



# Wadden monitoring in the spotlight

Wadden Sea Long-Term Ecosystem Research (WaLTER)  
Waddenacademie KNAW  
Common Wadden Sea Secretariat (CWSS)

# Wadden monitoring in the spotlight

Cross-bordering maps on ecology  
and socio-economy of Denmark,  
Germany and The Netherlands

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## Introduction

The Wadden Sea is a unique natural intertidal ecosystem of global importance, stretching from Den Helder in The Netherlands, past the rivers and estuaries in Germany to Esbjerg in Denmark. The Wadden Sea region not only harbours a suite of distinctive plants and animals, but is also home to humans, from tourists to people living and working in the area. Its Outstanding Universal Value (OUV) was acknowledged by UNESCO, resulting in the inscription of the Dutch-German Wadden Sea on the World Heritage List in 2009. Extension with the Danish part is anticipated for 2014. The World Heritage status underlines that the entire Wadden Sea is a single ecological entity which must be managed in a harmonised way, protecting its completeness and intactness. The inscription on the World Heritage List also offers new opportunities for regional sustainable development whilst safeguarding its OUV for the benefits of present and future generations.

Long-term monitoring efforts are essential to evaluate the effectiveness of management strategies to achieve these goals. Information on the status and trends of well-chosen ecological, socio-economic and cultural parameters of the Wadden Sea region enables the identification of the progress made as the result of these actions compared to natural changes. The Trilateral Monitoring and Assessment Programme (TMAP) and other long-term monitoring programmes such as national meteorological observations and demographic surveys, provide us with this opportunity.

Such programmes revealed, for example, that winters are getting milder, that during storm surges water levels may reach up to almost five meters above mean sea level, that the sheltered basins in the southern Wadden Sea are the hotspots for mussel beds and that the trend in the number of oystercatchers is very different from that of curlews. At the same time, monitoring shows that the change in numbers of inhabitants in Wadden Sea municipalities bordering the Wadden Sea greatly varies between regions, and that labour demand in the Wadden Sea area is lagging behind compared to the rest of Denmark, Germany and The Netherlands.

This booklet visualizes a selection of recent monitoring results of the entire trilateral Wadden Sea to illustrate that continued, harmonised and effective trilateral monitoring and assessment programmes, based on sound scientific evidence, are necessary to expand our knowledge on the on-going and ever-changing interactions between ecological and socio-economic drivers within this region. Present and future information and insights from monitoring are not only essential for the protection of natural values and livelihoods of the Wadden Sea, but also provide lessons of wider scientific importance for wetlands of international value and for coastal management.

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Common Wadden Sea Secretariat

# Science-Policy Matrix

At the 2010 trilateral Wadden Sea Conference (Sylt, Germany) the governments of Denmark, Germany and The Netherlands agreed that a trilateral research agenda should be developed. At its meeting in March 2013, the Wadden Sea Board has requested the Waddenacademie to present an overview of the most pressing policy issues in relation to the availability of relevant information. Following this request, the Waddenacademie and the Common Wadden Sea Secretariat developed a so-called “science-policy matrix”, in which policy relevance and knowledge availability have been integrated<sup>1</sup>. After testing the relevance and usability of the matrix by experts, including the Trilateral Monitoring and Assessment Group and the trilateral Task Group “Management”, the structure and entries of the matrix were further refined during a trilateral workshop. The matrix is now ready to be used as a starting point for discussions between policy makers and the scientific community on prioritising trilateral policy-relevant research.

<sup>1</sup> Based on the concept presented by Fergus Molloy of the Great Barrier Reef Marine Park Authority (Australia) during the 13<sup>th</sup> International Scientific Wadden Sea Symposium, 21 November 2012, Leeuwarden, The Netherlands.

<b>Degree of concern to management</b>	High	Management has a high level of concern for the value due to its current degraded condition and/or the high level of single or cumulative pressures affecting it.	
	Moderate	Management has a moderate level of concern for the value due to its current condition and/or the moderate level of single or cumulative pressures affecting it.	
	Low	Management has a low level of concern for the value due to its current good condition and/or the low level of single or cumulative pressures affecting it.	

<b>Adequacy of information</b> NB. “Information” includes data availability on developments, as well as understanding the causes of changes observed.	Good	The good level of information available directly supports management decisions and is currently sufficient to allow progress on the particular issue/interaction. However, further information to support ongoing adaptive management may still be required.	
	Moderate	The moderate level of information gives a reasonable basis for management decisions, but decisions regarding some aspects of the issue/interaction may be hampered by current knowledge gaps.	
	Low	The low amount or adequacy of information is a hindrance to management. Decisions are pending the availability of improved scientific understanding of the issue/interaction.	

		Tourism	Coastal Protection Activities	Fishing & Aquaculture	Agriculture	Mining	Energy Generation	Ports & Shipping	Population Development	Alien Species	Pollution	Eutrophication	Climate Change	Sea Level Rise	Governance & Government
<b>GEO-SCIENCES</b>	Subsurface & Geofluids														
	Long-Term Geomorphology														
	Short-Term Morphodynamics														
<b>ECOLOGY</b>	Marine Mammals														
	Birds														
	Fish														
	Salt Marshes														
	Beaches & Dunes														
	Tidal Area: Intertidal Habitats														
	Tidal Area: Subtidal Habitats														
	Offshore Area														
	Estuaries														
<b>ECONOMY &amp; SOCIETY</b>	Employment														
	Income														
	Demographic Structure														
	Liveability														
	Livelihood & Identity														
<b>CULTURAL HERITAGE</b>	Historical Landscape <sup>1</sup>														
	Tangible Heritage <sup>2</sup>														
	Intangible Heritage <sup>3</sup>														
	Use & Management														
<b>CLIMATE &amp; WATER</b>	Safety														
	Water Quality														
	Freshwater Availability														

As defined in:

1 European landscape convention 2000;

2 Convention concerning the protection of the world cultural and natural heritage;

3 Convention for the safeguarding of intangible cultural heritage 2003.

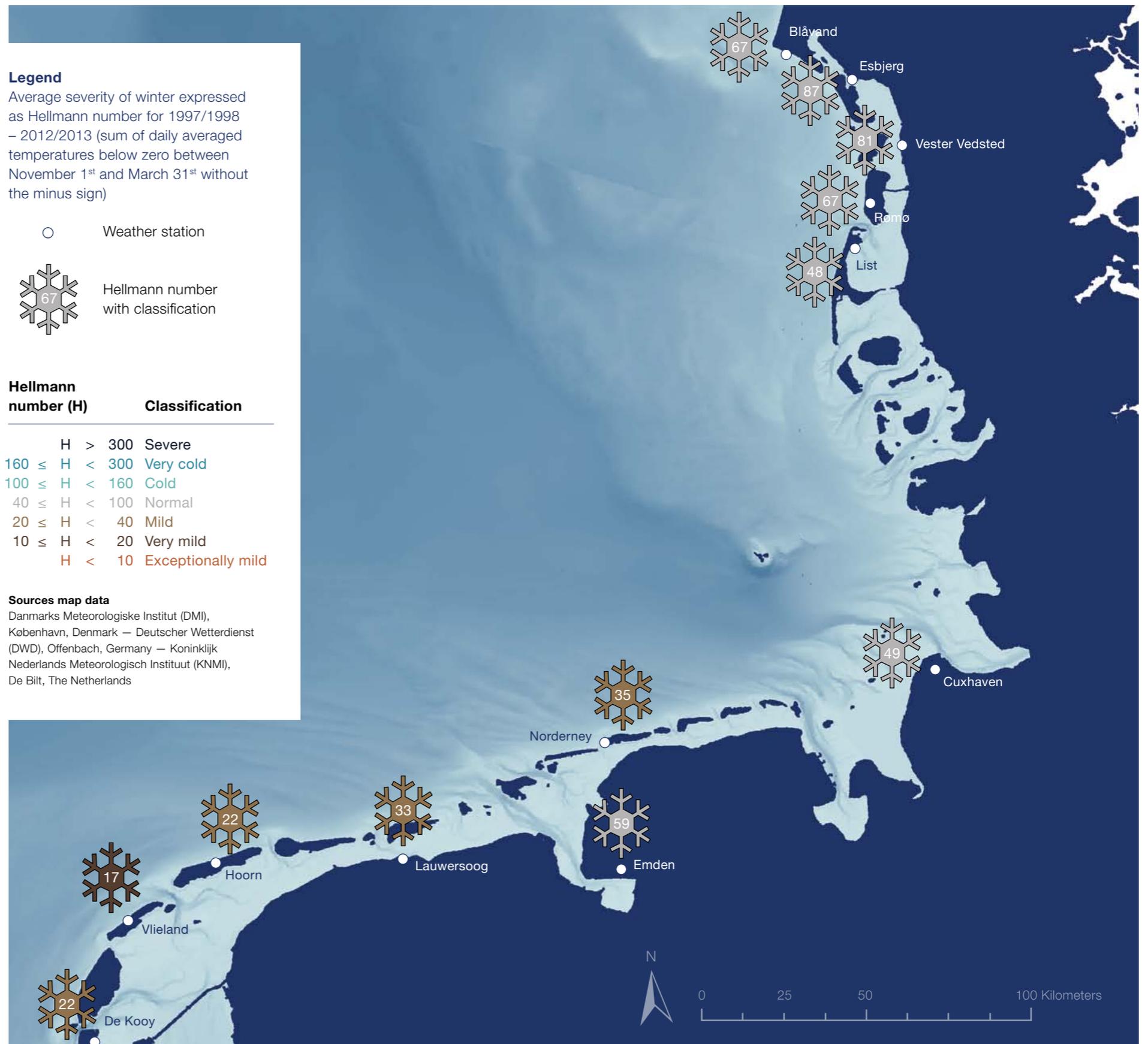
“It’s cold up north,  
but gradually  
getting warmer”



# 01 Winter severity

Temperatures are far from homogenous in the Wadden Sea area. Based on average values for an index for winter severity, the so-called Hellmann number<sup>1</sup>, winters (1997/1998-2012/2013) in the Wadden Sea ranged between normal in the north-eastern part to very mild in the south-western part. (But year-to-year variation in the Hellmann number at each station is larger than the regional differences presented in the figure.) Since winter severity is correlated with the rates of ecological processes such as the recruitment success of bivalves<sup>2</sup> and the survival of wintering birds<sup>3</sup>, spatial differences in temperature may result in regional variation in species and habitats of the Wadden Sea. The Wadden Sea is located close to the North Sea and Baltic Sea, which are the two fastest warming large marine ecosystems in the world<sup>4</sup>. Within north-western Europe, winter temperatures have already risen<sup>5</sup> and are expected to rise further, whilst winters will also become wetter and extreme precipitation amounts will increase<sup>6</sup>. Consequences of these changes in environmental conditions for the natural values of the Wadden Sea area are, however, difficult to assess due to the complex interactions within the ecosystem<sup>7,8</sup>.

1 Hellmann G, 1917. Über strenge Winter. Abhandlungen der Königlich Preussische Akademie der Wissenschaften. Reichsdruckerei, Berlin.  
 2 Beukema JJ, Dekker R, Jansen JM, 2009. Some like it cold: populations of the tellinid bivalve *Macoma balthica* (L.) suffer in various ways from a warming climate. Marine Ecology Progress Series 384, 135-145.  
 3 Joint Monitoring Group of Breeding Birds, 2013. CWSS Workshop Report Breeding Birds in Trouble, Wilhelmshaven, 18 April 2013.  
 4 Belkin IM, 2009. Rapid warming of large marine ecosystems. Progress in Oceanography 81, 223-236.  
 5 <http://www.knmi.nl/klimatologie/lijsten/hellmann.html>  
 6 Intergovernmental Panel on Climate Change, 2013. Fifth Assessment Report.  
 7 Philippart K, Epping E, 2009. Climate change and ecology. Thematic Report No. 4.2. In: Marencic H, de Vlas J (Eds) 2009. Quality Status Report 2009. Wadden Sea Ecosystem No. 25. Common Wadden Sea Secretariat, Trilateral Monitoring and Assessment Group, Wilhelmshaven, Germany.  
 8 Oost A, Kabat P, Wiersma A, Hofstede J, 2009. Climate. Thematic Report No. 4.1. In: Marencic H, de Vlas J (Eds) 2009. Quality Status Report 2009. Wadden Sea Ecosystem No. 25. Common Wadden Sea Secretariat, Trilateral Monitoring and Assessment Group, Wilhelmshaven, Germany.



“Growing safely  
with the sea”



## 02 Storm surges

More than 10,000 years of rising sea levels but also regional differences in tides and storm intensity have shaped the Wadden Sea as we know it today<sup>1</sup>. The length of the barrier islands, for example, increases from the Elbe/Weser area in Niedersachsen towards the north and west as the result of decreasing tidal ranges in these directions. In the past, storm surges turned large parts of the land into tidal areas, which could grow with rising sea levels through sedimentation. Nowadays coastal defence structures safeguard the land from being flooded. At the same time, the mainland behind the dikes may rise or fall depending on the local conditions. A lowering of the land, in some locations of Groningen in The Netherlands of more than 60 cm by 2050<sup>2</sup>, increases the potential impacts of flooding as well as the costs of maintaining a certain safety standard. It might be time to rethink our strategies: can we create a landscape that is able to grow safely with the sea<sup>3</sup>?

- 1 Wiersma AP, Oost AP, van der Berg MW, Vos PC, Marges V, de Vries S, 2009. Geomorphology. Thematic Report No. 9. In: Marencic H, de Vlas J (Eds) 2009. Quality Status Report 2009. Wadden Sea Ecosystem No. 25. Common Wadden Sea Secretariat, Trilateral Monitoring and Assessment Group, Wilhelmshaven, Germany.
- 2 <http://www.natuurinformatie.nl/ndb.mcp/natuurdatabase.nl/1000877.html>
- 3 Reise K, 2013. A natural history of the Wadden Sea – riddled by contingencies. Waddenacademie, Leeuwarden.

### Legend

Maximum sea levels (meters above mean sea level) during storm surges since local records began

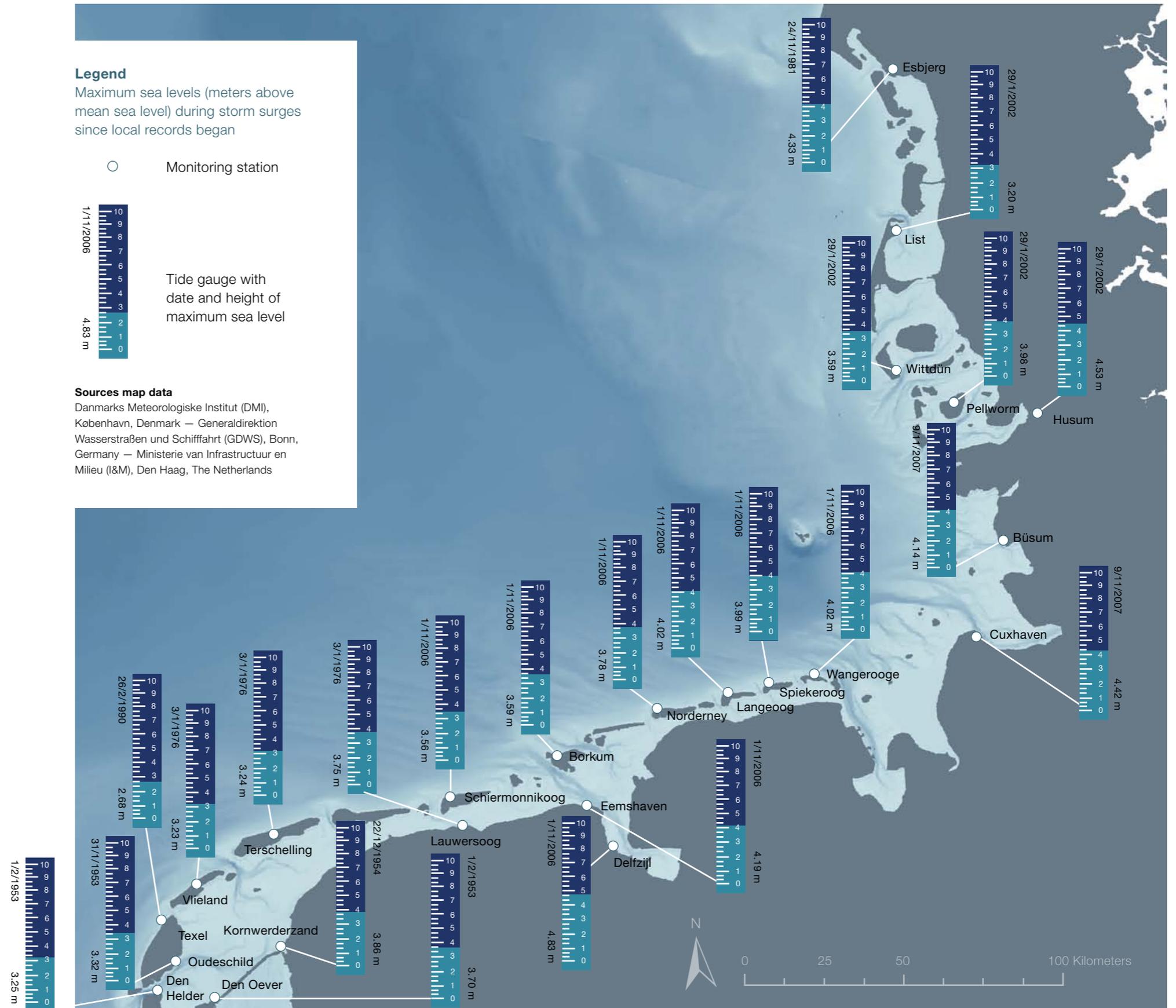
○ Monitoring station



Tide gauge with date and height of maximum sea level

### Sources map data

Danmarks Meteorologiske Institut (DMI), København, Denmark — Generaldirektion Wasserstraßen und Schifffahrt (GDWS), Bonn, Germany — Ministerie van Infrastructuur en Milieu (I&M), Den Haag, The Netherlands

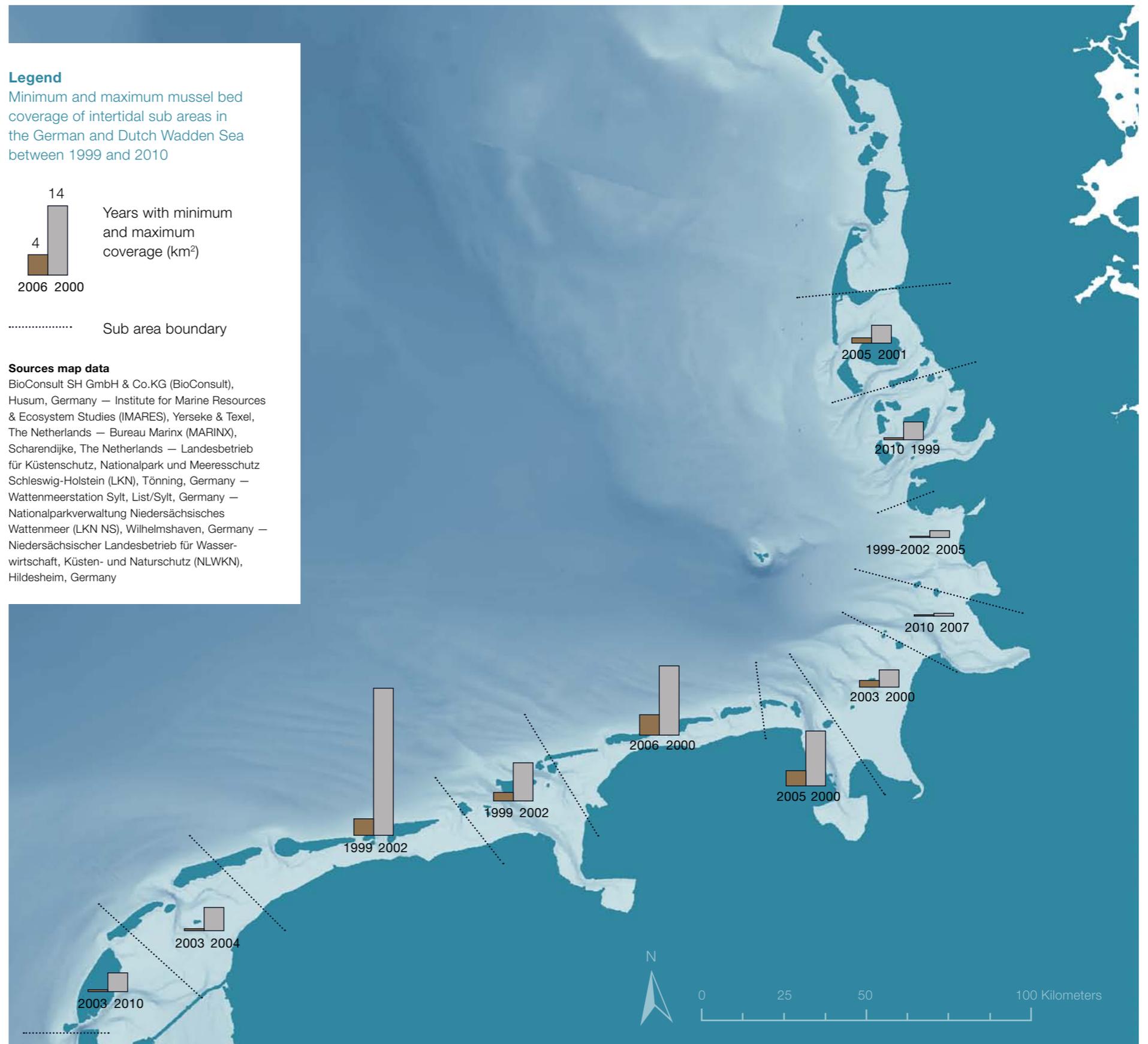


**“Hotspots of  
cold-blooded animals”**

### 03 Intertidal mussel beds

Intertidal mussel beds are of central importance for the Wadden Sea, both as a structuring component of tidal habitats and as a food source for shellfish-eating birds. Not all parts of the Wadden Sea are equally suited for harbouring mussel beds. Since the late 1960s, highest coverage of tidal flats by mussel beds occurred in the sheltered basins in the southern Wadden Sea whilst the hydrodynamically exposed tidal flats near the Elbe estuary were almost devoid of mussels<sup>1,2</sup>. Although the overall Wadden Sea wide patterns in “hot-spots” and “cold-spots” for intertidal mussel beds were more or less stable during the past decades, the coverage of tidal flats by mussel beds varied strongly from year to year. South of the islands of Terschelling and Ameland, for example, the area of the tidal flats covered by mussel beds ranged between 3 km<sup>2</sup> in 1999 to almost 30 km<sup>2</sup> in 2002. These annual variations in coverage by adult mussels are mostly due to recruitment success, i.e. the number of new-born mussels that are able to settle and survive on the tidal flats<sup>3,4</sup>.

1 Dijkema KS, van Thienen G, van Beek JG, 1989. Habitats of The Netherlands, German and Danish Wadden Sea. Texel: Research Institute for Nature Management, Veth Foundation, Leiden.  
 2 Folmer EO, Drent J, Troost K, Büttger H, Dankers N, Jansen J, van Stralen M, Millat G, Herlyn M, Philippart CJM, 2014. Large-scale spatial dynamics of intertidal mussel (*Mytilus edulis* L.) bed coverage in the German and Dutch Wadden Sea. Ecosystems (in press).  
 3 Beukema JJ, Dekker R, Essink K, Michaelis H, 2001. Synchronized reproductive success of the main bivalve species in the Wadden Sea: causes and consequences. Marine Ecology Progress Series 211, 143-155.  
 4 Strasser M, Dekker R, Essink K, Günther CP, Jaklin S, Kröncke I, Madsen PB, Michaelis H, Vedel G, 2003. How predictable is high bivalve recruitment in the Wadden Sea after a severe winter? Journal of Sea Research 49, 47-57.



“In the Wadden Sea region,  
the increase in the number  
of jobs is relatively slow”



## 04 Employment

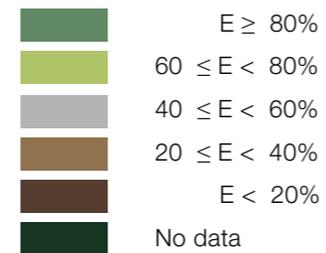
Whilst many inhabitants of the Wadden Sea region used to earn their income within the fisheries and agriculture sector, more and more people in this area are now employed in the service sector associated with tourism. On the mainland coast and especially in the harbour cities of the Wadden Sea, employment in the industrial sector, such as the automobile industry, can also be substantial. Employment is highest on Sylt due to the large net flow of workers to this municipality from neighbouring areas, while Emden also ranks high<sup>1</sup>. In general, however, employment in the German Wadden Sea area is currently lower than that in the Dutch part of the Wadden Sea. Data analysis shows that in the past decade, the number of jobs in the Wadden Sea region has grown at a much slower rate than their respective national averages, implying that labour demand in the Wadden Sea area is lagging behind with respect to the rest of Denmark, Germany and The Netherlands.

<sup>1</sup> Sijtsma FJ, Broersma L, Daams MN, Mehnen N, Oostra M, Sietes A, 2014. A socio-economic sketch of the international Wadden area. Data analysis was performed within the framework of Wadden Sea Long-Term Ecosystem Research (WaLTER).

### Legend

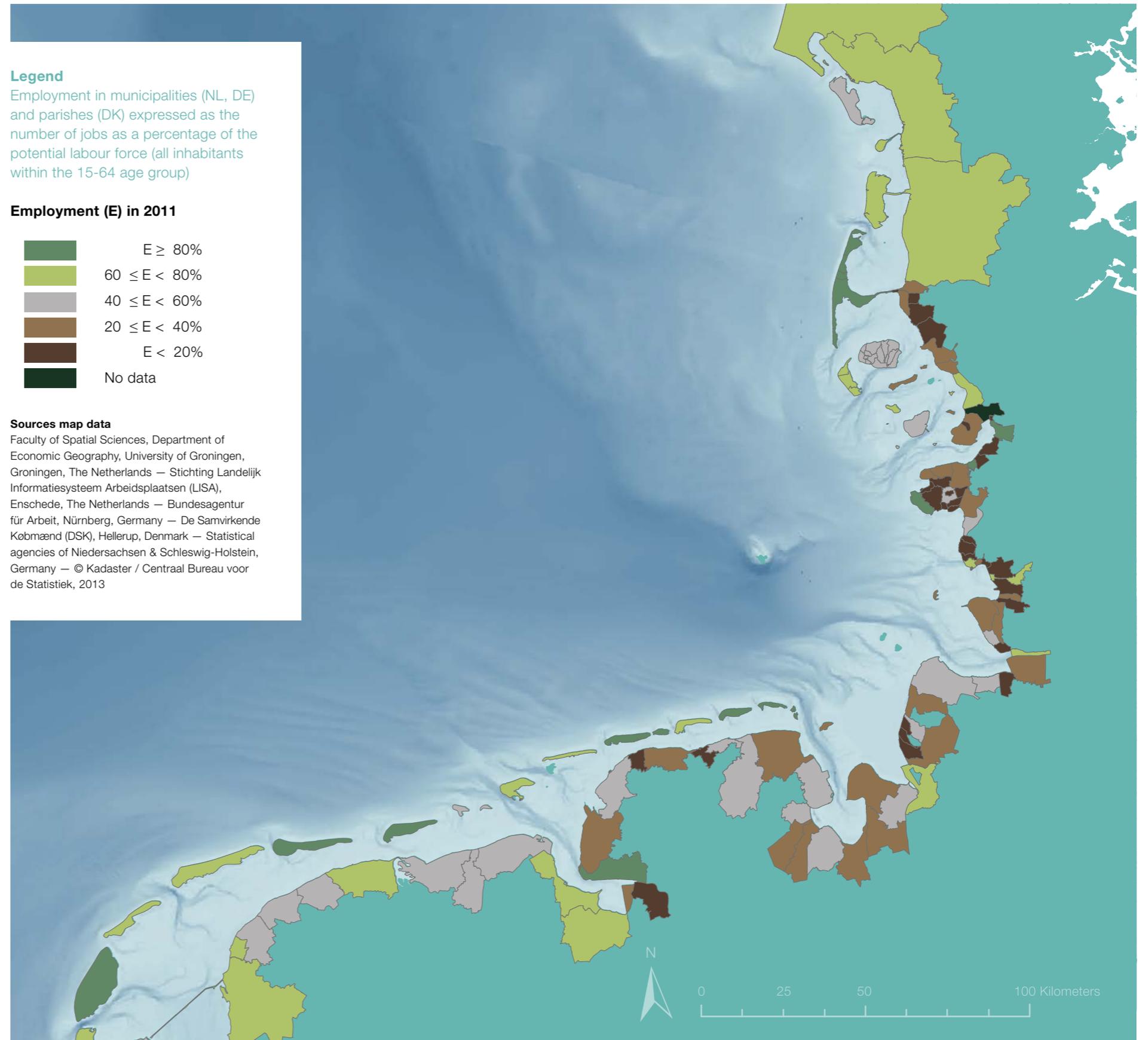
Employment in municipalities (NL, DE) and parishes (DK) expressed as the number of jobs as a percentage of the potential labour force (all inhabitants within the 15-64 age group)

### Employment (E) in 2011



### Sources map data

Faculty of Spatial Sciences, Department of Economic Geography, University of Groningen, Groningen, The Netherlands — Stichting Landelijk Informatiesysteem Arbeidsplaatsen (LISA), Enschede, The Netherlands — Bundesagentur für Arbeit, Nürnberg, Germany — De Samvirkende Købmænd (DSK), Hellerup, Denmark — Statistical agencies of Niedersachsen & Schleswig-Holstein, Germany — © Kadaster / Centraal Bureau voor de Statistiek, 2013





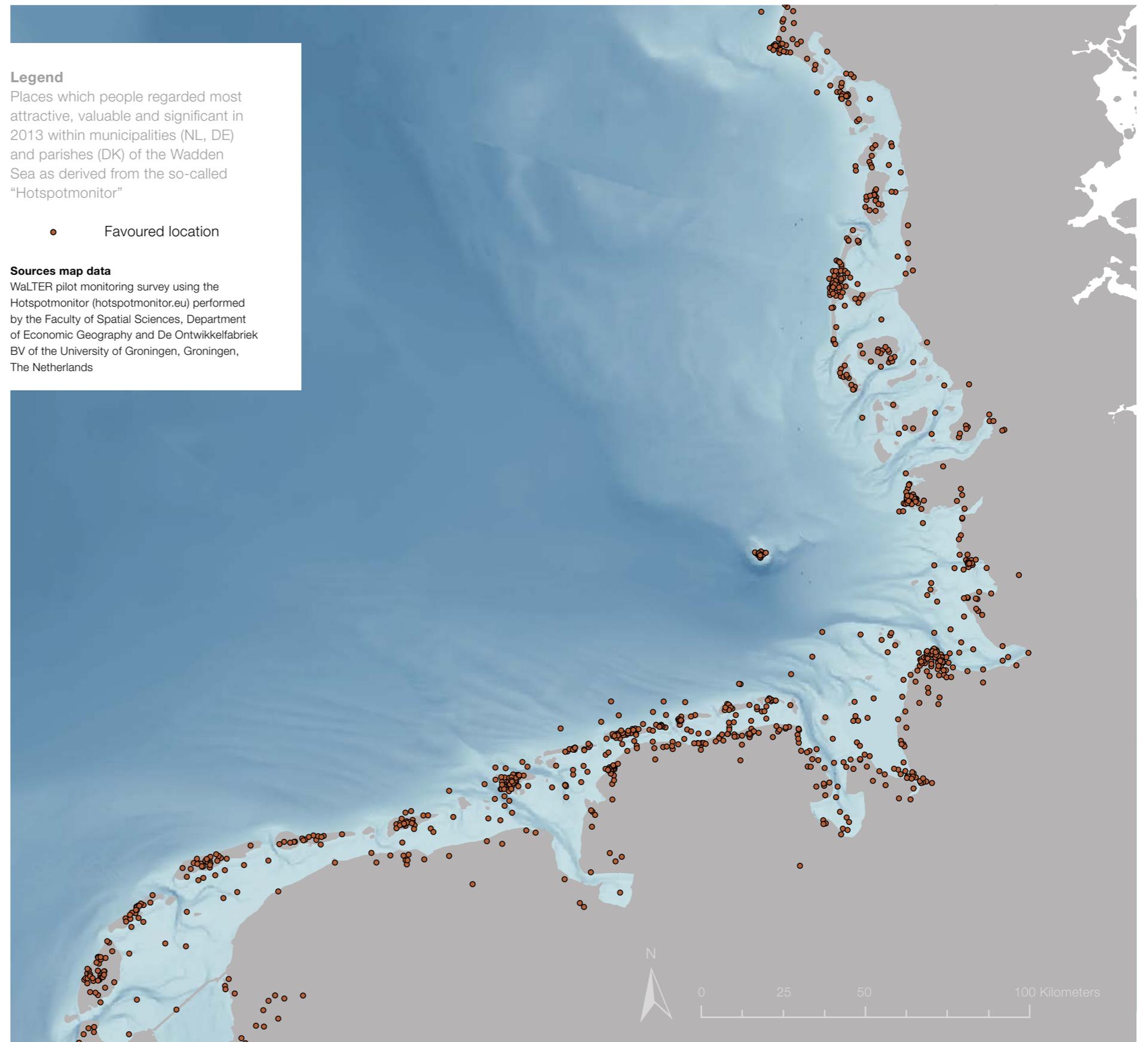
“Wonderful nature”

## 05 Scenery

Millions of visitors come to the Wadden Sea area every year. They experience its environmental qualities such as the purity and immensity of the natural surroundings and they often feel strongly connected to nature in this setting<sup>1</sup>. The islands are generally considered very appealing throughout the trilateral area<sup>2</sup>. As one respondent in a survey<sup>1</sup> to examine the incentives of tourists for visiting the Wadden Sea region said "Purenness, peacefulness, wonderful nature. Actually: fantastic!". With regard to the mainland, the scenery of the coastline of Niedersachsen is clearly much more appreciated than that of the Netherlands and Denmark<sup>2</sup>. This could be due to the long history of seaside resorts on the East Frisian coast in contrast to the other areas in the Wadden Sea region where such activities were only started in the 20<sup>th</sup> century. Today, small villages and harbour towns throughout the German Wadden Sea area still attract a lot of tourists, who deeply value the characteristic landscapes.

1 Sijsma FJ, Daams MN, Farjon H, Buijs AE, 2012. Deep feelings around a shallow coast. A spatial analysis of tourism jobs and the attractiveness of nature in the Dutch Wadden area. *Ocean & Coastal Management* 68, 138-148.

2 Sijsma FJ, Broersma L, Daams MN, Mehnen N, Oostra M, Sietses A, 2014. A socio-economic sketch of the international Wadden area. Within the WaLTER project, socio-economic scientists initiated a trilateral survey with the so-called "Hotspotmonitor". Over 7000 respondents throughout the three countries were requested to mark on a map which natural areas they find highly appealing, valuable or important on a national scale (<http://hotspotmonitor.eu>).



“Oystercatchers as tell-tales, but what is the tale that they are telling us?”

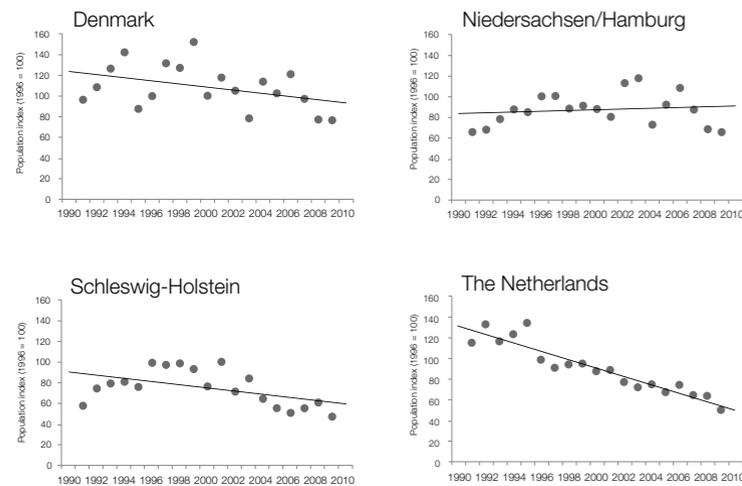


## 06 Oystercatchers

Since 1991, breeding oystercatchers have been in decline in nearly all parts of the Wadden Sea region<sup>1</sup>. This decline has accelerated since 2000, with numbers dropping on average by 4% each year. Poor breeding success is considered one of the main reasons for this decline<sup>1</sup>. In The Netherlands, the increased frequency of flooding appears to have caused many nests to fail<sup>1</sup>. If this is indeed the case, it raises important questions regarding how current management practices of natural and manmade salt marshes may have contributed to the observed declines. At many sites along the mainland throughout the Wadden Sea region, oystercatchers also suffered from increased predation. Furthermore, during winter these birds may have experienced food shortages<sup>2</sup> and started their breeding season in poor condition resulting in low breeding success. The different rates of this downward trend in the different areas suggest that the strength and nature of these causes are not constant across the entire Wadden Sea area, and that various factors are at play.

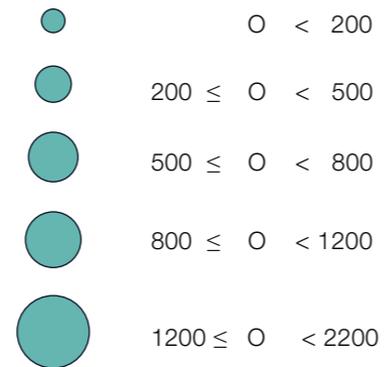
- 1 Joint Monitoring Group of Breeding Birds, 2013. CWSS Workshop Report Breeding Birds in Trouble, Wilhelmshaven, 18 April 2013.
- 2 van Roomen M, Laursen K, van Turnhout C, van Winden E, Blew J, Eskildsen K, Günther K, Hälterlein B, Kleefstra R, Potel P, Schrader S, Luerssen G, Ens BJ, 2012. Signals from the Wadden Sea: Population declines dominate among waterbirds depending on intertidal mudflats. *Ocean & Coastal Management* 68, 79-88.

### Trends in number of breeding pairs of oystercatchers in census areas in different sections of the Wadden Sea from 1991 to 2009, relative to the situation in 1996

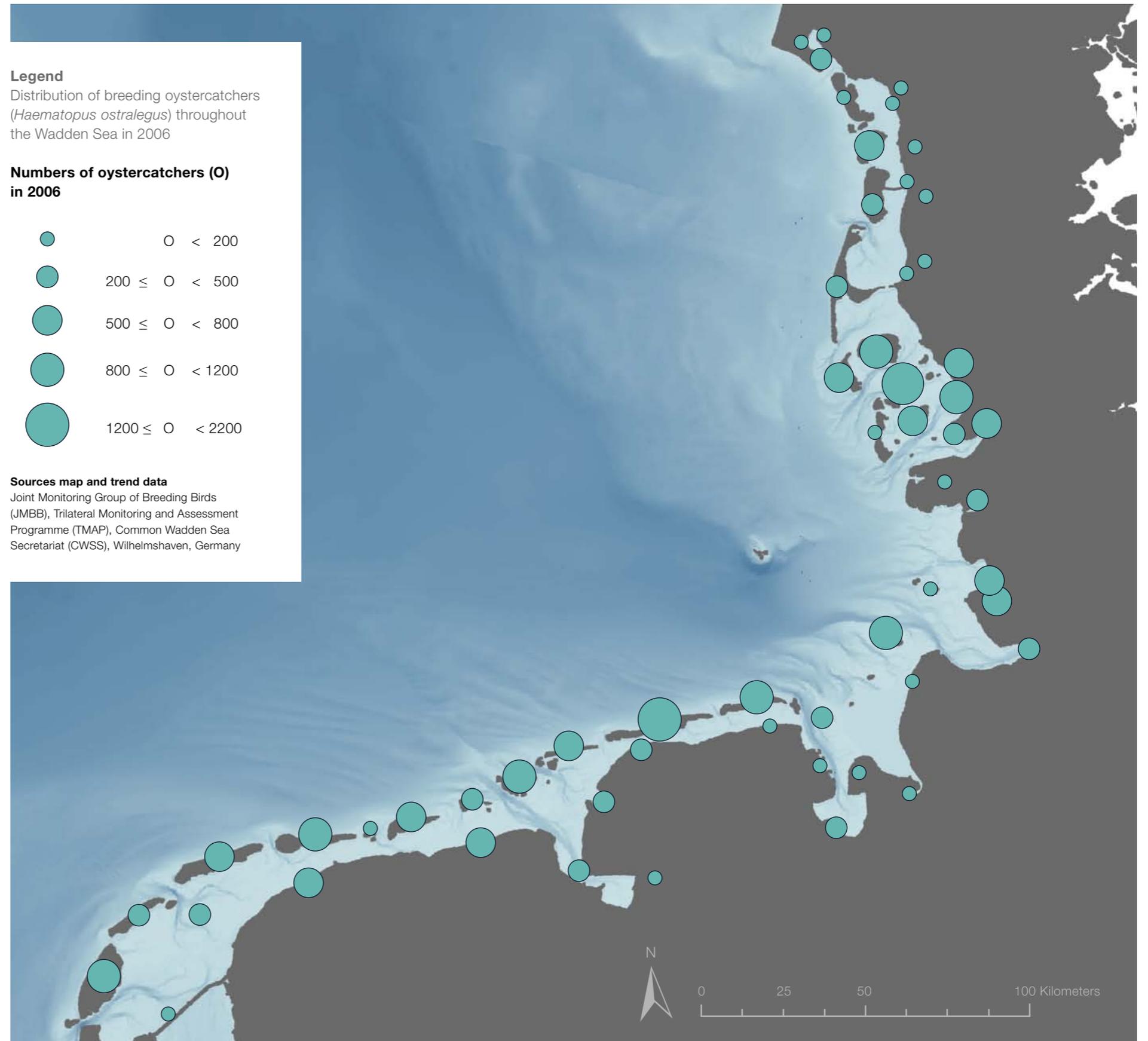


**Legend**  
Distribution of breeding oystercatchers (*Haematopus ostralegus*) throughout the Wadden Sea in 2006

#### Numbers of oystercatchers (O) in 2006



**Sources map and trend data**  
Joint Monitoring Group of Breeding Birds (JMBB), Trilateral Monitoring and Assessment Programme (TMAP), Common Wadden Sea Secretariat (CWSS), Wilhelmshaven, Germany



“Population decline  
is often followed  
by impoverishment”



## 07 Demography

Today, many coastal communities around the world face population declines, often followed by impoverished living conditions. Within the trilateral Wadden Sea area, the population size of approximately half of the coastal municipalities is slightly increasing<sup>1,2</sup>, in particular on the isles and in the western part. Nevertheless, during the last ten years the number of people living near the coast has declined in many of the Wadden Sea municipalities, predominantly in Schleswig-Holstein and Denmark, for example at the German isle of Gröde<sup>3</sup>. This general declining trend is expected to continue in many parts of the Wadden Sea area. For instance, the number of inhabitants in the north-eastern section of the Dutch Wadden Sea coastal region is expected to have declined by 15% by 2040<sup>4</sup>. Local initiatives are striving to counteract the decline and are aiming at attracting new inhabitants.

- 1 Sijsma FJ, Broersma L, Daams MN, Mehnen N, Oostra M, Sietses A, 2014. A socio-economic sketch of the international Wadden area. Data analysis was performed within the framework of Wadden Sea Long-Term Ecosystem Research (WaLTER).
- 2 Maximum population increase of +8,6% occurred at Danish parish of Mosevrå (as outlier excluded from the map).
- 3 Maximum population decrease of -17.9% occurred at German isle of Gröde (as outlier excluded from the map).
- 4 <http://www.pbl.nl/en/dossiers/Sustainabledevelopment>

### Legend

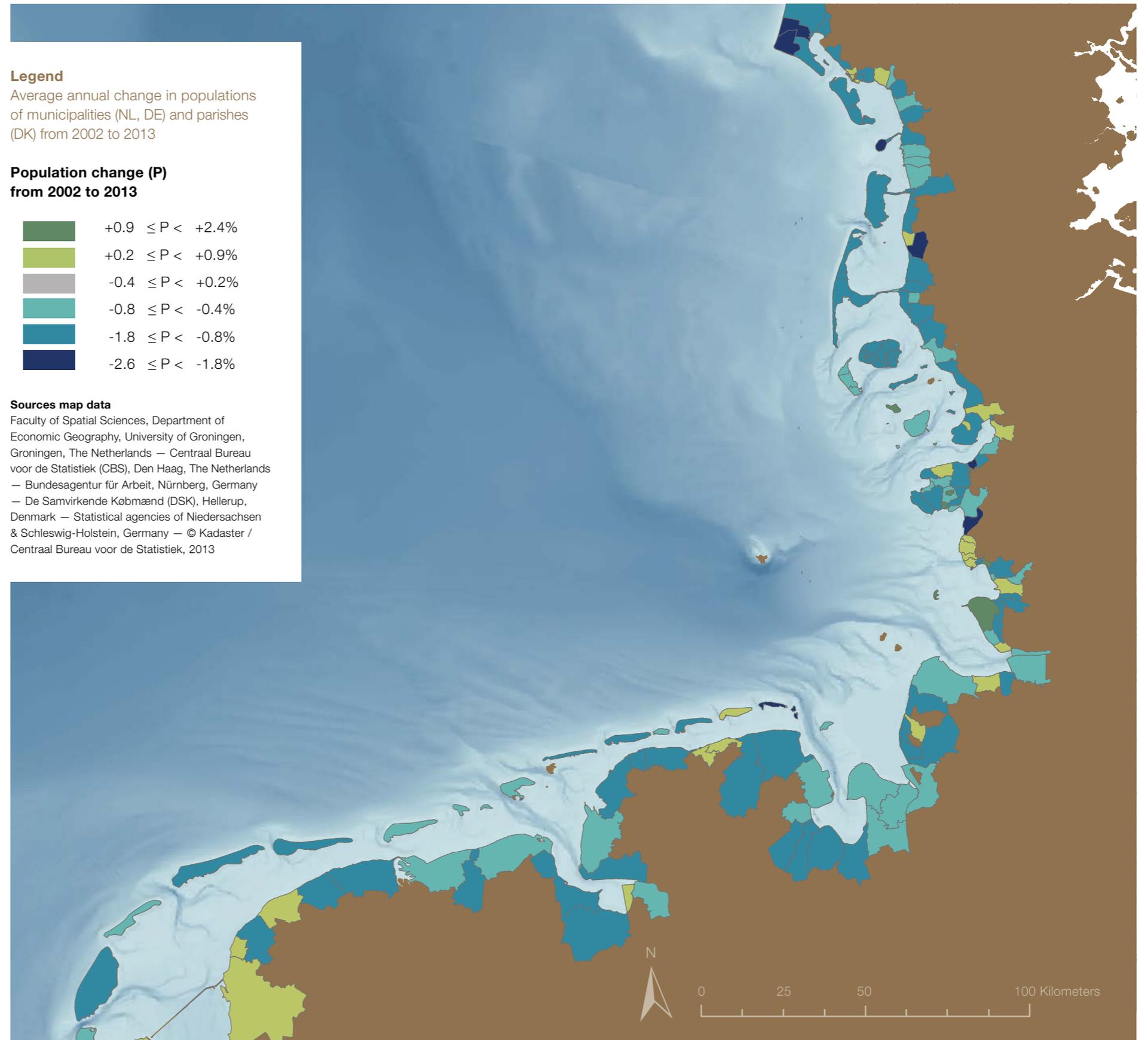
Average annual change in populations of municipalities (NL, DE) and parishes (DK) from 2002 to 2013

### Population change (P) from 2002 to 2013

	$+0.9 \leq P < +2.4\%$
	$+0.2 \leq P < +0.9\%$
	$-0.4 \leq P < +0.2\%$
	$-0.8 \leq P < -0.4\%$
	$-1.8 \leq P < -0.8\%$
	$-2.6 \leq P < -1.8\%$

### Sources map data

Faculty of Spatial Sciences, Department of Economic Geography, University of Groningen, Groningen, The Netherlands — Centraal Bureau voor de Statistiek (CBS), Den Haag, The Netherlands — Bundesagentur für Arbeit, Nürnberg, Germany — De Samvirkende Købmænd (DSK), Hellerup, Denmark — Statistical agencies of Niedersachsen & Schleswig-Holstein, Germany — © Kadaster / Centraal Bureau voor de Statistiek, 2013





“Stable numbers in the central Wadden Sea and going upward at the edges”

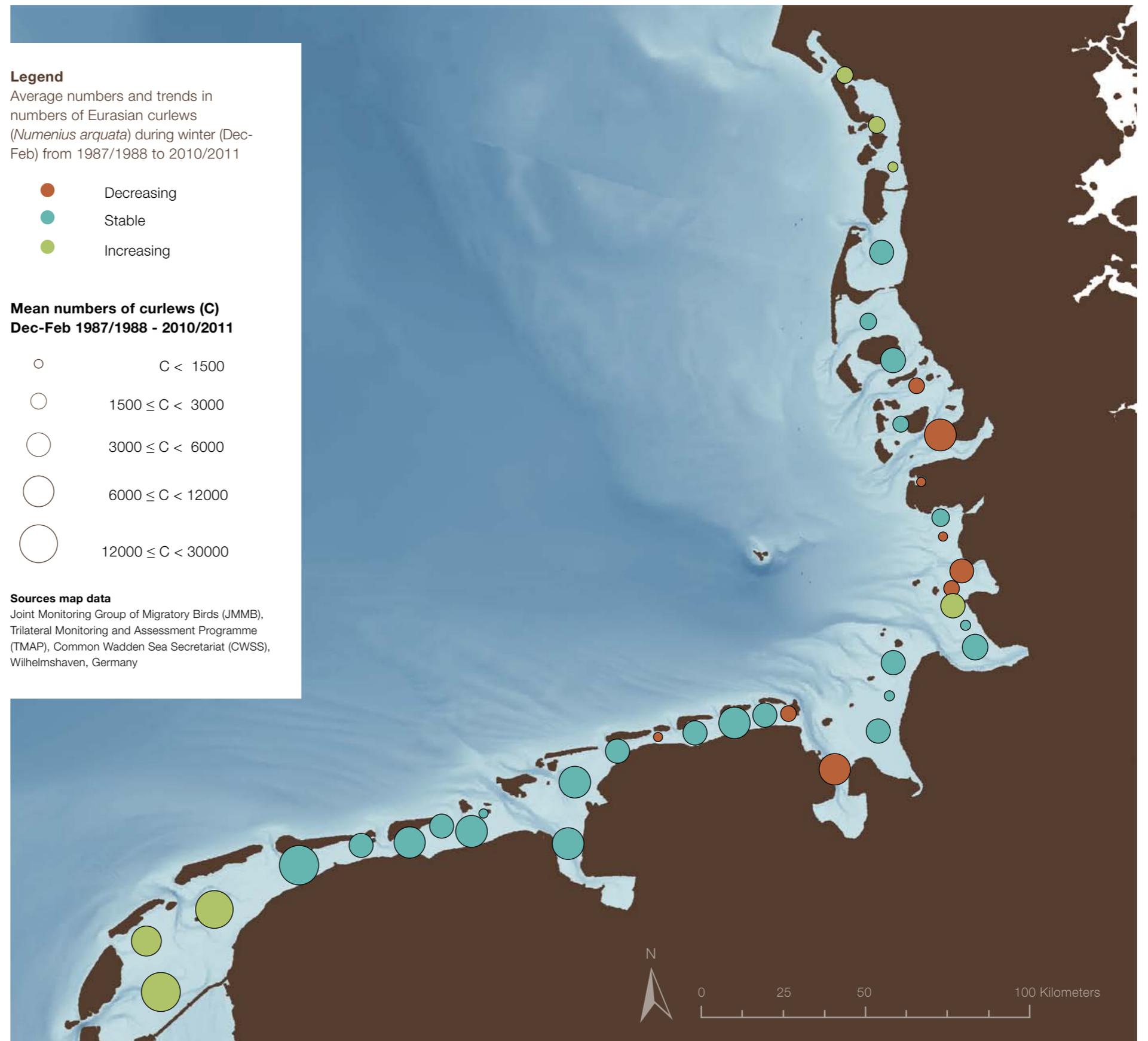
## 08 Eurasian curlews

Eurasian curlews are widespread inhabitants of the Wadden Sea region during the non-breeding season. They feed on the intertidal flats at low tide and during high tide also utilize inland roosts in large numbers<sup>1</sup>. Since the late 1980s, curlew numbers during winter were more or less constant for most of the Wadden Sea<sup>1</sup>. Only at the north-eastern and south-western fringes, these birds appear to have increased over the years. The increase of curlews at the northern edge of the Wadden Sea is generally considered to be the result of a gradual increase in hunting restrictions and a final hunting ban in 1992-1994 in Denmark<sup>2</sup>. The increase in curlews at the westernmost part of the Wadden Sea is in line with observations throughout north-western Europe of bird distributions shifting in a north-easterly direction<sup>3</sup>, e.g. birds moving from the UK to the Wadden Sea. Such a geographical redistribution might be due to birds responding to milder winters by shifting to new areas with environmental conditions which were previously too severe but they are now able to tolerate<sup>3</sup>.

1 Joint Monitoring Group of Migratory Birds (JMMB), 2013. Trends of migratory and wintering waterbirds in the Wadden Sea 1987/1988-2010/2011. Wadden Sea Ecosystem 31, 56 pp.

2 Laursen K, 2005. Curlews in the Wadden Sea. Effects of shooting protection in Denmark. In: Blew J, Südbeck P (Eds), Wadden Sea Ecosystem 20, 171-183.

3 Maclean IMD, Austin GE, Rehfishch MM, Blew J, Crowe O, Delany S, Devos K, Deceuninck B, Günther K, Laursen K, van Roomen M, Wahl J, 2008. Climate change causes rapid changes in the distribution and site abundance of birds in winter. Global Change Biology 14, 2489-2500.



**“Small shorebirds  
demonstrate that the Wadden  
Sea is one large entity”**



## 09 Red knots

Since the distribution of shorebirds searching for their prey is highly dynamic in time and space, monitoring of bird movements over vast areas has so far been a major challenge<sup>1,2</sup>. Satellite tracking appears to be the way forward, but this approach was so far only feasible for relatively large birds which could easily carry the additional weight of the tags. Innovative lightweight tags<sup>3,4</sup> are now yielding the first maps on the movements of relatively small shorebirds. On 3 October 2013, ten tag-carrying red knots were released on Texel. In their search for prey (in particular the small bivalve *Macoma balthica*) and safe foraging areas, most birds started to move throughout the international Wadden Sea region whilst one individual flew to the Wash in England. Interestingly, the young birds moved furthest away from the release point, possibly because they still had to monitor the distribution of their food sources. Adult shorebirds, such as red knots, may perhaps rely on a mental picture of good foraging areas which they build up during the first phase of their lives<sup>4</sup>.

1 TOP-grant "Shorebirds in space" awarded by the Netherlands Organisation for Scientific Research (to T. Piersma, University of Groningen & NIOZ Royal Netherlands Institute for Sea Research, The Netherlands; in association with T.L. Tibbitts, Alaska Science Center, US Geological Survey, Anchorage, USA).

2 "Metawad" awarded by the Waddenfonds (grant WF209925; see [www.metawad.nl](http://www.metawad.nl)).

3 Ultra-light (5 gram) solar-powered satellite tags developed by Microwave (Maryland, USA) and NIOZ (Texel, NL) with a predicted lifespan of 4-5 years which is comparable to that of the red knots.

4 Chan Y-C (in preparation) Ranging and migration behaviour of red knots in the East-Asian-Australasian Flyway. PhD Thesis, University of Groningen, Groningen, The Netherlands.



“In good shape following  
fast recoveries after  
two epidemics”



## 10 Harbour seals

Harbour seals are iconic for the Wadden Sea and, being large top predators, seen as a key species in the food web. The coordinated and simultaneous counts throughout the trilateral area enable estimating total numbers, avoiding possible biases as the result of temporary local variations. While the population was still recovering from centuries of hunting, seal epidemics resulted in a 50% reduction in numbers in 1988 and in 2002<sup>1</sup>. Both mass mortality events were followed by fast recoveries showing growth rates approaching the theoretical maximum of 13% increase per year<sup>2</sup>. Though population growth seemingly is slowing down, in 2013 the total count of 26,788 seals hauling out on sandbanks was the highest since the beginning of the Wadden Sea-wide seal counts in 1975<sup>3</sup>, when there were less than 5000 animals left. Taking the animals in the water into account as well, the total Wadden Sea harbour seal population in 2013 can be estimated at 39,400<sup>3</sup>. Based on local variations in numbers from year to year, it is clear that for harbour seals the Wadden Sea is a continuum in which they move around to optimise feeding and breeding<sup>4</sup>.

- 1 Härkönen T, Dietz R, Reijnders P, Teilmann J, Harding K, Hall A, Brasseur S, Siebert U, Goodman SJ, Jepson PD, Dau Rasmussen T, Thompson P, 2006. A review of the 1988 and 2002 phocine distemper virus epidemics in European harbour seals. *Diseases of Aquatic Organisms* 68, 115-130.
- 2 Härkönen T, Harding KC, Heide-Jørgensen MP, 2002. Rates of increase in age structured populations: a lesson from the European harbour seals. *Canadian Journal of Zoology* 80, 1498-1510.
- 3 <http://www.waddensea-secretariat.org/monitoring-tmap/topics/marine-mammals>
- 4 Trilateral Seal Expert Group (TSEG), Trilateral Monitoring and Assessment Programme (TMAP), Common Wadden Sea Secretariat (CWSS), Wilhelmshaven, Germany.





“Aliens from our own planet”

# 11 Marine bioinvasions

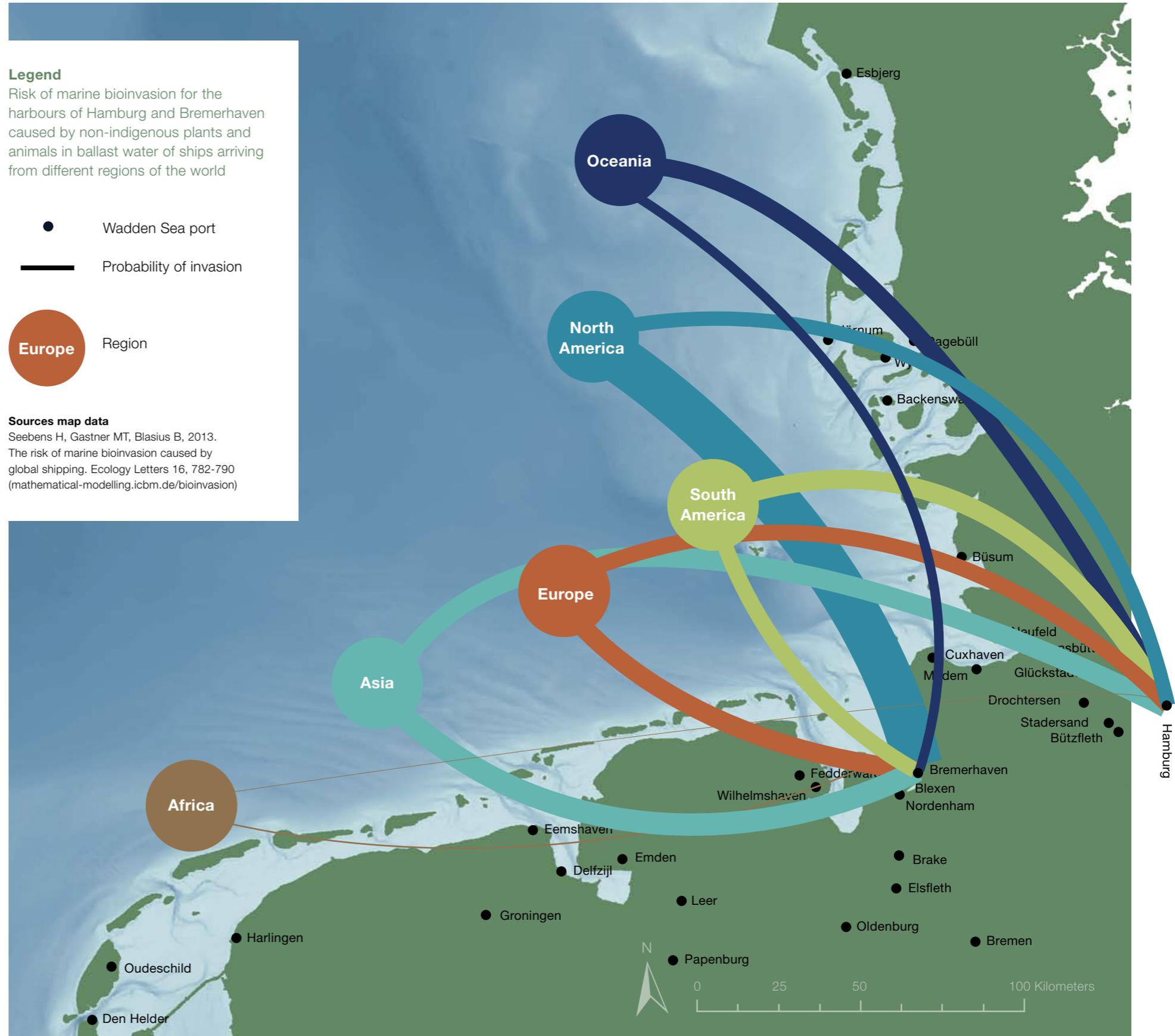
With over 90% of the world's trade carried by sea, the global network of ships criss-crossing the oceans<sup>1</sup> provides perhaps the most important mode of transportation, not only for goods, but also for non-indigenous marine species that “hitch-hike” with these ships. They can be carried in the ballast tanks or attached to the hull. Within the Wadden Sea region, the probability of biological invasion via ballast tanks is highest in major harbours such as Hamburg and Bremerhaven<sup>2</sup>. Transferred plants and animals may survive to establish a reproductive population in the host environment, becoming invasive, out-competing native species and multiplying into pest proportions. This risk of invasion via ballast water will be strongly reduced when the IMO's International Convention for the Control and Management of Ships' Ballast Water and Sediments<sup>3</sup> enters into force. This regulation, however, will still not shield the Wadden Sea from invasive species coming in via other pathways, in particular ship hulls and aquaculture.

1 <http://www.marinetraffic.com>  
 2 Seebens H, Gastner MT, Blasius B, 2013. The risk of marine bioinvasion caused by global shipping. Ecology Letters 16, 782-790.  
 3 <http://www.imo.org/OurWork/Environment/BallastWaterManagement>

**Legend**  
 Risk of marine bioinvasion for the harbours of Hamburg and Bremerhaven caused by non-indigenous plants and animals in ballast water of ships arriving from different regions of the world

- Wadden Sea port
- Probability of invasion
- Region

**Sources map data**  
 Seebens H, Gastner MT, Blasius B, 2013. The risk of marine bioinvasion caused by global shipping. Ecology Letters 16, 782-790 (mathematical-modelling.icbm.de/bioinvasion)



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The **Wadden Sea Long-Term Ecosystem Research (WaLTER)** project started in 2010 as an initiative of a number of institutes and organisations that carry out long-term measurements and research in the Wadden Sea area. With WaLTER existing research and monitoring programmes will be improved, possible gaps in the current monitoring network will be filled, and new and existing data will be made more readily accessible. The WaLTER project (2010-2015) is financed by the Waddenfonds with supporting contributions from the Dutch Provinces of Noord-Holland and Fryslân.

The **Waddenacademie KNAW** aims to identify gaps in our knowledge of the Wadden Sea region, to programme research and to disseminate the outcome covering geoscience, ecology, society and cultural history, social and spatial economics, and climate and water. The Waddenacademie aims to develop the Wadden Sea region into an incubator for widely applicable integrated knowledge of sustainable development of a coastal area, in which natural values are a key element and form the foundations of the local and regional economy. The Waddenacademie is financed by the Waddenfonds with supporting contributions from the Dutch Province of Fryslân.

The **Common Wadden Sea Secretariat (CWSS)** was established in 1987 to coordinate, promote and support the activities of the Trilateral Wadden Sea Cooperation. The Cooperation is based on the “Joint Declaration on the Protection of the Wadden Sea”, which was first signed in 1982 and then updated in 2010, following the Guiding Principle to “achieve, as far as possible, a natural and sustainable ecosystem in which natural processes proceed in an undisturbed way”. The CWSS is financed by the Danish Ministry of the Environment, the German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety, and the Dutch Ministry of Economic Affairs.

