Annexes to ETC/ICM Technical Report 2/2019
'EU Policy-Based Assessment of the Capacity of Marine Ecosystems to Supply Ecosystem Services'

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European Environment Agency
European Topic Centre on Inland, Coastal and Marine Waters

Cover photo
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Layout
F&U confirm, Leipzig

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ISBN 978-3-944280-63-9

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Suggested citation
Culhane, F., Frid, C., Royo Gelabert, E., Robinson, L., Annexes to ETC/ICM Technical Report 2/2019 ‘EU Policy-Based Assessment of the Capacity of Marine Ecosystems to Supply Ecosystem Services’, 249 pp.

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Acknowledgements:	Jan-Erik Petersen (EEA) Markus Erhard (EEA) Irene Del Barrio Alvarellos (EEA) Eleni Tryfon (EEA) Carlos Romao (EEA) Monika Peterlin (EEA) Stéphane Isoard (EEA) Ronan Uhel (EEA) Arjen Boon (Deltares) Anna-Stiina Heiskanen (SYKE) Kari Saulamo (SYKE) Harri Kuosa (SYKE) Annuka Eriksson (SYKE) Soile Oinonen (SYKE)	Giulia Mo (ISPRA) Leonardo Tunesi (ISPRA) Sabrina Agnesi (ISPRA) Olga Maschina (SYKE) Peter Chaniotis (JNCC) Charlotte Islev (EEA) Benjamin Boteler (Ecologic) Franziska Stuke (Ecologic) Manuel Lago (Ecologic) Sophie Condé (MNHN) Joona Salojärvi (SYKE) Elina Seppälä (SYKE) Anna Tainio (SYKE) Petteri Vihervaara (SYKE) Cristina Vina-Herbon (JNCC)
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[I] All affiliations are between 2014 and 2018, i.e. at the time of the development of the work described in this Report
[II] IMARES is now WMR

Annex I Linkages matrices of ecosystem components to ecosystem services: by habitat type

Disclaimer: *This Annex was developed in 2014 and has not been updated since then, while certain elements of the main Report have been updated since 2014. Thus, there may be some inconsistencies between the main Report and this Annex*

Here we show how each habitat can provide an array of different ecosystem services and we identify linkages between services and the biotic groups within those habitats, i.e. the ecosystem components. The linkages are considered by habitat because linking services to habitats should facilitate linking back to the MAES marine habitat types ('Level' 3), and showing which of those types would deliver which services (see Section 3). If the assessment of service supply capacity based on ecosystem state can be carried out at the level of the habitats proposed here ('Level3a', Section3), the assessment outcomes could then be mapped into the marine habitat typology of MAES or the MSFD predominant habitat types[1], but only if spatial data becomes available at the level of the habitats proposed here (which is not the case yet and neither for the MSFD's). It is also more common practice to manage human activities at the habitat level than at the biotic group or ecosystem service level. Hence it is important that we are aware of all of the services a particular habitat and its biota has the capacity to supply. A summary of all services that all the habitats considered in this study have the capacity to supply is shown in Table AI.24, which draws from the list of services in Table 2.2 (Section 2) and the linkages between habitats and biotic groups in Section 3.

As explained in Section 4, linkages illustrate a one-way interaction between ecosystem services and the parts of the marine ecosystem (ecosystem components) that hold the capacity to supply those ecosystem services (Figure 4.1); linkages included are based on ecological knowledge and scientific literature and are included based on an understanding of the (ecosystem) state-service (generation) relationship. An identified link only indicates that an ecosystem component has the capacity to supply or contribute[2] to the supply of that service. For each habitat, a table is provided showing all the services it can supply or contribute to, and which biota do so.

In general, a cross is placed in the matrix where there is both the potential for contribution of the component to the supply of a service <u>and</u> the service would actually be supplied in that habitat However, in some cases there are indirect links, which should also be represented to highlight the importance of other/different habitats in supporting a biotic group that directly contributes to/supplies a service in a given habitat type. Thus, an indirect link occurs where a habitat supports or is essential for an adult stage[3] of a biotic group that is directly contributing to/supplying a service elsewhere (in another habitat), and has been marked using 'o'. This distinction allows taking into account the fact that individuals in the biotic groups providing direct capacity for a service may move

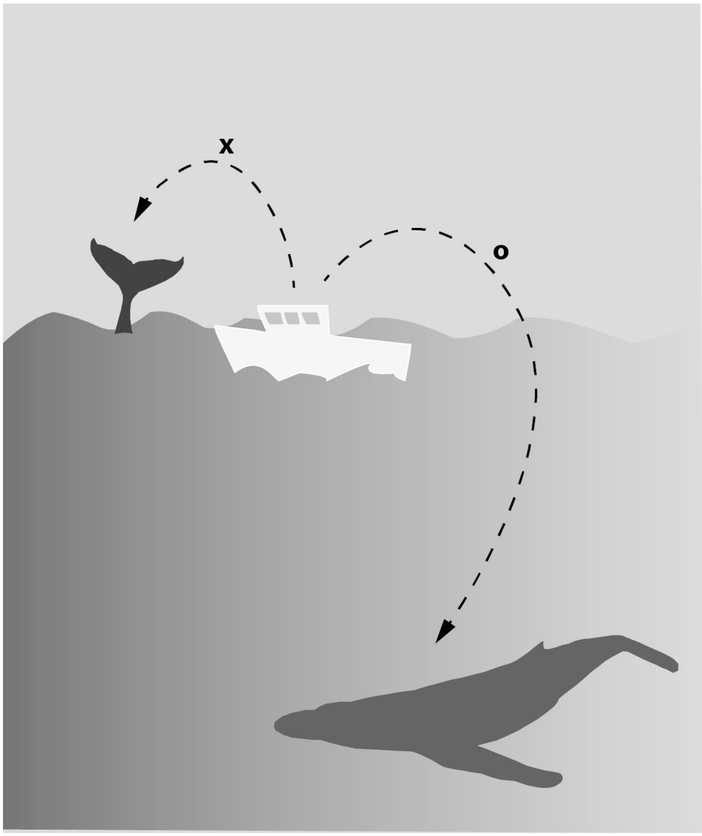
[1] We note the recent revisions of the MSFD's Annex III, where ecological characteristics are listed, and of the EC Decision on criteria and methodological standards on 'good environmental status, previously EC (2010) and now EC (2017), including for Descriptor 1, which may affect these characteristics. Both documents include the MSFD predominant habitat types and functional groups and so their reviews could have implications for the 'structural elements' of the assessment approach developed here. Further details on this are provided in Section 7.

[2] 'Contribute' is noted to illustrate where multiple ecosystem components may be important to providing the capacity to supply a particular ecosystem service.

[3] Because we only consider where a biotic group is directly contributing to a service elsewhere, we do not consider the larval stages of animals in indirect links. This is because the larval stages of marine animals function in different ways to the adults and for many, the planktonic stage will be picked up in the consideration of the services that can be supplied by zooplankton at the same time.

in and out of the habitat type where the specific service is supplied. This is where individuals make use of different habitats, for example migrating between feeding grounds, and also, where dead parts of an (e.g. shells, seagrass leaves) individual typical of one habitat type (e.g. shallow sublittoral coarse sediment) may wash into another habitat (e.g. a littoral beach), where it contributes to/supplies a service there (e.g. shells or seagrass leaves as a raw material). For example, the service *Recreation and leisure taken from whale-watching* may be supplied mainly in the *coastal water* habitat type, but the whales found in the *oceanic water* habitat type may be the same individuals that are found in *coastal water*s at other times. Therefore, an 'x' link should be placed in *coastal waters* where the service can actually be supplied, but an 'o' is placed in *oceanic waters*, because the state of whale populations in those habitats is relevant for the overall ecosystem capacity to supply this service over a longer timescale (Figure AI.1).

Figure AI.1: Representation of direct (x) and indirect links (o) for the service *Recreation and leisure from whale watching*



Notes: For the service *Recreation and leisure from whale watching*, a whale in the *coastal water* habitat type that can potentially be spotted by whale watchers is represented by a direct link (x). A whale in another habitat type that is not accessible to whale watchers, such as *oceanic waters* and deep-sea benthic habitats, does, therefore, not interact directly with whale watchers. However, this whale is likely to be from a connected population to those that are seen on whale watching trips in *coastal waters* and is, therefore, represented by an indirect link (o). An indirect link is given where a habitat supports or is essential to a biotic group that contributes to or supplies a service elsewhere (in another habitat).

Nevertheless, the indirect links would only be shown in individual service linkages matrices covering all the biotic groups occurring in a given habitat type, and only in some cases (see, e.g., Table Al.1). Thus, a direct link will, logically, always supersede an indirect link, so when both types of links could be included in a matrix for the same service, e.g. when providing an overview of all the service links for all habitat types in one matrix as per Table Al.24, the links included there are 'only' the direct links (x).

Some services (see Box AI.1) have links with biotic groups which mostly do not differ between habitats, i.e. the services can be supplied by the same biotic groups everywhere they occur. These will not be discussed per individual habitat here but will still be shown in the tables for each habitat (and will be discussed in cases where there are some differences in how biotic groups have the capacity to supply these services in the different habitats where this supply takes place).

All other services (not listed in Box AI.1) are discussed per habitat (below) as they show differences in how they are supplied in different habitats. For example, the service *waste and toxicant treatment* (service 10) is discussed per habitat because the biotic groups involved vary across habitats. In contrast, for the service *Waste and toxicant removal and storage* (11) every biotic group contributes in every habitat, if considering waste such as heavy metals which all biotic groups can store in their tissues. Thus, this service (11) is not discussed per habitat (below) as every biotic group in every habitat contributes to its supply. For full details of these services see Section 4.4.

Box AI.1 List of services with links to ecosystem components which do not differ between habitats

- 7. Genetic Materials
- 11. Waste and toxicant Removal and Storage
- 15. Oxygen Production
- 18. Gene Pool Protection
- 19. Pest Control
- 20. Disease Control
- 21. Sediment nutrient cycling
- 22. Chemical condition of seawater
- 23. Global Climate Regulation
- 25. Scientific
- 26. Educational
- 27. Heritage
- 28. Entertainment
- 29. Aesthetic
- 30. Symbolic
- 31. Sacred and/or religious
- 32. Existence
- 33. Bequest

Pelagic: Variable salinity waters (of coastal wetlands; coastal lagoons; estuaries; and inlets and embayments)

Variable salinity water habitats are those where freshwater mixes with marine salinity water, hence they are normally the closest to the shore, including in internal waters[4]. They can be found in the water column of:

- Land-sea interface features, such as coastal wetlands (i.e. saltmarshes, saltmeadows, salines and intertidal flats), coastal lagoons, estuaries[5], and inlets and embayments (e.g. fjords, sea lochs and other inlets as well as some bays), which can occur, in part of in full, within the intertidal/eulittoral zone[6] (or equivalent in non-(significantly)tidal seas), some of which may be relatively deep and comprise shallow sublittoral substrates.
- The supralittoral elements of any of those land-sea interface features (in, e.g., rock pools).
- Coastal wetlands (such as saltmarshes and saltmeadows) and coastal lagoons fully in the supralittoral.

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[4] Internal waters are those between the low-water line and the territorial baseline. Where the coastline is indented, such as in estuaries and coastal lagoons, the baseline is a straight line running across designated locations of the estuarine and lagoon entrances. Where the coastline is not considered to be indented, the territorial baseline coincides with the low-water line, and hence there are no internal waters.
[5] Estuaries could - in principle - extend beyond the baseline up to the 12 nm (territorial water) limit of the WFD transitional waters (and even beyond that, see EC, 2017).
[6] The marine zonation here refers to the sea's zonation, not that within the land-sea interface features.

These habitats encompass pelagic biotic groups (within their surrounding water column), and are considered to be photic (i.e. allowing the growth of photosynthesising organisms). They are distinguished from other pelagic habitats close to the shore based on their salinity, which would normally be brackish but can actually range from oligohaline to hyperhaline. Corresponding benthic habitats would be those out to and including the shallow sublittoral habitat types.

Variable salinity water pelagic habitats have the capacity to supply (or contribute to) a total of 28 ecosystem services through 11 biotic groups; amongst these 6 are provisioning services, 12 are regulation and maintenance services and 10 are cultural services (Table AI.1). In the table below, all services this habitat type has the capacity to supply (or contribute to) are shown (with the services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type, i.e. if how the ecosystem supplies a given service differs across habitat types, details specific to this habitat are then provided (the service number in relation to Table 2.2 and Table AI.1 is given in brackets in the text below so they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods and zooplankton (jellyfish) are directly harvested from *variable salinity waters* for *seafood* (Service 2 – herein, only the number of the service will be given). This could include artisanal fishing.
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested, e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals can be harvested directly from the water column. Birds are not hunted from pelagic habitats but from littoral habitats (or beyond) such as from the nest (in the case of gannets, where nests can be found in, e.g. the splash zone of cliffs), or from intertidal estuaries and saltmarshes (in the case of wildfowling). However, due to their high mobility, birds feeding or moving through this pelagic habitat type are likely to be from a connected population found in other benthic and pelagic habitats (hence link given as a ‘o’ as opposed to a ‘x’) (2)
- Macroalgae, fish and epifauna supply or contribute to *seafood* from in situ aquaculture (3, 4). Although epifauna in pelagic environments was not identified as an ecosystem component in this assessment approach, it is included here to represent shellfish which are suspended in the water column from ropes or trays (e.g. mussels), along with benthic algae which are also cultured suspended in the water column.
- Fish, cephalopods and zooplankton (jellyfish) can be used for oils or other *raw materials* (as well as for fishmeal used in aquaculture). (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition), and birds (wildfowl) could be used in taxidermy or for feathers for fly fishing lures; although there is only an indirect link for birds here as they are not hunted in this pelagic habitat (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, such as on an intertidal beach, hence an ‘o’ is given as it is not directly harvested from this pelagic habitat (5)

Regulation and Maintenance Services

- *Waste and toxicant treatment* can occur through bacteria, which break down waste (e.g. organic material or oil spills) via bioremediation, alongside phytoplankton and floating macroalgae, which break down waste materials via phytodegradation, and zooplankton, which can feed on particulate organic matter (POM). Epifauna and benthic macroalgae, which in this case are specifically suspended from artificial habitat in the water column, can also contribute to this service (10)

- Birds contribute to the mediation of *smell and visual impacts* by scavenging dead/rotting material from the surface waters; bacteria also contribute to the breakdown of material which could cause smell or visual impacts e.g. oil; epifauna (shellfish) and benthic algae from in situ aquaculture farms can also contribute by e.g. improving water clarity (12)
- In *variable salinity waters*, gamete dispersal carried out by birds, can occur directly by birds carrying gametes in droplets of water stuck to their feathers. This type of transport is important for populations that are isolated from source populations of relevant species, which could be the case for some populations in coastal lagoons. Seed dispersal (seagrass seeds are the only marine example) is not carried out directly in this pelagic habitat. However, Green Turtles and birds, which feeds on seagrass in the relevant benthic habitats, and can be found spending time in these pelagic habitats, can carry out this service in the relevant benthic habitats, thus there is an 'o' link for reptiles (and there is already a link for birds) (16)
- Floating macroalgae can provide important *nursery habitats* for juvenile fish. Reptiles (Green Sea Turtles) also contribute to habitat maintenance, of seagrass habitats, though there is only a direct link in those benthic habitats and not in pelagic habitats such as this type here, thus 'o' is given for turtles. Phytoplankton, zooplankton, fish and cephalopods have the potential to act as a source of prey for juveniles of commercial or migratory species (17)
- *Nursery habitats* (17), *pest control* (19) and *disease control* (20) would normally be contributed to by epifauna and benthic macroalgae but, as in pelagic habitats, such as this type here, these biotic groups are specifically from farms suspended in the water column, they are not considered to contribute to these services.

Cultural Services

- *Variable salinity water*s are important for cultural services, especially for *recreation and leisure*; all biotic groups in this habitat, except macroalgae (e.g. floating Sargassum, which may be considered a nuisance) and in situ farmed epifauna and benthic macroalgae, contribute to this service in this habitat (e.g. swimming, diving, boating, recreational fishing, etc.) (24).

Table AI.1 Ecosystem services that can be supplied in the *variable salinity water* (pelagic) habitat type showing the links with the biotic groups that hold the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Service	Variable Salinity Waters										
	Birds	Whales	Seals	Reptiles	Fish	Epi-fauna	Cephal-opods	Phyto-plankton	Zoo-plankton	Macro-algae	Bacte-ria
2. Seafood from Wild Animals	o		X		X		X		X		
3. Plant and Algal Seafood from In-situ aquaculture										X	
4. Animal Seafood from In-situ aquaculture					X	X					
5. Raw Materials	o	o	X		X		X		X		
6. Materials for agriculture and aquaculture					X		X				
7. Genetic Materials					X		X	X	X	X	X
10. Waste and Toxicant Treat-ment via Biota						X		X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X					X					X
15. Oxygen Production								X		X	
16. Seed and Gamete Dispersal	X			o							
17. Maintaining Nursery Popula-tions and Habitats				o	X		X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X		X	X	X	X	X
20. Disease Control	X	X	X	X	X		X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X		X	X	X		X
25. Scientific	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X				
28. Entertainment	X	X	X	X	X		X	X	X	X	X
29. Aesthetic	X	X	X	X	X		X	X	X	X	X
30. Symbolic	X	X	X	X	X		X		X		
31. Sacred and/or Religious	X	X	X	X	X		X		X		
32. Existence	X	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection)

Pelagic: Coastal Waters (includes fully marine features in the land-sea interface and fully open coastal waters)

Coastal water habitats are marine salinity water habitats relatively close to the shore, including in internal waters, and (normally) extending up to the shelf. They can be found in the water column of:

- Land-sea interface features with marine salinity, such as coastal wetlands, coastal lagoons, and inlets and embayments, as well as the nearshore, open coastal waters (up to 1 m from the territorial baseline), which can occur, in part or in full, within the intertidal/eulittoral zone (or equivalent in non-(significantly)tidal seas), some of which may be relatively deep and comprise shallow sublittoral substrates.
- The supralittoral elements of any of those land-sea interface features (in, e.g., rockpools).
- Coastal wetlands (such as saltmarshes) and coastal lagoons fully in the supralittoral.

In addition, they occur outside these features in fully open coastal waters (over the shallow sublittoral zone). These habitats encompass pelagic biotic groups (within their surrounding water column), and are considered to be photic (i.e. allowing the growth of photosynthesising organisms). Corresponding benthic habitats would be those out to and including the shallow sublittoral habitat types.

Coastal water pelagic habitats have the capacity to supply (or contribute to) a total of 28 ecosystem services through 11 biotic groups, amongst these 6 are provisioning services, 12 are regulation and maintenance services and 10 are cultural services (Table AI.2). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods and zooplankton (jellyfish) are directly harvested from coastal pelagic waters for *seafood* (Service 2 – herein, only number of service will be given).
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested, e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals can be harvested directly from the water column. Birds are not hunted from pelagic habitats but from littoral habitats (or beyond) - from the nest (in the case of gannets), or from intertidal estuaries and saltmarshes (in the case of wildfowling). However due to their high mobility, individual birds found in this pelagic habitat type are likely to be from a connected population found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x') (2)
- Macroalgae, fish and epifauna contribute to seafood from in situ *aquaculture* (3, 4). Although epifauna in pelagic environments was not identified as a component in this assessment approach, it is included here to represent shellfish (e.g. mussels), which are suspended in the water column from ropes or trays, along with benthic algae which are also cultured suspended in the water column.
- Fish, cephalopods and zooplankton (e.g. jellyfish) can be used for oils and other *raw materials* (as well as for fishmeal used in aquaculture) (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition), and birds (wildfowl) could be used in taxidermy or for feathers for fly fishing lures; although there is only an indirect link for birds here as they are not hunted from this pelagic habitat (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, such as an intertidal beach, hence 'o' is given as it is not directly harvested from this pelagic habitat (5)

Regulation and Maintenance Services

- *Waste and toxicant treatment* can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside phytoplankton and floating macroalgae, which break down waste materials via phytodegradation, and zooplankton, which can feed on POM. Epifauna and benthic macroalgae, which in this case are specifically suspended from artificial habitat in the water column, can also contribute to this service (10)
- Birds contribute to the mediation of *smell and visual impacts* by scavenging dead/rotting material from the surface waters; bacteria also contribute to the breakdown of materials which could cause smell or visual impacts e.g. oil; epifauna (shellfish) and benthic algae from farms can also contribute e.g. by improving water clarity (12)
- In *coastal waters*, gamete dispersal carried out by birds, can occur directly by birds carrying gametes in droplets of water stuck to their feathers. This type of transport is important for populations that are isolated from source populations of relevant species, which could be the case for some populations in *coastal water* inlets. Seed dispersal (seagrass seeds are the only marine example) is not carried out directly in this pelagic habitat. However, Green Turtles and birds, which feeds on seagrass in the relevant benthic habitats, and can be found spending time in these pelagic habitats, can carry out this service in the relevant benthic habitats, thus there is an 'o' link for reptiles (and there is already a link for birds) (16)
- Floating macroalgae can provide important *nursery habitats* for juvenile fish. Reptiles (Green Sea Turtles) also contribute to habitat maintenance, of seagrass habitats, though there is only a direct link in those benthic habitats and not in pelagic habitats such as this type here, thus 'o' is given for turtles. Phytoplankton, zooplankton, fish and cephalopods have the potential to act as a source of prey for juveniles of commercial or migratory species (17)
- *Nursery habitats* (17), *pest control* (19) and *disease control* (20) would normally be contributed to by epifauna and benthic macroalgae but, as in pelagic habitats, such as this type here, these biotic groups are specifically from farms suspended in the water column, they are not considered to contribute to these services.

Cultural

- *Coastal waters* are important for cultural services, especially for recreation and leisure; all biotic groups in this habitat, except macroalgae (e.g. floating Sargassum, which may be considered a nuisance) and farmed epifauna and benthic macroalgae, contribute to this service in this habitat (e.g. swimming, diving, boating, recreational fishing, etc.) (24)

Table AI.2 Ecosystem services that can be supplied in the *coastal water* (pelagic) habitat type showing the links with the biotic groups that hold the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Service	Coastal Waters										
	Birds	Whales	Seals	Reptiles	Fish	Epi-fauna	Cepha-lopods	Phyto-plankton	Zoo-plankton	Macro-algae	Bacteria
2. Seafood from Wild Animals	o		X		X		X		X		
3. Plant and Algal Seafood from In-situ aquaculture										X	
4. Animal Seafood from In-situ aquaculture					X	X					
5. Raw Materials	o	o	X		X		X		X		
6. Materials for agriculture and aquaculture					X		X				
7. Genetic Materials					X		X	X	X	X	X
10. Waste and Toxicant Treatment via Biota						X		X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X					X					X
15. Oxygen Production								X		X	
16. Seed and Gamete Dispersal	X			o							
17. Maintaining Nursery Popula-tions and Habitats				o	X		X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X		X	X	X	X	X
20. Disease Control	X	X	X	X	X		X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X		X	X	X		X
25. Scientific	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X				
28. Entertainment	X	X	X	X	X		X	X	X	X	X
29. Aesthetic	X	X	X	X	X		X	X	X	X	X
30. Symbolic	X	X	X	X	X		X		X		
31. Sacred and/or Religious	X	X	X	X	X		X		X		
32. Existence	X	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection).

Pelagic: Shelf waters

Shelf water habitats are the marine salinity water habitats over the shelf. These habitats encompass pelagic biotic groups (within the surrounding water column), and can be photic (i.e. allowing the growth of photosynthesising organisms) or aphotic. Corresponding benthic habitats are the shelf sublittoral habitat types. In some regions, however, the shelf may be close to the shore.

These pelagic habitats have the capacity to supply (or contribute to) a total of 27 ecosystem services through 10 biotic groups, amongst these 5 are provisioning services, 12 are regulation and maintenance services and 10 are cultural services (Table AI.3). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods and zooplankton (jellyfish) are directly harvested from shelf pelagic waters for *seafood* (Service 2 – herein, only number of service will be given).
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested, e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals can be harvested directly from the water column. Birds are not hunted from pelagic habitats but from littoral habitats (or beyond) – from the nest (in the case of gannets), or from intertidal estuaries and saltmarshes (in the case of wildfowling). However, due to their high mobility, individual birds found in pelagic habitats, such as this type here, are likely to be from a connected population found in other benthic and pelagic habitats that could occur in shelf waters in this case (hence link given as 'o' as opposed to 'x') (2)
- Fish contribute to in situ *aquaculture* (4). Shellfish (epifauna) and macroalgae *in situ* aquaculture is not considered to be found in shelf waters.
- Fish, cephalopods and zooplankton (jellyfish) can be used for oils or other *raw materials* (as well as for fishmeal used in aquaculture) (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition), and birds (wildfowl) could be used in taxidermy or for feathers for fly fishing lures; although there is only an indirect link for birds here as they are not hunted from this pelagic habitat (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, such as on an intertidal beach, hence 'o' is given as it is not directly harvested from this pelagic habitat (5)

Regulation and Maintenance Services

- *Waste and toxicant treatment* can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside phytoplankton and floating macroalgae, which break down waste materials via phytodegradation, and zooplankton, which can feed on POM (10)
- Birds contribute to the mediation of *smell and visual impacts* by scavenging dead/rotting material from the surface waters, this could be relevant for users of shelf waters. Bacteria also contribute to the mediation of visual impacts, such as those from oil spills, which could wash up onshore (12)
- In *shelf waters*, *seed and gamete dispersal* is not considered to be carried out as these habitats may be too far away from the habitats where this service is important or relevant (isolated habitats and seagrass beds). An 'o' link is given for reptiles as the Green turtle, which feeds on seagrass in the relevant benthic habitats, spends much of its life in the pelagic zone (especially shelf and oceanic waters). Therefore, the turtles that contribute to the dispersal of seagrass

seeds in benthic habitats are likely to be from a connected population found in other benthic and pelagic habitats to those present in this pelagic habitat type. For the dispersal of gametes of relevant species, the birds which feed in lagoon habitats, where gamete dispersal is important, are more likely to be intertidal or shallow water waders but could be connected to those populations found associated with shelf habitats, thus an 'o' link is given for birds (16)

- Floating macroalgae can provide important *nursery habitats* for juvenile fish. Reptiles (Green Sea Turtles) also contribute to habitat maintenance, of seagrass habitats, though there is only a direct link in those benthic habitats and not in pelagic habitats such as this type here, thus 'o' is given for turtles. Phytoplankton, zooplankton, fish and cephalopods have the potential to act as a source of prey for juveniles of commercial or migratory species (17)

Cultural

- Most *shelf water* habitats are likely to be less important for cultural services than those waters found nearer to the shore, although these waters provide opportunities for recreation and leisure activities such as deep sea sport fishing, boating, whale watching, etc., which can be underpinned to any degree by the biota linked to cultural services. All biotic groups, except macroalgae (e.g. floating Sargassum, which may be considered a nuisance), contribute to this service in the shelf zone (24)

Table AI.3 Ecosystem services that can be supplied in the *shelf water* (pelagic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Service	Shelf Waters									
	Birds	Whales	Seals	Reptiles	Fish	Cephal-opods	Phyto-plankton	Zoo-plankton	Macro-algae	Bacteria
2. Seafood from Wild Animals	o		X		X	X		X		
4. Animal Seafood from In-situ aquaculture					X					
5. Raw Materials	o	o	X		X	X		X		
6. Materials for agriculture and aquaculture					X	X				
7. Genetic Materials					X	X	X	X	X	X
10. Waste and Toxicant Treatment via Biota							X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X									X
15. Oxygen Production							X		X	
16. Seed and Gamete Dispersal	o			o						
17. Maintaining Nursery Populations and Habitats				o	X	X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X		X
25. Scientific	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X				
28. Entertainment	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X		X		
31. Sacred and/or Religious	X	X	X	X	X	X		X		
32. Existence	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae); 3 (Plant and Algal Seafood from In-situ aquaculture); 8,9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection).

Pelagic: Oceanic Waters

Oceanic water habitats are the marine salinity waters over the slope and beyond. These habitats encompass pelagic biotic groups (within their surrounding water column), and can be photic (i.e. allowing the growth of photosynthesising organisms) or aphotic. Corresponding benthic habitats are the bathyal and abyssal habitat types.

These pelagic habitats have the capacity to supply (or contribute to) a total of 26 ecosystem services through 10 biotic groups, amongst these 4 are provisioning services, 12 are regulation and maintenance services and 10 are cultural services (Table AI.4). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods and zooplankton (jellyfish) are directly harvested from oceanic pelagic waters for *seafood* (Service 2 – herein, only number of service will be given), and can also be used for oils or other *raw materials* (as well as for fishmeal used in aquaculture) (5, 6).
- Seabirds and seals are sometimes harvested on a very small scale under authorised culls, e.g. the Guga hunt in the Outer Hebrides for gannets. Seals can be harvested directly from the water column. Birds (Gannets) are not hunted from pelagic habitats but are taken from the nest (littoral habitats –the splash zone of cliffs). However, due to their high mobility, individual birds moving through or feeding in this pelagic habitat type are likely to be from a connected population found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x'). The types of birds hunted as part of wildfowling are not expected to be associated with oceanic waters (2)
- Fish are not considered to contribute to *in situ aquaculture* because aquaculture farms are not found in oceanic habitats (4)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition), (wildfowl birds, which are used for raw materials, are not expected to be associated with oceanic waters) (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, such as an intertidal beach, hence 'o' is given as it is not directly harvested from this pelagic habitat (5)

Regulation and Maintenance Services

- *Waste and toxicant treatment* can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside phytoplankton and floating macroalgae, which break down waste materials via phytodegradation, and zooplankton, which can feed on POM (10)
- Birds contribute to the mediation of *smell and visual impacts* by scavenging dead/rotting material from the surface waters. This is relevant in near shore waters where these impacts will have the potential to affect people, however the birds associated with oceanic waters are likely to be from a connected population to those found in other benthic and pelagic habitats nearer shore directly delivering the service, hence a 'o' is given here. Bacteria also contribute to the mediation of visual impacts such as those from oil spills which could wash up onshore (12)
- In *oceanic waters*, *seed and gamete dispersal* is not considered to be carried out as these habitats may be too far away from the habitats where this service is important or relevant (isolated habitats and seagrass beds). An 'o' link is given for reptiles as the Green turtle, which feeds on seagrass in the relevant benthic habitats, spends much of its life in the pelagic zone

(especially shelf and oceanic waters). Therefore, the turtles that contribute to the dispersal of seagrass seeds in benthic habitats are likely to be from a connected population found in other benthic and pelagic habitats to those present in this pelagic habitat type. For the dispersal of gametes of relevant species, the birds which feed in coastal lagoon habitats, where gamete dispersal is important, are more likely to be intertidal or shallow water waders and not connected to those populations found associated with oceanic habitats (16)

- Floating macroalgae can provide important *nursery habitats* for juvenile fish. Reptiles (Green Sea Turtles) also contribute to habitat maintenance, of seagrass habitats, though there is only a direct link in those benthic habitats and not in pelagic habitats such as this type here, thus ‘o’ is given for turtles. Phytoplankton, zooplankton, fish and cephalopods have the potential to act as a source of prey for juveniles of commercial or migratory species (17)

Cultural

- *Oceanic water* habitats are likely to be less important for cultural services than those waters found nearer to the shore, although these waters provide opportunities for *recreation and leisure* activities such as deep sea fishing, boating, whale watching, etc. which can be underpinned to any degree by the biota linked to cultural services. All biotic groups, except macroalgae (e.g. floating Sargassum, which may be considered a nuisance), contribute to this service in the oceanic zone (24)
- For *Sacred and/or religious services*, only the biotic components relevant for fishermen were given (i.e. those providing seafood, and not for scuba-divers as this activity would not be relevant in this habitat) (See Section 4.4 for full description of this service) (31).

Table AI.4 Ecosystem services that can be supplied in the *oceanic water* (pelagic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Oceanic Waters									
	Birds	Whales	Seals	Reptiles	Fish	Cephal-opods	Phyto-plankton	Zoo-plankton	Macro-algae	Bacteria
2. Seafood from Wild Animals	o		X		X	X		X		
5. Raw Materials		o	X		X	X		X		
6. Materials for agriculture and aquaculture					X	X				
7. Genetic Materials					X	X	X	X	X	X
10. Waste and Toxicant Treatment via Biota							X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	o									X
15. Oxygen Production							X		X	
16. Seed and Gamete Dispersal				o						
17. Maintaining Nursery Populations and Habitats				o	X	X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X			X
25. Scientific	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X				
28. Entertainment	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X		X		
31. Sacred and/or Religious					X	X				
32. Existence	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae); 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection).

Ice-associated Habitats

Ice-associated habitats are those associated to the seasonal sea ice that occurs in the Baltic Sea region, and which occur within, or on the topside or the underside of, the ice where zooplankton and fish may accumulate and feed.

These habitats have the capacity to supply (or contribute to) a total of 24 ecosystem services through 6 biotic groups, amongst these 3 are provisioning services, 11 are regulation and maintenance services and 10 are cultural services (Table AI.5). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish can be harvested from *ice-associated habitats* for *seafood* (ice-fishing, which can be artisanal and recreational) (Service 2 – herein, only number of service will be given). Jellyfish are not associated with ice habitats.
- Seals are sometimes harvested on a very small scale under authorised culls. These can be harvested from ice habitats (2)
- Bird species that are hunted for food in the Baltic Sea region (wildfowl) are not expected to be associated with ice habitats, thus no link is given for birds (2, 5)
- Fish can be used for oils and other *raw materials* (5)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition) (5)

Regulation and Maintenance Services

- *Waste and toxicant treatment* can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside phytoplankton, which break down waste materials via phytodegradation, and zooplankton, which can feed on POM (10)
- Birds contribute to the mediation of *smell and visual impacts* by scavenging dead/rotting material from the surface of the ice. Bacteria also contribute to the mediation of visual or smell impacts (12)
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is not considered to be directly supplied in ice habitats but is important for isolated populations such as those found in coastal lagoons or inlets associated to other benthic and pelagic habitats. Some birds associated with ice habitats are likely to be from connected populations found in these other benthic and pelagic habitats, thus an 'o' is given here. Ice habitats may represent an important over-wintering habitat for these populations (16)
- Seasonal sea ice habitats are not thought to be important for maintaining populations of juvenile species as, although ice habitats are important in some regions for juvenile species, e.g. in the Arctic (Sigler et al. 2016). Thus, commercially important or migratory species in the Baltic Sea tend to rely on warmer temperatures and alternative habitats during their juvenile stages (MacKenzie et al. 2007).

Cultural

- *Ice-associated habitats* are important for cultural services providing opportunities for recreation and leisure activities such as ice fishing, ice skating, walking on the ice, ice diving, which can be underpinned to any degree by the biota linked to cultural services, as well as the potential to see wildlife such as birds and seals (24)

- *Sacred and/or religious services* are included here. Indigenous people in the Baltic Sea region (the Saami) have sacred activities related to ice habitats as they believe all animals have souls. It is not known whether these also occur around Baltic Sea (seasonal sea) ice, or if they are associated with any particular biotic components there. Nevertheless, it is likely that at least the charismatic animals and animals important for food have some spiritual significance to people in these regions.

Table AI.5 Ecosystem services that can be supplied in the *ice associated* habitats showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Service	Ice Associated Habitats					
	Birds	Seals (breeding)	Fish	Phytoplankton	Zooplankton	Bacteria
2. Seafood from Wild Animals		x	x			
5. Raw Materials		x	x			
7. Genetic Materials			x	x	x	x
10. Waste Treatment via Biota				x	x	x
11. Waste and Toxicant Removal and Storage	x	x	x	x	x	x
12. Mediation of smell/ visual impacts	x					x
15. Oxygen Production				x		
16. Seed and Gamete Dispersal	o					
18. Gene Pool Protection	x	x	x	x	x	x
19. Pest Control	x	x	x	x	x	x
20. Disease Control	x	x	x	x	x	x
21. Sediment nutrient cycling	x	x	x	x	x	x
22. Chemical Condition of Seawater	x	x	x	x	x	x
23. Global Climate Regulation	x	x	x	x	x	x
24. Recreation and Leisure	x	x	x			
25. Scientific	x	x	x	x	x	x
26. Educational	x	x	x	x	x	x
27. Heritage	x	x	x			
28. Entertainment	x	x	x	x	x	x
29. Aesthetic	x	x	x	x	x	x
30. Symbolic	x	x	x			
31. Sacred/Religious	x	x	x			
32. Existence	x	x	x	x	x	x
33. Bequest	x	x	x	x	x	x

*Services not shown include: 1 (Seafood from Wild Plants and Algae); 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 6 (Agricultural Materials); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 17 (Maintaining Nursery Populations and Habitats).

Table AI.6 Ecosystem services that can be supplied in the *littoral rock and biogenic reef* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Service	Littoral Rock and Biogenic Reef										
	Birds	Whales (dead)	Seals (haul outs)	Fish	Cephalo-pods	Epi-fauna	Infauna	Macro-phytes	Macro-algae	Microphyto-benthos	Bacteria
1. Seafood from Wild Plants and Algae								X	X		
2. Seafood from Wild Animals	X		X	X	X	X					
4. Animal Seafood from In-situ aquaculture						X					
5. Raw Materials		X	X	X	X	X	X	X	X		
6. Materials for agriculture and aquaculture									X		
7. Genetic Materials				X	X	X	X	X	X	X	X
10. Waste and Toxicant Treatment via Biota						X	X	X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X					X	X				X
13. Erosion Prevention and Sediment Retention						X	X	X	X	X	
14. Flood Protection						X	X	X	X		
15. Oxygen Production								X	X	X	
16. Seed and Gamete Dispersal	X										
17. Maintaining Nursery Populations and Habitats				X	X	X	X	X	X	X	
18. Gene Pool Protection	X		X	X	X	X	X	X	X	X	X
19. Pest Control	X		X	X	X	X	X	X	X	X	X
20. Disease Control	X		X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	X		
25. Scientific	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X		X	X		
28. Entertainment	X	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X		X	X	X	X		X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	X		
32. Existence	X		X	X	X	X	X	X	X	X	X
33. Bequest	X		X	X	X	X	X	X	X	X	X

*Services not shown include: 3 (Plant and Algal Seafood from In-situ aquaculture); 8, 9 (Biofuels).

Benthic: Littoral Sediment

Littoral sediment habitats are the sandy, muddy, coarse and mixed sediment habitats in the supralittoral zone and the intertidal/eulittoral zone (or equivalent in non-(significantly) tidal seas) (e.g. in mud- and sandflats). They can be found in the seabed of:

- Land-sea interface features, such as coastal wetlands, coastal lagoons, estuaries, and inlets and embayments, as well as the nearshore, open coastal waters (up to 1nm from the territorial baseline), which can occur, in part or in full, within the intertidal/eulittoral zone (or equivalent in non-(significantly)tidal seas)
- Coastal wetlands (such as saltmarshes and saltmeadows) and coastal lagoons fully in the supralittoral.

These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be photic (i.e. allowing the growth of photosynthesising organisms). Corresponding pelagic habitats are the variable salinity water and coastal water habitat types.

Littoral sediment benthic habitats have the capacity to supply (or contribute to) a total of 30 ecosystem services through 12 biotic groups, amongst these 6 are provisioning services, 14 are regulation and maintenance services and 10 are cultural services (Table AI.7). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Macroalgae contributes to *seafood* and can be harvested from *littoral* habitats. Although rocky habitats may provide greater abundance of macroalgae, seaweeds can also be found attached to small rocks amongst finer sediment (Service 1 – herein, only number of service will be given). Macrophytes such as Samphire (*Salicornia* sp.) can be harvested from littoral habitats such as intertidal mud and sandflats[7] (1)
- Fish, cephalopods, epifauna (e.g. crabs) and infauna (e.g. razor clams) are directly harvested from intertidal sediment habitats for *seafood*, this may include artisanal harvesting of seafood (2)
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested, e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals can be culled from these habitats, and birds (wildfowl) can also be taken from intertidal estuaries and sandflats (2)
- Epifauna contribute to *in situ aquaculture* in the intertidal zone in this habitat e.g. oyster grown on the ground in tidal areas and infauna e.g. cockles on beaches (4). Macroalgae farming is not known to occur associated with benthic habitats (i.e. macroalgae are cultured suspended in the pelagic zone) (3).
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources, bait, and other *raw materials* (5)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition), and birds (wildfowl) feathers could be used for fly fishing lures or in taxidermy (5)
- Whales (sperm whales) provide ambergris, which washes up in *littoral* habitats such as on an intertidal beach (5)

[7] http://jncc.defra.gov.uk/protectedsites/sacselection/habitat.asp?FeatureIntCode=H1310

- Macroalgae can be used to produce substances such as agar or as a source of iodine, and macrophytes, e.g. Salicornia, can be used in the cosmetic industry. Dead seagrass litter (macrophytes) is washed up in littoral habitats and is collected to be used as building insulation (5)
- Macroalgae can be used as fertiliser and macrophytes can be used for grazing sheep in saltmarsh (littoral sediment) habitats (6)

Regulation and Maintenance Services

- *Waste and toxicant treatment* can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside macroalgae, macrophytes and microphytobenthos, which break down waste materials via phytodegradation, and epifauna and infauna which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material in littoral habitats such as on an intertidal beach, which could cause *smell or visual impacts* (12)
- Stabilisation of sediments, accumulation of sediment and attenuation of wave energy can be contributed to by macrophytes, macroalgae, microphytobenthos and (tube-forming) infauna all of which contribute to *erosion prevention and sediment retention*. Epifauna are not considered to contribute in littoral sediment (but do in littoral *rock and biogenic reef* habitats). (13)
- Attenuation of wave energy is contributed to by macrophytes and macroalgae, which contribute to *flood prevention*. Reef forming species (infauna and epifauna) are not considered to contribute here as these come under the *rock and biogenic reef* habitats. (14).
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets. Birds found in littoral habitats can also disperse seagrass seeds in the relevant habitats. Green turtles can disperse seagrass seeds. Green Sea Turtles using littoral habitats to access their nesting sites are likely to be from a connected populations found in other benthic and pelagic habitats to those contributing to this service for seagrass beds in shallow sublittoral benthic habitats. There is an indirect link ('o') here for reptiles as seagrass does not grow in littoral habitats (16)
- Epifauna and infauna contribute to the small scale spatial structure of soft sediment habitats, and macroalgae (e.g. *Fucus* sp.) and macrophytes (e.g. saltmarsh plants) can provide important *nursery habitats* for invertebrates and small fish. Reptiles (Green Sea Turtles) also contribute to habitat maintenance, of seagrass gardens/meadows, though there is only a direct link in sublittoral benthic habitats and not directly in littoral habitats (where the turtles are associated with nesting activities), thus 'o' is given for turtles. Epifauna, infauna, fish, cephalopods and microphytobenthos have the potential to act as a source of prey for juvenile commercial and migratory species (17)
- Dead whales (e.g. on the beach) are not considered to contribute to *gene pool protection*, *pest control* or *disease control* (where live whales are considered to contribute to these services).

Cultural

- *Littoral sediment* habitats are important for cultural services especially for *recreation and leisure*; all biotic groups contribute to this service in these habitats (e.g. through wildlife watching, walking, paddling, etc. which can be underpinned to any degree by the biota linked to cultural services), except microphytobenthos and bacteria, which are not considered to supply the *recreation and leisure* service in benthic habitats (24)
- Dead whales (e.g. on the beach) are not considered to contribute to *symbolic*, *existence* or *bequest* services (where live whales are considered to contribute to these services).

Table AI.7 Ecosystem services that can be supplied in the *littoral sediment* (benthic) habitats showing links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Littoral Sediment											
	Birds	Whales (dead)	Seals (haul outs)	Reptiles (nesting)	Fish	Cephalo-pods	Epifauna	Infauna	Macrophytes	Macroalgae	Micro-phytobenthos	Bacteria
1. Seafood from Wild Plants and Algae									X	X		
2. Seafood from Wild Animals	X		X		X	X	X	X				
4. Animal Seafood from In-situ aquaculture							X	X				
5. Raw Materials	X	X	X		X	X	X	X	X	X		
6. Agricultural Materials									X	X		
7. Genetic Materials					X	X	X	X	X	X	X	X
10. Waste Treatment via Biota							X	X	X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X				X
13. Erosion Prevention and Sediment Retention								X	X	X	X	
14. Flood Protection									X	X		
15. Oxygen Production									X	X	X	
16. Seed and Gamete Dispersal	X			o								
17. Maintaining Nursery Populations and Habitats				o	X	X	X	X	X	X	X	
18. Gene Pool Protection	X		X	X	X	X	X	X	X	X	X	X
19. Pest Control	X		X	X	X	X	X	X	X	X	X	X
20. Disease Control	X		X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	X	X		
25. Scientific	X	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	X	X		
28. Entertainment	X		X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X		X	X	X	X	X		X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	X	X		
32. Existence	X		X	X	X	X	X	X	X	X	X	X
33. Bequest	X		X	X	X	X	X	X	X	X	X	X

*Services not shown include: 3 (Plant and Algal Seafood from In-situ aquaculture); 8, 9 (Biofuels)

Benthic: Shallow Sublittoral Rock and Biogenic Reef

Shallow sublittoral rock and biogenic reef habitats are the rocky and biogenic reef habitats in the shallow, photic sublittoral zone. They can be found in the seabed of certain land-sea interface features (such as estuaries, and fjords, sea lochs and other inlets), including in the nearshore, open coastal waters (up to 1 nm from the territorial baseline). In addition, they occur outside these features as the seabed of fully open coastal waters. These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be photic (i.e. allowing the growth of photosynthetic organisms). Corresponding pelagic habitats are the variable salinity water and coastal water habitat types.

These benthic habitats have the capacity to supply (or contribute to) a total of 30 ecosystem services through 12 biotic groups, amongst these 6 are provisioning services, 14 are regulation and maintenance services and 10 are cultural services (Table AI.8). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Macroalgae, such as Dulse, contributes to seafood and can be harvested from sublittoral rocky habitats (Service 1 – herein, only number of service will be given). The species of macrophytes (seagrasses) which occur in shallow sublittoral habitats are not known to be a source of seafood in the EU.
- Fish, cephalopods and epifauna (e.g. lobster) are harvested from rocky sublittoral habitats for seafood, this may include artisanal harvesting of seafood (2)
- Seabirds (e.g. gannets) and seals are sometimes harvested on a very small scale under authorised culls, e.g. the Guga hunt in the Outer Hebrides for gannets. Seals are culled from the water column or land, and unlikely to be taken from these benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond. However, due to their high mobility, all these organisms may feed in these habitats but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x') Wildfowl birds which are used for food are not expected to be associated with rocky habitats (2)
- Epifauna can be cultured in shallow sublittoral habitats on the seabed (4). Infauna are not cultured in rocky habitats, and there are no known examples of algae which is cultured attached to the seabed (3).
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition) (wildfowl birds which are used for raw materials are not expected to be associated with rocky habitats) (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats such as on intertidal beaches, hence 'o' is given as it is not harvested from this habitat (5)
- Macroalgae can be used to produce substances such as agar or as a source of iodine, and can be also used as fertiliser for agriculture (5, 6). Dead seagrass litter is washed up in littoral habitats and is collected to be used as building insulation (no current agricultural use is known for seagrass). The living seagrass in these habitats supplies or contributes to the supply of this material, thus an 'o' link is given here to reflect the role this habitat plays in supporting this service.

Regulation and Maintenance Services

- Waste and toxicant treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside macroalgae, macrophytes and micro-phytobenthos, which break down waste materials via phytodegradation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material, which is subtidal and may wash up onshore, or by reducing visual impacts to users of this habitat such as scuba divers (12), which can be a final human use as per Section 4
- Stabilisation of sediments, accumulation of sediment and attenuation of wave energy can be contributed to by reef forming species of epifauna, e.g. mussel beds, and tube forming species of infauna (e.g. *Sabellaria* sp.), as well as by macrophytes macroalgae and microphytobenthos, all of which contribute to erosion prevention and sediment retention (13)
- Attenuation of wave energy is contributed to by reef forming species of epifauna, e.g. mussel beds, and tube forming species of infauna (e.g. *Sabellaria* sp.), as well as by macro-phytes and macroalgae, all of which contribute to flood prevention (14).
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets. Birds, fish (associated with benthic habitats) and reptiles (green turtles) can also contribute to seed dispersal of seagrass seeds (16)
- Epifauna and infauna (biogenic reefs), macroalgae, e.g. kelp forests, and macrophytes (any plant providing shelter) can provide important nursery habitats for invertebrates and small fish. Reptiles (Green Turtles) also contribute to habitat maintenance, of seagrass meadows, through their foraging activities. Epifauna, infauna, fish, cephalopods and micro-phytobenthos have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shallow sublittoral rock and biogenic reef* habitats are important for cultural services especially for *recreation and leisure*; all biotic groups contribute to this service in these habitats (e.g. coasteering, wildlife watching, snorkelling, etc. which can be underpinned to any degree by the biota linked to cultural services), except microphytobenthos and bacteria, which are not considered to supply the recreation and leisure service in benthic habitats (24)

Table AI.8 Ecosystem services that can be supplied in the *shallow sublittoral rock and biogenic reef* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shallow Sublittoral Rock and Biogenic Reef											
	Birds	Whales (dead)	Seals (haul outs)	Reptiles (nesting)	Fish	Cephalo-pods	Epifauna	Infauna	Macrophytes	Macroalgae	Micro-phytobenthos	Bacteria
1. Seafood from Wild Plants and Algae										X		
2. Seafood from Wild Animals	o		o		X	X	X					
4. Animal Seafood from In-situ aquaculture							X					
5. Raw Materials		o	o		X	X	X	X	o	X		
6. Agricultural Materials					X	X	X	X		X		
7. Genetic Materials					X	X	X	X	X	X	X	X
10. Waste Treatment via Biota							X	X	X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X				X
13. Erosion Prevention and Sediment Retention							X	X	X	X	X	
14. Flood Protection							X	X	X	X		
15. Oxygen Production									X	X	X	
16. Seed and Gamete Dispersal	X			X	X							
17. Maintaining Nursery Populations and Habitats				X	X	X	X	X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	X	X		
25. Scientific	X	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	X	X		
28. Entertainment	X	X	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	X	X		
32. Existence	X	X	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 3 (Plant and Algal Seafood from In-situ aquaculture); 8, 9 (Biofuels).

Benthic: Shallow sublittoral coarse sediment

Shallow sublittoral coarse sediment habitats are the coarse sedimentary habitats in the shallow, photic sublittoral zone. They can be found in the seabed of certain land-sea interface features (such as estuaries, and fjords, sea lochs and other inlets), including in the nearshore, open coastal waters (up to 1nm from the territorial baseline). In addition, they occur outside these features as the seabed of fully open coastal waters. These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be photic (i.e. allowing the growth of photosynthetic organisms). Corresponding pelagic habitats are the variable salinity water and coastal water habitat types.

These benthic habitats have the capacity to supply (or contribute to) a total of 30 ecosystem services through 12 biotic groups, amongst these 6 are provisioning, 14 are regulation and maintenance services and 10 are cultural (Table AI.9). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Macroalgae, such as Dulse, contributes to seafood and can be harvested from sublittoral coarse sediment habitats (Service 1 – herein, only number of service will be given). The species of macrophytes (seagrasses) which occur in shallow sublittoral habitats are not known to be a source of seafood in an EU context.
- Fish, cephalopods, epifauna (e.g. lobster and mussels) and infauna (e.g. cockles) are harvested from coarse sediment sublittoral habitats for seafood, this may include artisanal harvesting of seafood (2)
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested, e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond), or from estuaries and saltmarshes (in the case of wildfowling). However, due to their high mobility, all these organisms may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as a ‘o’ as opposed to a cross) (2)
- Epifauna e.g. scallops, and infauna e.g. cockles, can be cultured in shallow sublittoral habitats on the seabed (4). There are no known examples of algae which is cultured attached to the seabed (3).
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition); birds (wildfowl) feathers could be used for fly fishing lures or in taxidermy (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence ‘o’ is given as it is not directly harvested from this habitat (5)
- Macroalgae can be used to produce substances such as agar or as a source of iodine, and can be also used as fertiliser for agriculture (5, 6). Dead seagrass litter (macrophytes) is washed up in littoral habitats and is collected to be used as building insulation (no current agricultural use is known for seagrass). The living seagrass in these habitats supplies or contributes to the supply of this material, thus an ‘o’ link is given here to reflect the role this habitat plays in supporting this service.

Regulation and Maintenance Services

- Waste and toxicant treatment can occur through bacteria which break down waste (e.g. organic material) via bioremediation alongside macroalgae, macrophytes and microphyto-benthos which break down waste materials via phytodegradation and epifauna and infauna which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore, or by reducing visual impacts to users of this habitat such as scuba divers. (12)
- Stabilisation of sediments, accumulation of sediment and attenuation of wave energy can be contributed to by macrophytes, macroalgae, microphytobenthos and (tube-forming) infauna all of which contribute to erosion prevention and sediment retention. Epifauna are not considered to contribute here as their contribution comes under the 'rock and biogenic reef' and 'shallow sublittoral mud' habitats. (13)
- Attenuation of wave energy is contributed to by macrophytes and macroalgae all of which contribute to flood prevention. Reef forming species (infauna and epifauna) are not considered to contribute here as these come under the 'rock and biogenic reef' habitats. (14).
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets. Birds, fish (associated with benthic habitats) and reptiles (green turtles) can also contribute to seed dispersal of seagrass seeds (16)
- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats and macroalgae e.g. kelp forests and macrophytes (seagrass) can provide important nursery habitats for invertebrates and small fish. Reptiles (Green Turtles) also contribute to habitat maintenance, of seagrass meadows, through their foraging activities. Epifauna, infauna, fish, cephalopods and microphytobenthos have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shallow sublittoral coarse sediment* habitats are important for cultural services especially for recreation and leisure; all biotic groups contribute to this service in these habitats (e.g. scuba-diving, wildlife watching, snorkelling, etc. which can be underpinned to any degree by the biota linked to cultural services) except microphytobenthos and bacteria which are not considered to contribute to opportunities for recreation and leisure in benthic habitats (24).

Table AI.9 Ecosystem services that can be supplied in the *shallow sublittoral coarse sediment* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shallow Sublittoral Coarse Sediment											
	Birds	Whales (dead)	Seals (haul outs)	Reptiles (nesting)	Fish	Cephalo-pods	Epifauna	Infauna	Macrophytes	Macroalgae	Micro-phytobenthos	Bacteria
1. Seafood from Wild Plants and Algae										X		
2. Seafood from Wild Animals	o		o		X	X	X	X				
4. Animal Seafood from In-situ aquaculture							X	X				
5. Raw Materials	o	o	o		X	X	X	X	o	X		
6. Agricultural Materials					X	X	X	X		X		
7. Genetic Materials					X	X	X	X	X	X	X	X
10. Waste Treatment via Biota							X	X	X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X				X
13. Erosion Prevention and Sediment Retention								X	X	X	X	
14. Flood Protection									X	X		
15. Oxygen Production									X	X	X	
16. Seed and Gamete Dispersal	X			X	X							
17. Maintaining Nursery Populations and Habitats				X	X	X	X	X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	X	X		
25. Scientific	X	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	X	X		
28. Entertainment	X	X	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	X	X		
32. Existence	X	X	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 3 (Plant and Algal Seafood from In-situ aquaculture); 8, 9 (Biofuels).

Benthic: Shallow sublittoral sand

Shallow sublittoral sand habitats are the sandy habitats in the shallow, photic sublittoral zone. They can be found in the seabed of certain land-sea interface features (such as estuaries), including in the nearshore, open coastal waters (up to 1nm from the territorial baseline). In addition, they occur outside these features as the seabed of fully open coastal waters. These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be photic (i.e. allowing the growth of photosynthetic organisms). Corresponding pelagic habitats are the variable salinity water and coastal water habitat types.

These benthic habitats have the capacity to supply (or contribute to) a total of 30 ecosystem services through 12 biotic groups, amongst these 6 are provisioning, 14 are regulation and maintenance services and 10 are cultural (Table AI.10). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Macroalgae, such as Dulse, contributes to seafood and can be harvested from sublittoral sand habitats (Service 1 – herein, only number of service will be given). The species of macrophytes (seagrasses) which occur in shallow sublittoral habitats are not known to be a source of seafood in the EU.
- Fish, cephalopods, epifauna (e.g. lobster) and infauna (e.g. razor clams) are harvested from sand sublittoral habitats for seafood, this may include artisanal harvesting of seafood (2)
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested, e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond), or from intertidal estuaries and saltmarshes (in the case of wildfowling). However, due to their high mobility, all these organisms may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as ‘o’ as opposed to ‘x’) (2)
- Epifauna (e.g. scallops) and infauna (e.g. cockles) can be cultured in shallow sublittoral habitats on the seabed (4). There are no known examples of algae which is cultured attached to the seabed (3).
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition); birds (wildfowl) feathers could be used for fly fishing lures or in taxidermy (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats such as on an intertidal beach, hence ‘o’ is given as it is not directly harvested from this habitat (5)
- Macroalgae can be used to produce substances such as agar or as a source of iodine, and can be also used as fertiliser for agriculture (5, 6). Dead seagrass litter (macrophytes) is washed up in littoral habitats and is collected to be used as building insulation (no current agricultural use is known for seagrass). The living seagrass in these habitats supplies or contributes to the supply of this material, thus an ‘o’ link is given here to reflect the role this habitat plays in supporting this service.

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside macroalgae, macrophytes and microphytobenthos, which break down waste materials via phytodegradation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore, or by reducing visual impacts to users of this habitat such as scuba divers. (12)
- Stabilisation of sediments, accumulation of sediment and attenuation of wave energy can be contributed to by macrophytes, macroalgae, microphytobenthos and (tube-forming) infauna all of which contribute to erosion prevention and sediment retention. Epifauna are not considered to contribute here as their contribution comes under the 'rock and biogenic reef' and 'shallow sublittoral mud' habitats. (13)
- Attenuation of wave energy is contributed to by macrophytes and macroalgae all of which contribute to flood prevention. Reef forming species (infauna and epifauna) are not considered to contribute here as these come under the 'rock and biogenic reef' habitats.   (14).
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets. Birds, fish (associated with benthic habitats) and reptiles (green turtles) can also contribute to seed dispersal of seagrass seeds (16)
- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats and macroalgae e.g. kelp forests and macrophytes (seagrass) can provide important nursery habitats for invertebrates and small fish. Reptiles (Green Turtles) also contribute to habitat maintenance, of seagrass meadows, through their foraging activities. Epifauna, infauna, fish, cephalopods and microphytobenthos have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shallow sublittoral sand* habitats are important for cultural services especially for *recreation and leisure*; all biotic groups contribute to this service in these habitats (e.g. scuba-diving, wildlife watching, snorkelling, etc. which can be underpinned to any degree by the biota linked to cultural services) except microphytobenthos and bacteria which are not considered to contribute to opportunities for recreation and leisure in benthic habitats (24).

Table AI.10 Ecosystem services that can be supplied in the *shallow sublittoral sand* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shallow Sublittoral Sand											
	Birds	Whales (dead)	Seals (haul outs)	Reptiles (nesting)	Fish	Cephalo-pods	Epifauna	Infauna	Macrophytes	Macroalgae	Micro-phytobenthos	Bacteria
1. Seafood from Wild Plants and Algae										X		
2. Seafood from Wild Animals	o		o		X	X	X	X				
4. Animal Seafood from In-situ aquaculture							X	X				
5. Raw Materials	o	o	o		X	X	X	X	o	X		
6. Agricultural Materials					X	X	X	X		X		
7. Genetic Materials					X	X	X	X	X	X	X	X
10. Waste Treatment via Biota							X	X	X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X				X
13. Erosion Prevention and Sediment Retention								X	X	X	X	
14. Flood Protection									X	X		
15. Oxygen Production									X	X	X	
16. Seed and Gamete Dispersal	X			X	X							
17. Maintaining Nursery Populations and Habitats				X	X	X	X	X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	X	X		
25. Scientific	X	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	X	X		
28. Entertainment	X	X	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	X	X		
32. Existence	X	X	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 3 (Plant and Algal Seafood from In-situ aquaculture); 8, 9 (Biofuels).

Benthic: Shallow Sublittoral Mud

Shallow sublittoral mud habitats are the muddy habitats in the shallow, photic sublittoral zone. They can be found in the seabed of certain land-sea interface features (such as estuaries), including in the nearshore, open coastal waters (up to 1nm from the territorial baseline). In addition, they occur outside these features as the seabed of fully open coastal waters. These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be photic (i.e. allowing the growth of photosynthetic organisms). Corresponding pelagic habitats are the variable salinity water and coastal water habitat types.

These benthic habitats have the capacity to supply (or contribute to) a total of 30 ecosystem services through 12 biotic groups, amongst these 6 are provisioning, 14 are regulation and maintenance services and 10 are cultural (Table AI.11). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Macroalgae, such as Dulse, contributes to seafood and can be harvested from sublittoral mud habitats (Service 1 – herein, only number of service will be given). The species of macrophytes (seagrasses) which occur in shallow sublittoral habitats are not known to be a source of seafood in the EU.
- Fish, cephalopods, epifauna (e.g. lobster) and infauna (e.g. nephrops) are harvested from mud sediment sublittoral habitats for seafood, this may include artisanal harvesting of seafood (2)
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond), from or intertidal estuaries and saltmarshes (in the case of wildfowling). However, due to their high mobility all these organisms may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as ‘o’ as opposed to ‘x’) (2)
- Epifauna (e.g. scallops) and infauna (e.g. cockles) can be cultured in shallow sublittoral habitats on the seabed (4). There are no known examples of algae which is cultured attached to the seabed (3)
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition); birds (wildfowl) feathers could be used for fly fishing lures or in taxidermy (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats such as on an intertidal beach, hence ‘o’ is given as it is not directly harvested from this habitat (5)
- Macroalgae can be used to produce substances such as agar or as a source of iodine, and can be also used as fertiliser for agriculture (5, 6). Dead seagrass litter (macrophytes) is washed up in littoral habitats and is collected to be used as building insulation (no current agricultural use is known for seagrass). The living seagrass in these habitats supplies or contributes to the supply of this material, thus an ‘o’ link is given here to reflect the role this habitat plays in supporting this service.

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside macroalgae, macrophytes and microphytobenthos, which break down waste materials via phytodegradation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore, or by reducing visual impacts to users of this habitat such as scuba divers. (12)
- Stabilisation of sediments, accumulation of sediment and attenuation of wave energy can be contributed to by macrophytes, macroalgae, microphytobenthos and (tube-forming) infauna all of which contribute to erosion prevention and sediment retention. The relative contribution of macrophytes is likely to be greater than that of macroalgae in mud habitats since macroalgae need hard substrate to attach to and these may be sparse in mud habitats. Although the main contribution from epifauna comes in 'rock and biogenic reef habitats', they are considered to contribute to this service in mud habitats (due to the specific species present in shallow sublittoral mud habitats). (13)
- Attenuation of wave energy is contributed to by macrophytes and macroalgae all of which contribute to flood prevention. Reef forming species (infauna and epifauna) are not considered to contribute here as these come under the 'rock and biogenic reef' habitats. (14).
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets. Birds, fish (associated with benthic habitats) and reptiles (green turtles) can also contribute to seed dispersal of seagrass seeds (16)
- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats and macroalgae e.g. kelp forests and macrophytes (seagrass) can provide important nursery habitats for invertebrates and small fish. Reptiles (Green Turtles) also contribute to habitat maintenance, of seagrass meadows, through their foraging activities. Epifauna, infauna, fish, cephalopods and microphytobenthos have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shallow sublittoral mud* habitats are important for cultural services especially for *recreation and leisure*; all biotic groups contribute to this service in these habitats (e.g. scuba-diving, wildlife watching, snorkelling, etc. which can be underpinned to any degree by the biota linked to cultural services) except microphytobenthos and bacteria which are not considered to contribute to opportunities for recreation and leisure in benthic habitats (24).

Table AI.11 Ecosystem services that can be supplied in the *shallow sublittoral mud* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shallow Sublittoral Mud											
	Birds	Whales (dead)	Seals (haul outs)	Reptiles (nesting)	Fish	Cephalo-pods	Epifauna	Infauna	Macrophytes	Macroalgae	Micro-phytobenthos	Bacteria
1. Seafood from Wild Plants and Algae										X		
2. Seafood from Wild Animals	o		o		X	X	X	X				
4. Animal Seafood from In-situ aquaculture							X	X				
5. Raw Materials	o	o	o		X	X	X	X	o	X		
6. Agricultural Materials					X	X	X	X		X		
7. Genetic Materials					X	X	X	X	X	X	X	X
10. Waste Treatment via Biota							X	X	X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X				X
13. Erosion Prevention and Sediment Retention							X	X	X	X	X	
14. Flood Protection									X	X		
15. Oxygen Production									X	X	X	
16. Seed and Gamete Dispersal	X			X	X							
17. Maintaining Nursery Populations and Habitats				X	X	X	X	X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	X	X		
25. Scientific	X	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	X	X		
28. Entertainment	X	X	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	X	X		
32. Existence	X	X	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 3 (Plant and Algal Seafood from In-situ aquaculture); 8, 9 (Biofuels).

Benthic: Shallow Sublittoral Mixed Sediment

Shallow sublittoral mixed sediment habitats are the mixed sedimentary habitats in the shallow, photic sublittoral zone. They can be found in the seabed of certain land-sea interface features (such as estuaries), including in the nearshore, open coastal waters (up to 1 nm from the territorial baseline). In addition, they occur outside these features as the seabed of fully open coastal waters. These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be photic (i.e. allowing the growth of photosynthetic organisms). Corresponding pelagic habitats are the variable salinity water and coastal water habitat types.

These benthic habitats have the capacity to supply (or contribute to) a total of 30 ecosystem services through 12 biotic groups, amongst these 6 are provisioning, 14 are regulation and maintenance services and 10 are cultural (Table AI.12). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Macroalgae, such as Dulse, contributes to seafood and can be harvested from sublittoral mixed sediment habitats (Service 1 – herein, only number of service will be given). The species of macrophytes (seagrasses) which occur in shallow sublittoral habitats are not known to be a source of seafood in the EU.
- Fish, cephalopods, epifauna (e.g. lobster) and infauna (e.g. nephrops) are harvested from mixed sediment sublittoral habitats for seafood, this may include artisanal harvesting of seafood (2)
- Seals are sometimes harvested on a very small scale under authorised culls. Birds can also be harvested e.g. the Guga hunt in the Outer Hebrides for gannets or through wildfowling. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond), or from intertidal estuaries and saltmarshes (in the case of wildfowling). However, due to their high mobility all these organisms may feed in the habitat here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as ‘o’ as opposed to ‘x’) (2)
- Epifauna (e.g. scallops) and infauna (e.g. cockles) can be cultured in shallow sublittoral habitats on the seabed (4). There are no known examples of algae which is cultured attached to the seabed (3)
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition); birds (wildfowl) feathers could be used for fly fishing lures or in taxidermy (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats such as on an intertidal beach, hence ‘o’ is given as it is not directly harvested from this habitat (5)
- Macroalgae can be used to produce substances such as agar or as a source of iodine, and can be also used as fertiliser for agriculture (5, 6). Dead seagrass litter (macrophytes) is washed up in littoral habitats and is collected to be used as building insulation (no current agricultural use is known for seagrass). The living seagrass in these habitats supplies or contributes to the supply of this material, thus an ‘o’ link is given here to reflect the role this habitat plays in supporting this service.

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, alongside macroalgae, macrophytes and microphytobenthos, which break down waste materials via phytodegradation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore, or by reducing visual impacts to users of this habitat such as scuba divers. (12)
- Stabilisation of sediments, accumulation of sediment and attenuation of wave energy can be contributed to by macrophytes, macroalgae, microphytobenthos and (tube-forming) infauna all of which contribute to erosion prevention and sediment retention. Epifauna) are not considered to contribute here as their contribution comes under the 'rock and biogenic reef' and 'shallow sublittoral mud' habitats. (13)
- Attenuation of wave energy is contributed to by macrophytes and macroalgae all of which contribute to flood prevention. Reef forming species (infauna and epifauna) are not considered to contribute here as these come under the 'rock and biogenic reef' habitats. (14).
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets. Birds, fish (associated with benthic habitats) and reptiles (green turtles) can also contribute to seed dispersal of seagrass seeds (16)
- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats and macroalgae e.g. kelp forests and macrophytes can provide important nursery habitats for invertebrates and small fish. Reptiles (Green Turtles) also contribute to habitat maintenance, of seagrass meadows, through their foraging activities. Epifauna, infauna, fish, cephalopods and microphytobenthos have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shallow sublittoral mixed sediment* habitats are important for cultural services especially for *recreation and leisure*; all biotic groups contribute to this service in these habitats (e.g. scuba-diving, wildlife watching, snorkelling, etc. which can be underpinned to any degree by the biota linked to cultural services) except microphytobenthos and bacteria which are not considered to contribute to opportunities for recreation and leisure in benthic habitats (24)

Table AI.12 Ecosystem services that can be supplied in the *shallow sublittoral mixed sediment* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shallow Sublittoral Mixed Sediment											
	Birds	Whales (dead)	Seals (haul outs)	Reptiles (nesting)	Fish	Cephalo-pods	Epifauna	Infauna	Macrophytes	Macroalgae	Micro-phytobenthos	Bacteria
1. Seafood from Wild Plants and Algae										X		
2. Seafood from Wild Animals	o		o		X	X	X	X				
4. Animal Seafood from In-situ aquaculture							X	X				
5. Raw Materials	o	o	o		X	X	X	X	o	X		
6. Agricultural Materials					X	X	X	X		X		
7. Genetic Materials					X	X	X	X	X	X	X	X
10. Waste Treatment via Biota							X	X	X	X	X	X
11. Waste and Toxicant Removal and Storage	X	X	X	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X				X
13. Erosion Prevention and Sediment Retention								X	X	X	X	
14. Flood Protection									X	X		
15. Oxygen Production									X	X	X	
16. Seed and Gamete Dispersal	X			X	X							
17. Maintaining Nursery Populations and Habitats				X	X	X	X	X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	X	X		
25. Scientific	X	X	X	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	X	X		
28. Entertainment	X	X	X	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	X	X		
32. Existence	X	X	X	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X	X	X	X

*Services not shown include: 3 (Plant and Algal Seafood from In-situ aquaculture); 8, 9 (Biofuels).

Benthic: Shelf Sublittoral Rock and Biogenic Reef

Shelf sublittoral rock and biogenic reef habitats in the shelf, which can extend to depths of 200m (before the slope begins). These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be aphotic (i.e. cannot support photosynthetic organisms). In some regions, however, the shelf may be close to the shore. The corresponding pelagic habitat is the shelf water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 25 ecosystem services through 9 biotic groups, amongst these 4 are provisioning, 11 are regulation and maintenance services and 10 are cultural (Table AI.13). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods and epifauna (e.g. lobster) are harvested from rocky sublittoral habitats for seafood (2)
- Seabirds and seals are sometimes harvested on a very small scale under authorised culls e.g. the Guga hunt in the Outer Hebrides for gannets. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond). However, due to their high mobility, all these organisms may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as ‘o’ as opposed to ‘x’). Wildfowl are not expected to be associated with shelf habitats (2)
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition); Wildfowl are not expected to be associated with shelf habitats (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence ‘o’ is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore (12)
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets, although not directly supplied in shelf habitats. However, birds found feeding in the shelf may be from a connected populations found in other benthic and pelagic habitats to those directly supplying this service in the relevant habitats, hence ‘o’ link given. Turtles which are associated with seagrass seed dispersal, i.e. Green Sea Turtles, which are herbivorous, are not expected to be associated with shelf benthic habitats as they do not require these habitats for feeding. Therefore, there is no link for reptiles and seed and gamete dispersal in this habitat. The birds and fish associated with seagrass seed dispersal are also not expected to be associated with shelf habitats and no link is given here (16)

- Epifauna and infauna (biogenic reefs) can provide important nursery habitats for invertebrates and small fish. Green turtles associated with seagrass bed maintenance are not expected to be associated with shelf benthic habitats. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shelf sublittoral rock and biogenic reef* habitats can contribute to the supply of cultural services especially *recreation and leisure* although these habitats are likely to be less important than shallower habitats and/or habitats close to the shore (where shelf habitats are located further away). All biotic groups except bacteria contribute to this service in these habitats (e.g. wildlife watching, deep sea fishing, etc. which can be underpinned to any degree by the biota linked to cultural services).

Table AI.13 Ecosystem services that can be supplied in the *shelf sublittoral rock and biogenic reef* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shelf Sublittoral Rock and Biogenic Reef								
	Birds (feeding)	Whales (feeding)	Seals (feeding)	Reptiles (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bac-teria
2. Seafood from Wild Animals	o		o		X	X	X	X	
5. Raw Materials		o	o		X	X	X	X	
6. Materials for agriculture and aquaculture					X	X	X	X	
7. Genetic Materials					X	X	X	X	X
10. Waste and Toxicant Treatment via Biota							X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X	X
16. Seed and Gamete Dispersal	o								
17. Maintaining Nursery Populations and Habitats					X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	
25. Scientific	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	
28. Entertainment	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	
32. Existence	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production).

Benthic: Shelf Sublittoral Coarse Sediment

Shelf sublittoral coarse sediment habitats in the shelf, which can extend to depths of 200 m (before the slope begins). These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be aphotic (i.e. cannot support photosynthetic organisms). In some regions, however, the shelf may be close to the shore. The corresponding pelagic habitat is the shelf water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 25 ecosystem services through 9 biotic groups, amongst these 4 are provisioning, 11 are regulation and maintenance services and 10 are cultural (Table AI.14). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods, epifauna and infauna are harvested from coarse sediment sublittoral habitats for seafood (2)
- Seabirds (e.g. gannets) and seals are sometimes harvested on a very small scale under authorised culls e.g. the Guga hunt in the Outer Hebrides for gannets. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond). However, due to their high mobility, all these organisms may feed in these habitats but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x'). Wildfowl are not expected to be associated with shelf habitats (2)
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition); Wildfowl are not expected to be associated with shelf habitats (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore (12)
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets, although not directly supplied in shelf habitats. However, birds found feeding in the shelf may be from a connected populations found in other benthic and pelagic habitats to those directly supplying this service in the relevant habitats, hence 'o' link given. Turtles which are associated with seagrass seed dispersal, i.e. Green Sea Turtles, which are herbivorous, are not expected to be associated with shelf benthic habitats as they do not require these habitats for feeding. Therefore, there is no link for reptiles and seed and gamete dispersal in this habitat.

The birds and fish associated with seagrass seed dispersal are also not expected to be associated with shelf habitats and no link is given here (16)

- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats can provide important nursery habitats for invertebrates and small fish. Green turtles associated with seagrass bed maintenance are not expected to be associated with shelf benthic habitats. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shelf sublittoral coarse sediment* habitats can contribute to the supply of cultural services especially *recreation and leisure* although these habitats are likely to be less important than shallower habitats and/or habitats close to the shore (where shelf habitats are located further away). All biotic groups except bacteria contribute to this service in these habitats (e.g. wildlife watching, deep sea fishing, etc. which can be underpinned to any degree by the biota linked to cultural services).

Table AI.14 Ecosystem services that can be supplied in the *shelf coarse sediment* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shelf Coarse Sediment								
	Birds (feeding)	Whales (feeding)	Seals (feeding)	Reptiles (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bac-teria
2. Seafood from Wild Animals	o		o		X	X	X	X	
5. Raw Materials		o	o		X	X	X	X	
6. Materials for agriculture and aquaculture					X	X	X	X	
7. Genetic Materials					X	X	X	X	X
10. Waste and Toxicant Treatment via Biota							X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X	X
16. Seed and Gamete Dispersal	o								
17. Maintaining Nursery Populations and Habitats					X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	
25. Scientific	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	
28. Entertainment	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	
32. Existence	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production).

Benthic: Shelf Sublittoral Sand

Shelf sublittoral sand habitats are the sandy habitats in the shelf, which can extend to depths of 200m (before the slope begins). These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be aphotic (i.e. cannot support photosynthetic organisms). In some regions, however, the shelf may be close to the shore. The corresponding pelagic habitat is the shelf water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 25 ecosystem services through 9 biotic groups, amongst these 4 are provisioning, 11 are regulation and maintenance services and 10 are cultural (Table AI.15). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods and epifauna and infauna are harvested from sand shelf sublittoral habitats for seafood (2)
- Seabirds and seals are sometimes harvested on a very small scale under authorised culls e.g. the Guga hunt in the Outer Hebrides for gannets. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond). However, due to their high mobility, all these organisms may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x') (2)
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition) (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore (12)
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets, although not directly supplied in shelf habitats. However, birds found feeding in the shelf may be from a connected populations found in other benthic and pelagic habitats to those directly supplying this service in the relevant habitats, hence 'o' link given. Turtles which are associated with seagrass seed dispersal, i.e. Green Sea Turtles, which are herbivorous, are not expected to be associated with shelf benthic habitats as they do not require these habitats for feeding. Therefore, there is no link for reptiles and seed and gamete dispersal in this habitat. The birds and fish associated with seagrass seed dispersal are also not expected to be associated with shelf habitats and no link is given here (16)

- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats can provide important nursery habitats for invertebrates and small fish. Green turtles associated with seagrass bed maintenance are not expected to be associated with shelf benthic habitats. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shelf sublittoral sand* habitats can contribute to the supply of cultural services especially *recreation and leisure* although these habitats are likely to be less important than shallower habitats and/or habitats close to the shore (where shelf habitats are located further away). All biotic groups except bacteria contribute to this service in these habitats (e.g. wildlife watching, deep sea fishing, etc. which can be underpinned to any degree by the biota linked to cultural services).

Table AI.15 Ecosystem services that can be supplied in the *shelf sublittoral sand* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shelf Sublittoral Sand								
	Birds (feeding)	Whales (feeding)	Seals (feeding)	Reptiles (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bac-teria
2. Seafood from Wild Animals	o		o		X	X	X	X	
5. Raw Materials		o	o		X	X	X	X	
6. Materials for agriculture and aquaculture					X	X	X	X	
7. Genetic Materials					X	X	X	X	X
10. Waste and Toxicant Treatment via Biota							X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X	X
16. Seed and Gamete Dispersal	o								
17. Maintaining Nursery Populations and Habitats					X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	
25. Scientific	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	
28. Entertainment	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	
32. Existence	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production).

Benthic: Shelf Sublittoral Mud

Shelf sublittoral mud habitats are the muddy habitats in the shelf, which can extend to depths of 200m (before the slope begins). These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be aphotic (i.e. cannot support photosynthetic organisms). In some regions, however, the shelf may be close to the shore. The corresponding pelagic habitat is the shelf water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 25 ecosystem services through 9 biotic groups, amongst these 4 are provisioning, 11 are regulation and maintenance services and 10 are cultural (Table AI.16). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods and epifauna and infauna are harvested from mud shelf sublittoral habitats for seafood (2)
- Seabirds and seals are sometimes harvested on a very small scale under authorised culls and exceptions to legislation e.g. the Guga hunt in the Outer Hebrides for gannets. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond). However, due to their high mobility, all these organisms may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x') (2)
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition) (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore (12)
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets, although not directly supplied in shelf habitats. However, birds found feeding in the shelf may be from a connected populations found in other benthic and pelagic habitats to those directly supplying this service in the relevant habitats, hence 'o' link given. Turtles which are associated with seagrass seed dispersal, i.e. Green Sea Turtles, which are herbivorous, are not expected to be associated with shelf benthic habitats as they do not require these habitats for feeding. Therefore, there is no link for reptiles and seed and gamete dispersal in this habitat. The birds and fish associated with seagrass seed dispersal are also not expected to be associated with shelf habitats and no link is given here (16)

- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats can provide important nursery habitats for invertebrates and small fish. Green turtles associated with seagrass bed maintenance are not expected to be associated with shelf benthic habitats. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shelf sublittoral mud* habitats can contribute to the supply of cultural services especially *recreation and leisure* although these habitats are likely to be less important than shallower habitats and/or habitats close to the shore (where shelf habitats are located further away). All biotic groups except bacteria contribute to this service in these habitats (e.g. wildlife watching, deep sea fishing, etc. which can be underpinned to any degree by the biota linked to cultural services).

Table AI.16 Ecosystem services that can be supplied in the *shelf sublittoral mud* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shelf Sublittoral Mud								
	Birds (feeding)	Whales (feeding)	Seals (feeding)	Reptiles (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bac-teria
2. Seafood from Wild Animals	o		o		X	X	X	X	
5. Raw Materials		o	o		X	X	X	X	
6. Materials for agriculture and aquaculture					X	X	X	X	
7. Genetic Materials					X	X	X	X	X
10. Waste and Toxicant Treatment via Biota							X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X	X	X	X
12. Mediation of smell/ visual impacts	X						X	X	X
16. Seed and Gamete Dispersal	o								
17. Maintaining Nursery Populations and Habitats					X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X	X
24. Recreation and Leisure	X	X	X	X	X	X	X	X	
25. Scientific	X	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X	X
27. Heritage	X	X	X	X	X	X	X	X	
28. Entertainment	X	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X	X
30. Symbolic	X	X	X	X	X	X	X		
31. Sacred and/or Religious	X	X	X	X	X	X	X	X	
32. Existence	X	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production).

Benthic: Shelf Sublittoral Mixed Sediment

Shelf sublittoral mixed sediment habitats are the mixed sedimentary habitats in the shelf, which can extend to depths of 200m (before the slope begins). These habitats encompass benthic biotic groups (within their surrounding seabed), and are considered to be aphotic (i.e. cannot support photosynthetic organisms). In some regions, however, the shelf may be close to the shore. The corresponding pelagic habitat is the shelf water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 25 ecosystem services through 9 biotic groups, amongst these 4 are provisioning, 11 are regulation and maintenance services and 10 are cultural (Table AI.17). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish, cephalopods, epifauna and infauna are harvested from mixed sediment shelf sublittoral habitats for seafood (2)
- Seabirds and seals are sometimes harvested on a very small scale under authorised culls e.g. the Guga hunt in the Outer Hebrides for gannets. Seals are culled from the water column or land, and unlikely to be taken from benthic habitats. Birds are hunted from the nest (in the case of gannets, which could be in littoral habitats, e.g. the splash zone on cliffs, or beyond). However, due to their high mobility, all these organisms may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x's) (2)
- Fish, cephalopods, epifauna and infauna can be used for oils, ornamental resources and other raw materials, as well as for fishmeal in aquaculture and/or agriculture (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition) (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)
- All scavengers and detritivores including birds, epifauna, infauna and bacterial communities contribute to this service by removing rotting material which is subtidal and may wash up onshore (12)
- Birds can carry gametes as droplets of water stuck to their feathers. This type of transport is important for isolated populations of relevant species found in features such as some coastal lagoons and inlets, although not directly supplied in shelf habitats. However, birds found feeding in the shelf may be from a connected populations found in other benthic and pelagic habitats to those directly supplying this service in the relevant habitats, hence 'o' link given. Turtles which are associated with seagrass seed dispersal, i.e. Green Sea Turtles, which are herbivorous, are not expected to be associated with shelf benthic habitats as they do not require these habitats for feeding. Therefore, there is no link for reptiles and seed and gamete dispersal in this habitat. The birds and fish associated with seagrass seed dispersal are also not expected to be associated with shelf habitats and no link is given here (16)

- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats can provide important nursery habitats for invertebrates and small fish. Green turtles associated with seagrass bed maintenance are not expected to be associated with shelf benthic habitats. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile commercial and migratory species (17)

Cultural

- *Shelf sublittoral mixed* sediment habitats can contribute to the supply of cultural services especially *recreation and leisure* although these habitats are likely to be less important than shallower habitats and/or habitats close to the shore (where shelf habitats are located further away). All biotic groups except bacteria contribute to this service in these habitats (e.g. wildlife watching, deep sea fishing, etc. which can be underpinned to any degree by the biota linked to cultural services).

Table AI.17 Ecosystem services that can be supplied in the *shelf sublittoral mixed sediment* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Shelf Sublittoral Mixed Sediment								
	Birds (feeding)	Whales (feeding)	Seals (feeding)	Reptiles (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bac-teria
2. Seafood from Wild Animals	o		o		x	x	x	x	
5. Raw Materials		o	o		x	x	x	x	
6. Materials for agriculture and aquaculture					x	x	x	x	
7. Genetic Materials					x	x	x	x	x
10. Waste and Toxicant Treatment via Biota							x	x	x
11. Waste and Toxicant removal and storage	x	x	x	x	x	x	x	x	x
12. Mediation of smell/ visual impacts	x						x	x	x
16. Seed and Gamete Dispersal	o								
17. Maintaining Nursery Populations and Habitats					x	x	x	x	
18. Gene Pool Protection	x	x	x	x	x	x	x	x	x
19. Pest Control	x	x	x	x	x	x	x	x	x
20. Disease Control	x	x	x	x	x	x	x	x	x
21. Sediment nutrient cycling	x	x	x	x	x	x	x	x	x
22. Chemical Condition of Seawater	x	x	x	x	x	x	x	x	x
23. Global Climate Regulation	x	x	x	x	x	x	x	x	x
24. Recreation and Leisure	x	x	x	x	x	x	x	x	
25. Scientific	x	x	x	x	x	x	x	x	x
26. Educational	x	x	x	x	x	x	x	x	x
27. Heritage	x	x	x	x	x	x	x	x	
28. Entertainment	x	x	x	x	x	x	x	x	x
29. Aesthetic	x	x	x	x	x	x	x	x	x
30. Symbolic	x	x	x	x	x	x	x		
31. Sacred and/or Religious	x	x	x	x	x	x	x	x	
32. Existence	x	x	x	x	x	x	x	x	x
33. Bequest	x	x	x	x	x	x	x	x	x

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production).

Benthic: Upper Bathyal Rock and Biogenic Reef

Upper bathyal rock and biogenic reef habitats are the rocky and biogenic reef habitats along the slope, which can extend from depths of 200 m to 1450 m. These habitats encompass benthic biotic groups (within their surrounding seabed), and are aphotic (i.e. cannot support photosynthetic organisms). The corresponding pelagic habitat is the oceanic water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 23 ecosystem services through 8 biotic groups, amongst these 4 are provisioning, 9 are regulation and maintenance services and 10 are cultural (Table AI.18). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish are harvested from deep habitats for seafood (with suggestions of deep sea fishing in Europe at depths up to 2000 m) (2). Epifauna e.g. Deep-water red crab, can be harvested for seafood from this habitat. Fishing practices do not exploit cephalopods and infauna for food beyond the shelf (cephalopods are fished up to depths of around 400 m (Pierce et al. 2010)). EU regulations are in place to limit deep sea fishing below 800 m in the North East Atlantic or 1000 m in the Mediterranean. Links are included here to recognise the remaining possibility of deep sea commercial fishing under certain limiting conditions but it should be noted that regulations will affect the magnitude of the capacity for the supply of this service in deep-sea habitats (see Section 4 for more details).
- Seals are sometimes harvested on a very small scale under authorised culls. Seals are culled from the water column or land, but not from these benthic habitats. However, due to their high mobility, seals may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x's) (2). Fish, cephalopods, epifauna and infauna can be used for oils and other raw materials, as well as for fishmeal in aquaculture and/or agriculture. Even if species from these biotic groups are not targeted by commercial fisheries, any caught as bycatch could potentially be used as materials (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition) (5)
  - Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)
- *Mediation of smell and visual impacts* and seed and gamete dispersal were not considered to be relevant beyond the shelf (12, 16)
- Epifauna and infauna (biogenic reefs and deep water corals) can provide important nursery habitats for invertebrates and small fish. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile species. As with shelf habitats above, turtles which are associated with seagrass bed maintenance, i.e. Green Sea Turtles, which are herbivorous, are not expected to be associated with these benthic habitats as they do not require them for feeding. Therefore, there is no link for reptiles and habitat maintenance in this habitat (17)

Cultural

- *Recreation and leisure* is not considered to be supplied in upper bathyal rock and biogenic reef habitats as they are too deep and inaccessible for people. However, they support species of characteristic megafauna (reptiles, whales and seals), thus 'o' is given for these biotic groups in this habitat (24)
- *Heritage* and *symbolic* services are not considered to be supplied in *upper bathyal rock and biogenic reef* habitats as they are too deep and inaccessible for people, but they support species of characteristic megafauna (reptiles, whales and seals), thus 'o' is given for these biotic groups in this habitat (27, 30)
- For *sacred and/or religious* services, in other habitats links have been given to represent biotic groups important for fishers and scuba divers. There is a direct link for fish and epifauna as fishermen can exploit these habitats (though see above note on limits to deep sea fishing). Divers do not use these habitats but there are some biotic groups that could move between these habitats and the habitats divers do use. These are reptiles, whales and seals and are given 'o' links. Other biotic groups not already included in the links which are important for divers (cephalopods and infauna) are not expected to move between these habitats and habitats visited by divers and are not included (31)

Table AI.18 Ecosystem services that can be supplied in the *upper bathyal rock and biogenic reef* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Upper Bathyal Rock and Biogenic Reef							
	Whales (feeding)	Seals (feeding)	Reptiles (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bac-teria
2. Seafood from Wild Animals		o		X		X		
5. Raw Materials	o	o		X	X	X	X	
6. Materials for agriculture and aquaculture				X				
7. Genetic Materials				X	X	X	X	X
10. Waste and Toxicant Treatment via Biota						X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X	X	X
17. Maintaining Nursery Populations and Habitats				X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X	X	X
24. Recreation and Leisure	o	o	o					
25. Scientific	X	X	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X	X	X
27. Heritage	o	o	o					
28. Entertainment	X	X	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X	X	X
30. Symbolic	o	o	o					
31. Sacred and/or Religious	o	o	o	X		X		
32. Existence	X	X	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 12 (Mediation smell/visual impacts); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production); 16 (Seed and Gamete Dispersal).

Benthic: Upper Bathyal Sediment

Upper bathyal sediment habitats are the sedimentary habitats along the slope, which can extend from depths of 200m to 1450m. These habitats encompass benthic biotic groups (within their surrounding seabed), and are aphotic (i.e. cannot support photosynthetic organisms). The corresponding pelagic habitat is the oceanic water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 23 ecosystem services through 8 biotic groups, amongst these 4 are provisioning, 9 are regulation and maintenance services and 10 are cultural (Table AI.19). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish are harvested from deep habitats for seafood (with suggestions of deep sea fishing in Europe at depths up to 2000 m) (2). Epifauna e.g. Deep-water red crab, can be harvested for seafood from this habitat. Fishing practices do not exploit cephalopods and infauna for food beyond the shelf (cephalopods are fished up to depths of around 400 m (Pierce et al. 2010)). EU regulations are in place to limit deep sea fishing below 800 m in the North East Atlantic or 1000 m in the Mediterranean. Links are included here to recognise the remaining possibility of deep sea commercial fishing under certain limiting conditions but it should be noted that regulations will affect the magnitude of the capacity for the supply of this service in deep-sea habitats (see Section 4 for more details).
- Seals are sometimes harvested on a very small scale under authorised culls. Seals are culled from the water column or land, but not from these benthic habitats. However, due to their high mobility, seals may feed in these habitats here but are likely to be from a connected populations found in other benthic and pelagic habitats (hence link given as 'o' as opposed to 'x's) (2). Fish, cephalopods, epifauna and infauna can be used for oils and other raw materials, as well as for fishmeal in aquaculture and/or agriculture. Even if species from these biotic groups are not targeted by commercial fisheries, any caught as bycatch could potentially be used as materials (5, 6)
- Seals taken in restricted culls will also be used for fur etc. (as well as for nutrition) (5)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)
- *Mediation of smell and visual impacts* and *seed and gamete dispersal* were not considered to be relevant beyond the shelf (12, 16).
- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats providing important nursery habitats for invertebrates and small fish. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile species. As with shelf habitats above, turtles which are associated with seagrass bed maintenance, i.e. Green Sea Turtles, which are herbivorous, are not expected to be associated with these benthic habitats as they do not require them for feeding. Therefore, there is no link for reptiles and habitat maintenance in this habitat (17)

Cultural

- *Recreation and leisure* is not considered to be supplied in *upper bathyal sediment habitats* as they are too deep and inaccessible for people but they support species of characteristic megafauna (reptiles, whales and seals), thus 'o' is given for these biotic groups in this habitat (24)
- *Heritage* and *symbolic* services are not considered to be supplied in *upper bathyal sediment* habitats as they are too deep and inaccessible for people but they support species of characteristic megafauna (reptiles, whales and seals), thus 'o' is given for these biotic groups in this habitat (27, 30). For *sacred and/or religious* services, in other habitats links have been given to represent biotic groups important for fishers and scuba divers. There is a direct link for fish and epifauna as fishermen can exploit these habitats (though see above note on limits to deep sea fishing). Divers do not use these habitats but there are some biotic groups that could move between these habitats and the habitats divers do use. These are reptiles, whales and seals and are given 'o' links. Other biotic groups not already included in the links which are important for divers (cephalopods and infauna) are not expected to move between these habitats and habitats visited by divers and are not included (31).

Table AI.19 Ecosystem services that can be supplied in the *upper bathyal sediment* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Upper Bathyal Sediment							
	Whales (feeding)	Seals (feeding)	Reptiles (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bac-teria
2. Seafood from Wild Animals		o		x		x		
5. Raw Materials	o	o		x	x	x	x	
6. Materials for agriculture and aquaculture				x				
7. Genetic Materials				x	x	x	x	x
10. Waste and Toxicant Treatment via Biota						x	x	x
11. Waste and Toxicant removal and storage	x	x	x	x	x	x	x	x
17. Maintaining Nursery Populations and Habitats				x	x	x	x	
18. Gene Pool Protection	x	x	x	x	x	x	x	x
19. Pest Control	x	x	x	x	x	x	x	x
20. Disease Control	x	x	x	x	x	x	x	x
21. Sediment nutrient cycling	x	x	x	x	x	x	x	x
22. Chemical Condition of Seawater	x	x	x	x	x	x	x	x
23. Global Climate Regulation	x	x	x	x	x	x	x	x
24. Recreation and Leisure	o	o	o					
25. Scientific	x	x	x	x	x	x	x	x
26. Educational	x	x	x	x	x	x	x	x
27. Heritage	o	o	o					
28. Entertainment	x	x	x	x	x	x	x	x
29. Aesthetic	x	x	x	x	x	x	x	x
30. Symbolic	o	o	o					
31. Sacred and/or Religious	o	o	o	x		x		
32. Existence	x	x	x	x	x	x	x	x
33. Bequest	x	x	x	x	x	x	x	x

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 12 (Mediation smell/visual impacts); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production); 16 (Seed and Gamete Dispersal).

Benthic: Lower Bathyal Rock and Biogenic Reef

Lower bathyal rock and biogenic reef habitats are the rocky and biogenic reef habitats extending from depths of 1450 m to 2700 m. These habitats encompass benthic biotic groups (within their surrounding seabed), and are aphotic (i.e. cannot support photosynthetic organisms). The corresponding pelagic habitat is the oceanic water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 23 ecosystem services through 6 biotic groups, amongst these 4 are provisioning, 9 are regulation and maintenance services and 10 are cultural (Table AI.20). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish are harvested from deep habitats for seafood (with suggestions of deep sea fishing in Europe at depths up to 2000 m) (2). Epifauna e.g. Deep-water red crab, can be harvested for seafood from this habitat. Fishing practices do not exploit cephalopods and infauna for food beyond the shelf (cephalopods are fished up to depths of around 400 m (Pierce et al. 2010)). EU regulations are in place to limit deep sea fishing below 800 m in the North East Atlantic or 1000 m in the Mediterranean. Links are included here to recognise the remaining possibility of deep sea commercial fishing under certain limiting conditions but it should be noted that regulations will affect the magnitude of the capacity for the supply of this service in deep-sea habitats (see Section 4 for more details).
- Fish, cephalopods, epifauna and infauna can be used for oils and other raw materials, as well as for fishmeal in aquaculture and/or agriculture. Even if species from these biotic groups are not targeted by commercial fisheries, any caught as bycatch could potentially be used as materials (5, 6)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)
- Epifauna and infauna (biogenic reefs and deep water corals) can provide important nursery habitats for invertebrates and small fish. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile species (17)

Cultural

- *Recreation and leisure* is not considered to be supplied in *lower bathyal rock and biogenic reef* habitats as they are too deep an inaccessible for people but they support species of whales, thus a 'o' is given for this biotic group in this habitat (24)
- *Heritage* and *symbolic* services are not considered to be supplied in *lower bathyal rock and biogenic reef* habitats as they are too deep and inaccessible for people but they support species of characteristic megafauna (whales), thus 'o' is given for this biotic group in this habitat (27, 30). For *sacred and/or religious* services, in other habitats links have been given to represent biotic groups important for fishers and scuba divers. There is a direct link for fish and epifauna as fishermen can exploit these habitats (though see above note on limits to deep sea fishing).

Divers do not use these habitats but there are some biotic groups that could move between these habitats and the habitats divers do use. In this habitat, these are whales and are given 'o' links. Other biotic groups not already included in the links which are important for divers (cephalopods and infauna) are not expected to move between these habitats and habitats visited by divers and are not included (31).

Table AI.20 Ecosystem services that can be supplied in the *lower bathyal rock and biogenic reef* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Lower Bathyal Rock and Biogenic Reef					
	Whales (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bacteria
2. Seafood from Wild Animals		X		X		
5. Raw Materials	o	X	X	X	X	
6. Materials for agriculture and aquaculture		X				
7. Genetic Materials		X	X	X	X	X
10. Waste and Toxicant Treatment via Biota				X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X
17. Maintaining Nursery Populations and Habitats		X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X
24. Recreation and Leisure	o					
25. Scientific	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X
27. Heritage	o					
28. Entertainment	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X
30. Symbolic	o					
31. Sacred and/or Religious	o	X		X		
32. Existence	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 12 (Mediation smell/visual impacts); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production); 16 (Seed and Gamete Dispersal).

Benthic: Lower Bathyal Sediment

Lower bathyal sediment habitats extending from depths of 1450 m to 2700 m. These habitats encompass benthic biotic groups (within their surrounding seabed), and are aphotic (i.e. cannot support photosynthetic organisms). The corresponding pelagic habitat is the oceanic water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 23 ecosystem services through 6 biotic groups, amongst these 4 are provisioning, 9 are regulation and maintenance services and 10 are cultural (Table AI.21). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Fish are harvested from deep habitats for seafood (with suggestions of deep sea fishing in Europe at depths up to 2000 m) (2). Epifauna e.g. Deep-water red crab, can be harvested for seafood from this habitat. Fishing practices do not exploit cephalopods and infauna for food beyond the shelf (cephalopods are fished up to depths of around 400m (Pierce et al. 2010)). EU regulations are in place to limit deep sea fishing below 800m in the North East Atlantic or 1000 m in the Mediterranean. Links are included here to recognise the remaining possibility of deep sea commercial fishing under certain limiting conditions but it should be noted that regulations will affect the magnitude of the capacity for the supply of this service in deep-sea habitats (see Section 4 for more details).
- Fish, cephalopods, epifauna and infauna can be used for oils and other raw materials, as well as for fishmeal in aquaculture and/or agriculture. Even if species from these biotic groups are not targeted by commercial fisheries, any caught as bycatch could potentially be used as materials (5, 6)
- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10).
- Epifauna and infauna contribute to small scale spatial structure of soft sediment habitats providing important nursery habitats for invertebrates and small fish. Epifauna, infauna, fish and cephalopods have the potential to act as a source of prey for juvenile species. The nursery habitat service is included in this habitat as this is the deepest depth for fishing (17).

Cultural

- *Recreation and leisure* is not considered to be supplied in *lower bathyal sediment* habitats as they are too deep an inaccessible for people but they support species of whales, thus a 'o' is given for these biotic groups in this habitat (24).
- *Heritage* and *symbolic* services are not considered to be supplied in *lower bathyal sediment* habitats as they are too deep and inaccessible for people but they support species of whales, thus 'o' is given for whales in this habitat (27, 30). For *sacred and/or religious* services, in other habitats links have been given to represent biotic groups important for fishers and scuba divers. There is a direct link for fish and epifauna as fishermen can exploit these habitats (though see

above note on limits to deep sea fishing). Divers do not use these habitats but there are some biotic groups that could move between these habitats and the habitats divers do use. In this habitat, these are whales and are given 'o' links. Other biotic groups not already included in the links which are important for divers (cephalopods and infauna) are not expected to move between these habitats and habitats visited by divers and are not included (31).

Table AI.21 Ecosystem services that can be supplied in the *lower bathyal sediment* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Lower Bathyal Sediment					
	Whales (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bacteria
2. Seafood from Wild Animals		X		X		
5. Raw Materials	o	X	X	X	X	
6. Materials for agriculture and aquaculture		X				
7. Genetic Materials		X	X	X	X	X
10. Waste and Toxicant Treatment via Biota				X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X
17. Maintaining Nursery Populations and Habitats		X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X
24. Recreation and Leisure	o					
25. Scientific	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X
27. Heritage	o					
28. Entertainment	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X
30. Symbolic	o					
31. Sacred and/or Religious	o	X		X		
32. Existence	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 8, 9 (Biofuels); 12 (Mediation smell/visual impacts); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production); 16 (Seed and Gamete Dispersal).

Benthic: Abyssal Rock and biogenic reef

Abyssal rock and biogenic reef habitats are the rocky and biogenic reef habitats extending from depths of greater than 2700 m. These habitats encompass benthic biotic groups (within their surrounding seabed), and are aphotic (i.e. cannot support photosynthetic organisms). The corresponding pelagic habitat is the oceanic water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 20 ecosystem services through 6 biotic groups, amongst these 2 are provisioning, 8 are Regulation and maintenance services and 10 are cultural (Table AI.22). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna which can directly consume waste materials (10)

Cultural

- *Recreation and leisure* is not considered to be supplied in *abyssal* habitats as they are too deep an inaccessible for people but they support species of whales, thus a 'o' is given for these biotic groups in this habitat (24)
- *Heritage* and *symbolic* services are not considered to be supplied in *abyssal* habitats as they are too deep and inaccessible for people but whales, thus a 'o' is given for these biotic groups in this habitat (27, 30). For *sacred and/or religious*, the biotic groups which would contribute through the link of scuba-diving (whales only) are given 'o' links, as these habitats are too deep to be accessible for divers and other biotic groups present are not expected to move to habitats that divers do use. There is no link for fish or epifauna as fishers cannot exploit these habitats (31).

Table AI.22 Ecosystem services that can be supplied in the *abyssal rock and biogenic reef* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Abyssal Rock and Biogenic Reef					
	Whales (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bacteria
2. Seafood from Wild Animals		X		X		
5. Raw Materials	o	X	X	X	X	
6. Materials for agriculture and aquaculture		X				
7. Genetic Materials		X	X	X	X	X
10. Waste and Toxicant Treatment via Biota				X	X	X
11. Waste and Toxicant removal and storage	X	X	X	X	X	X
17. Maintaining Nursery Populations and Habitats		X	X	X	X	
18. Gene Pool Protection	X	X	X	X	X	X
19. Pest Control	X	X	X	X	X	X
20. Disease Control	X	X	X	X	X	X
21. Sediment nutrient cycling	X	X	X	X	X	X
22. Chemical Condition of Seawater	X	X	X	X	X	X
23. Global Climate Regulation	X	X	X	X	X	X
24. Recreation and Leisure	o					
25. Scientific	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X
27. Heritage	o					
28. Entertainment	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X
30. Symbolic	o					
31. Sacred and/or Religious	o	X		X		
32. Existence	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 2 (Seafood from Wild Animals); 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 6 (Agricultural Materials); 8, 9 (Biofuels); 12 (Mediation smell/visual impacts); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production); 16 (Seed and Gamete Dispersal); 17 (Maintaining Nursery Populations and Habitats).

Benthic: Abyssal Sediment

Abyssal sediment habitats are the sedimentary habitats extending from depths of greater than 2700 m. These habitats encompass benthic biotic groups (within their surrounding seabed), and are aphotic (i.e. cannot support photosynthetic organisms). The corresponding pelagic habitat is the oceanic water habitat type.

These benthic habitats have the capacity to supply (or contribute to) a total of 20 ecosystem services through 6 biotic groups, amongst these 2 are provisioning, 8 are regulation and maintenance services and 10 are cultural (Table AI.23). In the table below, all services this habitat type has the capacity to supply are shown (with services not supplied in this habitat type listed under the table). The text following only refers to those services which show differences based on their supply in this particular habitat type i.e. if how the ecosystem supplies this service differs across habitat types details specific to this habitat are described (the service number is given in brackets in the text below in order that they can be cross-referenced to the table).

Provisioning Services

- Whales (sperm whales) provide ambergris, which washes up in littoral habitats, hence 'o' is given as it is not directly harvested from this habitat (5)

Regulation and Maintenance Services

- Waste treatment can occur through bacteria, which break down waste (e.g. organic material) via bioremediation, and epifauna and infauna, which can directly consume waste materials (10)

Cultural

- *Recreation and leisure* is not considered to be supplied in *abyssa*l habitats as they are too deep an inaccessible for people but they support species of whales, thus a 'o' is given for these biotic groups in this habitat (24)
- *Heritage* and *symbolic* services are not considered to be supplied in *abyssal* habitats as they are too deep and inaccessible for people but they support species of characteristic megafauna (whales), thus 'o' is given for these biotic groups in this habitat (27, 30). For *sacred and/or religious*, the biotic groups which would contribute through the link of scuba-diving (whales only) are given 'o' links, as these habitats are too deep to be accessible for divers and other biotic groups present are not expected to move to habitats that divers do use. There is no link for fish or epifauna as fishers cannot exploit these habitats (31).

Table AI.23 Ecosystem services that can be supplied in the *abyssal sediment* (benthic) habitat type showing the links with the biotic groups holding the capacity to supply them. *Note only those services with links in this habitat type are shown

Ecosystem Services	Abyssal Sediment					
	Whales (feeding)	Fish	Cephalo-pods	Epi-fauna	In-fauna	Bacteria
23. Global Climate Regulation	X	X	X	X	X	X
24. Recreation and Leisure	o					
25. Scientific	X	X	X	X	X	X
26. Educational	X	X	X	X	X	X
27. Heritage	o					
28. Entertainment	X	X	X	X	X	X
29. Aesthetic	X	X	X	X	X	X
30. Symbolic	o					
31. Sacred and/or Religious	o					
32. Existence	X	X	X	X	X	X
33. Bequest	X	X	X	X	X	X

*Services not shown include: 1 (Seafood from Wild Plants and Algae), 2 (Seafood from Wild Animals); 3 (Plant and Algal Seafood from In-situ aquaculture); 4 (Animal Seafood from In-situ aquaculture); 6 (Agricultural Materials); 8, 9 (Biofuels); 12 (Mediation smell/visual impacts); 13 (Erosion Prevention and Sediment Retention); 14 (Flood Protection); 15 (Oxygen Production); 16 (Seed and Gamete Dispersal); 17 (Maintaining Nursery Populations and Habitats).

Table AI.24 Overview of all the linkages between habitat types and marine ecosystem services

Ecosystem Service	Habitat type																						
	Variable salinity water	Coastal Waters	Shelf Waters	Oceanic Waters	Ice-associated Habitats	Littoral Rock and Biogenic Reef	Littoral Sediment	Shallow Sublittoral Rock and Biogenic Reef	Shallow Sublittoral Coarse Sediment	Shallow Sublittoral Sand	Shallow Sublittoral Mud	Shallow Sublittoral Mixed Sediment	Shelf Sublittoral Rock and Biogenic Reef	Shelf Sublittoral Coarse Sediment	Shelf Sublittoral Sand	Shelf Sublittoral Mud	Shelf Sublittoral Mixed Sediment	Upper Bathyal Rock and Biogenic Reef	Upper Bathyal Sediment	Lower Bathyal Rock and Biogenic Reef	Lower Bathyal Sediment	Abyssal Rock and biogenic reef	Abyssal Sediment
1. Seafood from Wild Plants and Algae																							
2. Seafood from Wild Animals																							
3. Plants and Algal Seafood from In-situ aquaculture																							
4. Animal Seafood from In-situ aquaculture																							
5. Raw Materials																							
6. Materials for Agriculture and Aquaculture																							
7. Genetic Materials																							
8. Plant- and Algal-based Biofuels																							
9. Animal-based Biofuels																							
10. Waste and Toxicant Treatment via Biota																							
11. Waste and Toxicant Removal and Storage																							
12. Mediation of Smell/Visual Impacts																							

Ecosystem Service	Habitat type																					
	Variable salinity water	Coastal Waters	Shelf Waters	Oceanic Waters	Ice-associated Habitats	Littoral Rock and Biogenic Reef	Littoral Sediment	Shallow Sublittoral Rock and Biogenic Reef	Shallow Sublittoral Coarse Sediment	Shallow Sublittoral Sand	Shallow Sublittoral Mud	Shallow Sublittoral Mixed Sediment	Shelf Sublittoral Rock and Biogenic Reef	Shelf Sublittoral Coarse Sediment	Shelf Sublittoral Sand	Shelf Sublittoral Mud	Shelf Sublittoral Mixed Sediment	Upper Bathyal Rock and Biogenic Reef	Upper Bathyal Sediment	Lower Bathyal Rock and Biogenic Reef	Lower Bathyal Sediment	Abyssal Rock and biogenic reef	Abyssal Sediment
13. Erosion Prevention and Sediment Retention																							
14. Flood Protection																							
15. Oxygen Production																							
16. Seed and Gamete Dispersal																							
17. Maintaining Nursery Populations and Habitats																							
18. Gene Pool Protection																							
19. Pest Control																							
20. Disease Control																							
21. Sediment Nutrient Cycling																							
22. Chemical Condition of Seawater																							
23. Global Climate Regulation																							
24. Recreation and Leisure																							
25. Scientific																							
26. Educational																							
27. Heritage																							
28. Entertainment																							

Ecosystem Service	Habitat type																					
	Variable salinity water	Coastal Waters	Shelf Waters	Oceanic Waters	Ice-associated Habitats	Littoral Rock and Biogenic Reef	Littoral Sediment	Shallow Sublittoral Rock and Biogenic Reef	Shallow Sublittoral Coarse Sediment	Shallow Sublittoral Sand	Shallow Sublittoral Mud	Shallow Sublittoral Mixed Sediment	Shelf Sublittoral Rock and Biogenic Reef	Shelf Sublittoral Coarse Sediment	Shelf Sublittoral Sand	Shelf Sublittoral Mud	Shelf Sublittoral Mixed Sediment	Upper Bathyal Rock and Biogenic Reef	Upper Bathyal Sediment	Lower Bathyal Rock and Biogenic Reef	Lower Bathyal Sediment	Abyssal Rock and biogenic reef	Abyssal Sediment
29. Aesthetic																							
30. Symbolic																							
31. Sacred and/or religious																							
32. Existence																							
33. Bequest																							

Notes: Dark blue indicates where the habitat type can supply the service and grey where it cannot

Annex I References

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EC (2017). Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU, Official Journal of the European Union, vol. L 125, 18.5.2017, p. 43–74 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017D0848&from=EN).

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Sigler, M.F., Napp, J.M., Stabeno, P.J., Heintz, R.A., Lomas, M.W., and Hunt, G.L. (2016). Variation in annual production of copepods, euphausiids, and juvenile walleye pollock in the southeastern Bering Sea. *Deep Sea Research Part II: Topical Studies in Oceanography*, Volume 134, December 2016, 223–234 pp (https://doi.org/10.1016/j.dsr2.2016.01.003).

Annex II Test case assessment

Disclaimer: *This Annex was developed in 2014 and has not been updated since then, while certain elements of the main Report have been updated since 2014. Thus, there may be some inconsistencies between the main Report and this Annex*

Recreation and Leisure service class

Recreation and leisure from whale watching service type

Authors: F. Culhane & C. Frid

General Introduction

The cultural service recreation and leisure here joins together the 'experiential use of plants, animals and land-/seascapes in different environmental settings' and the 'physical use of land-/seascapes in different environmental settings' services from the CICES typology. This service covers a wide range of activities from going to the beach, swimming, rock-pooling, wildlife watching, scuba-diving, boating, leisure fishing, etc., which are underpinned to various degrees by the marine ecosystem. Cultural services as 'final services', this service being a prime example, are particularly linked to other final services acting as supporting or contributing services. In particular, it is the 'experiential' aspect of this service which is heavily dependent on other services. Any use of coastal habitats may be dependent on services such as 'Waste and toxicant treatment' for the provision of clean water to swim in, 'Mediation of smell or visual impacts to provide a pleasant sensory experience during a coastal walk, or 'Erosion prevention' to maintain preferred walking routes. If a full ecosystem service assessment, which considers all services, is carried out, these supporting services will be accounted for. However, if *only this* cultural service was being assessed, the other services which contribute should also be taken into consideration. In this test, the assessment of *only this* service is shown.

There is further overlap between this service and other services which needs to be considered as well. For example, hunting may be considered a recreational activity but also contributes to the provision of seafood and raw materials. In this assessment, it is considered that this sort of overlap does not result in double counting because of the different 'beneficiaries' of the activity (albeit one individual person may be many beneficiaries – of nutrition, raw materials, cultural experience, etc.). In the same way an ecosystem process can contribute different services and benefits (e.g. decomposition can contribute to 'Sediment nutrient cycling' and 'Waste and toxicant treatment'), the same cultural activity or process can lead to several end benefits.

Dependence of recreation and leisure activities on ecosystem components

When considering the ecologically mediated contribution of the ecosystem to the supply of this service (minus the aspects which are accounted for in other services such as 'Waste and toxicant treatment'), there are varying degrees to which the ecosystem components contribute to the service. For example, for an activity such as wildlife watching, the state of the ecosystem components is essential to the activity. For an activity such as walking along the coast, the state of the ecosystem components may not be essential to the activity (aside from the contribution from the supporting services), or at least not as important as the abiotically determined factors, such as whether it is sunny, whether there is a sandy beach, etc. Furthermore, there are many factors which may influence cultural services that are irrelevant to what the ecosystem is providing, such as the location, transport, convenience services provided, etc. For these services where there is a weaker

link between the state of ecosystem components and the activity, assessing the capacity of the ecosystem to supply the service may tell us little about the service itself. For example, having an estimation of saltmarsh habitat area may tell us that these habitats exist and could be used for enjoyment by people but may actually tell us very little about an activity such as walking. Even for those activities for which the state of the environment is essential, the relationship is still more complicated than is found for the regulation and provisioning services. For example, in a study of recreational trips by sea anglers on the Great Barrier Reef, the catch rates were found to have relatively little effect on the demand for angling (Prayaga et al. 2010). There are clearly many drivers affecting the supply of recreation and leisure services and this factor reduces the confidence in an assessment that attempts to measure only the capacity of the ecosystem to supply services and is thus a limitation of this approach.

The dependence of an activity of the ecosystem has been divided into three categories (Table AII.1) and these categories have been applied to a list of common activities which occur in the marine environment (Table AII.2). This approach could allow each type of activity to be scored to form a criterion for assigning a relative contribution. It is considered that the state-service relationship can differ greatly between these different types of activities and a different approach may be appropriate to assess each type, or the confidence will be greater in an assessment of the 'essential' type activities and low for the activities that have low dependence on the ecosystem.

Table AII.1 Different categories of recreation and leisure activities according to their dependence on the ecosystem

Dependence of Activity on Ecosystem Components (Category and Score)	Description of Category
Essential (3)	The activity is completely dependent on the state (e.g. population size and abundance, which determine the presence of relevant biota) of ecosystem components, e.g. wildlife watching
Moderate-High (2)	The activity has some, or considerable, elements that can be carried out without ecosystem components but is otherwise enhanced by the (good) state of ecosystem components, e.g. scuba-diving and visiting scenic areas
Low (1)	The activity, normally a type of sport, could be carried out completely in the absence of ecosystem components (is only dependent on the abiotic system) but is enhanced by the (good) state of ecosystem components, e.g. sailing

Table AII.2 Different recreation and leisure activities and their degree of dependence on the ecosystem

Activity	Can occur in habitat	Dependence on ecosystem components	Note
Recreational fishing/hunting/ wildfowling/ crabbing/bait collecting	Variable salinity water Coastal waters Shelf waters Oceanic waters Ice habitats Littoral habitats Shallow sublittoral habitats Shelf sublittoral habitats	Essential	Leisure fishing and hunting can include angling, foraging for shellfish and deep sea fishing, amongst others. These activities can occur in all pelagic habitats, ice habitats and benthic habitats out to the shelf.
Wildlife watching (whales, birds, seals) and enjoying nature (e.g. spotting saltmarsh plants)	Variable salinity water Coastal waters Shelf waters Oceanic waters Ice habitats Littoral habitats	Essential	Wildlife watching can occur anywhere the animals or plants are visible. Whales can be spotted from the shore close habitats or from boats in further habitats. Although even whale-watching boats are unlikely to go as far as oceanic waters, spotters may see whales from cruise ships in these habitats. Birds and seals can be watched in littoral or ice habitats and plants can be spotted in littoral habitats.
Rock pooling	Littoral habitats	Essential	Rock pools can be found in rocky littoral habitats.
Snorkelling	Variable salinity water Coastal waters Shallow sublittoral habitats Shelf sublittoral habitats	Essential: snorkelling to look at the wildlife	Snorkelling can be carried out in any type of water body. Snorkelers can benefit from both pelagic and benthic elements of the ecosystem. Although snorkelling in deeper waters off a boat (shelf) is possible, it is considered that most snorkelling occurs in shallower areas.
Enjoying bioluminescence	Variable salinity water Coastal waters Shelf waters Oceanic waters	Essential	Bioluminescence can be seen in all pelagic habitats such as at the shore line on the beach or in the open ocean from a cruise ship.
Scuba-diving	Variable salinity water Coastal waters Ice Shallow sublittoral habitats Shelf sublittoral habitats	Moderate – High: scuba diving can be carried out regardless of biotic elements (e.g. wreck diving), but is enhanced by biotic elements and in areas with no wrecks is greatly enhanced by biotic elements	Scuba-diving can be carried out in any type of water body and ice diving can also be carried out. Recreational divers dive to a maximum of around 40 m (e.g. PADI). Divers can benefit from both pelagic and benthic elements of the ecosystem.
Visiting scenic areas (where the ecological components contribute to the scenery)	Variable salinity water Coastal waters Shelf waters Oceanic waters Ice habitats Littoral habitats	Moderate: abiotic scenery (e.g. a sandy beach, sea cliffs) could be enjoyed as much as biotic elements but is enhanced by ecosystem components e.g. the presence of wildlife in the scenery	In this case, the activity occurs in the littoral habitat (or further inland) but all habitats within sight can contribute to the experience. It can also occur in other habitats from a boat.

Table AII.2 Cont.

Activity	Can occur in habitat	Dependence on ecosystem components	Note
Other sports/ water sports (where the ecological components add to the experience) – swimming, surfing, kayaking, coasteering	Variable salinity water Coastal waters Ice habitats Littoral habitats Shallow sublittoral habitats	Low: these activities could be carried out completely in the absence of ecosystem components but can be enhanced by their presence e.g. kayaking with whales or seals	Water sports such swimming, surfing and kayaking take place in the pelagic waters. Beyond the coastal area, these activities are less likely to occur due to the distance from the shore and also the experience is less likely to be influenced by the ecological components in the open water further from the coast. Coasteering makes use of pelagic, littoral and shallow sublittoral habitats. Ice-skating can take place on sea ice.
Walking, cycling or horse riding along the coast (where the ecological components adds to the experience)	Variable salinity water Coastal waters Ice habitats Littoral habitats	Low: these activities could be carried out completely in the absence of ecosystem components where the abiotic elements can be enjoyed but can be enhanced by their presence e.g. enjoying the smell of the sea air (Dimethyl sulphide produced by phytoplankton)	In this case, these activities occur in the littoral habitat (or further inland) but all habitats within site can contribute to the experience.
Sailing and Boat trips (where the ecological components add to the experience)	Variable salinity water Coastal waters Shelf waters Oceanic waters	Low: these activities could be carried out completely in the absence of ecosystem components where the abiotic elements can be enjoyed but can be enhanced by their presence e.g. enjoying the smell of the sea air (Dimethyl sulphide produced by phytoplankton), seeing dolphins, fish and birds	Conditions and ecological components in pelagic waters can contribute to the experience.
Going to the beach/seaside (where the ecological components add to the experience)	Variable salinity water Coastal waters Littoral habitats Shallow sublittoral habitats	Low: activity has considerable elements which can be carried out without ecosystem components such as sun bathing but is enhanced by ecosystem components e.g. enjoying the smell of the sea air (Dimethyl sulphide produced by phytoplankton)	In this case, the activity occurs in the littoral habitat (or further inland) but all habitats within site can contribute to the experience.

Relative importance of particular habitats

Most recreation and leisure activities occur closer to coastal areas and make use of multiple aspects of the habitat (e.g. for scuba diving it is the habitat with a range of biotic groups that is important). The use of the marine environment for recreation and leisure is likely to diminish with greater distance from the shore. In the terrestrial environment, the relationship between distance and attractiveness of an area and, thus, the likelihood of people travelling there for recreation has been measured using the 'distance to k' parameter and has an inverse exponential relationship (Baxter, 1979). This could mean, in some cases, that some habitats may be more important to the supply of

recreation and leisure than other habitats. Thus, when identifying the critical components, the focus may be on the habitat rather than specific biotic groups, with the habitats making up the coastal zone being the most important and all of the biotic groups within them. Although there are activities which operate beyond the coastal zone and into Open Ocean, the coastal area is most important for accessibility, value to tourism, etc.

Stage 1 of the assessment involves the identification of the contributing components to the service and this has been carried out as part of the development of the linkage matrix.

- All biotic groups except microphytobenthos are relevant for the contribution of this service but not in all habitats.

Habitats which are relevant:

- All habitats contribute either directly or indirectly to this service.

To assess the relative contribution of different habitats, ideally actual distance would be used with mapped habitat data where activities take place. An alternative to this would be to assign habitats to (scored) distance categories, based on their likelihood of distance from the shore in a particular region (e.g. shallow sublittoral habitats are more likely to be closer to the shore while shelf are further away in some areas while in other areas shelf habitats may be much closer to the shore) (Table AII.3).

Table AII.3 Habitats with capacity to supply recreation and leisure activities assigned to categories of distance from shore

Distance from Shore: Category (Score)	Description of Category
Zero (4)	Included in this category are some variable salinity habitats (a lagoon may be surrounded almost fully by land); littoral habitats; ice
Low (3) – easy to reach with low effort	Included in this are some variable salinity, some coastal waters and shallow sublittoral habitats
Moderate (2) – still easy to reach but requires some more effort	Included in this are some coastal waters, some shelf waters, some shelf sublittoral habitats
High (1) – requires considerable effort to reach	Included in this are some shelf waters, oceanic waters, some shelf sublittoral habitats

This approach is not applicable to all categories however. For activities such as whale watching, bird watching and recreational fishing, which depend on highly mobile species, the important aspect of the ecosystem components for the assessment of the service is more likely to be the state of the biotic group rather than whole habitats

Assessment

Step 1	Identifying the critical ecosystem components for service supply
1.1	Identify the service type

Given the range of different activities, it is necessary to identify types of activity (Table AII. 2). The following approach demonstrates the method that is required to carry out the assessment for an activity for which the state of the system is essential – whale watching (Cetaceans including whales and dolphins). A similar approach could be used to assess recreational fishing and other types of wildlife watching.

Step 1	Identifying the critical ecosystem components for service supply
1.1	Identify the service type
1.2	Assigning the relative contribution of components

The biotic group 'whales' in all habitats where whales are found (Section 2) are the relevant components. Due to the high mobility of whales, all habitats where live whales are found are relevant; even though watching does not occur in all habitats, the whales are likely to be from connected populations, thus these habitats contribute to the service. However, for this service where the state of whale populations is the most important factor and due to the type of information available for whales i.e. whale population data, the focus of the test case assessment is on the biotic group whales and not on their habitats.

Some species may be more important to the activity of whale watching than others (have a greater relative contribution), thus the types of whale species that are spotted with some regularity on whale watching trips were the focus of this assessment as opposed to the entire species list for a region. The assessment was carried out for two regions – the North East Atlantic Ocean (NEA) and the Mediterranean Sea.

Step 1.2 Confidence in the criteria developed to assign relative contribution:

The criterion used to assess relative contribution is based on:

- Whale species which are identified as being seen on whale watching trips

From expert judgement, there is high confidence that this reflects the potential supply of the service whale watching

The whale species which are spotted on whale watching trips were identified by searching the websites of several whale watching operators in a region and listing the species which the operators claim can potentially be seen (Tables AII.4 and AII.5). The advertised likelihood of sightings is based purely on qualitative, descriptive information available on the websites. The 'advertised likelihood of sightings' information gives an indication of the relative importance of the species to the business of the whale watch tour operator. There was a total of eighteen species listed for the NEA region and nine for the Mediterranean Sea region.

The likelihood of seeing particular whale species (whether they are common or rare) is only available as a qualitative description on websites of tour operators and is patchy. Therefore, a quantitative relative contribution was not assigned for each individual whale species. Each whale species listed on the tour operator websites is given an equal weighting. This is justified because while common species may guarantee a successful whale watching trip, spotting a rare species may be a special experience and, therefore, as valuable culturally as being more certain of seeing common species.

Table AII.4 List of species advertised by whale watch tour operators (nine tour operators consulted) in the North East Atlantic Ocean marine region

Species	Advertised Likelihood of sightings	Country	Source*
Minke Whales *Balaenoptera acutorostrata*	Common	Ireland (SW)	1
	Common	Scotland (Hebrides)	2
	Not indicated	England (Ramsey Island)	3
	Occasional	Portugal (Algarve)	5
	Not indicated	England (Whitby)	6
	Not indicated	Northern Spain	7
	Common	Ireland (NW)	8
	Common	Scotland (Shetland)	9
Sei whale *Balaenoptera borealis*	Rare	Scotland (Hebrides)	2
	Not indicated	England (Ramsey Island)	3
	Not indicated	England (Whitby)	6
The Fin whale *Balaenoptera physalus*	Common	Ireland (SW)	1
	Rare	Scotland (Hebrides)	2
	Not indicated	England (Ramsey Island)	3
	Not indicated	England (Whitby)	6
	Not indicated	Northern Spain	7
Short-beaked common dolphin *Delphinus delphis*	Common	Ireland (SW)	1
	Common	Scotland (Hebrides)	2
	Common	England (Ramsey Island)	3
	Common	Portugal (Algarve)	5
	Not indicated	Northern Spain	7
	Common	Ireland (NW)	8
	Not indicated	Northern Spain	7
Long-finned pilot whale *Globicephala melas*	Occasional	Ireland (SW)	1
	Rare	Scotland (Hebrides)	2
	Not indicated	Northern Spain	7
Risso's dolphin *Grampus griseus*	Common	Ireland (SW)	1
	Occasional	Scotland (Hebrides)	2
	Not indicated	England (Ramsey Island)	3
	Common	Portugal (Algarve)	5
	Not indicated	Northern Spain	7
	Common	Ireland (NW)	8
Northern bottlenose *Hyperoodon ampullatus*	Rare	Scotland (Hebrides)	2
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Occasional	Ireland (SW)	1
	Occasional	Scotland (Hebrides)	2
White-beaked dolphin *Lagenorhynchus albirostris*	Occasional	Ireland (SW)	1
	Occasional	Scotland (Hebrides)	2

Species	Advertised Likelihood of sightings	Country	Source*
The humpback whale *Megaptera novaeangliae*	Common	Ireland (SW)	1
	Occasional	Scotland (Hebrides)	2
	Not indicated	England (Whitby)	6
Sowerby's beaked whale *Mesoplodon bidens*	Not indicated	Northern Spain	7
True's beaked whale *Mesoplodon mirus*	Not indicated	Northern Spain	7
The killer whale *Orcinus orca*	Occasional	Ireland (SW)	1
	Occasional	Scotland (Hebrides)	2
	Not indicated	England (Ramsey Island)	3
	Occasional	Portugal (Algarve)	5
	Not indicated	Northern Spain	7
	Common	Ireland (NW)	8
	Common	Scotland (Shetland)	9
Harbour porpoise *Phocoena phocoena*	Common	Ireland (SW)	1
	Common	Scotland (Hebrides)	2
	Common	England (Ramsey Island)	3
	Common	Denmark	4
	Common	Portugal (Algarve)	5
	Common	England (Whitby)	6
	Not indicated	Northern Spain	7
	Common	Ireland (NW)	8
	Common	Scotland (Shetland)	9
The sperm whale *Physeter catodon*	Rare	Scotland (Hebrides)	2
	Not indicated	Northern Spain	7
Striped dolphin *Stenella coeruleoalba*	Occasional	Portugal (Algarve)	5
	Not indicated	Northern Spain	7
Common bottlenose dolphin *Tursiops truncatus*	Common	Ireland (SW)	1
	Occasional	Scotland (Hebrides)	2
	Not indicated	England (Ramsey Island)	3
	Common	Portugal (Algarve)	5
	Not indicated	Northern Spain	7
	Common	Ireland (NW)	8
Cuvier's Beaked Whale *Ziphius cavirostris*	Not indicated	Northern Spain	7
Dolphin (species not indicated)	Common	England (Whitby)	6
	Common	Scotland (Shetland)	9

*Sources for Table AII.4

1. http://www.whalewatchwestcork.com/
2. https://www.hebridean-whale-cruises.co.uk/
3. http://www.ramseyisland.co.uk
4. https://www.visitdenmark.com/
5. http://www.marilimitado.com
6. http://www.whitbywhalewatching.net/
7. http://www.iberianature.com
8. https://www.wildatlanticway.com/highlights/whale-dolphin-watching
9. http://www.visitscotland.com

Table AII.5 List of species advertised by whale watch tour operators (8 tour operators consulted) in the Mediterranean Sea region

Species	Advertised Likelihood of sightings	Country	Source**
The Fin whale *Balaenoptera physalus*	Not indicated	France	1
	Not indicated	Spain (Gibraltar)	2
	Rare	Spain	3
	Not indicated	Italy (Ligurian)	5
	Not indicated	France	6
	Rare	Spain	7
Short-beaked common dolphin *Delphinus delphis*	Not indicated	Spain (Gibraltar)	2
	Common	Spain	3
	Not indicated	France	6
	Not indicated	Spain	7
Pilot whale *Globicephala sp.* (probably the long-finned)*	Not indicated	France	1
	Not indicated	Spain (Gibraltar)	2
	Common	Spain	3
	Not indicated	France	6
	Not indicated	Spain	7
Risso's dolphin *Grampus griseus*	Not indicated	France	1
	Not indicated	France	6
The killer whale *Orcinus orca*	Not indicated	Spain (Gibraltar)	2
	Rare	Spain	3
	Not indicated	Spain	7
The sperm whale *Physeter catodon*	Not indicated	France	1
	Not indicated	Spain (Gibraltar)	2
	Occasional	Spain	3
	Not indicated	Italy (Ligurian)	4
	Not indicated	France	6
	Not indicated	Spain	7
	Not indicated	Greece (Crete)	8
Striped dolphin *Stenella coeruleoalba*	Not indicated	France	1
	Not indicated	Spain (Gibraltar)	2
	Common	Spain	3
	Not indicated	France	6
	Not indicated	Spain	7
	Not indicated	Greece (Crete)	8
Common bottlenose dolphin *Tursiops truncatus*	Not indicated	France	1
	Not indicated	Spain (Gibraltar)	2
	Common	Spain	3
	Not indicated	Italy (Ligurian)	5
	Not indicated	France	6
	Not indicated	Spain	7
Cuvier's Beaked Whale *Ziphius cavirostris*	Not indicated	Greece (Crete)	8
Dolphins (species not indicated)	Not indicated	Italy (Ligurian)	4
Rorquals (Balaenopteridae) (Species not indicated)	Not indicated	Italy (Ligurian)	4

*It is expected that the long-finned pilot whale is indicated as this species is recorded for the Mediterranean Sea in publications such as ACCOBAMS (Notarbartolo di Sciara and Birkun, 2010).

**Sources for Table AII.5

1. http://www.pezenas-languedoc.com
2. http://www.whalewatchtarifa.net
3. http://www.firmm.org
4. http://www.italia.it
5. http://www.roughguides.com
6. http://www.dolphins-whales-watching-med.com
7. http://thingstodo.viator.com
8. http://www.we-love-crete.com

Step 1.2 Confidence in assigning the relative contribution:

- Each whale species was given an equal weighting for the relative contribution. Some whale species are seen more commonly than others on whale watching trips and therefore may have a higher relative contribution to this service (although, as stated, rare species may provide a more special experience). However, a limited number of sources were used to identify the relevant whale species for whale watching and there is low confidence in the information from these sources – in particular in relation to the rare species which may be spotted on whale watching trips.

Thus there is low confidence in this step.

Step 1	**Identifying the critical ecosystem components for service supply**
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical

As each whale species identified as being relevant to whale watching was assigned an equal relative contribution, all of these species are critical and carried forward in the assessment.

Step 1.3 Confidence in deciding how many components are critical:

- No species identified as being relevant for whale watching was excluded

Thus there is high confidence in this step.

Overall confidence for step 1

- There was high confidence in two of the three aspects but low confidence in assigning the relative contribution. Taking the lowest of these, there is low confidence overall for Step 1.

Step	**Confidence**
Step 1	

Step 1	Identifying the critical ecosystem components for service supply
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical
Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship

It is assumed that whale watching is directly dependent on the population of whales, as a decrease in whale population would result in a decrease in the likelihood of being able to see whales and thus the capacity of the ecosystem to provide the service recreation and leisure from whale watching. This simple type of state-service relationship is considered to have high confidence. Other non-biological factors can also influence this service such as the availability of whale watching boats or the weather contributing to the likelihood of being able to spot whales, and these are not considered in this assessment as it is only the capacity of the ecosystem to supply the service that is considered.

Step 2.1 Confidence in the type of relationship:

- This is a simple relationship, with high confidence that an increase in whales would lead to an increase in the capacity to supply recreation and leisure from whale watching

Step	Confidence
Step 1	(red)
Step 2	(green)

Step 1	Identifying the critical ecosystem components for service supply
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical
Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship
2.2	Identify appropriate metrics of state

In this assessment, the current state of whale populations (identified as relevant for whale watching) and their current trends are used to indicate the state of the service 'whale watching', where 'state of the service' refers to the state of the capacity of the ecosystem to supply the service only.

Species which have been identified as important for whale watching are given equal weighting whether they are common or rare. This is assumed because while common species may guarantee a successful whale watching trip, spotting a rare species may be a special experience and, therefore, as valuable culturally as being more certain of seeing common species. Thus, the majority trend in species is used to infer the overall direction of change in the service (i.e. if more than 50 % of species

are increasing, the service is assumed to be improving) (Table AII.6). If equal numbers of whale species are increasing and decreasing, the overall service is considered stable.

Pressures affecting whale populations may decrease the population. There are a number of pressures which affect whale populations and these can also vary depending on the particular species. In this assessment, pressure data, along with whale population data, are used to indicate the potential future trends in whale populations. Future trends in whale populations can then be used to infer the future capacity of the ecosystem to deliver the service and there are several potential outcomes of this depending on current state and trends of the ecosystem service capacity and future trends of the ecosystem service capacity (Table AII. 7).

Table AII.6 Potential outcomes for the capacity of the ecosystem to supply the service 'whale watching' based the population trends of whale species (stable trends are not shown)

Scenario	Whale species	Population Trend	Service
A	Species A	Increasing	Improving
	Species B	Increasing	
	Species C	Increasing	
B	Species A	Increasing	Improving
	Species B	Decreasing	
	Species C	Increasing	
C	Species A	Increasing	Deteriorating
	Species B	Decreasing	
	Species C	Decreasing	
D	Species A	Decreasing	Deteriorating
	Species B	Decreasing	
	Species C	Decreasing	

Notes: The majority trend of the species is used to infer the overall direction of change in the service (i.e. if more than 50 % of species are increasing, the service is assumed to be improving)

Table AII.7 Potential outcomes for future state of services when current state of the service is known and future trend of the ecosystem component is known, and where 'state of service' is the state of the capacity of the ecosystem to deliver the service. In many cases, the future state is cannot be assessed as it is not known by how much the ecosystem component will change with future trends.

Legend

	Unable to assess
	Bad State
	Good State

Scenario	State and Direction Change of Service Capcity	Future Trend in Metric	Future Direction Change of Service Capacity	Future State of Service Capacity		Scenario	State and Direction Change of Service Capcity	Future Trend in Metric	Future Direction Change of Service Capacity	Future State of Service Capacity
A	Deteriorating	Stable	Stable			J	Deteriorating	Stable	Stable	
B	Deteriorating	Increasing	Improving			K	Deteriorating	Increasing	Improving	
C	Deteriorating	Decreasing	Deteriorating			L	Deteriorating	Decreasing	Deteriorating	
D	Stable	Stable	Stable			M	Stable	Stable	Stable	
E	Stable	Increasing	Improving			N	Stable	Increasing	Improving	
F	Stable	Decreasing	Deteriorating			O	Stable	Decreasing	Deteriorating	
G	Improving	Stable	Stable			P	Increasing	Stable	Stable	
H	Improving	Increasing	Improving			Q	Increasing	Increasing	Improving	
I	Improving	Decreasing	Deteriorating			R	Increasing	Decreasing	Deteriorating	

Step 1	**Identifying the critical ecosystem components for service supply**
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical
Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship
2.2	Identify appropriate metrics of state
Step 3	**Identifying the current state and trends of the critical ecosystem components**
3.1	Identify relevant policies/laws with reported information on the metrics identified in Step 2

A number of EU and regional policies/laws incorporate reporting on whale species and marine mammal populations (for a summary of the relevant identified policies/laws see Table ALII.8 and these are further described below).

International policy

IUCN Red List of Threatened Species

The IUCN Red List reports data on the state of whale populations and population trends, where known. Most reporting is done on global populations of whales but reporting on sub-populations and sub-species is also given where appropriate and which is relevant to specific regions. Since many whale species migrate great distances, global population trends are often relevant to those found in European regions.

- The information reported by the IUCN was considered to be useful for the assessment.

EU and other law and policy

Marine Strategy Framework Directive (MSFD)

From Annex III, Table 1 of the MSFD (EC, 2008), characteristics of biological features which are to be reported include:

"*A description of the population dynamics, natural and actual range and status of species of marine mammals and reptiles occurring in the marine region or sub-region*"

From the commission decision on criteria and methodological standards on good environmental status of marine waters (EC 2010), relevant descriptors of the MSFD also include:

- Descriptor 1: Biodiversity, where at the species level "*For each region, sub-region or subdivision, taking into account the different species and communities … contained in the indicative list in Table 1 of Annex III to Directive 2008/56/EC, it is necessary to draw up a set of relevant species and functional groups*" and at the habitat level, the water column, addresses "*both the abiotic characteristics and the associated biological community, treating both elements together in the sense of the term biotope*", thus including the whales (Table AII.8).

Table AII.8 Criteria for Descriptor 1 of the MSFD potentially relevant for the assessment of the ecosystem service: 'Whale watching'

Potentially Relevant Descriptor	**Descriptor 1: Biodiversity**						
Potentially Relevant criteria	Species Level			Habitat Level (Water column including phytoplankton)			Ecosystem Level
	Species Distri-bution	Population Size	Population condition	Habitat distribution	Habitat Extent	Habitat Condition	Ecosystem Structure

The relevant species (those identified as relevant for whale watching) reported for Descriptor 1 include those listed in Table AII.9. Member states sometimes reported on individual species as the 'biodiversity feature' and these were then presented under the aggregated form of 'marine mammals' but sometimes Member States reported on 'All Mammals'. The species reported by Member States was determined by the individual Member States and therefore it seems there is no consistency across different countries in how mammals are reported.

Table AII.9 Relevant whale species reported as biodiversity features by Member States for the MSFD (extracted from Annex 4, Table 4.1 in ETC/ICM, 2014a)

Reported Biodiversity Feature	Biodiversity Component	Reporting Schema
Balaenoptera physalus (Fin Whale)	Marine mammals	Species
Delphinus delphis (Short-beaked common dolphin)	Marine mammals	
Globicephala melas (Long-finned pilot whale)	Marine mammals	
Grampus griseus (Risso's dolphin)	Marine mammals	
Orcinus orca (Killer whale)	Marine mammals	
Phocoena phocoena (Harbour Porpoise)	Marine mammals	
Physeter macrocephalus (Sperm Whale)	Marine mammals	
Stenella coeruleoalba Meyen 1833 (Stenella) (Striped Dolphin)	Marine mammals	
Tursiops truncates (Common Bottlenose Dolphin)	Marine mammals	
Ziphius cavirostris (Cuvier's Beaked Whale)	Marine mammals	
Baleen whales	Marine mammals	Functional group
Cetaceans Functional Group Other	Marine mammals	
Mammals All	Marine mammals	
Mammals Ice	Marine mammals	
Mammals Toothed Whales	Marine mammals	
Toothed whales	Marine mammals	

- The information reported by Member States under the MSFD Descriptor 1 was considered to be useful for the assessment. Thus, the reported information under marine mammals could be used as a proxy but, as more directly relevant reported information was available (e.g. individual species data from the Habitats Directive, or all Member States reported on the individual species information and this was available), this information was used only as supporting information in this case since the marine mammal information included aggregated information on all marine mammals (including seals) and not directly in the assessment.

<u>The Habitats Directive</u>

The Habitats Directive Annex II and Annex IV contain Cetacean species, listed species (Common bottlenose dolphin, *Tursiops truncates*, and the Harbour porpoise, *Phocoena phocoena)* in Annex II and including all cetaceans in Annex IV.

- The information reported by the HD was considered to be useful for the assessment.

Regional Policy

North East Atlantic Ocean – OSPAR

OSPAR reports information on four species of cetaceans considered to be threatened and most in need of protection (OSPAR, 2010). Only one of these species, the Harbour Porpoise, overlaps with the species identified as relevant for whale watching (Table AII. 4).

- The information reported by OSPAR was considered to be useful for the assessment.

North East Atlantic Ocean – ASCOBANS

ASCOBANS (the Agreement on the Conservation of Small Cetaceans in the Baltic, North East Atlantic, Irish and North Seas, http://www.ascobans.org/) compiles information on species in this region. However, all state information on whale populations used IUCN classifications with no additional information added for this region. Therefore only IUCN data was used for this region.

- The information reported by ASCOBANS was not considered to be useful for the assessment.

Mediterranean Sea – ACCOBAMS

ACCOBAMS (the Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic Area http://www.accobams.org/) compiles known information on whale populations for the Mediterranean and Black Sea (Notarbartolo di Sciara and Birkun, 2010). Most state information used is taken from those reported in the IUCN Red List but some additional information is reported for some species.

- The information reported by ACCOBAMS was considered to be useful for the assessment.

Table AII.10 Summary of relevant policies/laws with reporting relevant for assessing the 'whale watching' service in the North East Atlantic Ocean and Mediterranean Sea

Regional Relevance	Policy	Indicators Reported
International	IUCN Red List	Categorisation of status of listed species and population trends
EU	Habitats Directive	Cetacean species Annex II and Annex IV
Regional	OSPAR Biological Diversity and Ecosystems Strategy	4 threatened species monitored, pressures on cetaceans recorded
	ACCOBAMS	Description of information known on whale populations, trends and pressures

Step 1	**Identifying the critical ecosystem components for service supply**
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical
Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship
2.2	Identify appropriate metrics of state
Step 3	**Identifying the current state and trends of the critical ecosystem components**
3.1	Identify relevant policies/laws with reported information on the metrics identified in Step 2
3.2	Synthesis of different policy metrics

Since all of the reported policy information taken forward in this assessment was information on individual whale species, a synthesis was not required.

Step 1	**Identifying the critical ecosystem components for service supply**
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical
Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship
2.2	Identify appropriate metrics of state
Step 3	**Identifying the current state and trends of the critical ecosystem components**
3.1	Identify relevant policies/laws with reported information on the metrics identified in Step 2
3.2	Synthesis of different policy metrics
3.3	Establish the quality classification (pass/fail) from each policy

Below, each policy is considered in turn and all outcomes and final outcomes are summarised. Outcomes are given per whale species where possible.

IUCN

The IUCN data present global information for the NEA species and specific information for many Mediterranean sub-populations of Cetacean species, therefore the reported information is presented separately for each region (Table AII.11 and AII.12).

Table AII.11 IUCN reported status results for Cetacean species of the North East Atlantic Ocean which are important to the whale watching industry. Population status and trends are global, except where indicated

Species	Population Status and Trend	Source Reference
Common Minke Whale *Balaenoptera acutorostrata*	Status: Least Concern Trend: Stable	Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2008a. *Balaenoptera acutorostrata*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Sei whale *Balaenoptera borealis*	Status: Endangered Trend: Unknown	Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2008b. *Balaenoptera borealis*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014.**
Fin whale *Balaenoptera physalus*	Status: Endangered Trend: Unknown but North Atlantic population may be increasing	Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2013. *Balaenoptera physalus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014.**
Short-beaked common dolphin *Delphinus delphis*	Status: Least concern Trend: unknown	Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. & Wilson, B. 2008a. *Delphinus delphis*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014.**
Long-finned pilot whale *Globicephala melas*	Data deficient	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008a. *Globicephala melas*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Risso's dolphin *Grampus griseus*	Status: Least concern Trend: Unknown	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J.K.B., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2012. *Grampus griseus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
North Atlantic bottlenose whale *Hyperoodon ampullatus*	Data deficient	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008b. *Hyperoodon ampullatus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Status: Least concern Trend: Unknown	Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. & Wilson, B. 2008b. *Lagenorhynchus acutus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
White-beaked dolphin *Lagenorhynchus albirostris*	Status: Least concern Trend: Unknown	Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K.A., Karkzmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. & Wilson, B. 2012a. *Lagenorhynchus albirostris*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.

Table AII.11 Cont.

Species	Population Status and Trend	Source Reference
Humpback whale *Megaptera novaeangliae*	Status: Least concern Trend: Increasing	Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell Jr., R.L., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. & Zerbini, A.N. 2008c. *Megaptera novaeangliae*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014.**
Sowerby's beaked whale *Mesoplodon bidens*	Data deficient	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008c. *Mesoplodon bidens*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014.**
True's beaked whale Mesoplodon mirus	Data deficient	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008d. *Mesoplodon mirus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Killer whale *Orcinus orca*	Data deficient	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2013. *Orcinus orca*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Harbour porpoise *Phocena phocena*	Status: Least concern Trend: Unknown	Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. & Wilson, B. 2008c. *Phocoena phocoena*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Sperm whale *Physeter catodon*	Status: Vulnerable Trend: Unknown	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008e. *Physeter macrocephalus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Striped dolphin *Stenella coeruleoalba*	Status: Least concern Trend: Unknown	Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. & Wilson, B. 2008d. *Stenella coeruleoalba*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Common bottlenose dolphin *Tursiops truncatus*	Status: Least concern Trend: Unknown	Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K.A., Karkzmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. & Wilson, B. 2012b. *Tursiops truncatus*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Cuvier's Beaked Whale *Ziphius cavirostris*	Status: Least concern Trend: Unknown	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008f. *Ziphius cavirostris*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.

Table AII.12 IUCN reported status results for Cetacean species of the Mediterranean Sea which are important to the whale watching industry. Population status and trends are mostly given for the Mediterranean subpopulation, except where indicated (in the species column)

Species	Population Status and Trend	Source Reference
Fin whale *Balaenoptera physalus* Med. subpop.	Status: Vulnerable Trend: Decreasing	Panigada, S. & Notarbartolo di Sciara, G. 2012. *Balaenoptera physalus (Mediterranean subpopulation)*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**
Short-beaked common dolphin *Delphinus delphis* Med. subpop.	Status: Endangered Trend: Decreasing	Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. & Wilson, B. 2008a. *Delphinus delphis*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Long-finned pilot whale *Globicephala melas* Med. subpop.	Data deficient	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2008a. *Globicephala melas*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Risso's dolphin, *Grampus griseus* Med. subpop.	Data deficient	Gaspari, S. & Natoli, A. 2012. *Grampus griseus (Mediterranean subpopulation)*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**
Killer whale *Orcinus orca* Global pop.	Data deficient	Taylor, B.L., Baird, R., Barlow, J., Dawson, S.M., Ford, J., Mead, J.G., Notarbartolo di Sciara, G., Wade, P. & Pitman, R.L. 2013. *Orcinus orca*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**
Sperm whale *Physeter catodon* Med. subpop.	Status: Endangered Trend: Decreasing	Notarbartolo di Sciara, G., Frantzis, A., Bearzi, G. & Reeves, R. 2012. *Physeter macrocephalus (Mediterranean subpopulation)*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Striped dolphin *Stenella coeruleoalba* Med. subpop.	Status: Vulnerable Trend: Unknown	Aguilar, A. & Gaspari, S. 2012. *Stenella coeruleoalba (Mediterranean subpopulation)*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.
Common bottlenose dolphin *Tursiops truncates* Med. subpop.	Status: Vulnerable Trend: Decreasing	Bearzi, G., Fortuna, C. & Reeves, R. 2012. *Tursiops truncatus (Mediterranean subpopulation)*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**
Cuvier's beaked whale *Ziphius cavirostris* Med. subpop.	Data deficient	Cañadas, A. 2012. *Ziphius cavirostris (Mediterranean subpopulation)*. The IUCN Red List of Threatened Species. Version 2014.2. <www.iucnredlist.org>. Downloaded on **28 August 2014**.

In general, the confidence in IUCN classifications is high as this is a long running and on-going source of reported information and is peer reviewed. However, the reported information is generally global. Thus high confidence is given for the assessments that are region-specific (e.g. Mediterranean subpopulations), but when global information is the source of the classification, this information would be considered to have lower confidence than assessments carried out at the specific regional scale (e.g. the Habitats Directive).

Habitats Directive (HD)

The species information from the Habitats Directive were obtained from http://bd.eionet.europa.eu/article17/reports2012/ (which are currently in draft form) and presented for each region (Table AII.13 and AII.14). The 'current state' comes from the classification in the 2007–2012 period. The trend was determined for this assessment based on the change in classification from the 2001–2006 to the 2007–2012 periods e.g. if the status was previously unfavourable and this changed to favourable in the most recent assessment, the trend was given as increasing.

Table AII.13 Results (draft version) for the Marine Atlantic region reported Cetacean data for the EU Habitats Directive

Species	2001–2006	2007–2012	Trend
Common Minke whale *Balaenoptera acutorostrata*	Unfavourable-Inadequate	Favourable	Increasing
Sei whale *Balaenoptera borealis*	Unknown	Unknown	Unknown
Fin whale *Balaenoptera physalus*	Unknown	Unknown	Unknown
Short-beaked common dolphin *Delphinus delphis*	Unknown	Unfavourable-Inadequate	Unknown
Long-finned pilot whale *Globicephala melas*	Unknown	Unknown	Unknown
Risso's dolphin *Grampus griseus*	Unknown	Unknown	Unknown
North Atlantic bottlenose whale *Hyperoodon ampullatus*	Unknown	Unknown	Unknown
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Unknown	Favourable	Unknown
White-beaked dolphin *Lagenorhynchus albirostris*	Unknown	Favourable	Unknown
Humpback whale *Megaptera novaeangliae*	Unknown	Unknown	Unknown
Sowerby's beaked whale *Mesoplodon bidens*	Unknown	Unknown	Unknown
True's beaked whale *Mesoplodon mirus*	Unknown	Unknown	Unknown
Killer whale *Orcinus orca*	Unknown	Unknown	Unknown
Harbour porpoise *Phocena phocena*	Unfavourable-Inadequate	Favourable	Increasing
Sperm whale *Physeter catodon*	Unfavourable-Inadequate	Unknown	Unknown
Striped dolphin *Stenella coeruleoalba*	Unknown	Unknown	Unknown
Common bottlenose dolphin *Tursiops truncatus*	Favourable	Unknown	Unknown
Cuvier's Beaked Whale *Ziphius cavirostris*	Unknown	Unknown	Unknown

Table AII.14 Results (draft version) for the Marine Mediterranean region reported Cetacean data for the EU Habitats Directive

Species	2001–2006	2007–2012	
Fin whale *Balaenoptera physalus*	Unknown	Unknown	Unknown
Short-beaked common dolphin *Delphinus delphis*	Unfavourable-Bad	Unfavourable-Bad	Stable
Long-finned pilot whale *Globicephala melas*	Unknown	Unfavourable-Inadequate	Unknown
Risso's dolphin *Grampus griseus*	Unknown	Unfavourable-Inadequate	Unknown
Killer whale *Orcinus orca*	Unknown	Favourable	Unknown
Sperm whale *Physeter catodon*	Unfavourable-Bad	Unfavourable-Bad	Stable
Striped dolphin *Stenella coeruleoalba*	Unknown	Unknown, likely that this species is in unfavourable condition	Unknown
Common bottlenose dolphin *Tursiops truncatus*	Unknown	Unfavourable-Inadequate	Unknown
Cuvier's Beaked Whale *Ziphius cavirostris*	Unknown but unfavourable	Unfavourable-Inadequate	Stable

Overall outcome:

Most species in the NEA region had unknown statuses. Several species in the Mediterranean Sea had less than favourable statuses with most of the statuses from the first time period 'unknown' and thus it was not possible to determine a trend.

Confidence in this assessment is currently low as the results are in draft form and still require review.

Regional Policies

North East Atlantic Ocean – OSPAR

Only one of the four species assessed as part of OSPAR's Biological Diversity and Ecosystems Strategy was relevant to whale watching in the EU NEA region (OSPAR, 2010) (Table AII.15).

Table AII.15 Species assessment of NEA Cetacean species by OSPAR (relevant to this assessment of the 'whale watching' service in the NEA)

Species	OSPAR region where occurs	OSPAR Regions where the species is under threat and/or in decline	Date of inclusion on the list	Key Pressures	Population trend
Phocoena phocoena Harbour porpoise	All	II, III	2003	Hazardous substances, Underwater noise, Removal of target and non-target species, Loss of prey species	Unknown

Mediterranean – ACCOBAMS

ACCOBAMS recorded information on whale species in the Mediterranean Sea use ICUN data but in some cases, e.g. the Killer whale, give extra specific information related to the regional populations (Table AII.16).

Table AII.16 Species assessments of Mediterranean Cetacean species by ACCOBAMS (relevant to this assessment of the 'whale watching' service in the Mediterranean Sea)

Species	Assessment
Fin whale *Balaenoptera physalus*	Vulnerable and probable decline in population size
Short-beaked common dolphin *Delphinus delphis*	Endangered, Decline in population
Long-finned pilot whale *Globicephala melas*	Data deficient
Risso's dolphin *Grampus griseus*	Data deficient, No population trends known, no evidence of decline
Killer whale *Orcinus orca*	The Gibraltar population – Critically Endangered, Continued population decline
Sperm whale *Physeter catodon*	Endangered – Small population, decline in mature individuals
Striped dolphin *Stenella coeruleoalba*	Vulnerable due to high number of threats, reduced abundance and impaired recovery
Common bottlenose dolphin *Tursiops truncatus*	Vulnerable status due to existing pressures
Cuvier's Beaked Whale *Ziphius cavirostris*	Data deficient, no information on population trends

Step 3.2 and 3.3 Confidence in the information sources used:

A number of factors are relevant for the assessment of confidence in the information sources used:

- All of the metrics used were reported as data at a species level and thus were directly relevant for the assessment
- IUCN data is reported at a global level for the NEA while the Habitats Directive reporting is at the EU regional level
- The Habitats Directive data used were in draft form and therefore have lower confidence associated with them

The type of information available is considered to have moderate confidence (where known) as the information is generally suitable and comes from robust sources but there are some discrepancies due to scales over which data are reported, and that fact the Habitats Directive data used is in draft form.

Step 1	**Identifying the critical ecosystem components for service supply**
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical
Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship
2.2	Identify appropriate metrics of state
Step 3	**Identifying the current state and trends of the critical ecosystem components**
3.1	Identify relevant policies/laws with reported information on the metrics identified in Step 2
3.2	Synthesis of different policy metrics
3.3	Establish the quality classification (pass/fail) from each policy
3.4	Synthesis of results from policy and overall assessment

Each policy has a number of classifications for status (e.g. the Habitats Directive categorises status into Favourable, Unfavourable-Inadequate and Unfavourable-Bad) with overall policy objectives (e.g. the objective of the Habitats Directive is to achieve Favourable environmental status) (Table AII.17). The status categories from each policy can be considered broadly to divide into a 'pass' or 'fail' (in achieving policy objectives), where the categories which correspond to achieving the policy objective (e.g. Favourable for the Habitats Directive) is placed under 'pass' and all other categories are considered to 'fail'. Although within the 'fail' category there are different degrees of disturbance or impact on state indicated, these distinctions are not considered within this assessment and any deviation from achieving the overall policy objective is considered a 'fail'.

Table AII.17 The status classification of each policy relevant for assessing the 'whale watching service' grouped under 'pass' (green) or 'fail' (orange and red)

Fail/Pass Policy Objective	EU and Other Law and Policy				
	IUCN	**MSFD**	**HD**	**OSPAR***	**ACCOBAMS****
Pass	**Least concern**	**Good**	**Favourable**	**N/A**	**Least concern**
Fail	**Near threatened**	**Not Good**	**Unfavourable – Inadequate**	**Threatened and/or declining**	**Near threatened**
	Vulnerable				**Vulnerable**
	Endangered		**Unfavourable – Bad**		**Endangered**
	Critically endangered				**Critically endangered**

*Only the most threatened species are reported for OSPAR, however this is not assumed to mean that all other species are at an acceptable level, thus n/a is given for the 'pass' category

**ACCOBAMS largely use the IUCN classification, thus there is overlap between these, however some additional information is given in the ACCOBAMS material, hence produces different results for some species.

The state of each of the relevant indicators of the critical component (whale species seen during whale watching trips) as given by each relevant policy is summarised in Table AII.18 (a–b) for each region. The overall assessment was determined using the majority approach (with the conservative approach also shown separately) along with confidence scores (see Section 5 for full description of method and also see a brief description below). The overall outcomes are presented as 'failing to achieve' policy objectives or 'achieving' policy objectives with direction towards or away from policy objective.

Some policies/laws may use the same information, for example, in this case it has been acknowledged that ACCOBAMS generally uses the IUCN classifications. Even in this case, the classifications from both policies/laws should be treated separately, as there were some differences noted between ACCOBAMS and IUCN, thus excluding one of these could lead to a loss in information. This does not lead to double-counting as the method of combining the policy classifications is not additive (i.e. the most common classification is used but the classifications are not weighted according to how many/few classifications are given, the number of laws/policies used in the assessment will not affect the outcome). It may however lead to false confidence in classifications as the assumption is that different sources have provided the classifications for each policy. This is a limitation of the approach but is accounted for in the confidence assessment as higher confidence is given to those classifications where different sources of information were used. If only one source of information was used (but reported by several policies/laws) this only counts as one classification in the confidence assessment

The confidence assessment takes into account whether the same or different sources of information are used and if the same sources are used, this can reduce the confidence in the assessment if there are no other corroborating data sources or the confidence in the sole source is low.

Majority Approach

- Where there is variation in the classifications, but a majority in favour of one, take the **most common**
- Where there is insufficient information
  In some cases, no classification may have been concluded from some of the sources used due to individual laws/policies not having enough information to do so. For example, **within** one law/policy, if there was greater than 50 % of the region not classified, the overall classification of 'insufficient information' would be carried forward. In this overall assessment **across** policies/information sources there is an exception to the general rule of taking the majority classification. This part of the assessment takes the majority *from sources where a classification has been made* i.e. within a metric, discard those information sources where the outcome was 'insufficient information'. The value of using data from several sources is the additional information that they contribute, therefore it is considered better to use classified information where available. In the extreme case of a single assessment then that value is taken to be the overall assessment. This recognises that the assessment, even if it is the only one available, has resulted from a classification process as required by the relevant law/policy and is therefore robust. This will lead to lower confidence in this classification compared to others where the classification is supported by several policies/laws.
- If 50-50 'pass'/'fail' or 'increasing'/'decreasing': take the least precautionary classification (as the other method, conservative, demonstrates the precautionary approach)

Conservative

- Always take the **most conservative** classification i.e. where conservative means the worst potential state of the ecosystem or worst potential change of state of the ecosystem, even if most classifications are a ‘pass’/’increasing’ trend and only one shows a ‘fail’.
- If there are some known and some ‘insufficient information’ classifications: The value of using data from several policies is the additional information that they contribute, therefore it is considered better to use classified information where given, even if other laws/policies have had insufficient information to classify a metric. Thus the most conservative classification out of those laws/policies where a classification has been made is taken.

Confidence assessment

When the same metrics are measured by several policies/laws and one overall classification is taken (as described in the methods above), the confidence is assessed by indicating the level of agreement between different sources.

High confidence: Two or more different sources of information agree on the outcomes.

Moderate confidence: only 1 assessment but confidence in this assessment (as given with the reported information) is high. Moderate is given if there is one ‘known’ assessment and one ‘insufficient information’ assessment *and* there is high the confidence is the ‘known’ assessment.

Low confidence: all other possibilities i.e. several sources of information which disagree, only one source of information which has an associated low or moderate confidence.

Table AI.18 The overall outcomes for the state of each whale species indicator reported under each policy for (a) the North East Atlantic Ocean_and (b) the Mediterranean Sea with associated confidence scores, as determined using the majority approach

Legend

	Not relevant indicator for this policy/law
	Fail to meet objectives
	Achieve objectives
	Unable to assess (insufficient information)
↑	Direction towards achieving objectives
↓	Direction away from achieving objectives
↔	No change in direction
No arrow	Unable to assess (insufficient information)

(a)North East Atlantic Ocean

		EU and Other Law and Policy			**Majority Assessment**		
		International	**Eu Level**	**Regional Level**			
	Metric	**IUCN**	**Habitats Directive**	**OSPAR**	**Overall assessment**	**Confidence: State**	**Confidence: Direction**
Population state and trend	Minke Whales *Balaenoptera acutorostrata*	↔	↑		↑	High	Low
	Sei whale *Balaenoptera borealis*					Low	
	The Fin whale *Balaenoptera physalus*	↑			↑	Low	Low
	Short-beaked common dolphin *Delphinus delphis*					Low	
	Long-finned pilot whale *Globicephala melas*						
	Risso's dolphin *Grampus griseus*					Low	
	Northern bottlenose *Hyperoodon ampullatus*						
	Atlantic white-sided dolphin *Lagenorhynchus acutus*					High	
	White-beaked dolphin *Lagenorhynchus albirostris*					High	
	The humpback whale *Megaptera novaeangliae*	↑			↑	Low	Low
	Sowerby's beaked whale *Mesoplodon bidens*						
	True's beaked whale *Mesoplodon mirus*						
	The killer whale *Orcinus orca*						
	Harbour porpoise *Phocoena phocoena*		↑		↑	High	Low
	The sperm whale *Physeter catodon*					Low	
	Striped dolphin *Stenella coeruleoalba*					Low	
	Common bottlenose dolphin *Tursiops truncatus*					Low	
	Cuvier's Beaked Whale *Ziphius cavirostris*					Low	

Table AI.18 Cont.

(b)Mediterranean Sea

		EU and Other Law and Policy			Majority Assessment		
		International	EU Level	Regional Level			
	Metric	IUCN	Habitats Directive	ACCOBAMS	Overall assessment	Confidence: State	Confidence: Direction
Population state and trend	The Fin whale *Balaenoptera physalus*	↓		↓	↓	Moderate	Moderate
	Short-beaked common dolphin *Delphinus delphis*	↓	↔	↓	↓	High	Low
	Long-finned pilot whale *Globicephala melas*					Low	
	Risso's dolphin *Grampus griseus*					Low	
	The killer whale *Orcinus orca*			↓	↓	Low	Low
	The sperm whale *Physeter catodon*	↓	↔	↓	↓	High	Low
	Striped dolphin *Stenella coeruleoalba*			↓	↓	High	Low
	Common bottlenose dolphin *Tursiops truncatus*	↓			↓	High	Low
	Cuvier's Beaked Whale *Ziphius cavirostris*		↔		↔	Low	Low

The confidence assessment is based on the agreement between different sources of data. The IUCN, Habitats Directive and OSPAR are considered to be independent sources of data from each other. ACCOBAMS is not considered as a separate source of data from the IUCN (as it uses the classifications from the IUCN Red List as its main source), except where additional specific information was given.

For many NEA species, a classification was given by the IUCN and 'insufficient information' (data deficient) was given by the Habitats Directive. In these cases, the confidence in the IUCN classification was considered to be low since these classifications are based on global populations and the Habitats Directive is considered to be more reflective of the specific European regional situation.

For the Mediterranean Sea, in general ACCOBAMS was considered to be the same source of data as the IUCN thus where both IUCN and ACCOBAMS give a classification, this is counted as one source of data (the only exception was for Killer Whales). Confidence in the IUCN classification was considered high when these classifications were based on the Mediterranean sub-populations.

Below, the outcomes from the state assessment of the different whale species (Table AII.18) are summarised across species, in order to determine the overall state and trend classification for all whale species assessed. Given the state-service relationship described for this test case assessment (Step 2) that each whale species is considered equal to the activity of whale watching, where the majority trend in species is used to infer the overall trend in the service (i.e. if more than 50 % of species are increasing, the service is assumed to be increasing), the most frequent of overall classifications of the whale species is taken as the overall outcome for the state.

North East Atlantic Ocean

Out of 18 whale species, 10 (56 %) are achieving policy objectives (Table AII.19). Population distributions and sizes of marine mammal populations as assessed for the MSFD were found to be in a 'good' state (ETC/ICM, 2014b), supporting the outcome here. Trends in species mostly could not be assessed (78 %) due to 'insufficient information' being available. This is greater than the 50 % threshold for assigning a classification when there is 'insufficient information', thus the trends in whale species relevant for whale watching overall could not be assessed. 3 species (17 %) are considered to be 'failing' to achieve policy objectives and 5 species have 'unknown' states (28 %). Together, these 8 species (those 'failing' and those unable to be assessed) make up almost 50 % of the species relevant for whale watching. If the 'unknown' species of these are also 'failing', this introduces uncertainty into the 'good' result – although the overall outcome would not change because the majority of the species are achieving policy objectives.

Table AII.19 Summary of results and confidence classifications for the current state and direction of change of the metrics relevant to assess the 'whale watching' service in the NEA with the most frequent classification highlighted in yellow

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Pass	56	4	0	8
	Fail	17	0	0	4
	Insufficient Information	28			
Direction of change	Increasing	22	0	0	4
	Stable	0			
	Decreasing	0			
	Insufficient Information	78			

Step 3.4 Confidence in the aggregation of different law/policy outcomes.

The outcome for 'whale watching' species in the NEA was a 'pass' classification, while the direction of change in the population could not be assessed. The confidence in the 'pass' classification was mostly low (8 species out of 12 had low confidence in this classification, Table AII.19).

Mediterranean Sea

Out of 9 whale species, 8 (89 %) are 'failing' to achieve policy objectives (Table AII.20). Of these, trends are mostly 'decreasing' (67 %). Only one species was reported as being in a 'good' state and no species were reported as 'increasing'. Overall mammal population criteria reported for the MSFD were all found to be in an 'unknown' state but with 'decreasing' trends (ETC/ICM, 2014a).

Table AII.20 Summary of results and confidence classifications for the current state and direction of change of the metrics relevant to assess the 'whale watching' service in the Mediterranean Sea with most frequent classification highlighted in yellow

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Pass	11	0	0	1
	Fail	89	4	1	4
	Unknown	0			
Direction of change	Increasing	0			
	Stable	11	0	0	1
	Decreasing	67	0	1	5
	Unknown	22			

Step 3.4 Confidence in the aggregation of different law/policy outcomes.

The outcome for 'whale watching' species in the Mediterranean Sea was a 'fail' classification, while the direction of change in the population was 'decreasing'. The confidence in the 'fail' classification had equal proportions of high and low classifications, thus a moderate classification was taken (Table AII.20). The confidence in the trend was low (5 out of 6 species assessments had low confidence).

Step 3 Overall confidence assessment for this step is a combination of the confidence in the sources of information (which was given as moderate for all regions) with the confidence on the aggregation of the law/policy outcomes. The lowest confidence score is taken forward for the overall assessment.

NEA: Confidence in the aggregation: Low for state (trend could not be assessed), thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Mediterranean Sea: Confidence in the aggregation: Moderate for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Conservative Approach

Box AII.1 Two tables (a-b) showing the overall outcomes and confidence for each whale species metric reported under each policy for (a) the North East Atlantic Ocean, and (b) the Mediterranean Sea, using the conservative approach

(a) North East Atlantic Ocean

			EU and Other Law and Policy			Conservative Assessment		
			International	Eu Level	Regional			
	Metric		IUCN	Habitats	OSPAR	Overall	Confidence: State	Confidence:
Population state and trend	Minke Whales	*Balaenoptera acutorostrata*	↔	↑		↔	High	Low
	Sei whale	*Balaenoptera borealis*					Low	
	The Fin whale	*Balaenoptera physalus*	↑			↑	Low	Low
	Short-beaked common dolphin	*Delphinus delphis*					Low	
	Long-finned pilot whale	*Globicephala melas*						
	Risso's dolphin	*Grampus griseus*					Low	
	Northern bottlenose	*Hyperoodon ampullatus*						
	Atlantic white-sided dolphin	*Lagenorhynchus acutus*					High	
	White-beaked dolphin	*Lagenorhynchus albirostris*					High	
	The humpback whale	*Megaptera novaeangliae*	↑			↑	Low	Low
	Sowerby's beaked whale	*Mesoplodon bidens*						
	True's beaked whale	*Mesoplodon mirus*						
	The killer whale	*Orcinus orca*						
	Harbour porpoise	*Phocoena phocoena*		↑		↑	Low	Low
	The sperm whale	*Physeter catodon*					Low	
	Striped dolphin	*Stenella coeruleoalba*					Low	
	Common bottlenose dolphin	*Tursiops truncatus*					Low	
	Cuvier's Beaked Whale	*Ziphius cavirostris*					Low	

Box AII.1 Cont.

Conservative Approach

(b) Mediterranean Sea

		EU and Other Law and Policy			Conservative Assessment		
		International	EU Level	Regional Level			
	Metric	IUCN	Habitats Directive	ACCOBAMS	Overall assessment	Confidence: State	Confidence: Direction
Population state and trend	The Fin whale *Balaenoptera physalus*	↓		↓	↓	Moderate	Moderate
	Short-beaked common dolphin *Delphinus delphis*	↓	↔	↓	↓	High	Low
	Long-finned pilot whale *Globicephala melas*					Low	
	Risso's dolphin *Grampus griseus*					Low	
	The killer whale *Orcinus orca*			↓	↓	Low	Low
	The sperm whale *Physeter catodon*	↓	↔	↓	↓	High	Low
	Striped dolphin *Stenella coeruleoalba*			↓	↓	High	Low
	Common bottlenose dolphin *Tursiops truncatus*	↓			↓	High	Low
	Cuvier's Beaked Whale *Ziphius cavirostris*		↔		↔	Low	Low

Below, the outcomes from the state assessment of the different whale species (Box AII.1) are summarised across species, in order to determine the most frequent classification for all whale species assessed (as determined using the conservative approach). Given the state-service relationship described for this test case assessment (Step 2) that each whale species is considered equal to the activity of whale watching, where the majority trend in species is used to infer the overall trend in the service (i.e. if more than 50 % of species are increasing, the service is assumed to be increasing), the most frequent of overall classifications of the whale species is taken as the overall outcome for the state.

North East Atlantic

Using the conservative method, 8 whale species (44 %) are considered to be in a 'good' state or achieving policy objectives (Table AII.21). 5 species (28 %) are considered to be in 'bad' state failing to achieve policy objectives. Of the known trends, these were found to be 'increasing' or 'stable', although most trends were 'unknown'. The overall abundance of mammals as reported by the MSFD was found to be increasing also (ETC/ICM, 2014a). Several species (5, 28 %) were found to be data deficient or have 'insufficient information' to assess state. Trends in species mostly could not be assessed (78 %) due to 'insufficient information' being available.

Table AII.21 Summary of results and confidence classifications for the current state and direction of change of the metrics relevant to assess the 'whale watching' service in the NEA with most frequent classification highlighted in yellow (conservative approach)

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Pass	44	3	0	7
	Fail	28	0	0	6
	Unknown	28			
Direction of change	Increasing	17	0	0	3
	Stable	6	0	0	1
	Decreasing	0			
	Unknown	78			

Step 3.4 Confidence in the aggregation of different law/policy outcomes.

The outcome for 'whale watching' species in the NEA (conservative approach) was a 'pass' classification, while the direction of change in the population could not be assessed. The confidence in the 'pass' classification was mostly low (7 species out of 10 had low confidence in this classification, Table AII.21).

Mediterranean Sea

Using the conservative method, 100 % of Mediterranean species important to the whale watching industry were found to be in a 'bad' state (failing to achieve policy objectives) (Table AII.21). 6 of these were found to have 'decreasing' trends in quality (67 %), one trend was found to be 'stable' and two 'unknown'. Overall mammal population criteria reported for the MSFD were all found to be in an 'unknown' state but with 'decreasing' trends (ETC/ICM, 2014a).

Table AII.22 Summary of results and confidence classifications for the current state and direction of change of the metrics relevant to assess the 'whale watching' service in the Mediterranean Sea with most frequent classification highlighted in yellow (conservative approach)

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Pass	0			
	Fail	100	4	1	4
	Unknown	0			
Direction of change	Increasing	0			
	Stable	11	0	0	1
	Decreasing	67	0	1	5
	Unknown	22			

Step 3.4 Confidence in the aggregation of different law/policy outcomes.

The outcome for 'whale watching' species in the Mediterranean Sea (conservative approach) was a 'fail' classification, while the direction of change in the population was 'decreasing'. The confidence in the 'fail' classification had equal proportions of high and low classifications, thus a moderate classification was taken (Table AII.22). The confidence in the trend was low (5 out of 6 species assessments had low confidence).

Step 3 Overall confidence in the assessment (conservative approach) for this step is a combination of the confidence in the sources of information (which was given as moderate for all regions) with the confidence on the aggregation of the law/policy outcomes. The lowest confidence score is taken forward for the overall assessment.

NEA: Confidence in the aggregation: Low for state (trend could not be assessed), thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Mediterranean Sea: Confidence in the aggregation: Moderate for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Step 1	**Identifying the critical ecosystem components for service supply**
1.1	Identify the service type
1.2	Assigning the relative contribution of components
1.3	Deciding how many components are considered to be critical
Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship
2.2	Identify appropriate metrics of state
Step 3	**Identifying the current state and trends of the critical ecosystem components**
3.1	Identify relevant policies/laws with reported information on the metrics identified in Step 2
3.2	Synthesis of different policy metrics
3.3	Establish the quality classification (pass/fail) from each policy
3.4	Synthesis of results from policy and overall assessment
Step 4	**Identifying the current state and/or change in the capacity of the ecosystem to supply a service based on state of the critical ecosystem components**

Once results of the state were obtained (Table AII.18 and summarised Tables AII.19–20), these were used to infer the state of the ecosystem service capacity using what is known about the state-service relationship (as outlined in step 2). The overall results are displayed in Tables AII.23–24, and described below.

Assumptions:

- An overall failure to achieve policy objectives is assumed to infer a 'bad' current state of the capacity of the ecosystem to supply the service, while an overall achievement of policy objectives is assumed to mean a 'good' state of capacity of the ecosystem to deliver services.
- A trend ('increasing' or 'decreasing') in the state of components towards or away from policy objectives is assumed to infer that the capacity of the ecosystem to supply the service is 'improving' (increasing) or 'deteriorating' (getting worse, decreasing), where, in this case, a simple state-service relationship is assumed (see Step 2).
- The assessment is based on known classifications and trends (where 50 % or more are classified).

North East Atlantic

As the majority of species were found to be in a 'good' state (achieving policy objectives) (Table AII.19) this service is considered to be in a **'good' state** but the direction of change in potential service supply could not be assessed (Table AII.23).

Step 4 Confidence in translating ecosystem state to the potential supply of a service: NEA

Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'good' potential supply of the service is moderate. This is because 56 % of the whale species were found to be 'passing' (in relation to the policy objectives) and the combination of the 'failing' and 'insufficient information' species was 44 % (Table AII.19). If those species which could not be assessed were 'failing' to achieve policy objectives, the majority of species would still be in a 'good' state but the proportion of 'good' versus 'bad' states would be similar.

Table AII.23. Summary of current state and direction of change of service supply capacity for the service recreation and leisure from whale watching in the NEA, where the colour refers to the state (green = good, pink = bad, no colour = unable to assess), as determined using the majority approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

Ecosystem Service	Critical component(s)	Current Assessment	Confidence
Recreation and leisure from whale watching	Whale species relevant for whale watching	Unable to assess	Step Confidence Step 1 Step 2 Step 3 Step 4

Mediterranean Sea

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Mediterranean Sea

Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'bad' capacity to supply the service, which is 'deteriorating', is high. This is because the majority of the whale species were found to be 'failing' (89 %) and 'decreasing' (67 %) (in relation to the policy objectives) (Table AII.20).

As the majority of species were found to be in a 'bad' state and known trends indicated mostly a decrease in populations (Table AII.20), this service is considered to be in a **'bad' state** and '**deteriorating'** in the Mediterranean Sea (Table AII.24).

Table AII.24 Summary of current state and direction of change service supply capacity for the service recreation and leisure from whale watching in the Mediterranean Sea, where the colour refers to the state (green=good, pink=bad, no colour=unable to assess), as determined using the majority approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

Ecosystem Service	Critical component(s)	Current Assessment	Confidence
Recreation and leisure from whale watching	Whale species relevant for whale watching	Deteriorating	Step Confidence Step 1 Step 2 Step 3 Step 4

Conservative Approach

Once results of the state were obtained (Box AII.1 and summarised Tables AII.21–22), these were used to infer the state of the ecosystem service using what is known about the state-service relationship (as outlined in step 2). The overall results are displayed in Table AII.25–26, and described below.

North East Atlantic

As the majority of whale species were found to be in a 'good' state (achieving policy objectives) (Table AII.21) this service is considered to be in a **'good' state** but the direction of change in potential service supply could not be assessed (Table AII.25).

> Step 4 Confidence in translating ecosystem state to the capacity to supply a service: NEA
>
> Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'good' capacity to supply the service is low. This is because 44 % of the whale species were found to be 'passing' (in relation to the policy objectives, conservative approach) and the combination of the 'failing' and 'insufficient information' species was 66% (Table AII.21). If those species which could not be assessed were 'failing' to achieve policy objectives, the majority of species would be in a 'bad' state.

Table AII.25 Summary of current state and direction of change of service supply capacity for the service recreation and leisure from whale watching in the NEA, where the colour refers to the state (green=good, pink=bad, no colour = unable to assess), as determined using the conservative approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

<table>
<tr><th>Ecosystem Service</th><th>Critical component(s)</th><th>Current Assessment</th><th>Confidence</th></tr>
<tr><td>Recreation and leisure from whale watching</td><td>Whale species relevant for whale watching</td><td>Unable to assess</td><td><table><tr><th>Step</th><th>Confidence</th></tr><tr><td>Step 1</td><td>red</td></tr><tr><td>Step 2</td><td>green</td></tr><tr><td>Step 3</td><td>red</td></tr><tr><td>Step 4</td><td>red</td></tr></table></td></tr>
</table>

Mediterranean Sea

As the majority of species were found to be in a 'bad' state and known trends indicated mostly a decrease in populations (Table AII.22), this service is considered to be in a **'bad' state** and **'deteriorating'** in the Mediterranean Sea (Table AII.26).

> Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Mediterranean Sea
>
> Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'bad' capacity to supply the service which is deteriorating is high. This is because all species were found to be 'failing' (100 %) (in relation to the policy objectives, conservative approach) and the majority 'decreasing' (67 %) (Table AII.22).

Table AII.26 Summary of current state and direction of change of service supply capacity for the service recreation and leisure from whale watching in the Mediterranean Sea, where the colour refers to the state (green = good, pink=bad, no colour = unable to assess), as determined using the conservative approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

Ecosystem Service	Critical component(s)	Current Assessment	Confidence
Recreation and leisure from whale watching	Whale species relevant for whale watching	Deteriorating	Step: Confidence Step 1: red Step 2: green Step 3: red

Step 5	Assessing Future Change in Service Supply Capacity

Future assessment is based on the outlook for whale populations, where given, or using trends in the pressures affecting the critical components as a proxy.

Step 5	Assessing Future Change in Service Supply Capacity
5.A	Using predicted future trends to assess the future capacity of the ecosystem to deliver services

Marine mammal data collected under the MSFD Biodiversity descriptor should predict the future trend in marine mammal populations for the Mediterranean Sea and NEA. In the NEA, most future trends are 'unknown' for mammal populations (Table AII.27). Thus, a proxy (pressures) should be used for assessing future trends in marine mammal populations of the NEA (described below). Metrics of marine mammal populations in the Mediterranean Sea, where classified, are classified as 'stable', although there are also high proportions of 'unknown' features. The Habitats Directive is an example of a policy information source that makes future predictions on the state of species and habitats, this information would be the ideal information to simply make an assessment of the future capacity and direction of change of the service, following the same approach for the assessment of the current capacity and direction, though we do not show an example of this here as many of the relevant species had an unknown status[8].

[8] We did not carry out an example of future state of whale populations for the service recreation and leisure from whale watching using the Habitats Directive due to the number of unknown classifications for the relevant species. Thus, we showed alternative approaches to assess future state, including using the aggregated MSFD information. However, the Habitats Directive could be a potential source of relevant information for other services for this part of the assessment, or for this service where relevant species have been classified.

Table AII.27 Marine mammals: Tabular summary of the future trends of the MSFD Commission Decision criteria for reported features at the Regional Sea level (from ETC/ICM, 2014a) with the most frequent trend highlighted

Regional Sea	Criterion	Percentage of features of each assigned to each trend classification (%)				
		Increasing	Stable	Decreasing	Unknown	Number of reported features
NE Atlantic Ocean	Distribution	0	0	0	100	10
	Population Size	0	0	0	100	10
	Population Condition	0	0	0	100	10
	Species Composition	4	0	0	96	26
	Abundance / Biomass	4	0	0	96	26
Mediterranean Sea	Distribution	0	24	0	76	41
	Population Size	0	22	0	78	41
	Population Condition	0	24	0	76	41
	Species Composition	0	50	0	50	12
	Abundance / Biomass	0	50	0	50	12

Based on species composition and abundance/biomass of marine mammal populations in the Mediterranean Sea (which each are the only indicators not to have more than 50 % insufficient information ('unknown')), this is taken to indicate that the outlook for mammals is stable, and hence the future direction of change of capacity of the Mediterranean Sea ecosystem to supply the service 'whale-watching' is stable, and given its current state of service supply is bad, this would indicate the future state of the capacity of the ecosystem to deliver the service is: bad state, stable trend (Table AII.27bis). See Table AII.7 for potential scenarios that arrive at different outcomes for future service supply capacity.

Table AII.27bis Summary of current and future state and change in the capacity of the ecosystem to supply the service recreation and leisure from whale watching in the Mediterranean Sea, where the colour refers to the state (green = good, pink = bad, no colour = unable to assess), as determined using the majority approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

Ecosystem Service	Critical ecosystem component (s)	Current capacity for service supply	Future capacity for service supply	Confidence in the assessment
Recreation and leisure from whale watching	Whales relevant for whale watching	(Deteriorating)	(Stable)	Step / Confidence Step 5.A (i): red Step 5.A (ii): red

Mediterranean Sea (NEA cannot be assessed)

Step 5.A (i) Confidence in the information source

The confidence in the type of information is low as the data is an aggregation of marine mammals (and so includes seals as well as whales). In addition, there is a high proportion of 'insufficient information' in the region.

Step 5.A (ii) Interpretation of the changes in ecosystem state relative to the potential change in service supply

The prediction that the service will be in a 'bad' state and 'stable' in the future is high for state as it is unlikely the state of whales will move into a 'good' state, but low for the trend as only 50 % of two indicators show a 'stable' trend, therefore there is a high proportion of 'insufficient information'.

Step 5	**Assessing Future Change in Service Supply Capacity**
5.C	Using pressure as a proxy to assess future trends where pressure needs to be identified

As described above, predicted future trends are given for marine mammal populations in the MSFD, however these were unknown for the NEA, thus a different approach using pressures as a proxy for future trends in whale populations will be used. As the main pressures affecting whales have not been identified as part of the current assessment, a number of steps need to be carried out, and these are described below. Although a future outlook for Mediterranean Sea whale populations are given, the same approach is shown here for both regions for comparison purposes.

Step 5	**Assessing Future Change in Service Supply Capacity**
5.C	Using pressure as a proxy to assess future trends where pressure needs to be identified
5.C.1	Identify the critical pressure on the ecosystem component – from literature or reporting; identify what the major threat is to the component.

Identify the critical pressure on whales

The approach, following the critical pathway analysis, is to take the most critical pressure on whale populations. Reporting from the IUCN was used to identify the most important threats (although these are not quantitatively reported) and thus a critical threat per species (Table AII.28). Reporting on these threats in EU and other law and policy is then used as part of the assessment.

Table AII.28 IUCN reporting on most important threats to whale species (for specific sources for each species see Table AII.11)

Species	Main threats	
	Region	
	NEA	MED
Minke Whales *Balaenoptera acutorostrata*	Whaling (outside of EU region)	
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Incidental catches/by-catch	
Common bottlenose dolphin *Tursiops truncatus*	Hunting, Incidental catches/by-catch, and habitat degradation	Incidental catches/by-catch and the reduced availability of key prey
Cuvier's Beaked Whale *Ziphius cavirostris*	Loss of prey species	Underwater noise
Harbour porpoise *Phocoena phocoena*	Incidental catches/by-catch	
Long-finned pilot whale *Globicephala melas*	Incidental catches/by-catch	Pathogens/parasites
Northern bottlenose *Hyperoodon ampullatus*	Underwater noise	
Risso’s dolphin *Grampus griseus*	Incidental catches/by-catch	Incidental catches/by-catch
Sei whale *Balaenoptera borealis*	Whaling (outside of EU region), trend unknown (IUCN)	
Short-beaked common dolphin *Delphinus delphis*	Incidental catches/by-catch	Climate change and combined human impacts (Loss of prey species and habitat degradation)
Sowerby's beaked whale *Mesoplodon bidens*	Unknown – Incidental catches/by-catch / underwater noise	
Striped dolphin *Stenella coeruleoalba*	Incidental catches/by-catch	Pathogens/parasites
The Fin whale *Balaenoptera physalus*	Ship strikes	Ship strikes and underwater noise
The humpback whale *Megaptera novaeangliae*	Incidental catches/by-catch and ship strikes	
The killer whale *Orcinus orca*	Persecution and hazardous substances	Persecution and hazardous substances
The sperm whale *Physeter catodon*	Incidental catches/by-catch	Incidental catches/by-catch
True's beaked whale *Mesoplodon mirus*	Incidental catches/by-catch	
White-beaked dolphin *Lagenorhynchus albirostris*	Incidental catches/by-catch	

Following Table AII.28, this results in a total list of pressures:

- Whaling/hunting/Persecution (outside of EU region)
- Incidental catches/by-catch
- Habitat degradation
- Loss of prey species
- Underwater noise
- Pathogens/parasites
- Climate change
- Ship strikes
- Hazardous substances

Step 5.C.1 Confidence in the identification of the major threats to the component:

The major threat information used was species specific leading to high confidence, however the information was not quantitative and therefore the certainty that a particular threat was the greatest threat was moderate.

There is moderate confidence in this step.

Step	**Confidence**
Step 5.C.1	

Step 5.2.2 Identify relevant policies/laws where there is reporting on the critical pressure (s)

Step 5	**Assessing Future Change in Service Supply Capacity**
5.C	Using pressure as a proxy to assess future trends where pressure needs to be identified
5.C.2	Identify relevant policies/laws where there is reporting on the critical pressure (s)

Pressure on whale populations is reported for whales (or mammals) in several policies/laws (see Table AII.29 for a summary).

Table AII.29 Summary of pressure information relevant for whale populations collected in policy

Regional Relevance	Policy	Indicators Reported
EU	MSFD	Reporting for Pressures and Impacts on Biodiversity (Descriptor 1)
	Common Fisheries Policy (CFP)	Marine mammal species caught as by-catch
Regional	OSPAR Biological Diversity and Ecosystems Strategy	4 threatened species monitored, pressures on cetaceans recorded
	ACCOBAMS	Description of information known on whale populations, trends and pressures

Step 5	Assessing Future Change in Service Supply Capacity
5.C	Using pressure as a proxy to assess future trends where pressure needs to be identified
5.C.3	Synthesise the indicators of the pressure(s) from the different policies/laws

The pressures can be called under different names in different policies/laws. Following the list of critical pressures above (Table AII.28), a synthesis of pressures is presented here which identified the pressures mentioned in each relevant policy (Table AII.29) and grouped them under common names or types of pressures (Table AII.30).

Table AII.30 Synthesis of the names of different pressures from different policies/laws

Name of Indicator	Corresponding name used in Table AII.28	EU and Other Law and Policy			
		MSFD	CFP	OSPAR	ACCOBAMS
Climate change	Climate change	-	-	Climate change	
Underwater noise	Underwater noise	Other physical disturbance which includes Underwater noise	-	Underwater noise	Noise pollution
Ship Strikes	Ship Strikes	Other physical disturbance which includes death or injury by ship strikes	-	Death or injury by ship strikes	
Hazardous substances	Hazardous substances	Contamination by hazardous substances	-	Hazardous substances	
Removal of target and non-target species	Incidental catches/ by-catch	Biological disturbance which includes selective extraction of species, including incidental non-target catches	Accidental by-catch of marine mammals	Removal of target and non-target species	Including: harvesting, accidental mortality, persecution
Loss of prey species	Loss of prey species	Biological disturbance which includes extraction of species: fish & shellfish	-	Loss of prey species	Changes in native species dynamics: prey/food base
Habitat Loss	Habitat degradation	Physical loss and Physical damage	-	Habitat Loss	Habitat loss/degradation
Pathogens/ parasites	Pathogens/ parasites	Biological disturbance which includes introduction of microbial pathogens	-	-	Changes in native species dynamics: pathogens/ parasites
Threats outside EU areas	Whaling/ hunting/ Persecution (outside of EU region)	-	-	-	-

Step 5.2.4 Report the trends (future or current assumed to continue in the future) for each pressure from each policy

Step 5	**Assessing Future Change in Service Supply Capacity**
5.C	Using pressure as a proxy to assess future trends where pressure needs to be identified
5.C.4	Report the trends (future or current assumed to continue in the future) for each pressure from each law/policy

Once the pressures relevant for individual whale species have been identified, the trends in these pressures are taken from where they are reported on in policy. In many cases, the pressures may not be reported on for the specific purposes of assessing threats to whales (although in some cases they are, e.g. marine mammal by-catch data collected for the CFP). However, once the main threats to whales have been identified, information on these threats reported in policies/laws can be used regardless of the original purpose of the information.

Below, each policy is taken in turn and the results of the relevant trends in pressures presented. In some cases current trends are given while in others the 'outlook' or future prediction of the trends is given. Where only current trends are given, these are assumed to continue on their current trajectory in the future and therefore represent future trends.

Where a range of classifications are reported by the policy (e.g. the MSFD), the most frequent classification is taken with the following rules applied:

- The most frequent classifications (increasing, stable or decreasing) are taken, except where more than 50 % is unknown/insufficient data.
- If the classification is equal between two assigned categories, the more conservative classification is taken.

MSFD

Habitat Loss – composed of the pressures Physical Loss and Physical Damage as reported under the MSFD

Physical Loss

The trend (and confidence in the assessment) in physical loss is presented for the Mediterranean Sea and for the NEA (Tables AII.31 and AII.32). For both regions there is 'insufficient information' to assessing a classification in either region (greater than 50 % 'insufficient information').

Table AII.31 Trends in the assessment of pressure level caused by physical loss reported on a regional level (from ETC/ICM, 2014b) with the most frequent classification highlighted in yellow

Regional Sea	Trend increasing	Trend stable	Trend decreasing	Insufficient Information	Area of reported national waters (km^2)
Mediterranean Sea	0	0	0	100	1,411,459
NE Atlantic Ocean	12	2	0	86	2,539,392

Table AII.32 Confidence level in the assessment of pressure level caused by physical loss reported on a regional level (from ETC/ICM, 2014b)

Regional Sea	Confidence high	Confidence moderate	Confidence low	Unknown	Not reported/ not assessed	Area of reported national waters (km²)
Mediterranean Sea	0	0	7	32	60	1,411,459
NE Atlantic Ocean	33	3	2	43	19	2,539,392

Physical Damage

The trend (and confidence in the assessment) in physical damage is presented for the Mediterranean Sea and for the NEA (Tables AII.33 and AII.34). For both regions there is 'insufficient information' to assessing a classification in either region.

Table AII.33 Trends in the assessment of level of pressure due to physical damage and corresponding area (km^2) for % area exposed (from ETC/ICM, 2014b) with the most frequent classification highlighted in yellow

Regional overview	Trend increasing	Trend stable	Trend decreasing	Insufficient Information	Area of reported national waters (km²)
Mediterranean Sea	0	0	0	100	1,411,459
NE Atlantic Ocean	12	0	3	85	2,539,392

Table AII.34 Confidence in the assessment of level of pressure due to physical damage and corresponding area (km^2) for % area exposed (from ETC/ICM, 2014b)

Regional overview	Confidence high	Confidence moderate	Confidence low	Confidence not relevant	Not reported/ not assessed	Area of reported national waters (km²)
Mediterranean Sea	0	0	12	32	56	1,411,459
NE Atlantic Ocean	33	4	35	9	19	2,539,392

No classification can be given for these two criteria (physical loss and physical damage) to give an overall classification of habitat loss as there is 'insufficient information'.

Loss of prey species (reported under the MSFD as extraction of species: fish & shellfish)

Only fish species were used, as it is unlikely that the reported shellfish form an important part of cetacean diet.

Fish

The trend (and confidence in the assessment) in extraction of fish is presented for the Mediterranean Sea (where there is 'insufficient information' to assess the trend) and for the NEA (where the classification is mostly 'stable' where known) (Tables AII.35 and AII.36). The most frequent classifications of the assigned categories are taken.

Table AII.35 Trend in the assessment of level of pressure due to extraction of species: Fish corresponding area (km^2) for % area exposed (from ETC/ICM, 2014b) with the most frequent classification highlighted in yellow

Regional overview	Trend increasing	Trend stable	Trend decreasing	Insufficient Information	Area of reported national waters (km^2)
Mediterranean Sea	0	25	0	75	1,411,459
NE Atlantic Ocean	0	42	13	44	2,539,392

Table AII.36. Confidence in the assessment of level of pressure due to extraction of species: Fish corresponding area (km^2) for % area exposed (from ETC/ICM, 2014b)

Regional overview	Confidence high	Confidence moderate	Confidence low	Confidence not relevant	Not reported/ not assessed	Area of reported national waters (km^2)
Mediterranean Sea	3	0	37	7	54	1,411,459
NE Atlantic Ocean	2	2	0	28	69	2,539,392

Underwater Noise

The trend (and confidence in the assessment) in underwater noise is presented for the Mediterranean Sea (where there is 'insufficient information' to assess the trend) and for the NEA (where the classification is mostly 'stable' where known) (Table AII.37 and AII.38). The most frequent classifications of the assigned categories are taken.

Table AII.37 Trend in the assessment of level of pressure due to underwater noise corresponding area (km^2) for % area exposed (from ETC/ICM, 2014b) with the most frequent classification highlighted in yellow.

Regional overview	Trend increasing	Trend stable	Trend decreasing	Insufficient Information	Area of reported national waters (km^2)
Mediterranean Sea	8	0	0	92	1,411,459
NE Atlantic Ocean	21	34	10	35	2,539,392

Table AII.38 Confidence in the assessment of level of pressure due to underwater noise corresponding area (km²) for % area exposed (from ETC/ICM, 2014b)

Regional Sea	Confidence high	Confidence moderate	Confidence low	Confidence not relevant	Not reported/ not assessed	Area of reported national waters (km²)
Mediterranean Sea	0	0	43	0	57	1,411,459
NE Atlantic Ocean	0	0	21	0	79	2,539,392

Hazardous substances (reported as non-synthetic substances and synthetic substances under the MSFD)

Note that radionuclide substances, although also reported under hazardous substances for the MSFD, were not included since there is no known impact of these on cetaceans (OSPAR, 2010).

Non-synthetic substances

The trend (and confidence in the assessment) in non-synthetic substances is presented for the Mediterranean Sea (where there is 'insufficient information' to assess the trend) and for the NEA (where the classification is mostly 'decreasing' where known) (Table AII.39 and AII.40). The most frequent classification of the assigned categories is taken.

Table AII.39 Trend in the assessment of level of pressure due to non-synthetic substances corresponding area (km²) for % area exposed (from ETC/ICM, 2014b) with the most frequent classification highlighted in yellow

Regional overview	Trend increasing	Trend stable	Trend decreasing	Insufficient Information	Area of reported national waters (km²)
Mediterranean Sea	0	25	0	75	1,411,459
NE Atlantic Ocean	2	0	51	47	2,539,392

Table AII.40 Confidence in the assessment of level of pressure due to non-synthetic substances corresponding area (km²) for % area exposed (from ETC/ICM, 2014b)

Regional Sea	Confidence high	Confidence moderate	Confidence low	Confidence not relevant	Not reported/ not assessed	Area of reported national waters (km²)
Mediterranean Sea	0	25	2	7	66	1,411,459
NE Atlantic Ocean	2	3	34	42	19	2,539,392

Synthetic substances

The trend (and confidence in the assessment) in synthetic substances is presented for the Mediterranean Sea and NEA (Table AII.41 and AII.42). For both regions there is insufficient information to assess the trend.

Table AII.41 Trend in the assessment of level of pressure due to synthetic substances corresponding area (km^2) for % area exposed (from ETC/ICM, 2014b) with the most frequent classification highlighted in yellow

Regional overview	Trend increasing	Trend stable	Trend decreasing	Insufficient information	Area of reported national waters (km^2)
Mediterranean Sea	0	5	5	90	1,411,459
NE Atlantic Ocean	0	3	38	59	2,539,392

Table AII.42 Confidence in the assessment of level of pressure due to synthetic substances corresponding area (km^2) for % area exposed (from ETC/ICM, 2014b)

Regional overview	Confidence high	Confidence moderate	Confidence low	Confidence not relevant	Not reported/ not assessed	Area of reported national waters (km^2)
Mediterranean Sea	0	5	7	22	66	1,411,459
NE Atlantic Ocean	0	5	0	76	19	2,539,392

These two criteria (synthetic and non-synthetic substances) need to be combined into an overall classification of hazardous substances. For the Mediterranean Sea, no assessment can be made, as there was ‘insufficient information’. For the NEA, there was ‘insufficient information’ for synthetic substances but non-synthetic substances were found to be ‘decreasing’. An overall trend of ‘decreasing’ was therefore taken as the overall classification for the NEA, however this has low confidence since the trend in synthetic substances is not known.

CFP

CFP accidental by-catch reporting indicates the rates of mammal by-catch in parts of the NEA and Mediterranean Sea (http://www.eea.europa.eu/data-and-maps/indicators/accidental-by-catch-birds-mammals).

- The rate of accidental by-catch of mammals in the Mediterranean and North seas demonstrate a negative impact of fisheries on the marine ecosystem.
- The rate of accidental catch of porpoises in the North Sea has remained stable for the period 1990–1997
- The rate of accidental catch of mammals in the Western Mediterranean increased by 130 % between the years 1999–2000

Thus, for the NEA, the rates of harbour porpoise by-catch are assumed to be 'stable' (assuming trends are still the same and will continue to be the same) and for the Mediterranean Sea, the rates of cetacean by-catch are assumed to be 'increasing' for all species (assuming trends are still the same and will continue to be the same).

Confidence in the CFP data is considered low, as the trends reported are old.

OSPAR

Threats identified as affecting whale populations are identified in OSPAR (2010) with trends of whether they will 'increase' or 'decrease' in the future (where known) (Table AII.43). Trends from OSPAR come from text descriptions of each pressure dealt with individually or from assessment of the key issues in the quality status report.

Table AII.43 Outlook for pressures on cetacean populations as described in OSPAR (2010)

Pressure	Changes	Outlook
Climate Change	Sea-ice loss, Sea temperature rise and acidification all expected to increase in all OSPAR regions. Range shifts of fish species and plankton/food web changes unknown in all regions.	Increasing
Hazardous Substances	Expected to increase in Region I and unknown in all other OSPAR regions but problems currently in all regions	Increasing/unknown
Fishing (contributing to Removal of target and non-target species and Loss of prey species, Death or injury by ship strikes)	Pressure overall expected to decrease in all regions except Region V where the outlook is unknown. Impacts include damage to seabed, deep-sea species, status of stocks including cod, whiting, sole, herring, Bluefin tuna, anchovy and mixed fisheries, discards, by-catch of marine mammals	Decreasing/unknown
Noise (from a variety of sources including construction, oil & gas, shipping, wind farms, sand & gravel extraction, dredging & dumping, dumped munitions,	Overall, noise is increasing and expected to continue to increase. OSPAR Regions II and II most affected	Increasing
Death or injury by ship strikes (due to shipping)	Shipping is expected to increase in Regions I and II but predictions are difficult due to socio-economic factors.	Increasing
Habitat Loss	could result from a number of sources including the combination of the above listed threats	Unknown
Threats outside the OSPAR area	Similar issues face whales worldwide and as whales are migratory, impacts outside of the EU region may affect the same population	Unknown

ACCOBAMS

The ACCOBAMS (Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and contiguous Atlantic area (http://www.accobams.org/) report compiles a list of pressures and the likely impact of these on different whale species and in the discussion of these, indicates whether these pressures may be 'increasing' or 'decreasing' (although this is not exhaustive). Trends are indicated in summary Tables AII.44, 45.

Step 5.C.3 and 5.C.4 Confidence in the information sources used:

A number of factors are relevant for the assessment of confidence in the information sources used:

- Information from policies/laws is reported at different scales (e.g. MSFD: regional sea, OSPAR: OSPAR regions which extend beyond the regional sea)
- Even where assigned, much of the MSFD data had large proportions of the area with 'insufficient information' to assess the whole region
- Trends are compared across the different information sources although these have been collected over different time periods (e.g. CFP and MSFD) and are applied at different spatial scales
- CFP data is not recent

Given these sources of uncertainty, the confidence is assigned as moderate in this step. This assessment is given for both regions.

Step 5	**Assessing Future Change in Potential Service Supply**
5. C	Using pressure as a proxy to assess future trends where pressure needs to be identified
5. C.5	Carry out an overall assessment

The trend in each of the relevant pressures for each whale species from each policy is summarised in Table AII.44 (a–b) for each region. Each pressure outcome for each policy is given separately. The outcomes are presented as trends towards improving quality or deteriorating quality of ecosystem state i.e. using the pressure trends to infer changes in ecosystem state. In this way, the arrows shown may seem counter intuitive as an increasing pressure is represented with a ↓ however, this is done to show what the pressure trend represents for the ecosystem component in question and an increasing pressure represents decreasing quality of whale populations. An overall trend classification for each pressure for each species is then given in the final two columns of the table.

The majority approach of aggregating the trends is shown below, with the conservative approach shown separately. Where there was more than one critical threat, the majority/conservative approach was taken firstly across policies/laws and then across pressures. A confidence assessment was carried out and where there were several critical pressures, the lowest confidence score was used.

Table AII.44 The overall trends and confidence in assessment for each pressure on the relevant whale species reported under each policy for (a) the North East Atlantic, and (b) the Mediterranean Sea as determined using the majority approach. Note: Trends given in OSPAR and ACCOBAMS are 'outlooks' for future pressure trends while MSFD and CFP are current (or past) trends, which are assumed to continue. Note that while the MSFD in principle reports future trends for pressures, in reality, future trends were not available for this period because very few Member States had reported them and there was no consistency at the EU level. Pressure outcomes per policy are presented as trends towards improving quality or deteriorating quality of ecosystem state and so an increasing pressure is represented with a ↓ to show that the pressure trend represents a deterioration of the quality

Legend

	Unknown
↑	Improving
↔	Stable
↓	Deteriorating

(a) North East Atlantic Ocean

		EU and Other Law and Policy			Majority		Confidence	
Species	**Pressure Metric**	**Marine Strategy Framework Directive**	**CFP**	**OSPAR**	**Pressure**	**Outlook for Whales**	**Pressure**	**Outlook for Whales**
Minke Whales *Balaenoptera acutorostrata*	Threats outside EU areas							
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Removal of target and non-target species			↑	↑	↑	Low	Low
Common bottlenose dolphin *Tursiops truncatus*	Threats outside EU areas							
	Removal of target and non-target species			↑	↑	↑	Low	Low
	Habitat Loss							
Cuvier's Beaked Whale *Ziphius cavirostris*	Loss of prey species	↔		↑	↑	↑	Low	Low
Harbour porpoise *Phocoena phocoena*	Removal of target and non-target species		↔	↑	↑	↑	Low	Low
Long-finned pilot whale *Globicephala melas*	Removal of target and non-target species			↑	↑	↑	Low	Low
Northern bottlenose *Hyperoodon ampullatus*	Underwater noise	↔		↓	↔	↔	Low	Low
Risso's dolphin *Grampus griseus*	Removal of target and non-target species			↑	↑	↑	Low	Low
Sei whale *Balaenoptera borealis*	Threats outside EU areas							
Short-beaked common dolphin *Delphinus delphis*	Removal of target and non-target species			↑	↑	↑	Low	Low
Sowerby's beaked whale *Mesoplodon bidens*	Removal of target and non-target species			↑	↑	↑	Low	Low
	Underwater noise	↔		↓	↔		Low	
Striped dolphin *Stenella coeruleoalba*	Removal of target and non-target species			↑	↑	↑	Low	Low
The Fin whale *Balaenoptera physalus*	Ship strikes			↓	↓	↓	Low	Low
The humpback whale *Megaptera novaeangliae*	Removal of target and non-target species			↑	↑	↑	Low	Low
	Ship strikes			↓	↓		Low	
The killer whale *Orcinus orca*	Threats outside EU areas							
	Hazardous substances	↑		↓	↑	↑	Low	Low
The sperm whale *Physeter catodon*	Removal of target and non-target species			↑	↑	↑	Low	Low
True's beaked whale *Mesoplodon mirus*	Removal of target and non-target species			↑	↑	↑	Low	Low
White-beaked dolphin *Lagenorhynchus albirostris*	Removal of target and non-target species			↑	↑	↑	Low	Low

Table AII.44 Cont.

(b) Mediterranean Sea

Species	Pressure Metric	EU and Other Law and Policy: Marine Strategy Framework Directive	EU and Other Law and Policy: CFP	EU and Other Law and Policy: ACCOBA MS	Majority: Pressure	Majority: Outlook for Whales	Confidence: Pressure	Confidence: Outlook for Whales
Common bottlenose dolphin *Tursiops truncatus*	Removal of target and non-target species		↓		↓	↓	Low	Low
	Loss of prey species							
Cuvier's Beaked Whale *Ziphius cavirostris*	Underwater noise							
Long-finned pilot whale *Globicephala melas*	Pathogens/parasites							
Risso's dolphin *Grampus griseus*	Removal of target and non-target species		↓		↓	↓	Low	Low
Short-beaked common dolphin *Delphinus delphis*	Climate change			↓	↓	↓	Low	Low
	Loss of prey species							
	Habitat Loss							
Striped dolphin *Stenella coeruleoalba*	Pathogens/parasites							
The Fin whale *Balaenoptera physalus*	Ship strikes			↓	↓	↓	Low	Low
	Underwater noise						Low	
The killer whale *Orcinus orca*	Threats outside EU areas					↑		Low
	Hazardous substances			↑	↑		Low	
The sperm whale *Physeter catodon*	Removal of target and non-target species		↓		↓	↓	Low	Low

Step 5.C.5 Confidence in the aggregation of different law/policy outcomes is given for each metric in the tables above (majority approach).

For both the NEA and the Mediterranean Sea, the confidence was low in the aggregation of pressure trends for each species.

The overall confidence for steps 5.C.3, 4 and 5 is given i.e. a combination of the confidence in the sources of information (which was given as moderate for all regions) with the confidence on the aggregation of the law/policy outcomes. The lowest confidence score is taken forward for the overall assessment. As the confidence was low in the aggregation of pressure trends for every species, the confidence is low overall

NEA

Step	**Confidence**
Step 5.C.1	
Step 5.C.3/4 and 5	

Mediterranean Sea

Step	**Confidence**
Step 5.C.1	
Step 5.C.3/4 and 5	

Conservative Approach

Table AII.45 The overall trends and confidence in assessment for each pressure on the relevant whale species reported under each policy for (a) the North East Atlantic, and (b) the Mediterranean Sea as determined using the conservative approach. Note: Trends given in OSPAR and ACCOBAMS are 'outlooks' for future pressure trends while MSFD and CFP are current (or past) trends which are assumed to continue. Note that while the MSFD in principle reports future trends for pressures, in reality, future trends were not available for this period because very few Member States had reported them and there was no consistency at the EU level. Pressure outcomes per policy are presented as trends towards improving quality or deteriorating quality of ecosystem state and so an increasing pressure is represented with a ↓ to show that the pressure trend represents a deterioration of the quality

Legend

(grey)	Unknown
↑	Improving
↔	Stable
↓	Deteriorating

(a) North East Atlantic

		EU and Other Law and Policy			Conservative		Confidence	
Species	Pressure Metric	Marine Strategy Framework Directive	CFP	OSPAR	Pressure	Outlook for Whales	Pressure	Outlook for Whales
Minke Whales *Balaenoptera acutorostrata*	Threats outside EU areas							
Atlantic white-sided dolphin *Lagenorhynchus acutus*	Removal of target and non-target species			↑	↑	↑	Low	Low
	Threats outside EU areas							
Common bottlenose dolphin *Tursiops truncatus*	Removal of target and non-target species			↑	↑	↑	Low	Low
	Habitat Loss							
Cuvier's Beaked Whale *Ziphius cavirostris*	Loss of prey species	↔		↑	↔	↔	Low	Low
Harbour porpoise *Phocoena phocoena*	Removal of target and non-target species		↔	↑	↔	↔	Low	Low
Long-finned pilot whale *Globicephala melas*	Removal of target and non-target species			↑	↔	↔	Low	Low
Northern bottlenose *Hyperoodon ampullatus*	Underwater noise	↔		↓	↓	↓	Low	Low
Risso's dolphin *Grampus griseus*	Removal of target and non-target species			↑	↑	↑	Low	Low
Sei whale *Balaenoptera borealis*	Threats outside EU areas							
Short-beaked common dolphin *Delphinus delphis*	Removal of target and non-target species			↑	↑	↑	Low	Low
Sowerby's beaked whale *Mesoplodon bidens*	Removal of target and non-target species			↑	↑	↓	Low	Low
	Underwater noise	↔		↓	↓		Low	
Striped dolphin *Stenella coeruleoalba*	Removal of target and non-target species			↑	↑	↑	Low	Low
The Fin whale *Balaenoptera physalus*	Ship strikes			↓	↓	↓	Low	Low
The humpback whale *Megaptera novaeangliae*	Removal of target and non-target species			↑	↑	↓	Low	Low
	Ship strikes			↓	↓		Low	
The killer whale *Orcinus orca*	Threats outside EU areas							
	Hazardous substances	↑		↓	↓	↓	Low	Low
The sperm whale *Physeter catodon*	Removal of target and non-target species			↑	↑	↑	Low	Low
True's beaked whale *Mesoplodon mirus*	Removal of target and non-target species			↑	↑	↑	Low	Low
White-beaked dolphin *Lagenorhynchus albirostris*	Removal of target and non-target species			↑	↑	↑	Low	Low

Table AII.45 Cont.

(b) Mediterranean Sea

		EU and Other Law and Policy			Conservative		Confidence	
Species	Pressure Metric	Marine Strategy Framework Directive	CFP	ACCOBAMS	Pressure	Outlook for Whales	Pressure	Outlook for Whales
Common bottlenose dolphin *Tursiops truncatus*	Removal of target and non-target species		↓		↓	↓	Low	Low
	Loss of prey species							
Cuvier's Beaked Whale *Ziphius cavirostris*	Underwater noise							
Long-finned pilot whale *Globicephala melas*	Pathogens/parasites							
Risso's dolphin *Grampus griseus*	Removal of target and non-target species		↓		↓	↓	Low	Low
Short-beaked common dolphin *Delphinus delphis*	Climate change			↓	↓	↓	Low	Low
	Loss of prey species							
	Habitat Loss							
Striped dolphin *Stenella coeruleoalba*	Pathogens/parasites							
The Fin whale *Balaenoptera physalus*	Ship strikes			↓	↓	↓	Low	Low
	Underwater noise				↓		Low	
The killer whale *Orcinus orca*	Threats outside EU areas					↑		Low
	Hazardous substances			↑	↑		Low	
The sperm whale *Physeter catodon*	Removal of target and non-target species		↓		↓	↓	Low	Low

Step 5.C.5 Confidence in the aggregation of different law/policy outcomes is given for each metric in the tables above (conservative approach).

For both the NEA and the Mediterranean Sea, the confidence was low in the aggregation of pressure trends for each species.

The overall confidence for steps 5.C.3, 4 and 5 is given i.e. a combination of the confidence in the sources of information (which was given as moderate for all regions) with the confidence on the aggregation of the law/policy outcomes. The lowest confidence score is taken forward for the overall assessment. As the confidence was low in the aggregation of pressure trends for every species, the confidence is low overall

NEA

Step	Confidence
Step 5.C.1	
Step 5.C.3/4 and 5	

Mediterranean Sea

Step	Confidence
Step 5.C.1	
Step 5.C.3/4 and 5	

Step 5	Assessing Future Change in Service Supply Capacity
5. C	Using pressure as a proxy to assess future trends where pressure needs to be identified
5. C.6	Based on the state-service relationship and the assessment of pressure trends, determine the future state (if possible) and change in the capacity of the ecosystem to supply the ecosystem service

The future trend of the capacity of the ecosystem to provide the service recreation and leisure from whale watching is assumed to have a direct relationship with whale populations. This in turn is assumed to be directly related to the pressures which have been identified as the critical pressures affecting particular species of whales. For this, we assume a simple relationship in the pressure-state relationship (between the pressure and whale populations). As we do not know the specific type of relationship, nor by how much the pressure is changing and what effect this would have on the whale populations, a simple relationship is assumed i.e. if the pressure is decreasing (or quality is increasing), the whale population is expected to increase, and the service is expected to increase. It is also assumed that where current pressure trends have been used, that these trends will continue on this trajectory in the future, although this may not be the case. As described in Step 2, the state-service relationship for future trends can lead to a number of potential outcomes (Table AII.7) and in some cases this can be used to predict the future state as well as the trend, but in other cases the future state is unknown as the degree of change in pressure and the type of relationship between the state of whale populations and the pressures are unknown. The future of the capacity of each whale species to deliver the service 'whale watching' is summarised in Table AII.46.

Table AII.46 The future outcomes of the capacity of each whale species to deliver the service recreation and leisure from whale watching based on current state, recent trends and trends in pressures, following the majority approach. The 'current and recent trends' are based on the results from Table AII. 18 and the 'outlook for whales' is based on the results from Table AII.44. These are given for (a) the North East Atlantic and (b) the Mediterranean Sea. Confidence is not shown as it was low in all cases

Legend

	Fail to meet policy objectives
	Achieve policy objectives
↑	Future whale population increasing
↔	Future whale population stable
↓	Future whale population decreasing
↑	Improving trend
↔	Stable trend
↓	Deteriorating Trend

(a) North East Atlantic Ocean

Species	Majority				
	Current state and Direction of Change of Critical Ecosystem Components	Current Assessment of Service Supply Capacity and Direction of Change	Outlook for Whales	Future Direction of Change of Service	Future State of Service Capacity
Atlantic white-sided dolphin *Lagenorhynchus acutus*			↑	↑	
Common bottlenose dolphin *Tursiops truncatus*			↑	↑	
Cuvier's Beaked Whale *Ziphius cavirostris*			↑	↑	
Harbour porpoise *Phocoena phocoena*	↑	↑	↑	↑	
Long-finned pilot whale *Globicephala melas*			↑	↑	
Minke Whales *Balaenoptera acutorostrata*	↑	↑			
Northern bottlenose *Hyperoodon ampullatus*			↔	↔	
Risso's dolphin *Grampus griseus*			↑	↑	
Sei whale *Balaenoptera borealis*					
Short-beaked common dolphin *Delphinus delphis*			↑	↑	
Sowerby's beaked whale *Mesoplodon bidens*			↑	↑	
Striped dolphin *Stenella coeruleoalba*			↑	↑	
The Fin whale *Balaenoptera physalus*	↑	↑	↓	↓	
The humpback whale *Megaptera novaeangliae*	↑	↑	↑	↑	
The killer whale *Orcinus orca*			↑	↑	
The sperm whale *Physeter catodon*			↑	↑	
True's beaked whale *Mesoplodon mirus*			↑	↑	
White-beaked dolphin *Lagenorhynchus albirostris*			↑	↑	

Table AII.46 Cont.

(b) Mediterranean Sea

Species	Majority				
	Current state and Direction of Change of Critical Ecosystem Components	**Current Assessment of Service Supply Capacity and Direction of Change**	**Outlook for Whales**	**Future Direction of Change of Service**	**Future State of Service Capacity**
Common bottlenose dolphin *Tursiops truncatus*	↓	↓	↓	↓	
Cuvier's Beaked Whale *Ziphius cavirostris*	↔	↔	↓	↓	
Long-finned pilot whale *Globicephala melas*					
Risso's dolphin *Grampus griseus*			↓	↓	
Short-beaked common dolphin *Delphinus delphis*	↓	↓	↓	↓	
Striped dolphin *Stenella coeruleoalba*	↓	↓			
The Fin whale *Balaenoptera physalus*	↓	↓	↓	↓	
The killer whale *Orcinus orca*	↓	↓	↑	↑	
The sperm whale *Physeter catodon*	↓	↓	↓	↓	

Overall assessment of the service recreation and leisure from whale watching

The trend in the majority of whale species is taken as the overall trend. If there were 50 % 'improving and 50 % 'deteriorating, this would be taken as a 'stable' trend since the type of species is not necessarily important to the activity of whale watching and all species are assumed to have equal importance to the activity of whale watching.

NEA

A summary of the future states and change in the capacity to supply the service recreation and leisure from whale watching are shown in Table AII.48 and the current and future trends of capacity to the supply the service by whale species are presented for the NEA in Table AII.47 with the description of how future trends were determined below.

Table AII.47 Summary of results and confidence classifications for future state and direction of change in capacity to supply of the service recreation and leisure from whale watching in the NEA, as determined using the majority approach

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Good	50	0	0	9
	Bad	0			
	Unknown	50			
Direction of change	Improve	78	0	0	14
	Stable	6	0	0	1
	Deteriorate	0			
	Unknown	17			

Results following the majority approach: 14 out of 18 species (78 %) expected to 'improve (1 'stable', 0 'deteriorate' and 3 'unknown') and 9 out 18 species (50 %) expected to be in a 'good' state (with 50 % 'unknown') leading to the conclusion that this service is expected to '**improve'** overall in the future and have a '**good'** state (Table AII.48).

Step 5.C.6 Confidence in translating ecosystem state to the capacity to supply a service: NEA

Based on the metrics, the confidence is high that this translates to improving capacity to supply the service since 78 % of the species were found to potentially 'improve'. The confidence that the state would be 'good' is moderate since 50 % are 'unknown' (Table AII.47). The lowest of these is taken giving an overall moderate confidence in this step.

Step	Confidence
Step 5.C.1	(yellow)
Step 5.C.3/4 and 5	(red)
Step 5.C.6	(yellow)

Table AII.48 Summary of current and future state and change in the capacity of the ecosystem to supply the service recreation and leisure from whale watching in the North East Atlantic, where the colour refers to the state (green = good, pink = bad, no colour = unable to assess), as determined using the majority approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

Ecosystem Service	Critical component (s)	Current Assessment	Future Assessment	Confidence
Recreation and leisure from whale watching	Whale species relevant for whale watching	Unable to assess	Improving	Step: Confidence Step 1: red Step 2: green Step 3: red Step 4: yellow Step 5.C.1: yellow Step 5.C.3/4 and 5: red Step 5.C.6: yellow

Mediterranean Sea

A summary of the future states and change in the capacity to supply the service recreation and leisure from whale watching are shown in Table AII.50 and the current and future trends for whale species are presented for the Mediterranean Sea in Table AII.49 with the description of how future trends were determined below.

Table AII.49 Summary of results and confidence classifications for future state and direction of change in capacity to supply the service recreation and leisure from whale watching in the Mediterranean Sea, as determined using the majority approach

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Good	0			
	Bad	67	0	0	6
	Unknown	33			
Direction of change	Improve	11	0	0	1
	Stable	0			
	Deteriorate	67	0	0	6
	Unknown	22			

Results following the majority approach: 6 out of 9 species (67 %) expected to ‘deteriorate’ (0 ‘stable’, 1 ‘improve’ and 2 ‘unknown’) leading to the conclusion that this service is expected to ‘**deteriorate’** overall in the future. For the state, 6 out 9 species (67 %) are expected to be in a ‘**bad’** state in the future. There is low confidence in this assessment for both state and trend (Table AII.50).

Step 5.C.6 Confidence in translating ecosystem state to the capacity to supply a service: Mediterranean Sea

Based on the metrics, the confidence that this translates to a 'bad' capacity to supply the service and which is 'deteriorating' is high since 67 % of the species were found to potentially 'deteriorate' and be in a 'bad' state.

Step	Confidence
Step 5.C.1	
Step 5.C.3/4 and 5	
Step 5.C.6	

Table AII.50 Summary of current and future state and change in the capacity of the ecosystem to supply the service recreation and leisure from whale watching in the Mediterranean Sea, where the colour refers to the state (green = good, pink = bad, no colour = unable to assess), as determined using the majority approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

Ecosystem Service	Critical component (s)	Current Assessment	Future Assessment	Confidence
Recreation and leisure from whale watching	Whale species relevant for whale watching	Deteriorating	Deteriorating	see table below

Step	Confidence
Step 1	
Step 2	
Step 3	
Step 4	
Step 5.C.1	
Step 5.C.3/4 and 5	
Step 5.C.6	

The Mediterranean Sea results disagree with the overall assessment for marine mammal populations as carried out under the MSFD (ETC/ICM, 2014a). Only aggregated data are available (including seals), therefore, the reasons for these differences cannot be established at this time.

Conservative Approach

Table AII.51 The future outcomes of the capacity of each whale species to deliver the service recreation and leisure from whale watching based on current state, recent trends and trends in pressures, following the conservative approach. The 'current and recent trends' are based on the results from Box AII.1 and the 'outlook for whales' is based on the results from Table ALII.45. These are given for (a) the North East Atlantic and (b) the Mediterranean Sea. Confidence is not shown, as it was low in all cases.

Legend

	Fail to meet objectives
	Achieve objectives
↑	Future whale population increasing
↔	Future whale population stable
↓	Future whale population decreasing
	Good future capacity of system to deliver service
	Bad future capacity of system to deliver service
↑	Improving trend
↔	Stable trend

(a) North East Atlantic

Species	Conservative				
	Current state and Direction of Change of Critical Ecosystem Components	**Current Assessment of Service Supply Capacity**	**Outlook for Whales**	**Future Direction of Change of Service**	**Future State of Service Capacity**
Minke Whales *Balaenoptera acutorostrata*	↔	↔			
Atlantic white-sided dolphin *Lagenorhynchus acutus*			↑	↑	
Common bottlenose dolphin *Tursiops truncatus*			↑	↑	
Cuvier's Beaked Whale *Ziphius cavirostris*			↔	↔	
Harbour porpoise *Phocoena phocoena*	↑	↑	↔	↔	
Long-finned pilot whale *Globicephala melas*			↔	↔	
Northern bottlenose *Hyperoodon ampullatus*			↓	↓	
Risso's dolphin *Grampus griseus*			↑	↑	
Sei whale *Balaenoptera borealis*					
Short-beaked common dolphin *Delphinus delphis*			↑	↑	
Sowerby's beaked whale *Mesoplodon bidens*			↓	↓	
Striped dolphin *Stenella coeruleoalba*			↑	↑	
The Fin whale *Balaenoptera physalus*	↑	↑	↓	↓	
The humpback whale *Megaptera novaeangliae*	↑	↑	↓	↓	
The killer whale *Orcinus orca*			↓	↓	
The sperm whale *Physeter catodon*			↑	↑	
True's beaked whale *Mesoplodon mirus*			↑	↑	
White-beaked dolphin *Lagenorhynchus albirostris*			↑	↑	

(b) Mediterranean Sea

Species	Conservative				
	Current state and Direction of Change of Critical Ecosystem Components	**Current Assessment of Service Supply Capacity**	**Outlook for Whales**	**Future Direction of Change of Service**	**Future State of Service Capacity**
Common bottlenose dolphin *Tursiops truncatus*	↓	↓	↓	↓	
Cuvier's Beaked Whale *Ziphius cavirostris*	↔	↔	↓	↓	
Long-finned pilot whale *Globicephala melas*					
Risso's dolphin *Grampus griseus*			↓	↓	
Short-beaked common dolphin *Delphinus delphis*	↓	↓	↓	↓	
Striped dolphin *Stenella coeruleoalba*	↓	↓			
The Fin whale *Balaenoptera physalus*	↓	↓	↓	↓	
The killer whale *Orcinus orca*	↓	↓	↑	↑	
The sperm whale *Physeter catodon*	↓	↓	↓	↓	

Overall assessment of service recreation and leisure from whale watching (conservative approach)

The trend in the majority of species is taken as the overall trend. If there were 50 % 'increasing' and 50 % 'decreasing', this would be taken as a 'stable' trend since the type of species is not necessarily important to the activity of whale watching and all species are assumed to have equal importance to the activity of whale watching.

North East Atlantic

Table AII.52 Summary of results and confidence classifications for future state and direction of change in capacity to supply the service recreation and leisure from whale watching in the NEA, as determined using the conservative approach

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Good	33	0	0	5
	Bad	0			
	Unknown	67			
Direction of change	Increase	44	0	0	7
	Stable	17	0	0	3
	Decrease	28	0	0	6
	Unknown	11			

Results following the Conservative Approach: 8 out of 18 species (44 %) expected to 'increase' (3 (17 %) expected to remain 'stable', 5 (28 %) to 'decrease' and 2 (11 %)' unknown') (Table AII.52) leading to the conclusion that this service is expected to '**improve**' in the future. 6 species (33 %) are expected to be in a 'good' state in the future and 12 (67 %) are expected to be 'unknown'. As the state of more than 50 % cannot be predicted for the future, no classification is given (Table AII.53).

Step 5.C.6 Confidence in translating ecosystem state to the capacity to supply a service: NEA

Based on the metrics, the confidence that this translates to a capacity to supply the service which is 'improving' is low since only a small majority of the species were found to potentially 'improve' (44 %) (Table AII.52). State could not be assessed.

Step	Confidence
Step 5.C.1	
Step 5.C.3/4 and 5	
Step 5.C.6	

Table AII.53 Summary of current and future state and direction of change of service supply capacity for the service recreation and leisure from whale watching in the NEA, where the colour refers to the state (green = good, pink = bad, no colour = unable to assess), as determined using the conservative approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

<table>
<tr><th>Ecosystem Service</th><th>Critical component(s)</th><th>Current Assessment</th><th>Future Assessment</th><th>Confidence</th></tr>
<tr><td>Recreation and leisure from whale watching</td><td>Whale species relevant for whale watching</td><td>Unable to assess</td><td>Improving</td><td><table><tr><th>Step</th><th>Confidence</th></tr><tr><td>Step 1</td><td></td></tr><tr><td>Step 2</td><td></td></tr><tr><td>Step 3</td><td></td></tr><tr><td>Step 4</td><td></td></tr><tr><td>Step 5.C.1</td><td></td></tr><tr><td>Step 5.C.3/4 and 5</td><td></td></tr><tr><td>Step 5.C.6</td><td></td></tr></table></td></tr>
</table>

Mediterranean Sea

Table AII.54 Summary of results and confidence classifications for future state and direction of change in capacity to supply the service recreation and leisure from whale watching in the Mediterranean Sea, as determined using the conservative approach

Indicator	Classification	% Whale species assigned	Confidence (No. of whale species)		
			High	Moderate	Low
State	Good	0			
	Bad	67	0	0	6
	Unknown	33			
Direction of change	Increase	11	0	0	1
	Stable	0			
	Decrease	67	0	0	6
	Unknown	22			

Results following the Conservative Approach: 6 out of 9 species (67 %) expected to 'decrease' (0 'expected' to remain 'stable', 1 'increase' and 2 'unknown') (Table AII.54) leading to the conclusion that this service is expected to **'deteriorate'** in the future. 6 out of 9 species (67 %) are expected to be in a 'bad' state in the future (Table AII.55).

Step 5.C.6 Confidence in translating ecosystem state to the capacity to supply a service: Mediterranean Sea

Based on the metrics, the confidence that this translates to a 'bad' capacity to supply the service which is 'deteriorating' is high since most species were expected to be in a 'bad' state and 'deteriorating' in the future (Table AII.54).

Step	Confidence
Step 5.C.1	
Step 5.C.3/4 and 5	
Step 5.C.6	

Table AII.55 Summary of current and future state and direction of change of service supply capacity for the service recreation and leisure from whale watching in the Mediterranean Sea, where the colour refers to the state (green = good, pink = bad, no colour = unable to assess), as determined using the conservative approach. The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence.

Ecosystem Service	Critical component (s)	Current Assessment	Future Assessment	Confidence
Recreation and leisure from whale watching	Whale species relevant for whale watching	Deteriorating	Deteriorating	

Step	Confidence
Step 1	
Step 2	
Step 3	
Step 4	
Step 5.C.1	
Step 5.C.3/4 and 5	
Step 5.C.6	

Discussion

The overall assessment of recreation and leisure from whale watching for the NEA is 'good' and set to improve in the future (but current change in direction could not be assessed) while in the Mediterranean Sea, the service is 'bad 'and set to 'deteriorate' now and in the future. The NEA populations of whales are connected to global populations, while the Mediterranean populations are often sub-populations which may have little or no mixing with populations outside of the Mediterranean Sea. Thus, the Mediterranean populations are likely to be more sensitive to any pressures. Both the majority and conservative approaches produced broadly the same outcome. This was due, largely, to the different sources of information used being in agreement with each other in their assessments of whale species so that even when the more precautionary approach was taken, the overall outcome did not change. The only difference in overall outcome was that the future state

of the capacity of the ecosystem to supply recreation and leisure from whale watching in the NEA could not be assessed. The confidence in the assessment was low for Steps 1 and 3 for both regions. For Step 1, this was due to assigning the relative contribution of different whale species. No quantitative information is available on which species are more or less important than others for the supply of 'whale watching', therefore all species were given an equal weighting, although it is likely that some may be more important than others. For Step 3, assessment of the current state and trends of whale species, there was low confidence due to the lack of information on many of the species assessed and low confidence in the assessments used (e.g. using global IUCN data for the NEA region or draft Habitats Directive data). Due to the long lifespan of whales, it is more difficult to assess population trends than in other groups and this may be reflected in the lack of sufficient information to assess many species.

This assessment only considers the capacity of the ecosystem to supply this service but does not assess use or demand of the service itself which may depend on a number of factors, such as, availability of whale tour boat operators, weather conditions, cost, etc. This is noteworthy since whale watching itself is an activity rather than an ecosystem service and any human activity will be dependent on many other aspects which may be completely independent of the state of the ecosystem. However, this assessment only aimed to assess aspects of ecosystem services such as recreation and leisure which are connected to the state of the ecosystem and are underpinned by the marine ecosystem (*sensu* the CICES definition of an ecosystem service). Thus, there are limitations to the conclusions which can be drawn from this assessment in the wider ecosystem services assessment context which considers both the supply and demand of services. This is discussed in Section 6 in the main report.

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Annex III Test case assessment

Disclaimer: *This Annex was developed in 2014 and has not been updated since then, while certain elements of the main Report have been updated since 2014. Thus, there may be some inconsistencies between the main Report and the case study presented in this Annexes.*

Waste and Toxicant Removal and Storage via Biota service class

Waste nutrient removal and storage service type

Authors: F. Culhane, L. White, P. Scott, and C. Frid

Introduction

Components of the marine system can accumulate various wastes through their natural processes of filtration, sequestration, storage and accumulation. The types of waste which are inputs to the marine environment include dissolved nutrients, particulate wastes from dredge spoil, oil, heavy metals, hydrocarbons, chlorinated compound and radionuclides. All of these wastes are moved through the marine system in various ways. Recent decades have seen a large number of initiatives that have sought to reduce – reuse – recycle waste materials but for many substances ultimately they need to be disposed of. Traditionally wastes were simply discarded and when human populations were small and, where the materials were degradable, this did not cause a problem. However, with an increasing population and an increasing range of materials, the wastes exceeded the capacity of the local environment to deal with them and waste management procedures were introduced. In many cases these still aim to utilise the environment as a repository or 'treater' of the waste but limit the levels of demand to match environmental capacity (e.g. the input of dissolved nutrients is acceptable unless symptoms of eutrophication develop). The global value of all marine treatment of waste in 1994 was estimated to be at least US$ 1.5 trillion (Costanza et al. 1997), largely derived from the cost saving from not having to build and operate treatment plants.

In considering the thousands of wastes that enter the marine environment, it is helpful to consider them within a structuring framework (see Clark et al., 1997 for a fuller consideration of these issues). Firstly, we should distinguish wastes that degrade in the environment as distinct from those that persist in an essentially unchanged form (although they are dispersed and diluted, their chemical form remains essentially the same). Examples of degradable wastes include organic material (sewage, food processing waste, paper mill effluent) that will be degraded by microbial processes (often facilitated by macro-biota) into, ultimately, carbon dioxide, water and inorganic nutrients and salts. Persistent wastes include heavy metals, many pesticides (e.g. the derivative of DDT (dichlorodiphenyltrichloroethane), DDE and the 'drins). Some persistent pollutants can accumulate (bioaccumulation) in biological material and can become concentrated (biomagnified) up the food chain (see Clark et al., 1997).

Within both the degradable wastes and the persistent wastes are materials that enter the marine environment naturally. However, the waste management and the ecosystem service of dealing with the waste really only apply to the anthropogenic inputs of these materials. This, therefore, is only part of the process going on in the environment – natural processes do not distinguish a molecule of copper that enters the sea from weathered rock from a molecule leached from an antifouling coating on a vessel. However, for our purposes, the former is a natural process and the latter is an ecosystem service with an associated economic value. Distinguishing between these and hence providing accurate assessment and valuation is a major challenge for this group of materials.

The fate of a waste in the environment can be thought of as following one of three pathways.

- A persistent waste can be diluted and dispersed by physical and chemical processes. For some wastes they will undergo chemical reactions (for example binding to clay minerals) and these may remove them from the water column and begin the process of sequestering into sediments. However, other substances (^{137}Cs for example) that remain associated with the fluid phase ultimately become mixed through the entire World Ocean. To date this has been observed for non-naturally occurring substances (pesticides, radio-nucleotides). For heavy metals, the global human inputs are considerably less than the natural fluxes from weathering or volcanic emissions for example. Therefore, persistent waste substances enter the environment and may ultimately be subject to dilution and dispersion or to geological storage.
- Degradable wastes follow one of two pathways. Some are primarily degraded by physical and chemical processes with *no biologically mediated* contributions. Examples would include photo-oxidation of oils in surface waters.
- The degradation of most organic waste substances is ultimately part of a biogeochemical pathway with microscopic (microbes, phytoplankton, zooplankton) and macrobiota contributing. For example, the degradation of organic material in shelf sea sediments. This third pathway ultimately has bacteria breaking down the organic molecules into carbon dioxide, water and small amounts of inorganic salts (nutrients), with the macrofauna physically breaking down the waste by feeding on it (and so increase the surface area for bacterial colonisation). In the sedimentary environment macrobiota (e.g. polychaete worms) may further increase rates of bacterial processes by bioturbating and oxygenating the sediments.

Therefore, only the third of these pathways is strictly an 'ecosystem process', however many of the chemical reactions are equilibrial and so the presence of biota using the materials (nutrients and micronutrients) may be argued as contributing to the rate of chemical degradation as they remove the products and so 'pull' the reaction along. For example, the oceans have absorbed about 50 % of the excess carbon dioxide (CO_2) by the burning of fossil fuels. The balance between dissolved $CO_{2,}$ hydrogen bicarbonate (HCO_3) and carbonate (CO_3^{2}) is an equilibrium reaction and biota taking up bicarbonate ions to lay down calcium carbonate skeletons 'pulls' the reaction, 'reducing' dissolved carbon dioxide and so providing capacity for more to be absorbed from the atmosphere (Hardman-Mountford et al. 2009).

The chemical constituents of waste frequently enter the biota – dissolved substances such as metals and pesticides simply by being absorbed from the surrounding medium over cell surfaces or, in higher organisms, across the gut, gills etc. Once in the body of an organism they may be subject to metabolic activity that sees them excreted, stored in biologically inert forms or simply dissolved in the tissues as a body burden (for example many pesticides and heavy metals accumulate in lipid rich (storage) tissues). This creates the scope for the biomagnification and sees the biota acting as a store of material. However, these are short-term stores (when the organism dies and is degraded the contaminants are released back into the environment). Thus the total biological inventory is affecting the dynamics of these wastes but is not contributing to their sequestration, it is merely delaying the entry of some proportion of the inventory into the system. In other words, when a non-degradable substance enters the marine environment and it is not stored in the sediment (or removed by for example fishing removing the contaminants in the bodies of the fish), it remains circulating within the marine ecosystem, becoming temporally 'stored' in organisms, and causing toxicological effects, for example, mercury (Minemata) poisoning in Japan as a result of fishing communities consuming cetaceans containing mercury in their flesh (Larson 2014).

The pathways of waste entering the environment described above involve elements of both bioremediation and waste and toxicant removal and storage, and demonstrate that these services are inherently linked in the marine environment. While bioremediation involves the processing of waste from one substance into another, waste and toxicant removal and storage involves the movement or repackaging of waste within the system. In practice, it is difficult to separate the two as part of an assessment as both occur together and the ecological processes which facilitate them are linked. However, the processes that are the focus of this test case service assessment are the filtration, sequestration, storage and accumulation of wastes. Examples of filtration are the invertebrate filter feeders, such as sponges, which can ingest wastes along with the ingestion of food particles (Roberts et al. 2008). Phytoplankton sequesters dissolved nutrients from the water column for growth and many invertebrates are known to selectively accumulate certain materials (Robert et al. 2008). To some extent all marine organisms have the capacity to store and accumulate wastes (e.g. ascidians, Roberts et al. 2008; or marine mammals, Das et al. 2003).

The EEA (2015) State of the Europe's Seas Report describes nutrient enrichment as a key problem for the marine environment in Europe, with nitrogen loads coming from agriculture and ship emissions as being major drivers. This has been echoed in the regional quality status assessments of Europe (e.g. OSPAR, 2010; HELCOM, 2009a; BSC, 2008s) and further in the initial assessments of the water column for the MSFD where nutrient enrichment was found to be the most important pressure (ETC/ICM, 2014a). Given these considerations, in this case study we focus on nutrients as a key waste that can be sequestered by marine organisms.

Nutrients enter the marine environment in a variety of forms from diffuse run-off, direct discharges and atmospheric deposition. The marine environment deals with the input of some of these forms of nutrients through carrying out the services of waste and toxicant treatment (bioremediation) (treatment of the organics wastes for example, liberates nutrients) and waste removal and storage (filtration/ sequestration/ storage/ accumulation – the service considered here). When the nutrient load becomes too high, the service can be considered to reach the limits of its potential as negative impacts of the nutrient enrichment (eutrophication) become evident in the wider environment. Eutrophication has been defined as "*Eutrophication is a process driven by enrichment of water by nutrients, especially compounds of nitrogen and/or phosphorus, leading to: increased growth, primary production and biomass of algae; changes in the balance of organisms; and water quality degradation. The consequences of eutrophication are undesirable if they appreciably degrade ecosystem health and/or the sustainable provision of goods and services*" (Ferreira et al. 2010). Eutrophication currently occurs in all EU marine regions despite efforts to reduce nutrient loads (e.g. OSPAR, 2010; HELCOM, 2009b; BSC, 2008; EEA, 2014). If the marine system was not carrying out these waste treatment and removal services, the management burden of preventing eutrophication and reducing nutrient inputs would be much greater and have further knock-on impacts on land-based industries and agriculture.

Stage 1 of the assessment

Stage 1 of the assessment involves the identification of the contributing components to the service waste and toxicant removal and storage, which has been carried out as part of the development of the linkage matrix in Section 4 of this Report.

Stage 2 of the assessment

Step 1	Identifying the critical ecosystem components for service supply
1.1	Identify the service type

For the service waste and toxicant removal and storage, the information available differs depending on the type of waste (nutrients, synthetic substances, non-synthetic substances, etc.). For ease of

assessment, it is therefore helpful to consider each of these types separately. Furthermore, each of these types may enter the system in different ways and have a different fate within the system. Thus one service type of waste and toxicant removal and storage is the removal and storage of waste nutrients. As discussed in the introduction to this test case assessment, nutrients are a key waste in European waters, thus the focus of this test case assessment was waste nutrient removal and storage, specifically dissolved inorganic nitrogen and phosphorus. Nutrients are a natural part of the ecosystem; the nutrients considered in this assessment are those which are input due to anthropogenic activities i.e. the nutrients which are a waste product of human activities which would otherwise need to be treated or removed. This service is taken to be the removal of waste nutrients in a way that is not detrimental to the environment, thus before impacts of eutrophication affects the wider environment.

Step 1	**Identifying the critical ecosystem components for service supply**
1.2	Assigning the relative contribution of components

Plants and algae require phosphorus to photosynthesise (i.e. convert carbon dioxide and water into sugar and oxygen, using light) and nitrogen for growth. Aquatic plants and algae can absorb nutrients directly from the water column. Thus, for the service waste nutrient removal and storage (under waste and toxicant removal and storage), the photosynthesising ecosystem components were identified as the most relevant contributing components with the rate of primary production representing the growth of photosynthesising components and hence their nutrient uptake. Other components (such as invertebrates) may absorb dissolved nutrients directly from the water column (Uchida et al. 2010), but only do so to a very small degree compared to plants and algae, thus only the photosynthesising components were carried forward and the biotic groups involved in the removal of nutrients are all photosynthesising groups:

- Phytoplankton
- Macrophytes
- Macroalgae
- Microphytobenthos

Nutrients mostly enter the system in coastal regions but can be transported by ocean currents to areas far removed from the source. Similarly, nutrients entering from atmospheric deposition can be transported by wind to all areas of a system. Thus, all of the physical habitats with which these biotic groups are associated are relevant to the potential supply of this service, thus only the biotic groups will be specifically referred herein, although the habitats within which they exist are implicitly assumed at all times.

Step 1.2 Confidence in the criteria developed to assign relative contribution:

The criterion used to assign relative contribution is based on the knowledge that:

- Plants and algae require nutrients for photosynthesis and growth
- Primary production represents the growth of photosynthesising components and hence their nutrient uptake
- Primary production can be used to represent the capacity of the ecosystem to assimilate nutrients

From expert judgement, there is high confidence in these statements

The overall net primary production of photosynthesising components is assumed to reflect the capacity of these components to sequester nutrients. The proportional use of nutrients by different photosynthesising components of a system can depend on the species present, relative abundances

and particular ecosystem characteristics, and can also vary over space and time. For example, opportunistic macroalgae can dominate primary production in eutrophic and low energy shallow estuaries and coastal sites and peaks in production can switch from macroalgae to phytoplankton over time (Kinney and Roman, 1998). Thus, within particular areas, the critical components that can potentially deliver the service may vary. This may be significant since some areas will also have greater inputs of waste and nutrients than others. However, as this assessment is being carried out at a regional scale, it is assumed the overall net contribution to net production by different primary producers on a global scale reflects the contributions at the European marine regional scale. Production has been estimated for different groups of primary producers (Table AIII.1) and these have been assigned to the biotic groups used in this study (Table AIII.2) to estimate the relative contribution of each group to the potential supply of this service. There was no estimation for the contribution of microphytobenthos. However, this is unlikely to affect the overall outcome as phytoplankton makes a much greater contribution than all other biotic groups.

Table AIII.1 Primary production in lakes, seas, and oceans (reproduced from De Vooys, 1979)*

Production Category	Production in 10^{15} g C/year	Percentage of total aquatic production
Kelps	0.02	0.04
Other weeds	0.01	0.02
Angiosperms	0.49	1.07
Estuaries	0.92	2.00
Seas and oceans (phytoplankton)	43.50	94.89
Coral reefs	0.30	0.65
Freshwater	0.58	1.27
Total aquatic primary production	45.82	

*Although this reference is old, more recent literature indicates that phytoplankton are the dominant primary producers in the ocean (Field et al. 1998; Cloern et al. 2014) but as these sources do not estimate the production of other biotic groups, the De Vooys (1979) source was used to give a cross biotic group comparison.

Table AIII.2 The relative contribution of ecosystem components used in this assessment using values in Table AIII.1

Ecosystem component (with production category from Table A1.1)	Percentage of total contributing production
Macroalgae (Kelp, Other weeds)	0.07
Macrophytes (Angiosperms)	1.09
Microphytobenthos	unknown
Phytoplankton (Seas and oceans)	96.80
Other (Estuaries)	2.05

Step 1.2 Confidence in assigning the relative contribution:

- The information used to assign the relative contribution comes from a general estimation from the literature of the different components involved in the supply of the service. In general this type of information would have moderate confidence. However, it is well understood and several sources of information identify that phytoplankton is the major contributor and there is high confidence in this.

Thus there is high confidence in this step.

Step 1	**Identifying the critical ecosystem components for service supply**
1.3	Deciding how many components are considered to be critical

The greatest contribution to removal of nutrients comes from phytoplankton. This is assumed since the overall net production of phytoplankton is by far greater at the regional sea scale than the combination of other photosynthetic components of the system (Table AIII.2 and Field et al 1998). Further, phytoplankton is the dominant contributor to total primary production in all coastal temperate seas (Cloern et al. 2014). Therefore, the critical component for supply of this service is phytoplankton in all pelagic habitats.

Determining the critical component using general knowledge from background literature as per above was carried out to demonstrate the approach needed when data are limited. If data are available, a full mapping exercise can be carried out to determine the relative contribution of each of the contributing components. This has been carried out in this test for the Irish Sea and is shown below.

Step 1.3 Confidence in deciding how many components are critical:

Phytoplankton is the major contributor to the supply of this service and its contribution far exceeds the contribution of other components.

Thus there is high confidence in this step.

Overall confidence for step 1

- There was high confidence in each of the three different aspects for assessing the confidence in this step, thus there is high confidence overall for Step 1.

Step	**Confidence**
Step 1	

Estimating the relative contribution of components to service supply in the Irish Sea

For this example, Step 1.1 is as described above, and a more detailed case study is shown starting from Step 1.2.

Step 1	Identifying the critical ecosystem components for service supply
1.2	Assigning the relative contribution of components

The Irish Sea encompasses an area of 106,300 km^2 (Gowen et al. 2008) (with its northern boundary lying from 54° 38' N to 54° 20' N and in its southern boundary lying from 51° 54 N, 5° 19 W to 52° 10 N, 6° 22 W (IHO 1953)), Figure AIII.1. Within the Irish Sea, primary production occurs within the photic zone (Gowen et al. 2008). The photic zone of the water column is defined as the area of irradiance where photosynthetic production exceeds respiration (Cloern et al. 2014). Depth of the photic zone can vary from coastal to open ocean and due to the degree of turbidity (Church et al. 2004, Cloern et al. 2014). While the water column supports phytoplankton, the substrate that occurs within the photic zone supports a variety of photosynthetically active organisms including marine angiosperms (macrophytes), macroalgae and microphytobenthos.

Identifying relative contribution of contributing components in the Irish Sea

Following the assumption that primary productivity reflects the capacity of photosynthetic organisms to assimilate waste, the primary productivity of the contributing components in the Irish Sea was calculated.

The approach:

(a) Identified suitable mapped proxies of the relevant components
(b) Estimated the spatial extent of the components (through the extent of the proxies)
(c) Used the spatial extent of the components with an estimation of their rates of primary productivity to calculate the total productivity contributed by each component

In addition:

- The benthic habitats of the EU are categorised by the EUNIS (European Nature Information System) hierarchical classification system of habitats and biotopes and include habitats occurring within the marine photic zone (saltmarsh, infralittoral, circalittoral) (Connor et al. 2004).
- The EUNIS habitats are contained within the EUSeaMap (CompositeEUNISHabitatMap) habitat mapping downloadable GIS layer. The EUSeaMap (CompositeEUNISHabitatMap) was projected in ArcGIS (v10.1) using the ETRS1989 LAEA coordinate system. The data layer was then clipped to the extent of the Irish Sea (IHO 1953), using 'data-frame select clipping' to identify the benthic habitats specific to the Irish Sea area.
- Dickie et al. (2014) identified the relevant Level 3 EUNIS habitats supporting primary densities of assemblages of photosynthesising organisms for the UK and these were then cross referenced with the mapped habitats for the Irish Sea, identifying a range of Irish Sea habitats (or biotopes), which could be used as a proxy for the extent of biotic groups contributing to primary production (Table AIII.3). Level 3 EUNIS habitats were used since there was a greater likelihood of availability of primary productivity rate information at this level as opposed to the detail which would be required at higher EUNIS levels. The result of this was that the biotic group 'macroalgae' was simplified to only consider fucoids and kelp and microphytobenthos was not specifically considered, although this group and other macroalgal species would be implicitly included within the biotopes which were used.

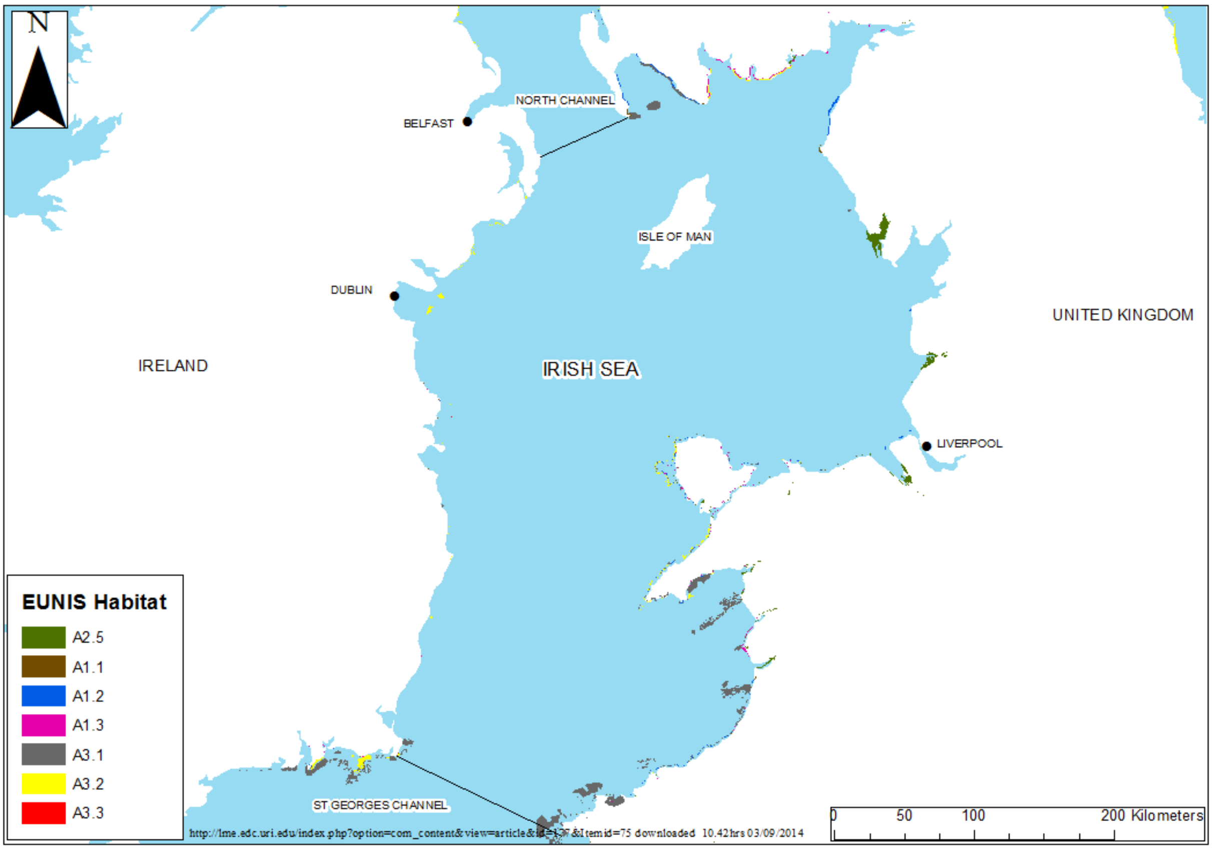
- Each biotope was then selected, using 'select by attributes'. The area of each of these layers was calculated by summing the area of each polygon using 'geoprocessing / dissolve'. The geometry of the fields was then obtained using the 'calculate geometry' function within the attribute table and the area of each substrate type within the Irish Sea was calculated (Table AIII.3, Figure AIII.1).
- For phytoplankton, all pelagic, water column habitats were used as a proxy, occupying the total area of the Irish Sea (Table AIII.3).

Table AIII.3 Habitats identified as supporting the primary densities of photosynthesising assemblages with calculated areas in the Irish Sea (where the total area of the Irish Sea was taken to represent the area of water column habitats supporting phytoplankton)

EUNIS Classification	Substrate Description	Dominant Primary Producer	Area* (km^2)
A1.1	High energy littoral rock	Fucoids (Macroalgae)	16.97
A1.2	Moderate energy littoral rock		108.04
A1.3	Low energy littoral rock		77.60
A3.1	Atlantic and Mediterranean high energy infralittoral rock	Kelp (Macroalgae)	574.31
A3.2	Atlantic and Mediterranean moderate energy infralittoral rock		223.83
A3.3	Atlantic and Mediterranean low energy infralittoral rock		0.81
A2.5	Coastal saltmarshes and saline reedbeds	Macrophytes	311.63
Total Area of EUNIS biotopes contributing to primary production			**1,313.19**
Total Area of Irish Sea			**106,300.00**

*Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats project (www.emodnet-seabedhabitats.eu), funded by the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE).

Figure AIII.1: Biotopes found within the Irish Sea associated with photosynthetic primary production: See Table AIII.3 for descriptions of biotopes



Information contained here has been derived from data that is made available under the European Marine Observation Data Network (EMODnet) Seabed Habitats project (www.emodnet-seabedhabitats.eu), funded by the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE).

Method:

- The primary productivity of each benthic biotope was then calculated following Dickie et al. (2014). Dickie et al. (2014) used literature derived information to estimate primary productivity values (kg m^{-2} yr^{-1} dry weight) for fucoids, kelp and saltmarsh, which they down-weighted by 25 % to account for natural patchiness and these were subsequently converted to kgC m^{-2} yr^{-1} (Table AIII.4). The values quoted in Dickie et al. were converted to kgC m^{-2} yr^{-1} using a conversion factor based on an estimation of a mean of 24.8 % carbon content of macroalgae to convert dry weight measurements to carbon from Duarte (1992). This value was derived specifically for macroalgae but was applied to all benthic components, including saltmarsh.
- Multiplying the productivity values (Table AIII.4) and the area of the EUNIS habitats (Table AIII.3), a total value in kg yr^{-1} was calculated for macroalgae and macrophytes within the area defined as the Irish Sea.
- The productivity value for phytoplankton used (Table AIII.4) is an estimated value for the Irish Sea mean (Gowen et al. 2008) and this was multiplied with the total surface area of the Irish Sea (Table AIII.3) to give a total annual estimation of productivity.

Table AIII.4 Primary production of biotope types and contribution of each biotope type to total primary production in the Irish Sea. For EUNIS habitat types see Table AIII.3.

Broadscale Habitat (dominant primary producer)	Primary Productivity of Biotope Type ($kg\ m^{-2}\ yr^{-1}$ dry weight)*	Primary Productivity of Biotope Type ($kgC\ m^{-2}\ yr^{-1}$ dry weight)~	Contribution to primary productivity in the Irish Sea (10^6 kg yr^{-1} dry weight)^
EUNIS A1.1 (Fucoid)	0.19	0.06	1.05
EUNIS A1.2 (Fucoid)	0.75	0.25	26.79
EUNIS A1.3 (Fucoid)	1.50	0.50	38.49
EUNIS A3.1 (Kelp)	7.50	2.48	1,424.29
EUNIS A3.2 (Kelp)	11.25	3.72	832.65
EUNIS A3.3 (Kelp)	7.50	2.48	2.01
EUNIS A2.5 (Saltmarsh Macrophytes)	0.48	0.12	36.71
Water Column: Irish Sea (Phytoplankton)	N/A	0.19	20,197.00
Irish Sea Total Primary Productivity			**22,558.99**
Macroalgae Proportional Contribution			**10 %**
Macrophyte Proportional Contribution			**< 1 %**
Phytoplankton Proportional Contribution			**90 %**

*Productivity values are estimates for each benthic habitat downweighted by 25 % for natural patchiness from Dickie et al (In publication) and ~ Productivity values in kgC are estimates for each benthic habitat using a conversion factor for dry weight of macroalgae to carbon of 0.248 from Duarte (1992). For the water column the mean value of primary productivity for phytoplankton from Gowan et al (2008) was used.
^Productivity was estimated based on primary productivity of the biotope type and the area of each biotope (See Table AIII.3)

Step 1.2 Confidence in assigning the relative contribution for the Irish Sea example:

- The information used to assign the relative contribution comes from a quantitative assessment of how much each relevant component contributes relative to the other components using mapped spatial extent of components in combination with their efficiency at potentially supplying a service. The confidence in this relative contribution is high.

Thus there is high confidence in this step.

Step 1	**Identifying the critical ecosystem components for service supply**
1.3	Deciding how many components are considered to be critical

The relative contribution of the photosynthesising components (except microphytobenthos) in the Irish sea shows that phytoplankton (in the water column) is by far the most critical component contributing to primary productivity and thus waste treatment of nutrients, contributing 90 % of the primary productivity (Table AIII.4). Macroalgae are the second most important contributors at 10 % while macrophytes contribute very little at less than 1 %. Although microphytobenthos are not taken into account, it is unlikely knowing its contribution would change the overall outcome of phyto-plankton as the critical component for consideration in this assessment.

Step 1.3 Confidence in deciding how many components are critical in the Irish Sea example:

- Phytoplankton is the major contributor to the supply of this service and its contribution far exceeds the contribution of other components.

Thus there is high confidence in this step.

Overall confidence for step 1 in the Irish Sea example

- There was high confidence in each of the three different aspects for assessing the confidence in this step, thus there is high confidence overall for Step 1.

Step	Confidence
Step 1	

Step 2	**Identifying the state-service relationship and appropriate metrics of state**
2.1	Identify the type of relationship

This service is taken to be the removal of anthropogenic waste nutrients so their levels are not detrimental to the environment, thus before impacts of eutrophication are affecting the wider environment, such as anoxia in the seabed (benthic environment). In a simplified state-service relationship between the input of nutrients (the 'waste') and the state of the biotic group phytoplankton, as the waste input increases, the phytoplankton, which are nutrient limited, grow exponentially, thus increasing both the flow of the service and the capacity of the ecosystem to supply the service (due to ever greater numbers of phytoplankton using the nutrients). However, a threshold of service supply is reached where eutrophication begins to have an impact on the wider environment. The uptake of nutrients by phytoplankton may continue after this point has been reached. However, even if nutrient uptake by phytoplankton continues, there is a trade-off between the supply of this service and the negative impacts of the eutrophication (which can include negative impacts on the benthos). The sustainability of the service breaks down as the ecosystem no longer has the capacity to deal with the waste in a way that does not negatively impact on the ecosystem as a whole.

Thus, as the amount of nutrient input increases, the capacity of the ecosystem to supply the service increases, but as the impacts of eutrophication on the wider environment increase, the capacity of the ecosystem to supply the service decreases. This type of relationship is considered complex.
It is important to note that an increase in the potential supply of the service or the capacity of the ecosystem to supply the service does not necessarily coincide with improvements in ecological state, and thus policy objectives. For example, at a certain point in time, as the amount of nutrients and concentration of phytoplankton increase, the service may also increase, but there is likely to be a loss in biodiversity of phytoplankton as opportunistic species become dominant. However, in this assessment, in relation to eutrophication, the service is not considered to be limited by changes in the phytoplankton. The service is considered to be compromised when the negative effects of nutrient input extend beyond the phytoplankton component. Thus, when there are impacts on additional components of the ecosystem (such as the benthos).

Step 2.1 Confidence in the type of relationship:

- Even though it is a complex relationship, the relationship between phytoplankton, nutrients and the impacts of eutrophication on the benthos are well understood, thus there is high confidence in the type of relationship and high confidence overall for Step 2.

Step	Confidence
Step 1	
Step 2	

Step 2	Identifying the state-service relationship and appropriate metrics of state
2.2	Identify appropriate metrics of state

Relevant indicators of this service should include trends in the concentration of phytoplankton (the critical ecosystem component), trends in the concentration of nutrients (the' waste'), and trends in indicators of the negative impacts of eutrophication to the wider environment, such as impacts on the benthos. Given this, assessment of the capacity to supply this service should consider:

- The relationship between the phytoplankton trends and nutrient trends
- Impact on the benthos (i.e. indication of eutrophication on wider environment)

This assessment considers two potential 'states' of the service (where 'state' is the capacity of the ecosystem to supply the service) (see also Table AIII.5(a)):

- **Good State:** Wider impacts of eutrophication are not apparent, thus the system has capacity to assimilate more nutrients (i.e. the benthos is in a good state and phytoplankton sequestration capacity is not compromised)
- **Not good state**: Wider impacts of eutrophication are apparent and, therefore, the ecosystem capacity to supply the service is unsustainable (i.e. the benthos is in a bad state and there is low potential for nutrient sequestration by the phytoplankton)

There are eight potential 'trends' of the capacity of the ecosystem to supply the service when considering increasing or decreasing trends of the relevant indicators (further combinations are also possible when considering 'stable' to be an option for one of the trends) (Table AIII.5(b)). The state-service relationship is such that, even when the concentration of phytoplankton is increasing, if eutrophication impacts are also increasing, the service is decreasing (e.g. A, F Table AIII.5(b)) since the system is showing a reduced capacity to receive more nutrients without wider negative impacts occurring (within the definition of the service in this assessment which takes the service to be the removal of waste in a way that is *not* detrimental to the environment, thus before impacts of eutrophication are affecting the wider environment). It can also be the case that even when phytoplankton concentrations are decreasing, the service can be increasing (e.g. B, Table AIII.5(b)). In this case, the decrease in phytoplankton is likely to be due to the decrease in nutrients but not necessarily a decreased *capacity* to assimilate more nutrients, while the concurrent reduction in the wider impacts of eutrophication suggest the system has an increased capacity to assimilate more nutrients.

Table AIII.5 Potential outcomes for the capacity of the ecosystem to supply the service of removing nutrients (a) the state of service supply capacity (based on the state of critical ecosystem component(s) and other relevant metrics, and (b) the direction of change of service supply capacity, based on trends in the critical ecosystem component(s) and other relevant metrics (possible outcomes for 'stable' trends not shown)

(a) Estimating the state of the ecosystem capacity to supply the *Waste nutrient removal and storage* service

	State of Metric		State of Service			State of Metric		State of Service
A	Good	Bad			E	Good	Bad	Service
Phytoplankton Concentration					Phytoplankton Concentration			
Nutrient Concentration					Nutrient Concentration			
Impact on benthos					Impact on benthos			
B					F			
Phytoplankton Concentration					Phytoplankton Concentration			
Nutrient Concentration					Nutrient Concentration			
Impact on benthos					Impact on benthos			
C					G			
Phytoplankton Concentration					Phytoplankton Concentration			
Nutrient Concentration					Nutrient Concentration			
Impact on benthos					Impact on benthos			
D					H			
Phytoplankton Concentration					Phytoplankton Concentration			
Nutrient Concentration					Nutrient Concentration			
Impact on benthos					Impact on benthos			

Table AIII.5 Cont.

(b) Estimating the direction of change of the ecosystem capacity to supply the *Waste nutrient removal and storage* service

A	Increasing	Decreasing	Service
Phytoplankton Concentration	■		**Deteriorating**
Nutrient Concentration	■		
Impact on benthos	■		

B	Increasing	Decreasing	Service
Phytoplankton Concentration		■	**Improving**
Nutrient Concentration		■	
Impact on benthos		■	

C	Increasing	Decreasing	Service
Phytoplankton Concentration	■		**Improving**
Nutrient Concentration		■	
Impact on benthos		■	

D	Increasing	Decreasing	Service
Phytoplankton Concentration		■	**Deteriorating**
Nutrient Concentration	■		
Impact on benthos	■		

E	Increasing	Decreasing	Service
Phytoplankton Concentration		■	**Deteriorating**
Nutrient Concentration	■		
Impact on benthos		■	

F	Increasing	Decreasing	Service
Phytoplankton Concentration	■		**Deteriorating**
Nutrient Concentration		■	
Impact on benthos	■		

G	Increasing	Decreasing	Service
Phytoplankton Concentration		■	**Deteriorating**
Nutrient Concentration		■	
Impact on benthos	■		

H	Increasing	Decreasing	Service
Phytoplankton Concentration	■		**Improving**
Nutrient Concentration	■		
Impact on benthos		■	

Step 3 Identifying the current state and trends of the critical ecosystem components

Step 3	**Identifying the current state and trends of the critical ecosystem components**
3.1	Identify relevant policies/laws with reported information on the metrics identified in Step 2

In Step 2, phytoplankton, nutrients and indicators of eutrophication on the wider environment were identified to be important factors for the assessment of the ecosystem's capacity to deliver this service. A number of EU and regional policies/laws incorporate reporting on phytoplankton, water column habitats, nutrient concentrations and eutrophication, and these were identified (for a summary of the relevant identified policies/laws see Table AIII.6 and these are further described below).

EU and other law and policy

Marine Strategy Framework Directive (MSFD)

There are a number of potential sources of information within the MSFD which could be relevant for this service. From Annex III, Table 1 of the MSFD (EC 2008), characteristics of biological features which are to be reported include:

"*A description of the biological communities associated with the predominant seabed and water column habitats. This would include information on the phytoplankton and zooplankton communities, including the species and seasonal and geographical variability*"

From the Commission Decision on criteria and methodological standards on good environmental status of marine waters (EC 2010), relevant descriptors of the MSFD also include:

- Descriptor 1: Biodiversity, where at the species level "*For each region, sub-region or subdivision, taking into account the different species and communities (e.g. for phytoplankton and zooplankton) contained in the indicative list in Table 1 of Annex III to Directive 2008/56/EC, it is necessary to draw up a set of relevant species and functional groups*" and at the habitat level, the water column, addresses "*both the abiotic characteristics and the associated biological community, treating both elements together in the sense of the term biotope*", thus including the phytoplankton (Table AIII.6).

Table AIII.6 Criteria for Descriptor 1 of the MSFD potentially relevant for the assessment of the ecosystem service: 'waste nutrient removal and storage'

Potentially Relevant Descriptor	**Descriptor 1: Biodiversity**						
Potentially Relevant criteria	**Species Level**			**Habitat Level (Water column including phytoplankton)**			**Ecosystem Level**
	Species Distribution	Population Size	Population condition	Habitat distribution	Habitat Extent	Habitat Condition	Ecosystem Structure

- The information reported by the MSFD under Descriptor 1 was considered to be useful for the assessment. The reported information under water columns could be used as a proxy but, as more directly relevant reported information was available (e.g. direct effects of eutrophication under Descriptor 5 of the MSFD), this information was used only as supporting information in this case.
- Descriptor 4: Marine Food Webs, includes reporting on "*Productivity (production per unit biomass) of key species or trophic groups*" and "*groups with fast turnover rates (e.g. phytoplankton, zooplankton, jellyfish, short-living pelagic fish) that will respond quickly to ecosystem change and are useful as early warning indicators*" (Table AIII.7).

Table AIII.7 Criteria for Descriptor 4 of the MSFD potentially relevant for the assessment of the ecosystem service: 'waste nutrient removal and storage'

Potentially Relevant Descriptor	**Descriptor 4: Food webs**
Potentially Relevant criteria	Abundance/distribution of key trophic groups
	• Abundance trends of functionally important selected groups/species…including where appropriate: • Groups with fast turnover rates (e.g. phytoplankton…), • Groups/species that are…indirectly affected [by human activities], • Groups/species that are tightly linked to specific groups/species at another trophic level

- The information reported by the MSFD under Descriptor 4 was not taken forward as no results were available for this descriptor as reporting by Member States was carried out under the 'Ecosystem' feature and the assessments were very limited.
- Descriptor 5: Human-Induced Eutrophication, where there is reporting on nutrient concentration in the water column, nutrient ratios and direct effects of nutrient enrichment including chlorophyll concentration in the water column, amongst other indicators (Table AIII.8).

Table AIII.8 Criteria for Descriptor 5 of the MSFD potentially relevant for the assessment of the ecosystem service: 'waste nutrient removal and storage

Potentially Relevant Descriptor	**Descriptor 5: Eutrophication**						
Potentially Relevant criteria	**Nutrient Levels**		**Direct effects of nutrient enrichment**			**Indirect effects of nutrient enrichment**	
	Nutrient concen-tration in the water column	Nutrient ratios	Chlorophyll concentration in the water column	Water transpa-rency related to increased suspended algae	Species shift in floristic composition such as diatom to flagellate ratio, benthic to pelagic shifts, as well as bloom events of nuisance/toxic algal blooms (e.g. cyano-bacteria) caused by human activities	Abundance of perennial seaweeds and sea-grasses ad-versely im-pacted by decrease in water trans-parency	Dissolved oxygen, i.e. changes due to increased organic matter de-composition and size of the area concerned

- The information reported by the MSFD under Descriptor 5 was considered to be suitable for use in the assessment, however as the information reported is aggregated into an overall assessment for each criterion, assumptions were required in order to report a state and trend for each relevant indicator (see below, Table AIII.13).

Water Framework Directive (WFD)

In Annex V of the WFD (EC 2000), the quality elements for classification of ecological status include phytoplankton (composition, abundance and biomass) and nutrient conditions for transitional and coastal waters. The information is reported as overall ecological quality status of surface water bodies (coastal and transitional waters).

- The information reported by the WFD was considered to be suitable for use in the assessment, however as the information reported is aggregated into an overall assessment for ecological quality status, assumptions were required in order to report a state and trend for each relevant indicator (see below, Table AIII.13).

EU Urban Waste Water Treatment Directive (UWWT)

The UWWT Directive (EC 1991a) requires the monitoring of nutrient levels (Total nitrogen and total phosphorus) in sewage discharges, the identification of areas sensitive and less sensitive to eutrophication and the quality of receiving waters. However, the sensitivity of receiving waters is reported mostly only on land (rivers and lakes). The reported information from this directive can indicate the level of pressure such as from a proxy of how compliant the Member State is to fulfilling the obligations of the directive in terms of waste treatment.

- The information reported for the UWWT Directive was not taken forward as the data available would only serve as a proxy for the indicators already identified. This type of proxy information is unnecessary for this assessment as more direct data are available.

EU Nitrates Directive

The Nitrates Directive (EC 1991b) requires identification of estuaries, coastal and marine waters which are eutrophic or at risk of becoming eutrophic, and reporting on nitrates concentrations, eutrophication and future trends in water quality. The outputs of the Nitrates Directive form part of those for the WFD (http://ec.europa.eu/environment/water/water-nitrates/index_en.html).

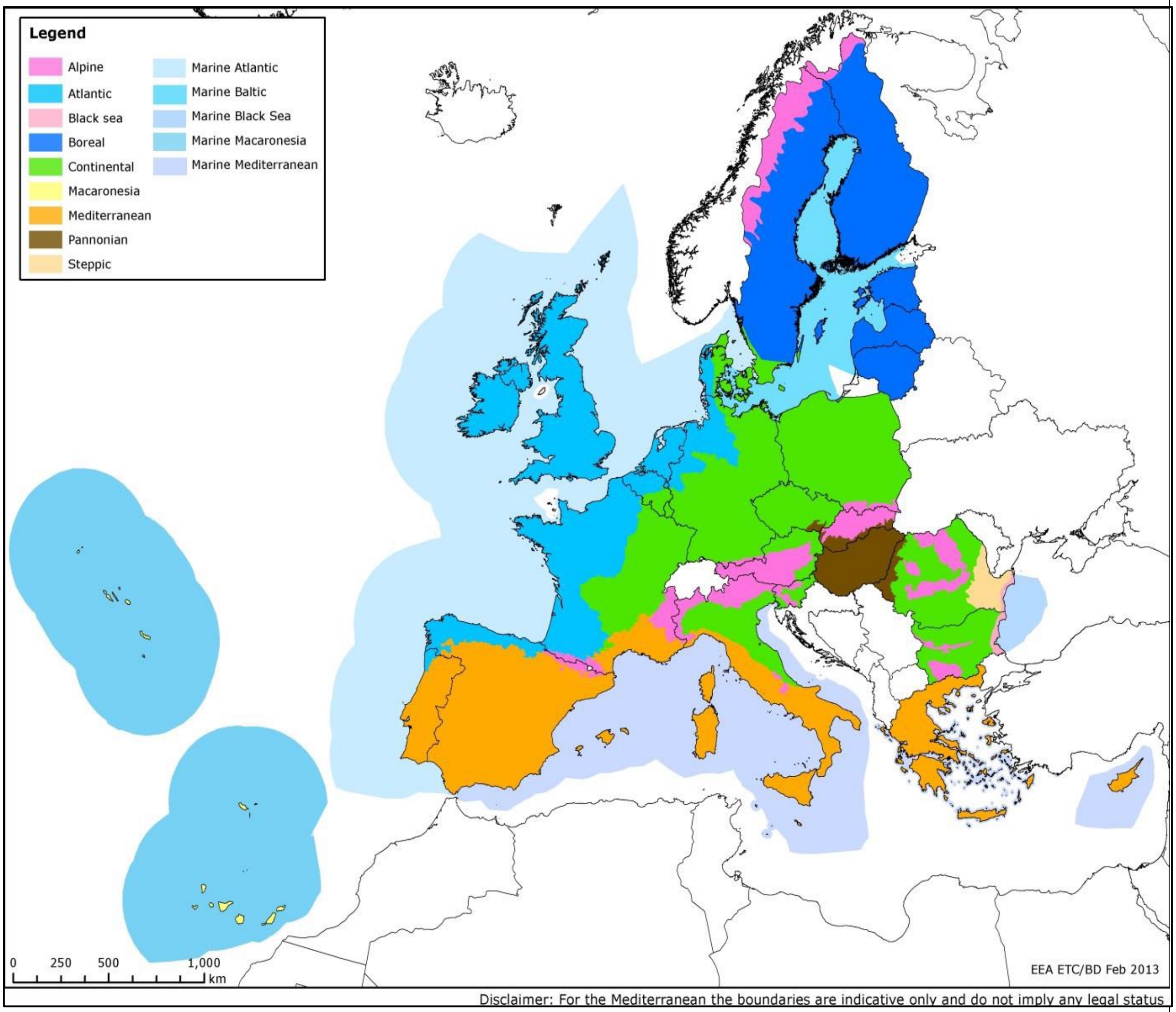
- The information reported for the Nitrates Directive was not taken forward directly, as the data was not directly available and considered to be reported under the WFD.

EU Habitats Directive (HD)

Listed relevant habitats in Annex I of the Directive (EC 1992) include: Estuaries, Large shallow inlets and bays, Coastal lagoons and Boreal narrow inlets. Although phytoplankton or nutrient levels are not specifically contained within the habitat descriptions of these habitats (see EUNIS factsheets http://eunis.eea.europa.eu/habitats.jsp), changes in these conditions would impact the macroalgae and benthic communities listed in these habitats.

Delineations of the regions in the Habitats Directive differ from the MSFD and WFD marine regions, which makes comparison with other policies/laws difficult (see Figure AIII.2 for the Habitat Directive subregions). For example, under the Habitats Directive Biogeographical regions, 'Continental' includes parts of the Baltic and the Mediterranean.

Figure AIII.2: The biogeographical and marine regions for reporting under Article 17 of the Habitats Directive (from ETC/BD, 2014).



Assessment of trends using this data is also problematic since the reporting changed from the 2001–2006 period to the 2007–2011 period e.g. in 2001–2006 Estuaries were reported under the 'Atlantic' region, while in 2007–2011, Estuaries were reported under the 'Marine Atlantic Region', although these two regions are assumed to be equivalent for these habitats – as are Black Sea and Marine Black Sea. However, for 2007–2001, Marine Baltic could be made up of both Boreal and Continental from 2001–2006, and Marine Mediterranean could be made up of both Mediterranean and Continental from 2001–2006.

- The information reported by the HD was considered to be unsuitable for use in the assessment. This is because of the difficulty in aligning the regions reported under the HD to the regions used in this assessment, but also because of the limited range of habitats covered by the assessment (Estuaries, Large shallow inlets and bays, Coastal lagoons and Boreal narrow inlets), the state of which are not likely to be representative of the regional sea as a whole.

European Environment Agency (EEA)

The EEA provides information on trends of phytoplankton and nutrients in Europe using data reported by Member States. The reported information includes a status (high, moderate or low) and a trend in the indicators.

- The information reported by the EEA was considered to be suitable for use in the assessment, however as no specific policy objectives align with the status information reported (i.e. high, moderate or low), it was assumed that high would correspond to a failure of policy objectives and low would correspond to a pass, while moderate could not be interpreted. Thus, where the status was reported as moderate, only the trend information could be used.

Regional Policy

North East Atlantic Ocean (NEA)

OSPAR

OSPAR recommends five specific Ecological Quality Objectives (EcoQOs) to assess eutrophication in the NEA: nutrient enrichment i.e. winter nutrients (Dissolved Inorganic Nitrogen (DIN) & Dissolved Inorganic Phosphorus (DIP)), phytoplankton chlorophyll a concentration, phytoplankton indicator species, oxygen depletion and benthos (OSPAR, 2010). Measured variables include those to assess winter nutrients (Table AIII.9) and direct/indirect eutrophication events (Table AIII.10).

Table AIII.9 Variables in OSPAR reporting to assess winter nutrients

Nutrient enrichment
NH_4-N[2,4] (µmol l^{-1})
NO_2-N[2,4] (µmol l^{-1})
NO_3-N[2,4] (µmol l^{-1})
PO_4-P[3,4] (µmol l^{-1})
SiO_4-Si[4] (µmol l^{-1})
Salinity
Temperature

Table AIII.10 Variables in OSPAR reporting to assess direct/indirect eutrophication events

Direct and indirect eutrophication effects
Phytoplankton chlorophyll *a* (µg l^{-1})
Phytoplankton indicator species (cells l^{-1}; species composition)
Macrophytes, including macroalgae and angiosperms[3]
O_2 concentration (mg l^{-1}; including % O_2 saturation)
(Zoo) Benthic communities

- The information reported by OSPAR was considered to be suitable for use in the assessment, however as the information reported is aggregated into an overall assessment for eutrophication, assumptions were required in order to report a state and trend for each relevant indicator (see below, Table AIII.13–AIII.14).

Baltic Sea

HELCOM

HELCOM reports the status of eutrophication using the HEAT 3.0 tool, which aggregates the indicators under the three MSFD Criteria (HELCOM, 2014). The assessment integrates the status data from a core set of indicators which include inorganic nitrogen (DIN), inorganic phosphorus (DIP), chlorophyll a, water transparency (Secchi depth) and oxygen conditions (oxygen debt).

- The information reported by HELCOM was considered to be suitable for use in the assessment.

Black Sea

The Black Sea Commission (BSC 2008) is in the process of developing and implementing environmental targets for the Strategic Action Plan for the Environmental Protection and Rehabilitation of the Black Sea - EcoQO 3: Reduce eutrophication. However, this was not operational/included in the last reporting period (State of Environment Report 2009 (2001–2006/7)). The State of the Environment report provides descriptive information about indicators including nutrient concentrations, nutrient ratios, phytoplankton biomass and composition and wider effects of eutrophication.

- Descriptive information on the trends in the indicators mentioned above were used in the assessment.

Mediterranean Sea

UNEP/MAP coordinates the MED POL programme for reporting data on nutrients in the Mediterranean, although only nutrient hotspots are reported on and reporting is voluntary and irregular (EEA, 2014). Eutrophication status assessments were carried out in 1996, 2007, and 2012 by UNEP/MAP, and in 1999 and 2006 jointly with the EEA. Nutrient concentrations, chlorophyll a concentrations and dissolved oxygen are used in most Mediterranean countries to assess eutrophication, and in several cases toxic phytoplankton occurrence, toxins in shellfish tissues, mortality of organisms and faecal coliforms (or a subset of these) are used.

- Information available was not in a useable form, thus any information that was given was used as supporting information but not directly in the assessment.

The policy information taken forward in the assessment is listed below in Table AIII.11.

Table AIII.11 Summary of relevant policies/laws with reporting relevant to the 'waste nutrient removal and storage' by phytoplankton service taken forward for the assessment

Regional Relevance	Policy (or relevant information source)	Indicators Reported
EU	Marine Strategy Framework Directive	Reporting for Descriptor 5 (Phytoplankton, nutrients, effects of eutrophication)
	Water Framework Directive	Phytoplankton, nutrients
	EEA	EEA indicators: phytoplankton and nutrients (EEA, 2013b, 2013c)
Regional	OSPAR's strategy to combat eutrophication	Eutrophication: five specific EcoQOs for winter nutrients, phytoplankton chlorophyll a, phytoplankton indicator species, oxygen and benthos
	HELCOM	Nutrients, phytoplankton chlorophyll a, secchi disc, oxygen debt
	BSC	Information on nutrients, phytoplankton and eutrophication

Policy relevant for the Irish Sea

The most detailed reported information for the Irish Sea comes from the data reported to OSPAR by the UK and Ireland. The individual country reports (OSPAR, 2008; National Report on the Eutrophication Status of UK water, 2008) were consulted and the relevant sub regions (for the Irish Sea) extracted from these (Table AIII.12). More recent data may be available for reporting for the MSFD for this region, however, this is only available in an aggregated form, and thus it is considered that the OSPAR data fulfils the information needs for this assessment more directly. More recent data could be used to support and verify the outcome (although it is a limitation not to use the most recently available information).

Table AIII.12 Reported indicators for the application of the OSPAR common procedure for Ireland and the UK

Indicator	Indicator Descriptor
DI	Dissolved nutrients (Winter DIN and/or DIP)
Ca	Maximum and mean Chlorophyll α concentration
O^2	Degree of oxygen deficiency
NP	Increased winter N/P ratio
Ck	Changes/kills in zoobenthos and fish kills
Ps	Region/area specific phytoplankton indicator species
Mp	Macrophytes including macroalgae
NI	Nutrient Input (Riverine inputs and direct discharges of total N and total P)
Oc	Organic carbon/organic matter
At	Algal toxins (DSP/PSP mussel infection events)

Step 3	Identifying the current state and trends of the critical ecosystem components
3.2	Synthesis of different policy metrics

The different sources of information describe what essentially, are the same indicators, in different ways and/or report the information in an aggregated way (e.g. as described above for OSPAR). In order to compare outcomes across different policies/laws, some synthesis of the indicators actually reported is required. A final list of indicators was decided (based on requirements to carry out the assessment (see state-service relationship in Step 2) and what is available from the policies/laws. This has been carried out for the relevant policies/laws shown above in Table AIII.11 and the results shown in Table AIII.13. In some cases, an aggregated reported criterion for a policy is given as the assessment across all indicators that are described in the actual policy document, even though the reported aggregated classification may not always represent all of these indicators. Ideally, disaggregated information at the level of the required indicators would be available for all reported policies/laws but that is not the case (e.g. WFD, OSPAR, and MSFD). EU policies/laws are shown in Table (AIII.13) and Regional in Table (AIII.14).

Table AIII.13 Synthesis of indicators reported in each EU and other law and policy relevant to the 'waste nutrient removal and storage' by phytoplankton service

Name of Indicator	MSFD	WFD	EEA Indicators
Nitrogen concentration	The MSFD reports on the criteria 'nutrient levels' which includes an aggregation of nutrient concentrations and nutrient ratios. For the purposes of this assessment, the *same* classification for the aggregated 'nutrient levels' criterion is applied to *both* of the indicators 'nitrogen concentration' and 'phosphorus concentration'.	In the WFD the quality elements for classification of ecological status include phytoplankton (composition, abundance and biomass) and nutrient conditions for transitional and coastal waters. The WFD operates a one-out-all-out rule, thus the aggregated status classification (for ecological) was applied for all relevant indicators: phytoplankton biomass, and nitrogen and phosphorus concentrations.	The EEA report on winter oxidized nitrogen (NO_2+NO_3) concentrations
Phosphorus concentration			The EEA report on winter orthophosphate concentrations
Phytoplankton biomass (Chlorophyll-a)	The MSFD 'direct effects of enrichment' criterion aggregates the indicators chlorophyll concentration, phytoplankton community composition and water transparency. For the purposes of this assessment, this aggregated classification for 'direct effects of enrichment' criterion is applied to 'phytoplankton composition' used here.		The EEA report on Chlorophyll-a concentration
Benthos	The MSFD 'indirect effects of enrichment' criterion aggregates the indicators 'abundance of perennial seaweeds and seagrasses' and levels of 'dissolved oxygen'. For the purposes of this assessment, this classification for the aggregated 'indirect effects of enrichment' criterion is applied to 'Benthos' used here.		

Table AIII.14 Synthesis of indicators reported in each regional policy relevant to the 'waste nutrient removal and storage' by phytoplankton service

Name of Indicator	OSPAR	HELCOM	BSC
Nitrogen concentration	OSPAR uses (recommends) five specific EcoQOs to assess eutrophication in the NEA: nutrient enrichment i.e. winter nutrients (DIN & DIP), phytoplankton chlorophyll a concentration, phytoplankton indicator species, oxygen depletion and benthos. Not all have been strictly followed by contracted parties however in most cases nutrients, chlorophyll and oxygen are reported on and in some cases riverine inputs, macrophytes, organic matter and algal toxins are also monitored/assessed. The reported information by OSPAR is given as an overall assessment for Eutrophication for each region. For the purposes of this assessment, the same classification is applied for each of the five OSPAR criteria: i.e. Chlorophyll-a, Phytoplankton composition (or indicator species), Nitrogen and Phosphorus, Oxygen and Benthos.	Nitrogen concentration	Trend in nitrogen concentration
Phosphorus concentration		Phosphorus concentration	Trend in phosphorus concentration
Phytoplankton biomass (Chlorophyll-a)		Chlorophyll-a	Trend in phytoplankton biomass
Oxygen		Oxygen	Trend in hypoxic events
Benthos			Trend in benthic condition

Step 3.3 Establish the quality classification (pass/fail) from each policy

Step 3	**Identifying the current state and trends of the critical ecosystem components**
3.3	Establish the quality classification (pass/fail) from each policy

Aligning the objectives of each law/policy used

For each policy, the reported status information was divided into 'pass' or 'fail' in reference to policy objectives for that policy (Table AIII.15). The WFD has five quality classifications, however the policy objective is to achieve at least 'good' status, therefore 'moderate and lower' were grouped under 'fail' and 'good' or higher were grouped under 'pass'. For the MSFD, data are reported under two quality classifications and the objective is to achieve 'good' status, thus 'good' was aligned with 'pass' and 'not good' was aligned with 'fail'. As discussed above, the EEA have no specific policy objectives with the status information reported (i.e. 'high', 'moderate' or 'low'), but it was assumed that 'high' would correspond to a failure of policy objectives and 'low' would correspond to a pass, while moderate could not be interpreted. For OSPAR, eutrophication problems are reported as 'no problems', 'some problems' or 'many problems'. 'No problems' was considered to be a 'pass' while the other two categories were considered to 'fail' policy objectives. HELCOM reports eutrophication indicators as being within or outside of targets, where 'within target' was considered a 'pass' and 'outside target' was considered a 'fail'.

Table AIII.15 The status classifications of each policy grouped under 'pass' (green and blue) or 'fail' (yellow, orange and red)

Fail/Pass Policy Objective	**EU and Other Law and Policy**				
	Water Framework Directive	**MSFD**	**EEA**	**OSPAR**	**HELCOM**
Pass	**High**	**Good**	**Low**	**No Problems**	**Within Target**
	Good				
Fail	**Moderate**	**Not Good**	**High**	**Some Problems**	**Outside Target**
	Poor			**Many Problems**	
	Bad				

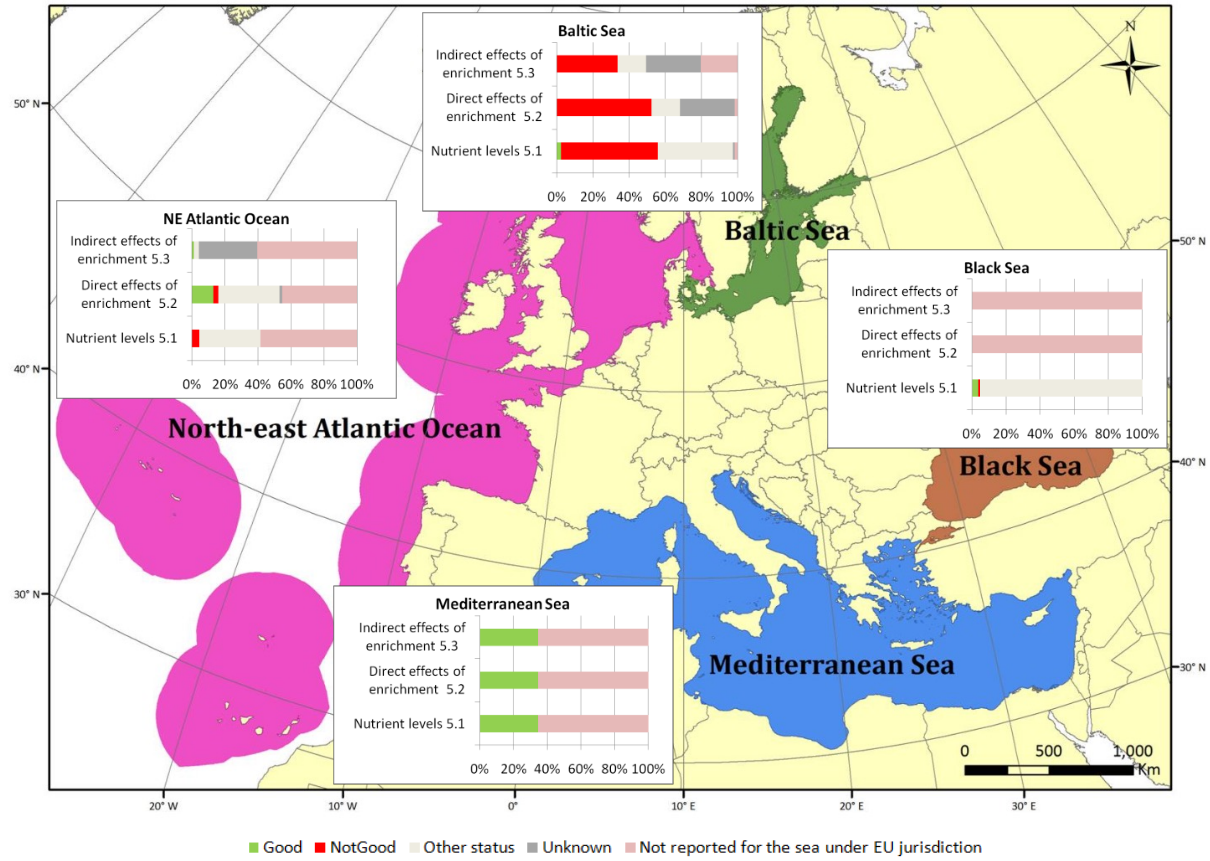
Status classification from each law/policy

MSFD

Descriptor 5: Eutrophication

The MSFD reporting gives a level of pressure (from nitrogen, phosphorus and organic matter) and level of impact on the water column due to nutrients in terms of percentage area affected. These metrics are then integrated to give a quality classification (Good or Not Good) according to the three criteria: Nutrient levels, Direct effects of enrichment and indirect effects of enrichment (Figure AIII.3). The quality classifications were used in this assessment.

Figure AIII.3: Reported information on nutrients assessment (from ETC/ICM, 2014b)



The greatest proportion of area assigned as 'good', 'not good' or 'unknown' (or 'other') for each region and each criterion was given as the overall outcome for each criterion.

Note that the EU-level 2012 reporting on the MSFD Initial assessment (Article 8) and thus the status of the GES descriptors available for this study refers only to Member State reporting on status i.e. whether the marine region is achieving 'Good' or 'Not good' status (or 'other', 'unknown', 'not reported/not assessed'). This also applies to the trends reported, which are trends in whether there is an improvement (trend increase) or worsening (trend decrease) in achieving 'Good' status. The trends shown for the following MSFD criteria are, therefore, not trends in the actual criteria reported (e.g. the trend in criterion 5.2 on the 'Direct effects of enrichment' regarding e.g. chlorophyll concentrations, which could be an aggregation of several metrics and thus differ depending on the Member State reporting) but trends in the status.

Criteria 5.1 Nutrient Levels

This criterion includes the measurement of nutrient concentrations in the water column and nutrient ratios. Original data was presented as area (km^2) in ETC/ICM report 2014b and these have been presented as the proportion of the total area classified as 'good', 'not good' or 'insufficient information', and the associated confidence levels, in Tables AI.18–A1.20. Information reported as 'other', 'unknown' and 'not reported/assessed' were included under 'insufficient information', as these could not be interpreted in terms of a 'pass' or 'fail' in policy objectives.

Table AIII.16 Status of assessment areas reported for MSFD Criterion 5.1 Nutrient levels with the greatest proportion and thus the overall outcome highlighted for each EU region (original data from ETC/ICM report 2014b). 'Insufficient information' includes information reported as 'other', 'unknown' and 'not reported/assessed'

Region	Percentage area of each region assigned to each quality classification (%)		
	Good	Not Good	Insufficient Information
Baltic Sea	2.4	53.6	44.0
Black Sea	3.6	1.2	95.2
Mediterranean Sea	34.6	0	65.4
NE Atlantic Ocean	0	4.6	95.4
EU overview	11.5	6.9	81.5

Table AIII.17 Trends* for assessment areas reported for MSFD Criterion 5.1 Nutrient levels with the greatest proportion and thus the overall outcome highlighted for each EU region (original data from ETC/ICM report 2014b). 'Insufficient information' includes information reported as 'other', 'unknown' and 'not reported/assessed'

Region	Percentage area of each region assigned to each trend (%)			
	Trend increasing	Trend stable	Trend decreasing	Insufficient Information
Baltic Sea	31.9	23.8	16.1	28.1
Black Sea	31.7	0	31.7	36.6
Mediterranean Sea	13.1	12.3	0	74.6
NE Atlantic Ocean	5.9	35.4	0	58.7
EU overview	10.5	26.7	1.5	61.3

***Note:** Trends for the MSFD GES descriptors/criteria are trends of status, i.e. whether the region is moving away from (decreasing trend i.e. deteriorating) or towards (increasing trend i.e. improving) achieving 'Good' status and do not represent a trend in the actual metrics for the criterion.

Table AIII.18 Confidence levels for assessment areas reported for MSFD Criterion 5.1 Nutrient levels. Note that these are the original reported confidence levels for the MSFD initial assessment (original data from ETC/ICM report 2014b)

Region	Percentage area of each region assigned to each assessment confidence level (%)				
	Confidence high	Confidence moderate	Confidence low	Confidence unknown	Not reported/ not assessed
Baltic Sea	13.0	32.2	0.0	42.4	12.4
Black Sea	0.0	100.0	0.0	0.0	0.0
Mediterranean Sea	25.4	0.0	9.2	0.0	65.4
NE Atlantic Ocean	40.0	0.8	0.0	0.0	59.3
EU overview	32.8	3.7	3.0	3.3	57.2

Criteria 5.2 Direct Effects of Enrichment

This criterion includes the measurement of chlorophyll concentration, phytoplankton community composition and water transparency. Original data was presented as area (km^2) in ETC/ICM report 2014b and these have been presented as the proportion of the total area classified as 'good', 'not good', 'other', 'unknown' or 'not reported/assessed', and the associated confidence levels, in Tables AIII.19–AIII.21.

Table AIII.19 Status of assessment areas reported for MSFD Criterion 5.2 Direct Effects of Enrichment with the greatest proportion and thus the overall outcome highlighted for each EU region (original data from ETC/ICM report 2014b). 'Insufficient information' includes information reported as 'other', 'unknown' and 'not reported/assessed'

Region	Percentage area of each region assigned to each quality classification (%)		
	Good	Not Good	Insufficient Information
Baltic Sea	0	52.3	47.7
Black Sea	0	0	100
Mediterranean Sea	34.6	0	65.4
NE Atlantic Ocean	13.1	3	83.8
EU overview	19	5.9	75.1

Table AIII.20 Trends* for assessment areas reported for MSFD Criterion 5.2 Direct Effects of Enrichment with the greatest proportion and thus the overall outcome highlighted for each EU region (original data from ETC/ICM report 2014b). 'Insufficient information' includes information reported as 'other', 'unknown' and 'not reported/assessed'

Region	Percentage area of each region assigned to each trend (%)			
	Trend increasing	Trend stable	Trend decreasing	Insufficient Information
Baltic Sea	11.2	12.6	30.4	45.8
Black Sea	0	0	0	100
Mediterranean Sea	13.1	12.3	0	74.6
NE Atlantic Ocean	3	36.1	0	60.9
EU overview	6.9	26.2	2.4	64.4

***Note:** Trends for the MSFD GES descriptors/criteria are trends of status, i.e. whether the region is moving away from (decreasing trend) or towards (increasing trend) achieving 'Good' status and do not represent a trend in the actual metrics for the criterion.

Table AIII.21 Confidence levels for assessment areas reported for MSFD Criterion 5.2 Direct Effects of Enrichment. Note that these are the original reported confidence levels for the MSFD initial assessment (original data from ETC/ICM report 2014b)

Region	Percentage area of each region assigned to each assessment confidence level (%)				
	Confidence high	Confidence moderate	Confidence low	Confidence unknown	Not reported/ not assessed
Baltic Sea	8.5	33.0	4.6	41.4	12.5
Black Sea	0.0	0.0	0.0	0.0	100.0
Mediterranean Sea	25.4	0.0	9.3	0.0	65.4
NE Atlantic Ocean	39.1	0.0	1.6	13.1	46.1
EU overview	32.0	2.6	4.3	11.0	50.1

Criteria 5.3 Indirect Effects of Enrichment

This criterion includes the measurement of abundance of perennial seaweeds and seagrasses and levels of dissolved oxygen. Original data was presented as area (km^2) in ETC/ICM report 2014b and these have been presented as the proportion of the total area classified as 'good', 'not good', 'other', 'unknown' or 'not reported/assessed', and the associated confidence levels, in Tables AIII.22–AIII.24.

Table AIII.22 Status of assessment areas reported for MSFD Criterion 5.3 Indirect Effects of Enrichment with the greatest proportion and thus the overall outcome highlighted for each EU region (original data from ETC/ICM report 2014b). 'Insufficient information' includes information reported as 'other', 'unknown' and 'not reported/assessed'

Region	Percentage area of each region assigned to each quality classification (%)		
	Good	Not Good	Insufficient Information
Baltic Sea	0.1	33.4	66.5
Black Sea	0	0	100
Mediterranean Sea	34.6	0	65.4
NE Atlantic Ocean	1.2	0	98.8
EU overview	12	2.6	85.4

Table AIII.23 Trends* for assessment areas reported for MSFD Criterion 5.3 Indirect Effects of Enrichment with the greatest proportion and thus the overall outcome highlighted for each EU region (original data from ETC/ICM report 2014b). 'Insufficient information' includes information reported as 'other', 'unknown' and 'not reported/assessed'

Region	Percentage area of each region assigned to each trend (%)			
	Trend decreasing	Trend stable	Trend increasing	Insufficient Information
Baltic Sea	30.4	10.7	2.7	56.1
Black Sea	0	0	0	100
Mediterranean Sea	0	12.3	13.1	74.6
NE Atlantic Ocean	0	2.3	0	97.7
EU overview	2.4	6.2	4.5	86.9

***Note:** Trends for the MSFD GES descriptors/criteria are trends of status, i.e. whether the region is moving away from (decreasing trend) or towards (increasing trend) achieving 'Good' status and do not represent a trend in the actual metrics for the criterion.

Table AIII.24 Confidence levels for assessment areas reported for MSFD Criterion 5.3 Indirect Effects of Enrichment. Note that these are the original reported confidence levels for the MSFD initial assessment (original data from ETC/ICM report 2014b)

Region	Percentage area of each region assigned to each assessment confidence level (%)				
	Confidence high	Confidence moderate	Confidence low	Confidence unknown	Not reported/ not assessed
Baltic Sea	0.0	22.8	4.6	41.4	31.2
Black Sea	0.0	0.0	0.0	0.0	100.0
Mediterranean Sea	25.4	0.0	9.3	0.0	65.4
NE Atlantic Ocean	0.0	2.3	1.6	35.0	61.1
EU overview	8.3	3.2	4.3	23.8	60.4

Overall outcome

From the Tables above (Table AIII.16-AIII.24), an overall assessment is given for each region weighted based on the highest proportion of areas with a given classification (Table AIII.25) (except where greater than 50 % of the area had 'insufficient information'). For the NEA, an 'other' status was mostly reported for all criteria and this was not useable for this assessment and is given here as 'insufficient information'. For the Mediterranean there was also 'insufficient information' to assess state and trends. For the Baltic region, an overall 'not good' status was found for Criteria 5.1 and 5.2, and an 'increasing' trend was found for Criteria 5.1 and 'decreasing' trend for Criteria 5.2. There was 'insufficient information' to assess Criteria 5.3. In the Black Sea, there was 'insufficient information' to assess the states and trends except for the trend for Criteria 5.1 which showed both 'increasing' and 'decreasing trends' in nutrients in equal proportions. This is given as 'stable' in the overall summary.

Table AIII.25 Overall assessment of state and trends* for each criteria from MSFD Descriptor 5 for each region, where 'good state' represents a 'pass' and 'not good state' represents a 'fail' of policy objectives. Where there is 'Insufficient information', the assessment is not possible.

	Region			
GES Descriptor Criterion	**NEA**	**Mediterranean**	**Baltic**	**Black**
Criteria 5.1 Nutrient Levels	State: Insufficient Information, Trend: Insufficient Information	State: Insufficient Information, Trend: Insufficient Information	Not Good State, Trend Increasing	State: Insufficient Information, Trend Stable
Criteria 5.2 Direct Effects of Enrichment	State: Insufficient Information, Trend: Insufficient Information	State: Insufficient Information, Trend: Insufficient Information	Not Good State, Trend Decreasing	State: Insufficient Information, Trend: Insufficient Information
Criteria 5.3 Indirect Effects of Enrichment	State: Insufficient Information, Trend: Insufficient Information	State: Insufficient Information, Trend: Insufficient Information	State: Insufficient Information, Trend: Insufficient Information	State: Insufficient Information, Trend: Insufficient Information

***Note:** Trends for the MSFD GES descriptors/criteria are trends of status, i.e. whether the region is moving away from (decreasing trend) or towards (increasing trend) achieving 'Good' status and do not represent a trend in the actual metrics for the criterion.

WFD

Subsets of data of classifications of water bodies are available from the WFD WISE database including the ecological status of surface water bodies. For this assessment, the transitional and coastal water bodies were extracted. Data came from 10 countries, thus the dataset available was incomplete.

River Basin Districts (RBD) are given a classification for transitional waters and coastal waters. For this study, each RBD was assigned a region (where possible – e.g. RBD DK1 from Denmark spans both Baltic and North East Atlantic regions). In order to determine the most frequent quality classification, the outcome classifications (which are given as percentage High, Good, Moderate, Poor, Bad, Unknown or Not applicable) were scaled according to the area of the surface water (transitional or coastal) by taking the sum of the areas in the whole region and assigning a value between 0 and 1 to each individual surface water and multiplying this by the percentage of area classified as good, moderate, etc. This gave the percentage of each classification of surface waters for each region (Table AIII.26).

Table AI.26 Ecological status of transitional and coastal surface water bodies from the WISE WFD database (from http://www.eea.europa.eu/data-and-maps/data/wise_wfd)

Region	Area (km^2)	Number of countries	High (%)	Good (%)	Moderate (%)	Poor (%)	Bad (%)	Unknown (%)	Not applicable (%)
Baltic	61863	4	0.1	19.1	54.4	7.7	0.9	17.8	0.0
Black (Romania)	1537	1	0.0	21.6	10.9	64.5	3.1	0.0	0.0
Med	1654400	4	1.3	63.6	17.4	8.5	7.7	1.6	0.0
NEA	24148	4	14.6	14.9	26.4	9.5	0.1	33.3	1.2
NEA/Baltic	37092	2	0.0	0.0	14.2	30.8	1.8	53.2	0.0

For this assessment, the only important criteria were whether the classifications 'pass' or 'fail' the policy objectives. A 'fail' for the WFD is moderate quality or less. Therefore, the data in Table 28 was aggregated into a total 'pass' and a total 'fail' and this is shown in Table AIII.27.

Table AIII.27 Ecological status of transitional and coastal surface water bodies from the WISE WFD database simplified to 'pass' or 'fail' for each region with the most frequent assigned quality classification highlighted in yellow

Region	Area (km^2)	Number of countries	Pass % (Aggregation of High + Good)	Fail % (Aggregation of Moderate + Poor + Bad)	Unknown (%)	Not applicable (%)
Baltic	61863	4	19.2	63	17.8	0
Black (Romania)	1537	1	21.6	78.5	0	0
Med	1654400	4	64.9	33.6	1.6	0
NEA	24148	4	29.5	36	33.3	1.2
NEA/Baltic	37092	2	0	46.8	53.2	0

Overall outcome

Although the data were incomplete, the most frequent classification result (classifications highlighted in yellow in Table AIII.27) was used as an indication of each region as a whole (Table AIII.28). Where there was an ambiguous region between the NEA and the Baltic, there was insufficient information (over 50 % unknown) to classify this area and this information was discarded.

Table AIII.28 Overall assessment of state from the WFD for each region. Trends were unavailable

	Region			
	NEA	**Mediterranean**	**Baltic**	**Black**
Overall WFD classification	Fail	Pass	Fail	Fail

The confidence in the WFD reported data is expected to be high but the information available here may not be widely representative of the regions due to a limited number of country's data used.

EEA Indicators

Data are available which show recent concentrations of phytoplankton and nutrients, as well as trends per regional sea from 1985-2010 (phytoplankton from http://www.eea.europa.eu/data-and-maps/indicators/chlorophyll-in-transitional-coastal-and/chlorophyll-in-transitional-coastal-and-3 and nutrients from http://www.eea.europa.eu/data-and-maps/indicators/nutrients-in-transitional-coastal-and/nutrients-in-transitional-coastal-and-4). These are reported as a number of monitoring stations which fall into 'high', 'moderate' or 'low' categories of concentration of phytoplankton or nutrients Table AIII.29, and trends are reported as increasing, decreasing or no trend (Table AIII.30-AIII.34).

The 'high', 'moderate' and 'low' concentration classifications given by the reported EEA data do not correspond to any specific policy objectives, however it was assumed that 'low' concentration would be equivalent to a 'pass' in policy objectives and 'high' concentration would be equivalent to a 'fail' in policy objectives. However, it was not possible to interpret 'moderate' in relation to a 'pass' or 'fail' in policy objectives. Thus, where the outcome was 'moderate', no state classification was given

and only trends were used. The most frequent classification or trend was taken in each case (most frequent highlighted in yellow in Tables AIII.30–AIII.34).

Table AIII.29 EEA reported levels of Chlorophyll-a concentration with the greatest proportion of stations and thus the overall outcome highlighted for each EU region

Region		Percent of stations where concentration is:		
	No. of stations	High	Moderate	Low
Bay of Biscay	49	18	59	20
Celtic Sea	168	15	63	23
Greater North Sea	156	21	60	20
North East Atlantic Ocean (first three rows combined)	373	18	61	21
Baltic	266	20	60	20
Black	27	22	56	22
Med	59	20	59	20

Table AIII.30 EEA reported trends in Chlorophyll-a concentration with the greatest proportion of stations and thus the overall outcome highlighted for each EU region

Region		Percent of stations where trend is:		
	No. of stations	Increasing	Decreasing	No trend
Atlantic	75	15	3	83
North Sea	165	2	13	85
Atlantic and North Sea (first two rows combined)	240	6	10	84
Baltic	441	7	7	86
Black Sea	Not available			
Mediterranean	52	0	12	88

Table AIII.31 EEA reported levels of winter oxidized nitrogen (NO_2+NO_3) concentrations with the greatest proportion of stations and thus the overall outcome highlighted for each EU region

Region		Approx. percent of stations where concentration is:		
	Approx. no. of stations	High	Moderate	Low
Bay of Biscay	17	24	53	24
Celtic Sea	93	20	59	20
Greater North Sea	154	19	61	20
North East Atlantic Ocean (first three rows combined)	264	20	60	21
Baltic	240	21	59	20
Black	-	Insufficient data		
Med	12	25	50	25

Table AIII.32 EEA reported trends in winter oxidized nitrogen (NO2+NO3) concentrations with the greatest proportion of stations and thus the overall outcome highlighted for each EU region

Region		Percent of stations where trend is:		
	No. of stations	Increasing	Decreasing	No trend
Greater North Sea	151	0	13	87
Celtic Seas, Bay of Biscay and Iberian Coast	101	Insufficient data		
Baltic	309	3	19	78
Black	-	Insufficient data		
Mediterranean	18	Insufficient data		

Table AIII.33 EEA reported levels of winter orthophosphate concentrations with the greatest proportion of stations and thus the overall outcome highlighted for each EU region

		Number		
Region	No. of stations	High	Moderate	Low
Baltic Sea, Middle	66	15	85	0
Baltic Sea, North	106	27	28	44
Baltic Sea, West	76	14	82	4
Baltic Sea	248	20	60	20
Bay of Biscay & Iberian Coast	42	21	57	21
Celtic Seas	79	20	59	20
Greater North Sea	151	21	62	18
North East Atlantic Ocean	272	21	60	19
Mediterranean	21	24	57	19
Black Sea	No data			

Table AIII.34 EEA reported trends in winter orthophosphate concentrations with the greatest proportion of stations and thus the overall outcome highlighted for each EU region

Region		Percent of stations where trend is:		
	No. of stations	Increasing	Decreasing	No trend
Greater North Sea	160	1	28	71
Celtic Seas, Bay of Biscay and Iberian Coast	104	Insufficient data		
Baltic	303	10	5	85
Black	-	Insufficient data		
Mediterranean	19	Insufficient data		

The overall assessment is given for each region for each indicator and is based on the highest proportion of stations with a given classification (Table AIII.35). For the NEA, each indicator and the overall classification was given as 'moderate' and the trend 'stable'. For the Mediterranean, concentrations of chlorophyll and nutrients were found to be 'moderate' for this region. Trends in

phytoplankton were 'stable' but there was 'insufficient information' to assess trends in nutrients. For the Baltic a 'moderate' status was found in all indicators and a 'stable' trend. In the Black Sea, no trends were known and only a 'moderate' status was assigned for chlorophyll concentrations.

Only trends are shown in Table AIII.35 as all reported statuses of phytoplankton and nutrients were 'moderate' and as discussed above, this classification cannot be interpreted in terms of policy objectives.

Table AIII.35 Overall assessment of (state and) trends for each EEA indicator per marine region relevant to the 'waste nutrient removal and storage' by phytoplankton service

	Region			
	NEA	**Mediterranean**	**Baltic**	**Black**
Phytoplankton (Chlorophyll-a)	Stable Trend	Stable Trend	Stable Trend	Trend: Insufficient information
Nitrogen	Stable Trend	Trend: Insufficient information	Stable Trend	Trend: Insufficient information
Phosphorus	Stable Trend	Trend: Insufficient information	Stable Trend	Trend: Insufficient information

Confidence in EEA reporting is expected to be high since the trends are based on a long time series (data incorporated from 1985–2010).

OSPAR in the North East Atlantic

OSPAR uses (recommends) five specific EcoQOs to assess eutrophication in the NEA which include the metrics of focus in this study: nutrient enrichment i.e. winter nutrients (DIN & DIP), phytoplankton chlorophyll a concentration, and benthos (OSPAR, 2010). Not all metrics have been adopted/strictly followed by contracted parties. However, in most cases, nutrients, chlorophyll and oxygen are reported on and, in some cases, riverine inputs, macrophytes, organic matter and algal toxins are also monitored/assessed.

Although the majority of two of the regions (Region I and Region V) do not overlap with the EU area, exchange of phytoplankton and nutrients between OSPAR regions is likely to make the whole of the OSPAR region relevant for the potential delivery of this service. The degree of exchange within the North East Atlantic region is currently being investigated in projects such as FASTNEt (https://www.bodc.ac.uk/projects/data_management/uk/fastnet/). Thus, the results from the entire OSPAR region was included in the assessment (Table AIII.36–AIII.37).

Table AIII.36 Reported status of eutrophication in each of the OSPAR regions

	Region	Eutrophication status (by 2010)	Change in status	Marine surface area (km²)	% Region
I	Arctic Waters	No problems	No trend	5,491,483.54	41
II	Greater North Sea	Many Problems	No trend*	766,884.8	6
III	Celtic seas	Some problems	No trend*	366,358.21	3
IV	Bay of Biscay and Iberian Coast	Some problems	No trend*	533,432.69	4
V	Wider Atlantic	No problems	No trend	6,316,602.85	47
	TOTAL			13,474,762.00	

*2001–2006 compared to 1990–2000

Table AIII.37 Reported confidence in OSPAR eutrophication assessment in each of the OSPAR regions

	Region	Eutrophication status (by 2010)	Change in status	Marine surface area (km²)	% Region
I	Arctic Waters	Low	Low	5,491,483.54	41
II	Greater North Sea	High	High	766,884.8	6
III	Celtic seas	High	High	366,358.21	3
IV	Bay of Biscay and Iberian Coast	High	High	533,432.69	4
V	Wider Atlantic	Low	Low	6,316,602.85	47
	TOTAL			13,474,762	

For this assessment, the only important criteria were whether the classifications 'pass' or 'fail' the policy objectives. A 'fail' for OSPAR is considered as 'some' or 'many' problems and a 'pass' as having 'no problems'. Therefore, the data in Table AI.38 was aggregated into a total 'pass' and a total 'fail' and this is shown in Table AIII.38. The overall outcome shows that 88 % of the region has 'no problems' and no trend. Thus the overall outcome can be given as 'no problems'.

Table AIII.38 Total proportion of OSPAR areas passing or failing policy objectives

Eutrophication status (by 2010)	Change in status	% Region
No problems	No trend	88
Many Problems	No trend	6
Some problems	No trend	7
Total Pass		**88**
Total Fail		**13**

HELCOM in the Baltic Sea

HELCOM reports a number of indicators relevant to the 'waste nutrient removal and storage' by phytoplankton service and whether these fall within or outside of targets (Table AIII.39). These are reported per station with a total of 189 stations in 17 sub-basins. The overall outcomes and confidence in assessment were assigned by weighting the classifications according to number of stations assigned as being within or outside of the target (or the proportion of high, medium and low confidence in the case of confidence in the assessment) (Table AIII.40–AIII.41).

Table AIII.39 Averaged from 2007–2011, green indicates 'within HELCOM targets' whereas red indicates 'outside targets' with the reported confidence (data from HELCOM, 2014)

Baltic Sub-Region	Chlorophyll-a concentration	Nitrogen concentration	Phosphorus concentration (µmol l^{-1})	Oxygen (mg l^{-1})	Secchi depth (m)	Confidence
Kattegat	Pass	Fail	Fail		Pass	High
Great Belt	Fail	Fail	Fail		Fail	High
The Sound	Fail	Fail	Fail		Fail	High
Kiel Bay	Fail	Fail	Fail		Fail	High
Bay of Mecklenburg	Fail	Fail	Fail		Fail	High
Arkona Basin	Fail	Fail	Fail		Fail	High
Bornholm Basin	Fail	Fail	Fail	Fail	Fail	High
Eastern Gotland Basin	Fail	Fail	Fail	Fail	Fail	High
Gdansk Basin	Fail	Fail	Fail		Fail	Mod
Western Gotland Basin	Fail	Fail	Fail	Fail	Fail	Mod
Northern Baltic Proper	Fail	Fail	Fail	Fail	Fail	High
Gulf of Riga	Pass	Pass	Fail		Fail	Low
Gulf of Finland	Fail	Fail	Fail	Fail	Fail	Mod
Åland Sea	Fail	Fail	Fail		Fail	Mod
Bothnian Sea	Fail	Fail	Fail		Fail	Mod
The Quark	Fail	Fail	Pass		Fail	Mod
Bothnian Bay	Fail	Fail	Pass		Pass	Mod

Table AIII.40 Overall outcome for indicators relevant to the 'waste nutrient removal and storage' by phytoplankton service reported to HELCOM. Overall, targets were not met for any metric, red indicates 'outside HELCOM targets'

	(% of sub-basins assessed)				
	Chlorophyll-a concentration	Nitrogen concentration	Phosphorus concentration	Oxygen	Secchi depth
Within Target	12	6	12		6
Outside Target	88	94	88	100	94

Table AIII.41 Summary of confidence levels given for Baltic region

Confidence Level	Proportion (%)
High	53
Med	45
Low	3

Black Sea Commission in the Black Sea

Without targets or reference points, this report provides descriptive information about commonly used indicators (BSC 2008):

- DIN and DIP declined since the 80s
- Decline in phytoplankton biomass (1997–2005)
- N:P ratio increased over last decade
- Increased phytoplankton diversity and richness
- Reduced blooms and biomass
- Increase in diatom fraction i.e. dominance
- Hypoxic events decreasing
- Previous dead zones colonized.

UNEP/MAP and MED POL in the Mediterranean Sea

The joint EEA and UNEP/MAP 2006 study found 15 coastal countries reported eutrophication problems, among which 11 countries classifying these problems as medium (Albania, Algeria, Greece, France, Israel, Morocco, Palestine, Slovenia, Spain, Syria and Tunisia) and 4 countries as important (Croatia, Egypt, Italy, Turkey).

More recent assessments in the Mediterranean show eutrophication impacts occurring in coastal, developed areas and hotspots, mostly along the northern coastline and increasing gradually along the southern coastline (EEA 2014). 14 countries (out of a total 21), which responded, designated 72 sites as being eutrophic or at risk to become eutrophic. However, most of the Mediterranean is characterised by low nutrients.

Step 3.2 and 3.3 Confidence in the information sources used:

A number of factors are relevant for the assessment of confidence in the information sources used:

- Metrics are aggregated and not direct metrics in several cases (e.g. MSFD, WFD, OSPAR) but not HELCOM
- EEA data did not align with policy objectives and the 'moderate' data were discarded
- WFD, MSFD, OSPAR and EEA report on data at different scales (e.g. MSFD: regional sea, WFD: coastal, OSPAR: OSPAR regions which extend beyond the regional sea)
- Even where assigned, much of the MSFD data had large proportions of the area with 'insufficient information' to assess the whole region
- WFD data were incomplete (not all relevant countries included)
- Trends and states are combined across the different information sources although these have been collected over different time periods (e.g. using EEA trend with MSFD state) and are applied at different spatial scales

Given these sources of uncertainty, the confidence is assigned as moderate in this step. This assessment is given for all regions.

Step 3	Identifying the current state and trends of the critical ecosystem components
3.4	Synthesis of results from law/policy and overall assessment

The state of each of the relevant indicators of the critical component (phytoplankton) as given by each relevant policy/law is summarised in Table AIII.42 (a-d) for each region. The overall assessment was determined using the majority approach (with the conservative approach also shown separately) along with confidence scores (see Section 5 for full description of method and also see a brief description below). The overall outcomes are presented as 'failing' to achieve policy/law objectives or 'achieving' policy/law objectives with direction towards or away from policy/law objective. Where the direction is given towards or away from a policy/law objective, this is counter-intuitive where the indicator is also a pressure i.e. the pressure trend is not shown, but the direction which indicates an improvement/deterioration in state.

The confidence assessment takes into account whether the same or different sources of information are used and if the same sources are used, this can reduce the confidence in the assessment if there are no other corroborating data sources or the confidence in the sole source is low. For NEA it is assumed the MSFD and OSPAR data come from separate sources although this is unknown and this would change the confidence classifications made.

Majority Approach:

- Where there is variation in the classifications, but a majority in favour of one, take the **most common**
- Where there is insufficient information:
  - In this overall assessment **across** policies/information sources there is an exception to the general rule of taking the majority classification. This part of the assessment takes the majority *from sources where a classification has been made* i.e. within a metric, discard those information sources where the outcome was 'insufficient information'. The value of using data from several sources is the additional information that they contribute, therefore it is considered better to use classified information where available. In the extreme case of a single assessment then that value is taken to be the overall assessment. This recognises that the assessment, even if it is the only one available, has resulted from a classification process as required by the relevant law/policy and is therefore robust.
  - If 50-50 'pass'/'fail' or 'increasing'/'decreasing': take the least precautionary classification (as the other method, conservative, demonstrates the precautionary approach)

Conservative

- Always take the **most conservative** classification i.e. where conservative means the worst potential state of the ecosystem or worst potential change of state of the ecosystem, even if most classifications are a 'pass'/'increasing' trend and only one shows a 'fail'.
- If there are some known and some 'insufficient information' classifications: The value of using data from several policies is the additional information that they contribute, therefore it is considered better to use classified information where given, even if other laws/policies have had 'insufficient information to classify a metric'.

Confidence assessment

When the same metrics are measured by several policies/laws and one overall classification is taken (as described in the methods above), the confidence is assessed by indicating the level of agreement between different sources.

- **High confidence:** 2 or more different sources of information agree on the outcomes (e.g. in Table AIII.39, the same trend for Nitrogen concentration is reported by the MSFD, the EEA and OSPAR. It is assumed the sources of data for OSPAR and the EEA are the same but that data used for the MSFD are from a separate source, thus there are at two different sources of data which are in agreement leading to high confidence in this trend).
- **Moderate confidence:** only 1 assessment but confidence in this assessment (as given with the reported information) is high. Moderate is given if there is one 'known' assessment and one 'insufficient information' assessment *and* there is high the confidence is the 'known' assessment (e.g. if a classification came from only the MSFD and this classification was 'good', the confidence reported with that assessment of 'good' status would be referred to, and if this was high, the overall assessment here would be assigned 'moderate' confidence).
- **Low confidence:** all other possibilities i.e. several sources of information which disagree, only one source of information which has an associated low or moderate confidence (e.g. in Table AIII.40, the WFD and OSPAR classifications of state of nitrogen concentration disagree and therefore low confidence is assigned

Table AIII.42 (a–d) The overall outcomes for each metric relevant to the 'waste nutrient removal and storage' by phytoplankton service reported under each policy/law for (a) the North East Atlantic, (b) the Baltic Sea, (c) the Mediterranean Sea, and (d) the Black Sea. Note: Only metrics considered the most direct are shown in the tables below, with the exception of 'oxygen' which is considered as a proxy for impact on the benthos where no classification for this impact was available

Legend

(grey)	Not relevant indicator for this policy/law
(red)	Fail to meet objectives
(green)	Achieve objectives
(light blue)	Unable to assess (insufficient information)
↑	Direction towards achieving objectives
↓	Direction away from achieving objectives
↔	No change in direction
No arrow	Unable to assess (insufficient information)

(a) North East Atlantic Ocean

	EU and Other Law and Policy				Majority Assessment		
	EU level			Regional Level			
Indicator	Marine Strategy Framework Directive	Water Framework Directive	EEA Indicators	OSPAR	Overall assessment	Confidence: State	Confidence: Direction
Nitrogen concentration	(light blue)	(red)	(light blue) ↔	(green) ↔	(green) ↔	Low	Low
Phosphorus concentration	(light blue)	(red)	(light blue) ↔	(green) ↔	(green) ↔	Low	Low
Phytoplankton biomass (Chlorophyll-a)	(light blue)	(red)	(light blue) ↔	(green) ↔	(green) ↔	Low	Low
Benthos	(light blue)	(grey)	(grey)	(green) ↔	(green) ↔	Low	Low

North East Atlantic Ocean: The overall assessment for the North East Atlantic was a 'pass' with stable for all metrics used. For the 'state' (pass), using the majority approach, this outcome was determined since there were equal classifications of pass (OSPAR) and fail (WFD), and the least precautionary (best quality outcome) was taken forward from these. The confidence in the change in state ('stable'), where known, was given as low. Although both the EEA and OSPAR reported this trend, it is assumed that the same source of information/data was used by both the EEA and OSPAR. Thus, this was counted as only one source of information. The confidence in the OSPAR reported trends for the majority of the NEA region is low (Table AIII.42), therefore the confidence in these assessment results are low.

Table AIII.42 (a–d) Cont. I

(b) Baltic Sea

Indicator	EU and Other Law and Policy: EU level: Marine Strategy Framework Directive	Water Framework Directive	EEA Indicators	Regional Level: HELCOM	Majority Assessment: Overall assessment	Confidence: State	Confidence: Direction
Nitrogen concentration	↑		↔		↑	Moderate	Low
Phosphorus concentration	↑		↔		↑	Moderate	Low
Phytoplankton biomass (Chlorophyll-a)	↓		↔		↔	Moderate	Low
Oxygen						Moderate	
Benthos							

Baltic Sea: The overall outcome for all metrics used for the Baltic was 'fail' with nutrients going in a direction towards achieving policy/law objectives (allowing the overall environmental quality to improve) and phytoplankton concentrations stable. There was no classification for benthos, thus oxygen was used as a proxy for the benthos in this case. For nutrient and phytoplankton concentrations, the MSFD, WFD and HELCOM are all assumed to use the same information to arrive at their assessment outcomes. Since the confidence in these assessments are high (HELCOM, Table AIII.42) this meant that the confidence in these outcomes was moderate. However, for the direction of changes in state, the EEA and MSFD disagreed. The least precautionary outcome was taken for the overall assessment but this led to a low confidence in these. For oxygen, only one source was available (HELCOM), as the confidence in the HELCOM assessments in high overall (Table AIII.42), the confidence for this assessment is moderate.

Table AIII.42 (a–d) Cont. II

(c) Mediterranean Sea

Indicator	EU and Other Law and Policy – EU level: Marine Strategy Framework Directive	Water Framework Directive	EEA Indicators	Majority Assessment: Overall assessment	Confidence: State	Confidence: Direction
Nitrogen concentration					Low	
Phosphorus concentration			↔	↔	Low	
Phytoplankton biomass (Chlorophyll-a)					Low	Moderate
Benthos						

Mediterranean Sea: The overall assessment for the Mediterranean was a 'pass' for all metrics (except the benthos which could not be assessed). Only one trend could be assessed – phytoplankton concentration and this was found to be 'stable'. The confidence in the assessments was low for all state metrics and there was only one source of information, the WFD, and this was based on only four countries data so is not widely representative of the region. The confidence of the trend came from only once source, the EEA. The confidence in the original EEA assessment is high, therefore, following the confidence assessment rules above, the confidence for this assessment is moderate.

Table AIII.42 (a–d) Cont. III

(d) Black Sea

Indicator	EU and Other Law and Policy				Majority Assessment		
	EU level			Regional Level			
	Marine Strategy Framework Directive	Water Framework Directive	EEA Indicators	Black Sea Commission*	Overall assessment	Confidence: State	Confidence: Direction
Nitrogen concentration	↔			↑	↑	Low	Low
Phosphorus concentration	↔			↑	↑	Low	Low
Phytoplankton biomass (Chlorophyll-a)				↑	↑	Low	Low
Benthos				↑	↑		Low

Black Sea: The overall assessment for the Black Sea was a 'fail' (except the benthos which could not be assessed) with a direction towards achieving policy/law objectives for all metrics. For nutrient concentrations the MSFD and Black Sea Commission disagreed on the direction of state change, thus the least precautionary of these was taken and the confidence assigned was low. The confidence for all other classifications was also low as these were based on a single source of data, where for the WFD this was based on data from only one country and for the Black Sea Commission, the confidence in the original assessment is unknown.

Step 3.4 Confidence in the aggregation of different law/policy outcomes is given for each metric in the tables above (majority approach). The overall confidence assessment for this step (Step 3) is a combination of the confidence in the sources of information (which was given as moderate for all regions) with the confidence on the aggregation of the law/policy outcomes. The lowest confidence score is taken forward for the overall assessment.

NEA: Confidence in the aggregation: Low for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Baltic Sea: Confidence in the aggregation: Moderate for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Mediterranean Sea: Confidence in the aggregation: Low for state and Moderate for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Black Sea: Confidence in the aggregation: Low for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Conservative Approach

Box AIII.1 Four tables (a–d) showing the overall outcomes and confidence for each metric reported under each policy/law for (a) the North East Atlantic, (b) the Baltic Sea, (c) the Mediterranean Sea, and (d) the Black Sea using the conservative approach. Note: only metrics considered the most direct are shown in the tables below, with the exception of 'oxygen' which is considered as a proxy for impact on the benthos where no classification for this impact was available

(a) North East Atlantic Ocean

Indicator	EU and Other Law and Policy				Conservative Assessment		
	EU level			Regional Level			
	Marine Strategy Framework Directive	Water Framework Directive	EEA Indicators	OSPAR	Overall assessment	Confidence: State	Confidence: Direction
Nitrogen concentration			↔	↔	↔	Low	Low
Phosphorus concentration			↔	↔	↔	Low	Low
Phytoplankton biomass (Chlorophyll-a)			↔	↔	↔	Low	Low
Benthos				↔	↔	Low	Low

The overall assessment for the North East Atlantic was a 'fail' (except for the benthos) with stable for all metrics used. For the 'state' (pass/fail), using the conservative approach, this outcome was determined since there were equal classifications of pass (OSPAR) and fail (WFD) (except for benthos where there was only once classification), and the most precautionary (worst quality outcome) was taken forward from these. The confidence in the direction of change ('stable'), where known, was given as low. Although both the EEA and OSPAR reported this direction, it is assumed that the same source of information/data was used by both the EEA and OSPAR. Thus, this was counted as only one source of information. The confidence in the OSPAR reported trends for the majority of the NEA region is low (Table AIII.42), therefore the confidence in these assessment results are low.

Box AIII.1 Cont. I

(b) Baltic Sea

	EU and Other Law and Policy				Conservative Assessment		
	EU level			Regional Level			
Indicator	**Marine Strategy Framework Directive**	**Water Framework Directive**	**EEA Indicators**	**HELCOM**	**Overall assessment**	**Confidence: State**	**Confidence: Direction**
Nitrogen concentration	↑		↔		↔	Moderate	Low
Phosphorus concentration	↑		↔		↔	Moderate	Low
Phytoplankton biomass (Chlorophyll-a)	↓		↔		↓	Moderate	Low
Oxygen						Moderate	
Benthos							

The overall outcome for all metrics used for the Baltic was 'fail' with nutrients 'stable' and phytoplankton concentrations moving away from policy objectives. There was no classification for benthos, thus oxygen was used as a proxy for the benthos in this case. For nutrient and phytoplankton concentrations, the MSFD, WFD and HELCOM are all assumed to use the same information to arrive at their assessment outcomes. Since the confidence in these assessments are high (HELCOM, Table AIII.42) this meant that the confidence in these outcomes was moderate. However, for the direction of changes in state, the EEA and MSFD disagreed. The most precautionary outcome was taken for the overall assessment but this led to a low confidence in these. For oxygen, only one source was available (HELCOM), as the confidence in the HELCOM assessments in high overall (Table AIII.42), the confidence for this assessment is moderate.

Box AIII.1 Cont. II

(c) Mediterranean Sea

	EU and Other Law and Policy			Conservative Assessment		
	EU level					
Indicator	Marine Strategy Framework Directive	Water Framework Directive	EEA Indicators	Overall assessment	Confidence: State	Confidence: Direction
Nitrogen concentration					Low	
Phosphorus concentration					Low	
Phytoplankton biomass (Chlorophyll-a)			↔	↔	Low	Moderate
Benthos						

The overall assessment for the Mediterranean was a 'pass' for all metrics (except the benthos which could not be assessed). Only one direction of change could be assessed – phytoplankton concentration, and this was found to be 'stable'. The confidence in the assessments was low for all state metrics and there was only one source of information, the WFD, and this was based on only four countries data so is not widely representative of the region. The confidence of the trend came from only once source, the EEA. The confidence in the original EEA assessment is high, therefore, following the confidence assessment rules above, the confidence for this assessment is moderate.

Box AIII.1 Cont. III

(d) Black Sea

Indicator	EU and Other Law and Policy				Conservative Assessment		
	EU level			Regional Level			
	Marine Strategy Framework Directive	Water Framework Directive	EEA Indicators	Black Sea Commission*	Overall assessment	Confidence: State	Confidence: Direction
Nitrogen concentration	↔			↑	↔	Low	Low
Phosphorus concentration	↔			↑	↔	Low	Low
Phytoplankton biomass (Chlorophyll-a)				↑	↑	Low	Low
Benthos				↑	↑		Low

The overall assessment for the Black Sea was a 'fail' (except the benthos which could not be assessed) with nutrients 'stable' and a direction towards achieving policy objectives for phytoplankton and impact on benthos. For nutrient concentrations the MSFD and Black Sea Commission disagreed on the direction of state change, thus the most precautionary of these was taken and the confidence assigned was low. The confidence for all other classifications was also low as these were based on a single source of data, where for the WFD this was based on data from only one country and for the Black Sea Commission, the confidence in the original assessment is unknown.

Step 3.4 Confidence in the aggregation of different law/policy outcomes is given for each metric in the tables above (conservative approach). The overall confidence assessment for this step (Step 3) is a combination of the confidence in the sources of information (which was given as moderate for all regions) with the confidence on the aggregation of the law/policy outcomes. The lowest confidence score is taken forward for the overall assessment.

NEA: Confidence in the aggregation: Low for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Baltic Sea: Confidence in the aggregation: Moderate for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Mediterranean Sea: Confidence in the aggregation: Low for state and Moderate for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Black Sea: Confidence in the aggregation: Low for state and Low for trend, thus Low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Irish Sea Detailed Example

Step 3	Identifying the current state and trends of the critical ecosystem components
3.1	Identify relevant policies/laws with reported information on the metrics identified in Step 2
3.2	Synthesis of different policy/law metrics
3.3	Establish the quality classification (pass/fail) from each policy/law
3.4	Synthesis of results from policy/law and overall assessment

The most detailed reported information for the Irish Sea comes from the data reported to OSPAR by the UK and Ireland. The individual country reports (OSPAR, 2008; National Report on the Eutrophication Status of UK water, 2008) were used and the relevant sub regions (for the Irish Sea) extracted from these (Table AIII.43). The reported data were combined into an overall 'pass' or 'fail' based on the proportion of sites which passed or failed for each indicator. 34 estuarine and near shore coastal water, sub-areas for Ireland and the UK were contained within the Irish Sea. Ten eutrophication indicators were measured for these areas, during a six year period, three of the indicators, dissolved nutrient Input (NI), organic carbon / organic matter volume (Oc) and algal toxin events (At), met the policy objectives at all times and the overall results showed that every indicator passed in the majority of regions in the Irish Sea. Specific trends for the Irish Sea were not given in these country reports but the corresponding OSPAR reported trend for Region III (Celtic Seas) showed no trend (Table AIII.44).

As only one policy reported information is being used, the majority and conservative approaches do not need to be used (since there is no aggregation of policy information). Thus there is only one overall outcome which is a 'pass' for all indicators based on the proportion of sites which passed in the region.

Table AIII.43 Summary of the results of the application of the OSPAR common Procedure for Ireland and the UK based upon data collected primarily between 2001 and 2006. For indicator abbreviations see Table AIII.12

Country	Site	Indicator										
		NI	DI	NP	Ca	Ps	Mp	O2	Ck	Oc	At	Confidence
United Kingdom	Northeast Irish Sea											High
	Liverpool Bay											High
	Ythan Estuary											Medium
	Inner Belfast Lough											High
	Outer Belfast Lough											High
	Carlingford Lough											Medium
	Foyle Estuary and Lough											Medium
	Strangford Lough North											Medium
	Strangford Lough South											High
	Larne Lough											High
Ireland	Castletown Estuary											High
	Inner Dundalk Bay											High
	Outer Dundalk Bay											High
	Boyne Estuary											Medium
	Boyne Estuary Plume Zone											High
	Rogerstown Estuary (Inner)											High
	Rogerstown Estuary (Outer)											High
	Adjacent Coastal											High
	Broadmeadow Estuary (Inner)											High
	Broadmeadow Estuary (Outer)											Medium
	Adjacent Coastal											High
	Liffey Estuary											Medium
	Dublin Bay											High
	Adjacent Coastal Area											High
	Avoca Estuary											High
	Adjacant Coastal											High
	Slaney Estuary (Upper)											Medium
	Slaney Estuary (Lower)											High
	South Wexford Harbour											High
	Wexford Harbour											Medium
	Carlingford-Wicklow (Coastal)											High
	Northwest Irish Sea (Offshore)											High
	Wicklow Carnsore (Offshore)											High
	St Georges Channel (Offshore)											High
	Total Pass (%)	**100**	**53**	**91**	**76**	**97**	**97**	**79**	**91**	**100**	**100**	
	Total Fail (%)	**0**	**47**	**9**	**24**	**3**	**3**	**21**	**9**	**0**	**0**	
	Confidence (high) (%)											74
	Confidence (medium) (%)											26

Table AIII.44 OSPAR region III trend which includes the Irish Sea

Region		Change in status	Confidence
III	**Celtic seas**	No trend	High

Step 3.2 and 3.3 Confidence in the information sources used:

Both state and trend information come from OSPAR and the reported confidence in this information is mostly high, thus the confidence is assigned as high in this step.

As only one source of information was used, aggregation of different law/policy outcomes for Step 3.4 was not necessary. Thus the overall confidence for Step 3 is high.

Step	Confidence
Step 1	
Step 2	
Step 3	

Step 4 Identifying the current state and/or change in the capacity of the ecosystem to supply a service based on state of the critical ecosystem components

The metrics directly relevant to the potential for the system to supply services are: the nutrient concentrations, phytoplankton abundance (chlorophyll concentration), and the impact on the benthos (benthos and/or oxygen) (See step 2).

For each region, the outcomes of the key metrics from the overall assessment using the majority approach and the confidence in the state and direction of change in state of these are given (Tables AIII.45-AIII.48). Here the results regarding concentration of nutrients and the impact on the benthos are not expressed in terms of achieving or failing to achieve policy objectives (as done in Table AllI.25, Step 3) but according to whether **the actual** concentrations/impact are 'increasing' or 'decreasing' . This is needed to be in line with Table AIII.5 (Step 2) and the description of the state-service relationship and hence to be able to conclude an overall outcome for service capacity. Therefore, the direction of the trend in nutrient concentrations differs from how it was reported in Table AIII.42 (majority approach) (and Box AIII.1 – conservative approach), which did so in relation to the overall environmental state quality in the context of achieving or failing to achieve policy objectives.

North East Atlantic Ocean

Phytoplankton and nutrient concentrations and the impact on the benthos were found to be 'stable' in the North East Atlantic suggesting the current direction of change in service supply capacity is 'stable' (Table AIII.45). The state of each of these metrics was found to be 'good'.

Table AIII.45 Summary of the overall assessment (majority approach) of each metric directly relevant to assess the capacity of the ecosystem to deliver the service 'waste nutrient removal and storage' by phytoplankton for the North East Atlantic with the current state and trend in the service given based on the state-service relationship described in Step 2

Metric		Classification	Service
State	Nutrient (Nitrogen and Phosphorus) concentration	Good State	Good State, Stable
	Phytoplankton biomass	Good State	
	Benthos	Good State	
Direction of change	Nutrient (Nitrogen and Phosphorus) concentration	Stable	
	Phytoplankton biomass	Stable	
	Impact on Benthos	Stable	

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: NEA

Based on the state and trends of the metrics of ecosystem state, the confidence that this translates to a 'good' capacity to supply the service which is stable is high.

Baltic Sea

The concentrations of nutrients would follow a decreasing trend in the Baltic (given that the contribution of this metric allowed the overall environmental quality to move towards achieving policy objectives and so to improve[9]) but as the phytoplankton was found to be 'stable', this could indicate that the overall potential supply of the service is not changing. However, the direction of change in impact on the benthos could not be assessed and a change in this impact could indicate an improvement or deterioration in the capacity to supply the service if this information was available. Therefore, the direction of change in state could not be determined. The state of each of these metrics was found to be 'bad'.

Table AIII.46 Summary of the overall assessment of each metric directly relevant to assess the capacity of the ecosystem to deliver the service 'waste nutrient removal and storage by phytoplankton for the Baltic Sea with the current state and direction of change in the service given based on the state-service relationship described in Step 2

Metric		Classification	Service
State	Nutrient (Nitrogen and Phosphorus) concentration	Bad State	Bad State, Unable to assess direction of change
	Phytoplankton biomass	Bad State	
	Benthos	Bad State	
Direction of change	Nutrient (Nitrogen and Phosphorus) concentration	Decreasing	
	Phytoplankton biomass	Stable	
	Impact on Benthos	Insufficient Information	

[9] See Table AIll.25. Note, therefore, that the way the direction of the trend in nutrient concentrations is expressed here is different from Table AIII.42 (majority approach) (and Box AIII.1 – conservative approach)

> Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Baltic
>
> Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'bad' capacity to supply the service is high (change in state could not be assessed)

Mediterranean Sea

Phytoplankton was found to be stable in the Mediterranean but there was insufficient information to assess the direction of change in nutrients and the impact on the benthos, thus the current direction of change in capacity to supply the service could not be assessed (Table AIII.47). The state of each of these indicators was found to be good.

Table AIII.47 Summary of the overall assessment of each metric directly relevant to assess the capacity of the ecosystem to deliver the service 'waste nutrient removal and storage' by phytoplankton for the Mediterranean Sea with the current state and trend in the service given based on the state-service relationship described in Step 2

Indicator		Classification	Service
State	Nutrient (Nitrogen and Phosphorus) concentration	Good State	Good State, Unable to assess direction of change
	Phytoplankton biomass	Good State	
	Benthos	Good State	
Direction of change	Nutrient (Nitrogen and Phosphorus) concentration	Insufficient Information	
	Phytoplankton biomass	Stable	
	Impact on Benthos	Insufficient Information	

> Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Mediterranean
>
> Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'good' capacity to supply the service is high (change in state could not be assessed)

Black Sea

Phytoplankton and nutrient concentrations and the impact on the benthos were found to be 'decreasing' in the Black Sea suggesting the current state of the service is 'improving' (Table AIII.48). A 'bad' state was found for nutrients and phytoplankton in terms of achieving policy/law objectives. This does not necessarily represent a 'bad' state of the service, however as eutrophication is known to be a problem in the Black Sea where (BSC, 2008), it is expected that the current state of service supply capacity is 'bad'. Thus an overall 'bad' state was assigned and the 'improving' trend of the service is increasing from a 'bad' point.

Table AIII.48 Summary of the overall assessment of each metric directly relevant to assess the capacity of the ecosystem to deliver the service 'waste nutrient removal and storage' by phytoplankton for the Black Sea with the current state and direction of state change in the service given based on the state-service relationship described in Step 2

Metric		Classification	Confidence	Service
State	Nutrient (Nitrogen and Phosphorus) concentration	Bad State	Low	Bad State, Improving (Scenario B in Table AIII.5(b))
	Phytoplankton biomass	Bad State	Low	
	Benthos	Insufficient Information	Low	
Direction of change	Nutrient (Nitrogen and Phosphorus) concentration	Decreasing	Low	
	Phytoplankton biomass	Decreasing	Low	
	Impact on Benthos	Decreasing	Low	

> Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Black Sea
>
> Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'bad' capacity to supply the service is moderate. This is because one of the metrics could not be assessed due to 'insufficient information', but contextual information on the Black Sea could be used to make the assessment. As all metrics were 'decreasing', confidence in the direction of change of state was high. The overall confidence is taken as the lowest of these i.e. moderate.

The overall assessment of the service for each region is presented below (Tables AIII.49 a–d).

Table AIII.49 a–d Summary of the current state and change in capacity to supply the service nutrient waste removal and storage by phytoplankton in each EU region (a) The North East Atlantic, (b) the Baltic, (c) the Mediterranean and (d) the Black Sea. The colour refers to the state (green=good, pink=bad). The word refers to the change in capacity to supply the service (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

(a) North East Atlantic Ocean

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/Storage: Nutrients	Phytoplankton in all pelagic habitats	Stable	Step | Confidence Step 1 | Step 2 | Step 3 | Step 4 |

(b) Baltic Sea

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/Storage: Nutrients	Phytoplankton in all pelagic habitats	Unable to assess	Step – Confidence Step 1 – (green) Step 2 – (green) Step 3 – (red) Step 4 – (green)

(c) Mediterranean Sea

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/Storage: Nutrients	Phytoplankton in all pelagic habitats	Unable to assess	Step – Confidence Step 1 – (green) Step 2 – (green) Step 3 – (red) Step 4 – (green)

(d) Black Sea

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/Storage: Nutrients	Phytoplankton in all pelagic habitats	Improving	Step – Confidence Step 1 – (green) Step 2 – (green) Step 3 – (red) Step 4 – (yellow)

Conservative Approach

The outcomes of the key metrics from the overall assessment using the conservative approach and the confidence in the state and direction of change in state of these are given for each region (a–d).

(a) North East Atlantic Ocean

Phytoplankton and nutrient concentrations and the impact on the benthos were found to be 'stable' in the North East Atlantic suggesting the current change in potential supply of the service is 'stable' (Table AIII.50). The state of each of phytoplankton and nutrient concentrations was found to be 'bad' while the state of the benthos was found to be 'good'. This would suggest the overall state of the service is 'good' since the effect of potentially elevated nutrient concentrations (as indicated by

‘bad’ state) is not having an impact on the wider ecosystem (as indicated by the ‘good’ state in the benthos). This example shows a situation where potential objectives of the service (if an objective may be to have a ‘good state’ of potential supply) do not align with ecosystem state objectives (where objectives are to have lower concentrations of nutrients and phytoplankton).

Table AIII.50 Summary of the overall assessment of each metric directly relevant to assess the capacity of the ecosystem to deliver the service ‘waste nutrient removal and storage’ by phytoplankton for the NEA with the current state and direction of state change in the service given based on the state-service relationship described in Step 2, as determined using the conservative approach

Metric		Classification	Service
State	Nutrient (Nitrogen and Phosphorus) concentration	Bad State	Good State, Stable
	Phytoplankton biomass	Bad State	
	Benthos	Good State	
Direction of change	Nutrient (Nitrogen and Phosphorus) concentration	Stable	
	Phytoplankton biomass	Stable	
	Impact on Benthos	Stable	

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: NEA

Although the state of the benthos was found to be ‘good’, the state of each of phytoplankton and nutrient concentrations was found to be ‘bad’. From the state-service relationship (Step 2), this suggests the overall state of the service is ‘good’ since the effect of potentially elevated nutrient concentrations (as indicated by ‘bad’ state) is not having an impact on the wider ecosystem (as indicated by the ‘good’ state in the benthos). However, there is lower confidence in this compared to if all metrics were in a good state. The confidence that this translates to a ‘good’ potential supply of the service, which is ‘stable’, is moderate.

(b) Baltic Sea

The concentrations of nutrients were found to be ‘stable’ in the Baltic but as the phytoplankton was found to be increasing, this could indicate that the overall potential supply of the service is potentially ‘improving’ (as there is more phytoplankton to sequester nutrients) (Table AIII.51). However, the direction of change in impact on the benthos could not be assessed and a change in this impact could indicate an improvement or deterioration in the service potential supply if this information was available. The state of each of these metrics was found to be ‘bad’.

Table AIII.51 Summary of the overall assessment of each metrics directly relevant to assess the capacity of the ecosystem to deliver the service 'waste nutrient removal and storage by phytoplankton for the Baltic with the current state and direction of state change in the service given based on the state-service relationship described in Step 2, as determined using the conservative approach

<table>
<tr><th colspan="2">Indicator</th><th>Classification</th><th>Service</th></tr>
<tr><td rowspan="3">State</td><td>Nutrient (Nitrogen and Phosphorus) concentration</td><td>Bad State</td><td rowspan="6">Bad State, Unable to assess direction of change</td></tr>
<tr><td>Phytoplankton biomass</td><td>Bad State</td></tr>
<tr><td>Benthos</td><td>Bad State</td></tr>
<tr><td rowspan="3">Direction of change</td><td>Nutrient (Nitrogen and Phosphorus) concentration</td><td>Stable</td></tr>
<tr><td>Phytoplankton biomass</td><td>Increasing</td></tr>
<tr><td>Impact on Benthos</td><td>Insufficient Information</td></tr>
</table>

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Baltic

Based on the state of the metrics of ecosystem state, the confidence that this translates to a 'bad' capacity to supply the service is high (change in state could not be assessed)

(c) Mediterranean Sea

Phytoplankton was found to be 'stable' in the Mediterranean but there was 'insufficient information' to assess the direction of change in nutrients and the impact on the benthos, thus the current direction of change in capacity to supply the service could not be assessed (Table AIII.52). The state of each of these indicators was found to be 'good'.

Table AIII.52 Summary of the overall assessment of each metric directly relevant to assess the capacity of the ecosystem to deliver the service 'waste nutrient removal and storage by phytoplankton for the Mediterranean with the current state and direction of state change in the service given based on the state-service relationship described in Step 2, as determined using the *conservative* approach

<table>
<tr><th colspan="2">Metric</th><th>Classification</th><th>Service</th></tr>
<tr><td rowspan="3">State</td><td>Nutrient (Nitrogen and Phosphorus) concentration</td><td>Good State</td><td rowspan="6">Good State, Unable to assess direction of change</td></tr>
<tr><td>Phytoplankton biomass</td><td>Good State</td></tr>
<tr><td>Benthos</td><td>Good State</td></tr>
<tr><td rowspan="3">Direction of change</td><td>Nutrient (Nitrogen and Phosphorus) concentration</td><td>Insufficient Information</td></tr>
<tr><td>Phytoplankton biomass</td><td>Stable</td></tr>
<tr><td>Impact on Benthos</td><td>Insufficient Information</td></tr>
</table>

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Mediterranean

Based on the state of the metrics of ecosystem state, the confidence that this translates to a ‘good’ capacity to supply the service is high (change in state could not be assessed)

(d) Black Sea

Phytoplankton concentration and the impact on the benthos were found to be ‘decreasing’ in the Black Sea and nutrient concentrations were found to be ‘stable’ suggesting the current state of the service is improving (Table AIII.53). A ‘bad’ state was found for nutrients and phytoplankton in terms of achieving policy/law objectives. This does not necessarily represent a ‘bad’ state of the service, however as eutrophication is known to be a problem in the Black Sea where (BSC, 2008), it is expected that the current state of potential service supply is ‘bad’. Thus an overall ‘bad’ state was assigned and the improving trend of the service is increasing from a ‘bad’ point. The overall confidence in the state and trends was low.

Table AIII.53 Summary of the overall assessment of each metrics directly relevant to assess the capacity of the ecosystem to deliver the service ‘waste nutrient removal and storage by phytoplankton for the Black Sea with the current state and direction of state change in the service given based on the state-service relationship described in Step 2, as determined using the *conservative* approach

Metric		Classification	Service
State	Nutrient (Nitrogen and Phosphorus) concentration	Bad State	Bad State, Improving
	Phytoplankton biomass	Bad State	
	Benthos	Insufficient Information	
Direction of change	Nutrient (Nitrogen and Phosphorus) concentration	Stable	
	Phytoplankton biomass	Decreasing	
	Impact on Benthos	Decreasing	

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Black Sea

Based on the state of the metrics of ecosystem state, the confidence that this translates to a ‘bad’ capacity to supply the service is moderate. This is because one of the metrics could not be assessed due to insufficient information, but contextual information on the Black Sea could be used to make the assessment. Two metrics were ‘decreasing’ while one was ‘stable’, thus confidence in the change in direction of state was moderate. The overall confidence is taken as the lowest of these i.e. moderate.

The overall assessment of the service for each region as determined using the conservative approach is presented below (Tables AIII.54 a–d).

Table AIII.54 a–d. Summary of current state and change in capacity to supply the service 'waste nutrient removal and storage' by phytoplankton (based on the conservative approach) in each EU region (a) The North East Atlantic, (b) the Baltic, (c) the Mediterranean and (d) the Black Sea. The colour refers to the state (green=good, pink=bad). The word refers to the change in potential supply of the service (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

(a) North East Atlantic Ocean

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/ Storage: Nutrients	Phytoplankton in all pelagic habitats	Stable (green)	Step 1: green; Step 2: green; Step 3: red; Step 4: yellow

(b) Baltic Sea

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/ Storage: Nutrients	Phytoplankton in all pelagic habitats	Unable to assess (pink)	Step 1: green; Step 2: green; Step 3: red; Step 4: green

(c) Mediterranean Sea

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/ Storage: Nutrients	Phytoplankton in all pelagic habitats	Unable to assess (green)	Step 1: green; Step 2: green; Step 3: red; Step 4: green

(d) Black Sea

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/ Storage: Nutrients	Phytoplankton in all pelagic habitats	Improving (pink)	Step 1: green; Step 2: green; Step 3: red; Step 4: yellow

The Irish Sea

Step 4 Identifying the current state and/or change in the capacity of the ecosystem to supply a service based on state of the critical ecosystem components

For the Irish Sea, the outcomes of the key indicators from the overall assessment and the confidence in the state and trends of these are given (Table AIII.55). Here the concentration of nutrients and the impact on the benthos are reported according to whether the actual concentrations/impact are increasing or decreasing to be in line with Table AIII.5 (Step 2) and the description of the state-service relationship.

Phytoplankton and nutrient concentrations and the impact on the benthos were found to be in a 'good' state and 'stable' in the Irish Sea suggesting the current capacity to supply the service is 'stable' (Table AIII.55). The overall confidence in the state was high for all indicators, thus high overall, and high for all trends, thus high overall.

Table AIII.55 Summary of the overall assessment of each metric directly relevant to assess the capacity of the ecosystem to deliver the service 'waste nutrient removal and storage' by phytoplankton for the Irish Sea with the current state and direction of change in state in the capacity to supply the service given based on the state-service relationship described in Step 2

Indicator		Classification	Service
State	Nutrient (Nitrogen and Phosphorus) concentration	Good	Good State, Stable
	Phytoplankton biomass	Good	
	Benthos (measured as changes/kills in zoobenthos and fish kills, macrophytes)	Good	
Direction of Change	Nutrient (Nitrogen and Phosphorus) concentration	Stable	
	Phytoplankton biomass	Stable	
	Impact on Benthos (measured as changes/kills in zoobenthos and fish kills, macrophytes)	Stable	

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: Irish Sea

Based on the state and trends of the metrics of ecosystem state, the confidence that this translates to a 'good' capacity to supply the service which is stable is high.

The overall assessment of the service for the Irish Sea is presented below (Table AIII.56).

Table AIII.56 Summary of current state and change in capacity to supply the service 'waste nutrient removal and storage' by phytoplankton in the Irish Sea. The colour refers to the state (green = good, pink = bad). The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

Ecosystem Service	Critical component(s)	Assessment	Confidence
Waste Removal/Storage: Nutrients	Phytoplankton in all pelagic habitats	Stable	<table><tr><th>Step</th><th>Confidence</th></tr><tr><td>Step 1</td><td></td></tr><tr><td>Step 2</td><td></td></tr><tr><td>Step 3</td><td></td></tr><tr><td>Step 4</td><td></td></tr></table>

Step 5 Assessing Future Change in Service Supply Capacity

Step 5 Assessing Future Change in Service Supply Capacity

5. B Using pressure as a proxy to assess future trends where pressure has already been identified

No prediction of the future trends of phytoplankton or impact on the benthos was available, thus pressure was used as a proxy to infer potential future trends of change in state of phytoplankton and impact on benthos, and hence potential change in the capacity to supply the service. For this service, the pressure (i.e. nutrients) was already identified as part of the current assessment.

The best available information for this assessment is predicted outlook for trends in the pressure. An alternative is to use current (or recent) trends in pressures and assume that these will continue in the future. There is a greater level of confidence associated with predicted future trends than using current (or recent) trends. The available information differed between the regions – only the North East Atlantic had a predicted outlook for the pressure while for the other three regions the current (or recent) trends in nutrients were assumed to continue on the same trend in the future.

North East Atlantic Ocean

OSPAR reports the outlook for the pressures of eutrophication (Table AIII.57), allowing estimation of future trends of the service. The pressures are expected to increase in 88% of the region (Table AIII.58).

Table AIII.57 Outlook for pressures related to eutrophication for each OSPAR region

Region		Eutrophication status (by 2010)	Outlook for pressure	Marine surface area (km²)	% Region
I	**Arctic Waters**	No problems	Increasing	5,491,483.54	41
II	**Greater North Sea**	Many problems	No trend	766,884.80	6
III	**Celtic seas**	Some problems	No trend	366,358.21	3
IV	**Bay of Biscay and Iberian Coast**	Some problems	No trend	533,432.69	4
V	**Wider Atlantic**	No problems	Increasing	6,316,602.85	47
	TOTAL			13,474,762.00	

Table AIII.58 Summary of outlook for pressures related to eutrophication across the entire OSPAR region

Outlook for pressure	% Region
Increasing	88
No trend	13

The overall current and future assessment of the service for the NEA is presented below (Table AIII.59). Since only one policy information source was used, there was no requirement to carry out an aggregation step (majority/conservative assessment), so only one assessment outcome is given. The overall trend in future pressures in most of the OSPAR region is 'increasing'. This implies an increase in nutrients, phytoplankton biomass and impacts on the benthos. Thus in the future, the direction of change in the capacity to supply this service in the NEA is expected to 'deteriorate'. The prediction of future state of the capacity to supply the service is not possible as it is not known by how much the pressures will increase and whether this will reach a point where the system would move from good to bad state.

NEA

Step 5.B (i) Confidence in the information source

The confidence in the type of information is high as the pressure trend given is the predicted outlook (as opposed to current or recent trends), however confidence for the predicted outlook of pressures by OSPAR is not given and as the current confidence assessment for OSPAR is low for most of the OSPAR area (Table AIII.59), the future assessment confidence is also assumed to be low in the majority of the area.

Step 5.B (ii) Understanding of the pressure-state relationship and translating this to the change in service supply capacity

The prediction that the service will 'deteriorate' in the future is high.

Table AIII.59 Summary of the current and future state and change in capacity to supply the service 'waste nutrient removal and storage' by phytoplankton in the NEA. The colour refers to the state (green = good, pink = bad, no colour = unable to assess). The word refers to the change in direction of potential supply of the service (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

<table>
<tr><th>Ecosystem Service</th><th>Critical component(s)</th><th>Current Assessment</th><th>Future Assessment</th><th colspan="2">Confidence</th></tr>
<tr><td rowspan="7">Waste Removal/ Storage: Nutrients</td><td rowspan="7">Phytoplankton in all pelagic habitats</td><td rowspan="7">Stable</td><td rowspan="7">Deteriorating</td><td>Step</td><td>Confidence</td></tr>
<tr><td>Step 1</td><td>(green)</td></tr>
<tr><td>Step 2</td><td>(green)</td></tr>
<tr><td>Step 3</td><td>(red)</td></tr>
<tr><td>Step 4</td><td>(green)</td></tr>
<tr><td>Step 5.B(i)</td><td>(red)</td></tr>
<tr><td>Step 5.b (ii)</td><td>(green)</td></tr>
</table>

Baltic Sea

For the Baltic Sea, no prediction in future trends of pressures was available. Although the current direction of change in potential service supply could not be assessed for the Baltic region, the future assessment is based only on the trends in pressure. There was an assessment of the current (or recent) trends in nutrients for the Baltic, and these are assumed to continue into the future and to impact on the phytoplankton and benthos. Nutrients in the Baltic were assessed to be 'decreasing' (or 'stable' if using the conservative approach).

As nutrients are decreasing, it is assumed that the phytoplankton concentration and the impact on the benthos will 'decrease' in the future. This corresponds to scenario D in Table AIII.5 (b) (Step 2), thus an 'improvement' in the service in expected in the future.

Using the conservative approach, the nutrients are 'stable.' It is assumed that the phytoplankton concentration and the impact on the benthos will remain 'stable' in the future and therefore that the capacity to supply the service will not be changing in the future.

We could not assess the future state of service supply capacity using either the majority or conservative approach because the current direction of change of service supply are unknown. Therefore, we do not know if the state could be changing from 'bad' to 'good', or staying 'bad' in either case.

The overall current and future assessment of the service for the Baltic is presented below (Table AIII.60).

Baltic

Step 5.B (i) Confidence in the information source (majority and conservative)

The confidence in the type of information is low as only recent trends were available.

Step 5.B (ii) Understanding of the pressure-state relationship and translating this to the potential change in service supply

Majority

The prediction that the service will improve in the future is moderate. Although nutrients are 'decreasing', it is not certain that this will allow the recovery of the phytoplankton and benthic components which are both currently in a 'bad' state.

Conservative

The prediction that that the service will remain 'stable' is the future is high, as long as nutrients do not change.

Table AIII.60 Summary of the current and future state and change in capacity to supply the service 'waste nutrient removal and storage' by phytoplankton in the Baltic (a) majority approach and (b) conservative approach. The colour refers to the state (green=good, pink=bad, no colour=unable to assess). The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

(a) Majority

<table>
<tr><th>Ecosystem Service</th><th>Critical component(s)</th><th>Current Assessment</th><th>Future Assessment</th><th>Confidence</th></tr>
<tr><td>Waste Removal/Storage: Nutrients</td><td>Phytoplankton in all pelagic habitats</td><td>Unable to assess</td><td>Improve</td><td><table><tr><th>Step</th><th>Confidence</th></tr><tr><td>Step 1</td><td></td></tr><tr><td>Step 2</td><td></td></tr><tr><td>Step 3</td><td></td></tr><tr><td>Step 4</td><td></td></tr><tr><td>Step 5.B (i)</td><td></td></tr><tr><td>Step 5.B (ii)</td><td></td></tr></table></td></tr>
</table>

(b) Conservative

<table>
<tr><th>Ecosystem Service</th><th>Critical component(s)</th><th>Current Assessment</th><th>Future Assessment</th><th>Confidence</th></tr>
<tr><td>Waste Removal/Storage: Nutrients</td><td>Phytoplankton in all pelagic habitats</td><td>Unable to assess</td><td>Stable</td><td><table><tr><th>Step</th><th>Confidence</th></tr><tr><td>Step 1</td><td></td></tr><tr><td>Step 2</td><td></td></tr><tr><td>Step 3</td><td></td></tr><tr><td>Step 4</td><td></td></tr><tr><td>Step 5.B (i)</td><td></td></tr><tr><td>Step 5.B (ii)</td><td></td></tr></table></td></tr>
</table>

Mediterranean Sea

For the Mediterranean, no prediction in future trends or current trends of pressures was available, thus no future assessment could be carried out.

Black Sea

For the Black Sea, no prediction in future trends of pressures was available. Although the current direction of change in service supply capacity could not be assessed for the Black Sea region, the future assessment is based only on the trends in pressure. There was an assessment of the current (or recent) trends in nutrients for the Black Sea, and these are assumed to continue into the future and to impact on the phytoplankton and benthos. Nutrients in the Black Sea were assessed to be 'decreasing' (or 'stable' if using the conservative approach).

As nutrients are 'decreasing', it is assumed that the phytoplankton concentration and the impact on the benthos will 'decrease' in the future. This corresponds to scenario D in Table AIII.5 (b) (Step 2), thus an 'improvement' in the service is expected in the future.

Using the conservative approach, the nutrients are 'stable'. It is assumed that the phytoplankton concentration and the impact on the benthos will remain 'stable' in the future and therefore that the capacity to supply the service will not be changing in the future.

We could not assess the future state of service supply capacity using either the majority or conservative approach because the current direction of change of service supply is improving and in a 'bad' state. We do not know if the state could be improving from 'bad' to 'good', or not improving enough and staying 'bad' in either case. Thus, the future states could be 'bad' or 'good' depending on the magnitude of improvement.

The overall current and future assessment of the service for the Black Sea is presented below (Table AIII.61).

> Black Sea
>
> Step 5.B (i) Confidence in the information source (majority and conservative)
>
> The confidence in the type of information is low as predicted trends were not available.
>
> Step 5.B (ii) Understanding of the pressure-state relationship and translating this to the potential change in service supply capacity
>
> Majority
>
> The prediction that the service will 'improve' in the future is moderate. Although nutrients are 'decreasing', it is not certain that this will allow the recovery of the phytoplankton and benthic components which are both currently in a 'bad' state.
>
> Conservative
>
> The prediction that that the service will remain 'stable' is the future is high, as long as nutrients do not change.

Table AIII.61 Summary of the current and future state and change in capacity to supply the service 'waste nutrient removal and storage' by phytoplankton in the Black Sea (a) majority approach and (b) conservative approach. The colour refers to the state (green = good, pink = bad, no colour = unable to assess). The word refers to the trend (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

(a) Majority

Ecosystem Service	Critical component(s)	Current Assessment	Future Assessment	Confidence
Waste Removal/Storage: Nutrients	Phytoplankton in all pelagic habitats	Improving (pink)	Improve	see below

Step	Confidence
Step 1	(green)
Step 2	(green)
Step 3	(red)
Step 4	(yellow)
Step 5.B (i)	(red)
Step 5.B (ii)	(yellow)

(b) Conservative

<table>
<tr><th>Ecosystem Service</th><th>Critical component(s)</th><th>Current Assessment</th><th>Future Assessment</th><th>Confidence</th></tr>
<tr><td>Waste Removal/Storage: Nutrients</td><td>Phytoplankton in all pelagic habitats</td><td>Improving</td><td>Stable</td><td><table><tr><th>Step</th><th>Confidence</th></tr><tr><td>Step 1</td><td></td></tr><tr><td>Step 2</td><td></td></tr><tr><td>Step 3</td><td></td></tr><tr><td>Step 4</td><td></td></tr><tr><td>Step 5.B (i)</td><td></td></tr><tr><td>Step 5.B (ii)</td><td></td></tr></table></td></tr>
</table>

Irish Sea

OSPAR reports the outlook for the pressures of eutrophication in the Celtic Seas (OSPAR region III) (Table AIII.57) which is no trend, allowing estimation of future trends of the service.

The overall current and future assessment of the service for the Irish Sea is presented below (Table AIII.62). Since only one policy information source was used, there was no requirement to carry out a majority/conservative assessment, so only one assessment outcome is given. The overall trend in future pressures in the Irish Sea area is 'stable'. This implies no change in nutrients, phytoplankton biomass and impacts on the benthos and hence, no change to the capacity to supply the service. Thus in the future, this service in the Irish Sea is expected to remain the same (i.e. 'good' state and 'stable' trend).

Irish Sea

Step 5.B (i) Confidence in the information source

The confidence in the type of information is high as the pressure trend given is the predicted outlook (as opposed to current or recent trends). Confidence for the predicted outlook of pressures by OSPAR is not given but as the current confidence assessment for OSPAR is high for this region (Table AIII.62), the future assessment confidence is also assumed to be high.

Step 5.B (ii) Understanding of the pressure-state relationship and translating this to the potential change in service supply capacity

The prediction that that the service will remain 'stable' with a 'good' state in the future is high.

Table AIII.62 Summary of the current and future state and direction of change in service supply capacity for 'waste nutrient removal and storage' by phytoplankton in the Irish Sea. The colour refers to the state (green = good, pink = bad, no colour = unable to assess). The word refers to the direction of change (improving, deteriorating or stable). Confidence is shown for each step of the assessment where red = low, yellow = moderate, and green = high confidence

Ecosystem Service	Critical component(s)	Assessment	Future Assessment	Confidence
Waste Removal/Storage: Nutrients	Phytoplankton in all pelagic habitats	Stable	Stable	Step / Confidence Step 1 Step 2 Step 3 Step 4 Step 5.B (i) Step 5.B (ii)

Discussion and Conclusion

The North East Atlantic currently shows a good capacity to assimilate nutrients and this is stable. This is a large and well-mixed region, which would suggest that it has a high capacity for assimilating nutrient inputs. The Irish Sea example also showed the same outcome. However, it is known that at more localised areas in the NEA, there are more problems and less capacity for the service (OSPAR, 2010). In the NEA there has been slow progress in controlling pressures from farming, which is the largest source of nitrogen in the North Sea and Celtic Seas (OSPAR, 2010). Atmospheric deposition of nitrogen is also high and increasing due to shipping and this has resulted in an assessment of a potential decrease in the service capacity in the future. The outcome for the future assessment for the Irish Sea did not change, in contrast to the NEA as a whole. This may be because the main sources of nutrient input (agriculturally derived, OSPAR, 2010) have been and are continuing to be controlled in a consistent way. The classifications for the state of the metrics in the NEA by OSPAR and WFD disagreed. These two sources do not cover the same spatial scale with OSPAR covering a much larger area and arguably a more appropriate scale for this assessment than that covered by the WFD (since mixing and nutrient exchange with the open ocean would be important for the capacity for the ecosystem to supply this service).

The Baltic Sea showed 'bad' current states of this service but would potentially 'improve' (or remain 'stable') in the future. This corresponds to the generally 'bad' state of eutrophication currently in the Baltic Sea. Almost the entire open Baltic Sea was assessed by HELCOM as being in a state of eutrophication and only the open Bothnian Bay was described as being unaffected by eutrophication (Pyhälä et al. 2013, HELCOM, 2014). In 2013, it was established that the level of nutrient inputs to the Baltic Sea has not changed from that of the early 1960s and that a reduction in nutrient input levels is required to see a reduction in Baltic Sea nutrient concentrations (Pyhälä et al. 2013). This may suggest that the conservative approach, which concluded in a 'stable' future outlook for this service would be the most appropriate assessment for this region. The 'majority' approach (which takes the least conservative state assessment) was based largely on MSFD reporting which found an improvement in nutrient concentrations, but only by a relatively small margin, in the Baltic and this could imply that there is some potential for improvement of this service in future in at least part of the region, while other parts of the region are not improving. Obtaining one outcome for an entire region may not always be representative where there are differences within that region. Nevertheless, any improvement is starting from a 'bad' state and may not necessarily move the state

to ‘good’. This example also highlights that targets associated with policy objectives may not always correspond to a target associated with ecosystem service supply. Although the Baltic region is largely considered to be eutrophic (such as in terms of having a high phytoplankton biomass), this does not mean that the service of waste nutrient removal is not occurring, and the high phytoplankton biomass is contributing to the supply of this service.

The capacity for this service in the Mediterranean is good. This corresponds to what is known about the Mediterranean in general, which is that eutrophication is localised in hotspots rather than being a problem that is extensive in the region (EEA 2014).

The Black Sea showed a ‘bad’ capacity for this service but signs that this may ‘improve’ as inputs of nutrients continue to reduce in the regional sea (BSC, 2008).

This service (‘waste nutrient removal and storage’) is linked with other services, not only waste and toxicant treatment (bioremediation), also a regulation and maintenance service, but also with seafood production, a provisioning service. The annual phytoplankton primary production has been shown to be closely correlated to fish landings (Cloern et al. 2014). For example, in the Baltic Sea the increase in phytoplankton production has resulted in an associated increase in fish landings (Cloern et al. 2014). However, although related, an increase in the ‘waste nutrient removal and storage’ service does not necessarily correlate with an increase in seafood production. As discussed, the service considered here has a complex state-service relationship, with different potential outcomes depending on the changes in phytoplankton, nutrients and the impact on the benthos. An increase in the capacity to supply this service and the capacity to supply seafood may follow an increase in phytoplankton. However, a decrease in phytoplankton can lead to an increase in the capacity of the ecosystem to supply the ‘waste nutrient removal and storage’ service, but not an increase in seafood. This is because the ecosystem may still have the capacity to support phytoplankton and it is only nutrient limited. Once a waste (nutrients) is added, the phytoplankton can start to increase again. Thus, even when there is a low and/or decreasing concentration of phytoplankton, this does not mean that the ecosystem does not have the capacity to support them once they are required for waste nutrient removal and storage. A limitation of this approach is the consideration of each service in isolation, without recognising the relationship with other services and the trade-offs which may exist between these. Using the approach described in Section 5.3, of assessing a single component and considering all services to which it contributes may be a way of overcoming this limitation.

Carrying out the more detailed assessment for the Irish Sea example highlighted that the method can detect differences within regions, provided the data available is specific for these sub-regions (as the future assessment for the Irish sea differed the NEA overall). Carrying out a more detailed assessment compared to the less detailed regional assessments did not add a great deal of information or understanding but does add a greater degree of confidence and certainty to the assessment.

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Annex IV Test case assessment

***Disclaimer:** This Annex was developed in 2014 and has not been updated since then, while certain elements of the main Report have been updated since 2014. Thus, there may be some inconsistencies between the main Report and the case study presented in this Annexes.*

Seafood from wild Animals service class

Seafood from wild commercial fish and shellfish stocks service type

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Introduction

The ecosystem service classification according to CICES (v.4.3) provides the following classification for the Provisioning section for seafood*:*

- Division:
  - Nutrition
- Group:
  - Biomass
- Class:
  - Wild animals and their outputs
  - Animals from in-situ aquaculture
  - Wild plants, algae and their outputs
  - Plants and algae from in-situ aquaculture

For this case study we focussed only on the CICES (v.4.3) ecosystem service class "Wild animals and their outputs", named *Seafood from wild animals* in this assessment, and further focussed on all the fish and shellfish biomass landed (i.e. catch minus discards) for the purpose of human consumption by commercial fisheries only. This focus therefore excludes seafood from aquaculture or the capture of wild plants and algae (e.g. seaweed) and ignores any biomass landed from recreational or subsistence fishing (i.e. does not have sale or profit connotations). To put this focus into the wider perspective a consultation of Eurostat data[10] showed that for the EU, twenty seven commercial fisheries made up between 75–85 % of the total provisioning of marine animals in tonnes live weight.

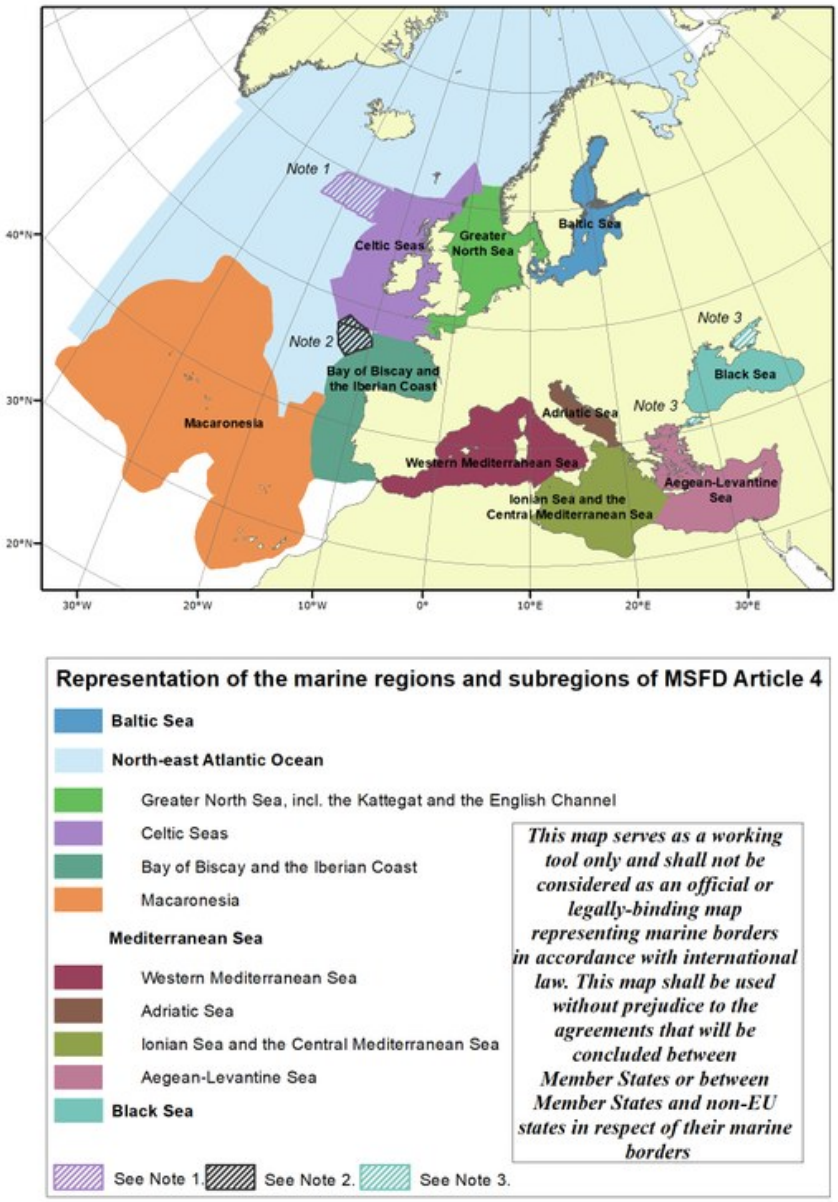
For this assessment of the *Seafood from wild commercial fish and shellfish stocks* service type (called just 'service' hereon) we follow the stages and steps identified in the main report (Sections 4 and 5). This involves stage 1, identification of the relevant components and a stage 2, the actual assessment:

1. Identifying the critical ecosystem components for service supply
2. Identifying the State-service Relationship
3. Identifying the current state of the critical ecosystem components from reported policy information
4. Identifying the current state of the capacity of the ecosystem to supply a service based on state of the critical ecosystem components
5. Assessing Future Trends

Each of these will be addressed in detail for two Marine Strategy Framework Directive (MSFD) subregions: the (relatively) data-rich North Sea and the data-poor Western Mediterranean (Figure AIV.1).

[10] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Fishery_Statistics

Figure AIV.1: Marine regions and subregions of MSFD
(reproduced from https://water.europa.eu/marine/regions)



Note 1: The area shaded in purple and white indicates an area to which both the United Kingdom and the Government of the Kingdom of Denmark together with the Government of the Faroes have transmitted overlapping submissions to the Commission on the Limits of the Continental Shelf (CLCS) in fulfilment of their respective rights and obligations under Article 76 and Annex II to the United Nations Convention on the Law of the Sea in order to determine entitlement of outer continental shelf areas. This map should not be used in any way to prejudice the determination of that question by the CLCS in due course.

Note 2: The area shaded in black and white shows the delineation of the outer limits of the continental shelf beyond 200 m from the territorial sea baselines of France, Ireland, Spain and the United Kingdom in respect of the area of the Celtic Sea and the Bay of Biscay, as provided by the four countries to the Commission on the Limits of the Continental Shelf (CLCS) and included in its recommendations issued on 24 March 2009. The map of the continental shelf's extent shall be used without prejudice to the agreements that will be concluded in due course between these Member States on their marine borders in this area.

Note 3: The seas of Azov and Marmara are shown as shaded as they do not fall within the geographic scope of application of the Bucharest Convention.

Background

European oceans, coasts and maritime sectors are governed by multiple legal instruments which seek to combine the sustainable use of maritime resources with an effective means of accessing the economic benefits of them. The provisioning of seafood by commercial fisheries is regulated primarily by the Common Fisheries Policy (CFP) but also the Marine Strategy Framework Directive (MSFD). These are aligned in terms of their requirements related to the state and exploitation of the critical ecosystem components (fish and shellfish).

The Common Fisheries Policy (CFP) is the EU's governing mechanism for fisheries management to protect marine natural resources, namely fish stocks. According to the CFP the exploitation of marine biological resources restores and maintains populations of harvested stocks above levels that can produce the maximum sustainable yield.

The Marine Strategy Framework Directive (MSFD) is the environmental pillar of the EU's Integrated Maritime Policy (IMP) and aspires to achieve or maintain "Good Environmental Status" (GES) of marine waters by 2020 (EC, 2008a). Here "Good Environmental Status" means the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive within their intrinsic conditions, and the use of the marine environment is at a level that is sustainable, thus safeguarding the potential for uses and activities by current and future generations. To that end MSs should determine for their marine waters a set of characteristics for GES captured by eleven qualitative descriptors. The GES descriptor directly related to the provisioning of seafood is Descriptor 3 defined as "Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock" (Directive 2008/56/EC, Annex I) which consists of three criteria of which the first two can be the basis to describe the current state of the critical ecosystem components (Step 2) and assessment of the current state (Step 3), while the third may have implications for the future provisioning of seafood (Step 5).

- Criterion 3.1 Level of pressure of the fishing activity: F < FMSY
- Criterion 3.2 Reproductive capacity of the stock: SSB > SSBMSY Btrigger
- Criterion 3.3 Population age and size distribution: this should be indicative of a healthy stock

Relevant components

The "wild animals" considered include in this assessment all marine biological resources which are targeted for economic profit including the bony fish (teleosts), sharks and rays (elasmobranchs), crustaceans such as lobsters and shrimps, and molluscs (including bivalves and cephalopods) in all habitats where they are found that it is also technologically feasible to catch them. Other marine biological resources (e.g. jellyfish and starfish) might be included if commercially exploited and managed under the Common Fisheries Policy.

Reporting for this ecosystem component is usually in terms of "species", which may consist of several stocks, i.e. the functional unit for management/assessment purposes. Although a stock may be made up of several "subpopulations" these are not used for reporting purposes and are therefore not further considered in this assessment.

Thus, these marine biological resources divided into species represent the relevant components for the North Sea and Mediterranean where relevance is determined by their contribution to the regional catches. Based on this we identified the "critical ecosystem components" further elaborated in Step 1.

Step 1: Identifying the critical ecosystem components for service supply

Tables AIV.1 and AIV.2 show the "critical ecosystem components" which contribute most to the catches or are considered of significant socio-economic importance for other reasons and for some of which quantitative stock assessments provide the information required in steps 2–5. For now, an arbitrary threshold of > 0.1 % contribution to the total catches was applied to determine whether the species represented a critical contribution. For future analysis a more thorough process is required to determine for each MSFD (sub) region what taxa make up these "critical ecosystem components".

As the analysis presented in these subsequent steps can only be conducted for those species for which recent quantitative stock assessment are available the aim should be to have as much as possible of these critical ecosystem components covered by quantitative stock assessments.

Table AIV.1 Critical ecosystem components of the North Sea in terms of food provisioning. For each of the fish and shellfish taxa the catch (mean over period 1985-2010) is given and if it is covered by quantitative stock assessments (X)

Scientific name	English name	Catch (tonnes)	Assessed
Ammodytes	Sandeels (= Sandlances)	683,895	X
Clupea harengus	Atlantic herring	354,234	X
Scomber scombrus	Atlantic mackerel	202,885	X
Trisopterus esmarkii	Norway pout	140,533	X
Sprattus sprattus	European sprat	139,353	X
Pollachius virens	Saithe(=Pollock)	100,513	X
Pleuronectes platessa	European plaice	95,843	X
Gadus morhua	Atlantic cod	78,174	X
Trachurus trachurus	Atlantic horse mackerel	76,956	X
Mytilus edulis	Blue mussel	68,669	
Micromesistius poutassou	Blue whiting (= Poutassou)	66,420	X
Melanogrammus aeglefinus	Haddock	62,568	X
Cerastoderma edule	Common edible cockle	38,388	
Merlangius merlangus	Whiting	33,295	X
Crangon crangon	Common shrimp	30,819	
Solea solea	Common sole	20,802	X
Nephrops norvegicus	Norway lobster	15,895	
Cancer pagurus	Edible crab	13,389	
Pecten maximus	Great Atlantic scallop	12,616	
Sardina pilchardus	European pilchard(=Sardine)	12,473	
Lophius piscatorius	Angler(= Monk)	12,105	
Molva molva	Ling	10,626	
Buccinum undatum	Whelk	7,848	
Pandalus borealis	Northern prawn	7,525	
Limanda limanda	Common dab	7,387	
Eutrigla gurnardus	Grey gurnard	5,966	
Microstomus kitt	Lemon sole	5,858	
Laminaria digitata	Tangle	4,832	
Squalus acanthias	Picked dogfish	4,190	
Scophthalmus maximus	Turbot	3,952	
Raja spp	Raja rays	3,677	
Pectinidae	Scallops	3,528	
Brosme brosme	Tusk (= Cusk)	3,480	
Sepiidae, Sepiolidae	Cuttlefish, bobtail squids	3,395	
Pollachius pollachius	Pollack	3,285	
Merluccius merluccius	European hake	3,281	
Platichthys flesus	European flounder	2,816	
Trisopterus luscus	Pouting (= Bib)	2,320	
Glyptocephalus cynoglossus	Witch flounder	1,911	

Table AIV.2 Catch (mean over period 1985–2010) of the main fish and shellfish taxa for the Mediterranean showing which were recently (2012) assessed (X)

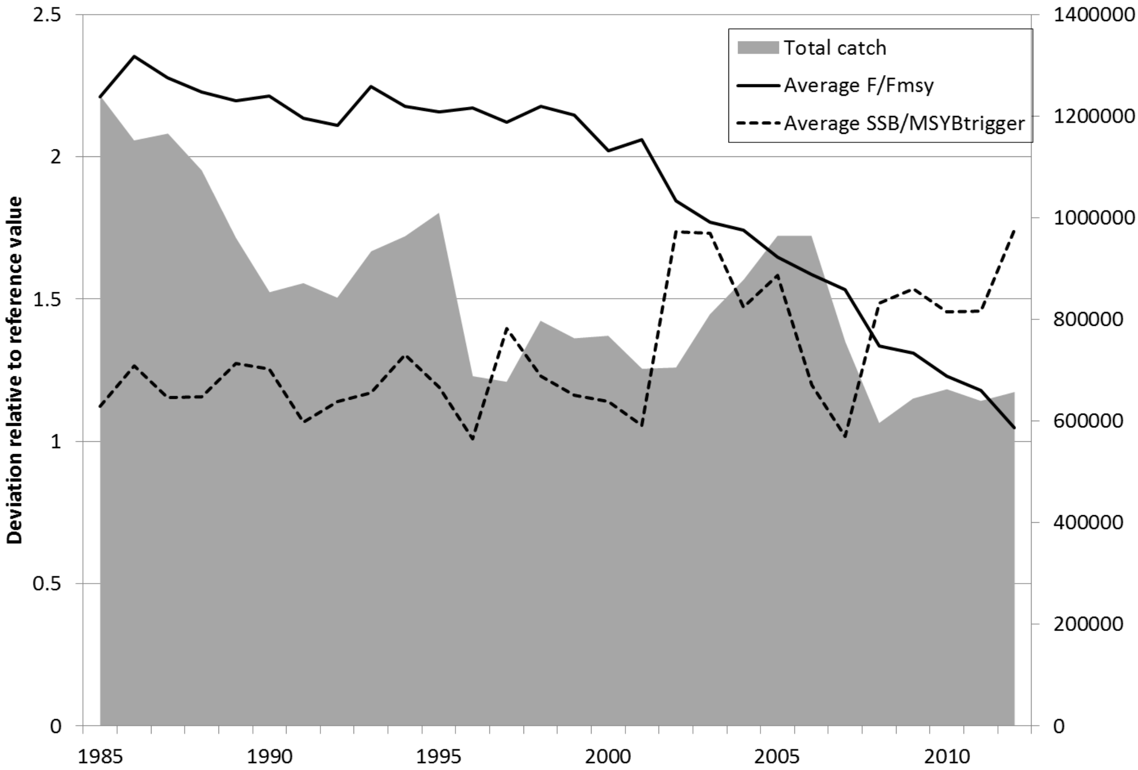
Scientific name	English name	Catch (tonnes)	Assessed
Engraulis encrasicolus	European anchovy	12,521	X
Sardina pilchardus	European pilchard (= Sardine)	9,102	X
Raja asterias	Mediterranean starry ray	4,497	
Clupeonella cultriventris	Black and Caspian Sea sprat	4,376	
Chamelea gallina	Striped venus	4,065	
Mytilus galloprovincialis	Mediterranean mussel	3,236	X
Pleuronectiformes	Flatfishes nei	3,062	X
Dicentrarchus labrax	European seabass	3,039	
Sardinella spp	Sardinellas nei	2,880	
Corallium rubrum	Sardinia coral	2,788	
Lepidorhombus whiffiagonis	Megrim	2,225	
Acipenser gueldenstaedtii	Danube sturgeon (= Osetr)	2,036	
Sphyraena sphyraena	European barracuda	1,880	
Osteichthyes	Marine fishes nei	1,684	
Conger conger	European conger	1,584	
Scyliorhinus spp	Catsharks, nursehounds nei	1,469	
Merlangius merlangus	Whiting	1,458	
Mugil soiuy	So-iuy mullet	1,439	
Trachurus spp	Jack and horse mackerels nei	1,435	
Bivalvia	Clams, etc. nei	1,433	
Diplodus annularis	Annular seabream	1,433	
Merluccius merluccius	European hake	1,391	X
Callista chione	Smooth callista	1,335	
Phycis phycis	Forkbeard	1,324	X
Loligo vulgaris	European squid	1,281	
Trisopterus luscus	Pouting(=Bib)	1,234	
Mollusca	Marine molluscs nei	1,221	
Sarda sarda	Atlantic bonito	1,207	
Ex Mollusca	Marine shells nei	1,205	
Micromesistius poutassou	Blue whiting (= Poutassou)	1,148	
Rhopilema spp	Jellyfishes nei	1,114	
Pagellus erythrinus	Common pandora	1,103	
Scomber japonicus	Chub mackerel	1,094	
Boops boops	Bogue	1,066	X
Thunnus thynnus	Atlantic bluefin tuna	1,023	
Raja naevus	Cuckoo ray	1,006	
Scomberomorus commerson	Narrow-barred Spanish mackerel	939	
Sepia officinalis	Common cuttlefish	893	
Aristeidae	Aristeid shrimps nei	859	X
Caranx spp	Jacks, crevalles nei	851	

Step 2: Identifying the State-service Relationship

At present the state of the critical ecosystem components is reflected in two indicators: F the level of fishing mortality and SSB the reproductive capacity of the stock. These two indicators represent relevant aspects for the provisioning of seafood by commercial fisheries as this depends both on the status of the resource, i.e. fish and shellfish species targeted by fisheries (reflected by the Spawning Stock Biomass, SSB), as well as the capacity to exploit this (reflected by the fishing-induced mortality, F). How these two indicators relate to the provisioning of seafood is explored in this section.

Figure AIV.2 shows how the *Seafood from wild commercial fish and shellfish stocks* service (i.e. catch) is related to the average status for 8 North Sea stocks (i.e. cod-347d, her-47d3, ple-nsea, sol-eche, sol-nsea, spr-nsea, had-346a, sai-3a46) for the period 1985-2012 expressed in fishing mortality and reproductive capacity. Both variables are presented in relation to their target values (i.e. Fmsy and MSYBtrigger). Note that exploitation is considered sub-optimal, potentially unsustainable, when fishing mortality exceeds Fmsy and reproductive capacity drops below MSYBtrigger. In other words, for fishing mortality 1 is considered a target value above which exploitation is unsustainable while for reproductive capacity 1 is considered a precautionary limit below which there is a high risk that next year's recruitment is impaired. Figure AIV.2 shows how management resulted in a decline in fishing mortality towards Fmsy, which, in turn, caused an increase in reproductive capacity further above the limit MSYBtrigger. Even though the SSB slightly increased over time, the marked reduction in F resulted in a decrease in total catch of the North Sea stocks.

Figure AIV.2: Status of stocks over time assessed in the ICES region (NEA and Baltic Sea). The status of these stocks is expressed by two metrics, fishing mortality (F) and reproductive capacity (SSB), reflecting their average deviation relative to policy thresholds for Good Environmental Status (GES). Note that for fishing mortality 1 is a target (FMSY) above which exploitation is unsustainable while for reproductive capacity 1 is a precautionary limit (SSBpa) below which there is high risk that it is impaired



To further explore the relationship between the state of the stocks and the *Seafood from wild commercial fish and shellfish stocks* service we conducted linear regression analyses (Table AIV.3). The values in Table AIV.3 indicate the significance of the relationship between the amount of landings and either F, SSB or both. Values close to 1 indicate a strong relationship. The results showed that this relationship is highly significant ($p < 0.01$) for each species and stock. F alone explains on average slightly more (82 %) than SSB alone (79 %) while the combination explains on average 90 % (see Table AIV.3). In other words, greater fishing effort and a larger biomass of fish in the sea leads to greater landings.

Table AIV.3 Correlation coefficients (R) of two indicators of state, Fishing mortality (F) and Spawning Stock Biomass (SSB) with landings

Species	Stock	F	SSB	F*SSB
Sandeel	san_ns1	0.73	0.79	0.86
	san_ns2	0.64	0.80	0.84
	san_ns3	0.80	0.79	0.90
Herring	her-47d3	0.88	0.84	0.96
Cod	cod-347d	0.84	0.94	0.93
Haddock	had-346a	0.91	0.56	0.95
Whiting	whg-47d	0.96	0.88	0.96
Plaice	ple-nsea	0.89	0.80	0.93
Saithe	sai-3a46	0.86	0.92	0.99
Sole	sol-nsea	0.90	0.93	0.98
	sol-eche	0.63	0.61	0.62
Sprat	spr-nsea	0.70	0.83	0.89
Norway pout	Nop-34-j	0.90	0.57	0.90
Average		0.82	0.79	0.90

Step 3: Identifying the current state of the critical ecosystem components from reported policy information

The two main policy frameworks relevant for the provisioning of seafood, CFP and MSFD, are aligned in that at present the same two criteria apply for the assessment of state.

- Criterion 3.1 Level of pressure of the fishing activity: F < FMSY
- Criterion 3.2 Reproductive capacity of the stock: SSB > MSY Btrigger

State is therefore measured using two indicators: Fishing mortality (F) and Spawning Stock Biomass (SSB) which are compared to their respective reference levels.

FMSY is the level of fishing mortality (F) that achieves maximum sustainable yield (MSY) over the long term based on growth and natural mortality rates, the selection pattern of the fishery and recruitment changes associated with the level of adult biomass (stock-recruitment relationship). Thus any measure that affects this selectivity such as the recently agreed landings obligation, if successful, will change the selection pattern of the fishery and, hence, the FMSY reference value. Consequently, the reference levels are unlikely to be stable in the long-term and will require recalculation as stocks rebuild and the balance of predators and prey changes over time. FMSY is defined on the basis of single species analysis which does not include predator-prey interactions or linkages to ecosystem productivity. This implies that the calculation of FMSY in a multi-species

context would result in different values and that the requirement of achieving policy objectives based on single-species FMSY values will probably not result in a maximum sustainable provisioning of seafood at the ecosystem level.

MSY Btrigger is a Spawning Stock Biomass (SSB) safeguard capable of producing maximum sustainable yield. An appropriate choice of MSY Btrigger requires contemporary data with fishing at FMSY to experience the normal range of fluctuations in SSB. Until this experience is gained, Bpa has, for the time being, been adopted for many stocks assessed by ICES as MSY Btrigger even though Bpa and BMSY-trigger formally correspond to different concepts.

Table AIV.4 and AIV.5 show the recent estimates of fishing mortality (F) and spawning stock biomass (SSB) together with existing reference points for the main stocks fished in the North Sea and the Mediterranean, respectively.

Table AIV.4 Current state of the main fish stocks in the North Sea described by two indicators, F the level of fishing mortality and SSB the reproductive capacity of the stock, and their respective reference levels. Values are for 2012, based on the ICES assessment carried out in 2013

Fish Stock	Scientific Name	Landings	F	FMSY	SSB	MSYBtrigger
cod-347d	*Gadus morhua*	34,132	0.44	0.19	48,194	150,000
had-346a	*Melanogrammus aeglefinus*	38,162	0.18	0.35	311,850	88,000
her-47d3	*Clupea harengus*	434,710	0.17	0.27	2,475,616	1,000,000
ple-nsea	*Pleuronectes platessa*	73,830	0.24	0.25	507,032	230,000
sai-3a46	*Pollachius virens*	77,447	0.33	0.30	183,311	200,000
sol-eche	*Solea solea*	4,048	0.41	0.29	12,941	8,000
sol-nsea	*Solea solea*	11,610	0.25	0.22	42,309	35,000
spr-nsea	Sprattus sprattus	85,627	0.38	1.20	23,4283	142,000

Table AIV.5 Current state of the main fish stocks in the Mediterranean described by two indicators, F the level of fishing mortality and SSB the reproductive capacity of the stock, and their respective reference levels. Values based on the 2012 assessment. For Euroepan Hake only the deviation relative to FMSY was given

Stock Code	Species Name	Scientific Name	FMSY	F	SSBMSY	SSB
ANE - 16	European anchovy	*Engraulis encrasicolus*	0.40	0.58	14,152	5070
ANE - 17	European anchovy	*Engraulis encrasicolus*	0.40	0.47	2,506	333.4
ANK - 15	Blackbellied angler	*Lophius budegassa*	0.16	0.30		
ANK - 5	Blackbellied angler	*Lophius budegassa*	0.18	1.13		
ANK - 6	Blackbellied angler	*Lophius budegassa*	0.15	0.72		
ANK - 7	Blackbellied angler	*Lophius budegassa*	0.29	0.97		
ARA - 10	Blue and red shrimp	*Aristeus antennatus*	0.28	0.43		
ARA - 6	Blue and red shrimp	*Aristeus antennatus*	0.30	1.05		
ARS - 10	Giant red shrimp	*Aristaeomorpha foliacea*	0.40	0.48		
ARS - 15	Giant red shrimp	*Aristaeomorpha foliacea*	0.30	1.67		
ARS - 18	Giant red shrimp	*Aristaeomorpha foliacea*	0.30	1.00		
DPS - 11	Deep-water rose shrimp	*Parapenaeus longirostris*	0.49	0.69		
DPS - 18	Deep-water rose shrimp	*Parapenaeus longirostris*	1.38	2.90		
GFB - 9	Greater forkbeard	*Phycus blennoides*	0.32	1.01		
MTS - 10	Spottail mantis squillid	*Squilla mantis*	0.41	1.08		
MTS - 17	Spottail mantis squillid	*Squilla mantis*	0.30	1.00		
MTS - 18	Spottail mantis squillid	*Squilla mantis*	0.27	1.04		
MUT - 11	Red mullet	*Mullus barbatus*	0.29	2.50		
MUT - 15	Red mullet	*Mullus barbatus*	0.45	1.30		
MUT - 17	Red mullet	*Mullus barbatus*	0.36	0.71		
MUT - 18	Red mullet	*Mullus barbatus*	0.50	1.50		
MUT - 19	Red mullet	*Mullus barbatus*	0.30	1.94		
MUT - 7	Red mullet	*Mullus barbatus*	0.51	1.26		
MUT - 9	Red mullet	*Mullus barbatus*	0.61	0.68		
NEP - 1	Norway lobster	*Nephrops norvegicus*	0.20	0.32		
NEP - 18	Norway lobster	*Nephrops norvegicus*	0.30	0.54		
NEP - 5	Norway lobster	*Nephrops norvegicus*	0.42	0.55		
NEP - 6	Norway lobster	*Nephrops norvegicus*	0.15	0.63		
OCC - 5	Common octopus	*Octopus vulgaris*	0.32	0.47		
PAC - 15	Common pandora	*Pagellus erythrinus*	0.30	0.72		
PIL - 16	European pilchard	*Sardina pilchardus*	0.40	0.15	32.527	
PIL - 17	European pilchard	*Sardina pilchardus*	0.40	0.57		
PIL - 9	European pilchard	*Sardina pilchardus*	0.40	0.41		
POD - 9	Poor cod	*Trisopterus minutus*	0.74	0.90		
SOL - 17	Common sole	*Solea solea*	0.26	1.43		
HKE - 17	European hake	*Merluccius merluccius*		9.10		
HKE - 18	European hake	*Merluccius merluccius*		3.38		
HKE - 19	European hake	*Merluccius merluccius*		7.33		
HKE - 11	European hake	*Merluccius merluccius*		5.25		
HKE - 7	European hake	*Merluccius merluccius*		4.96		
WHB - 1	Blue whiting	*Micromesistius poutassou*	0.40	1.40		
WHB - 6	Blue whiting	*Micromesistius poutassou*	0.32	1.05		
WHB - 9	Blue whiting	*Micromesistius poutassou*	0.53	1.12		

Step 4: Identifying the current state of the capacity of the ecosystem to supply a service based on state of the critical ecosystem components

The current management towards MSY is specifically aimed at sustainably providing the maximum amount of seafood. As was shown in Step 2, in the ICES region (NEA and Baltic Sea) the fishing mortality has (overall) decreased close to FMSY and as a consequence SSB is increasing and will continue to increase until the level that corresponds to MSY is reached, and it will fluctuate around this value depending on each year's recruitment. Food provisioning is, therefore, expected to increase, especially since Step 3 shows there are still major differences between the stocks so that once all stocks are exploited at MSY levels the maximum level of food provisioning (with the current size selectivity, see step 5) is achieved. Therefore, the trend in the status of the main fish stocks in the North Sea is 'increasing' as it is moving towards achieving MSY. No such analysis has been done recently for the Mediterranean, so the current state and trends in this region are less well understood. Therefore, the trend in the status of the main fish stocks in the Western Mediterranean Sea is 'unknown'.

Step 5: Assessing Future Trends

Step 5.1 Future trend if MSY objective is achieved

In order to ascertain what benefits in terms of resource provisioning could be gained in future, a simple analysis was conducted to estimate what average level of landings could be expected if all stocks were at full reproductive capacity and managed according to F_{MSY}. There are a number of limitations in such work, such as uncertainty around multi-species vs. single species F_{MSY} (see Step 3) and future changes in fishery selectivity (see below). This example assumes that selectivity remains the same as the average observed over the last five years.

Additionally, the yield obtained fishing at F_{MSY} will naturally fluctuate over time as the stock size varies due to ecological and environmental changes. In particular, the short-lived sprat displays large fluctuations in recruitment and stock size over time. This stock is managed under a $B_{escapement}$ system, whereby enough biomass is left in the sea each year such that reproduction is not affected. Any biomass above this escapement value can be landed. This makes future predictions of MSY catches for this stock particularly problematic, and it is left out of this analysis. The remaining stocks as presented in Table AIV. 4 are analysed here (main North Sea fish stocks).

The analyses are conducted using an ICES standard software package: PlotMSY (ICES 2013). This software was developed in 2010 to support the estimation of MSY-based fishing mortality reference points. It uses the Markov Chain Monte Carlo (MCMC) analyses to characterize uncertainty around estimates (500 iterations).

The software fits three stock–recruit relationships (SRRs), namely Ricker, Beverton–Holt and a smooth version of the Hockey-stick. These three different SRRs cover a range of potential relationships between SSB and recruitment e.g. Ricker includes reduced recruitment at high SSB (a negative density dependent effect) while the Beverton and Holt and Hockey-stick functions reach a maximum recruitment level at some point, which does not decline as the stock gets larger. All three include reduced recruitment at low biomass. The outputs from these three SRRs are combined to derive integrated estimates, weighted according to harmonic means of the likelihood of individual samples from the MCMC chains i.e. the results from each SRR are weighted according to the goodness of fit of the SRR to the raw data. This allows for a single integrated estimate of MSY taking into account the uncertainty in stock-recruit relationship. In addition to stock-recruit parameters, further uncertainty in the analysis is included by sampling from the distributions of other

productivity parameters (i.e. natural mortality, weights-at-age, maturities, and selectivity) i.e. uncertainty in these parameters is estimated based on past fluctuations. This does not account for any future trends (e.g. change in selectivity), but does account for noise around the currently observed values.

The results of PlotMSY include estimates of the fishing mortality that leads to maximum sustainable yield (F_{MSY}) and well as the associated equilibrium maximum sustainable yield (MSY) and biomass (B_{MSY}), with uncertainty bounds. Equilibrium values are theoretical i.e. they describe what would be possible on average if everything remained the same for many years. This is rarely the case in practice, so it cannot be automatically expected that simply fishing at F_{MSY} will lead to these equilibrium catches in the short term. These are also single species values that do not take into account interactions with other species when all stocks are at a high biomass, and therefore are in most cases likely overestimates of the true yields we could expect to get simultaneously from these stocks. Hence, the results below are indicative of potential future yields, but contain a large degree of uncertainty.

The results from the analyses in terms of potential equilibrium biomass (B_{MSY}) and maximum sustainable yield (MSY) are shown in Tables AIV.6 and AIV.7 below. There is significant uncertainty in the estimated values of B_{MSY}. e.g. B_{MSY} for cod-347d is estimated to be between 1 million tons and 11 million tons. This large uncertainty stems mainly from uncertainty in stock recruitment function (Ricker leading to much lower equilibrium biomasses than Beverton and Holt or Hockey-stick in most cases). Given these large ranges it is not surprising that all stocks, with the exception of cod-347d which is currently recovering from a collapsed state, have current SSBs that are within the 5-95% range. However, only three stocks are considered to be above the median estimate of B_{MSY} (her-47d3, sol-eche and sol-nsea).

None of the stocks are currently estimated to be delivering yields that could be expected under MSY management, though the two sole stocks are near to this level at present. The estimated MSY values also have a large degree of uncertainty. For all stocks except for cod-347d the maximum historic annual catch is greater than the median MSY estimate, suggesting that these values are not completely unreasonable estimates and such catches can in fact be taken from these stocks. However, the upper bounds (95th percentiles) are unlikely to be reached in some cases (e.g. cod-347d). In total current landings are under half of the potential future landings under MSY, mainly due to low catches relative to MSY for cod-347d and her-47d3 and ple-nsea and had-346a to a lesser degree.

Table AIV.6 Current state of the main fish stocks in the North Sea (SSB in 2013) compared to the estimated equilibrium biomass (B_{MSY}) when stocks are fished at F_{MSY} (median and lower 5th and upper 95th percentiles presented)

Stock	SSB in 2013	Median B_{MSY}	B_{MSY} uncertainty (5 %–95 %)	Current SSB as a percentage of B_{MSY} vs. Median	vs. 5 %	vs. 95 %
cod-347d	57,996	1,269,670	(972,457–11,693,800)	5 %	6 %	< 1 %
had-346a	235,300	249,013	(113,080–644,501)	94 %	208 %	37 %
her-47d3	2,115,153	1,473,205	(1,014,811–2,304,175)	144 %	208 %	92 %
ple-nsea	553,631	1,127,450	(422,097–2,174,163)	49 %	131 %	25 %
sai-3a46	186,306	268,891	(146,720–509,624)	69 %	127 %	37 %
sol-eche	13,370	6,633	(3,996–31,423)	202 %	335 %	43 %
sol-nsea	48,873	42,834	(23,362–84,122)	114 %	209 %	58 %
TOTAL	**3,210,629**	**4,437,695**	**(269,6522–17,441,808)**	**72 %**	**119 %**	**18 %**

Table AIV.7 Current landings from the main fish stocks in the North Sea (five year average from 2009–2013) compared to the estimated equilibrium yield (MSY) when stocks are fished at F_{MSY} (median and lower 5th and upper 95th percentiles presented)

Stock	5yr avg. landings (2009-2013)	Max. historic landings	Median MSY	MSY uncertainty (5 %–95 %)	Current landings as a percentage of MSY vs. Median	vs. 5 %	vs. 95 %
cod-347d	32,946	353,938	358,493	(283,660–2,876,130)	9 %	12 %	1 %
had-346a	37,150	234,140	108,801	(71,337–192,714)	34 %	52 %	19 %
her-47d3	305,732	1,168,800	745,643	(641,448–897,495)	41 %	48 %	34 %
ple-nsea	67,560	171,319	103,034	(76,443–169,698)	66 %	88 %	40 %
sai-3a46	94,207	343,967	132,211	(113,834–159,056)	71 %	83 %	59 %
sol-eche	4,423	5,261	4,691	(3,538–7,675)	94 %	125 %	58 %
sol-nsea	12,558	3,5120	15,577	(12,936–18,844)	81 %	97 %	67 %
TOTAL	**554575**		**1468448**	**(1203197–4321612)**	**38 %**	**46 %**	**13 %**

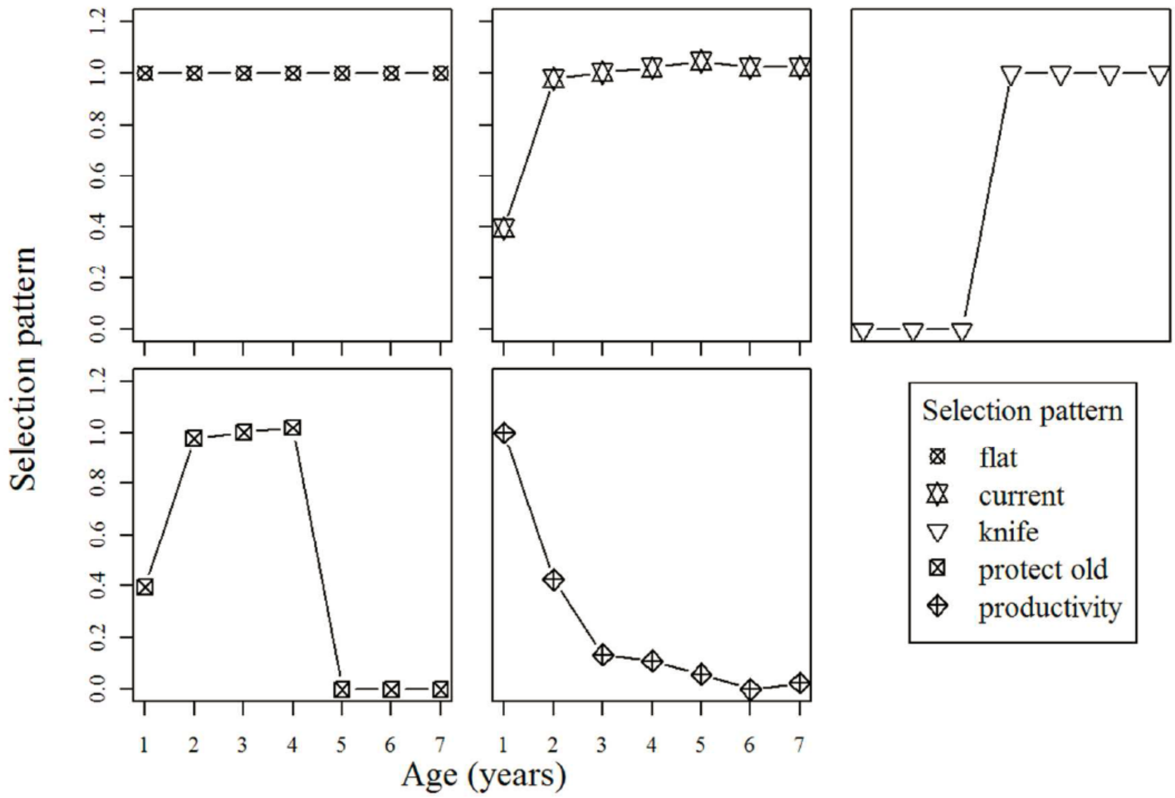
These results suggest that once stocks have recovered to full reproductive capacity, there is room for growth in landings in the North Sea under MSY management. However, these results are theoretical estimates of future potential capacity to supply the service, and in practice it is unlikely that all species in an ecosystem will be at full reproductive potential at the same time.

Step 5.2 Changes in the selectivity of the fishery

The current paradigm in fisheries management consists in promoting selective fishing in order to protect the youngest fish to let them grow and have the opportunity to reproduce before being caught. Because of its consequence on the age-structure, this type of selective fishing is now being challenged and it has been suggested that instead of (or at least in addition to) protecting the small fish, management measures should be taken to protect the older and larger individuals (such as setting a maximum landing size (Arlinghaus et al., 2010) or through marine protected areas (Berkeley et al., 2004)). More recently, Garcia et al (2012) and Law et al. (2012) suggested that balanced harvesting, where fishing mortality is distributed across species and size-classes in an ecosystem in proportion of the natural productivity of the corresponding species and size-class, would preserve the natural size composition and at the same time maximise the total yield taken from the ecosystem. However, it has not yet been investigated whether or not this principle also applies at the scale of a single stock. To that end Brunel & Piet (2013) identified five different selection patterns, which were defined as follows (see also figure AIV.3):

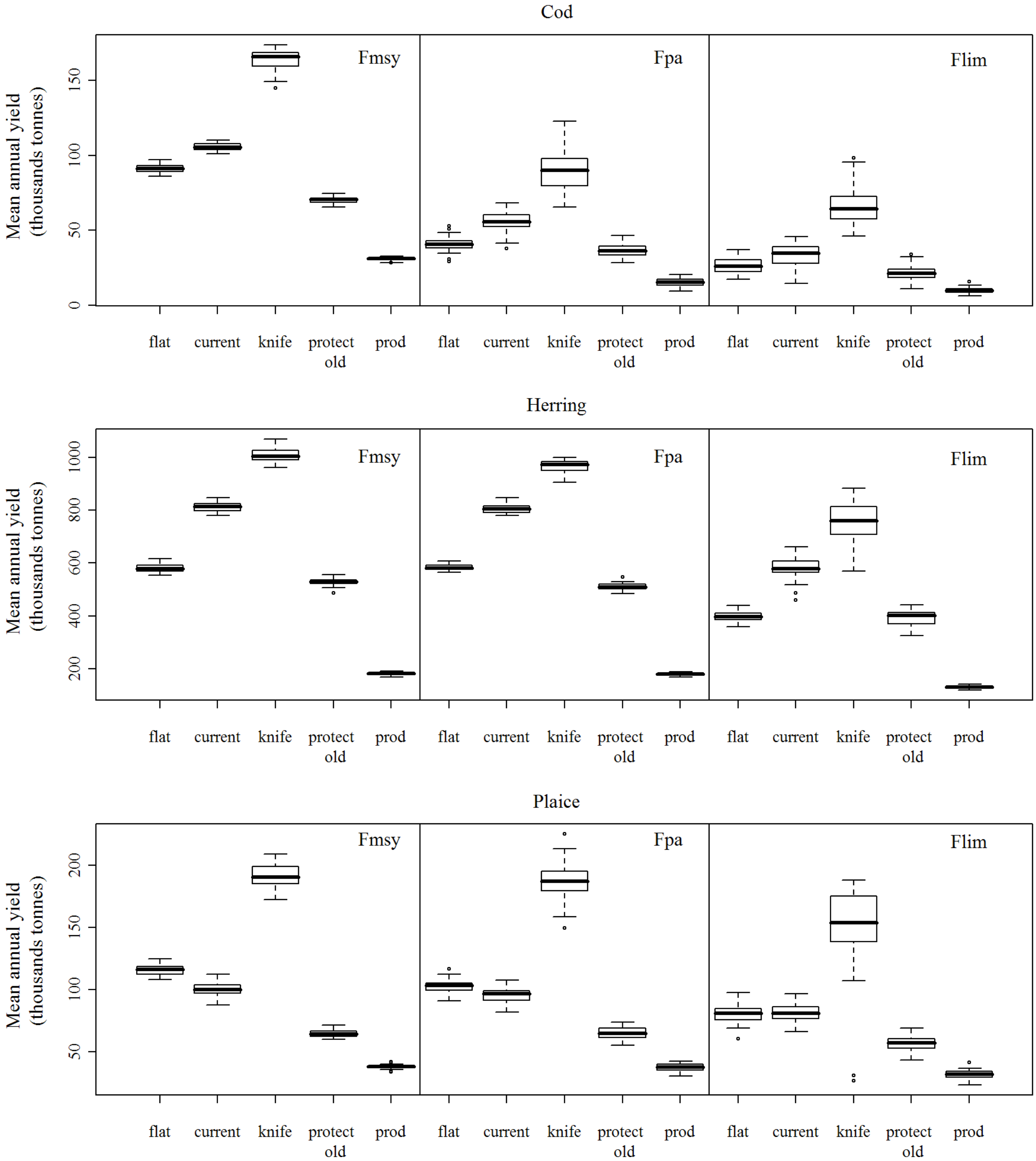
- "flat": selection pattern constant at 1 across ages
- "current": selection pattern equal to the average of the fishing mortality at age over the last 5 years of the assessment.
- "knife-edge": selection pattern equal to 0 for age < A_{biomax} and 1 for age >= A_{biomax}, where A_{biomax} = -log(0.33)/K , age at which a cohort reaches its maximal biomass in absence of fishing mortality (Froese et al., 2008).
- "protect old": same as "current" selection pattern, but with 0 for ages 5 and older.
- "productivity": the selectivity at age is scaled to the natural productivity of the stock defined as the "amount of new organic matter produced per biomass unit during a given period of time" (Garcia et al., 2012). In the present age-structured population model, natural productivity at age a was defined as $(B_{a+1} - B_a)/B_a$, where B_a is the biomass of a cohort at age a calculated for a constant recruitment and in absence of fishing mortality.

Figure AIV.3: The 5 selection patterns used to generate different age structure (example for cod) (reproduced from Brunel & Piet (2013))



Comparison of the effect of applying these different selection patterns on the fisheries exploiting three of the main North Sea species, i.e. cod, plaice and herring, shows this considerably affects the annual yield and thus the provision of seafood. If the three species are exploited at MSY a shift from the current selectivity towards a knife-edge selectivity could increase catches maximal 23 % for herring, 58 % for cod and 98 % for plaice (see figure AIV.4). Note, however, that this is a maximum based on a simulated extreme of each type of selectivity pattern which cannot be achieved in reality. However, this does indicate that through modification of the selection patterns there is scope for improvement in terms of quantity albeit with consequences in terms of quality (i.e. smaller fish). Though this analysis was conducted on North Sea stocks, the conclusion that altering selectivity patterns can enhance maximum sustainable yield is generally applicable. However, to determine what changes in selectivity could be beneficial would require age- or size-based assessments and estimates of selectivity.

Figure AIV.4: Annual yield of three North Sea stocks under different simulated fishing scenarios (determined by fishing mortality and selection pattern) (reproduced from Brunel & Piet (2013)).



Discussion and Conclusion

Here we summarise the results and discuss their use in the overall assessment of the capacity of the European ecosystems to deliver the service "seafood from wild animals". Each of the operational steps for ecosystem service assessment are considered and discussed based on the two selected regions, i.e. the North Sea and the Western Mediterranean which can be considered exemplary for respectively, the relatively data-rich and data-poor European regions.

Step 1

The critical ecosystem components for the provisioning of "seafood from wild animals" service are the fish and shellfish (biotic group epifauna) where both the state of the component and the service it provides are usually given at the species level but occasionally higher taxonomic groupings are applied (i.e. reporting of landings). Although the actual relative contribution of specific taxa may vary over time due to changes in fishing practices, this does not necessarily affect the assessment of the *capacity* of the ecosystem to provide food. The relative contribution of taxa over time is usually known and the taxa contributing most to the service are usually also the ones with the most reliable information. However, while in some EU regions (e.g. North Sea) most of the landings come from species for which the most reliable information, i.e. based on quantitative stock assessments, is available this is often not the case in all regions (e.g. most Mediterranean sub-regions). The two regions on which this study focussed (i.e. North Sea with 79 % of the catches covered and Western Mediterranean with 30 % of the catches covered) are in that respect representative for respectively the data-rich northerly regions (with 76 % of the catches covered) and the data-poor southerly regions (with 24 % of the catches covered).

Another point to consider is that the selection of critical ecosystem components is now entirely based on information from commercially exploited taxa while recreational fisheries may contribute, depending on the region, significantly to the *Seafood from wild commercial fish and shellfish stocks* service. However, from expert judgement, there is high confidence that even in the European regions where the contribution of recreational fishing is relatively high the landings from commercial fishing operations sufficiently represent the food provisioning capacity of the ecosystem.

Step 2

There is a strong link between the state of the component and the potential supply of seafood. While this is a complex relationship as it also depends on the level of exploitation it is well understood and mostly covered by the current assessments of state but with distinct regional differences. The state of the critical fish species is reflected in two indicators: Spawning Stock Biomass (SSB), the reproductive capacity of the stock, which represents the status of the resource, i.e. fish and shellfish species targeted by fisheries and the level of fishing mortality (F) which represents the level of exploitation.

Step 3

The current state and trends of the critical ecosystem components are reported regularly as part of the obligations for the Common Fisheries Policy and Marine Strategy Framework Directive. In the northern European marine regions (i.e. North East Atlantic including North Sea and Baltic Sea) this is coordinated by ICES, in the southern (i.e. Mediterranean and Black Sea) by GFCM and ICCAT. The status of the main (shell)fish stocks in terms of both SSB and F are reported annually by ICES while GFCM reports less regularly and usually only the level of exploitation (F), not the status of the stocks (SSB).

For all EU regions the same policy goal applies in that the level of exploitation and stock biomass should be such that Maximum Sustainable Yield (MSY) can be achieved. To that end target values (i.e. Fmsy and MSYBtrigger) have been identified for each indicator (respectively F and SSB) which, if achieved, should result in the highest sustainable level of seafood provided by each of the regional ecosystem(s). Status assessments of the main commercial species show that currently in the North

Sea 4 out of 8 of the main species are exploited at unsustainable levels, while in the Mediterranean all species are unsustainably exploited in at least one part of the region. Most of the main species in the North Sea (7 out of 8) are currently at SSB levels, which can provide MSY, this is not assessed in the Mediterranean. An assessment of the status in relation to Good Environmental Status (GES) of all stocks per European MSFD (sub)region shows 67 % of the North Sea species meet objectives while this is only 4 % in the Western Mediterranean. This is comparable to the percentages in of 84 % in the northerly regions that meet the objectives and 16 % in the southerly regions (see EEA CSI032 Status on marine (shell)fish in European Seas 2014). Therefore, the current status of the main fish stocks in the North Sea is 'moderate', as it has not achieved MSY yet (which would be 'good'), and 'bad' in the Western Mediterranean Sea. Information from the data-rich northerly regions shows on average fishing mortality is approaching the MSY policy target but as part of the stocks is still overexploited this implies that other stocks are being exploited at levels below what should deliver MSY.

Step 4

The assessment of state of (some of) the species that mainly contribute to the food provisioning capacity shows that the current state will not provide the seafood equivalent of the MSY per stock and as such there is scope for an improvement of the capacity of all EU ecosystems (including the North Sea and Mediterranean) to provide seafood.

This, however, is based on available information which comes from only a proportion of the species/stocks that contribute to the *Seafood from wild commercial fish and shellfish stocks* service. While these species/stocks may be sufficiently representative for the wider (shell)fish community to allow any conclusions on the total (shell)fish community in the data-rich EU regions, this is probably not the case in the data-poor regions. The availability of information in terms of the proportion of the landings covered by quantitative stock assessments therefore clearly determines the confidence in the outcome of the *Seafood from wild commercial fish and shellfish stocks* service assessment.

Step 5

The critical pressure affecting the state of the European (shell)fish communities is fishing. The estimated fishing mortality in the North Sea was found to be decreasing towards levels that would provide MSY. This is partly achieved through limitations to the fleet capacity and the amount of time that can be spent at sea by that fleet in order to achieve a sustainable balance between fishing capacity and fishing opportunities. Both fishing capacity (number or tonnage of fishing vessels) and fishing effort (days-at-sea) were observed to decrease in all EU regions thus increasing the likelihood that in time fishing pressure will be reduced to sustainable levels in all EU regions.

In addition to effort management the latest revision of the CFP introduced the landings obligation which comes into practice from 2015 onwards, where all catches have to be kept on board, landed and counted against the quotas. While this will probably not affect the provision of food for human consumption directly as undersized fish cannot be marketed for human consumption purposes, it may contribute indirectly as it will be turned into fishmeal. The landings obligation is expected to affect the selectivity of the fishery which may, in turn, affect the MSY levels as these are dependent on the selectivity of the fishery.

As management of fish stocks has always been species- or stock-specific, the assessment of the capacity to provide seafood presented here also based on species- or stock-specific information and

considered the maximum level of seafood provisioning achievable would be a summation of all the stock-specific MSYs. However, if the management was primarily aimed at maximising the provision of seafood for nutritional purposes without any consideration of the composition in terms of species or size, it is very likely that a much higher food provisioning capacity can be achieved.

Finally, there is the issue of climate change. This is likely to affect many of the currently present European (shell)fish species which contribute to the *Seafood from wild commercial fish and shellfish stocks* service and may result in new entries into the fishery while other species disappear. It is unclear, however, how climate change will affect the service in European waters.

The future evolution of current service supply capacity was not assessed in either region. However, recent evidence (see e.g., https://www.eea.europa.eu/data-and-maps/indicators/status-of-marine-fish-stocks-3/assessment-1) shows that the northerly situation has kept on 'improving', while the southerly one has remained 'bad'. In the absence of outlooks of future trends in the state of wild fish and shellfish stocks, trends in pressures could be used here to carry out an assessment of the future state and direction of change of this service, as outlined in Step 5.C, Section 5 (see also Annex II). This would require the trends in the critical pressures, including climate change, affecting each species, to be identified, and an expert judgement made about how these pressure trends or combinations of pressure trends may affect the outlook for the given species. Finally, this information would then be aggregated to find an overall trend for this service (as illustrated in Section 5 and Annex II for whale species).

Step 6

An extensive system for the assessment and management of the European (shell)fish stocks is already in place. This carries out annual assessments for most of the main stocks in the northern European waters while the frequency is often lower (several years) and covers less of the important stocks in the southerly European waters. There is a process aiming to increase the proportion of species/stocks for which regular assessments take place which should result in an increased confidence in the assessment of the status of the (shell)fish and their capacity to provide seafood.

Overall assessment

Based on the above steps the overall assessment shows a marked difference between the northerly data-rich and southerly data-poor European regions both in terms of the current status as well as the level of confidence (Tables AIV.8-9). For the overall assessment the level of confidence is determined by the information in steps 1 and 2. Step 1 shows most of the landings (> 75 %) are covered by appropriate metrics in the northerly regions while this is < 25 % in the southerly areas. Step 2 shows that in general the two metrics that characterise/determine the *Seafood from wild commercial fish and shellfish stocks* service (i.e. state of the stocks and level of exploitation) are estimated in the northerly areas while this is not the case (only the exploitation level) in the southerly areas. Steps 1 and 2 combined therefore result in a high level of confidence for the northerly areas and low for the southerly areas. The current state and trend is based on the steps 3 and 4, where the relatively high proportion of species that meet the objectives results in a classification of the seafood provisioning capacity to be 'moderate' and following an 'improving' direction of change in the northerly regions; while it is 'bad' in the southerly regions, where the direction of change is 'unknown'.

Table AIV.8 Summary of the relevant information for the assessment of the capacity of European marine ecosystems to deliver the service "seafood from wild animals". Two specific regions were chosen which are considered exemplary of the data-rich and data-poor European regions. Whenever numbers are given, the number between brackets is the average across several regions

	Step 1	Step 2	Step 3	Step 4	Step 5
EU region	**Information availability for critical components**	**Relationship metrics of state and service**	**Current state**	**Current trend**	**Future change[11]**
North Sea (data-rich northerly regions)	79 % (76 %) of landings covered by appropriate metrics	Both aspects of the state-service relationship covered by appropriate metrics	67 % (84 %) of species meet objectives/ MSY ('moderate' as they do not all meet them)	'Increasing' (moving towards meeting the objectives/MSY)	'Unknown' due to the effects of climate change
Western Medi-terranean Sea (data-poor southerly regions)	30 % (24 %) of landings covered by appropriate metrics	Only one aspect of the state-service relationship covered by appropriate metrics	4 % (16 %) of species meet objectives ('bad')	'Unknown'	'Unknown' due to the effects of climate change

Table AIV.9 Overall assessment of the capacity of European marine ecosystems to deliver the service*Seafood from wild commercial fish and shellfish stock*. Green = good or high, orange = moderate while red = bad or low

EU region	Confidence	Current capacity and direction of change
North Sea (data-rich northerly regions)		Improving
Western Mediterranean (data-poor southerly regions)		Unable to assess

[11] An assessment of the future evolution of current service supply capacity was not assessed in either region. However, this could be carried out using a pressure assessment based approach. See Step 5 above for further details.

Annex IV References

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Annex V Confidence assessment linked to MECSA's Operational Steps in Section 5 of the main Report

Disclaimer: *This Annex was developed in 2014 and has not been updated since then, while certain elements of the main Report have been updated since 2014. Thus, there may be some inconsistencies between the main Report and the case study presented in this Annexes.*

In order to develop the MECSA method outlined in Section 5 of the main Report, a number of assumptions had to be made. The rationale for, and hence confidence in, those assumptions are discussed in Section 6. In the confidence assessment for the method, the degree of confidence is given wherever there is an expert judgement made and a source of information is used (Table AV.1). For any given application of the assessment, a confidence in the process can be determined which reflects the availability and quality of the information that has gone in and the opinion of the experts that make any judgement required. The confidence assessment is carried out throughout the entire process, but is summarised here. There are a number of points throughout the assessment where an assessment of confidence needs to be carried out and these are mentioned throughout the description of the assessment above and extracted per Step here. One confidence score is given for each step, and this is carried through to the overall assessment. Due to the variety of services and the differences in the specific assessment which is required for each service, a detailed and systematic confidence assessment cannot be presented. It is the aim of this Annex to provide guidelines to make up a high level framework within which a confidence assessment can be carried out which can be applied to all services. All steps referred to in this Annex, are described in Section 5 of the main report.

Table AV.1 Points throughout the MECSA method where an assessment of confidence is made. For the description of the steps, see Section 5 of the main Report

Step		Aspects that are relevant for determining the overall confidence in the assessment
Step 1	**Identify the critical ecosystem components for service supply capacity**	
1.1	Identify the service class or type to be assessed	
1.2	Determine the relative contribution of all components to the ecosystem capacity to supply the service class or type	• Developing criteria to assign relative contribution • Assigning relative contribution
1.3	Identify the component(s) critical for the ecosystem capacity to supply the service class or type	• Deciding on the critical components
Step 2	**Establish the relationship between the critical ecosystem component(s) and the service class or type, and identify metric(s) describing this relationship**	
2.1	Establish the (ecosystem) state-service (generation) relationship	• Establishing the type of relationship
2.2	Identify metric(s) describing the (ecosystem) state-service (generation) relationship, including of the critical ecosystem component(s) and other parts of the ecosystem if relevant	
Step 3	**Assess the current state and direction of change in the state of the critical ecosystem component(s) and other parts of the ecosystem where relevant**	
3.1	Identify EU (and other) legislation and policy generating ecosystem state and trend information to assess the metric(s) of the critical ecosystem component(s) and other parts of the ecosystem, where relevant, identified in Step 2	
3.2	Synthesise the ecosystem state and trend information from the different pieces of EU (and other) legislation and policy used to assess the metric(s)	• Information sources used
3.3	Establish the quality classifications for the ecosystem state ('pass'/'fail') and trend ('increasing'/'decreasing'/'stable') information from each piece of EU (and other) legislation/policy used to assess each metric(s)	
3.4	Aggregate the quality classifications for the ecosystem state and trend information across all pieces of EU (and other) legislation and policy used to assess each metric(s), and determine the overall current state and direction of change in the state of the critical ecosystem component(s) and other parts of the ecosystem where relevant	• Confidence in the aggregation of different policy outcomes
Step 4	**Assess the current state of and direction of change in the capacity of the ecosystem to supply the service class or type**	• Translating ecosystem state into the capacity to supply a service
Step 5	**Assess the future state and direction of change in the state of the critical ecosystem component(s), and other parts of the ecosystem where relevant, and use that to determine the future state of and direction of change in the capacity of the ecosystem to supply the service class or type**	There are several points in Step 5 where confidence is assessed. These depend on the method used and are fully described under Step 5 and in Annex V

An overall confidence assessment is given for each step (1-4) and this is presented for the final overall current assessment. The confidence table is colour coded: High confidence: green; Moderate confidence: yellow; and Low confidence: red.

Step	Confidence
Step 1	High
Step 2	Moderate
Step 3	Low
Step 4	Moderate

Step 1

There are three points in step one where there is an associated degree of confidence - confidence in the criteria developed to assign the relative contribution; confidence in the relative contribution assigned; and confidence in how many components are considered critical. For each of the points, an expert judgement in the degree of confidence should be made. For the overall confidence in the step, the lowest of these three is taken as the overall outcome.

Example: Waste nutrient removal and storage service test case assessment

The confidence assessments for the *Waste nutrient removal and storage* service test case assessment are shown as an example (for full details see Annex III).

Step 1.2 Confidence in the criteria developed to assign relative contribution:

The criterion used to assign relative contribution, i.e. that primary production can be used to represent the capacity of the ecosystem to assimilate nutrients, is based on the knowledge that:

- Plants and algae require nutrients for photosynthesis and growth
- Primary production represents the growth of photosynthesising components and hence their nutrient uptake

From expert judgement, there is high confidence in these statements

Step 1.2 Confidence in assigning the relative contribution:

- The information used to assign the relative contribution comes from a general estimation from the literature of the different components involved in the supply of the service. In general, this type of information would have moderate confidence. However, it is well understood and several sources of information identify that phytoplankton is the major contributor and there is high confidence in this.

Thus, there is high confidence in this step.

Step 1.3 Confidence in deciding how many components are critical:

- Phytoplankton is the major contributor to the supply of this service and its contribution far exceeds the contribution of other components.

Thus, there is high confidence in this step.

Overall confidence for step 1

- There was high confidence in each of the three different aspects for assessing the confidence in this step, thus there is high confidence overall for Step 1.

Step	Confidence
Step 1	

Step 2

Step 2.1 Confidence in the type of relationship

The confidence is Step 2 is related to the understanding of the relationship between the state of the ecosystem components and the ecosystem capacity to supply the service. Expert judgement should be used to decide the confidence in this relationship.

Example: Waste nutrient removal and storage service test case assessment

The confidence assessment for the *Waste nutrient removal and storage* service test case assessment are shown as an example (for full details see Annex III).

Step 2.1 Confidence in the type of relationship:

- Even though it is a complex relationship, the relationship between phytoplankton, nutrients and the impacts of eutrophication on the benthos are well understood, thus there is high confidence in the type of relationship and high confidence overall for Step 2.

Step	Confidence
Step 1	
Step 2	

Step 3

There are two aspects of Step 3 in which it is appropriate to provide an assessment of the level of confidence in the outcome. The first of these is the quality of the information sources used to assess the state of the ecosystem (Step 3.2 and Step 3.3), while the second is the degree of confidence in the aggregation of the different EU (and other) legislation/policy assessment outcomes into the overall assessment of the state of the ecosystem (Step 3.4).

Step 3.2 and 3.3 Confidence in the information sources used

Step 3.2 and 3.3 require a number of decisions to be made about the information to use to assess ecosystem state, hence an assessment of confidence is required, taking into account different factors that may affect the outcome of the service supply capacity assessment. The information sources used and the potential sources of uncertainty associated with them will vary depending on the service being assessed. The evaluation of the quality of the information is ultimately carried out as part of the 'expert judgement' process and the expectation is thereof re that the 'experts' reflect on and record their confidence in the process. Guidelines are suggested to assist and guide this process and, thus, to provide consistency, which have been used by the authors of this work. (Table AV.2).

There are a number of factors related to the information source, which should be reflected in the confidence assessment. A list is provided below, although this is not exhaustive, as factors will differ depending on the service being assessed.

- Where the information used is an assessment product from the implementation of EU (and other) legislation/policy, the information will have already gone through a degree of interpretation by the reporters of the data/information (e.g. expert judgement has been used in assigning data to 'high', 'good', 'moderate', etc. for the WFD)
- For this assessment approach, information on the state of the critical ecosystem components and other ecosystem attributes is assigned to a 'pass' or 'fail'. In some cases, this assignation aligns directly with EU (and other) legislation/policy objectives, while in other cases, expert judgement is used to assign the information to a 'pass' or 'fail' (e.g. nutrient data is assessed and reported/scored as 'high', 'moderate' or 'low' in EEA indicators but these categories do not directly correspond to any particular legislation/policy objectives). Even where the 'pass' or 'fail' categories can be aligned with legislation/policy objectives, these objectives may, in turn, not align with what is required to assess the ecosystem capacity to supply a service.
- The information used from the EU (and other) legislation/policy may directly align with the actual metric that needs to be assessed, or may be in an aggregated form (See Table 5.20)
- The reported information may be collected at different scales; it must be considered how appropriate the scale is for the assessment (regional/sub-regional, etc.)
- It must be considered how recent the EU (and other) legislation/policy assessments (products or indicators or data) used are
- It must be considered how comparable the different sources of information are (timing, scale, indicators used, etc.). If one state classification from one assessment is being compared with a trend from another assessment (e.g. using an MSFD state classification with a trend from EEA indicators), this has lower confidence than if the state and trend information come from the same source.
- In this assessment approach, where several classification for the assessment of an EU marine region are provided by a relevant piece of EU (and other) legislation/policy used as an information source in the assessment, the 'most frequent classification' is taken to represent an EU marine region. However, it must be considered how representative this classification is of the whole region (e.g. are there also large proportions of the data with 'insufficient information' or other classifications, i.e. different from 'good', 'bad', etc.)

Table AV.2 Suggested guidelines for use by expert assessors to assign confidence in the outcomes of their work relating to the criteria for selection of the assessment information as highlighted at the beginning of Step 3.1

Level of confidence	Narrative criteria
High	All sources fit criteria for selection well (e.g. represent the state-service relationship well, and have good temporal and spatial fit for the assessment) and the quality of the information used is good (i.e. not including large gaps in assessment coverage).
Moderate	The fit of the information sources to certain criteria (e.g. state-service relationship) is good, but to other is poor. Here data quality could still be good but the fit not ideal.
Low	There are concerns with fit of the sources to all criteria. Quality of data could be okay but could also be poor.

Example: Waste nutrient removal and storage service test case assessment

The confidence assessment for the *Waste nutrient removal and storage* service test case assessment are shown as an example (for full details see Annex III).

Step 3.2 and 3.3 Confidence in the information sources used:

A number of factors are relevant for the assessment of confidence in the information sources used:

- Assessment information is aggregated and not directly aligned to the metrics being assessed in several cases (e.g. MSFD, WFD, OSPAR) but not HELCOM
- EEA indicator scores did not align with EU (and other) policy objectives and the 'moderate' score was discarded
- WFD, MSFD, OSPAR and EEA report on assessment products/indicators at different scales (e.g. MSFD: regional sea, WFD: coastal, OSPAR: OSPAR regions which extend beyond the regional sea)
- Even where assigned, much of the MSFD assessment products available included large proportions of the area of the EU marine region assessed with 'insufficient information' to assess the whole region
- The spatial scope of WFD assessment products was incomplete (not all relevant countries included)
- Trends and state information are combined across the different information sources, although these have been collected over various time periods (e.g. using an EEA (indicator) trend with a MSFD state (assessment product)) and are applied at different spatial scales

Given these sources of uncertainty, the confidence is assigned as moderate in this step.

Step 3.4 Confidence in the aggregation of different EU (and other) legislation/policy assessment outcomes

The confidence in this part of the assessment is measured as the level of agreement between different sources of assessment information. It accounts for whether different EU (and other) legislation/policy assessments appear to use different data sources, or if reporting of different laws or policies appears to all be based on the same data sources (where this is known or can be assumed). This assumes that there is an equal degree of confidence associated with all the assessments carried out under all the different pieces of legislation/policy. However, when only one legislation/policy classification appears to be used, the actual confidence in that assessment is taken into account.

Thus, when the same metrics are assessed by several pieces of EU (and other) legislation/policy and one overall classification is taken forward for the assessment here (as described in the aggregation methods above), the confidence is assessed by indicating the level of agreement between different information sources as follows:

- **High confidence:** Two or more different sources of information agree on the outcomes.
- **Moderate confidence:** Only one assessment but confidence in this assessment (as given with the reported information) is 'high' (e.g. for the state of 'Oxygen' in Table 5.21). 'Moderate' confidence is also given if there is one 'known' assessment (status classification) and one 'insufficient information' assessment, *and* there is high confidence in the information source of the 'known' assessment. In Table 5.21, the same state for 'Nitrogen concentration' is reported by the MSFD, the WFD and HELCOM. Based on knowledge of how and when Member States have carried out their national assessments, it is assumed that the data used by HELCOM is the same as generated under the WFD and the MSFD (and so reported assessment products would be based on the same data). The confidence assessment here is, thus, as if there was only one information source used (i.e. a maximum of 'moderate' confidence can be given). There is high confidence in the HELCOM assessment, thus 'moderate' is given here.
- **Low confidence:** all other possibilities, i.e. several sources of information, which disagree; or only one source of information, which has an associated 'low' or 'moderate' confidence (e.g. in Table 5.21, the trends towards policy objectives for 'Nitrogen concentration' from the MSFD and the EEA disagree and, therefore, 'low' confidence is assigned for the direction of change).

In this step, a confidence level is given for each metric. Where these metrics are used concurrently (e.g. for the *Waste nutrient removal and storage* service, phytoplankton biomass, nutrient concentration and impact on benthos are the metrics used to assess the capacity to supply the service), the lowest degree of confidence is taken as the overall confidence. Where metrics are combined, e.g. in *Recreation and leisure from whale watching* service, there is a confidence score for each metric, i.e. whale species. The 'most frequent classification' is taken and the confidence score associated with this classification is taken as the overall confidence in that outcome.

Example: Waste nutrient removal and storage service test case assessment

The confidence assessment for the *Waste nutrient removal and storage* service test case assessment are shown as an example (for full details see Annex III) with the confidence in the aggregation shown in Table AV.3 and the confidence overall for Step 3 shown below.

Table AV.3 The overall outcomes for each metric relevant to the *Waste nutrient removal and storage* service reported under each policy for the North East Atlantic Ocean (taken from Table AIII.42)

Legend

	Metric not directly assessed under this legislation/policy
	Fail to meet policy objectives
	Achieve policy objectives
	Unable to assess (insufficient information)
↑	Direction towards achieving policy objectives
↓	Direction away from achieving policy objectives
↔	No change in direction
No arrow	Unable to assess (insufficient information)

	EU and Other Law and Policy				Majority Assessment		
	EU level			Regional Level			
Metric	**Marine Strategy Framework Directive**	**Water Framework Directive**	**EEA Indicators**	**OSPAR**	**Overall assessment**	**Confidence: State**	**Confidence: Direction**
Nitrogen concentration			↔	↔	↔	Low	Low
Phosphorus concentration			↔	↔	↔	Low	Low
Phytoplankton biomass (Chlorophyll-a)			↔	↔	↔	Low	Low
Benthos				↔	↔	Low	Low

Step 3.4 Confidence in the aggregation of different EU (and other) legislation/policy outcomes is given for each metric in the table above (majority approach). The overall confidence assessment for this step (Step 3) is a combination of the confidence in the sources of information (which was given as moderate) with the confidence on the aggregation of the legislation/policy outcomes. The lowest confidence score is taken forward for the overall assessment.

Waste nutrient removal and storage service in the North East Atlantic Ocean: Confidence in the aggregation: Low for state and low trend, thus low overall.

Step	Confidence
Step 1	
Step 2	
Step 3	

Step 4

Step 4 Confidence in translating ecosystem state to the capacity to supply a service

In the final Step, there may be further decisions made which are associated with a degree of confidence, and these can depend on the service being assessed. This step is carried out as part of the 'expert judgement' process and the expectation is thereof that the 'experts' reflect on and record their confidence in the process. These can include:

- Expert judgement in interpreting the state of the metrics and what this means for the overall capacity to supply the service.
- Determining an overall assessment (taking the 'most frequent classification') but where there may also be high proportions of 'insufficient information' or other classifications (than 'good', 'bad', etc.).

Expert judgement should be used to assign a degree of high, moderate or low confidence in this step.

The overall confidence assessment is presented as a table with a score for each step. This will allow a more transparent assessment, highlighting particular steps where there may be lower confidence, understanding or less good quality sources of information to carry out the process.

Example: Waste nutrient removal and storage service test case assessment

The confidence assessment for the *Waste nutrient removal and storage* service test case assessment are shown as an example (for full details see Annex III).

Step 4 Confidence in translating ecosystem state to the capacity to supply a service: *Waste nutrient removal and storage* service in the North East Atlantic Ocean

Phytoplankton and nutrient concentrations and the impact on the benthos were found to be 'stable' in the North East Atlantic Ocean suggesting the current change of the service supply is 'stable' The state of each of these metrics was found to be 'good'.

Based on the state and trends of the metrics of ecosystem state, the confidence that this translates to a 'good' capacity to supply the service that is 'stable', is high.

Step	Confidence
Step 1	
Step 2	
Step 3	
Step 4	

Step 5

Step 5 Assessing the Confidence of the Future Assessment

The future assessment requires its own confidence assessment, since there are a number of additional steps that are required, but also carries forward the confidence from the previous steps (current assessment), as these form the basis underlying the future assessment (Table AV.4).

Table AV.4 Points throughout the MECSA method to assess the future state and direction of change in the capacity of the ecosystem to supply a service where an assessment of confidence is made. For the description of the steps, see Section 5 of the main Report

Step 5	**Assess the future state and direction of change in the capacity of the critical ecosystem component(s), and other parts of the ecosystem where relevant, and use that to determine the future state and direction of change in the capacity of the ecosystem to supply the service class or type**
5.A	In the absence of outlooks on future ecosystem state, base future changes in service supply capacity on the future trend in the state of the metric(s) identified in Step 2 and assess that using outlooks on future trends in ecosystem state.
5.B	In the absence of outlooks on future trends in ecosystem state and if critical pressure(s) on the critical ecosystem component(s) are known, when basing future changes in service supply capacity on the future trend in the state of the metric(s) identified in Step 2, assess that using future trend(s) in the critical pressure(s).
5.C	In the absence of outlooks on future trends in ecosystem state and if critical pressure(s) on the critical ecosystem component(s) are not known, identify these and, when basing future changes in service supply capacity on the future trend in the state of the metric(s) identified in Step 2, assess that using future trend(s) in the critical pressure(s).
5.C.1	Identify the critical pressure(s) on the critical ecosystem component(s)
5.C.2	Identify EU (and other) legislation/policy generating information on trends in critical pressures on the critical ecosystem component(s)
5.C.3	Synthesise the information on the critical pressure(s) on the critical ecosystem component(s) from different pieces of EU (and other) legislation/policy
5.C.4	Report the trend (future or current assumed to continue in the future) for each critical pressure from each piece of EU (and other) legislation/policy
5.C.5	Carry out an overall assessment of the future trend in the critical pressure(s) and determine the outlook (future trend in the state) for the critical ecosystem component(s)
5.C.6	Determine the future direction of change in the capacity of the ecosystem to supply the service class or type and, if possible, the future state of this capacity

Step 5.A Confidence in the source of information used

(i) Where the source of information gives a prediction for the future changes of state of the ecosystem component:

- The associated confidence classification for the information source should be considered.

(ii) As was carried out in Step 4, this step also requires the interpretation of the changes in state relative to the potential change in service supply. Thus, the confidence assessment should also consider:

- Expert judgement in interpreting the state of the metrics and what this means for the overall capacity to supply the service.
- Determining an overall assessment (taking the 'most frequent classification') but where there may also be high proportions of 'insufficient information' or other unknown classifications (different from 'good', 'bad', etc.).

Confidence for (i) and (ii) should be presented separately as demonstrated in the example below.

Example: Recreation and leisure from whale watching service test case assessment in the Mediterranean Sea

The confidence assessment for the *recreation and leisure from whale watching* test case assessment is shown as an example (for full details see Section 5.1, Step 5.A).

Future of the *Recreation and leisure from whale watching* service in the Mediterranean Sea based on the predicted future trends of marine mammals as reported in the MSFD

Step 5.A (i) Confidence in the information source

The confidence in the type of information is low as the assessment product is an aggregation of marine mammals (and so includes seals as well as whales). In addition, there is a high proportion of 'insufficient information' in the region.

Step 5.A (ii) Interpretation of the changes in ecosystem state relative to the potential change in service supply

The prediction that the service will be in a 'bad' state and 'stable' in the future is high for state as it is unlikely the state of whales will move from 'bad' into a 'good' state but low for the trend, as there is a high proportion of 'insufficient information'.

Step	**Confidence**
Step 5.A (i)	
Step 5.A (ii)	

Step 5.B Confidence assessment for using future trend(s) in the critical pressure(s) as a proxy to assess the future trends in the state of the metric(s) identified in Step 2, as the basis for assessing future changes in service supply capacity, when the critical pressure(s) on the critical ecosystem component(s) has already been identified

(i) In this route, the relationship between the pressure and the state of the component, if already identified as part of the current assessment, will have already been accounted for in the confidence assessment for Step 2.1. Thus, the assessment of confidence at this point should consider:

- the source of information with its associated confidence classification
- the type of information where the best available information (higher confidence) is predicted outlook for trends in the pressure and alternative information is to use current (or recent) trends in pressures and assume that these will continue in the future (lower confidence).

(ii) This step also requires the interpretation of the changes in pressure (and hence ecosystem state) relative to the potential change in service supply. Thus, the confidence assessment should also consider:

- Expert judgement in interpreting the state of the metrics and what this means for the overall capacity to supply the service.
- Determining an overall assessment (taking the 'most frequent classification') but where there may also be high proportions of 'insufficient information' or other unknown classifications (different from 'good', 'bad', etc.).

Confidence for (i) and (ii) should be presented separately as demonstrated in the example below.

Example: Waste nutrient removal and storage service test case assessment

The confidence assessment for the *Waste nutrient removal and storage* service test case assessment are shown as an example (for full details see Annex III).

Future of the *Waste nutrient removal and storage* service in the North East Atlantic Ocean based on the predicted outlook for eutrophication as reported by OSPAR

Step 5.B (i) Confidence in the information source

The confidence in the type of information is high as the pressure trend given is the predicted outlook (as opposed to current or recent trends), however confidence for the predicted outlook of pressures by OSPAR is not given and as the current confidence assessment for OSPAR is low for most of the OSPAR area (Table AIII.59), the future assessment confidence is also assumed to be low in the majority of the area.

Step 5.B (ii) Interpretation of the changes in pressure (and hence ecosystem state) relative to the potential change in service supply

The prediction that the service will 'deteriorate' in the future is high.

Step	**Confidence**
Step 1	
Step 2	
Step 3	
Step 4	
Step 5.B(i)	
Step 5.B(ii)	

Step 5.C Confidence assessment for using future trend(s) in the critical pressure(s) as a proxy to assess the future trends in the state of the metric(s) identified in Step 2, as the basis for assessing future changes in service supply capacity, when the critical pressure(s) on the critical ecosystem component(s) are not known

Step 5.C involves carrying out a number of sub-steps. A number of these steps have confidence associated with them (Table AV.4).

Step 5.C.1 Confidence in the identity of the critical pressure on the ecosystem component
Identifying the critical threat has confidence associated with:

- The source of information – how robust is the source
- How directly relevant the information is to the critical ecosystem components (e.g. having the major threat information for each individual whale species relevant for whale watching has a higher confidence than having the main threats for marine mammals in general).

Example: Recreation and leisure from whale watching service test case assessment

The confidence assessment for the *recreation and leisure from whale watching* test case assessment is shown as an example (for full details see Annex II).

Step 5.C.1 Confidence in the identity of the major threat to the component:

The major threat information used was species specific for the whales identified as contributing to whale watching leading to high confidence, however the information was not quantitative and therefore the certainty that a particular threat was the greatest threat was moderate.

There is moderate confidence in this step.

Step	**Confidence**
Step 5.C.1	

Step 5.C.3 and 5.C.4 Confidence in the information sources used

The evaluation of the quality of the information is ultimately carried out as part of the 'expert judgement' process and the expectation is thereof re that the 'experts' reflect on and record their confidence in the process. Guidelines are given to assist and guide this process and to provide consistency (Table AV.5).

There are a number of factors related to the information source, which should be reflected in the confidence assessment. A list is provided below, although this is not exhaustive, as factors will differ depending on the service being assessed.

- The information used from EU (and other) legislation/policies may directly align with what is required to assess the metrics
- The reported information may be collected at different scales, how appropriate is the scale for the assessment (regional/sub-regional, etc.)
- How recent are the assessments used
- How comparable are the different sources of information (timing, scale, metrics and indicators used, what states and trends reported are measuring)

- In this assessment approach, where several classifications for the assessment of an EU marine region are provided by a relevant piece of EU (and other) legislation/policy used as an information source in the assessment, the 'most frequent classification' is taken to represent an EU marine region. However, it must be considered how representative this classification is of the whole region (e.g. are there also large proportions of the data with 'insufficient information' or other classifications, i.e. different from 'good', 'bad', etc.)

Table AV.5 Suggested guidelines for use by expert assessors to assign confidence in the outcomes of their work relating to the criteria for selection of the assessment information

Level of confidence	Narrative criteria
High	All sources of information (data, assessment products, expert opinions) align and are seen as being robust sources of information
Moderate	There are concerns about the quality/appropriateness of data/information but the sources of information mostly align
Low	There are discrepancies between sources of information available

Example: Recreation and leisure from whale watching service test case assessment

The confidence assessment for the *recreation and leisure from whale watching* test case assessment is shown as an example (for full details see Annex II).

Step 5.C.3 and 5.C.4 Confidence in the information sources used:

A number of factors are relevant for the assessment of confidence in the information sources used:

- Information from policies/legislation is reported at different scales (e.g. MSFD: regional sea, OSPAR: OSPAR regions which extend beyond the regional sea)
- Even where assigned, much of the MSFD assessment products available included large proportions of the area of the EU marine region assessed with 'insufficient information' to assess the whole region
- Trends are compared across the different information sources although these have been collected over different time periods (e.g. CFP and MSFD) and are applied at different spatial scales
- CFP information is not recent

Given these sources of uncertainty, the confidence is assigned as moderate in this step. This assessment is given for both regions.

Step 5.C.5 Confidence in the aggregation of EU (and other) legislation/different policy assessment outcomes

A confidence assessment on the aggregation of the outcomes of the sources used is required and this takes into account how well the different EU (and other) legislation/policy assessment outcomes agree (there is high confidence if two or more agree on an outcome), whether the source of data used by separate policies/legislation is the same or independent, and if relying on only one source of information, the confidence in this source of information.

When the same metrics are measured by several policies/legislation and one overall classification is taken (as described in the methods above), the confidence is assessed by indicating the level of agreement between different sources.

- **High confidence:** Two or more different sources of information agree on the outcomes
- **Moderate confidence:** only one assessment but confidence in this assessment (as given with the reported information) is high. Moderate is given if there is one 'known' assessment and one 'insufficient information' assessment *and* there is high the confidence is the 'known' assessment
- **Low confidence:** all other possibilities i.e. several sources of information that disagree, only one source of information that has an associated low or moderate confidence

Where there are several critical pressures, the lowest confidence score is used.

One overall confidence classification is given for Step 5.C.3/4 and 5.C.5 as these both relate to the overall assessment of potential future state of the ecosystem components and the information that has been used to carry out the assessment. The lowest confidence classification is taken as the overall assessment for the combination of these steps.

Example: Recreation and leisure from whale watching service test case assessment

The confidence assessment for the *recreation and leisure from whale watching* test case assessment is shown as an example (for full details see Annex II) with the confidence in the aggregation of pressure trends first shown and the overall confidence for Steps 5.C.3-5 then shown.

Step 5.C.5 Confidence in the aggregation of different EU (and other) legislation/policy assessment outcomes was low in the aggregation of pressure trends for each species.

The overall confidence for steps 5.C.3, 4 and 5 is given i.e. a combination of the confidence in the sources of information (which was given as moderate for all regions) with the confidence on the aggregation of the EU (and other) legislation/policy assessment outcomes.

confidence score is taken forward for the overall assessment. As the confidence was low in the aggregation of pressure trends for every species, the confidence is low overall

The lowest confidence score is taken forward for the overall assessment. As the confidence was low in the aggregation of pressure trends for every species, the confidence is low overall

Recreation and leisure from whale watching service in the North East Atlantic Ocean

Step	**Confidence**
Step 5.C.1	
Step 5.C.3/4 and 5	

Recreation and leisure from whale watching service in the Mediterranean Sea

Step	**Confidence**
Step 5.C.1	
Step 5.C.3/4 and 5	

Step 5.C.6 Confidence in translating pressure to ecosystem state to ecosystem capacity to supply a service

This step requires the interpretation of the changes in pressure (and hence ecosystem state) relative to the potential change in service supply capacity. Thus, the confidence assessment must consider:

- Expert judgement in interpreting the state of the metrics and what this means for the overall capacity to supply the service.
- Determining an overall assessment (taking the 'most frequent classification') but where there may also be high proportions of 'insufficient information' or other unknown classifications (different from 'good', 'bad', etc.).

Confidence should be presented separately for each sub-step, as demonstrated in the example below.

Example: Recreation and leisure from whale watching service test case assessment

The confidence assessment for the *recreation and leisure from whale watching* test case assessment is shown as an example (for full details see Annex II).

Step 5.C.6 Confidence in translating ecosystem state to the capacity to supply a service: *Recreation and leisure from whale watching* service in the North East Atlantic Ocean

Based on the metrics, the confidence that this translates to an improving capacity to supply the service is high since 78 % of the species were found to 'improve'. The confidence that the state would be 'good' is moderate since 50 % are unknown (Table AII.47). The lowest of these is taken giving an overall moderate confidence in this step.

Step	**Confidence**
Step 5.C.1	
Step 5.C.3/4 and 5	
Step 5.C.6	

Full confidence assessment for each step for the North East Atlantic Ocean

Step	**Confidence**
Step 1	
Step 2	
Step 3	
Step 4	
Step 5.C.1	
Step 5.C.3/4	
Step 5.C.6	

Annex VI Application of the new (from January 2018) CICES version 5.1 to marine ecosystems, including its implications for some key outputs of this Report

Annex VI is a separate MS Excel file presenting a customisation of the new (from January 2018) CICES version 5.1 for its (improved) application to marine ecosystems, which is to be used in future work rather than the typology and list of marine ecosystem services used by the MECSA approach (as that is based on CICES version 4.3). The Excel includes an updated list of marine ecosystem services based on CICES v.5.1 (building on Table 2.2 in Section 2 of this Report) and a short description of each of the new services (building on those provided in Section 4 of this Report). It also includes a cross-walk between the MECSA marine ecosystem services list based on CICES v.4.3 and this updated list based on CICES v.5.1, as well as an in-depth comparison between them. It further includes updated linkages matrices between biotic groups and the updated list of services based on CICES v.5.1 (building on that provided in Section 4 of this Report), and between these services and habitats (building on that provided in Annex I of this Report), where the habitats are based on the (new) MSFD broad habitat types. Annex VI was developed following the completion of Sections 1–7 and Annexes I–V of the Report. The Annex VI Excel file is attached to the document holding all the Annexes of the Report.

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