

APPENDIX 2 – APPLICATION OF THE ECOSYSTEM SERVICES APPROACH IN BGTW

1. Introduction

As indicated in MSFD Guidance, the economic and social analysis of marine waters can also be conducted by applying an Ecosystem Services Approach. In contrast with the Marine Water Accounts Approach, it does not only allow an assessment of the direct socioeconomic impacts of marine uses and activities but also indirect impacts and benefits:

Table 1: Coverage of analysis applying the Marine Water Accounts Approach (O) and the Ecosystem Services Approach (X)

	Identify	Quantify	Value
Marine uses / Activities			
Direct use - Economic sectors	XO	XO	XO
Direct use - Other uses	X	X	X
Indirect use	X	X	X
Non-use	X	X	X
Pressures			
Emissions from economic sectors	XO	XO	XO
Other pressures	X	X	X

The ecosystem services approach assesses the value associated with the ecosystem services obtained from marine waters and on which marine uses and activities rely. Ecosystem services can be divided into:

- **Final services:** Those that link directly to human welfare, e.g. food provisioning, raw materials and energy; and
- **Intermediate services:** Underlying services that affect the final services (e.g. habitat, climate regulation, eutrophication mitigation and resilience) and will therefore require a deeper understanding of the dynamics and interactions of the marine ecosystems in order to be identified.

One limitation of ecosystem services approaches, however, is their inability to capture those marine uses which are largely independent of the ecosystem state (e.g. transport- shipping), a consideration that should be taken into account when developing and applying an ecosystem-based approach for BGTW.

The MSFD Guidance recommends following these steps:

- Identify ecosystem services of the marine areas in comparison with the analysis of status (Art. 8.1 (a) MSFD) and the analysis of pressures and impacts (Art. 8.1(b) MSFD);
- Identify and, if possible, quantify and value the welfare derived from the ecosystem services using different methods to estimate the use and non-use values of these services; and
- Identify the drivers and pressures affecting the ecosystem services.

The GES assessment completed for each of the 11 MSFD descriptors could in the future provide information relevant to value ecosystem services allowing the use of environmental data for more than one purpose. However, there are significant challenges associated with the assessment and quantification of ecosystem services. These include data scarcity and difficulty in collecting other relevant data; the degree to which processes are spatially and temporally dynamic (leading to differences between where services are generated and where the benefits are realised); understanding and assessing the link services, functions and the underlying biodiversity; the lack of a standardized list of indicators for marine ecosystem services to enable comparison at EU level and the degree of

importance of social dynamics and cultural values in publicly owned spaces which are still subject to ongoing research¹. The use of indicators as proxies for complex phenomena can facilitate this process².

Given current data gaps and limitations, this Appendix presents a non-exhaustive review of existing frameworks / guides available and outlines a proposed framework to identify and value ecosystem services relevant to BGTW. The aim is to facilitate the development of the evidence base to inform subsequent assessments. Should this approach be applied in the future, the proposed framework should be reviewed and updated periodically and/or in light of new developments in this field.

2. Framework Selection

Classifications/typologies for marine ecosystem services are continuously evolving and whilst there are a number of ecosystem service classifications available for the marine environment in the scientific literature, there is less understanding of the ecosystem features and functions and few precedents for the ecosystem approach compared to terrestrial environments. In addition, authors tend to adapt existing frameworks, tailoring them to the research question which limits comparability. A selection of frameworks and guides are described below (the list is not exhaustive):

- **Millennium Ecosystem Assessment (MA) classification of ecosystem services (2005)**³ is one of the most cited and widely applied and is the basis on which subsequent ecosystem service classifications have been developed. The MA defines ecosystem services as “the benefits people obtain from ecosystems”, and groups them into four ecosystem service categories: supporting, provisioning, regulating and cultural services.
- **DEFRA (2007)**⁴ provides an introduction to the valuation of ecosystem services. The guide builds on previous approaches to valuing the environment but takes a more systematic approach to the assessment of impacts on the natural terrestrial environment. This guide is cited in the MSFD Guidance as an example checklist for marine ecosystem services. However, the list provided by the guide is not marine specific and therefore, not considered the most suitable for this assessment.
- **The Economics of Ecosystems and Biodiversity (TEEB) Approach (2010)**⁵ was commissioned by the G8+5 and launched in 2007 by Germany and the EU Commission. It builds on the analysis of the MA and takes the analysis further by demonstrating the economic significance of biodiversity loss and ecosystem degradation in terms of negative effects on human well-being. It suggests a tiered approach to analysing problems and ascertaining suitable policy responses. The approach distinguishes between ecosystem processes, services, benefits and values, where biophysical structures and processes interact and generate ecological functions. In turn, these ecological functions generate ecosystem services that are measurable entities. This approach forms the basis of the proposed framework to be applied to BGTW (see below).
- **Common International Classification of Ecosystem Services (CICES) (2018)**⁶ has been designed to help measure, account for and assess ecosystem services. It is recognised and

¹ Broszeit, S., Beaumont, N.J., Uyerra, M.C., Heiskanen, A.S., Frost, M., Somerfield, P.J., Rossberg, A.G., Teixeira, H. and Austen, M.C. (2017) What can indicators of good environmental status tell us about ecosystem services? Reducing efforts and increasing cost-effectiveness by reapplying biodiversity indicator data. *Ecological indicators*, 81, pp.409-442.

² Hattam, C., Atkins, J.P., Beaumont, N., Börger, T., Böhnke-Henrichs, A., Burdon, D., de Groot, R., Hoefnagel, E., Nunes, P.A., Piowarczyk, J. and Sastre, S. (2015) Marine ecosystem services: linking indicators to their classification. *Ecological Indicators*, 49, pp.61-75.

³ Millennium Ecosystem Assessment, M.E. (2005) *Ecosystems and human well-being* (Vol. 5, p. 563). Washington, DC: Island press.

⁴ Defra (Department for Environment, Food and Rural Affairs) (2007) *An Introductory Guide to Valuing Ecosystem Services*. London: Department of Food and Rural Affairs. Available at: <https://www.gov.uk> [Accessed 07/01/2020]

⁵ TEEB - The Economics of Ecosystems and Biodiversity for Local and Regional Policy Makers (2010) Available at: <http://www.teebweb.org> [Accessed 14/01/2020]

⁶ Towards a Common International Classification of Ecosystem Services (CICES) for Integrated Environmental and Economic Accounting. Available at: <https://cices.eu> [Accessed 07/01/2020]

applied internationally. CICES was particularly designed for accounting purposes and offers a structure that links with the framework of the UN System of Environmental-Economic Accounts (SEEA), although this framework is being increasingly used for ecosystem service assessments.

CICES defines ecosystem services as “contributions that ecosystems make to human well-being, and distinct from the goods and benefits that people subsequently derive from them”. It aims to classify the contributions that ecosystems make to human well-being that arise from living processes, and builds on existing classifications (MA, TEEB). CICES only considers final services and excludes supporting or intermediate services as it considers that these are part of the processes and functions that characterise ecosystems and thus are only consumed or used by people indirectly. While the focus of the CICES framework on final services avoids double counting when valuing the benefits derived from the marine ecosystem services, it does not enable the identification and characterization of intermediate services as recommended by the MSFD Guidance Document. Omitting services such as ecosystem resilience could lead to irreversible changes in the marine environment and therefore the CICES framework has not been selected for the purpose of this assessment.

- **Map and Assess the condition of Ecosystems and their Services (MAES) approach (2013)**^{7,8} is an EU initiative aimed at improving the knowledge and evidence base of Europe’s natural assets in order to guide decisions on complex public issues. It is based on the idea that biodiversity contributes to ecosystem functioning and to delivering ecosystem services. It has developed an analytical framework to be applied by the EU and its Member States in order to ensure consistent approaches are used. MAES proposes a typology with 12 main ecosystems based on the higher levels of the EUNIS Habitat Classification and provides guidance and indicators proposed to map and assess ecosystem conditions and ecosystem services. MAES promotes the CICES classification for ecosystem services, which is not considered the most suited to meet the recommendations of the MSFD Guidance Document and thus the initiative is not discussed further in this document.
- **Culhane *et al.* (unpublished) European Topic Centre on Inland, Coastal and Marine Waters ETC-ICM.** The MSFD Guidance for reporting^{Error! Bookmark not defined.} provides instructions on how to complete the schemas used in the MSFD XML reporting, including in relation to the Economic and Social Analysis using an ecosystem services approach. This means that the XML reports provide a list of ecosystem services, based on an unpublished classification made by Culhane *et al.* (ETC-ICM). However, given that there is no available guidance on how to apply the categories, and there are no indicators provided, this approach is not considered suitable for this preliminary identification of ecosystem services, although comparison with the selected approach has been made for easy reference.
- **Böhnke-Henrichs *et al.* (2013)**¹⁹² have developed a marine-specific ecosystem service typology to Marine Spatial Planning (MSP) and Ecosystem-based Management (EBM) consistent with the TEEB framework (see above). It defines ecosystem services as the “direct and indirect contribution of ecosystems to human well-being” and uses an ecosystem cascade as a structuring framework, establishing a clear distinction between ecosystem processes, services, benefits and value (i.e. ecosystem service cascade levels) to facilitate the analysis of

¹⁸⁷ Maes, J., Teller, A., Erhard, M., Murphy, P., Paracchini, M.L., Barredo, J.I., Grizzetti, B., Cardoso, A., Somma, F., Petersen, J.E. and Meiner, A., (2013) Mapping and Assessment of Ecosystems and their Services. An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Publications office of the European Union, Luxembourg.: 60 pp.

⁸ Boon, A., Uyarra, M.C., Heiskanen, A.S., Van der Meulen, M., Galparsoro, I., Viitasalo, M., Stolte, W., Garmendia, J.M., Murillas, A., Borja, A. (2015) Mapping and assessment of marine ecosystem services and link to Good Environmental Status (phase 1) - Roadmap for an integrated approach to a marine MAES. Project under Framework contract No ENV.D2/FRA/2012/0019

¹⁸⁹ Salomidi M, Katsanevakis S, Borja A, Braeckman U, Damalas D, Galparsoro I, Mifsud R, Mirto S, Pascual M, Pipitone C, Rabaut M. Assessment of goods and services, vulnerability, and conservation status of European seabed biotopes: a stepping stone towards ecosystem-based marine spatial management. (2012) *Mediterranean Marine Science*. 13(1), pp.49-88.

trade-offs implied by human actions and environmental management strategies. It provides consistent “generic” definitions and “specific” descriptions, definitions and examples of the various ecosystem services, avoiding overlap between each of the services and facilitating the understanding of explicit links between ecological processes responsible for the ecosystem service provision and the economic valuation of benefits derived from those services. This clear ecosystem service definition, operationalised by a list of indicators, is essential to avoid false comparison between the supply and use of ecosystem service and makes the Böhnke-Henrichs *et al.* (2013) framework suitable to inform the design of marine management responses. In light of Gibraltar’s ongoing MSP review within BGTW, this framework is considered relevant for BGTW and can be used as a starting point to inform the development of the evidence base.

- **Von Thene *et al.* (2019)**⁹ builds on the work of Böhnke-Henrichs *et al.* (2013), Potschin-Young *et al.* (2018)¹⁰ and Liqueste *et al.*, (2013)¹¹, amongst others, to develop a structured indicator pool of ecosystem services based on the ecosystem cascade to inform future scenario analysis. The cascade version adopted combines ecosystem structures and processes and ecological functions into one category of “ecosystem capacity” that provides a “service” from which a socioeconomic “benefit” is derived. “Values” measure the importance attributed to that benefit by its beneficiaries. These terms are defined below and the cascade structure is represented in Figure 1.
 - o Ecosystem capacity: interaction of species, structures, substrates, conditions and processes that determine the provision of ecosystem services.
 - o Ecosystem services: the direct and indirect contributions of ecosystems to human well-being; their fundamental characteristic is that they retain the link to underlying ecosystem functions, processes and structures.
 - o Benefits: the direct and indirect outputs from ecosystems that have been turned into goods or experiences that are no longer functionally connected to the systems from which they were derived. Benefits are things that can be valued either in monetary or social terms.
 - o Values: the importance attributed to the benefits. This can be economic, social, health or intrinsic value.

Whilst this indicator pool structure is based on CICES, a shortlist of indicators can be selected that meet the Böhnke-Henrichs *et al.* (2013) definition for each ecosystem service for use in initial ecosystem service assessments in BGTW. Thus, as a first step towards the development of the evidence base for BGTW, capacity and service indicators were reviewed and a proposed selection is summarized in Table 2.

In the future, the cascade can be used to inform and structure the analysis steps of MSP in BGTW (refer to Figure 1). The cascade structure can be read bottom-up (to establish the links between ecosystem capacity, the ecosystem services in the planning area and the benefits to society) and can be used in a scenario analysis to assess how the delivery of ecosystem services may change due to changing environmental conditions and future uses and how this may impact beneficiaries. A top-down approach can also be applied in scenario analysis to elucidate the values that people attach to a marine area, which mix of goods and services should be produced from that area and which ecosystem components are essential for these.

⁹ von Thenen, M., Frederiksen, P., Hansen, H.S. and Schiele, K.S., 2019. A structured indicator pool to operationalize expert-based ecosystem service assessments for marine spatial planning. *Ocean & Coastal Management*, p.105071.

¹⁰ Potschin-Young, M., Haines-Young, R., G€org, C., Heink, U., Jax, K., Schleyer, C., 2018. Understanding the role of conceptual frameworks: reading the ecosystem service cascade. *Ecosyst. Serv.* 29, 428–440. <https://doi.org/10.1016/j.ecoser.2017.05.015>.

¹¹ Liqueste, C., Zulian, G., Delgado, I., Stips, A., Maes, J., 2013. Assessment of coastal protection as an ecosystem service in Europe. *Ecol. Indic.* 30, 205–217. <https://doi.org/10.1016/j.ecolind.2013.02.013>.

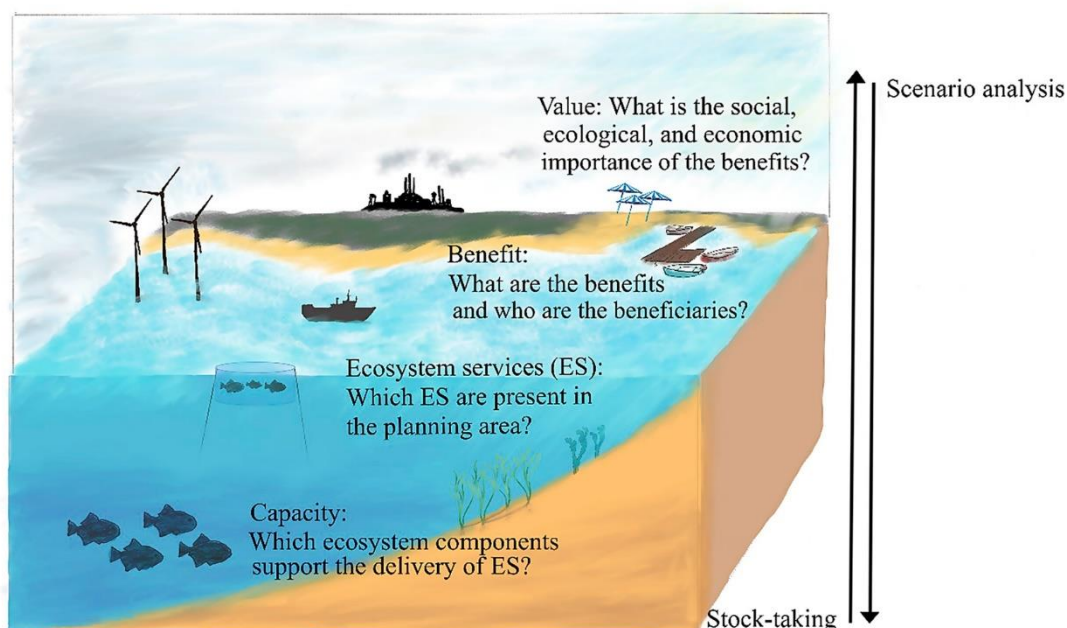


Figure 1: Ecosystem cascade structure to stock-taking and scenario analysis steps. Source: Von Thene et al. (2019)

3. Other relevant information sources

A number of databases exist which contain marine valuation estimates. Monetary valuations can inform the valuation step in an ecosystem-based approach once sufficient information has been gathered to inform the baseline (and potential future conditions, when scenario analyses are being conducted) for ecosystem capacity, services and benefits in BGTW. Refer to Skourtos *et al.* (2015)¹² for a review of eight different databases of potential interest: Marine Ecosystem Services Partnership (MESP), National Ocean Economics Program (NNOEP), Cost-impact Marine Valuation Database (COST-IMPACT), Gulf of Mexico ecosystem services valuation database (GecoServ), Environmental valuation reference inventory (EVRI), environmental valuation database (ENVALUE), Greek Environmental Valuation Database (GEVAD), ecosystem services valuation database (ESVD) and the Valuation database for Marine Ecosystem Services of Southern European Sea (V-MESSES).

In this document, the **V- MESSES database**¹³ in particular is discussed, as it has been specifically developed to facilitate economic valuation in the context of the MSFD or its national equivalent.

The **V-MESSES database** was developed in the context of policy-oriented marine Environmental Research for the Southern European Seas (PERSEUS)¹⁴ research as part of its **Adaptive Marine Policy (AMP)**¹⁵ **Toolbox** and is the result of close collaboration between scientists and socio-economists. The PERSEUS project is focused on the assessment of the dual impact of human activity and natural pressures on the Mediterranean Sea and the Black Sea. The reference values contained in this database have been derived from 128 studies conducted in the period 1997 to 2014 with the objective of providing monetary values for Southern European Seas (SES) to be used in cost-benefit and cost-effectiveness applications, thus these values can be potentially applied to BGTW through benefit transfer approaches.

¹² Skourtos, M., Damigos, D., Tsitakis, D., Kontogianni, A., Tourkolias, C. and Streftaris, N., 2015. In Search of Marine Ecosystem Services Values: The V-MESSES Database. *Journal of Environmental Assessment Policy and Management*, 17(04), p.1550037.

¹³ http://www.perseus-net.eu/en/database_marine_valuation/index.html

¹⁴ <http://www.perseus-net.eu/site/content.php>

¹⁵ http://www.perseus-net.eu/en/about_the_apf_toolbox/index.html

4. Ecosystem Services Screening and Proposed Indicators

Based on the ecosystem services typology developed by Böhnke-Henrichs *et al.* (2013) (adapted) an ecosystem services screening has been conducted to identify those ecosystem services on which marine uses and activities are dependent and should be prioritised for further assessment. These are summarized in Table 2 below.

Table 2: Ecosystem Service Prioritisation

Ecosystem Service (ES)	ES Description	Relevance for BGTW	Prioritised for assessment?
			Y/N
Provisioning services – biotic and abiotic			
1. Sea food	All available marine fauna and flora extracted from coastal/marine environments for the specific purpose of human consumption as food (i.e. excluding for consumption as supplements) (e.g. fish, shellfish, seaweed).	Although there is no commercial fishing fleet in BGTW, small-scale cottage fishing and recreational fishing does occur in BGTW.	Y
2. Sea water	Marine water in oceans, seas and inland seas that is extracted for use/directly used in human industry and economic activity (e.g. seawater used in shipping, industrial cooling, desalination).	Marine water is extracted for use in human industry and economic activity, used directly for sanitary purposes and fire protection and providing the main source of potable water supply in Gibraltar (through desalination).	Y
3. Raw Materials	The extraction of any material from coastal/ marine environments, excluding that which is covered by service 6 (e.g. algae (non-food), sand, salt).	There is currently no provision or extraction of raw materials within BGTW.	N
4. Genetic Resources	The provision/ extraction of genetic material from marine flora and fauna for use in nonmarine, non-medicinal contexts, excluding the research value on Genetic Resources which is covered by service 20 (e.g. use of marine flora/fauna-derived genetic material to improve crop resistance to saline conditions)	There is currently no provision or extraction of genetic material from marine flora / fauna for use in non-marine, non-medicinal contexts within BGTW.	N
5. Medicinal Resources	Any material that is extracted from the coastal/ marine environment for its ability to provide medicinal benefits, excluding the research value on Medicinal Resources which is covered by service 20 (e.g. marine-derived pharmaceuticals; marine/coastal-derived salt-water used for health purposes)	There is currently no extraction of material from BGTW for medicinal purposes.	N
6. Ornamental Resources	Any material extracted for use in decoration, fashion, handicrafts, souvenirs, etc. (e.g. shells, aquarium fish, pearls, coral).	There is currently no extraction of material from BGTW for use in decoration, fashion, handicrafts, souvenirs, etc.	N

Ecosystem Service (ES)	ES Description	Relevance for BGTW	Prioritised for assessment? <hr/> Y/N
Supporting services - biotic and abiotic			
7. Air Purification	Air purification provided by a coastal/marine (e.g. removal from the air of pollutants like fine dust and particulate matter, sulphur dioxide, carbon dioxide, etc.).	Coastal and marine ecosystems within BGTW provide air purification.	Y
8. Climate Regulation	The contribution of the biotic elements of a coastal/marine ecosystem to the maintenance of a favourable climate via their impact on the hydrological cycle and their contribution to the climate-influencing substances in the atmosphere (e.g. production, consumption and use by marine organisms of gases such as carbon dioxide, water vapour, nitrous oxides, methane, and dimethyl sulphide).	Coastal and marine ecosystems within BGTW contribute to the maintenance of a favourable climate conditions.	Y
9. Disturbance Prevention or Moderation	The contribution of marine ecosystem structures to the dampening of the intensity of environmental disturbances such as storm floods, tsunamis, and hurricanes (e.g. reduction in the intensity of and/or damage caused by environmental disturbances resulting directly from marine ecosystem structures like salt marshes, sea grass beds, and mangroves).	The extent to which marine ecosystem structures contribute to the dampening of the intensity of environmental disturbances such as storm floods is considered limited as flood protection in Gibraltar relies on man-made structures. The capacity of the ecosystem to provide this service in BGTW is limited and therefore it has not been prioritised for further assessment.	N
10. Regulation of Water Flows	The contribution of marine and coastal ecosystems to the maintenance of localized coastal current structures (e.g. effect of macro algae on localized current intensity; maintenance of deep channels for shipping by coastal currents).	Marine and coastal ecosystems contribute to the maintenance of localised coastal current structures, with coastal currents naturally maintaining local depths for shipping.	Y
11. Waste Treatment	The removal by coastal/marine ecosystems of pollutants added to coastal/marine environments by humans through processes such as storage, burial, and biochemical recycling (e.g. breakdown of chemical pollutants by marine microorganisms; filtering of coastal water by shellfish).	Marine and coastal ecosystems contribute to the removal of pollutants added to BGTW by humans through flushing and dispersion, degradation, filtering, etc.	Y
12. Coastal Erosion Prevention	The contribution of coastal/marine ecosystems to Coastal Erosion Prevention, excluding what is covered by service 10 (i.e. transportation or deposition of sediments by coastal currents) (e.g. maintenance of coastal dunes by coastal vegetation; the reduction in scouring potential that results from near-shore macro-algae forests).	The extent to which coastal and marine ecosystems contribute to coastal erosion prevention in BGTW is considered limited. Erosion is minimised through the use of man-made structures such as breakwaters. The capacity of the ecosystem to provide this service in BGTW is limited and therefore it has not been prioritised for further assessment.	N

Ecosystem Service (ES)	ES Description	Relevance for BGTW	Prioritised for assessment?
			Y/N
13. Biological Control	The contribution of marine/coastal ecosystems to the maintenance of natural healthy population dynamics to support ecosystem resilience through maintaining food web structure and flows (e.g. the support of reef ecosystems by herbivorous fish that keep algae populations in check; the role that top predators play in limiting the population sizes of opportunistic species).	Marine and coastal ecosystems in BGTW are considered to contribute to the maintenance of natural healthy population dynamics.	Y
<i>Habitat services</i>			
14. Lifecycle Maintenance	The contribution of a particular habitat to migratory species' populations through the provision of essential habitat for reproduction and juvenile maturation.	Marine and coastal habitats in BGTW contribute to essential habitat for reproduction.	Y
15. Gene Pool Protection	The contribution of marine habitats to the maintenance of viable gene pools through natural selection/ evolutionary processes (e.g. inter- and intra-specific genetic diversity that is supported by marine ecosystems which enhances adaptability of species to environmental changes).	Marine and coastal habitats in BGTW contribute to the maintenance of viable gene pools through natural selection / evolutionary processes.	Y
<i>Cultural and amenity services - biotic and abiotic</i>			
16. Recreation and Leisure	The provision of opportunities for recreation and leisure that depend on a particular state of marine/coastal ecosystems (e.g. bird/cetacean watching, sailing, recreational fishing, SCUBA diving, etc.).	BGTW provide opportunities for recreation and leisure that depend on the good condition of marine and coastal ecosystems, including recreational fishing, cetacean tours, water sports, etc.	Y
17. Aesthetic Information	The contribution that a coastal/marine ecosystem makes to the existence of a surface or subsurface landscape that generates a noticeable emotional response within the individual observer. This includes informal Spiritual Experiences but excludes that which is covered by services 16, 18, 19, and 21 (e.g. particular visual facets of a 'sea-scape' (like open 'blue' water), a 'reef-scape' (with abundant and colourful marine life), a 'beachscape' (with open sand), etc. that emotionally resonate with individual observers).	BGTW offers landscapes that generate noticeable emotional responses within the individual observer, including visual facets of the seascape, beachscape, underwater landscapes, etc.	Y
18. Inspiration for Culture, Art and Design	The contribution that a coastal/marine ecosystem makes to the existence of environmental features that inspire elements of culture, art, and/or design.	BGTW inspire elements of culture, art and/or design.	Y
19. Spiritual Experience	The contribution that a coastal/marine ecosystem makes to formal religious experiences.	Not applicable.	N

Ecosystem Service (ES)	ES Description	Relevance for BGTW	Prioritised for assessment? Y/N
20. Information for Cognitive Development	The contribution that a coastal/marine ecosystem makes to education, research, etc. This includes the contribution that a coastal/ marine ecosystem makes to bionic design and bio-mimetics and to research on applications of marine Genetic Resources and pharmaceuticals (e.g. the environmental education of children and adults; the development of surfaces to reduce marine biofouling based on similar surfaces found in marine environments; the application of hydrodynamic flow analysis to marine animals for ship design; utilization of marine animal swimming mechanisms in engineering design).	BGTW contribute to education and research.	Y
21. Cultural Heritage and Identity	The contribution that a coastal/marine ecosystem makes to Cultural Heritage and Identity (excluding aesthetic and formal religious experiences). This includes the importance of marine/coastal environments in cultural traditions and folklore. This covers the appreciation of a coastal community for local coastal/marine environments and ecosystems (e.g. for a particular coastline or cliff formation) as well as the global importance that may be associated with a particular marine landscape (e.g. the Wadden Sea is listed as UNESCO World Heritage site).	There are coastal and marine ecosystems that contribute to Cultural Heritage and Identity.	Y

The level of dependence of marine activity/use on the prioritised ecosystem services is summarized in Table 3. Proposed indicators of capacity and service for each ecosystem service have been selected / adapted from Böhnke-Henrichs *et al.* (2013), Lillebø *et al.* (2017)¹⁶ and Von Thene *et al.* (2019), are summarized in Table 4 and their link to GES descriptors provided.

¹⁶ Lillebø, A.I., Pita, C., Rodrigues, J.G., Ramos, S. and Villasante, S. (2017) How can marine ecosystem services support the Blue Growth agenda? *Marine Policy*, 81, pp.132-142

Table 3: Ecosystem service dependence for each BGTW marine activity/use

Ecosystem services	Socio-economic activities/uses											
	Coastal defence and flood protection	Restructuring of seabed morphology	Extraction of water	Renewable energy generation	Transmission of electricity and communications	Fish and shellfish harvesting (professional, recreational)	Transport - infrastructure	Transport - shipping	Waste treatment and disposal - wastewater	Waste treatment and disposal - port waste	Tourism and leisure infrastructure	Tourism and leisure activities
Provisioning services - biotic and abiotic												
2. Sea water			High	Low			High	Moderate			High	
Supporting services - biotic and abiotic												
7. Air Purification						Moderate					Moderate	Moderate
8. Climate Regulation	High	Moderate				Moderate	Moderate				Moderate	Moderate
10. Regulation of Water Flows		High				Moderate	High					
11. Waste Treatment						Moderate		High			Moderate	
13. Biological Control						High					Moderate	High
Habitat services												
14. Lifecycle Maintenance						High					Moderate	High
15. Gene Pool Protection						High					Moderate	High
Cultural and amenity services - biotic and abiotic												
16. Recreation and Leisure						High					High	High
17. Aesthetic Information												High
18. Inspiration for Culture, Art and Design												High
20. Information for Cognitive Development												High
21. Cultural Heritage and Identity											Moderate	High

Key

- High/direct dependence on ecosystem service condition
- Moderate/indirect dependence on ecosystem service condition
- Low/indirect dependence on ecosystem service condition

Table 4: Proposed capacity and service descriptors for BGTW and their relationship with GES descriptors

Ecosystem Service	Proposed indicators		Related GES Descriptors
	Capacity	Service	
Provisioning services - biotic and abiotic			
2. Sea water	<ul style="list-style-type: none"> - Number of days sea that water is of insufficient quality; - Wave resource (height, energy potential) per area. 	<ul style="list-style-type: none"> - Volume of seawater extracted (m³/year) - Volume of potable water produced by desalination plant (m³/year) - Wave energy production (W) 	Hydrographic conditions (D7) Contaminants (D8, D9) Eutrophication (D5)
Supporting services - biotic and abiotic			
7. Air Purification	<ul style="list-style-type: none"> - Air quality 	<ul style="list-style-type: none"> - Amount of fine dust/NOx or SO2 captured (kg/ha/year) 	Hydrographic conditions (D7)
8. Climate Regulation	<ul style="list-style-type: none"> - Climate conditions 	<ul style="list-style-type: none"> - Amount of CO₂ sequestered (kg/ha/year) 	Hydrographic conditions (D7)
10. Regulation of Water Flows	<ul style="list-style-type: none"> - Bathymetry conditions 	<ul style="list-style-type: none"> - Amount of sediment prevented from sedimentation in natural channels used for shipping (m³/year) 	Hydrographic conditions (D7)
11. Waste Treatment	<ul style="list-style-type: none"> - Water quality 	<ul style="list-style-type: none"> - Biochemical degradation capacity of COD (g/m³/day) 	Contaminants (D8, 9) Marine litter (D10) Eutrophication (D5) Hydrographic conditions (D7)
13. Biological Control	<ul style="list-style-type: none"> - Biodiversity condition - Presence/absence/frequency of invasive/harmful species (e.g. algal blooms, NIS, etc.) (count) 	<ul style="list-style-type: none"> - Species richness, diversity and abundance 	Biodiversity (D1) Non-indigenous species (D2) Marine food webs (D4) Seafloor integrity (D6)
Habitat services			
14. Lifecycle Maintenance	<ul style="list-style-type: none"> - Marine food chain condition - Condition of breeding habitats 	<ul style="list-style-type: none"> - Number of calves (dolphins) and chicks (seabirds) recorded per year in relation to overall population figures 	Biodiversity (D1) Marine food webs (D4)
15. Gene Pool Protection	<ul style="list-style-type: none"> - Biodiversity condition 	<ul style="list-style-type: none"> - Genetic diversity 	Biodiversity (D1) Marine food webs (D4)
Cultural and amenity services - biotic and abiotic			
16. Recreation and Leisure	<ul style="list-style-type: none"> - Condition of BGTW - Number and quality of beaches (number and size of blue flag beaches) - Recreational offer - Tourism infrastructure 	<ul style="list-style-type: none"> - Amount or catch rate of target species (recreational fishing) - Sea space available for recreation - Number of participants in recreational activities per year - Number of cetacean tours per year - Number of cruises / cruise passengers received per year 	Biodiversity (D1) Marine food webs (D4) Contaminants (D8, D9) Marine litter (D10) Eutrophication (D5) Hydrographic conditions (D7) Underwater noise (D11)

Ecosystem Service	Proposed indicators		Related GES Descriptors
	Capacity	Service	
17. Aesthetic Information	<ul style="list-style-type: none"> - Number of beach days/extent of bathing season - Extent and variability of coastal / marine seascapes (number per ha) 	<ul style="list-style-type: none"> - % of total natural seascape - Seascape beauty estimation (questionnaires, seascape metrics) 	Contaminants (D8, D9) Marine litter (D10) Eutrophication (D5) Hydrographic conditions (D7) Underwater noise (D11)
18. Inspiration for Culture, Art and Design	N/A	<ul style="list-style-type: none"> - Number of cultural events (public / private) with some form of relationship with the marine environment 	Biodiversity (D1) Marine food webs (D4) Contaminants (D8, D9) Marine litter (D10) Eutrophication (D5) Hydrographic conditions (D7)
20. Information for Cognitive Development	<ul style="list-style-type: none"> - Condition of BGTW 	<ul style="list-style-type: none"> - Number of species, habitats and ecosystems that are being or can potentially be studied for educational purposes - Number of species, habitats and ecosystems that are being or can potentially be studied for scientific purposes - Number of scientific publications per year 	Biodiversity (D1) Marine food webs (D4) Contaminants (D8, D9) Marine litter (D10) Eutrophication (D5) Hydrographic conditions (D7) Underwater noise (D11)
21. Cultural Heritage and Identity	<ul style="list-style-type: none"> - Number / extension of heritage sites (designated or not) 	<ul style="list-style-type: none"> - Number of visitors to heritage sites - Number of households that consider an area or aspects of an area as cultural heritage (number per ha) 	Hydrographic conditions (D7)

Table 5 presents the correspondence between ES relevant to BGTW and categories identified by Culhane *et al.* (ETC-ICEM).

Table 5: Correspondence between ES categories proposed by Böhnke-Henrichs *et al.* 2013 and Culhane *et al.* ETC-ICEM (used in MSFD reporting schemas)

Ecosystem Services relevant to BGTW (Böhnke-Henrichs <i>et al.</i> 2013)	Equivalent Ecosystem Service Categories (Culhane <i>et al.</i> ETC-ICEM)	Code for use in MSFD reporting
Sea Water	Chemical condition of salt waters (<i>Theme - Maintenance of physical, chemical, biological conditions</i>)	EcosysServMainCondChem
Air Purification	Ventilation and transpiration (<i>Theme - Mediation of Flows</i>)	EcosysServFlowsOxygenProd
Climate Regulation	Global climate regulation by reduction of greenhouse gas concentrations (<i>Theme - Maintenance of physical, chemical, biological conditions</i>)	EcosysServMainCondClim
Regulation of Water Flows	No equivalent available	N/A

Ecosystem Services relevant to BGTW (Böhnke-Henrichs et al. 2013)	Equivalent Ecosystem Service Categories (Culhane et al. ETC-ICEM)	Code for use in MSFD reporting
Waste Treatment	Bio-remediation by micro-organisms, algae, plants, and animals Mediation by ecosystems (<i>Theme - Mediation of waste, toxics and other nuisances</i>)	EcosysServWasteTreatment
	Filtration/sequestration/storage/accumulation by micro-organisms, algae, plants, and animals Mediation of waste, toxics and other nuisances (<i>Theme - Mediation of waste, toxics and other nuisances</i>)	EcosysServWasteRemovalBy Organ
	Filtration/sequestration/storage/accumulation by ecosystems (<i>Theme - Mediation of waste, toxics and other nuisances</i>)	EcosysServWasteRemovalBy Ecosys
Biological Control	Pest control (<i>Theme - Maintenance of physical, chemical, biological conditions</i>)	EcosysServMainCondPest
	Disease control (<i>Theme - Maintenance of physical, chemical, biological conditions</i>)	EcosysServMainCondDis
Lifecycle Maintenance	Maintaining Nursery Populations and Habitats (<i>Theme - Maintenance of physical, chemical, biological conditions</i>)	EcosysServMainCondNurs
Gene Pool Protection	Gene pool protection (<i>Theme - Maintenance of physical, chemical, biological conditions</i>)	EcosysServMainCondGene
Recreation and Leisure	Entertainment (<i>Theme - Underpinning and/or enhancing physical and intellectual interactions</i>)	EcosysServInteracPhyEntert
Aesthetic Information	Aesthetic (<i>Theme - Underpinning and/or enhancing physical and intellectual interactions</i>)	EcosysServInteracPhyAesthe
Inspiration for Culture, Art and Design	Symbolic (<i>Theme - Underpinning and/or enhancing spiritual, symbolic and other interactions</i>)	EcosysServInteracSpiSymb
Information for Cognitive Development	Scientific (<i>Theme - Underpinning and/or enhancing physical and intellectual interactions</i>)	EcosysServInteracPhyScientif
	Educational (<i>Theme - Underpinning and/or enhancing physical and intellectual interactions</i>)	EcosysServInteracPhyEducat
Cultural Heritage and Identity	Heritage, cultural (<i>Theme - Underpinning and/or enhancing physical and intellectual interactions</i>)	EcosysServInteracPhyCultur