ATLAS Deliverable 5.1
Inventory of Ecosystem Services

Project acronym:	ATLAS
Grant Agreement:	678760
Deliverable number:	Deliverable 5.1
Work Package:	WP5
Date of completion:	January 31st 2018
Author:	Naomi S. Foley, Claire W. Armstrong, Stephen Hynes, Katherine Needham and Adriana Ressurreição
Contributors	The ATLAS community

Objective

The objective of this report is to provide an inventory of ecosystem services found in the network of 12 ATLAS case study areas spanning the Atlantic, along with blue growth potential in these areas. To achieve this, the report includes a discussion on ecosystem service frameworks, a catalogue of ecosystems goods and services for the case study areas using both the MA and CICES frameworks and blue growth potential. Two frameworks are used to catalogue the ecosystem services – the Millennium Ecosystem Assessment (MA) to include supporting services provided by the deep sea, and the CICES framework in order to set the scene for future valuation of ecosystem services in the case study areas. The catalogue is informed through a review of the literature, a survey of experts and outputs from other WPs. The outcome of this report will be the foundation for the monetary evaluation framework to be delivered later in the project.

1. Introduction

The ATLAS project aims to advance our understanding of the North Atlantic's deep-sea ecosystems, including their connectivity, functioning and responses to future predicted changes in human use and ocean climate. Healthy oceans and seas are central to our well-being and the economic security of Europe and other nations that border the Atlantic. The deep North Atlantic harbours ecosystems that support a biologically rich variety of life and which are crucial to the cycling of primary production, carbon and nutrients from the ocean surface to the deep seafloor (Oevelen, Duineveld et al. 2009; Vanreusel, Fonseca et al. 2010; Beazley, Kenchington et al. 2013; Henry, Vad et al. 2014). Such systems include features such as cold-water corals, sponges, seamounts and hydrothermal vents. In addition, these ecosystems underpin and provide many ecosystem goods and services which contribute to maritime economic activities and also underpin wellbeing of Atlantic nations and their citizens (Galparsoro, Borja et al. 2014). Furthermore, the European Commission Blue Growth Strategy seeks to support sustainable growth in the marine and maritime sectors as a whole with a focus on 5 key sectors: aquaculture, coastal tourism, marine biotechnology, ocean energy and seabed mining (https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en). This poses a challenge to the business and policy communities seeking to balance societal needs with environmental sustainability. In the following, we investigate this challenge by identifying ecosystem services provided by the North Atlantic's deep-sea environments, and potential trade-offs amongst these. We focus especially on the case study areas of the ATLAS project.

'Ecosystem services' are the ecological characteristics, functions and processes that directly or indirectly contribute to human wellbeing: the benefits that people derive from functioning ecosystems (Costanza, d'Arge et al. 1997; MA 2005; Costanza, de Groot et al. 2017). Knowledge of marine ecosystem services and their socioeconomic values are limited (Armstrong, Foley et al. 2012), being best researched and developed for coastal ecosystems in the tropics (De Groot, Blignaut et al. 2013). However, there is increasing interest in identifying and estimating marine ecosystem services and values, though largely focusing on coastal areas (de Groot, Brander et al. 2012; Liquete, Piroddi et al. 2013; Beaumont, Jones et al. 2014). Although less studied than terrestrial, fresh water and coastal environments, there is increasing recognition of the importance of the services provided by the deep sea (Tinch, Armstrong et al. 2011). van den Hove and Moreau (2007) discuss the socio economics of the deep sea including ecosystem services, as well as the impacts and pressures the deep sea environment faces from human activities. Armstrong et al (2010; 2012) build on the work of van den Hove and Moreau (2007) presenting a categorisation and synthesis of deep sea ecosystem goods and services, review the current state of knowledge of these services and possible methods for their valuation. Thurber et al (2014) provide further discussion on deep sea ecosystem services and functions, identifying traits that differentiate the deep sea habitats from other global biomes. Foley et al (2010) identify the ecological goods and services associated with cold water coral ecosystems. Armstrong et al (2014) underline the importance of supporting services that may determine the flow of the more direct provisioning, regulating and cultural services with regards CWC. It still remains that deep sea habitats receive less attention than environments closer to home due to their remoteness and difficulty to access. Despite this, services from the deep are in increasing demand, and pressure to utilize more fully deep sea products such as seafood, energy resources and minerals are on the rise (Thurber, Sweetman et al. 2014).

The identification of services, their values and conflict areas are important for policy making, in particular, marine spatial planning and blue growth (Armstrong et al, 2014). Recognising that human pressures directly impact on ecosystem services and that ecosystem services directly benefit human well-being has led to the integration of ecosystem services in policy and management (Galparsoro, Borja et al. 2014). In Europe, action 5 of the EU Biodiversity Strategy 2020 calls for mapping and assessment of ecosystems and their services. Similarly, the EU Blue Growth Strategy requires maritime spatial planning to ensure efficient and sustainable management of activities at sea. Blue growth is about fostering development in marine economic activities in such a manner that the long term ability of the marine environment to continue to provide ecosystem services is not compromised. Knowing what those services are and how they will be impacted by changes in the economic activity taking place is vital for decision-making regarding the best use of those resources and to ensure blue growth

(Norton et al, 2018). More specifically to ATLAS, the Atlantic Action Plan aims to drive forward the blue economy while preserving the environmental and ecological stability of the Atlantic Ocean. Balancing the needs of society with a long-term strategy that maintains ocean ecosystems for generations to come is a serious challenge. One element of a long term strategy is the identification of ecosystem goods and services. Information on services associated with the deep sea aids decision makers to focus their attentions on the best initiatives to protect deep sea ecosystems while also safeguarding commercial interests, livelihoods and societal values.

The objective of this report is to provide an inventory of ecosystem services found in the network of 12 ATLAS case study areas spanning the Atlantic along with blue growth potential in these areas. To achieve this, the report includes a discussion on ecosystem service frameworks, a catalogue of ecosystems goods and services for the case study areas using both the MA and CICES frameworks and blue growth potential. The catalogue is informed through a review of the literature, a survey of experts and outputs from other WPs. The outcome of this report will be the foundation for the monetary evaluation framework to be delivered later in the project (D5.3).

2. Ecosystem Service Frameworks

In recent years there has been a strong emphasis on the theoretical and practical development of approaches to identifying, measuring and in some cases valuing the goods and services provided by ecosystems (Costanza, d'Arge et al. 1997; Daily 1997; Boyd and Banzhaf 2007; Fisher and Turner 2008; Haines-Young, Potschin et al. 2009; Luck, Harrington et al. 2009; Mace, Bateman et al. 2009). The concept of ecosystem services captures the dependence of human well-being on natural capital and the flow of services it provides (Daily 1997; MA 2005; Armstrong, Foley et al. 2010). Ecosystem services can be defined as '*the benefits that people obtain from ecosystems*' (MA 2005) or '*the direct and indirect contributions of ecosystems to human well-being*' (TEEB 2010).

The framework for the identification, measurement and valuation of ecosystem services in the deep Atlantic is presented in Figure 1. It assumes that changes in marine policy affect the functioning of the marine environment to deliver both functions and services. The changes in ecosystem services produce benefits and costs to society that can be valued using economic valuation methods. The results of the economic analysis can be used to inform marine management and policy. The purpose of this report is to identify the ecosystem services provided. Later WP5 deliverables will value ecosystem services, feeding into policy and management.

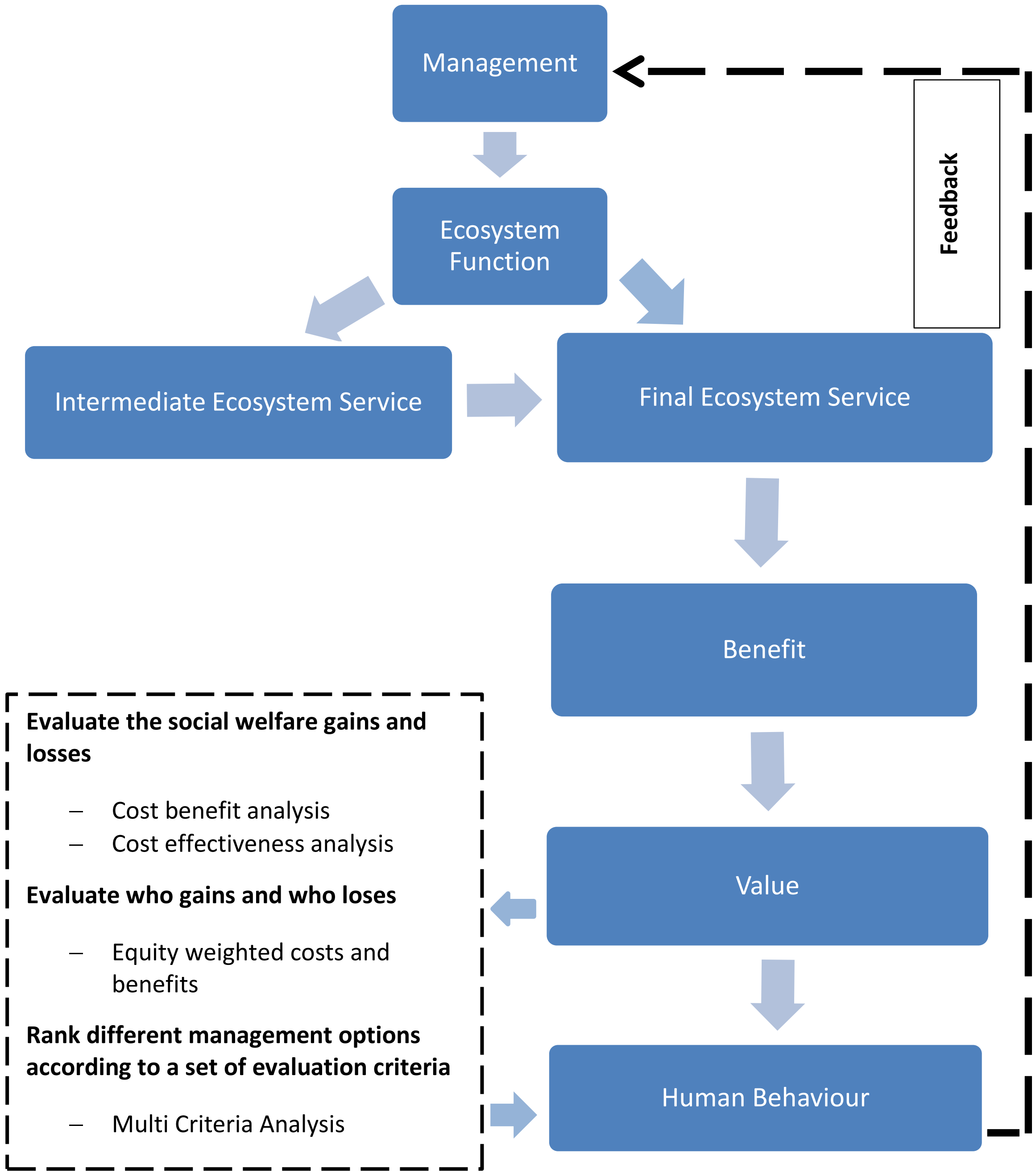

Figure 1: Ecosystem service conceptual framework. Adapted from Hanley et al (2015)

Frameworks for the identification and classification of ecosystem services have evolved over the years in particular since the publication of the Millennium Ecosystem Assessment (MA) (MA 2005; Tinch, Armstrong et al. 2011). Among these are The Economics of Ecosystems and Biodiversity (TEEB), the UN Common International Classification of Ecosystem Services (CICES) and the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) (TEEB 2010; CICES 2013; IPBES 2017). Such frameworks have been developed to help differentiate, give structure to and provide the basis to evaluate ecosystem services (Thurber, Sweetman et al. 2014). The following categorisation of ecosystem services was proposed by the Millennium Ecosystem Assessment (2005) and form the basis of most other classification systems (Costanza, de Groot et al. 2017).

Provisioning Services are the products used by humans that are obtained directly from the ecosystem for example commercial fish

Regulating Services are the benefits obtained through the natural regulation of ecosystem processes such as gas and climate regulation, and carbon sequestration

Cultural Services are the often non-material benefits people obtain from ecosystems through recreation, aesthetic environment, ‘inspiration’ and ‘awe’

Supporting Services are those functions and processes that are necessary for the production of all other ecosystem services, i.e. they feed into provisioning, regulating and cultural services thus feeding *indirectly* to human wellbeing.

There is no single best way to classify ecosystem services, and the frameworks have evolved over the years, depending on the ecosystem and policy context (Tinch, Armstrong et al. 2011). The main evolution in the ES frameworks from the MA is that they focus on the direct services; provisioning, regulating and cultural largely excluding the indirect supporting services. The motivation for excluding supporting services is to avoid the issue of double counting ecosystem services in valuation. A supporting service is defined with respect to the final services it supports; therefore including values for both supporting services and final services implies counting the same value twice (Haines-Young, Potschin et al. 2009). TEEB was the first framework to underline the issue of double counting when including supporting services, yet this framework does include habitats. CICES followed, also excluding supporting services, but developed the service types in more detail, and at several levels. The IPBES framework has added gifts from nature alongside services, more in line with indigenous people and others who find the services concept to be too utilitarian and market focused. Avoiding the issue of double counting is clearly important for a comprehensive accounting framework. This report focuses on the identification of ES, and valuation will not be undertaken at this stage. This allows us to include supporting services, and further discussion on supporting services and the deep sea is provided below.

2.1 Functions, Processes and Services

Ecosystem goods and services represent the benefits human populations derive directly or indirectly from ecosystem functions (Costanza, d'Arge et al. 1997). The distinction between ecosystem function and processes and ecosystem service is often made. Function and processes refer to a natural process that may generate services that contribute to human well-being, but exists and can be measured independently of humans. They are biophysical relationships that exist regardless of human benefit (Costanza, de Groot et al. 2017). Services are the results of ecosystem functions that give benefits to human well-being, and only exist as services by reference to human users of the service. Services can benefit people directly (direct value) or indirectly (indirectly or supporting service) (Armstrong, Foley et al. 2010; Costanza, de Groot et al. 2017).

2.2 Supporting Services and the Deep Sea

Supporting services differ from provisioning, regulating and cultural services in that their impacts on people are usually indirect, both physically and temporally (Armstrong, Foley et al. 2014). The distinction that supporting services contribute indirectly and are thus inherent in all other services is crucial if supporting services are valued, as this leads to double counting of values (Hattam, Atkins et al. 2015; Costanza, de Groot et al. 2017). In the process of service identification (i.e. prior to, or exempting any kind of valuation), however, the inclusion of supporting services may be important in order to clarify important links or trade-offs between the direct services and indirect supporting services.

Armstrong et al (2010) highlight the importance of supporting services in the context of the deep sea given their essential role in other parts of the ocean and to terrestrial environments, and ultimately to all life on our planet (Tinch, Armstrong et al. 2011). In contrast to many terrestrial and coastal ecosystems, the deep sea provides services that have an indirect benefit to human beings, separated in time and space from the final services they feed into (van den Hove and Moreau 2007). For instance, a large proportion of coastal biodiversity and biomass is linked to, and supported by, the deep sea (*op. cit).* To present the role of the deep sea for human wellbeing in a transparent way, ecosystem functions or supporting services need to be described (Armstrong, Foley et al. 2010). Many of the final services supported by deep sea functions create values distant in space and time from the deep sea. It is essential to consider the supporting services of the deep sea that maintain the ability of the other systems to provide final services (Tinch, Armstrong et al. 2011). The MA, though the older of the frameworks, is useful to describe services in the deep sea as it includes supporting services.

2.3 Biotic and Abiotic Services

The inclusion of abiotic components of ecosystems into ecosystem services classifications has been disputed (Hattam, Atkins et al. 2015). Ecosystem services frameworks generally focus on biotic resources and exclude abiotic goods such as minerals or aggregates extraction (Armstrong, Foley et al. 2012). The deep sea is an area where the exclusion of abiotic processes and functions would be a disservice to our understanding of deep sea ecosystem services (Thurber, Sweetman et al. 2014). Many of the abiotic resources connected with the deep sea such as space to host pipelines and cables, oil and gas exploration and mineral extraction all are linked with the so called 'blue growth' agenda. There is, therefore, interest from management and policy to take the values of these abiotic resources into account (Armstrong, Foley et al. 2010). Armstrong et al (2010; 2012) adapt the MA framework to include some goods and services that would not conventionally be considered ecosystem services, including oil, gas and minerals and also the less obvious dense water cascading. CICES developed an additional and complementary classification for abiotic outputs from ecosystems (Haines-Young and Potschin 2013).

2.4 Ecosystem Frameworks and ATLAS

This report will present ecosystem services using two frameworks. The objective of this report is to present the ecosystem services of the deep sea, not value them, and hence inclusion of supporting services is important. To describe supporting services in the deep sea the inventory of ES here applies the Armstrong et al (2010) adaptation of the MA framework. This presents the role of the deep sea in a transparent way, showing all the services provided by the deep sea including some abiotic resources. Later research in ATLAS WP5 will involve the valuation of ES. To avoid the issue of double counting services, also the CICES framework is presented, setting the scene for valuation.

3. Inventory of Ecosystem Services

The deep sea is lacking in ecosystem service assessments compared to other marine environments (Galparsoro, Borja et al. 2014). Despite this, there is a growing literature identifying ES for deep sea and benthic environments (van den Hove and Moreau 2007; Foley, Van Rensburg et al. 2010; Armstrong, Foley et al. 2012; Armstrong, Foley et al. 2014; Thurber, Sweetman et al. 2014). Building on the earlier work of van den Hove and Moreau (2007), Armstrong et al (2010; 2012) catalogue ecosystem goods and services of the deep sea. Following the adapted MA framework by Armstrong et al (2012), we classify the ecosystem services of the ATLAS case study areas. Figure 2 presents the ES of the deep identified by Armstrong et al (2012) using the MA framework.

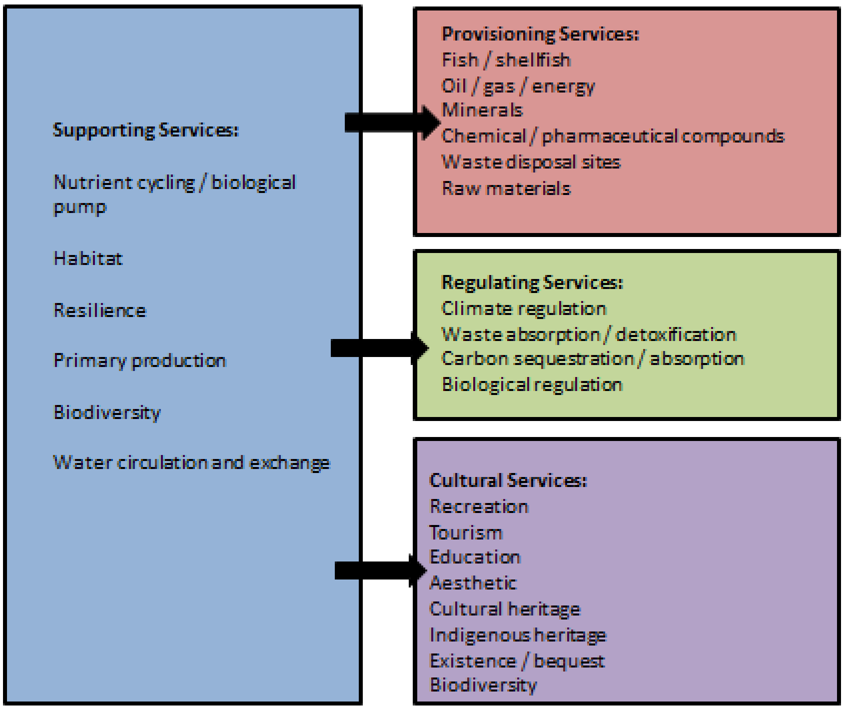

Figure 2: Deep Sea Ecosystem Goods and Services. Adapted from Armstrong et al (2012)

A survey of ecosystem services was carried out among ATLAS members during spring 2017 as part of the Delphi ecosystem service risk assessment (for further detail see D5.2). To identify the ecosystem services per case study area experts were asked to identify ecosystem services in case study areas they were familiar with. In addition, a review of literature for each area was carried out.

In the ATLAS case study areas, benthic habitats include cold water corals (CWC) reefs, coral gardens, sponges, hydrothermal vents, carbonate mounds and cold seeps. These provide a variety of ecosystem services including hotspots for biodiversity, refuge for fish, sources of chemical compounds and minerals, habitats and nurseries. CWC have received most attention with regard socio-economics with several studies identifying their ecosystem services (Foley, Van Rensburg et al. 2010; Wattage, Glenn et al. 2011; Armstrong, Foley et al. 2014; Aanesen, Armstrong et al. 2015). CWC have been found to act as nursery and spawning grounds for commercially important species (Husebø, Nøttestad et al. 2002), hence providing supporting services, in addition to cultural services (LaRiviere, Czajkowski et al. 2014; Aanesen, Armstrong et al. 2015). In Mingulay Reef deep water shark eggs were found nested in corals (Henry, Navas et al. 2013). Hydrothermal vents host a unique fauna of microbes, invertebrates and fish (van den Hove and Moreau 2007). Deep sea bioprospecting has focused on microbial communities associated with hydrothermal vents; these communities are highly diverse and thrive in extreme conditions (Armstrong, Foley et al. 2010). Seamounts often harbour numerous fragile, vulnerable and long lived epifauna that create areas of high biodiversity and rich fishing grounds (Thurber, Sweetman et al. 2014). Sponges are also areas of high biodiversity, provide refuge for fish and are sources of unique chemical compounds (Hogg, Tendal et al. 2010).

The inventory of ecosystem services focuses on the specific case study areas and the services within these areas.

Table 1 presents the inventory of ecosystem services for each case study area. Despite the many unknowns regarding the deep sea, a large number of services – supporting, regulating, provisioning and cultural – were identified for the areas.

ECOSYSTEM SERVICES		LoVe	Mingulay	Azores	Flemish Cap	West of Shetland and W of Scotland Slope	Rockall Bank	Porcupine Seabight	Bay of Biscay	Gulf of Cadiz/Strait of Gibraltar/Alboran Sea	Reykjanes Ridge	S Davis Strait/Western Greenland/Labrador Sea	SE USA (Bermuda Transect)
SUPPORTING	Nutrient cycling/biological pump	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Habitat	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Resilience	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Primary production	✔		✔	✔		✔	✔	✔	✔	✔	✔	✔
	Biodiversity	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Water circulation/exchange	✔	✔	✔	✔		✔	✔	✔	✔	✔	✔	✔
PROVISIONING	Fish/shellfish	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Oil/gas/energy	✔	✔	✔	✔	✔	✔	✔		✔		✔	✔
	Minerals			✔	✔	✔		✔		✔	✔		✔
	Chemical/Pharmaceuticals		✔	✔	✔	✔	✔	✔		✔	✔		✔
	Waste disposal sites	✔		✔	✔ (fishing and shipping)	✔			✔	✔			✔
	Raw materials	✔	✔					✔		✔			✔

REGULATING	Climate regulation	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
	Waste absorption/detoxification	✔	✔	✔	✔	✔		✔	✔	✔			✔
	Carbon sequestration/absorption	✔	✔	✔	✔	✔	✔	✔	✔	✔		✔	✔
	Biological regulation		✔	✔	✔		✔	✔	✔	✔	✔	✔	✔
CULTURAL	Recreation	✔	✔	✔					✔	✔			✔
	Tourism	✔	✔	✔		✔				✔			✔
	Educational	✔	✔	✔	✔	✔	✔		✔	✔	✔		✔
	Aesthetic	✔	✔	✔	✔		✔			✔	✔	✔	✔
	Cultural heritage	✔	✔		✔	✔	✔	✔		✔		✔	✔
	Indigenous heritage		✔			✔				✔		✔	✔
	Existence/bequest	✔	✔	✔	✔	✔	✔		✔	✔	✔	✔	✔
	Biodiversity	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔

Table 1: ATLAS expert assessment of ecosystem services in case study areas

3.1 Blue Growth

The importance of marine resources for economic development has come to the fore in recent years with reference often made to the *blue economy* (Foley, Corless et al. 2014). The blue economy refers to the overall economic contribution of the oceans and coasts to the national economy. Sectors within the blue economy include transport (cargo and ferry), fisheries, offshore oil and gas, coastal and maritime tourism, aquaculture, renewable energy, mineral resources and biotechnology along with shipbuilding and ship repair. There are a number of European policies which have been adopted to drive forward the blue growth agenda and these are outlined below.

In 2012, the European Commission formulated its Blue Growth strategy to harness the potential of Europe's oceans, seas and coasts for growth and jobs (COM 2012). The aim was to drive forward the EU's Integrated Maritime Policy (IMP) by promoting the EU's blue economy (Mulazzani and Malorgio 2017). The strategy aims to *contribute to the EU's competitiveness, resource efficiency, job creation and new sources of growth whilst safeguarding biodiversity and protecting the marine environment, thus preserving the services that healthy and resilient marine and coastal ecosystems provide* (COM 2012). In addition to the traditional sectors of the blue economy (fisheries, oil and gas, shipbuilding and ship repair, and ferry and cargo transport), the strategy identified five areas for the development of blue growth: blue energy, aquaculture, coastal and marine tourism, blue biotechnology and seabed mineral resources. Implementation of the Blue Growth Strategy is linked with other initiatives including the Marine Strategy Framework Directive and sea basin strategies such as a Maritime Strategy for the Atlantic Ocean Area (Johnson, Ferreira et al. 2017).

The Atlantic Action Plan contributes to the Blue Growth strategy aiming to support the marine and marine economy in the Atlantic Ocean area (COM 2013). Its objectives, among others, are to drive forward the blue economy while preserving the environmental and ecological stability of the Atlantic Ocean. The plan encourages member states to cooperate in both traditional activities such as fisheries as well as emerging industries such as biotech and offshore renewables, while also preserving the environmental and ecological stability of the Atlantic.

The Marine Strategy Framework Directive (MSFD) is considered the environmental pillar of the IMP representing an ecosystem based approach to marine management (Mulazzani and Malorgio 2017). The directive aims to protect the resource base upon which marine related economic and social activities depend. Included in the objectives is an analysis of the goods and services provided by the marine environment as well as the costs of degradation from anthropogenic activities (Mulazzani and Malorgio 2017).

Blue growth refers not only to the five areas identified for development (biotechnology, marine mineral resources, renewable energy, aquaculture and marine and coastal tourism) by the Blue Growth Strategy but also traditional marine sectors such as fisheries and offshore oil and gas. For ATLAS (this report) the focus is on:

- **Fisheries and Aquaculture:** Sustainably managed deep-sea ecosystems can provide economically valuable fisheries resources. Sustainable management of the resources will ensure that the economic benefits provided by fisheries will be maintained in the future. This is relevant for all ATLAS case study areas to a greater or lesser degree. Aquaculture is one of the world's fastest growing food sectors, but not relevant for most ATLAS case study areas, as they are mainly offshore. In some of the ATLAS case study areas closer to shore, such as Mingulay off the UK coast and LoVe on the Norwegian coast, there is a push for offshore aquaculture. This may be especially relevant for the LoVe case study, as Norwegian aquaculture policy encourages development of amongst other things offshore aquaculture via the allocation of salmon development permits based on company plans for R&D in this direction.
- **Oil and gas:** Offshore production contributes to the EU's Blue Economy. More than 5% of the world's liquid hydrocarbon resources are believed to lie in deep-water reservoirs, and future oil/gas production is relevant for many of the ATLAS case study areas (see D6.2).
- **Marine mineral mining:** The quantity of minerals occupying the seafloor is potentially large. Seabed mining is concerned with the retrieval of these minerals. In particular, the areas around hydrothermal vents have proved interesting for marine mineral extraction. Relative to the majority of the deep sea, the areas around hydrothermal vents are biologically more productive, often hosting complex communities making the requirement for understanding the complexity of their ecosystems highly relevant in terms of conflict with extraction opportunities. Since the establishment of the International Seabed Authority (ISA) under the United Nations Convention on the Law of the Sea, the ISA has the authority to issue mineral exploration licenses on the seafloor that lies beyond national jurisdiction. The ISA has established a framework for licensing exclusive Seafloor Massive Sulphides (SMS) exploration along sections of mid-ocean ridges with France and Russia holding licenses to explore the Mid-Atlantic Ridge (http://www.unclosuk.org/international-seabed-authority-isa). Especially the Azores case study area with is relevant in relation to mining.
- **Marine Biotechnology:** Blue biotechnology is concerned with the exploration and exploitation of diverse marine organisms that have adapted to survive in extreme conditions to create new pharmaceuticals or industrial enzymes. This is potentially relevant in all deep sea areas,

though some are more relevant than others. Especially organisms operating in extreme conditions, such as near hydrothermal vents and the like, are of interest for blue biotechnology.

- **Tourism:** Some of the ATLAS case study areas (E.g. Mingulay Reef Complex and LoVe Observatory and the Azores) encompass areas with developing marine tourism interests such as recreational sea angling and big game fishing. Case study areas also indirectly support marine tourism through supporting services such as nursery grounds for certain whale and shark species.
- **Renewable Energy:** Our seas and oceans offer a vast renewable energy resource, particularly, but not only, along the Atlantic seaboard. Ocean energy technologies are currently being developed to exploit the potential of tides and waves as well as differences in temperature and salinity (https://ec.europa.eu/maritimeaffairs/policy/blue_growth_en). Currently, this is most relevant for the more nearshore case study areas, such as Mingulay and LoVe.

Table 2 presents current and potential growth activities in the ATLAS case study areas. This is an adaptation of the matrix developed by WP6. Fisheries is the common activity currently taking place among case studies and most also identify the development of new fisheries resources as a potential for blue growth. Although not common to the ATLAS studies, aquaculture is identified as an area for growth for case studies closer to shore including LoVe, Mingulay and also potentially the Azores.

	LoVe	North and West of Shetland	Rockall	Mingulay Reef Complex	Porcupine Seabight	Bay of Biscay	Gulf of Cadiz	Azores	Davis Strait	Flemish Cap	US Atlantic Bight
Current Activities	*Fisheries *Tourism *Offshore Wind *Scientific Observatory	*Cables *Fisheries *Oil and gas *Tourism	*Fisheries	*Fisheries *Cables *Tourism	*Oil and gas exploitation	*Military *Fisheries *Biotechnology *Shipping	*Fisheries *Recreational fisheries *Shipping *Cables *Aquaculture *Tourism	*Fisheries *Shipping *Cables *Tourism *Scientific research	*Fisheries *Oil and gas *Tourism *Indigenous fisheries	*Fisheries *Oil and gas *Shipping *Cables	*Fisheries *Recreational fisheries *Cables *Tourism *Shipping *Research
Blue Growth Potential											
Minerals	✓						✓	✓			✓
Renewable Energy	✓		(✓)	(✓)			✓	✓			
Aquaculture	✓			✓			✓	✓			
Tourism	✓			✓	(✓)		✓	✓	✓		✓
Biotechnology	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Oil and Gas	✓	✓	✓		✓	(✓)	✓		✓	✓	✓
Shipping	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓
Cables		✓		✓	✓	✓	✓			✓	✓
New Fisheries Resources		✓	✓	✓	✓	✓		✓	✓	✓	✓
Scientific Reference Sites / Observatories		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 2: Matrix identifying current and potential growth in case study areas. Note, those in parentheses ( ) have been identified as potential but uncertain growth opportunities. Adapted from D6.1

In the following, we briefly present each case study area and their ecosystem services, both existing and potential. All case study areas are relatively well studied, and show potential for growth in educational and research resources, as well as scientific observation, and many identify oil and gas as an area for growth. In our presentation of each case study area, we do not mention regulating services which are relevant to all, such as natural carbon storage and nutrient cycling. For more detail regarding each case study area, see D6.1.

3.2 Synthesis of Case Study Areas

Case Study	Mingulay Reef Complex
Location	The Mingulay Reef Complex is situated off the west coast of Scotland, 14km east of the island of Mingulay in the Sea of the Hebrides. It is the only known inshore cold water coral reef in UK waters.
Ecosystems	**Cold water coral reefs** Distinctive coral mounds up to 5m high are formed by the stony coral *Lophelia pertusa*, mounds which have been growing periodically over the last 7,000 years. Mingulay is unique in that it is currently the only known area with extensive cold-water coral reefs within UK territorial waters.
Ecosystem Services of Note	Since its discovery in 2003, Mingulay Reef has become one of the most studied CWC reefs in the world. Studies have identified ecosystem services including habitat, nursery, biodiversity, nutrient cycling and tidal downwelling. Of particular note, the reefs are also used by sharks for egg-laying and resting sites, with the deep-water shark *Galeus melastomus* coming in year after year to the same area to lay eggs on live corals (Henry, Navas et al. 2013). Henry et al (2013) found that blackmouth catshark abundance was significantly higher near reef areas in Mingulay. Rapid downwelling of surface waters is known to supply warmer phytoplankton rich waters to corals growing on the northern flank of an east west trending seabed ridge (Findlay et al, 2013).
Blue Growth	The reef complex is part of the East Mingulay Marine Protected Area, a Special Area of Conservation designated under the EC's Birds and Habitats Directive. Blue Growth opportunities in the area include potential growth for the creel fishing industry, as well as ecotourism including sea-angling, sailing, and whale watching, and offshore aquaculture, marine renewables and pharmaceutical compounds. The identified supporting service of nursery to the blackmouth catshark indirectly contributes to the developing marine tourism in the area.

Case Study	Lofoten-Vesterålen (LoVe Obervatory)
Location	The Lofoten Vesterålen case study is based at a cabled observatory in northern Norway. The islands of Lofoten and Vesterålen are part of an archipelago north of the Arctic Circle in Northern Norway. Due to the narrow continental shelf, the area is described as the gateway to the Barents Sea.
Ecosystems	**Cold water coral reefs, sponges** Particular focus is on cold-water corals including *Lophelia pertusa* which form a substantial framework reefs in this area, including the largest known cold water coral reef, the Røst reef. Other important benthic species include sponges and soft corals.
Ecosystem Services of Note	The marine ecosystem is highly valuable and productive; and an important habitat and spawning ground for a number of key species in northern ecosystems, such as the Northeast Atlantic cod stock and the Norwegian Spring-Spawning herring stock. A number of other smaller fisheries are also carried out in this area. Close to shore, marine tourism and recreation are important cultural ecosystem services, as Lofoten especially is one of the most well-known tourist areas in Norway. Sea angling and surfing, as well as other recreational activities, are common. Salmon aquaculture is also carried out in the area.
Blue Growth	Fisheries and, closer to shore, tourism are important sectors in the region. The area is not open for oil and gas activities; however, this is currently under discussion. There are also discussions of marine wind farms in the vicinity of this area. Offshore aquaculture is an area of potential growth in Norway, and currently in the development phase on many parts of the coast.

Case Study	Azores
Location	The Azores is a volcanic archipelago located in the northeast Atlantic, lying above a tectonically active triple junction between the North American, Eurasian and African plates.
Ecosystems	**Hydrothermal vents, seamounts, coral gardens, sponge grounds** The seafloor that surrounds the archipelago comprises a variety of open ocean deep-sea habitats, from island slopes and numerous seamounts to hydrothermal vents at various depths and abyssal plains exceeding 5,000m depth. Cold-water corals are prominent habitats in the region, with more than twenty different types of coral gardens and 165 species identified to date. Sponge aggregations are also important habitats, covering extensive areas particularly below 500 m.
Ecosystem Services of Note	The seafloor that surrounds the archipelago comprises a variety of open ocean deep-sea habitats that are important for commercial fish species in the Azores. The Azores is an important area for deep-sea fisheries exploitation including bottom longlining, pelagic longlining and tuna fishing. The Azorean waters support a wide range of marine ecotourism activities including big game and recreational fishing, sailing, SCUBA diving and whale watching. While unquestionably the importance of whale watching, both economically and sociologically, as well as being a marketing banner for marine based ecotourism in the Azores, other marine based tourism activities have recently gained momentum attracting significant visitors to the Azores such as shark diving. These activities take place mostly in coastal and offshore seamounts. Hydrothermal vents in the Azores provide a source of deep-sea minerals. In the deep sea, in the absence of sunlight, some organisms can utilise chemical energy in the form of hydrogen, methane, hydrogen sulphide, ammonium and iron to fix CO_2 (Armstrong, Foley et al. 2010). Chemosynthetic primary producers form the basis of the food web associated with hydrothermal vents.
Blue Growth	The Azores is seen as an area of increased Blue Growth opportunities in the shape of bio-prospecting, deep-sea mining and marine tourism.

	South of the Azores there are four known fields of hydrothermal active vents within the actual Portuguese EEZ on the Mid-Atlantic Ridge. Analyses show that the Mid-Atlantic ridge system near the Azores hosts seafloor massive sulfides (SMS) deposits. Furthermore, there are manganese nodules and cobalt-rich crusts to be found within the Portuguese EEZ and extended continental shelf, which may be an additional source for deep-sea minerals.

Case Study	Flemish Cap
Location	The Flemish Cap is an Oceanic Bank located in an Area Beyond National Jurisdiction within the Northwest Atlantic Fisheries Organisation Regulatory Area (NAFO) and separated from the Grand Banks by the Flemish Pass. It is situated in a transition area between the cold-waters of the Labrador Current and warmer waters influenced by the Gulf Stream.
Ecosystems	**Coral gardens, sponge grounds** The Flemish Cap is mainly covered with soft sediments and there are stones scattered in the entire area. The main focal benthic ecosystems are sponge grounds, cold-water corals and sea pens. The Flemish Cap is the only known area in international waters where sponge grounds and sea pen concentrations have been found.
Ecosystem Services of Note	The Flemish Cap includes important international fishing grounds for both trawling and longlining. Species targeted include Greenland halibut, redfish and cod. High coral/sponge density offer shelter, feeding and breeding areas for invertebrates and fish. The structural habitat created by corals and sponges enhances biodiversity in the area. Many fish species are abundant within the area attracting top predators including whales and pinnipeds. The area is an important ground for the northern bottlenose whale, listed as endangered by Canada's Species at Risk Act, as well as the northern and spotted wolfish.
Blue Growth	The main activities in the region are shipping, undersea cable routes, fisheries, scientific research and hydrocarbon exploration. There is potential for increased hydrocarbon exploration and exploitation, as well as bioprospecting – search and research on natural compounds. This may present conflict for existing activities in the area. There is also potential for the development of new fisheries resources.

Case Study	Faro Shetland Channel (UK)
Location	The Faroe Shetland Sponge Belt lies in the offshore waters to the west of the Shetland Islands. The site is located on the Scottish side of the Faroe Shetland Channel, a large rift basin that separates the Scottish and Faroese Continental Shelf.
Ecosystems	Sponge grounds, coral gardens Large protists, sponges, corals, and surface-dwelling acorn worms are just some of the fauna forming distinctive habitats that are known to support diverse communities of associated species in the region. Stalked sponges occupy deep-water sandy sediments, brittlestar beds are found on gravel, sponges and soft corals colonise mixed gravel-cobble-boulder bottoms, and well-developed communities inhabit coarse sediments built up into the furrows and ridges created by grounded icebergs. A diverse range of benthic ecosystems occurs in the channel, including cold-water coral reefs, deep-sea sponge aggregations and offshore deep-sea muds. The patchy but dense occurrence of sponges in the Faroe-Shetland Channel is striking. This distinct sponge "belt" occurs between depths of 400–600 m that seems to extend from the junction with the Faroe Bank Channel to the very northeastern reaches of the West Shetland Channel.
Ecosystem Services of Note	Supporting services including biodiversity, nutrient cycling and habitat, provisioning services are deep sea fisheries.
Blue Growth	The main blue economy sectors operating in the area include oil and gas exploitation, fisheries and telecommunications. Blue growth opportunities, in particular, relate to the potential to discover and extract oil and gas. There is potential for biotechnology/bioactive compounds from sponges.

Case Study	Rockall Bank, Northern NE Atlantic
Location	The Rockall Bank is a shallow bank situated beyond the continental shelf, approximately 350km from Ireland. The Rockall Bank is a large isolated geomorphological feature in the NE Atlantic that lies partially within the Exclusive Economic Zone of the UK and Ireland and partially in the high seas. The bank lies at depths ranging from 220m to 65m, though a small pinnacle of land does break the sea surface toward the northern end of the bank.
Ecosystems	**CWC reefs, coral gardens, carbonate mounds, sponge grounds, cold seeps, seapen fields** Enhanced hydrographic mixing, upwelling and down-welling around the bank may give rise to highly localised and specialised biological communities such as sponge aggregations, *Lophelia* reefs and coral gardens. *Lophelia pertusa* occurs on Rockall Bank principally at depths between 200-400 m, but also in certain areas deeper than 500 m on the slopes of the bank. Gorgonians and black corals are found on the bank and down the slopes. Sea-pens are recorded from the bank and especially the sedimentary slope areas. Sponges have been recorded across the bank, most notably from the western slope. There is evidence of an active cold-seep ecosystem in the area on the western margin of Rockall Bank at a depth of 1200 m.
Ecosystem Services of Note	The Rockall Bank supports large and productive stocks of fish. Some of the fish stocks are thought to be endemic to the bank, e.g. haddock, while others, e.g. saithe, are thought to migrate to the bank from elsewhere. There are profitable bottom trawl fisheries targeting mainly squid, haddock and monkfish. To a lesser extent, there are deep-water trawl and long-line fisheries. Pelagic fisheries for blue whiting operate over the western slope of the bank. The bank is clearly productive which may reflect nutrient upwelling and complex bentho-pelagic coupling.
Blue Growth	The main blue economy sector currently in the area is fisheries. There is interest in oil and gas for the area but at present, there are no active exploration projects and no exploitation. Fisheries have the potential to grow in this area provided they can show no adverse impacts on

	VMEs and are done in a manner to ensure long term sustainable harvesting.

Case Study	Porcupine Seabight and Bank
Location	The Porcupine Seabight is situated off the west coast of Ireland. It is bordered by the Slyne Ridge in the north, the Porcupine Bank in the west and the Goban Spur in the south. The Porcupine Seabight opens to the southwest onto the Porcupine Abyssal Plain. Water depths in the Porcupine Seabight range from approximately 400 m in the north to 3,000 m at its mouth in the southwest. The Porcupine Bank separates the Porcupine Seabight from the Rockall Trough. The summit of the Porcupine Bank is shallow lying at 145 m water depth.
Ecosystems	**CWC reefs, coral gardens, carbonate mounds, sponge grounds** The Porcupine Seabight contains some of the best investigated deep-water carbonate mounds in the world. Carbonate mounds, which can reach heights of up to 350 m, are formed from the accumulation of cold-water corals that trap fine-grained sediment. These mounds can be found at depths of 500 to 1000 m. The western and northern slopes of the Porcupine Bank facing the Rockall Trough are characterised by irregularly spaced canyons and the south-western slope of the Porcupine Bank is especially steep and eroded. Notwithstanding historical research presence in the area, the importance of Porcupine Seabight cold-water corals only came to prominence at the beginning of this century. The Belgica Mound province was one of four areas designated by the Irish authorities as a candidate Special Area of Conservation (SAC) under the European Union's Habitats Directive in 2006 – the first offshore SACs in the EU.
Ecosystem Services of Note	A large number and variety of sea life and cetaceans migrate through the area which is regarded as a prominent habitat for them, including blue whales and fin whales. Provisioning service of fisheries is substantial in the area. It is also an area of significant scientific research, highlighting the important cultural values in the area. The habitats provide supporting services, and the decision to create an SAC indicates cultural services and values.

Blue Growth	The main blue economy sector in the Porcupine Seabight and on the Bank area is fisheries, managed in accordance with TAC and environmental considerations under the EU Common Fisheries policy. The area is the focus of national and international scientific research. Interest in oil and gas exploration has increased in recent years with new exploratory wells scheduled for drilling in 2019. Blue Growth opportunity in the area also includes the potential discovery of commercial quantities of gas.

Case Study	Bay of Biscay
Location	The Bay of Biscay is located west of France and North of Spain. The continental margin of the northern Bay of Biscay is divided into the Celtic and Armorican margins, which are both characterised by a relatively broad continental shelf and a steep, canyon-dominated, slope.
Ecosystems	**Cold water corals** Historical data on the occurrences of frame-building scleractinian cold-water corals, antipatharians, gorgonians and large sponges in the Bay of Biscay has mainly come from fisheries surveys. More recent studies confirmed the occurrence of cold-water coral habitats, at the boundary between the Eastern North Atlantic Central Water (ENACW) and the Mediterranean Outflow Water (MOW). The distribution of *Lophelia pertusa* and *Madrepora oculata* is skewed towards the northern half of the Bay.
Ecosystem Services of Note	Supporting services of habitats and fisheries are present. Also, the presence of a Natura 2000 SAC indicates cultural services.
Blue Growth	The main blue economy sector operating in the Bay of Biscay area is fisheries. The area is also used by the French submarine fleet and is an area that is the focus of scientific research. Fisheries currently operate in relation to environmental objectives for the protection of VMEs and the potential goods and services they provide. Fisheries have the potential to grow provided they can demonstrate they have no adverse impacts on VMEs in the area and are managed in compliance with the requirements of a planned network of Natura 2000 SACs to protect reefs.

Case Study	Gulf of Cadiz/Strait of Gibraltar/Alboran Sea
Location	The Gulf of Cádiz is the arm of the Atlantic Ocean between Cabo de Santa Maria, the southernmost point of mainland Portugal and Cape Trafalgar at the western end of the Strait of Gibraltar. It is enclosed by the southern Iberian and northern Moroccan margins, west of Gibraltar Strait. The Strait of Gibraltar is a narrow strait that connects the Atlantic Ocean and the Mediterranean Sea and separates the Iberian Peninsula (southern Europe) and northern Africa by 7.7 nautical miles (14.3 km) of ocean at the strait's narrowest point. The Alborán Sea is the westernmost portion of the Mediterranean Sea, lying between the Iberian Peninsula and the north of Africa.
Ecosystems	**CWC reefs, coral gardens, sponge grounds, mud volcanoes** Many deep-sea species, including cold-water corals and a wide variety of gorgonians and sponges, as well as several species of fish and other invertebrates are distributed in both the Atlantic and the Mediterranean basins. The Gulf of Cadiz area encompasses over sixty mud volcanoes.
Ecosystem Services of Note	The Gulf of Cadiz case study area represents an area of socioeconomic and scientific importance for oceanographic, geological and biological processes. For example, The Alborán Sea is habitat for the largest population of bottlenose dolphins in the western Mediterranean, is home to the last population of harbour porpoises in the western Mediterranean, and is one of the most important feeding grounds for loggerhead sea turtles in Europe. The Alborán Sea also hosts important commercial fisheries, including sardines and swordfish. The area is important for conservation with several protected areas declared indicating cultural services in the area.
Blue Growth	The area supports intensive anthropogenic activity, including tourism, fisheries, aquaculture, oil and gas exploitation, bioactive compound prospecting, wind energy and maritime traffic. Blue Growth sectors include Biotechnology, Fisheries, Oil and Gas and renewal energy (e.g. tidal energy). In addition, the area is the focus of much international marine research because of its strategic location as a gateway to the

	Mediterranean and a crossroad of cultures, biogeographic regions and basins (Atlantic Ocean and Mediterranean).

Case Study	Reykjanes Ridge
Location	Located to the south of Iceland, within and outside of the Icelandic EEZ. The Reykjanes Ridge constitutes the part of the mid-Atlantic ridge that is located between the Reykjanes peninsula and the Bright Fracture Zone (57°N). There is a gradual shallowing of water depth from south to north along the Ridge, towards the Icelandic continental shelf.
Ecosystems	**Hydrothermal vents, CWC reefs, coral gardens, sponge grounds** Mid-ocean ridges are among the largest continuous marine habitats known, with an area comparable or larger than the relatively well-studied continental shelf and slope habitats. Ridge community ecology and biodiversity are relatively poorly understood, with the exception of chemosynthetic ecosystems such as hydrothermal vents. Coral and sponge gardens are associated with V-shaped ridges along the Mid-Atlantic Ridge and can be found on both sides of the Reykjanes Ridge.
Ecosystem Services of Note	Ridge communities are of considerable scientific and commercial interest as they may express endemism (e.g. hydrothermal vent communities) and may also significantly influence the processes affecting the slope and shelf biota such as intercontinental migration and dispersion (Bergstad & Godo, 2002). Fishing activities on and around the Reykjanes Ridge take place outside the 200 nm EEZ of Iceland. This includes a small blue ling (*Molva dypterygia*) fishery on and around the seamount "Franshóll" at the southern limit of the EEZ. There are also pelagic fisheries targeting beaked redfish (*Sebastes mentella*), and some smaller fisheries for other pelagic species both within and outside the EEZ. Fisheries targeting various demersal fish species take place along the northern part of the Ridge and on its flanks.
Blue Growth	The main active blue economy sector for the Reykjanes Ridge area is fisheries. Other sectoral activities occurring on and around the Ridge include shipping and submarine cables. There are two blue growth sectors that could become operational on the Reykjanes Ridge region in the future; deep sea mineral resources and carbon dioxide sequestration into the bedrock. Manganese nodules have been found in the northern part of the Ridge but mining of these was shown to be

	not economically viable. There are no plans for further mining activities at the Reykjanes Ridge within the Icelandic EEZ. Secondly, carbon dioxide sequestration into bedrock on the Reykjanes Ridge is considered to be feasible as there are vast areas of basalt that have been shown to react with carbon dioxide to form calcium carbonate within the bedrock. The Reykjanes Ridge could therefore potentially store large amounts of carbon dioxide.

Case Study	Davis Strait, Eastern Arctic
Location	The Davis Strait joins two oceanic basins, Baffin Bay and the Labrador Sea, and separates western Greenland and Baffin Island. It connects to the Arctic Ocean in the north via the Baffin Bay and to the Atlantic Ocean in the south via the Labrador Sea.
Ecosystems	**CWC reefs, coral gardens, sponge grounds** On these slopes, coral and sponge have been found, including the only known *Lophelia pertusa* reef in Greenlandic waters. Large and small gorgonian corals, sea pens and sponges are significant benthic areas (SBA). The shelves extending from both Canada and Greenland typically range between 20 and 100 m in depth and are traversed by deep troughs. At its narrowest point, a ridge or sill up to approximately 600 m depth extends between Greenland (at Holsteinborg, Sisimiut) and Baffin Island (at Cape Dyer). The slopes along the Labrador Sea flank of this ridge and farther south along the Labrador and West Greenland shelves drop to 2500 m or more.
Ecosystem Services of Note	South of Davis Strait the waters off west Greenland support intense phytoplankton blooms in April. These blooms are characterised by high phytoplankton biomass and a community of grazers dominated by large copepods, i.e. *Calanus*. Within the study region, *Calanus* provide an important food source for higher trophic levels (*e.g.* fish, seabirds, whales). In addition, they play a key ecological role in supplying the benthic communities with high-quality food via the production of large and fast-sinking faecal pellets. The Baffin Bay and the Davis Strait have the only large-scale commercial fisheries in Canada's Arctic. Fisheries include shrimp and ground fisheries for Greenland halibut with fixed and bottom gears. Narwhals overwinter in the Davis Strait, along the slopes and near the ice edge. Beluga, humpback, baleen whales and humpbacks transit through the area. Other mammals in the area include hooded, ringed, bearded, harp and harbour seals. Areas protected against bottom-touching fishing gear indicate values related to cultural services.

Blue Growth	With retreating ice, longer fishing seasons open for growth in fisheries. In Greenland's waters, oil and gas has been suggested to be potential industry. Bioprospecting may clearly also be relevant in the future.

Case Study	Mid-Atlantic Canyons
Location	The western North Atlantic Ocean between Cape Hatteras and Cape Cod (USA, Middle Atlantic Bight, MAB). This ATLAS case study focuses on the area between Baltimore Canyon and Cape Hatteras but also draws on relevant data from recent studies on the Blake Plateau off the southeastern US. This area represents a unique transition from the rocky and carbonate bottom Blake Plateau that is oceanographically dominated by the Gulf Stream to the softer sediment, canyon dominated area north of Cape Hatteras, influenced by colder currents.
Ecosystems	The western North Atlantic Ocean between Cape Hatteras and Cape Cod (USA, Middle Atlantic Bight, MAB) is characterised by numerous and diverse submarine canyons that straddle the outer shelf and slope. Extensive recent studies in and around Baltimore and Norfolk canyons revealed that the physical environment in the canyons was different from that on the open slope, that it varied over relatively small spatial scales, and that the oceanography and geology have great influence on the character of the benthic community, especially sessile invertebrates (corals, sponges, infauna).
Ecosystem Services of Note	These canyons provide extensive rugged, hard substrata habitats that support diverse deep-sea coral communities, although most of the mobile fauna was influenced by habitat structure and not presence or absence of corals. Newly discovered methane seeps in this area also supported both chemosynthetic communities and a variety of other organisms drawn to habitat structure derived from the seeps. The rugged canyon and seep habitats provided refuge for a number of exploited species (e.g., American lobster, squids, tusk, sharks). Because of the high productivity, fragile habitats, presence of corals, and vulnerability to impact, the MAB canyons and surroundings were recently given protected area status by US agencies. Both commercial and recreational fisheries take place in the area.
Blue Growth	Research interests in these canyons and associated ecosystems have increased in the last 20 years, largely in response to potential energy exploration and development. Fisheries are largely maximally

	exploited, but there is expectation of oil and gas, mining and bioprospecting in the future.

4. CICES

From an economic perspective, the way to value services is to estimate the flow of values emanating from natural sources (Armstrong et al, 2014). However, the danger of double counting these values, first as supporting service values, and then as values inherent in provisioning, regulating or cultural values, was pointed to as a serious problem early on in the development of ecosystem service valuation, and has underlined the need to keep these values separate (Beaumont, Austen et al. 2008). While it remains important to take account of supporting services in particular for the deep sea, when it comes to valuation it is necessary to avoid double counting. Therefore, for the valuation of ecosystem services in WP5 we will use the CICES framework. The CICES framework also includes a more layered presentation of ecosystem services; in that, it divides the services into several types (see Division, Group and Class in Table 3). This allows for a more systematic presentation, and also opens for identification of services that might otherwise go un-noticed.

Ecosystem service values will be mapped in line with EU MAES recommendations as part of WP6. Mapping and Assessment of Ecosystems and their Services (MAES) is one of the keystones of the EU Biodiversity Strategy 2020 to improve knowledge of ecosystems and their services in the EU (Maes, Teller et al. 2013). Among other aims, MAES will contribute to the assessment of the economic value of ecosystem services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020 (Galparsoro, Borja et al. 2014). MAES has adopted the CICES framework for the classification of ecosytem services.

Table 3 presents case study ES using the CICES framework. This sets the scene for further ecosystem services work, translating the ecosystem services identified using the MA framework across to the CICES framework. In this instance supporting services are omitted with the exception of habitat and nurseries. As noted with the outcome of the MA matrix, it is significant to note the number of ecosystem services that have been identified for enviroments which are mainly in the deep sea. Abiotic resources are then presented in Table 4. For abiotic resources, the table remains incomplete particularly with regard cultural settings. Examples of these abiotic cultural settings in the deep sea could include shipwrecks. It is something to be explored further for the case study areas.

Section	Division	Group	Armstrong et al (2010, 2012); THURBER (2014)	LoVe	Mingulay	Azores	Flemish Cap	West of Shetland and W of Scotland Slope	Rockall Bank	Porcupine Seabight	Bay of Biscay	Gulf of Cadiz/Strait of Gibraltar/Alboran Sea	Reykjanes Ridge	S Davis Strait/Western Greenland/Labrador Sea	SE USA (Bermuda Transect)
Provisioning	Nutrition	Biomass	*Finfish, shellfish, marine mammals*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			Aquaculture (not in Armstrong et al)									✓			
	Materials	Biomass	*Raw materials*	✓	✓					✓	✓	✓			✓
			Chemical compounds for industrial or pharmaceutical use		✓	✓	✓	✓	✓	✓		✓	✓		✓
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota	*Waste absorption and detoxification*	✓	✓	✓	✓	✓		✓	✓	✓			✓
			Carbon sequestration / absorption	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
		Mediation by ecosystems	*Carbon sequestration / absorption*	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
			Waste absorption and detoxification	✓	✓	✓	✓	✓		✓	✓	✓			✓
	Mediation of flows	Mass flows	*Waste absorption and detoxification*	✓	✓	✓	✓	✓		✓	✓	✓			✓
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection	*Habitat & nursery (supporting)*	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
		Pest and disease control	*Biological regulation*		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
			Biological regulation		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓
		Water conditions	?	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Atmospheric composition and climate regulation	*Gas and climate regulation*	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Cultural	Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	Physical and experiential interactions	*Tourism*	✓	✓	✓		✓				✓			✓
			Recreation	✓	✓	✓					✓	✓			✓
		Intellectual and representative interactions	*Scientific research*	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			Educational	✓	✓	✓	✓	✓	✓		✓	✓	✓		✓
			Cultural heritage	✓	✓		✓	✓	✓	✓		✓		✓	✓
			Indigenous heritage		✓			✓				✓		✓	✓
			Entertainment (documentaries)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
			Aesthetic	✓	✓	✓	✓		✓			✓	✓	✓	✓
		Other cultural outputs	*Existence*	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
			Bequest	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓

Table 3: CICES Framework Ecosystem Services for ATLAS Case Studies

Section	Division	Group	Armstrong et al (2010, 2012); MA Adapted Framework	LoVe	Mingulay	Azores	Flemish Cap	West of Shetland and W of Scotland Slope	Rockall Bank	Porcupine Seabight	Bay of Biscay	Gulf of Cadiz/Strait of Gibraltar/Alboran Sea	Reykjanes Ridge	S Davis Strait/Western Greenland/Labrador Sea	SE USA (Bermuda Transect)
Abiotic Provisioning	Nutritional abiotic substances	Mineral	Minerals (provisioning)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Abiotic materials	Non-metallic	Minerals (provisioning)			✓	✓	✓		✓		✓	✓		✓
	Energy	Renewable abiotic energy sources	Energy (provisioning)	✓	✓	✓			✓			✓			
		Non-renewable energy sources	Oil and Gas (provisioning)	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓
Regulation & Maintenance by natural physical structures and processes	Mediation of waste, toxics and other nuisances	By natural chemical and physical processes	Waste disposal sites (provisioning)	✓		✓	✓ (fishing and shipping)	✓			✓	✓			✓
Cultural settings dependent on abiotic structures	Physical and intellectual interactions with land-/seascapes [physical settings]	By physical and experiential interactions or intellectual and representational interactions	Research of the deep sea	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Spiritual, symbolic and other interactions with land-/seascapes [physical settings]	By type	Shipwrecks?												

Table 4: CICES Identification of Abiotic Resources

5. Conclusions and Next Steps

This report classifies the existing ecosystem services connected with the case study areas. It is the first step towards a monetary evaluation of ecosystem goods and services. A major outcome of this study is the large number of different services emanating from the deep sea. However, the issue of quantifying them remains extremely challenging, especially as many of these are supporting services that are removed in time and space from the final services that can be valued.

Economic valuation of the deep sea is limited. Existing information is usually tied to the provisioning services of the ocean such as fisheries and fish habitat; with little information on regulating and cultural services, or future potential services from Blue Growth. Provisioning services such as fisheries are quantifiable, but regulating or cultural services are not well known to the public. This makes total valuation a demanding exercise, but one that has been attempted for a few deep sea ecosystems, such as cold water corals. Applied valuation studies to the deep sea and associated ecosystems include discrete choice experiments (Glenn, Wattage et al. 2010; Wattage, Glenn et al. 2011; Jobstvogt, Hanley et al. 2014; Aanesen, Armstrong et al. 2015), contingent valuation surveys (Ressurreição, Gibbons et al. 2011; Ressurreição, Gibbons et al. 2012; Ressurreição, Zarzycki et al. 2012) and benefit transfer (Beaumont et al, 2008).

To value deep-sea ecosystems and their goods and services, we need knowledge about the biodiversity, structure and functioning of the systems, and the factors influencing these. We need to have knowledge about the threats and pressures impacting on the systems, and how the systems and services respond over time (Armstrong, Foley et al. 2010). This report has set the scene for the next stages of the ATLAS valuation of ecosystem services, namely deliverable 5.3 which will develop a monetary evaluation framework for ecosystem goods and services. Using the CICES framework, monetary values will be estimated for ecosystem services where possible. The inventory also puts the groundwork in place for task 6.2 in the maritime spatial planning work package in which maps will be created for ecosystem goods and services in the case study areas.

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