ESPON

EUROPEAN OBSERVATION NETWORK
TERRITORIAL DEVELOPMENT AND COHESION

ESaTDOR
European Seas and Territorial Development, Opportunities and Risks

ANNEX 7 to the Scientific Report:

North Sea Regional Profile

Applied Research 2013/1/5

Version 16/1/2013

Regional Sea Profile: the North Sea

1 Introduction

In the last few years there has been growing acknowledgement that the seas which surround Europe offer significant opportunities for - and potential risks to - territorial development. The sea provides resources on and in its waters and on and under the sea bed that can be harnessed as the basis for territorial development; it enables the flow of goods, services and people, connecting different parts of Europe to each other and the wider global community; and it provides an important environmental asset that needs careful management not least because the health of the sea is critical to efforts to combat climate change. However, different stakeholders have different priorities in terms of what uses and priorities should be privileged in different parts of the maritime environment and few have an overview of the range of issues that require consideration in making such judgements in an informed way.

Whilst there has been a growing recognition of the need for improved planning of maritime space, as exemplified by the growth of integrated coastal zone management and marine spatial planning, more broadly little has yet been done to explore the potentials and challenges of planning for these areas, particularly in relation to their transnational and cross border dimensions. As a step forward, this ESPON project aims to explore the territorial development opportunities and risks facing the seas of Europe by distilling key land/sea and transnational interconnections. Each European regional sea has its own specific characteristics in terms of territorial development opportunities and risks, and uses different governance structures to manage competing claims. This report focuses on one of the six regional seas which are covered by the project and provides a profile of the North Sea.

Each Regional Sea Profile report is subdivided into two parts. The first part seeks to provide a detailed characterisation of the regional sea as it exists today. The second part starts to look to the future and describes the potential opportunities and risks pertaining to each sea, and sets out policy recommendations that can help guide territorial development within the region.

Part 1 begins with a brief section which provides contextual information including a description of how the boundaries of the regional sea have been defined for the purposes of this project. In some instances this has been relatively straightforward. In others we have had to make pragmatic decisions as varying boundary definitions are in use and in some areas are still very much contested. The second section then describes in more detail key thematic characteristics of each regional sea focusing on the maritime economy, transport, energy and undersea infrastructure and the environment. This characterisation reflects the existing situation and is based around a standardised series of maps which draw upon the limited number of data sets we have uncovered that relate to these themes where there is good European wide coverage. The maps have, in some cases, been supplemented by local information which is seen as being an exemplar of good practice and which might have relevance to other European regional seas in terms of improving data coverage and mapping to inform policy development.

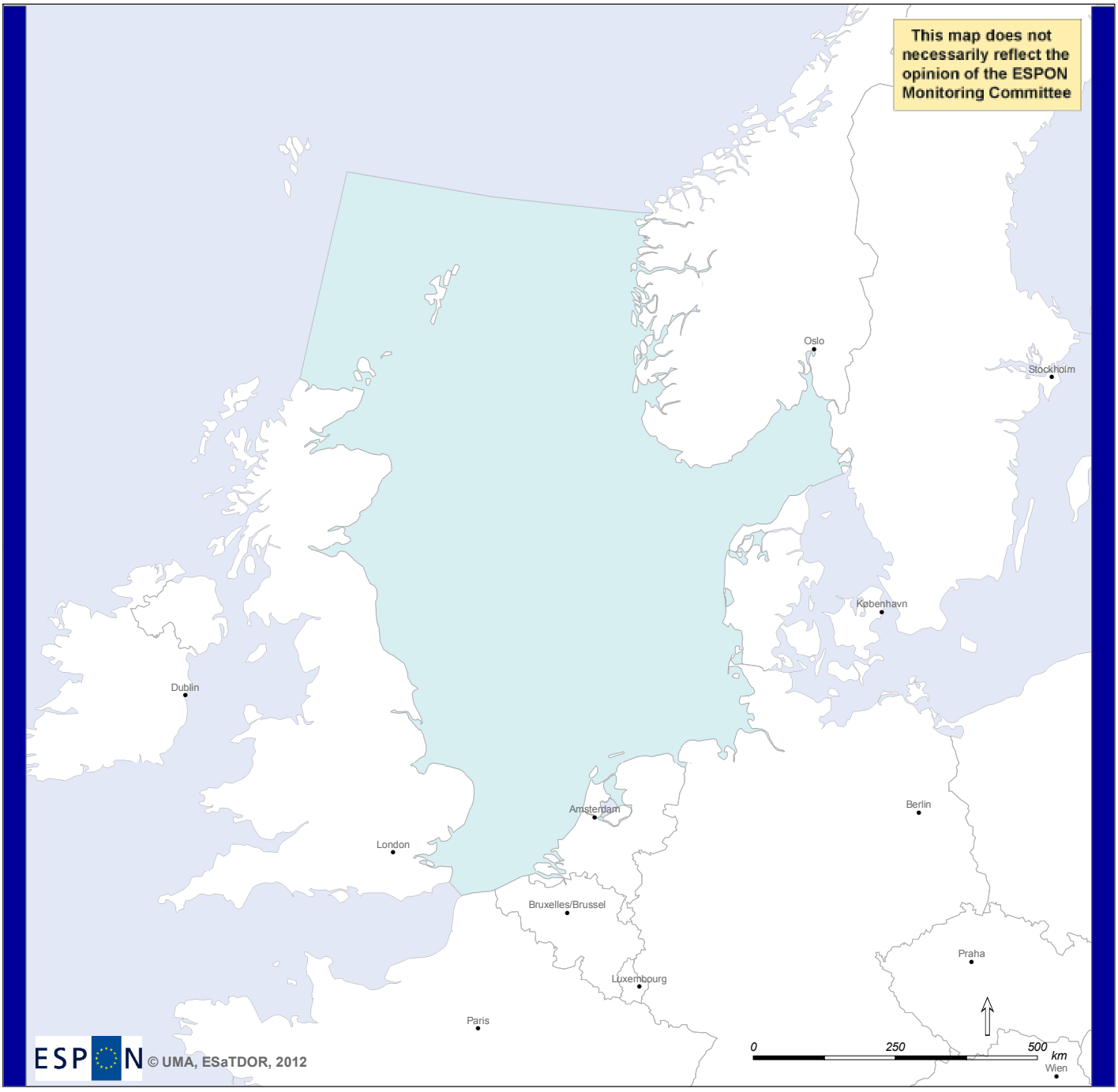
One of the critical characteristics of all of the regional seas is that the effective management of both the opportunities and risks will require cross boundary and transnational cooperation between the

members states of the EU, members of the European Economic Area and potential accession countries and other countries who share a common interest in a particular sea. The configuration of interested nation states varies from regional sea to regional sea, although how transnational and cross boundary issues are being managed at the present time is reflected on in the governance section. Here a limited number of case studies are used to explore the effectiveness (or otherwise) of various maritime governance regimes designed to address specific cross border and transnational issues.

The final section of the first part provides an overall characterisation of the regional seas based on composite maps of flows, economic significance and environmental pressures. The purpose of these composite maps is to characterise the maritime regions covering both land and sea in terms of intensity of use and land sea interactions. Drawing upon these composite maps a baseline typology of maritime regions is presented which classifies these areas as European Core, Regional Hub, Transition, Rural and Wilderness based on their current attributes.

In the second part of the report the focus shifts to the future and it comprises two elements. First we summarise key opportunities and risks for future territorial development for the regional sea based on the understanding of current and potential land sea interactions. Second this assessment leads to a set of policy recommendations targeted at different stakeholder groups related to future planning and development in the region.

North Sea Boundaries



Map N1. North Sea Boundaries (defined for ESaTDOR project)

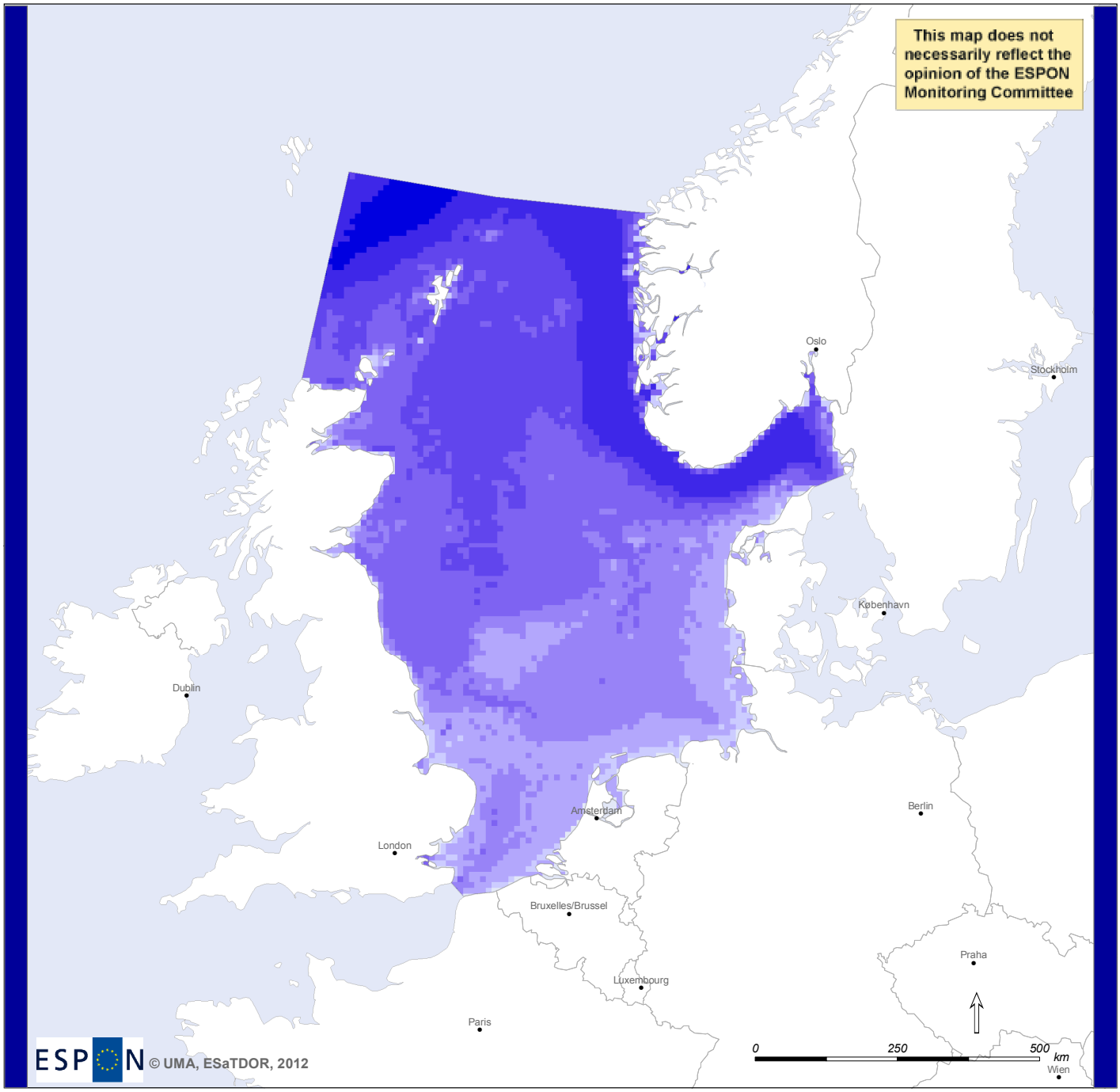
2. Context

The North Sea is a semi-enclosed sea situated on the continental shelf of northwestern Europe. It opens into the Atlantic Ocean in the northwest, the Norwegian Sea to the north, the Channel to the south, and the Baltic Sea to the east via the Skagerrak-Kattegat. The North Sea's northern (62°N) and northwestern (5°W) boundaries follow a line between Scotland and Norway. These boundaries conform to other delineations, such OSPAR's Region II – the Greater North Sea [1,2,3,4,5]. For the purposes of the ESaTDOR project the southern border of the sea is defined as the entrance to the Channel (48°N 5°W) (see map N1), which also conforms to UNEP's delineation of the North Sea Large Marine Ecosystem (Map N3). OSPAR treats the Channel as part of the Greater North Sea, but its physical, oceanographic and environmental features are very different as is its economic importance to Europe. Consequently ESaTDOR does not include the Channel in the North Sea. The North Sea's eastern border with the Baltic Sea lies between Skaggerak, which falls within the North Sea, and Kattegat, which is part of the Baltic. The two seas are separated by a line drawn between the city of Skagen at the northern tip of Denmark and the Pater Noster Skären islands in Sweden. Such a border corresponds with the definition of the Baltic Sea Region by DG Regio and is relevant to ESaTDOR's focus on Territorial Development. It also corresponds to boundaries for the Baltic Sea catchment and it is supported by HELCOM.

Relative to other European regional seas, the North Sea is shallow (Map N2). The 50 metre isobath marks the transition between shallow, well-mixed turbid conditions typical of the southern North Sea and coasts, and deeper, seasonally stratified waters to the north [6, 7]. This delineation between well-mixed and seasonally stratified water masses is significant in distinguishing among marine biological assemblages and the transition sometimes forms 'fronts' with high biological productivity and biodiversity [7]. The northern North Sea is subject to strong oceanic influences entering from the north, and modest inputs of land-based wastes. This southern part is subject to a gyre that flows counter-clockwise from the north, as well as oceanic inputs via the Channel that generate strong tidal currents. It also has high levels of sediment loads and notable land-based waste inputs.

The North Sea is a large marine ecosystem (LME) and is predominantly one European ecoregion (see Map N3). The North Sea LME has a surface area of ~750 000 km^2, a volume of about ~94 000 km^3, and an average depth of ~90 m with a maximum of 725 m [1, 2, 4, 5 and see Map N2].

Sea Depth (Bathymetry)



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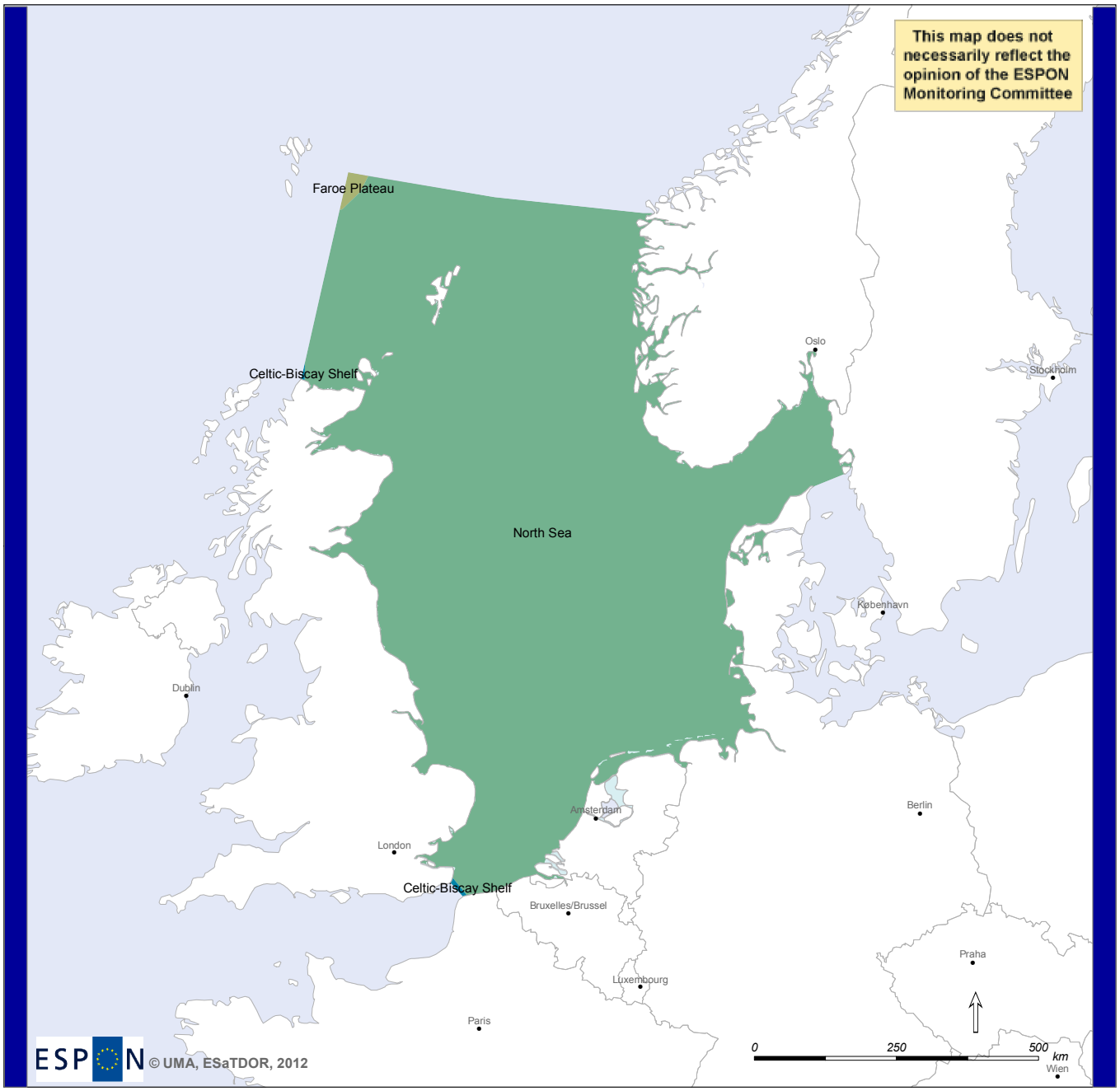
Thematic data: Sea Depth, GEBCO.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Sea depth (m)

- 0 to10
- 11 to 30
- 31 to 50
- 51 to 100
- 101 to 200
- 201 to 1,000
- > 1,000m

Map N2. Sea depth (bathymetry), North Sea.

North Sea Marine Ecosystems



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Thematic data: UNEP, WCMC.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Large Marine Ecosystems

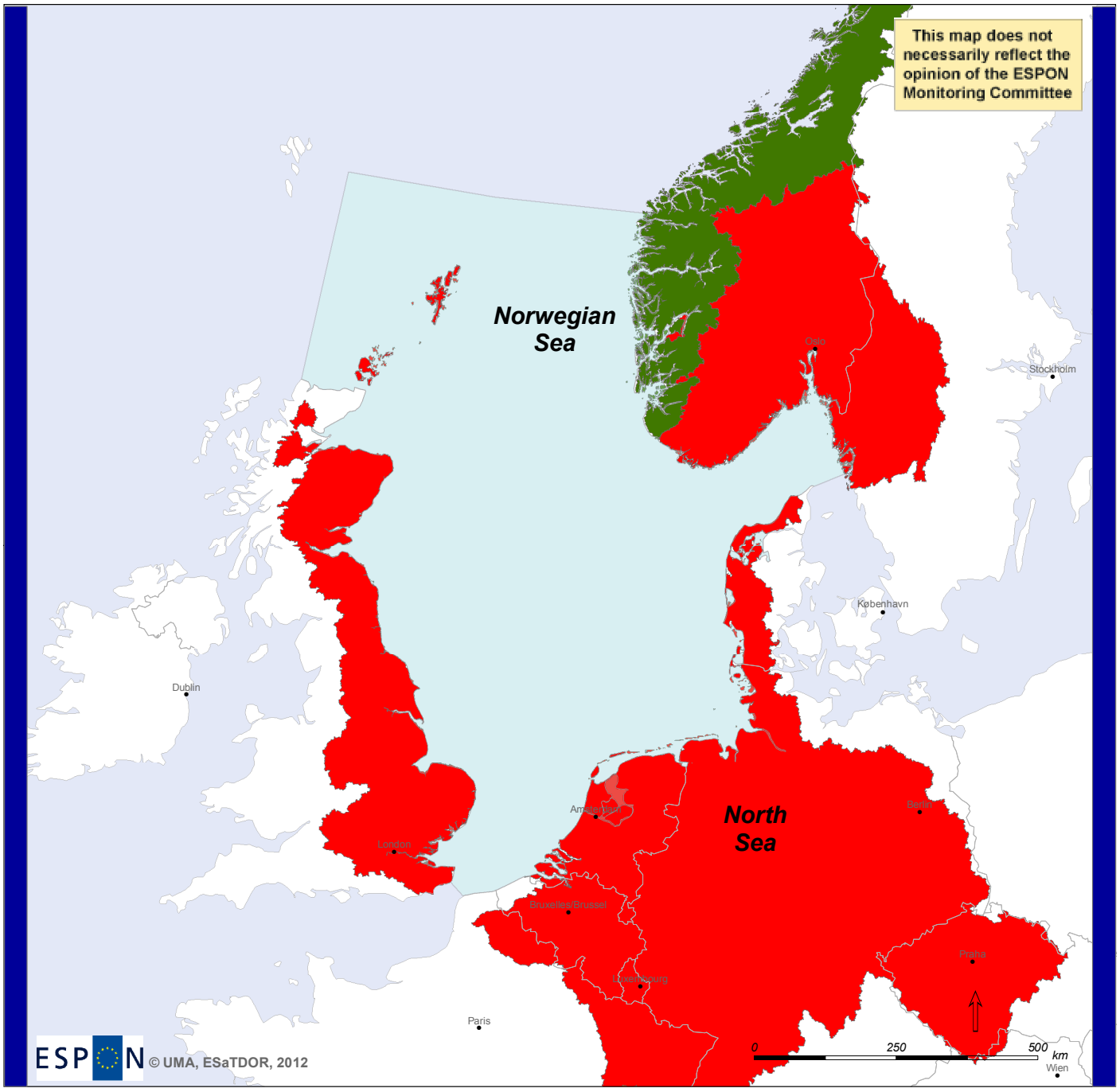
- Baltic Sea
- Barents Sea
- Black Sea
- Canary Current
- Celtic-Biscay Shelf
- East Greenland Shelf
- Faroe Plateau
- Iberian Coastal
- Iceland Shelf
- Mediterranean Sea
- North Sea
- Norwegian Sea

Map N3. Large Marine Ecosystems in the North Sea

The North Sea is one of the most frequently traversed sea areas of the world with two of the world's largest ports situated on its coasts (Rotterdam and Hamburg). The North Sea's catchment is heavily industrialised. The North Sea is bordered by Belgium, Denmark, France, Germany, the Netherlands, Norway and United-Kingdom, but its catchment also includes Luxembourg and parts of Switzerland and the Czech Republic (Map N4a). The North Sea's catchment is densely populated, comprising a large part of Europe's population (see Map N4b).

Despite the overall density of the sea catchment, population density along the coast of the North Sea is variable (see Map N4c). For much of the UK, coastal populations are not dense and well below the national average. High densities are associated with the Netherlands, large urban areas (e.g. Amsterdam) and ports (e.g. Rotterdam, Antwerp and Hamburg). The coastal zone is used intensively for recreation, urban development and agriculture. Major maritime activities include fishing, sand and gravel extraction, and offshore energy winning – exploitation of oil and gas reserves including the laying of pipelines, and wind farm development.

Inland Catchments and Population Density



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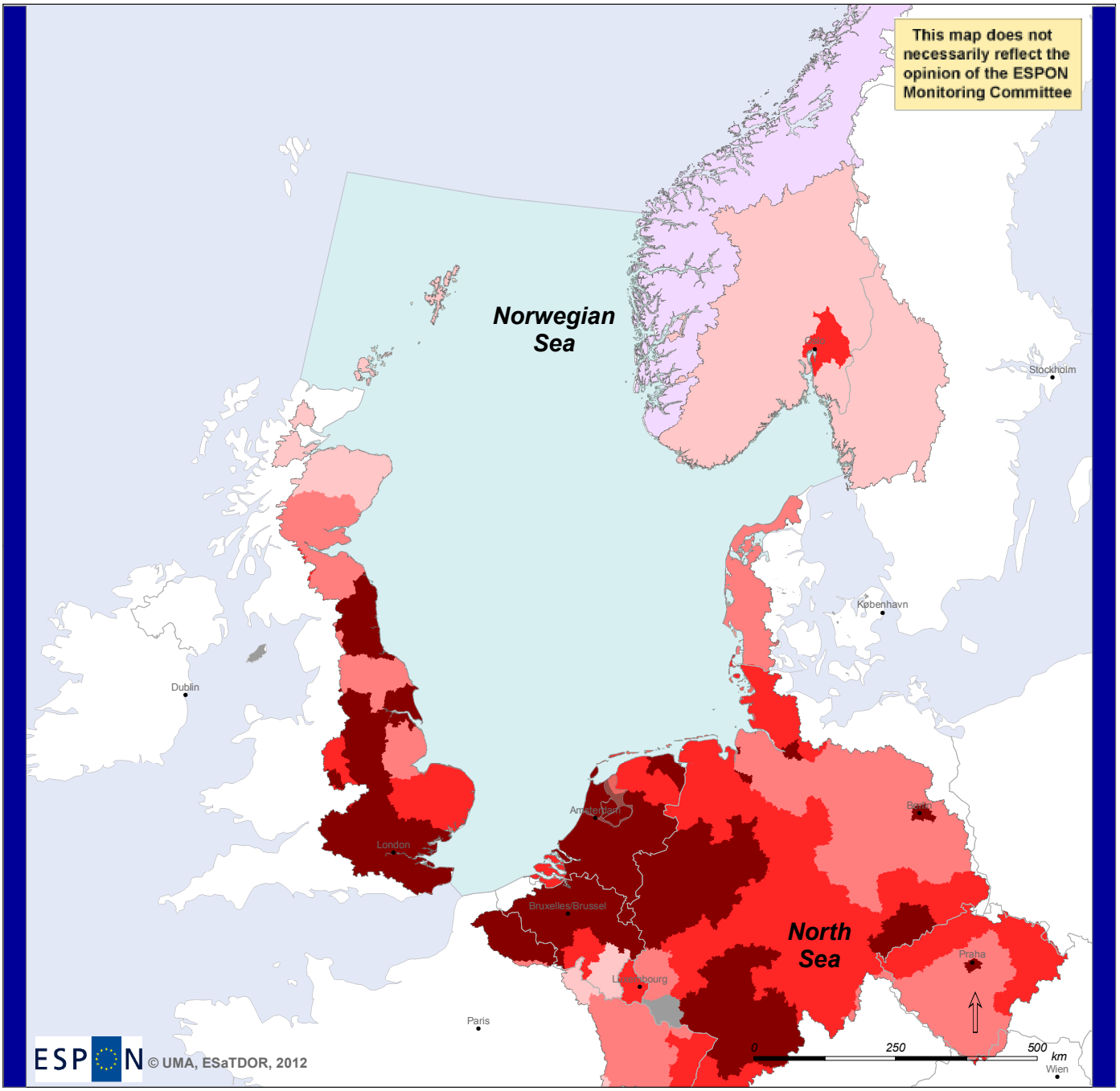
Thematic data: Water catchments, UNEP; EUROSTAT, 2008.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS3.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Population density within sea catchment (persons/km^2)

4	108
22	123
39	164
57	246

Map N4a. Inland catchment area and population density within North Sea region.

Population Density at NUTS2 Level



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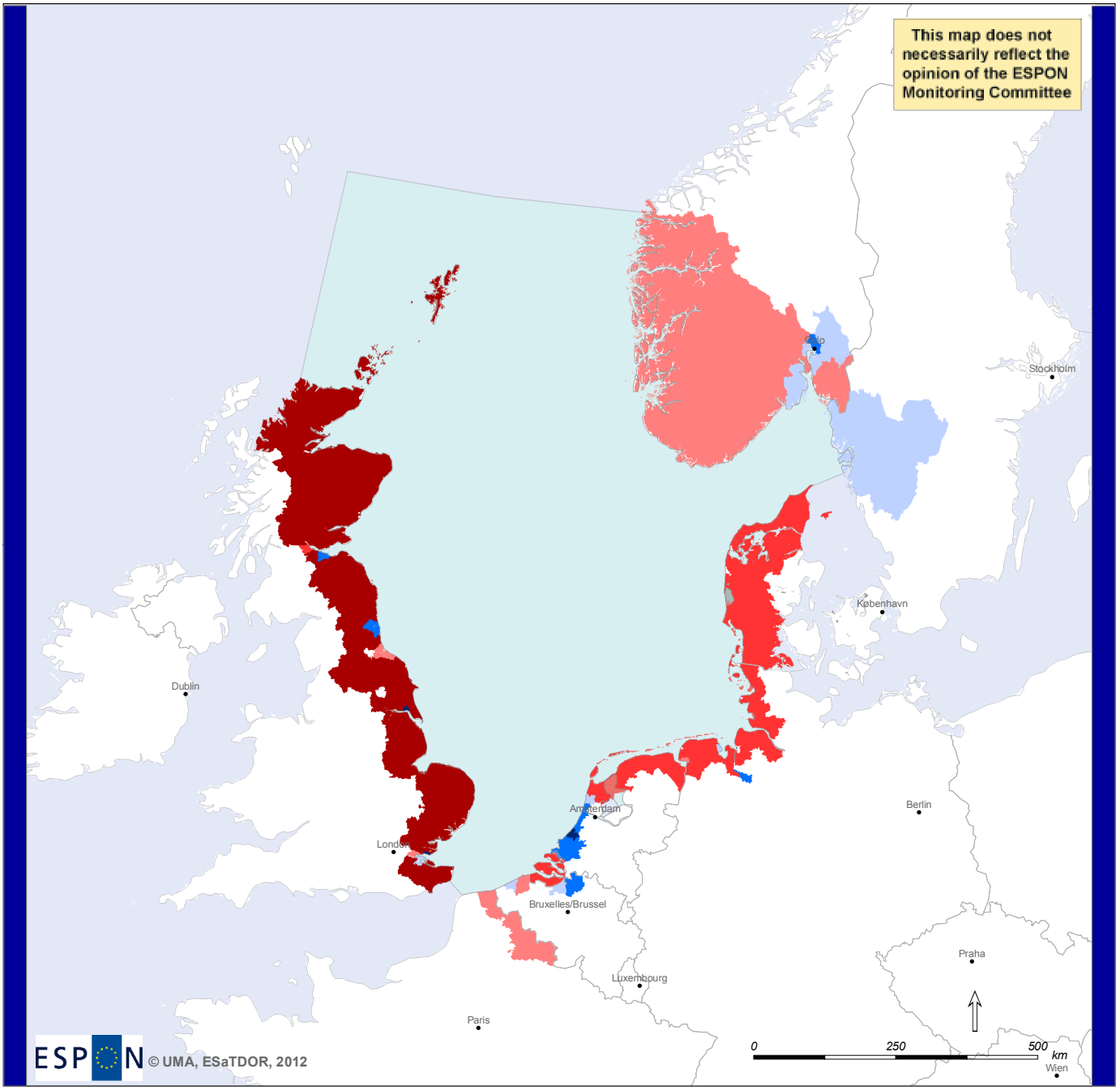
Thematic data: Water catchments, UNEP; EUROSTAT, 2008.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Population density per NUTS2 region within catchment (persons/km^2)

- 3 to 70
- 71 to 120
- 121 to 245
- 245 to 9493
- No Data

Map N4b. Population density per NUTS2 region (2008), North Sea.

Population Density in Coastal Regions



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Thematic data: Population density,EUROSTAT, 2008
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS3.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Population density in coastal regions 2008 (persons/km² compared to national averages)

Above Mean
- 1,801 to 4,900
- 401 to 1,800
- 1 to 400
- 0

Under Mean
- -300 to -1
- -750 to -301
- -1,200 to -751

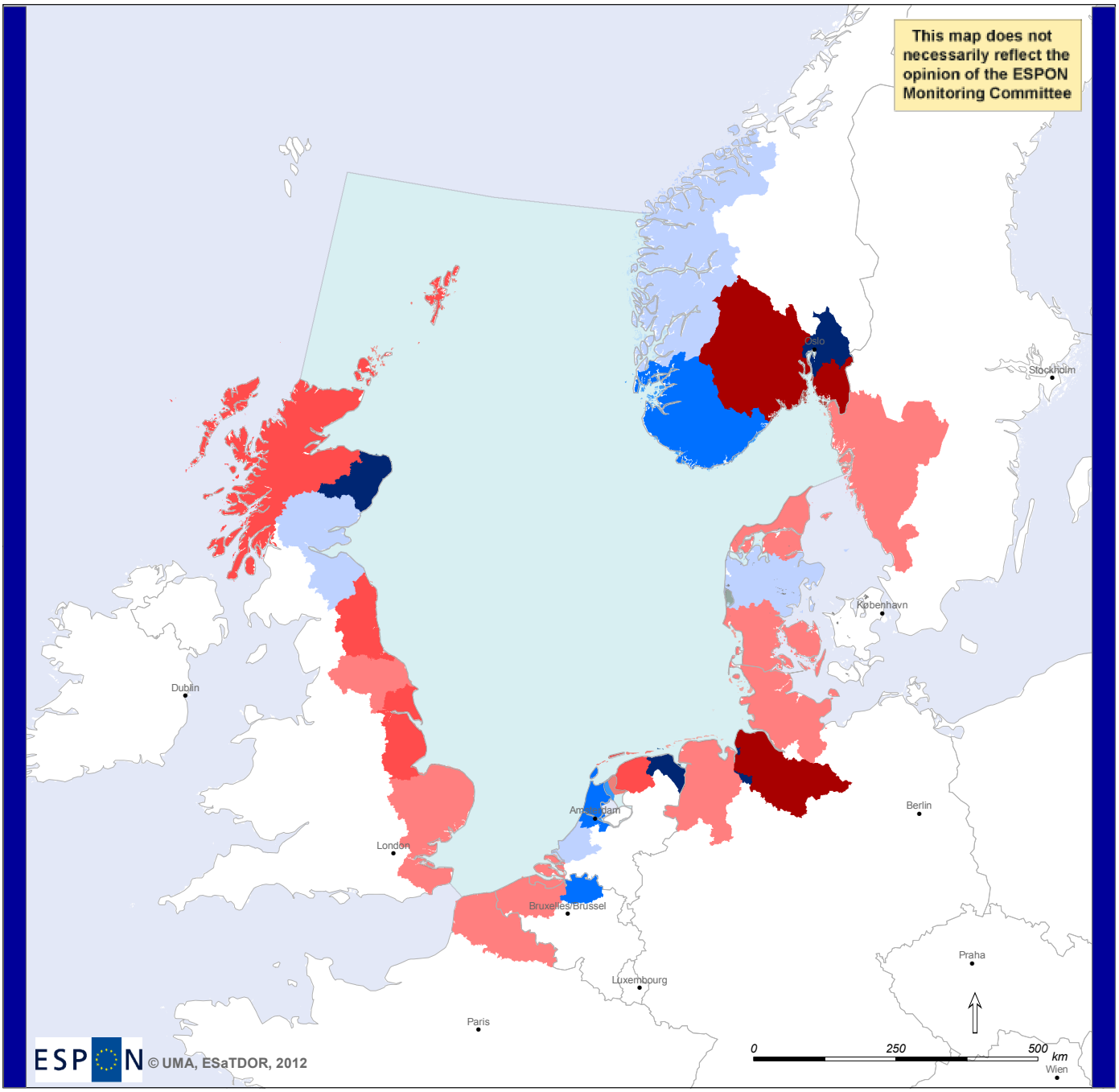
No data

Map N4c. Population density in coastal regions relative to national averages (2008), North Sea.

Comparing GDP in NUTS2 regions with national averages, coastal activities, with a few exceptions, contribute less to GDP than inland activities. Much of the coast of the North Sea is below national averages (see Map N5a). Areas above national averages are associated with ports (e.g. Hamburg), urban-industrial complexes (e.g. North Holland), and oil and gas exploitation (e.g. parts of Norway and Scotland).

However, in comparison with the rest of the ESPON space, GDP associated with North Sea coastal populations and industries are well above the European average (see Map N5b). North Sea coasts are among the most affluent, measured in terms of GDP, in Europe. However comparing Maps N4b and N5a, population density is not a good indicator of affluence. While ports and urban areas tend to have a high GDP, oil and gas exploitation clearly contributes much to relatively sparsely populated areas, such as in Norway and northern parts of the UK.

GDP Compared to National Average



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Thematic data: GDP, EUROSTAT, 2009; STATISTICS NORWAY, 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

GDP in coastal regions (Euros/person compared to national averages)

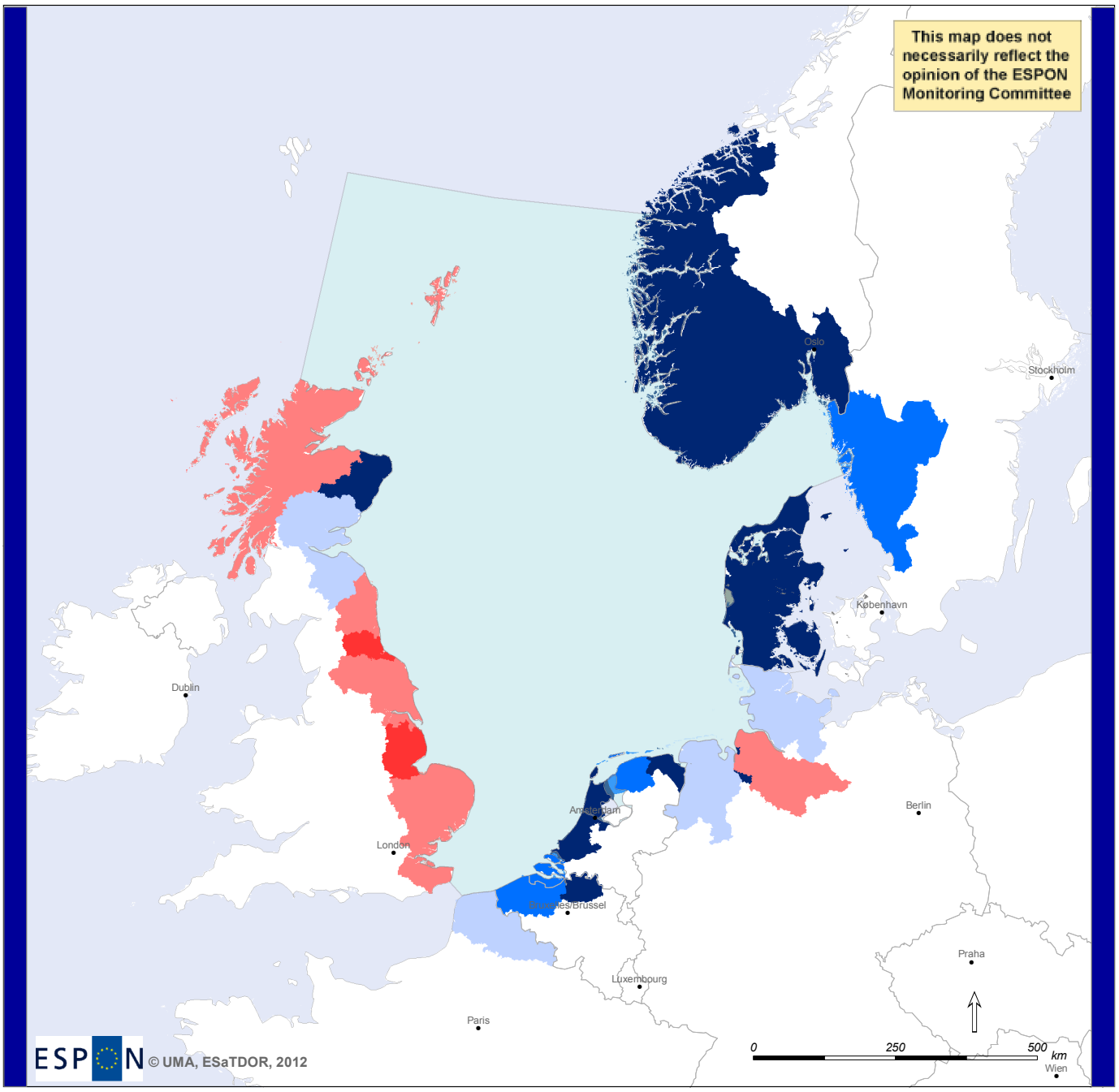
Above Mean
- 9,001 to 18,768
- 3,001 to 9,000
- 1 to 3,000
- 0

Under Mean
- -3,000 to -1
- -6,000 to -3,001
- -8,643 to -6,001

No data

Map N5a. GDP in coastal regions relative to national averages (2009), North Sea.

GDP Compared to Coastal Average



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Thematic data: GDP, EUROSTAT, 2009; STATISTICS NORWAY, 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

GDP in coastal regions (Euros/person compared to ESPON Seas coastal regions average)

Above Mean
- 10,001 to 37,615
- 3,501 to 10,000
- 1 to 3,500
- 0

Under Mean
- -5,000 to -1
- -10,000 to -5,001
- -10,001 to -20,107

No data

Map N5b. GDP in North Sea coastal regions (2009) compared to average across ESPON coastal regions

3. Thematic Sections

The North Sea, and particularly the shallower, southern region, is heavily used. Uses include: cables and pipelines, defence, fisheries, heritage (natural and cultural), mariculture, nature protection and marine protected areas (MPA), marine research, maritime transport, offshore wind farms, oil and gas extraction, other infrastructure, sand and gravel extraction, and tourism and leisure. The intensity and spatial distribution of uses varies. The southern North Sea, the coastline in general, and the vicinity of ports in particular are the most heavily used. Conflicts and competition among uses have a strong spatial dimension. Hot spots for multiple use of the North Sea include: the Dogger Bank, with conflicts between fisheries and proposed wind farm development; the Wadden Sea, where its recent World Heritage status exacerbate conflicts among tourism, defence, oil and gas extraction, offshore wind farm development, fisheries (including mariculture), maritime transport, and sand and gravel extraction; German Bight, with (potential) conflicts among maritime transport, offshore wind farms, and fisheries; and the Western Scheldt, with conflicts between the Netherlands and Belgium regarding its use for maritime transport, nature development, and cultural heritage.

3.1 Maritime Economy

Maritime economy addresses the following sectors and in particular employment in these sectors: fisheries, shipbuilding, other traditional maritime sectors, other sectors associated with the maritime cluster, transport and tourism. See Maps N6-12. Employment an additional sector, oil & gas, is shown in Section 3.3. Figure 1 provides a sectoral breakdown of employment for the North Sea, based on the data provided in Table 2, "Persons employed in traditional maritime sectors - EU27 and Norway", contained in Annex 1 (Economic Use) of the ESaTDOR Interim Report. The figure shows the importance of seaports and maritime services (~160 000 employed), as well as navy and coastguard (> 93 000 employed), offshore supply (> 83 000 employed), marine equipment and shipbuilding (together ~140 000 employed).

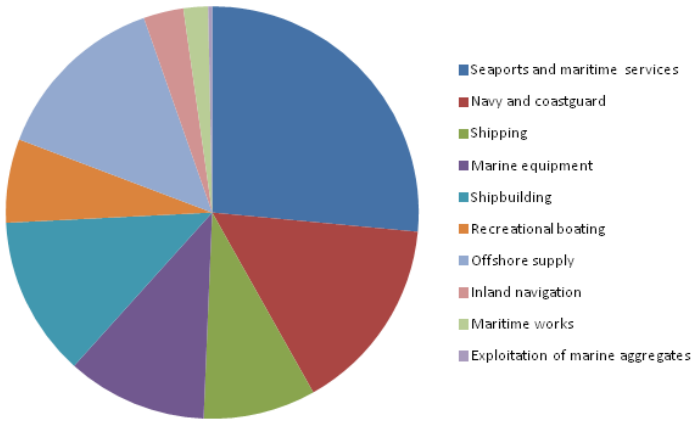


Figure 1: Persons employed in traditional maritime sectors (calculations based on figures provided by Policy Research Corporation 13 November 2008–28 country reports http://ec.europa.eu/maritimeaffairs/clusters_en.html#2; see ESaTDOR Interim Report Annex 1 (Economic Use), Table 2.

Employment in fisheries is relatively high, particularly in regions where population density is low, but even here is rarely exceeds 10% of total employment. (See Map Nc.) Fishing has historically been a major activity in the North Sea, particularly the shallower southern North Sea where its importance has probably been diluted by other economic activities.

Fishing fleets are highly industrialised and the larger vessels fish throughout the Atlantic and even other oceans. Total landings of fish from the North Sea have been declining since around 1998 (see Figure 2). While the North Sea once supported abundant stocks of commercial fish species [8], stocks are heavily exploited and many are considered to be in a seriously depleted condition. With commitments to maintain or restore stocks to levels that can support a maximum sustainable yield, fleet overcapacity is being tackled and overall fishing effort in the North Sea fell by about 25% between 2000 and 2006 [3].

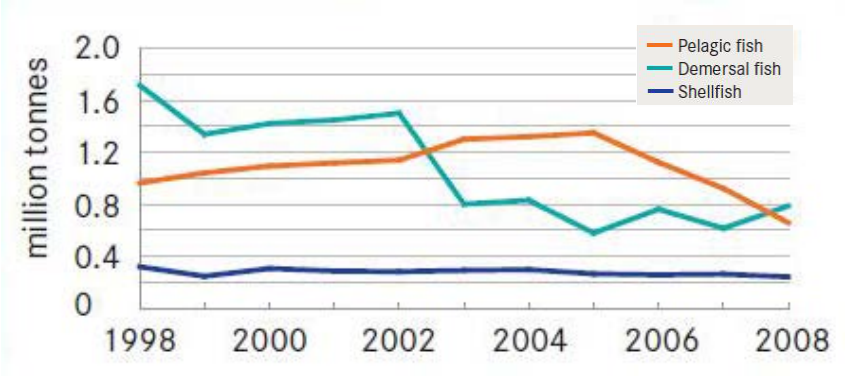


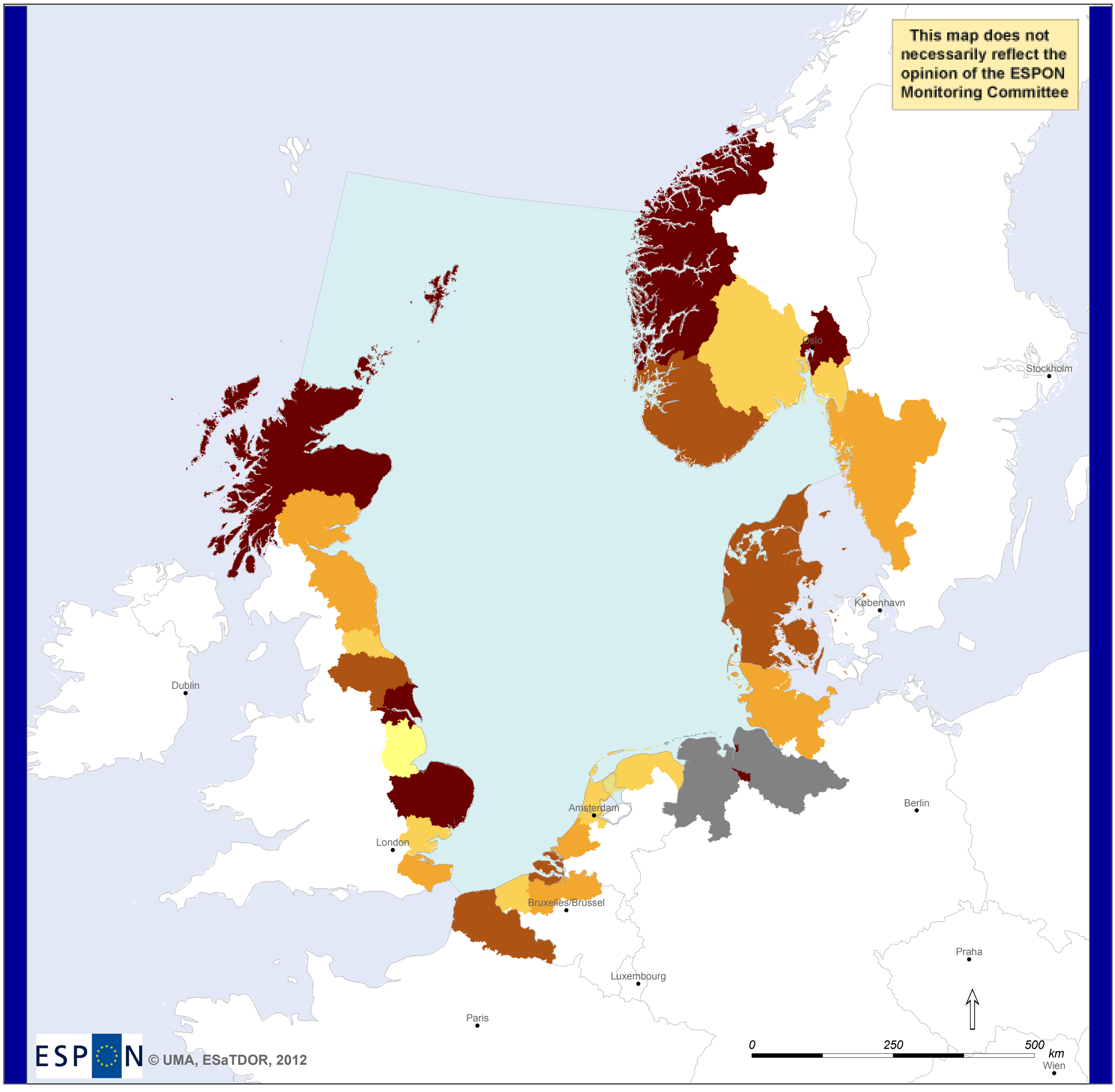
Figure 2. Landings of demersal fish, pelagic fish and shellfish 1998-2008 [3]

Shipbuilding (see Map N7) is a relatively minor employer (less than 5%), with the highest percentages on the continent and/or in the sparsely population northern coasts.

Other traditional maritime sectors and other sectors associated with the maritime cluster (see Maps N8 and N9) are also relatively minor employers (less than 7%), although makŜ l· greater contribution in relatively sparsely populated areas (e.g. northern nations such as Norway and Denmark, parts of the UK east coast).

Note that all of the above economic activities are relatively minor employers in coastal areas of the southern North Sea, which is both more densely populated as well as more heavily industrialised, presumably with industries less connected with the sea.

Employment in Fisheries



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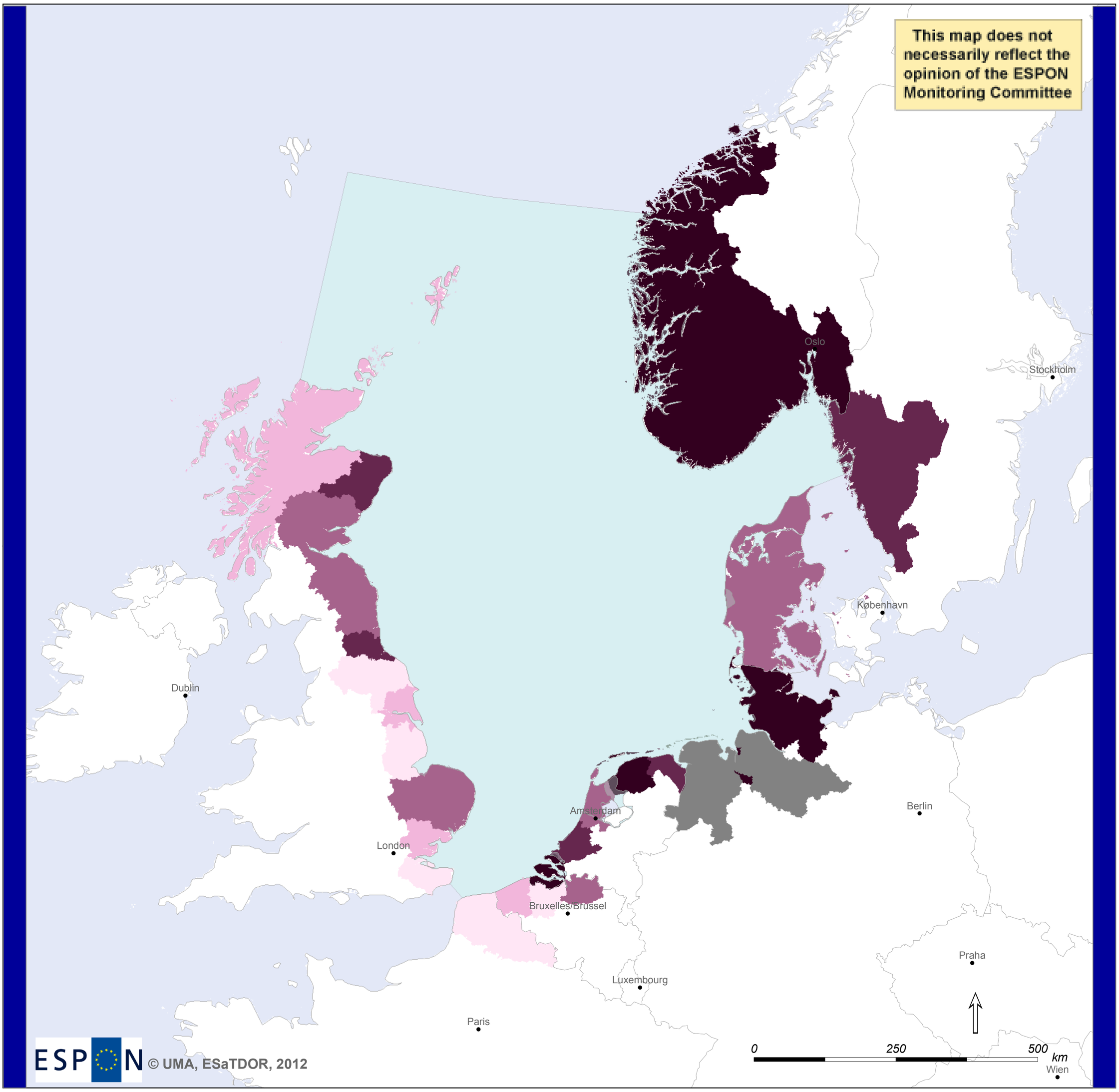
Thematic data: Economic Use, European Cluster Observatory, 2011.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Employment in Fisheries 2009, (percentage of total employment).

- 0.22 to 0.52
- 0.53 to 0.67
- 0.68 to 0.90
- 0.91 to 1.19
- 1.20 to 8.27
- No data

Map N6. Employment in fisheries 2009 (as a percentage of total employment), North Sea.

Employment in Shipbuilding



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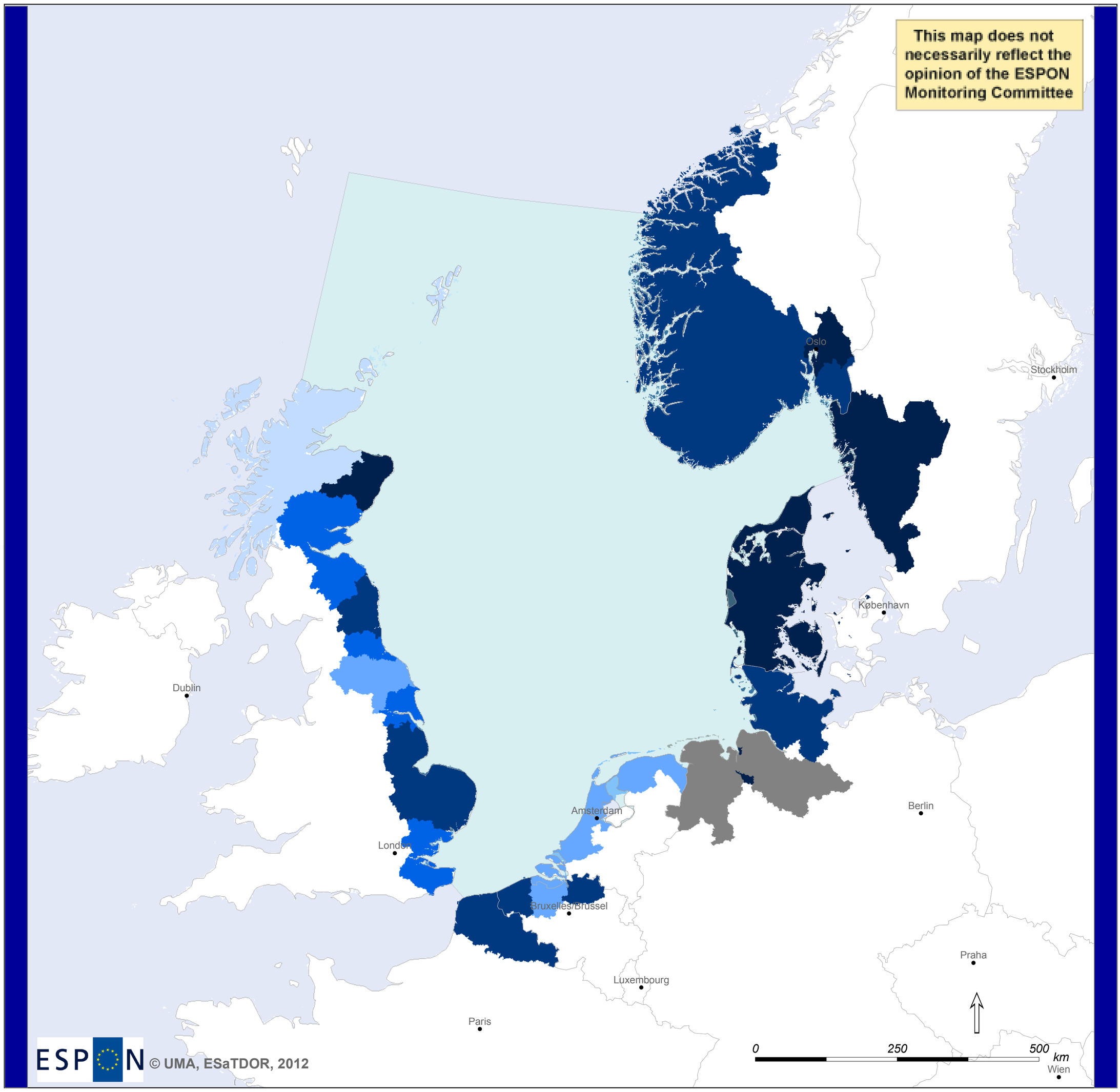
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Employment in Shipbuilding, 2009 (percentage of total employment).

- 0 to 0.04
- 0.05 to 0.10
- 0.11 to 0.17
- 0.18 to 0.37
- 0.38 to 3.05
- No data

Map N7. Employment in shipbuilding 2009 (as a percentage of total employment), North Sea.

Employment in Other Traditional Maritime Sectors



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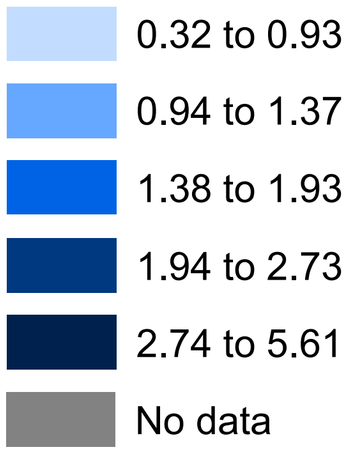
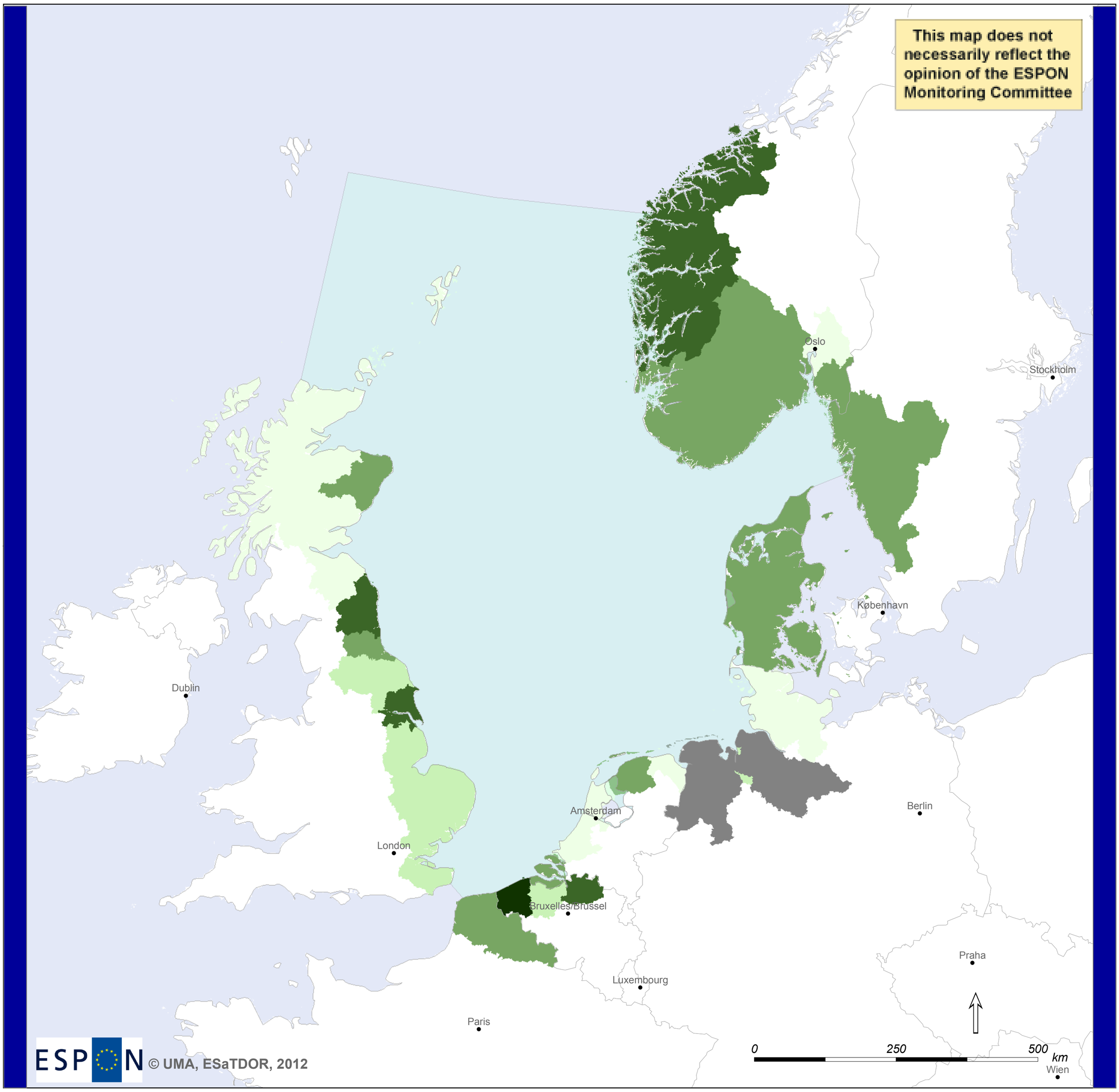
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Employment in other traditional maritime sectors, 2009 (percentage of total employment).



Map N8. Employment in other traditional maritime sectors 2009 (as a percentage of total employment), North Sea.

Employment in Other Sectors Associated with the Maritime Cluster



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Thematic data: Economic Use, European Cluster Observatory, 2011.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Employment in other sectors associated with the maritime cluster, 2009 (percentage of total employment).

- 0.28 to 0.85
- 0.86 to 1.21
- 1.22 to 1.47
- 1.48 to 2.06
- 2.07 to 6.10
- No data

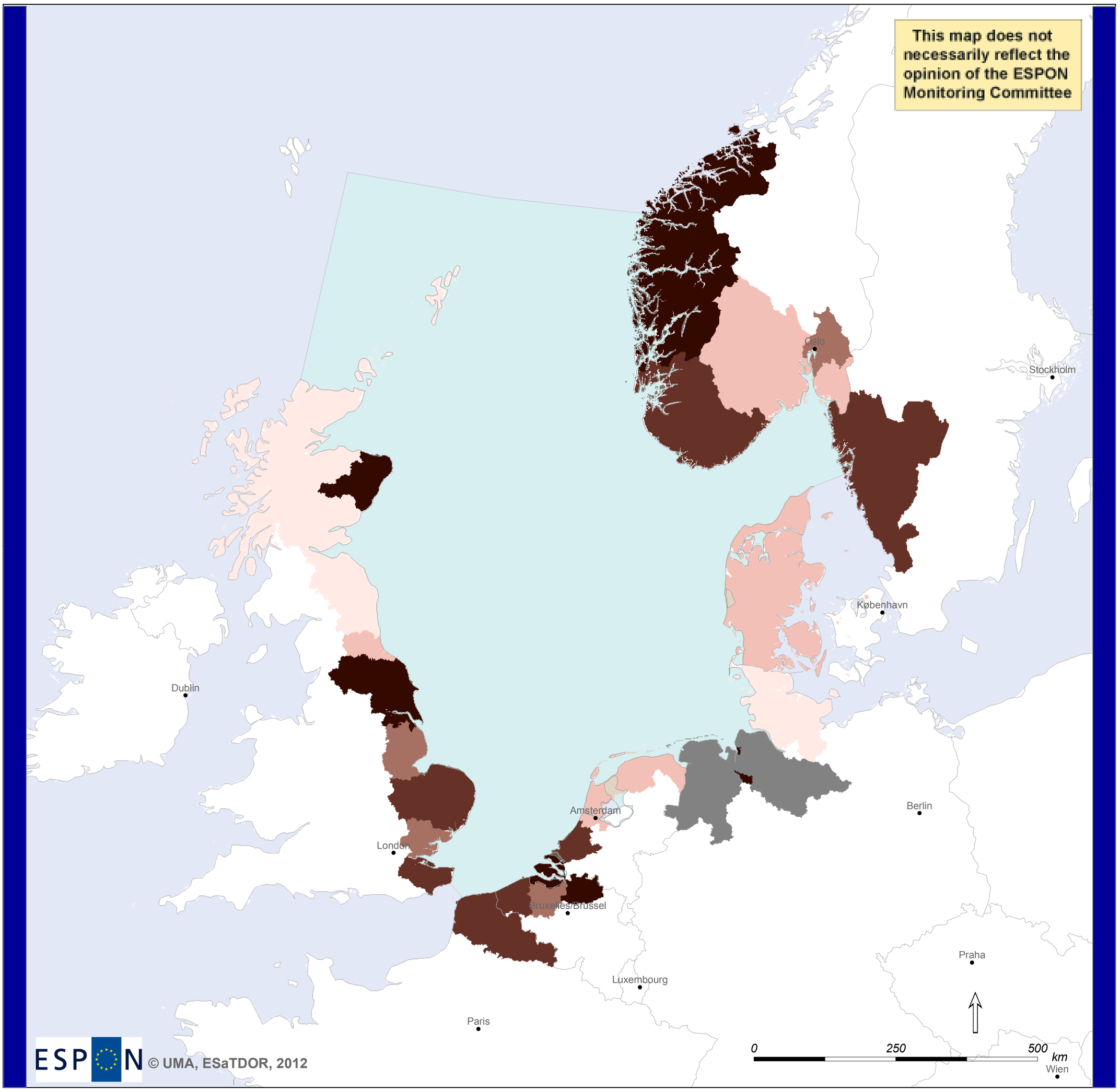
Map N9. Employment in other sectors assocaited with the maritime cluster 2009 (as a percentage of total employment), North Sea.

Map N10 shows the percentage of total employment that is employed in transport. Comprising less than 5%, transport is not a major employer. Employment is greatest in major ports (e.g. Rotterdam, Antwerp, Hamburg) and coastal areas supporting soil and gas exploitation (Aberdeen in Scotland, Norway). Employment linked to ferries is indicated by relatively high employment on both sides of the Strait of Dover.

Tourism intensity, measured in terms of establishments, bedrooms and beds/km^2, is light in comparison with other regional seas (see Map N11), and somewhat greater on the coast of the southern North Sea.

The coast of the North Sea is popular for recreation and tourism, particularly the southern North Sea. Tourist arrivals to the coastal North Sea have been increasing steadily, from around 50 million in 1998 to 80 million in 2007 [3]. Map N12 shows employment in tourism. Tourism is a major employer (in places nearly 30%) in relatively sparsely populated coastal areas of the UK. On the continent it is generally less.

Employment in Transport



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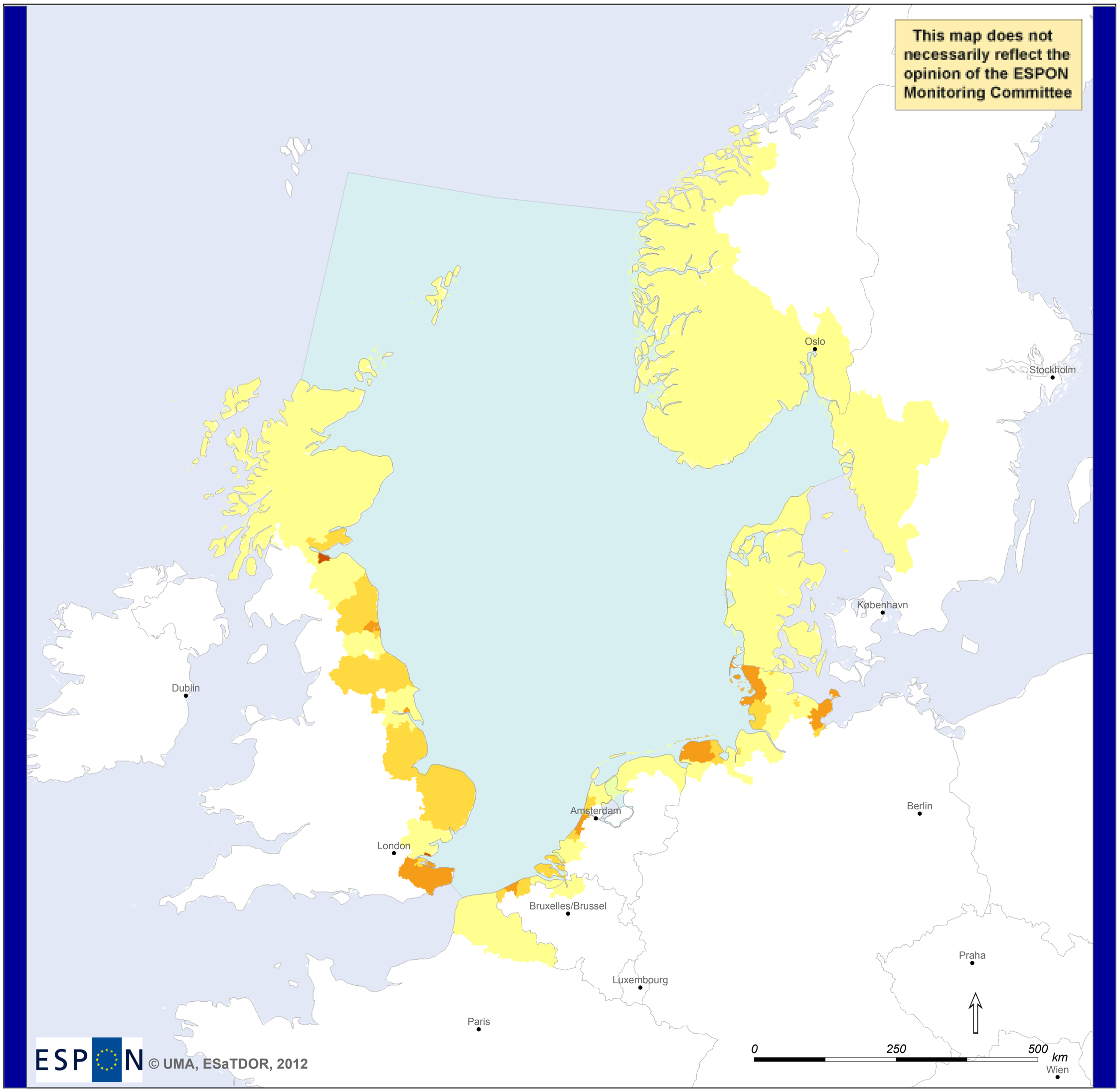
Thematic data: Economic Use, European Cluster Observatory, 2011.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Employment in Transport 2009 (percentage of total employment)

- 0 to 1.49
- 1.50 to 1.78
- 1.79 to 2.02
- 2.03 to 2.45
- 2.46 to 4.12
- No data

Map N10. Employment in transport 2009 (as a percentage of total employment), North Sea.

Tourism Intensity



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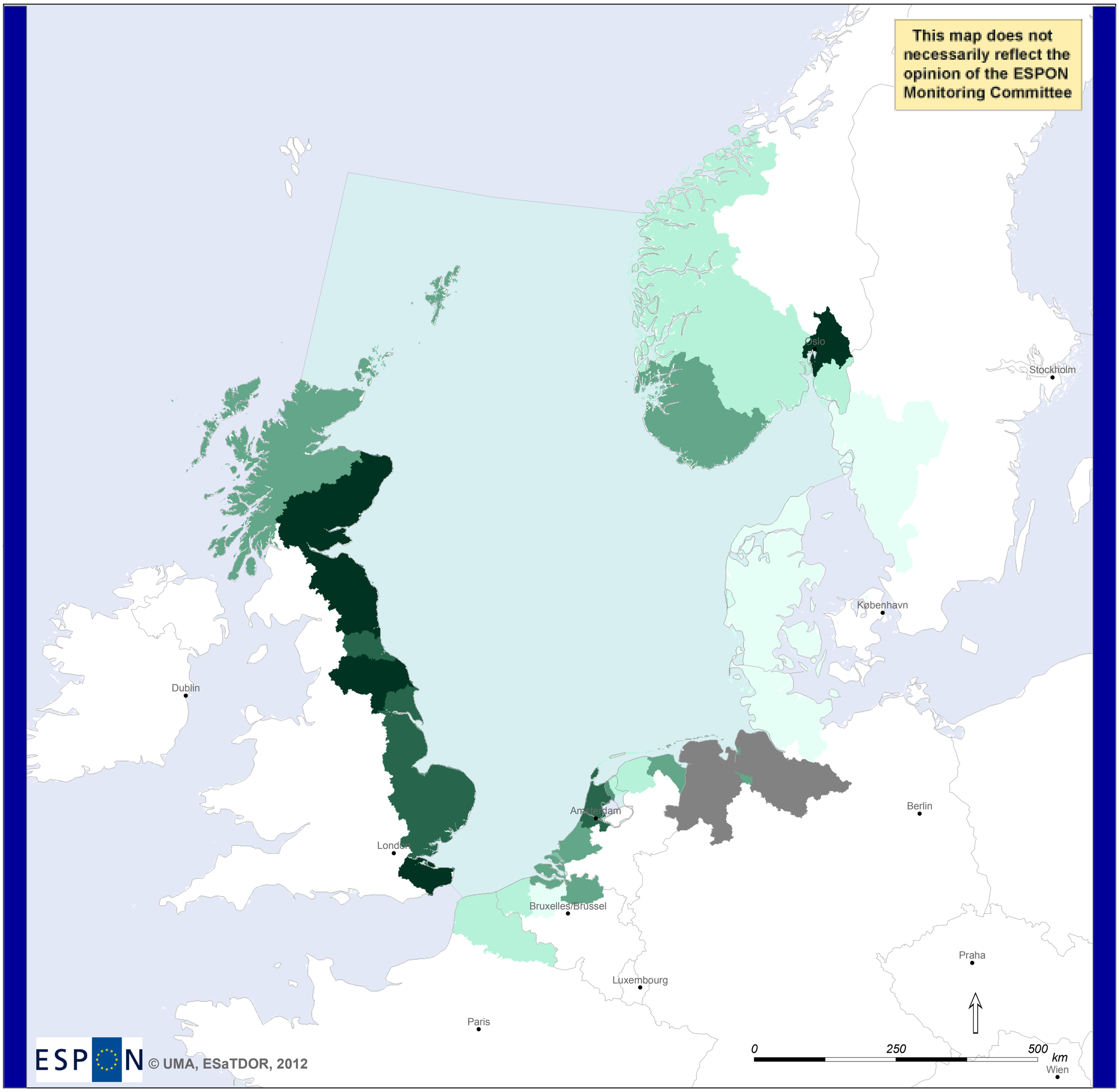
Thematic data: Tourism Intensity, EUROSTAT, 2009
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS3.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Tourism Intensity (establishments, bedrooms and bedplaces/km^2)

- 0.02 - 0.25
- 0.26 - 0.50
- 0.51 - 1.00
- 1.01 - 5.00
- 5.01 - 15.00
- 15.01 - 61.13

Map N11. Tourism intensity measured as number of establishments, bedrooms and bedplaces/km^2, North Sea

Employment in Tourism



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Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Employment in Tourism 2009 (percentage of total employment)

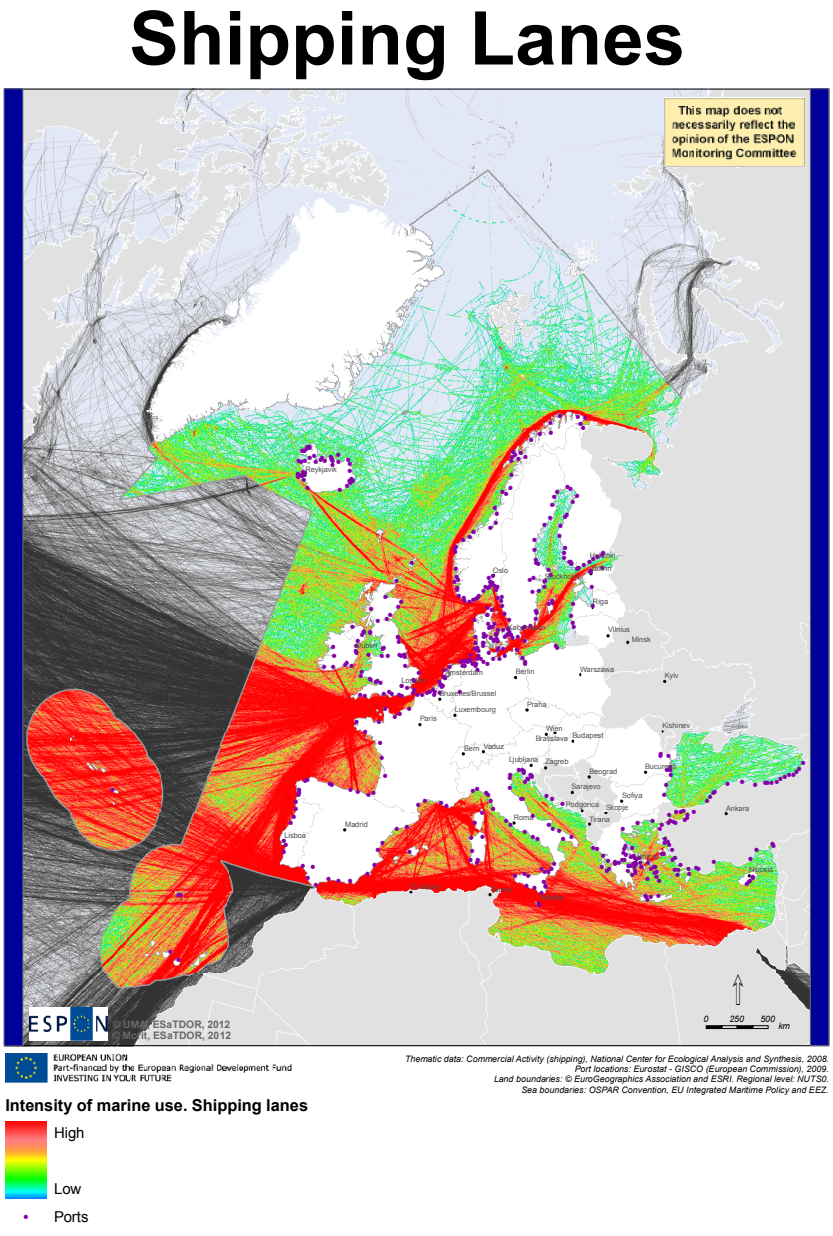
- 0 to 8.70
- 8.71 to 11.60
- 11.61 to 13.55
- 13.56 to 17.90
- 17.91 to 29.42
- No data

Map N12. Employment in tourism 2009 (as a percentage of total employment), North Sea.

3.2 Transport

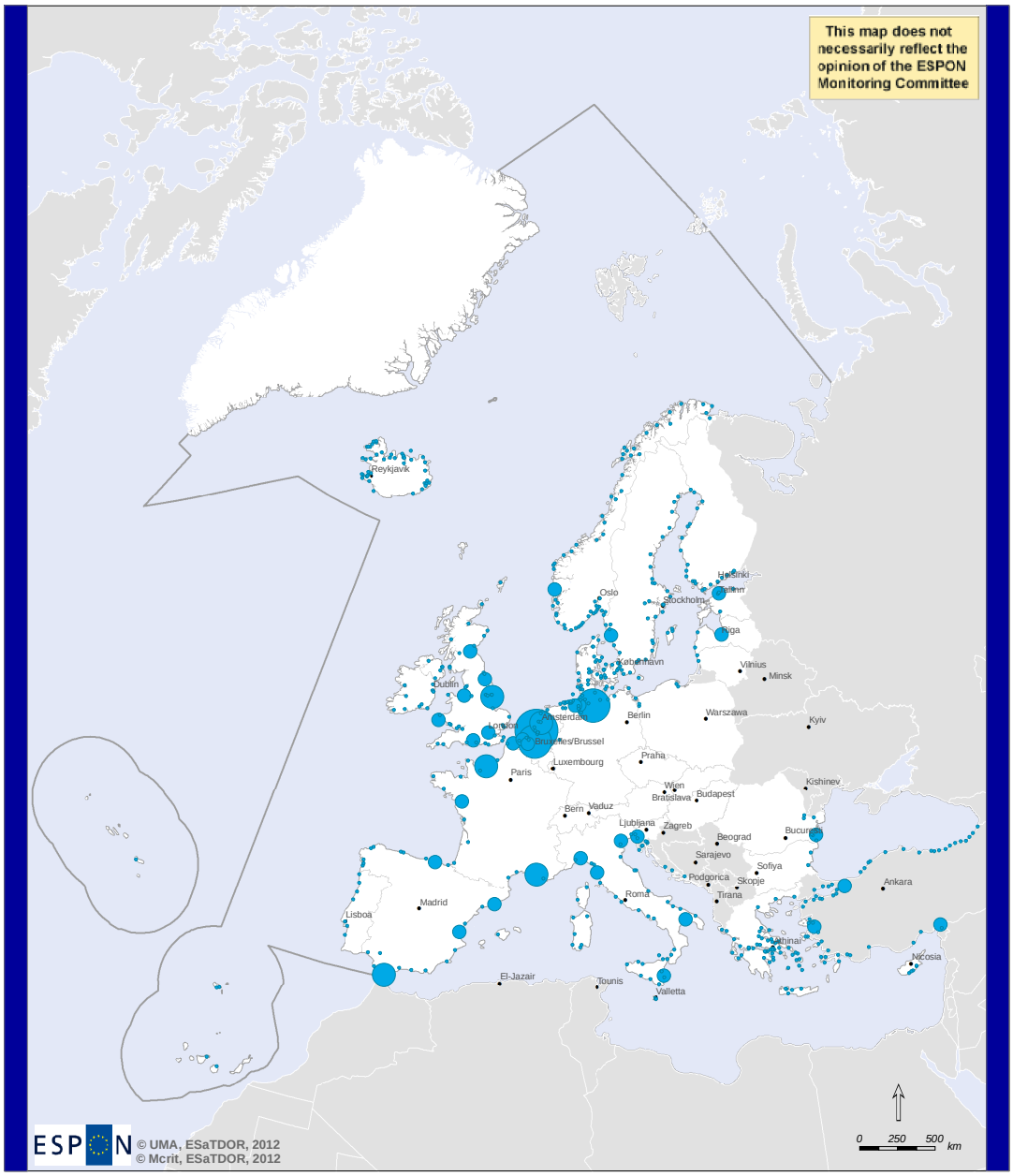
The North Sea contains some of the busiest shipping routes and largest ports in Europe as can be seen from Maps N13, N14 and N15a). The North Sea is home to Europe's largest port (Port of Rotterdam) which is also the world's third largest. Some of this traffic is en route to and from the Baltic and Barents Seas. More than 400 ships pass daily through the Channel and more than 600 ships per day cross the North Sea (including 200 ferries) at the Strait of Dover. Approximately half the shipping activity in the North Sea and the Channel combined consists of ferries and roll-on/roll-off vessels on fixed routes [3].

Predictions for shipping until 2020 are difficult, but an increase is expected, particularly of through-traffic oil tankers [3]. While of economic importance, shipping presents clear threats to environmental quality, notably: hazardous substances (e.g. chemicals and oil released deliberately and as a result of collisions); emissions of greenhouse gases, NOx, SOx and particulates; litter and oily wastes; non-indigenous species; use of organotin compounds in anti-foulants.



Map N13. Shipping Lanes

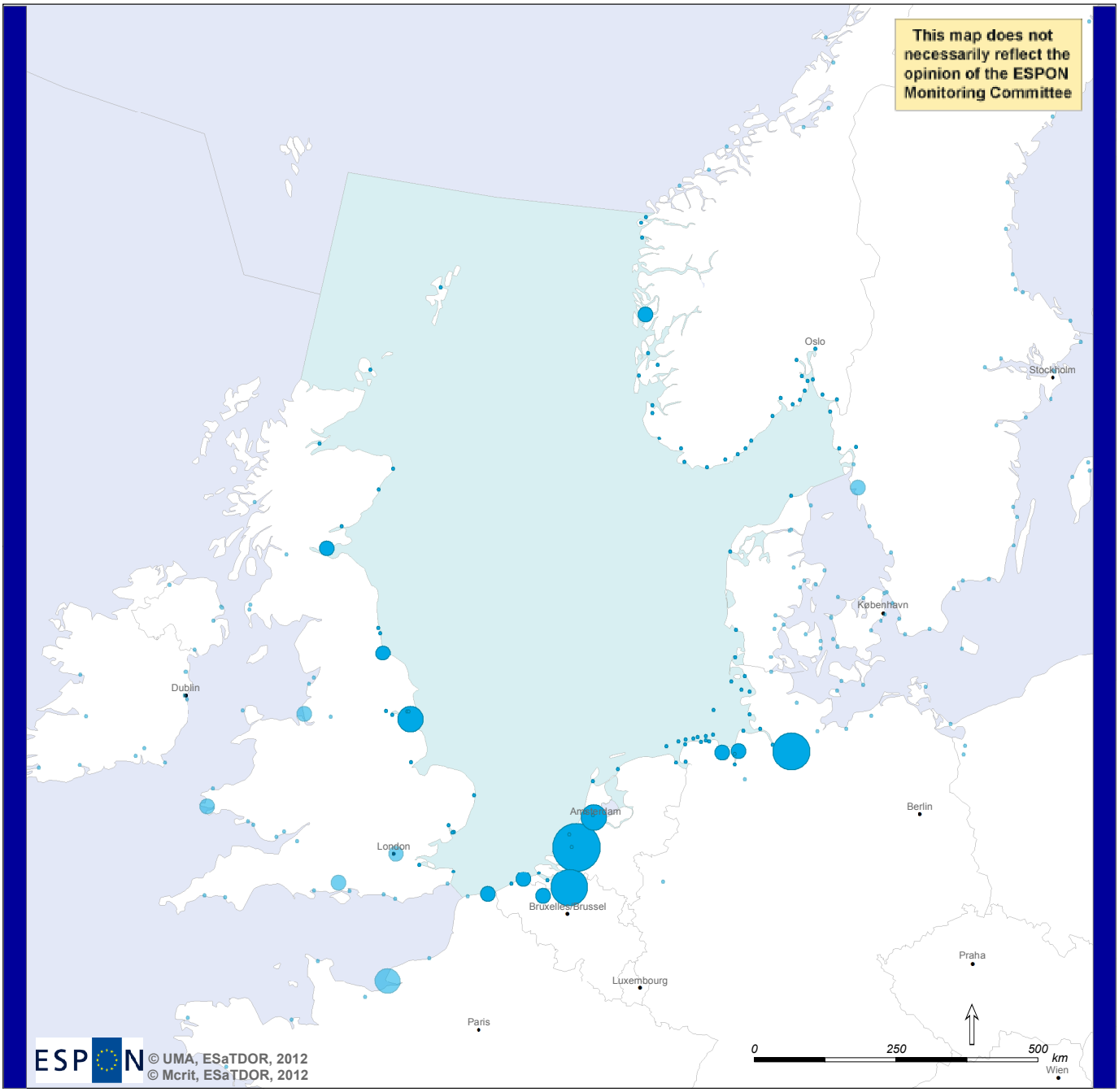
Total Cargo Shipping



Map N14. Total cargo shipping at European ports (million tonnes), 2008

Map N15a shows that this regional sea sports a number of ports that are almost as large, notably as Hamburg and Antwerp. Map N15b shows that the majority of goods carried by ships in 2008 was inbound. Exceptions in the UK and Norway relate to the export of oil. Shipping generally increased 2004-2008 (see Map N15c).

Total Cargo Shipping, North Sea



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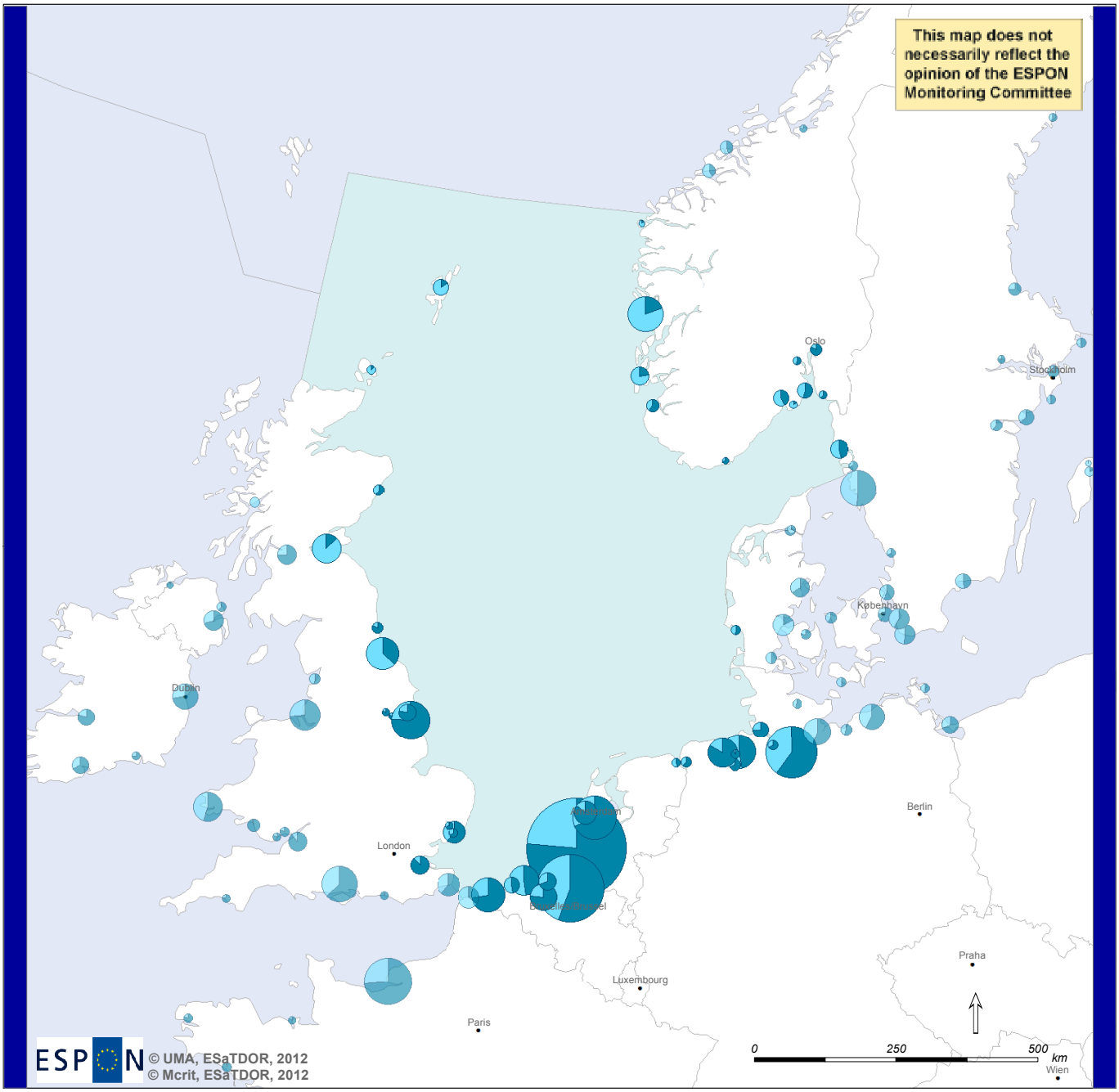
Thematic data: Gross weight of goods handled in all ports, EUROSTAT, 2008.
Iceland data: EUROSTAT, 2006.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Total shipping at ports, 2008 (million tonnes). All ports.

- 1 - 250
- 250 - 500
- 500 - 1000
- 1000 - 2000
- > 2000

Map N15a. Total shipping at North Sea ports (million tonnes), 2008.

Cargo Shipping by Direction



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Thematic data: Gross weight of goods handled in all ports by direction, EUROSTAT, 2008.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

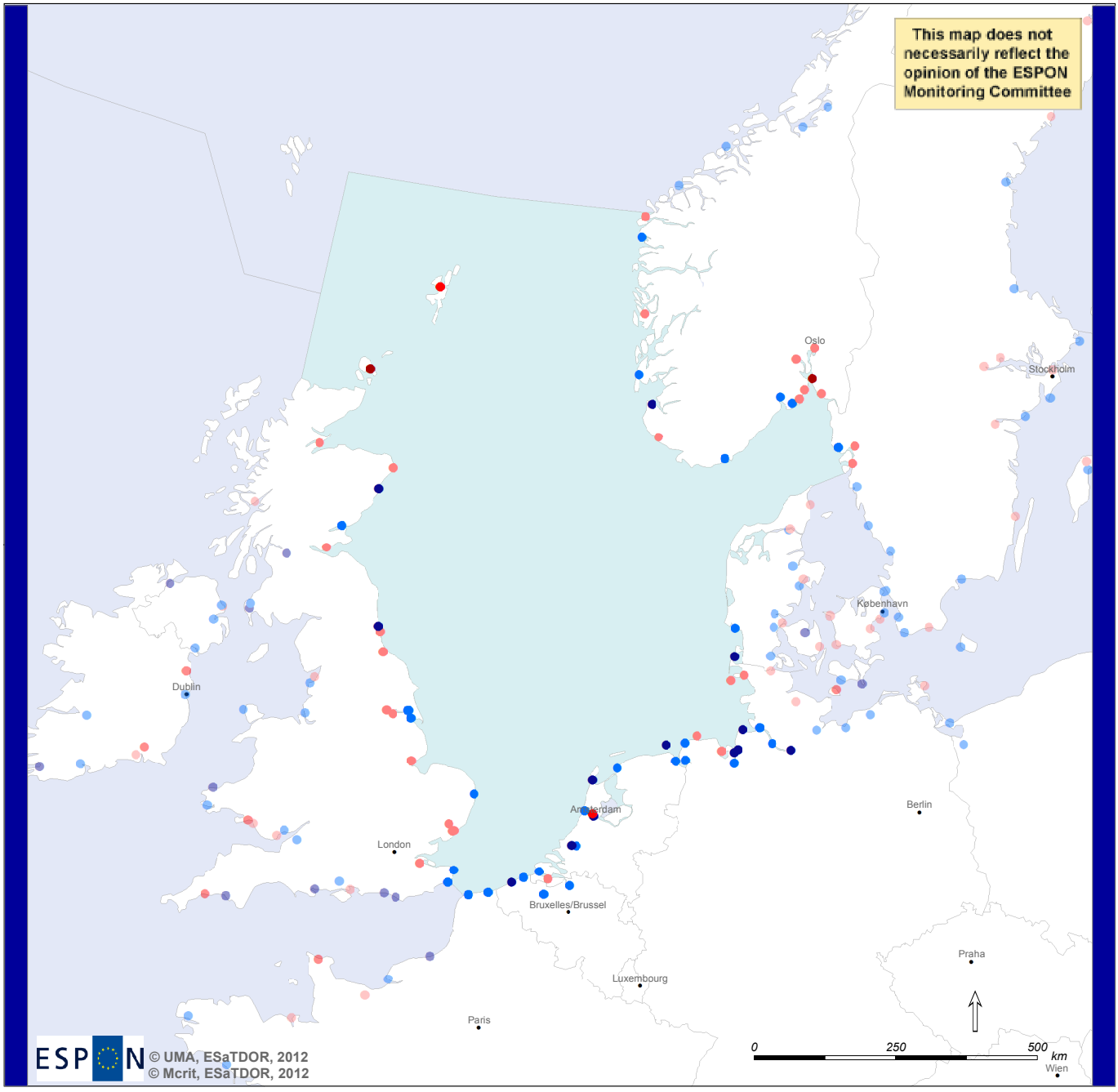
Total shipping at ports by direction, 2008.

Inward direction

Outward direction

Map N15b. Cargo shipping at North Sea ports by inward/outward direction, 2008.

Shipping Trends



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Thematic data: Gross weight of goods handled in all ports by direction, EUROSTAT, 2004 - 2008.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

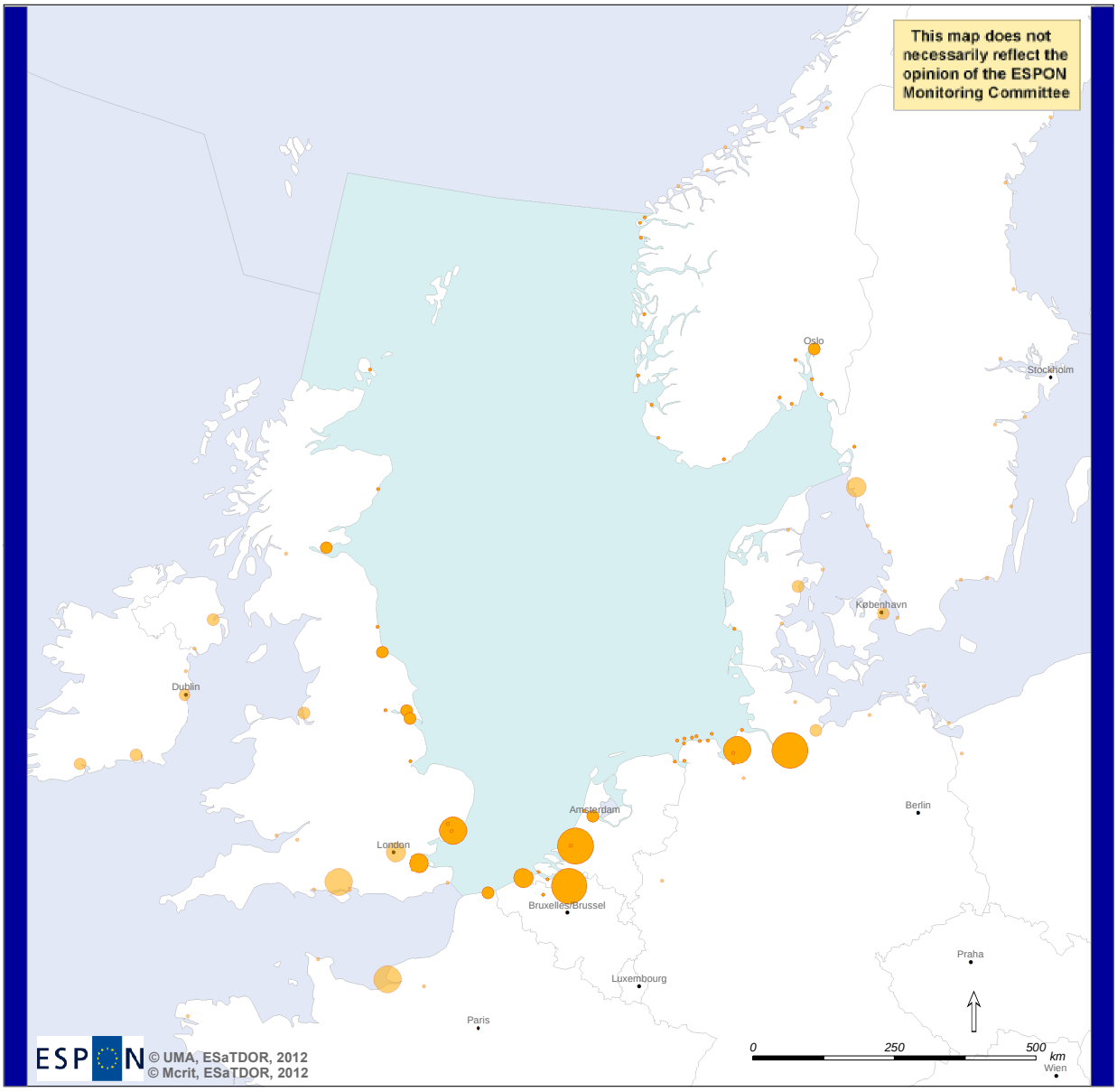
Total shipping at ports. Average annual traffic increase, 2004 - 2008 (%).

- < -20%
- -20% to -10%
- -10% to 0%
- 0% to 10%
- > 10%

Map N15c. Average annnual traffic increase (percentage of goods handled), 2004-2008. North Sea ports.

Map N16a shows the volume of container shipping at North Sea ports. Ports in the southern North Sea, notably Rotterdam, Antwerp and Hamburg, have considerable container traffic. Map N16b shows that containers were approximately equally divided between inbound and outbound. Map N16c shows that container shipping is increasing throughout the region, but particularly in ports in the southern North Sea already with heavy container traffic.

Container Shipping, 2008



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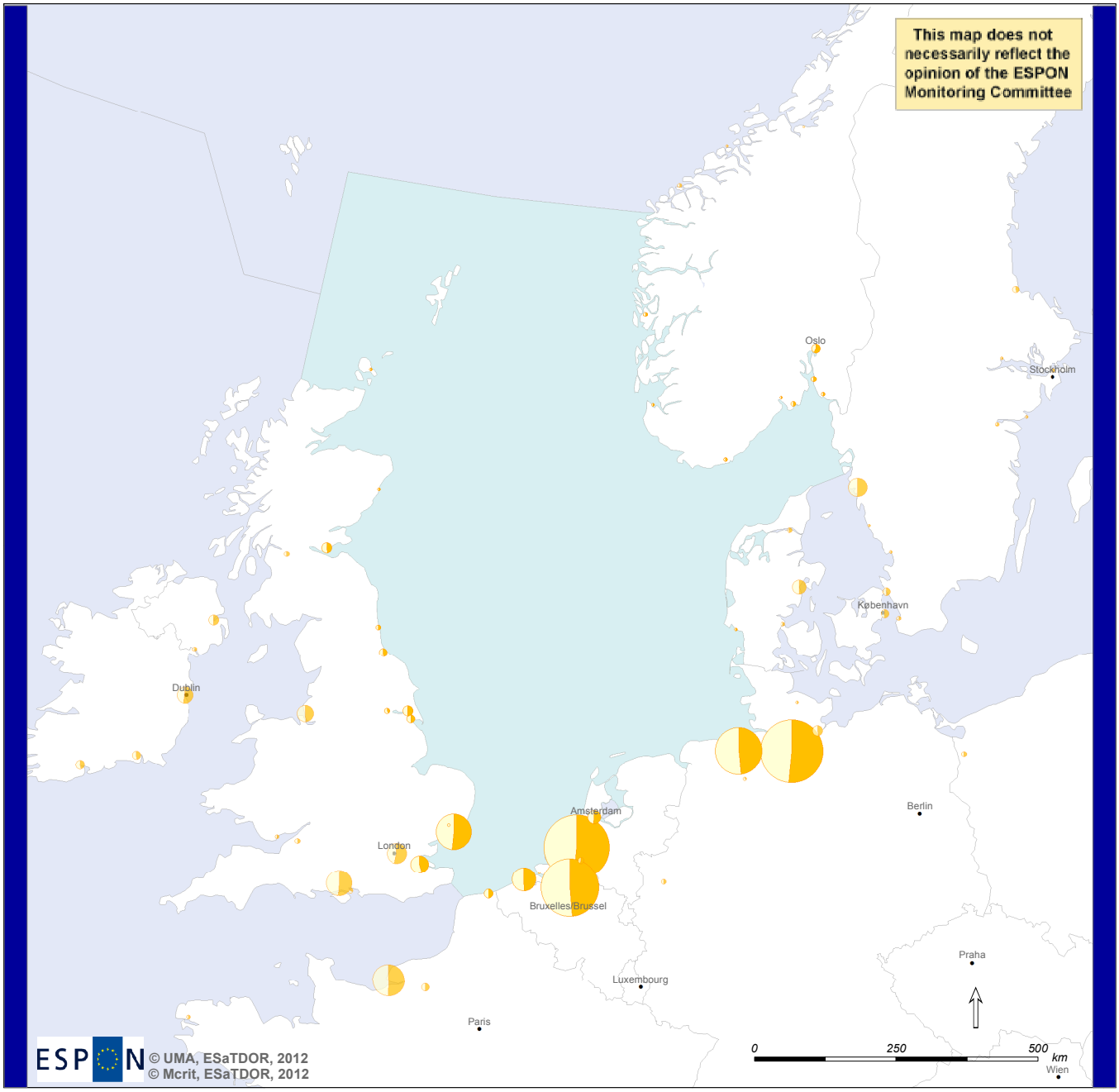
Thematic data: Containers handled in all ports by direction, EUROSTAT, 2008.
**Marsaxlokk data: Freeport Malta, 2008*
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Container shipping at ports, 2008 (million TEU). All ports.

- 0 - 0.15
- 0.15 - 0.70
- 0.70 - 1.6
- 1.6 - 5.5
- > 5.5

Map N16a. Container shipping at North Sea ports (million TEU), 2008.

Container Shipping by Direction, 2008



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Thematic data: Containers handled in all ports by direction, EUROSTAT, 2008.
**Marsaxlokk data: Freeport Malta, 2008*
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

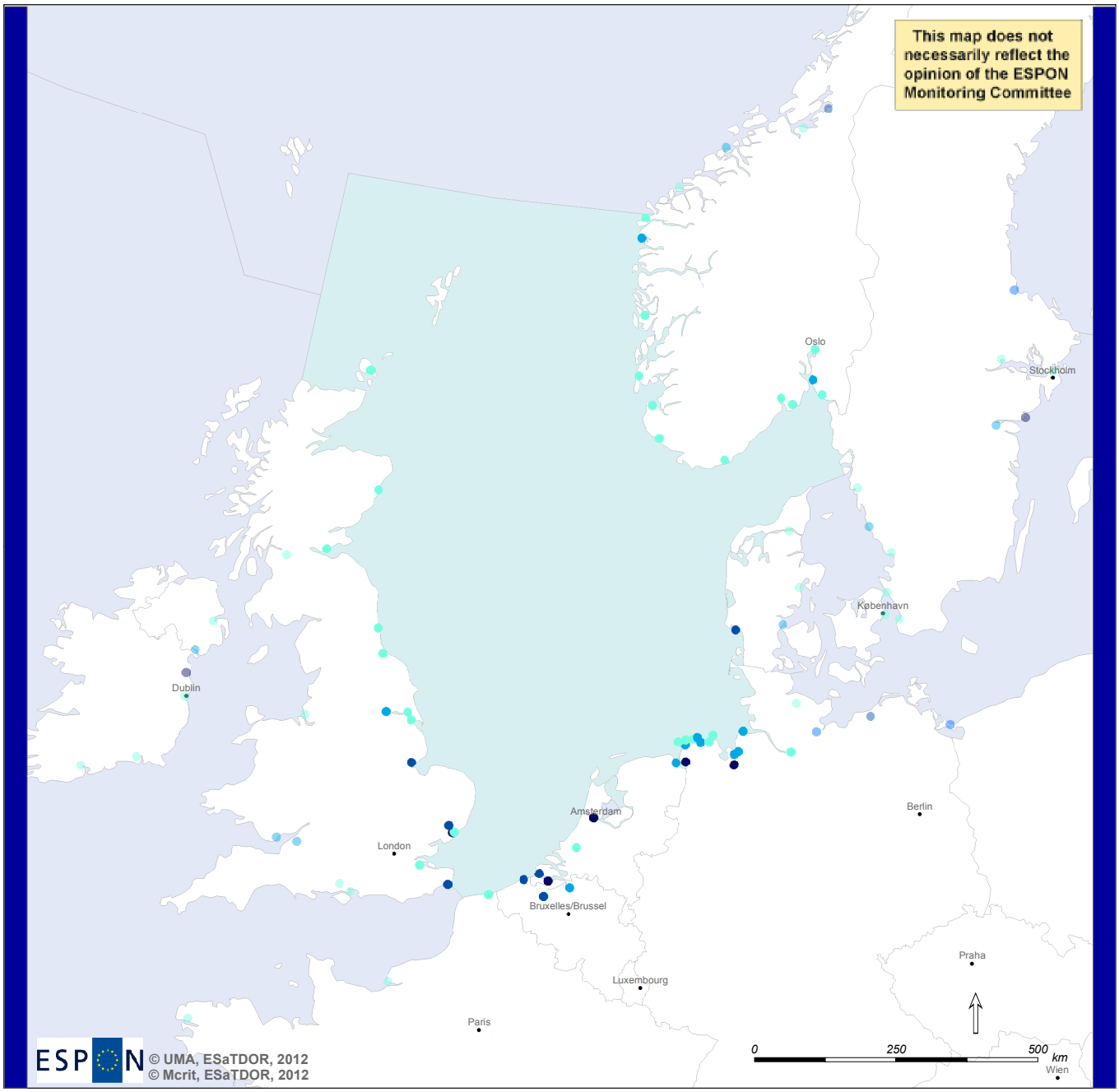
Container shipping at ports by direction, 2008.

Inward direction

Outward direction

Map N16b. Container shipping at North Sea ports by inward/outward direction, 2008.

Container Shipping Trends



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Thematic data: Containers handled in all ports by direction, EUROSTAT, 2008.
**Marsaxlokk data: Freeport Malta, 2008.*
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

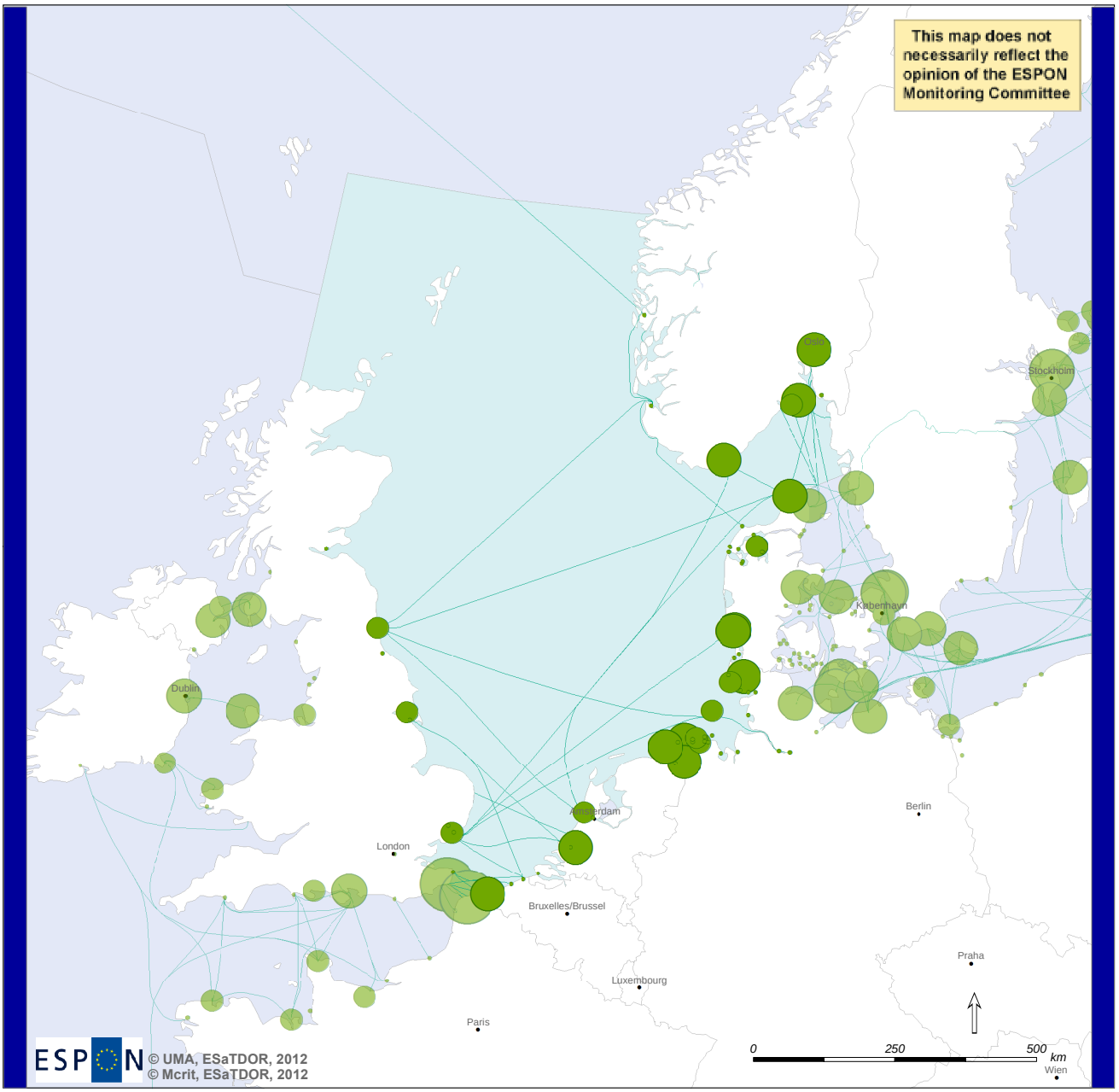
Container shipping at ports. Average annual traffic increase 2004 - 2008 (%).

- 0% - 10%
- 10% - 20%
- 20% - 30%
- 30% - 50%
- > 50%

Map N16c. Average annual increase in container shipping (tonnes handled), 2008.

Ferry passengers at ports are shown in Map N17a. Most passenger ferry activity occurs in the southern North Sea, which also borders on the Channel, and across the Skaggerak. Ferry passenger traffic at port showed a decline 2004-2008 (Map N17b). Eastern ports, notably in the vicinity of the German Wadden Sea and Denmark, showed an increase over this period.

Ferry Passengers, 2008



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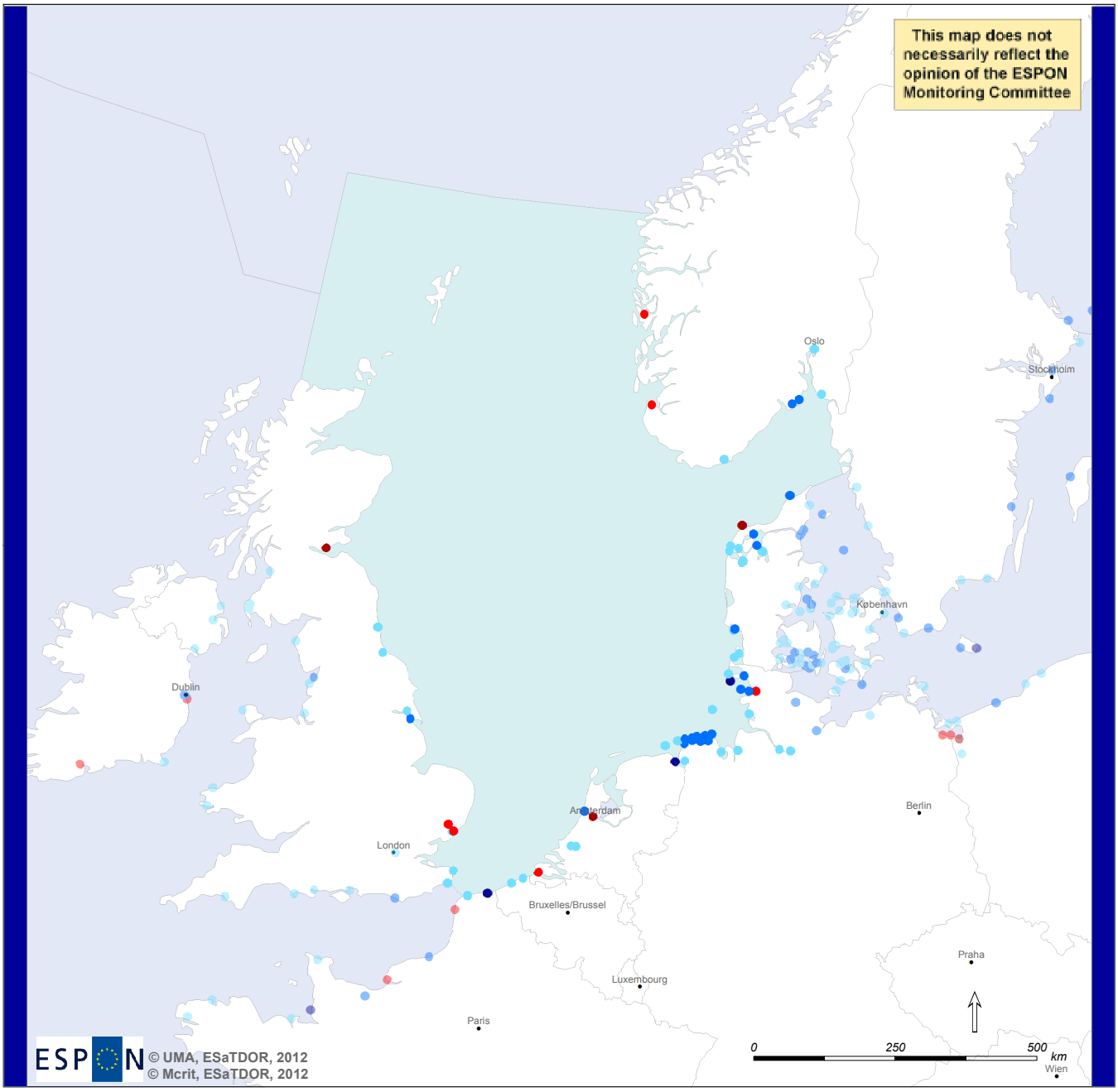
Thematic data: Passengers maritime transport by direction and type of traffic, EUROSTAT, 2008.
Ferry routes: TRANS-TOOLS (European Commission), 2005.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Ferry passengers at ports, 2008 (Mpax).

- < 500000
- 500000 - 1000000
- 1000000 - 5000000
- 5000000 - 10000000
- > 10000000
- Ferry routes

Map N17a. Ferry passengers at North Sea ports, 2008.

Ferry Passenger Trends



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Thematic data: Passengers maritime transport by direction and type of traffic, EUROSTAT, 2008.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

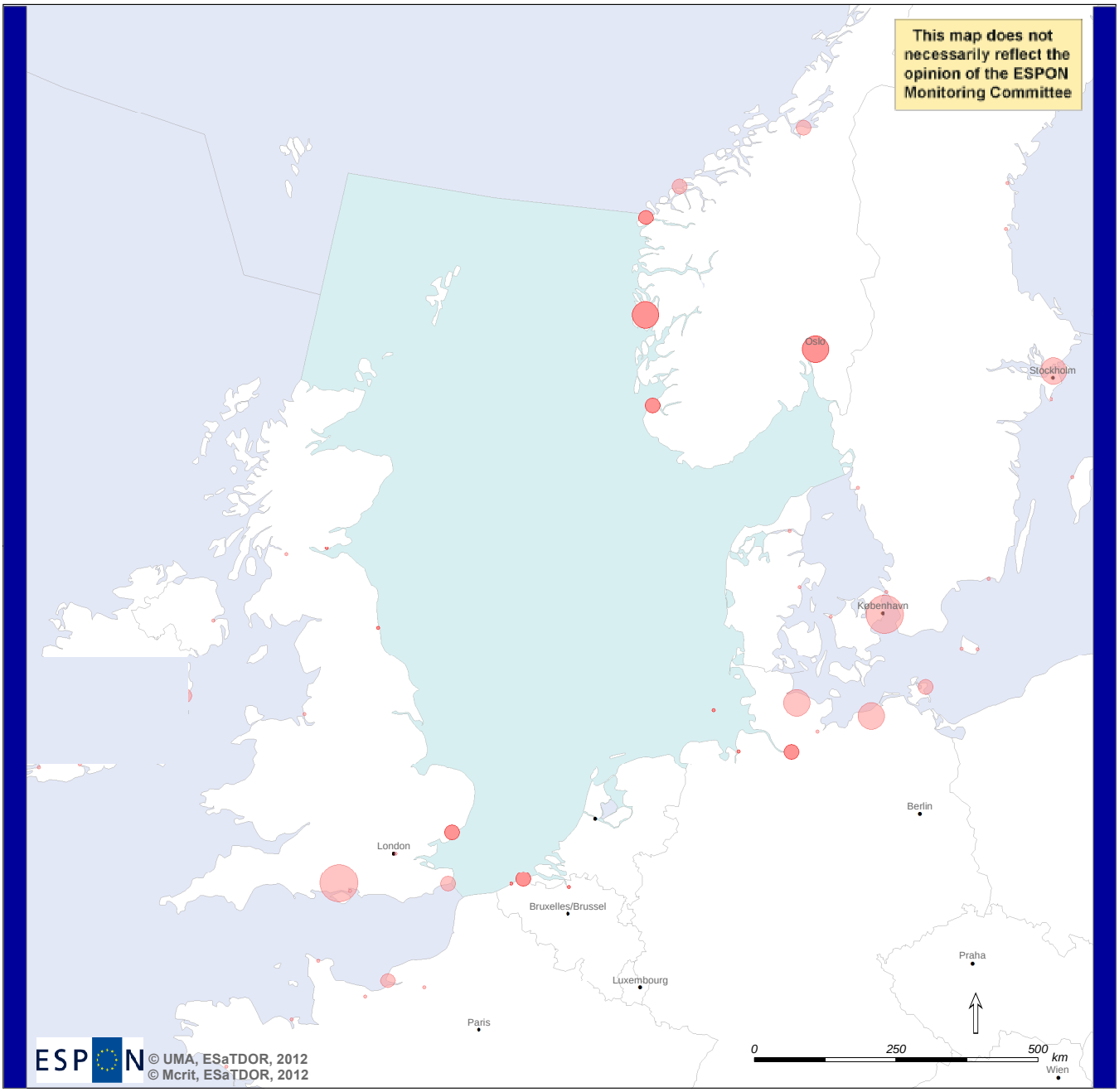
Ferry passengers at ports. Average annual traffic increase of ferry passengers 2004 - 2008 (%).

- > -35%
- -35% to -15%
- -15% to 0%
- 0% to 15%
- > 15%

Map N17b. Average annual increase in ferry passengers, North Sea ports (2004-2008).

Cruise activity at ports is more evenly distributed throughout the North Sea, and if anything, more concentrated in the northerly regions with ports such as Copenhagen, Oslo and Bergen (see Map N18a). Map N18b shows that cruise activity in the more northern ports is largely throughput. Passengers board and leave boats in the southern North Sea ports and in Copenhagen. Cruise activity has increased somewhat over 2005-2008 (see Map N18c), but not at all ports.

Cruise Shipping, 2008



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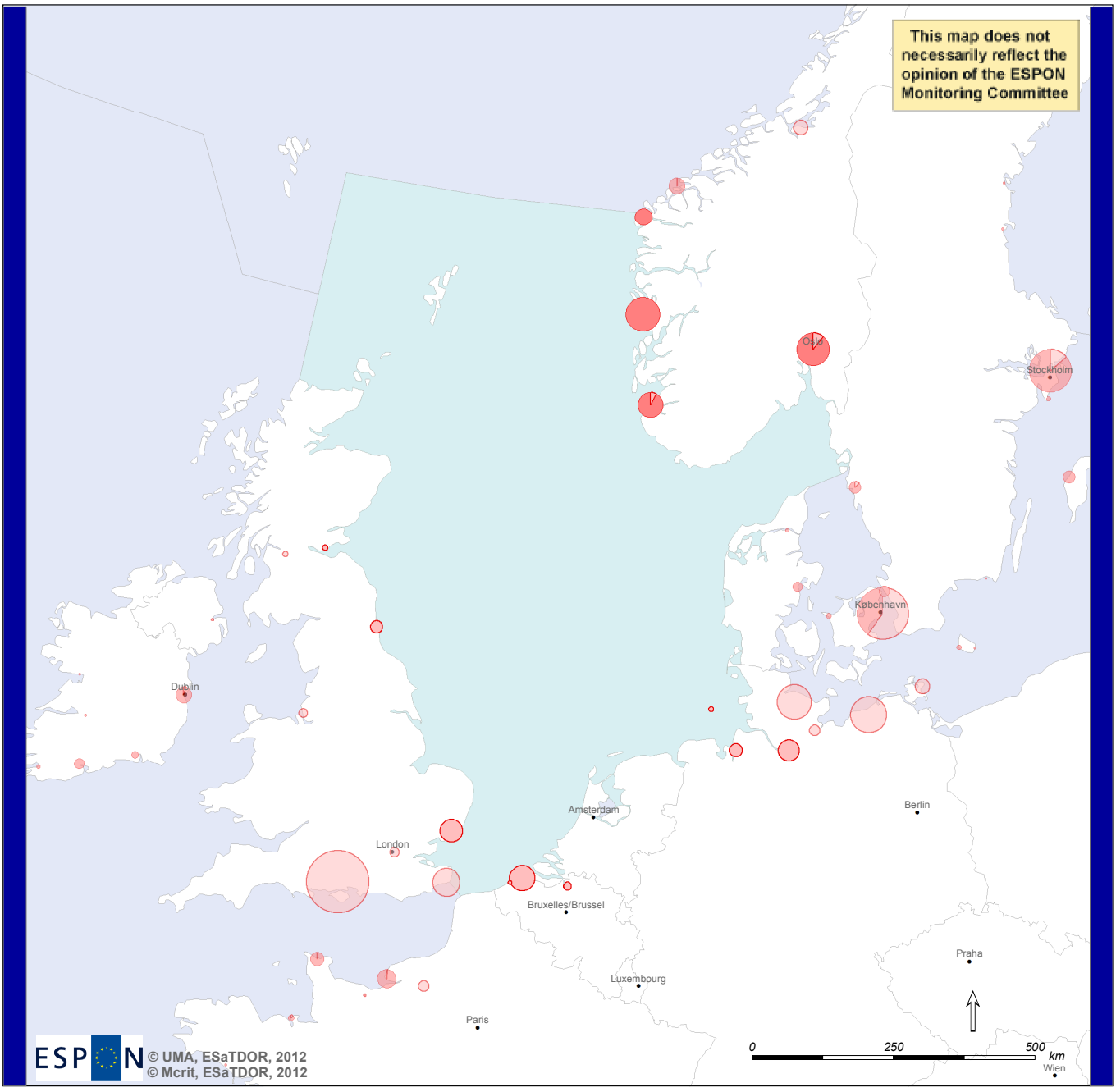
Thematic data: Passengers maritime transport by direction and type of traffic, EUROSTAT, 2008.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Cruise activity at ports, 2008. (Thousand passengers). All ports.

- 1 - 50
- 50 - 250
- 250 - 500
- 500 - 1000
- > 1000

Map N18a. Cruise activity (passengers) at North Sea ports, 2008.

Cruise Activity by Passenger Type, 2008



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Thematic data: Passengers maritime transport by direction and type of traffic, EUROSTAT, 2008.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

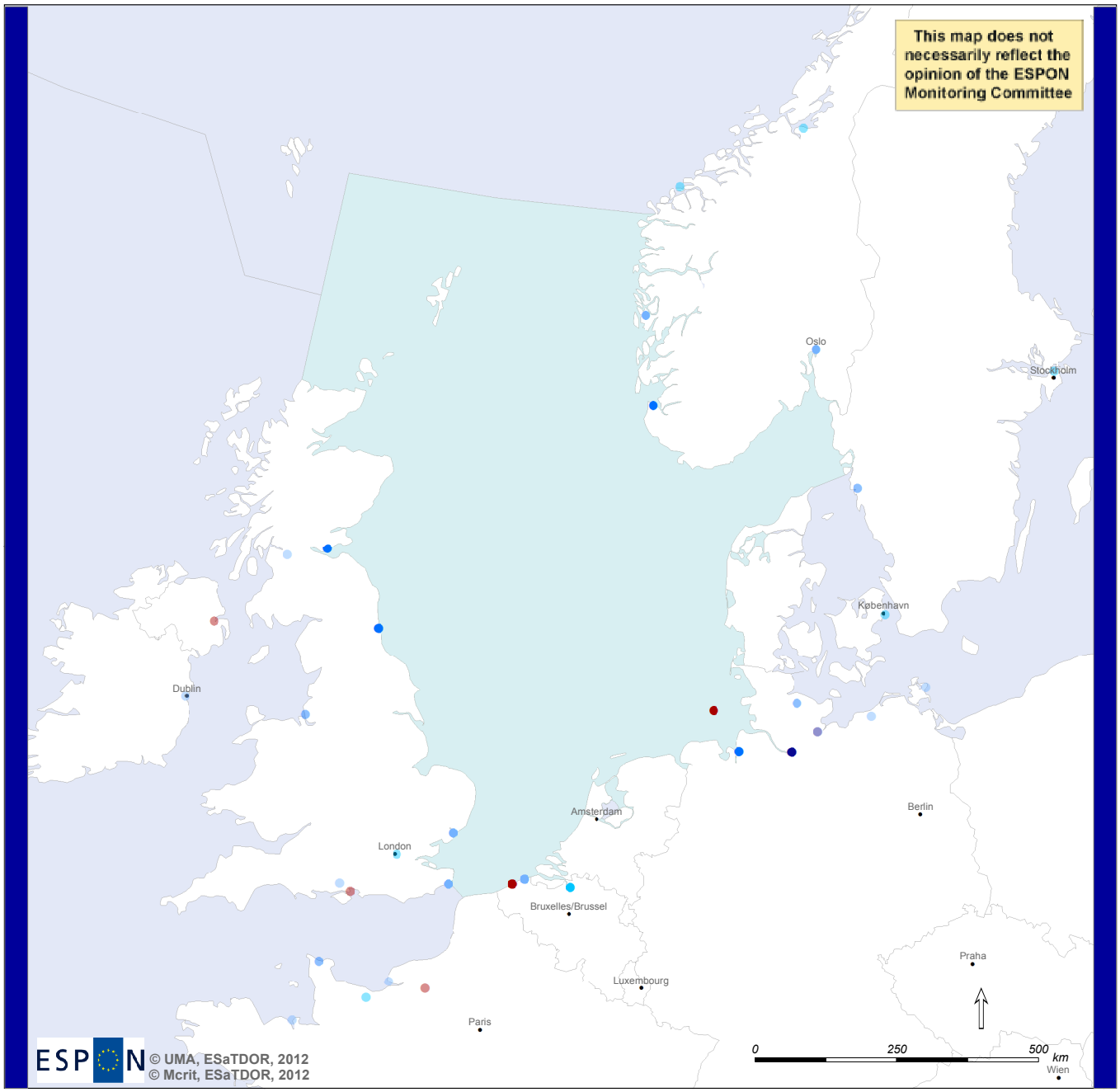
Cruise activity at ports by passenger type, 2008.

Starting or ending a cruise

On excursion

Map N18b. Cruise activity at North Sea ports by passenger type, 2008.

Cruise Passenger Trends



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Thematic data: Passengers maritime transport by direction and type of traffic, EUROSTAT, 2008.
Port locations: Eurostat - GISCO (European Commission), 2009.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Average annual passenger increase of cruise passengers, 2005 - 2008 (%).

- < 0%
- 0% - 10%
- 10% - 20%
- 20% - 30%
- > 30%

Map N18c. Average annual increase of cruise passengers 2005-2008, North Sea ports.

3.3 Energy and undersea infrastructure

The North Sea is one of Europe's premier energy-production regions, due to large-scale oil & gas production over the last four decades, mostly in Norwegian, UK and Dutch waters. However, overall production is now declining quite rapidly, having peaked in 1999 (see Figure 3). The total amount of oil and gas produced has decreased by about 14% since 2001 to around 442 million TOEQ in 2007 while the number of offshore installations has increased, indicating a shift to smaller fields [3].

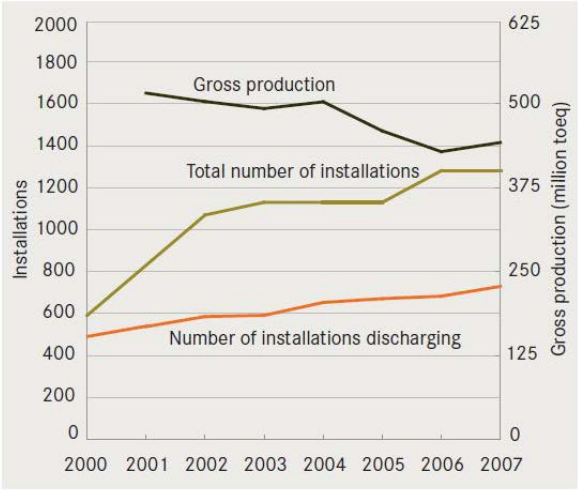


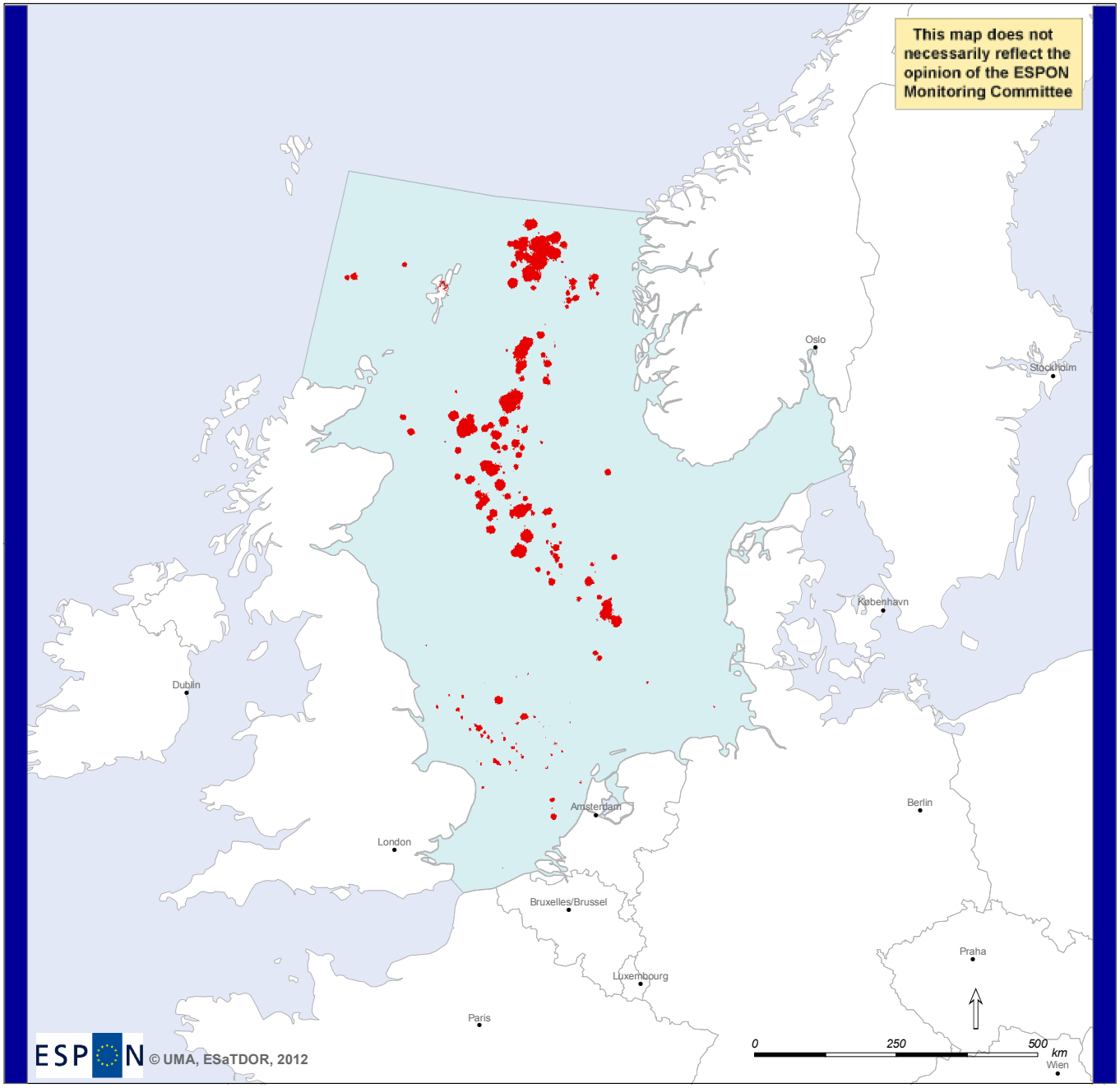
Figure 3: Numbers of offshore installations and total production of oil and gas (2000-2007)[1] [3]

Hundreds of platforms are dispersed throughout two main, large areas in central and northern, and southern North Sea. Their exact location could not be ascertained. Map N19a shows the potential location of these oil rigs. An extensive network of pipelines connects supply to a number of main land terminals.

Employment in oil and gas exploitation is shown in Map N19b. The main areas where this industry supports a high percentage of employment are northern Scotland, Norway, northern Denmark, and the Netherlands.

[1] The increase in the number of installations between 2001 and 2002 is mainly due to a change in definition; offshore installations are now defined as any manmade structure, plant, velle, or part thereof, whether floating or fixed to the seabed.

Location of Oil and Gas Rigs



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Thematic data: National Center for Ecological Analysis and Synthesis based on data from NOAA's National Geophysical Data Center, 2008; HELCOM and LOTOS Petrobaltic S.A., 2011.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

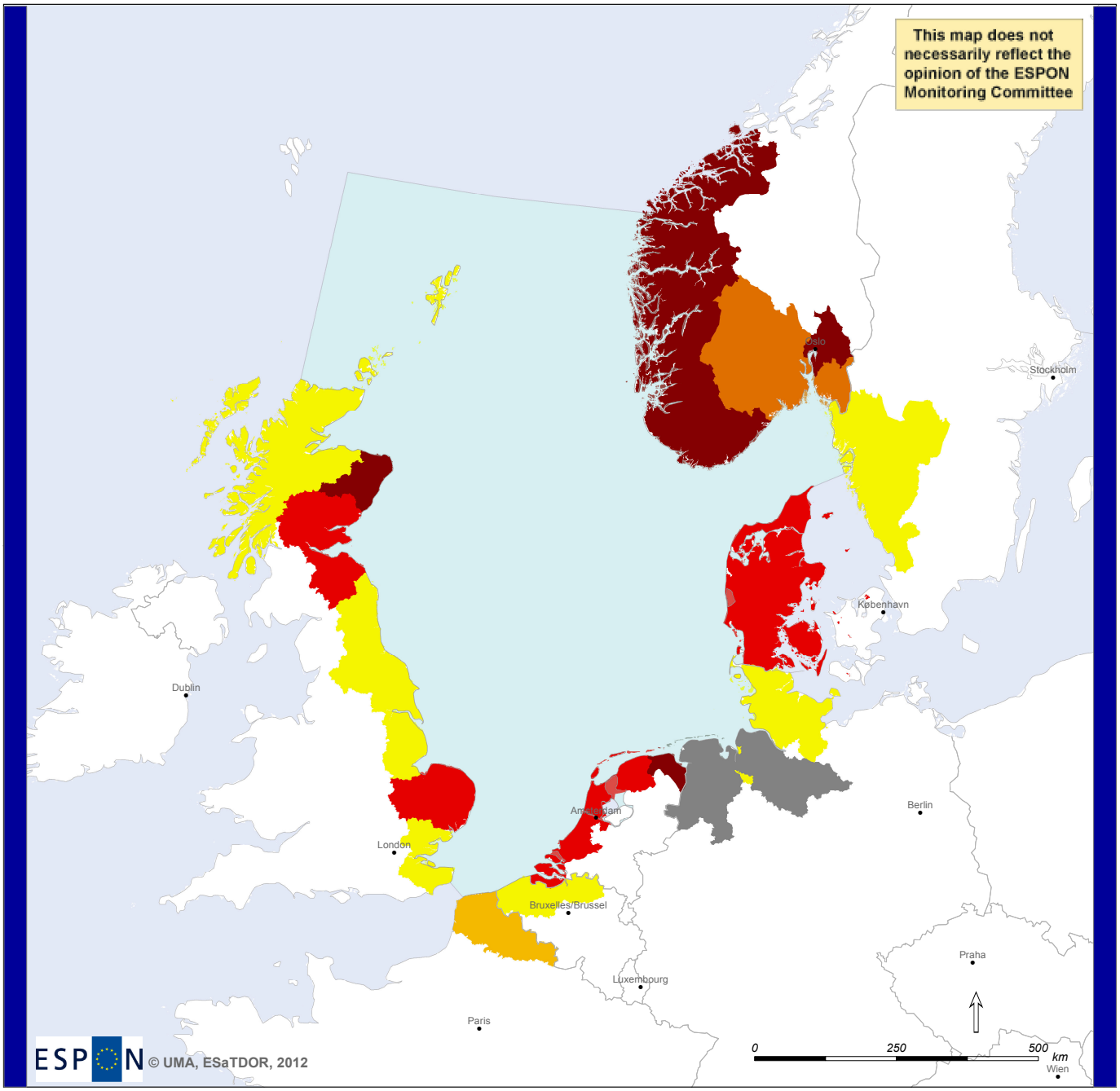
Location of Oil and Gas rigs

Oil and gas rigs

This map is produced using data on the location of stable lights at night (the Stable Lights of the World dataset) of a NOAA program with ephemeral sources of lights (e.g. fires, mobile structures) removed. Data represents presence/absence of light in a resolution of 30 arc-second for 2003. This has been integrated into a 10km x 10km grid based on the presence or absence of light in every cell, which does not mean that the whole cell is occupied by oil or gas rigs.

Map N19a. Location of oil and gas rigs in the North Sea

Employment in Oil and Gas



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Thematic data: Economic Use, European Cluster Observatory, 2011.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Oil and gas 2009 (percentage of total employment).

- 0
- 0.001 to 0.003
- 0.004 to 0.03
- 0.04 to 0.11
- 0.12 to 8.88
- No data

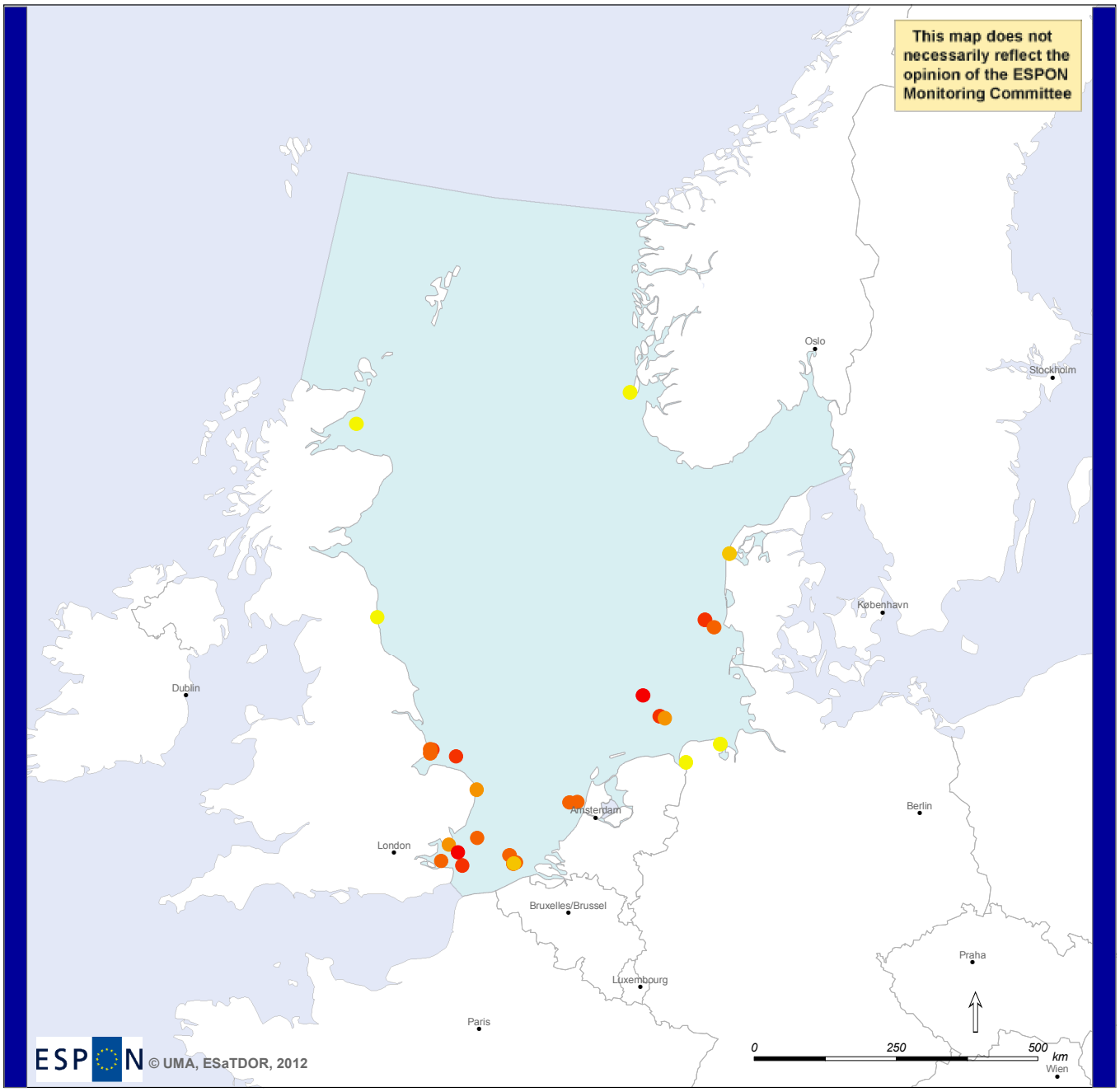
Map N19b. Employment in the oil and gas sector 2009 (as a percentage of total employment), North Sea.

The North Sea has also become home to the greatest concentration of offshore wind arrays (wind farms) in the world, mostly developed in recent years following the Renewables Directive (009/28/EC). Their location points to shallow waters, consistent and high wind speeds, and close proximity to centres of electricity demand. North Sea countries, especially the UK and Germany, plan to expand this wind energy capacity, making marine wind energy a major component of their national energy mixes. Associated with this is the development of offshore grid systems to bring supply onshore and plans to develop a transnational North Sea grid to facilitate power sharing across northern Europe. Map N20 shows the location of existing wind farm developments, and the scale of that development (in terms of generation capacity). Offshore grid systems should interconnect northwest Europe's electricity networks and North Sea wind energy.

The Renewables Directive has also stimulated interest in harnessing wave power. Map N21 shows wave power potential, which is greatest in the more open areas of the North Sea.

There are risks associated with marine renewable energy development. Wind farms can conflict with other uses notably shipping and fishing, and have an uncertain environmental impact. In addition, there is potential for the North Sea to become a centre for carbon storage, making use of depleted oil and gas fields. Marine renewable innovation is moving ahead in Scottish waters and a carbon storage facility is already in operation in Norwegian waters

Offshore Wind Energy



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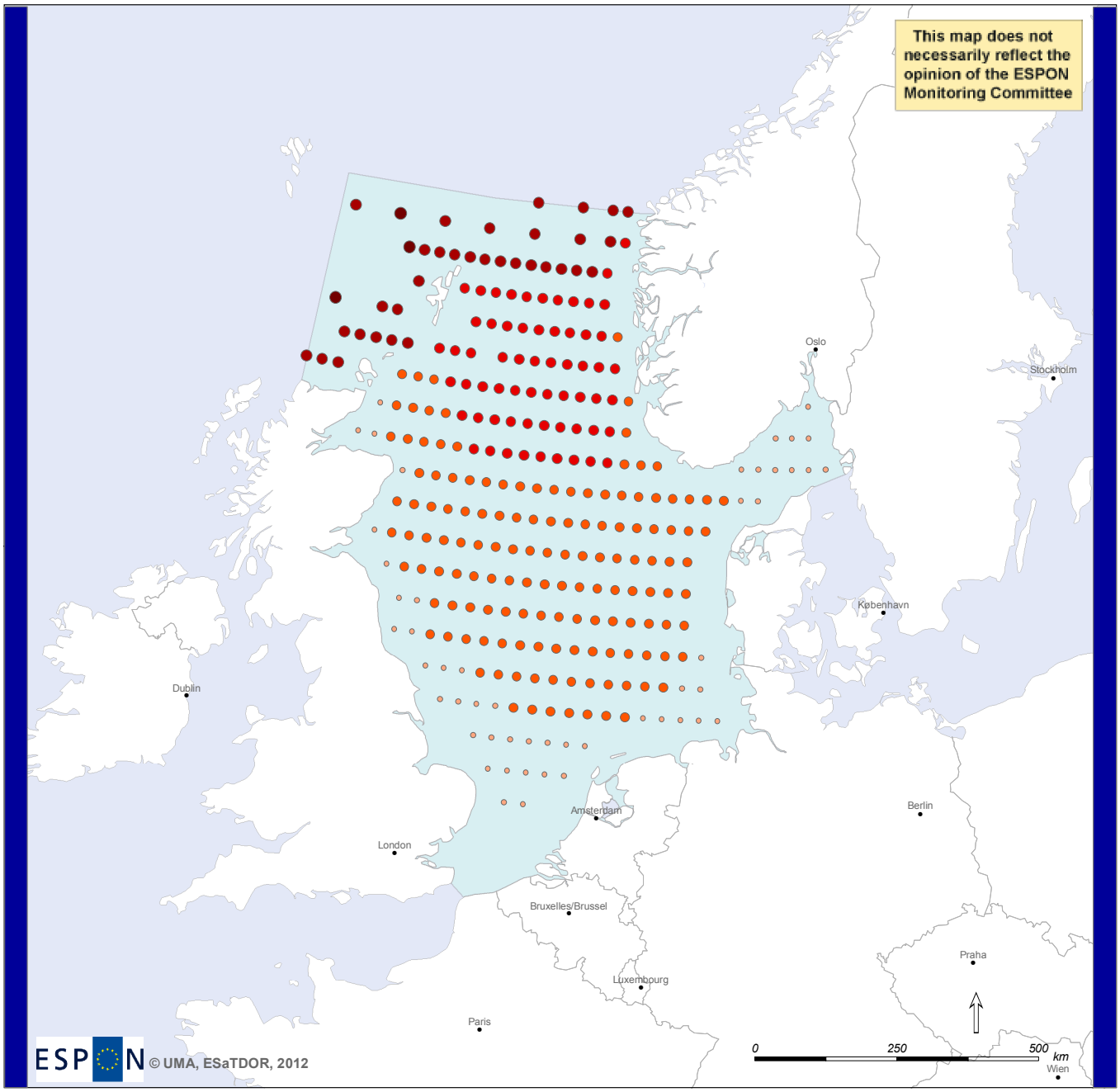
Thematic data: 4c Offshore/LORC Knowledge.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Installed offshore wind energy capacity (W/m^2)

- 0 to 10.5
- 10.6 to 30
- 30.1 to 60
- 60.1 to 165
- 166 to 317
- 318 to 630

Map N20. Existing wind farm generation capacity in the North Sea

Wave Power Potential



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Thematic data: Fugro OCEANOR, Worldwaves, 2008.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

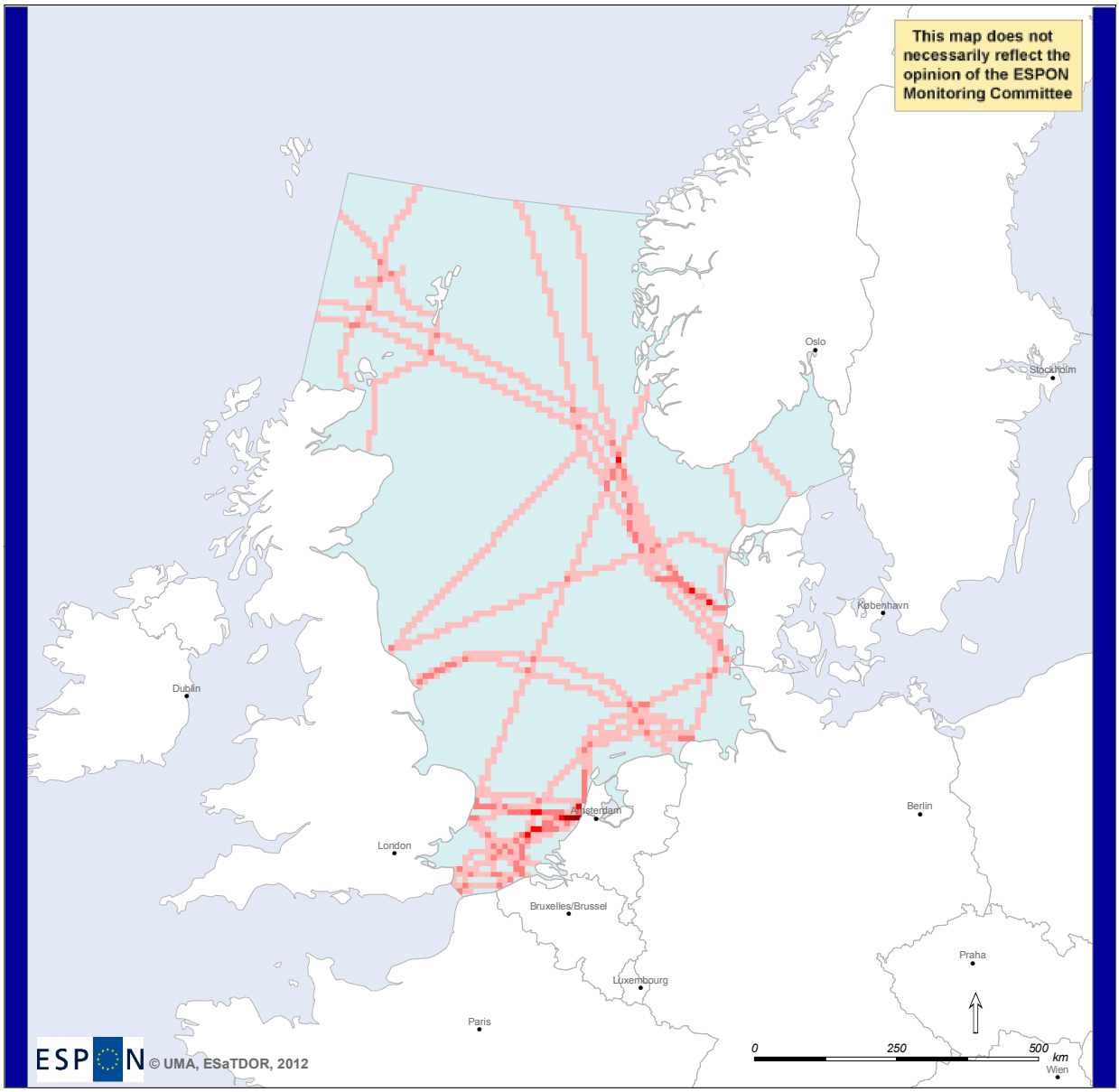
Wave power potential (KW/m)

- 0.5 to 11.0
- 11.1 to 24.3
- 24.4 to 39.0
- 39.1 to 55.9
- 56.0 to 81.6

Map N21. Wave power potential in the North Sea

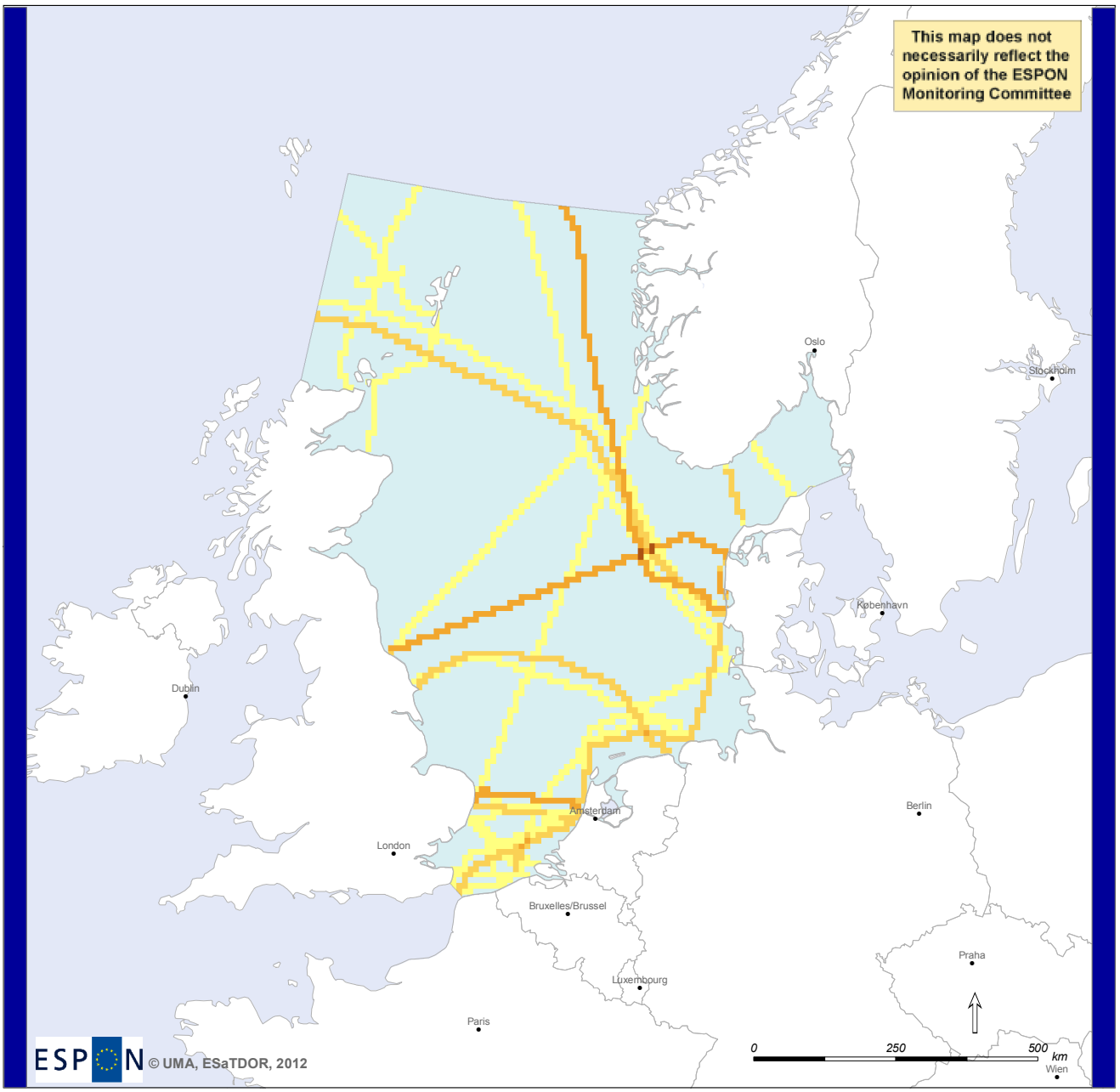
Submarine cables have a long history in telecommunications services and are increasingly important for transmission of electricity. The North Sea has a high concentration of power and telecommunications cables linking its bordering countries. Telecommunications cable length and capacity are given in Maps N22a and N22b.

Undersea Cables (Length)



Map N22a. Undersea telecommunications cables (length per 10km grid square), North Sea.

Undersea Cables (Capacity)



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Thematic data: Greg Mahlknecht, www.cablemap.info, updated 22 -02-12
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Cable capacity (Gigabytes/s per 10km grid square)

- 1 to 5,000
- 5,001 to 15,000
- 15,001 to 30,000
- 30,001 to 120,000
- More than 120,000
- Cables outside of the area

Map N22b. Undersea telecommunications cable capacity (Gb/s per 10km grid square), North Sea

3.5 Environment

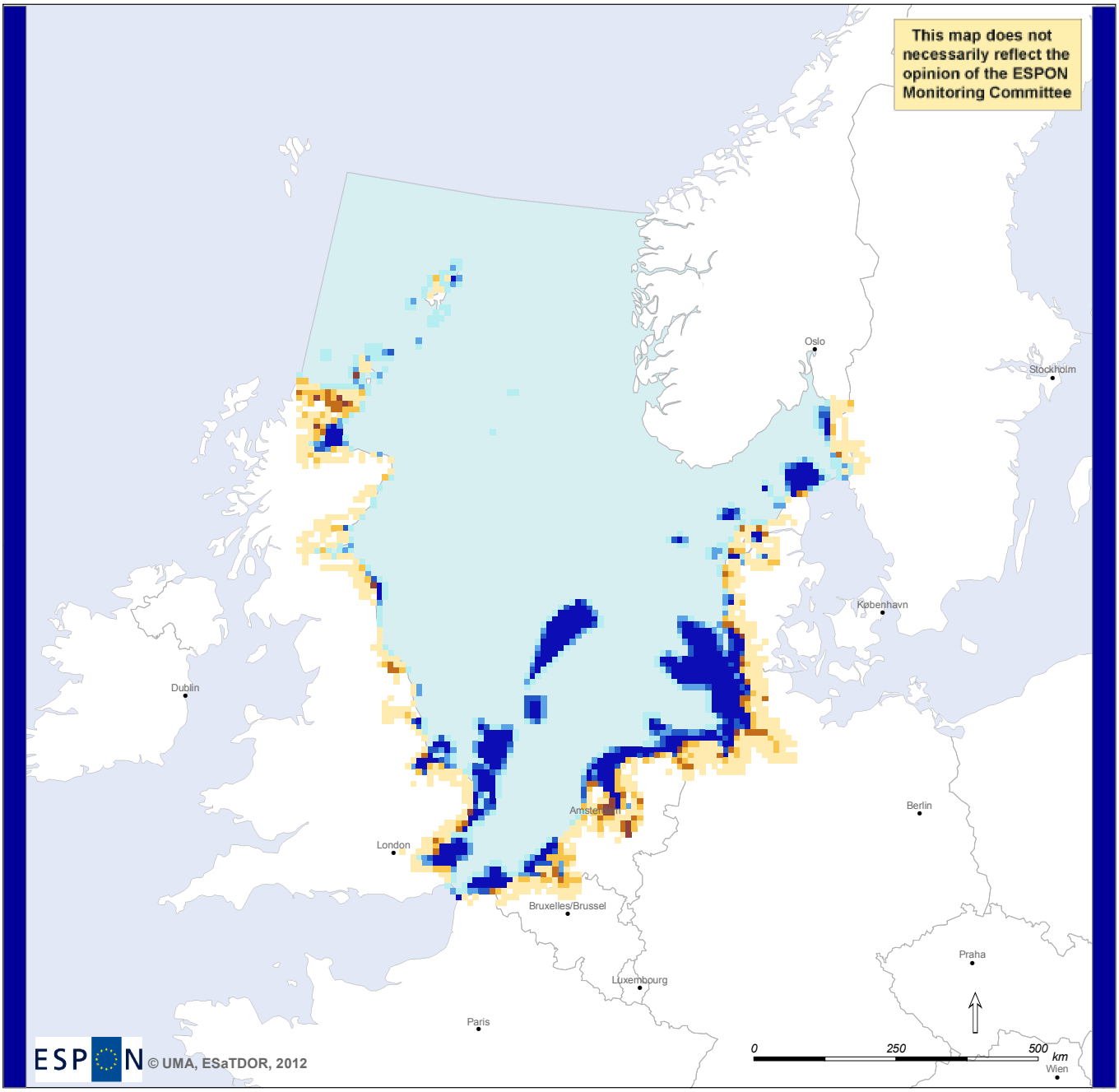
The North Sea is a large marine ecosystem (LME) and is also relatively shallow. The 50 metre isobath (see Map N2) marks the transition between shallow, well-mixed turbid conditions typical of the southern North Sea and coasts, and deeper, seasonally stratified waters to the north [6,7]. This delineation between well-mixed and seasonally stratified water masses is significant in distinguishing among marine biological assemblages and the transition sometimes forms 'fronts' with high biological productivity and biodiversity [7]. The northern North Sea is subject to strong oceanic influences entering from the north, and modest inputs of land-based wastes. This southern part is subject to a gyre that flows counter-clockwise from the north, as well as oceanic inputs via the Channel that generate strong tidal currents. It also has high levels of sediment loads and notable land-based waste inputs.

The North Sea is a moderately productive ecosystem, with highest primary productivity occurring in coastal regions under the influence of terrestrial nutrient inputs, and in areas such as the Dogger Bank and tidal fronts. Ecosystems are rich and complex. Extensive estuaries with mudflats and salt marshes, such as the Wadden Sea in the southeast, are important areas for migrating birds. Offshore islands in the northwest support major colonies of seabirds. Benthic and pelagic processes are strongly coupled and work together to make the sea highly productive, supporting large commercial fish stocks as well as substantial populations of key prey species, such as sandeels [3].

The Convention on Biological Diversity (CBD) expressed in 1992 serious concerns regarding the ongoing decrease in biodiversity, and the members of the Convention pledged themselves to a number of (legally binding) commitments regarding the sustenance of biodiversity values within their borders. This included the creation of an extensive system of protected areas that could protect valuable species, habitats and ecosystems. This prompted EU directives (Birds Directive and Habitats Directive) that require the formation of the NATURA 2000 ecological network, in which member states were required to propose a system of interconnected nature reserves.

Riparian nations of the North Sea are signatories to the Convention on Biological Diversity and are active in designating marine protected areas (MPAs) via Natura 2000 and with the support of OSPAR. Map N23 shows the current extent of protected areas in the North Sea. It attempts to distinguish between the truly aquatic and the adjacent land (e.g. islands, beaches), which might also include lagoons and other transitional water bodies. About 5% of the seabed and water of the North Sea is protected [3], and while this is quite good coverage, the CBD requires that 10% be designated by 2012. Consequently there is still some way to go. One of the main challenges of marine spatial planning is to integrate management of these MPAs with wider spatial plans.

Protected Areas



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Thematic data: Natura 2000 Network, European Commission - European Environment Agency, 2010.
CAFF Arctic Protected Areas, CAFF and PAME Arctic Council, 2011.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Percentage of grid size (Land)

- > 25%
- 25 to 50%
- 50 to 75%
- > 75%

Percentage of grid size (Sea)

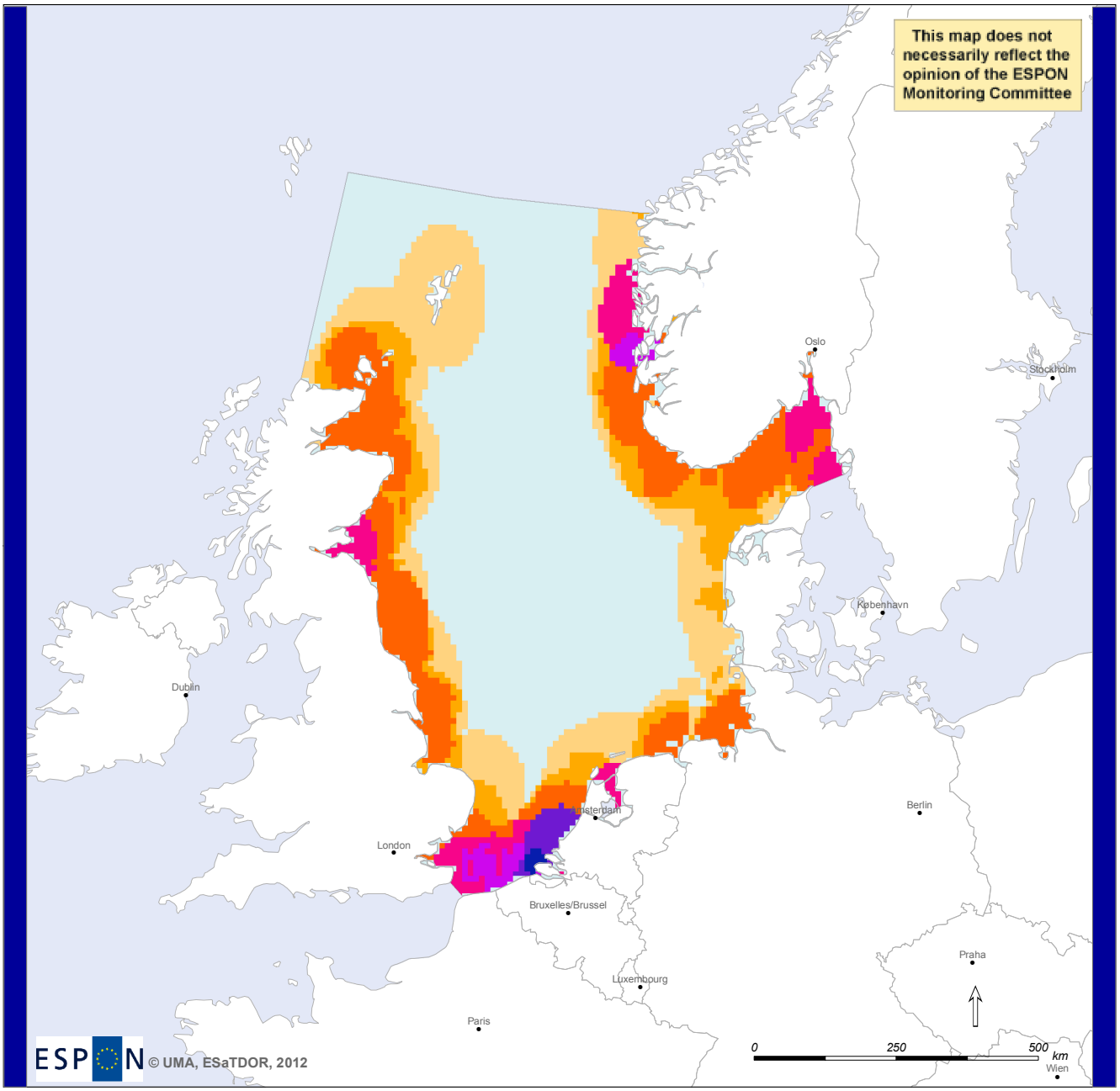
- > 25%
- 25 to 50%
- 50 to 75%
- > 75%

Map N23. Protected areas (Natura 2000 and CAFF sites), percentage designated per 10km grid square. North Sea.

One of the main environmental threats to the environment of the North Sea comes from invasive species [3], such as escapees from aquaculture (e.g. the Pacific oyster, *Crassostrea gigas*) and aquaria, and species carried in the ballast water of ships. Warming of the oceans with anthropogenic climate change adds to this risk, as invaders in waters to the south of the North Sea extend their ranges. Shipping is one of, if not the, major source of invasive species in coastal zones and marine environments. Ships take on and release water as ballast, and take unwanted species on board and transport them to new areas. The Ballast Water Convention set-up by the International Maritime Organization (IMO) is addressing this issue, but it will take time before the measures described in this convention will take effect. Most invasive species transported through ballast water are intertidal or shallow subtidal species.

The dataset behind Map N24 represents the incidence of invasive species along the European coastline to a limit of <60m depth. The incidence of invasive species was modelled as a function of the amount of shipping cargo transported through European ports, with a diffusion model to mimic the expansion of invasive species around these ports. The map shows that the risk of invasion is greatest in the southern North Sea, in the vicinity of the very busy Channel and of large ports.

Invasive Species



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Thematic data: Invasive Species, National Center for Ecological Analysis and Synthesis, 2008
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

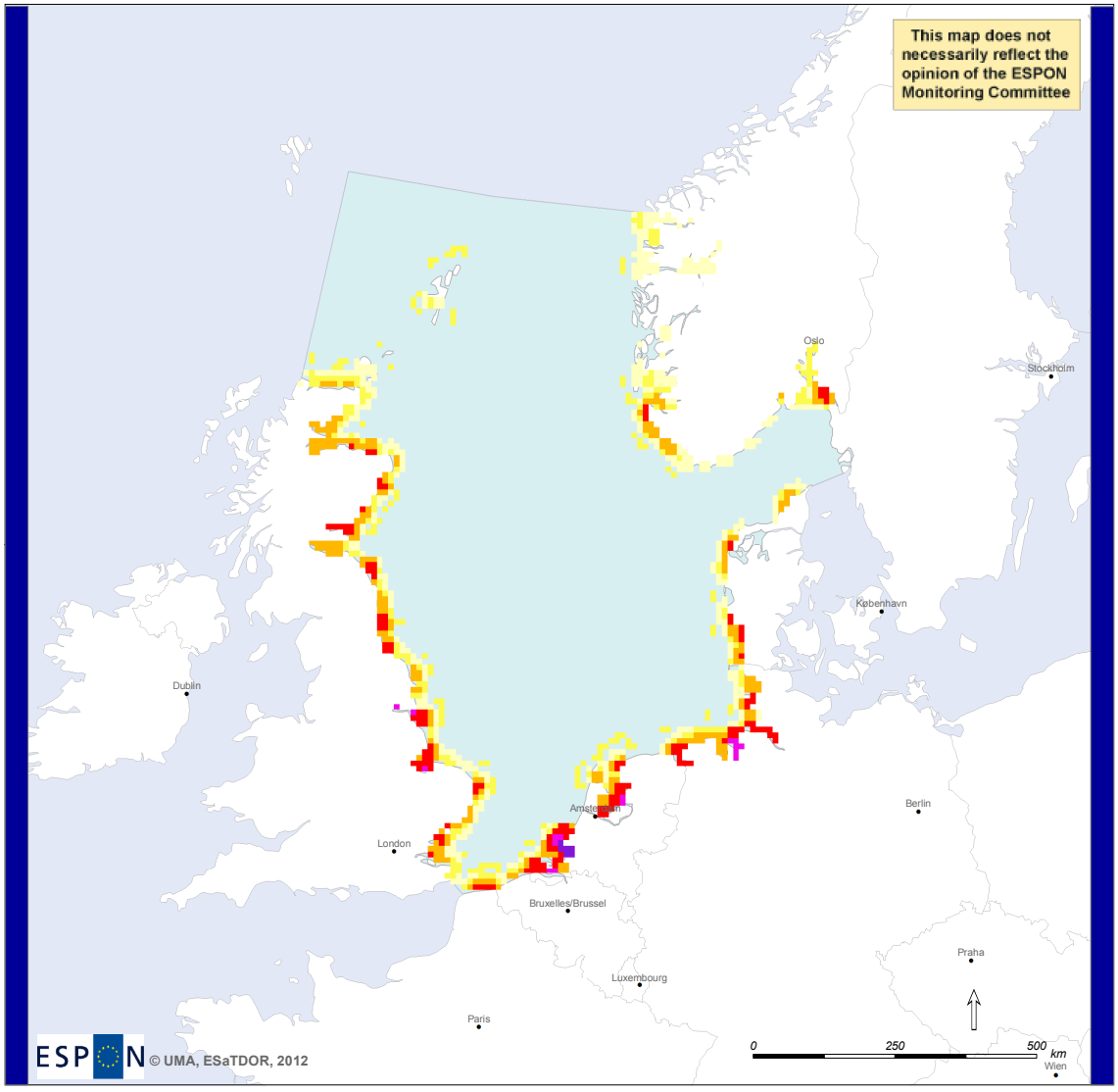
Total number of invasive species per grid square (October 2004 - October 2005)

0	301 to 600
1 to 50	601 to 1,200
51 to 100	1,201 to 2,400
101 to 300	2,401 to 3,011

Map N24. Incidence of invasive species per 10km grid square, October 2004 - October 2005, North Sea.

Land-based human activities release substances directly into the North Sea and/or into the rivers that drain its catchment. Map N25 shows the load of organic substances, but specifically of pesticides (used in agriculture) from the North Sea catchment, for the period 1992-2001. These national statistics have been downscaled over the land area, and then transport of these contaminants through the hydrological network towards sea was modelled. The size of a catchment and the level of agricultural intensity in the catchment have a strong influence on the results, as indicated by hotspots associated with the Rhine, Elbe and Humber Rivers.

Organic Pollution



Map N25. Organic pollution (total kg of pesticides), 2008. North Sea.

Status of Bathing Waters

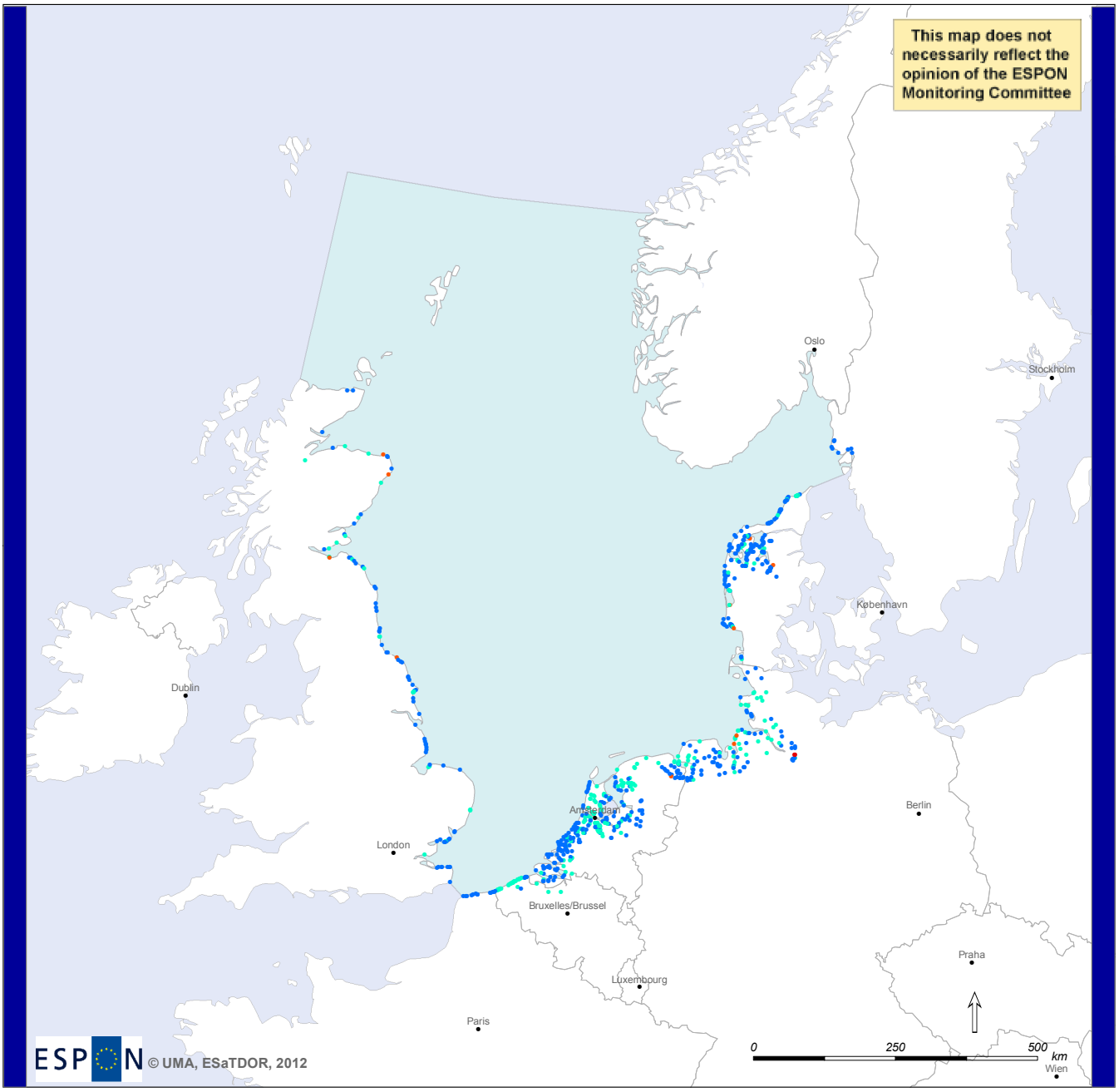
Water quality is an issue for the maintenance of aquatic ecosystems, but it also has a direct impact on humans themselves, largely through health effects. The EU Bathing Water Directive provides water quality standards and requires member states to monitor and report on their bathing water quality. Map N24 shows the status of bathing water (i.e. coastal water) in 2008. Bathing water complies with standards in all but a handful of places.

Climate Change: Sea surface temperature

Sea surface temperature (SST) is an aspect of climate change and climate variability that affects marine ecosystems. SST has environmental relevance because many marine ecological processes are profoundly influenced by temperature. Important differences are found between ecosystems at different latitudes with different temperature profiles. Map N27 shows the average SST, based on monthly averages, for the period 1/12/1981-30/1/2012. UK coastal waters and Skaggerak appear to have warmed relatively more than other regions of the North Sea.

Increases in temperature over this period may not have been caused by climate change. This period overlaps with at least one climatic regime shift (in the late 1980s) associated with the North Atlantic Oscillation (NAO). The shift was paired with increased oceanic influence and warmer water temperatures (among other variables) [9, 10, 11]. Even so, a recent publication [12] argues that much oceanic warming over the recent decades is of anthropogenic origin.

Bathing Water Quality, 2008



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Thematic data: European Commission, Bathing Water Directive 76/160/EEC Report, 2010
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

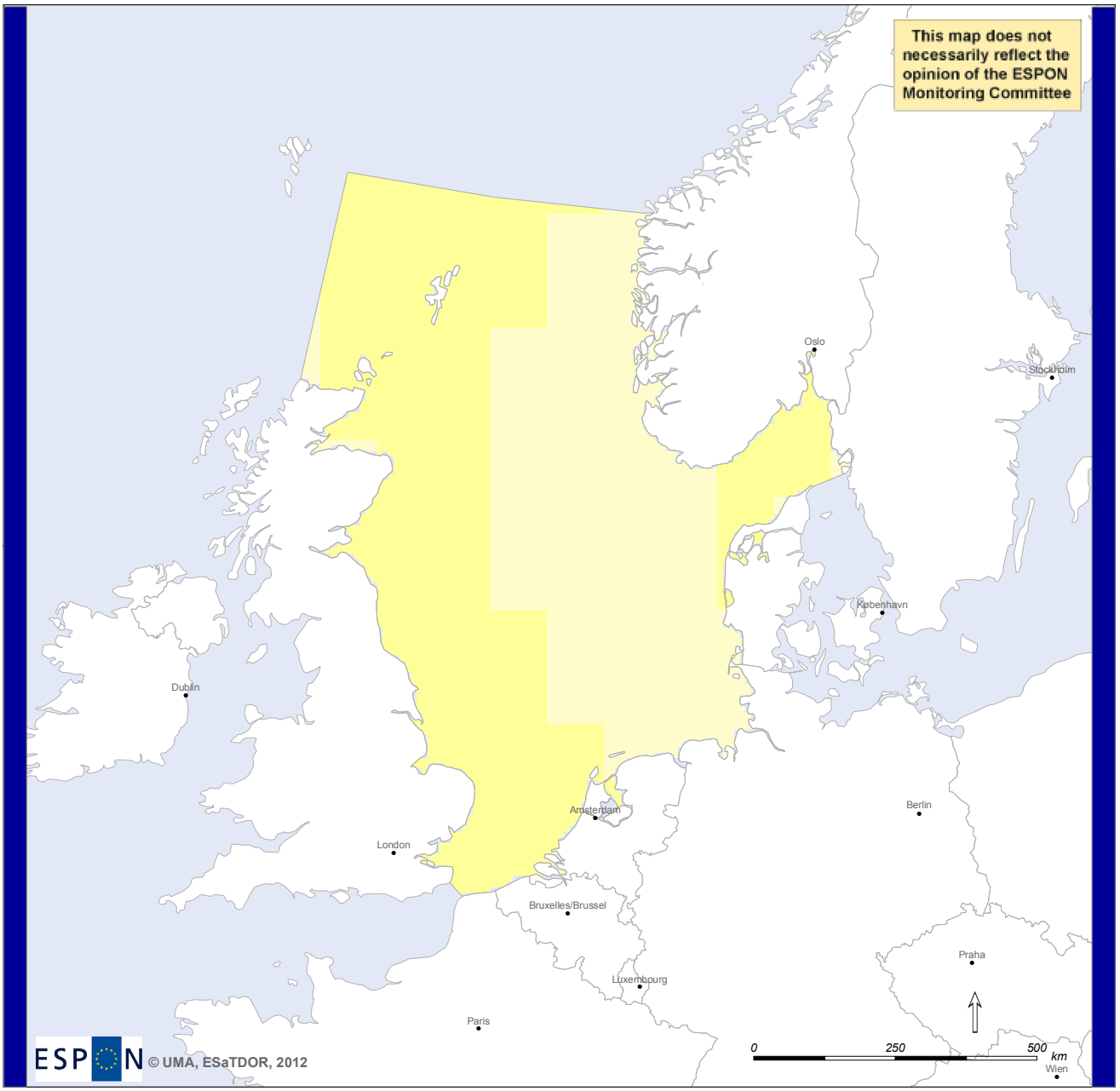
Status of bathing water for year 2008

(Please note: symbols of upper categories are placed on top)

- Banned or closed (temporarily or throughout the season)
- Not compliant with the mandatory values of the Directive
- Compliant with the mandatory values of the Directive
- Compliant with the mandatory and the guide values of the Directive

Map N26. Status of bathing waters relative to the Bathing Water Directive, 2008. North Sea.

Increase in Sea Surface Temperature



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Thematic data: National Oceanic & Atmospheric Administration (NOAA), Optimum Interpolation (OI) Sea Surface Temperature (SST) V2, 2012
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS0.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Increase in sea surface temperature between 1981-2011 (degrees Celsius)

-2.1 to -2	0.01 to 0.5	2.6 to 3
-1.9 to -1.5	0.51 to 1	3.1 to 3.5
-1.4 to -1	1.1 to 1.5	3.6 to 4
-0.9 to -0.5	1.6 to 2	
-0.49 to 0	2.1 to 2.5	

Map N27. Increase in sea surface temperature 1981-2011 (degrees Celsius), North Sea.

4. Governance Case Studies

Having provided a thematic overview of the existing character of the North Sea, this section now explores three case study examples of transnational governance arrangements that attempt to achieve more coherent maritime planning and management in the region. The North Sea case studies deal with the OSPAR Convention, the Trilateral Wadden Sea Cooperation, and the Flemish-Dutch cooperation on the Scheldt. The case studies examined the effectiveness (achieving goals) and inclusiveness (stakeholder involvement and participation in policy-making) of the governance arrangement. This is summarised and compared in Table 1.

The key messages from each of the case studies and lessons for future maritime governance in the region are outlined below. A full account of the North Sea case studies and those for the other European sea is set out in a separate project report on governance which is available via the ESPON website.

Table 1: Assessment of North Sea governance arrangements

	OSPAR	**Trilateral Wadden Sea Cooperation**	**Flemish-Dutch cooperation on the Scheldt**
Drivers	Nature conservation, pollution	Nature conservation, fisheries, energy exploitation, tourism, shipping	Flood risk protection, nature development, port access
Governance challenges	Novel approach that will maintain its relevance given the MSFD and initiatives at EU level	Harmonised implementation of EU legislation and reaping benefits of UNESCO World Heritage Status	Restoring trust and full implementation of the OS2010
Substantive challenges	Fisheries, shipping, energy generation	Climate change, biodiversity, tourism	Realisation of next stages of Long Term Vision Scheldt 2030
Legal status	Legal agreement, elaborated via binding decisions and non-binding recommendations	Political agreement, not legally binding	Legally binding based on Scheldt Treaty of 2005
Effectiveness	Medium	High/medium	Low
Inclusiveness[2]	High	Medium	Was medium; is now low

[2] Note: stakeholder involvement AND participation in policy making.

OSPAR's success as a governance arrangement lies in its pioneering of innovative approaches and its inclusion of stakeholders. However, due to its focus on environmental and nature protection, key stakeholders from industry and fisheries are less well represented and not sufficiently active. Furthermore, OSPAR has limited ability to enforce compliance on its members. It relies on the EU, with whom it has good interaction if not mutual reliance. OSPAR offers considerable potential as a regional forum and as a means to upscale national to regional marine spatial planning.

The Trilateral Wadden Sea Cooperation is a pioneering model for the protection and management of a transboundary ecological system. It provides a good example of an effective, non-binding governance arrangement. Its success may be attributed to flexibility in adapting objectives and policies to new developments and willingness to undergo critical review of its own functioning. Stakeholders are involved and participate, but have no formal position in the decision-making structure. The Cooperation has met with less success in coordinating harmonised implementation of EU legislation, with participating countries pursuing their own agendas.

The Flemish-Dutch cooperation on the Scheldt shows that even a well-prepared, legally binding agreement, ratified by the parties concerned, is not a waterproof guarantee for compliance. There is an historical dynamic of conflict and cooperation between the Netherlands and Belgium on Scheldt-related issues. After the conclusion of an agreement in 2005, the focus of the debate in the Netherlands shifted to specific local interests instead of honouring the agreement. This case study highlights that compliance ultimately depends on political will to implement whatever has been agreed upon.

5. Characterisation of the Sea (current position)

The spatial information about anthropogenic activities and their influences in the North Sea region presented above, together with similar information for other European seas, provide the basis for deeper analysis of spatial patterns and interlinkages. The integration of the thematic information into composite maps gives a general overview on the economic, transport and environmental situation of Europe's seas and helps to refine and decipher the particular characteristics of different parts of the North Sea.

Economic Use

A sum of percentages was calculated of every economic sector related to maritime activities in each NUTS 2 region[3] (percentage of the total employment representing the maritime cluster) to generate an economic use composite map. These sums have been classified by quintiles as follows:

Table 2: Composite classification of maritime economic use

Total Percentage	Total Employees	Category name
5.42 - 15.52	8,005 - 51,861	Very Low
15.52 - 17.60	51,861 - 109,775	Low
17.60 - 21.06	109,775 - 162,63	Medium
21.06 - 24.69	162,923 - 263,461	High
24.69 - 36.35	263,461 - 674,442	Very High

Map N28 shows the composite map for economic use, based on total maritime cluster employees within each NUTS2 region. Marine and coastal economic activities are important in a number of select areas (e.g. Denmark, East Anglia and North and South Holland). Map N29, which shows employment as a percentage of total employment, shows almost opposite trends with the exceptions of East Anglia and parts of eastern Scotland.

Environmental Pressures and Flows

A similar approach was undertaken for maritime transport patterns to produce a flows composite map and to produce a composite picture of environmental pressure. The environmental pressure composite map was obtained by calculating the average (equal weight basis) of layers with information about invasive species as well as organic and inorganic inputs. Their values were reclassified into five groups (based on quintiles) as follows:

[3] Data for Denmark, Ireland and Slovenia are on national level because as no data was available on NUTS-2-level

Table 3: Composite classification of environmental impacts

Organic Inputs	Invasive Species	Inorganic Inputs	Category name
-	0*	-	-
1 – 60	1 – 60	0.1 – 320	Very Low
60 -120	60 -120	320 - 640	Low
120 – 180	120 – 180	640 - 960	Medium
180 - 240	180 - 240	960 – 1,280	High
240 – 7,662	240 – 3,030	1,280 – 10,186	Very High

Map N30 shows a composite indicator of environmental pressure. Here we see the effects of river discharges (of organic and inorganic contaminants) and of ports (invasives). The southern North Sea, in particular in the vicinity of the Port of Rotterdam and the mouths of the Rhine, Meuse and Scheldt Rivers, is subject to considerable pressure.

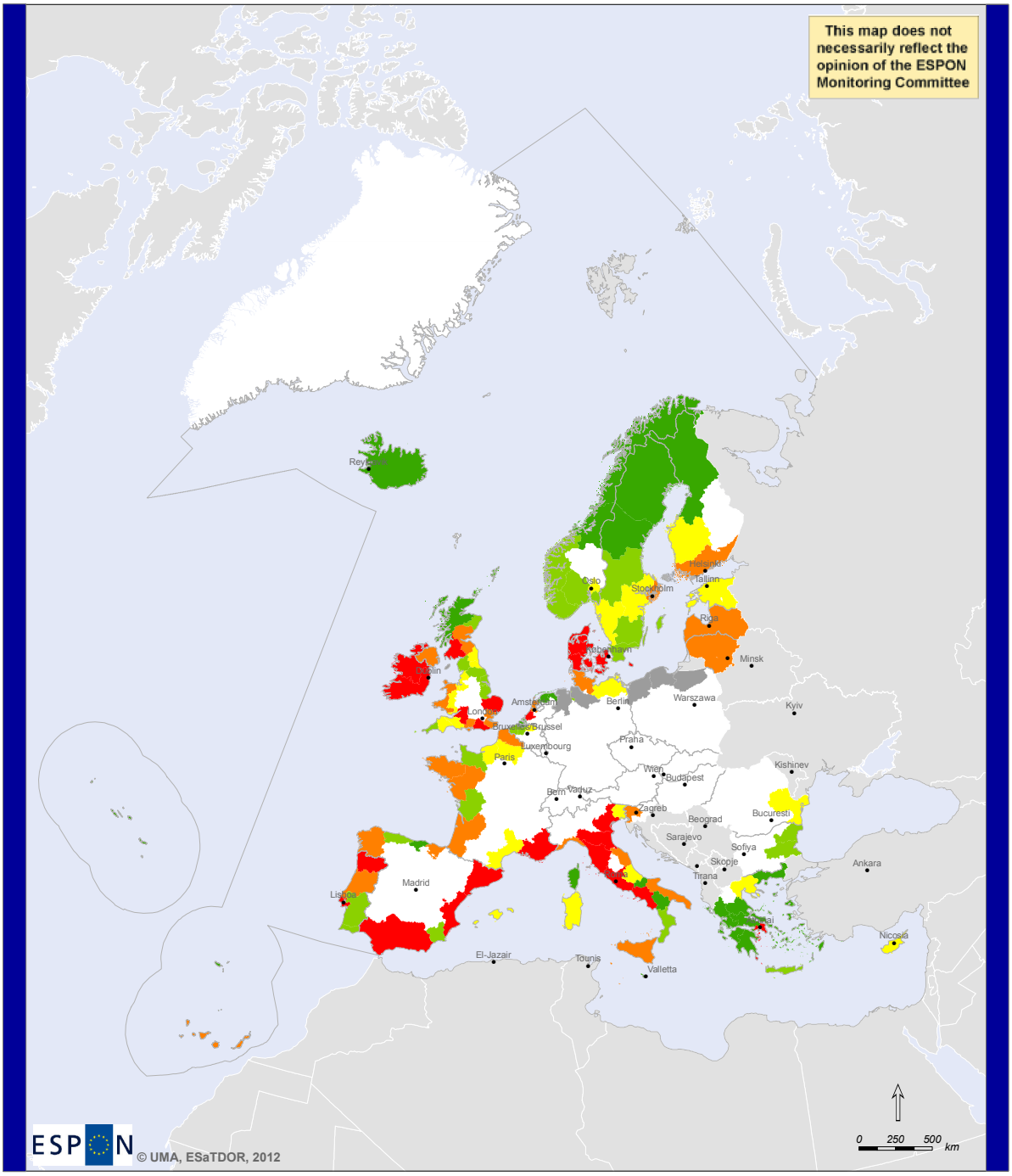
The Flows map (Map N31) was created using a combination of data related to the transport of goods, people, information and energy (shipping of liquid bulk energy products, see Table 4). Each of the datasets has been given a particular weight according to their relevance, based on expert judging. The average of the datasets in each cell provides has been used to determine the Very low to Very high values in the flows map.

Table 4: Data used in Flows composite map

Category / Map	Weight
Economic influence of container ports, based on port proximity and container volume	50%
Economic influence of cruise ports	30%
Marine exposure due to port influence, based on port proximity and volume of liquid energetic products	10%
Undersea cable influence	10%
FLOWS COMPOSITE MAP	**100%**

Map N31 shows that for the North Sea, as can be inferred from previous maps showing the location and activities of main ports, that the highest flows are located in the southern North Sea, closely connected with the ports of Dunkerque, Antwerp, Rotterdam and Amsterdam. A second area of very high flows occurs around the German coast associated with the ports at Bremerhaven and Hamburg. At higher latitudes, the influence of shipping activity in the North Sea is much lower.

Total Number of Employees in the Maritime Sector, 2009



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Thematic data: Economic Significance Composite Map.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

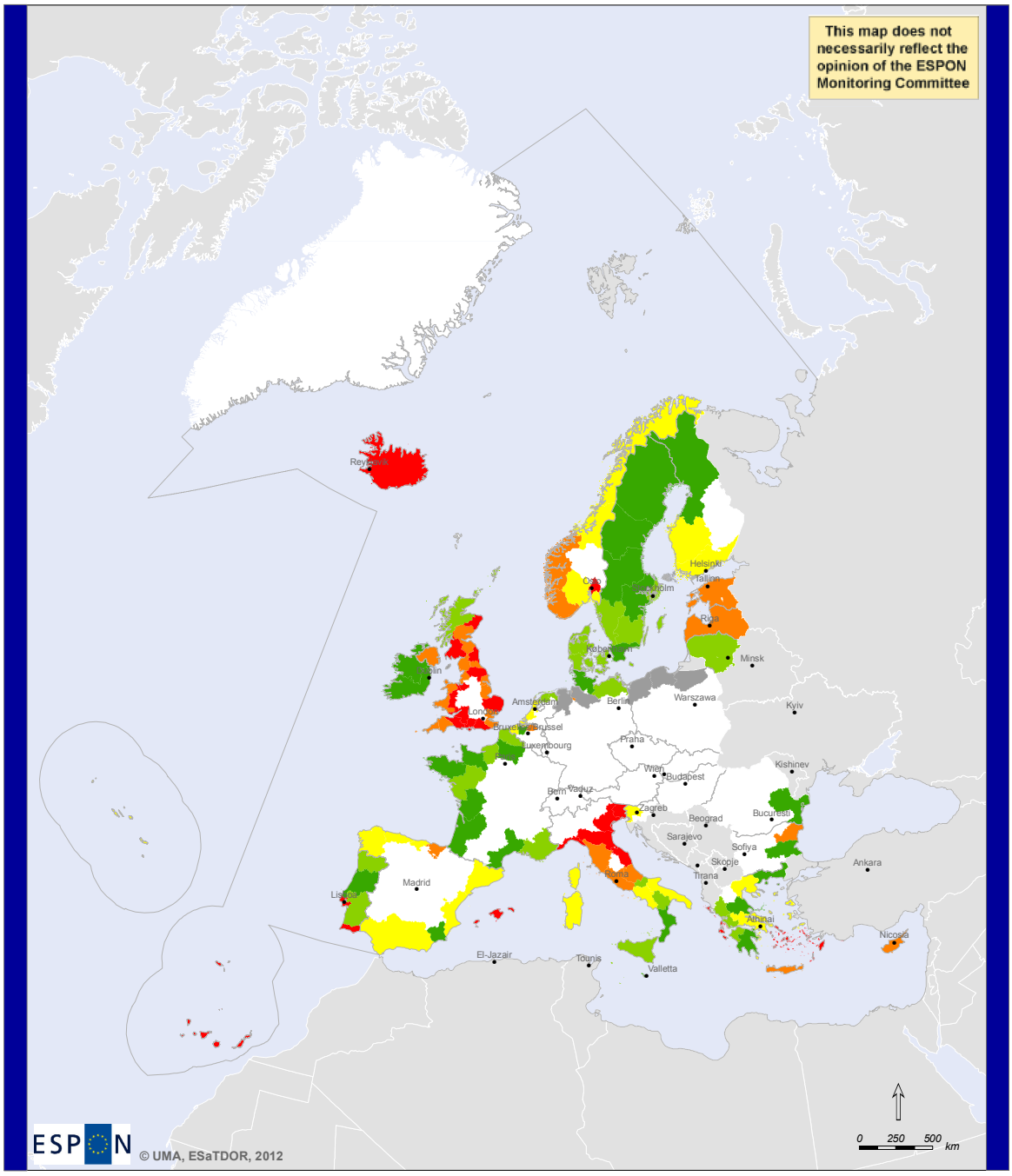
Economic Use Composite Map (total maritime cluster employees within each NUTS2 region).

- Very Low (8,005 - 51,861)
- Low (51,862 - 109,775)
- Medium (109,776 - 162,923)
- High (162,924 - 263,461)
- Very High (263,462 - 674,442)
- No data

NOTE: This composite map consists of data from the European Cluster Observatory on the number of persons employed in fisheries, shipbuilding, other traditional maritime sectors, sectors associated with the maritime cluster, tourism and transport within each NUTS2 region.

Map N28. Total maritime cluster employees per NUTS2 region, 2009

Employment in the Maritime Sector, 2009 (as a % of Total Employment)



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Thematic data: Economic Significance Composite Map.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

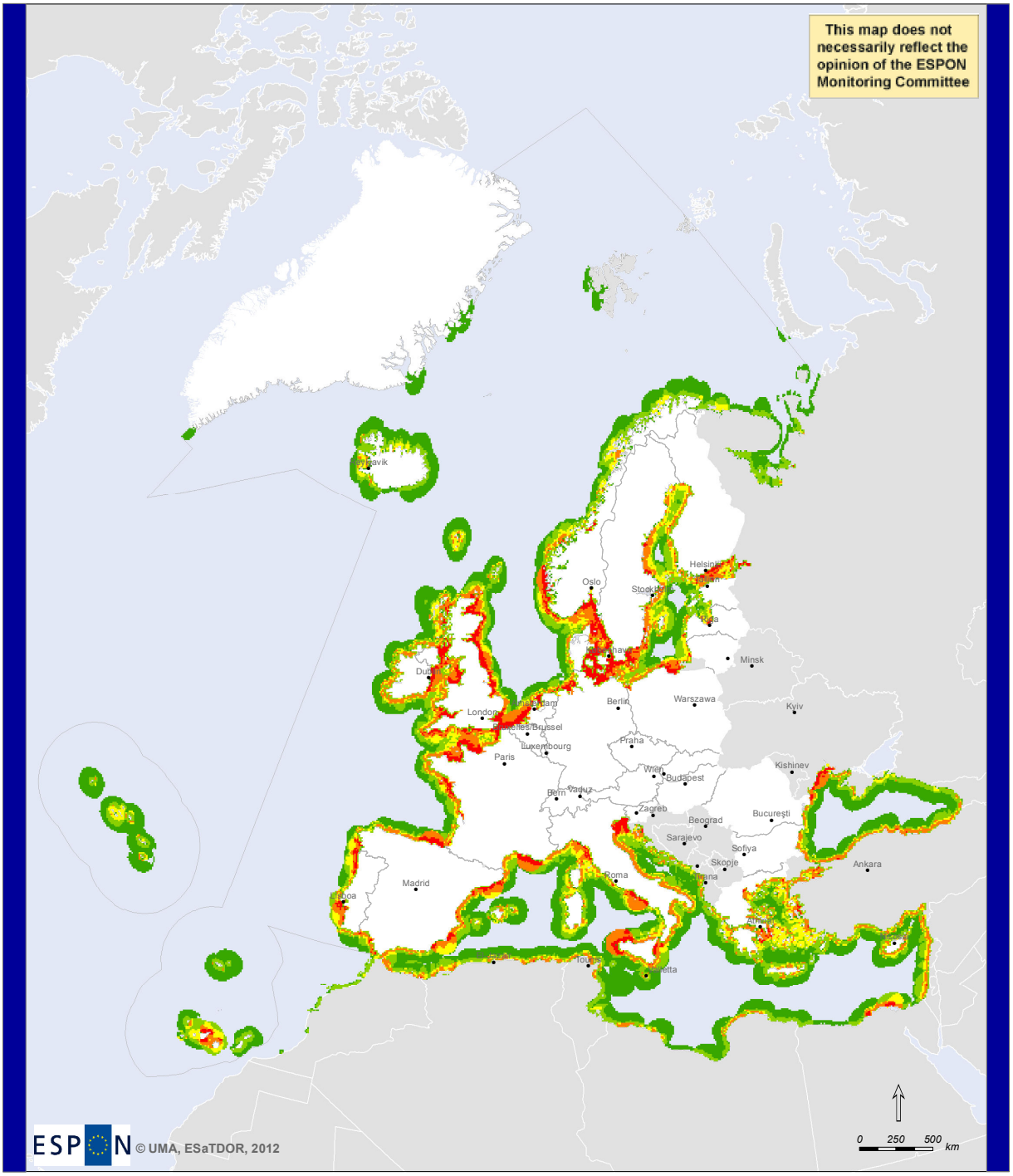
Total Maritime Employment Composite Map (percentage of total employment within each NUTS2 region)

- Very Low (5.42 - 15.52)
- Low (15.53 - 17.60)
- Medium (17.61 - 21.06)
- High (21.07 - 24.69)
- Very High (24.70 - 36.35)
- No data

NOTE: This composite map consists of data from the European Cluster Observatory on persons employed in fisheries, shipbuilding, other traditional maritime sectors, sectors associated with the maritime cluster, tourism and transport as a percentage of total employment within each NUTS2 region.

Map N29. Total maritime cluster employees (as a percentage of total employment) per NUTS2 region, 2009

Environmental Pressures



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Thematic data: Environmental Pressures Composite Map.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

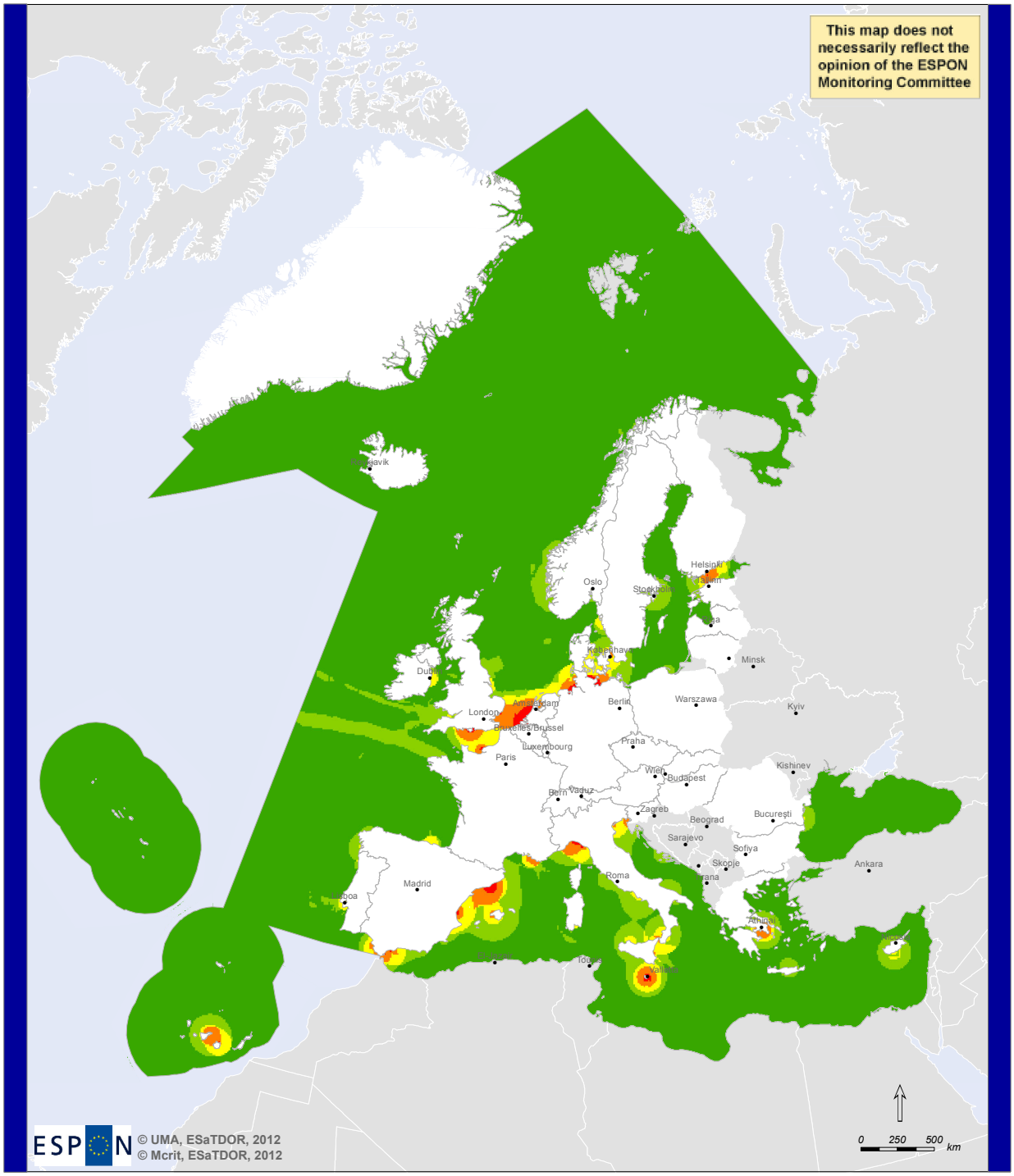
Environmental Pressures Composite Map

- Very Low
- Low
- Medium
- High
- Very High

This map is based on three data sets: incidence of invasive species, organic pollution (pesticides) and inorganic pollution (fertilisers).

Map N30. Environmental pressures in Europe's coastal and marine regions (composite map)

Flows



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Thematic data: Flows Composite Map.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Flows Composite Map

- Very Low
- Low
- Medium
- High
- Very High

The Flows composite map is a proxy to land-sea interactions of goods, people, energy and information based on the analysis of flow magnitudes and interchange nodes. Influence of interchange nodes is higher with proximity to node and size of associated flow (container traffic, cruise traffic and LBK traffic plus Gb/s through cables).

Map N31. Flows composite map

5.1 Towards a marine typology

Combining the composite pictures of economic use, transport flows and environmental pressures shown above has enabled maps showing cold spots (Map N32a) and hot spots (Map N32b) for maritime related activity within Europe's regional sea areas to be produced. This sets the background for the final step towards a maritime typology shown in Map N34 which categorises maritime regions into a five-way typology: European Core, Regional Hub, Transition, Rural and Wilderness. The typology map is a simplified graphic presentation of the pattern of broad divisions evident from the data. The zones identified cover both land and sea and have deliberately 'fuzzy' boundaries reflecting data quality and availability issues which are discussed in more detail in the Data and Mapping sections of the Scientific Report.

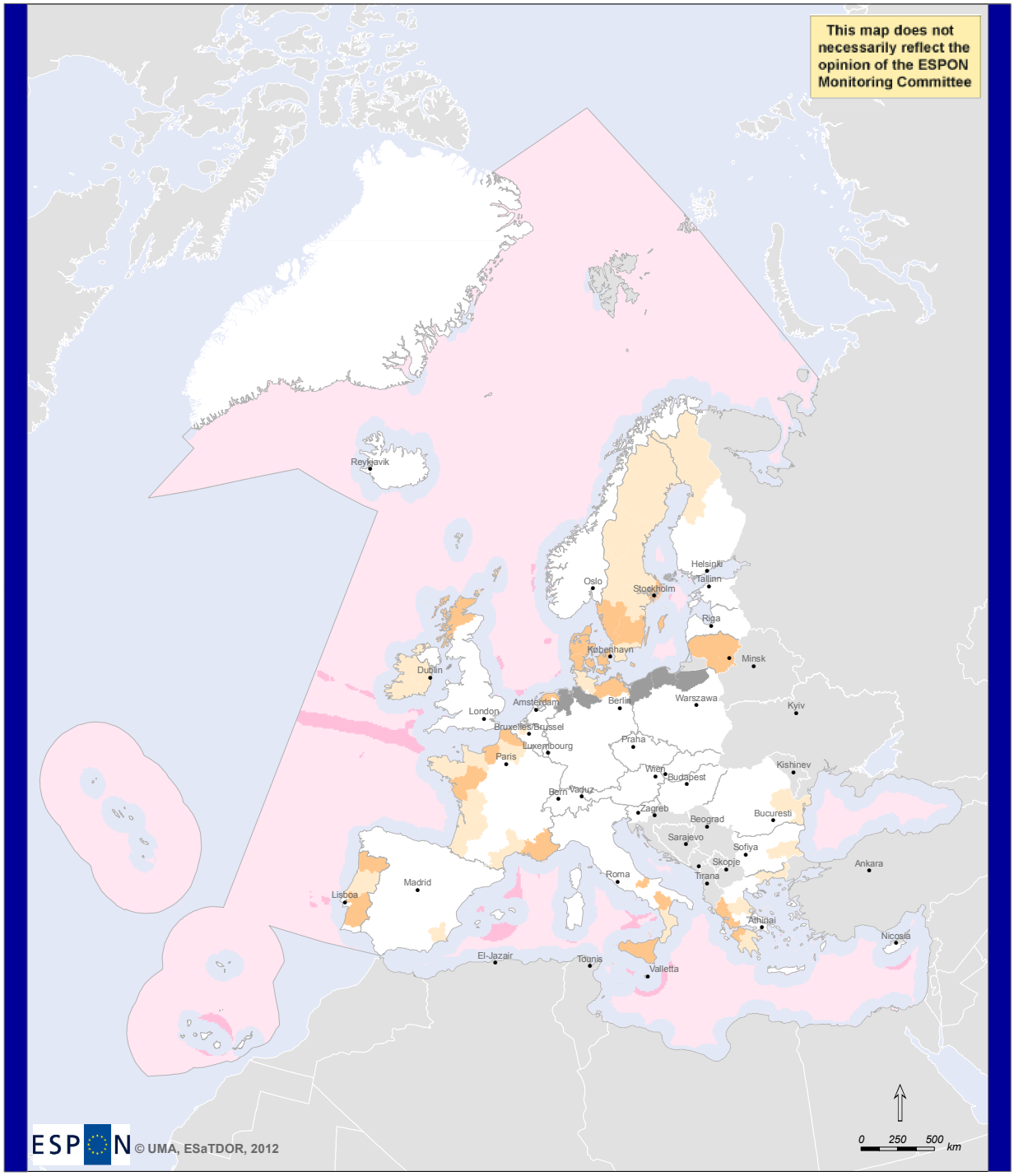
One of the premises for these maps was the selection of European data sets to ensure Europe wide comparability of maritime characteristics. For many sectors (such as fisheries) and issues (such as underwater noise, dredging and eutrophication) adequate information was not available on a European level although very good data exists in relation to some regional seas. For example data collected for OSPAR purposes provides a very good basis for understanding many aspects of the Atlantic and North Sea marine environment, but compatible data is not available for other European seas. The picture presented is therefore less than ideal and the following maps N32a, b and N34 should be understood as a first iteration of a European maritime typology demonstrating how this concept could be developed over time as data improves.

Map N33 is the typology composite combining the hot and cold spots combining data for employment (economic significance, land-based), and for flows (transport) and environmental pressure. Maps N32a and N32b show cold- and hotspots respectively. Economic significance is clearly high for the eastern UK, Norway and southern continental part of the North Sea Region. For largely continental, riparian nations economic significance of economic activity in the North Sea Region (Denmark, eastern Germany and northern Netherlands is less significant. In terms of the regional sea itself, the southern North Sea in particular, and the coastal North Sea in general, is intensively used and subject to high environmental pressure. Beyond the coastal zone the intensity of use and the threats to environmental integrity are less apparent, although this is in part a function of data availability.

Overall this is an intensively used regional sea. The European Core which exhibits an intensity of land sea interaction is focused at the southern end of the North Sea region and this extends into the Atlantic through the English Channel. This European core is coincidental with what has been recognised for many years, as the pentagon. The importance of land sea interactions for this European core is based on this area acting as the predominant gateway between Europe and the rest of the world, and from this entrance a great deal of goods and services are transhipped throughout Europe, either via short sea shipping activities of through inland transport networks. For much of the region, the risk from invasive species brought in by shipping and the pollution from land, a function of the intensity of urbanisation surrounding the basin and major European rivers with extensive catchments flowing into the North Sea. Beyond the core two regional hubs can be identified, and the lack of available data within the marine environment probably leads to under

playing of the links between the two regional hubs, one which focuses on the west coast of the United Kingdom, and from Denmark through to southern part of Norway, focused around Oslo. Between these two regional hubs, the marine part of the North Sea has been characterised as a transitional zone, indicating an area that is already being extensively used for a variety of different uses, and indeed it is possible to argue that the North Sea basin itself is one of the most extensively exploited sea basins, particularly for both renewable and non-renewable energy resources.

"Cold Spots" of Land-Sea Interactions



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Thematic data: Typology Map.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Typology Map (coldspots)

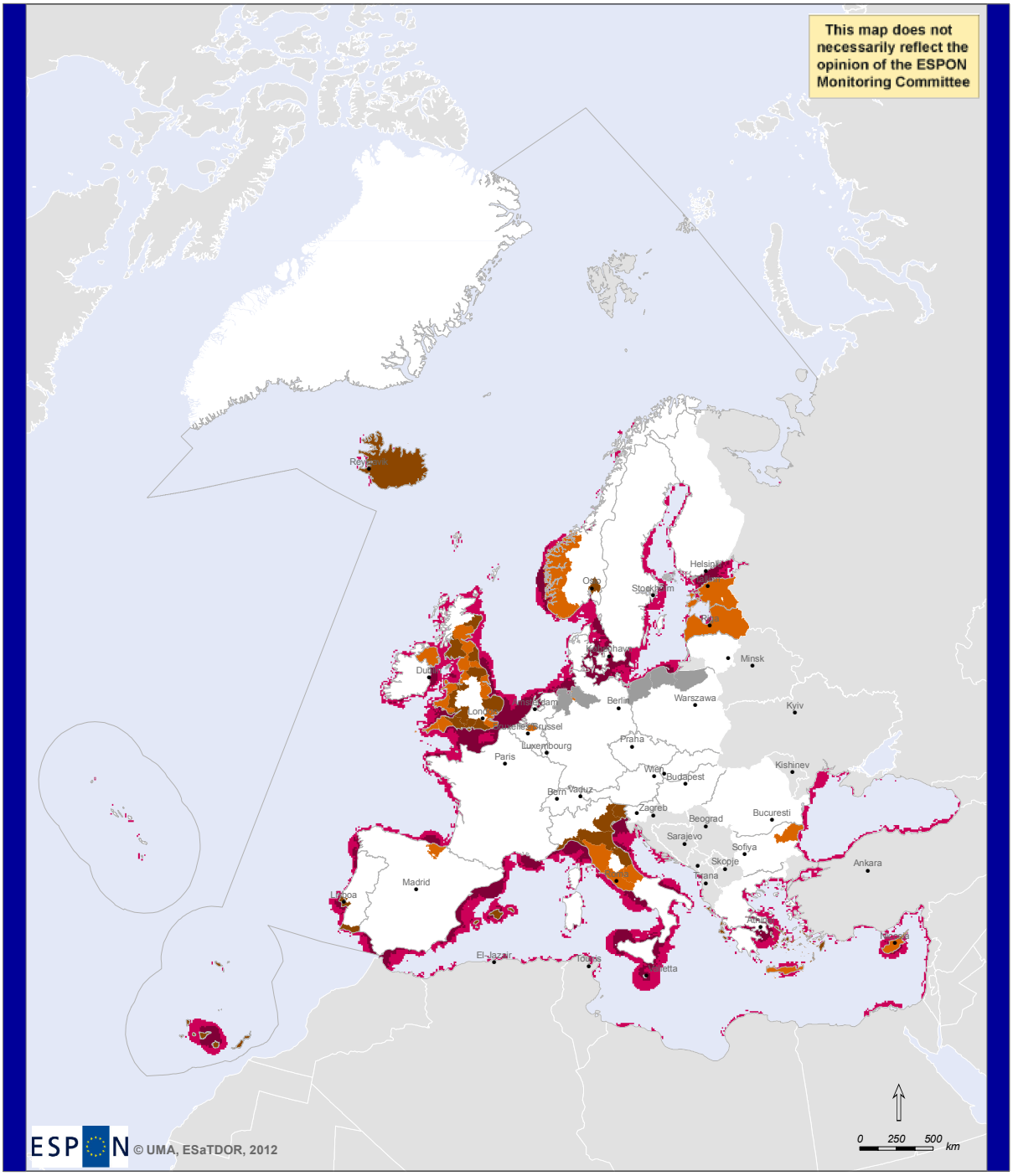
Sea *(Enviromental Pressures and Flows)*
- Very low intensity
- Low intensity

Land *(Economic Significance)*
- Very low intensity
- Low intensity
- No Data

This map shows where land-sea interactions are at their least intense in Europe's seas. The effect of the sea on the land is measured in terms of economic significance employment in maritime sectors) and the effects of anthropogenic activities on the sea are resented by environmental pressures (pollution from pesticides and fertilisers, incidence of invasive species introduced by shipping) and flows (of goods, including container traffic and liquid energetic products, people, from cruise ships and information, from telecommunications cables).

Map N32a. "Cold spots" of land-sea interactions (low intensity)

"Hot Spots" of Land-Sea Interactions



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Thematic data: Typology Map.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Typology Map (hotspots)

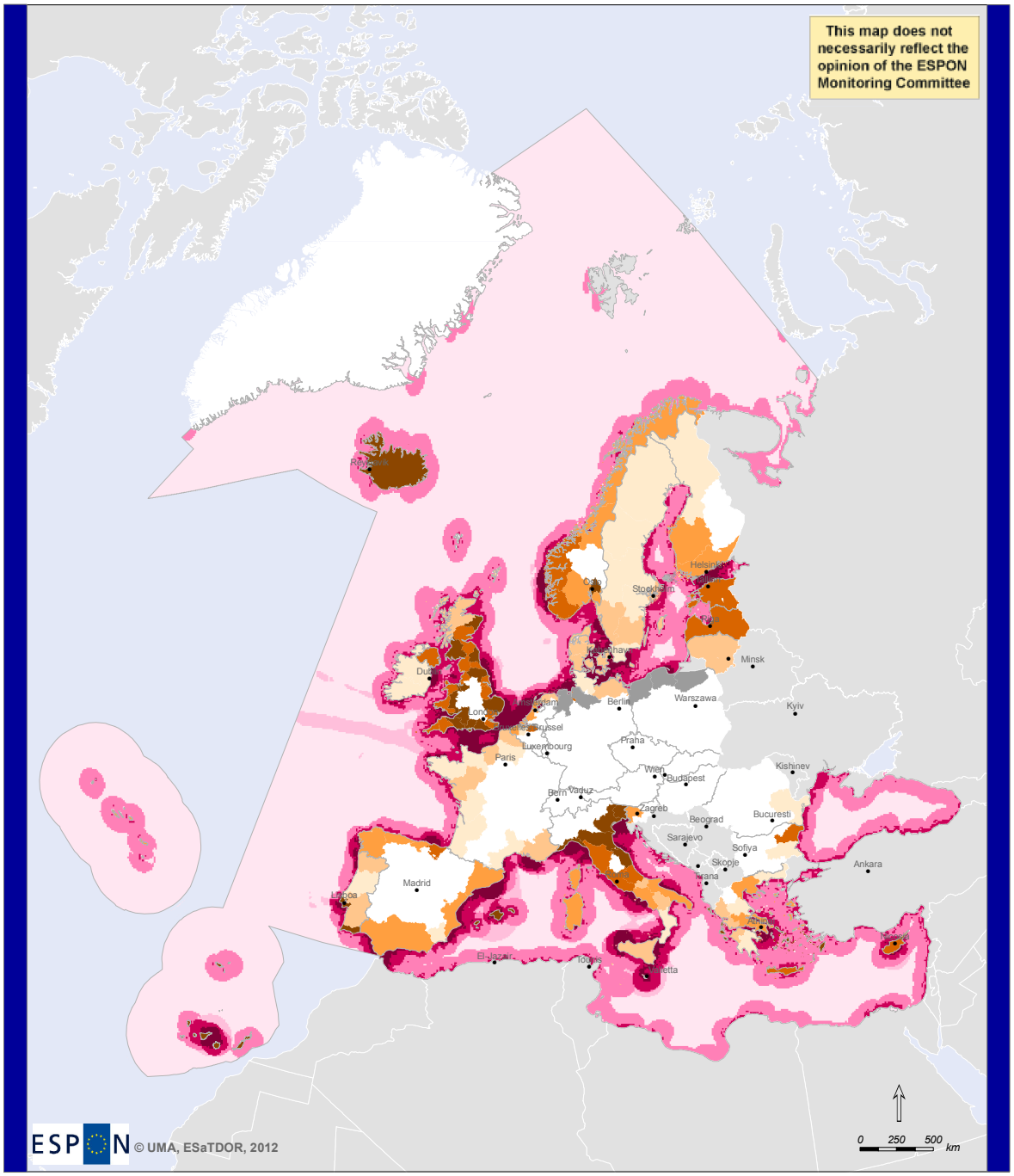
Sea *(Enviromental Pressures and Flows)*
- High intensity
- Very high intensity

Land *(Economic Significance)*
- High intensity
- Very high intensity
- No Data

This map shows where land-sea interactions are at their most intense in Europe's seas. The effect of the sea on the land is measured in terms of economic significance employment in maritime sectors) and the effects of anthropogenic activities on the sea are resented by environmental pressures (pollution from pesticides and fertilisers, incidence of invasive species introduced by shipping) and flows (of goods, including container traffic and liquid energetic products, people, from cruise ships and information, from telecommunications cables).

Map N32b. "Hot spots" of land-sea interactions (high intensity)

Intensity of Land-Sea Interactions Across Europe



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Thematic data: Typology Map.
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Typology Map

Sea *(Enviromental Pressures and Flows)*

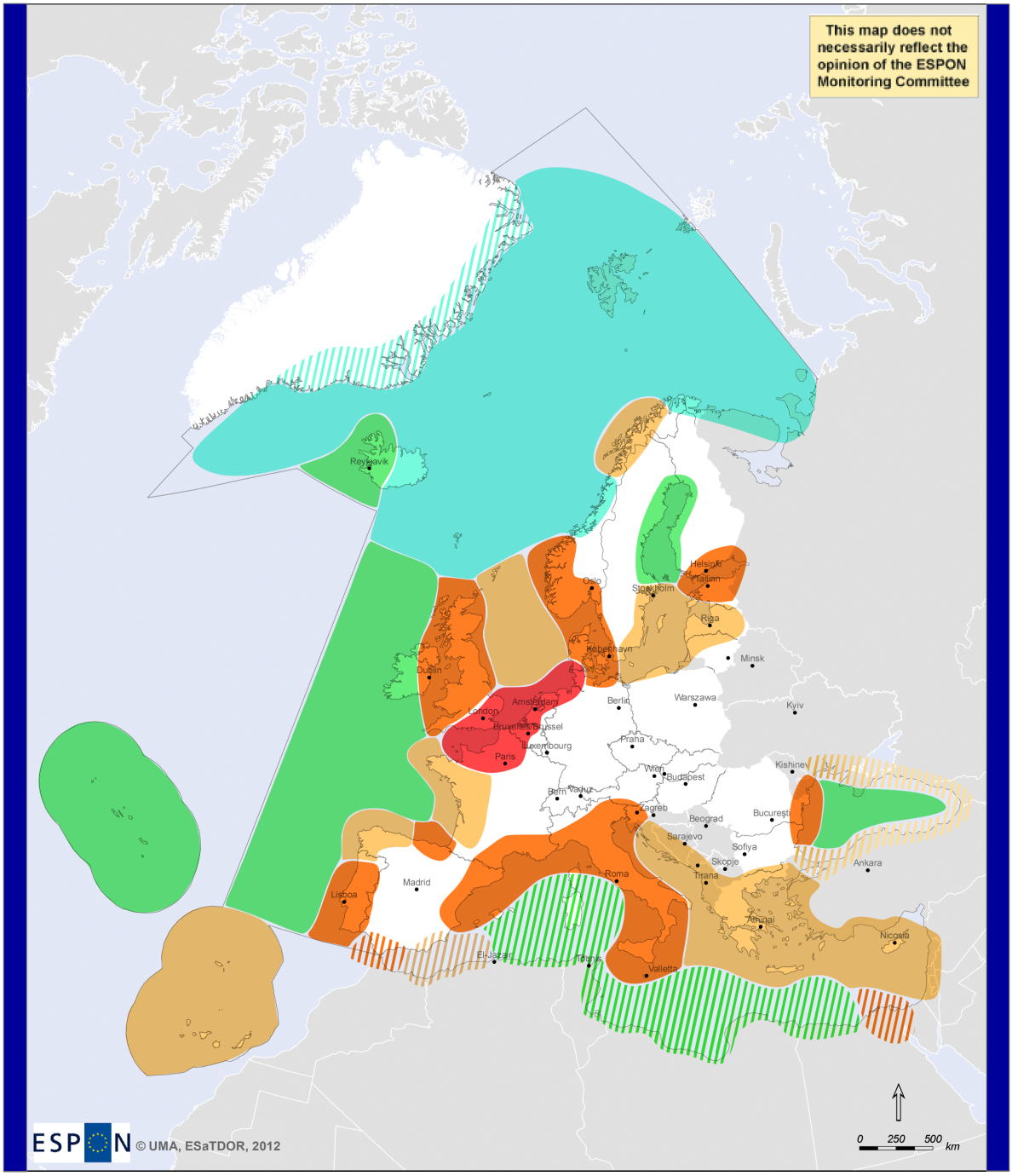
- Very low intensity
- Low intensity
- Medium intensity
- High intensity
- Very high intensity

Land *(Economic Significance)*

- Very low intensity
- Low intensity
- Medium intensity
- High intensity
- Very high intensity
- No Data

Map N33. Intensity of land-sea interactions across Europe

Typology of European Maritime Regions



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Thematic data: Typology Map, Economic Significance and Environmental Pressures Composite Maps
Land boundaries: © EuroGeographics Association and ESRI. Regional level: NUTS2.
Sea boundaries: OSPAR Convention, EU Integrated Maritime Policy and EEZ.

Regions derived from typology map

- European Core
- Regional Hub
- Transition
- Rural
- Wilderness
- Typology influenced by lack of data

This schematic typology map shows how Europe's coastal and maritime regions may be classified based on the intensity of land-sea interactions (economic activities, flows of goods, people and information and environmental pressures). These interactions are greatest in the European Core and at their lowest in the Wilderness.

Map N34. Typology of European maritime regions (schematic map)

6. Key Territorial Development Opportunities and Risks

A number of arrangements cater for cooperation among the riparian nations of the North Sea, and also among the nations of the North Sea's catchment. Many of these arrangements have come into being over the last three decades. Together with the EU Cohesion Policy, new opportunities for growth and employment as well as increased environmental and social development have emerged. The sea itself has been traditionally a driver for regional development. It is heavily exploited economically – from fisheries to maritime transport to communication to energy. Even so, new developments can be envisaged. Of particular note here are the development of renewable energy via offshore wind farms and a network of marine protected areas as required by the Convention on Biological Diversity.

Intense development, particularly of and adjacent to the shallow North Sea, has resulted in conflicting interests in the use of marine resources, aggravated by pollution. Pollution derives largely from land-based activities in the sea's catchment. Overuse of marine resources combined with deterioration of the marine environment and the potential for future deterioration of the marine landscape may have long term negative consequences for regional development.

Table 5 summarises possible conflicts and synergies between different users of the North Sea. The categories are not the same as those used in elsewhere in this report. Some 'sectors' have been subdivided: fisheries into fisheries and mariculture; energy into oil & gas and wind farms; transport into shipping routes and ports & harbours; and environment into conservation and Good Environmental Status (as required under the Marine Strategy Framework Directive).

Table 5: Spatial conflicts (red) and synergies (green) of different North Sea uses; table should be read so that activities in the first column have an effect on activities in the top row

	Fisheries	Mariculture	Tourism	Oil & gas	Windfarms	Shipping routes	Ports & harbours	Conservation	GEnS[1]
Fisheries						collision risk		biodiversity, seafloor integrity	biodiversity, seafloor integrity
Mariculture	possible source of parasites and disease		access, landscape		competition for shallow areas				
Tourism								damage to heritage values	damage to biodiversity
Oil & gas	no-fish zones		horizon pollution			collision risk			pollution
Windfarms	no-fish zones	competition for shallow areas	horizon pollution			collision risk		implicit MPAs	e.g. non-indigenous species
Shipping routes	collision risk			collision risk	collision risk			e.g. chemicals, damage, non-indigenous species	e.g. chemicals, non-indigenous species
Ports & harbours			horizon pollution, noise, etc.					e.g. non-indigenous species	e.g. non-indigenous species
Conservation	restricted access or use	restricted access or use	restricted access or use	restricted access or use	restricted access or use	restricted access or use	restricted access or use		e.g. supporting biodiversity
GEnS[1]	fish stocks	seed for culture, production	especially ecotourism					e.g. supporting biodiversity	

1 Good Environmental Status, as defined by the Marine Strategy Framework Directive; acronym distinguishes between Good Environmental Status (MSFD) and Good Ecological Status (Water Framework Directive)

Economic use

Opportunities

- *Climate Change > new fishery species*
  Climate change is likely to change the distribution and abundance of fish in the North Sea and might facilitate the establishment of non-indigenous, commercial species. There is no record of this having yet occurred.
- *Infrastructure associated with new maritime routes*
  (see topic *New infrastructure* under "Transport")
- *Aquaculture development*
  Due to decreasing fish stocks aquaculture is likely to develop further in the North Sea, as in most European seas. Only in quiet regions with restricted exchange, such as the Wadden Sea but perhaps also the German Bight and river estuaries, is this likely to lead to water quality problems.
- *Increased cruise tourism*
  (see topic *Cruise activity* under "Transport")
- *Ecotourism*
  (see topic *Ecotourism* under "Environment")
- *New technologies in shipbuilding and marine renewable energy production*
  Maritime industry is of importance for many riparian nations of the North Sea. While shipbuilding on a larger scale is in decline there has been a notable innovation capacity in the last years, especially by SMEs. Core topics are green shipping, off-shore installations (energy and mariculture), maintenance as well as issues of security, safety and surveillance. Currently these markets cannot be quantified exactly as most of the technology existing has a pre-commercial status [13].

Risks

- *Environmental pressures caused by intensive (coastal) land use*
  Intensive (coastal) land use is a source of nutrients, which in turn may cause symptoms of eutrophication (algal growth) in coastal and marine waters. In the North Sea, eutrophication is largely a nearshore problem, and can be particularly acute in the Wadden Sea. In the larger North Sea, increasing algal biomass has been linked to increasing water transparency, in turn caused by climatic factors, and has occurred despite declining nutrient concentrations [10, 11, 14]. This decline can be attributed to various national policies, such as reduced use of phosphorus in detergents, as well as EU policy such as the Urban Wastewater Treatment and Nitrates Directive. The main threat from eutrophication is to mariculture, which can lose stocks to harmful algal blooms, and to some extent to beach recreation, largely associated with *Phaeocystis* blooms in early spring. Eutrophication also threatens the structure and functioning of the entire marine ecosystem and a reduction in ecosystem resilience, although specifics here are remain unclear.
- *Pollution threat to marine living an non-living resources [2]*
  Contaminants are probably second to fisheries in terms of their effects on the structure and function of North Sea ecosystems and their threat to marine resources. One-third of OSPAR's priority chemicals are expected to be phased out in the OSPAR area by 2020 if current efforts continue. Environmental concentrations of monitored chemicals have

generally fallen but are still above acceptable concentrations in coastal areas of the North Sea. Contamination by persistent organic pollutants is widespread. Historic pollution in aquatic sediments is a continued source of contamination.

Cadmium and mercury loads of river are declining, but concentrations in fish and shellfish have risen, for example around the Dogger Bank, some UK estuaries and the southern North Sea. The time series is too short to rule out natural variation as the cause. PAH concentrations in fish and shellfish are generally declining, but remain at levels that pose a risk of pollution effects in many estuaries and urbanised and industrialised locations. PCBs in fish and shellfish still pose a risk of pollution effects, even 25 years after their ban. The effect of TBT-specific effects on dogwhelks and other marine snails has declined since 2003, when monitoring began. In comparison with other OSPAR regions, the North Sea has high background levels of many substances, largely a legacy of past pollution.

Transport

<u>Opportunities</u>

- *Growth of shipping*
  The North Sea is one of, if not the busiest, European sea. Both the number of ships and the size of ships (and so the quantities of cargo) have been growing until 2008 with a decrease in 2009 due to the economic crisis 2008/2009 [15]. Further growth of maritime transport is assumed (see transport briefing paper) in the near future.
- *New maritime routes*
  With its connection to the Arctic Sea, the opening of new maritime routes could result in increased shipping. Diversification of ferry routes is also possible.
- *Short Sea Shipping*
  Short Sea Shipping already takes place, grew by 21% between 2000 and 2005, and is expected to increase further [15].
- *Cruise activity*
  Cruise shipping is of major importance for various ports around the North Sea. Despite the economic crisis, the Dutch demand for cruises grew by 5% between 2009 and 2010 [16].
- *New infrastructure*
  Many harbours and ports around the North Sea, e.g. Rotterdam, have plans for expansion and/or improvement in the services provided, responding to increased shipping, technological revolutions and changes in demand.
- *Gas and oil shipping*
  Gas and oil shipping from North Sea fields is generally declining. Increases can be expected with export of Russian oil via the Baltic Sea. The energy dependence of North Sea riparian nations is increasing gradually [15], suggesting an increase in imports and so a decrease in exports.
- *Fishing*
  Fish stocks in the North Sea are fully exploited, for some stocks over-exploited, and so there are few opportunities for this sector. Aquaculture take place in the Wadden Sea and Rhine Delta, but are unlikely to expand.
- *Leisure development*

On-going increase in tourism development might lead to an increased in the number of leisure boats and marinas, especially in southern parts of the North Sea [16].

Risks

- *Shipping accidents and pollution*
  As one of the busiest seas in the world, safeguarding the smooth and safe flow of shipping traffic is one of the primary objectives of North Sea policy. A range of management instruments is available to promote shipping safety. These instruments generally function well in practice. The annual statistics for significant accidents show that the number of accidents per year is declining (following a worldwide trend) and that nautical management helps to make the North Sea a relatively safe transport route. Policy and management are geared mainly towards at least maintaining the status quo and, where possible, improving the current level of safety. Systematic adjustment of North Sea policy to keep it in line with the other usage functions of the North Sea is essential in this respect. An important option is to optimise the individual instruments for preventing and/or limiting the impact of disasters and incidents to ensure that these instruments work in concert [13].
- *Administrative barriers to shipping*
  As in other European seas the EU customs legislation is an obstacle for maritime transport, a hurdle which can be cleared but raises transport costs. A solution to this problem would be to eliminate the border formalities in maritime transport in intra-EU trade. Elimination of customs formalities in maritime transport has been proposed by the European Commission initiative of the Common European Maritime Transport Space without Barriers.

Energy and Pipelines

Opportunities

- *Fossil fuel Development*
  Oil and gas production in the North Sea has peaked and is now declining [2].
- *Marine Renewables*
  This is an important new and growing activity in the North Sea, and at present centres on the development of offshore windfarms [2, 17].
- *International energy and telecommunication grids*
  Associated with the development of offshore windfarms is the development of a transnational offshore grid systems [2, 17].
- *Carbon storage*
  . Carbon Capture and Storage (CCS) research and development projects are currently under development in most riparian nations. Maritime carbon storage is not developed yet but is possibility for the future.

Risks

- *Increased carbon emissions associated with oil and gas development*
  With the decline in oil and gas production, carbon emissions from this source are expected to decline.

- *Environmental damage associated with new energy sources*
  New energy sources (offshore wind farms) and new energy transport grids (cables, pipelines) can lead to various environmental impacts including changes in food web and habitat structures. Development of new energy sources can be expected to be an additional pressure on the already heavily used southern North Sea.
- *Restrictions to other sea uses associated with energy development*
  Offshore windfarm development exacerbates existing spatial conflicts, particularly in the southern North Sea. The main source of conflict is with fisheries, as windfarms development is expected to create 'no-fish' zones and constrain fisheries activities.

Environment

Opportunities

- *Ecosystem preservation/improvement*
  There is evidence of a substantial change to North Sea habitats and species over the last 100-150 years [8], and in environmental quality in general [2]. Fisheries activities, particularly trawling, are a major cause of this change but ecosystems have also been adversely affected by nutrient and contaminant loads, habitat loss with coastal development, and the presence of non-indigenous species. In response to the requirements of the Marine Strategy Framework and Water Framework Directives, the desired quality of the North Sea and its coastal environments is being specified as a first step to achieving Good Environmental/Ecological Status. As part of this process, some habitats and ecosystems may be restored, others will be preserved in protected areas, and the sources of environmental degradation constrained. Improved environmental quality provides opportunities for a number of economic sectors, notably fisheries (although uncertain and a contentious issue with fishermen), tourism and conservation.
- *Ecotourism*
  Tourism is also a major benefactor of good environmental quality. The European Commission's proposed strategy on Integrated Coastal Zone Management (ICZM) highlights the contribution that sustainable tourism could make to minimising adverse environmental impact of this sector. Sustainable tourism is highlighted in the most recent OSPAR Quality Status Report [2].
- *Maintaining fish stocks*
  Fisheries have been declining in the North Sea for most of the 20th century [8]. The Common Fisheries Policy has not been successful in constraining overfishing or the damage that fishing does to the marine environment. It will be interesting to see what improvements are brought about with the current revision of this policy, its interaction with the Marine Strategy Framework Directive and the Integrated Maritime Policy.
- *Increased resilience*
  Better environmental management of the North Sea is hoped to generate more resilience ecosystems that will deliver a reliable supply of ecosystem services. Known constraints to resilience relate to climate variability, as illustrated by ecosystem regimes shifts that appear to correlate with the North Atlantic Oscillation.
- *Carbon buffering*

The carbon budget of the North Sea is dominated by carbon inputs from rivers, the Baltic Sea and the atmosphere [18]. The North Sea acts as a sink for organic carbon and exports it to the North Atlantic Ocean. More than 90% of the CO2 taken up from the atmosphere is exported to the North Atlantic Ocean making the North Sea a highly efficient continental shelf pump for carbon.

Risks

- *Fisheries and aquaculture depletion*
  Many fish stocks are in decline in the Baltic Sea. Fishing fleets of riparian nations focus their activities beyond the North Sea [19]. There are strong arguments that long-term and frequent beam and otter trawling have depleted the habitats and food sources of many benthic species. Mariculture occurs in the Wadden Sea and in the estuaries of incoming rivers. Mussel culturing could be threatened by insufficient spatfall or reduced survival of spat due to climatic conditions [8].
- *Species loss*
  The OSPAR Quality Status report [2] identifies some 29 species and 10 habitats in the North Sea that are threatened. Reasons include: habitat loss and decline, fisheries including by-catch, hazardous substances, introduction of non-indigenous species, death or injury from ship strikes, oil pollution, predation, loss of prey species, microbial pathogens, barriers to species movement, threats from outside the OSPAR area, and litter. This document also reports more than 160 non-indigenous species in the OSPAR region.
- *Loss of natural sea defences*
  Parts of the natural coastline have been reinforced by dykes, groynes, and other structures, usually for the protection of human activities. Sea level rise poses a further threat to human security and may be met with further loss of natural sea defences and heavy investment in human-made sea defence. Coastal retreat and the return of natural defences are being trialled in various riparian nations. Natural habitats/ecosystems are likely to be lost, in the absence of adequate planning, as they are caught between a rising water level and inflexible/unmoveable human habitat (coastal squeeze).
- *Decline in water-based tourism*
  Bathing tourism is of great importance, particularly in the southern North Sea and good water quality is one of the main demands of summer tourist in this region. Decreasing water quality would hamper an important economic sector. Currently many beaches have Blue Flag status; the reasons why beaches do not have this status is usually not because of water quality issues.
- *Human health impacts*
  Hygienic water quality of coastal waters is of great importance for human health especially in areas with bathing and leisure activities. Coli and vibrio bacteria cause few problems in the North Sea, largely due to widespread wastewater treatment.

7. Initial Policy Recommendations

1. Focus on the sea as a resource, rather than take a sectoral or single resource perspective

A number of governance arrangements and fora exist to facilitate communication and cooperation among riparian nations and catchment nations of the North Sea. The case studies showed that the informal nature of some of these arrangements provides a flexibility that fosters discussion and cooperation.

However, such fora tend to be single-sector – e.g. environment, or energy, or shipping. Given how different activities impinge on each other, and notably on environment, fora are needed to promote more integrated development strategies and management of resources.

Marine Spatial Planning (MSP) is hailed as one means to facilitate such integration. Certainly there is a need to reduce the ways in which activities adversely affect each other. However there is a stark difference between zoning where activities may take place (current national emphasis) and the planning of activities so that their spatial and temporal effects are taken into consideration. Planning implies management, and the recent trend in environmental management focuses on adaptive management. Zoning, in providing fixed and relatively permanent rights of us, could contradict the principles of adaptive management.

2. Southern North Sea as a case

The southern North Sea is a core area in terms of economic importance, flows and environmental pressure. A forum is needed specifically for this area, and in particular with the pressure for renewable energy and particularly windfarm development. We recommend measures to make rational choices before the ad hoc development constrains options.

3. Sustainable food and sustainable energy

These two topics should drive the southern North Sea forum. Sustainable food includes fisheries, which for the North Sea are largely unsustainable, as well as agriculture in the North Sea catchment with its use of pesticides and fertilizers. Large-scale renewable energy developments are expected in the North Sea, exacerbating an already heavily used area. Studies are needed to understand both the economic (not only energy but also fisheries and shipping) and environmental implications of these development.

4. Data should be centrally collected and publicly available

The North Sea is much richer in data that the above maps indicate. Data are, in general, consistently and regularly collected, although differences between nations exist. The availability of such databases is a larger issue, with different data policies in different nations. Rationalisation of databases, their central housing and public availability is needed.

5. MSFD and INSPIRE Directive should use common language/definitions

Data on the marine environment are stimulated from different fronts, notably the MSFD and INSPIRE Directives, but also the Water Framework Directive. Common and consistent language and definitions are needed and will reinforce the second recommendation.

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