A comparative analysis of the Wadden Sea for the nomination on the World Heritage list

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1. Introduction

The format for the nomination of properties for inscription in the World Heritage List requires a comparative analysis (including state of conservation of similar properties) of the similar sites, whether on the World Heritage List or not. The comparison should outline the similarities the nominated property has with other properties and the reasons that make the nominated property stand out. The comparative analysis should aim to explain the importance of the nominated property both in its national and international context.

The objective is: a comparative table in which the Wadden Sea area to be nominated for inscription on the World Heritage List is compared with similar areas in the world, listed and non-listed.

2. Approach

2.1. Listed sites

As a first step in the comparison analysis, 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 have been selected for further analysis. As a second step, sites have been selected that that host a high biodiversity and/or waterfowl and migratory birds. This results in 9 World Heritage sites, namely Galapagos National Park and Marine Reserve, Everglades National Park, Great Barrier Reef, Doñana National Park, The Sundarbans, Banc d´Arguin National Park, Fraser Island, Whale Sanctuary of El Vizcaíno and Greater St. Lucia Wetland Park.

Table 1: Preselected World Heritage sites, sizes and major biophysical setting.

World Heritage Site	Size (km^2)	Biophysical setting
Galapagos National Park and Marine Reserve	7,665	Volcanic archipelago and ocean
Everglades National Park	5,929	Freshwater and coastal marshes, mangrove swamps
Great Barrier Reef	348,700	Coral reef system and ocean
Doñana National Park	507	Coastal marshlands and dunes
Sundarbans (Bangladesh & India)	7,280	Deltaic islands, waterways, intertidal area with extensive mangrove cover
Banc d´Arguin National Park	12,000	Mudflats, dunes, islands
Fraser Island	1,663	Sand island
Whale Sanctuary of El Vizcaíno	3,710	Lagoons with some mangrove and seagrass
Greater St. Lucia Wetland Park	2,396	Coastal lakes, dunes and continental shelf

Firstly, it must be noted that all nine properties are located in a different biogeographical region than the Wadden Sea. The only European property is Doñana. The Doñana is located along the borders of the North-east Atlantic Ocean Region, whereas the Wadden Sea is located in the North Sea Region (EEA, 2002).

Secondly, many of the listed properties contain islands. The Galapagos are volcanic islands in an ocean surrounding, the Great Barrier reef has many coral islands, Fraser Island is an enormous sandy island, the Sundarbans consist of deltaic islands, Banc d'Arguin contains (partly rocky) islands and Florida Bay, which covers about 1800 km^2 of the Everglades National Park, contains hundreds of mangrove covered islands. However, the characteristics of these islands differ markedly from that of the Wadden islands.

Thirdly, and more important for the comparison with the Wadden Sea, the properties Sundarbans, Everglades (i.e., Florida Bay), Doñana and Banc d'Arguin contain intertidal flats within the property. The Wadden Sea is characterised by **extensive contiguous sand flats and mud flats.** The

Sundarbans contain plots of mudflats mainly in the lee side of dunes, Florida Bay is a shallow lagoon with mudflats fringing the mangrove covered islands, Doñana has a relatively small proportion of mudflats on the inner side along the banks of the Guadalquivir River, Greater St. Lucia has hardly any intertidal area and El Vizcaíno has some intertidal area covered with mangrove and seagrass.

The only World Heritage property that has extensive mudflats and with which the Wadden Sea can be compared, is the **Banc d´Arguin National Park** in Mauritania. Approximately 630 km^2 consists of intertidal mudflats (Hughes & Hughes, 1992). This is considerably smaller than the Wadden Sea, which has 4,534 km^2 of bare intertidal areas (Meltofte *et al*., 2004). Moreover, the Banc d'Arguin is of great importance for Palearctic migrating birds, as is the Wadden Sea. However, the Banc d'Arguin is located in a different biogeographical region and does not have barrier islands. In fact, the comparative analysis in the nomination dossier of the Parc national du Banc d'Arguin does not even consider the Wadden Sea as a comparable site. In their dossier a comparison is made with other areas with a combination of hot desert and coastal features.

2.2. Non-listed sites

The non-listed sites have been selected from various sources, in particular the overview by Deppe (2000). This overview is based on a broad number of sources (e.g. Ramsar Wetlands of International Importance, National Parks, Special Protected Areas, Wildlife Rerves).
Deppe (2000) described and compared 350 intertidal mudflat sites worldwide. Intertidal mudflat coasts may result from various geological and present day processes. At low tidal ranges lagoon-type mudflats may develop, at macrotidal ranges intertidal areas attached to the coast may develop, and many estuaries, bays and deltas contain mudflats.

Selection criteria
To be comparable to the Wadden Sea, which has over 4500 km^2 of intertidal mudflats, **a size criterion** of a minimum of 300 km^2 is applied to the long-list of 350 mudflat sites. This results in a total of 44 sites that qualify, Table 2.

Table 2: Mudflat sites in the world larger than 300 km^2 (in many cases the total size of the site is given, this is usually larger than the size of the intertidal flats).

Site	Size (km^2)	Coordinates	Type
Aqajarua-Sllorsuaq (Greenland)	300	69°40'N 52°00'W	Estuary
Qinnquata Marra-Kuussuaq (Greenland)	6000	69°56'N 54°17'W	Estuary
Baie du Mont Saint-Michel (France)	6200	48°40'N 01°40'W	Bay & estuary
Oosterschelde (Netherlands)	3800	51°30'N 04°10'E	Estuary
Kandalaksja Bay (Russia)	20800	65°N 35°E	Bays & estuaries
Karaginsky Island (Russia)	1936	58°45'N 163°42'E	Estuaries & open flats
Morecambe Bay (UK)	359	54°07'N 02°57'W	Bay & deltaic barrier
The Wash (UK)	622	52°56N 00°17'E	Bay & estuary
Upper Solway Flats & Marshes (UK)	307	54°54'N 03°25'W	Estuary
Archipelago dos Bijagos (Guinea-Bissau)	15700	12°20'N 16°00'W	Island coast & estuaries
St. Lucia (South-Africa)	1555	28°00'S 32°28'E	Estuary
Bahia Blanca (Argentine)	3000	38°50'S 62°00'W	Bay & estuary
Bahia de Samborombon (Argentine)	2440	35°47'S 57°50'W	Estuary
San Antonio Oeste Rio Negro (Argentine)	350	64°55'S 40°45'W	Bay
Dewey Soper (Canada)	8159	66°10'N 74°00'W	Open flats
Hudson Bay (Canada)	24087	52°30'N 84°30'W	Bay, estuaries & open flats
Queen Maud Gulf (Canada)	62782	67°00'N 102°00'W	Bay, estuaries & open flats
Bay of Fundy (Canada)	620	45°30'N 64°20'W	Bay & estuaries
Bigi Pan (Suriname)	683	05°55'N 56°45'W	Estuary & open flats
Wia Wia (Suriname)	900	05°56'N 54°55'W	Estuary & open flats
Chesapeake Bay (USA)	450	38°00'N 76°20'W	Bay & estuaries
Delaware Bay (USA)	512	39°11'N 75°14'W	Bay & estuaries
Georgia Bight (USA)	8000	32°17'N 80°35'W	Barrier islands & estuaries
Copper River Delta (USA)	1513	60°30'N 145°00'W	Deltaic barrier & estuaries
Delta del Rio Colorado (Mexico)	2500	31°50'N 114°59'W	Estuary
Khuran Straits (Iran)	1000	26°45'N 55°40'E	Estuary & deltaic barrier
Khor-al Amaya & Khor Musa (Iran)	4000	30°30'N 48°45'E	Estuaries & deltaic barriers
Kuwait Bay (Kuwait)	2000	29°20'N 48°00'E	Bay
Ras Al Khaymas (UAE)	3000	24°50'N 53°00'E	Barrier beach ridges
Gulf of Khambhat (India)	2500	21°50'N 72°23'E	Estuary
Korea Bay (China)	757	39°50'N 124°00'E	Estuary & bay
Liaodong Wan (China)	1247	40°00'N 121°50'E	Bay
Yellow river delta (China)	3712	37°50'N 118°50'E	Estuary
Korea Bay (North Korea)	1340	39°00'N 125°00'E	Estuary & bay
Yellow Sea coast (North Korea)	932	37°50'N 126°00'E	Estuaries & deltaic barriers
Yellow Sea coast (South Korea)	2900	36°00'N 127°00'E	Estuaries & deltaic barriers
Gulf of Thailand (Thailand)	400	13°20'N 100°25'E	Estuary & bay
Bowling Green Bay (Australia)	355	19°27'S 147°15'E	Estuary & bay
Corner Inlet (Australia)	672	38°45'S 146°32'E	Estuary & deltaic barriers
Eighty-mile Beach (Australia)	1250	19°29'S 120°35'E	Estuary & bays
Moreton Bay (Australia)	1133	27°20'S 153°10'E	Estuary & deltaic barriers
Roebuck Bay (Australia)	550	18°07'S 122°16'E	Bay
Shoalwater & Corio Bays (Australia)	2391	22°40'S 150°17'E	Estuaries & bay
Western Port (Australia)	593	38°22'S 145°17'E	Estuaries & deltaic barriers

The Wadden Sea mudflats are characterised by their location in tidal inlets of barrier islands. They contain a sequence of large and small ebb and flood gullies and their energy gradients follow from the morphology. The Wadden Sea (geological name: German Bight) 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 (Stutz & Pilkey, 2002). In North America and Europe, therefore, the barrier islands have a different geological origin. A second criterion, therefore, is the **presence of barrier islands that do not have a river delta origin**.

Of all sites larger than 300 km^2 this results in one comparable area: The **Georgia Bight**. The Georgia Bight (also named South Atlantic Bight) extends for a distance of 1200 km between Cape Hatteras in North Carolina to Cape Canaveral in Florida. Both the German Bight and 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.

Comparing to non-listed areas, in the European context the Wadden Sea is unique in every respect.. The Ria Formosa is a barrier island system and lagoon, but is a lot smaller (160 km^2) and does not contain the complex system of habitats and biotopes as the Wadden Sea. Morecambe Bay and The Wash have large mudflat areas, but are coastal bays, not barrier island coasts and they lack the specific morphological setting.

Other intertidal areas world-wide in the temperate region do not compare to the Wadden Sea. The Yellow Sea coast of China and Korea has a comparable mudflat size. However, there are no barrier islands like the Wadden Sea, the biophysical and biological features are different and the area is located on a different flyway. The Bay of Fundy, Delaware Bay and Chesapeake Bay for instance, have large mudflat areas, but have a very different morphological setting. Other areas are often located in different climate zones, but more important, do not have the non-deltaic barrier coast.

3. Comparison

Table 3 presents the comparison of the Wadden Sea with the two most similar areas. The Banc d'Arguin is comparable to the Wadden Sea for its function in the East Atlantic Flyway. Moreover, both areas are indispensable for the survival of millions of migrating birds and are thus linked over a distance of more than 4000 km. Apart from this, the Banc d'Arguin is situated in a different climate, has a very different morphological genesis and morphology and has a significantly smaller mudflat area, which is for the majority covered by seagrass.

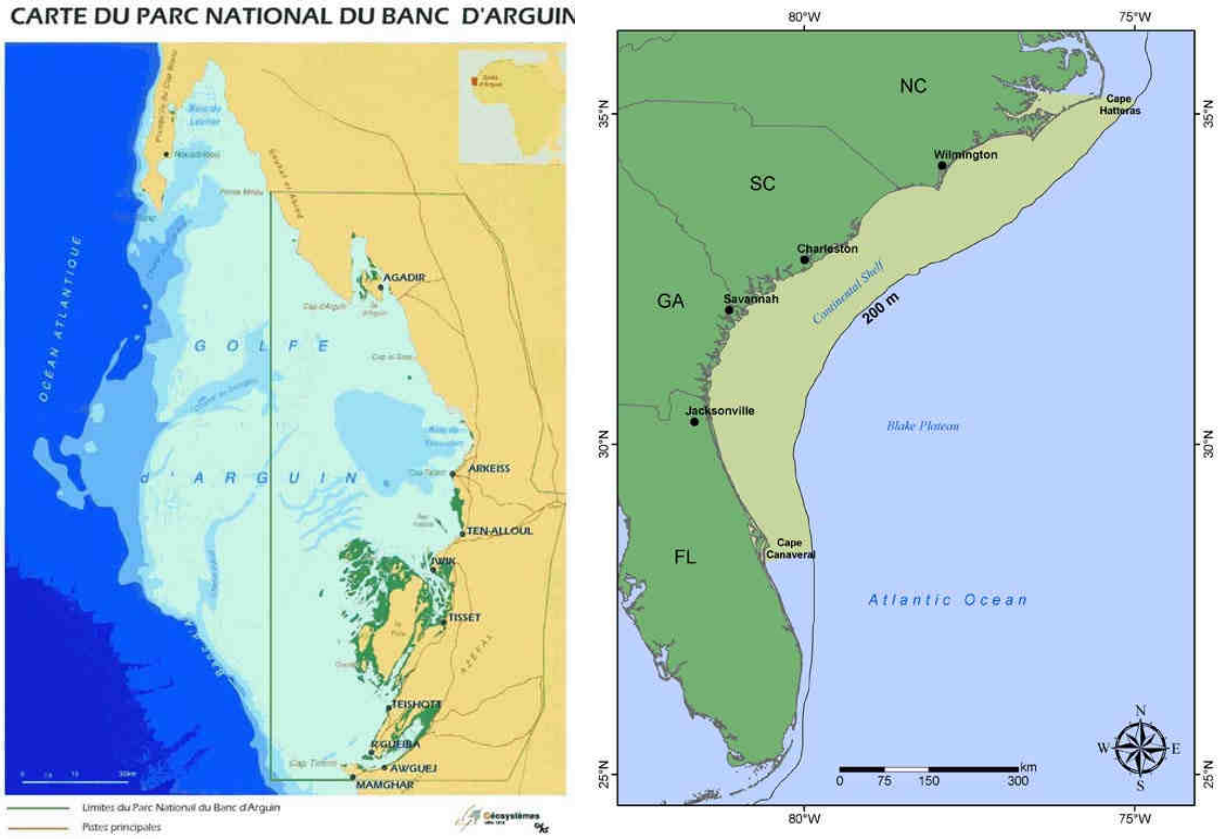
The most important (and major) difference between the Georgia Bight system and the Wadden Sea is that the Wadden Sea has open intertidal flats fringed by salt marshes, whereas the tidal basins along the Georgia Bight comprise tidal channels, narrow intertidal flats fringing the channels, and huge expanses 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. A major difference to the Wadden Sea with a dominance of bare mudflats is a prevalence of the saltmarsh habitat while mudflats are marginal. At first glance, both systems are quite similar in their primary production. It should be noted, however, that the Wadden Sea is located between 52^o 53' N – 54^o 53' N, whereas the Georgia Bight is located between 28^o 28' N - 35^o 13' N, and receives considerably more light.

4. Conclusion

The Wadden Sea is to be regarded as of outstanding and unique universal value compared to similar areas world-wide.

Table 3: Comparison of Wadden Sea with Banc d'Arguin and Georgia Bight.

FEATURES	**Wadden Sea (maps in nomination dossier)**	**Banc d'Arguin (map below)**	**Georgia Bight (map below)**
designation WH	to be nominated	1989	not WH
country	Germany / Netherlands	Mauritania	USA
climate zone	temperate	continental, arid sub-tropics, dry	temperate
description setting	mixed energy to tide-dominated mesotidal barrier coast (not deltaic)	back barrier islands and open mud flats, relic of former deltas	mixed energy to tide-dominated mesotidal barrier coast (not deltaic)
total area	10,000 km^2	12,000 km^2 (50% marine)	~8,000 km^2
mudflat area	4,100 km^2	630 km^2	~300 km^2
tidal differences / range	1.5 – 3.5 m	2.1 m	0.8 – 2.5 m
mean wave height / range	1.0 – 2.0 m	1.4 m	0.6 – 1.0 m
contiguous character	large and contiguous area of intertidal habitats	contiguous between Cap Timiris and Pointe Minou, isolated section at Cap Blanc	not a contiguous intertidal system
habitats, biotopes	complex mosaic of bare intertidal flats fringed by saltmarshes, tidal channels, seagrass meadows, mussel beds	sand dunes, coastal swamps, small islands, intertidal areas with 80% seagrass cover	tidal channels with narrow band of bare intertidal flat. Intertidal almost completely covered by *Spartina* and *Juncus* saltmarshes
salt marshes km^2	310 km^2	591 km^2	4,237 km^2
mangroves km^2	none	31 km^2 mangrove *Avicennia africana*	some mangrove *Avicennia germinans*
major estuaries	5 estuaries	0 estuaries	13 estuaries
migrating birds	6,1 million present at the same time; on average 10 to 12 million each year; East Atlantic Flyway	2,1 million over-wintering birds (106 species) East Atlantic Flyway	Important stop-over for millions of migrating birds West Atlantic Flyway
productivity	Primary production (gC/m^2/**y**): phytoplankton 100-200 microphytes 150 seagrass 500 macrophytes 500-1000	Primary production (gC/m^2/**d**): phytoplankton 2.1-8.9	Primary production (gC/m^2/**y**): phytoplankton 200-400 microphytes 60 seagrass 150-700 macrophytes 800-2000
State of conservation	RAMSAR site, PSSA by the IMO, MAB by UNESCO, EU Natura 2000, EU WFD, contracting party of African-Eurasian Waterbird Agreement (AEWA)	RAMSAR site, National Park, has Fondation Internationale du Banc d'Arguin (FIBA) as management authority, **not** contracting party of AEWA	Not contiguously protected. Two Western Hemisphere Shorebird Reserves, Carolinian-South Atlantic MAB, **no** RAMSAR sites, **no** PSSA.



Overview maps of National Park **Banc d'Arguin** (source: http://effectivempa.noaa.gov/images/maps/bancdarguin_map_lg.jpg) and **Georgia Bight** (source: www.dnr.sc.gov/marine/sertc/index.html)

References

African-Eurasian Waterbird Agreement, http://www.unep-aewa.org/.

Alexander, C. & M. Robinson, 2004. Semi-annotated bibliography of barrier island studies Applicable to Georgia Back-Barrier Islands. Report from the Georgia Coastal Zone Management Program.

Anthony, E.J. & J.D. Orford, 2002. Between Wave- and Tide-Dominated Coasts: the Middle Ground Revisited. Journal of Coastal Research SI36, 8-15.

Berghuis, E.M., G.C.A. Duineveld & J. Hegeman, 1993. Primary production and distribution of phytopigments in the water column and sediments on the upwelling shelf off the Mauritanian coast (Northwest Africa). Hydrobiologia 258 : 81-93.

Dame, M. Alber, D. Allen, M. Mallin, C. Montague, A. Lewitus, A. Chalmers, R. Gardner, C. Gilman, B. Kjerfve, J. Pinckney & N. Smith, 2000. Estuaries of the South Atlantic Coast of North America: Their Geographical Signatures. Estuaries 23(6): 793-819.

Deppe, F, 2000. Intertidal Mudflats Worldwide. Wilhelmshaven, Common Wadden Sea Secretariat (CWSS), 100 p.

Duineveld, G.C.A., P.A.W.J. de Wilde, E.M. Berghuis & A. Kok, 1993. The benthic infauna and benthic respiration off the Banc d'Arguin (Mauritania, Northwest Africa). Hydrobiologia 258 : 107-117.

Engle, V.D. & J.K. Summers, 1999. Latitudinal gradients in benthic community composition in Western Atlantic estuaries. Journal of Biogeography 26: 1007-1023.

EEA, 2002. European Environment Agency Biogeographical Regions and Seas: http://reports.eea.europa.eu/report_2002_0524_154909/en.

Fondation Internationale du Banc d'Arguin (FIBA), http://www.fibarguin.org/.

Jager, Z., 1993. The distribution and abundance of young fish in the Banc d'Arguin, Mauritania. Hydrobiologia 258 : 185-196.

Hagemeijer, E.J.M., Smit C.J. (Eds.), de Boer, P., van Dijk, A.J., Ravenscroft, N., van Roomen, M.W.J. & Wright, M., 2004. Wader- and waterfowl count on the Banc d'Arguin, Mauritania, January-February 2000. WIWO report 81, Beek-Ubbergen, 146 p.

Hughes R. & S. Hughes, 1992. Directory of African Wetlands. IUCN, Switzerland /UNEP, Nairobi / WCMC, Cambridge, UK.

Man and the Biosphere Program, http://www.unesco.org/mab/.

Meltofte, H., J. Blew, J. Frikke, H-U Rösner & C.J. Smit, 1994. Numbers and distribution of waterbirds in the Wadden Sea; Results and evaluation of 36 simultaneous counts in the Dutch-German-Danish Wadden Sea 1980-1991. IWRB Publication 34 / Wader Study Group Bulletin 74, Special Issue.

Particularly Sensitive Sea Areas (PSSA), http://www.imo.org/.

Ramsar Convention on Wetlands, http://www.ramsar.org/.

Rousseau, S. & P. Forget, 2004. Ocean wave mapping from ERS SAR images in the presence of swell and wind waves. Scientia Marina 68(1): 1-5.

Searles, R.B., 1984. Seaweed biogeography of the mid-Atlantic coast of the United States. Helgoländer Meeresuntersuchüngen 38: 259-271.

Stallins, J.A., 2000. Barrier Island Morphology and Dune Vegetation Pattern and Process in the Georgia Bight. Georgia, University of Georgia, PhD-thesis, 217 p.

Stutz, M.L. & O.H. Pilkey, 2002. Global distribution and morphology of deltaic barrier island systems. Journal of Coastal Research SI 36: 694-707.

Thorsell, J., R. Ferster Levy & T. Sigaty, 1997. A global overview of wetland and marine protected areas on the World Heritage list. Gland, Switzerland, IUCN, 47 p.

UNESCO, 1989. IUCN Technical Evaluation Banc d'Arguin National Park. 17 p.

Vermaat, J.E., J.A.J. Beijer, R. Gijlstra, M.J.M. Hootsmans, C.J.M. Philippart, N.W. van der Brink and W. van Vierssen, 1993. Leaf dynamics and standing stocks of intertidal Zostera noltii Horneman and Cymodocea nodosa (Ucria) Ascherson on the Banc d'Arguin (Mauritania). Hydrobiologia 258**:** 59–72.

Watson, C., C. Hayes, J. McCauley, A. Milliken, 2004. The South Atlantic Migratory Bird Initiative – An Integrated Approach to Conservation of "All Birds Across All Habitats". USDA Forest Service Gen. Tech. Rep. PSW-GTR-191.

Western Hemisphere Shorebird Reserves network, http://www.whsrn.org/.

Wigh, R. A review of bird species on the South Atlantic Bight. Report on skidaway.net.

Wolff, W.J., J. van der Land, P.H. Nienhuis & P.A.W.J. de Wilde, 1993. The functioning of the ecosystem of the Banc d'Arguin, Mauritania : a review. Hydrobiologia 258 : 211-222

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