The Wadden Sea, Germany and Netherlands (N1314) – Extension Denmark and Germany

- Volume One -
Colophon

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

Cover photos
S. Tourgaard - The Danish Wadden Sea
R. Czeck - Harbour porpoise in Niedersachsen

Binding
Besemann, Wittmund
We are pleased to submit the nomination to extend the Wadden Sea World Heritage to include the Danish Wadden Sea and an area offshore of the German Wadden Sea in Niedersachsen.

We are delighted to put forward this extension for inscription into the World Heritage List, because it is consistent with the decision of the World Heritage Committee when the Dutch-German Wadden Sea was inscribed on the World List in June 2009 to “encourage the State Party of Denmark to submit a nomination of the Danish part of the Wadden Sea as soon as feasible to extend and complement the existing property”. However, more importantly we are delighted to offer a nomination that will, if approved, complete a process to encompass the entire Wadden Sea, thus, addressing ecological integrity; one of the central criteria of the Convention. It will constitute a uniquely tri-national inscribed natural World Heritage property. It will strengthen, reinforce and enhance our generation long efforts to protect, conserve and manage the Wadden Sea as the World’s largest tidal barrier island system and a property shared between us for the benefit of present and future generations.

The inscription of the Dutch-German Wadden Sea on the World Heritage List has engendered enormous pride and received amazing support. It has been embraced by virtually all stakeholders in the Wadden Sea region. It has released an incredible amount of additional activity which has reinforced the management of the property, raised the profile of the area, created synergies and new partnerships, and brought new benefits and opportunities to the region in accordance with the aims of the World Heritage Convention. We are convinced that the extension with the Danish part will help reinforce what we have already embarked upon and will significantly contribute to the implementation of the Convention nationally and internationally. We are determined to meet our responsibilities to manage this precious heritage on behalf of the World community.

Marianne Jelved, Minister of Culture, Denmark
Ida Auken, Minister for the Environment, Denmark
Peter Altmaier, Federal Minister for the Environment, Nature Conservation and Nuclear Safety, Germany
Sharon Dijksma, Minister for Agriculture, The Netherlands
David McAllister, Prime Minister of Niedersachsen, Germany
Torsten Albig, Prime Minister of Schleswig-Holstein, Germany
Olaf Scholz, First Mayor of the Free and Hanseatic City of Hamburg, Germany
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2. List of Wadden Sea bird species.
3. List of endemic salt marsh species.
15. Danish Statutory Order on National Park Wadden Sea, BEK nr 1159 of 30/09/.
17. Designation of the Wadden Sea as Particularly Sensitive Sea Area (PSSA) by the International Maritime Organization, 2002.
18. Regional declarations supporting the nomination.
19. Image inventory list.
20. 40 topographical maps of the property, scale 1:50,000.
21. DVD with photographs, GIS data, topographical maps and all documents.
**State parties**

Denmark and Germany.

**State, province or region**

**Denmark:** The municipalities of Tønder, Esbjerg, Fanø and Varde.

**Germany:** Federal state of Niedersachsen.

**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 encompasses basically the Danish Wadden Sea Conservation Area and an offshore extension of the Niedersachsen Wadden Sea National Park. The nominated Danish Wadden Sea World Heritage property covers an area of 1,238.7 km² and the Niedersachsen extension an area of 406.3 km².

The nomination of the Danish Wadden Sea for inscription in the World Heritage List is an extension of the Dutch-German Wadden Sea World Heritage property inscribed in the List in 2009 and in response to the decision of the World Heritage Committee on the inscription of the property to encourage the State Party of Denmark to submit a nomination of the Danish part of the Wadden Sea as soon as feasible to extend and complement the existing property. Furthermore, on the occasion of the minor boundary modification of the property to include the Hamburg Wadden Sea National Park, the World Heritage Committee encourages the State Parties to continue to strengthen their transboundary collaboration in managing the property, and with the State Party of Denmark, and to consider the potential for nomination of an extension of the property to include the Danish Wadden Sea, taking account of the Committee’s recommendations at the time of inscription of the property on the World Heritage List.

On the inscription of the Danish part of the Wadden Sea and the German (Niedersachsen) extension the property will cover an area of 11,456.1 km².

The Danish Wadden Sea Conservation Area as designated by Statutory Order on the Nature and Wildlife Reserve Wadden Sea, 1982 and later amendments, which is part of the overall trilateral Conservation Area, is delimited landwards and on the three inhabited islands Romø, Mando and Fanø by the sea walls, or where the sea walls are absent the highest daily water level including high sands and state owned parts of the islands, and the land reclamations. Offshore the nominated property is delimited by the 3 nautical sea mile boundary. The state boundary between Denmark and Germany constitutes the southern boundary of the nominated property. In the north, the nominated

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<td>007</td>
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<td>539,742</td>
<td>D1/19 - D10/19</td>
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<td>008</td>
<td>Danish Wadden Sea Nature and Wildlife Reserve, part II</td>
<td>Denmark</td>
<td>55° 29' 56'' N 08° 11' 14'' N</td>
<td>19,937</td>
<td>DK1/3 - DK3/3</td>
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**Total Property** 1,145,609
The nominated property includes the peninsula of Skallingen and the Ho Bay. Some of the state owned parts of the islands such as the beaches of Rømø are included in the nominated property including the Margrethe Kog in the southern part, which was reclaimed in 1982.

The nominated property does not include the shipping lane to Esbjerg, which is not designated as a Natura 2000 area, the military exercise area the island of Rømø in conformity with the exclusion of similar exercise areas of the existing property, a very small area around the Rømø harbour for which a planning license has been granted in conjunction with an environmental assessment according to Art. 6 of the Habitats Directive and a small area in Margrethe Kog north.

The nominated property includes all habitats which belong to the Wadden Sea – salt marshes, tidal areas including the tidal inlets, channels and gullies, beaches and offshore areas and the Nature and Wildlife Reserve protects and conserves the ecological processes and its flora and fauna. Within the 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 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 such activities do not adversely affect the area and its ecological and landscape values. In addition, several activities are regulated in time and space. The nominated property is consistent with the 2009 inscribed Wadden Sea World Heritage which also covers the area of the trilateral Wadden Sea Conservation Area.

The German (Niedersachsen) extension of the property covers the offshore area off the East Frisian Islands and the Elbe-Weser triangle. The proposed extension modifies the boundaries of the German (Niedersachsen) part to basically align with the extension of the Niedersachsen National Park in 2010 to include offshore areas important for the protection of the sea birds and marine mammals in particular harbour porpoise. The main shipping lane of the Jade-Weser approach, the Traffic Separation Scheme (TSS) and an area of commercial sand extraction on the northern edge of the Elbe-Weser triangle have been excluded from the nominated property.

The Wadden Sea Plan 2010, as outlined in chapter 5.e, is valid for the Trilateral Wadden Sea Cooperation Area, in short the Wadden Sea Area. The Wadden Sea Plan fully applies to the nominated property.

The purpose of a 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. This approach is fully consistent with the approach for the Wadden Sea World Heritage property as inscribed on the List.

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 considered one of the most important areas for migratory birds in the world, and is connected to a network of other key sites for migratory birds. Its importance is not only in the context of the East Atlantic Flyway but also in the critical role it plays in the conservation of African–Eurasian migratory waterbirds. In the Wadden Sea up to 6.1 million birds can be present at the same time, and an average of 10–12 million pass through it each year.

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.

Criteria under which the property is nominated

By decision 33 COM 8B.4 “The Wadden Sea, Germany and Netherlands” was inscribed on the World Heritage List under natural criteria (viii), (ix) and (x). The nominated property is an extension of the already inscribed property and the natural criteria under which the latter was inscribed unreservedly apply to the nominated property:

Criterion viii: “be outstanding examples representing major stages of earth’s history, including the record of life, significant ongoing 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
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, 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 intertidal 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 moultng 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.
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T +49(0)4421 91080
F +49(0)4421 910830
enemark@waddensea-secretariat.org
1. IDENTIFICATION OF THE PROPERTY

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1.b State, province or region

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**Germany**: Federal state of Niedersachsen.

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"THE WADDEN SEA"

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<tr>
<td><strong>Total Property</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>1,145,609</strong></td>
<td></td>
</tr>
</tbody>
</table>
1.e Maps and plans, showing the boundaries of the nominated property

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

Figure 1.2 (right): The Wadden Sea (A3 map on the following page).

Figure 1.3: The Wadden Sea World Heritage and the nominated property

World Heritage property "The Wadden Sea"

Legend
- World Heritage property
- Nominated property
- National boundary

Map showing the geographical layout of the Wadden Sea, highlighting its boundaries and various environmental features.
Chapter 1 Identification of the Property

Figure 1.4: The Wadden Sea World Heritage and the nominated property.
Figure 1.5: The nominated Danish World Heritage property.
Table 1.2: Coordinates of prominent points of the 8 component parts of the inscribed and nominated property. Figure 1.4 shows the location of the component parts and the prominent and centre points. Component parts with the offshore extension of the Niedersachsen Wadden Sea and the nominated property in the Danish Wadden Sea are shaded in red.

An A3 overview map indicates the distribution of the 40 detailed topographical maps 1:50,000 which are in Annex 20.

<table>
<thead>
<tr>
<th>Component Part</th>
<th>Name</th>
<th>Prominent Points (see A3 map)</th>
<th>Latitude N</th>
<th>Longitude E</th>
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<tr>
<td>001</td>
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<td>1.1 53° 33' 33'' 06° 36' 03''</td>
<td>1.2 53° 25' 47'' 05° 25' 26''</td>
<td>1.3 52° 57' 13'' 04° 43' 15''</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.4 53° 19' 16'' 05° 45' 16''</td>
<td>1.5 53° 27' 48'' 06° 49' 58''</td>
<td>Centre point 53° 23' 27'' 05° 39' 57''</td>
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<td>2.1 53° 27' 41'' 06° 50' 32''</td>
<td>2.2 53° 19' 03'' 06° 59' 48''</td>
<td>Centre point 53° 22' 00'' 06° 53' 47''</td>
</tr>
<tr>
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<td>3.2 53° 18' 49'' 07° 00' 46''</td>
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<td>4.3 53° 22' 08'' 06° 59' 50''</td>
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<td></td>
<td>4.4 53° 34' 17'' 07° 05' 14''</td>
<td>4.5 53° 41' 02'' 07° 28' 40''</td>
<td>4.6 53° 38' 47'' 08° 05' 29''</td>
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<td></td>
<td></td>
<td>4.7 53° 47' 08'' 08° 01' 04''</td>
<td>4.8 53° 50' 40'' 07° 41' 45''</td>
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<td></td>
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<td></td>
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<tr>
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<tr>
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<td></td>
<td>7.4 54° 30' 04'' 08° 02' 20''</td>
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<td>7.6 53° 59' 58'' 08° 16' 03''</td>
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<tr>
<td></td>
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<td>7.7 53° 53' 29'' 08° 59' 07''</td>
<td>7.8 54° 31' 11'' 08° 59' 08''</td>
<td>7.9 54° 54' 02'' 08° 38' 16''</td>
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<tr>
<td></td>
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<td>7.10 55° 09' 37'' 08° 42' 05''</td>
<td>7.11 55° 28' 58'' 08° 22' 27''</td>
<td>Centre point 54° 36' 31'' 08° 27' 59''</td>
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<td>8.1 55° 33' 29'' 07° 59' 00''</td>
<td>8.2 55° 25' 34'' 08° 13' 37''</td>
<td>8.3 55° 29' 51'' 08° 23' 37''</td>
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<td></td>
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<td>8.4 55° 35' 46'' 08° 16' 36''</td>
<td>Centre point 55° 29' 56'' 08° 11' 14''</td>
<td></td>
</tr>
</tbody>
</table>
The nominated property encompasses basically the Danish Wadden Sea Conservation Area and an offshore extension of the Niedersachsen Wadden Sea National Park. The nominated Danish Wadden Sea World Heritage property covers an area of 1,238.7 km² and the Niedersachsen extension an area of 406.3 km².

The nomination of the Danish Wadden Sea for inscription in the World Heritage List is an extension of the Dutch–German Wadden Sea World Heritage property inscribed in the List in 2009 and in response to the decision of the World Heritage Committee on the inscription of the property to "encourage the State Party of Denmark to submit a nomination of the Danish part of the Wadden Sea as soon as feasible to extend and complement the existing property." Furthermore, on the occasion of the minor boundary modification of the property to include the Hamburg Wadden Sea National Park, the World Heritage Committee "encourages the State Parties to continue to strengthen their transboundary collaboration in managing the property, and with the State Party of Denmark, and to consider the potential for nomination of an extension of the property to include the Danish Wadden Sea, taking account of the Committee’s recommendations at the time of inscription of the property on the World Heritage List.”

On the inscription of the Danish part of the Wadden Sea and the German (Niedersachsen) extension the property will cover an area of 11,456.1 km².

The Danish Wadden Sea Conservation Area as designated by Statutory Order on the Nature and Wildlife Reserve Wadden Sea, 1982 and later amendments, which is part of the overall trilateral Conservation Area, is delimited landwards and on the three inhabited islands Rømø, Mandø and Fanø by the sea walls, or where the sea walls are absent the highest daily water level including high sands and state owned parts of the islands, and the land reclamations. Offshore the nominated property is delimited by the 3 nautical sea mile boundary. The state boundary between Denmark and Germany constitutes the southern boundary of the nominated property. In the north, the nominated property includes the peninsula of Skallingen and the Ho Bay. Some of the state owned parts of the islands such as the beaches of Rømø are included in the nominated property including the Margrethe Kog in the southern part, which was reclaimed in 1982.

The nominated property does not include the shipping lane to Esbjerg, which is not designated as a Natura 2000 area, the military exercise area the island of Rømø in conformity with the exclusion of similar exercise areas of the existing property, a very small area around the Rømø harbour for which a planning license has been granted in conjunction with an environmental assessment according to Art. 6 of the Habitats Directive and a small area in Margrethe Kog north.

The nominated property includes all habitats which belong to the Wadden Sea – salt marshes, tidal areas including the tidal inlets, channels and gullies, beaches and offshore areas and the Nature and Wildlife Reserve protects and conserves the ecological processes and its flora and fauna. Within the 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 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 such activities do not adversely affect the area and its ecological and landscape values. In addition, several activities are regulated in time and space. The nominated property is consistent with the 2009 inscribed Wadden Sea World Heritage which also covers the area of the trilateral Wadden Sea Conservation Area.

The German (Niedersachsen) extension of the property covers the offshore area off the East Frisian islands and the Elbe–Weser triangle. The proposed extension modifies the boundaries of the German (Niedersachsen) part to basically align with the extension of the Niedersachsen National Park in 2010 to include offshore areas important for the protection of the sea birds and marine mammals in particular harbour porpoise. The main shipping lane of the Jade-Weser approach, the Traffic Separation Scheme (TSS) and an area of commercial sand extraction on the northern edge of the Elbe–Weser triangle have been excluded from the nominated property.

The Wadden Sea Plan 2010, as outlined in chapter 5.e, is valid for the Trilateral Wadden Sea Cooperation Area, in short the Wadden Sea Area. The Wadden Sea Plan fully applies to the nominated property.

The purpose of a 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. This approach is fully consistent with the approach for the Wadden Sea World Heritage property as inscribed on the List.

1.f Area of nominated property

The nominated property encompasses basically the Danish Wadden Sea Conservation Area and an offshore extension of the Niedersachsen Wadden Sea National Park and extends and complements the existing Wadden Sea World Heritage property, which basically encompasses the Dutch Wadden Sea Key Planning Decision Area, the German Wadden Sea National Parks of Niedersachsen, Hamburg and Schleswig-Holstein.

<table>
<thead>
<tr>
<th>Component Part</th>
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<td><strong>Total Property</strong></td>
<td></td>
<td><strong>1,145,609</strong></td>
<td><strong>11456.1</strong></td>
</tr>
</tbody>
</table>

Table 1.3: Size and distribution of the inscribed and nominated property. Component parts with the offshore extension of the Niedersachsen Wadden Sea and the nominated property in the Danish Wadden Sea are shaded in red.
2. Description of the Property

2. a Description of the property ¹

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 nor refuges for relicts of the past. Instead, they share biological species over a wide range of latitudes. This is a consequence of Holocene range extensions and wide physiological tolerance limits needed to survive in dynamic coastal environments. As a corollary, coastal wetlands are susceptible to biological invasions when species are translocated across oceans by human carriers.

Biota of coastal wetlands have 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 potential of 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

¹ Chapter 2.a is an update of the 2008 nomination document to include recent information in particular from the 2009 Wadden Sea Quality Status Report; separate chapters on the Danish Wadden Sea and the Niedersachsen extension have been added at the end of the chapter to inform the nomination.
The biota in coastal wetlands has attracted people from early on with the benefit of combining marine, riverine and terrestrial food sources. 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, hence the name wadden for tidal flats. The unique character and the outstanding vastness of these tidal flats with fringing salt marshes, beaches, dune islands and shoals and the spectacular abundance of wildlife form the basis for the designation as World Heritage Site.

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.

In this chapter, the "Wadden Sea" refers both to the inscribed and 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 inscribed and nominated property, because natural processes and, in particular, migratory organisms do not respect administrative boundaries.

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.

The Wadden Sea is a gigantic coastal filter and an ecological hotline for biotic production and migrant animals. People have been living in the 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). The coastal people 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.

**Physical environment**

The inscribed and 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 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 (Fig. 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 Wadden Sea is located right in the centre of the southeastern continental coastline of the North Sea, which stretches from Cape Cris Nez near Calais at the Straight of Dover over a length of 1,200 km to Skagen, the northern tip of Jutland at the Skagerrak. Within that sigmoid bended, sedimentary coast, the 500 km sector of the Wadden Sea is not an arbitrary unit but represents a natural entity. It is almost as self-contained as an island or a lake. This is primarily caused by a symmetric tidal regime. The Wadden Sea begins and ends at a tidal range just high enough for the formation of barrier islands sheltering tidal basins (mesotidal range). Adjacent coastlines at both ends exhibit a continuous sandy barrier without tidal basins but enclosed lagoons or land (microtidal range). The natural boundaries of the Wadden Sea are the Den Helder peninsula in the South and Skallingen peninsula with Blåvandshuk in the North. Tidal range increases from both ends towards the centre. There the tidal range achieves macrotidal height and the chains of barrier islands and high sands fade. This hydromorphological symmetry gives the Wadden Sea the character of a natural coastal entity with a unique set of hydrological, geomorphological and ecological characteristics.

The shallow southern North Sea meets an extremely flat marshland in the Wadden Sea, only occasionally intersected by moderate elevations of glacial origin or of Holocene dunes. These elevations 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 500 km of coastline and an average width of 250 km, the profile remains within the narrow vertical confines of about 100 m.

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 14,900 km², which com-
prises a maritime zone from flat land to shallow waters (Tab. 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. Sediment supply from the sea is not sufficient to compensate sea level rise and barrier islands slowly shift in the direction of the mainland. 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 latter a storm surge barrier has been built, and Weser and Elbe have been partly transformed into deep shipping canals. 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. Sediment supply from the sea locally even over-compensates sea level rise. With the Jadebusen a large embayment extends deep into the marshland.

- 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. Sediment supply from the sea is insufficient to compensate sea level rise, similar to the situation in the Southern Wadden Sea. However, the most northern part benefits from an external sediment supply entering the shore from the North. Large estuaries are absent, while only in this part of the Wadden Sea cliffed glacial deposits occur at the shore.

**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 northwestern 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 4,700 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 35 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
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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 (Fig. 2.5).

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. This further contributes to the dominance of marine conditions in the tidal zone.

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 northwestern 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...
The Wadden Sea, all between 40° and 50° N. Climatic conditions in the Wadden Sea 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 past. 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. Occurrence of ice is very irregular between years and is more frequent in the Northern than in the Southern Wadden Sea.

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. During spring, shallow Wadden Sea water heats up faster than deeper North Sea water, while in winter North Sea water cools down slower than the shallow Wadden Sea water (Fig 2.6). Some fish and invertebrates respond to this seasonal reversal in temperature difference with inshore-offshore migrations to seek optimal conditions and avoid lethal extremes. 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.

In spring, a density driven circulation perpendicular to the shoreline starts with diluted and warmer water flowing near the surface in offshore direction, while near the bottom more marine and cooler water is flowing inshore. The latter transports significant amounts of suspended organic matter produced by planktonic microalgal blooms into the Wadden Sea. There it feeds the benthic fauna. When autumn cooling starts this transport ceases.

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 global 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%.

![Figure 2.6: Seasonal development of water temperature in the Wadden Sea and North Sea (modified from: Het beheer van de Wadden 1985).](image-url)
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 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 Quarternary 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 grinded 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 slowed down from about one meter to 10 to 20 cm per century 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. Some active cliffs occur in the Northern Wadden Sea, mainly on the island of Sylt and at the Danish mainland.

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, as it was common practice in the entire marsh area of the Wadden Sea before dike building commenced. Such dwelling mounds are the only parts of the Halligen which remain above water during storm tides. These Halligen 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. Islands populated until a few centuries ago and which have disappeared are Bosch and Buise in the Southern and Jordsand in the Northern Wadden Sea. New dunes on formerly bare high sands are recently developing on Kachelotplate in the Southern and Norderoogsand in the Northern Wadden Sea. 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-finining 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 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 aluvial mud particles. This process often generates inverted wedge-shaped salt marsh profiles. In salt marsh depressions soils become anoxic under waterlogged 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 inner delta of 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 under 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 a roll-over process in Wadden Sea dynamics.

**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...
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Fanø  
Mandø  
Rømø  
Sylt  
Juist  
Norderney  
Spiekeroog  
Wangerooge  
Föhr  
Amrum  
Texel  
Terschelling  
Ameland  
Schiermonnikoog  
Borkum  
Vlieland  
Pellworm  
Süderoogsand  
Nordstrand  
Langeoog  
Neuwerk  
Mellum  
Helgoland  
Baltrum  
Trischen  
Skallingen  
Blåvandshuk  
Hooge  
Langli  
Langeneß  
Oland  
Hamburger Hallig  
Süderoog  
Norderoogsand  
Japsand  
Scharhörn  
Rottumerplaat  
Meldorfer Bucht

Den Helder  
Harlingen  
Leeuwarden  
Groningen  
Delfzijl  
Emden  
Wilhelmshaven  
Bremerhaven  
Cuxhaven  
Heide  
Tönning  
Husum  
Tønder  
Ribe  
Esbjerg

THE NETHERLANDS

GERMANY

Figure 2.7: Major habitats in the Wadden Sea Area.

The Wadden Sea

The Wadden Sea Area

Mainland

- Lakes and Rivers
- Peatland
- Dune, Beach and Sand
- Geest
- Marsh

- Tidal area
- Depth < 10 m
- Depth 10 - 20 m
- Depth > 20 m

North Sea

THE NETHERLANDS

DENMARK

GERMANY

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.

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 inscribed and 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
Chapter 2 Description of the Property

At the inshore tidal flats over a distance up to 50 km, the offshore belt supports secondary production as a source of food to suspension and deposit feeders. There it constitutes a major belt and are transported via the bottom current flocculate and sink to the bottom in the offshore Sea. Suspended particles, mainly microalgal cells, high benthic biomass production in the Wadden Sea. This phenomenon is vital to the tidal basins while heavier bottom water flows to the shore. This is most pronounced in spring and summer when lighter surface water leaves the tidal basins while heavier bottom water flows in opposite direction. This phenomenon is vital to high benthic biomass production in the Wadden Sea. Suspended particles, mainly microalgal cells, flocculate and sink to the bottom in the offshore belt and are transported via the bottom current into the Wadden Sea. There it constitutes a major source of food to suspension and deposit feeders. Thus, primary production in the surface water of the offshore belt supports secondary production at the inshore tidal flats over a distance up to 50 km or even more. High remineralisation rates in the intertidal zone supply seaward flowing surface water with nutrients in return.

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 (Platytys flesus), adult flatfish stay mostly offshore while their larvae drift inshore, metamorphose and then start feeding on benthic prey on muddy tidal flats. Be-
fore 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 adjacent to the tidal area is an essential habitat for the Wadden Sea ecosystem. Phytoplankton blooms are transported from the 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. The boundary at the North Sea side is determined by an artificial line between the tips of barrier islands and outer sand bars. The inner boundaries at 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.

Tidal flats

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 visitor 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 and the various bedforms 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.

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 soilds and sediments).

Lugworms irrigate their burrows with water from above to supply their gills with oxygen and thus build up an oxic 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., *Typhiloplacystis rubra*, *Scoliopterygium arenicola*, *Coelogyponora 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 confined to very short periods of inundation. However, during low tide exposure there is a specialized predator in the form of the nemertine worm (*Tetrastemma melancephalum*). 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 to 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.

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...
The Wadden Sea, Germany and Netherlands (N1314) - Extension Denmark and Germany

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 the offshore belt. 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.
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, seagrass photosynthesis would be inhibited by shading the chloroplasts. 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 wigeon (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 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 pattern 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 pseudo-faeces 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. Mussel beds are important for the budget of fine-grained, organic-rich sediments (mud) in the Wadden Sea.

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 macroalgae 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 such 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 Eiders 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. While the worms find a safe home in the shell, 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, once oysters attain their large size, they provide shelter to young mussels remaining thus undetected by their predators. This advantage is partly reversed because the mussels grow slower and remain small for the oysters take most of their suspended food. Although mussel beds may partly be transformed into oyster reefs, mussels still manage to persist albeit as subtenant instead of its former role as house-owner. 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 Sabellaria spinulosa is capable of building massive solid reefs up to 50 cm high. Reefs have been reported in the past in the German part of the Wadden Sea only. Bottom trawling and changes in water current conditions are considered to be the main reason for the decline of Sabellaria reefs. Since trawling has been shifted mostly to the offshore belt, one may expect these Sabellaria reefs to recover. Similarly, beds of the European oyster which disappeared, partly due to overexploitation already at the beginning of the twentieth century, may eventually come back. The subtidal bottom provides habitat to the starfish, Asterias rubens. These seem to be excluded from the intertidal zone because gulls at low tide are particularly fond of this prey. Increased occurrence of starfish, in turn, may wipe out entire mussel beds in the subtidal zone.

The subtidal shoals and deep gullies are also important for the intertidal fauna as a refuge when seasonal conditions become too harsh in the intertidal zone. Particularly the young crabs, shrimp and fish which exploit the tidal flats soon begin to migrate with the ebbing tide into the subtidal zone and then return with the next flood. Some, like the shore crab (Carcinus maenas), hibernate in the subtidal but from spring onwards begin to commute with the tides between subtidal and intertidal zones. Crabs are very important predators, often decimating bivalve recruitment entirely.

Estuaries

Estuaries can be defined as tidally influenced transition zones between marine and riverine environments. World-wide, estuaries and deltas constitute the main coastal wetlands. The Wadden Sea is different in this regard. Although estuarine habitats are present, they are not a dominant feature and are small in size relative to the marine parts of the Wadden Sea. Nevertheless, they are of high relevance for the Wadden Sea ecosystem.
for various reasons: (1) they supply riverine inputs such as nutrients and toxic substances, (2) they are pathways for fish such as flounder (*Platichthys flesus*), smelt (*Osmerus eperlanus*) and eel (*Anguilla anguilla*) which migrate between fresh and marine waters, and (3) they form a specific habitat characterized by a strong variability of salinity, tidal range and turbidity. From an ecological point of view, they are important for the migration of a number of species and, additionally, they are inhabited by various obligate brackish-water species and thus are of special importance for conservation purposes. However, compared to the Wadden Sea, the estuaries have been strongly altered by human activities and only some parts are protected as nature reserves. Only the Ems estuary is partly located in the inscribed property. This estuary is a mesotidal coastal plain estuary with extensive muddy tidal flats.

There are also many sluices which discharge freshwater into the Wadden Sea. Some are small with only some m³ per second, but in the Western Dutch Wadden Sea a sluice in the Afsluitdijk of Lake IJssel discharges around 500 m³ per second in average. Since discharge is limited to low tide periods, more than 2,000 m³ per second are discharged during such intervals, which is three times larger than that of the Elbe. This kind of drainage creates estuarine conditions – although not completely natural – in this part of the Wadden Sea. However, the main difference between the Wadden Sea and other coastal wetlands is, besides its outstanding size, the prevalence of marine (euryhaline and polyhaline) conditions in the tidal area.

### 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 *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 inscribed 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, 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.

### Table 2.2: Area of salt marsh types (ha) in the Wadden Sea, including the pioneer zone, except for Denmark. The boundary between the pioneer zone and bare soil is chosen at 5% coverage (10% in Schleswig-Holstein) (Bakker et al. 2005). Barrier-connected salt marshes are mainly found on the sheltered parts of the islands. On the islands, de-embanked summerpolder may be added to the back-barrier marshes; on the mainland to the foreland-type salt marshes. (Source: QSR 2009).

<table>
<thead>
<tr>
<th>Salt marsh type</th>
<th>The Netherlands</th>
<th>Niedersachsen</th>
<th>Hamburg</th>
<th>Schleswig-Holstein</th>
<th>Denmark</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Barrier islands</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Back-barrier (incl. foreland)</td>
<td>4,280</td>
<td>3,680</td>
<td>260</td>
<td>1,250</td>
<td>2,230</td>
<td>11,680</td>
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<tr>
<td>Green beaches</td>
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<td>4</td>
<td>100</td>
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<td>60</td>
<td>80</td>
<td>0</td>
<td>0</td>
<td>150</td>
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<tr>
<td>De-embanked (summer) polder</td>
<td>90</td>
<td>150</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>280</td>
</tr>
<tr>
<td>2. Mainland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
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<td>0</td>
<td>720</td>
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<td>560</td>
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<td>11,250</td>
<td>384</td>
<td>12,110</td>
<td>6,420</td>
<td>40,634</td>
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</table>

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 seditation.

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 flooding 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 (Tab. 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 moored with stonewalls to stop cliff erosion at the salt marsh edge. The vegetation on the Halligen is dominated by Festuca rubra and Juncus gerardii 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 km² in the Wadden Sea Area and about 350 km² in the inscribed and 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

In the Wadden Sea with altogether about 470 km of sandy beaches, 91% occur at the barrier islands and high sands, the rest at the mainland. 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, Koresand in the Danish part and Richel in the Dutch part, form another important part of the sandy habitats in the 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 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
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Figure 2.10: The beach system (Source: I. Menn, 2001).

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The beach system

<table>
<thead>
<tr>
<th>Morphology</th>
<th>Subaerial beach</th>
<th>Surf zone</th>
<th>Nearshore zone</th>
<th>Inner continental shelf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wave process</td>
<td>Swash</td>
<td>Wave breaking</td>
<td>Wave shoaling</td>
<td></td>
</tr>
</tbody>
</table>

Beach System

Morphology

- Inner continental shelf
- Beach System
- Wave process
- Subaerial beach
- Surf zone
- Nearshore zone
- Wave breaking
- Wave shoaling

Beach Organisms

- Intermediate beaches
- Beach organisms
- Sandy beaches
- Macrofauna
- Microfauna
- Benthic macrofauna
- Benthic meiofauna
- Organic imports
- Organic microalgae
- Interstitial scavengers
- Interstitial carnivores
- Small body size
- Turbellarian worm
- Notocoryphasplana glandulosa
- Otoplanidae
- Turbellarian worms
- Several species
- Air-breathing sand hoppers
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The property or in the proposed extension area are listed

Dune vegetation types in eas which lie within the proposed Danish extension area (Source: OSR 2009)
(Note: only dune areas which lie within the property or in the proposed extension area are listed)

<table>
<thead>
<tr>
<th>Dune types</th>
<th>km²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry dune vegetation</td>
<td>48.7</td>
<td>87.5</td>
</tr>
<tr>
<td>Embryonic dunes</td>
<td>5.6</td>
<td>10.1</td>
</tr>
<tr>
<td>White dunes</td>
<td>8.4</td>
<td>15.5</td>
</tr>
<tr>
<td>Dune grassland</td>
<td>21.6</td>
<td>38.8</td>
</tr>
<tr>
<td>Dune heath</td>
<td>2.9</td>
<td>5.2</td>
</tr>
<tr>
<td>Dune scrub</td>
<td>8.0</td>
<td>14.4</td>
</tr>
<tr>
<td>Dune woodland</td>
<td>2.2</td>
<td>3.9</td>
</tr>
<tr>
<td>Wet dune vegetation</td>
<td>6.9</td>
<td>12.4</td>
</tr>
</tbody>
</table>

(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 microbfa 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 plagues 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 in contrast to seals and people who like to rest upon beaches, unaware of the high diversity of life in the interstices of the sand below them.

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 (xerosere) alternates with wet dune vegetation (hygrosere) in the dune valleys (slacks). With a few exceptions (e.g. Eiderstedt and Skallingen peninsulas) the dune habitat is confined to the Wadden Sea barrier islands. Dry dune vegetation dominates with 87.5% over wet dune slack vegetation types (Tab. 2.3). The dunes included in the property predominantly occur on the Eastfrisian islands and in the proposed Danish extension on the island of Rømø and at Skallingen peninsula.

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. High evaporation causes groundwater level to move upwards underneath dunes. Thus, roots need not to reach all the way down to the dune basis. Dunes dominated by marram grass are termed white dunes, because bare sand is still visible and is kept in motion by the wind. Vigour 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 succession brownish, because ferrous hydroxides are released (brown dunes).

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. On barrier islands in the Northern Wadden Sea, crowberries are succeeded by common heather (Calluna vulgaris).

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...
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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 an impressive scenery. However, dunes are also part of the coastal defence system, and for that purpose they have been stabilized in the vicinity of settlements. 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. canutus) 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 mollissima) 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 oenanthe) and red-backed shrike (Lanius collurio). In late summer whimbrel (Numenius phaeopus), gulls and starlings forage on berries (crow-, blue- and cranberry). 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 dune stabilization 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 (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. The 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 (Tab. 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 analysed 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 almost 1,000 species. Macroinvertebrates 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.

### Table 2.4: Overview on species richness in the Wadden Sea.

<table>
<thead>
<tr>
<th>Species Group</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vascular plants (seagrass)</td>
<td>2</td>
</tr>
<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>
<td>1,200</td>
</tr>
<tr>
<td>Benthic macrofauna</td>
<td>400</td>
</tr>
<tr>
<td>Fish</td>
<td>149</td>
</tr>
<tr>
<td>Marine mammals</td>
<td>3</td>
</tr>
<tr>
<td>Terrestrial, semi-terrestrial and freshwater organisms</td>
<td></td>
</tr>
<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>Birds(^1)</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.
moulting and wintering in the area. A list of breeding, migratory and offshore birds is in Annex 2.

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 (*Larus ridibundus*), lesser black-backed gull (*Larus fuscus*) and herring gull (*Larus argentatus*) being the most

![Figure 2.11: Comparison of breeding bird populations in the Wadden Sea in 2001 with NW-European population sizes (from: Koffijberg et al. 2006).](image)

Baranacle geese (Photo: Bo Lassen Christiansen).
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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 northwestern European populations breed in the Wadden Sea (Fig. 2.11). 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 (Fig. 2.12). 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 sediments 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 \((Somateria mollissima)\). 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 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 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 populations. 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. The population is spread fairly evenly throughout the Wadden Sea. In total, 26,220 were counted in 2012, 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 (71%), at the tips of the western Eastfrisian Islands, in the northern Wadden Sea off the islands of Amrum and Sylt, and just outside the Wadden Sea a colony became established at the island of Helgoland. Simultaneous aerial counts carried out in March-April 2011 during moulting came up with 3,312 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 inscribed property.
Fish

More than 140 species of fish have been recorded from the Wadden Sea. A list of fish species is in Annex 1. 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 Wad-
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 rount (*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 rount 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 fish 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 m²). 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. Medium sizes of cockles are the preferred prey of oystercatchers (*Haematopus ostralegus*). 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.

**Plants**

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’.

In the Wadden Sea, where 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 3.

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 during recent decades. Some species threatened in general find refuge in the Wadden Sea to some extent (Tab. 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

<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/Irnt</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>

Table 2.5: Threatened vertebrate animals on the IUCN Red List with survivors encountered in the Wadden Sea.
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, re-suspensions 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 photosynthesis is higher than in the shallow turbid waters laden with re-suspensions from the bottom. In the Wadden Sea, a purification of North Sea waters takes place due to abundant suspension feeders, high retention rates of organic particles in permeable sand, on sticky mud surfaces and in salt marshes. This coastal 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,
• Breath-taking 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.
Description of the Niedersachsen Offshore Belt

Geography

The nominated extension to the property „The Wadden Sea, Germany and Netherlands“ is part of the Lower-Saxon Coastal Waters and the Niedersachsen Wadden Sea National Park. It is located seaward of the chain of barrier islands resp. high sand bars as a broad strip parallel of the offshore belt parallel to the coastline between the Outer Ems Estuary in the west and the Outer Elbe Estuary in the east. The nominated property connects the open North Sea and the shallow tidal area. It completes the already inscribed block-shaped parts of the Lower-Saxon Offshore Belt and adds important geomorphological, hydrological and ecological elements and functions as well as secures the existing connectivity of habitats. The area is interrupted by the outer estuary of Jade and Weser. The eastern part is named „Roter Sand“, the western part „Küstenmeer vor den ostfriesischen Inseln. “The property is 40,628 ha/406.3 km² large. Measured along the base line parallel to the coast, it stretches over a distance of about 65 km.

Geology und Hydrology

The hydrological dynamics are driven by large scale, temporally variable circulation patterns of oceanic currents of the North Sea and by the influx of riverine water from the Ems, Weser and Elbe. The prevailing coastal current is running eastward and interacts with semi diurnal tidal currents. Water temperature varies seasonally and the annual amplitude takes an intermediate position between the open North Sea and the tidal area. Climatic warming has led to a continuous rise of the average water temperature over the last decades. Stable stratifications of the water column do not develop. Salinity and nutrient concentrations are determined by a mix of Atlantic water and the freshwater runoff from Ems, Weser and Elbe, most pronounced in the eastern area „Roter Sand“, characterized by an abrupt transition of concentrations, named “Convergence Zone of the German Bight”. The submarine slopes of the extension area at the northern edge of the Wadden Sea are 5 to 20 m below sea level. The seabed consists of sediments deposited during the Pleistocene and the Holocene. Varying sedimentation conditions led to different sediment types and grain size distributions. Under the influence of oceanic currents, tides and storm surges, sand is transported predominantly eastward, parallel to the coastline. Large areas are characterized by a highly dynamic dislocation of sediments. The offshore belt is part of a closely linked sand-sharing system with barrier islands, estuaries and tidal areas. The lower shore face located at the outskirts of the barrier islands and the Elbe-Weser-Triangle below a depth of about 10–12m is structured by a series of NE-striking ridges and valleys, the so-called shoreface connecting ridges with interspaces of several kilometres and heights of up to 6 m. Sediments consists of fine to medium sand. Relicts of the last iceage left an imprint on the morphology and the sediments of the deeper parts of the extension area. Particularly in the western part, stretches of coarse sand and occasionally also gravel and stones occur, imbedded between large patches of medium and medium to coarse sand.
Habitats

Between biota and climatic, hydrological and geo-morphological processes, strong interactions unfold their intense influence within the extension area and are indicated by the occurrence of typical habitats and communities.

The characteristic benthic association colonizing the fine to medium sandy bottom above the 10 m depth contour is the Macoma balthica - Community. Below this depth, the widespread Tellina fabula - Community has been recorded. The rare Goniadella - Spisula - Community occurs in coarse sand and gravel. Long-term warming has led to an increase in species numbers, abundance and biomass of the benthos.

The offshore belt and the tidal area together compose an ecological unit for numerous mobile animal species. The nominated German (Niedersachsen) extension to the property is an important spawning site for fish and invertebrate species, which is used as an essential part time habitat within the life cycle or during seasons. It links spatially and seasonally as reproduction-, retreat- and transfer zone the tidal area, the estuaries and the deeper North Sea, for example for the typical flatfish species sole (Solea solea) und plaice (Pleuronectes platessa) as well as brown shrimp (Crangon crangon): The most important habitats for adult brown shrimps are the gullies and channels of the tidal areas, the submarine slopes of the outer estuaries and in the offshore zone down to the 20 m depth contour. They migrate seasonally between the areas perpendicular to the coastline. In spring, the juveniles abound in the shallow zones and in autumn migrate offshore. Fish species are of vital importance for fish consuming seabirds like terns, divers and cormorants as well as for marine mammals.

Marine mammals indicate as top predators within the coastal ecosystem, how closely the area of the nominated extension to the property is linked to the tidal area and the open North Sea. In terms of spatial distribution, surveys of harbour porpoises (Phocoena phocoena) covering the German parts of the North Sea show that habitat use is heterogeneous, with the animals showing clear preferences for certain areas. These may be important foraging grounds. Although the number of counted harbour porpoises throughout the North Sea have remained almost stable since the first counts in 1994 the overall numbers of sightings of harbour porpoises in the southern North Sea are rising which includes the area of the nominated extension to the property.

Harbour seals (Phoca vitulina vitulina) prefer to feed on ground fish and are foraging in the extension area all year round. They favour depths between 12 and 25 m. Especial during the birth and lactation period, female individuals, resting on sandbanks in the tidal area, depend on the adjacent offshore belt as their foraging ground. For several centuries, grey seals (Halichoerus grypus)
had been missing in this region. Since a few years back, however, the species has been returning to the Niedersachsen Wadden Sea. The centre of the newly found colony lies at Kachelotplate near the island Juist. Grey seals use the area of the nominated extension to the property for foraging.

High biological productivity in the nominated extension area attracts coastal birds preying by diving for fish, mussels, shrimps and crabs or taking small organisms from the water surface. Seabirds and coastal birds use the offshore belt not only for foraging but also for resting and moulting.

The distribution and behaviour of seabirds in the offshore belt are highly variable, depending on season, location of the hydrological convergence zone, wind speed and tidal cycle. Large and connected protection zones for these species are needed to meet their variable demand of habitats. The extension area adds important resting, migrating and overwintering areas of red-throated diver (Gavia stellata), common gull (Larus canus) and a passage area for little gull (Hydrocoloeus minutus, Syn. Larus minutus) to the existing property.

Breeding birds from the islands use the offshore belt adjacent to their colonies as foraging area, depending on their preference for certain prey, preferring limited radii and water depths around their colonies. Thus, the extension area closes important gaps. In the Hamburg and Niedersachsen Wadden Sea, for example, several breeding colonies of sandwich tern (Sterna sandvicensis) occur. Sandwich terns forage almost exclusively within the offshore belt up to the 20m depth contour line. The extension areas contain essential parts of their basic food requirements. The offshore belt of the Niedersachsen Wadden Sea is also important for the food supply of breeding common tern (Sterna hirundo), arctic tern (Sterna paradisaea) and lesser black-backed gull (Larus fuscus).

Other, regularly detected bird species within the extension area are: Black-throated loon (Gavia arctica), northern fulmar (Fulmarus glacialis), northern gannet (Morus bassanus), great cormorant (Phalacrocorax carbo), common scoter (Melanitta nigra), common Eider (Somateria mollissima), velvet scoter (Melanitta fusca), common black-headed gull (Chroicocephalus ridibundus), herring gull (Larus argentatus), great black-backed gull (Larus marinus), black-legged kittiwake (Rissa tridactyla), common guillemot (Uria aalge) and razorbill (Alca torda).

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The entire Wadden Sea with the Danish part at its northern end constitutes a natural geographic entity at the southeastern continental coast of the North Sea. This entity has an inherent symmetry of hydrological and geomorphological characteristics which vary with tidal range. The tidal range swings from below 1.5 m at the southern end up to 4 m in the central parts and then down again to the 1.5 m range at the northern end. This is a crucial property because at about 1.5 m coastal morphology switches from continuous sandy barriers without tidal flats to a chain of barrier islands with tidal flats between islands and mainland. Islands tend to become shorter and ephemeral with increasing tidal range in the central Wadden Sea while tidal flats become more extensive, whereas wave height tends to decrease from both ends towards the central part.

This is caused by a bend in the coastline giving the Wadden Sea the shape of a wide funnel. The tidal wave is compressed and gains in height towards its inner part while wind waves diminish. The Danish Wadden Sea near the northern rim of this funnel constitutes the symmetric counterpart to the western Dutch Wadden Sea in the south. Without the Danish subregion this natural symmetry of the Wadden Sea would be broken. In other words, the Danish Wadden Sea is – in both geographical and biological ways – an essential part of the whole Wadden region and contributes significantly to protecting a natural integrity of this coastal landscape.

On a smaller scale, the German-Danish border and with this the boundary of the World Heritage Site since 2009 cuts diagonally through one of the largest tidal basins of the Wadden Sea. This border has reflected a compromise between national interests since 1920 but does not follow any natural features in the landscape. The intersected List tidal basin has an area of about 400 km² and is sheltered by the German island of Sylt in the south and the Danish island of Rømø in the north against the surf of the North Sea. Environmental research has bridged this border by joint German-Danish research projects and overlapping monitoring to overcome the obstacle of a national boundary cutting through a natural entity. Also coastal protection has been done in cross-boundary cooperation when the old dike in front of the Tønder Marsh required an adaptation to rising storm surge levels. A coherent new dike was built across the border in 1981. In the following description of natural values, the entire tidal basin is consequently taken into account without subdividing it arbitrarily.

The Danish Wadden Sea offers particular attributes which make this subregion a treasure box of natural values which considerably strengthen the value of the Wadden Sea World Heritage Site as a whole. (1) In the Danish Wadden Sea, the belt of marshlands is relatively small and at two sites
moraines of a former Ice Age approach the tidal area directly by forming active cliffs. (2) The Danish Wadden Sea receives more sand from the North Sea than most other parts. This may have given rise to a particularly high share of sand bars and plains remaining dry at normal high tide. (3) The Danish Wadden Sea is a very pristine part, fairly remote from industrial centers and the share of unmodified natural shorelines is particularly high. Most salt marsh areas have only been diked since last century, indicating a much shorter impact history than in other Wadden regions.

Although tidal range and the existence of barrier islands resemble very much the western Dutch Wadden Sea, there are more similarities with the adjacent German subregion from Sylt to Eiderstedt peninsula. Together with this part, the Danish Wadden Sea constitutes the Northern Wadden Sea region, one of the three major subdivisions based on physical attributes (Fig. 2.13). In the subsequent description of the Danish Wadden Sea, the particularities as well as the similarities with other parts of the Wadden Sea conservation area will be highlighted.

Geography

The Danish Wadden Sea Area covers an area of 1,545 km² of which the conservation area comprises 1,249 km². The coastal length is roughly 90 km or nearly one fifth of the entire outer Wadden Sea coastline. The width of the tidal area decreases from south to north and the average is about 13 km from the island beaches to the mainland shore. With the old town of Ribe there has been an important trading and cultural centre in the region since the 9th century. However, population density remained relatively low, and many aspects of coastal development emerged later than further south in the Wadden Sea. Embanking of the rather small belt of salt marshes with dikes commenced in the Tønder Marsh about 500 years later than in the Dutch Wadden Sea, and most other mainland marshes remained undiked until the early 20th century. The Varde Å entering the northernmost tidal basin forms the only estuary in the Wadden Sea not flanked by dikes nor intersected by barriers. The busy port of Esbjerg was founded in the 19th century for fishing and Danish commerce in the North Sea region. However, industrial development remained rather rudimentary near the Danish Wadden Sea. Environmental effects remained limited to the vicinity of Esbjerg. Tourism has developed over the last hundred years with a particular sprawl of summer houses on the islands of Rømø and Fanø since the 1960s.

Geology and hydrology

The Danish Wadden Sea came into existence at the same time as the southern parts, about 8,000 to 7,000 years ago. However, moraine elevations stemming from glaciation periods are more prominent than in any other part of the Wadden Sea due to the narrow salt marsh belt between the moraines and the tidal area. Over a total length...
of 18 km these moraines have developed active cliffs towards the sea, and a shoreline rich in boulders and pebbles is found at these sites. As a natural phenomenon this is otherwise rare in the sedimentary Wadden Sea. Similar cliffs can only be found south of the border at the islands of Sylt and Föhr. The mainland marshes have developed on the gently sloping sandy outwash plains between and in front of the moraines and subsequently also on marine deposits as it is generally the case at the islands and Skallingen peninsula.

Where the Wadden Sea finds its end in the north, a submarine moraine extends almost 40 km seaward, perpendicular to the coast. Horns Rev (The devil’s horn) with its shallows – up to 4 m below the level of the sea and a grave yard of many unfortunate ships in the past – is breaking waves during storms and deflects the prevailing northward coastal current. This, together with the projecting moraine of Sylt in the south, apparently provides a surplus of sand to the Danish Wadden Sea. The tidal area not only kept pace with sea level rise but sand bars grew seaward extending the Wadden region. The island of Rømø has one of the widest beaches in the world (1 to 1.5 km wide). At present a new dune ridge is developing at Havsand at the southern part of Rømø in front of the existing 3 to 4 old dune ridges. The high and large Koresand north of Rømø and also Blåvandshuk at the leeside of the drowned moraine of Horns Rev are extending seaward. At the island of Fanø, the western beach is apparently stable, only with some dune erosion. The 12 km long Skallingen peninsula exhibits an eroding beach lined by high dunes. Attempts to stabilize this shore with groins and a sand dike connecting the dunes have been more or less abandoned. At present, the peninsula is allowed to migrate naturally by wind and overwash during storm surges.

While Skallingen developed only 300 to 400 years ago, with dunes at most 200 years old, has now been eroding since the last decades, Rømø has been a high sand bar already since 8,000 years ago with dunes up to 1,000 years old, and this island is still growing seaward. There are some small remnant islands in the Danish Wadden Sea which suggest a chain of barrier islands about 3 to 4 km more landward from the present barrier, possibly existing during an earlier phase of development of the Danish Wadden Sea. One of these remnants, the island of Jordsand in the Lister Dyb tidal basin, extended over an area of about 600 ha with two farm sites in the 17th century but continuously eroded away to 2.3 ha in 1973 and since 1998 only a bare sand bar indicates where once this island had been. At exposed sites, wave erosion tends to prevail around high-tide level while sedimentation is often the dominating process on the tidal flats.

In the tidal area, marine deposits of 10 to 20 m have accumulated which more or less have compensated tectonic subsidence and sea level rise since the emergence of the Danish Wadden Sea. High deposition rates and sediment dynamics generally interfered with the access for ships to port locations and hampered the respective development in this part of the Wadden Sea. Only
in the southern part of the Lister Dyb, tidal basin erosion prevails over deposition. At Ho Bugt in the north, alternating layers of brackish reed marshes and marine salt marshes have been deposited over the last 4,000 years indicating perpetual changes in relative sea level and sediment supply.

Dams have been built to connect islands with the mainland. A causeway for trains was built to Sylt in 1927, for a road to Rømø in 1948 and an ebb road of about 60 cm above mean tide level to Mandø in 1978. These run more or less along the tidal divides but prevent or reduce the overflow of tidal waters from one tidal basin to the other. At the mainland, considerable sediment accretion, mainly at the southern side of the dams, has led to the development of wide salt marshes. A storm surge around 1560 has divided the small Island of Mandø in two but both were connected again by a dike in 1872 and most of the island became embanked by 1937.

The tidal range decreases northward from 2 m in the Lister Dyb tidal basin to 1.5 m in the Ho Bugt basin. Altogether, a tidal prism of roughly 1 km³ (7% of the tidal prism of the entire Wadden Sea) is moved in and out of the Danish Wadden Sea in the course of a tidal cycle. More than half of this water volume flows into the List tidal basin where strong currents of up to 2 m per second have scoured the bottom of the tidal inlet to a maximum depth of 40 m. The other tidal inlets (Juvre Dyb, Knude Dyb and Grådyb) reach only a depth of 9 to 13 m. At the bed of these inlets, submarine dunes of 3 to 5 m in height migrate, often 40 to 60 m per year seaward.

The offshore belt is gently sloping to the sea and shallower than in other parts of the Wadden Sea. This may explain the high abundance of common scoters (Melanitta nigra) in the area because of an easier access to the shellfish at the bottom which is their main prey. These ducks moult their feathers in the offshore belt and are highly sensitive to disturbance in this period, while breeding occurs in the Subarctic region to the northeast. The seaward barrier of the Danish Wadden Sea is characterized by very extensive dry sand bars and beaches. Presumably the wide shallow offshore belt mitigates the effects of strong surf on the exposed sands. The islands Rømø and Fanø together with Skallingen peninsula up to Blåvandshuk on the mainland coast are covered by dunes up to 20 m in height on their seaward sides while salt marshes occur on their Wadden side. Only a small share of the dunes is part of the conservation area and much of the salt marshes has been converted into pastures and arable land protected against flooding by dikes. In the vast tidal area, intertidal flats dominate over subtidal shoals and channels. The flats provide foraging grounds for huge flocks of migrating coastal birds on their way to and from the Arctic breeding sites. Four major tidal inlets connect this sheltered Wadden area with the offshore belt by a tidal exchange of coastal waters and with this plankton, shrimp, fish and seals commute to and from in high numbers. Along the mainland shore, moraine cliffs alternate with natural salt marsh habitats and artificially generated foreland. In the text below the habitats of the
tidal area and the salt marshes as the two main components of the conservation area are treated in more detail.

**Tidal area**

The tidal flats comprise an area of about 490 km² (including the German part of Lister Dyb tidal basin) which amounts to 62% of the tidal area. Muddy flats are only found as a narrow belt along sheltered parts of the mainland coast, at the lee sides of Rømø and Fano, and at the innermost part of Ho Bugt. By far the majority of tidal flats are sandy. Intertidal seagrass beds occur at the leesides of Rømø and Fano. Mussel beds at Lister Dyb and Grådyb have been extensive but have recently developed into mixed beds of mussels and oysters due to the spread of Pacific farm oysters introduced at a site near Sylt. It has been shown that high numbers of the common Eider (Somateria molissima) correlate with the stock size of mussels, and individuals feeding on mussels gain more weight than those feeding on cockles and other benthic prey. Eider ducks prefer small subtidal mussels which have a particularly thin shell, easy to crush in the duck's stomach. On the tidal flats the composition and abundance of the macrobenthic fauna resembles very much that of the entire Wadden Sea.

Outstanding in the Danish Wadden Sea are conspicuous high sand bars and plains with extensive areas above mean high tide level: Jordsand Flak in the Lister Dyb tidal basin, Havsand and Juvre Sand at Rømø, Koresand west of Manda, Keldsand and Peter Meyers Sand south of Fano and north of Fano the Søren Jessens Sand has merged with the island in the last decades. Together these high sands comprise almost 70 km², mostly bare dry sand and occasionally with some embryonic dunes. Submergence is limited to strong storm surges. This high proportion of high sandy areas is presumably related to an ample sand supply from the North Sea. These high sands are important roosting sites for migratory birds during high tide. The edges are preferred by Eider ducks, cormorants and seals. Of the latter, more than 3,000 have been counted during moulting season which may be about 13% of the entire harbour seal population in the Wadden Sea. In 1996 and 1997 entire schools of sperm whales stranded on these high sands and died - like ships in former times. The wide beaches with embryonic dunes are also very important breeding sites for little terns (Sterna albifrons) and Kentish plovers (Charadrius alexandrinus) which are rare and declining in the other parts of the Wadden Sea.

**Salt marshes**

The Danish Wadden Sea comprises a relatively high share of natural salt marsh developments, at the islands as well as along the mainland shores. Particularly along the shores of Ho Bugt (the most northern tidal basin of the Wadden Sea), salt marshes develop naturally on an area of about 10 km². At the lee side of Skallingen peninsula,
a large and natural salt marsh extends, which has been studied in detail. It developed on a high sand plain at the onset of the last century with the pioneering plants *Salicornia* and *Puccinellia*. Accretion rates were highest at the landward and seaward sides, leaving a central depression with enhanced salinities during evaporation in summer. Then gradually meandering creeks have developed and drained the central area. This subsequently allowed for vegetation development there as well. This marsh is partly grazed by domestic sheep. There, the grass *Puccinellia* dominates while the scrub *Halimione portulacoides* dominates where sheep had no access over the last decades. At the edge of this salt marsh a scarp indicates retreat while about 25% of the edges are prograding. Since 1963 the mean accretion rate at this salt marsh has been almost 2 mm per year which is slightly less than the relative sea level rise over the same period. To compensate the most recent rate of sea level rise with about 4 mm per year, accretion may lag behind in the future. On the adjacent tidal flats in the Ho Bugt, an accretion of 1.5 m has occurred over the last 2,000 years. This corresponds to an annual rate of less than 1 mm or less than half of the accretion rate observed on the salt marsh. This facilitates lateral erosion at salt marsh edges.

At the mainland shore near the town of Ribe, a different type of natural salt marsh development is ongoing. The Råhede Vade salt marsh is an interesting example for alternating effects of erosion and deposition. The edge of this marsh is eroded by the prevailing waves. In front of the emerging scarp of about 0.5 m in height, a runnel parallel to this cliff is developing and creates a sandy ridge on its seaward side. Once this ridge has grown up and approaches high tide level, pioneer vegetation begins to accrete fine material. Then a new salt marsh is developing in front of the old one. In the course of time the new marsh merges with the old one. Finally waves create a scarp at the seaward side of the new marsh and the whole process is repeating and a regular pattern of ridges at distances of about hundred meters has emerged on a time scale of a few decades. High deposition rates allow the repetitive sequence of retreating and prograding salt marsh edges. In the Danish Wadden Sea, such recent and ongoing salt marsh developments can be observed along parts of the mainland coast because past land claim operations were less intensive than in the other regions of the Wadden Sea.

As a special feature of the northern Wadden Sea, the lagoon cockle *Cerastoderma glaucum* lives in salt marsh creeks and occasionally also in sheltered seagrass beds with some cover of water throughout low tide period. This sister species to the common cockle *C. edule* which is abundant on the tidal flats, occurs in semi-isolated patches scattered throughout the Danish and North Frisian Wadden Sea. Connection between these patches as well as to more distant populations elsewhere along European coasts is primarily maintained by...
migrant birds which unintentionally carry the adhesive eggs of this bivalve over long distances. The reason for a thriving meta-population of lagoon cockles is the relatively large extent of natural and semi-natural salt marshes in this region.

The curlew increased significantly in numbers and its melodious calls are now often heard again in the tidal zone and salt marshes. Migrant dunlins form huge flocks when flying from the flats to their roosting sites at the edge of salt marshes. Only in the Danish part of the Wadden Sea pairs of the subspecies Calidris alpina schinzii of the dunlin breed in the salt marshes. Its main breeding range is in the Baltic region but it was once also common throughout the entire Wadden Sea. That it is still found in the Danish Wadden Sea may be attributed to the relatively low level of disturbances and high share of natural salt marshes. This particularly applies to the Island of Mandø which also provides breeding sites for high numbers of lapwings (Vanellus vanellus) and black-tailed godwits (Limosa limosa).

The Varde Å drains an inland area of more than 1,000 km² and discharges 12 m³ of water per second on average or about one million m³ per day. Contrary to other estuaries in the Wadden Sea the Varde Å remained without dikes and is meandering naturally through an old outwash plain towards the sea. At the mouth, the tidal range varies between 1.1 and 1.6 m and marine waters protrude 2 to 5 km upstream during high tides. Salt marsh deposits are found up to 10 km upstream. The tidal area extended at least 3 km into the present marsh but over the last thousand years sediment supply from the sea allowed the estuarine marsh growing into the Ho Bugt tidal area in spite of sea level rise. The marsh on either side of Varde Å is under agricultural use, mainly used to harvest grass. Only a small margin at the mouth is composed of natural brackish and salt marsh vegetation. This almost natural estuary is a showcase of estuarine development. It represents a habitat variety which has been lost or strongly transformed elsewhere in the Wadden Sea. As such it is of exemplary value for the Wadden Sea as a whole.

Prior to 1900, no dikes were built north of Emmerlev Klev. Storm surges could penetrate far inland into the marshes of Brede Å, Ribe Å and Sneum Å. Only at Vidå estuary dikes had been built since 1556 under Frisian and Dutch influence. The first sluice at the Vidå was built in 1566, the next further seaward in 1861 and the most recent one in 1981 when the last embankment in this border region occurred. The main part of the latest enclosed polder (Margrethe Kog) is not used for agriculture, but has the status of a nature reserve which on the Danish side belongs to the conservation area of the Wadden Sea. In front of the new dike, salt marsh development has been initiated by artificial sediment supplementation and brushwood groins. In the marsh area of the Brede Å, the northernmost dwelling mounds in the Wadden Sea had occurred but were given up after
severe storm surges in 1634 and 1825. This marsh became embanked in 1918. The Ribe Å estuary has been converted into a shipping canal in 1856 and the marsh became embanked in 1913. Overall, still existing salt marshes in the Danish Wadden Sea comprise 72 km² of which about half is still developing more or less naturally.

**History of Research**

Geological, ecological and biological research in the Danish Wadden Sea had a very early start and has contributed essentially to the understanding of the Wadden Sea coastal system. Possibly the first research in the Danish Wadden Sea dates back to Krøyer (1837) who mapped and described the status of the oyster beds which were of high commercial value at that time. When the stocks declined, Möbius (1893) began to study the prospects of the oyster population in 1869, particularly in the Lister Dyb tidal basin. On this occasion, he developed the ecological community concept (biocoenosis; Möbius 1877) which is still thriving in modern ecology. The first studies devoted to the fauna and flora of the tidal zone in the Wadden Sea commenced with Wesenberg-Lund (1904) at the Island of Fano. The study of zonation patterns in the tidal flat fauna was pioneered by Thamdrup (1935), investigating tidal flats between Skallingen and Langli. His studies together with those of Smidt (1951) in the 1940s have been used by Jensen (1992) to demonstrate that besides pronounced fluctuations between years, the tidal flat fauna has remained essentially the same over the past decades. Similar comparisons have been made in Königshafen, a small tidal bay at the northern tip of the island of Sylt. Smidt (1951) was the first to study benthic secondary production with respect to the Danish Wadden Sea as a nursery ground for plaice and other North Sea fish. Grøntved (1962) was the first to estimate benthic primary production by the microalgal films on tidal flats, investigated on mud flats between Sylt and Rømø. A comprehensive German-Danish ecosystem study has been conducted in the Lister Dyb tidal basin on the importance of exchange processes between the North Sea and Wadden Sea and between tidal waters and tidal flats (Gätje and Reise 1998; Madsen et al. 2010).
Seals and the breeding and migratory populations of birds have been monitored carefully, especially since the 1970s (Tougaard 1989; Salvig et al. 1994; Meltofte et al. 1994; Thorup and Laursen 2008). In addition a number of research projects have been carried out on the role of waterbirds in the Danish Wadden Sea ecosystem (Maagaard and Jensen 1994; Madsen 1988; Laursen and Frikke 2006; Laursen et al. 2009).

A Skallingen field laboratory was founded by Copenhagen University already in 1935 for geomorphological research (Nielsen 1935; Christiansen and Aagaard 2004) and is still used for field courses and research projects. Summaries of this research have been provided by Jacobsen (1993), Bartholdy and Pejrup (1994) and Christiansen et al. (2004). The Danish Wadden Sea is a well investigated area in the Wadden Sea with respect to natural morphodynamics, sedimentation rates and origin of deposited material. In particular, the development of Skallingen peninsula has been studied in great detail from geological and ecological perspectives. There may be no other dune and salt marsh area of which the morphogenesis is better known. Research in the Danish Wadden Sea has certainly contributed to the general understanding of the Wadden Sea nature area.

Exploitation of Natural Resources

The Niedersachsen Offshore Belt

Fishery is the only direct exploitation of natural resources which takes place within the boundary of the proposed extension area. All other uses of natural resources (i.e., extraction of sand, wind energy) are located outside the area although some are adjacent or quite close to the borders of the nominated extension to the property. See Chapter 4b.

Fishery

The extension area is of great importance for the inshore fishing sector in Niedersachsen. Traditionally, the fisheries in this area are for brown shrimps and flatfish using beam-trawling vessels which start from small harbour villages at the mainland coast. The fishery for brown shrimps takes place from the shoreline down to the 20m depth within the 3 nautical mile zone. Seawards up to the 6 mile border mixed fishery on brown shrimps and flatfish is practiced. Landings of flatfish from this part have become almost insignificant. Fishery for blue mussels does not play any role due to their rarity.

The fleet consists of small vessels (circa 120): small beam-trawling vessels with low draft and a motor capacity of 221 kW. Most of the vessels are run as a family business. In 2011 the landings of brown shrimps in all Niedersachsen coastal waters reached 6750 t.

Gas and oil

The state party confirms its commitment not to explore and extract oil and gas at locations within the boundaries of the property in line with law in force.

The Danish Wadden Sea

Gas and oil

Exploration and exploitation of gas and oil including seismic investigations is prohibited in the nominated property according to the Statutory Order on the Nature and Wildlife Reserve Wadden Sea.

Extraction of raw materials

Extraction of raw materials, i.e. sand, sediment and shells, is not allowed within the nominated property. Exemptions are subject to the strictest regulation. Hence, permissions are rarely given and follow exclusively the needs for societal security and maintenance of the flood protection – mainly the sea dikes. For maintenance and reinforcement of dikes material will only be extracted from the area in case suitable materials do not exist outside the area i.e. the embanked polders behind the sea dikes.

Salt marshes – Land use and management

Coastal flooding defence and protection

Beaches, dunes, coastal island heaths and tidal salt marshes and meadows are habitats created and maintained through dynamic and unimpaired natural processes. Restoration of wetlands and watercourses in the mainland are planned and partly already carried out. Yet a part of the water courses in the hinterland are still regulated primarily securing sufficient freshwater run-off for the needs of agricultural purposes.

A new dike southwest of Højer (Det Fremskudte Dige), built from 1979 to 1981, was the last coastal protection project that had a land reclamation effect on tidal areas in the Danish Wadden Sea. The project created Margrethe Kog, which together with Ny Frederikskog, Gammel Frederikskog and Magisterkogen, comprises a core area of approx. 2,500 ha of the much larger Tønder March (6,500 ha). A part of Margrethe Kog (250 out of 1,200 ha) consist of an artificial saltwater lagoon where inflation of seawater helps to maintain a rich marine fauna feeding the bird populations.
All sea dikes along the mainland coast (from the Danish/German border to Esbjerg) and the dikes at Mando and Rømø are maintained in order to meet the requirements for safety to the populations living behind these dikes. The maintenance follows regulations under the Coastal Protection Act and only after a careful Environmental Impact Assessment.

For safety reasons artificial sedimentation fields are in a few cases placed along areas where natural sedimentation processes and immigration of salt marsh vegetation do not take place, e.g. along Det Fremskudte Dige near Højer and the causeway to the island of Mando. Most forelands and dikes are as a part of the maintenance programme grazed with cattle in particular sheep.

Grazing and drainage

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 which may minimize the nature values. It may lead to a monotonous habitat structure and, in this way, to less attractive conditions for breeding birds. Low-rate grazing, on the other hand, can increase the diversity of plant and animal species on sites with a clay layer thicker than 15-20 cm, and improve conditions for most breeding bird species in salt marshes.

On the islands and in the peninsula of Skallingen, the majority of the vast salt marshes have developed naturally, and due to extensive or no grazing, they are left to natural succession and they show various transition stages. In addition the salt marshes in the Ho Bay area and in the northern parts of the islands Fano and Rømø are of more or less natural ancestry.

In former times, many sites were intensively used for agricultural purposes. However, livestock grazing for agricultural purposes has generally decreased in the area over the past 20 years, but still approx. 75% of the salt marshes in the protected area are grazed extensively and/or are under appointment of environmental friendly management. The agricultural utilization of the meadows and forelands is a cultural heritage which combines agriculture, coastal protection and nature management.

In about 50% of the salt marshes there were no drainage measures taken, and in an addition drainage has been reduced over the past 10 years.

Fishery

Fishery for shrimp, blue mussel and cockle is the only commercial fishery in the Danish Wadden Sea. Fishery is strictly regulated by the statutory order of the Nature and Wildlife Reserve Wadden Sea.

Shrimp fishery

The shrimp fishery is furthermore regulated by the statutory order for shrimp by the West coast of Jutland (Bekendtgørelse om fiskeri efter hesterej evr den jyske vestkyst). The Danish shrimp fishery fleet is located in the harbours of Høneby at Rømø and Esbjerg and to less extent in Hvide Sande and Thyborøn. There are currently 28 licenses for vessels from Høneby (5), Esbjerg (7) Hvide Sande, Thorsminde and Thyborøn. The annual landings are about 2-3,000 tonnes (2009).

The fishery takes place in the North Sea along the west coast of Jutland down to the Danish-German border and even further south in international waters. Shrimp fishery is not allowed east of the Wadden Sea islands, i.e. only west of the so-called "shrimp line", a zonation introduced in 1977, which separates the Wadden Sea from the North Sea. However, only travels with sieve-nets or veil-nets are allowed in order to reduce by-catches of fish.

Blue mussel fishery

Fishery for blue mussel (Mytilus edulis) in the nominated property is only allowed on wild mussel banks. Mussel cultural banks are not allowed in Denmark. Currently blue mussel fishery is prohibited. This ban is effective until the effects of the fishery in relation to securing sufficient food availability for migratory and breeding birds, e.g. common Eider and oystercatcher, in the protected area are well documented. About half of the Danish Wadden Sea has been closed for mussel fisheries with the aim to set aside about 10,000 tons of mussels for mussel eating birds.

In the Danish Wadden Sea, fishery for blue mussel and bivalves is restricted by NATURA 2000-directives and no permits for fishery on blue mussel is given before the impact of the fisheries is assessed according to the Habitats and Birds Directives. Impact of fishery with a traditional mussel dredge is evaluated. The evaluation of the impact is conducted with respect to parameters included in the list of protected species and habitats for the area where the fishery is taking place. A practice for estimation of the biomass of blue mussel that annually can be fished in the Danish Wadden Sea has been developed. The biomass of blue mussels required for bird consumption is included in the estimate.

The Wadden Sea, Germany and Netherlands (N1314) - Extension Denmark and Germany
Due to a low standing biomass of blue mussel the fishery was halted in 2005 and onwards. The fishery was stopped in 2008 and the needs of the bird populations were estimated to 40,000 t of blue mussel. This biomass has to be reached before the fishery can be re-opened. Over the last ten years the total biomass of blue mussel has not reached a level that allowed the fishery to be re-opened.

**Cockle fishery**

There is one licence for limited mechanical cockle fishery in a small part of the outer Wadden Sea area connected to the channel to Esbjerg harbour (Grådyb). The license is currently not used.

**Oyster fishery**

Commercial, industrial uptake of Pacific oyster is at present not allowed in the Danish part of the Wadden Sea. In 2012 one licence for manual collection of Pacific oyster was issued by the food authorities to a local restaurant. The oysters are harvested manually from the sea bottom. There is currently no information on how much has been collected. The public is allowed to manually collect Pacific oysters and blue mussels for private use only. The impact of manual collection is not considered to have a harmful impact on the Wadden Sea ecosystem.

**Other fisheries**

The employment and number of business in fisheries and related industries with regard to the Danish Wadden Sea are not known in details but is, in 2010, estimated to 70 jobs and 10 registered fishing companies and 60 jobs in related 15 services and processing companies.

Netting and the use of fykes in the nominated property is regulated by a statutory order issued by the fisheries authority. The use of gill-nets is prohibited because of concerns to the protected Atlantic salmon and houting (a highly protected fish species only found in the Danish part of the Wadden Sea). Fykes must be issued with a grille preventing otters, salmon and houting from entering the fyke.

Fishery in the river systems and watercourses connected to the Danish Wadden Sea is restricted according to a special statutory order that primarily determines the closing seasons of the fishery on salmon and seatrout, setting sustainable quotas and the methods by which the fishery including recreational fishery is performed.

**Hunting**

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 traditionally an integrated part of the livelihood of the inhabitants of the Wadden Sea area. Waterbirds were also hunted to be sold to provide an additional income, and the many duck decoys, of which some still exists along the coast, bear witness to this. Some of these have been restored and serve as museums. However, methods, equipment and also the purpose changed with time, as has legislation and public opinion on hunting. In Denmark, catching ducks in duck decoys was banned with a revision of the hunting legislation in 1931. Nowadays, hunting has changed into a mainly recreational activity, with the exception of hunting for rabbits for coastal protection reasons. 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 and in Denmark 1976). Exemptions for hunting for wildlife management and pest control are possible.

In the Danish Wadden Sea, hunting used to be intensive and widespread compared to hunting in the other parts of the international Wadden Sea. However in the context of the Nature and Wildlife Reserve Statutory Order hunting has been reduced significantly throughout recent decades. The most disturbing hunting activities, like hunting from active motorboats, has been phased out in the protected area, and today waterbird hunting along the coast lines is only allowed in some private salt marsh and marsh areas making up less than 5% of the reserve, and hunting in the sea territory from anchored boats or by wading is only allowed in the areas west of the islands. Hunting in autumn and winter at sea in the westernmost parts of the Danish Wadden Sea is to a high extent limited by weather conditions and is a leisure activity for very dedicated Eider duck hunters exclusively. The number of active hunters has gone down in recent decades and the general hunting pressure has decreased.

Hunting on coastal birds has been reduced in the Danish Wadden Sea. This has since then considerably reduced the flight distance of more species of geese and the curlew.

The revision of the executive order in 1998 resulted in the prohibition for hunting in large, state-owned areas, and hunting within the Wadden Sea reserve has since then been considered as sustainable in relation to management of the most vital parts of this very important refuge to a number of waterbird populations.
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.

Chapter 2.b is a marginal update of the 2008 nomination document.

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. Since then sediment deposition more or less kept pace with relative sea level rise and tidal deposits of 10 to 15 m magnitude have accumulated since the beginning of the Wadden coastscape. Some phases of stasis or fall may have occurred intermittently.

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

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Figure 2.14: Transgression curve (Source: K.-E. Behre, 2004).
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 inscribed property, as many as 77 megalithic graves and 1,000 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 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) piled up with 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. 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 bogs buried by marine sediments had disappeared and the terrain lowered by 1 to 2 m. This had aggravated the effects of storm surges. 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 on its own right 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 highly 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 and Danish 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 \textit{(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 affect 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 inscribed and nominated property will ensure that such features are also protected as part of the nomination and remain an integrated part of the heritage. Small-scale traditional uses are small-scale activities, mainly carried out by local inhabitants, in accordance 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 (drag-net 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 Wadden Sea Region is represented through a special kind of tension which can only be experienced with such intensity in this location: the tension between the ‘overwhelming natural phenomenon’ of a coastline that offers a particularly powerful experience of the sublime on the one hand, and the characteristic sharpening of the capacity for sensual experiences through what at first glance would seem to be unprepossessing natural phenomena on the other.

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. 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 form. 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 years. It is this complexity of habitats and biotopes so intricately linked in an elaborately interlinked ecosystem that stimulates the observer with its superlative intricacy.

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 Dykemaster 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 slacks 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, 66 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 extinction 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 (*Austrominius 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.

**Protecting and managing the ecosystem**

Since the beginning of the last century, small 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 been well known, 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 most 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, followed by Hamburg in 1990. The Danish Wadden Sea was declared a Nature and Wildlife Reserve in 1979/1982. In 2010, the Danish National Park Wadden Sea was instituted and comprises the Nature and Wildlife Reserve including the islands and parts of the mainland. 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 11th Ministerial Conference was held on the German island of Sylt on 18 March 2010.

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 was amended at the 11th Ministerial Conference. It is a declaration of intent of the three Wadden Sea
countries to protect and conserve the Wadden Sea as an ecological entity in accordance with the Guiding Principle, i.e. “to achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way”.

In 1987, the Common Wadden Sea Secretariat was established to facilitate and support the Cooperation. 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 has been updated in 2010 and 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.

The Wadden Sea Plan is declared the coordinated management for the Wadden Sea World Heritage property which also applies to the nominated property.

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 require cooperation at the scale of the entire northeast Atlantic coastal waters.

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. This will require innovative and flexible adaptations to protect both, the cultural land as well as the natural environment of the Wadden Sea region.
3. JUSTIFICATION FOR INSCRIPTION

3.1.a Brief synthesis

The Wadden Sea is the largest unbroken system of intertidal sand and mud flats in the world, with natural processes undisturbed throughout most of the area. It encompasses a multitude of transitional zones between land, the sea and freshwater environment, and is rich in species specially adapted to the demanding environmental conditions. It is considered one of the most important areas for migratory birds in the world, and is connected to a network of other key sites for migratory birds. Its importance is not only in the context of the East Atlantic Flyway but also in the critical role it plays in the conservation of African-Eurasian migratory waterbirds. In the Wadden Sea up to 6.1 million birds can be present at the same time, and an average of 10-12 million pass through it each year.

3.1.b Criteria under which inscription is proposed

By decision 33 COM 8B.4 “The Wadden Sea, Germany and Netherlands” was inscribed on the World Heritage List under natural criteria (viii), (ix) and (x). The nominated property is an extension of the already inscribed property and the natural criteria under which the latter was inscribed unreservedly apply to the nominated property:

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 net-
works 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. The lower shoreface of the offshore belt is structured into a series of typical ridges and troughs so-called shore-face connected ridges on a horizontal scale of several kilometres and heights of up to 6 m.

Excellent and broad scale examples of biogeomorphological 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 impor-
tant 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 pro-
cesses 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 adapta-
tion of bio-geomorphological processes within a
generation.

Criterion ix: "be outstanding examples represent-
ing significant on-going ecological and biological
processes in the evolution and development of
terrestrial, fresh water, coastal and marine eco-
systems 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 natu-
ral 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, fluctuations in
salinity, high temperatures during summer and oc-
casional ice cover in winter. These circumstances
have created numerous ecological niches, colo-
nized 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 func-
tions 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 intertidal 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 dominated 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 benthic systems in the open 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. The offshore belt of the Wadden Sea intermediates between the open and deeper North Sea and the tidal area. The Wadden Sea is 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 nurslings. The Wadden Sea is an important nursery area for sole (Solea solea), plaise (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, traversing the offshore belt 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

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also exploit the marshes and others dive in the gullies and the offshore belt for food. Although the availability of the food is crucial, it is more than just high benthic biomass that supports the enormous number of 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 intertidal habitats of such high diversity.

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 intertidal 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. bernicia) 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 Eu-
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The Wadden Sea, Germany and Netherlands (N1314) - Extension Denmark and Germany

3.1.c Statement of Integrity

The extension nomination of the existing Wadden Sea World Heritage property with the Danish part and the German (Niedersachsen) offshore extension will result in the inclusion of 77% of the Wadden Sea Area within the property and basically all critical ecological processes and key features and values that constitute the Wadden Sea will be comprised within the property meeting the criteria under which the nomination is proposed. The nomination therefore significantly contributes to enhance and strengthen its integrity in accordance with the decision of the World Heritage Committee on its inscription of the Dutch–German Wadden Sea on the World Heritage List at its 2009 session.

During the evaluation of the Dutch-German Wadden Sea nomination in 2008-09 the IUCN requested supplementary information on whether elements included in the nomination can be considered of Outstanding Universal Value without the Danish part. The comparison made between the Dutch-German Wadden Sea World Heritage property and the Danish part in response to the request confirmed that the Outstanding Universal Values that are found within the property are equally found within the Danish part of the Wadden Sea.

The nominated extension of the property comprises all the habitat types, including all features and processes that belong to a natural and dynamic Wadden Sea. The offshore zone of the Danish part is delimited by the three nautical miles from the baseline which constitutes a coherent geomorphological system that is linked to the intertidal processes and systems. It includes the tidal inlets between the islands with their highly dynamic sediment transport and constantly migrating sandbars and high sands of Lammelæger, Koresand, Langjord, Peter Meyers Sand, Søren Jessens Sand and Langli Sand. The area is important for young fish and foraging and moulting seabirds, for seals and harbour porpoises.

The major parts of the beaches and salt marshes of the islands of the Danish Wadden Sea are included in the nominated property together with the peninsula of Skallingen with its dunes and the great natural salt marshes created on the eastern side of the peninsula. The salt marshes in the Ho Bay, on the uninhabited island of Langli, along the mainland coast from Esbjerg to Ballum, along the Rømø causeway and the extensive marshes in the Margrethe Kog are all located along the mainland coast from Esbjerg to Ballum, along the Rømø causeway and the extensive marshes in the Margrethe Kog are all located...
within the nominated property. The salt marshes form a unique habitat for vegetation, especially adapted invertebrates and breeding bird species. Basically the entire tidal area including the deep gullies, the subtidal area and the intertidal flats is within the nominated property. The tidal flats are inhabited by a very rich and productive flora and invertebrate fauna associated with mussel beds and seagrass. The salt marshes form the upper part of the intertidal zone and are home to high concentrations of unique plant and invertebrate species of which many are endemic. The salt marshes also form important roosting, breeding and feeding grounds for many bird species.

Apart from the construction of the Rømø Causeway in the 1940s and some smaller embankments of which the Margrethe Kog around 1980 constitutes the last one, the Danish Wadden Sea has not been subject to impacts on its geomorphological and sediment processes. In conjunction with the very low activity level and use of the natural resources, the relatively low input of nutrients and pollutants and the comprehensive protection, the Danish Wadden Sea area may be considered a very natural part of the entire Wadden Sea. The Danish Wadden Sea is an integral part of the northern sub-region of the Wadden Sea which is defined by the occurrence of a well developed outer barrier composed of islands and high sands, an extensive tidal area with some scattered marshy islets interspersed of which some become submerged during storm tides because they have remained undefended by high seawalls.

The German (Niedersachsen) part of the nomination includes an extension of the offshore belt of the property to complement, enhance and ensure the integrity and the spatial connectivity by including areas of importance for the ecological interchange between the tidal area and the open North Sea, geomorphological processes and for foraging and moulting seabirds and marine mammals. It covers a stretch of nearly 60km parallel to the three nautical miles line and represents a complete set of characteristic subtidal habitats towards the open North Sea down to the 20m depth contour. Some fisheries take place throughout the proposed extension area. If there are other uses of natural resources or development pressures in coastal waters (f. e. extraction of sand, wind energy), they take place outside the proposed offshore extension. Directly adjacent to the extension area, traffic-management route-systems, called Traffic Separation Scheme (TSSs Terschelling German Bight and German Bight Western Approach) exist to manage the traffic safely and efficiently.

Despite the considerable progress made in the improvement of shipping safety and the environmental protection measures intended to minimize maritime pollution, shipping will continue to be a potential source of risk for damaging the property and its adjacent coastline. The low activity level and use of the natural resources combined with a consistent and strict national protection regime effectively preserve the geological and natural values of the proposed offshore extension.

The tip of the peninsula Skallingen in Denmark (Photo: John Frikke).
3.1.d Protection and Management Requirements

The nominated property is subject to a comprehensive protection and management scheme. The German extension is part of the Niedersachsen Wadden Sea National Park and within zone 1, the core zone, the highest protection zone of the National Park. It has the legal purpose of preserving and protecting the Wadden Sea’s unique natural assets and landscape, to ensure that the natural processes in these habitats remain in force and to conserve the natural diversity of the plant and animal species. It is entirely state owned property and the competent management authority is the Niedersachsen Wadden Sea National Park Authority.

The Danish Wadden Sea is subject to a comprehensive protection in the framework of the Statutory Order of the Nature and Wildlife Reserve Wadden Sea established in 1979/1982. The overall objective of the Nature and Wildlife Reserve Wadden Sea is to protect and conserve the area as a complete nature area of national and international importance including its natural dynamic processes and ensure a sustainable use taking account of the overall protection goal. The reserve is zoned into areas which are permanently closed for access and any use and areas where e.g. shellfish fishery is prohibited. Exploration and exploitation of gas and oil and bottom material is strictly forbidden.

As is the case for the German extension, the Danish Wadden Sea is fully embedded within the overall trilateral protection and management scheme in the context of the Joint Declaration on the Protection of the Wadden Sea (2010) and the Wadden Sea Plan (2010) including the Declarations of the various Wadden Sea Ministerial meetings since 1978. The Joint Declaration includes the Guiding Principle for the Wadden Sea Conservation Area, which 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 constitutes the common framework for the protection and sustainable management of the Wadden Sea as an ecological entity. The Wadden Sea Plan is declared the coordinated management for the Wadden Sea World Heritage property which also applies to the nominated property. In the context of the Wadden Sea Plan, the Trilateral Monitoring and Assessment Programme ensures an appropriate monitoring and assessment of the ecological status of the system.

Furthermore, the whole nominated 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. Additionally the Water Framework Directive and the Marine Strategy Framework Directive of the European Union applies to the nominated property.

The whole nominated property is also subject to other international protection regimes such as the Particularly Sensitive Sea Area (PSSA), designated by the IMO, the African-Eurasian Waterbird Agreement (AEWA) and as a Wetland of International Importance under the Ramsar Convention. On regional level, it is part of the ‘Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas’ (ASCOBANS) and the ‘Seal Agreement’ on harbour seals and grey seals, which both are part of the Convention on the Conservation of Migratory Species (CMS) of Wild Animals (Bonn Convention).

The competent management authority for Danish part of the nominated property is the Nature Agency under the Danish Ministry of the Environment. It is adequately staffed and resourced to meet current and future challenges and the information and awareness on the reserve is provided by a dense net of information centres. The nominated property is part of the Danish Wadden Sea National Park which, in addition to the objectives of the reserve, aims to support the sustainable development of the region in cooperation with the local stakeholders through the National Park Board and its Advisory Committee.

All human activities within the nominated property which are assessed to cause adverse effects are well regulated in time and space or, as appropriate, prohibited. New activities, both within the nominated property or at its fringe, are only allowed following an assessment of their impact in accordance with Art. 6 of the Habitats Directive.

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.

Increased tourism following also a possible inscription of the nominated property on the List will be addressed in the context of a sustainable tourism strategy developed together with the industry and regional and local governments as
requested by the World Heritage Committee on the inscription of the Dutch–German Wadden Sea on the List in 2009. The strategy shall also cover the nominated property.

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 high priority in relation to the protection and management of the nominated Site.

As for the existing property the state parties confirm their commitment, not to explore and extract oil and gas at locations within the boundaries of the nominated property in line with law in force.

3.2 Comparative analysis

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 was made of similar properties in the 2008 nomination9. This comparison was acknowledged in the IUCN Technical Evaluation of the Wadden Sea 2009. The comparison also fully applies to the nominated extension and reinforces the comparison.

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.

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 inscribed, are listed in Tab. 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.

<table>
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<th>Criteria</th>
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<th>Banc d’Arguin</th>
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<td><strong>Designation WH</strong></td>
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<td>German Dutch part 2009 under criteria viii, ix and x</td>
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<td><strong>Country</strong></td>
<td></td>
<td>Germany / Netherlands</td>
<td>Mauritania</td>
<td>USA</td>
</tr>
<tr>
<td><strong>Climate zone</strong></td>
<td></td>
<td>temperate</td>
<td>continental, arid subtropics, dry</td>
<td>temperate</td>
</tr>
<tr>
<td><strong>Description setting</strong></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><strong>Total area</strong></td>
<td></td>
<td>11,456 km²</td>
<td>12,000 km² (50% marine)</td>
<td>8,000 km²</td>
</tr>
<tr>
<td><strong>Mudflat area</strong></td>
<td></td>
<td>4,500 km²</td>
<td>630 km²</td>
<td>300 km²</td>
</tr>
<tr>
<td><strong>Tidal difference/ range</strong></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><strong>Mean wave height/ range</strong></td>
<td></td>
<td>1.0 – 2.0 m</td>
<td>1.4 m</td>
<td>0.6 – 1.0 m</td>
</tr>
<tr>
<td><strong>Contiguous character</strong></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><strong>Major estuaries</strong></td>
<td></td>
<td>5 estuaries</td>
<td>0 estuaries</td>
<td>13 estuaries</td>
</tr>
<tr>
<td><strong>Habitats, biotopes</strong></td>
<td>ix</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 Spartina and Juncus saltmarshes</td>
</tr>
<tr>
<td><strong>Salt marshes</strong></td>
<td></td>
<td>406 km²</td>
<td>591 km²</td>
<td>4,237 km²</td>
</tr>
<tr>
<td><strong>Mangroves km²</strong></td>
<td></td>
<td>none</td>
<td>31 km² mangrove Avicennia germinans</td>
<td>some mangrove Avicennia germinans</td>
</tr>
<tr>
<td><strong>Productivity</strong></td>
<td></td>
<td>primary production (gC/m²/ly): phytoplankton 100–200; microphytes 150; seagrass 500; macrophytes 500–1,000</td>
<td>primary production (gC/m²/ly): phytoplankton 2.1–8.9</td>
<td>primary production (gC/m²/ly): phytoplankton 200–400; microphytes 60; seagrass 150–700; macrophytes 800–2,000</td>
</tr>
<tr>
<td><strong>Migrating birds</strong></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><strong>State of conservation</strong></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>
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 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.

3.3 Proposed statement of outstanding universal value

The Wadden Sea is the largest unbroken system of intertidal sand and mud flats in the world, with natural processes undisturbed throughout most of the area. It encompasses a multitude of open habitats with a high diversity of invertebrates, fish and birds. The Wadden Sea is a key feeding and resting area for migratory waterfowl along the East Atlantic Flyway. It is also an important habitat for local populations of breeding birds, such as gulls and terns. The Wadden Sea is an important site for the conservation of marine biodiversity and is of outstanding universal value.

10 The proposed statement of outstanding universal value is identical with the Statement of Outstanding Value for The Wadden Sea, Germany and Netherlands (Decision 33 COM 8B.4) to align with and reaffirm the existing statement as the nominated property is an extension of the already inscribed one.
of transitional zones between land, the sea and freshwater environment, and is rich in species specially adapted to the demanding environmental conditions. It is considered one of the most important areas for migratory birds in the world, and is connected to a network of other key sites for migratory birds. Its importance is not only in the context of the East Atlantic Flyway but also in the critical role it plays in the conservation of African-Eurasian migratory waterbirds. In the Wadden Sea up to 6.1 million birds can be present at the same time, and an average of 10-12 million pass through it each year.

**Criterion (viii):** The Wadden Sea is a depositional coastline of unparalleled scale and diversity. It is distinctive in being almost entirely a tidal flat and barrier system with only minor river influences, and an outstanding example of the large-scale development of an intricate and complex temperate climate sandy barrier coast under conditions of rising sea level. Highly dynamic natural processes are uninterrupted across the vast majority of the property, creating a variety of different barrier islands, channels, flats, gullies, saltmarshes and other coastal and sedimentary features. It is also one of the best-studied coastal areas on the planet, providing lessons of wider scientific importance for wetland and coastal management of international importance.

**Criterion (ix):** The Wadden Sea is one of the last remaining natural large-scale intertidal ecosystems, where natural processes continue to function largely undisturbed. Its geological and geomorphologic features are closely entwined with biophysical processes and provide an invaluable record of the ongoing dynamic adaptation of coastal environments to global change. There are a multitude of transitional zones between land, sea and freshwater that are the basis for the species richness of the property. The productivity of biomass in the Wadden Sea is one of the highest in the world, most significantly demonstrated in the numbers of fish, shellfish and birds supported by the property. The property is a key site for migratory birds and its ecosystems sustain wildlife populations well beyond its borders.

**Criterion (x):** Coastal wetlands are not always the richest sites in relation to faunal diversity, however this is not the case for the Wadden Sea. The salt marshes host around 2,300 species of flora and fauna, and the marine and brackish areas a further 2,700 species, and 30 species of breeding birds. The clearest indicator of the importance of the property is the support it provides to migratory birds as a staging, moulting and wintering area. Up to 6.1 million birds can be present at the same time, and an average of 10-12 million each year pass through the property. The availability of food and a low level of disturbance are essential factors that contribute to the key role of the nominated property in supporting the survival of migratory species. The nominated property is the essential stopover that enables the functioning of the East Atlantic and African-Eurasian migratory flyways. Biodiversity on a worldwide scale is reliant on the Wadden Sea.
The boundaries of the nominated property include all of the habitat types, features and processes that exemplify a natural and dynamic Wadden Sea. Together with the existing property it encompasses 77%\(^{11}\) of the entire Wadden Sea ecosystems and is sufficient to maintain the critical ecological processes and to protect the key features and values. The extension of the property with the Danish Wadden Sea and the German (Niedersachsen) offshore extension to now virtually comprising the entire Wadden Sea will provide a high level of integrity and a significant assurance that its values can be maintained and enhanced, where necessary, in the future.

The property is subject to a comprehensive protection, management and monitoring regime which is supported by adequate human and financial resources. Human use and influences are well regulated with clear and agreed targets. Activities that are incompatible with its conservation have either been banned, or are heavily regulated and monitored to ensure they do not impact adversely on the property. As the property is surrounded by a significant population and contains human uses, the continued priority for the protection and conservation of the Wadden Sea is an important feature of the planning and regulation of use, including within land/water-use plans, the provision and regulation of coastal defences, maritime traffic and drainage. Key threats requiring ongoing attention include fisheries activities, harbours, industrial facilities and maritime traffic, residential and tourism development and climate change.

\(^{11}\) This percentage refers to the entire property.

### Requirements for protection and management

Maintaining the hydrological and ecological processes of the contiguous tidal flat system of the Wadden Sea is an overarching requirement for the protection and integrity of this property. Therefore conservation of marine, coastal and freshwater ecosystems through the effective management of protected areas, including marine no-take zones, is essential. The effective management of the property also needs to ensure an ecosystem approach that integrates the management of the existing protected areas with other key activities occurring in the property, including fisheries, shipping and tourism.

Specific expectations for the long term conservation and management of the property include maintaining and enhancing the level of financial and human resources required for the effective management of the property. Research, monitoring and assessment of the protected areas that make up the property also require adequate resources to be provided. Maintenance of consultation and participatory approaches in planning and management of the property is needed to reinforce the support and commitment from local communities and NGOs to the conservation and management of the property. The State Parties should also maintain their commitment of not allowing oil and gas exploration and exploitation within the boundaries of the property. Any development projects, such as planned wind farms in the North Sea, should be subject of rigorous Environmental Impacts Assessments to avoid any impacts to the values and integrity of the property.
4. State of Conservation

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 2009) was published in preparation for the Trilateral Governmental Conference in 2010. The information in this chapter is based on the QSR 2004 and 2009, supplemented with information that has become available since the QSR 2009 was issued.


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 inscribed and nominated property is located off the Wadden islands of the German and Danish 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 (Sterna sandvicensis) which feeds on sand eel up to 15 km from the breeding colonies, and the lesser black-backed gull (Larus fuscus).

Off the North Frisian and Danish 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 than 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 and Denmark within and outside the inscribed and nominated property. The offshore area of the World Heritage 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, Germany and Denmark has a total size of about 8,400 km², of which about 4,700 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 reclamation in historic times (since 1600) and sea level rise.

### Seagrass

The two seagrass species (*Zostera marina* and *Z. noltii*) are the only submerged 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 *Laby-
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 and an increase of seagrass areas has been observed since the middle of the 1990s.

The highest occurrence with about 13,000 ha (77%) (all type of beds) were on the northern part (Schleswig-Holstein and Denmark), an increase of over 5,000 ha compared to the QSR 2004. The real figure may be even higher because beds with densities lower than 20% are not recorded in Schleswig-Holstein.

Today, intertidal seagrass beds (seagrass density > 20%) are unevenly distributed with a major occurrence (over 95%) in the northern Schleswig-Holstein and Danish Wadden Sea (about 10,000 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.

### Mussel beds

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. 4.1). 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 4.1: Area (ha) (top) and biomass (t) (bottom) of intertidal blue mussel beds in the Netherlands Germany (Niedersachsen, Schleswig-Holstein) and Denmark (no bars = no data).](image)
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 2,700 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 about 40,000 ha in the Wadden Sea (QSR 2009) which is an increase of 5% of the salt marsh area compared to the 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.
eral. In the Hamburg Wadden Sea, for example, about 35% of the salt marshes have never been influenced by any land use or artificial drainage. In addition, about 690 ha of salt marshes (310 in Niedersachsen, 40 in Hamburg 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 4.2). 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 Denmark, about 43% of the salt marshes are classified as undrained, further 39% as moderately drained, and only 18% as intensively drained on average with only minor differences between the islands and the mainland (QSR 2009, Thematic Report No. 8 Salt Marshes).

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 prostrata, 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 7,600 ha of dunes are located in the inscribed and nominated property, with 4,500 ha on the islands of Niedersachsen which represent the typical Wadden Sea barrier island, about 670 ha in Denmark (islands and mainland) and 100 ha in Schleswig-Holstein (mainland).

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 analysed 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 minimizing the impact of groundwater extraction on vegetation which has locally led to a regeneration of pioneer stages.

Similar developments were also observed in dune areas adjacent to the property, e.g. on the Dutch and Schleswig-Holstein islands, as well as on the Danish islands adjacent to the nominated Danish extension.

The Wadden Sea dunes are also hot spots of biodiversity with almost 8,000 animal species recorded from the East Frisian islands with about 100 arthropod species that either have their main distribution in the dunes or are highly endangered (QSR 2009, Thematic Report No. 15 Beaches and Dunes).

Species and population trends and developments

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 six 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 18 years of monitoring (since 1991), a reliable evaluation of trends has become possible, both for the entire period as well as for the last ten years. The latter can be used as an alert for recent changes (Tab. 4.3).

Over the period 1991-2008 and considering the entire Wadden Sea, seven species increased significantly. The highest rates of increase are observed for the great cormorant, lesser black-backed gull, Eurasian spoonbill and mediterranean gull (Tab 4.3). Nearly all of these species have expanded their geographical breeding range in the past decade and showed further increases in 2002-2008. The breeding population of most increasing species continued to grow during the entire period covered by the surveys (see Tab. 4.3).

Significant declines have occurred in thirteen 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, turnstone, little gull). Recent counts (up to 2008) 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 until the last trend calculation for 2008.

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 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, 

Table 4.3: Breeding birds in the Wadden Sea in 2001 and trends in 1991–2008 (JMBB, 2010.). 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 1991–2008: ++ = strong increase, + = increase, 0 = stable, – = moderate decrease, -- = strong decrease, ? = uncertain (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.

<table>
<thead>
<tr>
<th></th>
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<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Great cormorant Phalacrocorax carbo</td>
<td>x 1-5</td>
<td>-</td>
<td>2,248</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Eurasian spoonbill Platalea leucorodia</td>
<td>x &gt;25</td>
<td>SUS</td>
<td>831</td>
<td>++</td>
<td>++</td>
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<tr>
<td>Shelduck Tadorna tadorna*</td>
<td>- 5-25</td>
<td>-</td>
<td>6,480</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Common eider Somateria mollissima*</td>
<td>- 1-5</td>
<td>-</td>
<td>15,000</td>
<td>0</td>
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</tr>
<tr>
<td>Red-breasted merganser Mergus serrator</td>
<td>- &lt;1</td>
<td>VUL</td>
<td>44</td>
<td>+</td>
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<tr>
<td>Hen harrier Circus cyaneus</td>
<td>x 1-5</td>
<td>-</td>
<td>126</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Oystercatcher Haematopus ostralegus*</td>
<td>- 5-25</td>
<td>-</td>
<td>39,928</td>
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<td>0</td>
</tr>
<tr>
<td>Avocet Recurvirostra avosetta*</td>
<td>x &gt;25</td>
<td>-</td>
<td>10,170</td>
<td>-</td>
<td>-</td>
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1 trend calculation was not possible due to lack of data
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 1987/88 – 2009/10 revealed alarming results: 16 out of 34 waterbird species experienced statistically significant declines.

The sixteen species showing negative trends also for a longer period (1987/88 – 2009/10), include mallard, which flyway population decreases, as well as oystercatcher and herring gull, which are shellfish eaters. The overall negative trend of golden plover seems to be greatly determined by Schleswig-Holstein, Danish and Niedersachsen birds, while in the Netherlands the numbers are uncertain. In general, regional differences in distribution occur for a number of species, the reasons for which have to be further investigated.

The trend calculation over the recent ten year-period 1999/00 – 2009/2010 which highlights the actual developments in the Wadden Sea (JMBB 2011) showed that 2 waterbird species (common shelduck, ruddy turnstone) in the Wadden Sea seems to have improved compared to the long-term trend calculation (Tab. 4.4a). 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.

In Table 4.4a and 4.4b, 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 seal and the harbour porpoise are subject to the ASCOBANS agreement which is a regional agreement 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 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. The Seal Management Plan covers monitoring and protection of both seal species (harbour and grey seal).
Grey seals

Grey seals had been extinct in the Wadden Sea area (south-eastern North Sea) for centuries probably 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.

The maximum number of grey seals counted in the Wadden Sea during the moult in March/April 2012 amounted to 3,479 animals. Numbers were higher compared to the previous count in 2011 (+22%). In the Netherlands, 3,059 animals were counted (+28%), in Lower Saxony/Hamburg 348 (+46%) and in Schleswig-Holstein 72 which is a slight decrease compared to the previous year. Currently, an increased number of grey seals is also observed in the Danish Wadden Sea.

In the Wadden Sea grey seal pups are born in mid-winter. In November-January 2011/2012, the maximum numbers of new-born pups counted in the Wadden Sea of the Netherlands, Lower Saxony/Hamburg, Schleswig-Holstein, and Helgoland (which is linked to the Wadden Sea population) were 288, 59, 35, and 140 respectively, bringing an estimate of the total number of pups at 522.

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. In the Danish Wadden Sea up to 76 grey seals were counted during the harbour seal pup counts in June 2012. Although this represents a 33% increase from the previous year, no grey seal births have been documented in the Danish Wadden Sea, and dedicated grey seal counts have therefore not yet been initiated.

The increase compared to the previous year was 22%. This high rate can be explained by bringing immigration from the UK into consideration.

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. 4.4). 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 2012, the total number of seals counted during coordinated surveys in the moult period in the German-Dutch-Danish Wadden Sea in August was 26,220 (3,966 in Denmark, 9,268 in Schleswig-Holstein, 6,457 in Niedersachsen/Hamburg and 6,529 in the Netherlands). The maximum number of pups counted during the whelping season in June was 7,267 (570 in Denmark, 3,247 in Schleswig-Holstein, 1,977 in Niedersachsen/Hamburg and 1,473 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 known 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 but a shift has been observed in the core area. In 1994 most harbour porpoises were counted in the northern part, whereas in 2005, most of the porpoises were seen in the southern part. It is assumed, that this effect depends on the presence of fish. 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 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.

The houting is one of the most endangered species in Europe. A Danish restoration project with the aim of safeguard the houting was funded under EU’s LIFE programmes. The restoration project comprises a variety of measures in the rivers connected to the Danish Wadden Sea (Varde, Sneum, Ribe and Vidaa rivers). The project started in 2005 and has removed fish farms, blockings for the migratory fish and restored wetlands as spawning grounds. The project has additional positive effects.
for the ecosystem. Beside increased living conditions for the houting the project also had positive effects on habitats and species, e.g. salmon and other species on the EU list of endangered species.

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.

Overall, the number of fish species and the species composition in terms of ecological guilds has not shown any significant changes over the last 30 years. The number of estuarine resident species is remarkably stable, especially in the western and eastern Dutch Wadden Sea. Not much variation is observed in the number of marine juvenile species either. Most of the variation in species richness is caused by the number of diadromous species or other (marine seasonal and marine adventitious) species (QSR 2009).

The 14 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 (Tab. 4.5).

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.

### Table 4.5: Summary of trends in abundance of 14 fish species by Wadden Sea sub-area determined by TrendSpotter analysis of the DFS and DYFS (Bole et al., 2009). The period in which the trend was significant is indicated. Grey color means that there was no sampling. Green indicates a significant increasing trend, red a significant decreasing trend in fish abundance of a species. Explanation of the area codes: 1. Western Dutch Wadden Sea, 2. Eastern Dutch Wadden Sea, 3. Ems-Dollard, 4. East Frisia, 5. Jade, 6. Weser, 7. Elbe, 8. Dithmarschen, 9. North Frisia. * potential data errors (Source: QSR 2009).

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The Wadden Sea, Germany and Netherlands (N1314) - Extension Denmark and Germany
### State of Conservation and Factors Affecting the Property

#### Sole

- **Overall description**: Increase
- **Area 1**: Decrease
- **Area 2**: Decrease
- **Area 3**: No significant trend
- **Area 4**: Increase\decrease
- **Area 7**: Increase\decrease
- **Area 8**: Decrease
- **Area 9**: Decrease

#### Dab

- **Overall description**: Increase\decrease
- **Area 1**: Decrease
- **Area 2**: Decrease
- **Area 3**: Decrease
- **Area 4**: Increase\decrease
- **Area 7**: Decrease
- **Area 8**: Decrease
- **Area 9**: Decrease

#### Cod

- **Overall description**: Increase\decrease
- **Area 1**: No significant trend
- **Area 2**: Increase\decrease
- **Area 3**: Increase\decrease
- **Area 4**: Increase=decrease
- **Area 7**: Increase=decrease
- **Area 8**: Decrease
- **Area 9**: Decrease

#### Whiting

- **Overall description**: Increase\decrease
- **Area 1**: Increase\decrease
- **Area 2**: Increase\decrease
- **Area 3**: Increase\decrease
- **Area 4**: Increase=decrease
- **Area 7**: No significant trend
- **Area 8**: No significant trend
- **Area 9**: No trend

#### Herring

- **Overall description**: Increase\decrease
- **Area 1**: Increase\decrease
- **Area 2**: Increase\decrease
- **Area 3**: Increase\decrease
- **Area 4**: Increase=decrease
- **Area 7**: Increase=decrease
- **Area 8**: No significant trend
- **Area 9**: No significant trend

#### Sprat

- **Overall description**: Increase=decrease
- **Area 1**: No significant trend
- **Area 2**: Increase=decrease
- **Area 3**: Increase=decrease
- **Area 4**: Increase=decrease
- **Area 7**: Increase=decrease
- **Area 8**: No significant trend
- **Area 9**: No significant trend

* Potential data errors, see text

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**Razor mussels**  
(Photo: John Frikke).
The numbers of juvenile flatfish using the Dutch Wadden Sea as a nursery area are declining, in particular the abundance of dab, sole and plaice. This is mainly caused by an offshore shift in the distribution of juvenile flatfish which is attributed primarily to increased summer temperatures, however; the causal factors for this shift are not yet fully understood (QSR 2009). Increasing water temperatures have a positive effect on the occurrence of more southern species such as the anchovy. Exotic or aliens fish species introduced from outside the North East Atlantic seas are still rare in the Wadden Sea (QSR 2009).

**Macrozoobenthos**

The benthic macrofauna communities play a key role in the Wadden Sea food web. On the one hand, they are important grazers of phytoplankton and microphytobenthos, on the other hand macrozoobenthos is the major food source of many predatory bird and fish species of the Wadden Sea. Long-term data sets go back to the 1970s. Without such a long-term data set it would be impossible to distinguish real changes from incidental highs or lows. However, consistent monitoring series at sites throughout the Wadden Sea are only available from 1988 onwards. In general, it can be concluded that these long-time series show different signals in different sites. Also small scale, within-site, variations may play a role.

Average species composition at the monitoring stations in the mid intertidal range calculated over the 1988-2008 period show differences between the stations in the northeastern and the southwestern Wadden Sea. In general, these differences between the monitoring sites in the northeastern and southwestern Wadden Sea are consistent over the entire period between 1988 and 2008.

In the period between 1988 and 2008, at six monitoring areas in the mid tidal range in the Wadden Sea, Macrozoobenthos biomass showed considerable variability but no clear long-term trends (Fig. 4.5). In the two areas in the northeastern Wadden Sea Ho Bugt and Rømø and also at Norderney in the southwestern Wadden Sea, fluctuations in the *Cerastoderma edule* biomass strongly influence the overall variability in macrozoobenthos biomass. *Mya arenaria* and *Arenicola marina* are relatively important and stable species in the southwestern Wadden Sea. Especially in the Balgzand area *M. arenaria* reaches high biomass values. It is also at the Balgzand area where around 2000 the invasive *Marenzelleria viridis* reached highest biomass values in the series presented here. However, the clear and significant increase of total biomass in Balgzand during winter/early spring can not be extrapolated to other areas. At monitoring sites in the Netherlands total summer biomass is declining while winter biomass continuous to increase or remains stable.

Also in the subtidal, *M. viridis* has become one of the most important species. *Ensis directus* is another invasive species which locally has a large impact on the macrozoobenthos biomass. This species is now strongly established in the subtidal and low exposed intertidal areas of the western Dutch Wadden Sea (Dekker and Beukema 2012). Despite that the invasive *M. viridis* and *E. americanus* can locally reach very high biomass values, there is no strong evidence that these species have a negative impact on the original benthic fauna.

It is still 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. *Crassostrea gigas* develops reef-like structures offering hard substrate and protection for other species, severely impacting species composition.

At present, there is no clear indication of any effects of climate change on most of the macrozoobenthos species. However, the number of species has increased with increasing winter temperatures and some cold tolerant species are declining most notably *Macoma balthica*. Global warming may have a negative impact on the recruitment success of the bivalves *Macoma balthica*, *Cerastoderma edulis*, *Mya arenaria* and *Mytilus edulis*.

There is no strong indication of effects of the reduction in eutrophication on macrozoobenthos – there may be some indications of summer biomass reduction in the western Wadden Sea.
Figure 4.5:
Time series of macrozoobenthos biomass at six monitoring areas in the Wadden Sea between 1988 and 2008. Areas are ordered from north east to south west. Bars are subdivided for the thirteen species with largest biomass and remainder of the community. Species are ordered according to the overall average biomass. (cered = Cerastoderma edule, myaare = Mya arenaria, mytedu = Mytilis edulis, aremar = Arenicola marina, macbal = Macoma balthica, nereid = Nereis diversicolor, heftil = Hermodice carunculata, hydsp = Hydrobia ulvae, litlit = Littorina littorea, lancon = Lanice conchilega, scoarm = Scoloplos armiger, scrpla = Scrobicularia plana, marvir = Marenzelleria viridis, rest = others)
4.b Factors affecting the property

(i) Development pressures

All human activities within the inscribed and 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. Art. 6 (3) of the Habitats Directive stipulates 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. [...] 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 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 German National park acts, the Federal and states Nature Conservation Acts, the Danish Nature Conservation Act 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 management of the Wadden Sea. The result is that the inscribed and nominated property is not subject to significant development pressures.

There are, however, a number of activities, the most prominent ones taking place outside the inscribed and 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, and coastal protection. Further, the issue of alien 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 inscribed and nominated property.

In many of these activities the natural dynamic processes which change the Wadden Sea over time have to be taken into account; e.g. natural gullies used as shipping routes have moved substantially in the course of the centuries. Over the long run, the borders of the inscribed and nominated property 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.

Germany (Niedersachsen)

As regards the German (Niedersachsen) extension of the property in the offshore area, there are very few human activities which affect the property. The main activity in the extension is shrimp fishery which, as outlined in the 2008 nomination document, does not negatively affect the nominated extension of the property.

Constructions of new wind turbines are not allowed within the nominated property, Cables have been and will be constructed through the area from windparks constructed further offshore in the framework of the German energy transition policy which aims at a significant extension of wind power. The construction of such cables is subject to assessment and permission under the Habitat Directive. Two corridors for laying power cables across the nomination area have been approved after passing the assessments and permission under the Habitats Directive. One corridor crosses from north to south via the island Norderney and a second one passes west off the Island Borkum.

Designated areas for the extraction of sand for building purposes lie entirely outside but partly adjacent to the nominated extension. Possible adverse side impacts on the property are subject to the Habitats Directive and the National Park Act.

Disturbance may ensue from civil air traffic crossing the offshore area including helicopter flights from airports on the mainland to offshore installations. 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. Furthermore, it should be acknowledged that all dumping sites for dredged material are located outside the nominated extension. Hunting is not allowed in the nominated extension area.

The state party confirms its commitment not to explore and extract oil and gas at locations within the property and the nominated extension area in line with law in force.

There are no coastal protection measures in the German extension of the property.

**Danish Wadden Sea**

Harbours, industrial facilities and dredging

There are three harbours (Esbjerg, Havneby, Nordby) 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 maritime installations, the traffic to and from the islands. 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 hydro-morphological and geomorphological conditions are highly dynamic and additionally very sensitive to climate change with its sea level rise and variations in storminess. Access to the harbours also demands an integrated sediment management, both to maintain the shopping 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.

In the Danish part of the nominated property channels and harbours are regularly dredged for maintenance of water depth. There are two major and three minor deposit sites outside Esbjerg harbour and one deposit site outside Havneby harbour. The dredged material from the maintenance of Esbjerg harbour is mainly deposited at sites outside the nominated property. Deposit sites are for marine dumping of dredged material re-entering the natural sedimentation balance.

At these sites dumped material is comparable in quantity, type and structure to natural sedimentation dynamics in the area. Dumping is only allowed if no toxic substances are detected, and if dumping is considered to be without effect on the ecosystem. The material is regulated through dumping method, deposit site, quantify, frequency and season. The amounts of dredged material dumped into the entire Danish Wadden Sea varied between 9 - 26 million t/y (dry weight) over the period 1998 - 2003 (average 14.8 million t/y).

Yearly Esbjerg harbour authority is dredging 417,000 m³ sediment from the basins (average from 1993 – 2003) (DHI, 2005). In total the dry weight of marine dumped material is 117,000 tons, of which 20,000 tons are sand and 97,000 tons are fine-grained material (DHI, 2005). The main dumping sites are situated in areas of Grådyb with strong tidal currents. The result is that dumped material is not accumulated on the dumping sites, but kept in – or placed in – suspension by the tides. Thus the marine dumped material (re)enters into the gross sediment budget on 2.2 mill m³ per year.

The basins in the Esbjerg harbour act as a heavy sedimentation trap for the material transported by the tides in the Grådyb. The material will – on its way towards the inner parts of the tidal area – reach the harbour area, where a large percentage will deposit as sediment. It is important to regard the maintenance as an activity that neutralises the effect of the harbour on the environment if marine dumping of the material can take place without affecting the environment, and on the condition that the dredged material is not polluted. The dredged material belongs to the total natural sediment budget, so to speak, and is only temporarily impeded in the natural transportation by the harbour (Geografisk Institut, 1993).

Because dredging for maintenance is the main source of dumped material, the amounts depend mainly on natural variation of sedimentation and re-suspension processes. In general, no trend can be observed in the amounts of dredged material dumped.

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-
Coastal flood defense and protection

Coastal flood defense and protection, including the drainage of the hinterland, are inherent features of the Danish 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 defense 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 defense standards demand, however, continuous reinforcement and adaptations of future coastal protection measures to a rising sea level. Reinforcement of the existing dikes in front of threatened areas will be carried out.

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 some 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.

Fishery may affect the natural environment of the nominated property. As outlined in Chapter 2, the most important fisheries within the nominated property are for shrimp. Shrimp fishery is mainly performed in the area off the islands. These fisheries are subject to a coordinated management scheme which aims to ensure that the nominated property will not be negatively affected. Generally the fishery complies with the provisions of Natura 2000 stipulations and is managed in a sustainable way. Commercial fishery after bivalves – especially the blue mussel – is halted. Pacific oyster is only collected manually on a small scale basis.

Other fishery activities inside the nominated property including the use of fykes is restricted and limited in time due to concerns for migrating salmonoids including smolts and the highly threatened houting. The use of gill-nets is forbidden inside the islands. Fishery with gill-nets is allowed on the west coast of the islands and is practiced especially on Rømø and the peninsula of Skallingen.

Disturbance may ensue from recreational civil air traffic over the nominated property, but also from route flights between airports and helicopter flights from airports on the mainland to offshore installations. Accordingly minimum flight altitudes and corridors have been introduced in some cases to minimize disturbance. Also, ultra-light aircraft and advertisement flights are prohibited or regulated. The minimum flight altitude over the Danish part of the nominated property is 1,000 feet (300 m) according to the Executive Order issued on 24 September 2012 by the Danish Transport Authority, but it is strongly recommended to use higher flight altitudes.

Hunting is almost phased out in the entire Wadden Sea, but in the Danish parts of the nominated property a regulated water bird hunting in a few salt marsh areas and hunting in the sea territory from anchored boats or by wading in the sea territory west of the islands takes place. Further exemptions for hunting for wildlife management and pest control are possible in the whole area.

There is one exercise area with air to ground missiles within the Danish Conservation Area on the island of Rømø. The extent of military activities has been significantly reduced over the last years. All activities are limited in time to take account of the breeding and moulting times for birds and seals. The military exercise area has been excluded from the nominated property in conformity with the exclusion of similar exercise areas of the existing property.

Alien species

At the North Sea coast, alien 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 alien 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) (Fig. 4.6). 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 *Crassostrea*. Global warming may benefit *Spartina, 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.

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.

As a follow-up of the decision of the World Heritage Committee on the inscription of the Wadden Sea World Heritage on the List in 2009, acknowledging the research and control system provided by the States Parties of Germany and the Netherlands to mitigate the introduced species, encouraged the parties to implement a strict monitoring programme to control invasive species associated with ballast waters and aquaculture in the property, an aliens species strategy for dealing with alien species introductions in the Wadden Sea is currently being developed as decided at the 2010 Wadden Sea Ministerial Conference.

(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. Along the German and Danish coast, a number of small rivers also contribute to the discharge but cover only a minor part of the total catchment area. 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 (Fig. 4.7).

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 (Fig. 4.9). For a number of xenobiotic compounds, discharges to and concentrations in the Wadden Sea have decreased (Fig. 4.8). 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 inscribed and 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 Wadden Sea 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 envisioned 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 up to 75% in Germany and Denmark 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 inscribed and 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. Thousands 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 inscribed and nominated property is, 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 Danish part of the nominated property is also part the Particularly Sensitive Sea Area (PSSA) Wadden Sea. 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 inscribed and 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 inscribed and nominated property that it is essential to take the broader scope when describing and assessing tourism and visitor activities.

As requested by the World Heritage Committee in 2009, a project started in October 2011 to develop an overall Tourism Development Strategy for the property that fully considers the integrity and ecological requirements of the property and that provides a consistent approach to tourism operations in the property (www.prowad.org).

Apart from very limited recreational navigation there are no recreational activities taking place in the nominated German extension of the property.

The area around the Danish Wadden Sea covers a wide range of opportunities for recreational activities related to the natural and cultural history assets. The recreational infrastructure is highly developed. The experiences are of great variety, covering everything from windsurfing, mountain biking and horseback riding to swimming, boating and hiking in nature. 60–90 percent of the area’s residents and tourists are active users of outdoor activities. The most visited areas are the southeastern part of the island of Rømø, the coastline of the island of Manda and the beaches of Hjerding and the western part of the island of Fano.

Tourism in the Danish Wadden Sea area is organized and marketed mainly through the tourism organizations Destination South West Jutland, represented by the municipalities of Esbjerg, Fano, Tonder and Varde. Destination South West Jutland is evolving and has launched several initiatives, e.g. travel packages, trails at sea and land, and thematic adventures such as gastronomy and art, and collaboration with local stakeholders about the dissemination of the activities.

Second homes represent the largest portion of the offered accommodation, followed by camp-sites, holiday apartments and centers, while the proportion of hotels is limited. Tourism is seasonal.
The number of overnight stays and day trippers in the Danish Wadden Sea was in 2010 estimated to around 9.7 million. The turnover of the tourist sector is estimated to app. EUR 500 million per year and the number of employees app. 5,305 full time equivalent (FTE). The number of visitors at the three largest visitor centers was 183,000 in 2007 and 30,000 visited the unstaffed exhibitions free of charge. The number of visitors at the beaches of Rømø and Fanø was in 2004 estimated to app. 2 million.

Tidal flat walking predominately takes place at guided tours offered by both public and private providers. Privately arranged tidal flat walking is not prohibited. The number of participants in guided tours was 105,000 in 2007. The number covers both tidal flat walking and other guided tours in the Danish Wadden Sea.

There are 11 recreational boat clubs in the Danish Wadden Sea which comprise around 1,300 members. Together with a number of rowing and kayak clubs they form much of the non-commercial recreational boating. The greatest activity is seen in Grådyb tidal area encompassing Esbjerg, Hjerting Varde and Nordby. Recreational boating from Varde goes via Varde river into the Ho bay. There is also a small - but growing activity - starting from Ribe/Kammerslusen, from Højern Sluice and Lægan in the Vida River, and Havneby on Rømø. In Juvre Deep recreational boating is exceptionally rare.

Tourism and recreational activities are comprehensively regulated in the Danish Wadden Sea primarily in the context of the Statutory Order on the Nature and Wild Life Reserve. Access to certain areas is prohibited predominantly for the whole year. This concerns areas important for seals and roosting and breeding birds and other ecologically sensitive areas covering the island of Langli and areas around the island, the high sands of Jordsand, Koresand, Lammelæger, Trinden and Keldsand and the reclamation fields of Rømø causeway and the ebbe road to Mando, and the southern part of the Lister Deep.

Any form of motorized transport and the use of any means of transport propelled by sail is prohibited in the reserve. Car traffic is however allowed in specific zones on the beaches of the islands of Rømø and Fanø and on the Mando ebbe road.

Navigation east of the baseline at a speed exceeding 10 knots is only permitted within buoyed areas of the major shipping channels of the Grådyb, Knudedyb and Listerdyb. Any navigation by water scooters, jet skis, water skis catamarans and vessels propelled by air props and windsurfing is in principle prohibited in the area. Windsurfing and navigation with catamarans is allowed in specifically designated areas along the west coast of Skallingen, Fanø and Rømø and in the Grådyb in the summer half year. The activities at the beaches are regulated in dedicated zones where windsurfing is allowed, and on the islands of Rømø there are zones specifically dedicated for kite buggy and beach sailing.
For activities in the areas adjacent to the nominated property, 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 activities and prevent an adverse impact resulting from them on the nominated site.

(v) Number of inhabitants within the property

The number of inhabitants within the nominated property is 2 (2012) which results in a total number of 45 within the inscribed and nominated property.
5. PROTECTION AND MANAGEMENT OF THE PROPERTY

5. a Ownership

The extension of the German (Niedersachsen) part of the property of 40,628 ha / 406,3 km² is fully owned by the Federal Government being the competent authority for navigational waters.

As regards the Danish Wadden Sea the large majority of the reserve is state owned (almost 99%). The rest (some 1%) is owned by adjacent municipalities and private persons. This concerns predominately salt marsh areas and the northern part of the Margrethe Kog.

The landownership of the inscribed and nominated property the Wadden Sea is in table 5.1.

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 Symposium was held in 1975. In 2012 the 13th Scientific Symposium has 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 11th Wadden Sea Conference was held in 2010 at the island of Sylt.

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”
Table 5.1: Overview of land ownership of the inscribed and nominated property. Component parts with the offshore extension of the Niedersachsen Wadden Sea and the nominated property in the Danish Wadden Sea are shaded in red.

<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>255,031</td>
<td>2,550.3</td>
<td>93.8 % state owned, 1.7 % &quot;Groninger Landschap&quot;, 0.05 % &quot;Noord-Hollands Landschap&quot;, 4.2 % &quot;Natuurmonumenten&quot;, 0.3 % &quot;Wetterskip Fryslan&quot;</td>
</tr>
<tr>
<td>Wadden Sea National Park Niedersachsen</td>
<td>324,160</td>
<td>3,241.6</td>
<td>93.5 % federally owned, 5.2 % state owned, 0.9 % owned by municipalities, 0.4 % private property</td>
</tr>
<tr>
<td>Wadden Sea National Park Hamburg</td>
<td>13,611</td>
<td>136.1</td>
<td>97.8 % federally owned by the City of Hamburg, 2 % private property</td>
</tr>
<tr>
<td>Wadden Sea National Park Schleswig-Holstein</td>
<td>436,698</td>
<td>4,367.0</td>
<td>98.3 % federally owned, 1.6 % state owned, 0.1 % private property</td>
</tr>
<tr>
<td>Danish Nature and Wildlife Reserve</td>
<td>124,792</td>
<td>1,247.9</td>
<td>99.0 % state owned, 0.1 % owned by municipalities, 0.9 % private property</td>
</tr>
<tr>
<td><strong>TOTAL PROPERTY</strong></td>
<td><strong>1,154,292</strong></td>
<td><strong>11,542.9</strong></td>
<td></td>
</tr>
</tbody>
</table>

* The total size of the land ownership is calculated on basis of national conservation areas and differs from the total size of the 8 component parts. Reasons are overlaps or gaps between the national conservation areas caused by inconsistency of geographical data based upon the unclear definition of the borders between the Netherlands, Niedersachsen, Schleswig-Holstein and Denmark. The inconsistencies in size are neutralized by joint component parts shared by states and countries.

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.

### Trilateral Wadden Sea Cooperation


The Joint Declaration on the Protection of the Wadden Sea 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.

At the 11th Trilateral Governmental Conference on the Protection of the Wadden Sea, 17–18 March 2010, a new Joint Declaration on the Protection of the Wadden Sea was adopted (Annex 6). The 2010 Joint Declaration does not alter the spirit or legal status of the Cooperation. It encompasses the overall principles for the protection of the Wadden Sea and the objectives and areas of cooperation. The 2010 Joint Declaration also introduces new governance arrangements. The Trilateral Wadden Sea Governmental Council is the politically responsible body (Ministers) for the Cooperation. The Wadden Sea Board is the governing body of the Cooperation. The new Joint Declaration and Governance Arrangements will ensure that the Cooperation will be able to meet present and future needs.


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 concluded in 1987 between the competent ministries of the three countries. In conjunction with the 2010 Joint Declaration also a new legally binding Administrative Agreement for the Common Wadden Sea Secretariat was signed to provide the secretariat with a legal status (Annex 7). The Administrative Agreement stipulates the legal status, 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 8) 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 Guiding Principle is now codified in the 2010 Joint Declaration. 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. Since 2011, the WSF is a formal stakeholder association under German law.

National Protection of the Wadden Sea

Germany

In Germany the federal states are responsible for the implementation of the Federal Nature Conservation Act (BNatSchG). Main habitats of the German Wadden Sea are, amongst others, legally protected by § 30 of the Federal Nature Conservation Act.
Conservation Act (Annex 10). Actions that could lead to the destruction or other significant adverse effects are prohibited.

Schleswig-Holstein, Niedersachsen and Hamburg established national parks for the property in 1985, 1986 and 1990, respectively. 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.

1. Act on the Niedersachsen Wadden Sea National Park, 2010

The Niedersachsen Wadden Sea National Park was designated in 1986 by state statutory order, which was given the status of state act in 1999. 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. A second major amendment in 2010 extended the National Park to include large parts of the offshore belt. The full legal protection regime for the core zone (zone I) applies to the extension area as well. General exceptions are made for the dumping of sand from maintenance dredging in accordance with national regulations which refer to OSPAR and London Convention requirements, recreational fishery and, as far as the protection goals are not contradictory hereto, the extraction of sand for coastal protection purposes and the construction of cables and pipelines (Annex 11).

2. 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 of Transport, Building and Urban Development. An order was issued in 1992 and amended in 1995 and 1997. The order establishes speed limits for navigation in the National Parks and closed areas comprising of seal haul out sites, and breeding and moulting areas for birds.

Denmark

1. Nature Protection Act

The purpose of this act is to contribute to safeguarding nature and environment in Denmark, thus ensuring sustainable social development in respect of human conditions of life as well as the protection of flora and fauna. The objective of the act is to protect nature with its stock of wild animal and plants and their habitats as well as its scenic, cultural historic, natural science and educational values. The act furthermore aims to improve and restore or create areas of significance for wild animals and plants and for landscape and historical interests and to provide access to nature and to improve opportunities for open-air recreation. The most recent amendment of the act was in 2008 (Annex 12).

2. Statutory Order on the Nature and Wildlife Reserve Wadden Sea

The Wadden Sea order specifically intends to promote the sustainable management of the Wadden Sea and preserve the area as a coherent natural area of national and international importance and as a habitat for seals and populations of waterfowl. The order seeks to protect the area’s natural ecology and environment and cultural heritage values in balance with the area’s use for commercial and recreational purposes, taking into account infrastructure and the local population’s security, while not affecting the natural dynamics of landscape evolution unnecessarily. This order ensures the fulfilment of Denmark’s international obligations under the Joint Declaration. The first Statutory Order on Wildlife Management in the Wadden Sea was introduced in 1979 followed by the Statutory Order on the Wadden Sea Nature Reserve in 1982. Both orders were merged into one Statutory Order on the Nature and Wildlife Reserve in 1992. The most recent amendment of the order was 2007 (Annex 13).

3. Act on National Parks

The Danish part of the Wadden Sea is covered by the National Park Wadden Sea. The National Park is designated in accordance with national legislation. The purpose of the Act on National Parks in Denmark is to create and secure coherent nature and landscape of national and international importance. As a part of the designation of the National Park a foundation has been established that prepares a plan for the National Park establishment and development. The act was adopted by parliament in 2007 (Annex 14).
4. Statutory order on special fishing regulations and conservation zones in the Wadden Sea and in some streams in southern Jutland

The order is based on the Danish fisheries act, which provides the overall, overarching framework for regulating fishing in saltwater and freshwater, creating a coherent set of rules for commercial fishing and recreational fishing. The order on fishing and conservation in the Wadden Sea specifically aims to ensure that migratory fish moving from rivers into the sea are allowed to do so without hindrances. Therefore conservation zones, where fishing is prohibited, are put in place where rivers and streams flow into the ocean in the Wadden Sea area. The most recent amendment of the order was in 2012.

5. The Spatial Planning Act

This act ensures that the overall planning synthesizes the interests of society with respect to land use and contributes to protecting the country’s nature and environment, so that sustainable development of society with respect to people’s living conditions and for the conservation of wildlife and vegetation is secured. The act explicitly states that the country's coastal areas are to be kept as free as possible of development and installations that do not need to be located near the coast. The most recent amendment of the act was in 2007.

6. Coastal Protection Act

The purpose of the coastal protection act is to protect people and property from flooding and degradation of the sea, fjords, or other parts of the territorial sea. This purpose is served by balancing several considerations such as: 1) The need for coastal protection, 2) economic considerations 3) the technical and environmental quality of coastal protection 4) the preservation and restoration of coastal landscapes, 5) natural dynamics of the coastline 6) recreational use of the coastal zone 7) the need to secure the existing access to the coastal zone. The most recent amendment of the act was in 2009.

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 in particular to the OSPAR Convention.

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 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 17) 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 was done in preparation of the 2010 Wadden Sea Conference. As a result of the evaluation Governments agreed to develop a vision on maritime
safety and pollution prevention for the Wadden Sea PSSA together with the main stakeholders including the shipping sector. This vision which will also encompass operational measures is currently under development.

3. Man and Biosphere Reserves
The nominated extension of the German part of the property is also part of the Man and Biosphere (MAB) Reserve under the UNESCO Man and Biosphere Program in line with the protected area status. In Niedersachsen, a development zone, which should contain 50% of the whole MAB reserve in accordance to the UNESCO criteria, is under development in the adjacent hinterland. Crucial is that planning, management and configuration find the acceptance of the local population.

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. The two flyway projects initiated in the framework of the Wadden Sea World Heritage following the request of the World Heritage Committee on the inscription of the property in 2009, the Wadden Sea Flyway Initiative, is closely coordinated with AEWA.

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 2009/147/EC on the conservation of wild birds (Birds Directive) aims at the protection of all species of naturally occur-

Figure 5.2: Map of the Particularly Sensitive Sea Area (PSSA) Wadden Sea and the Traffic Separation Scheme (TSS).
ring 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 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...
The Wadden Sea, Germany and Netherlands (N1314) - Extension Denmark and Germany

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 the overall coherence of the NATURA 2000 network. These provisions are legally enforceable by the European Court of Justice.

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 had 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 eight 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 Sylt Conference reaffirmed that a coordinated and consistent implementation will continue to be a central aim. The Wadden Sea Plan has been 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 Marine Strategy Framework Directive, the
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 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.

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” and incorporated in the Joint Declaration 2010. 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 was 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. 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 Niedersachsen National Park, which includes the uninhabited part of the East Frisian Islands, is divided into three zones. Zone 1 – the core zone – covers 68.6% 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. The extension is fully part of the Niedersachsen Wadden Sea National Park and within the core zone (Zone 1).

Zone 2 – the intermediate zone – covers 31% of the total area. In general, the protection regime is similar to the core zone. In deviation of the core zone, exemptions for certain uses are made provided that the protections aims are not jeopardized. 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 16 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 assessments in accordance with the Habitats Directive.

The Danish Wadden Sea Nature and Wildlife Reserve is divided into a number of zones which regulate admission and use of the area. Access and hunting is strictly prohibited in some 10% of the reserve. This zone encompasses the ecologically most valuable areas such as breeding and resting areas for harbour seals and breeding and roosting areas for birds. Within the reserve motorized transport and use of any means of transport propelled by wind power is prohibited except for specifically defined areas. Furthermore, navigation with 10 knots or more east of the islands is only allowed in the shipping lanes and moreover windsurfing and similar navigation is only allowed in four defined areas. Jet scooters and similar equipment is prohibited.

Hunting on migratory birds is prohibited within the reserve except for certain salt mash areas and hunting from anchored vessels and by wading west of the so-called shrimp line, basically west of the barrier islands. Blue mussel fishery is prohibited some 30% of the reserve, i.e., in the Ho Bay, the Juvre tidal basin and the southern part of the Lister Deep basin. Currently the blue mussel fishery is prohibited in consequence of the assessment in accordance with the Habitat Directive. Cockle fishery is also defined to 3 smaller areas around the shipping lane to Esbjerg.

Stakeholder involvement

Advisory Boards have been established both in the existing as well as 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 Advisory Board of the Niedersachsen National Park is 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.

In the Danish Wadden Sea context, there are two advisory boards. The Wadden Sea Advisory Board is the advisory committee in the context of the Nature and Wildlife Reserve. It is governed by the municipalities and the all relevant government and user stakeholders are members. The Advisory Board is consulted in all issues which relate to the use and governance of the reserve.

The National Park Advisory Board advises the National Park Board on major issues and issues of a principle character. The Advisory Board shall furthermore ensure that the national park develops with the support of the local community. The Advisory Board encompasses all relevant stakeholders including scientific institutes and museums.

Stakeholder involvement is ensured through other forums. The ‘Green Council’ is a voluntarily municipal forum consisting of representatives from local nature and recreational organisations, business and the municipality. The Green Council is a dialog forum for exchange of views on current topics and ideas for development on nature, environment and spatial planning.

The four Danish Wadden Sea municipalities are engaged in another stakeholder forum: The Local Authorities International Environmental Organisation – KIMO. KIMO was founded by local municipalities with a shared concern for the state of the environment. KIMO is designed to give municipalities a political voice at the international...
level, to share best practice and to find solutions to marine political problems that affect coastal communities. Also Dutch and German municipalities are members of KIMO, an organization which might be helpful in a World Heritage context.

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 designated as SACs. Furthermore, conservation status objectives have been elaborated as a basis for the legal protection and management of the site.

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 is obliged to 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 Transport, Building and Urban Development 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, Hamburg and Niedersachsen have 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 Niedersachsen area, wardens employed at the coastal protection authorities and volunteers together with non-governmental organizations 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.

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.

Also in Niedersachsen, voluntary agreements and certifications, e.g. guided tours and ship excursions 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, running also a partner programme. All three national parks in Germany work together on promoting the concept of voluntary agreements with potential national park partners.
In the Danish Wadden Sea, the Nature Agency of the Ministry of the Environment is the competent authority for the implementation of the Statutory Order. All activities in the protected area require a permit or an exemption from the Agency. In cases where the Agency is not the legal competent authority e.g. with regard to fisheries or coastal protection measures the Agency must be consulted and approve of a permit or a measure. The recently issued Natura 2000 nature management plan for the area includes the overall management objectives and a comprehensive set of guidelines and efforts necessary to reach these objectives. The management plan is aligned with the river basin management plan under the Water Framework Directive, also issued recently.

The enforcement of the rules and regulations is done primarily by the staff of the responsible local state forest district which is also responsible for the management of state owned areas. The forest district also liaises with user groups and other interest organizations to ensure an effective management of the area.

The national park plan for the Wadden Sea National Park is anticipated to reinforce the management of the area and to ensure the necessary stakeholder support for and involvement in the management on the basis of the principles of cooperation and voluntary engagement.

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.

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, 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 benefit 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 envisions 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 inscribed property as well as the nominated offshore extension 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”) further stipulates that the world heritage property as well as the nominated extension is to be protected, supported and developed in its uniqueness through appropriate developments in the surrounding area in addition to maintaining and developing the status of the whole property.

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 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.

Denmark
The Danish Wadden Sea is fully embedded within national and local planning. As indicated in 5.b the Spatial Planning stipulates that the country’s coastal areas are to be kept as free as possible of development and installations that do not need to be located near the coast. The national park plan is a key plan for the integrated planning of the Wadden Sea area which has been approved by the National Park board after a public consultation. The Plan is aligned with the municipal planning of vice versa.

The municipality planning in the Wadden Sea is primarily obligated by the commitments and responsibilities determined in the national legislation on protection of the Wadden Sea and on spatial planning. This means that municipal plans are based on national legislation and that changing national regulation typically will be directly reflected and implemented in the municipal planning.

The Advisory Board of the Danish Wadden Sea (RuV)
After the municipality reform in 2007, the four Danish Wadden Sea municipalities formed a municipal Wadden Sea secretariat with responsibility for the Advisory Board for the Wadden Sea. Since 1998, the Advisory Board has not been statutory but since then acting as stakeholder forum. The bi/tri-annual meetings are public (advertised in the media) – the number of meetings depends on present topics and is scheduled to coordinate the Danish contribution to the Wadden Sea Forum. The Advisory Board of the Wadden Sea consists of representatives of national, regional and mu-
municipal authorities, including a political delegate from each of the four municipal councils, and also delegates from relevant stakeholders, institutions and organisations with affiliated with the Wadden Sea region. The foundation of the work of the advisory board is preservation and development of the Wadden Sea as an area of both natural and cultural importance. Economical and recreational use is based on sustainability — that is in a process balanced and integrated between the ecological, economic and social interests and with consideration for national and international responsibilities.

The Municipality Wadden Sea Secretariat

The Danish Municipality Wadden Sea Secretariat was established in 2007 as a joint municipal secretariat for Esbjerg, Fanø, Tønder and Varde municipalities in order to fulfil the four municipalities’ interests in relation to the management of the Wadden Sea in a variety of topics and in collaboration with other agencies.

The main objectives of the secretariat comprise:
- Secretariat for the Advisory Board of the Wadden Sea; coordinate and initiate tasks related to engineering and environment as related to municipal responsibilities in the Wadden Sea; coordination of the municipal assignments in relation to the National Park Wadden Sea; participate in project development in the Wadden Sea; participate as municipal representative in the Trilateral Wadden Sea Cooperation; contribute to activities within the culture and cultural environment — including municipal cultural cooperation and projects under the Cultural Agreement.

Wadden Sea Inter-municipal Planning Cooperation (VTP)

The primary purpose of the VTP is to create opportunity for collaboration on regional topics on spatial planning and integrate them into the municipality work. The VTP has also the aim of contributing to a mutual information and inspiration on the spatial planning and the process of this; and to establish an inter-municipal network of personal contacts; to incorporate cross-cutting elements in the affected municipality plans and to report on major project affecting adjacent municipalities.

Southwest Jutland Development Forum (SVUF)

The SVUF is a common municipal association with Esbjerg, Fanø, Tønder, Varde and Vejen municipalities as members. The SVUF has among others the responsibility of initiating and ensuring the implementation of initiatives that support growth and development as well as good conditions in the Southwest Jutland part of the South Denmark Region on areas of business, settlement, education and tourism. In addition member municipalities’ tourism and business councils work closely together by regularly contributing concrete proposals.

Local Action Groups (LAG)

There are a total of seven LAG’s within the four Wadden Sea Municipalities which are financed through the EU and the Ministry of Food, Agriculture and Fisheries of Denmark. The funds support local projects and the running of the LAG associations. The EU funding is given by both European Fisheries Fund and the European Agricultural Fund for Rural Development.
5.e Property management plan or other management system

Management

All partners concerned are aware of the outstanding universal value of the extension nomination and of the 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.waddensea-secretariat.org) as in regional declarations and decisions supporting the nomination (see Annex 18, 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 continue to 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 transboundary site 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 9. The Wadden Sea Plan applies to the existing property “The Wadden Sea” as well as the nominated areas and the adjacent areas covered by the Wadden Sea cooperation. Following this ecosystem approach the World Heritage property 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 was updated in 2010 to be brought into line with the inscription of the Wadden Sea World Heritage property into the World Heritage List by including the criteria for which it was inscribed on the List and by aligning, as appropriate, policies and management. Also the requests encompassed in the decision of the World Heritage Committee on the inscription of the Wadden Sea in the World Heritage List have been included in the Wadden Sea Plan (WSP). The WSP constitutes the common trans-boundary policy and management plan for the Wadden Sea Area. The Guiding Principle for “the Nature Conservation Area”, as laid down in the “Joint Declaration”, is “[t]o achieve as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way”. Such an ecosystem contains the full range of natural and dynamic habitat types each of which needing a certain quality (natural dynamics, presence of typical species, absence of disturbance, absence of pollution), which can be reached by proper conservation and management. The quality of the habitats shall be maintained or improved by working towards achieving Targets which have been agreed upon for the tidal area, the offshore area, estuaries, salt marshes, beaches and dunes, the rural area, water and sediment quality, fish, birds and marine mammals, as well as landscape and cultural aspects.

In addition to the Guiding Principle, seven Management Principles have been adopted which are fundamental to decisions concerning the protection and management within the Wadden Sea Area:

- 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 have been adopted with the objective of maintaining and enhancing the area which is natural, dynamic and undisturbed, including targets for birds, marine mammals and fish. The approach as outlined is fully aligned with the criteria for the existing and the nominated property and compatible with the integrity requirements, namely includes all elements necessary to express its outstanding universal value, is of adequate size to ensure the complete representation of the features and processes which convey the property’s significance, and does not suffer from adverse effects of development and neglect.

In addition, for the rural areas on the islands and the mainland supplementary targets aim to improve the conditions for birds. Also supplementary targets on marine mammals, birds, fish and mussel beds have been agreed upon, because these are important indicators of the biological quality of the ecosystem. Targets on the chemical quality of the Wadden Sea have been set as well. The essence of these targets: the concentrations of naturally occurring substances (for example nutrients and heavy metals) should be at natural levels and the discharges of non-natural substances, for example pesticides, should be zero.

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.

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, 5 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.

As a consequence of the “Agreement on the Conservation of Seals in the Wadden Sea” mentioned above, a Conservation and Management Plan was adopted in 1991 and been revised periodically. The latest revision was undertaken in 2011. The Seal 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.
### LANDSCAPE AND CULTURE
- **Identity** - to preserve, restore and develop the elements that contribute to the character, or identity, of the landscape, which forms the basis for life of the people living in the region.
- **Variety** - to maintain the full variety of cultural landscapes, typical for the Wadden Sea landscape.
- **History** - to conserve the cultural-historic heritage.
- **Scenery** - to pay special attention to the environmental perception of the landscape and the cultural-historic contributions in the context of management and planning.

### WATER AND SEDIMENT
- Background concentrations of natural micropollutants.
- Concentration of man-made substance as resulting from zero-discharges.
- A Wadden Sea ecosystem which can be regarded as eutrophication non-problem area.
- Improvement of habitat quality for conservation of species.

### SALT MARSHES
- To maintain the full range of variety of salt marshes typical for the Wadden Sea landscape.
- An increased area of salt marsh with natural dynamics; including natural drainage of mainland salt marshes, under the condition that the present surface area is not reduced;
- A salt marsh vegetation diversity reflecting the geomorphological conditions of the habitat with variation in vegetation structure.
- Favourable conditions for all typical species.

### TIDAL AREA
- A natural dynamic situation in the tidal area.
- An increased area of geomorphologically and biologically undisturbed tidal flats and subtidal areas.
- A natural size, distribution and development of natural mussel beds, *Sabellaria* reefs and *Zostera* fields.
- The Targets for birds, marine mammals and fish are relevant for the tidal area.

### BEACHES AND DUNES
- Increased natural dynamics of beaches, primary dunes, beach planes and primary dune valleys in connection with the offshore zone.
- An increased presence of a complete natural vegetation succession.
- The Targets for birds are relevant for beaches and dunes.

### ESTUARIES
- Protection of valuable parts of the estuaries.
- Maintaining and where possible restoring natural habitats and tidal dynamics typical of estuaries.
- Maintaining and, as far as possible, restoring the river banks in their natural state.
- Maintaining and where possible restoring the function as migration route and breeding area for fish and birds.

### OFF-SHORE AREA
- An increased natural morphology, including the outer deltas between the islands.
- The Targets for water and sediment, birds, marine mammals and fish are relevant for the offshore area.

### RURAL AREA
- Favourable conditions for flora and fauna, especially migrating and breeding birds.
- Good ecological connectivity between the tidal area, salt marshes and rural areas.

### BIRDS
- Stable or increasing numbers and distribution taking into account that abundance of species is in line with prevailing physiographic, geographic and climatic conditions.
- Breeding success and survival determined by natural processes.
- Breeding, feeding, moulting and roosting sites supporting a natural population.
- Undisturbed connectivity between breeding, feeding, moulting and roosting sites.
- Fluctuations in food stocks determined by natural processes.
- Habitat, food stocks and connectivity between habitats supporting a favourable conservation status.

### MARINE MAMMALS
- Viable stocks and a natural reproduction capacity, including juvenile survival, of harbour seal and grey seal.
- Viable stock and a natural reproduction capacity of harbour porpoise.
- Conservation of habitat quality for conservation of species.

### FISH
- Viable stocks of populations and a natural reproduction of typical Wadden Sea fish species.
- Occurrence and abundance of fish species according to the natural dynamics in (a)biotic conditions.
- Favourable living conditions for endangered fish species.
- Maintenance of the diversity of natural habitats to provide substratum for spawning and nursery functions for juvenile fish.
- Maintaining and restoring the possibilities for the passage of migrating fish between the Wadden Sea and inland waters.
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

As outlined above the Wadden Sea Plan is the policy and management plan for the existing as well as the nominated property. Both the extension of the German (Niedersachsen) part of the property as well as the Danish nominated property is fully covered by WSP. The WSP is in combination with the national management systems and the relevant EU legislations key elements for the management of the Wadden Sea.

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, Niedersachsen and Hamburg established national parks in 1985, 1986 and 1990 respectively. 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 Niedersachsen respectively. The stakeholder involvement aims at advising the national park authority 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 enforcement 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 Tri-lateral 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 Danish part of the nominated property, the agreements of the WSP is implemented through the comprehensive provisions of the Statutory Order on the Wadden Sea Nature and Wildlife Reserve, the municipal planning and the administration of the international protection areas in the Wadden Sea region. The Statutory Order is administrated by the Danish Nature Agency of the Ministry of the Environment.

In 2010 the Danish National Park Wadden Sea was established and a board appointed to govern the National Park. The board is responsible for the implementation of the National Park Plan, the provisions of the law on national parks including the Statutory Order on the National Park Wadden Sea. The Board is supported by an Advisory Board in which important stakeholder interests are represented. Enforcement of national legislation is not within the tasks of the board.

By 1 January 2013, the final National Park Plan will come into force after being adopted by the board and a public consultation period in 2012. The plan will constitute the basis for the development of the national park for the coming six years. It contains guidelines for the National Park's nature, landscape and cultural heritage values – and sets up objectives for the development and strengthening of these values. The Plan also sets up objectives for recreational activities, interpretation, dissemination and business development in the National Park, however they act accordingly to national legislation for the environment, forest, raw material and spatial planning. The National Park Plan also describes how the objectives can be met. According to the Statutory Order of the National Park, the plan must be in alignment with the protective legislation of the area. The regional management of the national law pertaining to the Danish part of nominated property is mainly under the responsibility of the four municipalities. However, the coastal protection act is administrated by the Danish Coastal Authority.

The recently issued Natura 2000 plans for the Danish Wadden Sea area are the key management plans for the area. The plans are legally binding
plans and encompass the overall objectives for the area and the efforts to reach the objectives. As indicated previously, the plans are aligned with the relevant river basin management plans and in conjunction with the Wadden Sea Plan which is the coordinated management plan for the Wadden Sea Area including the nominated property, the Natura 2000 plans constitute a comprehensive management of the nominated property.

5.5 Sources and levels of finance

The overview of the sources and level of funding is 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.

Of the amount of almost 3.8 million € for the National Park Authority in Niedersachsen, 1 million € are 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 € and a yearly distribution rate of approx. 1 million €. 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.

The amount of 2.5 million € in Denmark is public funding for the management of the nominated property also including public information services such as educational activities. Visitor facilities are run both by public funding and private donations, and the substantial but diverse funding for visitor centres is not included in the amount. NGOs are not included in the amount.

<table>
<thead>
<tr>
<th>Governments</th>
<th>Source</th>
<th>Amount State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany (Niedersachsen):</td>
<td>State</td>
<td>3,800,000 EUR</td>
</tr>
<tr>
<td>National Park Authority and Services (Information Centres, Wardens) and NGOs</td>
<td>State</td>
<td>3,800,000 EUR</td>
</tr>
<tr>
<td>Denmark:</td>
<td>State</td>
<td>2,500,000 EUR</td>
</tr>
<tr>
<td>Nature Agency, Municipal Wadden Sea Secretariat, National Park, Coastal Authority, Agrifish Agency</td>
<td>State</td>
<td>672,600 EUR</td>
</tr>
<tr>
<td>Common Wadden Sea Secretariat</td>
<td>State</td>
<td>672,600 EUR</td>
</tr>
</tbody>
</table>

Table 5.2: Sources and level of funding in 2012.
Chapter 5 Protection and Management of the Property

The Wadden Sea, Germany and Netherlands (N1314) - Extension Denmark and Germany

The funding available to the nominated property is substantially 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, the DEMOWAD-Project for data handling within the TMAP or Water-logging and grassland extensification in Niedersachsen to improve habitats of the cornrake (Crex crex) and the black-tailed godwit (Limosa limosa) in the Niedersachsen part.

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.

Niedersachsen

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 Wasserwirtschaft, Küstenschutz und Naturschutz”), the “Senckenberg by the Sea” research station (Wilhelmshaven), the Ornithological Research Institute (Institut für Vogelforschung, Wilhelmshaven), the National Park Authority 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, and the offshore belt). 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.

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.

The national park authority provides regular training programmes to official and voluntary wardens.

Another supplementary 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”.

The Wadden Sea, Germany and Netherlands (N1314) - Extension Denmark and Germany
As regards the extension pioneering research has been done by the Senckenberg Institute on the geomorphology of the offshore area and importance of sediment movements for the system as well as regular monitoring has established the offshore area as being of crucial importance for sea birds and cetaceans.

**Denmark**

Denmark has a long tradition of research in the Danish Wadden Sea. Studies are conducted by a number of institutes with expertise on various aspects of coastal ecosystems and tidal areas, e.g. the Fisheries and Maritime Museum, Danish Centre of Environment and Energy (DCE, Aarhus University) and the Geological Survey of Denmark and Greenland (GEUS, Copenhagen University). In addition, resource management, sustainable tourism and local development are researched at the Centre for Tourism, Innovation and Culture (TIC), University of Southern Denmark.

Since the late 1970s, the Danish Wadden Sea is protected by the Statutory Order on the Nature and Wildlife Reserve and since 2010 the area has been declared a national park. This means that there is a long tradition of management of the protected natural area that includes cooperation and knowledge sharing between governmental and local authorities and also involvement of other relevant authorities and NGOs in the management. The cooperation is formalized through the Advisory Board for the Wadden Sea which provides advices for the municipalities. There are other cooperation forums as described previously in this chapter (section 5d). A lot of experiences are available from NGOs who have supported the protection of the area and contributing with substantial practical and theoretical knowledge about the area, often collected over decades. Especially the Danish Ornithological Society contributes by taking part in monitoring birds.

**5.6 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.

Extensive information on the Wadden Sea, also for visitors to the inscribed and nominated property, is also available electronically via [www.waddensea-worldheritage.org](http://www.waddensea-worldheritage.org).
The German (Niedersachsen) extension is fully integrated within the already existing visitor facilities of a total of 16 information facilities – 2 larger visitor centers in Wilhelmshaven and Cuxhaven as well as 14 information houses on the East Frisian Islands and on the mainland. The 2 larger centres have recently been extended and designated officially as UNESCO World Heritage Visitor Centres. The 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 figure of 800,000 visitors to the facilities 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 have 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.

All Information sites in the area of the National Park and Biosphere Reserve offer nature and environmental education on several levels. Different programs for all ages can be booked. Children and young people with special interests in nature can join the Junior Ranger Program. In a first step they learn about different tasks of nature conservationists, later they follow their own interests in small projects and courses. In the end they get the chance to guide other children and even adult guests, help in monitoring projects and become tutors for younger children. To ensure a common high grade of education, the advisors are connected with colleagues in networks not only in Niedersachsen but, under the umbrella of EURO-PARC all over Germany and by the International Wadden Sea School (IWSS) in a trilateral context.

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.

**Denmark**

Visitor facilities in Denmark consist mainly of three different elements: visitor centers or exhibitions, nature guides, and open air facilities including hiking routes, bridle and cycle paths. Together the facilities aim at providing visitors high quality experiences and activities while at the same time increase their knowledge about the Wadden Sea’s natural and cultural values. A vast network of 10 large and small information centers and exhibitions are situated along the coast and on the islands. Some centers are staffed with nature guides while others have affiliated nature guides, and finally, a number of centers are unmanned displays. A common goal of the centers is that they are using posters, articles or electronic media to tell the natural and cultural history of the area they are located in.

**The Wadden Sea Interpreter Forum (VFF)**

The VFF is a Danish Wadden Sea collaboration between the public and independent institutions in the Wadden Sea raising awareness of the Wadden Sea natural and cultural history. Since the start in 2006 the purpose of the collaboration has been to establish a platform for a coherent dissemination along the Wadden Sea coast where the interpretation of natural, cultural and recreational forms a whole.

The visitor centres are the basis for the VFF which offers, in cooperation with the “National Park Wadden Sea”, a coordinated and effective communication through guided tours, activities and educational activities. Beside the VVF, a variety of local guides and storytellers offer guided tours.

The collaboration has developed towards a common understanding of standards and content of the interpretation of nature and history, e.g. through the digital platform www.vadehav.dk as well as active participant in the IWSS. In addition, it has developed an educational programme – My Wadden Sea – that is driven through the portal www.mitvadehav.dk. The establishment of VWF has resulted in a comprehensive collaboration and exchange of ideas across intermediation institutions and the local/national/regional tourist- and educational actors. Thus VFF has a close cooperation with the National Park Wadden Sea’s communication effort and in 2011 ‘My Wadden Sea’ was adopted as the national park’s official educational programme. The management of the VFF is done by a coordinating group responsible for the operations and development, including guidance of the employed interpretation coordinator.

In recent years, there has been a particular focus on educational activities for children, both nationally through the national park educational programme “Mit Vadehav” www.mitvadehav.dk and internationally through “The International Wadden Sea School” www.iwss.org where Danish nature guides are collaborating with German and Dutch nature guides. The educational programme ‘Mit vadehav’ is developed by the VVF and the Esbjerg Municipality school development programme. Finally the area has a well distributed infrastructure of information boards and facilities in the landscape like picnic areas, shelters, marked trails, nature playgrounds with special activities, etc. These facilities are important for providing free public events in a sustainable way for nature and for the local communities while at the same time raising awareness of the uniqueness of the landscape.

The Danish visitor centers and nature guides serve approx. 300,000 visitors a year. There is a great span of variation from 125,000 visitors at the Fisheries and Maritime Museum in Esbjerg to 6,000 guests at the local Nature Agency activities.

**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). There is no dedicated statistics available for the Danish nominated property. However the number of overnight stays and day trippers can be estimated to approximately 9.7 million in 2010. More details on visitor statistics are given in chapter 4.
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 website www.unesco-welterbe.org. 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 three Wadden Sea National Parks and the presentation in local media. The National Park Authorities together with information centres and other educational institutions provide further education for regional disseminators (e.g. national park partners and tour-guides) on how to communicate the topic World Heritage competently. Niedersachsen designated two Wadden Sea UNESCO World Heritage Visitor Centres in Wilhelmshaven and Cuxhaven and produced new exhibitions integrated the new corporate design and the topic World Heritage into its print materials, information boards, the internet presentations, produced a World Heritage leaflet, postcards and a movie, realized several exhibitions, publications and presentations of the topic and created and produced a World Heritage information column in cooperation with Schleswig-Holstein and Hamburg. Along the main motorways leading to the property, World Heritage road signs are in place. The cooperation between nature conservation and tourism has been significantly improved since the inscription into the World Heritage List.

The presentation and promotion of the Danish Wadden Sea are communicated primarily through direct communication and indirect through exhibitions, information boards and websites such as www.naturstyrelsen.dk, www.danmarksnationalparker.dk/vadehavet, www.vadehav.dk, etc. Denmark also expects to contribute to targeted promotion of the Wadden Sea through participation in the trilateral Interreg project PROWAD.

Denmark considers education in nature and environment as a key factor in the presentation of the Wadden Sea, especially after the establishment of the Wadden Sea National Park. Educational activities are a part of building awareness and ownership of the protection of the Wadden Sea. The primary strategy for communication is a combination of educational activities offered to schools and daycare centers, public information in the form of excursions and outdoor activities, and exhibitions targeting specific localities. The education, presentation and promotion of the area are considered a shared obligation at the governmental, municipal and private level.

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. The website for the property which is the central information and promotion site is www.waddensea-worldheritage.org.

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 Authority in Niedersachsen has a staff of 40 persons. The staff of the administration is supported by normal and water police forces, and by a network of wardens from coastal authorities (8), voluntary organisations/NGOs and counties (about 30). Information centres employ additional staff to do information and educational work.
The Danish staff level amounts to a total of 31. Most of the staff (25) is directly involved in the governmental management and protection of the nominated property. The National Park is still in an opening state and the permanent staff is currently 2 but expected to increase when the National Park comes into operation. Other public authorities employ staff who supports the protection and management. Visitor centres employ additional staff doing information and educational work.

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 Authority and Services (wardens, information centres) Niedersachsen</td>
<td>76</td>
</tr>
<tr>
<td>Denmark: Nature Agency, National Park, other Governmental agencies, Municipal Wadden Sea secretariat</td>
<td>31</td>
</tr>
<tr>
<td>Common Wadden Sea Secretariat</td>
<td>6</td>
</tr>
</tbody>
</table>

Table 5.3 Overview of staffing level
6. Monitoring

The state of conservation of the inscribed and nominated property is regularly reviewed and reported within the Trilateral Monitoring and Assessment Program (TMAP) and additional monitoring carried out within the area. 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 (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. Within the Hamburg national park, a reference area of about 10,400 ha has been designated (about 76% of the National Park). 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.

The TMAP Manual was updated in 2009 to meet the requirements of the European Union Directives and other international obligations.

<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>Nutrient inputs (riverine, atmospheric). Dissolved inorganic nutrients in water, total N and P.</td>
<td>Monthly / weekly (depends on location)</td>
<td>1 – 6 stations per region</td>
<td>TMAP Database</td>
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<tr>
<td>Contaminants in Water and Sediment</td>
<td>Metals in Sediment</td>
<td>As, Cr, Ni, Cu, Hg, Pb, Zn</td>
<td>Every 3 years (minimum)</td>
<td>3 sites per country (min.)</td>
<td>TMAP Database</td>
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<td></td>
<td>Organotin in Sediment</td>
<td>TBT substances (TBT, DBT, MBT, TPT)</td>
<td>Every 3-6 years (1/y at few stations)</td>
<td>1-6 stations per region</td>
<td>TMAP Database</td>
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<tr>
<td></td>
<td>Organochlorines, PAHs and PCBs in sediment</td>
<td>DDTs, HCHs, HCB, PAH (CEMPT WFD-PS), PCB (28, 52, 101, 118,138, 153, 180)</td>
<td>Every 3-6 years (1/y at few stations)</td>
<td>1-6 stations per region</td>
<td>TMAP Database</td>
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<tr>
<td>Plankton</td>
<td>Phytoplankton</td>
<td>Species composition and abundance, chlorophyll, co-variables</td>
<td>1/week – 1/month</td>
<td>1 – 6 stations per region</td>
<td>TMAP Database</td>
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<tr>
<td>Benthos</td>
<td>Macroalgae</td>
<td>Location and, area, biomass, species composition</td>
<td>Yearly</td>
<td>1 – 6 stations per region</td>
<td>TMAP Database</td>
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<td></td>
<td>Eelgrass</td>
<td>Location, area, coverage,</td>
<td>Entire area every 6 years, selected sites 1/y</td>
<td>Entire area and representative areas</td>
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<td></td>
<td>Macrozoobenthos communities</td>
<td>Species abundance, biomass, species composition</td>
<td>1/y to very 3 years</td>
<td>1-2 transects per region</td>
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<td>Blue mussels beds</td>
<td>Size of beds, (GIS contours of beds), biomass, mussel coverage of beds, additional parameters for selected beds (field surveys)</td>
<td>Yearly</td>
<td>All intertidal flats</td>
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<td>Contaminants in Blue mussels</td>
<td>Heavy metals, organochlorines, organotin, PAHs, PCBs</td>
<td>1/y to every 2 years</td>
<td>1-6 stations per region</td>
<td>TMAP Database</td>
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<tr>
<td>Fish</td>
<td>Distribution and abundance of fish species</td>
<td>Abundance and mean length of priority species, species composition, (all species), Transitional waters: abundance of pelagic species</td>
<td>Wadden Sea 1/y</td>
<td>Existing locations</td>
<td>TMAP Database</td>
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<td></td>
<td>Contaminants in Flounder</td>
<td>Heavy metals, organochlorines, organotin, PAHs, PCBs</td>
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<td>1 – 6 stations per region</td>
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<tr>
<td></td>
<td>Fishery parameters</td>
<td>Landings, vessels, size of culture lots, size of closed area</td>
<td>Yearly</td>
<td>Whole area</td>
<td>TMAP Database</td>
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## Chapter 6 Monitoring

<table>
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<th>Indicator</th>
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<td>2–4 sites per region</td>
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<td>Complete survey</td>
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<td>Synchronous counts (certain species)</td>
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<td>Every 6 years</td>
<td>Whole area</td>
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### 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 databases 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.

6.b Administrative arrangements for monitoring of the property

The Trilateral Monitoring and Assessment Expert Group (TMAG) is in charge to secure the harmonized management and methodological soundness of the TMAP, i.e. that assessments are produced with equal methodology and quality control, and Quality Status Reports are regularly produced, annual progress reports on the implementation of the TMAP made, and issues defined that need decision by the Cooperation. The chairperson of the TMAG is simultaneously member of the Task Group Management.

Expert network 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 continued to exchange information, coordinate monitoring, assess the results, and provide advice on the scientific basis for management.

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.

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 2009, the latest Quality Status Report (QSR 2009) of the Wadden Sea was published. After 1991, 1995, 1999 and 2004, it was the fifth 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”.

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.
Chapter 6 Monitoring

All reports are available from the Common Wadden Sea Secretariat (QSR Synthesis 2010, QSR 2009 see Annex 4 and Annex 5):


TMAP Reports in the publication series “Wadden Sea Ecosystem”


7. DOCUMENTATION

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 19.
The photographs about the Wadden Sea are compiled on a DVD Annex 21.

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
Designation of the Wadden Sea as Particularly Sensitive Sea Area (PSSA) by the International Maritime Organization, 2002, Annex 17.

Denmark

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 (English translation).
Of special importance to the Wadden Sea are the National Park Acts.

Niedersachsen

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:
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 manage-
ment 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. The recent Quality Status Reports 2009 together with the Synthesis Report 2010 is at www.waddensea-secretariat.org.

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:

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Nature Agency
Skovridervej 3,
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nst@nst.dk
www.naturstyrelsen.dk

Germany
Niedersachsen
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Virchowstr. 1
D- 26382 Wilhelmshaven
www.nationalpark-wattenmeer.de

7.e Bibliography

A list of references for the Wadden Sea including an update since 2009 and a more specific one for the Danish part of the Wadden Sea is provided below. This is a small part of the large scientific literature which exists for the nominated property. A comprehensive bibliography for the property and the nominated extension containing over 700 references was provided in Annex 9 of the nomination dossier 2008.


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### 8. Other local institutions

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<tr>
<td>Natur- og Kulturformidlingscenter Myrthuegård</td>
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### Contact Information

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<tr>
<td>Nationalpark-Haus Wangerooge</td>
<td>Friedrich-August-Str. 18</td>
<td>D-26486</td>
<td>Wangerooge</td>
<td><a href="mailto:nationalparkhaus@wangerooge.de">nationalparkhaus@wangerooge.de</a></td>
</tr>
<tr>
<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>
</tr>
<tr>
<td>UNESCO-Weltnaturerbe Wattenmeer Besucherzentrum Cuxhaven</td>
<td>Hans-Claußen-Str. 19</td>
<td>D-27476</td>
<td>Cuxhaven</td>
<td><a href="mailto:wattbz@cuxhaven.de">wattbz@cuxhaven.de</a></td>
</tr>
<tr>
<td>UNESCO-Weltnaturerbe Wattenmeer Besucherzentrum Wilhelmshaven</td>
<td>Südstrand 110 B</td>
<td>D-26382</td>
<td>Wilhelmshaven</td>
<td><a href="mailto:info@wattenmeer-besucherzentrum.de">info@wattenmeer-besucherzentrum.de</a></td>
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<tr>
<td>Nationalpark-Haus Wittbülen 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>
</tr>
<tr>
<td>Nationalpark-Haus Wangerland</td>
<td>Kirchstraße 9</td>
<td>D-26434</td>
<td>Wangerland-Minsen</td>
<td><a href="mailto:nationalpark-haus@wangerland.de">nationalpark-haus@wangerland.de</a></td>
</tr>
</tbody>
</table>

### 8.d Official Web addresses

The official website of the property with links also to further websites

[www.waddensea-worldheritage.org](http://www.waddensea-worldheritage.org)
9. SIGNATURES

For the Kingdom of Denmark

Minister of Culture

Marianne Jelved

Co-signed by the Kingdom of the Netherlands as state party to the property

Minister for Agriculture

Sharon Dijksma

For the Government of the Federal Republic of Germany

Federal Minister for the Environment, Nature Conservation and Nuclear Safety, Germany

Peter Altmaier

Prime Minister of Niedersachsen

David McAllister