Ecosystem service assessment of Jersey's marine habitats

Marine Resources, Jersey

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Contents

1. Introduction

As an island with a strong maritime history, Jersey has strong ties to the ocean, both culturally and economically. There are many benefits derived from the sea that support human well-being and this report will summarise these in relation to identified marine habitats in Jersey. Despite close ties to both French and English history, Jersey has always had its own identity in a large part because of the maritime boundary that surrounds the island.

"People are part of ecosystems and ecosystem services (ES) are the benefits that people obtain from ecosystems" (UNEP 2006a).

Ecosystem services (ES) are essential to human well-being (Beaumont et al. 2007), and can be defined as the supporting, regulating, provisioning and cultural services which are supplied by the habitats within the ecosystem (Maass et al. 2005). ES supply is the full potential of an ecosystem to provide a service, irrespective of whether humans actually use or value that function (Cesar 2002). Human well-being and economy depends on the marine environment in multi-faceted ways. From basic human needs such as oxygen and food generation, to higher level needs such as culture, tourism and well-being. These services can only be supplied to humans if ecosystem function is conserved. Ecosystem function is the ability of natural systems to support human needs, either directly or indirectly, through the supply of ecosystem services (Fletcher et al. 2012; Groot, Wilson, and Boumans 2002; Harvey et al. 2017; Rees et al. 2013).

The assessment of ecosystem services and mapping them to their habitats is one of the core actions of the EU Biodiversity Strategy for 2030. The strategy aims to protect nature and reverse the degradation of ecosystems (European Commission 2020). There are many human activities which put pressure on habitats, affecting their ability to supply ES. Effective fisheries management needs to be ecosystem based and, as such, should consider the biotic, abiotic and socio-economic factors (Gaines et al. 2010; Laffoley et al. 2004; Pikitch et al. 2004).

1.2. Valuing Ecosystem Services

Blampied et al. (2022) previously considered habitat value in terms of their contribution to commercial fisheries in Jersey. This provides an economic basis to build on. However, it is not enough to solely consider fish and shellfish landings when determining the value of a habitat or the impact of fishing gears. There are other ecosystem services that are important to measure that have strong links to both ecological health and human wellbeing (Fletcher et al. 2012). Human activities put pressure on the ecosystem service supply of habitats in a number of ways. For example, bottom-towed fishing gears will impact more than just the targeted fish stocks as they disturb the seabed, altering the structure and function of the benthic communities and associated trophic structures (Bradshaw et al. 2001; Thrush and Dayton 2002; Sheehan et al. 2013; Howarth and Stewart 2014; Stewart and Howarth 2016; Kaiser et al. 2018).

The valuation of ES is difficult and involves some degree of subjectivity as it is not possible to assign a monetary value to most services. There are many examples of ES supply matrices that use a weighting system based on both literature and expert opinion (Galparsoro, Borja, and Uyarra 2014; Potts et al. 2014). A similar matrix has been applied to the marine habitats in Jersey. Through the identification of priority areas for ES supply and assessing the current and future risks to the habitats that supply them, spatial prioritisation of human activities can be refined in management.

2. Methods

2.2. Habitat grouping

Jerseys marine substrates consist of sands, gravels, boulders and rock that are further classified into habitats based on their exposure, depth and their living components such as seaweeds, seagrasses, polychaetes, bivalves, and turf communities. An assessment of Jersey's marine habitats using a combination of the JNCCs and EUNIS habitat classification systems revealed 66 habitats (see Table1 for a list of habitats and their corresponding EUNIS codes), that can be further grouped into 14 key habitat types. The intertidal zone contains numerous habitat types but these have been grouped with their corresponding subtidal habitats, i.e. subtidal and intertidal seagrass, as, for the purposes of this assessment they provide largely the same Ecosystem services.

ES were classified into Supporting, Provisioning, Regulating and Cultural services. These services were valued based on the methods of Galparsoro et al. (2014). If the supply of a specific service from a habitat was widely accepted in the literature it was considered as providing a high value (score = 2). When a service was or could be provided by a habitat but was considered to be lower than that provided by other habitats, based on literature and expert opinion, a low value (score = 1) was assigned. In all other cases, ES were classified as negligible or unknown (score = 0). For each ES category (Supporting services; Provisioning services; Regulating services and Cultural services), the total ES score was summed, and these cumulative ES values were used to map the distribution of ES value across the whole of Jersey's territorial waters using a graduated colour scale (from light yellow to dark blue, the darker the colour, the higher the score). Previous ES assessments were consulted to inform the scoring (Fletcher et al. 2012; Potts et al. 2014; Salomidi et al. 2012). Where information was not available, ES supply importance has been estimated from comparable habitats.

Table 1. Groupings of EUNIS habitat categories identified in Jersey territorial waters.

Name	Description	EUNIS codes
Rock: barnacle communities	Intertidal and subtidal rock that is dominated by barnacles and limpets.	A1.112, A1.1131, A1.1133
Rock: seaweed communities	Intertidal and subtidal rock that is dominated by seaweed, such as *Fucus* spp. and *Ascophyllum nodosum*.	A1.125, A1.211, A1.212, A1.214, A1.2142, A1.215, A1.3122, A1.313, A1.3132, A1.314, A1.3142, A1.3152, A1.451
Rockpool communities	Pools of various shapes and sizes within rocky intertidal areas.	A1.4111, A1.4121, A1.413, A1.4131, A1.421
Rock: kelp	Kelp and associated seaweed species on rock substrate. Includes both kelp forest and kelp park.	A3.12, A3.125, A3.126, A3.211, A3.214, A3.2142, A3.222, A3.223, A3.2231
Sediment: sparse fauna	Fine, medium and coarse sediments with sparse infauna. Typically high energy sites with mobile sediments.	A2.211, A2.22, A2.221, A2.2221, A2.223, A2.224, A2.225, A2.226, A2.231, A5.231, A2.111
Sediment: robust fauna	Coarse sand and gravel with robust infauna. Typically moderate energy sites. Characterised by infaunal polychaetes, mobile crustacea and bivalves.	A5.133, A5.135, A5.14, A5.145
Sediment: rich fauna	Fine and mixed sediments with rich infauna such as tube building amphipods and polychaetes and diverse bivalve communities.	A5.234, A5.24, A5.33, A5.433, A5.451

Sediment: seaweed	Sediment with high coverage of seaweeds, such as *Sargassum muticum*, *Chorda filum* and kelps.	A3.315, A5.52
Sandmason worms	Sediments dominated by sandmason worms.	A2.245, A2.421, A5.137
Seagrass	Sediments dominated by seagrass.	A2.6111, A5.5331
Maerl	Free growing coralline red algae that grows in branched and noduled structures that accumulates on the seafloor.	A5.51
Slipper limpets	Sediments with a high coverage (>50%) of slipper limpets (*Crepidula fornicata*).	A5.431
Hard ground: stable	Subtidal bedrock and boulders that are stable and have a high faunal diversity in terms of encrusting and filter feeding species, such as sponges, seasquirts, bryozoans, hydroids, anemones and corals.	A3.7, A4.13
Hard ground: unstable	Unstable cobbles and pebbles characterised by fast growing species such as barnacles and bryozoans.	A5.141

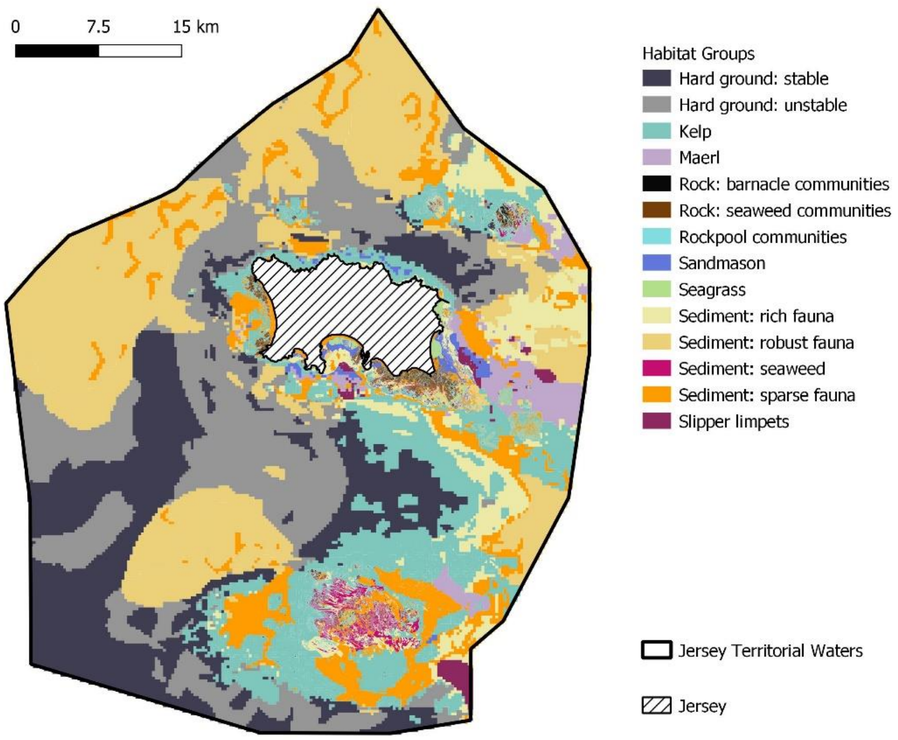

Figure 1. Spatial extent of Jerseys marine habitat types.

2.3. Literature search

Google Scholar was primarily used to find the relevant ES literature for each habitat.

The search terms used were typically: “Habitat” AND/OR “Habitat” AND “Ecosystem Service” AND “Location” OR “Location” OR “Location”

Eg: “Intertidal” AND “Primary production” AND “Europe” OR “UK” OR “Atlantic”

If no results were found using all criteria, Location was dropped from the search.

First search: "subtidal" AND "Rock" AND "Sand" AND "Primary production" AND "UK" OR "Europe" OR "Atlantic"

The first search yielded 15 relevant search results in preliminary scanning. Further reading of abstracts eliminated 3 results, leaving 12 for use in the assessment of the habitat type. Due to the sparse literature surrounding certain ES and habitats, other avenues of literature searching were used, such as searching for literature cited within the original articles found through Google Scholar. Information from local research has also been used.

3. Results

3.1. Ecosystem service summaries by habitat

A brief description of the habitat and its spatial extent is given in each section below, followed by a table detailing the ES of each habitat. There are six categories under supporting, six under regulating, four under provisioning and four under cultural services. A glossary of the categories can be found at the end of this document.

3.1.1. Rock: barnacle communities

This habitat is primarily intertidal and consists of exposed rock surfaces that are dominated by barnacle communities, typically *Semibalanus balanoides*. Limpets (*Patella vulgata*), dog whelks (*Nucella lapillus*) and sparse seaweed communities are also associated with this habitat.

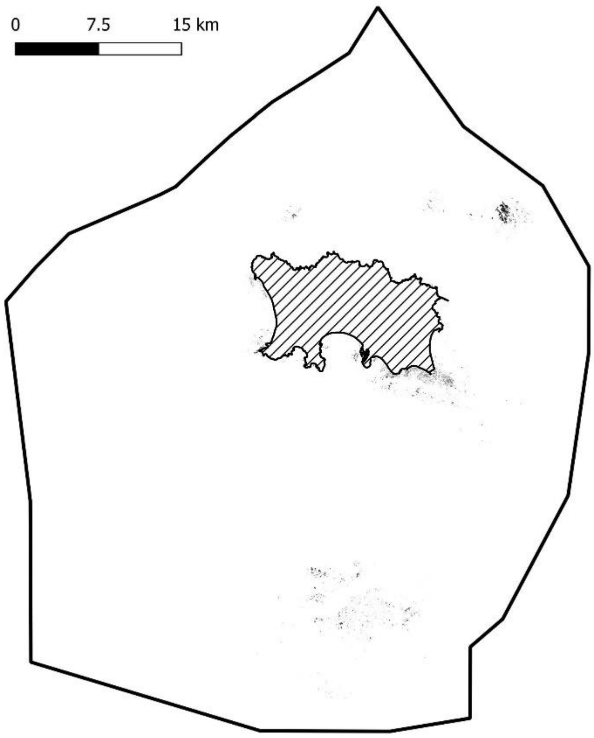

Figure 2. Spatial extent of habitat type: Rock: barnacle communities.

Table 2. Summary of ecosystem services provided by Rock: barnacle communities and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	This habitat is typically found in the intertidal zone and has limited associated biodiversity that will contribute to Primary Productivity.	0
Larval / Gamete supply	Low – Expert opinion. Barnacles and other species such as limpets that are found on this habitat will reproduce via larval dispersal. Dog whelks (*Nucella lapillus*) will also lay their eggs in crevices on this habitat.	1
Nutrient cycling	Barnacles and other associated species on this habitat will excrete Nitrogen and Phosphorus, as do most marine	0

	organisms (Hall et al. 2007), contributing to the nutrient cycle, but the scale at which this occurs on this habitat is likely negligible – Expert opinion.	
Formation of species habitat	This habitat is typically exposed to the air for long periods or is located in areas with high tidal flow, making it suitable for species such as barnacles to colonise but unsuitable for many other species, especially those intolerant of desiccation, wave exposure and high current flows.	1
Formation of physical barriers	This habitat creates a physical barrier in the intertidal and upper infralittoral zone. The rocky substratum will help to dissipate wave energy before it hits the shore.	2
Formation of seabed structure	This habitat forms part of the intertidal seascape, that, combined with the other habitats, creates a varied seascape of rocky outcrops and gullies throughout the intertidal and upper infralittoral.	2
Regulating services		
Biological control	While there are numerous non-native and invasive species within Jersey's intertidal rock habitat, it is not well understood if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	This habitat has low algal cover and contains no sediments and is therefore unlikely to contribute to the assimilation or immobilisation of pollutants.	0
Regulation of water and sediment quality	Negligible – expert opinion.	0
Carbon sequestration	This habitat has low algal cover and contains no sediments and is therefore unlikely to contribute to carbon sequestration. Dead shell material from barnacles and molluscs may contribute to inorganic carbon stocks but the amount of inorganic matter derived from this source is unknown.	0
Healthy climate	Negligible – expert opinion	0
Prevention of coastal erosion/Sea defence	The intertidal rocky area, of which this habitat forms a large component, will play a role in dissipating wave energy before it hits the upper shore.	2
Provisioning services		
Food	There are few species, commercial or otherwise, living on rock dominated by barnacles due to the relatively harsh environment (high exposure and long periods uncovered by the tide), and therefore little in the way of harvestable food for human consumption.	0
Fish feed	There are no species taken from rock dominated by barnacles that are intended for use in fish feed.	0
Fertiliser (and biofuels and building materials)	This habitat does not produce material that is used in fertiliser or biofuels.	0
Medicines and blue biotechnology	This habitat is not thought to contribute toward medical technologies, and little in the way of biotechnology. One example is the use of barnacles as inspiration for the development of adhesive materials due to their ability to strong adhere to underwater surfaces (Gan et al. 2022).	0
Cultural services		

Tourism/recreation/ nature watching	As this habitat forms a large part of the intertidal it will contribute to nature watching as various species will use this habitat at both high tide and low tide. This habitat also forms part of the coastline used for coasteering.	1
Spiritual / cultural wellbeing	Culturally, the intertidal has been utilised by many generations of local fishers and foragers. However, the low biodiversity associated with barnacle dominated rock is unlikely to attract much attention of islanders other than from what it contributes to the natural aesthetic of the intertidal zone. Jersey's sense of identity is heavily entwined with its proximity to the sea and ever-changing view between high and low tide. Many yoga classes operate on the coast in view of the intertidal or sometimes directly on the beach, where the beauty of the surroundings adds to the spiritual experience of this practice.	1
Aesthetic benefits	The intertidal zone, of which barnacle dominated rock forms a part of, is visible from all areas of Jersey's coast that are frequented by both locals and visitors. Part of this aesthetic beauty is tied to the impressive change in scene between high and low tide. Unrestricted, stretching views to the horizon are appreciated by locals and tourists alike.	2
Education	School groups often utilise the upper intertidal zone rockpools to teach students about the local marine life and ecosystem processes. This is also a way of increasing awareness about beach safety and how to respect the marine environment.	2

3.1.2. Rock: seaweed communities

This habitat is primarily intertidal where dense seaweed communities cover rock surfaces. Typically, this habitat is characterised by fucoids but there is also a high diversity of red and green algaes. Other species associated with this habitat are limpets (*Patella vulgata*), barnacles, whelk (*Nucella lapillus*) and beadlet anemones (*Actinia equina*).

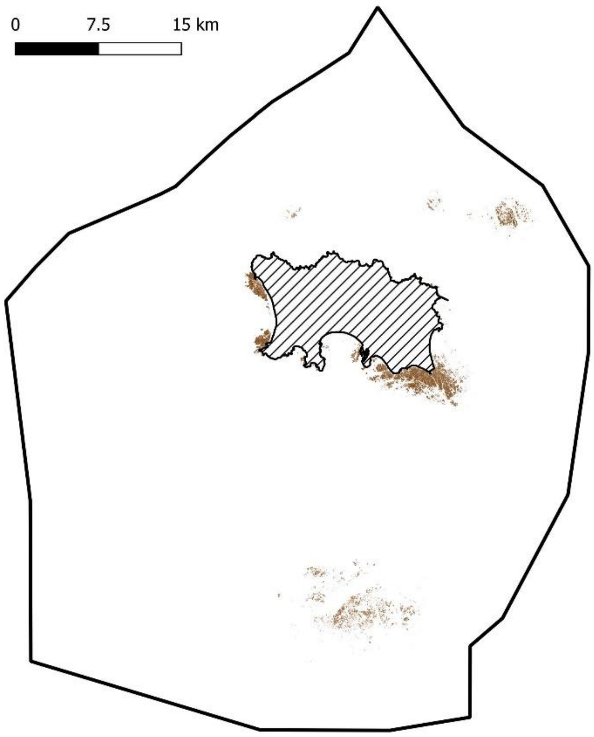

Figure 3. Spatial extent of habitat type: Rock: seaweed communities.

Table 3. Summary of ecosystem services provided by Rock: seaweed communities and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Brown and red algae have high/moderate Net Primary Production (NPP): brown: 0.546 kg C/m^2/year red: 0.105 kg C/m^2/year (Duarte et al. 2022). High/moderate depending on algae composition (Cramer and Katz 2021; Duarte et al. 2022).	2
Larval / Gamete supply	High – Expert opinion	2
Nutrient cycling	The large biomass of macroalgae associated with this habitat will contribute to Carbon and Nitrogen cycling through the uptake of nutrients from the surrounding water at high tide (Gamfeldt and Bracken 2009), with some species contributing more than others.	2
Formation of species habitat	The layer of seaweed covering the rocks creates habitat for many species and will be utilised by different animals between high and low tide. At high tide the seaweed will float and create a canopy, under which many species of fish and invertebrates will shelter and forage, and at low tide the seaweed will lie closer to the rocks, creating shelter for resident fauna.	2
Formation of physical barriers	Hard substrates in coastal areas help to prevent damage from storms, dense macroalgae will also help to buffer energy from	2

	storms. Seaweed dominated rock in Jersey's intertidal and infralittoral will provide a barrier to oncoming swells, helping to dissipate the energy before it hits the coasts or seawalls.	
Formation of structure	This habitat forms part of the intertidal seascape, that, combined with the other habitats, creates a varied seascape of rocky outcrops and gullies throughout the intertidal and upper infralittoral. The seaweed will float at high tide, anchored to the rock by its holdfast, creating a canopy that is utilised by many species for shelter and foraging.	2
Regulating services		
Biological control	While there are numerous non-native and invasive species within Jersey's intertidal rock and seaweed communities, it is not well understood if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	Brown algae, such as those found in rockpools, may contribute to the phytoremediation of some heavy metals (Al-Rashid and Khanna 2021). However, the longevity of algaes is relatively short and the heavy metals will be later released back into the water column as the algae breaks down.	0
Regulation of water and sediment quality	The assimilation of nutrients by seaweed will contribute to water quality (Racine et al. 2021).	1
Carbon sequestration	This habitat will contribute to the production of carbon in terms of algal biomass but will not contribute to the long-term storage of carbon itself – it is thought that some algae may end up buried in sediments, the scale at which this occurs is currently unquantified.	1
Healthy climate	The high biomass of photosynthesising algae associated with this habitat will contribute to the carbon cycle by taking up carbon dioxide from the water and releasing oxygen.	1
Prevention of coastal erosion/Sea defence	The intertidal rocky area and areas of high algal density will play a role in dissipating wave energy before it hits the upper shore.	2
Provisioning services		
Food	There are many species living within the intertidal zone that are exploitable for human consumption. Seaweeds in particular have been harvested for human consumptions for many years. Further afield, seaweeds hold value for the health food industry (Kenicer, Bridgewater, and Milliken 2000). This habitat also supports low water fishing.	2
Fish feed	There are no species taken from seaweed dominated rock that are intended for use in fish feed.	0
Fertiliser (and biofuels and building materials)	There is a high biomass of seaweed associated with this habitat that is accessible for harvesting. The use of seaweed as fertiliser has been used both domestically and commercially for many years (Kenicer et al. 2000). Locally, vraic (brown seaweeds such as *Ascophyllum nodosum* and *fucus* spp.) is sometimes collected from the shore to be used as fertiliser in agriculture.	2
Medicines and blue biotechnology	Some seaweed species are being investigated for their potential as biofuels or in medicine. Many species of brown	2

	algae have properties that make them suitable for use in the medical industry (Al-Rashid and Khanna 2021; Carson and Clarke 2018).	
Cultural services		
Tourism/recreation/ nature watching	As this habitat forms a large part of the intertidal it will contribute to nature watching as various species will use this habitat at both high tide and low tide. This habitat also forms part of the coastline used for coasteering. Locally there is a seashore guiding business that takes groups out to explore the intertidal and the variety of seaweeds found there. The number of species living in the seaweed also attract intertidal birds which in turn attracts bird watchers.	2
Spiritual / cultural wellbeing	'Vraicing' has been a local pastime for many generations, for both domestic and agricultural purposes. This involves the collection of certain seaweed species from the seashore to be used as fertiliser on land. Jersey's sense of identity is also heavily entwined with its proximity to the sea and ever-changing views and opportunities for exploration and exploitation between high and low tide. Low water fishing is also a cultural activity that is supported by this habitat. Many yoga classes operate on the coast in view of the intertidal, of which seaweed dominated rock forms a large part, or sometimes directly on the beach, where the beauty of the surroundings adds to the spiritual experience of this practice.	2
Aesthetic benefits	The intertidal zone, of which seaweed dominated rock forms a large part, is visible from all areas of Jersey's coast that are frequented by both locals and visitors. Part of this aesthetic beauty is tied to the impressive change in scene between high and low tide. Unrestricted, stretching views to the horizon are appreciated by locals and tourists alike.	2
Education	The intertidal can be used as a source of learning for school children (Mackintosh 2017). School groups often utilise the upper intertidal zone to teach students about the local marine life and ecosystem processes.	2

3.1.3. Rockpool communities

Rockpools are seawater filled depressions in the intertidal zone and consist of pools in a variety of shapes, depths and sizes. These pools support a range of intertidal species and are typically characterised by seaweeds such as *Corallina officinalis*, encrusting algae, *Furcellaria lumbricalis*, and fucoids. Some rockpools may have a layer of sediment at the bottom in which burrowing species, such as the daisy anemone (*Cereus pendunculatus*), can be found.

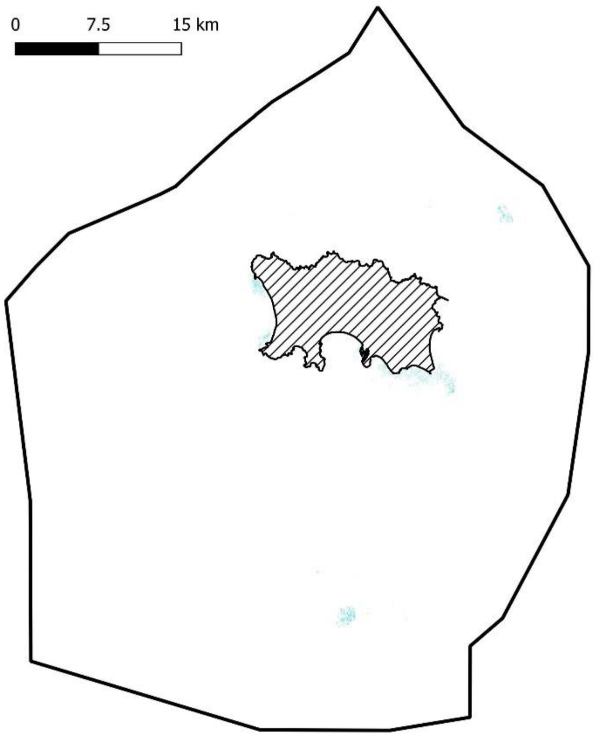

Figure 4. Spatial extent of habitat type: Rockpool communities.

Table 4. Summary of ecosystem services provided by rockpools and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	"The global macroalgal biome is comparable, in area and Net Primary Production, to the Amazon forest, but is globally distributed as a thin strip around shorelines" (Duarte et al. 2022). Intertidal algae – high NPP: 0.587 kg C/m^2/year (Duarte et al. 2022), and intertidal algae will occur in rockpools as well as on the surrounding rock.	2
Larval / Gamete supply	High – Expert opinion. Many species that are adapted to live in the rockpools will spawn in the rockpools, fertilisation success will depend on tidal height and connectivity to other pools (Engel and Destombe 2002). Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with exception of species poor, mobile sediments.	2
Nutrient cycling	The biomass of macroalgae in rockpools will contribute to Carbon and Nitrogen cycling, with some species contributing more than others – invasive species such as sargassum have the potential to reduce this service (Rossi et al. 2019).	2
Formation of species habitat	The large area of rockpools in various shapes, sizes and exposure to the elements provide habitat niches for a large number of species. There are many species that are adapted	2

	for life in rockpools, such as snakelocks anemones (*Anemonia viridis*), gobies and blennies (various species), and porcelain crabs (*Porcellana platycheles*). Juvenile brown crab (*Cancer pagurus*) and juvenile lobster (Homarus gammarus) are commercially important species that also make use of rockpools.	
Formation of physical barriers	The intertidal rocky area in which rockpools are found may play a role in dissipating wave energy before it hits the upper shore. Larger rockpools may contribute to this.	1
Formation of structure	The rocky intertidal landscape is punctuated by crystal clear pools of all shapes and sizes that harbour a number of faunal and algal species.	2
Regulating services		
Biological control	While there are numerous non-native and invasive species within Jersey's intertidal, it is not well understood if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	Brown algae, such as those found in rockpools, may contribute to the phytoremediation of some heavy metals (Al-Rashid and Khanna 2021). However, the longevity of algaes is relatively short and the heavy metals will be later released back into the water column as the algae breaks down.	0
Regulation of water and sediment quality	Negligible – expert opinion.	0
Carbon sequestration	Rockpools will contribute to the production of carbon in terms of algal biomass but will not contribute to the long-term storage of carbon itself – it is thought that some algae may end up buried in sediments the scale at which this occurs is currently unquantified.	0
Healthy climate	Negligible – expert opinion	0
Prevention of coastal erosion/sea defence	The intertidal rocky area in which rockpools are found may play a role in dissipating wave energy before it hits the upper shore. Larger rockpools may contribute to this.	1
Provisioning services		
Food	There are many species living within rockpools that are exploitable for human consumption. In Jersey, examples include lobsters, ormers, limpets and seaweeds. Further afield, seaweeds hold value for the health food industry (Kenicer et al. 2000). *Chondrus crispus* (sometimes known as carageen or Irish moss) that is found growing in lower shore rockpools contains gelose and has been used in the food industry as a thinking agent (MacDougall 1948).	1
Fish feed	There are no species taken from rockpools that are intended for use in fish feed.	0
Fertiliser (and biofuels and building materials)	The use of seaweed as fertiliser has been used both domestically and commercially for many years (Kenicer et al. 2000). Some of the seaweeds found in rockpools are suitable for use as fertiliser in agriculture but typically brown algae growing on the rocks in the upper intertidal (outside of the rockpools) is favoured for this.	1

Medicines and blue biotechnology	Brown algaes, such as those found in rockpools, have a number of bioactive compounds that can be used for medicinal and medical purposes (Al-Rashid and Khanna 2021). *Chondrus crispus* (sometimes known as carageen or Irish moss) that is found growing in lower shore rockpools has properties that make it suitable for use in antibacterial products (Alipour and Javanshir 2018).	1
Cultural services		
Tourism/recreation/ nature watching	The variety of crystal clear pools of all shapes and sizes that harbour a number of faunal and algal species attract many visitors to the seashore. Locally there is a seashore guiding business that takes groups out into the intertidal to explore the rockpools. The rockpools also attract intertidal birds which in turn attracts bird watchers.	2
Spiritual / cultural wellbeing	Rockpooling has been a local pastime for many generations, for both leisure and foraging purposes. Some of the species found in rockpools are of cultural significance in Jersey such as the Ormer (*Haliotis tuberculata*).	2
Aesthetic benefits	The crystal-clear pools that are revealed at low tide capture the imagination of visitors to the shore. Rockpools are often one of the first images conjured when thinking of the seashore and the micro-seascape provided by the pools provides an accessible connection with the ocean. The species and micro-landscapes within rockpools are also a source of artistic inspiration (Basquin and Pebbles 2020).	2
Education	Rockpools can be used as a source of learning for school children (Mackintosh 2017). Rockpool sessions are frequently run for local school groups by various organisations to teach pupils about the marine environment on their doorstep.	2

3.1.4. Sediment: seaweed

This habitat is composed of mixed sediments and is typically found in the shallow subtidal (from the sublittoral fringe to the 5m below chart datum). *Sargassum muticum* is strongly associated with this habitat where, in areas of shallow standing water over sediment, it anchors to small rocks and pebbles in the sandy sediment. Species such as bootlace weed (*Chorda filum*), sugar kelp (*Laminaria saccharina*) and various red algaes are also associated with this habitat.

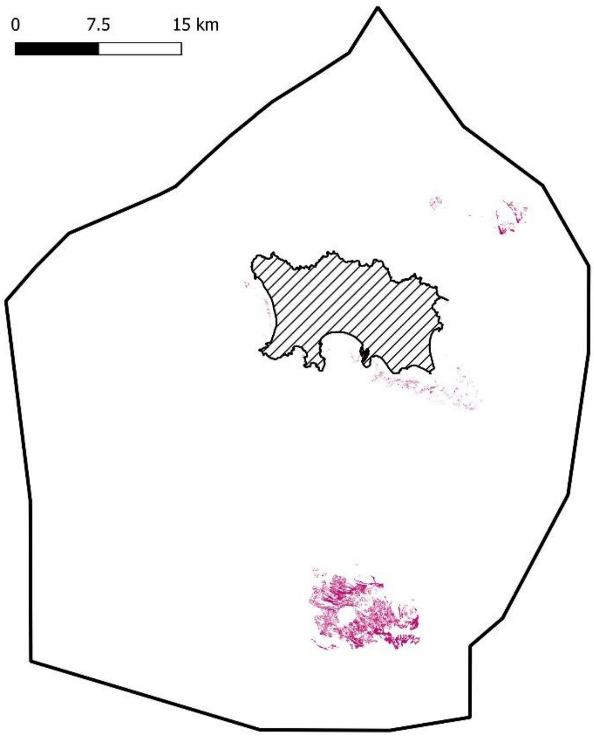

Figure 5. Spatial extent of habitat type: Sediment: seaweed.

Table 5. Summary of ecosystem services provided by Sediment: seaweed and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Subtidal brown and red algae have high/moderate NPP: brown: 0.546 kg C/m^2/year red: 0.105 kg C/m^2/year (Duarte et al. 2022). High/moderate depending on algae composition (Cramer and Katz 2021; Duarte et al. 2022).	2
Larval / Gamete supply	High – Expert opinion	2
Nutrient cycling	The large biomass of macroalgae associated with this habitat will contribute to Carbon and Nitrogen cycling through the uptake of nutrients from the surrounding water at high tide (Gamfeldt and Bracken 2009), with some species contributing more than others. Invasive seaweed species such as sargassum have the potential to reduce this service (Rossi et al. 2019). Species living within the sediment, such as filter feeding bivalves and polychaetes, will contribute to nutrient cycling across the water-sediment interface.	2
Formation of species habitat	This habitat is typically found in the upper infralittoral zone and lower intertidal where the sand is rarely uncovered by the tide. The seaweed will float, while anchored to the sediment by a holdfast, creating a canopy under which many species of fish and invertebrates will shelter and forage. The canopy of some larger species of seaweed, such as *Sargassum muticum*,	2

	create shade in pools and in shallow water at low tide that many species benefit from.	
Formation of physical barriers	Dense macroalgae communities in the upper infralittoral and lower intertidal will help to buffer energy from storms.	1
Formation of structure	This habitat forms part of the intertidal seascape, that, combined with the other habitats, creates a varied seascape.	2
Regulating services		
Biological control	While there are numerous non-native and invasive species within Jersey's intertidal rock and seaweed communities, it is not well understood if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	Brown algae, such as those found on this habitat, may contribute to the phytoremediation of some heavy metals (Al-Rashid and Khanna 2021). However, the longevity of algaes is relatively short and the heavy metals will be later released back into the water column as the algae breaks down. Sediments play a role in the immobilisation of pollutants (Burdige 2007). This typically only occurs in lower energy environments with stable sediments. Sediments that have high seaweed biomass associated with them may be comparatively stable and therefore contribute to the immobilisation of pollutants.	1
Regulation of water and sediment quality	Where seaweed biomass is high on the sediments there may be improved sediment stability that may increase water quality. The assimilation of nutrients by the seaweed will also contribute to this (Racine et al. 2021).	1
Carbon sequestration	This habitat will contribute to the production of carbon in terms of algal biomass but will not contribute to the long-term storage of carbon itself – it is thought that some algae may end up buried in sediments the scale at which this occurs is currently unquantified.	1
Healthy climate	Negligible – expert opinion	0
Prevention of coastal erosion/Sea defence	Areas of high algal density will play a role in dissipating wave energy before it hits the upper shore.	2
Provisioning services		
Food	There are many species living within the intertidal zone that are exploitable for human consumption. Seaweeds in particular have been harvested for human consumption for many years. Further afield, seaweeds hold value for the health food industry (Kenicer et al. 2000). Further, this habitat supports commercially targeted species, such as bass, that can be found in the shade created by the larger species of seaweed, such as *Sargassum muticum*, growing on this habitat. Green shore crab is associated with this habitat and is sought for bait in commercial and recreational fishing.	2
Fish feed	There are no species taken from seaweed dominated rock that are intended for use in fish feed.	0
Fertiliser (and biofuels and building materials)	There is a high biomass of seaweed associated with this habitat that is accessible for harvesting. The use of seaweed as fertiliser has been used both domestically and commercially for many years (Kenicer et al. 2000). However, it is typically	0

	the vraic species growing on rocky habitat that are targeted for this purpose, rather than the seaweed species found on the sediments.	
Medicines and blue biotechnology	Some seaweed species are being investigated for their potential as biofuels or in medicine. Many species of brown algae have properties that make them suitable for use in the medical industry (Al-Rashid and Khanna 2021; Carson and Clarke 2018). *Sargassum muticum,* a prevalent species in Jersey's intertidal in the summer months, may hold potential for pharmaceuticals as it has a high content of anti-oxidants and anti-cancer compounds (Milledge, Nielsen, and Bailey 2016).	2
Cultural services		
Tourism/recreation/ nature watching	As this habitat forms a large part of the intertidal it will contribute to nature watching as various species are present at both high and low tide. This habitat also forms part of the coastline used for coasteering. Locally there is a seashore guiding business that takes groups out to explore the intertidal and the variety of seaweeds found there. The number of species living in the seaweed also attract intertidal birds which in turn attracts bird watchers. Some of the seaweed dominated sediments in large pools and gully complexes create an interesting landscape for snorkellers to explore.	2
Spiritual / cultural wellbeing	Jersey's sense of identity is heavily entwined with its proximity to the sea and ever-changing views and opportunities for exploration and exploitation between high and low tide.	2
Aesthetic benefits	The intertidal zone, of which seaweed dominated sediment forms a large part, is visible from Jersey's coast and is frequented by both locals and visitors. Part of this aesthetic beauty is tied to the impressive change in scene between high and low tide. Unrestricted, stretching views to the horizon are appreciated by locals and tourists alike.	2
Education	The intertidal can be used as a source of learning for school children (Mackintosh 2017). School groups often utilise the upper intertidal zone to teach students about the local marine life and ecosystem processes.	2

3.1.5. Sandmason worms (A5.137)

Coarse, medium and fine sands that are characterised by the tube building infaunal polychaete worm, the sandmason (*Lanice conchilega*). This habitat can be found in both intertidal and subtidal sediments. The ecosystem services of sandmason worms (*Lanice conchilega*) is similar to that of basin sand and gravel (see above) as this is the substrate they are found on. However, the presence of *L. conchilega* worms stabilises sediments and increases the flow of many services, such as primary production, nutrient cycling and biodiversity. *L. conchilega* occur in both the lower intertidal and subtidal.

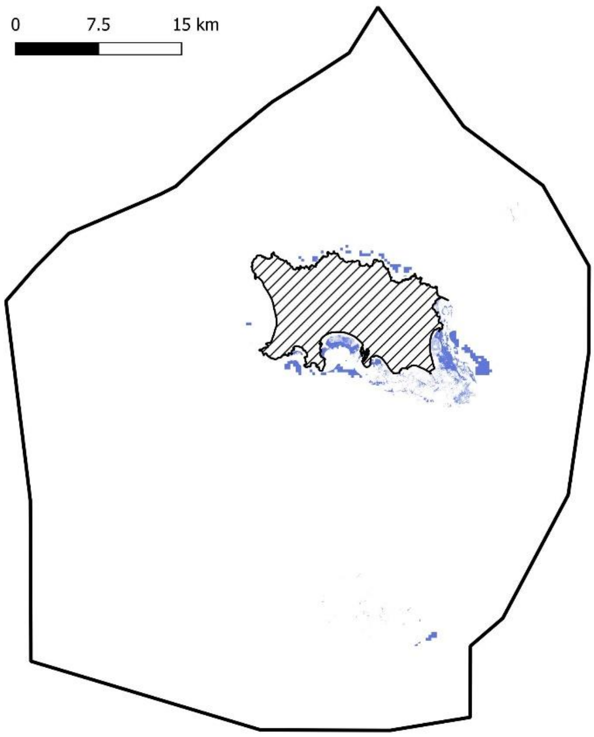

Figure 6. Spatial extent of habitat type: Sandmason worms.

Table 6. Summary of ecosystem services provided by sandmason worms and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Moderate/Low: "*Chlorophyll a concentrations appeared to be strongly controlled by the filter feeders*" (Cugier et al. 2010).	1
Larval / Gamete supply	High – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with the exception of species poor, mobile sediments. Sandmason worm beds in particular are key areas for polychaete reproduction.	2
Nutrient cycling	The dense aggregations of filter feeding *L. conchilega* worms contribute to the cycling of nutrients between the water column and the surface sediment layer (Bruschetti 2019). The bio-irrigation of *L. conchilega* transports both oxygen and de-nitrifiers to deeper layers in the sediment (Foshtomi et al. 2018).	2
Formation of species habitat	Flatfish species may select for habitat created by tube worms (*Chaetopterus* sp. and *Lanice conchilega*) (Salomidi et al. 2012). *L. conchilega* supports the foraging of flatfishes such as Pleuronectes platessa (Rabaut et al. 2010), a commercially targeted species. Local towed videos on this habitat have shown both epifaunal and mobile species to be living amongst the	2

	tubes, such as daisy anemones (*Cereus pedunculatus*), spider crabs (*Maja brachydactyla*) and various gobies.	
Formation of physical barriers	Low – expert opinion. Dense aggregations of sandmason worms will stabilise the sediment which may prevent the sand being washed away during storms and strong current flows. This will be particularly important in the intertidal to maintain beaches but is unlikely to prevent wave action reaching the upper shore.	1
Formation of structure	*L. conchilega* provides structure in an otherwise fairly flat landscape on the seafloor. As part of a wider seascape that comprises areas of sand amongst other habitat types, *L. conchilega* it is an important component in supporting habitat connectivity.	1
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not thought that many are found on *L. conchilega* habitat or, if there are any species that are acting as a biological control, further research is needed. It is worth noting that the invasive slipper limpet tends to preferentially colonise maerl beds, which may be as a result of dredging on this habitat that creates furrows ideal for slipper limpet settlement.	0
Natural hazard regulation	Sediments play a role in the immobilisation of pollutants (Burdige 2007), typically in lower energy environments with stable sediments. While areas of *L. conchilega* may be subject to high tidal streams, the dense aggregations of tubes stabilise the sediments that will prevent the re-mobilisation of any pollutants that may have made their way into this environment.	1
Regulation of water and sediment quality	Biogenic reefs may have a significant biological filtering capacity and *L. conchilega* acts as a pump, exchanging burrow water with the overlying water (Fletcher et al. 2012; Rabaut et al. 2007). The bio-irrigation of *L. conchilega* transports both oxygen and de-nitrifiers to deeper layers in the sediment (Foshtomi et al. 2018).	2
Carbon sequestration	Coarse and gravelly sediments are comparatively low in organic carbon compared to other sedimentary habitats (Salomidi et al. 2012). However, the presence of *L. conchilega* increases retention of organic material compared to adjacent bare sediments (Smet et al. 2016). This habitat also contains a moderate amount of inorganic carbon and is still of importance in the carbon cycle (Chambers et al. 2022).	1
Healthy climate	Expert opinion - Negligible	0
Prevention of coastal erosion/Sea defence	Biogenic reefs play a role in reducing wave energy before it hits the coastline (Fletcher et al. 2012). The extent at which *L. conchilega* beds are able to dissipate wave action is low as the protruding tubes are fairly short. However, they increase the stability of the sediments, which maintains the beach level and mitigates erosion from wave action.	1
Provisioning services		

Food	While not a major commercial species, plaice (*Pleuronectes platessa*) are associated with this habitat. Spider crab is also frequently found on this habitat.	1
Fish feed	Currently not thought to contribute to fish feed in Jersey.	0
Fertiliser (and biofuels and building materials)	Negligible – expert opinion.	0
Medicines and blue biotechnology	Negligible – expert opinion.	0
Cultural services		
Tourism/recreation/ nature watching	Recreational diving occurs on this habitat, primarily due to its patchy occurrence between other habitats (such as rocky reef and seagrass that are desirable dive sites) in accessible shore dive sites. Recreational spearfishers may target this habitat in search of plaice. *L. conchilega* in the intertidal. This habitat contributes to maintaining the sediment composition which supports wading birds and various intertidal species that attract nature watchers to the shore (Bruschetti 2019).	2
Spiritual / cultural wellbeing	Low direct cultural and spiritual significance. The main cultural connection to sandmason habitat locally is its association with plaice which is typically seen on restaurant menus in the summer.	1
Aesthetic benefits	*L. conchilega* contributes to maintaining the longevity of sandflats in both the intertidal and subtidal. The intertidal flats are visible from shore and add to the aesthetics of many bays.	1
Education	Assumed benefit. This habitat has been the focus of several research projects both locally and in Brittany (Cugier et al. 2010).	2

3.1.6. Seagrass beds (A5.53)

Seagrass is an angiosperm (flowering plant) that has adapted to live in the ocean, growing in intertidal and shallow subtidal areas that are relatively sheltered. *Zostera noltei* grows in the intertidal and *Zostera marina* grows in the shallow subtidal. The root structures of the seagrass help to stabilise the sediment and the canopy formed by the blades provides shelter for many species. Seagrass is a globally important habitat that is listed under OSPAR due to its associated biodiversity, carbon capture potential, and sensitivity to disturbance. As a signatory to OSPAR, Jersey is committing to maintaining its seagrass habitats in a favourable condition.

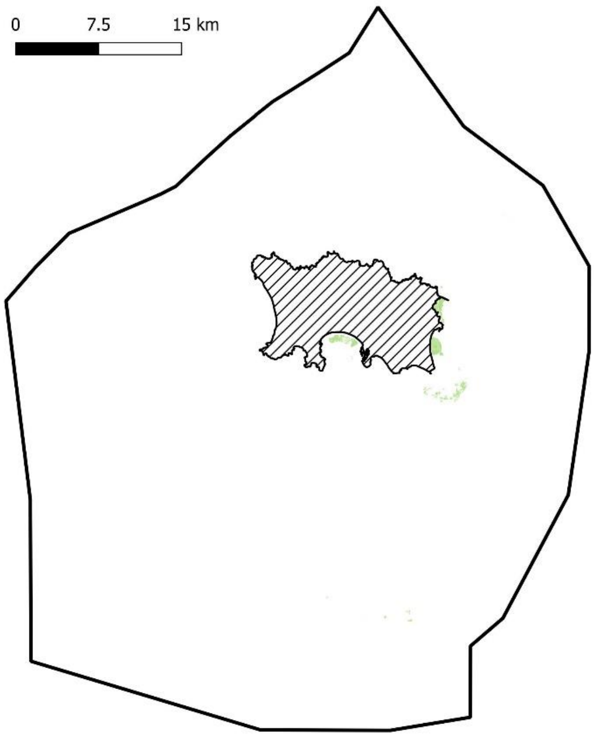

Figure 7. Spatial extent of habitat type: Seagrass beds.

Table 7. Summary of ecosystem services provided by seagrass beds and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	High (Cullen-Unsworth and Unsworth 2013; Duarte et al. 2022)	2
Larval / Gamete supply	High – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with exception of species poor, mobile sediments.	2
Nutrient cycling	Seagrass, as a flowering plant, has roots and therefore will uptake nutrients. Seagrass beds also trap and recycle nutrients (Duarte 2000).	2
Formation of species habitat	Many species, including those of commercial importance, use subtidal seagrass during some or all stages of their lifecycles (Blampied, Sheehan, et al. 2022; Cullen-Unsworth and Unsworth 2013). Juvenile black sea bream (*Spondyliosoma cantharus*) have a high association with seagrass in Jersey and are also heavily targeted commercially. Intertidal seagrass also harbours its own unique assemblage of species and also supports the foraging of wading and migratory birds, such as brent geese.	2
Formation of physical barriers	Seagrass beds are located close to coastal zones. Seagrass root structures help to stabilise sediments and the dense	2

	canopy of blades on the surface will help to dissipate wave energy before it hits the coastline.	
Formation of structure	The seascape created by seagrass is unique and provides structure on what would otherwise be bare sediments, supporting a vast range of species.	2
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not well understood how many are found on seagrass or if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	Sediments play a role in the immobilisation of pollutants (Burdige 2007). This typically occurs in lower energy environments with stable sediments, such as seagrass bed areas. The root structures stabilise the sediments and canopy of seagrass blades help to trap sediment particles that will prevent the re-mobilisation of any pollutants that may have made their way into this environment.	1
Regulation of water and sediment quality	The stabilisation of sediments provided by the network of root structures and the trapping of sediment provided by the blades helps to maintain water clarity, while the uptake of nutrients from this flowering plant during spring and early summer helps to maintain water quality (Moore, Beach, and Moore 2004).	2
Carbon sequestration	Seagrass has been identified as one of the major carbon sinks in the marine environment (Fourqurean et al. 2012). Different species of seagrass beds sequester carbon at different rates, and while the seagrass species in Jersey (*Zostera marina* and *Z. noltei*) do not sequester carbon to the same degree as species such as *Posedonia* (Pergent-martini 2021), the seagrass in Jersey is still capable of storing regionally significant quantities of carbon (Prentice et al. 2020) and is the greatest carbon sequestrating habitat per unit area in Jersey.	2
Healthy climate	See above.	2
Prevention of coastal erosion/sea defence	The location of seagrass close to shore and its stabilising effect on sediments will contribute to the buffering of wave action on coastal areas.	2
Provisioning services		
Food	Seagrass beds support global fisheries production (Unsworth, Nordlund, and Cullen-Unsworth 2019) and in Jersey they support several fishery species during certain life stages (Blampied, Sheehan, et al. 2022). Seagrass is particularly important for juvenile black sea bream (*Spondyliosoma cantharus*) (Blampied, Rees, et al. 2022; Jackson et al. 2002).	2
Fish feed	There are currently no species associated with seagrass that are targeted for fish feed in Jersey.	0
Fertiliser (and biofuels and building materials)	Seagrass has potential in the production of biofuel (Ravikumar, Kanagavel, and Thajuddin 2011) but is currently not harvested for any purpose in Jersey. There are also agricultural uses for seagrass (Aryuthaka et al. 2004) but due to its high importance for biodiversity and carbon sequestration it is unlikely that seagrass extraction would be permitted in Jersey.	1

Medicines and blue biotechnology	There may be several uses for seagrass in medicine and human health such as in cancer and diabetes therapies (Vasarri et al. 2021), anti-inflammatories (Hua et al. 2006) and anti-oxidants (Yuvaraj et al. 2012). *Zostera marina* contains the pectin zosterin which may have gastroprotective properties (Khasina, Tiupeleev, and Sgrebneva 2004). There are additional uses for seagrass in biotechnology (Heo, Lee, and Chung 2021).	2
Cultural services		
Tourism/recreation/ nature watching	Seagrass is important for tourism, recreation and nature watching, both intertidally and subtidally. The subtidal seagrass attracts divers, snorkellers, spearfishers and to some extent swimmers due to the high water clarity typically associated with seagrass areas. The intertidal seagrass attracts nature watchers in search of wading and migratory birds.	2
Spiritual / cultural wellbeing	There is a cultural significance to seagrass as it has been a part of the intertidal and shallow subtidal for many decades where it has supported many species of importance to the island, such as juvenile pollack in the subtidal seagrass and brent geese in the intertidal seagrass in the winter.	2
Aesthetic benefits	Seagrass is a vibrant jade green and is typically found in sheltered bays where it is visible at low tide. The canopy of seagrass blades standing tall off the seabed at high tide create a unique seascape that is populated by small gobies and dragonettes, juvenile wrasse, bream and pollack, catsharks, cuttlefish, crabs (including spider crab) and the occasional shoal of bass or mullet.	2
Education	The education benefits of seagrass are numerous, especially the intertidal seagrass that is highly accessible from shore that can be explored by school groups. Both the intertidal and subtidal seagrass have been the focus of many research projects locally, and seagrass worldwide has been studied extensively (S. Blampied 2022; Cullen-Unsworth and Unsworth 2013; Fourqurean et al. 2012; Irlandi, Orlando, and Ambrose 1999; Jackson et al. 2015; Unsworth et al. 2010).	2

3.1.7. Sediment: sparse fauna

Clean mobile sands (coarse, medium and fine) supporting a limited range of species. This habitat group includes barren, highly mobile sands and shingle at one end of the spectrum and relatively stable, clean sands at the other that support communities of isopods, amphipods and some polychaetes.

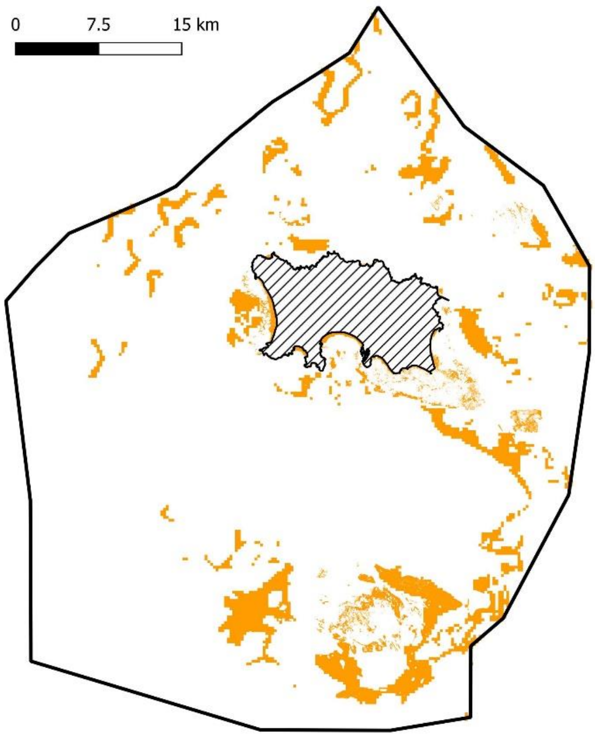

Figure 8. Spatial extent of habitat type: Sediment: sparse fauna.

Table 8. Summary of ecosystem services provided by Sediment: sparse fauna and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Low – expert opinion based on information from other habitats (Cramer and Katz 2021; Duarte et al. 2022; Ní Longphuirt et al. 2007)	1
Larval / Gamete supply	Low – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with the exception of species poor, mobile sediments. Brown crab is a key species that is known to use sediments during spawning but brown crab also migrate outside of Jersey waters into deeper water to spawn.	1
Nutrient cycling	Low (Galparsoro et al. 2014). The relatively low biodiversity in this habitat does not lend itself to productive nutrient cycling.	1
Formation of species habitat	High energy, mobile sediments exhibit relatively low infaunal and epifaunal biodiversity (Roche et al. 2007) but do provide habitat for certain species such as sand eel which in turn are a prey source for many other species. The mobile nature of this habitat means there is little opportunity for species to colonise the sediments.	1
Formation of physical barriers	Negligible – expert opinion.	0

Formation of structure	Wide areas of mobile sand form a very basic seascape with little features to provide complexity or shelter for marine species. However, as part of a wider seascape that comprises areas of gravelly sand amongst other habitat types, it is an important component in supporting habitat connectivity. This habitat may also play a part in replenishing beaches (Salomidi et al. 2012).	1
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not thought that many are found on mobile sand or if there are any species that are acting as a biological control on them – further research is needed.	0
Natural hazard regulation	Sediments play a role in the immobilisation of pollutants (Burdige 2007). However, this typically only occurs in lower energy environments with stable sediments. Mobile sand is, as the name suggests, highly mobile. This constant movement will result in mixing of sediments and the re-mobilisation of any pollutants that may have made their way into this environment.	0
Regulation of water and sediment quality	Negligible due to the high energy environment and low species diversity/lack of filter feeding organisms.	0
Carbon sequestration	Mobile sediments are comparatively low in organic carbon compared to other sedimentary habitats (Salomidi et al. 2012). However, this habitat contains a moderate amount of inorganic carbon and is still of importance in the carbon cycle (Chambers et al. 2022).	1
Healthy climate	Expert opinion - Negligible	0
Prevention of coastal erosion/Sea defence	This habitat may play a part in replenishing beaches (Salomidi et al. 2012).	1
Provisioning services		
Food	Indirectly provides food as sand eels are associated with this habitat and they support many commercially targeted species such as bass.	1
Fish feed	Sand eels, that are associated with gravelly sands, have been targeted for fish feed in other parts of the world (Samuelsen et al. 2014) but currently are not targeted in Jersey.	0
Fertiliser (and biofuels and building materials)	Negligible. Sand could be extracted for use in building materials but is currently not practiced in Jersey.	0
Medicines and blue biotechnology	Negligible – expert opinion.	0
Cultural services		
Tourism/recreation/ nature watching	While this habitat itself does not attract recreational divers, the presence of sand eels attracts diving seabirds such as gannets that are sometimes sought by nature watching vessels.	1
Spiritual / cultural wellbeing	Low direct cultural and spiritual significance but the capture of sand eels on this habitat feeds into the local bass fishery which has a strong cultural significance with islanders.	1
Aesthetic benefits	Low/negligible aesthetic benefit – expert opinion.	0
Education	Assumed benefit. This habitat has been the focus of several research projects, including a recent project to understand how this habitat is supporting the local puffin population.	2

3.1.8. Sediment: rich fauna

Moderately exposed and sheltered subtidal sediments (fine sands and muds with gravel and pebbles) that are characterised by a diverse assemblage of infaunal polychaetes, bivalves, amphipods. Many of the infaunal species are tube building filter or deposit feeders.

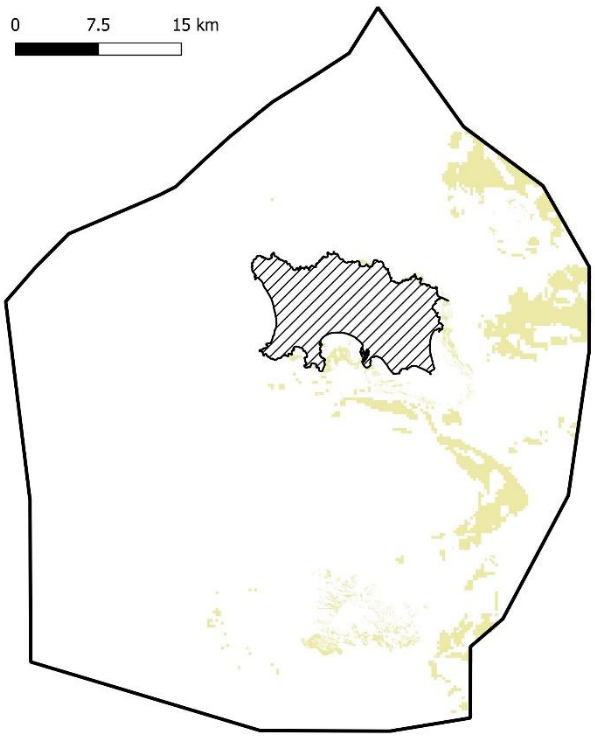

Figure 9. Spatial extent of habitat type: Sediment: rich fauna.

Table 9. Summary of ecosystem services provided by Sediment: rich fauna and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Moderate – expert opinion based on information from other habitats (Duarte et al. 2022; Ní Longphuirt et al. 2007).	1
Larval / Gamete supply	High – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with the exception of species poor, mobile sediments.	2
Nutrient cycling	Rich sediments harbour many infaunal species, many of which will be filter feeders and bioturbators that contribute to nutrient cycling (Welsh 2003).	2
Formation of species habitat	This habitat has a rich assemblage of infaunal species, primarily from the classes Bivalvia and Annelida (in particular Polychaete).	2

Formation of physical barriers	This habitat is unlikely to form a physical barrier to currents or wave actions.	0
Formation of structure	This habitat has relatively little structure associated with it, with the main features and species being infaunal. However, as part of a wider seascape that comprises areas of gravel and sand amongst other habitat types, it is an important component in supporting habitat connectivity. This habitat may also play a part in replenishing beaches (Salomidi et al. 2012).	1
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not thought that many are found on rich basin gravel and sand or if there are any species that are acting as a biological control – further research is needed.	0
Natural hazard regulation	Sediments play a role in the immobilisation of pollutants (Burdige 2007). This typically only occurs in lower energy environments with stable sediments. The rich basin gravel and sand may be subject to high tidal streams but is also located in one of Jersey's sediment basins to the east of the island. The deposition of sediment in this area may help to immobilise pollutants.	1
Regulation of water and sediment quality	The rich assemblage of filter feeding and bioturbating organisms will contribute to water and sediment quality.	2
Carbon sequestration	Gravelly sediments are typically low in organic carbon compared to other sedimentary habitats (Salomidi et al. 2012). However, the rich infaunal component of this habitat may contribute slightly to carbon sequestration, particularly in the finer and muddier sediments that form part of this habitat. This habitat is also located in one of the primary sediments basins in Jersey which is thought to be a sink for carbon produced in other areas of Jersey waters (Chambers et al. 2022).	2
Healthy climate	Expert opinion - Negligible	0
Prevention of coastal erosion/sea defence	This habitat may play a part in replenishing beaches (Salomidi et al. 2012).	1
Provisioning services		
Food	Locally, this habitat is targeted by scallop dredgers and divers and whelk potters as both king scallop (*Pecten maximus*) and whelk (*Buccinum undatum*) are associated with this habitat type. The bivalve component of this habitat will serve as a food source for other commercial species such as lobster (*Homarus gammarus*). Other commercial species that are supported by this habitat are spider crab (*Maja brachydactyla*), brown crab (*Cancer pagurus*), flat fish (such as *Solea solea* and *Pleuronectes platessa*) and rays (*Raja* spp.).	2
Fish feed	Sand eels, that are associated with gravels and sands, have been targeted for fish feed in other parts of the world (Samuelsen et al. 2014) but currently are not targeted in Jersey.	0

Fertiliser (and biofuels and building materials)	Negligible. Gravels and sands could be extracted for use in building materials but is currently not practiced in Jersey.	0
Medicines and blue biotechnology	Negligible – expert opinion.	0
Cultural services		
Tourism/recreation/ nature watching	This this habitat is typically not used for recreational purposes, in part due to its distance from land (making it relatively inaccessible) and lack of features on the seabed, but also in part due to the high level of commercial activity making it unattractive for recreational divers. However, this habitat will be supporting recreational angling from boats.	1
Spiritual / cultural wellbeing	This habitat has cultural significance in terms of the key commercial species that are caught there (scallop and whelk). Scallop in particular is sought by both commercial and recreational pursuits and many restaurants in Jersey will advertise the option of local scallops on their menus. Jersey hand dived scallop is a local brand set up by the Blue Marine Foundation to promote awareness of sustainably sourced seafood.	1
Aesthetic benefits	Low/negligible aesthetic benefit but to the lack of seabed features – expert opinion.	0
Education	Assumed benefit.	2

3.1.9. Rock: kelp (A3.21)

Rock substrate that is dominated primarily by kelp but also associated seaweed species. Kelp is a fast growing brown algae that creates habitat for other species. Both kelp forest (dense kelp areas) and kelp park (patchy kelp areas) have been grouped for this assessment as they provide similar ecosystem services. Kelp forest is an OSPAR priority habitat due to its role in supporting biodiversity and its role in the carbon cycle.

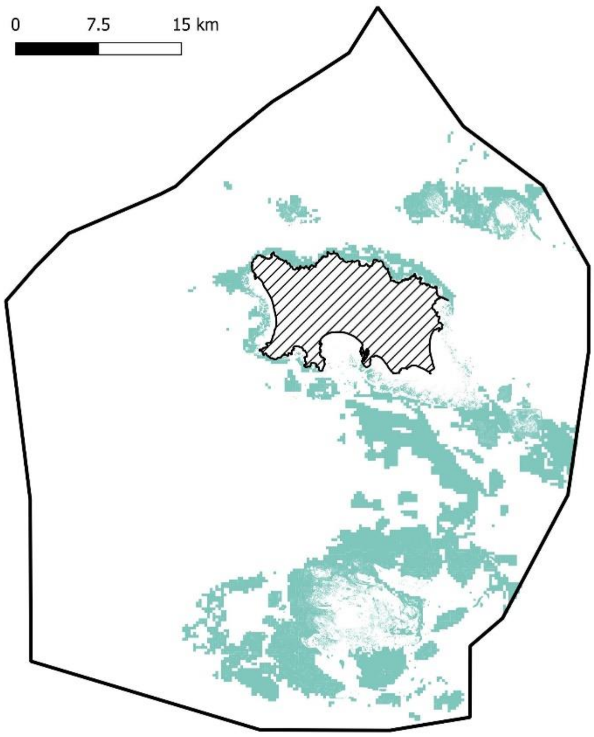

Figure 10. Spatial extent of habitat type: Kelp forest.

Table 10. Summary of ecosystem services provided by kelp forest and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	High Net Primary Production (Cramer and Katz 2021; Duarte et al. 2022)	2
Larval / Gamete supply	High – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with the exception of species poor, mobile sediments.	2
Nutrient cycling	Kelp contributes to Carbon, Nitrogen and Phosphorus cycling (Eger et al. 2021). Nutrient cycling services provided by coastal algae and seagrass beds were collectively estimated to contribute $28,916 USD (calculated from 2007 monetary values) per hectare per year (Costanza et al. 2014).	2
Formation of species habitat	Habitats that provide structure on the seafloor typically have higher associated biodiversity (Teagle et al. 2017), and kelp forests support higher levels of biodiversity than less complex, unstructured habitats (Smale et al. 2013).	2
Formation of physical barriers	Kelp creates a physical barrier in the upper infralittoral zone, typically just below the low water mark to around 20 m depth. The dense layer of kelp will help to dissipate wave energy before it hits the shore.	1

Formation of structure	The dense layer of kelp forms an unmistakable seascape of kelp fronds that stand around a meter tall off of their rocky base. Many seaweeds and encrusting organisms grow on the stalks of the kelp (Smale et al. 2020), creating a unique assemblage beneath the canopy that is seen from above. The presence of kelp habitat is also important for wider, connected seascapes that comprise a variety of habitats and create structural complexity that influences nursery function (Olson et al. 2019).	2
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not well understood how many are found in kelp forests or if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	No literature available.	0
Regulation of water and sediment quality	While kelp will influence the hydrodynamics of coastal environments (Rosman et al. 2007), it is unclear whether this aids in maintaining both water and sediment quality.	0
Carbon sequestration	Kelp contributes to the standing stock of carbon (Chambers et al. 2022) but it is unclear how much kelp biomass is sequestered for long term storage (Smale et al. 2013). Some macroalgae from the intertidal eventually becomes incorporated in deeper water sediments (Queirós et al. 2019) but the scale at which this occurs is currently not understood.	1
Healthy climate	The high biomass of photosynthesising algae associated with this habitat will contribute to the carbon cycle by taking up carbon dioxide from the water and releasing oxygen.	1
Prevention of coastal erosion/Sea defence	See 'formation of physical barriers'. While kelp will help to dissipate wave energy, this will only be most effective at low tide, and will have a lesser effect on preventing storm damage to coastal areas at high tide.	1
Provisioning services		
Food	Kelp supports various fisheries species worldwide (Eger et al. 2021; Smale et al. 2022). In Jersey, kelp is a key habitat for commercially targeted round fish such as Pollack (*Pollachuis pollachius*) and bass (*Dicentrarchus labrax*) in addition to providing foraging grounds for crab and lobster. Spider crab (*Maja brachydactyla*) in particular use this habitat as both a nursery and a foraging ground (Gonzalez-Gurriaran and Freire 1994).	2
Fish feed	Currently not thought to contribute to fish feed in Jersey.	0
Fertiliser (and biofuels and building materials)	Kelp is high in nutrients and alginates and has been used as fertiliser in agriculture and in domestic settings (Smale et al. 2013), including in Jersey. Kelp is being investigated as a source for biofuel and 'kelp ash' has been used in various practices (Smale et al. 2013) but is currently not harvested in Jersey for these purposes.	2
Medicines and blue biotechnology	In the past, kelp may have been used in medicine for it's iodine content. However, iodine derived from kelp is not currently	1

	used in modern day medical practices. There may be a place for kelp in cancer therapies (Clark, Bassett, and Burge 2003) or in biotechnologies (Qin, Jiang, and Tseng 2005).	
Cultural services		
Tourism/recreation/ nature watching	Many fish species take shelter or forage in the kelp, attracting recreational fishers, in particular spear fishers, and divers (Beaumont et al. 2008). The giant kelp in California is associated with seals and otters which draw in visitors. While this is less the case in Jersey, there are other species associated with the kelp that will attract diving tourism.	2
Spiritual / cultural wellbeing	As a habitat that is rarely visible from land, it may have less spiritual and cultural significance with local communities except for perhaps its use in agriculture. However, in some countries there is a cultural heritage tied to kelp (Vásquez et al. 2014). Some of the species associated with kelp may have a greater significance in Jersey as species such as pollack and bass have a cultural significance within fishing communities in Jersey.	1
Aesthetic benefits	The seascape formed by kelp and the species that inhabit it provide an aesthetic beauty that benefits snorkellers and divers, and also has been featured on programmes such as Blue Planet.	2
Education	Kelp is often used as an example of an ecosystem engineer in higher level education – as the loss of kelp from urchin grazing and the subsequent shift in habitat has been well documented.	1

3.1.10. Maerl beds (A5.51)

Maerl is a free growing, coralline red alga that forms nodular and branched structures on the sea floor. These nodules create dense accumulations on the seafloor that provides structure and habitat for many other species. This habitat is characterised by diverse infaunal communities, in particular bivalves, including the commercially important king scallop (*Pecten maximus*). Seagrass is a globally important habitat that is listed under OSPAR due to its associated biodiversity and sensitivity to certain fishing methods, and Jersey is committing to maintaining its maerl habitats in a favourable condition as a signatory to OSPAR.

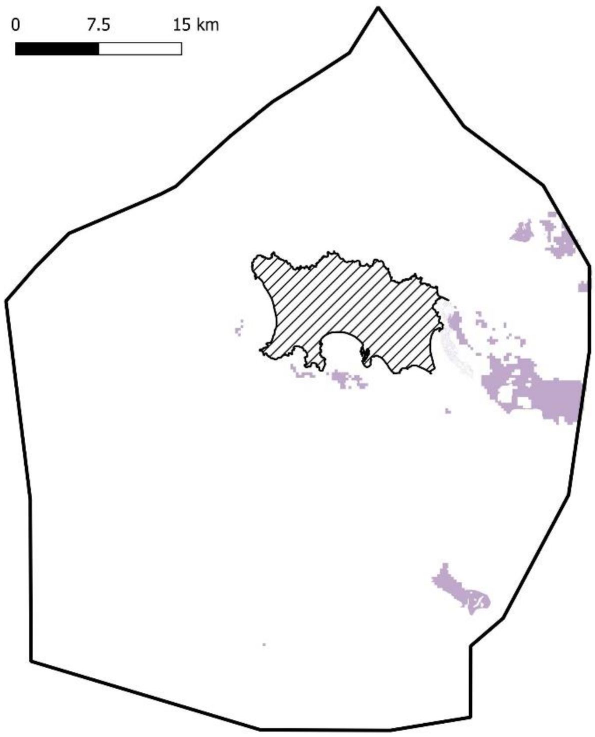

Figure 11. Spatial extent of habitat type: Maerl beds.

Table 11. Summary of ecosystem services provided by maerl beds and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Low/moderate NPP: 0.107 kg C/m^2/year (Duarte et al. 2022), greater than *Crepidula* but similar to fine sand (Ní Longphuirt et al. 2007).	2
Larval / Gamete supply	High – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with exception of species poor, mobile sediments.	2
Nutrient cycling	High/moderate (Sophie Martin et al. 2007; Potts et al. 2014)	2
Formation of species habitat	Maerl is an ecosystem engineer that forms a complex 3D structure on the seafloor. This complexity creates habitat for many infaunal and epifaunal species which in turn supports greater overall biodiversity. Bivalves, such as clams and scallops (both *Pecten maximus* and *Aquipecten opercularis*), are highly associated with maerl habitat.	2
Formation of physical barriers	While maerl creates a 3D structure, it is a relatively thin layer on the seabed (between 2 and 10 cm thick) that is also not stable as maerl grows in nodules and branches that are free standing and can be moved with the currents. In some areas where the maerl is very thick, it may form a partial barrier between the water column and the sediments underneath.	1

Formation of structure	Maerl creates a unique seascape. Where maerl is present the seabed is pink/purple in colour and typically characterised by algal species growing in association with the maerl and many burrowing species, some of which are visible from the surface, such as sea cucumbers that have their feeding appendages out to catch food drifting past. Some dragonettes that are associated with maerl habitat are more brightly coloured than their sand dwelling varieties, helping them to blend in with their more colourful environment.	2
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not well understood how many are found on maerl or if there are any species that are acting as a biological control on these species – further research is needed. It is worth noting that the invasive slipper limpet tends to preferentially colonise maerl beds, which maybe as a result of dredging on this habitat that creates furrows ideal for slipper limpet settlement.	0
Natural hazard regulation	Sediment stability may play a role in the immobilisation of pollutants (Barjoveanu et al. 2018). In areas where maerl is able to build up into a dense layer, it may prevent the mobilisation of buried contaminants within the sediments below.	1
Regulation of water and sediment quality	The presence of filter feeding organisms that are associated with maerl, such as bivalves and burrowing polychaetes, will aid in maintaining water quality. Maerl also has a high phosphorus absorbing capacity (Gray et al. 2000).	2
Carbon sequestration	Maerl is a significant standing stock of carbon but it is unlikely to sequester carbon over short time-scales (Chambers et al. 2022; Cott, Beca-Carretero, and Stengel 2021; Porter et al. 2020). Emphasis should be on protecting longstanding maerl beds to preserve historic stored carbon instead of protecting degraded maerl ecosystems to increase carbon sequestration.	1
Healthy climate	Dead maerl and dead shell material within maerl beds may buffer the effects of ocean acidification as the increasing acidity will dissolve the calcareous skeletons, releasing calcium carbonate into the water column that will neutralise dissolved carbon dioxide. Although it is thought that the scale at which this would happen is unlikely to noticeably buffer the effects of ocean acidification (Andersson and MacKenzie 2012).	0
Prevention of coastal erosion/sea defence	Negligible – expert opinion. While maerl can be located close to the coast it is not stable enough to act as buffer from storm damage.	0
Provisioning services		
Food	Maerl supports the commercially important king scallop (*Pecten maximus*) in all stages of its life cycle (Blampied, Sheehan, et al. 2022; Hall-Spencer et al. 2003). Scallop is one of the top fish commercially important species in Jersey in terms of weight and value landed annually (Marine Resources 2019). There are also other bivalve species (dog cockle and praire) associated with maerl that may be targeted for food. Additionally, the high biodiversity associated with maerl beds	2

	will also support many other species, some of which are exploited as a food source.	
Fish feed	There are currently no species associated with maerl that are targeted for fish feed in Jersey.	0
Fertiliser (and biofuels and building materials)	Live and dead maerl can be harvested as a source of lime and trace elements for agricultural use and as water filtration agents (Freire et al. 2016; Salomidi et al. 2012). However, there are no extractive practices on maerl in Jersey, this is in part due to its priority as a conservation habitat.	1
Medicines and blue biotechnology	Live and dead maerl can be harvested for use as a bioactive compound in the treatment of osteoporosis (Carson and Clarke 2018).	1
Cultural services		
Tourism/recreation/ nature watching	The high biodiversity associated with maerl attracts recreational divers.	1
Spiritual / cultural wellbeing	There is a cultural significance of scallop and clam species associated with maerl beds as they are sought by both commercial and recreational pursuits. Jersey hand dived scallop is a local brand set up by the Blue Marine Foundation to promote awareness of sustainably sourced seafood. Many restaurants in Jersey will advertise the option of local scallops on their menus.	2
Aesthetic benefits	The seascape formed by maerl is highly aesthetic due to the pink and purple hue it affords the seabed and the abundance of species such as anemones and red algaes visible amongst and on the maerl. However, due to its subtidal nature it is not visible to the majority of the public.	1
Education	Assumed benefit. Maerl has been the focus of many research projects both internationally and locally (Blampied, Sheehan, et al. 2022; S. R. Blampied 2022; Chambers et al. 2019). Jersey hand dived scallop is a local brand aimed at promoting the awareness of sustainably sourced seafood which highlights the importance of protecting scallop habitat to safeguard the future of this fishery.	2

3.1.11. Slipper limpets (A5.431)

Medium and coarse sands with gravel, shells, pebbles and cobbles on moderately exposed coasts that support populations of the slipper limpet *Crepidula fornicata*. The slipper limpets grow in chains on the seabed and can rapidly colonise an area, altering the biotope. Ascidians and anemones may grow on the shells of dead slipper limpets.

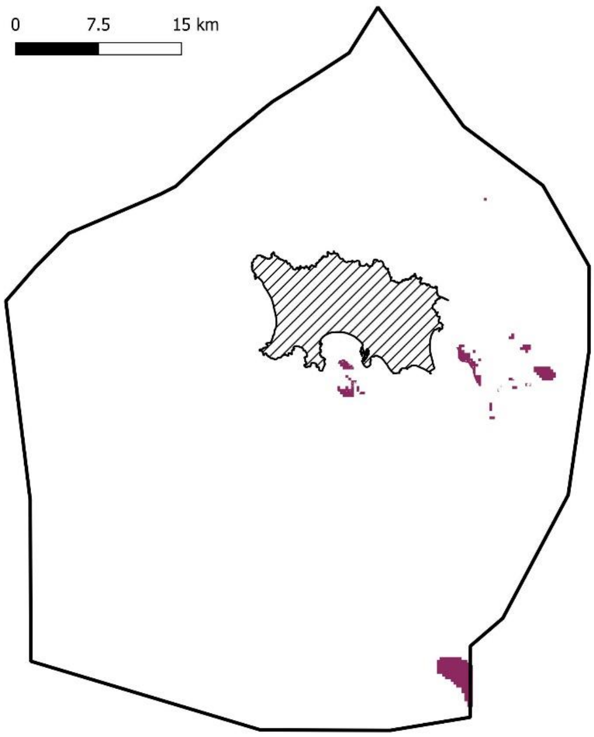

Figure 12. Spatial extent of habitat type: Slipper limpets.

Table 12. Summary of ecosystem services provided by slipper limpets and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Low Primary Productivity (PP) (Ní Longphuirt et al. 2007) (Androuin et al. 2018)(Cugier et al. 2010). Presence of *Crepidula* increases PP compared to bare sediments, but PP is low compared to macroalgal habitats (based on comparisons between (Ní Longphuirt et al. 2007) and (Duarte et al. 2022).	1
Larval / Gamete supply	High – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with the exception of species poor, mobile sediments.	2
Nutrient cycling	As filter feeders, slipper limpets have a role in nutrient cycling (Cugier et al. 2010). However, slipper limpets can compact sediments (Blanchard 2009), preventing the transport of nutrients to and from the sediments.	1
Formation of species habitat	Slipper limpets alter the sediments, enhance the growth of microphytobenthic biofilms (Androuin et al. 2018) and create a stability that will favour the settlement of some species (Androuin et al. 2014). However, this process is more likely to render the substrate uninhabitable for the species previously living there (Blanchard 2009), particularly where maerl beds are concerned, or compete with other molluscs such as the	0

	commercially important King scallop (*Pecten maximus*) (Menesguen and Gregoris 2018). Dense aggregations of slipper limpets also negatively impact on the density of juvenile common sole (*Solea solea*) in the Bay of Biscay (Pape, Guérault, and Désaunay 2004).	
Formation of physical barriers	Slipper limpets may form a physical barrier between the water column and the sediments below as they produce an excrement that, when in dense enough aggregations, can compact the sediment preventing the movement of water, nutrients and infaunal species across the surface layer (Blanchard 2009). It is not thought that slipper limpets provide a physical barrier to mitigate wave action from storms.	0
Formation of structure	Slipper limpets are ecosystem engineers and will alter the environment when they are in dense aggregations (Androuin et al. 2018).	1
Regulating services		
Biological control	Expert opinion	0
Natural hazard regulation	Expert opinion – dense slipper limpet aggregations may contribute to the immobilisation of pollutants as they compact the underlying sediments (Blanchard 2009).	1
Regulation of water and sediment quality	Filter feeding contributes to regulation of water quality (Cugier et al. 2010), but compaction of sediments may negatively impact on sediment quality.	1
Carbon sequestration	*Crepidula* beds are a source of carbon rather than a sink (Martin et al. 2006; S Martin et al. 2007).	0
Healthy climate	*Crepidula* beds are a source of carbon rather than a sink (Martin et al. 2006; S Martin et al. 2007).	0
Prevention of coastal erosion/ Sea defence	No literature available/not applicable	0
Provisioning services		
Food	Negligible. Leloup et al. (2008) found the slipper limpet beds at the nearby Mont St. Michel to be a trophic dead end. While slipper limpets themselves are edible, there is currently no market for them. The species associated with this habitat tend to be scavengers and are typically not targeted as a food source.	0
Fish feed	Slipper limpets themselves are not used as fish feed, nor are any species associated with slipper limpet habitat targeted for this purpose.	0
Fertiliser (and biofuels and building materials)	Slipper limpets may be used in industry in cement material (Bouasria et al. 2021)	1
Medicines and blue biotechnology	Currently no known use of slipper limpets in biotechnology or medicine.	0
Cultural services		
Tourism/recreation/ nature watching	Expert opinion. As slipper limpets typically do not create an aesthetically pleasing seascape, nor do they have charismatic species associated with them, it is not sought by recreational divers.	0
Spiritual / cultural wellbeing	No literature available/not applicable	0

Aesthetic benefits	Expert opinion – decreases the aesthetic beauty of marine landscapes	0
Education	Assumed benefit. Slipper limpets provide a classic example of invasive species colonisation that can be used in higher education studies.	2

3.1.12. Sediment: robust fauna

Moderately exposed or tide swept subtidal coarse sand and gravel that is characterised by robust infaunal species such as bivalves, polychaetes and mobile crustacea. Certain species of sea cucumber may be prevalent in areas of this habitat.

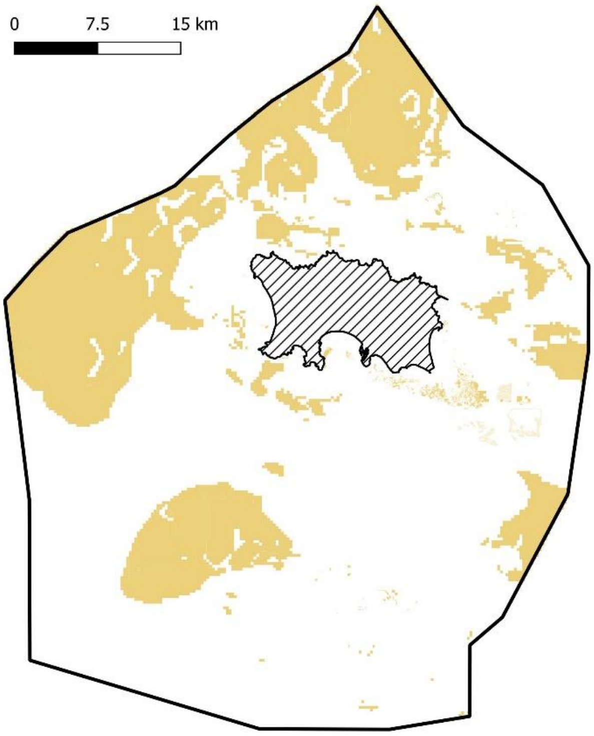

Figure 13. Spatial extent of habitat type: Sediment: robust fauna.

Table 13. Summary of ecosystem services provided by basin gravel and sand and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Moderate/Low Primary Production (Cramer and Katz 2021; Ní Longphuirt et al. 2007)	1
Larval / Gamete supply	Low – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with exception of species poor, mobile sediments.	1
Nutrient cycling	Low (Galparsoro et al. 2014). The relatively low biodiversity in this habitat does not lend itself to productive nutrient cycling. However, bivalve species associated with this habitat will aid in nutrient cycling to some extent.	1

Formation of species habitat	Gravelly sediments exhibit relatively low infaunal and epifaunal biodiversity (Roche et al. 2007) but do provide habitat for certain species such as sand eel which in turn are a prey source for many other species. Additionally, some areas of this habitat may support dense aggregations of king scallop (*Pecten maximus*) that are commercially important locally.	1
Formation of physical barriers	Negligible – expert opinion.	0
Formation of structure	Wide areas of gravelly sand form a very basic seascape with little features to provide complexity or shelter for marine species. However, as part of a wider seascape that comprises areas of gravelly sand amongst other habitat types, it is an important component in supporting habitat connectivity. This habitat may also play a part in replenishing beaches (Salomidi et al. 2012).	1
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not thought that many are found on sediments with robust fauna or if there are any species that are acting as a biological control on them – further research is needed.	0
Natural hazard regulation	Sediments play a role in the immobilisation of pollutants (Burdige 2007). However, this typically only occurs in lower energy environments with stable sediments. Basin gravel and sand may be subject to high tidal streams that will result in mixing, re-mobilising any pollutants that may have made their way into this environment.	0
Regulation of water and sediment quality	Overall low due to the high energy environment and relatively low species diversity. The presence of filter feeding species, such as scallop, clams and sea cucumbers in some areas will aid in maintaining water quality.	1
Carbon sequestration	Gravelly sediments are comparatively low in organic carbon compared to other sedimentary habitats (Salomidi et al. 2012). However, this habitat contains a moderate amount of inorganic carbon and is still of importance in the carbon cycle (Chambers et al. 2022).	1
Healthy climate	Negligible - Expert opinion	0
Prevention of coastal erosion/Sea defence	This habitat may play a part in replenishing beaches (Salomidi et al. 2012).	1
Provisioning services		
Food	Areas of this habitat support King scallop (*Pecten maximus*) that is heavily targeted commercial species. It also may indirectly provide food as sand eels are associated with this habitat and they support many commercially targeted species. Black seabream (*Spondyliosoma cantharus*) are also associated with this habitat.	1
Fish feed	Sand eels, that are associated with gravelly sands, have been targeted for fish feed in other parts of the world (Samuelsen, Mjos, and Oterhals 2014) but currently are not targeted in Jersey.	0

Fertiliser (and biofuels and building materials)	Negligible. Gravels and sands could be extracted for use in building materials but is currently not practiced in Jersey.	0
Medicines and blue biotechnology	Negligible – expert opinion.	0
Cultural services		
Tourism/recreation/ nature watching	While this habitat itself does not attract recreational divers, the presence of sand eels attracts diving seabirds such as gannets and puffins that are sometimes sought by nature watchers and tour boats.	1
Spiritual / cultural wellbeing	Moderate cultural and spiritual significance as the associated scallop is valued locally, with many restaurants in Jersey advertising the option of local scallops on their menus. Further, the capture of sand eels on this habitat feeds into the local bass fishery and supports the puffin population, both of which have a strong cultural significance with islanders.	1
Aesthetic benefits	Low/negligible aesthetic benefit – expert opinion.	0
Education	Assumed benefit. This habitat has been the focus of several research projects, including a recent project to understand how this habitat is supporting the local puffin population.	2

3.1.13. Hard ground - unstable (A5.141)

This habitat is very different in its faunal assemblages compared to stable hard ground (A4.13) as the unstable nature of this habitat limits colonisation to fast growing and robust species. This biotope is typically characterised by a few robust, fast growing species that are able to colonise pebbles and cobbles that are regularly moved by tidal currents. The calcareous tube worm, *Pomatoceros triqueter*, is a dominant species on this habitat.

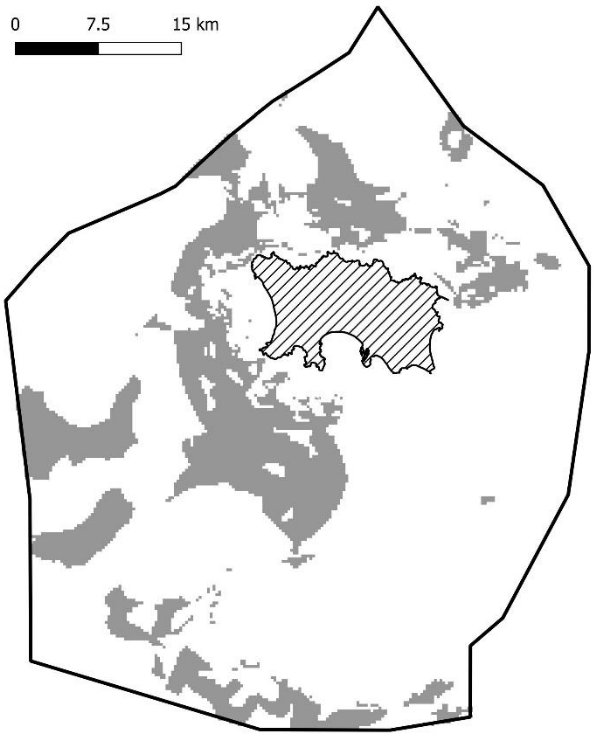

Figure 14. Spatial extent of habitat type: Hard ground - unstable.

Table 14. Summary of ecosystem services provided by unstable hard ground and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Low – expert opinion based on information from other habitats (Cramer and Katz 2021; Duarte et al. 2022; Ní Longphuirt et al. 2007)	1
Larval / Gamete supply	Low – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with exception of species poor, mobile sediments. This habitat in particular is known to be used by black seabream (*Spondyliosoma cantharus*) to build nests in which eggs will be laid.	1
Nutrient cycling	Low as there are little in the way of filter feeding organisms.	1
Formation of species habitat	The high energy environment combined with the unstable nature of the substrates results in a relatively low biodiversity, with most species being robust and fast growing. In lower energy environments, this habitat may support a diverse assemblage (Salomidi et al. 2012), but in Jersey it is typically characterised by barnacles and encrusting coralline algae and bryozoans.	1
Formation of physical barriers	Unstable hard ground isn't thought to have a significant effect on currents or wave energy.	0

Formation of structure	Wide areas of unstable cobbles form a very basic seascape with little features to provide complexity or shelter for marine species. However, as part of a wider seascape it may be an important component in supporting habitat connectivity.	1
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not well understood how many are found on unstable hard ground or if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	Negligible – expert opinion. No stable sediment or burrowing filter feeders.	0
Regulation of water and sediment quality	Negligible – expert opinion. No stable sediment or burrowing filter feeders.	0
Carbon sequestration	This habitat is considered to have a low carbon sequestration value (Chambers et al. 2022). There are few algal species and also little sediment and therefore no pathways for carbon burial.	0
Healthy climate	No literature available but thought to be negligible.	0
Prevention of coastal erosion/Sea defence	Negligible – this habitat is not located close to shore.	0
Provisioning services		
Food	Scallops are associated with this habitat but it typically isn't targeted by dredges due to the rough terrain. Scallop divers will target the shallower areas of this habitat to collect scallops.	1
Fish feed	Currently not thought to contribute to fish feed in Jersey.	0
Fertiliser (and biofuels and building materials)	This habitat is not currently exploited for fertiliser or biofuel purposes.	0
Medicines and blue biotechnology	Currently not thought to provide any medical or biotechnological uses.	0
Cultural services		
Tourism/recreation/ nature watching	This habitat does not typically attract divers or nature watchers.	0
Spiritual/cultural wellbeing	Low/negligible cultural and spiritual significance as there are no key commercial or locally valuable species associated with this habitat.	0
Aesthetic benefits	Low/negligible aesthetic benefit – expert opinion.	0
Education	Assumed benefit.	1

3.1.14. Hard ground - stable (A4.13)

Moderately exposed circalittoral bedrock and boulders dominated by encrusting sponges, ascidians, hydroids and bryozoans. This habitat also supports a diverse number of anemones, echinoderms, crustaceans and soft corals (such as pink seafan, *Eunicella verrucosa*, and dead mans fingers, *Alcyonium digitatum*).

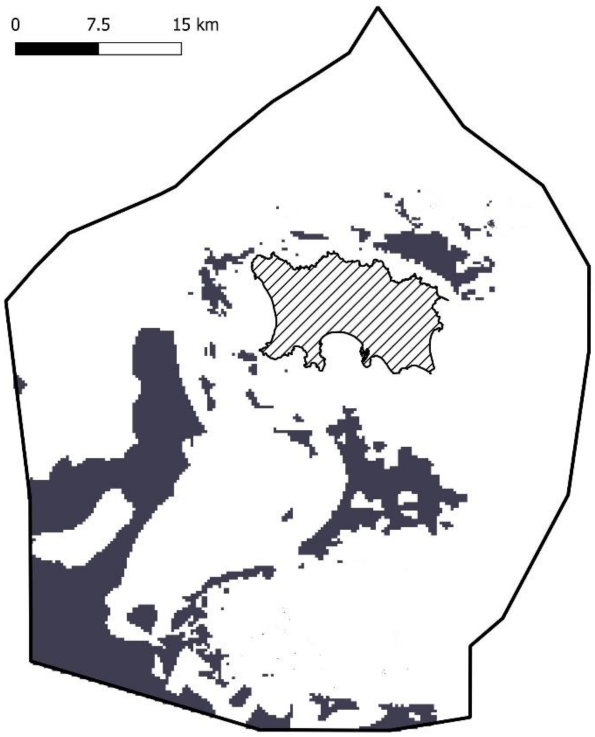

Figure 15. Spatial extent of habitat type: Hard ground - stable.

Table 15. Summary of ecosystem services provided by stable hard ground and supporting literature.

Ecosystem service	Literature	Rank
Supporting services		
Primary production	Moderate Primary Production (Cramer and Katz 2021).	1
Larval / Gamete supply	High – Expert opinion. Due to the strong tidal regimes and numerous species that reproduce through larval release, it is assumed that most habitats are equally supporting this ES, with the exception of species poor, mobile sediments.	2
Nutrient cycling	The associated sponge communities with this habitat are important contributors to nutrient cycling (Bell 2008; Salomidi et al. 2012).	2
Formation of species habitat	The three-dimensional structure created by the turf and filter feeding organisms provides habitat for many other species, including those of commercial importance (Salomidi et al. 2012).	2
Formation of physical barriers	The bedrock and boulders will create a physical barrier to currents, influencing water flow. The extent to which this occurs in Jersey is not well understood.	1
Formation of structure	The seascape created by this habitat, while rarely seen except in the case of divers, is complex and diverse. There is a lack of algae obscuring the substrates that are instead colonised by a multitude of encrusting and filter feeding species which create a 3D complexity that supports many other species (Salomidi et al. 2012). Some of the rarer species in Jersey are found on this habitat type, such as sunset cup corals (*Leptopsammia*	2

	pruvoti) and pink seafans (*Eunicella verrucosa),* both of which are protected under the Jersey Wildlife Law. Adding to the rich colours of this seascape are jewel anemones (*Corynactis viridis*) and various sponges. Many species live in the crevices in the bedrock and between the gaps in the boulders, including the commercially important lobster (*Homarus gammarus*).	
Regulating services		
Biological control	While there are numerous non-native and invasive species in Jersey waters, it is not well understood how many are found on hard ground or if there are any species that are acting as a biological control on these species – further research is needed.	0
Natural hazard regulation	Sponges play a role in bioremediation (Salomidi et al. 2012).	1
Regulation of water and sediment quality	This habitat is characterised primarily by filter feeding organisms that will aid in the filtration of water (Salomidi et al. 2012).	2
Carbon sequestration	This habitat is considered to have a low carbon sequestration value (Chambers et al. 2022). There are few algal species and also little sediments and therefore no pathways for carbon burial.	0
Healthy climate	No literature available but thought to be negligible.	0
Prevention of coastal erosion/Sea defence	Negligible – this habitat is not located close to shore.	0
Provisioning services		
Food	The fauna associated with this habitat (such as hydroids, byrozoans and ascidians) are a food source for many other species, some of which are of commercial importance. Crab and lobster will both forage and seek shelter in this habitat and is targeted by static gear fisheries. Black seabream (*Spondyliosoma cantharus*) are also associated with this habitat.	2
Fish feed	Currently not thought to contribute to fish feed in Jersey.	0
Fertiliser (and biofuels and building materials)	This habitat is not currently exploited for fertiliser or biofuel purposes.	0
Medicines and blue biotechnology	Sponges contribute to medicine as they produce bioactive compounds with important potential applications as medical drugs (Wijffels 2007). However, the diverse range of sponges associated with this habitat is yet to be explored for its potential.	1
Cultural services		
Tourism/recreation/ nature watching	Hard ground and its associated high faunal diversity attracts recreational divers. Several of Jersey's highly visited dive sites occur on this habitat, such as the Sauvage and Rigdon bank.	2
Spiritual / cultural wellbeing	As this habitat typically occurs at depth, it is not visible to the public and therefore is not well understood within the community. However, this habitat is culturally important to the fishing and diving communities.	1
Aesthetic benefits	The species associated with this habitat can be striking, both in colour and form. The aforementioned jewel anemones	2

	carpet areas of bedrock and boulders, and masses of elephant hide sponge creates further 3D structure. There are often multiple species of wrasse associated with this habitat that are aesthetically pleasing to look at with their bold patterns and colouring.	
Education	As some of the species associated with this habitat are protected (such as seafans and sunset cup corals), it provides an opportunity to educate the public around the importance of this habitat. With the potential future use of biotechnology and/or medicines from the sponges found on this habitat, there is an opportunity for further study, as well as scope for research on other aspects of this habitat, such as biodiversity and it's role in supporting local fishery species.	2

3.2. Cumulative ecosystem services

The scores for each category of ES (supporting, regulating, provisioning and cultural) were summed to give a total value for each habitat group (Table 16Table 1). Seagrass was the highest scoring habitat in terms of overall ES value, with a score of 34. This is due to its many roles in the ecosystem, from biodiversity and carbon storage, to nutrient cycling and maintenance of water quality. Many of the habitats that scored highly had high algal biomass associated with them, which resulted in high scores for ES such as food and fertiliser provisioning, formation of species habitat and cultural significance. Many of the high algal biomass habitats have a large area that falls within the intertidal. Due to Jersey's large tides, the intertidal is much larger and much more utilised than most other coastal nations, and habitats such as "rock: seaweed communities" make up a large portion of Jersey's marine landscape that is accessible on foot. Low scoring habitats were those that were typically unstable and low in biodiversity or algal biomass, meaning they contributed less to the benefits obtained from the ocean that support human well-being (Table 16).

Table 16. Summary of ecosystem service values from each habitat ranked from highest to lowest. The shaded cells are priority habitats identified by OSPAR.

Habitat	Supporting	Regulating	Provisioning	Cultural	Total
Seagrass	12	9	5	8	34
Rock: seaweed communities	12	5	6	8	31
Sediment: seaweeds	11	5	4	8	28
Kelp	11	3	5	6	25
Maerl beds	11	4	4	6	25
Rock pool communities	11	1	3	8	23
Hard ground - stable	10	3	3	7	23
Sandmason worms	9	5	1	6	21
Sediment: rich fauna	8	6	2	4	20
Rock: barnacle communities	6	2	0	6	14
Sediment: robust fauna	5	3	1	4	13
Sediment: sparse fauna	5	2	1	4	12
Slipper limpet beds	5	2	1	2	10
Hard ground - unstable	5	0	1	1	7

Habitats with higher ES supply can be observed in the shallower areas of Jerseys territorial waters, with much of the ES supply concentrated around the east of the island and around the offshore reefs (Figure 16). This will again be due to the association of algae with these habitats, as algae is a photosynthesising organism and will only be found on habitats that are in the photic zone (shallow enough to allow for sufficient light for algae and plant growth).

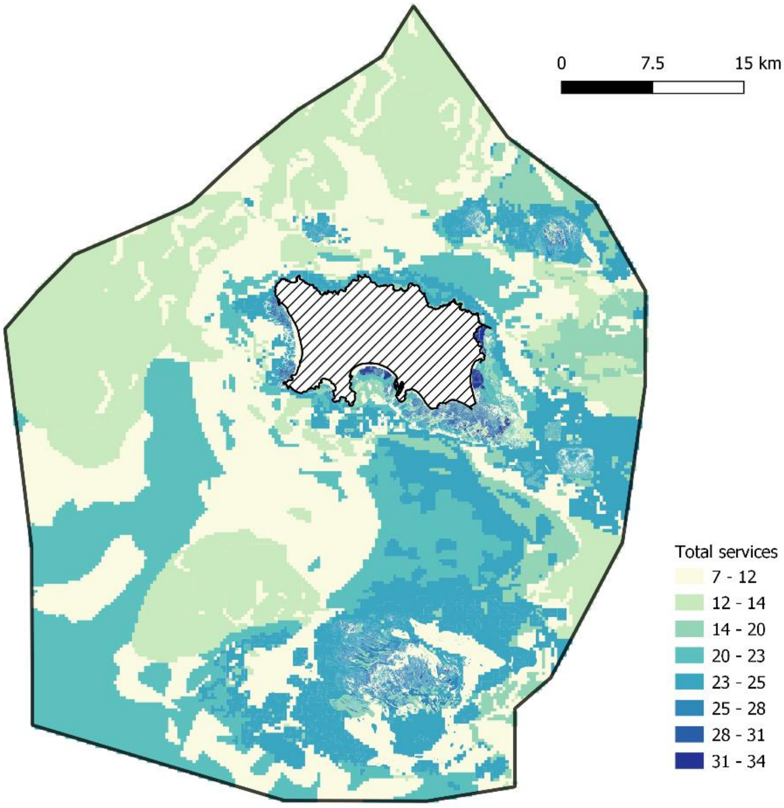

Figure 16. Cumulative Ecosystem Services provided by each habitat. Darker shading indicates a higher overall supply of ES.

3.2.1. Supporting services

The highest scoring habitats in terms of supporting services were "Rock: seaweed communities" and "seagrass", both with a value of 12 (Figure 17 a). This is due to the numerous services associated with high algal and plant biomass such as primary production, formation of species habitat and nutrient cycling. Other high scoring habitats were "Rockpool communities", "kelp", "sediment: seaweeds" and "maerl beds", all of which had a value of 11. Again, this is primarily due to the high algal biomass associated with these habitats. The lowest scoring habitats were "slipper limpet beds", "Sediment: sparse fauna", "Sediment: robust fauna" and "Hardground: unstable" all with a value of 5; "Rock: barnacle communities" also scored low with 6. This will in part be due to the low algal biomass associated with these habitats, but also due to unstable nature of most of these habitats that results in low biodiversity.

3.2.2. Regulating services

With a value of 9, the highest scoring habitat in terms of regulating services was "seagrass" (Figure 17 b). This is due to its carbon sequestrating and water quality regulating properties. The lowest scoring habitat was "Hardground: unstable", with a value of 0, as there was no literature available to attribute any regulating services to this habitat. Many other habitats scored low for regulating services, including “rockpool communities”, “slipper limpet beds”, “Sediment: sparse fauna”, and “Rock: barnacle communities” with scores of 1 or 2.

3.2.3. Provisioning services

The highest scoring habitat in terms of provisioning services was “Rock: seaweed communities”, with a value of 6 (Figure 17 c). Other high scoring habitats were “seagrass” and “kelp”, both of which had a value of 5. These habitats all scored highly due to their role in supporting fisheries species and also due to their high algal biomass that is used for fertiliser. “Rock: barnacle communities” scored 0 and this was due to the lack of food or fertiliser resources associated with this habitat. Other low scoring habitats were “Hardground: unstable”, “slipper limpets”, “Sediment: sparse fauna”, “Sediment: robust fauna” and “sand mason worms”, all of which had a value of 1 due to having few fishery species or algae that could be used as fertiliser. However, it is important to note that the life cycles of many fishery species are not fully understood, especially in terms of prey and prey habitat, many habitats that have scored low in this assessment will likely still be supporting fishery species and therefore providing a provisioning service.

3.2.4. Cultural services

With a value of 8, the highest scoring habitats for cultural services were “Rock: seaweed communities”, “seagrass”, “Sediment: seaweeds” and “Rockpool communities” (Figure 17 d). This is attributed to the close proximity of these habitats to land and they are therefore the most visited and explored habitats by islanders. These habitats also add to the intertidal aesthetic that attracts many visitors and they also support species that are of cultural value to the island, such as bass. Low scoring habitats were “Hard ground: unstable” (value of 1) and “slipper limpets” (value of 2) which are offshore habitats that are inaccessible by low water foragers and intertidal visitors and are also not sought by divers due to their low biodiversity. These habitats are also not associated with any species of cultural significance locally.

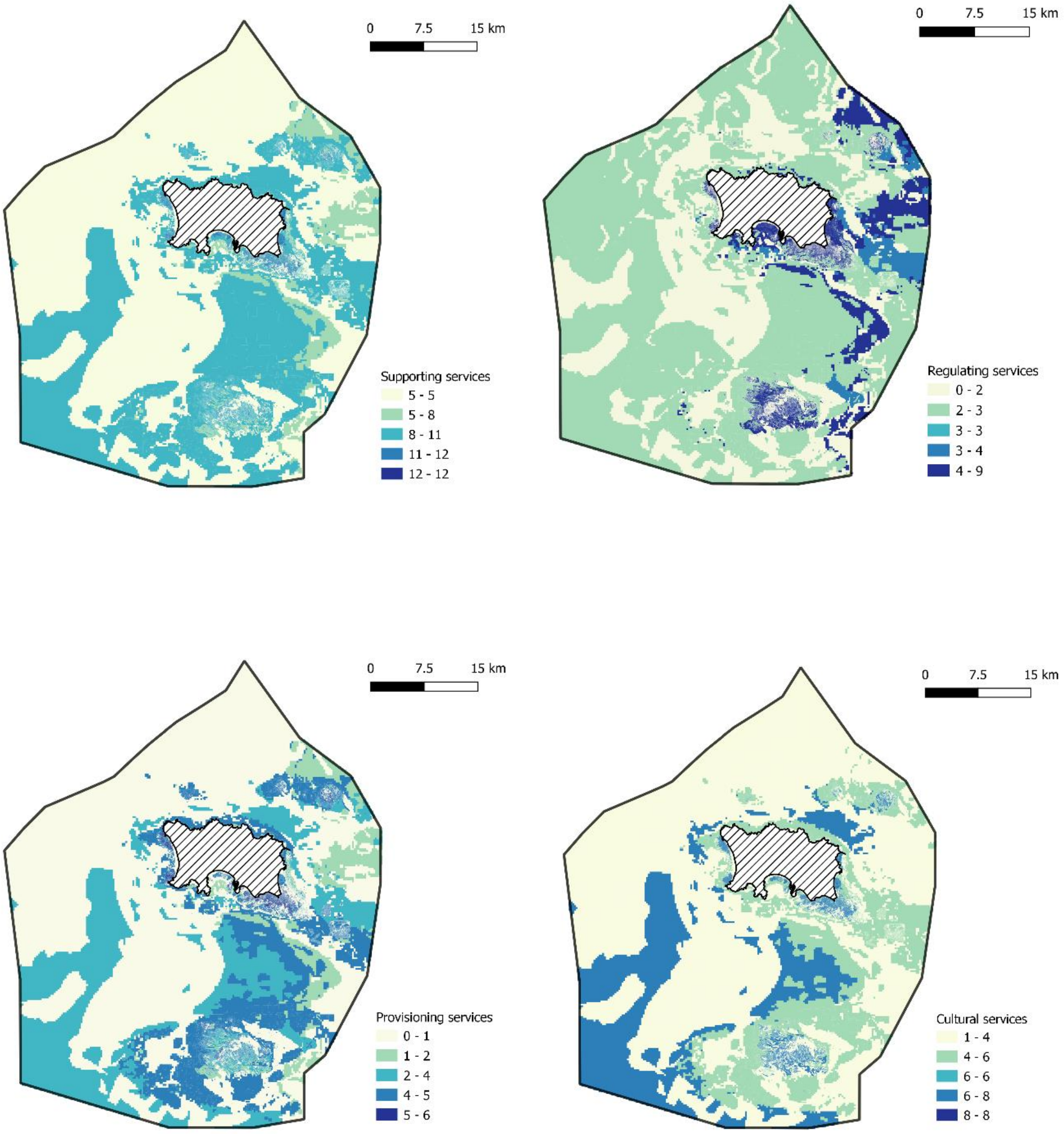

Figure 17. a) Supporting services, b) Regulating services, c) Provisioning services, d) Cultural services provided by each habitat. Darker shading indicates a higher ES supply.

4. Conclusion

This report has summarised the ecosystem services (ES) supplied by the key habitat types in Jersey's marine environment. While literature was lacking for some habitats, it was possible to make inferences based on similar habitats to value ES supply for the majority of habitats. All habitats supplied multiple ES, with habitats such as "seagrass" and "Rock: seaweed communities" scoring some of the highest values, particularly in terms of supporting and cultural services. In order to support human well-being, the supply of ES from Jersey's marine environment needs to be maintained at a sufficient level. Currently there are several human activities that have the potential to negatively impact on ES supply, such as destructive fishing techniques, over exploitation of certain species, and pollution (Marine Resources, 2023c). Through gaining an understanding of where ES supply is highest, it may be possible to spatially prioritise marine activities and development to minimise disruption of ES supply.

5. Glossary of Ecosystem Service terms

Ecosystem service	Glossary
Supporting services	
Primary production	Primary production is the process in which autotrophs generate organic matter from carbon dioxide and water. It benefits humans as food is either directly or indirectly produced by it.
Larval / Gamete supply	Quantity, quality & dispersal potential of larva/gametes. This supply may positively affect the production area, but can also affect a much wider area depending on the environmental variables affecting that location.
Nutrient cycling	The process where a chemical element or molecule moves through both biotic and abiotic compartments of ecosystems (e.g. nitrogen cycle, phosphorus cycle, carbon cycle).
Formation of species habitat	The physical structure created/provided by the habitat that supports the survival of species.
Formation of physical barriers	The physical structure created/provided by the habitat that block or slow physical processes such as wind or water flow.
Formation of seabed structure	The physical structure created/provided by the habitat that is aesthetically pleasing and contributes to the overall seascape and habitat connectivity.
Regulating services	
Biological control	Species associated with the habitat that aid in reducing the abundance of species that are considered a pest or invasive.
Natural hazard regulation	Processes that breakdown or prevent the mobilisation of hazardous pollutants within the marine environment.
Regulation of water and sediment quality	Processes within the habitat that aid in the cycling of water or sediments to keep them clean, such as through filtration. For sediments this may be through the cycling of organic matter and oxygen through bioturbation or infaunal species.
Carbon sequestration	The habitat is a net sink for carbon (it removes carbon from the surrounding environment and stores it).
Healthy climate	Regulation of climate, such as temperature or rainfall.
Prevention of coastal erosion/sea defence	Regulation of processes that prevent erosion, such as buffering storm damage.
Provisioning services	
Food	Species that live on the habitat provide a food source/are commercially and/or recreationally targeted.
Fish feed	Species that live on the habitat are targeted as a food source for non-human consumption.
Fertiliser (and biofuels and building materials)	Materials associated or created by the habitat are used, or could be used, in industrial or agricultural practices.
Medicines and blue biotechnology	Materials associated or created by the habitat are used, or could be used, in medical or technological practices.
Cultural services	
Tourism/nature watching	The habitat and/or associated species attract visitors and support nature tourism service providers.
Spiritual / cultural wellbeing	The habitat and/or associated species are a source of natural heritage or are associated with traditional knowledge or religion that create a sense of belonging.
Aesthetic benefits	The habitat and/or associated species are an attraction for sightseeing and are a source of inspiration for art, design, culture and science.
Education	The habitat and/or associated species provide opportunities for education.

References

Al-Rashid, Fahim, and Piyush Khanna. 2021. "An Overview of the Bioactive Compounds and Bioremediation Potential of Brown Algae." *Inventum Biologicum* 1(1):25–30.

Alipour, Atefeh, and Shahrzad Javanshir. 2018. "Preparation, Characterization and Antibacterial Activity Investigation of Hydrocolloids Based Irish Moss/ZnO/CuO Bio-Based Nanocomposite Films." *Journal of Cluster Science* 4. doi: 10.1007/s10876-018-1449-4.

Andersson, A. J., and F. T. MacKenzie. 2012. "Revisiting Four Scientific Debates in Ocean Acidification Research." *Biogeosciences* 9(3):893–905. doi: 10.5194/bg-9-893-2012.

Androuin, Thibault, Jacques Grall, Benoit Lebreton, Gaël Guillou, Gauthier Schaal, and Antoine Carlier. 2014. "How Does the Invasive Species Crepidula Fornicata Influence Benthic Trophic Diversity and Functioning in the Bay of Brest?" in *Applications of Stable Isotope Techniques to Ecological Studies*.

Androuin, Thibault, Lubos Polerecky, Priscilla Decottignies, Stanislas F. Dubois, Christine Dupuy, Cédric Hubas, Bruno Jesus, Erwan Le Gall, Martin P. Marzloff, and Antoine Carlier. 2018. "Subtidal Microphytobenthos: A Secret Garden Stimulated by the Engineer Species Crepidula Fornicata." *Frontiers in Marine Science* 5(DEC):1–12. doi: 10.3389/fmars.2018.00475.

Arbach Leloup, F., N. Desroy, P. Le Mao, D. Pauly, and O. Le Pape. 2008. "Interactions between a Natural Food Web, Shellfish Farming and Exotic Species: The Case of the Bay of Mont Saint Michel (France)." *Estuarine, Coastal and Shelf Science*. doi: 10.1016/j.ecss.2007.06.011.

Aryuthaka, Chittima, Miguel Fortes, Hutomo Malikusworo, Kim Sour, Suy Serywath, Xiaoping Huang, Tri Edi Kuriandewa, Kamarruddin bin Ibrahim, Marco Nemesio E. Montaño, Suvaluck Satumanatpan, Nguyen Van Tien, and Kelvin Passfield. 2004. *Seagrass in the South China Sea*. Bangkok, Thailand.

Barjoveanu, George, Sabino De Gisi, Rossella Casale, Francesco Todaro, Michele Notarnicola, and Carmen Teodosiu. 2018. "A Life Cycle Assessment Study on the Stabilization/Solidification Treatment Processes for Contaminated Marine Sediments." *Journal of Cleaner Production* 201:391–402. doi: 10.1016/j.jclepro.2018.08.053.

Basquin, Anne Marie, and Bryce Pebbles. 2020. "ART AND WATER COLLABORATION: INTERVIEW." *Junctures*, 56–64.

Beaumont, N. J., M. C. Austen, J. P. Atkins, D. Burdon, S. Degraer, T. P. Dentinho, S. Derous, P. Holm, T. Horton, E. van Ierland, A. H. Marboe, D. J. Starkey, M. Townsend, and T. Zarzycki. 2007. "Identification, Definition and Quantification of Goods and Services Provided by Marine Biodiversity: Implications for the Ecosystem Approach." *Marine Pollution Bulletin* 54(3):253–65. doi: 10.1016/j.marpolbul.2006.12.003.

Beaumont, N. J., M. C. Austen, S. C. Mangi, and M. Townsend. 2008. "Economic Valuation for the Conservation of Marine Biodiversity." *Marine Pollution Bulletin* 56(3):386–96. doi: 10.1016/j.marpolbul.2007.11.013.

Bell, James J. 2008. "The Functional Roles of Marine Sponges." *Estuarine, Coastal and Shelf Science* 79:341–53. doi: 10.1016/j.ecss.2008.05.002.

Blampied, S. 2022. “A Socio-Economic and Ecological Approach to Informing Sustainable Marine Management in Jersey, Channel Islands.” University of Plymouth.

Blampied, Samantha R. 2022. “A Socio-Economic and Ecological Approach to Informing Sustainable Marine Management in Jersey, Channel Islands.” University of Plymouth.

Blampied, Samantha R., Sian E. Rees, Martin J. Attrill, Francis C. T. Binney, and V. Sheehan. 2022. “Estuarine , Coastal and Shelf Science Removal of Bottom-Towed Fishing from Whole-Site Marine Protected Areas Promotes Mobile Species Biodiversity.” *Estuarine, Coastal and Shelf Science* 276:1–14. doi: 10.1016/j.ecss.2022.108033.

Blampied, Samantha R., Emma V Sheehan, Francis C. T. Binney, Martin J. Attrill, and Sian E. Rees. 2022. “Value of Coastal Habitats to Commercial Fisheries in Jersey, English Channel, and the Role of Marine Protected Areas.” *Fisheries Management and Ecologygement and Ecology* 1–11. doi: 10.1111/fme.12571.

Blanchard, Michel. 2009. “Recent Expansion of the Slipper Limpet Population (Crepidula Fornicata) in the Bay of Mont-Saint-Michel (Western Channel, France).” *Aquatic Living Resources* 22(1):11–19. doi: 10.1051/alr/2009004.

Bouasria, Manal, Fouzia Khadraoui, Mohammed Hichem Benzaama, Karim Touati, Daniel Chateigner, Stéphanie Gascoin, Valérie Pralong, Beate Orberger, Laidi Babouri, and Yassine El Mendili. 2021. “Partial Substitution of Cement by the Association of Ferronickel Slags and Crepidula Fornicata Shells.” *Journal of Building Engineering* 33(March 2020). doi: 10.1016/j.jobe.2020.101587.

Bruschetti, Martín. 2019. “Role of Reef-Building, Ecosystem Engineering Polychaetes in Shallow Water Ecosystems.” *Diversity* 11(168):1–19.

Burdige, D. J. 2007. *Geochemistry of Marine Sediments*. Princeton University Press.

Carson, Matthew A., and Susan A. Clarke. 2018. “Bioactive Compounds from Marine Organisms: Potential for Bone Growth and Healing.” *Marine Drugs* 16(9). doi: 10.3390/md16090340.

Cesar, Herman S. J. 2002. “Coral Reefs: Their Functions, Threats and Economic Value.” Pp. 14–39 in *Collected essays on the economics of coral reefs*, edited by H. S. J. Cesar.

Chambers, P. M., S. Blampied, F. Binney, W. E. N. Austin, and G. Morel. 2022. *Blue Carbon Resources An Assessment of Jersey’s Territorial Seas*.

Chambers, Paul, Chantelle De Gruchy, Greg Morel, Francis Binney, Gareth Jeffreys, Samantha Blampied, and Kevin McIlwee. 2019. “Crossing Jurisdictions: The Implementation of Offshore Marine Protected Areas in an International Fishery.” *Marine Protected Areas: Science, Policy and Management* 411–36. doi: 10.1016/B978-0-08-102698-4.00021-6.

Charles, Anthony, and Lisette Wilson. 2009. “Human Dimensions of Marine Protected Areas.” *ICES Journal of Marine Science* 66:6–15.

Clark, Clifford D., Bertram Bassett, and Mark R. Burge. 2003. “Effects of Kelp Supplementation on Thyroid Function in Euthyroid Subjects.” *Endocrine Practice* 9(5):363–69.

Costanza, Robert, Rudolf de Groot, Paul Sutton, Sander van der Ploeg, Sharolyn J. Anderson, Ida Kubiszewski, Stephen Farber, and R. Kerry Turner. 2014. “Changes in the Global Value of Ecosystem Services.” *Global Environmental Change* 26(1):152–58. doi: 10.1016/j.gloenvcha.2014.04.002.

Cott, G. M., P. Beca-Carretero, and D. B. Stengel. 2021. “Blue Carbon and Marine Carbon Sequestration in Irish Waters and Coastal Habitats.” (May):1–42.

Cramer, Alli N., and Stephen L. Katz. 2021. “Primary Production and Habitat Stability Organize Marine Communities.” *Global Ecology and Biogeography* 30(1):11–24. doi: 10.1111/geb.13192.

Cugier, Philippe, Caroline Struski, Michel Blanchard, Joseph Mazurié, Stéphane Pouvreau, Frédéric Olivier, Jihane R. Trigui, and Eric Thiébaut. 2010. “Assessing the Role of Benthic Filter Feeders on Phytoplankton Production in a Shellfish Farming Site: Mont Saint Michel Bay, France.” *Journal of Marine Systems* 82(1–2):21–34. doi: 10.1016/j.jmarsys.2010.02.013.

Cullen-Unsworth, Leanne, and Richard Unsworth. 2013. “Seagrass Meadows, Ecosystem Services, and Sustainability.” *Environment* 55(3):14–28. doi: 10.1080/00139157.2013.785864.

Duarte, Carlos M. 2000. “Marine Biodiversity and Ecosystem Services: An Elusive Link.” *Journal of Experimental Marine Biology and Ecology* 250:117–31.

Duarte, Carlos M., Jean Pierre Gattuso, Kasper Hancke, Hege Gundersen, Karen Filbee-Dexter, Morten F. Pedersen, Jack J. Middelburg, Michael T. Burrows, Kira A. Krumhansl, Thomas Wernberg, Pippa Moore, Albert Pessarrodona, Sarah B. Ørberg, Isabel S. Pinto, Jorge Assis, Ana M. Queirós, Dan A. Smale, Trine Bekkby, Ester A. Serrão, and Dorte Krause-Jensen. 2022. “Global Estimates of the Extent and Production of Macroalgal Forests.” *Global Ecology and Biogeography* 31(7):1422–39. doi: 10.1111/geb.13515.

Edgar, G. J., Rick D. Stuart-Smith, T. J. Willis, Stuart Kininmonth, Susan C. Baker, Stuart Banks, Neville S. Barrett, Mikel A. Becerro, Anthony T. F. Bernard, Just Berkhout, Colin D. Buxton, Stuart J. Campbell, Antonia T. Cooper, Marlene Davey, Sophie C. Edgar, Günter Försterra, David E. Galván, Alejo J. Irigoyen, David J. Kushner, Rodrigo Moura, P. Ed Parnell, Nick T. Shears, German Soler, Elisabeth M. A. Strain, and Russell J. Thomson. 2014. “Global Conservation Outcomes Depend on Marine Protected Areas with Five Key Features.” *Nature* 506(7487):216–20. doi: 10.1038/nature13022.

Eger, A., E. Marzinelli, Rodrigo Baes, Caitlin O. Blain, L. Blamey, P. Carnell, C. Choi, M. Hessing-Lewis, Kwang Young Kim, Julio Lorda, P. Moore, Y. Nakamura, O. Pontier, D. Smale, P. Steinberg, and A. Vergés. 2021. “The Economic Value of Fisheries, Blue Carbon, and Nutrient Cycling in Global Marine Forests.” *Environmental Science*.

Engel, Carolyn R., and Christophe Destombe. 2002. “Reproductive Ecology of an Intertidal Red Seaweed, Gracilaria Gracilis: Influence of High and Low Tides on Fertilization Success.” *Journal of the Marine Biological Association of the United Kingdom* 82(2):189–92.

European Commission. 2020. *EU Biodiversity Strategy for 2030 - Bringing Nature Back into Our Lives*. Brussels.

Fletcher, S., J. Saunders, R. J. H. Herbert, C. Roberts, and K. Dawson. 2012. *Marine Ecosystem Services. Description of the Ecosystem Services Provided by Broad-Scale Habitats and Features of Conservation Importance That Are Likely to Be Protected by Marine Protected Areas in the Marine Conservation Zone Project Area*.

Foshtomi, Maryam Yazdani, Frederik Leliaert, Sofie Derycke, Anne Willems, Magda Vincx, and Jan Vanaverbeke. 2018. “The Effect of Bio-Irrigation by the Polychaete Lanice Conchilega on Active Denitrifiers: Distribution, Diversity and Composition of NosZ Gene.” *Plos One* 13(2):1–25.

Fourqurean, J. W., C. M. Duarte, H. Kennedy, N. Marba, M. Holmer, M. A. Mateo, E. T. Apostolaki, G. A. Kendrick, D. Krause-Jensen, K. J. McGlathery, and O. Serrano. 2012. “Seagrass

Ecosystems as a Globally Significant Carbon Stock." *Nature Geoscience* 5(7):505–9. doi: 10.1038/ngeo1477.

Freire, V. Peña, J. Grall, J. Hall-Spencer, North East Atlantic Working Group, S. Gubbay, G. Saunders, H. Tyler-Walters, N. Dankers, F. Otero-Ferrer, J. Forde, K. Fürhaupter, R. Haroun Tabraue, and N. Sanders. 2016. *European Red List of Habitats - Marine Habitat Group - A5.51 Atlantic Mäerl Beds*.

Gaines, S. D., C. White, M. H. Carr, and S. R. Palumbi. 2010. "Designing Marine Reserve Networks for Both Conservation and Fisheries Management." *Proceedings of the National Academy of Sciences of the United States of America* 107(43):18286–93. doi: 10.1073/pnas.0906473107.

Galparsoro, Ibon, Angel Borja, and María C. Uyarra. 2014. "Mapping Ecosystem Services Provided by Benthic Habitats in the European North Atlantic Ocean." *Frontiers in Marine Science* 1(23):1–14. doi: 10.3389/fmars.2014.00023.

Gamfeldt, Lars, and Matthew E. S. Bracken. 2009. "The Role of Biodiversity for the Functioning of Rocky Reef Communities." Pp. 361–73 in *Ecological Studies*.

Gan, Kesheng, Chao Liang, Xiangyun Bi, Jizhe Wu, Zonghuang Ye, Wenjian Wu, and Biru Hu. 2022. "Adhesive Materials Inspired by Barnacle Underwater Adhesion: Biological Principles and Biomimetic Designs." *Frontiers in Bioengineering and Biotechnology* 10:1–18. doi: 10.3389/fbioe.2022.870445.

Gonzalez-Gurriaran, E., and J. Freire. 1994. "Movement Patterns and Habitat Utilization in the Spider Crab Maja-Squinado (Herbst) (Decapoda, Majidae) Measured By Ultrasonic Telemetry." *Journal of Experimental Marine Biology and Ecology* 184(2):269–91. doi: 10.1016/0022-0981(94)90009-4.

Gray, Shalla, John Kinross, Paul Read, and Angus Marland. 2000. "The Nutrient Assimilative Capacity of Maerl as a Substrate in Constructed Wetland Systems for Waste Treatment." *Water Resources* 34(8).

Groot, Rudolf S. De, Matthew A. Wilson, and Roelof M. J. Boumans. 2002. "A Typology for the Classification, Description and Valuation of Ecosystem Functions, Goods and Services." *Ecological Economics* 41:393–408.

Hall-Spencer, J. M., J. Grall, P. G. Moore, and R. J. A. Atkinson. 2003. "Bivalve Fishing and Maerl-Bed Conservation in France and the UK - Retrospect and Prospect." *Aquatic Conservation: Marine and Freshwater Ecosystems* 41(April 2001). doi: 10.1002/aqc.566.

Hall, Robert O., Benjamin J. Koch, Michael C. Marshall, Brad W. Taylor, and Lusha M. Tronstad. 2007. "How Body Size Mediates the Role of Animals in Nutrient Cycling in Aquatic Ecosystems." *Body Size: The Structure and Function of Aquatic Ecosystems* 286–305. doi: 10.1017/cbo9780511611223.016.

Harvey, Eric, Isabelle Gounand, Colette L. Ward, and Florian Altermatt. 2017. "Bridging Ecology and Conservation: From Ecological Networks to Ecosystem Function." *Journal of Applied Ecology* 54:371–79. doi: 10.1111/1365-2664.12769.

Heo, Jae Bok, Yong-suk Lee, and Chung-han Chung. 2021. "Seagrass-Based Platform Strategies for Sustainable Hydroxymethylfurfural (HMF) Production: Toward Bio-Based Chemical Products." *Critical Reviews in Biotechnology* 41(6):902–17. doi: 10.1080/07388551.2021.1892580.

Hua, Kuo-Feng, Hsien-Yeh Hsu, Yu-Chang Su, I. Fan Lin, Su-Sing Yang, Ya-Mai Chen, and Louis

Kuoping Chao. 2006. “Study on the Antiinflammatory Activity of Methanol Extract from Seagrass Zostera Japonica.” *Agricultural and Food Chemistry* 54:306–11.

Irlandi, E. A., B. A. Orlando, and W. G. Ambrose. 1999. “Influence of Seagrass Habitat Patch Size on Growth and Survival of Juvenile Bay Scallops, Argopecten Irradians Concentricus (Say).” *Journal of Experimental Marine Biology and Ecology* 235(1):21–43. doi: 10.1016/s0022-0981(98)00185-3.

Jackson, Emma, Sian E. Rees, C. Wilding, and Martin J. Attrill. 2015. “Use of a Seagrass Residency Index to Apportion Commercial Fishery Landing Values and Recreation Fisheries Expenditure to Seagrass Habitat Service.” *Conservation Biology* 29(3):899–909. doi: 10.1111/cobi.12436.

Jackson, Emma, Ashley A. Rowden, Martin J. Attrill, Simon F. Bossy, and Malcolm B. Jones. 2002. “Comparison of Fish and Mobile Macroinvertebrates Associated with Seagrass and Adjacent Sand at St. Catherine Bay, Jersey (English Channel): Emphasis on Commercial Species.” *Bulletin of Marine Science* 71(3):1333–41.

Kenicer, Gregory, Sam Bridgewater, and William Milliken. 2000. “The Ebb and Flow of Scottish Seaweed Use.” *Botanical Journal of Scotland* 52(2):119–48. doi: 10.1080/13594860009441750.

Khasina, Eleonora I., Piotr A. Tiupeleev, and Marina N. Sgrebneva. 2004. “Khasina 2004 Gastroprotective Effect of Zosterin, a Pectin from Seagrass Zostera Marina.” *Oriental Pharmacy and Experimental Medicine* 4(4):253–60.

Laffoley, D., E. Maltby, M. Vincent, L. Mee, E. Dunn, P. Gilliland, J. Hamer, D. Mortimer, and D. Pound. 2004. “The Ecosystem Approach. Coherent Actions for Marine and Coastal Environments. A Report to the UK Government.” *Report: English Nature*.

MacDougall, D. 1948. “Effect of Processing and Storage on the Quality of Gelose from Irish Moss (Chondrus Crispus).” *Canadian Journal of Research* 26f(3).

Mackintosh, Margaret. 2017. *Beach Schools*. Taylor and Francis Group.

Marine Resources. 2019. *Government of Jersey Marine Resources Annual Report 2019*.

Martin, S, G. Thouzeau, M. Richard, L. Chauvaud, F. Jean, and J. Clavier. 2007. “Benthic Community Respiration in Areas Impacted by the Invasive Mollusk Crepidula Fornicata.” *Marine Ecology Progress Series* 347:51–60. doi: 10.3354/meps07000.

Martin, Sophie, Jacques Clavier, Laurent Chauvaud, and Gérard Thouzeau. 2007. “Community Metabolism in Temperate Maerl Beds . II . Nutrient Fluxes.” 335:31–41.

Martin, Sophie, Gérard Thouzeau, Laurent Chauvaud, Frédéric Jean, Laurent Guérin, and Jacques Clavier. 2006. “Respiration, Calcification, and Excretion of the Invasive Slipper Limpet, Crepidula Fornicata L.: Implications for Carbon, Carbonate, and Nitrogen Fluxes in Affected Areas.” *Limnology and Oceanography* 51(5):1996–2007. doi: 10.4319/lo.2006.51.5.1996.

Menesguen, A., and T. Gregoris. 2018. “Modelling Benthic Invasion by the Colonial Gastropod Crepidula Fornicata and Its Competition with the Bivalve Pecten Maximus. 1. A New 0D Model for Population Dynamics of Colony-Forming Species.” *Ecological Modelling* 368:277–87. doi: 10.1016/j.ecolmodel.2017.12.005.

Milledge, John J., Birthe V. Nielsen, and David Bailey. 2016. “High-Value Products from Macroalgae: The Potential Uses of the Invasive Brown Seaweed, Sargassum Muticum.” *Reviews in Environmental Science and Biotechnology* 15:67–88. doi: 10.1007/s11157-015-

9381-7.

Moore, Kenneth A., West Palm Beach, and Kenneth A. Moore. 2004. “Influence of Seagrasses on Water Quality in Shallow Regions of the Lower Chesapeake Bay Influence of Seagrasses on Water Quality in Shallow Regions of the Lower Chesapeake Bay.” *Journal of Coastal Research* 45:162–78.

Ní Longphuirt, Sorcha, Jacques Clavier, Jacques Grall, Laurent Chauvaud, François Le Loc’h, Iwan Le Berre, Jonathon Flye-Sainte-Marie, Joëlle Richard, and Aude Leynaert. 2007. “Primary Production and Spatial Distribution of Subtidal Microphytobenthos in a Temperate Coastal System, the Bay of Brest, France.” *Estuarine, Coastal and Shelf Science* 74(3):367–80. doi: 10.1016/j.ecss.2007.04.025.

Olson, Angeleen M., Margot Hessing-Lewis, Dana Haggarty, and Francis Juanes. 2019. “Nearshore Seascape Connectivity Enhances Seagrass Meadow Nursery Function.” *Ecological Applications* 29(5):1–14. doi: 10.1002/eap.1897.

Pape, O. Le, D. Guérault, and Y. Désaunay. 2004. “Effect of an Invasive Mollusc, American Slipper Limpet Crepidula Fornicata, on Habitat Suitability for Juvenile Common Sole Solea Solea in the Bay of Biscay.” *Marine Ecology Progress Series* 277:107–15.

Pergent-martini, Christine. 2021. “Contribution of Posidonia Oceanica Meadows in the Context of Climate Change Mitigation in the Mediterranean Sea.” *Marine Environmental Research* 165. doi: 10.1016/j.marenvres.2020.105236.

Pikitch, Ellen K., Christine Santora, Elizabeth A. Babcock, Andrew Bakun, R. Bonfil, D. O. Conover, P. Dayton, P. Doukakis, D. Fluharty, B. Heneman, E. D. Houde, J. Link, P. A. Livingston, M. Mangel, M. K. McAllister, J. Pope, and K. J. Sainsbury. 2004. “Ecosystem-Based Fishery Management.” *Science* 305:14–16.

Porter, J., W. Austin, M. Burrows, D. Clarke, G. Davies, N. Kamenos, S. Riegel, C. Smeaton, C. Page, and A. Want. 2020. “Blue Carbon Audit of Orkney Waters (Scottish Marine and Freshwater Science).” *Scottish Marine and Freshwater Series* 11(3):96. doi: 10.7489/12262-1.

Potts, Tavis, Daryl Burdon, Emma Jackson, Jonathan Atkins, Justine Saunders, Emily Hastings, and Olivia Langmead. 2014. “Do Marine Protected Areas Deliver Flows of Ecosystem Services to Support Human Welfare?” *Marine Policy* 44:139–48. doi: 10.1016/j.marpol.2013.08.011.

Prentice, C., K. L. Poppe, M. Lutz, E. Murray, T. A. Stephens, and A. Spooner. 2020. “A Synthesis of Blue Carbon Stocks , Sources , and Accumulation Rates in Eelgrass (Zostera Marina) Meadows in the Northeast Paci Fi c Global Biogeochemical Cycles.” *Global Biogeochemical Cycles* 34:1–16. doi: 10.1029/2019GB006345.

Qin, Song, Peng Jiang, and Chengkui Tseng. 2005. “Transforming Kelp into a Marine Bioreactor.” *Trends in Biotechnology* 23(5):264–68. doi: 10.1016/j.tibtech.2005.03.010.

Queirós, Ana Moura, Nicholas Stephens, Stephen Widdicombe, Karen Tait, Sophie J. McCoy, Jeroen Ingels, Saskia Rühl, Ruth Airs, Amanda Beesley, Giorgia Carnovale, Pierre Cazenave, Sarah Dashfield, Er Hua, Mark Jones, Penelope Lindeque, Caroline L. McNeill, Joana Nunes, Helen Parry, Christine Pascoe, Claire Widdicombe, Tim Smyth, Angus Atkinson, Dorte Krause-Jensen, and Paul J. Somerfield. 2019. “Connected Macroalgal-Sediment Systems: Blue Carbon and Food Webs in the Deep Coastal Ocean.” *Ecological Monographs* 89(3):1–21. doi: 10.1002/ecm.1366.

Rabaut, M., K. Guilini, G. Van Hoey, M. Vincx, and S. Degraer. 2007. “A Bio-Engineered Soft-

Bottom Environment: The Impact of Lanice Conchilega on the Benthic Species-Specific Densities and Community Structure." *Estuarine Coastal and Shelf Science* 75:525–36.

Rabaut, M., L. de Moortel, M. Vincx, and S. Degraer. 2010. "Biogenic Reefs as Structuring Factor in Pleuronectes Platessa (Plaice) Nursery." *Journal of Sea Research* 64(1–2):102–6. doi: 10.1016/j.seares.2009.10.009.

Racine, Phoebe, Annaclaire Marley, Halley E. Froehlich, Steven D. Gaines, Ian Ladner, Ilan Macadam-somer, and Darcy Bradley. 2021. "A Case for Seaweed Aquaculture Inclusion in U.S. Nutrient Pollution Management." *Marine Policy* 129:1–5. doi: 10.1016/j.marpol.2021.104506.

Ravikumar, Suresh, Murugesan Kanagavel, and Nooruddin Thajuddin. 2011. "Production of Biofuel Ethanol from Pretreated Seagrass by Using Saccharomyces Cerevisiae." *Indian Jornal of Science and Technology* 4(9):1087–89. doi: 10.17485/ijst/2011/v4i9/30235.

Read, Andrew D., Ronald J. West, Max Haste, and Alan Jordan. 2011. "Optimizing Voluntary Compliance in Marine Protected Areas: A Comparison of Recreational Fisher and Enforcement Officer Perspectives Using Multi-Criteria Analysis." *Journal of Environmental Management* 92(10):2558–67. doi: 10.1016/j.jenvman.2011.05.022.

Rees, Sian E., Simon J. Pittman, Nicola Foster, Olivia Langmead, Charly Griffiths, Steve Fletcher, David E. Johnson, and Martin J. Attrill. 2018. "Bridging the Divide: Social-Ecological Coherence in Marine Protected Area Network Design." *Aquatic Conservation: Marine and Freshwater Ecosystems* 28(3):754–63. doi: 10.1002/aqc.2885.

Rees, Sian E., Emma V Sheehan, Emma Jackson, Sarah C. Gall, Sophie L. Cousens, Jean-luc Solandt, Matthew Boyer, and Martin J. Attrill. 2013. "A Legal and Ecological Perspective of 'Site Integrity' to Inform Policy Development and Management of Special Areas of Conservation in Europe." *Marine Pollution Bulletin* 72:14–21. doi: 10.1016/j.marpolbul.2013.03.036.

Roche, Caroline, David O. Lyons, José Fariňas Franco, and Brendan O'Connor. 2007. *Benthic Surveys of Sandbanks in the Irish Sea. Irish Wildlife Manuals No. 29*.

Rosman, Johanna H., Jeffrey R. Koseff, Stephen G. Monismith, and Jamie Grover. 2007. "A Field Investigation into the Effects of a Kelp Forest (Macrocystis Pyrifera) on Coastal Hydrodynamics and Transport." *Journal of Geophysical Research* 112:1–16. doi: 10.1029/2005JC003430.

Rossi, Francesca, Rosa M. Viejo, Linney Duarte, Fatima Vaz-pinto, Ignacio Gestoso, and Celia Olabarria. 2019. "Removal of an Established Invader Can Change Gross Primary Production of Native Macroalgae and Alter Carbon Flow in Intertidal Rock Pools." *PLoS ONE* 14(12):1–18.

Sachs, Jeff D. 2012. "From Millennium Development Goals to Sustainable Development Goals." *Viewpoint* 379:2206–11. doi: 10.1016/S0140-6736(12)60685-0.

Salomidi, M., S. Katsanevakis, A. Borja, U. Braeckman, I. Galparsoro, R. Mifsud, S. Mirto, M. Pascual, C. Pipitone, M. Rabaut, V. Todorova, V. Vassilopoulou, T. Vega Fernandez, and D. Damalas. 2012. "Assessment of Goods and Services, Vulnerability, and Conservation Status of European Seabed Biotopes: A Stepping Stone towards Ecosystem-Based Marine Spatial Management." *Mediterranean Marine Science* 13.

Samuelsen, T. A., S. A. Mjos, and A. Oterhals. 2014. "Influence of Type of Raw Material on Fishmeal Physiochemical Properties, the Extrusion Process, Starch Gelatinization and Physical Quality of Fish Feed." *Aquaculture Nutrition* 20:410–20. doi: 10.1111/anu.12093.

Smale, Dan A., Michael T. Burrows, Pippa Moore, Nessa O'Connor, and Stephen J. Hawkins. 2013. "Threats and Knowledge Gaps for Ecosystem Services Provided by Kelp Forests: A Northeast Atlantic Perspective." *Ecology and Evolution* 3(11):4016–38. doi: 10.1002/ece3.774.

Smale, Dan A., Graham Epstein, Esther Hughes, Andrew O. M. Mogg, and Pippa J. Moore. 2020. "Patterns and Drivers of Understory Macroalgal Assemblage Structure within Subtidal Kelp Forests." *Biodiversity and Conservation* 29:4173–92. doi: 10.1007/s10531-020-02070-x.

Smale, Dan A., Nathan G. King, Mathilde Jackson-bué, and Pippa J. Moore. 2022. "Quantifying Use of Kelp Forest Habitat by Commercially Important Crustaceans in the United Kingdom." *Journal of the Marine Biological Association of the United Kingdom* 102:627–634.

Smet, Bart De, Dick Van Oevelen, Magda Vincx, Jan Vanaverbeke, and Karline Soetaert. 2016. "Lanice Conchilega Structures Carbon Flows in Soft-Bottom Intertidal Areas." *Marine Ecology Progress Series* 552:47–60. doi: 10.3354/meps11747.

Teagle, H., S. J. Hawkins, P. J. Moore, and D. A. Smale. 2017. "The Role of Kelp Species as Biogenic Habitat Formers in Coastal Marine Ecosystems." *Journal of Experimental Marine Biology and Ecology* 492:81–98. doi: 10.1016/j.jembe.2017.01.017.

UNEP. 2006a. *Marine and Coastal Ecosystems and Human Well-Being : A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment*.

UNEP. 2006b. *Marine and Coastal Ecosystems and Human Well-Being: A Synthesis Report Based on the Findings of the Millennium Ecosystem Assessment*.

Unsworth, R. K. F., L. C. Cullen, J. N. Pretty, D. J. Smith, and J. J. Bell. 2010. "Economic and Subsistence Values of the Standing Stocks of Seagrass Fisheries: Potential Benefits of No-Fishing Marine Protected Area Management." *Ocean & Coastal Management* 53(5–6):218–24. doi: 10.1016/j.ocecoaman.2010.04.002.

Unsworth, Richard K. F., Lina Mtwana Nordlund, and Leanne C. Cullen-Unsworth. 2019. "Seagrass Meadows Support Global Fisheries Production." *Wiley. Conservation Letters* 12:1–8. doi: 10.1111/conl.12566.

Vasarri, Marzia, Anna Maria De Biasi, Emanuela Barletta, Carlo Pretti, and Donatella Degl Innocenti. 2021. "An Overview of New Insights into the Benefits of the Seagrass Posidonia Oceanica for Human Health." *Marine Drugs* 19(476):1–15.

Vásquez, Julio A., Sergio Zuñiga, Fadia Tala, Nicole Piaget, Deni C. Rodríguez, and J. M. Alons. Vega. 2014. "Economic Valuation of Kelp Forests in Northern Chile: Values of Goods and Services of the Ecosystem." *Journal of Applied Phycology* 26(2):1081–88. doi: 10.1007/s10811-013-0173-6.

Welsh, David T. 2003. "It's a Dirty Job but Someone Has to Do It: The Role of Marine Benthic Macrofauna in Organic Matter Turnover and Nutrient Recycling to the Water Column." *Chemistry and Ecology* 19(5):321–42. doi: 10.1080/0275754031000155474.

Wijffels, Rene H. 2007. "Potential of Sponges and Microalgae for Marine Biotechnology." *Trends in Biotechnology* 26(1):26–31. doi: 10.1016/j.tibtech.2007.10.002.

Yuvaraj, N., P. Kanmani, R. Satishkumar, A. Paari, V. Pattukumar, V. Arul, P. Kanmani, R. Satishkumar, A. Paari, V. Pattukumar, V. Arul, N. Yuvaraj, P. Kanmani, R. Satishkumar, A. Paari, V. Pattukumar, and V. Arul. 2012. "Seagrass as a Potential Source of Natural Antioxidant and Anti-Inflammatory Agents." *Pharmaceutical Biology* 50(4):458–67. doi: 10.3109/13880209.2011.611948.