is a mesotidal barrier island system that only has minor river influences fringing the flat and low-lying coastal plain. In accordance with the Operational Guidelines a comprehensive comparative analysis has been made of similar properties which is in Annex 03.

By comparing the Wadden Sea with the currently 31 listed World Heritage sites with significant marine components and the 24 World Heritage coastal island sites with no (or insignificant) marine areas it becomes apparent that there is only one listed property which the Wadden Sea compares with, and that is the Banc d'Arguin in Mauritania.

44 non-listed sites have been selected for the comparative analysis of a list of 350 intertidal mudflats world-wide. These 44 non-listed sites are mudflats larger than 300 km². An overview of these sites, their size, coordinates and types is in Table 1 of the comparative analysis in Annex 03.

As outlined above the Wadden Sea is a mesotidal barrier island system that only has minor river influences fringing the flat and low-lying coastal plain. Most of the mudflat systems in the world are connected to estuaries and bays. Some are connected with barrier islands that are closely related to rivers and their deltas, such as the Mississippi delta. Only 5% of these deltaic barrier islands are found in North America and Europe, due to differing sea level rise history. A further criterion, therefore, is the presence of barrier islands that do not have a river delta origin. Of all mudflat sites larger than 300 km² this results in one comparable area: The Georgia Bight.

The primary features of the two comparable properties, Banc d'Arguin and the Georgia Bight according to the criteria under which the Wadden Sea is nominated, are listed in Table 3.1. It should be acknowledged that the criteria and the associated features are to be considered integral features of the whole range of geomorphological and biophysical processes and interactions.

The Banc d'Arguin is a relic of former river deltas, which once flowed from the central Saharan basin to the Atlantic (indeed the Banc d'Arguin has been called “a warm Wadden Sea”). Bird numbers recorded at the Banc d'Arguin easily reach the millions. Both are large tidal areas and extraordinary productive ecosystems supporting a rich fish fauna with varied populations of piscivorous breeding birds. They both support huge populations of migratory waterfowl on the East Atlantic Flyway, thus being strongly linked to each...
### Table 3.1: Features of the Wadden Sea, Banc d’Arguin and Georgia Bight according to the criteria viii, ix and x.

<table>
<thead>
<tr>
<th>Features</th>
<th>Criteria</th>
<th>Wadden Sea</th>
<th>Banc d’Arguin</th>
<th>Georgia Bight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation WH</td>
<td></td>
<td>To be nominated</td>
<td>1989 under criteria ix and x</td>
<td>–</td>
</tr>
<tr>
<td>Country</td>
<td></td>
<td>Germany / Netherlands</td>
<td>Mauritania</td>
<td>USA</td>
</tr>
<tr>
<td>Climate zone</td>
<td></td>
<td>Temperate</td>
<td>Continental, arid sub tropics, dry</td>
<td>Temperate</td>
</tr>
<tr>
<td>Description setting</td>
<td></td>
<td>Mixed energy to tide dominated mesotidal barrier coast (not deltaic)</td>
<td>Back barrier islands and open mud flats, relic of former deltas</td>
<td>Mixed energy to tide dominated mesotidal barrier coast (not deltaic)</td>
</tr>
<tr>
<td>Total area</td>
<td></td>
<td>10,000 km²</td>
<td>12,000 km² (50% marine)</td>
<td>8,000 km²</td>
</tr>
<tr>
<td>Mudflat area</td>
<td></td>
<td>4,500 km²</td>
<td>630 km²</td>
<td>300 km²</td>
</tr>
<tr>
<td>Tidal differences / range</td>
<td>viii</td>
<td>1.5 – 3.5 m</td>
<td>2.1 m</td>
<td>0.8 – 2.5 m</td>
</tr>
<tr>
<td>Mean wave height/ range</td>
<td>ix / x</td>
<td>1.0 – 2.0 m</td>
<td>1.4 m</td>
<td>0.6 – 1.0 m</td>
</tr>
<tr>
<td>Contiguous character</td>
<td></td>
<td>Large and contiguous area of intertidal habitats</td>
<td>Contiguous between Cap Timiris and Pointe Minou, isolated section at Cap Blanc</td>
<td>Not a contiguous intertidal system</td>
</tr>
<tr>
<td>Major estuaries</td>
<td></td>
<td>5 estuaries</td>
<td>0 estuaries</td>
<td>13 estuaries</td>
</tr>
<tr>
<td>Productivity</td>
<td>ix</td>
<td>Primary production (gC/m²/y): phytoplankton 100-200; microphytes 150; seagrass 500; macrophytes 500-1,000</td>
<td>Primary production (gC/m²/d): phytoplankton 2.1-8.9</td>
<td>Primary production (gC/m²/y): phytoplankton 200-400; microphytes 60; seagrass 150-700; macrophytes 800-2,000</td>
</tr>
<tr>
<td>Habitats, biotopes</td>
<td>ix / x</td>
<td>Complex mosaic of bare intertidal flats fringed by saltmarshes, tidal channels, seagrass meadows, mussel beds</td>
<td>Sand dunes, coastal swamps, small islands, intertidal areas with 80% seagrass cover</td>
<td>Tidal channels with narrow band of bare intertidal flat. Intertidal almost completely covered by <em>Spartina</em> and <em>Juncus</em> saltmarshes</td>
</tr>
<tr>
<td>Salt marshes</td>
<td></td>
<td>310 km²</td>
<td>591 km²</td>
<td>4,237 km²</td>
</tr>
<tr>
<td>Mangroves km²</td>
<td></td>
<td>None</td>
<td>31 km² <em>Avicennia africana</em></td>
<td>Some mangrove <em>Avicennia germinans</em></td>
</tr>
<tr>
<td>Migrating birds</td>
<td>x</td>
<td>6.1 million present at the same time; on average 10 to 12 million each year; East Atlantic Flyway</td>
<td>2.1 million overwintering birds (106 species); East Atlantic Flyway</td>
<td>Important stop-over for millions of migrating birds; West Atlantic Flyway</td>
</tr>
<tr>
<td>State of conservation</td>
<td></td>
<td>Subject to a comprehensive international, trans-boundary and national protection and management system, RAMSAR site, FSSA by IMO, MAB by UNESCO, EU Natura 2000, EU WFD, contracting party of African-Eurasian Waterbird Agreement (AEWA)</td>
<td>RAMSAR site, National Park, has Fondation Internationale du Banc d’Arguin (FIBA) as management authority, not contracting party of AEWA</td>
<td>Not contiguously protected. Two Western Hemisphere Shorebird Reserves, Carolinian-South Atlantic MAB, no RAMSAR sites, no FSSA.</td>
</tr>
</tbody>
</table>
other and constituting the key feeding and resting areas on this flyway.

There are also significant differences. The marine area included in the property is only half of the listed property (6,000 km²) and only a very small part of that area – about 10% (630 km²) – is intertidal area. The Banc d’Arguin does not have barrier islands. Furthermore, the area is located in another climatic zone, the tropics, making it very different from the Wadden Sea in terms of the governing processes.

The Georgia Bight (also named South Atlantic Bight) extends for a distance of 1,200 km between Cape Hatteras in North Carolina to Cape Canaveral in Florida. Both, the German Bight as well as the Georgia Bight are mesotidal barrier coasts that fall within the mixed energy / tide-dominated classification and both have a coastal development affected by Holocene sea level rise.

The major difference between the Georgia Bight system and the Wadden Sea is that the Wadden Sea has open intertidal flats fringed by salt marshes, whereas the tidal basins along the Georgia Bight comprise tidal channels, narrow intertidal flats fringing the channels, and huge expanses of Spartina marsh which occupy what would otherwise have been open intertidal flats. The reason why Spartina has managed to encroach upon the former tidal flats is the large supply of mud (grain sizes <0.063 mm) to the coast by the local rivers. As a consequence, vertical accretion along the fringes of the marsh was so rapid that Spartina was able to occupy almost the entire intertidal area. The Georgia Bight tidal system thus looks very different from the Wadden Sea and also differs substantially in its ecology.

In conclusion, the Wadden Sea is to be regarded as of outstanding universal value compared to similar areas world-wide.

Parts of the Wadden Sea have been managed for hundreds of years to control flooding and to reclaim areas in particular to form agricultural lands. Despite some reduction in the areal extent of the ecosystem, these management interventions have maintained its natural dynamic processes and ecological functions. Over the past twenty years there have been enhanced efforts to protect and manage the Wadden Sea ecosystem in a sustainable way. There now exists a system of complementary national and international protection and management schemes that have produced remarkable results. The adverse impacts of pollution and input of nutrients to the area have been substantially reduced. The Wadden Sea in spite of its location on the rim of one of the most developed parts of Europe has maintained all the features that belong to a natural and sustainable ecosystem of outstanding international value.

In comparison to the other two areas, the Wadden Sea stands out as a remarkably well-conserved ecosystem. Comparing the Wadden Sea with the Great Barrier Reef in Australia is by no means fanciful in this respect. Both areas are incomparable to other systems and subject to a comprehensive protection scheme and ecosystem management.
3.d Integrity

The nominated property comprises all the habitat types, including all features and processes that belong to a natural and dynamic Wadden Sea. The offshore area encompasses the barrier islands and constitutes a coherent geomorphological system that is linked to the inter-tidal processes and systems. It includes the tidal inlets between the islands with their highly dynamic sediment transport and constantly migrating sandbars. The area is important for young fish and foraging and moulting ducks, for seals and harbour porpoises. The islands and salt marshes form a unique habitat for vegetation, especially adapted invertebrates and breeding bird species. The tidal area of the Wadden Sea system encompasses the tidal flats and the subtidal area and is characterized by an ever-changing pattern of gullies and flats.

The property includes all areas that are essential for maintaining the whole range of geomorphological processes that ultimately determine the biophysical, ecological and biological processes that are essential for the long-term conservation of the ecosystem and the biodiversity of the property. The Wadden Sea property is the singular most important coastal tidal area worldwide. Its importance is signified by its central role for migratory birds on the East Atlantic Flyway. Notwithstanding the human induced impacts on and modification of the property within in particular the last two generations, the Wadden Sea ecosystem contains all the elements that distinguishes it as a complete ecosystem in which the physical, ecological and biological processes continue to proceed to a wide extent in an undisturbed way. These same processes have created the beauty of the property, which is so highly regarded throughout the region.

The tidal flats are inhabited by a very rich and productive flora and invertebrate fauna associated with mussel beds and sea grass. The salt marshes form the upper part of the intertidal zone and are home to high concentrations of plant and invertebrate species of which many are endemic. The salt marshes also form important resting, breeding and feeding grounds for many bird species. The estuaries are characterized by high variability and are dynamic. They form an essential transition zone between the freshwater, brackish and the tidal area, and therefore form an important habitat for specialized species. They have been included in the property to only a limited extent since they are gateways to the harbours in the Wadden Sea region and in many cases represent a highly modified habitat type.

The nominated property has sufficient size to contain a functional coherence. Morphodynamic processes can take place without restrictions. Biological processes, which depend on and affect geomorphology can be found on many spatial and temporal scales, from seasonal microphytobenthos mats gluing the sediment together to salt marshes raising the sediment level and growing with sea level rise. Because of the size, the length and the different conservation regimes most of the natural biotopes of the barrier island salt marsh and tidal flat system still exist. Especially the mutual dependency of biotopes and habitats and completeness of the entire system can be found in the Wadden Sea. The quality of the area for migrating birds also is partly the result of its large size, which makes it easier to retreat to other parts of the area when locally the conditions are less optimal. The nominated property hence includes all elements necessary to express its outstanding universal value.

The nominated property furthermore comprises almost the entire Wadden Sea ecosystem and is hence of adequate size to ensure the complete representation and conservation of its essential features and processes which maintain its unique character and outstanding universal value.

The property is subject to a comprehensive ecosystem protection and management. It enjoys the highest protection status according to national nature protection legislation in the two countries. The entire German part of the property has been designated as national parks since the mid 1980s, and the Dutch part is subject to a national planning decree, which stipulates protection in conjunction with sustainable use of the Wadden ecosystem. Furthermore, the property is subject to protection under the European Union environment legislation, which has been transposed into national legislation. As a result of the designations under to the EC Birds and Habitats Directives the property is part of the European Natura 2000 network of protected areas.

Measures taken under to the EC Habitats Directive are directed at maintaining and restoring habitats and species at a favourable conservation status. The EC Habitats Directive, Article 6 (3) further stipulates that: "Any plan or project .......likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site's conservation objectives."
The competent national authorities shall agree to the plan or project only after having ascertained
that it will not adversely affect the integrity of the site." Article 6 (4) of the Directive stipulates that a plan or project, that will adversely affect the site, will only be permitted for imperative reasons of overriding public interest and in the absence of alternatives and only in combination with compensatory measures. It is worthwhile emphasizing these provisions because they legally codify that a prime objective is to maintain and advance the integrity of the site in terms of the sites conservation objectives.

Most of the Wadden Sea property has been designated as a natural water body. The EU Water Framework Directive applies to the Wadden Sea and will help ensure the maintenance of its sound ecological status by 2015. It is expected that the forthcoming Marine Strategy Directive will help to underpin the measures taken according to the foregoing EU Directives.

In addition to these designations the Wadden Sea is further subject to designation as a Wetland of International Importance under the Ramsar Convention and as a UNESCO Man and Biosphere Reserves. This constitutes a further international recognition of the nominated Site's international significance.

Since the 1970s the three Wadden Sea countries have cooperated in the protection of the Wadden Sea as one shared ecosystem. The guiding principle of the Wadden Sea policy and management as formulated in the Wadden Sea Plan is to achieve and maintain, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way. The policy and management measures are directed at maintaining the full-scale of habitat types, which belong to a natural and dynamic Wadden Sea. Environmental standards have been set for each of these habitats in respect to natural dynamics, absence of disturbance, and absence of pollution, which can be reached by proper conservation and management arrangements. The quality of the habitats shall then be maintained or improved by working towards achieving specified environmental targets for habitat types, concerning the quality of water and sediment, and for the conservation of birds and marine mammals. The common policies and management in relation to the specified targets are further specified in the Wadden Sea Plan 1997 which is currently being further developed.

The pollution resulting from the input of nutrients and hazardous substances has been significantly reduced in the past 10 years. Further measures will be taken according to existing and proposed legal instruments designed to achieve specified targets and to maintain a sound ecological status by 2015. The pollution resulting from operational discharges from shipping has likewise been reduced under the designation of the North Sea, including the Wadden Sea, as a Special Sea Area according to MARPOL, Annex I, II and V, and is reinforced by an extensive monitoring of any operational discharges. Shipping safety has been significantly enhanced during the last 10 years by the designation of traffic separation schemes in conjunction with the designation of the Wadden Sea as a Particularly Sensitive Sea Area (PSSA). Extensive contingency plans, including trans-boundary cooperation, are in place to deal with ship accidents.

The legal protection and the management of the property also aim to maintain the landscape values of the property such as the wide-open horizon. Infrastructure projects within the property are therefore to a wide extent banned. In the case of wind turbines there is a complete ban on the construction of such installations in the nominated area.

Anthropogenic influences are well regulated and a set of eco-targets has been agreed upon in 1994 and internationally based on the Esbjerg declaration. All resource use and other uses of the Wadden Sea have been regulated under a wide variety of legal measure that form the framework for protection of the area and through the overall high standards of the management system. All resource activities that have not been banned are subject to assessment and licensing in accordance with European legislation, including oil and gas development. It should be acknowledged that these assessments are applied to all activities and projects within and outside the property that may have a significant effect.

Some activities have been fully banned within the property such a mechanical cockle fishery and extraction of sand for commercial purposes. Certain areas have been designated as zero use or scientific reference areas where basically all resource use is prohibited, for example, no-take zones for the mussel fishery. They serve monitoring and research and form basic tools for the study of trends and support the maintenance of the integrity of the nominated property. Zoning is applied on a permanent or seasonal basis to regulate activities that could disturb birds and seals during critical periods of their lifecycle. Hunting is banned within the property with the exception of some of the inhabited islands where it is allowed, but heavily regulated, for a very short
Exemptions for wildlife management and pest control are possible.

Acceleration of sea level rise is a relatively new phenomenon that might potentially have a significant impact on the Wadden Sea in the coming centuries. The precise response of the Wadden Sea system, however, will depend to a large extent on local conditions and on the configuration of the tidal basins. Tidal flats and salt marshes are expected to be able to keep up with sea level rise due to faster sedimentation, at least up to a critical rate.

The safety of the inhabitants from flooding through appropriate coastal protection measures is and will be guaranteed in the future. Such measures have not and will not be compromised by the protection and management schemes. Other measures that are necessary for the safety of the area such as maritime traffic regulation infrastructure, the traffic within the area, drainage of the hinterland, public transport and the delivery of goods to the islands have and will be given priority in relation to the protection and management of the nominated Site.

The introduction of exotic species through the discharge of ballast water and aquaculture is a growing problem throughout the world. Controls are in place to minimise the introduction of exotic species, to monitor their effect, and to adjust quality standards and management measures in order to conserve present species assemblages. No species can be introduced into the nominated property e.g. for aquaculture without an assessment according to the Habitats Directive. Of some 52 known introduced species only six are considered to have a potentially strong effect on the composition of the existing biota in the Wadden Sea. These include: Cordgrass (Spartina anglica), Japanese seaweed (Sargassum muticum), Bristle Worm (Marenzelleria cf. viridisi), American razor clam (Ensis americanus), American slipper limpet (Crepidula fornicata), and Pacific oyster (Crassostrea gigas). These species differ in their effects, some of which may be of a dynamic character (i.e., sediment retention by Spartina, habitat provision by Sargassum, more food for birds by Ensis, displacement of seagrass by Spartina, competition to mussels by Crassostrea). Global warming may benefit Spartina, Crepidula and Crassostrea, resulting in changes in their dominance. Some introductions have become extremely numerous locally and then declined again, such as the bristle worm Marenzelleria. Its native biota has, however, had a long history of contact with immigrants.

In terms of harmonized international and national policies, management arrangements, and integrated environmental monitoring and assessment processes the Wadden Sea now after a generation of continued efforts enjoys a level of environmental protection and wise management that is unprecedented throughout Europe and other parts of the World. The current protection and management measures are designed to guarantee the sustainable use of the property and the integrity of the system including the ecological processes that maintain it.
4. STATE OF CONSERVATION AND FACTORS AFFECTING THE PROPERTY

4.a Present state of conservation

Information on status and developments in the Wadden Sea is compiled and assessed in regular Quality Status Reports which have the aim of assessing the implementation of the Wadden Sea Plan and providing a scientific assessment of the entire ecosystem. The recent Quality Status Report (QSR 2004) was published in preparation for the Trilateral Governmental Conference in 2005. The information in this chapter is based on the QSR 2004, supplemented with information that has become available since the QSR 2004 was issued.

The Wadden Sea Quality Status Report (QSR) 1999 is in Annex 07 and the Wadden Sea Quality Status Report (QSR) 2004 is in Annex 08, both as separate volumes.

Habitats and habitat developments

Offshore area

The Wadden Sea Plan aims for an increased natural morphology and favourable conditions for birds and marine mammals in the offshore area. The offshore area in the nominated property is located off the Wadden islands of the German part and extends up to 12 nautical miles into the North Sea to a water depth of 10 to 20 m. The area is subject to nature conservation under national and EU legislation.

The offshore area is characterized by high natural dynamics and is interlinked with the Wadden Sea ecosystem (see Chapter 2). The sediments of the seabed of the offshore area and of the channels and tidal flats in the Wadden Sea form a coherent ‘sand sharing’ system, thus allowing natural sediment transport along the coast and into the Wadden Sea. There is no evidence of any negative impacts on the natural dynamics of the geomorphology in the offshore area.

Birds

In the Wadden Sea offshore area, nine coastal bird species occur in numbers which are of international importance (Tab 4.1). Many of these coastal birds use the offshore area as foraging areas, such as the sandwich tern (Sterninae) which feeds on sand eel up to 15 km from the breeding colonies, and the great black-backed gull (Larus marinus).

Off the North Frisian islands (at water depths of 2 – 10 m), large concentrations of common scoter (Melanitta nigra) occur, most of which leave from there for their northern breeding grounds.

Among the marine bird species, guillemot (Uria aalga) and razorbill (Alca torda) occur in areas...
with water depths larger 10 m all over the entire North Sea in numbers of 2,000 – 3,000 individuals, but also use the coastal zone. The most common diver, the red-throated diver (Gavia stellata), occurs with about 36,000 individuals in the offshore area between the 4-26 m depth line.

**Marine mammals**

The offshore area is also an important area for marine mammals. Recent surveys indicated that harbour seals use the offshore area and the adjacent North Sea to a larger extent than known before. Harbour porpoises are distributed over the entire North Sea but show significantly high densities off the coast of Schleswig-Holstein within and outside the nominated property. The offshore area of the nominated property off the islands of Sylt and Amrum has specifically been designated as a whale protection area and extends up to 12 nautical miles.

**Tidal area**

The tidal area between the mainland and the islands covers the intertidal flats and the subtidal areas and is characterized by a high degree of natural dynamics: the positions and structures of tidal channels, shoals and emerging sand banks are changing continuously. The entire tidal area is subject to nature conservation by national and EU legislation. It is also covered by the trilateral Wadden Sea Plan, which aims for a natural dynamic situation and increased geomorphologically and biologically undisturbed areas in the tidal area. In addition, targets for blue mussel beds, seagrass beds and Sabellaria reefs have been formulated.

The tidal area in the Netherlands and Germany has a total size of about 6400 km², of which about 4700 km² consists of intertidal flats (mud and sand flats). The total area of the intertidal flats is almost the same as in the mid 1980s. Since then, no further embankments have been carried out. However, there seems to be a general depletion of fine-grained material close to the mainland coast due to hydromorphological changes as a combined result of land reclamations in historic times (since 1600) and sea level rise.

**Seagrass**

The two seagrass species (Zostera marina and Z. noltii) are the only submersed flowering plants in the Wadden Sea. They provide habitat for various animals and food for brent geese and widgeon. The trilateral Wadden Sea Plan aims for an increased area and a more natural distribution and development of seagrass fields.

Subtidal seagrass beds of Zostera marina disappeared in the 1930s because of a disease (an infestation with the pathogenic protist Labyrinthula zosterae). A decline of intertidal seagrass (Z. marina and Z. noltii) was observed from the 1950s...
to the 1990s in the southern and central Wadden Sea. This decline seems to have come to a halt, and some slow recovery is evident. In the Netherlands, about 130 ha is observed, located mainly in the Ems-Dollard. In Niedersachsen, a complete survey in 2002 revealed a total area of 750 ha (with a main occurrence of 580 ha in the Jade Bay).

Today, intertidal seagrass beds are unevenly distributed with a major occurrence (over 80%) in the northern Schleswig-Holstein Wadden Sea (about 6000 ha), because the decline was more prominent in the western parts of the Wadden Sea. Both *Zostera* species also show considerable fluctuations between years in the size and shape of local beds.

Eutrophication and changing hydrodynamics seem to be the overall variables determining seagrass distribution in the Wadden Sea, while positive effects of low salinity and negative effects of shellfish fishery and coastal protection works are of an important but more local relevance.

Figure 4.1: Area of seagrass in ha on intertidal flats in the Dutch Wadden Sea (seagrass bed coverage >5%) and the northern Schleswig-Holstein Wadden Sea (seagrass bed coverage >20%) (note the different x and y axes) (QSR 2004).

Blue mussel beds are subject to particular protection because of their biodiversity and special ecological significance. Therefore, fishery is regulated by management plans in the entire Wadden Sea (see chapter: resources / management). The trilateral Wadden Sea Plan aims for an increased area and a more natural distribution and development of natural blue mussel beds.

Naturally occurring blue mussel beds have thus been able to develop in the intertidal (Fig. 4.2). However, lack of recruitment since 1999 has caused deterioration and overall loss of biomass.

Spatfall is a crucial process in the population dynamics of blue mussels. The determining factors for spatfall are still not well understood, nor is the cause of regional differences in spatfall within the Wadden Sea.

Besides recruitment success, the impact of storms and ice cover is of major importance for the long-term development of blue mussel beds.

Figure 4.2: Area (ha) and biomass (t) of intertidal blue mussel beds in the Netherlands and Germany (Niedersachsen, Schleswig-Holstein), (no bars = no data).
Salt marshes

Salt marshes are the natural link between the land and the sea. They develop in close interaction between hydrodynamic processes and vegetation development. Salt marshes can be found on the barrier islands and Halligen, in the estuaries and along the mainland coast. During the last centuries, many salt marshes along the mainland coast were reclaimed, with subsequent creation of new salt marshes in front of the dikes, or were intensively grazed by cattle or sheep. Today, all Wadden Sea salt marshes are subject to nature conservation schemes by national and EU legislation, and they are also covered by the Wadden Sea Plan. The Wadden Sea Plan aims at an increased area of natural salt marshes, natural morphology and dynamics and an improved natural vegetation structure of man-made salt marshes.

The salt marsh area increased in most parts of the Wadden Sea during the past decades, mainly on the eastern parts of islands and in sheltered areas along the coast. The main increases were observed in Niedersachsen (about 2700 ha, 1966 – 1997) and in Schleswig-Holstein (about 700 ha, 1988 – 2001). The recent comprehensive inventory of all salt marshes based on regular complete vegetation mapping resulted in a total area of 31,070 ha in the nominated property (QSR 2004).

In the Netherlands and Germany, roughly 56% of the salt marshes on the islands and roughly 7% of the salt marshes on the mainland have never been artificially drained and are not grazed by livestock and thus can be regarded as natural. In addition, about 690 ha of salt marshes (310 in Niedersachsen and 340 in the Netherlands) have been de-embanked, and the possible development...
of new salt marsh areas and vegetation development are being monitored.

Since the 1980s, livestock grazing and artificial drainage for coastal protection or agricultural utilization has generally been reduced. In some cases, moderate grazing is carried out for biodiversity purposes or to gain sod for coastal protection measures. Many natural and semi-natural salt marsh areas have developed during these last two decades. On the islands, the majority of the salt marshes can develop naturally and show various transition stages. Livestock grazing for agricultural purposes has generally decreased in all areas during the past 20 years. In about 60% of the salt marshes no drainage measures have been taken at all, and in an additional 31% no artificial drainage measures have been carried out during the past 10 years.

The salt marshes along the mainland coast are normally situated in front of the sea dike. In most cases their development has been actively supported by man, for example by drainage or reduction of wave energy. In former times, many of them were intensively used for agricultural purposes. Since the mid 1980s, a reduction of 50% of areas with intensive grazing could be observed on the mainland salt marshes in the Netherlands and Germany (Figure 4.3). In about 39% of the mainland salt marshes, no drainage measures have been taken during the past 10 years. This has enhanced natural sedimentation and erosion processes and the development of natural salt marsh vegetation.

The salt marsh vegetation development is monitored by using a trilaterally harmonized vegetation key, which allows a consistent and detailed analysis of the salt marsh vegetation with regard to the Wadden Sea Plan Targets. This also entails an assessment of vegetation changes as a result of changes in management, sea level rise, and spreading of single species such as *Spartina anglica*, *Atriplex prostata*, *Elytrigia atherica*, *Elytrigia repens* and *Phragmites australis*.

Beaches and dunes

Beaches and dunes are subject to constant changes as a result of natural forces such as the North Sea currents, waves, and wind. About 4600 ha of dunes are located in the nominated property, with the majority on the islands of Niedersachsen. They represent the typical Wadden Sea barrier island.

Almost all beaches and dunes areas are subject to nature conservation under national and EU legislation and covered by the Wadden Sea Plan, which aims for an increased natural dynamic and vegetation succession.

Natural dynamics of beaches and dunes can be observed mainly in the eastern, uninhabited parts of the barrier islands where no coastal protection measures have to be carried out. Large beach plains as well as embryonic and primary dunes have developed in these areas as result of natural sand transport. Since the mid 1960s, about 870 ha of new dune areas have developed; at the same time, an erosion of 115 ha of dunes occurred.

In the western, inhabited parts of the islands, however, practically all dunes are an integrated part of the coastal defence system. The white dunes are maintained and protected from erosion, e.g. by planting of marram grass. In these areas, natural dynamics of beaches are locally and periodically influenced by coastal protection measures, e.g. in the form of stony groins and sand nourishment of the beach or foreshore. Coastal protection measures may increase in connection with continued sea level rise. Additionally, the beaches adjacent to the island villages are also main areas of recreational activities.

The development of the dunes on the Niedersachsen back barrier islands over a period of 50 years was analyzed by comparison of various vegetation maps from the 1940s with recent surveys:

- Embryonic dunes naturally develop on the beaches of the eastern parts of the islands, whereas they have decreased in areas with intensive recreational use;
- The area of white dunes has almost remained unchanged, also because of their importance for coastal defence;
- Grey dunes continue to represent the major dune type and a development in the direction of older successional stages such as heath or brushwood was observed;
- Species-rich dune slacks represent a rare but important dune type with a specific vegetation and biodiversity. On some islands, an accelerated succession of dune slacks to drier communities is caused by enhanced groundwater extraction. Therefore, a management scheme was established on the islands of Langeoog and Norderney to minimize the impact of groundwater extraction on vegetation.

Similar developments were also observed in dune areas adjacent to the nominated property, e.g. on the Dutch and Schleswig-Holstein islands.
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 4 State of Conservation and Factors Affecting the Property

Species and population trends and developments

Birds

Breeding birds

Many bird species breed on the Wadden Sea salt marshes, dunes and beaches. During this time they are particularly vulnerable. All bird species are protected under national and EU legislation. The trilateral Wadden Sea Plan aims at favourable conditions for breeding birds through favourable food availability and natural breeding success.

Among the 31 bird species regularly monitored in the Trilateral Monitoring and Assessment Program (TMAP), there are five species which occur with more than 25% of the NW European populations breeding in the Wadden Sea. Some species are rare, as the Wadden Sea is situated on the edge of their European breeding range.

The quality of various habitats has improved in recent decades, leading for instance to an increase in numbers of coastal birds such as the common redshank breeding on salt marshes. Thanks to nearly 15 years of monitoring (since 1994), a reliable evaluation of trends has become possible, both for the entire period as well as for the last five years. The latter can be used as an alert for recent changes (Tab. 4.2).

### Table 4.2: Breeding birds in the Wadden Sea in 2001 and trends in 1990–2001 (Koffi jberg et al., 2006.). Also given are international importance (expressed as percentage of the overall NW-European flyway population, after Rasmussen et al., 2000) and Red List status (Wadden Sea, SUS susceptible; VUL vulnerable; END Endangered; CRI critical; - no red list status, according to Rasmussen et al., 1996). 2001 refers to the breeding population in 2001. Trends are shown for the entire period 1981–2001 and for the last 5 years (since 1996) to detect recent changes: - significant decrease; = significantly stable; (=) fluctuating without significant trend; + significant increase (significant at P < 0.05). For some species, no trend could be calculated due to the small or scattered breeding population (‘no data’). Species included in Annex I of the EC Birds Directive are marked separately.

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<td>Great cormorant Phalacrocorax carbo</td>
<td>-</td>
<td>1-5</td>
<td>-</td>
<td>2,348</td>
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<td>+</td>
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<td>Eurasian spoonbill Platalea leucorodia</td>
<td>x</td>
<td>&gt;25</td>
<td>SUS</td>
<td>831</td>
<td>+</td>
<td>+</td>
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<td>Shelduck Tadorna tadorna*</td>
<td>-</td>
<td>5-25</td>
<td>-</td>
<td>6,480</td>
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<td>+</td>
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<td>-</td>
<td>10,500</td>
<td>+</td>
<td>(=)</td>
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<td>Red-breasted merganser Mergus serrator</td>
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<td>&lt;1</td>
<td>VUL</td>
<td>44</td>
<td>(+)</td>
<td>no data</td>
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<td>-</td>
<td>126</td>
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<td>-</td>
<td>39,928</td>
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<td>-</td>
<td>10,170</td>
<td>=</td>
<td>(=)</td>
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<tr>
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<td>-</td>
<td>1-5</td>
<td>VUL</td>
<td>1,093</td>
<td>-</td>
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<td>Kentish plover Charadrius alexandrinus*</td>
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<td>&gt;25</td>
<td>END</td>
<td>340</td>
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<td>-</td>
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<td>-</td>
<td>11,643</td>
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<td>Dunlin Calidris alpina schinzii</td>
<td>x</td>
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<td>CRI</td>
<td>24</td>
<td>(-)</td>
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<tr>
<td>Ruff Philomachus pugnax</td>
<td>x</td>
<td>&lt;1</td>
<td>CRI</td>
<td>33</td>
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<td>Common snipe Gallinago gallinago</td>
<td>-</td>
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<td>-</td>
<td>188</td>
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<td>Eurasian curlew Numenius arquata</td>
<td>-</td>
<td>&lt;1</td>
<td>-</td>
<td>640</td>
<td>(=)</td>
<td>(=)</td>
</tr>
<tr>
<td>Common redshank Tringa totanus*</td>
<td>-</td>
<td>5-25</td>
<td>-</td>
<td>17,815</td>
<td>(=)</td>
<td>(=)</td>
</tr>
<tr>
<td>Turnstone Arenaria interpres</td>
<td>-</td>
<td>&lt;1</td>
<td>CRI</td>
<td>1</td>
<td>no data</td>
<td>no data</td>
</tr>
<tr>
<td>Mediterranean gull Larus melanocephalus</td>
<td>x</td>
<td>1-5</td>
<td>-</td>
<td>9</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Little gull Larus minutus</td>
<td>x</td>
<td>&lt;1</td>
<td>SUS</td>
<td>-</td>
<td>no data</td>
<td>no data</td>
</tr>
<tr>
<td>Black-headed gull Larus ridibundus*</td>
<td>-</td>
<td>5-25</td>
<td>-</td>
<td>154,395</td>
<td>(=)</td>
<td>+</td>
</tr>
<tr>
<td>Common gull Larus canus*</td>
<td>-</td>
<td>1-5</td>
<td>-</td>
<td>13,827</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Lesser black-backed gull Larus fuscus*</td>
<td>-</td>
<td>5-25</td>
<td>-</td>
<td>79,679</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Herring gull Larus argentatus*</td>
<td>-</td>
<td>5-25</td>
<td>-</td>
<td>78,402</td>
<td>-</td>
<td>(=)</td>
</tr>
<tr>
<td>Great black-backed gull Larus marinus</td>
<td>-</td>
<td>&lt;1</td>
<td>-</td>
<td>27</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Guil-billed tern Gelochelidon nilotica</td>
<td>x</td>
<td>&gt;25</td>
<td>CRI</td>
<td>56</td>
<td>(=)</td>
<td>(=)</td>
</tr>
<tr>
<td>Sandwich tern Sterna sandvicensis*</td>
<td>x</td>
<td>&gt;25</td>
<td>END</td>
<td>17,172</td>
<td>=</td>
<td>(=)</td>
</tr>
<tr>
<td>Common tern Sterna hirundo*</td>
<td>x</td>
<td>5-25</td>
<td>-</td>
<td>13,594</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Arctic tern Sterna paradisaea*</td>
<td>x</td>
<td>1-5</td>
<td>-</td>
<td>8,464</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Little tern Sterna albifrons</td>
<td>x</td>
<td>&gt;25</td>
<td>END</td>
<td>1,099</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Short-eared owl Asio flammeus</td>
<td>x</td>
<td>&lt;1</td>
<td>END</td>
<td>89</td>
<td>(=)</td>
<td>(=)</td>
</tr>
</tbody>
</table>
Over the period 1990–2001 and considering the entire Wadden Sea, ten species increased significantly. The highest rates of increase are observed for the great cormorant, great black-backed gull, Eurasian spoonbill, lesser black-backed gull and Mediterranean gull (Tab 4.2). Nearly all of these species have expanded their geographical breeding range in the past decade and showed further increases in 2002–2004. The breeding population of most increasing species continued to grow during the entire period covered by the surveys (see Tab. 4.2). For common eider and arctic tern, a decreasing trend was observed if only the years from 1996 and 1998 are considered, respectively.

Significant declines have occurred in nine species, among them the great ringed plover, Kentish plover, black-tailed godwit and northern lapwing. The most dramatic declines seem to have occurred in three species for which proper trend calculations in the past decade are difficult to assess due to low numbers and scattered breeding (dunlin, ruff, common snipe). Recent counts (up to 2004) suggest that the rate of decline of the northern lapwing, black-tailed godwit and herring gull has levelled off, whereas a recovery has recently become apparent for the common tern. The great ringed plover and Kentish plover continued to decline in 2002–2004.

The decline in numbers of some species has been caused by increased recreational pressure on beaches and other breeding habitats. Protective measures for beach-breeding birds have been successful for the colony-breeding little tern, but Kentish plover and great ringed plover show an ongoing decline and need further protection effort. The decline in breeding populations of common eider (>75% in the Dutch Wadden Sea), oystercatchers and, probably, also herring gull, mainly in the Dutch Wadden Sea, was considered as an effect of intense shellfish fisheries (cockle and blue mussels), which has now been reduced in the Netherlands. In some areas, shifts in breeding numbers from the mainland coast to the islands were observed, caused by increasing predation pressure by mammalian predators, e.g. the red fox. For species breeding in salt marshes (e.g., waders, passerines) various trends and fluctuations have been observed, however, without a clear relationship with changes in agricultural use or vegetation development of these areas.

Migratory birds

The outstanding importance of the Wadden Sea for migratory birds has been acknowledged in several international conventions and directives, such as the Ramsar Convention, the Bonn Convention on Migratory Species and the EC Birds and Habitats Directive. These all have been implemented in national legislation and the respective protection regimes. The Wadden Sea Plan aims at favourable conditions for migratory birds and sufficiently large undisturbed roosting and moulting areas.

The amount and quality of data on migratory waterbirds has increased considerably in recent decades. In addition to surveys focusing on wintering numbers and distribution in the framework of the International Waterbird Census of Wetlands International, further synchronous and complete counts and bi-monthly spring-tide counts at numerous sites are carried out in the TMAP. Therefore, for the first time, overall trends of the most important species have been calculated for the entire Wadden Sea, including all months of the year.

The analysis of trends of migratory waterbirds utilizing the Wadden Sea for the period 1992 – 2000 revealed alarming results: 22 out of 34
Table 4.3a: Trend categories for the recent 10 years 1994/1995 - 2003/2004 for the Wadden Sea and the regions (in "trend tables") (after Blew et al., 2007). Trend categories: ++ = strong increase, + = increase, 0 = stable, − = decrease, F=fluctuating.

<table>
<thead>
<tr>
<th>Species</th>
<th>Wadden Sea</th>
<th>SH</th>
<th>Nds</th>
<th>NL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eurasian spoonbill</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Great cormorant</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Northern pintail</td>
<td>+</td>
<td>0</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Common ringed plover</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Sanderling</td>
<td>+</td>
<td>F</td>
<td>0</td>
<td>++</td>
</tr>
<tr>
<td>Bar-tailed godwit</td>
<td>+</td>
<td>−</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Northern shoveler</td>
<td>0</td>
<td>0</td>
<td>+</td>
<td>0</td>
</tr>
<tr>
<td>Common shelduck</td>
<td>0</td>
<td>−</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Barnacle goose</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Common greenshank</td>
<td>0</td>
<td>−</td>
<td>0</td>
<td>F</td>
</tr>
<tr>
<td>Northern lapwing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>F</td>
</tr>
<tr>
<td>Eurasian curlew</td>
<td>0</td>
<td>−</td>
<td>−</td>
<td>+</td>
</tr>
<tr>
<td>Common gull</td>
<td>0</td>
<td>0</td>
<td>F</td>
<td>0</td>
</tr>
<tr>
<td>Dunlin</td>
<td>0</td>
<td>−</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Black-headed gull</td>
<td>0</td>
<td>−</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Grey plover</td>
<td>0</td>
<td>−</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Whimbrel</td>
<td>0</td>
<td>F</td>
<td>−</td>
<td>F</td>
</tr>
<tr>
<td>Spotted redshank</td>
<td>0</td>
<td>−</td>
<td>0</td>
<td>−</td>
</tr>
<tr>
<td>Common redshank</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>0</td>
</tr>
<tr>
<td>Mallard</td>
<td>−</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>European golden plover</td>
<td>−</td>
<td>−</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>European herring gull</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Eurasian oystercatcher</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Pied avocet</td>
<td>−</td>
<td>−</td>
<td>0</td>
<td>−</td>
</tr>
<tr>
<td>Brent goose</td>
<td>−</td>
<td>−</td>
<td>0</td>
<td>−</td>
</tr>
<tr>
<td>Great Black-backed gull</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>F</td>
</tr>
<tr>
<td>Eurasian widgeon</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>F</td>
</tr>
<tr>
<td>Red knot</td>
<td>−</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Ruff</td>
<td>−</td>
<td>−</td>
<td>F</td>
<td>0</td>
</tr>
<tr>
<td>Curlew sandpiper</td>
<td>F</td>
<td>F</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Common teal</td>
<td>F</td>
<td>0</td>
<td>F</td>
<td>F</td>
</tr>
<tr>
<td>Ruddy turnstone</td>
<td>F</td>
<td>0</td>
<td>F</td>
<td>0</td>
</tr>
<tr>
<td>Kentish plover</td>
<td>F</td>
<td>0</td>
<td>F</td>
<td>F</td>
</tr>
</tbody>
</table>

Table 4.3b: Counts of trend categories for the recent 10 years (1994/1995-2003/2004) in the Wadden Sea (after Blew et al., 2007).

<table>
<thead>
<tr>
<th>Trend category</th>
<th>Wadden Sea</th>
<th>SH</th>
<th>Nds</th>
<th>NL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong decrease</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Decrease</td>
<td>11</td>
<td>18</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Stable</td>
<td>12</td>
<td>9</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Increase</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Strong increase</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Fluctuating / uncertain</td>
<td>4</td>
<td>3</td>
<td>6</td>
<td>8</td>
</tr>
</tbody>
</table>

Waterbird species experienced declines, of which 15 are statistically significant.

This trend calculation was updated to cover the recent ten year-period 1994/95 - 2003/04 and highlights the actual developments in the Wadden Sea (Blew et al., in prep). According to these updated results, the situation of 6 waterbird species in the Wadden Sea seems to have improved compared to the 1990s (Tab. 4.3 a). In general, less species showed a decline, however, negative trends for the mussel feeding species and regionally different trends for the most numerous species in the Wadden Sea need to be further assessed.

Most of the declining species were dependent on feeding on benthos, including bivalves, for ‘fast refuelling’ during their migration to the breeding and wintering areas. This is an indication of non-favourable food availability, although other risk...
factors such as wintering in Africa and breeding in the (sub)arctic may play a role. For the bird species within this group and specializing in molluscs (e.g., eider, oystercatcher, knot and herring gull), it has been proven for some parts of the Wadden Sea that food availability was impaired due to shellfish fishery. For herbivorous species (e.g., dark-bellied brent goose, Eurasian widgeon and barnacle goose) food availability seems not to be limited.

The eight species showing negative trends also for a longer period (1987/88 – 2003/04), include brent geese and mallard, with flyway population decreases as well as oystercatcher, knot and herring gull, as shellfish eaters. Also, the negative trends in the Wadden Sea of ruff and pied avocet remain for both periods. The overall negative trend of golden plover seems to be greatly determined by Schleswig-Holstein birds, while in the Netherlands and Niedersachsen the numbers are stable. In general, regional differences in distribution occur for a number of species, the reasons for which have to be further investigated.

In Table 4.3a and 4.3b, a summary of the trend categories for the Wadden Sea Area has been compiled.

High tide roosts are relatively well protected, with more than 80% of these roosts being located within Special Protection Areas. Despite this, disturbances can occur in all parts of the Wadden Sea. A main impact is by outdoor recreation, with peaks during July and August but also, increasingly, in spring and autumn. Potential conflicts are minimized and resolved by spatial and temporal zoning of recreational activities as well as convincing visitor information systems. Different protection schemes for roosting birds are in place along the Wadden Sea.

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

For common scoter, moulting areas are in the offshore zone, decreasing in importance from north to south. A realistic estimate of the numbers moulting in the Wadden Sea area does not, however, exist. Moulting areas are chosen according to the presence of their favoured food resource (e.g., bivalves such as Spisula spp.) and low disturbance level.

Marine mammals

The numbers of harbour seals and grey seals have significantly increased during the last decades. Trends for population size of harbour porpoise are not yet known specifically for the Wadden Sea, but sightings have increased in recent years. The harbour porpoise belongs to a North Sea population.

All marine mammals are protected under national and EU legislation. Harbour seals and grey seal are also subject to the Seal Agreement, the harbour porpoise is subject to the ASCOBANS agreement, both are regional agreements of the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention). The Seal Agreement was concluded between the three Wadden Sea countries with the aim to cooperate closely in achieving and maintaining a favourable conservation status for the harbour and grey seal populations in the Wadden Sea.

The Wadden Sea Plan aims at viable stocks and a natural reproduction capacity of harbour seals, grey seals and harbour porpoises.

Grey seals

Grey seals had been extinct in the Wadden Sea area (south-eastern North Sea) for centuries because of hunting. Today, the number of grey seals in the Wadden Sea is growing. In the western Dutch Wadden Sea, the development of the grey seal population since its establishment in the early 1980s has been robust. Surveys during moult (March/April) show an annual increase of 20% on average, amounting to about 1,500 animals counted during the moult in 2005 (Fig. 4.4).

In the Wadden Sea of Schleswig-Holstein, recent grey seal pup production (minimum estimates) was about 30. Surveys in the peak moulting season (early April) counted to about 160
grey seals in total. In general, numbers have been increasing by 4–5% per year on average.

Outside the reproductive colonies in the Dutch Wadden Sea and in the Wadden Sea of Schleswig-Holstein, grey seal colonies have established themselves in the Wadden Sea of Niedersachsen (more than 40 grey seals including pups at Borkum Riff in 2005) and on the Dune Isle of Helgoland in the German Bight, where about 150 grey seals were observed in spring 2005.

Harbour seal

The harbour seal (*Phoca vitulina*) is the most numerous native marine mammal species in the Wadden Sea, and its population in the entire Wadden Sea can be considered as an entity. Exchange with populations in other areas such as the Wash (UK) and the Kattegat/Skagerrak (Sweden and Denmark) does occur, however, on a very small scale.

In the Wadden Sea, harbour seals haul out predominantly on intertidal sand banks along the tidal channels, which are emerged during low tide. The sandbanks have a function for social contact, giving birth and nursing the pups and moult.

After a disastrous Phocine Distemper Virus (PDV)-epizootic in 1988, the harbour seal population recovered nearly fivefold, from some 4,400 animals counted in 1989 to 20,975 in 2002 (Fig. 4.5). In 2002, a second PDV-epizootic struck the population, and in 2003, only 47% of the expected number of seals (if no epizootic had occurred) was counted, namely 9654 in the German-Dutch Wadden Sea. This number is comparable to the population count in 1996.

In 2005, the total number of seals counted during coordinated surveys in the moult period in the German-Dutch Wadden Sea in August was 12,555 (5,505 in Schleswig-Holstein, 3,607 in Niedersachsen and 3,443 in the Netherlands). The maximum number of pups counted during the whelping season in June was 4,119 (2,046 in Schleswig-Holstein, 1,176 in Niedersachsen and 897 in the Netherlands). According to recent satellite telemetry investigations, seals use the North Sea to a much larger extent, in terms of numbers as well as range, than thought before.

Harbour porpoise

Harbour porpoises (*Phocoena phocoena*) are widely distributed throughout the North Sea and adjacent waters. They used to be sighted frequently in the big river mouths and in the Wadden Sea.

According to the SCANS surveys in the North Sea and adjacent waters in 1994 and 2005, about 230,000 harbour porpoises were distributed over the entire area of the North Sea. In comparison to other parts of the North Sea, high densities of harbour porpoises and, especially, mother-calf groups were documented for the Schleswig Holstein part. The German area west of Sylt plays an important role as rearing area for harbour porpoises.

Along the Dutch mainland coast, fixed observation sites exist which supply more regular counts. This data demonstrates that since the mid-1990s harbour porpoises are becoming year-round visitors. Mother-calf groups have been observed with increasing regularity and the number of harbour porpoises sighted has increased considerably, by 41% per annum.
Aerial surveys of harbour porpoises in the German Bight carried out in the summers of 2002-2006 revealed that the overall mean abundance of harbour porpoises in the German EEZ of the North Sea amounted to around 50,000 animals.

Fish

Fish play an important role in the ecology of the Wadden Sea and the connected estuaries. Protection schemes in the Wadden Sea are established under the Water Framework Directive (transitional waters and rivers) and the Habitats Directive. Fishery management schemes are implemented on the EU level and by national legislation.

Trends on the development of fish populations in the Wadden Sea can be drawn from long-time monitoring series of demersal fish in the Netherlands and Germany (back to the mid 1970s) and on pelagic fish in the Schleswig-Holstein Wadden Sea and some estuaries. The 23 fish species analyzed showed large regional differences in abundance as well as in seasonal distribution. In addition, fluctuations in abundance on larger time scales such as decades occur, which makes it sometimes difficult to detect spatial and regional developments.

Positive trends could be observed for herring, which is in agreement with the North Sea wide distribution pattern, and for anchovy, probably because of increased temperatures. High numbers and an increasing trend of twaite shad were recorded in Schleswig-Holstein (as also recorded in the German Bight), possibly from a stable spawning population in the Elbe estuary. Lower numbers were observed in the Ems estuary.

The numbers of juvenile flatfish using the Dutch Wadden Sea as a nursery area are declining, in particular the abundance of dab and plaice (Fig. 4.6). This is mainly caused by an offshore shift in the distribution of juvenile flatfish and is not related to local environmental changes in the Wadden Sea; the causal factors for this shift are not yet fully understood.

Five bearded rockling or hooknose, classified as (near) resident species, do not show any clear trends in abundance over longer time periods. The abundance of the true resident species bull rute and eelpout seem to fluctuate on a decadal scale (Fig. 4.7).

Macrozoobenthos

The benthic macrofauna communities play a key role in the Wadden Sea food web. They are characteristic species of several habitat types under the Habitats Directive and are included as biological quality element in the Water Framework Directive.
Long-term data sets back to the 1970s reveal large fluctuations in macrozoobenthos biomass and species abundances in different parts of the Wadden Sea. However, two opposite trends were observed: biomass of polychaete worms increased, whereas bivalve biomass declined. The reasons for these trends are not known yet. The observed decline in bivalve recruitment success over approximately the last 15 years, which was accompanied by a shoreward shift of their centres of distribution, may be explained largely by increasing predation pressure on the newly settled post-larvae by shrimps and shore crabs. This effect has been observed in different parts of the Wadden Sea and coincides with the occurrence of mild winters. This indicates the influence of climatic factors in governing recruitment, and therefore population sizes, of bivalves in the Wadden Sea. On a more regional scale, changes in sediment conditions may also play a role.

Changes in the composition of macrozoobenthos communities have been observed due to invasions of new species during the last century, such as the American razor clam (*Ensis americanus*) the American slipper limpet (*Crepidula fornicata*) and the estuarine polychaete worm *Marenzelleria cf. wirenii*. So far, these newcomers were integrated in the Wadden Sea ecosystem without any negative effects. It is yet unclear in which way the newly spread pacific oyster (*Crassostrea gigas*) will influence the ecology of the tidal flats, for example, by invading blue mussel bed habitats or influencing the food supply of mussel-eating birds.

In the northern German Wadden Sea, some 100 species were common in the first half of the 20th century. Of these, 28 have decreased considerably in abundance, mainly because of the disappearance of natural oyster beds and reefs of the tube building polychaete *Sabellaria spinulosa*. Other species increased in abundance, especially a number of polychaetes adapted to disturbed habitats.

### 4.b Factors affecting the property

#### (i) Development pressures

All human activities within the nominated property which are assessed to cause adverse effect are regulated in time and space or, as appropriate, prohibited. All activities that are allowed are subject to licensing following an assessment of their impact on the property in accordance with the stipulations of Art. 6 of the Habitats Directive, implemented by German and Dutch law. Art. 6 (3) of the Habitats Directive stipulates, as mentioned in Chapter 3, that "[A]ny plan or project not directly connected with or necessary to the management of the site but likely to have a significant effect thereon, either individually or in combination with other plans or projects, shall be subject to appropriate assessment of its implications for the site in view of the site’s conservation objectives. .[t]he competent national authorities shall agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned ..." Henceforth, subsection 4 of the directive stipulates that "[I]f, in spite of a negative assessment of the implications for the site and in the absence of alternative solutions, a plan or project must nevertheless be carried out for imperative reasons of overriding public interest, including those of a social or economic nature, the Member State shall take all compensatory measures necessary to ensure that the overall coherence of Natura 2000 is protected...". Thus within the framework of the approval procedures standardized preconditions have to be fulfilled obligatory. This includes relevant national nature protection regulations according to the Dutch Nature Conservation Act (1998), the PKB, the German National park acts, the Federal and states Nature Conservation Acts, as well as relevant EU Directives and other international regulations (e. g. PSSA, OSPAR, AEWA, MARPOL, RAMSAR-Agreement and Bonn-Agreement), the Wadden Sea Plan and other trilateral agreements.

Furthermore, in addition to the Targets, the Wadden Sea Plan also encompasses a number of Shared Principles which are fundamental to decisions concerning the protection and manage-
ment of the Wadden Sea. The result is that the nominated property is not subject to significant development pressures.

There are, however, a number of activities, the most prominent ones taking place outside the nominated property, that potentially affect it but are essential for the regional economy and the living conditions of the people living in the area or visiting it as tourists. These activities are shipping and the related (maintenance) dredging of the shipping routes and harbour developments, subsidence resulting from gas extraction and coastal protection. Further, the issue of introduced species is a potential pressure to address. Additionally, there are some activities such as civil air traffic, military activities, hunting and laying of cables that may potentially cause disturbance to the nominated property.

In many of these activities the natural dynamic processes which change the Wadden Sea over time have to be taken into account; eg. natural gullies used as shipping routes have moved substantially in the coarse of the centuries. Over the long run, the borders of the nominated area should reflect this dynamic. Minor modifications to the boundaries of the property in case of morphodynamic shifts will be dealt with in accordance with the Operational Guidelines.

**Harbors, industrial facilities and dredging**

There are many harbours located adjacent to the nominated property. The large majority of the smaller ports are located directly adjacent to the nominated property on the mainland or on the islands. They are vital infrastructure installations for the local and regional economy in terms of, in particular, the supply of the islands, the mainland and the maritime installations and the traffic to and from the islands. Furthermore, there are several major seaports of international significance adjacent to or in the vicinity of the nominated property, which are of significant economic importance both on the regional and the national/international level.

An appropriate sustainable and flexible access to the harbours now and in the future is hence indispensable, as well as navigation, maintenance and development of the fairway. As in the entire Wadden Sea the hydromorphological and geomorphological conditions are highly dynamic and additionally very sensitive to climate change with its sea level rise and variations in storminess i.e. this will have to be considered when thinking about line management of shipways with their river measures like training walls, groins and replacement respectively relocation areas beside the fairway area itself.

Access to the harbours also demands an integrated sediment management, both to maintain the shipping routes and to extend existing ones within the dynamic conditions of tidal coastal areas to allow for sustainable state-of-the-art shipping transport.

In the nominated property, new, not yet approved plans for new construction as well as for the extension or major modification of existing harbour and industrial facilities are not allowed unless such is necessary for imperative reasons of overriding public interest and if no alternatives can be found. In specific cases exemptions can be granted in accordance with the stipulations of Art. 6 of the Habitats Directive. Art. 6 (4) implemented in Dutch and German law, stipulates that if no alternatives can be found to an extension and there are imperative reasons of overriding public interest, a project, in this case a harbour (extension) project, can be undertaken provided that it is compensated to ensure the coherence of the site.

The amounts of dredged material dumped into the whole Wadden Sea Area varied between about 9-26 million t/yr (dry weight) during the period 1998 - 2003 (average 14.8 million t/yr) (Figure 4.8). On average, 12.3 million t/yr (dry weight) were dumped into or near the German part of the Wadden Sea, and 1.4 million t into the Dutch part. In both cases these average amounts decreased compared to the average amounts of dumped dredged material in the period 1989-1997.

Because maintenance dredging is the main source of dumped material, the amounts depend mainly on natural variation of sedimentation and resuspension processes. In general, no trend can be observed in the amounts of dredged material dumped. However, since 1999, yearly amounts have decreased in the Elbe, Jade and Weser areas compared to previous years.

Dredging may potentially lead to geomorphological changes or changes in the tidal regime. It is therefore subject to an environmental assessment of its impacts and subsequent licensing in case of extending existing channels or dredging new ones. Several environmental assessment studies have shown, however, that the impact of dredging is limited in time and space because it follows the natural morphological developments. In general, dredged material is dumped into the system again, provided that the dredged material does not exceed certain pollution or so-called ac-
tion levels. For highly polluted dredged material, land based deposition is mandatory. In specific cases dredged material may be used for coastal protection purposes.

The Netherlands intends to enlarge the shipping route from the North Sea towards the Ems harbour. The initiative is related to the plans of a number of energy companies to invest in the harbour area. At present, the bottleneck is the entrance to the harbour which is not deep enough for large ships (Panamax-size). Under specific conditions arising from the EU Directives such as the Water Framework, the Habitats and the Birds Directives as well as from the PKB, the Dutch government will facilitate the deepening to 15.5 meters below 0 and the widening of the waterway to 300 meters on straight sections and to 400 meters in curves. Additional research is needed to estimate effects on coastal defence and the costs and benefits. The Ems-Dollard Treaty between the Netherlands and Germany concerning the estuary will be taken into account for this project. Realisation of the works is foreseen in spring 2010.

The procedure for an Environmental Impact Assessment (EIA) will be followed on a voluntary basis to assess the environmental effects of different alternatives. Parallel to this project, the harbour authorities of Groningen Seaports will also conduct an environmental impact assessment for deepening and enlargement of the Ems harbour.

Currently, there is an application to develop the fairway of the Lower and Outer River Elbe, outside the nominated property, to ensure navigation for vessels with a draught of 14.5 m from the Port of Hamburg. Developments in the size of vessels used in transcontinental traffic make deepening the seaward approach to the Port of Hamburg essential to cope with the rising global flow of goods and to secure Hamburg’s position as a logistics hub with a favourable economic and ecological location. To create these improved access conditions, the present fairway outside the nominated property will have to be deepened by between 1.5 m and 2.4 m. A concept for hydraulic engineering is part of the deepening measure. 75% of the dredged sediments will be used for this concept. Key elements are two large-scale underwater structures in the estuary, which directly adjoin the nominated property. The hydrological effect of these structures will be to decrease flow velocities, avoid high water increases, and maintain low-tide water levels. Additionally, a smaller part of the dredged sediments will be relocated in the outer Elbe estuary. According to hydrodynamic modelling results smaller parts of the relocated material may drift. The fairway deepening measure is planned to start in 2009.

For the middle and long-term perspective there is a need for the development and implementation of an integrated concept for the Tidal River Elbe, which aims at a sustainable stabilisation of the tidal river system by managing the river mouth. This might include hydraulic engineering measures. Highest priority will be laid on the modification towards a balanced sediment budget within the coastal area as well as in the river system itself and to sustain both the ecological and economical values of the whole tidal system. To balance the water levels in the Tidal River
Elbe in order to reduce the actual unnatural high incoming tidal energy in the river mouth, it will be necessary to reduce the rate of tidal-pumping sediments river-upwards and flood risk as well. The actual morphological situation cannot be fixed in its presently existing borders. New science-based understanding with the support of hydrodynamic computer models will help to choose the best required measures. It might influence a small part of the nominated property. Within the framework of the approval procedures standardized preconditions have to be fulfilled obligatory. Consequently hydromorphological modifications of the Elbe River mouth, including the shipway with its sustainable sediment management, will be undertaken in accordance with natural dynamic development as much as possible and in compliance with the national laws of future maintenance of the Federal Waterways with its associated constructions as being non-contentious.

In the vicinity of the existing Jade industrial area outside the nominated property, plans for the expansion and installation of new industrial plants exist. In detail, these are additional power plant resources, the extension of the refinery capacity, the construction of a holding tank for liquid gas, the construction of additional chemical or petrochemical plants, including the necessary harbour facilities and infrastructure.

In the neighbourhood of an existing industrial area outside the nominated property, the construction of a new container terminal deepwater harbour, the “Jade Weser Port”, is planned to start in 2007 in Wilhelmshaven. The area concerned is situated at an industrial centre with an oil refinery, chemical plants and a power plant. The project is intended to meet the projected significant increase in container traffic and transshipment of the Jade Weser Port and the Jade shipping lane. The existing shipping lane will be partly relocated to the west of the present site with a view to minimize the tide–dynamic impacts and the future maintenance of the lane. Additional turning space for the ships will be established between the new shipping lane and the quay. The dredged material will be used for the embankment. Further expansion stages are under consideration.

An extensive environmental impact assessment of the project has been carried out. According to an expertise provided by the Federal Waterways Engineering and Research Institute ("Bundesanstalt für Wasserbau – BAW"), the construction of the Jade cross-section resulting from the harbour facilities of the Jade Weser Port will not significantly alter the tidal dynamics within the nominated property, and changes to the sedimentation and erosion situation can virtually be ruled out.

Furthermore, the environmental impact assessment did not confirm fears that the construction of the Jade Weser Port would make the Jade less valuable from the point of view of migrating species, in particular marine mammals. The general rise in the volume of shipping traffic to be anticipated in the southern North Sea and, as part of it, in the Jade may increase the risk of maritime accidents occurring and thus the likelihood of adverse effects on the conservation area, for instance as a result of oil tanker accidents. The enhanced technologies in the safety of ships and the vessel traffic system, especially AIS, which are established in the German Bight and which is the best available technology minimize the risk also for the Jade Port and the Jade shipping lane.

Also outside the nominated property, the enlargement of handling capacities and the construction of a coal power plant close to the harbour of Nordenham are under debate. South-east of the harbour of Cuxhaven, along the Elbe River, expansions of the existing harbour facilities respectively filling of gaps are planned.

In the PKB, an exemption to the prohibition on the extension of ports into or adjacent to the Wadden Sea is granted for a relocation of the TESO harbour for ferries in Den Helder and a limited extension of marinas on the islands. These exemptions will only be granted if they can fulfil the assessment framework of the PKB. A possible extension of the harbour of Harlingen will preferably be realized inside the dikes. If, in this last case, a scientifically based plan demonstrates that an extension into the nominated property is possible within the assessment framework of the PKB, the government will facilitate this by a partial adjustment of the PKB.
Chapter 4: State of Conservation and Factors Affecting the Property

Exploration and exploitation of gas and oil

Exploration activities must be authorised in accordance with mining law. They will be executed in compliance with the Dutch Nature Conservation Act (1998), the PKB, the German National Park Acts, Natura 2000, Water Acts and the Wadden Sea Plan (Stade Declaration 1997). Moreover, all international regulations for the protection of the sea and the coasts, e.g. PSSA, OSPAR, AEWA, MARPOL, PARCOM, the Ramsar Convention and the Bonn Convention will be applied.

In Schleswig-Holstein the Wadden Sea Plan is implemented by the National Park Act. Oil exploitation is confined to the existing exploitation site at Mittelplate in the Schleswig-Holstein Wadden Sea. In the Dutch Wadden Sea new exploration and exploitation of gas is only permitted from sites on land and from existing platforms in the North Sea coastal zone outside the nominated property in accordance with the Wadden Sea Plan.

Zuidwal is situated in the western Wadden Sea between Harlingen and Vlieland. The gas is transported to Harlingen by pipeline. An extensive study in 1999 and a report published by the Ministry of Transport and Water Management in 2004 showed that the effects of gas extraction from the Zuidwal site were most likely very minimal.

The main impact, resulting from the exploitation of gas resources adjacent to and within the nominated property from exploitation sites outside the Dutch part of the nominated property - with the exception of one location - is subsidence of the bottom. The potential impact due to subsidence has been monitored since 1963 when the production commenced. No loss of natural values have been found. Subsidence of tidal flats was fully compensated by natural sedimentation.

Salt marshes are still increasing in height due to sedimentation and until now no other ecological impacts have been found as a slowdown of the aging of these salt marshes. The only visible change in habitat on the island of Ameland outside the nominated property occurred locally in the sense that low dune valleys have become wetter and may become submerged for a significant period of time in winter.

Development of small fields in the Netherlands has clearly reached its peak, and it is expected that most small fields will stop producing in the coming decades. New, land or island based activities, however, will not be excluded, mostly in order to optimize the use of existing infrastructure and knowledge. In this respect, some activities are expected, but no new gas exploration/exploitation installations within the nominated property itself are foreseen.

The overall conclusion is that subsidence is not a problem in the Wadden Sea as long as the rate of subsidence is within the resilience of the system to cope with sea level rise. These natural boundaries were assessed to vary between 3 and 6 mm per year, depending on the size of the tidal basin. The present rate of sea level rise leaves sufficient space to allow for the subsidence in question. Coastal erosion of the island of Ameland due to sea level rise and subsidence is already managed and prevented by beach and coastal nourishment.

Formerly, the crude oil produced at the production site Mittelplate (Schleswig-Holstein part of the Wadden Sea) was transported to Brunsbüttel by three special double hulled tankers. In 2003, plans for a pipeline were approved, which went into operation in 2005. Disturbance of moulting Shelducks has hence been minimized and risks of oil spills basically excluded. Throughout the full operation period of the ’Mittelplate A’ a monitoring program has been conducted in order to screen the ecological impact of the drilling site. Until now, no negative effects have been found at the locality or its surroundings. The production facility can be characterized as a “zero-emission unit”.

In addition to the already known reserves of oil and natural gas under exploitation, further reserves are assumed to be present in the area of the German Wadden Sea. In as far as public interest demands it, it should in principle be possible in view of a wise use of energy resources to explore and where relevant to exploit the reserves of gas and oil under the Wadden Sea in compliance with the Wadden Sea Plan and relevant nature protection regulations, e.g. the National Park Acts.

On the basis of the current available knowledge, the following reserves are assumed to be present:

In the area of the Ems estuary east of the treaty area with the Netherlands it is in general known that natural gas can be found at the land-sea interface. In the area of the lower Jade and further into the Wadden Sea, oil reserves can be assumed. This is connected with the oil field "Mittelplate". Finally, it is to be assumed with high likelihood that there is oil in the area northwest of Cuxhaven, based on the underground structures.

In addition to the oil deposits already known, and those exploited by the Mittelplate production facility off the coast of Dithmarschen, which - according to monitoring results - does not have severe or longlasting effects for the environment, further considerable deposits of oil, oil chalk and
natural gas are suspected in the Schleswig-Holstein Wadden Sea area. These known or potential deposits are listed below:

- South of the Mittelplate drilling platform as far as the state border in the River Elbe.
- On the crown of the Büsum salt deposit east of Mittelplate as well as on the flanks of the Oldenswort salt deposit, e.g. southwest of Büsum.

At present it is not possible to foresee whether these oil reserves can be exploited completely from drilling locations outside the National Park. Exploration, and possible future exploitation of these deposits, will be carried out in compliance with the Schleswig-Holstein National Park Act.

Exploration and exploitation is to be carried out with the minimum possible interference in the environment and using the best available techniques. They must comply with EC, State and Federal laws and regulations, including the WSP and National Park Acts. The results of current monitoring demonstrate that the management of the Mittelplate deposit is very safe. The facility has been working without incidents since the start of production. In consideration of the aims of Natura 2000 and the National Park Act, the required environmental impact assessments are carried out in an exemplary manner.

Coastal flood defense and protection

Coastal flood defence and protection, including the drainage of the hinterland, is an inherent feature of the Wadden Sea coast. Basically the whole of the boundary coastline of the nominated property is delineated by seawalls or dune systems to protect the people living in the area and their economic assets. The current level of protection will not be compromised under any foreseeable circumstances. The current line and system of coastal flood defence and protection will be maintained and no further embankment will be undertaken or is planned in any parts of the nominated property in the foreseeable future. The aim is to keep the local impacts within a temporary timescale. The current and future flood defence standards demand, however, continuous reinforcement and adaptations of future coastal protection measures to rising sea level. This cannot be done without impacting the nominated property. Reinforcement of the existing dikes will be carried out on the dikes. The use of sand for sea defence purposes will be combined as far as possible with the maintenance dredging of the shipping lanes. Coastal protection on the islands within the nominated property will be done by sand nourishment from the offshore area, which is the most environmentally friendly and most efficient solution for stabilizing eroding coasts. Comprehensive research projects are being conducted in different regions to investigate the relationship between grazing and the accumulation of flotsam and jetsam. These projects are investigating the consequences of a reduction in grazing intensity on coastal protection and aim at achieving an appropriate level of grazing intensity.
Basically, as a management principle, since the natural dynamics in the tidal area are directly related to coastal flood defence and protection activities on the mainland coast, the islands and the offshore zone, coastal flood defence and protection policies will, as a principle, be based on these interrelationships.

Since the 1999 QSR, considerable progress has been made at the trilateral level on harmonizing the interests of nature protection and coastal defence as it has been agreed in the Wadden Sea Plan. One example is the establishment of the expert group on Coastal Protection and Sea Level Rise (CPSL) in 1999. For the first time, experts from national coastal defence and environmental administrations are discussing, on a trilateral level, strategies to maintain safety standards in coastal defence in a sustainable way that should be beneficial or, at least, not negative, for natural assets such as natural dynamics and habitat quality. In addition, an integration of nature protection and coastal defence has been achieved during the last years. Examples are the positive experiences from the first five years of an integrated salt marsh management in Schleswig-Holstein, the commonly agreed salt marsh plan set up for part of the coastline in Niedersachsen in 2003 and the re-embankment of summer polders in the area 'Noord Friesland buitendjiks' and on the island of Langeoog in the Niedersachsen part of the nominated property.

Introduced species

At the North Sea coast, introduced algae and invertebrates arrived via shipping or via aquaculture. They most often became established within estuaries and on hard substrates, with more than 80 known species, of which about 52 also occur within the Wadden Sea. Of the some 52 known introduced species, six have already had or are about to have effects on the composition of the existing biota in the Wadden Sea: cord-grass (*Spartina anglica*), Japanese seaweed (*Sargassum muticum*), bristle worm (*Marenzelleria cf. wireni*), American razor clam (*Ensis americanus*), American slipper limpet (*Crepidula fornicata*), and Pacific oyster (*Crassostrea gigas*). These species differ in their effects, some of which may be of a dynamic character (*i.e.*, sediment retention by *Spartina*, habitat provision by *Sargassum*, more food for birds by *Ensis*, displaced seagrass by *Spartina*, out-competing mussels by *Crepidula*, and *Crassostrea* in the coming years.)
resulting in further changes in dominance. Some introductions have become extremely numerous locally, such as the bristle worm *Marenzelleria*. It is as yet unknown what the community effects will be. There is, however, no evidence that introduced species have caused the extinction of natives in the Wadden Sea (Wolff, 2000).

The development with regard to introduced and immigrated species are followed and monitored carefully. No species can be intentionally introduced into the nominated property, e.g. for aquaculture, without an assessment according to the Habitats Directive.

**Other activities**

Though the construction of new wind turbines is not allowed within the nominated property, it can be expected that cables from planned and anticipated wind farms in the North Sea will have to cross the nominated property in the majority of the cases. This will, however, mainly cause only a temporary impact on the Wadden Sea. The construction of such cables is also subject to assessment and permission under the Habitats Directive.

It is unavoidable that further cables and pipelines will be constructed through the nominated property and, subsequently, also maintained, including such for the supplying of the islands. The construction of such infrastructure installations is likewise subject to assessment and permission under the Habitats Directive. It is the aim to keep the intervention into the nominated property of a temporary character.

Fishery may affect the natural environment of the nominated property. In the 1980s and 1990s, the quality of the different flats in the Dutch Wadden Sea decreased greatly, mainly because of the impact of mussel and cockle fishery, which had an impact on the biological quality, but also on the sediment dynamics and sediment composition. However, rehabilitation measures that have been taken since then have seemed to work out well. As outlined in Chapter 2, the most important fisheries within the nominated property nowadays are for blue mussel and shrimp. Shrimp fishery is mainly done in the area off the islands. These fisheries are subject to a comprehensive coordinated management scheme which aims to ensure that the nominated property will not be negatively affected.

Disturbance may ensue from civil air traffic over the nominated property, in particular overland flights to and from the islands, but also helicopter flights from airports on the mainland to offshore installations. The activity in terms of landings and take offs has decreased significantly in recent years in most parts. Moreover, minimum flight altitudes and corridors have been introduced to minimize disturbance. Also, ultra light aircraft and advertisement flights are prohibited or regulated. The German Wadden Sea National Parks are marked as sensitive areas in aerial flight maps, and it is recommended to steer clear of them. The minimum flight altitude in the Dutch part of the nominated property is 450 m and 300 m in specifically designated corridors if weather conditions make it necessary. It is strongly recommended to use higher flight altitudes.

Hunting is prohibited within the nominated property, with the exception of a few areas on the islands of Niedersachsen, confined to 10 days annually. Further exemptions for hunting for wildlife management and pest control are possible in the whole area.

The extent of military activities has been significantly reduced the last years. There are a few exercise areas within the nominated property such as the shooting range “Vliehors” on the island of Vlieland or the tidal area in front of the Meldorfer Bucht in Dithmarschen, Germany. All activities are limited in time to take account of the breeding and moulting times for birds and seals.

In addition to the already described uses, the following activities in the range of marine (bio-) technologies and marine research exist or are planned in the near future:

- The construction and operation of an application-oriented research facility for marine aquaculture in Büsum/Schleswig-Holstein outside the nominated property that is linked to the North Sea via a sea water pipe;
- The operation of an Ocean-Monitoring-System, covering nearly the whole Wadden Sea. The system delivers data for scientific projects and coastal protection measures and serves as a research platform for the participating companies;
- Algal farming outside the nominated property for production and further scientific development of methods for production of algae, especially for food consumption.

These projects will expand in the near future. It will be safeguarded that the expansion will not cause any adverse effects on the nominated property.
(ii) Environmental pressures (e.g., pollution, climate change, desertification)

Pollution

Rivers are by far the largest carrier of polluting substances from the land to the Wadden Sea. The German rivers Elbe, Weser and Ems, together with the Dutch IJsselmeer, discharge on average 60 km³ of water into the Wadden Sea each year. The rivers transport heavy metals, PCBs, pesticides like Lindane and large amounts of nutrients. The amount of polluting substances is to an important degree determined by the amount of water that is discharged by the rivers. This discharge shows large yearly fluctuations as a result of differences in rain and snowfall in the catchment areas. Major reductions in input of metals into the Wadden Sea mainly occurred in the late 1980s until the early 1990s, continuing moderately until 2002. In the Wadden Sea itself a general reduction in the concentration of pollutants can be observed.

Nutrients

The two most important nutrients are nitrate and phosphate. Of these, the concentrations of phosphate started to decrease in the water of the Wadden Sea in the second half of the 1980s, mainly as a result of the use of phosphate-free detergent and water purification.

Though inputs of nutrients, especially of phosphate, have decreased, the present level of nutrients in the Wadden Sea is still about five times higher than before industrialization. The entire Wadden Sea still has to be considered a eutrophication problem area, meaning that the Target of a Wadden Sea which can be regarded as "eutrophication non-problem area" has not yet been met. Regional differences observed indicate a more intense eutrophication in the southern than in the northern Wadden Sea.

Hazardous substances

For some metals like mercury, lead, zinc etc., the Target of background concentrations in sediment and biota (blue mussels and bird eggs) has not yet been reached in all sub areas of the Wadden Sea. In most parts of the Wadden Sea region, concentrations of many contaminants are falling in the sediment and in living creatures. For a number of xenobiotic compounds, discharges to and concentrations in the Wadden Sea have decreased. Some of these substances still pose a risk to the ecosystem. Many newly developed xenobiotics, including hormone disruptors, have a wide occurrence in the Wadden Sea ecosystem, and these may have deleterious effects on the ecosystem.

Oil pollution

The nominated property is located adjacent to one of the world’s busiest shipping routes off the coast of the southern North Sea. Furthermore, – from a climatic point of view – this region lies within the west wind zone, which is characterized by changeable weather with adverse weather situations, like heavy winds and restricted visibility. Despite all national and international activities and despite the progress made in the improvement of ships’ safety, shipping safety and the protection against maritime pollution, shipping will continue to be a potential source of risk for substantial damage to the Wadden Sea and the adjacent coastline. In the case of an accident with an oil tanker the damage would affect the area severely.

The most frequent source of oil pollution at sea is not tanker incidents but illegal discharges of fuel oil residues due to operational processes on board, which has caused a constant threat to
seabirds in spite of the designation of the North Sea as a Special Area according to Annex I and II of Marpol and the air surveillance of the whole area, which was introduced in 1986. A large proportion of seabirds washed onto beaches are contaminated with oil. Reported oil spills off the German and Dutch coast declined in comparison to the 1990s. Since the mid 1980s, the incidents identified per air hour declined from 1.5 to 0.2. Oil rates among beached birds of specific species of up to 90% in the 1980s have generally decreased, but are still high.

Climate change
Climate change and, in particular, its possible effects, have become a central issue in politics and science since the 1990s. To the layman the notion of climate change has almost become identical with anthropogenically-induced increases in the atmospheric concentrations of the so-called greenhouse gases, most notably carbon dioxide. As a result, increasing temperatures and, consequently, increasing water levels are predicted, caused by the thermal expansion of the ocean water and the melting of glaciers and polar ice caps. Also, changes in wind climate are expected or have, according to some publications, already occurred. Although climate has always changed, the new feature of the present situation is the expected speed of the change. This acceleration may induce significant changes in the Wadden Sea system.

Changes in any part of the system will cause sediment transport to or from other parts of the system, leading to a new dynamic equilibrium. Therefore, a moderate sea level rise in the Wadden Sea, resulting from both natural and man-induced processes, will be compensated by the import of sediment, which, in the long term, derives from the tidal channels, shore-face and the beaches and dunes of the barrier islands. In addition to these hydrodynamical and morphological processes, the importance of biotic processes for sedimentation and erosion has to be underlined. In this respect, the relevance of seagrass and mussel beds for biodeposition and reduction of erosion and the role of vegetation in the formation of dunes is emphasized.

It can be concluded that, generally, changes caused by sea level rise will not easily be distinguishable from changes resulting from the high natural variability, which is a specific feature of the Wadden Sea system. Moreover, there will be large differences in changes occurring in the different tidal basins. Because the Wadden Sea has a high resilience to changes, it is plausible that the system will be able to adapt to a sea level rise of up to some 25 cm per 50 years (the most realistic scenario) without substantial changes.

Beyond such levels, probably a breakpoint will occur, because the capacity of the system to balance the changes will become exhausted. When such a breakpoint, which will differ for different tidal basins, has been passed, substantial changes in morphological and, consequently, biological parameters are expected. One of the major changes will be a reduction of the size of the intertidal area. It is estimated that, under the worst-case scenario (50 cm per 50 years), the size of the tidal flats could decrease by 15%, the tidal basins becoming more the character of tidal lagoons. An increase in storminess would further enhance this development.

The reduction of tidal flats will have important consequences for biological parameters, most notably bird species depending on the intertidal areas for foraging. A reduction in the populations of such species can be expected, not only because the potential feeding area will be less than today but also, and probably more important, because the feeding time will be less. For the worst-case scenario, changes in other morphological and biological parameters may also be expected. They concern, amongst others, an increase of erosion on the barrier islands, a significant erosion of the salt marsh cliffs, a decrease in benthic biomass, a decrease in seagrass and an increase in typical salt marsh vegetation.

The main socioeconomic consequence envisaged is an increase in costs for coastal defence. Under the most realistic scenario (25 cm per 50 years) an increase of costs for dike maintenance and strengthening of at least 5 to 15% is expected. Under the worst-case scenario, costs to maintain dike safety may increase by 75% in Germany and even more in the Netherlands. Also, the costs for other coastal defence measures, such as sand nourishment and salt marsh works, will increase considerably. Another important consequence of increased sea level is that possibilities for discharging freshwater from the mainland into the sea will become less and that additional sluicing, pumping and/or freshwater storage capacity will be needed.
(iii) Natural disasters and risk preparedness (earthquakes, floods, fires, etc.)

It is not expected that the Wadden Sea is subject to natural disasters as meant by the guidelines in the sense that they constitute a threat to the whole area and its integrity. The nominated site is the result of a complex interaction of erosion and sedimentation at the shallow coastline of the North Sea. These still ongoing dynamics are the main feature of the site. The system has survived severe storm events in the past, which have altered the landscape and wiped out former settlement areas. Thousand of people and cattle drowned during these storm floods. These experiences have led to today's coastal defence and protection plans with the highest possible safety standards for the inhabitants inside and outside the Wadden Sea.

The nominated property, however, subject to certain risks from shipping offshore its boundaries. As indicated above, access to the ports in connection with transit traffic to Scandinavia or to the Baltic Sea has turned the sea area off the Dutch and German coast into one of the regions with the highest traffic concentrations in the world.

The (marine part of the) nominated property has been designated a Particularly Sensitive Sea Area (PSSA). The PSSA designation is part of a comprehensive regime of protection measures for shipping safety and ships' safety set up by the International Maritime Organization (IMO), the European Union, or at the trilateral or the national level. This regime includes in particular Vessel Traffic Management System (VTMS), Traffic Separation Scheme (TSS), pilotage and mutual emergency management.

The TSS divides the sea traffic according to the main traffic directions into two one-way routes. Vessels carrying dangerous goods and deep draft vessels navigate the offshore routes far away from the coast and are thus separated from the other traffic according to the mandatory routing system adopted by the International Maritime Organization (IMO). With the exception of recreational traffic, which is usually limited to the summer months, the volume of shipping is spread evenly over all the months of the year. In view of the vessel traffic characteristics of the area, the Wadden Sea and adjacent North Sea still have an excellent record of only a few accidents and incidents. For example, during the period 1995-1999, a total of almost 800,000 ship movements in the German North Sea resulted in just over 100 incidents.

In the case of an emergency, a comprehensive set of contingency plans are in place to respond to oil pollution, for emergency towing of ships and mutual assistance in case of emergencies between the Wadden Sea countries in the framework of the DENGERNETH-Agreement concluded under the Bonn Agreement for cooperation in dealing with pollution of the North Sea by oil and other harmful substances. The best approach remains to prevent accidents from occurring and continued effort is therefore being made to maintain and, where necessary, increase shipping safety and the safety of the ships through an improved VTMS and international cooperation.

Risk-bearing companies and/or substances are allowed, provided that in case of calamities no irreparable damage to the nominated property is caused.

(iv) Visitor/tourism pressures

Tourism and recreational activity are a substantial part of the public experience of the Wadden Sea. They constitute a unique opportunity to experience the natural and scenic values of the area and one which also makes an important contribution to the regional and local economy, but also may potentially have a negative impact on the values of the Wadden Sea. The major part of the tourist activities, including the development of e.g. infrastructure, takes place outside the Wadden Sea, but all activities are so intimately linked to the nominated property that it is essential to take the broader scope when describing and assessing tourism and visitor activities.

In describing the activities, it is normally discriminated between land-based tourism and recreation, tidal flat walking, which is a particular activity of the nominated property hardly known anywhere else, and, finally, recreational boating.

Land-based tourism and recreation

Approximately 10 million tourists stay overnight and 30-40 million day trippers visit the Wadden Sea region every year (the region being the Wadden Sea, the Wadden Sea islands and the adjacent mainland areas).

For the German coast, more detailed data is available which also cover accommodations not listed in the official statistics (Tab. 4.4). Recent studies in Schleswig-Holstein have shown that the official tourism statistics underestimate by far the real numbers of guests, overnight stays and, subsequently, turnover. Boarding houses and pensions with less than 9 beds as well as visits to friends and relatives contribute a considerable share (53% of total), which is not included in the official data collections (Tab. 4.4).
In the Niedersachsen Wadden Sea region, a turnover of 1.53 billion EUR for tourism (all kinds of accommodation) was calculated, based on 27.7 million overnight stays plus 2.6 million overnight stays on camping sites and 16.5 million day trips. Thus, as shown in Table 4.4, tourism figures are substantially higher than indicated in official statistics (accommodation facilities with more than 8 beds). Table 4.4 gives a sum of 43.5 million overnight stays for the Niedersachsen and Schleswig-Holstein Wadden Sea region per year.

The total number of overnight stays in the Dutch Wadden Sea region was 10 million in 2005 (data include facilities < 9 beds; data source: official national statistics: CBS 2005, Toerdata Noord, 2006).

Tourism has an extraordinarily high economic value for the region (estimated turnover of 2.8-5.3 billion EUR per year) and provides an increasing number of jobs (about 37,900 jobs in the entire Wadden Sea region in 2000). Due to globalization, intensified competition and modified consumer habits, tourism in the Wadden Sea is subject to changes, which opens up new opportunities at the same time. The growth markets of wellness/fitness, walking/hiking, and nature-oriented holidays and leisure activities fit well into the Wadden Sea region. Also, the aging population may have a positive consequence. Therefore, attractive outdoor and indoor offers are important for nature experience, emotional experiences and fun-oriented environmental education for all target groups, disabled and elderly people included.

**Tidal flat walking**

Tidal flat walking is the crossing of the tidal area during low water and offers a unique nature experience, which can be offered hardly at any other place on earth in this way. Walking on the “bottom of the sea” is the most exceptional way to undergo the “mystery” of the Wadden Sea and creates an intimate understanding of what this area is about and why it is so outstanding.

In the Netherlands, walking on tidal flats predominantly takes place on the ‘Groninger wad’ and the eastern part of the ‘Frisian wad’.

<table>
<thead>
<tr>
<th>Destination North Sea Coast Niedersachsen</th>
<th>Type of accommodation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overnight stays</td>
<td>Share of total %</td>
</tr>
<tr>
<td>Accommodation facilities &gt;8 beds</td>
<td>11.9 million</td>
</tr>
<tr>
<td>recorded in official statistics</td>
<td></td>
</tr>
<tr>
<td>Accommodation facilities &lt;9 beds</td>
<td>13.3 million</td>
</tr>
<tr>
<td>(boarding houses, pensions)</td>
<td></td>
</tr>
<tr>
<td>Visits to friends and relatives</td>
<td>2.5 million</td>
</tr>
<tr>
<td>Total</td>
<td>27.7 million</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Destination North Sea Coast Schleswig-Holstein</th>
<th>Type of accommodation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overnight stays</td>
<td>Share of total %</td>
</tr>
<tr>
<td>Accommodation facilities &gt;8 beds</td>
<td>7.5 million</td>
</tr>
<tr>
<td>recorded in official statistics</td>
<td></td>
</tr>
<tr>
<td>Accommodation facilities &lt;9 beds</td>
<td>7.1 million</td>
</tr>
<tr>
<td>(boarding houses, pensions)</td>
<td></td>
</tr>
<tr>
<td>Visits to friends and relatives</td>
<td>1.2 million</td>
</tr>
<tr>
<td>Total</td>
<td>15.8 million</td>
</tr>
</tbody>
</table>

The numbers of participants per year have been in the range of 65,000 to nearly 80,000 persons in the period 1997-2002. In Niedersachsen, the total numbers of persons counted in the Wadden Sea from aircraft varied between 10,000 in the year 2000 and 18,000 in 2002 (sum of five flights during the summer holidays respectively). Groups of walkers (assumed to be participants in a guided tour) constitute a 15-29% share of the total number of persons recorded. In Schleswig-Holstein the number of guided tours in the Wadden Sea increased by 20% during the period 1999-2002. In 2002 nearly 5,000 guided tours with 116,000 participants took place.

In the Netherlands, tidal flat walking is regulated in the ‘Provincial Tidal Flat Walking Bye-law’. Often, it concerns a ramble or a crossing to one of the islands. Tidal flat walking is only allowed with a permit granted by the province. For reasons of safety of participants and of protection of natural and landscape values of the area, it was recognized that extension of the number of tours and the number of participants was not advisable. Therefore, seven tidal flat walking organizations and the provinces signed the ‘Tidal Flat Walking Covenant’. This covenant includes agreements on the maximum number of tours and participants and on zoning of tours. In addition, a code of conduct for participants was set up. On a yearly basis the total number of walkers may not exceed 50,500. In the last years the numbers of walkers were well under this limit. The yearly average number of people that is involved in tidal flat walking activities is about 30,000 – 35,000. In addition to this, permits are given for guided tours for environmental education. In total, there are about 75,000 people that participate in one of these types of guided tours each year.

As in the Dutch part of the nominated property, there are strict regulations for tidal flat walking of groups in Niedersachsen also. Guidance of tours on the tidal flats of the mainland or the islands and for crossing to some of the islands (there are official routes only to 4 of the 7 East-Friesian islands) is only allowed with a permit, for which examinations in safety, first aid, tidal flat ecology and National Park matters have to be passed. Similar regulations apply to most of the Schleswig-Holstein part of the Wadden Sea. Guides who additionally take part in National Park educational courses receive certification as National Park Guides. In addition to the guided tours, tidal flat walking is a very popular recreational activity.

Recreational boating

In general, only in the Dutch Wadden Sea can a clear trend be seen with respect to the number of boats. Both the number of sluice passages and the number of berths have increased since 1982. The number of berths in the fourteen marinas surrounding in the Dutch Wadden Sea increased from 4100 in 2001 to 4377 in 2006. The yearly number of sluice passages in the Dutch Wadden Sea has increased from 105,000 in 1997 to 122,000 in 2005. In Schleswig-Holstein, the boat traffic has
not significantly increased or decreased during the last 20 years. The highest density of leisure boats and excursion boats/ferries was observed around the North-Frisian islands.

**Regulation**

The tourist and recreational activities in and adjacent to the nominated property are, as appropriate, comprehensively regulated. It is difficult if not impossible to determine the carrying capacity of an area like the nominated property, which is so vast and complex, but it is justified to state in general that recreational activities are so well regulated and managed that they do not cause any adverse impact on the property. It is perfectly capable of absorbing the current and, possibly, an increased activity level in the future.

On the contrary, while the nominated property attracts many tourists because they want to enjoy also the unique nature, the silence and the scenic beauty, they contribute to a significant extent to the comprehension of the natural values of the area, and in a wider sense to the protection and conservation of the Wadden Sea and the well being of those who live in the region.

Within the nominated property, a zoning system is applied which regulates access and recreational boating in time and space. The most sensitive areas, such as the breeding and resting areas for birds and seals, are closed the whole or part of the year. Also, regulations and a code of conduct apply for falling dry with recreational boats. Voluntary agreements exist between yachting associations and the nature protection authorities to provide additional protection and prevent disturbance in those areas where access is not prohibited. Tidal flat walking is basically only allowed with a permit and on designated routes. Speed limits have been imposed for recreational boating for the largest part of the nominated property. The use of jet skis, water skis and similar equipment is basically prohibited or confined to smaller designated areas within the nominated property.

For activities in the areas adjacent to the nominated site, a comprehensive planning system exists which aims to direct and regulate tourism. The building of tourist infrastructure, including e.g. marinas, is subject to assessment and planning and will only be allowed if there is no adverse impact on the nominated property. The planning system, including the spatial planning, also limits the use of space and natural resources. All things considered, the tourist and recreational activities are well controlled and the current planning, legal and management system is robust enough to sustain an increase in the activity and prevent an adverse impact to result from it on the nominated site.

**(v) Number of inhabitants within the property**

The number of inhabitants within the nominated property is 3 (2007).
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 4 State of Conservation and Factors Affecting the Property
5. PROTECTION AND MANAGEMENT OF THE PROPERTY

5.a Ownership

Most of the nominated property is state (federal or state) owned and only a very small part is privately owned.

In the Dutch part of the nominated property around 6% is owned by three private associations and one regional authority:

- The “Groninger Landschap” (the Groningen Landscape Society) is a private provincial nature conservation and management society. Its objective is to conserve nature and cultural history in the province of Groningen. The “Groninger Landschap” owns the “Punt van Reide” (46 ha), salt marshes in the “Dollard” (4204 ha) and the salt marshes “Noordkust” (200 ha);
- The “Noord-Hollands Landschap” (The Noord-Holland Landscape Society) owns some smaller areas, the “Balgzand” and “Amstelmeer”, in total 120 ha;
- “Natuurmonumenten” (Nature Monument Society) is a private nature conservation society; it owns almost 10,700 ha of the nominated property. The areas owned by “Natuurmonumenten” are “Uithuizerwad” (63 ha), mud flats in the “Dollard” (3846 ha), “Griend” (100 ha) and “De Schorren” (6681 ha);
- “Wetterskip Fryslân” (Friesland Water Authority), is a government agency in the province. The authority is responsible for water management in the province. It owns 670 ha of salt marshes at the north coast of the province of Fryslân.
- The private nature conservation societies “Groninger Landschap”, “Noord-Hollands Landschap” and “Natuurmonumenten” serve a public goal. They protect and manage the areas of the nominated property, basically on behalf of the national government, including the public awareness of these sites. Smaller parts, primarily mainland salt marshes, are owned by private owners such as farmers. They are organized in the Landowner Association.

<table>
<thead>
<tr>
<th>Area</th>
<th>ha</th>
<th>km²</th>
<th>Ownership</th>
</tr>
</thead>
<tbody>
<tr>
<td>Key Planning Decision Area (PKB) Wadden Sea</td>
<td>256,263</td>
<td>2,562.6</td>
<td>State owned 241,000 ha (94 %) “Groninger Landschap” 4,450 ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Noord-Hollands Landschap” 120 ha “Natuurmonumenten” 10,690 ha</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>“Wetterskip Fryslân” 670 ha</td>
</tr>
<tr>
<td>Wadden Sea National Park Niedersachsen</td>
<td>277,685</td>
<td>2,776.9</td>
<td>92.5 % federally owned 6 % state owned</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 % owned by municipalities 0.5 % private property</td>
</tr>
<tr>
<td>Wadden Sea National Park Schleswig-Holstein</td>
<td>439,614</td>
<td>4,396.1</td>
<td>98.3 % federally owned 1.6 % state owned</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.1 % private property</td>
</tr>
<tr>
<td>TOTAL WADDEN SEA PROPERTY</td>
<td>973,562</td>
<td>9,735.6</td>
<td></td>
</tr>
</tbody>
</table>
5.b Protective designation

As stated in Chapter 3 of the nomination, the Wadden Sea is subject to comprehensive protection, management and monitoring, both in the national as well as in the international context unprecedented in terms of its integrated and harmonized approach. The recognition that the Wadden Sea required a common protection and management approach in order to ensure that it would be protected and managed in respect of its shared character is more than a generation old.

The first formal International Wadden Sea Scientific Conference was held in 1975. In 2009 the 11th Scientific Conference will be held. At the Symposia, scientists from the three Wadden Sea countries exchange relevant research findings and formulate recommendations to the political level. The Symposia also deal with management issues. The findings of the scientific symposia have been and are important for the development of trilateral and national policies in terms of protection, management, monitoring and research.

The first Governmental Conference on the Protection of the Wadden Sea was held in 1978 in The Hague, the Netherlands. In 1982, at the 3rd Conference in Copenhagen, the “Joint Declaration on the Protection of the Wadden Sea” was signed. Within the Wadden Sea Cooperation, conferences are held every 3-4 years. The 10th Wadden Sea Conference was held in 2005 at the island of Schiermonnikoog.

Parallel to and within this framework, the national protection of the Wadden Sea developed in such a way that over the past generation the entire nominated property has been subject to the highest and most comprehensive legal protection under national legislation. It is very important to acknowledge the choice that was made a generation ago, i.e. to basically adopt “avant la lettre” an ecosystem and sustainable use approach to the long-term protection and management of the Wadden Sea, within which human activities will continue.

In addition, the nominated property is subject to protection under relevant European Union legislation and designations as well as under international agreements and conventions which contribute to enhancing and safeguarding its outstanding international importance.

1. The Joint Declaration on the Protection of the Wadden Sea, 1982

The Joint Declaration on the Protection of the Wadden Sea (Annex 10) was signed at the 3rd Trilateral Governmental Conference on the Protection of the Wadden Sea in Copenhagen in 1982. In this declaration, the governments recognize their responsibilities for the conservation of the ecosystem and declare their intention to coordinate their activities and measures to implement a number of international legal instruments in
the field of natural environmental protection, amongst others the Ramsar Convention and the EC Bird Directive, for a comprehensive protection of the Wadden Sea region as a whole, including its flora and fauna.

Since 1982, seven Governmental Wadden Sea Conferences have been held and the trilateral cooperation has been strengthened and intensified.

The Common Wadden Sea Secretariat was established in 1987 following a decision at the 4th Wadden Sea Conference in The Hague in 1985. The basis for the secretariat is the Administrative Agreement (Annex 11) concluded in 1987 between the competent ministries of the three countries. The Administrative Agreement stipulates the tasks and the financing of the secretariat and its staff. The secretariat has been located in Wilhelmshaven since its establishment in 1987.

3. Agreement on the Conservation of Seals in the Wadden Sea, 1990
The Seal Agreement (Annex 13) was enacted on October 1, 1991 as the first agreement, as defined in Article 4, of the Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention). The Seal Agreement was concluded between the Wadden Sea countries with the aim of cooperating closely in achieving and maintaining a favourable conservation status for the common seal population of the Wadden Sea.

The declarations issued on the occasions of the Wadden Sea Conferences are political declarations, in which agreements are made between the governments, which are relevant for all areas of the cooperation such as management, monitoring, international cooperation, etc. The declarations are therefore an integrated part of the total protection and management of the nominated property to which the governments have committed themselves. The Guiding Principle of the Trilateral Wadden Sea policy, as agreed upon at the 6th Conference in Esbjerg, 1991, is “to achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way”. The Wadden Sea Plan, the policy and management plan for the nominated property, which includes the central objectives and principles of the Wadden Sea Cooperation, is also an agreement made at the 8th Conference in Stade, 1997. The Trilateral Monitoring and Assessment Program (TMAP), associated with the implementation of the Wadden Sea Plan, was launched on the same occasion.

5. Wadden Sea Forum
At the 2001 Wadden Sea Conference the Wadden Sea Forum (WSF) was established. The WSF is a stakeholder forum of representatives of regional and local governments and main sectors in the Wadden Sea region. The task of the WSF was to develop a sustainable development strategy for the Wadden Sea Region respecting the current level of protection of the Wadden Sea. The WSF sustainable development strategy “Breaking the Ice” was submitted to the 2005 Wadden Sea Conference at which the Governments indicated that they subscribed to the strategy as a start of the process to implement this strategy through the WSF action plan.

National Protection of the Wadden Sea

The Netherlands
The protection of the Dutch part of the nominated property combines a unique national physical planning approach (the Key Planning Decision Wadden Sea (PKB)) with a designation of the nominated property under the Nature Conservation Act, 1998 supported by additional designations.

Since 1980 the Netherlands Wadden Sea has been protected according to the PKB Third Policy Document of the Wadden Sea (Annex 16), which is a national physical planning decree defining the overall objectives of conservation, management and use of the Wadden Sea. The PKB is a specific integrated physical planning instrument of the Spatial Planning Act and its objectives and conditions are binding for all state, regional and local authorities. The PKB document is valid for the whole Dutch part of the nominated property. The PKB is subject to amendment on a regular basis. The latest amendment was issued in 2007 after adoption by Parliament.

2. Nature Conservation Area
Through the Nature Conservation Act (1998) (Annex 15) nature areas designated as Special Areas of Conservation (SACs) according to the Habitats Directive, and as Special Protection Areas (SPAs) under the Birds Directive are protected under the aforementioned Act as nature reserves. The conservation objectives for these Natura 2000 areas
are stipulated in a ministerial order together with the delimitation of the area. Management plans outlining the required measures will be drawn up for each area. Arrangements will be made with provincial authorities to implement them. According to legislation it is prohibited without permission to undertake activities which destroy and damage the protected area including its flora and fauna or its scenic importance. The guiding principle is that human activities are allowed as long as they are consistent with the major goal of the policy given in the PKB document. Therefore, the actual legislation includes an assessment frame to be used when the acceptability of proposed new activities has to be determined.

3. Act on the Wadden Sea Council, 2002
The act establishes the Wadden Sea Council. The Council is to be considered a continuation of the Advisory Board established in 1982. The Wadden Sea Council is an independent advisory board and advises the governments and the parliament on issues of general importance for the Wadden Sea region such as policies (regional, national, trilateral) with regard to, for example, fishery, recreation, the development of management plans and the improvement of the governing structure for the area and with regard to the development of a sustainable development perspective. Its members are designated on the basis of their technical knowledge and do not represent specific sector interests.

4. Ecological Main Structure
The Dutch part of the nominated property is also designated part of the Ecological Main Structure (EMS), which is the coherent national ecological network of nature areas. The aim of the EMS is to prevent plants and animals from extinction in isolated areas and the devaluation of nature areas. For each of the areas of the EMS a specific ‘nature goal’ is defined. This is a testable objective for a nature area. At the national borders the EMS connects with other areas of the Pan European Ecological Network (PEEN).

5. National Parks
Parts of the islands of Schiermonnikoog and Texel, also within the nominated property, are designated national parks in accordance with national legislation.

6. Environmental Protection Area
Areas that have a special conservation status based on the Nature Conservation Act 1998 or the Ramsar Convention, and are thus part of the nominated property, are designated as Environmental Protection Areas in accordance with the Environmental Management Act. This means that the Environmental Decree issued by the provincial government includes at least regulations concerning the protection of the quality of groundwater and the prevention and restriction of nuisance by noise.

Germany
In Germany the coastal federal states are responsible for the implementation of the Federal Nature Conservation act. The Federal Nature Conservation Act is a federal framework act for nature conservation which includes provisions for the establishment of nature reserves and

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national parks. According to §24 of the Federal Nature Conservation Act (2002), national parks are larger areas of national importance of which the major part is undisturbed and qualify to be designated as a nature conservation area. The aim is to safeguard, in the greater part of the area concerned, undisturbed ecosystem interactions and their natural dynamic processes to the extent possible.

Schleswig-Holstein and Niedersachsen established national parks for the nominated property in 1985 and 1986. The objectives of the national parks are to protect the Wadden Sea and to allow natural process to take place with a minimum degree of disturbance and other detrimental effects of human activities. The national parks have been divided into two or three zones of which the zone I includes the ecologically most valuable areas. Therefore, strict regulations apply to the zone I, including extensive restrictions to public admittance. In zone II, utilization and activities are allowed under such conditions that the overall protection objectives are not impaired. Each national park is managed by an administrative authority, the national park authority, which is responsible for the implementation of the provisions of the national park instruments.


The Schleswig-Holstein Wadden Sea National Park was established in 1985 by state law, which was amended in October 1999 (Annex 18). In comparison with the 1985 law, the amended law entails in particular a seaward extension of the National Park, including the designation of a small cetacean conservation area off the islands of Sylt and Amrum, a new definition of the protection objective and the introduction of a new zoning system, including a zero use area. Two statutory boards of trustees represent the local authorities and the most important stakeholder interests on county level. They advise the national park authority on basic issues and long-term planning.

2. The Order on the Protection of Excavation, 1973

The order, issued in 1973, aims to protect the archaeological values of the marine area of the Schleswig-Holstein part of the nominated property north of the Eiderstedt Peninsula.

3. The Act on the National Park Niedersachsen Wadden Sea, 2001

The Niedersachsen Wadden Sea National Park was designated in 1986 by state statutory order, which was given the status of state act in 1999 (Annex 17). The act was amended in 2001 to include a major extension of the area seaward and in the Ems estuary, and a rezoning of the park. The inhabited islands, except for the villages, are part of the National Park.

4. Order on the Navigation on the Federal Waterways in the National Parks in the area of the North Sea, 1997

The marine area of the German part of the nominated property is federal waterways. Navigation is hence to be regulated by Order of the Federal Minister for Traffic. An order was issued in 1992 and amended in 1995 and 1997. The order estab-
lishes speed limits for navigation in the National Parks and closed areas comprising of seal haul out sites, and breeding and moulting areas for birds.

**International Protection of the Wadden Sea**

The Wadden Sea countries are contractual parties to a number of international agreements, conventions and treaties, in particular, the Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar Convention); the Convention on Biological Diversity (CBD), the Convention on the Conservation of Migratory Species of Wild Animals (CMS, Bonn Convention) also covering the Agreement on the Conservation of Seals in the Wadden Sea (Seal Agreement), the Agreement on the Conservation of African-Eurasian Waterbirds (AEWA) and the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention) and the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR Convention). The nominated property has also been designated as Man and Biosphere (MAB) Reserves under the United Nations Educational, Scientific and Cultural Organization (UNESCO).

Some of the most relevant international conventions and agreements for protecting the Wadden Sea will be mentioned here, being aware that there are more treaties and conventions valid for the property.

Due to the strong interactions between the Wadden Sea and the adjacent North Sea, the trilateral policy and management regarding pollution is closely related to the OSPAR Convention and the North Sea Conferences.

1. **Ramsar Sites**

The *Ramsar Convention* 1971 is a world wide treaty for the conservation of wetlands: shallow open waters and any land regularly or intermittently covered or saturated by water. In the framework of the Convention, wetlands of international importance are designated by the contracting parties. Nearly all parts of the Wadden Sea have

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**Figure 5.1:** Map of Ramsar sites within and adjacent to the nominated property.
been designated as Ramsar sites.

2. Particularly Sensitive Sea Area Wadden Sea

In 2002, the Wadden Sea was designated as a Particularly Sensitive Sea Area (PSSA) (Annex 14) by the International Maritime Organization (IMO).

The area designated as a PSSA is the marine area of the Wadden Sea. The PSSA covers an area of approximately 13,000 km²; the major shipping routes have been excluded from the designation. The PSSA does not limit shipping in the area nor the use of the Wadden Sea harbours. The designation of the PSSA Wadden Sea is seen as a recognition of the extensive regime of the national and international protective measures already in place in the Wadden Sea and adjacent the North Sea. Examples are the MARPOL Special Areas prohibiting discharges of oil and garbage, routing systems making certain routes compulsory for ships carrying hazardous goods and compulsory reporting for ships. An evaluation of the PSSA is agreed before the 2010 Wadden Sea Conference.

3. Man and Biosphere Reserves

The nominated property has been designated Man and Biosphere (MAB) Reserve under the UNESCO Man and Biosphere Program by the Netherlands and the two German states. Whereas the MAB Reserve in the Dutch and Niedersachsen part is nearly identical with the nominated property, the MAB Reserve in Schleswig-Holstein also includes 5 Halligen as development zone adjacent to the nominated property.

4. The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), 1991

The Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS) was concluded in 1991 under the auspices of the Convention on Migratory Species (UNEP/CMS or Bonn Convention) and entered into force in 1994. The nominated property is within the agreement area. The aim of the agreement is to promote close cooperation amongst parties with a view to achieving and maintaining a favourable conservation status for small cetaceans. A Conservation and
Management Plan forming part of the agreement obliges parties to engage in habitat conservation and management, surveys and research, pollution mitigation and public information.

5. The African-Eurasian Waterbird Agreement, 1995

The African-Eurasian Waterbird Agreement (AEWA) concluded under the Bonn Convention focuses on migratory waterbirds. It was concluded 1995 in The Hague, the Netherlands, and entered into force in 1999. The secretariat is located in Bonn, Germany. AEWA’s flyway approach to waterbird conservation is unique. Being a regional agreement, AEWA focuses on 235 waterbird species ecologically dependent on wetlands for at least part of their annual cycle, including many species of pelicans, storks, flamingos, ducks, waders, terns, gulls and geese. The AEWA Agreement area covers 117 Range States in Africa, Europe, as well as parts of Canada, Central Asia and the Middle East. The geographic area stretches from the northern reaches of Canada and the Russian Federation to the southernmost tip of Africa. The AEWA is of particular importance for the Wadden Sea, being the key stepping stone for migratory birds within the agreement area.

European Union

The European Union legislation in the field of environment is of specific significance for the Wadden Sea and has increased in importance during the past two decades. The European Union legislation is trans-boundary and, increasingly, covers all environmental policy areas. The legislation also has direct implications for Member States’ legislation. Of the comprehensive list of environmental legislation, the Habitats, Birds and the Water Framework Directives are the most relevant pieces of legislation for the protection and sustainable use of the nominated property.

1. Birds and Habitats Directives

The Council Directive 79/409/EEC on the conservation of wild birds (Birds Directive) was adopted in 1979 and aims at the protection of all species of naturally occurring birds in the territory of the member states. According to the Birds Directive,
member states must classify the most suitable territories for the conservation of the species listed in Annex 1 of the directive, as ‘Special Protection Areas’ (SPAs). The greater part of the nominated property has been designated as SPA.

The Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora (Habitats Directive), adopted in 1992, complements the 1979 Birds Directive. It has the aim of ensuring that biodiversity is maintained through conservation of important, rare or threatened habitats and the habitats of certain species. In the framework of the Habitats Directive a coherent ecological network, called NATURA 2000, is being established. NATURA 2000 will consist of Special Areas of Conservation (SACs) designated according to the Habitats Directive, and the SPAs of the Birds Directive. The nominated property has been or will be designated as SAC.

The Wadden Sea is part of NATURA 2000 and subject to the provisions of the Habitats Directive, of which Article 6 is a crucial one. Article 6 stipulates that for special areas of conservation, member states shall establish the necessary conservation measures involving, if need be, appropriate management plans specifically designed for the sites or integrated into other development plans. Member states shall also take appropriate steps to avoid, in the special areas of conservation, the deterioration of natural habitats and the habitats of species as well as disturbance of the species for which the areas have been designated, in so far as such disturbance could be significant in relation to the objectives of this directive. A report on the ecological status of NATURA 2000 areas has to be delivered to the European Commission every six years.

A plan or a project likely to have a significant effect on the areas shall be subject to an appropriate assessment of its implications for the site. Only if it will not adversely affect the designated conservation area shall a competent authority agree to the plan or project. If a project or plan must nevertheless be carried out for imperative reasons of overriding public interest in the absence of alternatives it must be compensated to ensure

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**Figure 5.4:** Map of the Special Areas of Conservation (SAC) within and adjacent to the nominated property.
2. Water Framework Directive
The Council Directive 2000/60/EC on establishing a framework for Community action in the field of water policy (Water Framework Directive, WFD) was enacted in 2000. It aims at a coordination of all water-related measures on the European level. The key elements of the WFD include the protection of all waters, surface and ground waters in a holistic way and the achievement of good quality (‘good ecological status’) by 2015. A first analysis of pressure and impacts was reported by the member states in 2005.

A River Basin Management Plan has to be prepared by 2009, based on the results of an operational monitoring program (to be established by 2006). River management plans are to be reviewed every 6 years.

The Wadden Sea has been assigned to six different River Basin Districts (RBDs), differentiated in coastal and transitional waters. These RBDs are the main management units of the WFD and cover all types of surface and ground waters. Coastal waters cover the areas up to 1 sm from the baseline and, with regard to the chemical status, also the territorial waters (up to 12 sm) (Figure 5.5).

Regarding the Habitats, Birds and Water Framework Directives, the Schiermonnikoog Conference reaffirmed that a coordinated and consistent implementation will continue to be a central aim. The Wadden Sea Plan will be further developed into a management plan in accordance with the stipulations of the mentioned directives.

3. Other European Union legislation
Other relevant European Union legislation includes the Environmental Impact Assessment Directive and the Strategic Environmental Assessment Directive, which are of central importance for the assessment of the environmental impacts of policies, plans and concrete projects. Also, the recommendation of the European Parliament and the Council on Integrated Coastal Zone Management is of particular importance for the Wadden Sea,
it being a site located at the interface between land and sea and to be managed according to this specific characteristic.

5.c Means of implementing protective measures

An essential feature of the protection afforded to the nominated property is that the framework of the trilateral Wadden Sea Cooperation provides it with one comprehensive protection and management scheme, with additional layers of protection ensuing from international legal instruments within the same comprehensive scheme.

The trilateral Wadden Sea Cooperation forms the overall common framework for the protection of the nominated property within the Joint Declaration signed by the parties. At consecutive ministerial conferences and within the Wadden Sea Plan, common principles, objectives and policies have been agreed upon. The Guiding Principle, as agreed at the 1991 Wadden Sea Conference, is "to achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way". This overall guiding principle is supported by several management principles such as the "Principle of Careful Decision Making" and the "Precautionary Principle". Further, a comprehensive set of primarily ecological Targets were agreed upon by the cooperation at the 1994 Wadden Sea Conference in conjunction with the common delimitation of the Wadden Sea Cooperation Area as a basis for the common management of the Wadden Sea. As mentioned above, this has been followed by many other additional agreements of significance for the protection of the Wadden Sea.

Though these agreements are of a political nature and have no direct legal implications, they are commitments that are made on the highest level between governments in the understanding that the governments will apply, enforce or implement them using their national and international instruments and their full scale of other regulatory and management possibilities.

Though there are differences how the relevant national legal protection instruments are composed within the overall framework, which naturally follows from the apparent differences in legal schemes, they are basically similar in objectives, protection regulations and enforcement.

German Wadden Sea

The protection objectives of the German Wadden Sea National Parks covering the German part of the nominated property are to protect the Wadden Sea and its natural development. The natural processes should be allowed to proceed as undisturbed as possible. It is explicitly stated, however, that coastal defence measures and measures undertaken in conjunction herewith are not to be restricted. Furthermore, the Schleswig-Holstein National Park Act explicitly stipulates that unreasonable impairment upon the interests and the customary practices of the local population shall be avoided. In addition, all issues of use and
exploitation have to be impartially considered in the light of the overall protection aims of the national parks and individual cases. The conservation of nature by the national park should lead to an improvement of the living and working conditions of the human population living within the region through positive repercussions on tourism and the reputation of the region. This is currently a common Wadden Sea wide understanding of the added function of the protection and management schemes for the nominated property also embraced by the Wadden Sea Plan.

The national parks are divided into two respectively three protection and management zones with different levels of regulations. In the highest protection zone, resource use and access is in principle prohibited. In the other zones access and use of resources is conditionally allowed.

The Schleswig-Holstein National Park is divided into two zones, in which different activities are allowed. The core zone, zone 1, comprises coherent tidal basins and covers about 36% of the National Park. Public access is prohibited, with the exception of e.g. tidal areas adjacent to the coastline, tidal flat walking routes, and commercial fishery as stipulated in Section 6 (2) of the act. Within the core zone, an area south of the Hindenburg causeway of 12,500 ha has been designated as a zone in which all resource use has been fully prohibited. It is only allowed to navigate in the zero use zone on the marked shipping lanes. The area covers about 3% of the National Park area. Any activity which could cause destruction, damage or change to the protected area or any part thereof or that could lead to lasting disturbance, is prohibited. Permitted activities are explicitly stated in Section 6 of the National Park Law. The kind and location of activities is primarily determined by the zoning concept. Additionally, hunting and cockle fishery, which prior to the new amendment were largely phased out, are now completely prohibited within the National Park. The same holds for wind turbines.

The Niedersachsen National Park, which includes the uninhabited part of the East Frisian Islands, is divided into three zones. Zone 1 – the core zone – covers 61% of the total area and includes the ecologically most valuable areas. All activities which destroy, damage or change the National Park or its components are prohibited. Public admittance is prohibited with the exception of assigned paths and routes. Some human activities (farming, hunting on parts of the islands and fishing) are still possible, but only under restricted conditions. Zone 2 – the intermediate zone – covers 38.5% of the total area. All activities which change the character of the Wadden Sea, including the islands, in particular the scenic value or nature impression, are prohibited. A list of specifically prohibited activities is annexed to the act. Admittance is allowed to this zone, with the exception of the salt marshes during the breeding season for birds, from 1 April until 31 July. Zone 3 – the recreational zone – covers about 0.5% of the total area. Only recreational activities and health resort activities are allowed there. Paragraph 17
of the Niedersachsen National Park Act regulates possible exemptions and exclusions.

Resource use and activities that are not prohibited, coastal defence activities or those of a traditional nature according to the above mentioned national park acts are subject to licensing. Prior to issuing permits and exemptions the activity or project must be made subject to an assessment in accordance with the Habitats Directive.

Dutch Wadden Sea
As indicated in the previous chapter the protection of the Dutch part of the nominated property, though similar in structure to the German protection, combines a unique national physical planning approach with a designation of the property under the Nature Conservation Act 1998 supported by additional designations.

The PKB has the status of a law and its objectives and conditions are binding upon all state, regional and local authorities. The main objective of the PKB is a sustainable protection and development of the Wadden Sea as a nature area and conservation of the open landscape. This explicitly includes the conservation of landscape qualities, in particular the quietness, the openness and the naturalness. This objective, as indicated in the PKB, closely relates to the Targets, as entailed in the Wadden Sea Plan. The PKB must hence be implemented in regional and local spatial plans, taking into account that the nominated property is municipalized amongst the adjacent three provinces and municipalities. The municipalisation was done in the 1980s to ensure that the PKB would be implemented within the framework of spatial planning and hence guarantee that the objectives and policies of the PKB would be also binding upon the lower government levels. The local plans are binding legal documents with direct implications for the individual citizen or company. This approach was also opted for to engage and commit the regional and local authorities.

The designation of the nominated property as a nature conservation area is to ensure that the Nature Conservation Act 1998 and its stipulations can be applied. The PKB, in combination with the Nature Conservation Act 1998, guarantees special protection for the Dutch part. According to this legislation it is prohibited without permission to undertake activities which destroy and damage the protected area including its flora and fauna or its scenic importance. The guiding principle is that human activities are allowed as long as they are consistent with the major goal of the policy given in the PKB document. Therefore, the actual legislation includes an assessment frame to be used when the acceptability of proposed new activities has to be determined.

The PKB, in combination with the Nature Conservation Act 1998 (article 20) or the Criminal Code (article 461), allows for closing of zones in the area for public admittance for the whole or part of the year. The delimitation of these zones can be updated each year. It concerns mainly zones that are important for seals and breeding birds. About a quarter of the tidal flats has been
closed for cockle and mussel fishery. Based on the trilateral agreement laid down in the PKB document and the Policy Decision on Shellfish Fisheries (2004) in the eastern part of the Dutch nominated property, a reference area is designated. This area is about 7,400 ha, which is about 3% of Dutch part of the property, and it includes all the important ecological features. It has been closed for shellfish fisheries since 1993. In the reference area, exploitation of biotic and abiotic resources and other disturbing activities is not allowed. The area serves comparative monitoring and research in the Wadden Sea.

**Stakeholder involvement**

Advisory Boards have been established in the Dutch, Niedersachsen and Schleswig-Holstein part of the nominated property. Though there are differences in the remits and composition of the boards they are very important in terms of consultation and advice on Wadden Sea matters and the involvement of local and regional stakeholders in matters of protection and management of the nominated property. The Dutch Wadden Sea Council is composed of persons with an expertise on specific issues and not a representation of local and sectoral interests. Its task is to provide advice to authorities on matters of general importance for Wadden Sea protection and management but it can also on its own initiative investigate issues and provide advice.

The two Schleswig-Holstein Boards of Trustees are composed of representatives of the regional and local governments and regional stakeholders representing commercial, recreational and environmental interests. The Boards in addition provide advice to the National park Authority and must be consulted and give their consent on principal matters and on long-term planning.

The Advisory Board of the Niedersachsen National Park is also composed of representatives of the regional and local governments, regional stakeholders representing commercial, recreational and environmental interests and of scientific institutions. In regular meetings, the board is informed on all major activities in the National Park and gives advice to the National Park Authority.

**European Union Legislation**

As outlined in the previous chapter the relevant European Union legislation becomes increasingly important also for the protection and management of the Wadden Sea. The Habitats Directive in conjunction with the Birds Directive are of particular significance for the nominated property. The objective of the NATURA 2000 network is to contribute towards ensuring bio-diversity through the conservation of natural habitats and of wild fauna and flora in the European territory of the member states. Measures taken pursuant to the Habitats Directive shall be designed to maintain or restore, at favourable conservation status, natural habitats and species of wild fauna and flora of Community interest.

The nominated property has been or will be
designated as SACs. In the case of the Wadden Sea this is already the case. Furthermore, conservation status objectives shall be elaborated as a basis for the legal protection and management of the site. This will be done within a trilateral framework. In the Netherlands this process has already been concluded (2007) in the sense that all NATURA 2000 areas will be officially designated, including the associated conservation targets. Management plans outlining the required measures will be drawn up for each area. Arrangements will be made with provincial authorities to implement them. For the German part of the nominated property conservation objectives have been or will be designated. These objectives are essential in the sense that they will indicate what should be done to maintain or restore habitats to a favourable conservation status.

Further, as outlined in the previous chapter, Article 6 of the Habitats Directive introduces the assessment of projects and plans as an integrated part of the licensing of such projects and plans and, in a broader sense all activities in the nominated property. If the assessment provides evidence that the plan or project will have an adverse effect on the property it may not be permitted unless for overriding public interest and in the absence of alternatives. Such must be compensated.

It is important to acknowledge that the authority that issues a permit is the competent authority and this is in many cases not the authority competent for nature protection. The competent authority will have to fully take account of the protection framework.

Enforcement

The protection measures outlined above and overall legal, planning and management framework is directly enforceable. Much attention is given to the enforceability of the regulations through the establishment of management and enforcement units, coordination with all other government authorities operating in the nominated property and the introduction of state of the art techniques for surveillance of regulations and also by aerial surveillance.

In Germany, most of the enforcement measures lie within the responsibility of the federal states. The most important responsibility in the Wadden Sea directly assigned to the federal level is the competence for regulating and enforcing all measures connected to shipping because the marine area of the property is a federal waterway. Shipping regulations are therefore kept under the surveillance of the Federal Ministry of Traffic through its federal shipping agencies. At state level, generally regulations are legally implemented through the regular terrestrial and water based police forces of the State Ministries of the Interior. The State Ministries responsible for e.g. nature conservation, coastal defence and protection, water management, fisheries and economic affairs act directly or through their respective regional authorities. There is a close cooperation on all levels, e.g. national park and fishing regulations being kept under surveillance of the water based police. For implementing regulations of the national park acts, the National Park Authorities in Schleswig-Holstein and Niedersachsen have
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direct responsibilities. They are – differing from state to state – supported by wardens, volunteers and NGO’s. The counties and municipalities also have their own share of responsibility for the enforcement of actual legislation being in force in the Wadden Sea.

In the Schleswig-Holstein part, 16 "Rangers" from the National Park Service support the National Park Authority in the wardening of the area, together with non-governmental organizations which have been given contractual tasks in this regard in the area. In the Niedersachsen area, wardens employed at the coastal protection authorities and volunteers give advice to visitors and take care of the area. Also, the Water Police plays a significant role in terms of enforcement in the German part of the nominated property.

In the Dutch part of the nominated property, the national government as well as the provinces and the municipalities have their own responsibilities for the enforcement of the actual national legislation that is in force in the Wadden Sea. The enforcement of regulations that are valid for mainly shipping, fishing and recreational activities is carried out by the Ministry for Agriculture, Food Quality and Nature, the Ministry for Transportation Public Works and Water Management, the Water Police, the Military Police and customs services. In addition some supervisors/investigators of the provinces and some land administrators and regional Police Corpses are involved incidentally. These organizations co-operate in the Wadden Sea Enforcement Consultation Body. Their enforcement projects are included in a common long-term action programme. Co-operation is further facilitated by the Service Office Enforcement Wadden Sea.

It must, however, be acknowledged that enforcement is an issue for various reasons. Enforcement is difficult in an area of the size of the nominated property with its natural features, i.e. marine tidal area with limited accessibility. Furthermore, legal enforcement does not contribute to enhanced acceptance and therefore during recent years voluntary agreements have increasingly played a role.

In the Dutch part of the property for a trial period of four years it is allowed to beach a vessel beyond 200 metres from the buoyage of the navigation route, except for the closed zones, provided that a code of conduct is complied with. To this end, the joint authorities and the water sports organizations in the Dutch Wadden Sea area have signed the policy document ‘Responsible beaching in the Wadden Sea’. The recreation organisations urge their members to adhere to the code of conduct “Wad, I love you” and that they take measures within their organizations in case the code is violated. The code of conduct not only applies to yachters but to everyone on the Wadden Sea. Also tidal flat walkers must follow the rules laid down in the code of conduct. The code of conduct is especially geared towards people’s behaviour with respect to the species and habitats to be protected on which the Wadden Sea’s designation as a Nature 2000 site is based. The
code of conduct is widely distributed and can be found in all marinas, in tourist information maps, in journals and magazines. Hydrographical maps of the Wadden Sea refer to the code of conduct. The trial is evaluated every year, and in 2007 a final evaluation will be made. Based on the positive results obtained so far it was decided to extend the trial for responsible beaching by a maximum of four years. The final decision on the formalization of this beaching policy will be based on an overall assessment that will be performed in the framework of the integral Wadden Sea Management and Development Plan (B&O-plan, see p. 129). The results of the final evaluation are important input for this overall assessment.

In the Schleswig-Holstein part of the nominated property there are many examples of such (voluntary) agreements between the National Park Authority and various stakeholders such as with the mussel and shrimp fishers or the water sport board. Ship companies operating in the area with excursion boats, tour guides, tourism enterprises and even local authorities have signed voluntary agreements as national park partners. Furthermore, contractual regulations with some municipalities are in force which govern in detail the use of individual coastal areas like St. Peter-Ording, Westerhever or Hamburger Hallig. Regular common evaluations have proven successful in creating win-win-situations for both partners. Also in Niedersachsen, voluntary agreements and certifications have become more and more important, especially with the arrangements initiated in the frame of the ongoing process of the implementation of a Biosphere Reserve development zone in the Wadden Sea region of Niedersachsen. All national parks in Germany work together on promoting the concept of voluntary agreements with potential national park partners.

5.d Existing plans related to municipality and region in which the proposed property is located (e.g., regional or local plan, conservation plan, tourism development plan)

It is important to acknowledge that the entire area of the nominated property is subject to a coherent protection and management system resulting from designations as a protected area and national parks and, hence, affording it the highest protection status nationally and internationally, including European legislation. As a rule, therefore, regional and local planning, including spatial planning, is to provide priority to the protection status of the nominated property in the sense of the criteria viii, ix and x. The planning system in place is therefore to be considered a supportive instrument to the current protection scheme.

An important development is currently unfolding. As a result of the European Parliament and Council recommendation on the development of Integrated Coastal Zone Management (ICZM) for the European Union coastal zone (2002/413/EG), the Netherlands and Germany have reported to the European Commission the status of ICZM for their coastal zones including the nominated property and how they intend to follow up with an ICZM strategy. This seems to be a very essential approach since the protection and management of marine areas is a challenge in the sense that many factors and developments are potentially very significant for the nominated property while, at the same time, such developments are subject to regulations under different national and international regimes. ICZM attempts to direct and manage such developments and, from the point of view of the nominated property, to ensure that it maintains its integrity and that developments take a sustainable approach. The nominated property is therefore potentially the area that will profit most from the further development of the ICZM strategy and, at the same time, the area that will be a most determining element within the ICZM strategy for this part of the coast and the adjacent marine area. The Trilateral Cooperation with e.g. the Wadden Sea Plan, supplemented by regional organisational structures like the Wadden Sea Forum or “Euregio the Wadden” are existing elements of an ICZM.

The large part of the ICZM strategy is already present in the current national planning that has also been developed or is relevant for the nominated property.

Germany

With regard to ICZM, in particular, the federal government, the Länder (German federal states) and local authorities have advanced activities parallel to the further development of the set of legal instruments in order to generate know-how and experience, foster sustainability in coastal zones, improve cooperation between governmental, economic, social and research institutions and organizations as well as to improve the quality of the available knowledge within the framework of research and project support.

With respect to the existing set of tools and activities, the national strategy envisages four
areas in which further steps should be pursued:

1. Further optimization of the set of legal instruments according to the basic ICZM principles;
2. Creation of the basis for continuation of the dialog process;
3. Best practice projects and their evaluation;

Planning, including spatial planning, is a competency of the state, regional and local levels of government. The state spatial planning of Niedersachsen and Schleswig-Holstein includes the territorial waters including the German part of the nominated property. In the spatial planning programs of both states, the nominated property is afforded the status of priority area for nature protection in the regional plans and, as such, also indicated on the state spatial planning maps. As a consequence, the spatial planning has to take full account of the status of the nominated property and its stipulations and nothing can be planned or undertaken which opposes this status.

The State Spatial Planning Program Niedersachsen (“Landesraumordnungsprogramm Niedersachsen”) is currently (2007) being revised. In addition to maintaining and developing the status of the nominated property, it further stipulates that the nominated property is to be protected, supported and developed in its uniqueness through appropriate developments in the surrounding area. It is further stipulated that the MAB area in the adjacent area to the nominated property is to be further developed through model projects in the sense of sustainable development.

The Schleswig-Holstein State Spatial Plan (“Landesraumordnungsplan”), 1998 affords the above mentioned status of the nominated property. The 2005 Spatial Planning Report for Coasts and Sea aims to provide a comprehensive overview of all the uses of the coastal zone, with spatial implications and resulting actions. It fully embeds the nominated property within future spatial planning in accordance with its planning status.

The state planning system, as outlined above, has made a significant step towards implementing an ICZM approach within which the German part of the nominated property is firmly nested and is afforded an additional layer of protection.

**The Netherlands**

It is recalled that the protection of the Dutch part of the nominated property is afforded within a spatial planning framework through the national planning decree PKB. Furthermore, the nominated property is municipalized in regard of the adjacent provinces and the municipalities which are obliged to apply their spatial planning competencies also to the nominated property. This was, as stated earlier, deliberately done to guarantee that the spatial planning of the three levels of governments would be applied in a consistent way and would also take account of the land-sea interface. Regional and local (spatial) planning has therefore been an inherent feature in the Dutch approach from the outset.

It should be recalled that the PKB is an obligatory instrument for the regional and local government. Some of the decisions are directly binding upon these governments. Others are of a more indicative character. The provinces and municipalities have to take these into account...
5.e Property management plan or other management system

Management

All partners concerned are aware of the outstanding universal value of the nominated property "The Wadden Sea" and their responsibility to preserve this site for present and future generations. This is reflected as well in the Trilateral Governmental Conferences and Declarations (www.wadden-sea-secretariat.org) as in regional declarations and decisions supporting the nomination (see Annex 20, Regional declarations supporting the nomination).

Based on this thoroughly shared understanding of the property the conservation of the outstanding universal value and the integrity of the nominated property "The Wadden Sea" is already and will be secured by an effective management system. It aims at safeguarding its geomorphological and biological processes, habitats and species and to maintain its biological diversity in line with the proposed criteria in chapter 3. This management system is a combination of the national management systems and the trilateral Wadden Sea Plan aiming at securing a coordinated management of the trans-boundary site located on the territory of two sovereign states, the Federal Republic of Germany and the Kingdom of the Netherlands and incorporating responsible authorities. An essential element of the management system of the nominated property is the Wadden Sea Plan (WSP), which is in Annex 12. The Wadden Sea Plan applies to both the nominated property "The Wadden Sea" and the adjacent areas covered by the Wadden Sea cooperation. Following this ecosystem approach the World Heritage Site will benefit from the fact that the management of the whole area coming under the trilateral Wadden Sea cooperation is based on the same comprehensive agreements set out in the Wadden Sea Plan.

The Trilateral Wadden Sea Plan was adopted at the 8th Wadden Sea Conference in Stade, Germany in 1997. The Wadden Sea Plan (WSP) constitutes the common trans-boundary policy and management plan for the Wadden Sea Area. It is important to acknowledge that the WSP is a policy and management plan adopted by governments for a trans-boundary area and therefore has a wider perspective than a traditional management plan for a site in the sense that the WSP encompasses also the vision, principles, policies and measures in their actual planning. A few are decisions of essential importance and can only be changed by a revision of the PKB.

The provinces Groningen, Fryslân and Noord-Holland cooperate in the Steering Committee Wadden Sea Provinces. The provinces have laid down a common integral policy in the Inter Provincial Policy Plan (IBW). This IBW includes the common view and goals concerning the future developments in the Wadden Sea. The major goal of the common policy is a sustainable conservation and development of the Wadden Sea as a nature reserve. Within this context, certain human activities are possible. There are two preconditions: safety of the inhabitants and accessibility of the islands and the harbours.

The IBW is used as a basis for:

- Gearing policies of provinces, municipalities and national government;
- Determining provincial views on policy and initiatives of the national government;
- Taking initiatives to get activities started that contribute to the realization of the common goals;
- Participation in management and implementation activities of others;
- Consultation with stakeholders such as public organizations and private companies in the region;
- Assessing plans of municipalities in the region concerned.

Based on the Calamities and Heavy Accidents Act and the Public Works and Water Management Act, the Regional Board for the Wadden Sea area (RCW) has stipulated the Co-ordination Plan Calamity Control Wadden Sea. The plan makes clear who is in charge at any given moment and for any given task and which administrative measures have to be taken in the nearby future to optimize the co-ordinated calamity control. Agreements on this as well as operational plans on calamity control are part of the plan. The plan has been signed by the involved municipalities, the provinces and the national government.

The Dutch islands in the Wadden Sea region cooperate in the council "De Waddeneilanden". Their common policy is laid down in the Policy Plan 2006 – 2010. The islands in Schleswig-Holstein cooperate within the "Island and Hallig Conference". Where international issues are concerned, a further cooperation between the Dutch, German and Danish islands is realized through a cooperation body entitled Euregio.
and is a framework for the integrated protection and management of the Wadden Sea. The Plan is an agreement of how the countries envisage the coordination and integration of management of the Wadden Sea Area and of the projects and actions that must be carried out to achieve the commonly agreed targets.

The WSP is a coherent approach to the protection and management of the Wadden Sea in a trans-boundary context. In essence, it is an ecosystem approach and directed towards achieving and, hence, also maintaining the geomorphological and biological processes and the full scale of habitat types which belong to a natural and dynamic Wadden Sea in order to maintain biological diversity.

It includes the vision, shared principles, targets and policies and management measures combined with actions. The vision of the WSP is

- A healthy environment which maintains the diversity of habitats and species, its ecological integrity and resilience as a global responsibility;
- Sustainable use;
- Maintenance and enhancement of values of ecological, economic, historical-cultural, social and coastal protection character, providing aspirations and enjoyment for the inhabitants and users;
- Integrated management of human activities which takes into account the socio-economic and ecological relationship between the Wadden Sea Area and the adjacent areas;
- An informed, involved and committed community.

The shared principles include the already central Guiding Principle as referred to above “to achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way”. The associated management principles are fundamental for the common management of the Wadden Sea:

- The Principle of Careful Decision Making, i.e. to take decisions on the basis of the best available information;
- The Principle of Avoidance, i.e. activities which are potentially damaging to the Wadden Sea should be avoided;
- The Precautionary Principle, i.e. to take action to avoid activities which are assumed to have significant damaging impact on the environment, even where there is no sufficient scientific evidence to prove a causal link between activities and their impact;
- The Principle of Translocation, i.e. to translocate activities which are harmful to the Wadden Sea environment to areas where they will cause less environmental impact;
- The Principle of Compensation, i.e. that the harmful effect of activities which cannot be avoided, must be balanced by compensatory measures; in those parts of the Wadden Sea, where the Principle has not yet been implemented, compensatory measures will be aimed for;
- The Principle of Restoration, i.e. that, where possible, parts of the Wadden Sea should be restored if it can be demonstrated by reference studies that the actual situation is not optimal, and that the original state is likely to be re-established;
- The Principles of Best Available Techniques and Best Environmental Practice, as defined by the Paris Commission.

A very essential principle is that unreasonable impairments of the interests of the local population and its traditional uses in the Wadden Sea Area have to be avoided. Any user interests have to be weighed on a fair and equitable basis in the light of the purpose of protection in general, and the particular case concerned.

As emphasized above the trilateral conservation policy and management is directed towards achieving the full scale of habitat types which belong to a natural and dynamic Wadden Sea. Each of these habitats needs a certain level of quality, which can be reached by proper management of the area. This quality level can be described by certain characteristic structures, the presence of certain organisms, the absence of disturbance and toxic effects and by the chemical condition of the habitat.

For the common management six habitat types are distinguished:

- The offshore zone
- The beaches and dunes
- The tidal area
- The salt marshes
- The estuaries
- The rural area.

For the first five of these habitats ecological targets were adopted with the objective of maintaining and enhancing the area which is natural, dynamic and undisturbed, including targets for birds and marine mammals. These targets also equally ad-
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The ecological targets are valid for the whole Wadden Sea Area. There are, however, differences as regards the extent to which the targets will be implemented, in the interest of balancing out nature conservation concerns and human use. The Wadden Sea Plan is valid for the whole Wadden Sea Area and covers also topics which are not all part of national conservation areas like estuaries, dunes and the offshore area. Common agreements for a comprehensive protection of the Wadden Sea have been endorsed for almost all human activities. The Wadden Sea Plan also stresses that sustainable human activities in the area remain possible in the future.

Projects and actions are part of the WSP. A number of projects and actions were agreed at the time of the adoption of the WSP in 1997 which are consistent with the target approach. The projects mainly relate to further investigations, whereas the actions are concrete actions for improved management. The large majority of these projects and actions have been implemented.

The state of conservation of the nominated property is regularly reviewed and reported within the Trilateral Monitoring and Assessment Program (TMAP) and additional monitoring carried out within the property. The TMAP is an integrated common monitoring program of the Wadden Sea states the Netherlands, Germany and Denmark (§ 33, Ministerial Declaration, 6th Trilateral Governmental Conference, 1991). The WSP is linked to the Trilateral Monitoring and Assessment Program (TMAP) outlined in chapter 6. The TMAP monitors the Wadden Sea in a manner consistent with the WSP approach and enables a permanent assessment of the status of the Wadden Sea and the implementation of the WSP. Periodic Quality Status Reports are published encompassing a comprehensive assessment of the status of the Wadden Sea ecosystem based on the information gathered in the framework of the TMAP. So far, four Quality Status Reports have been published, including the 1991 “Development Report”.

Since 1997, the implementation of the WSP has been assessed in terms of policy and management at each of the subsequent conferences in conjunction with the Quality Status Reports and the assessment laid down in public policy assessment reports. The WSP is therefore subject to
periodic assessment of its implementation not only in a technical framework but also at the highest political level, ensuring that the WSP is implemented at the government level (see Declaration of Schiermonnikoog 2005).

The WSP will be developed further and submitted to the 2010 Wadden Sea Conference in accordance with the stipulations of the EC Habitats, Birds and Water Framework Directives. The WSP will continue to constitute an essential element of the management system of the nominated property.

As a consequence of the “Agreement on the Conservation of Seals in the Wadden Sea” mentioned above, a Conservation and Management Plan has been adopted since 1991 and been revised periodically. The Seals Management Plan (SMP) outlines the management actions that are necessary to implement the stipulations of the Seals Agreement in conjunction with the Targets laid down in the WSP. The SMP also includes projects and actions to be implemented in the period jointly or by (one of) the contracting parties. The SMP is the only species-related common management plan within the Wadden Sea cooperation.

For stakeholder involvement advisory boards have been established. Though there are differences in the remits and composition of the boards they are very important in terms of consultation and advice on Wadden Sea matters and the involvement of local and regional stakeholders in matters of protection and management of the nominated property.

The Wadden Sea Forum is a stakeholder forum of representatives of regional and local governments and main sectors in the Wadden Sea region. The WSF has developed proposals for a sustainable development strategy for the Wadden Sea Region respecting the current level of protection of the Wadden Sea.

Implementation

The national management systems, the Wadden Sea Plan and the relevant EU legislations are important elements for the management of the Wadden Sea. The character and the application of the Wadden Sea Plan at the trilateral level and the implementation of the EU legislation has been explained above. The parties follow somewhat slightly different approaches in the sense that the formal implementation is different but not the substance and the achievements.

The involvement of stakeholders, allocation of resources and capacity, the cycle of implementation, monitoring, evaluation and feedback is secured. In addition, the enforcement programme assures the accurateness on a short-term base. In case of accidents the available calamity control system (5d) will be activated. The effectiveness is maintained by regular training-sessions. All these systems are subject to regular assessments and adaptations.

In Germany most of the implementation and enforcement measures of the national management system lie within the responsibility of the federal states. Schleswig-Holstein and Niedersachsen established national parks in
The agreements of the WSP are implemented through the national park acts in conjunction with the directives and the management structure established with the national park acts. The national authorities oversee the implementation of the policy and management agreements. Each national park is managed by an administrative authority, the national park authority, which is responsible for the implementation of the management regulations.

Advisory boards of trustees represent the local authorities and the most important stakeholder interests in Schleswig-Holstein and Niedersachsen respectively. The stakeholder involvement aims at advising the national park authorities on basic issues and long-term planning.

The regional management in Germany supporting the national park acts combines sectoral strategies on different levels, ranging from legal enforcements on the level of decrees e.g. the Order on the Navigation on the Federal Waterways in the National Parks in the Area of the North Sea, and contractual regulations e.g. on municipality level to voluntary agreements between the national park authorities and various stakeholder groups. Regular common evaluations have proven successful in creating improvements for all partners involved. The regional management is regularly assessed on the basis of the results of the Trilateral Monitoring and Assessment Program, thus enabling a proper adjustment of the regional management. This is done in close consultation with the relevant stakeholders.

In the Dutch part of the nominated property an elaborate management system is in place in the framework of the PKB and the Nature Conservation Act (1998). This elaborated management system constitutes of a management plan, an implementation plan and an enforcement programme. This system is based on a common vision on the unique values and the corresponding conservation objectives.

The PKB includes a development perspective until 2030. Based on this development perspective, the Regional Wadden Sea Coordination Council (RCW) is setting up an integral Wadden Sea Management and Development Plan ("B&O-plan"). The integral character is the result of the common tuning of different management aspects between the different authorities concerned (legal instruments, maintenance and inspection, monitoring, information and education) and of the integration of all management information and maps. The intention is to integrate the management plans framed under the terms of the amended Nature Conservation Act (1998) and the Water Framework Directive into the B&O-plan as well. The Management Plan shows how the PKB, the Inter-provincial Policy Plan Wadden Sea and different governmental notes concerning the Wadden Sea will be realized in concrete terms. The Management Plan is also an assessment frame to be used when a permit or an exemption is requested. The B&O-plan will be operational at the latest by the end of 2010. The B&O Plan will be revised at least once every six years in close consultation with the relevant stakeholders.

Based on the B&O-plan, a new Wadden Sea Implementation Program will be developed, describing measures and activities that are planned for the coming six years. In addition, periodically a Report Wadden Sea Implementation Programme will be issued describing the realization of the Wadden Sea Implementation Programme. Also, a new Wadden Sea Enforcement Programme will be developed, describing the modes of enforcement that are applied. These plans and programmes will be stipulated by the RCW. The RCW will take care that the different enforcement activities are co-ordinated efficiently.

For Schiermonnikoog National Park the Management Plan Schiermonnikoog National Park 1999-2008 is in force. This management plan describes the aims and starting points for the use and management of the National Park. It is the assessment frame for the project programme. Also for the national park “De Duinen” on Texel a management plan is in force.

# 5.f Sources and levels of finance

The funding available to the nominated property is complex when all funding is included for the ongoing protection and management of the area including enforcement, monitoring, awareness-raising and research, and activities related to trilateral and international work. The sources of funding are divided over many authorities and institutions, making it particularly difficult and challenging to make an exact estimate of the annual funding and the sources available for the nominated property in its entirety. The overview of the sources and level of funding has therefore been confined to the funding directly available for the protection and management of the property in terms of the protection objectives and the authorities and organizations directly responsible. Further sources of funding in addition to annual appropriations by governments and non-
government institutions have been listed to the extent possible. The overview in Table 5.2 gives an indication of the level of funding available. The appropriations are adopted annually by the national and state parliaments and may be subject to changes over time.

As outlined above wardening in the Schleswig-Holstein Wadden Sea is contractually delegated to NGOs. These NGO’s run some information centres and warden specific areas of the National Park. They are supported by the state of Schleswig-Holstein.

Of the amount of almost 3 million EUR for the National Park Authority in Niedersachsen, 1,010,000 EUR are to be allocated for the maintenance of 14 visitor centres.

In 1994 the “Niedersächsische Wattenmeerstiftung” was founded by the state of Niedersachsen together with “Statoil” and “Ruhrgas”, with a basic deposit of approx. 25 million EUR and a yearly distribution rate of approx. 1 million EUR. The fund supports scientific projects and activities with the aim to enhance the conservation status of the Wadden Sea or projects dealing with alternative energy.

In the Netherlands a Wadden Fund has been established. Through the Wadden Fund the Dutch government will make 800 million EUR available over the next 20 years.

The most important aims of the Wadden Sea Fund are to support activities that:

- Improve the values of nature and the landscape of the Wadden Sea area;
- Diminish or remove external threats to the natural wealth of the Wadden Sea;
- Contribute to a sustainable economic development in the Wadden Sea area or to a substantial transition to a sustainable energy household in the Wadden Sea area and the neighbouring areas (Groningen, Friesland and the northern part of Noord-Holland);
- Stimulate the development of an efficient and a sustainable knowledge management for the Wadden Sea area.

The capital comes from the benefits of natural gas production (750 million EUR) and from public funds (50 million EUR). Also the applicants themselves have to contribute to the funding of the project (co-financing). This increases the net investment. Thus the government expects to realise in the next 20 years a financial impulse of more than 1 billion Euros.

The government will set up an investment plan that describes the situation intended at the end of the funding period of twenty years based on the PKB. The government aims at funding projects that at the end of the funding period (20 years) will have contributed visibly to the improvement and conservation of the Wadden Sea area. During the first five years of this period, particularly projects will be funded that are urgent, that set a good example and that give results on a short term. The regional administrative bodies will have a prominent advising role in the assessment procedure for projects.

As indicated above, the funding available to the nominated property is much more if other funding is included in the overview. The funding of the research institutes with research tasks in the area, for example, has not been included in the overview. Because the nominated property constitutes a very important nature area, if not the most important one for research and monitoring in the countries, the funding is extensive. It concerns both annual funds as part of normal government appropriations as well as project funds. The latter constitute the larger part of the funds.

Financial support is also available from other funding agencies such as the European Union, which supports, for example, the LIFE-project, specifically designed for Natura 2000 areas and the LEADER+ programme for rural development. These funds are, however, appropriated to specific projects. Projects that have received funding from the LIFE programme are e.g. the visitor information system in the Schleswig-Holstein part of the nominated property, the trilateral seals project following the seals epidemic in 1988 or
the DEMOWAD-Project for data handling within the TMAP.

Also mostly not included in the overview are management costs to the area provided by other authorities than those responsible for nature protection.

5.g Sources of expertise and training in conservation and management techniques

The expertise and training available for the nominated property is very extensive. First of all, there is an extensive expertise available at the national park authorities and the conservation authorities. The staff involved in the conservation and management of the nominated property based at those authorities is academically trained and highly skilled. Also, those who are involved in daily management are based at authorities with decades of experience of working in the area. Furthermore, there is a long tradition of ecological research in the area from world wide recognized institutes and organizations. A generation ago, this resulted in the publication of the “Ecology of the Wadden Sea”, referred to earlier, which collected all the information available from researchers and experts on all relevant themes and issues with regard to the Wadden Sea. This publication was a crucial element in the commencement of the ecosystem protection of the nominated property.

Since the publication of “The Ecology of the Wadden Sea” extensive research programs have continued and intensified. In the 1980s and 1990s, large ecosystem research programs were carried out both in the Dutch part as well as in the German part of the nominated property. The aim of the German project was to develop scientific foundations for protecting the Wadden Sea ecosystem, taking account of conflicts between uses and protection. Project efforts included analysing the region’s natural dynamics, identifying and interpreting the processes that govern the spreading of plants and animals and developing mathematical models for describing the regional system.

Schleswig-Holstein

The national park office has cooperation agreements in place with all relevant research institutions around the area, such as the Wadden Sea station at the island of Sylt of the Alfred Wegener Institute in Bremerhaven, the Universities of Kiel (Büsum Research and Technology Centre (FTZ)) and Hamburg and the GKSS research centre in Geesthacht. Direct contacts are also in place with the West Coast University of Applied Science (Fachhochschule Westküste), the colleges of education of Kiel and Flensburg, the universities of Osnabrück and Bremen and the Royal Netherlands Institute for Sea Research (NIOZ) in the Netherlands.

The national park office regularly carries out training courses for “multipliers”, in cooperation with various tourist facilities and service providers. Such events bring participants up to date with the latest developments and provide information about the aims of the national park and the biosphere reserve. The participants include staff of nature conservation associations, conscientious objectors in alternate civilian service, persons performing a “Voluntary Ecological Service Year”, guides to tidal flats, staff of shipping companies and representatives of national-park communities and of the area’s youth hostels. Special training courses are also offered for volunteer national park rangers and for full-time rangers of the National Park Service. A special focus of such efforts is on explaining the balance between protection and uses in the national park.

In addition there is a lot of experience available from NGOs, e.g. nature conservation organizations, some of them having been active in the area for decades, and from local inhabitants, some of them looking after the area voluntarily or being officially appointed as national park wardens.
Since the 1930s, the Wadden Sea in Niedersachsen has been the subject of intensive ecological and hydrological research, carried out by various institutions, including the “coast” research center of the Niedersachsen state office for water, coastal protection and nature protection (“Niedersächsischer Landesbetrieb für Wassерwirtschaft, Küstenschutz und Naturschutz”), the “Senckenberg by the Sea” research station (Wilhelmshaven), the Ornithological Research Institute (Institut für Vogelforschung, Wilhelmshaven) and the University of Oldenburg. Research results have been published in numerous scientific publications. Studies have been carried out in all subsystems of the Wadden Sea ecosystem (open mud flats, salt marshes, beaches and dunes). The research emphases have included hydrodynamics, morphodynamics, sedimentology, flora and vegetation and faunistic population inventories, especially in the macrozoobenthos and among wading and water birds.

The National Park Authority is member of “Terramare, Institute for Coastal and Shallow Sea Research” in Wilhelmshaven, a scientific “umbrella” institution of the coastal and marine research institutes of Niedersachsen. In recent years, the National Park Authority has been focussing especially on enhancing remote-sensing procedures for terrestrial habitats (dunes, salt meadows). This work is currently being intensified, and it is being expanded to include surveys of sub-littoral habitats using hydro-acoustic procedures.

Another project, “Visitor Guide to the National Park / Tidal Flats” (“Nationalpark-Watt-/Gästeführer”), offers people the opportunity to earn certification as “visitor guides to the national park” or “visitor guides to the national park / tidal flats.”

In the Netherlands there are several research and advisory institutes which have specific expertise that is relevant for the conservation and management of the Wadden Sea, such as Wageningen University Research Institutes IMARES (Institute for Marine Resources & Ecosystem Studies) and ALterra, Royal Netherlands Institute for Sea Research (NIOZ), RWS National Institute for Coastal and Marine Management (RWS RIKZ) and The University of Groningen, University of Utrecht, Institute for Marine and Atmospheric Research, WL-Delft Hydraulics, TNO, Netherlands Institute of Applied Geoscience, Radboud University Nijmegen, NIOO, Netherlands Institute for Ecology-Centre for Estuarine and Marine Ecology.

Recently, the “Wadden Sea Academy” was established as a knowledge institute with the purpose of making an inventory of the demand for scientific research in the Wadden Sea area, to coordinate its implementation and to provide information on this to a wider audience. The academy will consist of five scientific members who will work one day per week for the academy and a supportive staff. The annual budget is almost 2 mio EUR, to be financed by the Wadden Sea Fund.
In addition, there is a lot of expertise available from other private organisations active in the area, such as:

- Groninger Landschap, It Fryske Gea, Noord-Hollands Landschap, Staatsbosbeheer, Natuurmonumenten, organisations that manage parts of the Dutch Wadden Sea;
- The Wadden Sea Society, an environmental NGO promoting the protection and sustainable use of the Wadden Sea;
- The visitors centres such as Ecomare, Visitor’s Centre National Park Schiermonnikoog, Nature Centre Ameland, Wadden Centre Pieterburen, Seal Rehabilitation and Research Centre Pieterburen, Nature Museum Terschelling and Information Centre Noordwester

Also, many local inhabitants, organisations and societies have substantial practical and theoretical knowledge about many aspects and phenomena characteristic for the area.

5.h Visitor facilities and statistics

Facilities

Through an extended net of information centres, visitor information systems, print and digital information and an increasing number of professional guides along the Wadden Sea, the quality of nature experience for visitors has improved significantly, benefiting both the visitors and nature. The information and interpretation centres adjacent to the nominated property are shown in Fig. 5.6. Furthermore, there is an extensive net of information tables and signs both at and within the nominated property on those locations where visitors are assumed to go and have a look at the site or follow the many trails specifically made to provide them with information and enjoyment while at the same time causing as little disturbance to the nominated property as possible.

Figure 5.6: Map of visitor centres within and adjacent to the nominated property.
Extensive information on the Wadden Sea, also for visitors to the nominated property, is also available electronically. The common link to all aspects of trilateral Wadden Sea matters is the website of the Common Wadden Sea Secretariat (www.waddensea-secretariat.org). The German link to the nominated property is via the national park web site (http://www.nationalpark-wattenmeer.de). This web site includes information on practically all aspects related to the protection and management of the German Wadden Sea and the activities of the national park authorities.

The Dutch link to the nominated property is via “Interwad”. This organization develops and operates the website www.waddenzee.nl. This website is a focal point for information, questions, answers and opinions related to the Wadden Sea. Interwad operates with funding of the national government and the provinces and communities that are adjacent to the Wadden Sea. The objectives of Interwad are to inform people, to raise awareness and to feed the discussion on all kind of aspects related to the Wadden Sea. A number of organizations that are involved in Wadden Sea policy, are partner of Interwad.

Schleswig-Holstein

A good number of environmental education facilities are located along the coast and on the area’s islands, including the Hallig islands. These facilities offer both local residents and visitors a wide range of events, guided tours and visits to relevant centres. In the “National park educational centre” (PZN) framework, a catalogue of “Learning sites in and near the national park” has been prepared that lists all of the available services in a clearly structured manner.

The information centres in and near the nominated property operate on the basis of a common concept and have coordinated their various topic emphases, and all now offer special focuses on the Wadden Sea ecosystem, along with guided tours in and near the site. The largest and most important information centre is the “Multimar Wattforum” National Park Centre in Tönning. With some 2,300 m² of exhibit space, and about 200,000 visitors yearly, it is one of the largest information centres in German protected areas and a main tourist attraction in Schleswig-Holstein. Various smaller centres scattered along the coast and on the islands are run by the National Park Service, NGO’s and municipalities, often in cooperation with each other, altogether being visited by nearly 800,000 guests per year. Some of them offer possibilities for training courses with overnight stays to schools and universities.

At the entrances to the national park, a range of pavilions, signs and maps within the visitor information system guide visitors through the area and provide information on the Wadden Sea. All of these resources have been individually tailored to their specific locations. The visitor information system (Besucherinformationssystem – BIS) provides specific information and it helps to minimize disturbances and improve protection for breeding, resting and moulting birds.
Chapter 5 Protection and Management of the Property

Niedersachsen

There is a total of 16 information facilities – two larger visitor centers in Wilhelmshaven and Cuxhaven as well as 14 information houses on the East Frisian Islands and on the mainland. These facilities, which are accountable to municipal authorities, are usually run jointly with a nature conservation association. 14 of the centres currently are subsidized by the state of Niedersachsen in terms of staff costs to a total amount of about Euro 0.9 million. The number of visitors to the facilities – between 600,000 and 700,000 a year – has been consistently large for years. Groups, in particular school classes but also people on study leave, make up about 15 per cent of these visitors.

All facilities also feature a small shop where visitors can buy information leaflets and souvenirs. There are sanitary facilities available to the visitors in all information centers and houses. In addition to the 16 visitor centres mentioned above, there are 13 regional and local education and awareness centers in the area.

Information signs have been put up in places with a high frequency of visitors, for instance in the large car parks for the visitors to the islands, on landing piers for ferries or any location where nature conservation requires that visitors be looked after and directed more closely. The number of information signs currently totals about 250. Furthermore, there are nature experience trails dealing with specific subjects where the visitor can find out about environmental issues.

The administrative office of the protected area provides a large number of information brochures, which visitors can order by mail or obtain from information facilities and numerous local authorities.

The Netherlands

In and adjacent to the Wadden Sea, a broad range of educational activities is offered, such as educational walks, tours by bike, by boat or by covered wagon, lectures, presentation of films and slides, excursions on the tidal washes. At different sites in the area there are cabins for the observation of birds, information desks and marked routes.

In addition, there are several information and visitor’s centres. Ecomare, Centre for Wadden and North Sea, lies in the National Park Dunes of Texel. Its objective is enlarging the public interest for the preservation and recovery of natural and cultural values (landscapes, ecosystem, species) in the Wadden region and the North Sea, with an emphasis on Texel. The centre is visited by almost 300,000 visitors each year.

Ecomare contains:
- A visitors centre with information about nature and culture on Texel (also for the National Park);
- The first seal sanctuary in the Netherlands, with a permanent group of seals;
- Regional bird sanctuary for victims of oil slicks and other confrontations;
- A museum with extensive expositions;
- An underground Water Hall with large marine aquariums;
- A centre for nature and environmental education, with excursions and nature programs;
- An information centre for the Wadden, coast and the North Sea.

The other visitor centres on Schiermonnikoog, Ameland, Pieterburen, including the Seals Rehabilitation Centre, Terschelling, Vlieland, Lauwersmeer and Termunten are visited by almost 450,000 people annually.

At present, seven of the environmental education centres in Germany and The Netherlands (plus three centres in Denmark) work together in the International Wadden Sea School (IWSS) network. The IWSS is a cross-border educational project for school classes from the Wadden Sea countries. Initiated by the Wadden Sea Cooperation, the aim of the IWSS is to enhance the awareness of the Wadden Sea Area as a shared natural heritage and to create an understanding among young people for the need to protect and sustainably manage the Wadden Sea region as a whole.

Visitor statistics

It is particularly difficult to provide reasonable visitor statistics for the nominated property and the adjacent areas. It is difficult to discriminate between tourists and visitors to the area and statistically there is no genuinely dependable figure. Tourist statistics have been given in Chapter 4. If visitors to the nominated site and adjacent area are defined as day trippers, there are some indications as to the numbers. In Niedersachsen the number of day trippers has been estimated to amount to 16.5 million annually (2000). The number for the Schleswig-Holstein part is probably around 10 million, with a little less in the Dutch part.

More detailed information on facilities and statistics is available on request.
5.i Policies and programmes related to the presentation and promotion of the property

Extensive programs for promoting the Wadden Sea already exist within the framework of the current programs for promoting the national parks and the protected areas. The advertising of the nominated property will be an integral part of this promotion.

Within Germany, the property will be presented and promoted via the already existing mechanisms, amongst others the homepage www.unesco-welterbe.de. The regional presentation of the property will be done with official governmental presentations in various media, as well as on the level of ongoing activities presenting the national parks. The main communication channels are the information centres, the regional tourism organisations, the web sites of the two Wadden Sea National Parks and the linked presentation in local media. In addition, in Schleswig-Holstein it is planned to install a regional “board” for the presentation and promotion of local aspects of the Wadden Sea as a World Heritage site.

The Dutch government considers information and education important conditions for realizing its Wadden Sea policy. The information of the government aims primarily at enlarging public support for its policy and at clarification of it. Regarding education, the government acts primarily as stimulator. As far as possible, the government uses nature and environmental conservation societies and visitors centres for policy communication and information. However, the government does not contribute structurally to the exploitation of these nature and environmental conservation societies and visitors centres.

In 1997, the Regional Wadden Sea Council stipulated the Frame Plan Communication Authorities Wadden Sea (KCOW). The aim of this KCOW is a professional communication by the authorities concerned which fulfils the needs of the environment. Therefore, this KCOW includes guidelines for communication activities by these authorities. Three forms of governmental communication are distinguished: policy communication, information and nature and environmental education. Also, the Interwad–platform referred to above will be used for the further promotion of the nominated property.

The Common Wadden Sea Secretariat undertakes various activities to promote the Wadden Sea, in particular in a trans-boundary context as well as internationally. The secretariat regularly publishes scientific and management reports in the “Ecosystem”-series and brochures and leaflets on various themes and topics such as World Heritage, the PSSA, coastal protection and sea level rise and cultural heritage of the area.
5.j Staffing levels (professional, technical, maintenance)

The overview of staffing level is confined to the staffing of government organizations which are directly related to the protection and management of the nominated property for its nature protection values. The overview does not include the extensive staff of non-governmental organizations working in this field notwithstanding their crucial importance for the protection of the nominated property. It is however not possible to provide an overview of the exact staffing level in this sense, since their tasks are very diverse. Neither have those organizations been included which execute normal management tasks in the nominated property such as nature managers, maintenance of shipping channels and installations for shipping safety, police tasks and other tasks vital for the overall management of the property. The overview is predominantly confined to staff directly involved in policy making and information tasks.

The national park administration in Schleswig-Holstein employs 76 professional and skilled persons, of which 16 are rangers. The staff of the administration is supported by normal police forces, and the above under 5g mentioned persons.

The National Park Authority in Niedersachsen has a staff of 28 persons. Of these, 8 are professionals and skilled in planning (landscape management) and 10 have science backgrounds (biology or geography), while 1 legal expert and 7 staff persons have general administrative duties. The staff of the administration is supported by normal police forces, and by a network of wardens from coastal authorities and counties.

The Dutch national government employs 25 policymakers (Ministry of Housing, Spatial Planning and the Environment – VROM; Ministry of Agriculture, Nature and Food Quality – LNV, Ministry of Public Works and Water Management – V&W). In addition, the national government has 14 staff members who are employed on 4 vessels for inspection and maintenance, routine research and monitoring. On a provincial level and on a local level another 6 policymakers are employed. The Regional Board for the Wadden Sea Region (RCW) and the Coordination Board of the Wadden Sea Region (CCW) employ 5 staff members. On the provincial level 4 persons are employed for inspection. The private organizations that own and/or manage parts of the Conservation Area together employ about 2 staff members and 2 rangers for activities in the area or concerning the area.

In addition to the above-mentioned organisations, a broad citizenship commitment exists. Numerous volunteers from non-governmental organisations are active in the Wadden Sea in supporting state organisations.

<table>
<thead>
<tr>
<th>Governments/Authorities</th>
<th>Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany: National Park Authorities and Services (wardens, information centres)</td>
<td>159</td>
</tr>
<tr>
<td>The Netherlands: National government, regional and local coordination</td>
<td>54</td>
</tr>
<tr>
<td>Common Wadden Sea Secretariat</td>
<td>6</td>
</tr>
<tr>
<td>Total</td>
<td>219</td>
</tr>
</tbody>
</table>

Table 5.3: Overview of staffing level.
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 5 Protection and Management of the Property
6. MONITORING

The state of conservation of the nominated property is regularly reviewed and reported within the Trilateral Monitoring and Assessment Program (TMAP) and additional monitoring carried out within the property. The TMAP is an integrated common monitoring program of the Wadden Sea states the Netherlands, Germany and Denmark (§ 33, Ministerial Declaration, 6th Trilateral Governmental Conference, 1991).

The aims of the TMAP are:

- To provide a scientific assessment of the status and development of the Wadden Sea ecosystem;
- To assess the status of implementation of the trilateral Targets of the Wadden Sea Plan;
- To propose management measures as consequence of the scientific assessment.

The TMAP consists of a "Common Package" of monitoring parameters including an associated data handling system which was adopted at the 8th Trilateral Governmental Conference in 1997 (Table 6.1).

Based on trilateral decisions dating back to the 1991 Ministerial Conference, Germany as well as the Netherlands have designated reference areas in the Wadden Sea. The Schleswig-Holstein reference area is the zero-use zone of 12,500 ha.

### Table 6.1: Overview of the TMAP Common Package Parameters (adopted at the Trilateral Governmental Conference 1997). The data are exchanged via TMAP Data Units in each country for trilateral assessment such as the Quality Status Report.

<table>
<thead>
<tr>
<th>Chemical Parameters:</th>
<th>Biological Parameters:</th>
<th>Human Use Parameters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrients</td>
<td>Phytoplankton</td>
<td>Fishery</td>
</tr>
<tr>
<td>Metals in sediment</td>
<td>Macroalgae</td>
<td>Recreational activities</td>
</tr>
<tr>
<td>Contaminants in blue mussels, flounders and birds eggs</td>
<td>Eelgrass</td>
<td>Agriculture</td>
</tr>
<tr>
<td>TBT in water and sediment</td>
<td>Macrobenthos</td>
<td>Coastal protection</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Habitat Parameters:</th>
<th>General Parameters:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blue Mussel beds</td>
<td>Geomorphology</td>
</tr>
<tr>
<td>Salt marshes</td>
<td>Flooding</td>
</tr>
<tr>
<td>Beaches and Dunes</td>
<td>Land use</td>
</tr>
<tr>
<td></td>
<td>Weather conditions</td>
</tr>
<tr>
<td></td>
<td>Hydrology</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Data Handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Unit The Netherlands</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thematic Reports, Quality Status Reports (QSR)</td>
</tr>
</tbody>
</table>
Table 6.2: Overview of parameters, periodicity, monitoring areas and locations of record according to the TMAP Manual (May 2004).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Parameter Group</th>
<th>Parameters</th>
<th>Periodicity</th>
<th>Area</th>
<th>Location of records</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrients</td>
<td>Nutrients in Water</td>
<td>Inorganic nutrients, total P, N, silicate</td>
<td>Monthly / every 14 days (depends on location)</td>
<td>8 Sub areas</td>
<td>TMAP Database</td>
</tr>
<tr>
<td>Contaminants in Water and Sediment</td>
<td>Metals in Sediment</td>
<td>Cd, Cu, Hag, Pb, Zn</td>
<td>Every 3 years (minimum)</td>
<td>3 sites per country (min.)</td>
<td>TMAP Database</td>
</tr>
<tr>
<td></td>
<td>TBT in Water and Sediment</td>
<td>TBT substances</td>
<td>Yearly</td>
<td>Sites to be selected by each country (Hot spots)</td>
<td>TMAP Database</td>
</tr>
<tr>
<td>Plankton</td>
<td>Phytoplankton</td>
<td>Number of main species, chlorophyll (biomass), co-variables</td>
<td>Every week or 2 weeks (depends on season and location)</td>
<td>Existing sampling sites (status 1997), additional sites recommended (map)</td>
<td>TMAP Database</td>
</tr>
<tr>
<td>Benthos</td>
<td>Macroalgae</td>
<td>Location, area, coverage, biomass</td>
<td>Yearly / 4-6 surveys per year if necessary</td>
<td>All intertidal flats, selected areas for ground truth</td>
<td>TMAP Database</td>
</tr>
<tr>
<td></td>
<td>Eelgrass</td>
<td>Location, area, coverage, biomass</td>
<td>Yearly</td>
<td>All intertidal flats, selected areas for ground truth</td>
<td>TMAP Database</td>
</tr>
<tr>
<td></td>
<td>Macrozoobenthos communities</td>
<td>Species abundance, biomass</td>
<td>2 times per year</td>
<td>Specific sites in each country</td>
<td>TMAP Database</td>
</tr>
<tr>
<td></td>
<td>Blue mussels beds</td>
<td>GIS contours of beds, additional parameters for selected beds (field surveys)</td>
<td>Yearly</td>
<td>All intertidal flats</td>
<td>TMAP Database</td>
</tr>
<tr>
<td></td>
<td>Contaminants in Blue mussels</td>
<td>Heavy metals, organochlorines</td>
<td>Yearly</td>
<td>Specific sites in each country</td>
<td>TMAP Database</td>
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<td>Fish</td>
<td>Contaminants in flounder</td>
<td>Heavy metals, organochlorines</td>
<td>Yearly</td>
<td>1 – 2 sites per country (to be selected on national level)</td>
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<td>Fishery parameters</td>
<td>Landings, vessels, size of culture lots, size of closed area</td>
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<td>Whole area</td>
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<td>Breeding birds</td>
<td>Counts in a number of census areas, Complete survey of selected species</td>
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<td>Counts of a larger range of species</td>
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<td>Every 5 years</td>
<td>Whole area</td>
<td>TMAP Database</td>
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<td>Migratory birds</td>
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<td>Yearly (mid-winter plus additional month)</td>
<td>Whole area</td>
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<td>Contaminants in bird eggs</td>
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<td>Yearly</td>
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<td>Beached birds survey</td>
<td>Number of beached birds, oiled birds, co-variables</td>
<td>Yearly</td>
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<td>Seal population</td>
<td>Seal numbers and distribution</td>
<td>Yearly (5 – 8 surveys)</td>
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<td>Salt Marshes</td>
<td>Location and area of salt marshes</td>
<td>Zonation (6 types) and main vegetation types (25 types)</td>
<td>Every 5 – 7 years</td>
<td>Whole area</td>
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<td>Agricultural utilization of salt marshes</td>
<td>Grazing and drainage types (3 categories)</td>
<td>Yearly</td>
<td>Whole area</td>
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<td>Beaches and Dunes</td>
<td>Location and area of beaches and dunes</td>
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<td>Every 5 – 7 years</td>
<td>Whole area</td>
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<td>Human activities</td>
<td>Numbers of boats at sea (all types) number of flat walker (guided tours)</td>
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<td>Geomorphology</td>
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<td>Whole area</td>
<td>Data record in the responsible institutions</td>
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<td>Sea level, salt marsh flooding, wave climate</td>
<td>(Different frequencies)</td>
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<td>Water and air temperature, wind, ice coverage, NAD index</td>
<td>Daily or monthly averages</td>
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<td>All relevant measures</td>
<td>Reporting every 5 years</td>
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<td>Land use</td>
<td>Agricultural use (main types).</td>
<td>Every 5 –10 years</td>
<td>Whole area</td>
<td>TMAP Database</td>
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</table>
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 5 Protection and Management of the Property

Chapter 6 Monitoring

(about 3% of the National Park), which is located south of the Hindenburg causeway. The area will also serve as a reference area with respect to the coastal water bodies implementing the EU Water Framework Directive. In Niedersachsen no official reference area has been established up to now, but large areas e.g. the islands of Mellum and Memmert and surrounding flats, and the Hohe Knechtsand area are without any human use.

In the Netherlands, a reference area in the eastern part of the Dutch Wadden Sea has been designated. It is an area of 7,400 ha (3% of the Dutch Wadden Sea), which is part of a larger area that had already been closed for shellfish fishery for a longer period. The reference area is closed for almost all human activities, including all fishery activities and all other resource exploitation.

6.a Key indicators for measuring state of conservation

TMAP parameters

The TMAP Common Package covers the entire Wadden Sea and spans a broad range from physiological processes (e.g. the effects of eutrophication) over population development (e.g. of seals, breeding and migratory birds) to changes in landscape and morphology (e.g. tidal flats, salt marshes and dunes). Furthermore, the TMAP considers the relevant EU Directives (Birds and Habitats, and Water Framework), as well as obligations from other international conventions like the Ramsar Convention, the Bonn Convention, and the OSPAR Convention. The TMAP objectives and structure, the TMAP monitoring guidelines and the TMAP data management are outlined and specified in the TMAP Manual.

Data handling

An elementary component of the TMAP is the common data handling, which makes monitoring data available for trilateral assessment. For this purpose, identical TMAP Data Units have been installed in each country. The monitoring data are available in a harmonized way and all the information which is necessary for the interpretation of the data is part of the database. Beside storage and maintenance, the TMAP data handling system also has the aim to exchange monitoring data in a common format which can be used directly in the trilateral assessment work. An overview of the data can be found in the data catalogue, which can also be accessed via the website of the Common Wadden Sea Secretariat. The TMAP, including the data handling system, serves the following tasks:

- Preparation of Quality Status Reports encompassing the most recent data and developments;
- Preparation of trilateral reports on specific topics (thematic reports, like breeding birds, migratory birds, seals, contaminants);
- Preparation of reports on unforeseeable events;
- Safeguarding long-term storage of relevant Wadden Sea data;
- Use of trilateral data for national and international programs.

The TMAP data handling system is also a valuable instrument for other reporting obligations (e.g. national status reports, EU reports concerning Natura 2000 and the Water Framework Directive, international reports concerning OSPAR, RAMSAR or other international conventions) by providing up-to-date and harmonized Wadden Sea data from different sources on the national and international level.

Additionally, the TMAP data handling system enhances the possibilities to present monitoring data to relevant authorities, interest groups and local citizens in accordance with the trilateral Wadden Sea Plan (Chapter 1, §15). In 2004, the TMAP data handling was evaluated by an external consultant (Orbis Institute, Canada). The Orbis Report concluded that the TMAP data handling is an effective tool in providing the required data at reasonable costs.

The TMAP and the associated data handling has recently been further developed to meet the requirements of the European Union Directives and other international obligations.

Additional monitoring

There are several national and regional monitoring programs, which are formally not part of the TMAP Common Package but deliver important information for the overall assessment of the nominated property and are also included in the regular Quality Status Reports. These are e.g. the monitoring carried out in connection with the exploitation of natural gas in the Dutch part of the nominated property, in particular with regard to subsidence, the monitoring of tourism and recreational activities in a wider context as included in the Common Package, the monitoring of human use of coastal waters on birds, the monitoring of fish fauna and epifauna in the western part of the Wadden Sea, the monitoring of demersal fish, the
monitoring of molluscs (littoral monitoring and beach monitoring), the monitoring of salt marshes (silt accretion, water levels, soil subsidence, vegetation), the biomass monitoring of blue mussel beds and of certain species.

6.b Administrative arrangements for monitoring property

The Trilateral Monitoring and Assessment Group (TMAG) is responsible for implementation and coordination of the TMAP. The TMAG consists of two to three delegates from the national administrations responsible for the coordination of the national monitoring programs and data management. Technical groups, like the Trilateral Data Handling Group (TDG), the Coordinator Group on the Joint Monitoring Program for Breeding Birds (JMBB) and the Coordinator Group on the Joint Monitoring Program for Migratory Birds (JMMB) have been installed under the responsibility of the TMAG.

The Common Wadden Sea Secretariat (CWSS) is the secretariat for the trilateral Wadden Sea cooperation, including the TMAP. In the framework of the TMAP, the secretariat is responsible for the day-to-day management of the program and the preparation of the meetings of the TMAG and of the technical monitoring groups.

The TMAP is carried out by national and regional authorities in charge of monitoring.

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<th>Country</th>
<th>Responsible Ministry</th>
<th>Responsible authority</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Schleswig-Holstein State Ministry for Agriculture, Rural Areas and Nature</td>
<td>National Park Authority, LANU</td>
</tr>
<tr>
<td></td>
<td>Niedersachsen State Ministry for Environment</td>
<td>National Park Authority, NLWKN</td>
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<tr>
<td></td>
<td>Ministry of Public Works and Water Management.</td>
<td>Centre for Water Management</td>
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</table>

Table 6.3: Overview of institutions in charge of the TMAP Wadden Sea monitoring in Germany and The Netherlands.
6.c Results of previous reporting exercises

Assessment reports Related to the Trilateral Governmental Conferences (every 3 to 4 years), Quality Status Reports of the Wadden Sea are elaborated. They describe and evaluate the current ecological status of the Wadden Sea, identify issues of concern and indicate possible measures. In March 2005, the latest Quality Status Report (QSR 2004) of the Wadden Sea was published. After 1991, 1995 and 1999 it was the fourth time that a comprehensive, integrated assessment of the Wadden Sea could be presented. Additionally, the results of the TMAP are published in workshop reports, thematic reports (the series “Wadden Sea Ecosystem”) (see below) and in the “Wadden Sea Newsletter”.

All reports are available from the Common Wadden Sea Secretariat (Quality Status Report 1999 see Annex 07 and Quality Status Report 2004 see Annex 08):

TMAP reports in the publication series “Wadden Sea Ecosystem”


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Chapter 5 Protection and Management of the Property
7. Documentation

7.a Photographs, slides, image inventory and authorization table and other audiovisual materials

An image inventory, including the photograph and audiovisual authorization form is given in Annex 23.

The photographs and a slideshow about the Wadden Sea are compiled on a DVD (Annex 24).

7.b Texts relating to protective designation, copies of property management plans or documented management systems and extracts of other plans relevant to the property

Trilateral level


The Netherlands

Third Wadden Sea memorandum (Derde Nota Waddenzee) Key Planning Decision (PKB), Annex 16.

Germany

The Federal Nature Conservation Act constitutes the framework legislation to be enacted by the federal government and the corresponding acts by the states. The actual versions of the acts can be obtained via www.bmu.de. Of special importance to the Wadden Sea are the National Park Acts.

The legal foundations of the three National Parks in the German Wadden Sea, constituting the proposed world heritage site in Germany are:

Niedersachsen


Schleswig-Holstein


Other regional or sectoral management systems and extracts of plans (e.g. foreland management concepts, framework agreement on mussel fisheries, ordinance on maritime navigation in German Wadden Sea national parks) are listed in Annex 19 and available upon request from the regional responsible authorities (see Chapter 8b).
7.c Form and date of most recent records or inventory of property

TMAP

All records and inventories of the nominated property according to TMAP are available, after registration, from the official web address of the TMAP:

http://www.waddensea-secretariat.org/TMAP/Monitoring.html

Additional data on national or regional level can be obtained via the regional responsible authorities (see Chapter 8b).

Quality Status Reports

The three Wadden Sea countries regularly produce joint Quality Status Reports on the basis of findings from the TMAP. These reports describe, in detail, the condition of the area’s most important biotic and abiotic factors; the extent and impacts of human activities, and protection and management of the Wadden Sea region. All of these factors are evaluated in sum and, where necessary and possible, recommendations for further management in the framework of the Wadden Sea Plan are provided. The Quality Status Report covers the periodic reporting obligations of the proposed property according to the operational guidelines.

Attached are the Quality Status Reports 2004, Annex 08 and 1999, Annex 07.

7.d Address where inventory, records and archives are held

The inventory records according to TMAP are held at the

Common Wadden Sea Secretariat
Virchowstr. 1
D – 26382 Wilhelmshaven
Germany

www.waddensea-secretariat.org

Additional regional inventories and data are held at the nationally or regionally responsible authorities:

The Netherlands

Centre for Water Management
Zuiderwagenplein 2
8224 AD Lelystad
The Netherlands
www.rijkswaterstaat.nl

7.e Bibliography

A list of references for this nomination is provided below. This is a small part of the large scientific literature which exists for the nominated property. A provisional bibliography for the nominated property, containing over 700 references is provided as Annex 09 to this nomination.


Hofstede, J.A.A., 1991. Sea level rise in the inner German Bight (Germany) since AD 600 and its implications upon tidal flats geomorphology. In: Brückner, H. and Radtke, U. (Eds.). From
the North Sea to the Indian Ocean. Franz Steiner Verlag, Stuttgart, pp. 11–27.


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### 8.c Other local institutions

#### The Netherlands

<table>
<thead>
<tr>
<th>Public Relations Official of</th>
<th>Address</th>
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<th>E-mail</th>
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<tr>
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<td><a href="mailto:geme.wieringen@wieringen.nl">geme.wieringen@wieringen.nl</a></td>
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<tr>
<td>Municipality Den Helder</td>
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<td>Den Helder</td>
<td><a href="mailto:info@denhelder.nl">info@denhelder.nl</a></td>
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<td>Municipality Harlingen</td>
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<td>8860 HA</td>
<td>Harlingen</td>
<td><a href="mailto:gemeentebestuur@harlingen.nl">gemeentebestuur@harlingen.nl</a></td>
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<td>Dollard Bezoekerscentrum Reidehoeve</td>
<td>Dallingewestweg 30</td>
<td>9947 TB</td>
<td>Termunten</td>
<td><a href="mailto:kantoor@groningerlandschap.nl">kantoor@groningerlandschap.nl</a></td>
</tr>
<tr>
<td>Zeehondencrèche Lenie ‘t Hart</td>
<td>Hoofdstraat 94a</td>
<td>9968 AG</td>
<td>Pieterburen</td>
<td><a href="mailto:info@ziehondencreeche.nl">info@ziehondencreeche.nl</a></td>
</tr>
<tr>
<td>Staatsbosbeheer district Texel</td>
<td>Molenstraat 83</td>
<td>1791 DK</td>
<td>Den Burg</td>
<td><a href="mailto:west@staatsbosbeheer.nl">west@staatsbosbeheer.nl</a></td>
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### Chapter 8 Contact Information

#### Germany

#### Niedersachsen

<table>
<thead>
<tr>
<th>Public Relations Official of</th>
<th>Address</th>
<th>Postal code</th>
<th>City</th>
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<tr>
<td>Landkreis Aurich</td>
<td>Fischteichweg 7-13</td>
<td>D-26603</td>
<td>Aurich</td>
<td><a href="mailto:eberhard.giese@landkreis-aurich.de">eberhard.giese@landkreis-aurich.de</a></td>
</tr>
<tr>
<td>Landkreis Wittmund</td>
<td>Postfach 13 55</td>
<td>D-26400</td>
<td>Wittmund</td>
<td><a href="mailto:reiner.janssen@lk.wittmund.de">reiner.janssen@lk.wittmund.de</a></td>
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<tr>
<td>Landkreis Leer</td>
<td>Friesenstr. 46</td>
<td>D-26789</td>
<td>Leer</td>
<td><a href="mailto:georg.kloppenburg@lkleer.de">georg.kloppenburg@lkleer.de</a></td>
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<tr>
<td>Landkreis Wesermarsch</td>
<td>Postfach 13 52</td>
<td>D-26913</td>
<td>Brake</td>
<td><a href="mailto:landkreis-wesermarsch@lkbra.de">landkreis-wesermarsch@lkbra.de</a></td>
</tr>
<tr>
<td>Landkreis Friesland</td>
<td>Lindenallee 1</td>
<td>D-26441</td>
<td>Jever</td>
<td><a href="mailto:i.logemann@friesland.de">i.logemann@friesland.de</a></td>
</tr>
<tr>
<td>Landkreis Cuxhaven</td>
<td>Postfach 328</td>
<td>D-27453</td>
<td>Cuxhaven</td>
<td><a href="mailto:67@landkreis-cuxhaven.de">67@landkreis-cuxhaven.de</a></td>
</tr>
<tr>
<td>Stadt Wilhelmshaven</td>
<td>Postfach 1140</td>
<td>D-26380</td>
<td>Wilhelmshaven</td>
<td><a href="mailto:hilke.onadt@stadt.wilhelmshaven.de">hilke.onadt@stadt.wilhelmshaven.de</a></td>
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<tr>
<td>Stadt Cuxhaven</td>
<td>Postfach 680</td>
<td>D-27456</td>
<td>Cuxhaven</td>
<td><a href="mailto:Udo.Jacob@cuxhaven.de">Udo.Jacob@cuxhaven.de</a></td>
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<tr>
<td>Stadt Emden</td>
<td>Frickensteinplatz 2</td>
<td>D-26721</td>
<td>Emden</td>
<td><a href="mailto:wegmann@emden.de">wegmann@emden.de</a></td>
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<td>Nationalpark-Häuser</td>
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<td>Nationalpark-Haus Baltrum</td>
<td>Haus Nr. 177</td>
<td>D-26579</td>
<td>Baltrum</td>
<td><a href="mailto:nlph.baltrum@gmx.de">nlph.baltrum@gmx.de</a></td>
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<tr>
<td>Nationalpark-Haus Carolinensiel</td>
<td>Pumphusen 3</td>
<td>D-26409</td>
<td>Wittmund-Carolinensiel</td>
<td><a href="mailto:nationalparkh.carolinensiel@t-online.de">nationalparkh.carolinensiel@t-online.de</a></td>
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<tr>
<td>Nationalpark-Haus Dangast</td>
<td>Zum Jadebusen 179</td>
<td>D-26316</td>
<td>Varel-Dangast</td>
<td><a href="mailto:nph-dangast@web.de">nph-dangast@web.de</a></td>
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<tr>
<td>Nationalpark-Haus Dornumersiel</td>
<td>Oll Deep 7</td>
<td>D-26553</td>
<td>Dornumersiel</td>
<td><a href="mailto:post@norseedhaus-dornumersiel.de">post@norseedhaus-dornumersiel.de</a></td>
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<tr>
<td>Nationalpark-Haus Fedderwardsiersiel</td>
<td>Am Hafen 4</td>
<td>D-26960</td>
<td>Butjadingen</td>
<td><a href="mailto:nlph.museum.fed-siel@nwn.de">nlph.museum.fed-siel@nwn.de</a></td>
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<tr>
<td>Nationalpark-Haus Greetsiel</td>
<td>Schatthaufer Weg 6</td>
<td>D-26736</td>
<td>Krummhörn-Greetsiel</td>
<td><a href="mailto:kontakt@nationalparkhaus-greetsiel.info">kontakt@nationalparkhaus-greetsiel.info</a></td>
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<tr>
<td>Nationalpark-Haus Juist</td>
<td>Carl-Stegmann-Str. 5</td>
<td>D-26571</td>
<td>Juist</td>
<td><a href="mailto:NLPH.Juist@t-online.de">NLPH.Juist@t-online.de</a></td>
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<tr>
<td>Nationalpark-Haus Land Wursten</td>
<td>Am Kutterhafen 1</td>
<td>D-27632</td>
<td>Dorum</td>
<td><a href="mailto:Nationalpark-Haus_Land_Wursten@t-online.de">Nationalpark-Haus_Land_Wursten@t-online.de</a></td>
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<tr>
<td>Nationalpark-Haus Norddeich</td>
<td>Dörper Weg 22</td>
<td>D-26506</td>
<td>Norden</td>
<td><a href="mailto:amariani@seehundstation-norddeich.de">amariani@seehundstation-norddeich.de</a></td>
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<tr>
<td>Nationalpark-Haus Norderney</td>
<td>Am Hafen 1</td>
<td>D-26548</td>
<td>Norderney</td>
<td><a href="mailto:nph.norderney@web.de">nph.norderney@web.de</a></td>
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<td>Nationalpark-Haus Wangerooge</td>
<td>Friedrich-August-Str. 18</td>
<td>D-26486</td>
<td>Wangerooge</td>
<td><a href="mailto:nationalparkhaus.wangerooge@t-online.de">nationalparkhaus.wangerooge@t-online.de</a></td>
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<td>Nationalpark-Schiff &quot;Feuerschiff Borkumriff&quot;</td>
<td>Am Nordufer</td>
<td>D-26757</td>
<td>Borkum</td>
<td><a href="mailto:fsbr@gmx.de">fsbr@gmx.de</a></td>
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<td>Nationalpark-Zentrum Cuxhaven</td>
<td>Hans-Claußen-Str. 19</td>
<td>D-27476</td>
<td>Cuxhaven</td>
<td><a href="mailto:info@nationalpark-wattenmeer-cuxhaven.de">info@nationalpark-wattenmeer-cuxhaven.de</a></td>
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<tr>
<td>Nationalpark-Zentrum Wilhelmshaven</td>
<td>Süßstr. 110 B</td>
<td>D-26382</td>
<td>Wilhelmshaven</td>
<td><a href="mailto:info@wattenmeerhaus.de">info@wattenmeerhaus.de</a></td>
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<tr>
<td>Umweltzentrum Wittbülten Spiekeroog</td>
<td>Hellerpad 2</td>
<td>D-26474</td>
<td>Spiekeroog</td>
<td><a href="mailto:info@wittbuelten.de">info@wittbuelten.de</a></td>
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<tr>
<td>Nordseehaus Wangerland</td>
<td>Kirchstraße 9</td>
<td>D-26434</td>
<td>Wangerland-Minsen</td>
<td><a href="mailto:nordseehaus@wangerland.de">nordseehaus@wangerland.de</a></td>
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### Chapter 8 Contact Information

#### Schleswig-Holstein

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Address</th>
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<th>City</th>
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<tr>
<td>NationalparkZentrum Multimar Wattforum</td>
<td>Robbenberg 1</td>
<td>D-25832</td>
<td>Tönning</td>
<td><a href="mailto:info@multimar-wattforum.de">info@multimar-wattforum.de</a></td>
</tr>
<tr>
<td>Kreis Dithmarschen</td>
<td>Stettiner Straße 30</td>
<td>D-25746</td>
<td>Heide</td>
<td><a href="mailto:erk.ulich@dithmarschen.de">erk.ulich@dithmarschen.de</a></td>
</tr>
<tr>
<td>Kreis Nordfriesland</td>
<td>Markstraße 6</td>
<td>D-25813</td>
<td>Husum</td>
<td><a href="mailto:info@nordfriesland.de">info@nordfriesland.de</a></td>
</tr>
<tr>
<td>Naturschutzgesellschaft Schutzstation Wattenmeer e.V.</td>
<td>Grafenstraße 23</td>
<td>D-24768</td>
<td>Rendsburg</td>
<td>geschä<a href="mailto:ftsstelle@schutzstation-wattenmeer.de">ftsstelle@schutzstation-wattenmeer.de</a></td>
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<tr>
<td>NSV Südtendern e.V.</td>
<td>Kreuzweg 1</td>
<td>D-25899</td>
<td>Dagebüll</td>
<td><a href="mailto:wp-a@gmx.de">wp-a@gmx.de</a></td>
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<tr>
<td>Öömrang Ferian</td>
<td>Strunwai 31</td>
<td>D-25946</td>
<td>Norddorf</td>
<td><a href="mailto:naturzentrumnorddorf@gmx.de">naturzentrumnorddorf@gmx.de</a></td>
</tr>
<tr>
<td>Naturschutzverein Mittleres Nordfriesland</td>
<td>Schobüller Str. 61</td>
<td>D-25813</td>
<td>Husum</td>
<td><a href="mailto:uwe.g.s.koch@web.de">uwe.g.s.koch@web.de</a></td>
</tr>
<tr>
<td>Widingharder Naturschutzverein</td>
<td>Widingharder Neuer Zoog 6</td>
<td>D-25924</td>
<td>Klanxbüll</td>
<td><a href="mailto:bboysen@t-online.de">bboysen@t-online.de</a></td>
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<tr>
<td>Verein Jordsand</td>
<td>Haus der Natur</td>
<td>D-22926</td>
<td>Ahrensburg</td>
<td><a href="mailto:info@jordsand.de">info@jordsand.de</a></td>
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<tr>
<td>Naturschutzbund Schleswig-Holstein</td>
<td>Färberstraße 51</td>
<td>D-24534</td>
<td>Neumünster</td>
<td><a href="mailto:Info@NABU-SH.de">Info@NABU-SH.de</a></td>
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<td>Söl'ring Foriining</td>
<td>Am Kliff 19a</td>
<td>D-25980</td>
<td>Keitum/Sylt</td>
<td><a href="mailto:soelring-foriining@t-online.de">soelring-foriining@t-online.de</a></td>
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<tr>
<td>Naturschutzgemeinschaft Sylt e.V.</td>
<td>M.-T.-Buchholz-Stich 10a</td>
<td>D-25996</td>
<td>Wenningstedt/Braderup</td>
<td><a href="mailto:naturschutz-sylt@t-online.de">naturschutz-sylt@t-online.de</a></td>
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<tr>
<td>WWF-Wattenmeerstation Husum</td>
<td>Hafenstraße 3</td>
<td>D-25813</td>
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<td><a href="mailto:roesner@wwf.de">roesner@wwf.de</a></td>
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<tr>
<td>Seehundstation Friedrichskoog</td>
<td>An der Seeschleuse 4</td>
<td>D-25718</td>
<td>Friedrichskoog</td>
<td><a href="mailto:Tanja.Rosenberger@seehundstation-friedrichskoog.de">Tanja.Rosenberger@seehundstation-friedrichskoog.de</a></td>
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<td>Biosphärenregion Halligen</td>
<td>Amt Pellworm</td>
<td>D-25849</td>
<td>Pellworm</td>
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<td>Mühlenweg 10</td>
<td>D-25938</td>
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<td><a href="mailto:info@inselundhalligkonferenz.de">info@inselundhalligkonferenz.de</a></td>
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<td>Nordsee-Tourismus-Service GmbH</td>
<td>Zingel 5</td>
<td>D-25813</td>
<td>Husum</td>
<td><a href="mailto:info@nordseetourismus.de">info@nordseetourismus.de</a></td>
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</table>

### 8.d Official Web addresses

**The Netherlands**

www.waddensea-secretariat.org

**Germany**

www.wattenmeer-nationalpark.de with links to the two Wadden Sea National Parks
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 5 Protection and Management of the Property
Nomination of the Dutch-German Wadden Sea as World Heritage Site

Chapter 5 Protection and Management of the Property
9. SIGNATURES

FOR THE GOVERNMENT OF THE KINGDOM OF THE NETHERLANDS:

Minister of Agriculture, Nature and Food Quality

Gerda Verburg

FOR THE GOVERNMENT OF THE FEDERAL REPUBLIC OF GERMANY:

Minister for the Environment, Nature Conservation and Nuclear Safety

Sigmar Gabriel

Prime Minister of Niedersachsen

Prime Minister of Schleswig-Holstein

Christian Wulff

Peter Harry Carstensen