Monitoring and Evaluation of Spatially Managed Areas

Deliverable 1.2

Catalogue of European seabed biotopes

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Introduction - Overview

MESMA focuses on marine spatial management and aims to supply a general framework and strategic tools for the sustainable development of European seas and coastal areas by combining an optimized use with a sustained ecosystem of high quality. As competition for marine resources increases and human activities have caused the degradation of the quality status of the marine environment, there is an urgent need for holistic, planned approaches to managing our seas.

The seas around Europe are home to an exceptionally wide range of marine habitats and their associated biodiversity. To achieve sustainable management and to conserve marine biodiversity, access to information about seabed biotic and abiotic characteristics is a prerequisite. Such information includes the distribution of seabed habitats and their associated bioocommunities, their current state and future trends, goods and services provided, and their vulnerability and impacts as a result of human activities. The relative value of the various aspects of the benthic marine environment is an important basis for the spatial management of marine areas and such assessments will thus play a key role in MESMA as a means of identifying priority biotopes of high value that are particularly vulnerable to anthropogenic effects and therefore in need of protection.

In this catalogue, existing information was compiled and analysed for the majority of European seabed biotopes as proposed and classified by the European Nature Information System (EUNIS) (http://eunis.eea.europa.eu). The EUNIS database provides a comprehensive pan-European approach that covers all types of habitats (from natural to artificial, from terrestrial to freshwater and marine) and their associated flora and fauna, with a view to facilitate the harmonised description and collection of data across Europe (EUNIS, 2002). However, for many of these sub-categories either no information or very limited data has so far been provided. Hence, building upon EUNIS, we greatly extended the available information in order to fulfil the needs of MESMA.

Within the MESMA perspective, this report focuses specifically on sublittoral, fully marine EUNIS habitat types at level-4 and beyond (EUNIS, 2002). Habitat types at EUNIS level-4 are hereby defined as *biotopes*, a term which accounts for a particular *habitat* (i.e. the environment's physical and chemical characteristics encompassing the substratum and the particular conditions of wave exposure, salinity, tidal streams and other environmental factors) together with its recurring associated *community of species* (Jones et al., 2000).

Special emphasis was given on the Mediterranean, Black Sea (Pontic), and deep-sea biotopes, for which little or no information was included in the original EUNIS database. In total, 66 biotopes at EUNIS level-4 were compiled, 6 of which are newly inserted for the Black Sea. Furthermore, 26 new sub-biotopes were inserted and described, 16 of which at EUNIS level-5, and 11 more at EUNIS level-6 (EUNIS, 2002).

Biotope factsheets were formatted according to a standard layout, compiling all existing and/or readily available information on the following fields:

- Biotope Name: The names used to describe each biotope are the currently accepted EUNIS titles, as they appear in the official (online) database. For newly inserted biotopes and sub-biotopes,optional names and numberings - indicated in the catalogue by an asterisk*- were proposed.
- Classification: Names (Titles) and Code Numbers according to the current EUNIS and NATURA 2000 typology are given for each biotope.
- Biotope Pictures: One or more pictures showing aspects of the biotope are given where available.
- Biotope Distribution: A map illustrating the existing geospatial information and /or potential distribution (as predicted by each biotope’s basic ecological requirements) is given for each biotope.
- Links to available maps: Web links to other regional/national official distribution maps are given where available.

- Biotope Requirements: The main environmental requirements (eg. substratum type, depth, hydrodynamism / water movement, temperature / salinity levels, light availability) are given for each biotope, as retrieved from the EUNIS database and/or other sources available.
- Biotope Description: A general description of the biotope and its characterizing / structuring / key / associated species, along with a list and description of all associated sub-biotopes (at EUNIS level-5 and, where appropriate, level-6) is given, based on the EUNIS database descriptions and/or other sources available.
- Biotope Evaluation: Goods and Services: A description and assessment of goods and services provided by the biotope, as further analysed below.
- Sensitivity to human activities: A compilation of reported and/or anticipated threats jeopardizing the existence and / or ecological status of the biotope.
- Conservation and Protection Status: A compilation of current protection/management tools which apply for the biotope at international and/or national level, as well as any critical issues and/or general recommendations to address management purposes.
- List of References: A list of all bibliographic sources used, additionally to the official EUNIS database.

More specifically, goods and services provided by each biotope were reviewed based on the Millennium Ecosystem Assessment 2003 and Beaumont et al. (2007), and rated intothree major evaluation classes "*High*", "*Low*", "*Negligible/Irrelevant/Unknown*". Namely, the following parameters were assessed:

Food provision [provisional service]
Definition: The extraction of marine organisms for human consumption.
Plants and animals derived directly from marine biodiversity provide a significant part of the human diet. Fisheries in particular, and the accompanying employment, provide a significant example of the importance of this function.

Raw materials [provisional service]
Definition: The extraction of marine organisms for all purposes, except human consumption.
A wide variety of raw materials are provided by marine biodiversity for a variety of different uses, for example, seaweed for industry and fertilizer, fishmeal for aquaculture and farming, pharmaceuticals, biochemicals, natural medicines, and ornamental goods such as shells. The provision of raw materials results in significant employment opportunities. This category does not include dredge materials, oil or aggregates as these are not supported by living marine organisms.

Air quality and climate regulation [regulating service]
Definition: The balance and maintenance of the chemical composition of the atmosphere and climate regulation by sequestering green house gases by marine living organisms.
The chemical composition of the atmosphere is maintained through a series of biogeochemical processes. The maintenance of a healthy, habitable planet is dependent on processes such as the regulation of the volatile organic halides, ozone, oxygen and dimethyl sulphide, and the exchange and regulation of carbon, by marine living organisms. For example, organisms in the marine environment play a significant role in climate control through their regulation of carbon fluxes, by acting as a reserve or sink for CO_2 in living tissue and by facilitating burial of carbon in sea bed sediments. The capacity of the marine environment to act as a carbon sink will be affected by changes in marine biodiversity.

Disturbance and natural hazard prevention [regulating service]
Definition: The dampening of environmental disturbances by biogenic structures.
Living marine flora and fauna can play a valuable role in the defense of coastal regions. The presence of organisms in the front line of sea defense can dampen and prevent the impact of tidal surges, storms and floods. This disturbance alleviation service is provided mainly by a diverse range of species which bind and stabilize sediments and create natural sea defenses, for example salt marshes, mangrove forests and sea grass beds (Huxley, 1992; Davison and Hughes, 1998). Specific biotopes play an important role in sediment retention and the prevention of coastal erosion or underwater sediment slides.

Water quality regulation and bioremediation of waste [regulating service]

Definition: Removal of pollutants through storage, burial and recycling.

A significant amount of human waste is deposited in the marine environment. Waste material can be organic, such as oil and sewage, as well as inorganic, comprising a huge variety of chemicals. Through either direct or indirect activity, marine living organisms store, bury and transform many waste materials through assimilation and chemical de- and re-composition. For example, the bioturbation activity (reworking and mixing of sediments) of mega- and macrofaunal organisms within the seabed can bury, sequester and process waste material through assimilation and/or chemical alteration. These detoxification and purification process are of critical importance to the health of the marine environment.

Water quality regulationrefers to the maintenance of the physical, chemical and biological characteristics of marine waters through the biological and ecosystem processes such as biofiltration, trophic control, nutrient and substance cycling; primary, secondary and tertiary production; sedimentation; bioaccumulation.

Cognitive benefits [cultural services]

Definition: Cognitive development, including education and research, resulting from marine organisms.

Marine living organisms provide stimulus for cognitive development, including education and research. Information 'held' in the natural environment can be adapted, harnessed or mimicked by humans, for technological and medicinal purposes. Current examples of the use of marine information include: the study of microbes in marine sediments to develop economical electricity in remote places (Chaudhuri and Lovley, 2003); the inhibition of cancerous tumor cells (Self, 2005); the use of *Aprodite* sp. spines to progress the field of photonic engineering, with potential implications for communication technologies and medical applications (Parker et al., 2001); the development of tougher, wear resistant ceramics for biomedical and structural engineering applications by studying the bivalve shell (Ross and Wyeth, 1997).

In addition, marine biodiversity can provide a long term environmental record of environmental resilience and stress. The fossil record can provide an insight into how the environment has changed in the past, enabling us to determine how it will change in the future. This is of particular relevance to current concerns about climate change.

Bio-indicators, such as changes in biodiversity, community composition and ecosystem functioning, are also beneficial for assessing and monitoring changes in the marine environment caused by human impact. Ecophysiological responses of marine organisms to the changes in their environment, defined as biomarkers, can provide significant information for development of early warning systems for environmental degradation (Walker et al., 2001).

Leisure, recreation and cultural inspiration [cultural services]

Definition: The refreshment and stimulation of the human body and mind through the perusal and study of, and engagement with marine habitats and living marine organisms in their natural environment.

Marine ecosystems and biodiversity provide the basis for a wide range of recreational activities including ecotourism, swimming, sport fishing, snorkelling, recreational diving, (sea) bird watching, rock pooling, beachcombing, and whale-watching. The provision of this service results in significant employment opportunities (tourism industry, diving industry, recreational fishing industry).

Cultural inspirationrefers to the opportunity provided by ecosystems for enjoying aesthetic and spiritual experience, inspiration for art and design.

Feel good or warm glow (non-use benefits) [cultural services]

Definition: Benefit which is derived from marine organisms without using them.

Bequest value: The current generation places value on ensuring the availability of biodiversity and ecosystem functioning to future generations. This is determined by aperson's concern that future generations should have access to resources and opportunities. It indicates a perception of benefit from the knowledge that resources and opportunities are being passed to descendants.

Existence value: This is the benefit, often reflected as a sense of well being, of simply knowing marine biodiversity exists, even if it is never utilised or experienced, peoplesimply derive benefit from the knowledge of its existence (Hageman, 1985; Loomis and White, 1996). The considerable importance which the wider public attach to maintaining diverse marine life is revealed through their interest in marine based media presentations, such as the ‘‘Blue Planet’’. In addition, articles on cold water corals frequently appear in the media. Despite the fact the majority of the general public will never see a cold water coral, they are interested in them and benefit from their existence.

Photosynthesis, chemosynthesis, and primary production [support services]

Definition: The production of oxygen by photosynthesis and the assimilation or accumulation of energy and nutrients by organisms or the biological conversion of one or more carbon molecules (usually carbon dioxide or methane) and nutrients into organic matter using the oxidation of inorganic molecules or methane as a source of energy (chemosynthesis).

Many marine habitats substantially contribute to the global production of oxygen and/or the production of organic compounds from aquatic carbon dioxide, methane, hydrogen sulfide or other inorganic molecules.

Nutrient cycling [support services]

Definition: The storage, cycling and maintenance of nutrients by living marine organisms.

The storage, cycling and maintenance of a supply of essential nutrients, for example nitrogen, phosphorus, sulphur and metals, is crucial for life. Nutrient cycling encourages productivity, including fisheries productivity, by making the necessary nutrients available to all levels of the food chains and webs. Nutrient cycling is undertaken in many components of the marine environment, in particular within seabed sediments and salt marshes in shallow coastal waters and in the water column in deeper, offshore waters.

Reproduction and nursery areas [support services]

Definition: The provision of the appropriate environmental conditions for reproduction and/or growing during the early stages of marine species.

Some biotopes may constitute areas where most individuals of a species aggregate to reproduce or where juveniles find food and safe shelter. Such biotopes are essential for the viability of some marine populations and the fitness of such populations is closely related to the status of these biotopes.

Maintenance of biodiversity

Definition: An ecosystem function resulting from the complex organization (ecosystem structure) and operation of ecosystems (ecosystem processes) that allows for the continuation and diversification of the variability among living organisms (within species and between species) over time.

Goods and Services provided by each seabed biotope, as assessed in the present catalogue, are summarised in Table 1.

Table 1. Summary of Goods and Services provided by each seabed biotope, as assessed in the present catalogue: the three major evaluation classes (*"High"*, *"Low"*, "*Negligible / Irrelevant / Unknown*") are given in dark blue, light blue and white respectively.

Biotopes	Food provision	Raw materials	Air quality and climate regulation	Disturbance and natural hazard prevention	Water quality regulation / Bioremediation of waste	Cognitive benefits	Leisure, recreation and cultural inspiration	Feel good or warm glow	Photosynthesis, chemosynthesis, and primary production	Nutrient cycling	Reproduction and nursery areas	Maintenance of biodiversity
Pontic communities of exposed mediolittoral rock					Low	Low	High	High		Low		Low
Pontic communities of lower mediolittoral rock moderately exposed to wave action	Low					Low	High	High	Low	Low		Low
Pontic communities of mediolittoral sands	Low					Low	High	High		Low	Low	Low
Pontic *Ficopomatus enigmaticus* reefs					High	High	Low	Low		High	High	High
Sediment-affected or disturbed kelp and seaweed communities	Low	High	Low		Low	Low	Low	Low	High	High		Low
Mediterranean and Pontic communities of infralittoral algae very exposed to wave action	Low	High	High		High	High	Low	Low	High	High	High	High
Frondose algal communities (other than kelp)	Low	High	Low	Low	Low	Low	High		High	High	High	High
Kelp and red seaweeds (moderate energy infralittoral rock)	High	High	High	High	High	Low	High		High	High	High	High
Mediterranean and Pontic communities of infralittoral algae moderately exposed to wave action	Low	High	High		High	High	Low	Low	High	High	High	High
Faunal communities on moderate energy infralittoral rock	High	Low	Low	Low	High	High	High	High	Low	High	High	High
Mediterranean submerged fucoids, green or red seaweeds on full salinity infralittoral rock	High	High	High		High	High	High	Low	High	High	High	High
Faunal communities on low energy infralittoral rock												
Faunal communities on variable or reduced salinity infralittoral rock												
Robust faunal cushions and crusts in surge gullies and caves	Low				Low	High	High	High	Low	Low	Low	Low
Infralittoral fouling seaweed communities	Low				High	High			Low	Low	Low	
Vents and seeps in infralittoral rock		High				High	Low		High			
Mixed faunal turf communities on circalittoral rock	High	High	Low	High	High	High	High	Low	High	High	High	High
Sabellaria reefs on circalittoral rock					High	Low				High	High	High
Communities on soft circalittoral rock	High								High	High	High	High
Mussel beds on circalittoral rock	High		Low	High	High				High	High	High	High
Mediterranean coralligenous communities moderately exposed to hydrodynamic action	High	Low	High		High	High	High	High	Low	High	High	High
Pontic *Phyllophora crispa* beds on circalittoral bedrock and boulders	Low	High	Low		High	High	High	High	High	High	High	High
Mediterranean coralligenous communities sheltered from hydrodynamic action	High	Low	High		High	High	High	High	Low	High	High	High

Table 1 (cont.). Summary of Goods and Services provided by each seabed biotope, as assessed in the present catalogue: the three major evaluation classes (*"High"*, *"Low"*, *"Negligible / Irrelevant / Unknown"*) are given in dark blue, light blue and white respectively.

Biotopes	Food provision	Raw materials	Air quality and climate regulation	Disturbance and natural hazard prevention	Water quality regulation / Bioremediation of waste	Cognitive benefits	Leisure, recreation and cultural inspiration	Feel good or warm glow	Photosynthesis, chemosynthesis, and primary production	Nutrient cycling	Reproduction and nursery areas	Maintenance of biodiversity
Faunal communities on deep low energy circalittoral rock					High					High		
Communities of circalittoral caves and overhangs						High	High	Low			Low	High
Infralittoral coarse sediment	High	High					Low	Low		Low	High	
Circalittoral coarse sediment	High	High								Low	Low	Low
Deep circalittoral coarse sediment	High	Low								Low		Low
Infralittoral fine sand	High	Low					Low	Low		Low		Low
Infralittoral muddy sand	High	Low			Low					Low	High	Low
Circalittoral fine sand	High	Low								Low	Low	Low
Circalittoral muddy sand	High	Low			Low					Low	Low	Low
Mediterranean communities of superficial muddy sands in sheltered waters	High				Low					Low	High	Low
Infralittoral sandy mud	High				Low					Low	Low	Low
Infralittoral fine mud	Low				Low					Low		Low
Circalittoral sandy mud	High				Low					Low	Low	Low
Circalittoral fine mud	High				Low					Low	Low	Low
Deep circalittoral mud	High				Low					Low	Low	Low
Mediterranean communities of muddy detritic bottoms	Low				Low					Low		Low
Mediterranean communities of coastal terrigenous muds	High									Low	Low	Low
Infralittoral mixed sediments	High	Low			Low					Low	Low	High
Circalittoral mixed sediments	High	Low			Low					Low	Low	High
Deep circalittoral mixed sediments	High	Low			Low					Low	Low	High
Mediterranean animal communities of coastal detritic bottoms	High				Low					Low	Low	High
Mediterranean communities of shelf-edge detritic bottoms	High				Low					Low		Low
Maerl beds	High	High	High			High	Low		High	Low	High	High
Sublittoral seagrass beds	High	Low	High	High	High	High	High	High	High	High	High	High
Sublittoral polychaete worm reefs on sediment	High				High		Low	Low	Low	High	High	High
Sublittoral mussel beds on sediment	High	Low		High	High		Low	Low		High	High	High
Pontic Ostrea edulis reefs	High		Low		High	High	High	High	Low	High	High	High
Organically-enriched or anoxic sublittoral habitats	High	Low	Low	Low	Low				Low	High	Low	Low

Table 1 (cont.). Summary of Goods and Services provided by each seabed biotope, as assessed in the present catalogue: the three major evaluation classes (“*High*”, “*Low*”, “*Negligible / Irrelevant / Unknown*”) are given in dark blue, light blue and white respectively.

Biotopes	Food provision	Raw materials	Air quality and climate regulation	Disturbance and natural hazard prevention	Water quality regulation / Bioremediation of waste	Cognitive benefits	Leisure, recreation and cultural inspiration	Feel good or warm glow	Photosynthesis, chemosynthesis, and primary production	Nutrient cycling	Reproduction and nursery areas	Maintenance of biodiversity
Deep-sea artificial hard substrata												
Deep-sea manganese nodules		High	Low		Low							High
Deep-sea biogenic gravels								High			Low	High
Communities of bathyal detritic sands with *Gryphus vitreus*	Low							High				High
Communities of deep-sea corals	High					High		High			High	High
Deep-sea sponge aggregations	Low					High	Low	Low		High	Low	High
Seamounts, knolls and banks	High				Low	Low		High		Low	High	High
Oceanic ridges	High							Low	Low	Low	Low	High
Abyssal hills												
Cold-water coral carbonate mounds	High				Low	High		High		Low	High	High
Submarine canyons on the continental slope	High				Low					High	High	Low
Deep-sea trenches		Low				Low		Low				Low
Deep-sea hydrothermal vents		High			High	High		High	High	Low		Low
Pontic anoxic H2S black muds of the slope and abyssal plain		High	High	High	High	High			High	High		
Pontic anaerobic microbial biogenic reefs above methane seeps		High	High	High		High		Low	High	High		Low

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References

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, T. Zarzycki, Identification, definition and quantification of goods and services provided by marine biodiversity: Implications for the ecosystem approach, Marine Pollution Bulletin, Volume 54, Issue 3, March 2007, Pages 253-265, ISSN 0025-326X, DOI: 10.1016/j.marpolbul.2006.12.003.

Chaudhuri, S.K., Lovley, D.R., 2003. Electricity generation by direct oxidation of glucose in mediatorless microbial fuel cells. NatureBiotechnology 21 (10), 1229–1232.

Davison, D.M., Hughes, D.J., 1998. Zostera Biotopes volume I. An Overview of Dynamics and Sensitivity Characteristics for Conservation Management of Marine SACs. Scottish Association for Marine Science UK Marine SACs Project. 95 pp.

EUNIS (2002) EUNIS Habitat Classification. European Environment Agency http://eunis.eea.eu.int.

Hageman, R., 1985. Valuing Marine Mammal Populations: Benefit Valuations in a Multi-species Ecosystem. National Marine Fisheries Service, Southwest Fisheries Centre, La Jolla, California, 1985. pp. 88.

Huxley, A., 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5.

Jones LA, Hiscock K & Connor DW (2000) Marine habitat reviews. A summary of ecological requirements and sensitivity characteristics for the conservation and management of marine SACs. Peterborough, Joint Nature Conservation Committee. (UK Marine SACs Project report.)

Loomis, J.B., White, D.S., 1996. Economic benefits of rare and endangered species: summary and meta-analysis. Ecological Economics 183,197–206.

Parker, A.R., McPhedran, R.C., McKenzie, D.R., Botten, L.C., Nicorovici, N.A., 2001. Photonic engineering: Aphrodite's iridescence. Nature 409, 36–37.

Ross, I.M., Wyeth, P., 1997. Sharp concepts, or just another boring bivalve? http://www.rdg.ac.uk/biomim/97ross.htm. Centre for Biomimetics, The University of Reading.

Self, D. 2005. Killing Cancer? Mote Magazine. http://www.mote.org/.

List of Abbreviations

General abbreviations

Abbreviation	Full description
AOM	Anaerobic microbial
CITES	Convention on Biological Diversity, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)
CR	Critically Endangered
EC	European Community
EEC	European Economic Community
EN	Endangered
EUNIS	European Nature Information System
ICATT	International Commission for the Conservation of Atlantic Tunas
ICES	International Council for the Exploration of the Sea
LC	Least concern
MAR	Mid-Atlantic Ridge
MLWS	Water level at mean low water springs
MOA	Methane oxidizing archaea bacteria
MPA	Marine Protected Area
NASCO	North Atlantic Salmon Conservation Organization
NEAFC	North East Atlantic fisheries Commission
NGO	Non-governmental organization
OSPAR	The Oslo and Paris Commissions, which have the objective of protecting the Northeast Atlantic against pollution. Member countries range from Finland to Portugal and Iceland.
PCB	Polychlorinated biphenyls
POM	Particulate organic matter
UNCLOS	United Nations Convention on the Law of the Sea
UNEP-MAP RAC/SPA	United Nations Environment Programme-Mediterranean Action Plan Regional Activity Centre/Specially Protected Areas
UNSFA	United Nations Fish Stocks Agreement
VU	Vulnerable

Abbreviations on the list of biotopes and corresponding codes:

Abbreviation	Full description
AalbNuc	*Abra alba* and *Nucula nitidosa* in circalittoral muddy sand or slightly mixed sediment
ClloMx	*Cerianthus lloydii* and other burrowing anemones in circalittoral muddy mixed sediment
CumCset	Cumaceans and *Chaetozone setosa* in infralittoral gravelly sand
EphR	Ephemeral red seaweeds
FfabMag	*Fabulina fabula* and *Magelona mirabilis* with venerid bivalves and amphipods in infralittoral compacted fine muddy sand
FluCoAs	*Flustra foliacea* community
KFaR	Wave exposed *Laminaria hyperborea* biotopes
Ldig	*Laminaria digitata*
Ldig.Bo	*Laminaria digitata* on boulder shores
Ldig.Ldig	*Laminaria digitata* forest on rocky shores
Ldig.Pid	Soft rock supporting L. digitata
LdigT	*Laminaria digitata* zone of the sublittoral fringe bedrock or boulders
LGS.Lan	Dense Lanice biotope
Lhyp	*Laminaria hyperborea* zones
Lhyp.Ft	*Laminaria hyperborea* forest
Lhyp.GzFt	Grazed kelp forest
Lhyp.GzPk	Grazed kelp park
Lhyp.Pk	Kelp park
Lhyp.Sab	Kelp with *Sabellaria spinulosa* reefs
LhypFa	*Laminaria hyperborea* zone
LhypR	*Laminaria hyperborea* kelp forest and park communities
LhypR.Ft	*Laminaria hyperborea* forest
LhypT.Ft	*Laminaria hyperborea* forest
LhypTX.Ft	Tide-swept kelp forest on upper infralittoral mixed substrata
LhypTX.Pk	Tide-swept kelp park on lower infralittoral mixed substrata
LSa.BarSa	Barren littoral coarse sand
LsacChoR	Kelp and Chorda filum in the shallows
ModHAs	*Modiolus modiolus* beds with fine hydroids and large solitary ascidians on very sheltered circalittoral mixed substrata
NcirBat	*Nephtys cirrosa* and *Bathyporeia* spp. in infralittoral sand
PomB	Mobile mixed substrata
ProtAhn	Robust scour-tolerant red seaweeds on sand-covered rock
SBR	Sublittoral biogenic reefs on sediment
SBR.ModMx	*Modiolus modiolus* beds on open coast circalittoral mixed sediment
SCS	Sublittoral coarse sediment
SCS.Glap	*Glycera lapidum* in impoverished infralittoral mobile gravel and sand
SCS.MedLumVen	*Mediomastus fragilis*, *Lumbrineris* spp. and venerid bivalves in circalittoral coarse sand or gravel
SCS.MoeVen	*Moerella* spp. with venerid bivalves in infralittoral gravelly sand
SCS.SLan	Dense *Lanice conchilega* and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand
SMP.Lcor	*Lithothamnion corallioides* maerl beds on infralittoral muddy gravel
SMP.Pcal	*Phymatolithon calcareum* maerl beds in infralittoral clean gravel or coarse sand

SMU.AmpPlon	*Ampelisca* spp., *Photis longicaudata* and other tube-building amphipods and polychaetes in infralittoral sandy mud
SMX	Sublittoral mixed sediment
SMX.FluHyd	*Flustra foliacea* and *Hydrallmania falcata* on tide-swept circalittoral mixed sediment
SRB	Sulfate-reducing bacteria
SS.SMP.Mrl	Maerl beds
SS.Ssa	Sandy sediments
XKHal	*Halidrys siliquosa* biotope
XKScrR	Abutting sand-scoured kelp on bedrock

The full list can be found on: http://www.jncc.gov.uk/files/04_05_full_biotope_list.zip

Table of contents

*Pontic communities of exposed mediolittoral rock

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	*A1.16	*Pontic communities of exposed mediolittoral rock

Picture(s)
Not available

Biotope Distribution
Not available

Links to available maps
Not available

Biotope requirements
Exposed upper shore on bedrock and boulders. In microtidal seas like the Black Sea (tidal range of about 0.3 m) this biotope is limited to a narrow strip in the upper part of the swash zone and is not permanently covered by water, being intermittently wetted by taller waves [1, 2].
Exposed rock in the lower mediolittoral, which in the Black Sea is a narrow zone located in the lower part of the swash zone and is covered by water most of the time. High and constant humidity, strong wave action and strong light are the dominant environmental factors for this biotope [1, 2].

Biotope Description

Associated Biotopes at EUNIS Level 5:
A1.161: Pontic exposed upper mediolittoral rock with Chthamalus stellatus, Melaraphe neritoides, Ligia italica. Harsh conditions make this biotope suitable only for a few species. The characteristic fauna is represented by the barnacle *Chthamalus stellatus,* the periwinkle *Melaraphe neritoides* found in crevices, the isopod *Ligia italica* [1, 4, 5, 6]. The crab *Pachygrapsus marmoratus* is often found outside the water in shaded crevices of rocky shore. In some occasions epi- and endolithic cyanobacteria that form slippery film are represent [2, 7, 8]. Typical of this biotope is the encrusting lichen *Verrucaria maura* that may form patches amongst *Chthamalus* and a distinct black zone above *Chthamalus*, which demarcates the upper limit of the biotope. *Chthamalus stellatus* is tolerant to desiccation therefore able to form a belt above the *Mytilus galloprovincialis* dominated community in the lower mediolittoral. However *Chthamalus* is sensitive to low temperatures and salinity therefore it is rare in the North-Western Black Sea. Winter frost is able to eliminate the populations of *Chthamalus*.
***A1.162: Pontic exposed lower mediolittoral rock with Mytilaster lineatus and Mytilus galloprovincialis, and corallines*.** The community is typically dominated by the small mussel *Mytilaster lineatus* capable of very firm attachment andsmall individuals of *Mytilus galloprovincialis* that form patches or band below the *Chthamalus stellatus* zone [1, 2, 3, 4, 5, 6]. Strong winter storms may remove the mussel cover. Barnacles *Balanus improvisus* are found on *Mytilus* or on the rocks uncovered by mussels. Other typical fauna includes animals able to adhere as the rare limpet *Patella ulyssiponensis* or good swimmers as the isopod crustacean *Idotea baltica basteri*. The crabs *Eriphia verrucosa* and *Pachygrapsus marmoratus* may be found sheltered in crevices. The flora of exposed coasts includes few types of seaweed able to tolerate wave wash such as the articulated coralline *Corallina officinalis*, which can form a dense turf in clean waters, the encrusting coralline *Lithophyllum incrustans,* the ephemeral red alga *Nemalion helminthoides* [7, 8].

Biotope Evaluation: Goods and Services
Rocky shore mussels may be a subject of small scale exploitation, for example by anglers for bait. *Patella ulyssiponensis* may be collected for decorative use. Few other species are likely to be subject to exploitation. Suspension feeding mussels and barnacles provide water quality regulation in coastal environments by

transferring pelagic phytoplanktonic primary production to secondary production (pelagic-benthic coupling) and increasing turnover of nutrients and organic carbon. Rocky shores provide a range of cultural services including opportunities for recreation and tourism, enjoyment of natural heritage, aesthetic and spiritual experience, inspiration for art, opportunities for scientific research and cognitive development.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

The occurrence of this biotope at the land-sea interface makes it vulnerable to coastal and maritime human activities. Substratum loss due to direct destruction by human modifications of the coastline will result in loss of the sessile mussels and barnacles and their associated community. Increased sediments will result in burial of mussels, decline in *Corallina officinalis* and smothering of barnacles. Under eutrophic conditions *Corallina officinalis* will decline and eventually disappear. Decrease in wave exposure owing to coastal constructions will decrease the dominant fauna of filter feeders and increase macroalgae. Various chemical and hydrocarbon contaminants result in decreased growth, reduced abundance and extent in mussels, while red algae, limpets and crustaceans have been shown to be particularly intolerant [9].

Conservation and protection status

Reefs are Natura 2000 habitat types listed under the EC/92/43 Habitats Directive.The Black Sea Red Data Book [9] lists the following species that occur in this biotope: *Pachygrapsus marmoratus* (enlisted as vulnerable), and *Eriphia verrucosa* and *Patella ulyssiponensis* (enlisted as endangered).

References

[1] Micu D, Zaharia T, Todorova V (2008) Natura 2000 habitat types from the Romanian Black Sea. In: Zaharia T, Micu D, Todorova V, Maximov V, Niţă V. The development of an indicative ecologically coherent network of marine protected areas in Romania, Romart Design Publishing, Constanta, pp 32

[2] Vershinin A, (2007) Life in the Black Sea. Maccentr, Moscow, pp 192 (in Russian)

[3] Living Black Sea, 2005. Marine Environmental Education Program in the Russian Federal Children Center Orlyonok (Black Sea coast, Russian Federation). Available at http://blacksea-education.ru

[4] Marinov T (1990) The zoobenthos from the Bulgarian Sector of the Black Sea. Publishing house of the Bulgarian Academy of Sciences, Sofia, pp 195 (in Bulgarian)

[5] Konsulov A (1998) Black Sea Biological Diversity: Bulgaria. Black Sea Environm Ser 5. United Nations Publications, New York, pp 131

[6] Zaitsev YP, Alexandrov BG (1998) Black Sea Biological Diversity: Ukraine. Black Sea Environm Ser 7. United Nations Publications, New York, pp 351

[7] Dimitrova-Konaklieva S (2000) Flora of the Marine Algae of Bulgaria (Rhodophyta, Phaeophyta, Chlorophyta). Pensoft, Sofia – Moscow, pp 304 (in Bulgarian)

[8] Kalugina-Gutnik AA (1975) Phytobenthos of the Black Sea. Naukova dumka, Kiev, pp 245 (in Russian)

[9] Black Sea Red Data Book. Available at http://www.grid.unep.ch/bsein/redbook/index.htm

**Pontic communities of lower mediolittoral rock moderately exposed to wave action*

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	*A1.24	*Pontic communities of lower mediolittoral rock moderately exposed to wave action

Picture(s)
Not available

Biotope Distribution
Not available

Links to available maps
Not available

Biotope requirements
Moderately exposed bedrock and boulders in the lower mediolittoral zone,often with nearby sandy sediments. High and constant humidity and strong light are the dominant environmental factors for this biotope. In the Black Sea the lower mediolittoral rock is a narrow zone located in the lower part of the swash zone and is covered by water most of the time [1].

Biotope Description
In the Black Sea moderately exposed lower swash zone is typically covered by dense large *Mytilus galloprovincialis* and *Mytilaster lineatus* that form a band [1, 2, 3, 4, 5]. Abundant barnacles *Balanus improvisus* are commonly found on both *Mytilus* valves and on patches of barerock. Characteristic fauna includes the chiton *Lepidochitona cinerea,* the rare limpet *Patella ulyssiponensis,* the isopod crustaceans *Idotea baltica basteri, Sphaeroma pulchellum,* the amphipods *Hyalepontica*, *Amphitoe ramondi,* and the crabs *Eriphia verrucosa* and *Pachygrapsus marmoratus* [1, 2, 6]. The characteristic flora is represented by the articulated coralline *Corallina officinalis*, which can form a dense turf in clean waters. On more wave-sheltered rocky shores mussels may be absent, while ephemeral macroalgae may form dense growths: e.g the red algae *Ceramium rubrum, Ceramium diaphanum, Porphyra leucosticta, Bangia atropurpurea,* the green algae *Ulva compressa, Ulva rigida, Ulva intestinalis, Cladophora vagabunda, Cladophora laetervirens, Ulothrix flacca* and the brown alga *Scytosiphon simplicissimus* [7, 8]. Eutrophicated areasare dominated by *Ulva intestinalis, Ulva rigida* and *Cladophora vagabunda* [3, 4, 7].

Biotope Evaluation: Goods and Services
Rocky shore mussel beds may be a subject of small scale exploitation for bait or food. The largest Black Sea crab *Eriphia verrucosa* is considered a gastronomic delicacy and may be caught for human consumption. Few other species are likely to be subject to exploitation. Macroalgae provide primary production and food web maintenance in the coastal zone. Suspension feeding mussels and barnacles transfer pelagic phytoplanktonic primary production to secondary production and provide nutrient cycling and water quality regulation in coastal environments. Rocky shores provide a range of cultural services including opportunities for recreation and tourism, enjoyment of natural heritage, aesthetic and spiritual experience, inspiration for art, scientific research and cognitive development.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☐	☐	☒

Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

The occurrence of this biotope at the land-sea interface makes it vulnerable to coastal and maritime human activities. Substratum loss due to direct destruction by human modifications of the coastline will result in loss of the sessile mussels and barnacles and their associated community. Increased sediments will result in burial of mussel beds, and smothering of barnacles. Ephemeral green algae such as *Ulva* spp. will increase under eutrophic conditions, while *Corallina officinalis* will decrease [3, 4, 5, 7]. Decrease in wave exposure owing to coastal constructions will decrease filter feeders and increase macroalgae. A number of chemical contaminants are likely to result in reduced growth and general degradation of the mussel population and hence the bed. Overall, red algae and crustaceans have been shown to be particularly intolerant to various chemical and hydrocarbon pollution [9].

Conservation and protection status

“Reefs” are Natura 2000 habitat types listed under the 92/43/EC Habitats Directive.The Black Sea Red Data Book [9] lists the following species that occur in this biotope: *Pachygrapsus marmoratus* (enlisted as vulnerable), and *Eriphia verrucosa* and *Patella ulyssiponensis* (enlisted as endangered).

References

[1] Micu D, Zaharia T, Todorova V (2008) Natura 2000 habitat types from the Romanian Black Sea. In: Zaharia T, Micu D, Todorova V, Maximov V, Niţă V. The development of an indicative ecologically coherent network of marine protected areas in Romania, Romart Design Publishing, Constanta, pp 32

[2] Marinov T (1990) The zoobenthos from the Bulgarian Sector of the Black Sea. Publishing house of the Bulgarian Academy of Sciences, Sofia, pp 195 (in Bulgarian)

[3] Petranu A (1997) Black Sea Biological Diversity: Romania. Black Sea Environm Ser 4. United Nations Publications, New York, pp 314

[4] Zaitsev YP, Alexandrov BG (1998) Black Sea Biological Diversity: Ukraine. Black Sea Environm Ser 7. United Nations Publications, New York, pp 351

[5] Konsulov A (1998) Black Sea Biological Diversity: Bulgaria. Black Sea Environm Ser 5. United Nations Publications, New York, pp 131

[6] Vershinin A (2007) Life in the Black Sea. Maccentr, Moscow, pp 192 (in Russian)

[7] Dimitrova-Konaklieva S (2000) Flora of the Marine Algae of Bulgaria (Rhodophyta, Phaeophyta, Chlorophyta). Pensoft, Sofia – Moscow, pp 304 (in Bulgarian)

[8] Kalugina-Gutnik AA (1975) Phytobenthos of the Black Sea. Naukova dumka, Kiev, pp 245 (in Russian)

[9] Black Sea Red Data Book. Available at http://www.grid.unep.ch/bsein/redbook/index.htm

Pontic communities of mediolittoral sands

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1140	Mudflats and sandflats not covered by water at low tide
EUNIS	*A2.26	*Pontic communities of mediolittoral sands

Picture(s)
Not available

Biotope Distribution
Not available

Links to available maps
Not available

Biotope requirements
Mediolittoral coarse, medium and fine sands, exposed, moderately exposed or sheltered from wave action. High levels of physical disturbance from wave action, wide temperature variability, and periods of desiccation are the dominant environmental conditions. In the microtidal Black Sea (tide range of about 0.3 m) this biotope is limited to the beach strip covered by the swash. It is narrow and does not exhibit the wide tidal flats of the Atlantic shores.

Biotope Description
Community composition depends on grain size with two subtypes distinguished – community of coarse/medium sand and community of fine sand. Diversity is usually low due to high physical disturbance from wave action but abundances may be high.

<u>Associated Biotopes at EUNIS Level 5</u>:
A2.261 (proposed new insertion/optional numbering): Donacilla cornea and Ophelia bicornis in medium-coarse mediolittoral sands. Coarse and medium sands of beaches exposed to wave action are inhabited by the burrowing wedge clam *Donacilla cornea,* which may attain abundances as high as thousands individuals per square meter [1, 2, 3]. *Donacilla* manifests depth segregation with the smaller, younger wedgeclams concentrated at the higher shore levels, while the larger, older ones preferring the lower levels [3]. *Donacilla* distribution extends towards the infralittoral to an approximate depth of 3 m [4]. Another characteristic species is the polychaete *Ophelia bicornis* which occupies the upper swash zone.
A2.262 (proposed new insertion/optional numbering): Pontogammarus maeoticus in fine mediolittoral sands.In fine sands the amphipod *Pontogammarus maeoticus* prevails, while *Donacilla* and *Ophelia* disappear [5]. Typical interstitial species are the crustaceans *Eurydice dolfusi, Gastrosaccus sanctus,* and the polychaetes *Nerine cirratulus, Saccocirrus papillocercus, Pisione remota, Hesionides arenaria* [1].

Biotope Evaluation: Goods and Services
Donacilla cornea may be potentially exploited for food although it is not traditionally consumed in the region. High prices on the European market however, have led to poaching by habitat-destructive dredging for illegal export.
Sandy beaches provide a range of cultural services including opportunities for recreation and tourism, enjoyment of natural heritage, aesthetic and spiritual experience, inspiration for art, scientific research and cognitive development.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

The occurence of this biotope at the land-sea interface makes it vulnerable to coastal and maritime human a ctivities. “Hard” beach defense constructions (dikes and groins), which alter natural beach dynamics (reduced wave exposure, grain size and oxygen concentration / penetration in sediment) have negative impact on *Donacilla* [3]. Trampling from tourists, marine and coastal litter, hypoxia due to eutrophication, various chemical and hydrocarbon pollution also present threats to the characteristic species of this biotope [4, 7].

Conservation and protection status

Sand flats not covered by seawater at low tide are Natura 2000 habitat types listed under the EC/92/43 Habitats Directive. The species *Ophelia bicornis, Hesionides arenarius*, *Donacilla cornea* which occur in this biotope are enlisted as endangered in the Black Sea Red Data Book [8].

References

[1] Marinov T (1990) The zoobenthos from the Bulgarian Sector of the Black Sea. Publishing house of the Bulgarian Academy of Sciences, Sofia, pp 195 (in Bulgarian)

[2] Kiseleva MI (1981) Benthos of Black Sea mobile substrates. Naukova dumka, Kiev, pp 165

[3] Micu D, Micu S (2006) Recent records and proposed IUCN status of *Donacilla cornea* (Poli, 1795) (Bivalvia: Veneroida: Mesodesmatidae) in the Romanian Black Sea. Cercet Mar 36: 117-132

[4] Todorova V, Micu D, Panayotova M, Konsulova T (2008) Marine Protected Areas in Bulgaria Present and Prospects. Steno Publishing House, Varna, pp 22

[5] Petranu A (1997) Black Sea Biological Diversity: Romania. Black Sea Environm Ser 4. United Nations Publications, New York, pp 314

[6] Micu D, Zaharia T, Todorova V (2008) Natura 2000 habitat types from the Romanian Black Sea. In: Zaharia T, Micu D, Todorova V, Maximov V, Niţă V. The development of an indicative ecologically coherent network of marine protected areas in Romania, Romart Design Publishing, Constanta, pp32

[7] BSERP (2007) Black Sea Transboundary Diagnostic Analysis. GEF Black Sea Ecosystem Recovery Project, Istanbul, May 2007. Available at http://ps-blacksea-commission.ath.cx/bserp/Text/Activities/BS_TDA

[8] Black Sea Red Data Book. Available at http://www.grid.unep.ch/bsein/redbook/index.htm

**Pontic Ficopomatus enigmaticus reefs*

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	*A2.73	*Pontic *Ficopomatus enigmaticus* reefs

Picture(s)

Not available

Biotope Distribution

Not available

Links to available maps

Not available

Biotope requirements

Sheltered shallow waters with a low current in harbours and lagoons, brackish or with variable salinity. Hard substratum – natural or artificial [1].

Biotope Description

In the presence of suitable habitat *Ficopomatus enigmaticus* may occupy the entire hard substratum with a mass of erect, contiguous and intertwined calcareous tubes (up to 20 cm long) cemented together. Successive generations of worms may raise the thickness of this biogenic reef up to 50 cm [1]. The associated fauna is extremely diverse, contrasting with the surrounding sedimentary areas. A single reef can shelter over 50 macrozoobenthic species: shrimps *Palaemon elegans, P. adspersus, Athanas nitescens, Philocheras fasciatus,* crabs *Pisidia longocornis, Rhitropanopeus harrisii, Pilumnus hirtelus, Xantho poressa, Pachygrapsus marmoratus;* endemic amphipods *Chaetogammarus placidus, Dikerogammarus villosus, D. haemobaphes, Pontogammarus crassus*, isopods, polychaetes, hydrozoans, ascidians [1, 2, 3]. *Ulva rigida* and *Ulva intestinalis* may grow sparsely on the reef.

Biotope Evaluation: Goods and Services

The reef has important ecological functional role, providing diverse microhabitats and food for other species. Also, due to high density of the tube-worm and the large surfaces it covers, it has a large biofiltering capacity and is locally important in nutrient cycling. The *Ficopomatus* reefs are able to sensibly improve the quality of the waters they develop in [1]. *Ficopomatus* is marked as a nuisance species, fouling on ship hulls, power station intake pipes and other submerged artifical structures, thus deemed harmful to certain human activities [2, 3].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation and bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☒	☐

Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Ficopomatus reefs are sensitive to loss of the hard substratum, smothering by sediments, increase in water flow rate, abrasion and physical disturbance by mooring and dredging [1].

Conservation and protection status

Biogenic reefs are Natura 2000 habitat types listed under the EC 92/43 Habitats Directive.

References

[1] Micu D, Micu S (2004) A new type of macrozoobenthic community from the rocky bottoms of the Black Sea. In: Ozturk B, Mokievsky VO and Topaloglu B (Eds) International Workshop on the Black Sea Benthos: 75-88. Turkish marine Research Foundation, Istanbul

[2] Kaneva-Abadjieva V, Marinov T (1965) Marine fouling along the Bulgarian Black Sea coast. Proc. IOF, 6: 137-145

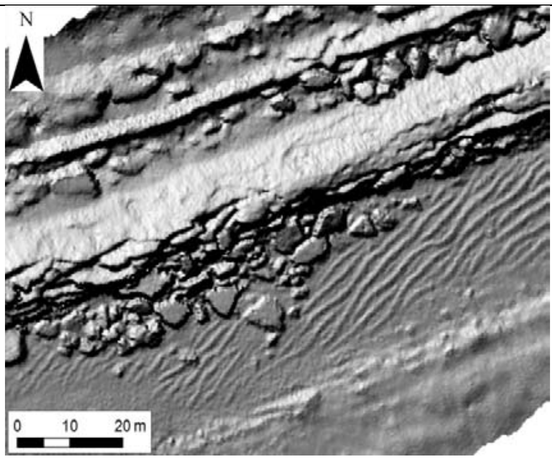
[3] Marinov T (1990) The zoobenthos from the Bulgarian Sector of the Black Sea. Publishing house of the Bulgarian Academy of Sciences, Sofia (in Bulgarian)

Sediment-affected or disturbed kelp and seaweed communities

Compiled by Ibon Galparsoro, Ángel Borja and Marta Pascual

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.12	Sediment-affected or disturbed kelp and seaweed communities

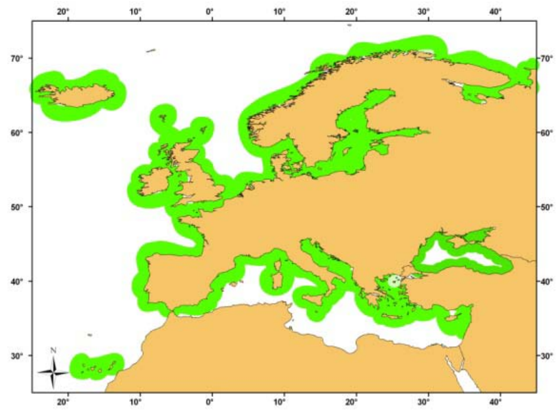
Picture(s)



(a) Shaded relieve model from multibeam echosounder data. 0.20 m grid resolution at 25 m water depth. Sedimentary features (megaripples) indicates wave energy action on the seafloor (modified from [1]).

(b) *In situ* picture (Image by AZTI – Tecnalia)

Biotope Distribution



Potential distribution map

Links to Available Maps

(UK:) http://www.jncc.gov.uk /marine/habitats/ habitat.aspx?habitat=JNCCMNCR00001534
http://www.taitdevelopments.co.uk/graphics/map1.png

Biotope Requirements

Atlantic and Mediterranean rocky habitats in the infralittoral zone fully saline (30-35 ppt); subject to extremely exposed wave action or strong tidal streams. Subject to disturbance through mobility of the substratum (boulders or cobbles) or abrasion/covering by nearby coarse sediments or suspended particulate matter (sand). The associated communities can be quite variable in character, depending on the particular conditions which prevail. The depth to which the kelp extends varies according to water clarity, exceptionally (e.g. St Kilda) reaching 45 m [2].

Biotope Description

The typical *Laminaria hyperborea* and red seaweed communities of stable open coast rocky habitats (EUNIS code: A3.21), are replaced by those, which include more ephemeral species or those tolerant of sand and gravel abrasion. As such *Laminaria saccharina*, *Saccorhiza polyschides* or *Halidrys siliquosa* may be dominant components of the community [2].

Exposed low-lying reefs in the sublittoral fringe or upper infralittoral (generally above 5 m depth), mainly in the southwest and west, dominated by the kelp *Saccorhiza polyschides*. This opportunistic coloniser replaces *Laminaria digitata* or *Laminaria hyperborea* as the dominant kelp, following 'disturbance' of the canopy. This may be the result of storms, when loose sediment and even cobbles or boulders are mobilised, scouring most seaweeds and animals from the surrounding rock. As *S. polyschides* is essentially a summer annual (occasionally it lasts into a second year), it is also particularly common close to rock/sand interfaces which become too scoured during winter months to prevent the longer-living kelps from surviving. As a result of the transient nature of this biotope, its composition is varied; it may contain several other kelp species, including *L. digitata*, *L. saccharina* and *Alaria esculenta*, at varying abundances. *Laminaria* spp sporelings can also be a prominent feature of the site. Beneath the kelp, (scour-tolerant) red seaweeds including *Corallina officinalis*, *Kallymenia reniformis*, *Plocamium cartilagineum*, *Chondrus crispus*, *Dilsea carnosa* and encrusting coralline algae are often present. Foliose red seaweeds such as *Callophyllis laciniata*, *Cryptopleura ramosa* and *Palmaria palmata* also occur in this biotope. *P. palmata* and *Delesseria sanguinea* often occur as epiphytes on the stipes of *L. hyperborea*, when it is present. The foliose green seaweed *Ulva* spp. is fast to colonise newly cleared areas of rock and is often present along with the foliose brown seaweed *Dictyota dichotoma*. Due to the disturbed nature of this biotope, fauna are generally sparse, being confined to encrusting bryozoans and/or sponges, such as *Halichondria panicea* and the gastropod *Gibbula cineraria*.

In the Bay of Biscay, the most simple was represented by a poor community, where prevailed ceramiaceous algae (*Antithamnionella spirographidis*, *Pterothamnion plumula*, *Anotrichum furcellatum)* and delesseriaceous algae (*Hypoglossum hypoglossoides*, *Erythroglossum laciniatum*), which substitute the typical community of *Gelidium corneum*. Sedimentation, turbidity and water toxicity were the principal factors responsible for the existence of different communities.

Gorostiaga et al. (1998) [3], applying multivariate analysis, detected that subtidal algal vegetation changed gradually as a continuum, without different discrete communities being distinguishable. These gradual changes in the vegetation, related mainly to increasing sedimentation levels, were: (i) a decrease in algal cover; (ii) a clear increase in species adapted to moderate-high (i.e. *Pterosiphonia complanata* and *Cystoseira baccata*) or very high sedimentation levels (i.e. *Halopitys incurvus*, *Chondracanthus acicularis*); and (iii) an increase in vegetation heterogeneity, diversity and epiphytism. In addition, an increase of allochthonous sediments and turbidity was the other environmental factor affecting the structure and composition of the vegetation, developing a poor vegetation consisting of species tolerant to heavy silt sedimentation, turbidity and water toxicity (i.e. *Falkenbergia rufolanosa*, *Cladostephus spongiosus*, *Chondria coerulescens*, *Pterosiphonia pennata*, *Bryopsidella halymeniae*, *Spirulina* sp.) [4].

Associated Biotopes at EUNIS Level 5:

A3.121: Saccorhiza polyschides and other opportunistic kelps on disturbed upper infralittoral rock. Exposed low-lying reefs in the sublittoral fringe or upper infralittoral (generally above 5m depth), mainly in the southwest and west, dominated by the kelp *Saccorhiza polyschides*. This opportunistic coloniser replaces *Laminaria digitata* or *Laminaria hyperborea* as the dominant kelp, following ‘disturbance’ of the canopy. This may be the result of storms, when loose sediment and even cobbles or boulders are mobilised, scouring most seaweeds and animals from the surrounding rock. As *S. polyschides* is essentially a summer annual (occasionally it lasts into a second year), it is also particularly common close to rock/sand interfaces which become too scoured during winter months to prevent the longer-living kelps from surviving. As a result of the transient nature of this biotope, its composition is varied; it may contain several other kelp species, including *L. digitata*, *Laminaria saccharina* and *Alaria esculenta*, at varying abundances. *Laminaria* spp. sporelings can also be a prominent feature of the site. Beneath the kelp, (scour-tolerant) red seaweeds including *Corallina officinalis*, *Kallymenia reniformis*, *Plocamium cartilagineum*, *Chondrus crispus*, *Dilsea carnosa* and encrusting coralline algae are often present. Foliose red seaweeds such as *Callophyllis laciniata*, *Cryptopleura ramosa* and *Palmaria palmata* also occur in this biotope. *P. palmata* and *Delesseria sanguinea* often occur as epiphytes on the stipes of *L. hyperborea*, when it is present. The foliose green seaweed *Ulva* spp. is fast to colonise newly cleared areas of rock and is often present along with the foliose brown seaweed *Dictyota dichotoma*. Due to the disturbed nature of this biotope, fauna are generally sparse, being confined to encrusting bryozoans and/or sponges, such as *Halichondria panicea* and the gastropod *Gibbula cineraria*. Situation: On some shores (for example in Cornwall and south-west Ireland), *S. polyschides* competes so effectively with the other laminarians that it forms a well-defined zone in shallow water, between the *L. digitata* (Ldig) and *L. hyperborea* zones (LhypR and Lhyp). Elsewhere, it is found at sites that have been physically disturbed, removing areas of established kelp (*L. hyperborea*) thus allowing this opportunistic biotope to develop over a short space of time. Temporal variation: There may be significant variations in this biotope over time, as by its very nature, it is dominated by many fast-growing annual seaweeds. The foliose green seaweed *Ulva* sp. is fast to colonise newly cleared areas of rock and can be present as a dense growth on the rock around the *Saccorhiza polyschides*. Similarly, large patches of *Laminaria* spp. sporelings may be present at times [2].

A3.122: Laminaria saccharina and/or Saccorhiza polyschides on exposed infralittoral rock. A forest or park of the fast-growing, opportunistic kelps *Laminaria saccharina* and/or *Saccorhiza polyschides* often occurs on seasonally unstable boulders or sand/pebble scoured infralittoral rock. The substratum varies from large boulders in exposed areas to smaller boulders and cobbles in areas of moderate wave exposure or nearby bedrock. In these cases, movement of the substratum during winter storms prevents a longer-lived forest of *Laminaria hyperborea* from becoming established. This biotope also develops on bedrock where it is affected by its close proximity to unstable substrata. Other fast-growing brown seaweeds such as *Desmarestia viridis*, *Desmarestia aculeata*, *Cutleria multifida* and *Dictyota dichotoma* are often present. Some *L. hyperborea* plants may occur in this biotope, but they are typically small since the plants do not survive many years. The kelp stipes are usually epiphytised by red seaweeds such as *Delesseria sanguinea* and *Phycodrys rubens*. Other red seaweeds present beneath the kelp canopy include *Plocamium cartilagineum*, *Nitophyllum punctatum*, *Callophyllis laciniata* and *Cryptopleura ramosa*. Encrusting algae often form a prominent cover on the rock surfaces, including red, brown and coralline crusts. Faunal richness and diversity is generally low compared to the more stable *L. hyperborea* kelp forest and park communities (LhypR). Where some protection is afforded the anthozoan *Alcyonium digitata* can occur in addition to the more robust species such as the tube-building worm *Pomatoceros triqueter*. Mobile species include the shell *Gibbula cineraria* and *Calliostoma zizyphinum* and the sea urchin *Echinus esculentus*. The hydroid *Obelia geniculata* and the bryozoan *Membranipora membranacea* can often be found colonising the kelp fronds. Situation: This biotope can be found below the *L. hyperborea* zone (LhypFa or LhypR), especially where close to a rock/ sand interface (where it is subject to sand/pebble scour in winter). Where this biotope occurs on bedrock, not scoured by mobile sediment, it is thought to occur as a result of intense wave action in winter storms which is too severe to allow *L. hyperborea* to develop and remain in shallow water. Temporal variation: Due to the disturbed nature of this biotope there can be significant changes in the structure of the community. Coralline and brown algal crusts with sparse kelp plants generally dominate areas that have been recently disturbed. Diversity is low and a few species of fast-growing seaweeds can dominate the seabed. A longer established community will have larger, mixed kelp plants and a greater diversity of red seaweeds [2].

A3.123: Laminaria saccharina, Chorda filum and dense red seaweeds on shallow unstable infralittoral boulders and cobbles. Seasonally disturbed unstable boulders and cobbles in very shallow water dominated by the fast-growing brown seaweed *Chorda filum* together with the kelp *Laminaria saccharina*. The brown seaweed *Desmaresti aaculeata* is also typical of this disturbed environment as well encrusting coralline algae and brown crusts. Beneath the prolific growth of *C. filum*, red and brown seaweeds densely cover many of the boulders, cobbles and pebbles. Other sediment-tolerant seaweeds such as species from the Ectocarpales (brown filamentous seaweeds) and the red seaweeds *Chondrus crispus*, *Phyllophora pseudoceranoides*, *Dilsea carnosa* and *Corallina officinalis* is normally present. Other red seaweeds which can be found here include *Chondria dasyphylla*, *Brongniartella byssoides*, *Polysiphonia elongata*, *Ceramium nodolosum*, *Cystoclonium purpureum*, *Heterosiphonia plumosa*, *Rhodomela confervoides* and *Plocamium cartilagineum*. The brown seaweeds *Punctaria* sp. and *Cladostephus spongiosus* are generally present. The faunal component of this biotope is typically sparse - the starfish *Asterias rubens* and the crabs *Pagurus bernhardus* and *Necora puber* are amongst the most conspicuous animals. The bryozoan crust *Electra pilosa* colonise many of the algae along with the ascidian *Botryllus schlosseri*. Occasional the polychaete *Lanice conchilega* may occur in the sand between pebbles, and the anthozoan *Urticina felina* may be found amongst pockets of gravel along with the gastropod *Gibbula cineraria*. At some sites the rock beneath the algae can be occupied by the tube-building polychaete *Pomatoceros triqueter*. This biotope is also present at other open coast sites around the UK where suitable shallow, seasonally stable boulders, cobbles and pebbles occur. Typical examples of this biotope occur on the shallowest areas of the Sarns in Cardigan Bay, Wales, where reef crests are formed by embedded and mobile boulders, together with cobbles and pebbles in between (typically at 2-3m depth). Situation: This biotope occurs in shallow water, often on the crest of an infralittoral boulder/cobble bank and as such will not have any biotope 'above ' it. More mobile areas of smaller boulders, cobbles and pebbles nearby may support dense ephemeral red seaweeds (EphR) or robust scour-tolerant red seaweeds on sand-covered rock (ProtAhn). The *Halidrys siliquosa* biotope XKHal also thrives under similar conditions, extending deeper than the shallow LsacChoR biotope. Deeper still in the circalittoral zone encrusting fauna is found on highly mobile mixed substrata (PomB). At a few sites, this biotope can occur within more extensive maerl beds (SS.SMP.Mrl) but more commonly is surrounded by sandy sediments (SS.SSa). Temporal variation: This biotope will change markedly with the seasons. During the winter months boulders and cobbles will be storm battered and overturned and much of the biota dislodged from the rocks. During more stable conditions in the late spring and summer months the fast-growing seaweeds that characterise this biotope (*C. filum* and *L. saccharina* in particular) will be quick to re-establish, growing at a phenomenal rate. The seasonal disturbance of the substratum prevents a stable *Laminaria hyperborea* forest from developing [2].

A3.124: Dense Desmarestia spp. with filamentous red seaweeds on exposed infralittoral cobbles, pebbles and bedrock. Wave-exposed seasonally mobile substrata (pebbles, cobbles) dominated by dense stands of the brown seaweed *Desmarestia aculeata* and/or *Desmarestia ligulata*. Infralittoral pebbles and cobbles that are scoured through mobility during storms, but become stable in the summer allowing the growth of such algae as *Desmarestia* spp. Filamentous red seaweeds such as *Bonnemaisonia asparagoides* and *Brongniartella byssoides* are usually present. Stunted individuals of the kelp such as *Laminaria hyperborea* and *Laminaria saccharina* may be present where bedrock is available. A variety of foliose red seaweeds such as *Cryptopleura ramosa*, *Chondrus crispus*, *Plocamium cartilagineum*, *Hypoglossum hypoglossoides* and *Nitophyllum punctatum* may on occasion be present underneath the kelp canopy. Other red algae including *Corallina officinalis*, *Rhodomelacon fervoides* and coralline crusts including *Lithothamnion* spp. may be present as well as well as the foliose brown seaweed *Dictyota dichotoma* and the green *Enteromorpha intestinalis*. Due to the nature of this biotope the faunal component is very impoverished though the gastropod *Gibbula cineraria* can be found among the cobbles. Situation: Often a narrow zone on mixed substrata below a stable zone of kelp on bedrock. Where seasonally mobile substrata affect nearby bedrock this biotope may occur in place of kelp forest [2].

A3.125: Mixed kelps with scour-tolerant and opportunistic foliose red seaweeds on scoured or sand-covered infralittoral rock. Bedrock and boulders, often in tide-swept areas, that are subject to scouring or periodic burial by sand, characterised by a canopy of mixed kelps such as *Laminaria saccharina*, *Laminaria hyperborea* and *Saccorhiza polyschides* and the brown seaweed *Desmarestia aculeata*; there may also be an understorey of foliose seaweeds that can withstand scour such as *Plocamium cartilagineum*, *Chondrus crispus*, *Dilsea carnosa*, *Callophyllis laciniata* as well as the filamentous *Heterosiphonia plumosa* and the foliose brown seaweed *Dictyota dichotoma*. The perennial red seaweed *Brongniartella byssoides* re-grows in the summer months. The *L. hyperborea* stipes often support a growth of epiphytes, such as *Delesseria sanguinea*, *Phycodrys rubens* and *Cryptopleura ramosa*. The scour can reduce the rock surface to bare coralline crusts at times; sponge crusts and the colonial ascidian *Botryllus schlosseri* can also grow on the stipes and holdfasts. The faunal diversity on the rock is usually low and restricted to robust, low-profile animals such as the tube-building polychaete *Pomatoceros triqueter*, the barnacle *Balanus crenatus*, encrusting bryozoans such as *Membranipora membranacea*, the anthozoan *Urticina felina*, the starfish *Asterias rubens* and the urchin *Echinus esculentus*. Deeper sites support more hydroids and bryozoans, particularly *Bugula* spp. Where this biotope occurs in very shallow water *Laminaria digitata* may be found in combination with the other kelp species. Other species present only in shallow water include the red algae *Corallina officinalis* and the sand-binding alga *Rhodothamniella floridula*. Situation: This biotope often occurs below a *L. hyperborea* forest (LhypR.Ft, Lhyp.Ft or LhypT.Ft), close to a rock-sediment boundary. It is also found on low-lying rock outcrops surrounded by sand or mixed sediment and nearby biotopes on mixed substrata may include EphR, ProtAhn or in very shallow water LsacChoR. A *Flustra foliacea* community (FluCoAs) often dominates deeper sand-scoured circalittoral rock. Temporal variation: During late autumn and winter seaweeds are sparse, leaving predominantly kelp and encrusting coralline algae. This is due in part to periods of intense scouring during stormy months, which may strip off all but the most tenacious seaweeds. In addition there will be the natural die back of many of the seaweeds such as *B. byssoides* and *C. ciliata* during the winter months which become conspicuous again during the summer months [2].

A3.126: Halidrys siliquosa and mixed kelps on tide-swept infralittoral rock with coarse sediment. Tide-swept boulders and cobbles, often with a mobile component to the substrata (pebbles, gravel and sand), characterised by dense stands of the brown seaweed *Halidrys siliquosa*. It is can be mixed with the foliose brown seaweed *Dictyota dichotoma* and kelp such as *Laminaria saccharina* and *Laminaria hyperborea*. Below the canopy is an undergrowth of red seaweeds that are tolerant of sand-scour such as *Phyllophora crispa*, *Phyllophora pseudoceranoides*, *Rhodomelacon fervoides*, *Corallina officinalis* and *Chondrus crispus*. Other red seaweeds such as *Plocamium cartilagineum*, *Calliblepharis ciliata*, *Cryptopleura ramosa*, *Delesseria sanguinea*, *Heterosiphonia*

plumosa, *Dilsea carnosa*, *Hypoglossum hypoglossoides* and *Brongniartella byssoides* may be locally abundant, particularly in the summer months. There may be a rich epibiota on *H. siliquosa*, including the hydroid *Aglaophenia pluma*, ascidians such as *Botryllus schlosseri*. There is generally a sparse faunal component colonising the boulders and cobbles, comprising the tube-building polychaete *Pomatoceros triqueter*, the crab *Cancer pagurus*, the starfish *Asterias rubens*, the gastropod *Gibbula cineraria* and the sea anthozoan *Urticina felina*. The bryozoan *Electra pilosa* can form colonies on the kelp. Situation: XKHal can occur below the tide-swept *Laminaria digitata* zone of the sublittoral fringe bedrock or boulders (LdigT). Less stable substrata of boulders, cobbles or pebbles may support kelp and *Chorda filum* in the shallows (LsacChoR) or dense ephemeral seaweeds (EphR). Sand-influenced rocky outcrops in deeper water may support a *Flustra foliacea* community (FluCoAs). This biotope is widespread and is found on the open coast in Wales, the south-west and the English Channel as well as more sheltered tidal rapids in the Scottish sealochs. It can form extensive forests or parks in certain areas (Dorset, Sarns). In Wales, the south-west and west of England the red seaweeds *Spyridia filamentosa* and *Halarachnion ligulatum* and brown seaweeds *Dictyopteris polypodioides* and *Taonia atomaria* are frequent. In Scotland, kelp occur at a greater proportion of sites, solitary ascidians such as *Ascidiella* spp. are more common and the featherstar *Antedon bifida* and brittlestars *Ophiothrix fragilis* are found. Temporal variation: Higher diversity of red seaweeds during the summer [2].
A3.127: Polyides rotundus, Ahnfeltia plicata and Chondrus crispus on sand-covered infralittoral rock. Low-lying rock surrounded by mobile sand and often subject to burying by the sand, with a turf of resilient red seaweeds *Chondrus crispus*, *Polyides rotundus* and *Ahnfeltiaplicata* typically protruding through the sand on the upper surfaces of the rock. Other scour-tolerant seaweeds include *Rhodomela confervoides*, *Phyllophora pseudoceranoides*, *Phyllophora crispa*, *Furcellaria lumbricalis*, *Gracilaria gracilis*, *Ceramium rubrum*, *Plocamium cartilagineum*, *Heterosiphonia plumosa*, *Cryptopleura ramosa* and *Dilsea carnosa*. Coralline crusts typically cover the rock, while scattered individuals of the brown seaweeds *Halidrys siliquosa*, *Cladostephus spongiosus*, *Dictyota dichotoma* and *Laminaria saccharina* can be present. The large anthozoan *Urticina felina* can occur in this biotope but there are few other conspicuous animals. Situation: This biotope occurs on shallow sand-covered rock, often below bedrock and boulders supporting kelp forest, which is above the effect of, sand scour (Lhyp) or abutting sand-scoured kelp on bedrock (XKScrR). It may also be found adjacent to the shallow kelp and *Chorda filum* biotope (LsacChoR) and similarly can be surrounded by a variety of sediment biotopes [2].

Biotope Evaluation: Goods and Services

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

No data available.

Conservation and protection status

Reefs (1170) are Natura 2000 habitat types listed under the EC 92/43 Habitats Directive.

References

[1] Galparsoro I, Borja Á, Legorburu I, Hernández C, Chust G, Liria P, Uriarte A (2010) Morphological characteristics of the Basque continental shelf (Bay of Biscay, northern Spain); their implications for Integrated Coastal Zone Management. Geomorphology, 118(3-4): 314-29.
[2] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB 2004. Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough. Available online: www.jncc.gov.uk/MarineHabitatClassification.
[3] Gorostiaga JM, Santolaria A, Secilla A, Díez I (1998) Sublittoral benthic vegetation of the eastern Basque coast (N. Spain): structure and environmental factors. Bot Mar 41: 455-65.
[4] Borja A, Collins M (2004) Oceanography and Marine Environment of the Basque Country. Elsevier Oceanography Series, 70: 616.

Mediterranean and Pontic communities of infralittoral algae very exposed to wave action

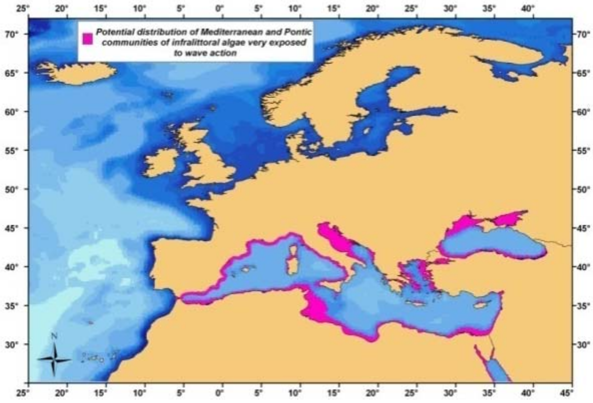
Compiled by Simone Mirto

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.13	Mediterranean communities of infralittoral algae very exposed to wave action

Picture(s)

Not available

Biotope Distribution



Potential distribution map

Links to Available Maps

(UK and Ireland):

http://www.jncc.gov.uk/marine/biotopes/maps/JNCCMNCR00001955.GIF

Biotope Requirements

Stage: Infralittoral
Nature of substratum: Hard beds
Bathymetrical distribution: from the surface down to 35 to 40 meters
Position: Open sea
Hydrodynamics: Weak, average, strong, very strong
Salinity: Normal range
Temperature: Normal range

Biotope Description [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23].

This biocenosis is located in the infralittoral stage. The infralittoral stage extends from areas where only accidentally does something emerge above the water, to the survival limit of the marine phanerogams and the photophilous algae. This lower limit depends on the penetration of light, and thus varies greatly with the topography and the quality of the water. In areas of very clear water, it can go down to 35-40 meters, whereas it is restricted to only a few metres in turbid areas. All the rocky substrata of the infralittoral stage where the conditions of the stage prevail are covered with different facies of the biocenosis of photophilous algae, an extremely rich population.

The biocenosis of photophilous algae is a biocenosis that is extremely rich and of great complexity, due to the strong physical gradients existing at its level.

The biotope shows many characteristic/indicator species, the main ones and abundant are various algae (e.g. *Lithophyllum incrustans, Tenarea tortuosa, Goniolithon byssoides, Padina pavonica, Stypocaulon scoparia, Laurencia obtusa, Amphiroa rigida, Jania rubens, Cystoseira amentacea stricta, Codium bursa*); the cnidarians *Actinia equina, Anemonia sulcata, Eudendrium* spp., *Sertularella ellisi, Aglaophenia octodonta;* the molluscs *Acanthochitona fascicularis, Patella aspera, Vermetus triqueter, Dendropoma petraeum, Columbella rustica,*

Mytilus galloprovincialis; the polychaetes *Amphiglena mediterranea, Branchiomma (=Dasychone) lucullana, Hermodice carunculata, Lepidonotus clava, Eunice vittata, Lumbrinereis gracilis, Lysidice ninetta, Perinereis cultrifera, Platynereis dumerilii, Polyophthalmus pictus, Syllis* spp.; the crustaceans *Balanus perforatus, Amphithoe ramondi, Dexamine spiniventris, Hyale spp., Acanthonyx lunulatus*; and the echinoderms *Amphipholis squamata, Arbacia lixula* and *Paracentrotus lividus.*
Three horizons can be made out: an upper horizon (0-1 metre) where the light and the hydrodynamic energy are strong; a middle horizon (1-15 meters) where the light and hydrodynamic factors are attenuated; a deep horizon (15-40 meters) where the light and hydrodynamics are extremely weak. For each of these horizons there are corresponding vegetal associations with very characteristic facies; the main ones are:
Upper horizon:
- The association with *Cystoseira amentacea* var. *stricta*, in pure, rough waters, strong luminosity
- The association with *Cystoseira crinita*, in pure, sheltered waters, strong luminosity
- The association with *Schottera nicaeensis*, in pure, rough waters, attenuated luminosity
- The association with *Stypocaulon* (=*Halopteris*) *scoparium*, in pure, sheltered waters, strong luminosity
- The association with *Sargassum vulgare*, in pure, rough waters, strong luminosity
- The association with *Dictyopteris polypodioides*, in pure, rough waters, strong luminosity
- The association with *Corallina elongata*, average waters, strong luminosity
- The association with crust-forming algae (*Lithophyllum* spp.), in waters with strong wave action
- The facies with *Mytilus galloprovincialis* in areas with strong organic addition
Middle horizon:
- Facies with big hydrozoans: *Aglaophenia* spp. and *Eudendrium* spp. dominant
Lower horizon:
- Association with *Cystoseira spinosa*.

Associated Biotopes at EUNIS Level 5:
A3.131: Overgrazing facies with encrusting algae and sea urchins [22]. This facies is characterised by a low coverage of erect algae due to overgrazing by sea urchins.
A3.132: Association with Cystoseira amentacea (var. amentacea, var. stricta, var. spicata) [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23]. This association is located in the first metre of the infralittoral (from –20 to –30 cm.). It requires pure water. This association, described by Molinier in 1958, forms belts in the photophilous biotopes where there is strong wave action, and whose rocky substratum is subvertical. It is often accompanied by *Cystoseira compressa*, which may replace it completely in places.
The association with *Cystoseira amentacea* is represented in the three major areas of the Mediterranean by different geographical varieties of this *Cystoseira*. The association with *Cystoseira amentacea amentacea* is endemic in the eastern Mediterranean, whereas *Cystoseira amentacea stricta* is found in the north-western Mediterranean and the *spicata* variety in the Adriatic. The three varieties of this *Cystoseira* are good indicators of the upper limit of the infralittoral stage. In the Sea of Alboran, all along the North African coast (Morocco, Algeria, Tunisia) and in the Strait of Messina, *Cystoseira tamariscifolia* is found instead of *Cystoseira amentacea*. This is a perennial, caespitose alga with leaves (spines on the branches). In exposed biotopes, it forms associations in dense belts with a greenish iridescence. The active vegetation period extends from February to July; in the winter, only the basal part covered with epiphytes remains. The young branches are iridescent. *Cystoseira amentacea* can be confused with certain other species of the same genus.
A3.133: Facies with Vermetus spp. [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 23]. The facies with vermetids is located in the middle level of the sea water and sometimes it forms well-developed vermetid platforms in Corsica, Sicily and on the Levantine coast. Vermetids are sessile gastropods which develop near the middle level of the sea. These organisms, associated with the *Neogoniolithon brassica-florida* calcareous algae, build up organogenous formations in three shapes:
- The cornice or rim form: below the middle level of the sea on a subvertical rocky slope. In the north-western Mediterranean, these formations are covered with the *Neogoniolithon brassica-florida* and *Lithophyllum lichenoides* calcareous algae.
- The atoll form: observed in the eastern Mediterranean (Israel and Crete), and in the Bermudas. These are rounded structures, depressed in the centre.
- The ‘pavement’ or ‘platform’ form: the standard structure described in Sicily is a horizontal corroded surface developed in the standing calcareous rock. The platform is pitted with shallow pools whose crests, as well as the outside edges (in the shape of pads or ledges) of the platform, are covered with *Dendropoma petraeum* vermetids (often called *Vermetus cristatus*). In addition, the bottoms of the bowls of the platform can be colonised by *Vermetus triqueter*, also known as “gregarious”. Although in the western Mediterranean the

position of the platform is below the middle level of the sea and is located at the upper limit of the infralittoral stage, it is always mediolittoral in the eastern Mediterranean, where the platform develops at 0.2-0.3 metres above mid-wave level.The particular shape of the biological constructions. Usually, *Dendropoma petraeum* develops on the outer edges and crests of the platforms, whereas *Vermetus triqueter* covers the bottoms of the bowls of the platforms. The fairly deep bowls of the platforms constitute enclaves for a flora and a fauna that belong to the biocenosis of photophilous algae. In well exposed places, the limit with the upper horizon of the infralittoral stage is sometimes hard to make out, due to the presence of a series of little half-cup pools between the level of the low tides and that of the platform as such.

A3.134: Mediterranean and Pontic facies with Mytilus galloprovincialis [22]. This facies characterised by the dominance of the mollusc bivalve *Mytilus galloprovincialis* is typical of areas with high levels of organic input.

A3.135: Association with Corallina elongata and Herposiphonia secunda [22]. This association with the red algae *Corallina elongata* and *Herposiphonia secunda* is typical of the upper infralittoral with strong wave action and strong luminosity.

A3.136: Mediterranean and Pontic association with Corallina officinalis [22]. This association with the red alga *Corallina officinalis* is typical in the upper horizon of the infralittoral in areas with strong luminosity and sheltered waters.

A3.137: Association with Schottera nicaeensis [22]. This association is characterised by the red alga *Schottera nicaeensis* living in pure, rough waters with strong luminosity.

A3.138: Pontic facies with Petricola lithophaga in very exposed vertical rock. Proposed reclassification under a new EUNIS biotope A3.243.

A3.139: Pontic Vermiliopsis infundibulum biogenic rocks. No further description available.

Biotope Evaluation: Goods and Services

This biotope is extremely rich as regards both quality and quantity, containing several hundred species. Its production is great and its biomass can attain several kilograms per square meter. Its seasonal dynamics are strong. The trophic network it supports is particularly complex and opens onto other habitats by exporting organisms and organic matter. Many fish species feed on the algae and animals which live in this biotope. Biotopes of infralittoral algae provide significant food sources for a great number of fish species either directly, or indirectly, by dispersing vegetal and animal detritus into adjacent areas. Several species of this biotope are characterized by increased nutrient and CO_2 uptakes [24], as well as a high capacity for heavy metal biosorption [e.g. 25], presenting thus a great potential as bioremediators.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

This biotope includes associations that are very sensitive to pollution; such is the case of many *Cystoseira* species (e.g. *Cystoseira amentacea stricta*) that are thus considered to be excellent indicators of the quality of the water and their disappearance may often be linked to pollution increase. Associations of this biotope are also quite sensitive to suspended load, the reason being twofold: turbid water decreases photosynthesis and thus affects the algal populations; sedimentation fills in the microcavities in between the algal thalli and eliminates small cryptic fauna. The biotope is subject to the pressure of more or less invasive introduced species (*Caulerpa taxifolia*, *C. racemosa*, *Stypopodium schimperi*) which can harm it or even destroy it. The ichthyofauna that occurs in this biotope is diverse and rich; it is thus subject to heavy pressures from commercial and leisure fishing activities. Collection of sea urchins and exploitation of natural mussel beds also take place here.

Conservation and protection status

“Reefs” are NATURA-1170 habitat types listed under the EC 92/43 Habitats Directive. This biotope is also listed as endangered in the Resolution no. 4, Council of Europe Bern Convention (1996): *Sublittoral rocky seabeds and kelp forests* (code 11.24).

References

[1] Airoldi L, Cinelli F (1997) Effects of sedimentation on subtidal assemblages: an experimental study from a Mediterranean rocky shore. J Exp Mar Biol Ecol 215: 269-288
[2] Ballesteros E (1992) Els vegetals i la zonacio litoral: espècies, comunitats i factors que influeixen la seva distribucio. Arxius de la Seccio de Ciencies CI, Institut d’Estudis Catalans, Barcelona, Spain, pp 616
[3] Bellan Santini D (1966) Contribution à l'étude du peuplement des cavités sciaphiles de l'encorbellement à Lithophyllum tortuosum dans la région marseillaise. Rec Trav Stat mar Endoume 4(56): 151-157
[4] Bellan Santini D (1969) Contribution à l'étude des peuplements infralittoraux sur substrat rocheux. Rec Trav Stat mar Endoume, 6(47): 1-123
[5] Bellan Santini D, Lacaze JC, Poizat C (1994) Les biocénoses marines et littorales de Méditerranée, synthèse, menaces et perspectives. Collection Patrimoines Naturels. Secrétariat de la Faune et de la Flore/MNHN 19: 1-246
[6] Ben Maiz N (2000) Menaces sur les espèces végétales marines en Méditerranée occidentale. Proceedings of the first Mediterranean Symposium on marine vegetation. pp 19-33
[7] Benedetti Cecchi L, Pannacciulli F, Bulleri F, Moschella PS, Airoldi L, Relini G, Cinelli F (2001) Predicting the consequences of anthropogenic disturbance : large-scale effects of loss of canopy algae on rocky shores. Mar Ecol Prog Ser 214: 137-150
[8] Boudouresque CF (1971) Contribution à l'étude phytosociologique des peuplements algaux des Côtes Varoises. Vegetatio 22: 83-184
[9] Dauvin JC, Bellan G, Bellan-Santini D, Castric A, Comolet-Tirman J,Francour P, Gentil F, Girard A, Gofas S, Mahe C, Noël P, De Reviers B (1994). Typologie des ZNIEFF-mer, liste des paramètres et des biocénoses des côtes françaises métropolitaines. 2ème Edition. Collection Patrimoines Naturels. Secrétariat de la Faune et la Flore/MNHN 12: 1-64.
[10] Drago D, Mannino AM, Sortino S (1997) La vegetazione sommersa dei mari siciliani. Mediterraneo, Guide naturalistiche 7. L'EPOS pp 117
[11] Garrabou J, Ballesteros E, Zabala M (2002) Structure and dynamics of north-western Mediterranean rocky benthic communities along a depth gradient. Estuar Coast Shelf S 55: 493-508
[12] Giaccone G, Alongi G, Cossu A, Di Geronimo RE, Serio D (1993) La vegetazione marine bentonica del Mediterraneo: I. Sopralittorale e Mesolittoral. Boll Acc Gioenia sci nat 26(341): 245-291
[13] Giaccone G, Alongi G, Pizzuto F, Cossu A (1994) La vegetazione marine bentonica del Mediterraneo: II Infralittorale e Circalittorale. Boll Acc Gioenia sci nat 27(346): 111-157
[14] Harmelin JG (1987) Structure et variabilité de l'ichtyofaune d'une zone rocheuse protégée en Méditerranée (Parc national de Port-Cros, France). P.S.Z.N.I. Mar Ecol 8(3): 263-284
[15] Laborel J (1987) Marine biogenic constructions in the Mediterranean, a review. Sci Rep Port-Cros natl Park 13: 97-126
[16] Marinopoulos J (1988) Etude des peuplements infralittoraux de substrats rocheux de la région de Marseille

et des facteurs abiotiques (lumière, hydrodynamique) les influençant. Thèse doctorat d' Etat. Université Aix-Marseille II pp 317
[17] Marinopoulos J (1989) Nouveaux concepts sur la structure des peuplements de l'infralittoral rocheux. C R Acad Sci Paris 309(3): 343-349
[18] Peres JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Méditerranée. Rec Trav Stat Mar Endoume, 31(47): 1-137
[19] Riedl R (1980) Marine Ecology - A century of changes. Mar Ecol 1(1): 3-46
[20] Ros JD, Romero J, Ballesteros E, Gili JM (1984) Diving in blue water. The benthos. 233-295 in: Margalef R (ed) Western Mediterranean. Oxford, Pergamon Press, pp 363
[21] Sala E, Boudouresque CF, Harmelin-Vivien M (1998) Fishing, trophic cascades, and the structure of algal assemblages: evaluation of an old but untested paradigm. Oikos 82: 425-439
[22] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)
[23] Bellan-Santini D, Bellan G, Bitar G, Harmelin JG, Pergent G (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. Publication of Regional Activity Centre for Specially Protected Areas, United Nations Environment Programme, Action Plan for the Mediterranean. Available at http://www.rac-spa.org/
[24] Gao K, Mckinley KR (1994) Use of macroalgae for marine biomass production and CO_2 remediation: a review. J Appl Phycol 6: 45-60
[25] Davis AT, Volesky B, Alfondo M (2003) A review of the biochemistry of heavy metal biosorption by brown algae. Wat Res 37: 4311-4330.

Frondose algal communities (other than kelp)

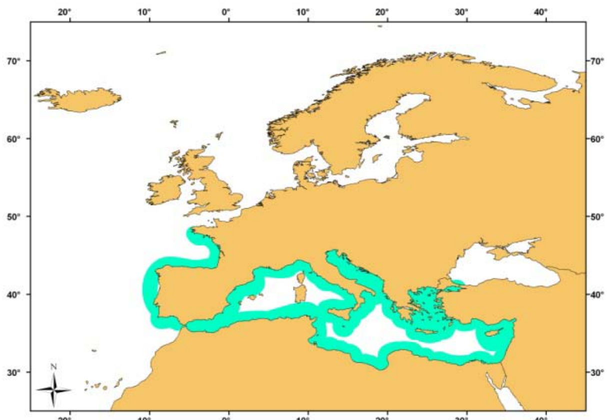
Compiled by Ibon Galparsoro, Marta Pascual, Ángel Borja

Classification	Code	Title
NATURA 2000	1170	Reefs
NATURA 2000	1160	Large shallow inlets and bays
EUNIS	A3.15	Frondose algal communities (other than kelp)

Picture(s)

Image courtesy: AZTI-Tecnalia

Biotope Distribution



Potential distribution map

Links to Available Maps

Not available

Biotope Requirements

Atlantic and Mediterranean infralittoral rock including habitats of bedrock, boulders and cobbles which occur in the shallow subtidal zone and typically support seaweed communities. Fully saline, subject to exposed or extremely exposed wave action or strong tidal streams. The depth to which this biotope extends varies according to water clarity exceptionally reaching 45 m [1].

Biotope Description

In the southern Bay of Biscay and the Iberian coasts (until Morocco, in the south), communities such as "*Gelidium corneum*" or "*Cystoseira baccata*" have been reported [2-4]. The most complex structural level was represented, within this study area, by the communities of *Gelidium corneum* and that of *Pterosiphonia complanata* in unpolluted waters. According to Borja [5-9] the eastern Basque coast (Gipuzkoa) presents a homogenous vegetation composed mainly of extensive beds of *Gelidium corneum*, extending from 0 to 10-15 m water depth (sometimes reaching 25 m mixed with *Cystoseira baccata*) [3, 10]. This community is favored by the

predominance of bedrock, little to moderate sand sedimentation and high exposure to wave action. This vegetation type utilizes the space through its complex vertical layering, consisting of a well-developed crustose layer of *Mesophyllum lichenoides* and *Zanardinia prototypus*, a poor underlying layer of *Pterosiphonia complanata*, *Corallina officinalis*, *Rhodymenia pseudopalmata* and *Cryptopleura ramosa*, a well–developed canopy of *Gelidium corneum*, and a poor summer epiphytic layer of *Plocamium cartilagineum* and *Dictyota dichotoma* (well developed in late spring). The fauna consists of mollusks, such as *Gastrochaena dubia* and *Aplysia punctata*; sponges (*Clathrina coriacea* and *Sycon ciliatum*); cnidaria (*Laomedea flexuosa* and *Halicornaria montagui*); crustacea (*Cymodoce truncata* and *Apherusa jurinei*); bryozoa (*Crisia eburnea*, etc) [3]. In this community *Gelidium corneum* and *Mesophyllum lichenoides* account for 72% of the overall algal cover. For the remainder, *Plocamium cartilagineum*, *Pterosiphonia complanata*, *Asparagopsis armata* (*Falkenbergia* phase), *Cystoseira baccata*, *Halopitys incurvus*, and *Corallina officinalis* were the most abundant macrophytes [5].
At a deeper water depth fringe, the *Halopteris filicina* community appears in water depths ranging from 25 to 50 m [3, 11]. The algae are mixed frequently with other rhodophyceae, such as *Phyllophora crispa* and *Peyssonnelia rubra*. The fauna consists of a cover of the cirripede *Verruca stroemia*, the sipuncula *Aspidosiphon clavatus*, the bivalve *Modiolus barbatus* and the cnidaria *Sertularella ellisi*, among others [3, 11].
In the Mediterranean province, in sunlit water and at strong or medium wave exposures in the upper sublittoral zone, one finds sun-adapted species of *Cystoseira*. This canopy algae form the greatest part of the algal biomass in this subzone. This biocenosis has been named after *C. stricta*, which occurs at the Côte d´Azur and is replaced by *C. mediterranea* as a variant (morphologically similar but geographically distant) species near Banyuls, the Balearic Islands, and along the coast of western Italy. Below the dense canopy of *Cystoseira* numerous smaller understory algae grow, for example, the red algae *Laurencia pinnatifida*, *Schottera* (=*Petrogossum*) *nicaeensis*, and the green alga *Valonia utricularis*. At locations where there is no light-protecting canopy of *Cystoseira*, biocenoses develop that are dominated by, for example, the green alga *Acetabularia acetabulum* and the mussel *Mytilus galloprovincialis*. In the eastern Mediterranean the crustose coralline algae *Tenarea tortuosa* (=*undulos*) and *Lithophyllum byssoides* are dominant. In warmer parts of the Mediterranean (Corsica, Balearic Islands, Algeria, Sicily, and Lebanon) the sessile vermet snail *Vermetus cristatus* forms a second protruding belt in the upper sublittoral zone below the trottoir of *Lithophyllum lichenoides* (=*tortuosum* [12]) [13].

Associated Biotopes at EUNIS Level 5:
A3.151: Cystoseira spp. on exposed infralittoral bedrock and boulders. There is no description of this biotope in the EUNIS, but it has been already described in the previous section.
A3.152: Pontic Ulva rigida communities on exposed infralittoral bedrock and boulders. Proposed reclassification under the EUNIS code A3.23.
A3.153: Pontic Gelidium latifolium communities on exposed infralittoral bedrock and boulders.Proposed reclassification under the EUNIS code A3.23.

Biotope Evaluation: Goods and Services

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☐	☒	☐
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☒	☐	☐

Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Under moderate pollution, the vegetation assemblages consisted of species such as *Drachiella minuta*, *Aglaothamnion cordatum*, *Codium decorticatum*, *Nitophyllum punctatum* and *Zanardinia prototypus*. At slightly polluted habitats, *Pterosiphonia complanata*, *Saccorhiza polyschides* and *Callophyllis laciniata* were more abundant [14].

Conservation and protection status

Listed as endangered in the Resolution no. 4, Council of Europe Bern Convention (1996): *Sublittoral rocky seabeds and kelp forests* (code 11.24).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB. 2004. Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough. www.jncc.gov.uk/MarineHabitatClassification

[2] Limia JM, Gorostiaga JM (1987) Flora marina bentónica sublitoral del tramo de costa comprendido entre Pta. Covarón y Pta. Muskes (Vizcaya, N.E. España). Act.VI Simp Nac Bot Cript: 81-88

[3] Borja A, Valencia V, García L, Arresti A (1995) Las comunidades bentónicas intermareales y submareales de San Sebastián - Pasajes (Guipúzcoa, norte de España). Actas del IV coloquio internacional sobre oceanografía del Golfo de Vizcaya: 165-81

[4] Díez I, Santolaria A, Secilla A, Gorostiaga JM (2000) Comunidades fitobentónicas submareales de la zona exterior de la Reserva de la Biosferade Urdaibai. Consideraciones sobre su estado ecológico. Vitoria: Gobierno Vasco (ed), pp 151-57

[5] Gorostiaga JM, Santolaria A, Secilla A, Díez I (1998) Sublittoral benthic vegetation of the eastern Basque coast (N. Spain): structure and environmental factors. Bot Mar 41: 455-65

[6] Diez I, Santolaria A, Gorostiaga JM (2003) The relationship of environmental factors to the structure and distribution of subtidal seaweed vegetation of the western Basque coast (N Spain). Estuar Coast Shelf S 56(5-6): 1041-54

[7] Borja A (1987) Cartografía, evaluación de la biomasa y arribazones del alga *Gelidium sesquipedale* (Clem.) Born. et Thur. en la costa guipuzcoana (N España). Inv Pesq 51(2): 199-224

[8] Borja A (1987) El alga *Gelidium* en la costa guipuzcoana, Report 2. pp 17

[9] Borja A (1987) El alga *Gelidium* en la costa vizcaína, Report 10. pp 57

[10] Borja Á, Valencia V, Castro R, Franco J, Bald J, Uriarte A, Mendizabal M, Aguirrezabalaga F (2000) Establecimiento de las bases técnicas de conocimiento del área de San Juan de Gaztelugatxe con vistas a su posible declaración como reserva marina. Informes Técnicos (Departamento de Agricultura y Pesca, Gobierno Vasco), Report 87. pp 152

[11] Borja A, Franco J, Belzunce MJ, Valencia V (2000) La red de vigilancia y control de la calidad de las aguas litorales del País Vasco: años 1998-1999, Report 55. pp 94

[12] Pérés JM (1967) The Mediterranean benthos. Oceanogr Mar Biol Annu Rev 5, 449-533

[13] Luning K (1990) Seaweeds. Their environment, biogeography and ecophysiology. pp527

[14] Diez I, Santolaria A, Gorostiaga JM (2003) The relationship of environmental factors to the structure and distribution of subtidal seaweed vegetation of the western Basque coast (N Spain). Estuar Coast Shelf S 56(5-6): 1041-54

Kelp and red seaweeds (moderate energy infralittoral rock)

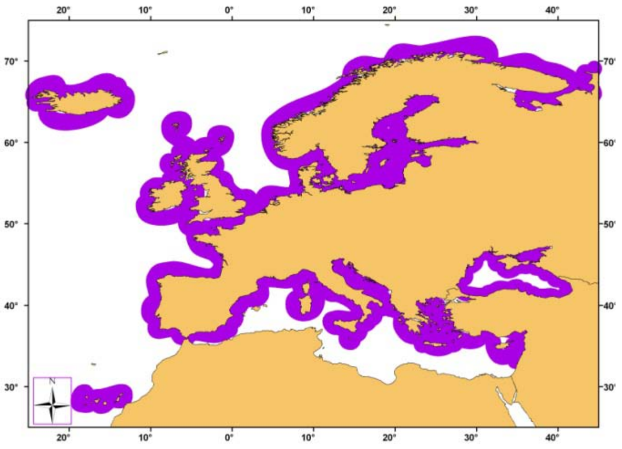
Compiled by Ibon Galparsoro, Ángel Borja, Marta Pascual

Classification	Code	Title
NATURA 2000	1170	Reefs
NATURA 2000	1160	Large shallow inlets and bays
EUNIS	A3.21	Kelp and red seaweeds (moderate energy infralittoral rock)

Picture(s)

Not available

Biotope Distribution



Potential distribution map

Links to Available Maps

http://www.jncc.gov.uk/marine/habitats/habitat.aspx?habitat=JNCCMNCR00001532

Biotope Requirements

Atlantic and Mediterranean moderate energy infralittoral rock includes habitats of bedrock, boulders and cobbles which occur in the shallow subtidal zone and typically support seaweed communities. Subject to moderate wave exposure, or moderately strong tidal streams on more sheltered coasts.

Biotope Description

The upper limit is marked by the top of the kelp zone whilst the lower limit is marked by the lower limit of kelp growth or the lower limit of dense seaweed growth. Infralittoral rock typically has an upper zone of dense kelp (forest) and a lower zone of sparse kelp (park), both with an understorey of erect seaweeds. In exposed conditions the kelp is *Laminaria hyperborea* whilst in more sheltered habitats it is usually *Laminaria saccharina*; other kelp species may dominate under certain conditions. On the extreme lower shore and in the very shallow subtidal (sublittoral fringe) there is usually a narrow band of dabberlocks *Alaria esculenta* (exposed coasts) or the kelps *Laminaria digitata* (moderately exposed) or *L. saccharina* (very sheltered). Areas of mixed ground, lacking stable rock, may lack kelps but support seaweed communities. In estuaries and other turbid-water areas the shallow subtidal may be dominated by animal communities, with only poorly developed seaweed communities.

Associated biotopes at EUNIS Level 5 and 6:

A3.211: Laminaria digitata on moderately exposed sublittoral fringe rock. Exposed to moderately exposed sublittoral fringe rock characterised by the kelp *Laminaria digitata* with coralline crusts covering the rock beneath the kelp canopy. Foliose red seaweeds such as *Palmaria palmata*, *Membranoptera alata*, *Chondrus crispus* and *Mastocarpus stellatus* are often present along with the calcareous *Corallina officinalis*. The brown seaweed *Fucus serratus* and the green seaweeds *Cladophora rupestris* and *Ulva lactuca* can be present as well.

The sponge *Halichondria panicea* can be found among the kelp holdfasts or underneath overhangs. Also present on the rock are the tube-building polychaete *Pomatoceros triqueter*, the gastropods *Patella vulgata* and *Gibbula cineraria*. The bryozoan *Electra pilosa* can form colonies on especially *C. crispus*, *M. stellatus* and *F. serratus* while the hydroid *Dynanema pumila* are more common on the kelp. Three variants of this biotope are described: *L. digitata* forest on rocky shores (Ldig.Ldig). *L. digitata* on boulder shores (Ldig.Bo) and soft rock supporting *L. digitata*, such as the chalk found in south-east England (Ldig.Pid). For *L. digitata* in sheltered, tide-swept conditions see LdigT [1].
Associated sub-biotopes:
A3.2111: Laminaria digitata on moderately exposed sublittoral fringe bedrock.
A3.2112: Laminaria digitata and under-boulder fauna on sublittoral fringe boulders.
A3.2113: Laminaria digitata and piddocks on sublittoral fringe soft rock.

A3.212: Laminaria hyperborea on tide-swept, infralittoral rock. Exposed to moderately exposed sublittoral fringe rock characterised by the kelp *Laminaria digitata* with coralline crusts covering the rock beneath the kelp canopy. Foliose red seaweeds such as *Palmaria palmata*, *Membranoptera alata*, *Chondrus crispus* and *Mastocarpus stellatus* are often present along with the calcareous *Corallina officinalis*. The brown seaweed *Fucus serratus* and the green seaweeds *Cladophora rupestris* and *Ulva lactuca* can be present as well. The sponge *Halichondria panicea* can be found among the kelp holdfasts or underneath overhangs. Also present on the rock are the tube-building polychaete *Pomatoceros triqueter*, and the gastropods *Patella vulgata* and *Gibbula cineraria*. The bryozoan *Electra pilosa* can form colonies on especially *C. crispus*, *M. stellatus* and *F. serratus* while the hydroids *Dynanema pumila* are more common on the kelp. Three variants of this biotope are described: *L. digitata* forest on rocky shores (Ldig.Ldig). *L. digitata* on boulder shores (Ldig.Bo) and soft rock supporting *L. digitata*, such as the chalk found in south-east England (Ldig.Pid). For *L. digitata* in sheltered, tide-swept conditions see LdigT [1].
Associated sub-biotopes:
A3.2121: Laminaria hyperborea forest, foliose red seaweeds and a diverse fauna on tide-swept upper infralittoral rock.
A3.2122: Laminaria hyperborea park with hydroids, bryozoans and sponges on tide-swept lower infralittoral rock.

A.213: Laminaria hyperborea on tide-swept infralittoral mixed substrata. Wave-exposed through to wave-sheltered, tide-swept infralittoral mixed substrata with *Laminaria hyperborea* forest/park and other kelp species such as *Laminaria saccharina*. The rich under-storey and stipe flora is characterised by foliose seaweeds including the brown algae *Dictyota dichotoma*. The kelp stipes support epiphytes such as *Cryptopleura ramosa*, *Callophyllis laciniata* and *Phycodrys rubens*. At some sites, instead of being covered by red seaweeds, the kelp stipes are heavily encrusted by the ascidians *Botryllus schlosseri* and the bryozoan *Alcyonidium diaphanum*. Epilithic seaweeds such as *Desmerestia aculeata*, *Odonthalia dentate*, *Delesseria sanguinea*, *Plocamium cartilagineum*, *Callophyllis laciniata*, and crustose seaweeds commonly occur beneath the kelp. The kelp fronds are often covered with growths of the hydroid *Obelia geniculata* or the bryozoan *Membranipora membranacea*. On the rock surface, a rich fauna comprising anthozoans such as *Alcyonium digitatum* and *Urticina felina*, colonial ascidians such as *Clavelina lepadiformis* and the calcareous tubeworm *Pomatoceros triqueter* occurs. More mobile species include the gastropods *Gibulla cineria* and *Calliostoma zizyphinum*, the crab *Cancer pagurus* and the echinoderms *Crossaster papposus*, *Henricia oculata*, *Asterias rubens* and *Echinus esculentus*. Two variants are described; tide-swept kelp forest on upper infralittoral mixed substrata (LhypTX.Ft) and tide-swept kelp park on lower infralittoral mixed substrata (LhypTX.Pk) [1].
Associated sub-biotopes:
A3.2121: Laminaria hyperborea forest, foliose red seaweeds and a diverse fauna on tide-swept upper infralittoral rock.
A3.2122: Laminaria hyperborea park with hydroids, bryozoans and sponges on tide-swept lower infralittoral rock.

A3.214: Laminaria hyperborea and foliose red seaweeds on moderately exposed infralittoral rock. Moderately exposed infralittoral bedrock and boulders characterised by a canopy of the kelp *Laminaria hyperborea* beneath which is an under-storey of foliose red seaweeds and coralline crusts. Some red seaweeds can be found as epiphytes on the kelp stipes and include *Delesseria sanguinea* and *Phycodrys rubens*. Other red seaweeds present include the *Plocamium cartilagineum*, *Callophyllis laciniata*, *Cryptopleura ramosa* and the brown seaweeds *Dictyota dichotoma* and *Cutleria multifida*. The kelp fronds can be colonised by the hydroid *Obelia*

geniculata or the bryozoans *Membranipora membranacea*. The echinoderm *Antedon bifida*, the ascidian *Clavelina lepadiformis*, the tube-building polychaete *Pomatoceros triqueter*, the anthozoans *Alcyonium digitatum* and *Urticina felina* can be found on the rock beneath the canopy. Mobile species often present include the gastropods *Gibbula cineraria* and *Calliostoma zizyphinum* and the echinoderms *Echinus esculentus* and *Asterias rubens*. Five variants has been described: Kelp forest (Lhyp.Ft), kelp park (Lhyp.Pk), grazed kelp forest (Lhyp.GzFt), grazed kelp park (Lhyp.GzPk) and kelp with *Sabellaria spinulosa* reefs (Lhyp.Sab). This suite of biotopes differs from the wave exposed *L. hyperborea* biotopes (KFaR) by having a lower diversity of cushion-forming faunal species. The foliose red seaweed component of the two suites of biotopes may also differ in composition with a tendency for Lhyp to include some more delicate filamentous species [1].
Associated sub-biotopes:
A3.2141: Laminaria hyperborea forest and foliose red seaweeds on moderately exposed upper infralittoral rock.
A3.2142: Laminaria hyperborea park and foliose red seaweeds on moderately exposed lower infralittoral rock.
A3.2143: Grazed Laminaria hyperborea forest with coralline crusts on upper infralittoral rock
A3.2144: Grazed Laminaria hyperborea park with coralline crusts on lower infralittoral rock
A3.2145: Sabellaria spinulosa with kelp and red seaweeds on sand-influenced infralittoral rock.

A3.215: Dense foliose red seaweeds on silty moderately exposed infralittoral rock. Upward-facing surfaces of shallow, infralittoral bedrock and boulders in areas of turbid water dominated by dense red seaweeds, with the notable absence of kelp. The stable rock, which can be cobbles or boulders but is more typically bedrock, is usually silted. Individual species of foliose red seaweeds such as *Plocamium cartilagineum* or *Calliblepharis ciliata* often dominate. Other red seaweeds likely to be present include *Phyllophora crispa*, *Rhodymenia holmesii*, *Halurus flosculosus*, *Cryptopleura ramosa*, *Hypoglossum hypoglossoides*, *Heterosiphonia plumosa* and coralline crusts. The brown seaweed *Dictyota dichotoma* is sometimes present, although never abundant. This biotope does not generally occur below kelp park but rather occurs on shallow, silted rock on which kelp would normally grow in less turbid conditions. The fauna can be variable but is generally typified by the presence of silt-tolerant animals such as encrusting sponges, particularly *Dysidea fragilis* and *Halichondria panicea*, the hydroid *Tubularia indivisa*, bryozoan crusts and scattered *Sabellaria spinulosa* and *Balanus crenatus*. In the summer months the seaweeds can become heavily encrusted with the bryozoan *Electra pilosa* and the ascidian *Molgula manhattensis* which can also form dense mats on the rock. The polychaete *Lanice conchilega* can be present, where sandy and muddy patches occur. Where this biotope occurs on chalk bedrock, such as off the Sussex coast, the piddock *Pholas dactylus* is often found bored into the rock. This biotope is recorded from the English Channel, off Kent, Sussex and the Isle of Wight. Please notice that individual sites of this biotope can vary significantly in the species composition. Situation: This biotope generally occurs on discrete bedrock outcrops surrounded by areas of mixed sediment or mobile sand. Off Sussex, it occurs on the horizontal chalk bedrock forming the tops of cliffs (2-3m in height). Temporal variation: The seaweeds die back in late autumn and summer leaving, silted, coralline-encrusted rock with a sparse fauna of sponges, *S. spinulosa* and occasional hydroids and bryozoans. The bryozoan *Amathia lendigera* can also become abundant amongst the seaweeds during the summer months [1].

A3.216: Laminaria hyperborea on moderately exposed vertical rock. Upward-facing surfaces of shallow, infralittoral bedrock and boulders in areas of turbid water dominated by dense red seaweeds, with the notable absence of kelp. The stable rock, which can be cobbles or boulders but is more typically bedrock, is usually silted. Individual species of foliose red seaweeds such as *Plocamium cartilagineum* or *Calliblepharis ciliata* often dominate. Other red seaweeds likely to be present include *Phyllophora crispa*, *Rhodymenia holmesii*, *Halurus flosculosus*, *Cryptopleura ramosa*, *Hypoglossum hypoglossoides*, *Heterosiphonia plumosa* and coralline crusts. The brown seaweed *Dictyota dichotoma* is sometimes present, although never abundant. This biotope does not generally occur below kelp park but rather occurs on shallow, silted rock on which kelp would normally grow in less turbid conditions. The fauna can be variable but is generally typified by the presence of silt-tolerant animals such as encrusting sponges, particularly *Dysidea fragilis* and *Halichondria panicea*, the hydroid *Tubularia indivisa*, bryozoan crusts and scattered *Sabellaria spinulosa* and *Balanus crenatus*. In the summer months the seaweeds can become heavily encrusted with the bryozoan *Electra pilosa* and the ascidian *Molgula manhattensis* which can also form dense mats on the rock. The polychaete *Lanice conchilega* can be present, where sandy and muddy patches occur. Where this biotope occurs on chalk bedrock, such as off the Sussex coast, the piddock *Pholas dactylus* is often found bored into the rock. This biotope is recorded from the English Channel, off Kent, Sussex and the Isle of Wight. Please notice that individual sites of this biotope can vary significantly in the species composition. Situation: This biotope generally occurs on discrete bedrock outcrops surrounded by areas of mixed sediment or mobile sand. Off Sussex, it occurs on the horizontal chalk bedrock forming the tops of cliffs (2-3m in height). Temporal variation: The seaweeds die back in late autumn and summer leaving, silted, coralline-encrusted rock with a sparse fauna of sponges, *S. spinulosa* and occasional hydroids and bryozoans. The bryozoan *Amathia lendigera* can also become abundant amongst the seaweeds during the summer months [1].

A3.217: Hiatella arctica and seaweeds on vertical limestone / chalk. This biotope is found in the infralittoral zone on moderately exposed vertical limestone/chalk surfaces in weak tidal streams, and has been recorded most frequently between 0-10m. This biotope is characterised by abundant *Hiatella arctica* and a rich sponge community including *Cliona celata*, *Dysidea fragilis* and *Pachymatisma johnstonia*. Other species that may be frequent in this biotope are the crab *Necora puber*, the sea squirt *Clavelina lepadiformis*, and the top shell *Calliostoma zizyphinum*, although these species are found in other vertical rock biotopes, however in lesser abundance. Situation: Shallow rocky coasts with vertical limestone faces [1].

Biotope Evaluation: Goods and Services

Although it contributes much in regulating climatically active gases, the processes involved in providing this service, the rate at which it is delivered, and the spatial scales required, are yet unknown for this particular biotope. The overall estimated value of this service provided by the UK marine environment, however, is between £41million - £4 billion [2]. Following mass mortalities associated with oil spills, recovery can occur within 1-2 years for wave exposed intertidal rocky reefs and 7-10 years for more sheltered shores (Frid, pers. obs.). Nutrient cycling, waste treatment, food provision and biological control are also important services provided by this and other marine biotopes [2, 3]. These services however may be significantly reduced by the removal of kelp, which in some countries (e.g. France) are commercially harvested. The kelp beds provide a physically complex habitat for juvenile fish [4, 5]. This biotope is also of importance for recreational divers and anglers, contributing to an estimated value of £11.7 billion for the UK alone [2]. *Laminaria hyperborea* biotopes support diverse and abundant invertebrate communities. The invertebrate fauna supported by NE Atlantic kelps are dominated by crustaceans and molluscs [6, 7, 8]. Invertebrate abundance is particularly high in the kelp holdfasts and associated with epiphytes on the stipes [9]. A study by Christie *et al*. [6] showed that 56 individual *Laminaria hyperborea* specimens supported 238 species, with an average density of almost 8000 individuals per kelp.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☒	☐	☐
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

This biotope is sensitive to physical disturbance and is likely to be particularly sensitive to activities which may increase the turbidity of the water column. The main threats to the biotope and the biological community it supports include: smothering (e.g. by disposal of dredge spoil), suspended sediment (e.g. run-off, dredging, outfalls), nutrient enrichment (e.g. agricultural run-off, outfalls), organic enrichment (e.g. mariculture, outfalls), introduction of microbial pathogens, introduction of non-native species and translocations, selective extraction of species (e.g. commercial & recreational fishing). Other threats may include substratum loss (e.g. by permanent constructions), selective extraction (e.g. aggregate dredging, entanglement), abrasion (e.g. boating, anchoring), introduction of synthetic compounds (e.g. pesticides, antifoulants, PCBs (Polichlorobifenyls), and introduction of non-synthetic compounds (e.g. heavy metals, hydrocarbons). All of these threats will affect the ecological functioning of the biotope, and the goods and services it provides. Impacts which affect kelp are likely to affect the biotope's functions and goods and services most adversely. It was universally agreed that any areas considered important for juvenile fish should be protected. Fishermen argued that habitats should only be protected when juvenile fish are present at a certain density. However, they also said that they avoided rocky areas to prevent damage to their gears, although as the technology was improving, they could get closer. Non-Governmental Organisations recognised that these rocky habitats were important for biodiversity and should be protected on that basis. Some stakeholders argued that management should not be changed for the benefit of some of the smaller habitat types as their existence alone indicates that management is working correctly, especially in areas as highly impacted as in the North Sea. Stakeholders considered it sensible to delineate areas along existing management boundaries (e.g. ICES rectangles or subsections of them). It was agreed that the areas to be protected would have to be delineated for sensible ecological reasons. The location of any protected areas was also of concern, as local fishers felt that they may be disproportionately impacted if the protected area was located within their fishing area.

Conservation and protection status

"Reefs" NATURA-1170 habitat types listed under the EC 92/43 Habitats Directive. However, parts of this biotope may also be classified as NATURA 2000 "Large shallow inlets and bays". The biotope is also listed as endangered in the Resolution no. 4, Council of Europe Bern Convention (1996): "Sublittoral rocky seabeds and kelp forests" (code 11.24).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough. www.jncc.gov.uk/MarineHabitatClassification.

[2] Beaumont NJ, Townsend M, Mangi S, Austen MC (2006) Marine biodiversity: an economic valuation. Defra: Bristol. pp 24

[3] Paramor O, Frid C (2006) Further development of objectives for marine habitats. DEFRA (www.defra.gov.uk). pp135

[4] Gaines SD, Roughgarden J (1987) Fish in offshore kelp forests affect recruitment to intertidal barnacle populations. Science 235: 479-80

[5] Henriques M, Almada VC (1998) Juveniles of non-resident fish found in sheltered rocky subtidal areas. J Fish Biol 52: 1301- 1304

[6] Christie H, Jørgensen NM, Norderhaug KM, Waage-Nielsen E (2003) Species distribution and habitat exploitation of fauna associated with kelp (*Laminaria hyperborea*) along the Norwegian coast. J Mar Biol Assoc UK, 83: 687-99

[7] Moore PG (1972) Particulate matter in the sublittoral zone of an exposed coast and its ecological signifcance with special reference to the fauna inhabiting kelp holdfasts. J Exp Mar Biol Ecol 10: 59-80

[8] Schultze K, Janke K, Krüß A, Weidemann W (1990) The macrofauna and macroflora associated with *Laminaria digitata* and *L. hyperborea* at the island of Helgoland (German Bight, North Sea). Helgol Meer 44: 39-51

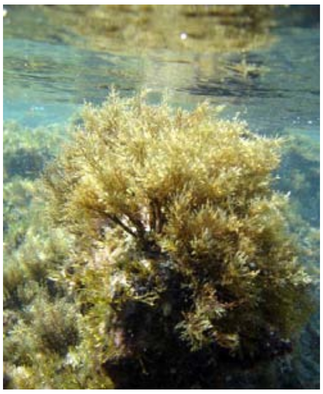
[9] Norderhaug KM, Christie H, Rinde E (2002) Colonisation of kelp imitations by epiphyte and holdfast fauna; a study of mobility patterns. Mar Biol 141: 965-973

Mediterranean and Pontic communities of infralittoral algae moderately exposed to wave action

Compiled by Maria Salomidi and Valentina Todorova

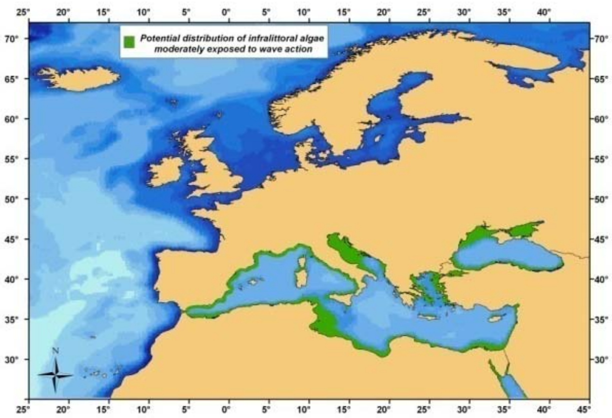
Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.23	Mediterranean and Pontic communities of infralittoral algae moderately exposed to wave action

Picture(s)


Shallow infralittoral algal communities on rocky shores moderately exposed to wave action. From left to right: *Sargassum vulgare, Cystoseira* spp. and *Codium fragile* among *Ulva* sp. fronds (Photos by Maria Salomidi)

Biotope Distribution



Potential distribution map

Links to Available Maps

http://data.gbif.org/species/13149690

Biotope Requirements

In well-lit rocky shores, moderately exposed to wave action. Depth range can vary according to local water clarity, from the mean low-water mark down to 10-20m or more. In fully saline conditions, ranging between 36-39 ppt in the Mediterranean, and 17-18 ppt in the Black Sea.

Biotope Description

Taking over the role of Laminariales in colder temperate regions, Fucales are the main benthic components of the upper sublittoral algal canopy in the Mediterranean and Black Seas [1].

The large photophilous algae of the genera *Cystoseira* and *Sargassum,* in particular, thrive in well-lit and pristine (oligotrophic) conditions, forming extensive stands that may host a large variety of associated sessile invertebrates (e.g. barnacles, hydroids, bryozoans, ascidians, sponges, anthozoa, polychaetes) as well as an exceptional diversity of vagile crustaceans and fish [1, 2, 3]. Among the Mediterranean Fucales, *Cystoseira* is the

most species-rich genus, comprising over 50 different species, of various ecological demands [3, 4, 5].
Associated Biotopes at EUNIS Level 5 and 6:
A3.234: Association with Cystoseira tamariscifolia and Saccorhiza polyschides. It is possible to find this association on seabottoms exposed to high currents (e.g. Strait of Messina, Strait of Alboran, etc.)
A3.239: Association with Cystoseira brachycarpa.
A3.23A: Association with Cystoseira crinita. In pure, rough waters with strong luminosity.
A3.23B: Association with Cystoseira crinitophylla.
A3.23C: Association with Cystoseira sauvageauana.
A3.23D: Association with Cystoseira spinosa. In pure, rough waters with strong luminosity.
A3.23E: Association with Sargassum vulgare. In pure, rough waters with strong luminosity.
****A3.23M (proposed new insertion/optional numbering): Pontic associations with Cystoseira barbata and Cystoseira crinita***. Although also common in the Mediterranean, this association is of particular importance in the Black Sea, where it contributes about 9% of the total biomass in the euphotic zone [1]. Understory of *Dilophus fasciola* and *Cladostephus spongiosus* is typical of oligotrophic waters (*Cystoseiretum dilophoso-cladostephosum*). A third layer is formed by *Padina pavonia* and *Corallina elongata*. *Gelidium latifolium* and *G. spinosum* (= *G. crinale*) are present as assectators. A fourth layerof crust-forming *Hilden brandtia rubra* (= *H. prototypus*) is also typical. Epiphytic algae include *Laurensia coronopus*, *Polysiphonia subulifera*, *Ceramium rubrum,Corynophlaea umbellata,Stilophora rhizodes, Janiarubens* [6, 7].
Associated sub-biotopes:
**A3.23M1 (proposed new insertion/optional numbering): Pontic associations with Cystoseira barbata and Ulva rigida*[6, 7]. In moderately eutrophicated waters of the Black Sea, the *Cystoseira barbata - C. crinita* association is replaced by the association of *Cystoseira barbata* and *Ulva rigida*.
**A3.23M2 (proposed new insertion/optional numbering): Pontic associations with Ulva rigida and Ceramium rubrum* is typical of mesotrophic infralittoral waters in the Black Sea [6, 7].
**A3.23M3 (proposed new insertion/optional numbering): Pontic associations with Cladophora spp. And Enteromorpha spp.* is typical of mesotrophic infralittoral waters in the Black Sea [6, 7].
**A3.23M4 (proposed new insertion/optional numbering): Pontic associations with Enteromorpha linza and Polysiphonia opaca* are typical of mesotrophic infralittoral waters in the Black Sea [6, 7].
**A3.23M5 (proposed new insertion/optional numbering): Pontic associations with Ulva intestinalis and Ceramiun rubrum or monodominant Ulva intestinalis*, is typical of eutrophic conditions in the Black Sea [6, 7].
**A3.23M6 (proposed new insertion/optional numbering): Pontic associations with Cystoseira barbata and Phyllophora crispa* is typical of oligotrophic but somewhat more shaded upper infralittoral.

Light is widely recognized among the most important driving factors determining the structure of algal communities [1]. On northern rock faces, or otherwise less sunlit sublittoral environments, other erect brown algae of the order Dictyotales may become dominant, forming extensive pseudo-canopies during the warm summer months, at the peak of their abundance.
Associated Biotopes at EUNIS Level 5:
A3.236: Association with Lobophora variegata.
A3.23F: Association with Dictyopteris polypodioides.

In shaded vertical rocks, overhangs and caverns, the canopy-forming brown algae are outcompeted by various semi-sciaphilous species of red and, to a lesser degree, green algae.
Associated Biotopes at EUNIS Level 5:
A3.231: *Association with Codium vermilara and Rhodymenia ardissonei*. This association of the green alga *C. vermilara* and the red alga *R. ardissonei* populates the middle horizon of the infralittoral zone, with low light and hydrodynamics.
A3.232: Association with Dasycladus vermicularis. This association with the green alga *D. vermicularis* populates the middle horizon of the infralittoral zone with low light and hydrodynamics.
A3.233: Association with Alsidium helminthochorton*.* This association is typical of the upper horizon of the infralittoral zone with weak light and hydrodynamics.
A3.235: Association with Gelidium spinosum v. hystrix.
A3.237: Association with Ceramium rubrum. This association is characterised by the high abundance of the red alga *Ceramium virgatum ex. C. rubrum*.
A3.23G: Association with Colpomenia sinuosa. In weak light and hydrodynamics, but also tolerant to nutrient enrichment.
A3.23H: Association with Rhodymenia ardissonei and Rhodophyllis divaricata. No further description available.

A3.23J: Association with Flabellia petiolata and Peyssonnelia squamaria. The green alga *Halimeda tuna* may also be a common associate.
A3.23K: Association with Halymenia floresia and Halarachnion ligatatum. This semi-sciaphilous association is characterised by a mixed cover of these two red algae, typical of shaded hard bottoms.
A3.23L: Association with Peyssonnelia rubra and Peyssonnelia spp. This semi-sciaphilous association is characterised by a mixed cover of various species of the genus *Peyssonnelia* and is typical of shaded hard bottoms.
****A3.23P (proposed new insertion/optional numbering): Association with Codium vermilara and Phyllophora crispa in the Black Sea (Codietum phyllophorosum)*** develops in the lower infralittoral at depth 10-25 m[6, 7].
****A3.23Q (proposed new insertion/optional numbering): Association with pure Phyllophora crispa in the Black Sea (Phyllophoretum purum)*** develops in the lower infralittoral at depth 10-25 m [6, 7].

Occasionally, where light and hydrodynamic conditions become favourable, certain invertebrates rather than algae, may dominate the infralittoral zone.
Associated Biotopes at EUNIS Level 5:
A3.238: Facies with Cladocora caespitosa. This facies is characterised by the abundance of the Mediterranean scleractinian coral *Cladocora caespitosa* which may locally form extensive biogenic build-ups [8].
A3.23I: Facies with Astroides calycularis. This facies is characterised by the madreporarian *A. calycularis* and is typical of the western Mediterranean pre-coralligenous zone.

Biotope Evaluation: Goods and Services

Marine benthic macrophytes are considered *ecosystem engineers* since they provide structural base for many coastal habitats and associated food webs [9, 10]. This is especially true for large perennial algae as are species of the order Fucales and Laminariales [1, 11]. These communities are known to host a large variety of algal and animal epiphytes, and provide shelter, food and nursery grounds for numerous fish and invertebrate species [1, 2]. Coastal macroalgae have been estimated to contribute to about one tenth of the world’s marine primary production [12]. As sessile organisms they integrate and respond rapidly and predictably to nutrient pollution and other environmental impacts, thus serving as sensitive bioindicators of water quality [10, 11, 13, 14, 15, 16] Moreover, this biotope constitutes a well-defined system, easily accessible and able to express the anthropogenic stress in long-term environmental quality monitoring studies, as foreseen in the Water Framework Directive [11, 15, 17]. Algae have been harvested or cultivated for human and animal food as well as fertilizers for centuries. Much of their economic value however seems yet to lie in their high potential as sources of long- and short-chain chemicals with wide medicinal and industrial uses [18], as well as their high potential for environmental and industrial bioremediation [19].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☒	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐

Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Many researchers have observed the degradation or complete regression of macroalgal infralittoral communities under various anthropogenic disturbances [2 and references therein]. *Cystoseira* populations, in particular, have been often described as especially susceptible to increased pollution levels [12, 20]. Water turbidity and habitat destruction due to the proliferation of coastal structures pose also a serious threat to this biotope [21]. Mechanical disturbance, i.e. human trampling in shallow and crowded coastal areas, collection of specimens for scientific purposes, and net fishing in deeper zones can be particularly destructive, especially so for those algal species with long life spans, low recruitment levels, and low growth rates [2 and references therein]. Sea urchin population blooms -as an indirect effect of overfishing - have also been described as a factor contributing to the disappearance of *Cystoseira* assemblages and other canopy-forming algae in the infralittoral zone [21, 23]. Furthermore, similar disappearances were recently ascribed to overgrazing by the herbivorous lessepsian fish species *Siganus* spp. in the Eastern Mediterranean basin [24].

Conservation and protection status

The algal communities of the upper infralittoral zone are included in the Annex I of the EU Habitats Directive under the code 1170 (*Reefs*) as well as the Bern Convention under the code 11.24 (*Sublittoral rocky seabeds and kelp forests*).

References

[1] Lüning K (1990) Seaweeds. Their environment, biogeography, and ecophysiology. John Wiley and Sons, Inc., NY, pp 527

[2] Thibaut T, Pinedo S, Torras X, Ballesteros E (2005) Long-term decline of the populations of Fucales (*Cystoseira* spp. and *Sargassum* spp.) in the Alberes coast (France, North-western Mediterranean), Mar Pollut Bull 50 (12): 1472-1489

[3] Kocataç A, Katağan T, Sezgin M, Kirkim F, Koçak C (2004) Crustacean Diversity Among the Cystoseira Facies of the Aegean Coast of Turkey. Turk J Zool 28: 309-316

[4] Huvé H (1972). Apercu sur la distribution en mer Egee de quelques especes du genre *Cystoseira* (Phaeophyceae, Fucales). Bull Soc Phycol Fr 17: 22-37

[5] Montesanto B, Panayotidis P (2001) The *Cystoseira* spp. communities from the Aegean Sea (NE Mediterranean). Med Mar Scie 2(1): 57-67

[6] Afanasiev D (2010) State and succession of macrophytobenthos in the Russian Azov-Black Sea shelf in the end of the 20th and the beginning of 21st centuries. DSci Thesis (in Russian)

[7] Kalugina-Gutnik A (1975) Phytobenthos of the Black Sea. Naukova Dumka, Kiev, pp 246 (in Russian)

[8] Morri C, Peirano A, Nike Bianchi C (2001) Is the Mediterranean coral *Cladocora caespitosa* an indicator of climatic change? Archo Oceanogr Limnol 22: 139-144

[9] McRoy CP, Lloyd DS (1981) Comparative Function and Stability of Macrophyte-based Ecosystems. In: Longhurst AR (ed) Analysis of Marine Ecosystems, Academic Press, London

[10] Orfanidis S, Panayotidis P, Stamatis N (2001) Ecological evaluation of transitional and coastal waters: A marine benthic macrophytes-based model. Med Mar Sci 2(2): 45-65

[11] Arevalo R, Pinedo S, Ballesteros E (2007) Changes in the composition and structure of Mediterranean rocky-shore communities following a gradient of nutrient enrichment: Descriptive study and test of proposed methods to assess water quality regarding macroalgae, Mar Pollut Bull 55 (1-6), Implementation of the Water Framework Directive in European marine waters, pp 104-113

[12] Charpy-Roubaud CJ, Sournia A (1990) The comparative estimation of phytoplanktonic, microphytobenthic and macrophytobenthic primary production in the oceans. Mar Microb Food Webs, 4 (1): 31-57

[13] Soltan D, Verlaque M, Boudouresque CF, Francour P (2001) Changes in macroalgal communities in the vicinity of a Mediterranean sewage outfall after the setting up of a treatment plant. Mar Pollut Bull 42: 59–70

[14] Orfanidis S, Panayotidis P, Stamatis N (2003) An insight to the ecological evaluation index (EEI). EcolIndic

3(1): 27-33
[15] Ballesteros E, Torras X, Pinedo S, Garcia M, Mangialajo L, de Torres M (2007) A new methodology based on littoral community cartography dominated by macroalgae for the implementation of the European Water Framework Directive. Mar Pollut Bull 55(1-6): pp 172-180
[16] Fytianos K, Evgenidou E, Zachariadis G (1999) Use of Macroalgae as Biological Indicators of Heavy Metal Pollution in Thermaikos Gulf, Greece. Bull Environ Contam Toxicol 62: 630-637
[17] Panayotidis P, Montesanto B, Orfanidis S (2004) Use of low-budget monitoring of macroalgae to implement the European Water Framework Directive. J Appl Phyc 16: 49-59
[18] Guiry MD, Blunden G (eds) (1991) Seaweed resources in Europe: uses and potential. Chichester, UK: John Wiley & Sons
[19] Davis AT, Volesky B, Alfondo M (2003) A review of the biochemistry of heavy metal biosorption by brown algae. Wat Res 37: 4311-4330
[20] Panayotidis P, Feretopoulou J, Montesanto B (1999) Benthic vegetation as an ecological quality descriptor in an Eastern Mediterranean coastal area (Kalloni Bay, Aegean Sea, Greece). Estuar Coast Shelf S 48: 205–214
[21] Cormaci M, Furnari G (1999) Changes of the benthic algal flora of the Tremiti Islands (southern Adriatic) Italy. Hydrobiol 398– 399: 75–79
[22] Sala E, Boudouresque CF, Harmelin-Vivien M (1998) Fishing, trophic cascades and the structure of algal assemblages: evaluation of an old but untested paradigm. Oikos 82: 425–439
[23] Hereu B (2006) Depletion of palatable algae by sea urchins and fish in a Mediterranean subtidal community. Mar Ecol Prog Ser 313: 95–103
[24] Sala E, Kizilkaya Z, Yildirim D, Ballesteros E (2011) Alien Marine Fishes Deplete Algal Biomass in the Eastern Mediterranean. *PLoS ONE,* 6 (2): e17356. doi:10.1371/journal.pone.0017356

Faunal communities on moderate energy infralittoral rock

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.24	Faunal communities on moderate energy infralittoral rock

Picture(s)
Not available

Biotope Distribution
Not available

Links to available maps
Not available

Biotope requirements
Hard substratum – bedrock, boulders, firm clay beds, (wood, being a specific substratum, is included here tentatively); moderate wave/current energy; reduced water luminosity due to increased turbidity driven by natural or anthropogenic eutrophication, especially in the Black Sea.

Biotope Description
In naturally or human-induced eutrophicated regions, the infralittoral rock communities can be dominated by fauna due to reduced transparency and less luminosity of waters, which constrains the development of algal communities. Shaded surfaces inside underwater rocky canyons and under overhangs are also typically overgrown by sedentary fauna. Algal growth may be limited by unstable hard substrata such as firm clay or very soft chalk.

A3.241 (proposed new insertion/optional numbering): Pontic Mytilus galloprovincialis beds on infralittoral rock. *Mytilus galloprovincialis* mussel beds on rock are one of the most prominent and widespread biotopes in the Black Sea [1, 2, 3, 4, 5, 6]. Mussels are always present under the changing algal cover of the infralittoral rock, thus this biotope partially overlaps the photophilic algal zone, but it continues deeper to the circalittoral reaching down to 30-35 m (occasionally 50-70 m), the lower limit of Black Sea rocky bottoms. In regions with high organic input and less transparent waters algae may be sparse thus mussels become the dominant species. Characterisitc algae that grow between or on mussel shells include the chlorophytes *Ulva intestinalis, Ulva rigida, Briopsis plumosa, Cladophora vagabunda* and the rhodophytes *Ceramium rubrum, Callithamniom corymbosum, Polysiphonia denudata, Porphyra leucosticta* (winter aspect) [7, 8]. Sciaphilous algae *Zanardinia typus, Phyllophora* spp. and *Peyssonnelia rubra* occur on deeper mussel beds. The associated fauna is very diverse, including many invertebrate and fish species, which occur only in this biotope, some of them rare or protected. A wide variety of epifaunal colonisers on the mussel valves is present, including sponges *Halichondria panicea, Dysidea fragilis, Petrosia dura*, anemones *Actinia equina*, barnacles *Balanus improvisus,* hydrozoans *Aglaophenia pluma, Campanularia integriformis, Obelia* spp., encrusting bryozoans *Membranipora membranacea, Lepralia pallasiana,* serpulid polychaetes *Pomatoceros triqueter, Janua pagenstecheri, Serpula vermicularis* (the largest Black Sea sedentary polychaete) and the colonial ascidians *Botryllus schlosseri*. Mobile fauna includes the chiton *Lepidochitona cinerea*, polychaetes *Platynereis dumerilii, Perinereis cultrifera*, isopods, amphipods and variety of crabs – the largest Black Sea crab *Eriphia verrucosa*, and the smallest - *Pisidia longicornis,* as well as *Pilumnus hirtellus, Pachygrapsus marmoratus*, *Xantho poressa, Rhithropanopeus harrisii, Clibanarius erythropus* and shrimps *Palaemon adspersus, Hippolyte leptocerus*, *Athanas nitescens.* Fish fauna is also highly diverse including but not limited to *Lisaaurata*, *Lisasaliens*, *Chelon labrosus*, *Syngnathus typhle*, *Syngnathus tenuirostris*, *Symphodus tinca*, *Symphodus ocellatus*, *Salaria pavo*, *Aidablennius sphinx*, *Parablennius sanguinolentus*, *Coryphoblennius galerita*, *Scorpaena porcus*, *Pomatoschistus minutus*, *Chromogobius quadrivittatus*, *Gobius niger*, *Gobius cobitis*, *Gobius paganellus*, *Neogobius platyrostris*, *Neogobius cephalarges*, *Neogobius melanostomus*, *Neogobius ratan*, *Mesogobius batrachocephalus* [6, 9].

**** A3.242 (proposed new insertion/optional numbering): Pontic soft rock beds with piddocks (Pholadidae) burrows.*** The biotope features infralittoral platforms or outcrops of firm clay or reefs of chalk, sufficiently soft to be bored by piddocks – key structuring species. *Pholas dactylus* is the most widespread borer in the Black Sea and may be abundant [10]. *Barnea candida* may occur as well, although it is less common. The rock surface is very erodible, therefore unsuitable for algae or larger epifaunal species to attach. Piddock burrowing increases structural complexity creating habitats for other animals that inhabit vacant burrows – for example, the crab *Brachynotus sexdentatus* and the blenny *Aidablennius sphinx*.

****A3.243 (proposed new insertion/optional numbering): Pontic hard rock with Petricola lithophaga.*** Hard rock such as limestone is bored by another piddock - *Petricola lithophaga*. Boreholes may be dense, with usually smaller diameter than those of *Pholas*.

****A3.244 (proposed new insertion/optional numbering): Pontic Ostrea edulis and Sabellaria taurica concretions.*** Biogenic concretions encrusting infralittoral boulders and rocky reefs, constructed mainly of *Ostrea edulis* shells, with calcareous tubes of *Sabellaria taurica* present as cementing material [11, 12]. These concretions may have high structural complexity with uneven surface and numerous crevices that provide shelter and microhabitats for diverse colonising epifauna, decapod crustaceans and fishes. Although the physical structure of this biotope is still present, its functional role is severely diminished due to absence of live oysters in the concretion mass, which is colonised by other epifauna, mostly mussels. Separate live oysters attached to rock still may be observed along southern and south-eastern Black Sea coasts.

****A3.245 (proposed new insertion/optional numbering): Pontic faunal crusts on infralittoral rock.*** Bare or with sparse algae and mussels infralittoral rock may be covered by colonial ascidians *Botryllus schlosseri* and encrusting bryozoans *Membranipora membranacea* and *Lepralia pallasiana.* Shadowed faces in crevices and canyons or lower infralittoral and circalittoral rock may be occupied by encrusting or cushion sponges, brightly coloured in blue, red, purple and green - *Halichondria panicea, Dysidea fragilis, Petrosia dura, Haliclona implexa, H. flavescens, Hymeniacidon sanguinea*. Sponge crusts are typical also of cave entrances, gullies and under overhangs.

****A3.246 (proposed new insertion/optional numbering): Pontic solitary ascidians on infralittoral rock.***This biotope occurs on vertical faces of lower infralittoral boulders. It is charaterised by solitary ascidians - the native *Molgula euprocta* or the alien *Molgula manhattensis*, attached in groups to vertical rock faces amongst patches of sponges, mussels and filamentous algae.

****A3.247 (proposed new insertion/optional numbering): Spirorbid worms on cobbles*. ** The bristleworm *Janua pagenstecheri* may cover densely cobbles and stones, as well as shells. With its tightly coiled white tubes of calcium carbonate with the opening facing anti-clockwise *Janua* is unmistakable and gives a distinctive appearance of this biotope.

****A3.248 (proposed new insertion/optional numbering): Teredo navalis burrows in large wooden debris.*** The shipworm *Teredo navalis*bores in wooden debris, forming characteristic, winding burrows that are lined with calcareous deposits [4, 13, 14]. These burrows can be seen when the wood is split apart. The tubes are up to 60 cm long and 0.8 cm in diameter. *Teredo* is a thermophilic and halophilous species, limited by salinities less than 11 ppt. Mass development and distribution of this species was directly linked with use of the wood in shipbuilding and waterworks (berths, bearings of stationary nets etc). Because of replacement of wood by concrete and metallic underwater constructions, the shipworm has become rarer. However, sufficient supply of wood material is provided where the coast is covered by forests, thus *Teredo* may be locally common.

Biotope Evaluation: Goods and Services

Rocky reefs support an abundant, productive and much more diverse marine life than sedimentary bottoms [1]. *Mytilus* beds on infralittoral rock are very important biotopes due to their crucial contribution in the ecosystem's self-cleansing capacity and the benthic-pelagic coupling. The biological production of these biotopes can exceed 10 kg m^{-2}, with a complex food web, which links it to several other biotopes [15]. They are also important feeding and nursery grounds, as well as refuges for many commercially valuable fish species, and they provide much of the biofiltering capacity essential for maintaining the quality of coastal waters. *Mytilus* is an important food source for demersal fishes (gobbies, flounder), crabs and the predatory alien whelk *Rapana venosa*. Furthermore, mussel eggs and larvae are probably an important food source for pelagic fish larvae and zooplankton. Mussels can be harvested for food and bait, although this is mostly a recreational, rather than a commercial activity. Natural mussel beds provide seed for mussel culture, which has become a fast-growing industry. Some artisanal and subsistence fishery for gobies take place in this biotope and, locally, small scale harvest for the crab *Eriphia verrucosa* may exist. Potentially, the piddock *Pholas dactylus* and the date mussel *Lithophaga lithophaga* may be harvested or cultured. Mussels colonize artificial substrata such as piles, buoys and harbour structures and may thus be a serious nuisance to marine shipping and power stations' cooling water pipes. The shipworm *Teredo navalis* is a menace to wooden boats and submersed constructions. Reefs provide a range of cultural services including opportunities for recreation and tourism, enjoyment of natural heritage, aesthetic and spiritual experience, inspiration for art, opportunities for scientific research and cognitive development.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☐	☒	☐
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Generally, epifaunal communities are sensitive to substratum loss and displacement, physical disturbance and abrasion. Most of the characteristic species on infralittoral rock are permanently attached and will not re-attach after displacement. Therefore the biotope will not recover through re-attachment but through new settlement. Some *Mytilus* species are capable of re-attaching themselves, however decrease in mussel bed coverage would result in decreased species richness of the associated fauna. Mussel beds can be extremely prone to biological invasions as has been the case for the invasive alien gastropod *Rapana venosa* which caused complete obliteration of mussels and subsequent loss of the associated community in the Black Sea [12]. Many *Mytilus* species are rather tolerant to hypoxia, and therefore able to thrive in eutrophicated conditions. They are also relatively tolerant to various chemical and hydrocarbon contaminants. *Pholas dactylus* and *Lithophaga*

lithophaga, some of the key structuring species of this biotope, are highly intolerant to substratum loss and displacement because once removed from their burrows they cannot excavate a new chamber and are thus likely to die. These species are also intolerant to synthetic compound contamination. *Pholas dactylus* and *Lithophaga lithophaga* are harvested by the use of a hammer and chisel has had a destructive impact on habitats and has now been banned throughout the Mediterranean. However, both species are still harvested and served illegally in many restaurants and fish markets.

Conservation and protection status

"Reefs" are NATURA-1170 habitat types listed under the EC/92/43 Habitats Directive. *Pholas dactylus* and *Lithophaga lithophaga*, in particular, are protected by the Bern and Barcelona conventions, enforced by local legislations.

References

[1] Marinov T (1990) The zoobenthos from the Bulgarian Sector of the Black Sea. Publishing house of the Bulgarian Academy of Sciences, Sofia, pp 195 (in Bulgarian)
[2] Micu D, Zaharia T, Todorova V (2008) Natura 2000 habitat types from the Romanian Black Sea. In: Zaharia T, Micu D, Todorova V, Maximov V, Niţă V. The development of an indicative ecologically coherent network of marine protected areas in Romania, Romart Design Publishing, Constanta, pp 32
[3] Petranu A (1997) Black Sea Biological Diversity: Romania. Black Sea Environm Ser 4, United Nations Publications, New York, pp 314
[4] Todorova V, Micu D, Panayotova M, Konsulova T (2008) Marine Protected Areas in Bulgaria Present and Prospects. Steno Publishing House, Varna, pp 22
[5] Vershinin A (2007) Life in the Black Sea. Maccentr, Moscow, pp 192 (in Russian)
[6] Zaitsev YP, Alexandrov BG (1998) Black Sea Biological Diversity: Ukraine. Black Sea Environm Ser 7. United Nations Publications, New York, pp 351
[7] Dimitrova-Konaklieva S (2000) Flora of the Marine Algae of Bulgaria (Rhodophyta, Phaeophyta, Chlorophyta). Pensoft, Sofia - Moscow, pp 304 (in Bulgarian)
[8] Kalugina-Gutnik AA (1975) Phytobenthos of the Black Sea. Naukova dumka, Kiev, pp 245 (in Russian)
[9] Karapetkova M, Zhivkov M (2006) Fishes in Bulgaria. Gea Libris, Sofia, pp 216 (in Bulgarian)
[10] Micu D (2007) Recent Records of Pholas dactylus (Bivalvia: Myoida: Pholadidae) from the Romanian Black Sea, with Considerations on its Habitat and Proposed IUCN Regional Status. Acta zool bulgarica 59 (3): 267-274
[11] Todorova V, Micu D, Klisurov L (2009) Unique Oyster reefs discovered in the Bulgarian Black Sea. Comptes de l'Academie bulgare des Sciences, 62 (7): 871-874
[12] Micu D, Todorova V (2007) A fresh look at the western Black Sea biodiversity. MarBEF Newsl 7: 26-28
[13] Cvetkov L, Matinov T (1986) Faunistic Enrichment of the Black Sea and Changes in Its Benthic Ecosystems. Hydrobiol 27: 3-21 [in Russian]
[14] Zaitsev Y, Ozturk B (2001) Exotic Species in the Aegean, Marmara, Black, Azov and Caspian Seas. Turkish Marine Research Foundation Istanbul, pp 267
[15] Bacescu MC, Muller GI, Gomoiu M-T (1971) Ecretari de ecologie bentala in Marea neagra (analiza cantitativa, calitativa si comparata a faunei bentale pontice). Ecologie marina vol. IV. Editura Academiei R.S.R., Bucuresti, pp 357

Mediterranean submerged fucoids, green or red seaweeds on full salinity infralittoral rock

Compiled by Simone Mirto

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.33	Mediterranean submerged fucoids, green or red seaweeds on full salinity infralittoral rock

Picture(s)
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements
Stage: Infralittoral
Nature of substratum: Hard beds
Bathymetrical distribution: from the surface down to 35 to 40 metres
Position: Open sea
Hydrodynamics: Weak, average, strong, very strong
Salinity: Normal range
Temperature: Normal range.

Biotope Description
This community is characterised by the presence of many photophilic algae covering hard bottoms in exposed areas with normal or high salinity [1].

Associated biotopes at EUNIS level 5:

***A3.331: Association with Stypocaulon scoparium (=Halopteris scoparia*)** [1]. This association is characterized by the brown alga *Stypocaulon scoparium*, living in pure, sheltered waters with strong luminosity.

A3.332: Association with Trichosolen myura and Liagora farinose [1]. This association is characterized by the green alga *Trichosolen myura* and the red alga *Liagora farinosa*, also called "soft spaghetti weed".

A3.333: Association with Cystoseira compressa [2, 3, 4, 5, 6, 7]. This association is characterised by the brown alga *Cystoseira compressa*, an endemic of the Mediterranean, described for the first time in Corsica. It can form dense prairies in the first metre of the infralittoral. *Cystoseira compressa* is not an indicator of either a mode or a well-determined level, since it is found, in the first metre, in both areas with strong wave action at midwave level and in sheltered areas. In the eastern Mediterranean, it is met, with *Sargassum vulgare* and *Laurencia papillosa*, at the outside edges of the vermetid platforms where *Dendropoma petraeum* forms kinds of pads. This association, that includes several strata, is characterised by a certain specific richness; it shelters epibiont organisms and substratum organisms. Species that are found within it mainly belong to the algae, the polychaetes, the molluscs and the crustaceans. The alga itself is used in industry; as well as iodine, it contains algines and various compounds.

A3.334: Association with Pterocladiella capillacea and Ulva laetevirens [1]. This association is characterised by a vegetation with the red alga *Pterocladiella capillacea* and the green alga *Ulva laetevirens*. It is found in areas with mixed salinity.

A3.335: Facies with large Hydrozoa [1]. This facies is characterised by the high presence of large Hydrozoa (e.g. *Aglaophenia* spp. and *Eudendrium* spp.).

A3.336: Association with Pterothamnion crispum and Compsothamnion thuyoides [1]. This association is characterised by a mixed vegetation of the red algae *Pterothamnion crispum* and *Compsothamnion thuyoides*.

Biotope Evaluation: Goods and Services

This biotope is extremely rich both in biodiversity and abundance, containing several hundreds of species. It is also considered highly productive as its biomass can attain several kilograms per square meter. The biotope is characterized by strong seasonal dynamics and a highly complex trophic network which also supports several other habitats by dispersion of organisms and organic matter. It consists of various seaweeds and animals, offering thus a valuable food source to many commercially and otherwise important fish species. Many algal species that abound in this biotope have been described as highly efficient in removing nutrients, CO_2, and heavy metals from the seawater [8, 9].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Being directly subject to various human activities, this biotope is especially prone to impacts such as coastal pollution (urban, agricultural, industrial, fish-farming, etc.), unsustainable development (i.e. building, concreting, destroying biogenic platforms, riprap, sedimentary filling in and sediment removal), as well as the deliberate or accidental introduction of alien and potentially invasive species. Monitoring such anthropogenic effects and the ecological quality of these coastal water bodies is thus emerging as a necessity.

Conservation and protection status

This biotope is part of the wider "Reef" NATURA-1170 habitat type (Annex I of the EU Habitats Directive). It is also part of the "Sublittoral rocky seabeds and kelp forests" (code 11.24) listed as endangered in the Resolution no. 4 of the Council of Europe Bern Convention (1996).

References

[1] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010).

[2] Barceló Marti MC, Gallardo García T, Gómez Gareta A, Pérez-Ruzafa IM, Ribera Siguan MA, Rull Lluch J (2001) Flora phycologica iberica. Vol 1: Fucales. Gómez Gareta A (ed), Universidad de Murcia, Spain, pp 192

[3] Benedetti-Cecchi L, Pannacciulli F, Bullieri F, Moschella PS, Airoldi L, Relini G, Cinelli F (2001) Predicting the consequences of anthropogenic disturbance: large-scale effects of loss of canopy algae on rocky shores. Mar Ecol Prog Ser 214: 137-150

[4] Cabioch J, Floch JY, Le Toquin A, Boudouresque CF, Meinesz A, Verlaque M (1992) Guide des Algues des mers d'Europe. Manche/Atlantique. Delachaux et Niestlé, 231p

[5] Giaccone G, Alongi G, Pizzuto F, Cossu A (1994) La vegetazione marina bentonica fotofila del Mediterraneo: II. Infralitorale e Circalitorale Proposte di aggiornamento. Boll Accad Gioenia Sci Nat Catania (27) 346: 111-157

[6] Molinier R (1960) Etude des biocénoses marines du Cap Corse (France). Vegetatio (9): 1- 312

[7] Bellan-Santini D, Bellan G, Bitar G, Harmelin JG, Pergent G (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. Publication of Regional Activity Centre for Specially Protected Areas, United Nations Environment Programme, Action Plan for the Mediterranean. Available at http://www.rac-spa.org/

[8] Gao K, Mckinley KR (1994) Use of macroalgae for marine biomass production and CO_2 remediation: a review. J Appl Phycol 6: 45-60

[9] Davis AT, Volesky B, Alfondo M (2003) A review of the biochemistry of heavy metal biosorption by brown algae. Wat Res 37: 4311-4330.

Faunal communities on low energy infralittoral rock

Compiled by Marijn Rabaut

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.35	Faunal communities on low energy infralittoral rock

Picture
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements
Hard substratum with low tidal energy where algae are lacking (fauna dominated).

Biotope Description
Shallow rocky ecosystems provide a great variety of habitats suitable for polychaetes, which are often one of the dominant taxa there [1, 2]. This biotope is dominated by faunal communities typified by vagile polychaetes (syllids, nereids) and scarce algal cover [1]. Besides, a scattering of barnacles (*Verruca stroemia* and *Balanus crenatus*), tubiculous polychaetes (*Pomatoceros triqueter* and *Spriorbis* spp.) and some small hydroids, polyzoans, and compound ascidians. Crawling over the surface may be chitons, cowries and nudibranchs [3]. The biotope is less rich and diverse due to to rare species which occur in more complex habitats [1, 3].

Biotope Evaluation: Goods and Services
No information available

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒

Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities
No information on sensitivity available.

Conservation and protection status
No demonstrated need for conservation

References
[1] Serrano A, Preciado I (2007) Environmental factors structuring polychaete communities in shallow rocky habitats: role of physical stress versus habitat complexity. Helgol MarRes 61: 17-29. doi: 10.1007/s10152-006-0050-7
[2] Giangrande A (1988) Polychaete zonation and its relation to algal distribution down a vertical cliff in the Western Mediterranean (Italy): A structural analysis. J Exp Mar Biol Ecol 120: 263-276
[3] Stephenson TA, Stephenson A (1972) Life between tidemarks on rocky shores. W.H. Freeman and company, San Francisco, pp 425

Faunal communities on variable or reduced salinity infralittoral rock

Compiled by Marijn Rabaut

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.36	Faunal communities on variable or reduced salinity infralittoral rock

Picture

Not available

Biotope Distribution

Not available

Links to Available Maps

Not available

Biotope Requirements

Hard substratum where algae are (almost) lacking (fauna dominated) and where salinity is reduced (estuaries) or variable.

Biotope Description

Shallow subtidal rocky habitats which support faunal-dominated communities, with seaweed communities only poorly developed or absent. In some sealochs dense mussel *Mytilus edulis* beds develop in tide-swept channels, whilst upper estuarine rocky habitats in the south-west coast rias may support particular brackish-water tolerant faunas [1]. The biotope is less rich and diverse due to to rare species which occur in complex habitats and are excluded from this less complex biotope [2, 3].

Associated biotopes at EUNIS Level 5 [1]:

A3.361: Mussel beds (Mytilus edulis) on reduced salinity infralittoral rock. This biotopeoccurs in shallow, often tide-swept, reduced salinity conditions. Dense beds of the mussel *Mytilus edulis* with the occasional barnacle *Balanus crenatus*. A wide variety of epifaunal colonisers on the mussel valves, including seaweeds, hydroids and bryozoans can be present. Predatory starfish *Asterias rubens* can be very common in this biotope. This biotope generally appears to lack large kelp plants, although transitional examples containing mussels and kelps plants may also occur. More information needed to validate this description. Situation: Occurs in tide-swept entrance channels in very enclosed basins of sealochs where the basins are typically of lowered salinity. Also occurs in very sheltered subtidal rock (often vertical) in lagoons.

A3.362: Cordylophora caspia and Electra crustulenta on reduced salinity infralittoral rock. They occur in shallow sublittoral rock in the upper estuary of one of the south-west inlets (Tamar) with very high turbidity and therefore no seaweeds. The brackish-water hydroid *Cordylophora caspia* and small colonies of the encrusting bryozoan *Electra crustulenta* and a few *Balanus crenatus* characterise this biotope. More information required to validate this description.

A3.363: Hartlaubella gelatinosa and Conopeum reticulum on low salinity infralittoral mixed substrataoccur in the upper estuarine mixed hard substrata colonised by very sparse communities of animals with low species richness and with a few seaweeds in very shallow water. In the Tamar estuary the hydroid *Hartlaubella gelatinosa* and bryozoan *Conopeum reticulum* are found on stones. In the River Dart the bryozoan *Bowerbankia imbricata* is most abundant. The mussel *Mytilus edulis*, the crab *Carcinus maenas* and the hydroid *Obelia dichotoma* can be present. A similar brackish-water rocky biotope is recorded from the Bann Estuary, Northern Ireland. There are considerable differences in species composition between sites, but all occur in brackish turbid-water conditions. (More information is required to validate this description).

Biotope Evaluation: Goods and Services

No information available

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

No information on sensitivity available.

Conservation and protection status

No demonstrated need for conservation.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The marine habitat classification for Britain and Ireland version 04.05. In: Joint Nature Conservation Committee Report, Peterborough, UK. www.jncc.gov.uk/MarineHabitatClassification (Accessed 15 March 2010)

[2] Serrano A, Preciado I (2007) Environmental factors structuring polychaete communities in shallow rocky habitats: role of physical stress versus habitat complexity. Helgoland Marine Research 61: 17-29. doi: 10.1007/s10152-006-0050-7

[3] Stephenson TA, Stephenson A (1972) Life between tidemarks on rocky shores. W.H. Freeman and company, San Francisco, pp 425

Robust faunal cushions and crusts in surge gullies and caves

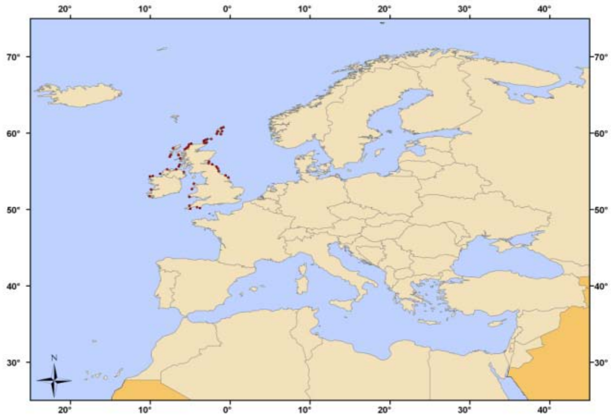
Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	8330	Submerged or partially submerged sea caves
NATURA 2000	1170	Reefs
EUNIS	A3.71	Robust faunal cushions and crusts in surge gullies and caves

Picture(s)

Not available

Biotope Distribution



Map showing UK observed sites only.

Links to Available Maps

http://www.jncc.gov.uk/marine/habitats/habitat.aspx?habitat=JNCCMNCR00001531
http://www.marlin.ac.uk/habitatsbasicinfo.php?habitatid=242&code=2004#

Biotope Requirements

Vertical and overhanging rock in gullies or caves; infralittoral and sublittoral fringeat depth range 0-20 m, moderate or greater wave action, and reduced light are the dominant environmental factors in this biotope.

Biotope Description

Infralittoral rocky habitats subject to strong wave surge conditions, as found in surge gullies and shallow caves, and typically colonised by faunal communities of encrusting or cushion sponges, colonial ascidians, short turf-forming bryozoans, anthozoans, barnacles and, where there is sufficient light, red seaweeds [1, 2]. These features usually consist of vertical bedrock walls, occasionally with overhanging faces, and support communities which reflect the degree of wave surge they are subject to, and any scour from mobile substrata on the cave/gully floors. The larger cave and gully systems typically show a marked zonation from the entrance to the rear of the gully/cave as wave surge increases and light reduces. This is reflected in communities of anthozoans, ascidians, bryozoans and red seaweeds near the entrance, leading to sponge crust-dominated communities and finally barnacle and spirorbid worm communities in the most severe surge conditions [1]. Gully/cave floors usually have mobile boulders, cobbles, pebbles or coarse sediment. The mobile nature of the gully/cave floors leads to communities of encrusting species, tolerant of scour and abrasion or fast summer-growing ephemeral species. The lower zone of the gully side walls are also often scoured, and typically colonised by coralline crusts and barnacles [1].

Associated Biotopes at EUNIS Level 5:

A3.711: Foliose seaweeds and coralline crusts in surge gully entrances [1]. This biotope is found on steep wave-surged entrances to gullies and caves and on unstable boulders in the entrance to caves and gullies and tends to be dominated by dense foliose seaweeds that grow rapidly in the calmer summer months. The flora of this biotope is relatively varied, depending upon the amount of light and degree of abrasion or rock mobility with red seaweeds such as *Cryptopleura ramosa, Plocamium cartilagineum, Odonthalia dentata, Callophyllis laciniata, Phycodrys rubens, Hypoglossum hypoglossoides, Phyllophora crispa* and *Corallina officinalis*. The brown seaweed *Dictyota dichotoma* also occurs in these conditions, since it is tolerant of some sand scour. During the summer months small fast-growing kelp plants can arise in this biotope, although the mobility of the substratum prevents the kelp from forming a kelp forest. The faunal community consist of the anemone *Urticina felina*, the sponge *Halichondria panicea* and the ascidian *Dendrodoa grossularia*. More mobile fauna include the echinoderms *Asterias rubens* and *Echinus esculentus*, the top shell *Gibbula cineraria* and the crab *Cancer pagurus*.

A3.712: Anemones, including Corynactis viridis, crustose sponges and colonial ascidians on very exposed or wave surged vertical infralittoral rock [1]. Vertical very exposed and exposed bedrock gullies, tunnels and cave entrances subject to wave-surge dominated by sponge crusts such as *Clathrina coriacea, Myxilla incrustans, Pachymatisma johnstonia* and *Halichondria panicea* and anthozoans such as *Sagartia elegans, Urticina felina, Alcyonium digitatum, Corynactis viridis* and dwarf *Metridium senile* generally dominate the area; the anthozoans often appearing to protrude through the sponge layer. There may be dense aggregations of the hydroid *Tubularia indivisa,* the cup coral *Caryophyllia smithii* and the colonial ascidians *Botrylloides leachi* and *Polyclinum aurantium*. There may be a short crisiid turf, interspersed with *Scrupocellaria reptans*. Encrusting coralline algae may occur on well-illuminated rock faces. The echinoderms *Asterias rubens*, *Marthasterias glacialis*, *Echinus esculentus*, *Antedon bifida* and *Ophiothrix fragilis*, the topshell *Calliostoma zizphinum* and the calcareous tubeworm *Pomatoceros triqueter* may also be present on the rock face. The crabs *Cancer pagurus* and *Necora puber* may also be recorded. Due to the wave-surged nature and vertical orientation of these biotopes, kelps are rare and certainly never dominate.

A3.713: Crustose sponges and colonial ascidians withDendrodoa grossularia or barnacles on wave-surged infralittoral rock [1]. Vertical and overhanging, exposed to moderately exposed bedrock gullies, tunnels and cave entrances subject to wave surge, and dominated by the crustose sponges *Halichondria panicea*, *Myxilla incrustans*, *Clathrina coriacea*, *Leucosolenia botryoides*, *Esperiopsis fucorum* and *Grantia compressa.* There may also be dense aggregations of the anthozoan *Sagartia elegans,* dwarf *Metridium senile, Alcyonium digitatum,* and *Urticina felina,* and a dense covering of the barnacle *Balanus crenatus* on the bare rock face. Dense aggregations of the robust hydroid *Tubularia indivisa* may be recorded, growing through the sponge crust. Colonial ascidians such as *Polyclinum aurantium, Botryllus schlosseri, Botrylloides leachi, Aplidium nordmanni* and the solitary ascidian *Dendrodoa grossularia* may all be recorded. The echinoderms *Asterias rubens*, *Echinus esculentus*, *Henricia* sp., the crab *Cancer pagurus* and the calcareous tubeworm *Pomatoceros triqueter* may also be present on the rock face, along with encrusting coralline algae.

A3.714: Dendrodoa grossularia and Clathrina coriacea on wave-surged vertical infralittoral rock [1]. Vertical or overhanging infralittoral rock subject to considerable wave-surge, especially in the middle or back of caves but also in gullies and tunnels, and dominated by dense sheets of the ascidian *Dendrodoa grossularia*, together with variable quantities of the sponge *Clathrina coriacea*. At some sites *D. grossularia* forms continuous sheets, with few other species present. Other sponges such as *Esperiopsis fucorum*, *Pachymatisma johnstonia*, *Leucosolenia botryoides*, *Scypha ciliata* and *Halichondria panicea* regularly occur in this biotope, though generally at low abundance. Other ascidians, especially *Polyclinum aurantium*, *Diplosoma* spp. and other didemnids may also occur, though only *P. aurantium* is ever as abundant as *D. grossularia*. Being characteristically found in the middle or towards the backs of the caves mean that there is generally insufficient light to support any foliose seaweeds, although encrusting coralline algae are not uncommon. More scoured areas may also contain the anemone *Urticina felina*, whilst *Sagartia elegans* is often present in low numbers. Mobile fauna are often limited to the starfish *Asterias rubens* and *Henricia* spp., the brittlestar *Ophiopholis aculeata* and crabs *Cancer pagurus* and *Necora puber*. The barnacle *Balanus crenatus* can occur, usually in low densities.

A3.715: Crustose sponges on extremely wave-surged infralittoral cave or gully walls [1]. Walls, or massive boulders, in caves or gullies that are subject to severe wave-surge and characterised by extensive thin crusts of the sponge *Halichondria panicea* with smaller patches of other sponges such as *Esperiopsis fucorum* or *Clathrina coriacea*. Small turfs of robust hydroids, such as *Diphasia rosacea* and *Ventromma halecioides*, and patches of the barnacle *Balanus crenatus*, coralline crusts and tube-building spirorbid polychaetes may be present. The starfish *Henricia* spp., the brittlestar *Ophiopholis aculeata* and the crabs *Cancer pagurus* and *Necora puber* can be present. The anemones *Sagartia elegans*, *Urticina felina* and *Actinia equina* can be found in cracks and crevices or under boulders. The mussel *Mytilus edulis* may be present in low densities.

A3.716: Coralline crusts in surge gullies and scoured infralittoral rock [1]. Scoured rock in wave-surged caves, tunnels or gullies often looks rather bare, and may be characterised by a limited scour-tolerant fauna of *Balanus* *crenatus* and/or *Pomatoceros triqueter* with spirorbid polychaetes. In areas where sufficient light is available and scour is severe, encrusting coralline algae and non-calcareous crusts cover the rock surface, giving a pink appearance. This biotope most commonly occurs at the bottom of walls in caves and gullies, where abrasion by cobbles and stones is severe, especially during winter. In some gullies, extreme scouring and abrasion produces a narrow band of bare coralline algal crust at the very bottom of the walls, with a band of *P. triqueter* and/or *B. crenatus* immediately above. Other scour-tolerant species, such as encrusting bryozoans may also be common. Crevices and cracks in the rock provide a refuge for sponge crusts such as *Halichondria panicea* and occasional anemones *Urticina felina* and *Sagartia elegans*. More mobile fauna is usually restricted to the echinoderms *Asterias rubens* and *Echinus esculentus* as well as the crab *Cancer pagurus*. Two variants have been identified: Wave-surged bedrock with coralline crust, *B. crenatus* and *P. triqueter* and coralline crusts on mobile boulders in severely scoured caves.

***A3.717 (proposed new insertion/optional numbering): Pontic caves, overhangs and surge gullies** [3, 4]. Shady cave entrances and overhanging faces can be overgrown by the sciaphilous red seaweed *Phyllophora crispa.* The shade-tolerant brown alga *Zanardinia typus* may be found at cave and gulley entrances. Crustose corallines occur on well illuminated vertical and upper faces, especially on scoured rock. The most characteristic cave fauna consists of encrusting or cushion sponges (*Halichondria panicea, Dysidea fragilis, Haliclona implexa*). On vertical walls inside surge gullies, aggregations of the short turf-forming hydroid *Aglaophenia pluma* can proliferate, while in caves the colonies of *Obelia* sp. are more typical. Other representative fauna includes the anemone *Actinia equina* and the colonial ascidians *Botryllus schlosseri*. The spirorbid tubeworm *Janua pagenstecheri* may form dense or sparser population, depending on wave scour, on cobbles and stones that usually cover gully/cave floors. Mobile fauna is represented by endemic mysids *Hemimysis* sp., the shrimp *Palaemon elegans,* and the crabs *Pachygrapsus marmoratus* and *Eriphia verrucosa.*

Biotope Evaluation: Goods and Services

Apart from some crabs (i.e. *Cancer pagurus*, *Eriphia verrucosa*) and the lobsters (*Palinurus elephas, Homarus gammarus*) that can be taken from deep recesses under overhangs, few other species are likely to be subject to exploitation. The faunal assemblage is dominated by active suspension feeders that transfer pelagic phytoplanktonic primary production to secondary production, and together with other rocky shore habitats contributes for the nutrient cycling and water quality regulation in coastal environments. Rocky shores and their features caves, overhangs and gullies provide a range of cultural services including opportunities for recreation and tourism, enjoyment of natural heritage, aesthetic and spiritual experience, inspiration for art, scientific research and cognitive development.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☒	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐

Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Substratum loss due to direct destruction by human modifications of the coastline will result in loss of the associated community. The cryptic nature of these biotopes makes them less vulnerable to displacement and extraction, physical disturbance and abrasion from human activities. Generally, red algae and crustaceans have been shown to be particularly intolerant to various chemical and hydrocarbon contaminants. The existing information is insufficient for the majority of characteristic species to allow for a more detailed assessment.

Conservation and protection status

Submerged or partially submerged sea caves (habitat type 8330) and reefs (habitat type 1170) are listed under the EC/92/43 Habitats Directive.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen, KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough. Available at: www.jncc.gov.uk/MarineHabitatClassification

[2] Hiscock K (2008) Overhangs and caves. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom [cited 15/03/2010]. Available online at: http://www.marlin.ac.uk/habitatreproduction.php?habitatid=242&code=2004

[3] Vershinin A (2007) Life in the Black Sea. Maccentr, Moscow, pp192 (in Russian)

[4] Micu D, Zaharia T, Todorova V (2008) Natura 2000 habitat types from the Romanian Black Sea. In: Zaharia T, Micu D, Todorova V, Maximov V, Niţă V. The development of an indicative ecologically coherent network of marine protected areas in Romania, Romart Design Publishing, Constanta, pp 32

Infralittoral fouling seaweed communities

Compiled by Maria Salomidi

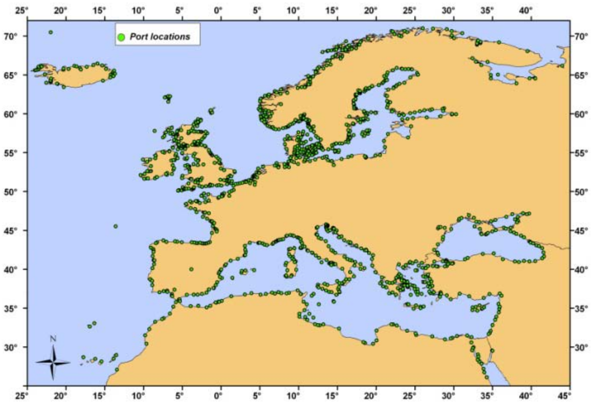
Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A3.72	Infralittoral fouling seaweed communities

Picture(s)

Cystoseira spp. communities thriving on a shallow 10yr old wreck in the Aegean Sea (Photo by Maria Salomidi)

Biotope Distribution

Scattered all around European waters and especially in the vicinity of urban and touristic centres along the coastal zone. Port locations map, indicating plausible sites of fouling communities.



Links to Available Maps

Not available

Biotope Requirements

Artificial substrata such as steel wrecks, concrete pilings, cable debris etc, moderately exposed to extremely sheltered from wave or tidal action, in fully saline conditions and at depths between 0-20 m.

Biotope Description

According to the official EUNIS description, this habitat type is characterised by a dense covering of filamentous and foliose algae on vertical as well as the upper faces of the substrata.

However, it is generally accepted that fouling communities' composition and structure can vary significantly depending on local food availability and water quality, with eutrophic conditions favouring heterotrophs rather than autotrophs, the latter generally abounding in rather nutrient-poor conditions [1, 2, 3, 4, 5]. Moreover, light availability (depth and inclination), substratum material and time of immersion have also been shown to affect the composition of marine fouling communities [1, 6].

Fouling communities may go through various succession stages, before reaching a rather stable state, eventually reflecting the several aforementioned environmental factors [6, 7]. Microbial mats, ephemeral algal species as well as various grazers (e.g. crabs and sea urchins) are typically among the first colonizers, while later stages may comprise:
Oligotrophic waters: Species of *Cystoseira*, *Jania*, *Acetabularia*, *Padina* and other foliose and articulated algae, often associated with barnacles, hydroids and various molluscs.
Mesotrophic waters: *Corallina* and *Ulva* communities, often co-dominated by extended *Mytilus* beds.
Eutrophic Waters: Various ascidians (e.g. *Pyura*, *Ciona*, *Botryllus*, Didemnidae), bryozoans (e.g. *Zoobothryon*, *Schizobrachiella*) and polychaete species (e.g. Serpulidae and Sabellidae), dominating over opportunistic filamentous and turf algae.

Biotope Evaluation: Goods and Services

Fouling communities have been traditionally considered a nuisance especially with regards toships, navigation buoys, cooling towers, pipelines, etc. However, fouling processes are driven by exactly the same biological forces that are commonly regarded as highly beneficiary in the case of mussel and other bivalve cultures. Moreover, fouling communities of ports, sewage outfalls or fish cultures can significantly contribute to the extraction of dissolved and particulate matter from the water column, and due to their high efficiency in mitigating eutrophication impacts and removing metabolic products and vibrios, they have been suggested as potential biofiltration / bioremediation factors [1, 8]. In the absence of suitable natural substrata, man-made structures, both purpose designed and those of opportunity (e.g. rope lines, mooring buoys, wrecks etc), may attract various benthic and pelagic species, thus enhancing local biodiversity and fisheries [9].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

In the last decades, various alien species have become prominent constituents of fouling communities [10, 11, 12, 13]. This fact, which may be partially attributed to the considerably low biological competition characterizing the bare or scarcely colonized immersed artificial structures [11, 13], could render artificial habitats along with their associated fouling communities as suitable early warning indicators for a wide range of biological invasions [14].

Conservation and protection status

To our knowledge, there have been no conservation or protection efforts related to fouling communities. Several researchers, however, have emphasized the need to consider limiting coastal artificial structures and destruction of natural hard-substrata as a means to hinder further spread and proliferation of alien species [10, 13].

References

[1] Cook EJ, Black KD, Sayer MDJ, Cromey CJ, Angel DL, Spanier E, Tsemel A, Katz T, Eden N, Karakassis I, Tsapakis M, Apostolaki ET, Malej A (2006) The influence of caged mariculture on the early development of sublittoral fouling communities: a pan-European study. ICES J Mar Scie 63: 637-649

[2] Bombace G (1989) Artificial reefs in the Mediterranean Sea. Bull Mar Scie 44: 1023-1032

[3] Badalamenti F, D'Anna G, Gristina M, Scalisi M, Tumbiolo L (1992) Remarks on a method to quantify the total biomass of a benthic community on artificial substrata. Rapport et Procés-Verbaux Commission Internationale pour l'Exploration Scientifique de la Mer Méditerraneée, 33: 377

[4] Karalis P, Antoniadou C, Chintiroglou CC (2003) Structure of the artificial hard substrate assemblages in ports in Thermaikos Gulf (North Aegean Sea). Ocean. Acta: 215-224.

[5] Canning-Clode J, Kaufmann M, Molis M, Wahl M, Lenz M (2008) Influence of disturbance and nutrient enrichment on early successional fouling communities in an oligotrophic marine system. Mar Ecol 29(1): 115-124

[6] Scheer BT (1945) The development of marine fouling communities. Biol Bull 89(1): 103-121

[7] Zardus JD, Nedved BT, Huang Y, Tran C, Hadfield MG (2008) Microbial biofilms facilitate adhesion in biofouling invertebrates. Biol Bull 214: 91-98

[8] Licciano M, Stabili L, Giangrande A (2005) Clearance rates of *Sabella spallanzanii* and *Branchiomma luctuosum* (Annelida: Polychaeta) on a pure culture of *Vibrio alginolyticus*. Wat Res 39 (18): 4375-4384

[9] Collins KJ, Jensen AC, Lockwood APM, Lockwood SJ (1994) Coastal Structures, Waste Materials and Fishery Enhancement. Bull Mar Scie 55(2-3): 1240-1250

[10] Tyrell MC, Byers JE (2007) Do artificial substrates favor nonindigenous fouling species over natives? J Exp Mar Biol Ecol 342(1): 54–60

[11] Shenkar N, Loya Y (2009) Non-indigenous ascidians along the Mediterranean coast of Israel. Mar Biodiv Rec 2: 1-7

[12] ICES (2007) Alien Species Alert: *Undaria pinnatifida* (wakame or Japanese kelp). ICES Cooperative Research Report No.283, pp 36

[13] Bulleri F, Airoldi L (2005) Artificial marine structures facilitate the spread of a non-indigenous green alga, *Codium fragile ssp. tomentosoides*, in the north Adriatic Sea. J Appl Ecol 42: 1063–1072

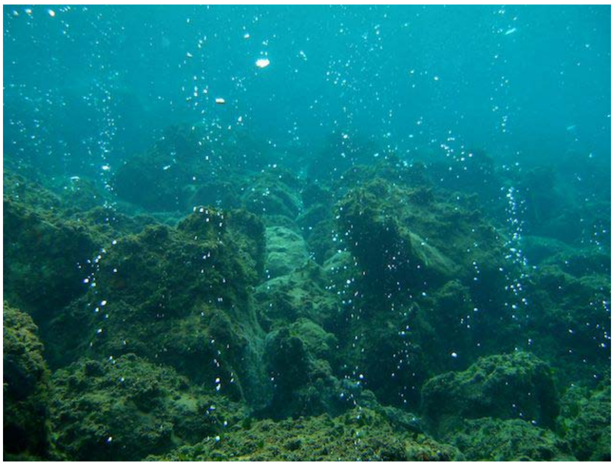
[14] Hulme PE (2006) Beyond control: wider implications for the management of biological invasions. J Appl Ecol 43: 835–847

Vents and seeps in infralittoral rock

Compiled by Maria Salomidi

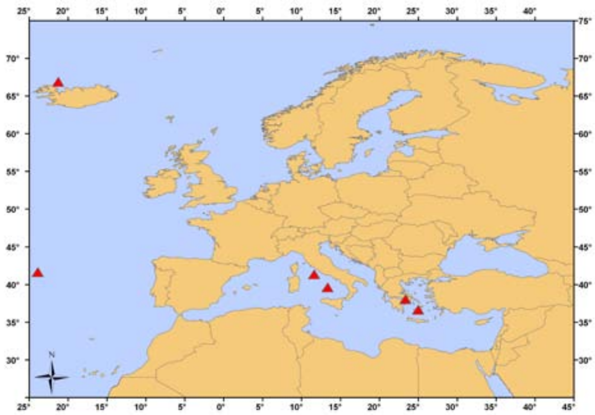
Classification	Code	Title
NATURA 2000	1180	Submarine structures made by leaking gases
EUNIS	A3.73	Vents and seeps in infralittoral rock

Picture(s)



Shallow hydrothermal vents at Methana, Greece (Photo by Maria Salomidi)

Biotope Distribution



Map depicting shallow vents and seeps in European waters

Links to Available Maps

http://www.jncc.gov.uk/ProtectedSites/SACselection/habitat.asp?FeatureIntCode=H1180

Biotope Requirements

Shallow infralittoral down to 10-20 m or more. On rocky and other natural hard-bottom substrata (boulders; non-mobile cobbles; etc). Environmental parameters may vary significantly, locally and/or seasonally, due and according to vent and/or seep emissions. Freshwater discharges may considerably reduce salinity and temperature down to estuarine levels, while temperatures at hydrothermal vent sites may well surpass 200 [1].

Biotope Description

This biotope includes all submarine emissions of various gases and fluids, in the infralittoral zone. Vents are usually hot springs of the gasohydrothermal type and mostly occur in volcanically active areas [1], while seepages may comprise mixed liquid and gaseous components (bubbling springs, groundwater or hydrocarbon wells) [2].

Associated biotopes at EUNIS Level 5:

A3.731: Freshwater seeps in infralittoral rock. These are submarine groundwater discharges mainly flowing to the sea through porous rocks and seeping up through the seabed. Such phenomena can be particularly common in the infralittoral zones of volcanic or karst terrains. [4]. In general, submarine freshwater seeps and their impacts on the coastal environment are very difficult to assess as they can be strongly influenced by bathymetry, micro-topology and hydrology, as well as the biogeochemical processes occurring at the freshwater / saltwaterinterface [5]. Consequently, biocommunities associated with this biotope can also be highly variable and they are naturally depended on both the quality and the quantity of the discharge. In this perspective, this biotope may well be associated with other EUNIS biotopes under the influence of freshwater discharges (i.e. A3.32: Kelp in variable salinity on low energy infralittoral rock; A3.34: Submerged fucoids, green or red seaweeds in low salinity infralittoral rock; A3.36: Faunal communities on variable or reduced salinity infralittoral rock).

A3.73: Oil seeps in infralittoral rock. Oil seeps (part of a greater phenomenon known as cold-vents) consist of hydrocarbons that may reach the sea floor in liquid (crude oil), gas, and solid (hydrate) forms [5]. Contrary to their soft-bottom counterparts, for which some substantial information exists [6], rocky micro- and macrobenthic communities under the influence of natural oil seepage have not been studied so far.

A3.733: Vents in infralittoral rock. Shallow water vents, though less spectacular than their deep-sea counterparts, may produce large volumes of free gas (gasohydrothermal vents) with temperatures of more than 100˚C and toxic chemicals such as heavy metals and H_2S [7]. Vents typically consist of mixtures of various gases (e.g. H_2S, H_2, CO, CH_4 and He), but CO_2 is reportedly by far the main component (up to 98%) [1]. Although mats of bacteria (sulphur- or iron-oxidisers and photosynthetic) as well as diatoms consist typical macroscopic evidence of hydrothermalism, they are mainly associated with soft sediments on the fringes of the venting [8, 9, 10]. Hard-bottom macrobenthic communities associated with shallow hydrothermal vents are still little investigated [3]. In most described cases, almost all typical macrobenthic taxa (hydroids, anthozoans, serpuloids, sponges and algae) were found well-represented in some shallow rocky vent sites (Milos isl., Aegean Sea; Panarea isl. and Ischia isl., Tyrrhenian Sea; Terceira and São Miguel, Azorean Archipelago) and no major differences directly related to the vent effect, or any vent-endemic macrobenthic species were identified [1, 8, 11, 12, 13, 14, 15, 16]. These findings led to the suggestion that the actual effect of hydrothermalism on the sessile epibenthos of shallow hard substrata is rather weak in comparison to the highly specialized deep-water vent communities [7, 8, 17]. More recent studies however brought up a new perspective by showing a clear shift from typical shallow rocky communities with abundant calcareous organisms to communities lacking scleractinian corals and significant reductions in sea urchin and coralline algal abundance, along gradients of normal pH (8.1–8.2) to lowered pH (mean 7.8–7.9, minimum 7.4–7.5) at some Mediterranean CO_2 vent sites [18].

Biotope Evaluation: Goods and Services

Offshore and onshore gas and oil seeps are important sources of greenhouse gas and photochemical pollutants, and they are estimated to be the second most important natural source ofatmospheric methane, after wetlands, both on global and European scale [19]. From an exploitation perspective, they are considered as indicators of petroleum or natural gas reservoirs [8] as well as sources of elements that can generate oxide, sulfide, and precious metal ore deposits [20]. Moreover, they often indicate the occurrence of a fault or a potential geo-hazard [19]. So far, the role of shallow venting on coastal ecosystem processes has not been sufficiently understood and evaluated [20]. Shallow-water hydrothermal vents, and especially those predominated by CO_2 emissions, have lately drawn much scientific attention as natural labs for testing the effects of ocean acidification and rising sea temperatures on shallow marine ecosystems [17]. Apart from providing insight into upcoming climatic changes, vent-sites are important biological sources of thermophile and hyperthermophile prokaryotes that show a great potential for biotechnological applications [1]. Though extremely difficult to gauge and assess, submarine groundwater discharge in coastal karst aquifers can be larger than river discharge, especially during low stream flow [21, 22]. Freshwater or low-salinity seepage in shallow coastal environments may induce changes in the morphology of substrata and provide particular habitats for fishery stocks [22]. Reclaiming freshwater seepage from the marine environment is still expensive and ecologically risky as intensive pumping may increase saltwater intrusion in coastal aquifers [22].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☐	☒
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

The elevated sea temperatures in and around hydrothermal vent sites have been suggested to favour thermophilic species, a fact that may render these biotopes particularly vulnerable to biological invasions [1, 8, 23, 24]. The quality of freshwater seeps is of great concern for coastal management, as groundwaters can easily become contaminated with sewage, fertilizers, pathogens, pesticides or industrial wastes, thus diffusing pollution to the marine environment [22].

Conservation and protection status

Shallow vents and seeps, particularly those of the gasohydrothermal type, though usually deprived of carbonate structures, are also regarded as “bubbling reefs” and are thus included in the Annex I of the EC/92/43 Habitats Directive under the code 1180 (*Submarine structures made by leaking gases*). To our knowledge however, there has been no concerted action to document these biotopes’ distribution and/or ensure their protection in European scale.

References

[1] Dando PR, Stuben D, Varnavas SP (1999) Hydrothermalism in the Mediterranean Sea, Prog Oceanogr 44: 333–367

[2] Etiope G (2009) Natural emissions of methane from geological seepage in Europe. Atmosph Environment, 43: 1430-1443

[3] UNESCO (2004) Submarine groundwater discharge-management implications, measurements and effects, Scientific Committee on Oceanic Research (SCOR) and Land-Ocean Interactions in the Coastal Zone (LOICZ). Series on groundwater No. 5, IOC Manuals and guides No. 44

[4] Krupa SL, Gefvert CJ (2005) Submarine Groundwater Discharge. In: Schwartz ML (ed) The Encyclopedia of Coastal Science, pp 915-922

[5] Aharon P (1994) Geology and biology of modern and ancient submarine hydrocarbon seeps and vents: an introduction. Geo-Mar Lett 14: 69-73

[6] National Research Council NRC (1985) Oil in the Sea: Inputs, Fates, and Effects, National Academy Press, Washington, DC pp 601

[7] De Biasi AM, Bianchi CN, Aliani S, Cocito S, Peirano A, Dando PR, Morri C (2004) Epibenthic communities in a

marine shallow area with hydrothermal vents (Milos Island, Aegean Sea), Chem Ecol 20(3): 89-105
[8] Sartoni G, De Biasi AM (1999) A survey of the marine algae of Milos Island, Greece. Cryptog Algol 20: 271–283
[9] Dando PR, Aliani S, Arab H, Bianchi CN, Brehmer M (2000) Hydrothermal studies in the Aegean Sea, Phys Chem Earth 25: 1–8
[10] Bianchi CN (2009) Priority habitats according to the SPA/BIO protocol (Barcelona Convention) present in Italy. Identification sheets. III. 2. 3. 7. Facies of hydrothermal vents with *Cyclope neritea* and nematodes. Biol Mar Medit, 16(1): 106-110
[11] Morri C, Bianchi CN (1999) Hydroids (Cnidaria: Hydrozoa) from the Aegean Sea, mostly epiphytic on algae. Cah Biolog Mar 40: 283–29
[12] Bianchi CN, Morri C (2000) Serpuloidea (Anellida Polychaeta) from Milos, an island in the Aegean Sea with submarine hydrothermalism. J Mar Biol Assoc UK 80: 259–269
[13] Morri C, Vafidis D, Peirano A, Chintiroglou CC, Bianchi CN (2000) Anthozoa from a subtidal hydrothermal area of Milos Island (Aegean Sea), with notes on the construction potential of the scleractinian coral *Madracis pharensis*. Ital J Zool 67: 319–325
[14] Pansini M, Morri C, Bianchi CN (2000) The sponge community of a subtidal area with hydrothermal vents: Milos Island, Aegean Sea. Estuar Coast Shelf S 51: 627–635
[15] Cardigos F, Colaço A Dando PR, Ávila SP, Sarradin P-M, Tempera F, Conceição P, Pascoal A, Santos RS (2005) Shallow water hydrothermal vent field fluids and communities of the D. João de Castro Seamount (Azores). Chem Geol 224: 153–168
[16] Ávila SP, Cardigos F, Santos RS (2007) Comparison of the community structure of the marine mollusc of the “Banco D. João de Castro” seamount (Azores, Portugal) with that of typical inshore habitats on the Azores archipelago. Helgol Mar Res 61: 43–53
[17] Tarasov VG, Gebruk AV, Mironov AN, Moskalev LI (2005) Deep-sea and shallow-water hydrothermal vent communities: Two different phenomena? Chem Geol 224 (1-3): 5-39
[18] Hall-Spencer JM, Rodolfo-Metalpa R, Martin S, Ransome E, Fine M, Turner SM, Rowley S, Tedesco D & Buia M-C. (2008) Volcanic carbon dioxide vents reveal ecosystem effects of ocean acidification. Nature 454: 96–99
[19] Etiope G (2009) Natural emissions of methane from geological seepage in Europe. Atmosph Environment, 43: 1430-1443 doi:10.1016/j.atmosenv.2008.03.014
[20] Prol-Ledesma RM, Dando PR, de Ronde CEJ (2005) Special issue on "shallow-water hydrothermal venting" Chem Geol 224(1-3): 1-4
[21] Moore W (1996) Large Ground-Water Inputs to Coastal Waters Revealed by 226Ra Enrichment, Nature (London), 380(575): 612–614
[22] UNESCO (2004) Submarine groundwater discharge—management implications, measurements and effects, Scientific Committee on Oceanic Research (SCOR) and Land-Ocean Interactions in the Coastal Zone (LOICZ). Series on groundwater No. 5, IOC Manuals and guides No. 44
[23] De Biasi AM, Aliani S (2003) Shallow water hydrothermal vents in the Mediterranean sea: stepping-stones for Lessepsian migration? Hydrobiol 502: 37-44
[24] Gambi MC, Barbieri F, Bianchi CN (2009) New record of the alien seagrass *Halophila stipulacea* (Hydrocharitaceae) in the western Mediterranean: a further clue to changing Mediterranean Sea biogeography. Mar Biod Rec 2: e84 doi: 10.1017/S175526720900058X

Mixed faunal turf communities on circalittoral rock

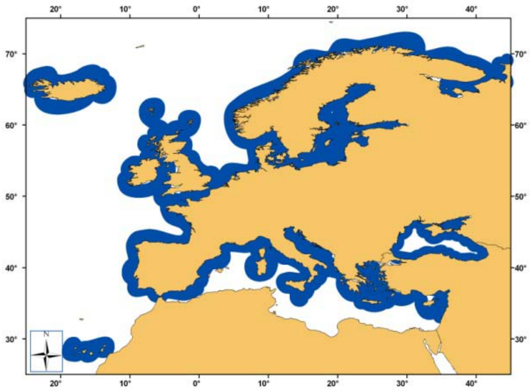
Compiled by Ibon Galparsoro, Marta Pascual and Ángel Borja

Classification	**Code**	**Title**
NATURA 2000	1170	Reefs
EUNIS	A4.13	Mixed faunal turf communities on circalittoral rock

Picture(s)

Not available

Biotope Distribution



Potential distribution map

Links to Available Maps

http://www.jncc.gov.uk/Marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002153
http://www.jncc.gov.uk/Marine/biotopes/biotope.aspx?biotope=JNCCMNCR00001957.
http://www.ices.dk/products/ newsletters/ices42.pdf

Biotope Requirements

This biotope occurs on fully saline, wave-exposed circalittoral bedrock and boulders, subject to tidal streams ranging from strong to moderately strong. The circalittoral zone can itself be split into two sub-zones; upper circalittoral (foliose red algae present but not dominant) and lower circalittoral (foliose red algae absent). The depth at which the circalittoral zone begins is directly dependent on the intensity of light reaching the seabed; in highly turbid conditions, the circalittoral zone may begin just below water level at mean low water springs (MLWS) [1].

A number of environmental factors influence the distribution of this biotope, often interacting so that individual effects are difficult to discriminate. Seawater temperature is the major factor controlling this biotope´s geographical distribution as there are cold water and warm water species and biotopes with restricted distributions. The depth range of this biotope is determined by the interaction of light availability, water turbidity and substratum slope. The upper limit occurs where the available light becomes insufficient for macroalgae to dominate the community, and light becomes less with greater depth, higher turbidity, and increasing slope. In caves or under overhangs, or in very turbid waters, this biotope may occur at depths of only few metres. In contrast, on gently sloping substrata in clear oceanic water the upper limit may be at 20 m or greater. The lower limit is set only by the availability of hard substratum. The factors exerting the main influence on the type of the community found locally for this type of biotope are amount of water movement, prevalence of scour, amount of suspended material, and reduction or variation of salinity - in that order of importance [2].

Biotope Description

Circalittoral rock is characterised by animal dominated communities of hard substrata (a departure from the algae dominated communities in the infralittoral zone) where most of the prominent species are sessile filter feeders, either fixed permanently in one place like barnacles or corals, or like anemones capable of only very limited movement, and live attached to the substratum. The character of the fauna varies enormously and is affected mainly by wave action, tidal stream strength, salinity, turbidity, the degree of scouring and rock topography. It is typical for the community not to be dominated by single species, as is common in shore and infralittoral habitats, but rather comprise a mosaic of species. This, coupled with the range of influencing factors,

makes circalittoral rock a difficult area to satisfactorily classify; particular care should therefore be taken in matching species and habitat data to the classification [1]. Mixed faunal turf communities are important, very diverse, and considerably aesthetic appealing biotopes [2].
This complex is characterised by its diverse range of hydroids (*Halecium halecinum*, *Nemertesia antennina* and *Nemertesia ramosa*), bryozoans (*Alcyonidium diaphanum*, *Flustra foliacea*, *Bugula flabellata* and *Bugula plumosa*) and sponges (*Scypha ciliata*, *Pachymatisma johnstonia*, *Cliona celata*, *Raspailia ramosa*, *Esperiopsis fucorum*, *Hemimycale columella* and *Dysidea fragilis*) forming an often dense, mixed faunal turf. Other species found within this complex are *Alcyonium digitatum*, *Urticina felina*, *Sagartia elegans*, *Actinothoe sphyrodeta*, *Caryophyllia smithii*, *Pomatoceros triqueter*, *Balanus crenatus*, *Cancer pagurus*, *Necora puber*, *Asterias rubens*, *Echinus esculentus* and *Clavelina lepadiformis* [1].

Associated Biotopes at EUNIS Level 5 and 6:
A4.131: Bryozoan turf and erect sponges on tide-swept circalittoral rock.
Associated sub-biotopes:
A4.1311: Eunicella verrucosa and Pentapora foliacea on wave-exposed circalittoral rock.
A4.1312: Mixed turf of bryozoans and erect sponges with Dysidea fragilis and Actinothoe sphyrodeta on tide-swept wave-exposed circalittoral rock.
A4.1313: Mixed turf of bryozoans and erect sponges with Sagartia elegans on tide-swept ciraclittoral rock.

A4.132: Corynactis viridis and a mixed turf of crisiids, Bugula, Scrupocellaria, and Cellaria on moderately tide-swept exposed circalittoral rock. No further description available.

A4.133: Mixed turf of hydroids and large ascidians with Swiftia pallida and Caryophyllia smithii on weakly tide-swept circalittoral rock. No further description available.

A4.134: Flustra foliacea and colonial ascidians on tide-swept moderately wave-exposed circalittoral rock.
Associated sub-biotopes:
A4.1341: Polyclinum aurantium and Flustra foliacea on sand-scoured tide-swept moderately wave-exposed circalittoral rock.
A4.1342: Flustra foliacea, small solitary and colonial ascidians on tide-swept circalittoral bedrock or boulders.
A4.1343: Flustra foliacea and colonial ascidians on tide-swept exposed circalittoral mixed substrata.

A4.135: Sparse sponges, Nemertesia spp., and Alcyonidium diaphanum on circalittoral mixed substrata. No further description available.

A4.136: Suberites spp. with a mixed turf of crisiids and Bugula spp. on heavily silted moderately wave-exposed shallow circalittoral rock. No further description available.

A4.137: Flustra foliacea and Haliclona oculata with a rich faunal turf on tide-swept circalittoral mixed substrata. No further description available.

A4.138: Molgula manhattensis with a hydroid and bryozoan turf on tide-swept moderately wave-exposed circalittoral rock. No further description available.

A4.139: Sponges and anemones on vertical circalittoral bedrock. No further description available.

Biotope Evaluation: Goods and Services

Mixed faunal turf communities are important, very diverse, and considerably aesthetic appealing habitats that enhance the maintenance of biodiversity. The majority of the organisms are filter feeders, depending on suspended material in the water column and providing important water quality regulation and nutrient cycling services [2]. Amongst others, sponges, bryozoans, hydroids, ascidians and sea-anemones, whose functional roles are of high importance, form these communities. The importance of sponges on substratum, sponge bentho-pelagic coupling, and sponge interactions and associations is described in [3], where their functional roles as nutrient cyclers (carbon, silicon, nitrogen, etc.), substratum stabilizers, predation protection providers, and primary production providers are enhanced. The bioremediation role in polluted seawaters of some sponge species, such as *Chondrilla nucula* and *Spongia officinalis var. adriatica*, has also been corroborated by some authors [4, 5]. Slow-growing complex three-dimensional biogenic structures created by hydroids, bryozoans and sponges, modify the flow of currents, consolidate sediments and provide a three-dimensional habitat to a multitude of associated species, including many commercially important species [6]. Furthermore, ascidians, hydrozoans and bryozoans also act as food source for many kinds of fish, crustaceans, and mollusks like nudibranchs.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☒	☐	☐
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Global warming may affect species with limited distributions. Natural fluctuations in abundance of grazers and predators could affect community balance, and need more study [2]. Organic based effluents such as sewage or intensive fish farming could certainly be a threat especially in enclosed gulfs or embayments, and any new or changed inputs of such type would need careful evaluation. The same considerations would apply to any other effluents originating from a point source, which might contain heavy metals, pesticides, PCBs, or other potential toxins. The effects of eutrophication will include reduced water transparency, affecting light transmission and algal growth, and the toxic effects and deoxygenation induced by algal blooms [2]. Commercial diving, recreational diving and recreational angling, when carried out at current levels following present codes of practice, pose little risk. However, in both cases the incidental damage from anchoring, and excessive concentrations of activity, are matters of possible concern [2]. Mobile fishing gears such as scallop dredges and rockhopper trawls are by far the greatest impact both directly through dislodging and flattening animals and indirectly by leaving the surrounding environment smothered with sediment. Strings of crab pots, anchor chains, fishing lines, netting and divers can also damage delicate epifauna, although the level of these impacts is much smaller.

Conservation and protection status

Communities of the circalittoral rock can be classified as *Reefs* (1170) under the EC 92/43 Habitats Directive.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough.

www.jncc.gov.uk/MarineHabitatClassification
[2] Hartnoll RG (1998) Volume VIII. Circalittoral faunal turf biotopes. Scottish Association of Marine Sciences (UK Marine SAC Project), Oban, Scotland, pp 109
[3] Bell JJ (2008) The functional roles of marine sponges. *Est Coast Shelf Scie* 79 (3): 341-353
[4] Milanese M, Chelossi E, Manconi R, Sarà A, Sidri M, Pronzato R (2003) The marine sponge *Chondrilla nucula* Schmidt, 1862 as an elective candidate for bioremediation in integrated aquaculture. *Biomol Engin* 20 (4-6): 363-368.
[5] Stabili L, Licciano M, Giangrande A, Longo C, Mercurio M, Marzano CN, Corriero G (2006) Filtering activity of *Spongia officinalis* var. *adriatica* (Schmidt) (Porifera, Demospongiae) on bacterioplankton: Implications for bioremediation of polluted seawater. *Wat Res* 40 (16): 3083-3090.
[6] Christiansen S (2009) Towards Good Environmental Status: A Network of Marine Protected Areas for the North Sea. Lutter, S (Ed.) WWF Germany, Frankfurt am Main.

Sabellaria reefs on circalittoral rock

Compiled by Marijn Rabaut

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A4.22	*Sabellaria* reefs on circalittoral rock

Picture

Not available

Biotope Distribution

Not available

Links to Available Maps

http://www.jncc.gov.uk/Marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002125

Biotope Requirements

This biotope is typically found encrusting the upper faces of wave-exposed and moderately wave-exposed circalittoral bedrock, boulders and cobbles subject to strong/moderately strong tidal streams in areas with high turbidity [1].

Biotope Description

Associated Biotope at EUNIS level 5:

A4.221: Sabellaria spinulosa encrusted circalittoral rock. The crusts formed by the sandy tubes of the polychaete worm *Sabellaria spinulosa* may even completely cover the rock, binding the substratum together to form a crust. A diverse fauna may be found attached to, and sometimes obscuring the crust, often reflecting the character of surrounding biotopes (*i.e.* rock). *Sabellaria spinulosa*, is the most common species being found subtidally [2]. A clear structuring function on the benthic species composition was suggested [2 and references therein], though no unique species have been found [3]. Bryozoans such as *Flustra foliacea*, *Pentapora foliacea* and *Alcyonidium diaphanum*, anemones such as *Urticina felina* and *Sagartia elegans*, the polychaete *Pomatoceros triqueter*, *Alcyonium digitatum*, the hydroid *Nemertesia antennina* and echinoderms such as *Asterias rubens* and *Crossaster papposus* may all be recorded within this biotope. There are two variants. The first contains significant cover of barnacles (*Balanus crenatus*) and bryozoans. The second has a dense turf of didemnid ascidians as well as scour-tolerant bryozoans such as *F. foliacea*, sponges such as *Tethya aurantium* and *Phorbas fictitius*, colonies of the serpulid worm *Salmacina dysteri* and patchy occurrences of the ascidians *Distomus variolosus*, *Polycarpa pomaria* and *Polycarpa scuba* [1].

Biotope Evaluation: Goods and Services

Marine biogenic structures that reach a few centimeters into the water column can have a profound effect on the structure and functioning of marine ecosystems. These systems are heavily used by a variety of taxa, including post-settlement juveniles of commercially important fish species [4]. The crusts formed by the sandy tubes of the polychaete worm *Sabellaria spinulosa* may even completely cover the underlying rock, increasing habitat complexity and supporting high diversities and richness of benthic epifauna [2].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒

Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

In general, anthropogenic influences can strongly modify the engineering community by removing autogenic ecosystem engineers through e.g. bottom trawling [5]. The phenomenon of ecosystem engineers in relation to fisheries activities is largely understudied ([6] and references therein), given the importance of structure (both abiotic and biotic) to fisheries productivity and the declines of so many species resulting from fishing pressure. The loss of habitat structure generally leads to lower abundance (biomass) and often to declines in species richness [7]. Therefore, the impact of fisheries on marine ecosystem engineers is considered as a potentially serious problem because engineering activity influences both biological diversity and ecosystem functioning. Holt *et al*. [2] review the impact of bottom fisheries on *Sabellaria spinulosa*. The disappearance of the species in some areas in the Wadden Sea has been suggested as a good indicator for fishing intensity. Large areas in the North Sea with *S. spinulosa* reefs have been reported to disappear due to fisheries activities and commercial shrimp fisheries are known to search for *S. spinulosa* upon which they trawl for shrimps ([2] and references therein). Vorberg [8] found in a one-off experimental disturbance with a shrimp beam trawl that in the short-run, the reef structure itself does not disappear as the natural growth and capacity for repair is such that they can rebuild destroyed parts of their dwellings within a few days. The author indicates, however, that trawling in the medium to long-term can have consequences for the integrity of the reefs in the event of intensive fishing. In addition to fishing activities, *Sabellaria* reefs would suffer, at least in the short term, severe direct damage by extensive aggregate dredging activities [2].

Conservation and protection status

Sabellaria reefs (either geogenic reef overgrown with *Sabellaria* spp. or biogenic reefs formed on sediments by tube building polychaetes such as *Sabellaria* spp. - EUNIS code A5.61) are included in NATURA-1170 habitat type (Habitats Directive Annex 1 habitat types of community interest, whose conservation requires the designation of special areas of conservation). *Sabellaria* reefs on circalittoral rock are rare and of high conservation value, and the Habitats Directive dictates the maintenance of a favourable conservation status.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The marine habitat classification for Britain and Ireland version 04.05. In: Joint Nature Conservation Committee Report, Peterborough, UK www.jncc.gov.uk/MarineHabitatClassification Accessed 15 March 2010

[2] Holt TJ, Rees EI, Hawkins SJ, Seed R (1998) Biogenic Reefs. An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project), Volume IX

[3] Hendrick VJ, Foster-Smith RL (2006) *Sabellaria spinulosa* reef: A scoring system for evaluating 'reefiness' in the context of the Habitats Directive. J Mar Biol Ass UK 86: 665-677

[4] Watling L, Norse EA (1998) Disturbance of the seabed by mobile fishing gear: A comparison to forest clearcutting. Cons Biol 12: 1180-1197

[5] Bouma T, Olenin S, Reise K, Ysebaert T (2009) Ecosystem engineering and biodiversity in coastal sediments: Posing hypotheses. Helgol Mar Res 63: 95-106
[6] Coleman FC, Williams SL (2002) Overexploiting marine ecosystem engineers: Potential consequences for biodiversity. Trends Ecol Evol 17: 40-44
[7] Airoldi L, Balata D, Beck MW (2008) The Gray Zone: Relationships between habitat loss and marine diversity and their applications in conservation. J Exp Mar Biol Ecol 366: 8-15. doi: 10.1016/j.jembe.2008.07.034
[8] Vorberg R (2000) Effects of shrimp fisheries on reefs of *Sabellaria spinulosa* (Polychaeta). ICES J Mar Sci 57: 1416-1420

Communities on soft circalittoral rock

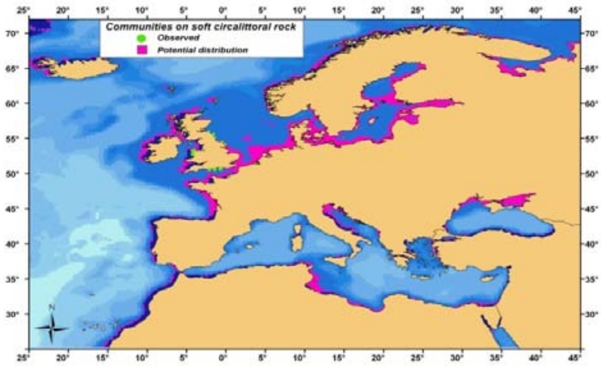
Compiled by Ulrike Braeckman and Marijn Rabaut

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A4.23	Communities on soft circalittoral rock

Pictures

Not available

Biotope Distribution



Observed and potential distribution in European waters.

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002126
http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002162

Biotope Requirements

Circalittoral rock communities occur on bedrock in highly turbid, moderately wave-exposed areas with tidal streams of 1-3 knots, within a depth range of 0-20 m. In highly turbid areas, these communities can also occur within the (infra)littoral zone [1].

Biotope Description

This complex is dominated by the piddock *Pholas dactylus*. Other species typical of this complex include the polychaete *Polydora* and *Bispira volutacornis*, the sponges *Cliona celata* and *Suberites ficus*, the bryozoan *Flustra foliacea*, *Alcyonium digitatum*, the starfish *Asterias rubens*, the mussel *Mytilus edulis* and the crab *Necora puber* and *Cancer pagurus*. Foliose red algae may also be present [1]. A similar complex is dominated by the paddock *Barnea parva* and other boring bivalves as *Gastrochaena dubia*, *Kellia suborbicularis* and *Hiatella* spp. It hosts similar epibionts like *Suberites ficus*, *Flustra foliacea*, *Alcyonium digitatum* and Bryozoans hosting mobile fauna like nudibranchs and decapods [2].

Biotope Evaluation: Goods and Services

These biotopes are dominated by the piddock *Pholas dactylus*, a marine, rock-boring, bivalve mollusc, characterised by its bioluminescence [3] and/or the tube-building polychaetes *Polydora* spp. and *Bispira volutacornis*. A similar complex is dominated by the paddock *Barnea parva* and other boring bivalves. Polychaete tubes exert profound effects on near-bed flow, which above a certain threshold abundance lead to sediment stabilization where passive deposition of larvae or juveniles is enhanced [4, 5]. Piddock burrows increase habitat complexity and provide a variety of microhabitats for other species, thereby increasing local assemblage diversity [6]. Where abundant, pholad borings, which are found in both vertical and horizontal bedrock, can severely compromise the structural stability of the shore, and can result in increased rates of coastal erosion [7, 8]. It is estimated that an individual *P. dactylus* could remove 10.1 cm^3 of substratum over a maximum period of 12 years [6]. Soft rock communities have a nursery function and act as a refuge [2]. *P. dactylus* has been extensively fished for human consumption and to be used as fishing bait [3].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Pholas dactylus was once prevalent across the entire Mediterranean and on the Atlantic coast of Europe, but they have disappeared from most sites due to human collection for food and bait and as a result of pollution [3]. Various pholad species are still eaten today in parts of Europe and Asia and there has been recent interest in their mariculture [9, 10, 11]. Epibenthos from soft rock communities is affected by fisheries [2].

Conservation and protection status

Owing to the habitat structuring characteristics of the dominant species in this biotope type, the biotope deserves special attention in conservation policy. Although the species associated with this biotope are not mentioned in the interpretation manual of the Habitats Directive, soft rock habitats can be classified under the definition of NATURA 1170 habitat type "reefs". This biotope qualifies for the OSPAR (Oslo-Paris Convention) criteria for the identification and selection of MPA's because of its unique and threatened species [11]. *Pholas dactylus* is under strict protection by the Bern Convention (Annex II) and the Protocol for Specially Protected Areas and Biological Diversity in the Mediterranean of the Barcelona Convention (Annex II).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The marine habitat classification for Britain and Ireland version 04.05. In: Joint Nature Conservation Committee Report, Peterborough, UK www.jncc.gov.uk/MarineHabitatClassification (Accessed 15 March 2010)

[2] Houziaux JS, kerckhof F, Degrendele K, Roche M, Norro A (2008) The Hinder Banks: yet an important region for the Belgian marine biodiversity. Belgian Scien Pol, Brussels

[3] Katsanevakis S, Lefkaditou E, Galinou-Mitsoudi S, Koutsoubas D, Zenetos A (2008) Molluscan species of minor commercial interest in Hellenic seas: distribution, exploitation and conservation status. *Medit Mar Scie* 9 (1): 77-118

[4] Eckman JE (1983) Hydrodynamic processes affecting benthic recruitment. Limnol Oceanogr 28: 241-257

[5] Friedrichs M, Graf G, Springer B (2000) Skimming flow induced over a simulated polychaete tube lawn at low population densities. Mar Ecol Prog Ser 192: 219-228

[6] Pinn EH, Thompson RC, Hawkins SJ (2008) Piddocks (Mollusca: Bivalvia: Pholadidae) increase topographical complexity and species diversity in the intertidal. Mar Ecol Prog Ser 355: 173-182

[8] Trudgill ST, Crabtree RW (1987) Bioerosion of intertidal limestone, Co. Clare, Eire-2: *Hiatella arctica*. *Mar Geol* 72: 99-109

[9] Marasigan ET, Laureta LV (2001) Broodstock maintenance and early gonadal maturation of *Pholas orientalis* (Bivalvia: Pholadidae). J Shellfish Res 20: 1095-1100

[10] Bombace G, Fabi G, Fiorentini L (2000) Artificial Reefs in the Adriatic Sea. In: Jensen AC, Collins KJ, Lockwood APM (eds) Artificial reefs in European seas. Kluwer, London, pp 31-61

[11] Haelters J, Kerckhof F, Houziaux JS (2007) The designation of marine protected areas in the Belgian part of the North Sea: a possible implementation of OSPAR Recommendation 2003/3 in Belgium. Koninklijk Belgisch Instituut voor Natuurwetenschappen - Beheerseenheid Mathematisch Model Noordzee, Brussels

Mussel beds on circalittoral rock

Compiled by Marijn Rabaut

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A4.24	Mussel beds on circalittoral rock

Picture

Not available

Biotope Distribution

Not available

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002127

Biotope Requirements

This biotope occurs on moderately wave-exposed upper circalittoral bedrock subject to strong or moderately strong tidal streams [1].

Biotope Description

This complex is characterised by dense aggregations of the mussels *Mytilus edulis* or *Musculus discors* carpeting the underlying substrata [1]. *Mytilus edulis* is widespread and common in north-west Europe where it is found from the middle shore to the shallow sublittoral. It is attached by byssus threads to stones, rocks, and piers. *Musculus discors* is widely distributed in north-west Europe and is commonly found in Britain on the middle shore and below and into the shallow sublittoral among rocks, shells, and seaweed, especially *Corallina officinalis* [2]. Seafloor topographic complexity is ecologically important because it provides habitat structure and alters boundary-layer flow over the bottom [3]. Sponges that may be recorded in this complex are *Scypha ciliata*, *Tethya aurantium*, *Pachymatisma johnstonia*, *Dysidea fragilis* and *Cliona celata*. A sparse hydroid/bryozoan turf composed primarily of *Nemertesia antennina*, *Alcyonidium diaphanum* and *Flustra foliacea* is often recorded. Anemones present are *Urticina felina* and *Sagartia elegans*. Other species recorded are the crabs *Cancer pagurus*, *Carcinus maenas* and *Necora puber*, the starfish *Crossaster papposus* and *Asterias rubens*, and *Alcyonium digitatum* and in this upper circalittoral complex, algae species such as *Dictyota dichotoma*, *Cryptopleura ramosa* and *Plocamium cartilagineum*.

Biotope Evaluation: Goods and Services

There are mussel fisheries at a number of localities and mussels are often farmed: banks of small overcrowded mussels are moved to more favorable areas where growth is rapid. In many traditional mussel culture areas, new functions have developed, such as recreation and nature conservation, and therefore extension of mussel culture is now also space limited. Expansion of mussel culture in Europe takes place in areas like Spain, Scottish fjords, Ireland and Greece, and is planned in Norway. Further development of sustainable mussel culture in Europe has different requirements for traditional and for new areas [4]. Mussel beds on circalittoral rock support increased biodiversity and high abundances as they provide a structured habitat of increased complexity suitable for many benthic species. Mussels constitute an important food source for many species, including marine mammals, birds, crustaceans, and fish. Mussel beds may alter water flow, which can influence the recruitment of macrofauna including the settlement of larvae as well as redistribution of settled individuals [3]. Mussel beds induce a significant uptake of total suspended sediments, chlorophyll a, total organic carbon, nitrites and nitrates while there is a significant release of ammonium and orthophosphate [5]. The potential primary production induced by the nutrient release of the mussel bed is higher than the uptake of phytoplankton by the mussel bed. It is also probable that mussels extract nitrogen from particulate organic material other than phytoplankton. While mussels strongly reduce phytoplankton biomass, mussel beds also have the potential to significantly promote primary production [6].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☒	☐	☐
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Mussel beds have declined in European waters, mainly due to overexploitation [7]. The probable role of marine pollution has also been stressed [8].

Conservation and protection status

It is not only necessary to value the function of ecosystem engineers in their environment but also to recognize the consequences of their anthropogenically induced degradation. Therefore, ecosystem engineers merit increased scientific and conservation emphasis, because of the fundamental role that they play in shaping habitat and the dependent communities from microbes to predators [9]. While traditional conservation efforts are focusing on charismatic species, the species that are the most critical in retaining community and ecosystem integrity and function are the ecosystem engineers that provide stress amelioration and associational defences, and these should be the primary target of modern conservation efforts [10]. Within the Habitats Directive, this biotope can be protected under the habitat type 1170. However, the consolidated compact substratum for this biotope is formed by rock rather than by the mussels; it concerns a geogenic reef overgrown with dense mussel aggregations. This is different from biogenic reefs formed by mussel aggregations on soft sedimented areas (see 'sublittoral mussel beds on sediment'; EUNIS code A5.62).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The marine habitat classification for Britain and Ireland version 04.05. In: Joint Nature Conservation Committee Report, Peterborough, UK www.jncc.gov.uk/MarineHabitatClassification (Accessed 15 March 2010)
[2] Fish JD, Fish S (1989) A student's guide to the seashore. Cambridge Univ Pr, Cambridge
[3] Commito JA, Rusignuolo BR (2000) Structural complexity in mussel beds: the fractal geometry of surface topography. J Exp Mar Biol Ecol 255: 133-152
[4] Smaal AC (2002) European mussel cultivation along the Atlantic coast: production status, problems and perspectives. Hydrobiol 484: 89-98
[5] Dame RF, Dankers N (1988) Uptake and release of materials by a Wadden sea mussel bed. Exp Mar Biol Ecol 118: 207-216
[6] Asmus RM, Asmus H (1991) Mussel beds: limiting or promoting phytoplankton? J Exp Mar Biol Ecol 148: 215-

232
[7] Dankers N, Brinkman AG, Meijboom A, Dijkman E (2001) Recovery of intertidal mussel beds in the Waddensea: use of habitat maps in the management of the fishery. *Hydrobiol* 465: 21-30.
[8] Herlyn M, Millat G (2000) Decline of the intertidal blue mussel (*Mytilus edulis*) stock at the coast of Lower Saxony (Waddensea) and influence of mussel fishery on the development of young mussel beds. *Hydrobiol* 426: 203-210.
[9] Coleman FC, Williams SL (2002) Overexploiting marine ecosystem engineers: Potential consequences for biodiversity. Trends Ecol Evol 17: 40-44
[10] Crain CM, Bertness MD (2006) Ecosystem engineering across environmental gradients: Implications for conservation and management. Biosci 56: 211-218

Mediterranean coralligenous communities moderately exposed to hydrodynamic action

Compiled by Maria Salomidi

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A4.26	Mediterranean coralligenous communities moderately exposed to hydrodynamic action

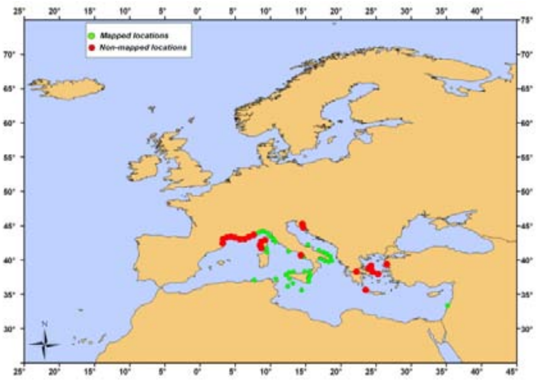
Picture(s)

Coralligenous assemblages with facies of the gorgonian *Eunicella cavolinii*, Korinthiakos Gulf, Greece (Photo by Yiannis Issaris)

Coralligenous assemblages with facies of the gorgonian *Paramuricea clavata*, Medes isl., Spain (Photo by Yiannis Issaris)

Biotope Distribution

Coralligenous buildups are common all around the Mediterranean coasts, with the possible exception of those of Lebanon and Israel [1].



Links to Available Maps

Not available

Biotope Requirements

This biotope is present in the Mediterranean on hard rocky and/or biogenic horizontal substrata formed by coralligenous formations developed within sedimentary beds that are well supplied by currents up to 100 metres in depth or more, in clear waters with moderate hydrodynamic action [2]. The upper limit of these communities may occur as shallow as 10-15 m, but deeper depths are much more typical (20-30 m for the western, and 40-50 m for the eastern Mediterranean basin) [3]. Light is very important for the development of this biotope, as its main builders are macroalgae which need sufficient, yet relatively low levels of irradiance to grow (0.05% - 3% of the surface irradiance according to some authors) [3, 4]. Although most coralligenous species are generally considered as stenotherms, their communities may well withstand the normal Mediterranean seasonal range of temperatures (10-23°C) [3].

Biotope Description

The Mediterranean coralligenous communities are very complex in structure and, in fact, consist of several subsets of communities i.e. those dominated by living algae, suspension feeders, borers, and, at places, even soft-bottom fauna [3]. Algae usually dominate in horizontal to sub-horizontal surfaces, while animal assemblages can greatly differ according to light levels, current intensity, sedimentation rates and spatial distribution; facies of gorgonians usually develop in relatively eutrophic areas, with rather constant and low water temperatures, but are almost completely absent in the more oligotrophic or low-current areas with higher or seasonally variable temperature, where instead sponges, bryozoans and/or ascidians take dominance [5]. Due to the low hydrodynamics and strong sedimentation that characterize these latter coralligenous sub-biotopes, however, these are separately classified under the EUNIS A4.32 (Mediterranean coralligenous communities sheltered from hydrodynamic action).

Associated Biotopes at EUNIS Level 5 [2]:

A4.261: Association with Cystoseira zosteroides. This association is characterised by the high abundance of the brown alga *Cystoseira zosteroides*. The association can include in its higher levels both sciaphilous and photophilous species such as the brown algae *Phyllariopsis brevipes*, *Arthrocladia villosa*, and others.

A4.262: Association with Cystoseira usneoides. This association characterised by the brown alga *Cystoseira usneoides* is present in relatively deep rocky areas crossed by currents.

A4.263: Association with Cystoseira dubia. This association characterised by the brown alga *Cystoseira dubia* occurs on hard substrata subject to weak hydrodynamics and relatively strong sedimentation.

A4.264: Association with Cystoseira corniculata. This association characterised by the brown alga *Cystoseira corniculata* occurs on hard substrata in the circalittoral zone.

A4.265: Association with Sargassum spp. This association characterised by the abundance of the brown algae *Sargassum* spp. occurs on hard substrata, simultaneously relatively deep and well-lit, in oligotrophic conditions.

A4.266: Association with Mesophyllum lichenoides. This association characterised by the red alga *Mesophyllum lichenoides* occurs on hard substrata with strong deep currents.

A4.267: Algal bioconcretion with Lithophyllum frondosum and Halimeda tuna. This association characterised by the red encrusting alga *Lithophyllum strictaeforme* (*Lithophyllum frondosum*) and the green alga *Halimeda tuna* is present on coralligenous horizontal formations developing within sedimentary beds affected by sea bottom currents.

A4.268: Association with Laminaria ochroleuca. This association characterised by the brown alga *Laminaria ochroleuca* occurs on hard or detritic substrata composed by sparse rocks located at 30 - 100 metres depth in areas affected by strong currents and the Atlantic influx (e.g. Strait of Messina, Sea of Alboran, Algerian coasts).

A4.269: Facies with Eunicella cavolinii. This facies is characterised by the high density of colonies of the gorgonian (sea-fan) *Eunicella cavolinii*.

A4.26A: Facies with Eunicella singularis. This facies is characterised by the high density of colonies of the gorgonian (sea-fan) *Eunicella singularis*.

A4.26B: Facies with Paramuricea clavata. This facies is characterised by the high density of colonies of the gorgonian (red sea-fan) *Paramuricea clavata*.

A4.26C: Facies with Parazoanthus axinellae. This facies is characterised by the high density of the cnidarian (sea anemone) *Parazoanthus axinellae*.

A4.26D: Coralligenous platforms. These are coralligenous horizontal formations developing within sedimentary beds subject to currents, at up to at least 100 metres depth in clear waters. These formations are not usually built on rock substrata but result from the active development of constructor organisms (e.g. calcified algae, hard-skeleton invertebrates) from scattered elements on loose beds, shells, stones, and graves. This biotope may share certain common characteristics with any of the above described associations/facies as well as the EUNIS biotope A5.51 (Maërl Beds).

Biotope Evaluation: Goods and Services

Coralligenous assemblages are considered the most important hot-spots of species diversity in the Mediterranean, together with *Posidonia oceanica* meadows [5]. According to some recent estimates, the coralligenous may host about 1666 species, but this number is thought to be highly underestimated due to the lack of extensive studies [6]. Many endangered species are known to live, feed or reproduce in these biotopes, among which the precious red coral *Corallium rubrum*, and various species of sharks (*Scyliorhinus stellaris, Mustelus asterias, Mustelus mustelus, Squalus acanthias* and *Squalus blainvillei*) [3 and references therein]. Some of the most common groups of species such as Porifera, Bryozoa and Tunicata which are known to thrive in the Mediterranean coralligenous communities have been shown to contain some of the most bioactive chemicals, providing, thus, useful insight to pharmaceutical research [7]. Moreover, the great variety and abundance of highly productive calcareous organisms render these biotopes the most important carbon sinks in the Mediterranean circalittoral zone [3]. Coralligenous seascapes, and particularly the ones with spectacular gorgonian facies, are widely renowned for their high aesthetic value, being amongst the most preferred diving spots worldwide.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Wastewater dumping, as well as any activities resulting in an increase of water turbidity and sedimentation are known to pose a severe threat to this biotope [5, 6]. Because they contain many sessile, long-lived organisms with slow growth dynamics and fragile skeletons, coralligenous communities are extremely prone to mechanical disturbance induced by trawling, fishing nets, anchoring and uncontrolled scuba-diving activities [5, 6, 8]. In the last decade, several key-species of the Mediterranean coralligenous suffered dramatic mass mortalities which were attributed to some unusually high summer temperatures, possibly related to global warming [3, 9, 10, 11]. Currently, three algal invasive species (*Womersleyella setacea, Caulerpa racemosa v. cylindracea* and *Caulerpa taxifolia*) are threatening coralligenous communities in the Western Mediterranean, by forming dense carpets, increasing sedimentation, and smothering indigenous populations [5]. The introduced *Asparagopsis taxiformis* and *Lophocladia lallemandii* are also becoming increasingly abundant in the Balearic Islands [3]. Although poorly studied, coralligenous banks of the Eastern Mediterranean basin seem also quite prone to the invasion of the green alga *Caulerpa racemosa var. cylindracea,* and the brown alga *Stypopodium schimperi* [e.g. 12, 13].

Conservation and protection status

This biotope is included in the NATURA 2000 Habitat Type 1170 (Reefs). This bulk category, however, is highly problematic for management purposes, as it comprises a large variety of natural habitats, e.g. *Biocoenosis of the upper mediolittoral rock, Biocoenosis of the lower mediolittoral rock, Biocoenosis of infralittoral algae, Coralligenous biocoenosis, Biocoenosis of deep sea corals*, etc. [14], which can differ significantly in their biological and ecological aspects. During the last decade, there has been increased awareness and concern from the European scientific community, asserting the immediate inclusion of Mediterranean coralligenous biotopes as priority natural habitat types in the EU Habitats Directive (92/43/EEC) as a means for the European countries to enable surveillance, develop management and protection plans, and ensure conservation of these valuable ecosystems [5].

References

[1] Laborel J (1987) Marine biogenic constructions in the Mediterranean. Scientific Reports of Port-Cros National Park, 13: 97-126

[2] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010).

[3] Ballesteros E (2003) The coralligenous in the Mediterranean Sea: Definition of the coralligenous assemblage inthe Mediterranean, its main builders, its richness and key role in benthic ecology as well as its threats. Project for the preparation of a Strategic Action Plan for the Conservation of the Biodiversity in the Mediterranean Region (SAP BIO). UNEP-MAP-RAC/SPA: pp 87

[4] Peres JM, Picard J (1964) Nouveau manuel de bionomie de la mer Méditerranée. Recl Trav Stn Mar Endoume 31: 5-137

[5] UNEP (2007) Draft Action Plan on Protecting the Coralligenous and other Calcareous Bio-Concretions in the Mediterranean. Report of the SPA/RAC Focal Points meeting. Palermo, Italy, 6-9 June 2007. UNEP (DEPI)/ MED WG.308/14 pp18

[6] Ballesteros E (2006) Mediterranean coralligenous assemblages: a synthesis of present knowledge. Oceanogr Mar Biol Ann Rev44: 123-195

[7] Uriz MJ, Martin D, Turon X, Ballesteros E, Hughes R, Acebal C (1991) An approach to the ecological significance of chemically mediated bioactivity in Mediterranean benthic communities. Mar Ecol Prog Ser 70: 175-188

[8] Garrabou J, Sala E, Arcas A, Zabala M (1998) The impact of diving on rocky sublittoral communities: a case study of a bryozoan population. Conserv Biol 12: 302- 312

[9] Romano JC, Bensoussan N, Younes WAN, Arlhac D (2000) Anomalies thermiques dans les eaux du golfe de Marseille durant l'été 1999. Une explication partielle de la mortalité d'invertébrés fixés. C R Acad Sci Paris, III 323: 415-427

[10] Perez T, Garrabou J, Sartoretto S, Harmelin JG, Francour P, Vacelet J (2000) Mortalité massive d'invertébrés marins: un événement sans précédent en Méditerranée nord-occidentale - Mass mortality of marine invertebrates: an unprecedented event in the NW Mediterranean. CR Acad Sci Paris, III 323: 853-865

[11] Cerrano C, Bavestrello G, Bianchi CN, Cattaneo-Vietti R, Bava S, Morganti C, Morri C, Picco P, Sara G, Schiaparelli S, Siccardi A, Sponga F (2000) A Catastrophic Mass-mortality Episode of Gorgonians and Other Organisms in the Ligurian Sea (North-western Mediterranean), Summer 1999. Ecol Lett 3: 284-293

[12] Bitar G, Harmelin JG, Verlaque M, Zibrowius H (2000) Sur la flore marine benthique supposée lessepsienne de la cote libanaise. Cas particulier de *Stypopodium schimperi*. *Mednature* 1: 97-100

[13] Bardamaskos A, Tsiamis K, Panayotidis P, Megalofonou P (2008) New records and range expansion of alien fishes and macroalgae in Greek waters (SE Ionian Sea), *JMBA2 Biod Rec* 6361

[14] Bellan-Santini D, Bellan G, Bitar G, Harmelin JG, Pergent (eds) (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. UNEP-MAP RAC/SPA Tunis pp 217

**Pontic Phyllophora crispa beds on circalittoral bedrock and boulders*

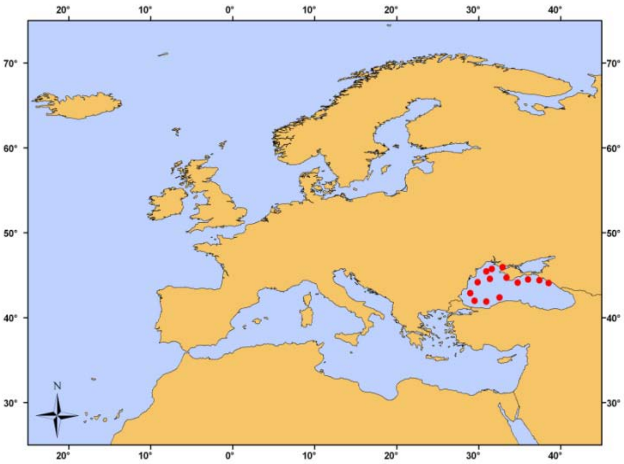
Compiled by Valentina Todorova

Classification	**Code**	**Title**
NATURA 2000	1170	Reefs
EUNIS	*A4.28	*Pontic *Phyllophora crispa* beds on circalittoral bedrock and boulders

Picture(s)

Not available

Biotope Distribution



Distribution of *Phyllophora crispa* beds in the Black Sea

Links to Available Maps

http://www.grid.unep.ch/bsein/redbook/txt/phyllo-n.htm

Biotope Requirements

Upper circalittoral bedrock or large boulders in the Black Sea, calm waters below the depth of wave action, very clear water but also deep enoughto provide the dim light preferred by the key structuring species *Phyllophora crispa*.

Biotope Description

This biotope is characterized by the predominance of the sciaphilous perennial red seaweed *Phyllophora crispa* (synonym: *P. nervosa*), growing in dense thickets (up to 80 % coverage) on rocky plains and large stone blocks at depths 15 - 25 m, below the infralittoral zone of the photophylous green, red and brown seaweeds [1, 2, 3, 4, 5]. The red, erect fronds form tuft up to 50 cm in height, attaining biomass of up to 4 $kg.m^{-2}$ [1]. The shape of the cartilaginous fronds with undulated margins is an adaptation against smothering - the weakest current is able to bring these fronds into movement thus shaking off detritus. *Phyllophora* beds are distinguished for supporting a diverse and productive community of marine life. Fronds are frequently encrusted with the spiral tube worm *Janua pagenstecheri*. Growths of *Mytilus galloprovicialis* extend from the infralittoral zone to this biotope and below. The tubeworm *Serpula vermicularis* occurs attached amongst mussel shells. Colourful sponges (*Halichondria panicea, Dysidea fragilis, Mycale syrinx*), hydroids (*Aglaophenia pluma*) and colonial ascidians (*Botryllus schlosseri*) are common. *Eriphia verrucosa* and *Pilumnus hirtellus* are the deepest dwelling crabs in the Black Sea and characteristic of this biotope. Typical fish fauna includes some rare fishes such as *Sciaena umbra, Umbrina cirrosa, Diplodus puntazzo, Ctenolabrus rupestris, Aphia minuta,* as well as abundant *Scorpaena porcus. Phyllophora crispa* is mentioned as an element of the sciaphilous algal communities of the Mediterranean [6] and occurs on all coasts around the British Isles [7]. However, nowhere else does it form mono-dominant growths such as *Phyllophora* meadows in the Black Sea.

Biotope Evaluation: Goods and Services

Phyllophora beds supply benthic primary production and oxygenation of waters in the circalittoral rock zone and provide reproduction, nursery and feeding grounds for diverse invertebrate and fish fauna. *Phyllophora crispa* can be commercially exploited as raw material for the production of agar [8] and iodine-containing compounds [9]. Potential for cultivation exists [10].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Phyllophora crispa is known to be particularly sensitive to shading by increased phytoplankton due to eutrophication [4, 11, 12]. Decreased depth of light penetration causes sharp decline in *Phyllophora* mats and loss of the associated community. Displacement from physical disturbance is not detrimental since *Phyllophora crispa* is able to grow and proliferate detached in the water column. It may form dense pelagic accumulations maintained by circular currents in the Black Sea. However extraction may cause major decline not only in the target species but in the associated fauna as well, posing threat to some rare species [13].

Conservation and protection status

As a result of the anthropogenic eutrophication in the Black Sea the depth range of the attached *Phyllophora crispa* has decreased by at least 10 m with the lower boundary shifted from 30 m in the 1970s to 20 m at the present, the coverage has diminished from 50-80% to 15-20% and the biomass has dropped from 1.5 - 4 kg m^{-2} to 0.3 - 0.5 kg m^{-2} along the Caucasus and Crimean coasts [12 and references therein]. One can now observe only rare small beds but still some have survived [5] and call for urgent management actions aimed at their conservation and restoration. In 1996 extraction of *Phyllophora* was forbidden in Ukraine due to stock depletion and significant by-catch of species listed in the Red Book [13]. *Phyllophora* meadows need to be included in the Natura 2000 network of Bulgaria and Romania, under the 1170 NATURA code (*Reefs*). The Black Sea Red Data Book lists the following species that occur in this biotope: *Phyllophora crispa* (Vulnerable), *Halichondria panicea* (Vulnerable), *Eriphia verrucosa* (Endangered), *Pilumnus hirtellus* (Vulnerable), *Scorpaena porcus* (Vulnerable). A large (402,500 ha) offshore Marine Protected Area (MPA) called 'Zernov's *Phyllophora* field' was declared by Ukraine on November 2008 in the northwestern Black Sea. "Preservation of *Phyllophora* resources and the *Phyllophora* ecosystem as a whole, including the gene pool of rare, endemic and relic plant and animal species in the region" is among the goals of this MPA. KOSTYLEV *et al*. [14] have reported that gradual restoration of the benthic phytocoenosis within the MPA has begun.

References

[1] Kalugina-Gutnik AA (1975) Phytobenthos of the Black Sea. Naukova dumka, Kiev, pp 245 (in Russian)
[2] Karapetkova M, Zhivkov M (2006) Fishes in Bulgaria. Gea Libris, Sofia, pp 216 (in Bulgarian)
[3] Vershinin A (2007) Life in the Black Sea. MacCentr, Moscow, 192 pp (in Russian)
[4] Zaitsev YP (2008) An introduction to the Black Sea ecology. Smil Editing and Publishing Agency Ltd., Odessa, pp 226
[5] Todorova V, Micu D (2008) Unknown *Phyllophora nervosa* field discovered in the Bulgarian Black Sea. Available at: www.blacksea-commission.org
[6] Auglier H (1982) Inventory and classification of marine benthic biocoenoses of the Mediterranean. Council of Europe, Publication Section, Strasbourg, pp 57
[7] Heard J (2005) *Phyllophora crispa*. A red seaweed. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom [cited 16/03/2010]. Available at: http://www.marlin.ac.uk/speciesinformation.php?speciesID=4117
[8] Sur M, Güven KC (2002) Infrared Studies on *Phyllophora nervosa* Agar and Comparison with Various Agars and Carrageenans. J Black Sea/Mediterranean Environment 8 (3): 143-156
[9] Gazha PA, Yunusov TS, Shadrina TYu, Andrianov AM (1983) Iodine-containing complexes of the Black Sea alga *Phyllophora nervosa*. Chem Nat Compd 19 (6): 733-737
[10] Blinovaa EI, Trishinaa OA (1990) Cultivation of *Phyllophora nervosa* (DC) Grev. on rope collectors in the Black Sea. Aquaculture 84 (3-4): 257-265
[11] Zaitsev YP, Alexandrov BG (1998) Black Sea Biological Diversity: Ukraine. Black Sea Envir Ser 7. UN Publ, NY, pp 351
[12] Minicheva G et al (2008) The state of macrophytobenthos. In: Oguz T (ed) State of Environment Report 2001 - 2006/7. Publications of the Commission of the Protection of the Black Sea Against Pollution, 2008-3, Istanbul, Turkey, pp 448
[13] Goriup P (Ed) (2009) The Small Phyllophora Field in Karkinitsky Bay, Black Sea, Ukraine. Background Information for the Establishment of a Marine Protected Area. Available online at: http://www.ecbsea.org/files//content/Karkinitsky%20Bay%20MPA%20Dossier%20EN_1.pdf
[14] Kostylev EF, Tkachenko FP, Tretiak IP (2010) Establishment of "Zernov's *Phyllophora* field" marine reserve: Protection and restoration of a unique ecosystem. *Ocean Coast Manag* 53: 203-208

Mediterranean coralligenous communities sheltered from hydrodynamic action

Compiled by Maria Salomidi

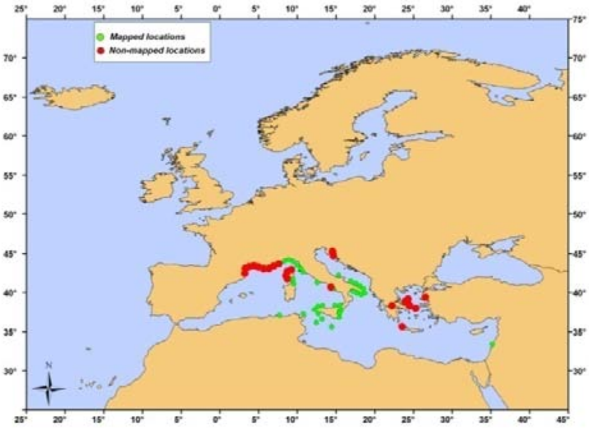
Classification	**Code**	**Title**
NATURA 2000	1170	Reefs
EUNIS	A4.32	Mediterranean coralligenous communities sheltered from hydrodynamic action

Picture(s)

Coralligenous beds dominated by active filter-feeders, such as various sponges and ascidians, Pagassitikos Gulf, Greece (Photo by Yiannis Issaris)

Biotope Distribution

Coralligenous buildups are common all around the Mediterranean coasts, with the possible exception of those of Lebanon and Israel [1].



Links to Available Maps

Not available

Biotope Requirements

Coralligenous formations on rocky or biogenic substrata under low or no hydrodynamic action, in typical Mediterranean salinity and temperature levels. Depth distribution may range significantly from a few metres down to more than 100 m, as a combined effect of light availability, water turbidity and substratum slope [1].

Biotope Description

The Mediterranean coralligenous communities are very complex in structure and, in fact, consist of several subsets of communities i.e. those dominated by living algae, suspension feeders, borers, and, at places, even soft-bottom fauna [1, 2]. Coralligenous formations that thrive in sheltered conditions in particular, are rarely characterized by spectacular dense gorgonian facies, as is rather the case in more exposed environments (EUNIS Code A4.26). Although red (e.g. Corallinaceae, Peyssonneliaceae) and -to a lesser degree- green calcareous algae remain the primary frame-builders, animals such as sponges (e.g. *Axinella* spp.*, Agelas oroides, Petrosia ficiformis, Oscarella lobularis, Cliona* spp.*, Phorbas tenacior, Hemimycale columella*), bryozoans (e.g. *Pentapora fascialis, Myriapora truncata, Beania* spp.*, Schizomavella* spp.*, Sertella* spp.), ascidians (e.g. *Cystodites dellechiajei, Ciona edwardsii, Halocynthia papillosa, Aplidium* spp., various Didemnidae), scleractinians (e.g. *Caryophyllia* spp.*, Hoplangia durotrix, Leptopsammia pruvoti, Madracis pharensis*) and polychaetes (numerous serpulids and sabellids) contribute significantly to the formation and consolidation of the build-ups [1, 3]. Other common encounters include several species of molluscs (e.g. *Serpulorbis arenarius, Lithophaga lithophaga, Lima lima, Arca noae, Bittium* spp., *Octopus vulgaris, Discodoris atromaculata, Flabellina affinis*), echinoderms (e.g. *Marthasterias glacialis, Hacelia attenuata,Ophidiaster ophidianus, Antedon* spp., *Sphaerechinus granularis, Centrostephanus longispinus, Holothuria forskali)*, hydroids (e.g. *Eudendrium* spp.*, Sertularella* spp.*)*, crustaceans (*Dromia personata, Palinurus elephas, Scyllarus arctus, Scyllarides latus, Homarus gammarus*) and fish (e.g. *Epinephelus marginatus, Sciaena umbra, Anthias anthias, Serranus cabrilla, Coris julis, Dentex dentex, Symphodus mediterraneus, Symphodus tinca, Diplodus vulgaris, Apogon imberbis, Chromis chromis, Phycis phycis, Helena muraena, Conger conger*) [1].

Associated Biotopes at EUNIS Level 5 [4]:

A4.321: Association with Rodriguezella strafforelli. This association populates poorly-lit hard substrata, in a environments, at about 25-45 metres depth. It reportedly hosts various other calcareous red algae (e.g. *Lithophyllum stictaeforme, Neogoniolithon mamillosum, Peyssonnelia rosa marina*), several laminar red algae (*Kallymenia, Fauchea, Sebdenia, Rhodophyllis, Predaea*), as well as the encrusting green alga *Palmophyllum crassum* [5].

A4.322: Facies with Leptogorgia sarmentosa. This facies is characterised by the high density of colonies of the gorgonian (sea-fan) *Leptogorgia sarmentosa*.

Biotope Evaluation: Goods and Services

Coralligenous assemblages are considered the most important hot-spots of species diversity in the Mediterranean, together with *Posidonia oceanica* meadows [6], and their aesthetic appeal attracts an increasing number of recreational divers [7, 8]. Some of the most common groups of species such as Porifera, Bryozoa and Tunicata, which are known to thrive in the Mediterranean coralligenous communities, have been identified as valuable sources of new bioactive compounds with great potential in pharmaceutical research [9]. Moreover, the great variety and abundance of calcareous organisms render these biotopes among the most important carbon sinks in the Mediterranean circalittoral zone [1]. Such calcareous species also present a high interest as possible indicators of palaeo-environmental conditions (*i.e. Myriapora truncata*; [10]).

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐

Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Eutrophication, organic based pollution (i.e. sewage, fish farming) and increasing sedimentation have reportedly degraded these biotopes, by decreasing species richness, eliminating sensitive taxa and even inhibiting coralligenous construction [1, 11, 12]. Other important threats include direct and indirect effects of fishing, as well as uncontrolled anchoring and diving activities [1, 8]. Currently, three algal invasive species (*Womersleyella setacea, Caulerpa racemosa v. cylindracea* and *Caulerpa taxifolia*) are threatening coralligenous communities in the Western Mediterranean, by forming dense carpets, increasing sedimentation, and smothering indigenous populations [6]. The introduced *Asparagopsis taxiformis* and *Lophocladia lallemandii* are also becoming increasingly abundant in the Balearic Islands [1]. Although poorly studied, coralligenous banks of the Eastern Mediterranean basin seem more prone to the invasion of the green alga *Caulerpa racemosa var. cylindracea,* and the brown alga *Stypopodium schimperi* [e.g. 13, 14].

Conservation and protection status

This biotope is classified as *Sublittoral organogenic concretions* (11.25) in the Bern Convention and as *Reefs* (Habitat Type 1170) in the EU Habitats Directive (92/43/EEC). These bulk categories, however, are highly problematic for management purposes, as they comprise a large variety of natural habitats (e.g. Biocenosis of the upper mediolittoral rock, Biocenosis of the lower mediolittoral rock, Biocenosis of infralittoral algae, Coralligenous biocenosis, Biocenosis of deep sea corals, etc *sensu* UNEP-MAP RAC/SPA [15]), which can differ significantly in their biological and ecological aspects. During the last decade, there has been increased scientific concern to accord the Mediterranean coralligenous communities a “priority” status [6].

References

[1] Ballesteros E (2003) The coralligenous in the Mediterranean Sea**:** Definition of the coralligenous assemblage inthe Mediterranean, its main builders, its richness and key role in benthic ecology as well as its threats. Project for the preparation of a Strategic Action Plan for the Conservation of the Biodiversity in the Mediterranean Region (SAP BIO). UNEP-MAP-RAC/SPA: pp 87

[2] Connor DW, Dalkin MJ, Hill TO, Holt RHF, Sanderson WG (1997) Marine Nature Conservation Review: marine biotope classification for Britain and Ireland. Volume 2. Sublittoral biotopes. Version 97.6. JNCC Report, No. 230

[3] Hong JS (1982) Contribution à l'étude des peuplements d'un fond coralligène dans la région marseillaise en Méditerranée Nord-Occidentale. Bulletin of KORDI 4: 27-51

[4] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: May 2010).

[5] Augier H, Boudouresque CF (1975). Dix ans de recherches dans la zone marine du Parc National de Port-Cros (France). Troisième partie. Ann Soc Sci Nat Arch Toulon Var 27: 131-170

[6] UNEP (2007) Draft Action Plan on Protecting the Coralligenous and other Calcareous Bio-Concretions in the Mediterranean. Report of the SPA/RAC Focal Points meeting. Palermo, Italy, 6-9 June 2007. UNEP (DEPI)/ MED WG.308/14 pp 18

[7] Lloret J, Marín A, Marín-Guirao L, Carreňo MF (2006) An alternative approach for managing scuba diving in small marine protected areas. Aquat Conserv: Mar Freshw Ecosyst 16: 579–591

[8] Luna-Perez B, Valle C, Vega Fernandez T, Sanchez-Lizaso JL, Ramos-Espla AA (2010) *Halocynthia papillosa* (Linnaeus, 1767) as an indicator of SCUBA diving impact, Ecol Indic 10(5): 1017-1024

[9] Uriz, MJ, Martin D, Turon X, Ballesteros E, Hughes R, Acebal C (1991) An approach to the ecological

significance of chemically mediated bioactivity in Mediterranean benthic communities. Mar Ecol Prog Ser 70: 175-188

[10] Berning B (2007) The Mediterranean bryozoan *Myriapora truncata* (Pallas, 1766): a potential indicator of (palaeo-) environmental conditions. Lethaia 40: 221-232 doi: 10.1111/j.1502-3931.2007.00019.x

[11] Hong JS (1980) Étude faunistique d'un fond de concrétionnement de type coralligène soumis à un gradient de pollution en Méditerranée nord-occidentale (Golfe de Fos). Thèse de Doctorat. Université d'Aix - Marseille II. pp 134

[12] Balata D, Piazzi L, Cecchi E, Cinelli F **(**2005) Variability of Mediterranean coralligenous assemblages subject to local variation in sediment deposition. Mar Envir Res 60(4): 403-421

[13] Bitar G, Harmelin JG, Verlaque M, Zibrowius H (2000) Sur la flore marine benthique supposée lessepsienne de la cote libanaise. Cas particulier de *Stypopodium schimperi*. *Mednature* 1: 97-100

[14] Bardamaskos A, Tsiamis K, Panayotidis P, Megalofonou P (2008) New records and range expansion of alien fishes and macroalgae in Greek waters (SE Ionian Sea), *JMBA2 Biod Rec:* 6361

[15] Bellan-Santini D, Bellan G, Bitar G, Harmelin JG, Pergent (eds) (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. UNEP-MAP RAC/SPA Tunis pp 217

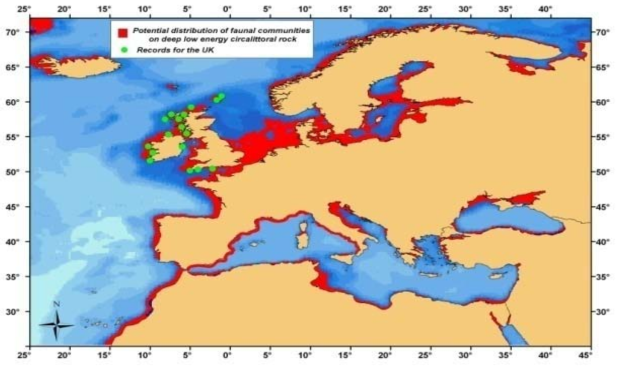
Faunal communities on deep low energy circalittoral rock

Compiled by Tomas Vega Fernandez		
Classification	**Code**	**Title**
NATURA	1170	Reefs
EUNIS	A4.33	Faunal communities on deep low energy circalittoral rock

Picture(s)

Not available

Biotope Distribution



Map of potential and recorded distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/habitats/habitat.aspx?habitat=JNCCMNCR00002120 (for UK and Ireland)

Biotope Requirements [1]

Salinity: Full (30-35 ppt), Reduced (18-30ppt)
Wave exposure: Sheltered, Very sheltered
Tidal streams: Weak (>1 kn), Very weak (negligible)
Substratum: Bedrock, boulders
Zone: Lower circalittoral
Depth band: 20-30 m.

Biotope Description

A habitat complex that occurs on wave-sheltered circalittoral bedrock and boulders subject to mainly weak or very weak tidal streams. This biotope is often dominated by encrusting red algae, brachiopods (*Neocrania anomala*) and ascidians (*Ciona intestinalis* and *Ascidia mentula*). Two fouling biotopes have also been identified: "Aasp" has been recorded from disused fishing nets and other artificial substrata, and is characterised by aggregations of *Ascidiella aspersa* whilst "AdigMsen" has been recorded from steel wrecks, and is characterised by dense aggregations of *Alcyonium digitatum* and *Metridium senile*.

Biotope Evaluation: Goods and Services

This biotope does not include high-diversity communities, but the ascidian *C. intestinalis* can become very abundant under certain environmental conditions, filtering the whole volume of semi-enclosed water bodies like fjords, harbours and estuaries at high rates [2].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

Ships are the most probable vector for large-scale ascidian transportation, and *C. intestinalis* has become an invasive species with detrimental effects on other communities.

Conservation and protection status

No information available.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] Lambert G (2007) Invasive sea squirts: A growing global problem. J Exp Mar Biol Ecol 342: 34-50

Communities of circalittoral caves and overhangs

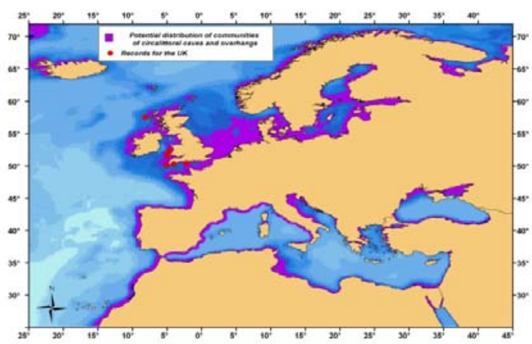
Compiled by Simone Mirto

Classification	Code	Title
NATURA 2000	8330	Submerged or partially submerged sea caves
NATURA 2000	1170	Reefs
EUNIS	A4.71	Communities of circalittoral caves and overhangs

Picture(s)

Not available

Biotope Distribution



Map of potential and recorded distribution

Links to Available Maps

http://map.eea.europa.eu/getmap.asp?coordsys=LL&size=W345H300&ImageQuality=100&Q=UK:4,SE:4,PT:4,PL:4,NL:4,MT:4,LV:4,IT:4,IE:4,GR:4,FR:4,FI:4,ES:4,EE:4,DK:4,DE:4,CY:4&PredefShade=heat7&maptype=Standard_b
http://www.marlin.ac.uk/images/distribution_maps/biotopes/CR.Cv.jpg (for UK and Ireland)
http://www.jncc.gov.uk/marine/biotopes/maps/JNCCMNCR00001546.GIF (for UK and Ireland)

Biotope Requirements

Salinity: Full (30-35 ppt)
Wave exposure: Very exposed, Exposed, Moderately exposed, Sheltered
Tidal streams: Weak (>1 kn), Very weak (negligible)
Water clarity preferences: Very high clarity / Very low turbidity; High clarity / Low turbidity; Medium clarity / Medium turbidity
Limiting Nutrients: Not relevant
Substratum: Bedrock
Zone: Circalittoral
Depth Band: 10-20 m, 20-30 m, 30-50 m.

Biotope Description

Caves and overhanging rock in the circalittoral zone, away from significant influence of strong wave action. This biotope may consist of a wide variety of species, with encrusting sponges including some that are seldom seen such as *Dercitus bucklandi* and *Thymosia guernii*, anemones *Parazoanthus* spp. and the cup corals *Caryophyllia inornatus*, *Hoplangia durotrix* [1, 2, 3, 4, 5, 6, 7, 8]. In the south-west, *Leptopsammia pruvoti* may be abundant in restricted areas [9]. The main components of the biotope probably interact very little and live independently. However, the corals provide a host for the barnacle *Boschia anglica* (in the south-west) and a calcareous substratum for boring species such as *Hiatella arctica*, *Potamilla reniformis* and the horseshoe worm *Phoronis hippocrepia* to live. Boring species may weaken the skeleton of the corals to the extent that they are easily detached [4]. The soft coral *Alcyonium glomeratum* may be predated on by the prosobranch *Simnia patula*. Encrusting sponges may overgrow other species and has shown how encrusting bryozoans may engulf cup corals and kill them. Grazers such as the sea urchin *Echinus esculentus*, may occasionally pass through the biotope grazing away barnacles and erect bryozoans especially, possible freeing space for new colonization (K. Hiscock, own observations). Most of the species in the biotope are long-lived. However, seasonal change occurs in the light-bulb ascidian *Clavellina lepadiformis* which grows rapidly in the spring to die-back in winter. A longer term

decline has been recorded in the abundance of long-lived species (especially *Leptopsammia pruvoti*, *Hoplangia durotrix* and *Alcyonium coralloides*) at Lundy (K. Hiscock, own observations).
There is little complexity in the biotope, most species living directly attached to the rock and not offering architectural complexity as shelter for other species.
Recruitment processes: Several of the species in the biotope appear to have short-lived benthic larvae. For instance, the soft coral *Alcyonium hibernicum* broods planulae larvae that are released at a late development phase and so probably has a short planktonic life [3], as *Alcyonium coralloides*). *Leptopsammia pruvoti* also seems to have short-lived planulae larvae which may settle immediately or very soon after release and recruitment at a site at Lundy has been extremely small (as low as 1% over the years 1983 to 1999 at least) (K. Hiscock, own observations). Sponges are likely to have a longer lived larva. Some species, such as the zoanthid anemones *Parazoanthus axinellae* and *Parazoanthus dixoni*, reproduce asexually to produce large colonies.
In the Mediterranean sea the ichthyic fauna [11] is represented by the following species: *Anthias anthias, Apogon imberbis, Scorpaena porcus, S. notata, Gobius niger*. Some species use these places as hideouts, as is the case with the conger eel (*Conger conger*), the dusky grouper (*Epinephelus marginatus*), the brown meagre (*Sciaena umbra*) and the Serranidae family of fish.
Sponges such as *Dercitus bucklandi* and the following anthozoans can be found in circalittoral caves: *Caryophyllia inornatus, Hoplangia durothrix, Parazoanthus* spp.
The representative species of sponges present in caves in total darkness as well as deep-sea cave walls [12] roofs and tunnels include *Chondrosia reniformes, Spongionella pulchella, Petrosia ficiformis, Coralistes nolitangere, Lacazella* sp. and *Ircinia* spp.
Algae are scarce and the species present in this biotope is usually calcareous algae located in the entrance of the caves such as *Peyssonnelia* spp. and *Lithothamnium* sp.

Associated Biotopes at EUNIS Level 5:
A4.711 Sponges, cup corals and anthozoans on shaded or overhanging circalittoral rock [9]. This biotope occurs on shaded and overhanging rock, such as on cave walls and ceilings although there are very few records of caves in conditions not subject to wave surge (i.e. deeper circalittoral biotopes) and almost all are different in species composition. There are also a few examples of similar communities on very deep (70-100 m+) upward-facing rock (in Loch Hourn) and more may be found through the use of ROVs. These often species-rich biotopes are almost invariably adjacent to well-mixed turbulent water. Characteristic species include the sponges *Stryphnus ponderosus*, *Dercitus bucklandi*, *Chelonaplysilla noevus*, *Pseudosuberites* sp. and *Spongosorite* spp., the anemones *Parazoanthus* spp., the cup corals *Leptopsammia pruvoti*, *Hoplangia durotrix*, *Caryophyllia inornatu* and the soft coral *Parerythropodium coralloides*. *Thymosia guernei* is sometimes present. This biotope is likely to need further splitting with further data and analysis. Situation: Subtidal rocky coasts.
A4.712 Caves and overhangs with Parazoanthus axinellae [10]. This facies, characterised by the colonial sea anemone *Parazoanthus axinellae*, occurs on hard bottoms affected by very rough water and relatively dim light. Found attached to rocks and sponges in open coast rocky habitats, it is often observed on vertical faces or beneath overhangs, at 6-100 m depth.
A4.713 Caves and overhangs with Corallium rubrum [10]. This facies, characterised by the high presence of the cnidarian (red coral) *Corallium rubrum*, occurs on walls of caves and/or cavities with coralligenous concretions and semi-dark overhangs. The vertical distribution of this facies occurs from 10 to 200 metres depth.
A4.714 Caves and overhangs with Leptopsammia pruvoti [8, 10]. This facies with the madreporian (yellow coral) *Leptopsammia pruvoti* occurs on hard substrata at the entrance to caves and under overhangs. In the Mediterranean Sea, the anemone *Telmatactis cricoides* is another representative species of this biotope, as well as the corals *Madracis asperula, Phyllangia mouchezii, Parazoanthus axinellae, Leptosammia pruvoti, Caryophillia inornata;* the bivalve*, Spondylus senegalensis;* the bryozoan*, Reptadeonella violacea;* the ascidians*, Ciona intestanilis* and *Halocynthia papillosa.* Moving fauna is represented by the echiuran, *Bonellia viridis*, which usually lives amongst the crevices of the rocky seabed or detritus at 10 to 100 meters depth, and only the trumpet can be seen peeking out of the crevices. The presence of *Octopus vulgaris* must be mentioned, as well as the crustaceans *Enoplometopus callistus, Stenopsus spinosus, Plesionika narval*, the spider crab (*Sternorhynchus lanceolatus*), the lobster (*Palinurus elephas*), the spiny lobster (*Panulirus echinatus*), the slipper lobster (*Scyllarus arctus*), the locust lobster (*Scyllarus latus*) and the crinoid, *Antedon bifida* associated to the crustacean *Hyppolite hunti*. The fish are represented by the cardinal fish (*Apogon imberbis*), the glasseye snapper (*Heteropriacanthus cruentatus*), the rockfish (*Scorpaena maderensis, S. canariensis*), forkbeards (*Phycis phycis*), various species of eels (*Muraena helena, M. augusti*), dusky grouper (*Epinephelus marginatus*), island grouper (*Mycteroperca fusca*), seabass (*Serranus cabrilla, S. stricauda*) and meagres (*Argyrosomus regius*).
A4.715 Caves and ducts in total darkness (including caves without light or water movement at upper levels)

[10, 14]. This biotope occurs in very large submerged cavities especially present in drowned karstic networks, isolated little cavities and microcavities in heaps of stones and within certain concretions. The caves in total darkness are enclaves of the aphotic area in the littoral area. These biotopes present extremely original environmental conditions, close to those found on the continental slope. The two most important ecological factors are the absence of light, which rules out photosynthetic organisms, and the confined space.
In the Mediterranean, in dark circalittoral caves or in conditions of scarce sunlight, species of sponges such as *Aplysina aerophoba, Hexadella racovitzai, Geodia cydonium, Cacospongia scalaris, Axinella damicornis, A. polypoides, Reniera cratera, Caminus vulcani, Corallistes nolitangere, Ircinia oros* and *Rhaphidostyla incisa* can be found. The anthozoans are represented by species such as *Madracis pharensis* and *Savalia (=Gerardia) savaglia* [13] that feed on the decapod *Balssia gasti*. Other anthozoans include the red gorgonians *Leptogorgia spp.* and the black coral *Antipathes wollastoni* [14]. The decapod *Parapandalus narval* and the swallowtail seaperch (*Anthias anthias*) are very common in this type of biocenosis.

Biotope Evaluation: Goods and Services

Marine caves and overhangs may support a rich and at times exceptional biodiversity, due to a great and sharp variability of environmental parameters (light, physicochemical water properties, hydrodynamism, etc.) which result in an increased habitat diversification. From this perspective, the study of marine caves may provide useful insights into the complex relationships between species distribution and ecological factors [15]. Studies on the marine cave and other crevicular fauna have revealed the existence of unique communities characterized by high endemism, relict species and other unusual characteristics [15, 16]. Moreover, several common features shared between circalittoral caves and deep-sea habitats -such as lack of light, limited food resources and in some cases lack of hydrodynamism [17]- provide significant opportunities for studying and understanding deeper environments within the “scuba zone” [18]. Due to their high aesthetic value, many submerged Mediterranean marine caves are exploited as diving sites with a rapidly increasing popularity.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

The deterioration caused by organic or industrial contamination leads to a pronounced loss of biodiversity, to the disappearance of the most sensitive species and to the permanence of resistant species and the subsequent appearance of other ecologically tolerant and highly variable species [19]. This biotope is sensitive to the disturbances that affect communities inhabiting infralittoral and circalittoral waters, generally caused by coastal defense works or contamination [20]. It is also very sensitive to sedimentation due to the quantity of sessile filter feeders that comprise this biotope. Other activities such as uncontrolled sport-diving may produce negative effects either directly by mechanical disturbance or indirectly as a result of air-bubble accumulation which may affect organisms attached to the cave roof.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (Council of Europe Bern Convention, 1996): *Sea-caves* (code 12.7). Listed in the EU Habitats Directive Annex I as: *Reefs* (code 1170); *Submerged or partially submerged sea caves* (code 8330).

References

[1] Hiscock K (2008) Caves and overhangs (deep). Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom [cited 31/03/2010]. Available at: http://www.marlin.ac.uk/habitatimportance.php?habitatid=10&code=2004

[2] Fowler SL, Pilley GM (1992) Report on the Lundy and Isles of Scilly marine monitoring programmes 1984-1991. English Nature, Research Report no. 9.

[3] Hartnoll RG (1977) Reproductive strategy in two British species of *Alcyonium*. New York: Pergamon Press

[4] Hiscock K, Howlett R (1976) The ecology of *Caryophyllia smithii* Stokes & Broderip on south-western coasts of the British Isles. London: Academic Press

[5] Howson CM, Picton BE (eds) (1997) The species directory of the marine fauna and flora of the British Isles and surrounding seas. Belfast: Ulster Museum [Ulster Museum publication, no. 276]

[6] Mc Fadden CS (1999) Genetic and taxonomic relationships among northeastern Atlantic and Mediterranean populations of the soft coral *Alcyonium coralloides*. Mar Biol 133: 171-184

[7] Turner SJ (1988) Ecology of intertidal and sublittoral cryptic epifaunal assemblages. II. Non-lethal overgrowth of encrusting bryozoans by colonial tunicates. J Exp Mar Biol Ecol 115: 113-126

[8] OCEANA (2006) Habitats in Danger: Oceana´s proposal for protection. Fundaciòn Biodiversidad. pp 72 www.oceana.org

[9] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough

[10] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

[11] AA VV (1996) Guía submarina. Mediterráneo y Atlántico desde la superficie hasta 20 metros de profundidad. Número extraordinario de la revista Apnea.

[12] Harmelin JG, Vacelet J (1997) Clues to deep-sea biodiversity in a nearshore cave. Vie et milieu 47(4): 351-354

[13] Brito A, Cruz T, Moreno E, Pérez JM (1984). Fauna Marina de las Islas Canarias. Gobierno de Canarias. Tenerife, España

[14] Pérez Sánchez JM, Batet M (1991) Invertebrados marinos de Canarias. Ediciones del Cabildo Insular de Gran Canaria. Las Palmas de Gran Canaria, España: 335 pp

[15] Iliffe TM (1992) Anchialine caves biology. In: *The Natural History of Biospeleology.* Camacho AI (Ed) Monografías del Museo Nacional de Ciencias Naturales CSIC, Madrid, 613-636 pp

[16] Hart CW Jr, Manning RB, Iliffe TM (1985) The fauna of Atlantic marine caves: evidence of dispersal by sea floor spreading while maintaining ties with deep waters. *Proceedings of the Biological Society of Washington* 98: 288-292[17] Villora-Moreno S (1996) A new genus and species of the deep-sea family Coronarctidae (Tardigrada) from a submarine cave with a deep-sea like condition. *Sarsia* 81: 275-283

[18] Vacelet J, Boury-Esnault N & Harmelin JG (1994) Hexactinellid Cave, a unique deep-sea habitat in the scuba zone. *Deep-Sea Res I*, 41: 965-973

[19] Calvín JC (1995) El ecosistema marino mediterráneo. Guía de su flora y fauna. Murcia.

[20] Bellan-Santini D, Lacaze JC, Poizat C (1994) Les biocénoses marines et littorales de Méditerranée: Synthèse, menaces et perspectives, Museum National d'Histoire Naturelle, Paris, pp 246

Infralittoral coarse sediment

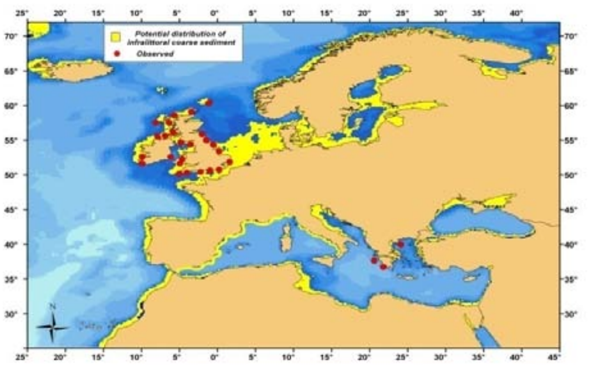
Compiled by Simone Mirto

Classification	Code	Title
EUNIS	A5.13	Infralittoral coarse sediment

Picture(s)

Not available

Biotope Distribution



Map of potential and recorded distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/maps/JNCCMNCR00002035.GIF

Biotope Requirements

Salinity: Full (30-35 ppt)
Wave exposure: Exposed, Moderately exposed, Sheltered
Tidal streams: Strong (3-6 kn), Moderately strong (1-3 kn), Weak (>1 kn), Very weak (negligible)
Substratum: Sand with gravel, pebbles and/or shingle
Zone: Infralittoral
Depth Band: 0-5 m, 5-10 m, 10-20 m.

Biotope Description

Moderately exposed habitats with coarse sand, gravelly sand, shingle and gravel in the infralittoral, are subject to disturbance by tidal steams and wave action [1, 2]. Such biotopes found on the open coast or in tide-swept marine inlets are characterised by a robust fauna of infaunal polychaetes such as *Chaetozone setosa* and *Lanice conchilega*, cumacean crustacea such as *Iphinoe trispinosa* and *Diastylis bradyi*, and venerid bivalves. Biotopes with the lancelet *Branchiostoma lanceolatum* may also occur.

Associated Biotopes at EUNIS Level 5:

A5.131: Sparse fauna on highly mobile sublittoral shingle (cobbles and pebbles) [1]. Sublittoral clean shingle and pebble habitats with a lack of conspicuous fauna. Unstable, rounded pebbles and stones (as opposed to sub-angular cobbles, which are often found lying on or embedded in other sediment) that are strongly affected by tidal steams and/or wave action can support few animals and are consequently faunally impoverished. The species composition of this biotope may be highly variable seasonally and is likely to comprise of low numbers of robust polychaetes or bivalves with occasional epibiota including echinoderms and crustacea such as *Liocarcinus* spp. and *Pagurus* spp. In more settled periods there may be colonisation by anemones such as *Urticina felina* and small populations of hydroids and Bryozoa. Situation: This biotope is found in marine inlets with very strong tidal currents as well as in very wave exposed open coast environments. Temporal variation: The faunal composition of this biotope is likely to be highly variable as a result of seasonal changes in wave and tidal energy.

A5.132: Halcampa chrysanthellum and Edwardsia timida on sublittoral clean stone gravel [1]. Periodically disturbed sublittoral stone gravel with small pebbles characterised by the presence of the anemones *Halcampa chrysanthellum* and *Edwardsia timida*. Associated species are often typical of a hydroid/bryozoan turf with polychaetes such as *Pomatoceros* spp. encrusting larger pebbles and low numbers of syllid and phyllodocid polychaetes living interstitially. In some areas this biotope may also contain opportunistic red seaweeds and infauna such as *Sabella pavonina*. It should be noted that this biotope may show considerable variation in community composition and it is possible that it is a sub-biotope of other gravel biotopes. Situation: This biotope tends to occur at the entrance to marine inlets where tidal currents are moderately strong. Temporal variation: The faunal composition and species richness of this biotope may vary seasonally as a result of disturbance from increased wave or tidal action.

A5.133: Moerella (=Tellina) spp. with venerid bivalves in infralittoral gravelly sand [1]. Infralittoral medium to coarse sand and gravelly sand which is subject to moderately strong water movement from tidal streams may be characterised by *Tellina (Moerella)* spp. with the polychaete *Glycera lapidum* (agg.) and venerid bivalves. Typical species include *Tellina pygmaea* or *T. donacina* with other robust bivalves such as *Dosinia lupinus*, *Timoclea ovata*, *Goodallia triangularis* and *Chamelea gallina*. Other infauna includes nephtyd and spionid polychaetes and amphipod crustacea. Another important component of this biotope in some areas is the bivalve *Spisula solida* which may be common or abundant. Epifaunal communities may be reduced in this biotope; surface sand waves which may be indicative of the presence of venerid bivalves. Remote grab sampling is likely to under-estimate venerid bivalves and other deep-burrowing and more dispersed species such as *Paphia*, *Ensis* and *Spatangus*. In southern areas of the UK and the North Sea, in slightly siltier sand and shelly sand, A5.133 may give way to the other *Spisula* biotope.

A5.134: Hesionura elongata and Microphthalmus similis with other interstitial polychaetes in infralittoral mobile coarse sand [1]. On infralittoral sandbanks and sandwaves and other areas of mobile medium-coarse sand, populations of interstitial polychaetes may be found. These biotopes consist of loosely packed grains of sand forming waves up to several metres high often with gravel, or occasionally silt, in the troughs of the waves. This biotope is commonly found both inshore along the east coast of the UK e.g. around the Race Bank, Docking Shoal and Inner Dowsing banks, and in the Southern Bight of the North Sea and off the Belgian coast. These biotopes support interstitial communities living in the spaces between the grains of sand, in particular hesionurid polychaetes such as *Hesionura elongata* and *Microphthalmus similis*, along with protodrilid polychaetes such as *Protodrilus* spp. and *Protodriloides* spp. Other important species may include *Turbellaria* spp. and larger deposit feeding polychaetes such as *Travisia forbesii*. An important feature of this biotope which is not reflected in much of the available data is the importance of the meiofaunal population which may exceed the macrofaunal population both in terms of abundance and biomass. Situation: This biotope is commonly found both in shore adjacent to the coast, and further away from the coast.

A5.135: Glycera lapidum in impoverished infralittoral mobile gravel and sand [1]. In infralittoral mixed slightly gravelly sands on exposed open coasts impoverished communities characterised by the polychaete *Glycera lapidum* (agg.) may be found. *Glycera lapidum* is a species complex and as such some variability in identification may be found in the literature. It is also quite widespread and may occur in a variety of coarser sediments and is often present in other SCS biotopes. However, it is rarely considered a characteristic species and where this is the case it is normally due to the exclusion of other species. Consequently it is considered that areas containing this biotope may be subject to continual or periodic sediment disturbance from wave action, which prevents the establishment of a more stable community. Other taxa include spionid polychaetes such as *Spio martinensis* and *Spiophanes bombyx*, *Nephtys* spp. and in some areas the bivalve *Spisula elliptica*. It is possible that SCS.Glap is not a true biotope, rather an impoverished, transitional community, which in more settled conditions develops into other more stable communities. Situation: In many cases e.g. along the East Yorkshire coast this biotope is found in shallow inshore areas facing directly into the prevailing wind and subject to considerable wave action. Temporal variation: Due to the variability in sediment regime at these biotopes there may be high seasonal or spatial variability within this community.

A5.136: Cumaceans and Chaetozone setosa in infralittoral gravelly sand [1]. In shallow medium-fine sands with gravel, on moderately exposed open coasts, communities dominated by cumacean crustaceans such as *Iphinoe trispinosa* and *Diastylis bradyi* along with the cirratulid polychaete *Chaetozone setosa* (agg.) may occur. *Chaetozone setosa* is a species complex so it is likely that some variability in nomenclature will be found in the literature. Other important taxa may include the polychaetes *Anaitides* spp., *Lanice conchilega*, *Eteone longa* and *Scoloplos armiger*. This community may be subject to periodical sedimentary disturbance, such that a sub-climactic community may develop with opportunistic taxa such as *C. setosa* and *S. armiger* often dominating the community. This biotope may be found in areas with moderate currents and wave action often facing into the prevailing wind and along the Holderness coast of the North Sea. It is possible that this biotope has developed due to chronic sedimentary disturbance in areas where the biotopes AalbNuc or FfabMag would normally develop as these biotopes are often found in more sheltered areas adjacent to CumCset. The importance of the cumacean crustaceans in this biotope is unusual, and their numbers are likely to fluctuate over time; at times of increased disturbance it is likely that *C. setosa* will become more dominant.

A5.137: Dense Lanice conchilega and other polychaetes in tide-swept infralittoral sand and mixed gravelly sand [1]. Dense beds of *Lanice conchilega* occur in coarse to medium fine gravelly sand in the shallow sublittoral, where there are strong tidal streams or wave action. Several other species of polychaete also occur as infauna e.g. *Spiophanes bombyx*, *Scoloplos armiger*, *Chaetozone setosa* and *Magelona mirabilis*. *Lanice* beds are found in a wide range of habitats including muddier mixed sediment. The dense *Lanice* biotope (LGS.Lan) on certain lower shores may be a littoral extension of the current biotope. The presence of *L. conchilega* in high numbers may, over time, stabilise the sediment to the extent where a more diverse community may develop. Possibly as a result of this, there is a high level of variation with regard the infauna found in SCS.SLan. It is likely that a number of sub-biotopes may subsequently be identified for this biotope. Offshore from the Wash and the North Norfolk coast *Lanice* beds are often found intermixed with *Sabellaria spinulosa* beds in muddier mixed sediment, particularly in the channels between the shallow sandbanks, which are so prevalent in this area. It is possible that the presence of *Lanice* has stabilised the habitat sufficiently to allow the deposition of finer material, which has subsequently assisted the development of *S. spinulosa*. It may be more accurate to define SLan as an epibiotic biotope which overlays a variety of infaunal biotopes (e.g. NcirBat in finer sands and AalbNuc or FfabMag in slightly muddier areas). At places where dense aggregations of *Lanice concilega* form distinct biogenic reefs, this biotope may be rather classified under the EUNIS code A5.61 (see proposed new insertion *A5.614: *Lanice conchilega* reefs).

A5.138: Association with rhodolithes in coarse sands and fine gravels mixed by waves [1]. This association occurs on coarse sands and fine gravels subjected to strong hydrodynamic action. Calcareous algae are attached to a small mineral or organic surface and then grow in successive layers to form rhodolithes of more or less nodulous shape and varying size.

A5.139: Facies with Gouania wildenowi [1]. This facies is characterised by the abundance of the little clingfish *Gouania willdenovii* that live in shallow waters.

A5.13A: Greenland cockle Serripes in shallow coarse sand (influenced by warm low-salinity melt water) of the Arctic [1]. No further description available.

Biotope Evaluation: Goods and Services

Gravelly sediments are generally low in organic carbon levels, and hence the existing epi- and infauna exhibit relatively low diversity and abundance levels [3]. The habitat includes few features that might create microhabitats or localized shelter, and can be important for opportunistic predators on component species [4]. In some areas and seasons artisanal fishery activities take place on infralittoral coarse biotopes that may also represent nursery grounds for certain fish species.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☐	☒

Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

This biotope is directly subjected to anthropogenic activity on the littoral: pollution emissions, turbid water, unsustainable development practices, etc. Additions of fine elements and sedimentation from watercourses or from anthropogenic waste take place, because the hydrodynamics are usually not strong enough to prevent this type of disturbances. The biotope has a role in maintaining the balance of the adjoining beaches, and could be affected by beach replenishment activities.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (Council of Europe Bern Convention, 1996): *Sublittoral soft seabeds* (code 11.22).

References

[1] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010).

[2] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[3] Roche C, Lyons DO, Farinas Franco J, O'Connor B (2007) Benthic surveys of sandbanks in the Irish Sea. In: *Irish Wildlife Manuals*, No. 29. National Parks and Wildlife Service, Department of Environment, Heritage and Local Government, Dublin, Ireland

[4] MarLIN (2004) Biodiversity & Conservation: Habitats. Available online at: http://marlin.ac.uk/habitatimportance/habitatid/2004codes

Circalittoral coarse sediment

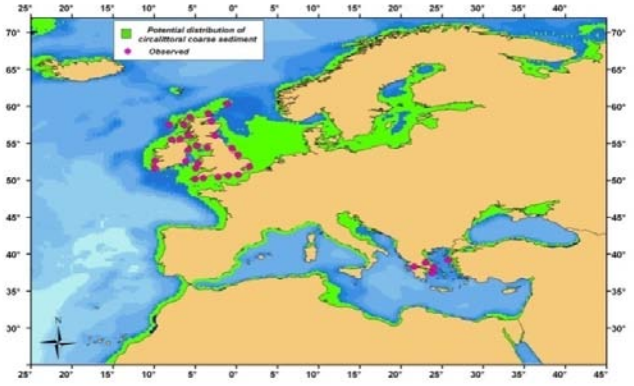
Compiled by Tomas Vega Fernandez

Classification	Code	Title
EUNIS	A5.14	Circalittoral coarse sediment

Pictures

Not available

Biotope Distribution



Map of potential and recorded distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002088 (for UK and Ireland)

Biotope Requirements [1]

Salinity: full (30-35 ppt)
Wave exposure: exposed, moderately exposed
Tidal streams: moderately strong (1-3 kn), weak (>1 kn), very weak (negligible)
Substratum: coarse sand and gravel with a minor finer sand fraction
Zone: lower infralittoral, circalittoral
Depth band: 10-20 m, 20-30 m, 30-50 m

Biotope Description

Tide-swept circalittoral coarse sand, gravel and shingle generally in depths of over 15-20m. This biotope may be found in tidal channels of marine inlets, along exposed coasts and offshore. This biotope, as with shallower coarse sediments, may be characterised by robust infaunal polychaetes, mobile crustacea and bivalves. Certain species of sea cucumber (e.g. *Neopentadactyla*) may also be prevalent in these areas along with the lancelet *Branchiostoma lanceolatum*. Taxa contributing most to shelf similarity (10% and above) are *Neopentadactyla mixta*, *Protodorvillea kefersteini*, Nemertea, *Asterias rubens* and *Pomatoceros triqueter*.

Associated Biotopes at EUNIS Level 5:
A5.141: Pomatoceros triqueter with barnacles and bryozoan crusts on unstable circalittoral cobbles and pebbles [1]. This biotope is characterised by a few ubiquitous robust and/or fast growing ephemeral species which are able to colonise pebbles and unstable cobbles and slates which are regularly moved by wave and tidal action. The main cover organisms tend to be restricted to calcareous tube worms such as *Pomatoceros triqueter* (or *P. lamarcki*), small barnacles including *Balanus crenatus* and *Balanus balanus*, and a few bryozoan and coralline algal crusts. Scour action from the mobile substratum prevents colonisation by more delicate species. Occasionally in tide-swept conditions tufts of hydroids such as *Sertularia argentea* and *Hydrallmania falcata* are present. This biotope often grades into SMX.FluHyd which is characterised by large amounts of the above hydroids on stones also covered in *Pomatoceros* and barnacles. The main difference here is that SMX.FluHyd seems to develop on more stable, consolidated cobbles and pebbles or larger stones set in sediment in moderate tides. These stones may be disturbed in the winter and therefore long-lived and fragile species are not found. Situation: This biotope is found on exposed open coasts as well as at the entrance to marine inlets.

A5.142: Mediomastus fragilis, Lumbrineris spp. and venerid bivalves in circalittoral coarse sand or gravel [1]. Circalittoral gravels, coarse to medium sands, and shell gravels, sometimes with a small amount of silt and generally in relatively deep water (generally over 15-20m), may be characterised by polychaetes such as *Mediomastus fragilis*, *Lumbrineris* spp., *Glycera lapidum* with the pea urchin *Echinocyamus pusillus*. Other taxa may include Nemertea spp., *Protodorvillea kefersteini*, *Owenia fusiformis*, *Spiophanes bombyx* and *Amphipholis squamata* along with amphipods such as *Ampelisca spinipes*. This biotope may also be characterised by the presence of conspicuous venerid bivalves, particularly *Timoclea ovata*. Other robust bivalve species such as *Tellina (=Moerella)* spp., *Glycymeris glycymeris* and *Astarte sulcata* may also be found in this biotope. *Spatangus purpureus* may be present especially where the interstices of the gravel are filled by finer particles, in which case, *Gari tellinella* may also be prevalent Venerid bivalves are often under-sampled in benthic grab surveys and as such may not be conspicuous in many infaunal datasets. Such communities in gravelly sediments may be relatively species-rich and they may also contain epifauna such as *Hydroides norvegicus* and *Pomatoceros lamarcki*. In sand wave areas this biotope may also contain elements of the FfabMag biotope, particularly *Magelona* species. This biotope has previously been described as the 'Deep *Venus* Community ' and the 'Boreal Off-Shore Gravel Association' and may also be part of the *Venus* community or the infralittoral etage. SCS.MedLumVen may be quite variable over time and in fact may be closer to a biotope complex in which a number of biotopes or sub-biotopes may yet be defined (e.g. *Echinocardium cordatum* - *Chamelea gallina* and *Spatangus purpurea* - *Clausinella fasciata*). Furthermore, mosaics of cobble and lag gravel often contain ridges of coarse gravelly sand and these localised patches are also characterised by robust veneriid and similar bivalves including *Arcopagia crassa*, *Laevicardium crassum* and others including *Glycymeris glycymeris*. This high porosity fine gravel or coarse sand may be a separate biotope. Situation: This biotope and variants of it make up a significant proportion of the offshore Irish Sea benthos. Temporal variation: MedLumVen may be quite variable over time.

A5.143: Protodorvillea kefersteini and other polychaetes in impoverished circalittoral mixed gravelly sand [1]. In coarse gravelly or shelly sand sometimes with slight mud content, along open coasts in depths of 10 to 30m, and in shallower offshore areas, an impoverished community characterised by *Protodorvillea kefersteini* may be found. This biotope has a number of other species associated with it including Nemertea spp., *Caulleriella zetlandica*, *Minuspio cirrifera*, *Glycera lapidum*, *Ampelisca spinipes* and numerous other polychaete species all occurring at low abundances. The polychaete *Sabellaria spinulosa* is also found in low numbers in this biotope Situation: This biotope has been reported in the North Sea along the Norfolk/Lincolnshire coast located in and around marine aggregate dredging areas. Temporal variation: This biotope may be quite variable both spatially and temporally in terms community structure and also sediment type which is often borderline between the SCS complex and the SMX complex.

A5.144: Neopentadactyla mixta in circalittoral shell gravel or coarse sand [1]. Sublittoral plains of clean, shell, maerl and/or stone gravels or sometimes coarse sands, with frequent *Neopentadactyla mixta*. *Pecten maximus* may occur occasionally along with *Lanice conchilega*. Other epifaunal species may include *Ophiura albida*, *Pagurus* spp. and *Callionymus* spp. These sediments may be thrown into dunes by wave action or tidal streams. Widespread species such as *Cerianthus lloydii* and *Chaetopterus variopedatus* are present in many examples of this biotope. Scarcely recorded species such as *Molgula oculata*, *Ophiopsila annulosa* and *Amphiura securigera* may also be found. *O. annulosa* only occurs in records from the south-west of the British Isles. It should be noted that *Neopentadactyla* may exhibit periodicity in its projection out of, and retraction into, the sediment.This biotope may be an epibiotic overlay of the biotope MedLumVen. Situation: This biotope may occur adjacent to maerl beds and to some extent in the lower infralittoral where some seaweeds may occur in low abundances.

A5.145: Branchiostoma lanceolatum in circalittoral coarse sand with shell gravel [1]. Gravel and coarse sand with shell gravel often contains communities of robust venerid bivalves (SCS.MedLumVen). Shallower examples, such as the biotope presented here, may support a significant population of *Branchiostoma lanceolatum*. Other conspicuous infauna may include *Echinocyamus pusillus*, *Glycera lapidum*, *Polygordius*, *Pisione remota* and *Arcopagia crassa* (in the south of UK). Sessile epifauna are typically a minor component of this community. This biotope has been described from a limited number of records and as such may need revising when further data become available. This biotope is related to the 'Boreal Offshore Gravel Association ' and 'Deep *Venus* Community ' described by other workers, and may also be closely allied as the '*Venus fasciata* ' community of Cabioch. This biotope may be an epibiotic overlay of the biotope SCS.MoeVen or SCS.MedLumVen.

A5.146: Scallops on shell gravel and sand with some sand scour [2] Further description not available.

Biotope Evaluation: Goods and Services

This biotope includes features that create microhabitats or localized shelter. It may also serve as an important nursery ground for various juvenile fishes, and provide food for several commercially important species.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

May be severely impacted from coastal human activities, particularly trawl fishing, as well as dredging for sand and gravel; gravel habitats are severely modified by aggregate extraction in licensed areas [3]. In some places within the licensed dredged areas, the impact on the seabed can be greater per unit area than bottom fishing as both the substrata and fauna are removed, which prolongs the recovery of the habitat and benthic community. In the past, dumping of solid wastes could trigger pollution incidents, but currently it is prohibited in the EU. Depths of such biotopes might be also favourable to wind energy installations, whose impacts on ecological goods and services need to be also considered.

Conservation and protection status

Included in the Council of Europe Bern Convention Res. No. 4 1996 as *Sublittoral soft seabed* (code 11.22), and in the Barcelona Convention (1998) as *Biocoenosis of coarse sands and fine gravels under the influence of bottom currents* (code IV.2.4).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] OSPAR/ICES/EEA (2000). Summary Report of the 2nd Workshop on Marine Habitat Classification, Southampton, 18-22 September 2000. CLAS 00/8/1-E

[3] Anonymous, 1999. *UK Biodiversity Group: tranche 2 action plans: volume V- maritime species and habitats*, English Nature, Peterborough, UK

[4] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

Deep circalittoral coarse sediment

Compiled by Tomas Vega Fernandez

Classification	Code	Title
EUNIS	A5.15	Deep circalittoral coarse sediment

Pictures
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements
Info compiled from [1]:
Salinity: full (30-35 ppt)
Wave exposure: moderately exposed, sheltered, very sheltered
Tidal streams: moderately strong (1-3 kn), weak (>1 kn), very weak (negligible)
Substratum: gravel and coarse sand
Zone: circalittoral
Depth band: 50-100 m or deeper.

Biotope Description
Offshore (deep) circalittoral habitats with coarse sands and gravel or shell. This biotope may cover large areas of the offshore continental shelf although there is relatively little quantitative data available. Such biotopes are quite diverse compared to shallower analogues and generally characterised by robust infaunal polychaete and bivalve species. Animal communities are closely related to offshore mixed sediments and in some areas settlement of *Modiolus modiolus* larvae may occur and consequently these biotopes may occasionally have large numbers of juvenile *M. modiolus*. In areas where the mussels reach maturity their byssus threads bind the sediment together, increasing stability and allowing an increased deposition of silt leading to the development of the biotope SBR.ModMx.

Associated Biotopes at EUNIS Level 5:
A5.151: Glycera lapidum, Thyasira spp. and Amythasides macroglossus in offshore gravelly sand [1]. Offshore (deep) circalittoral habitats with coarse sands and gravel, stone or shell and occasionally a little silt (<5%) may be characterised by the polychaetes *Glycera lapidum* and *Amythasides macroglossus* with the bivalve *Thyasira* spp. (particularly *Thyasira succisa*). Other taxa include polychaetes such as *Exogone verugera*, *Notomastus latericeus*, *Spiophanes kroyeri*, *Aphelochaeta marioni* (=*Tharyx marioni*) and *Lumbrineris gracilis* and occasional numbers of the bivalve *Timoclea ovata*. This biotope bears some resemblance to the shallow SCS.Glap and also to the circalittoral and offshore venerid biotopes (SCS.MedLumVen and SMX.PoVen) but differs by the range of polychaete and bivalve fauna present. This biotope is notable for the presence of the rarely recorded ampharetid polychaete *Amythasides macroglossus* and also for the small ear file clam *Limatula subauriculata* which is common in some examples of this biotope.
A5.152: Hesionura elongata and Protodorvillea kefersteini in offshore coarse sand [1]. Offshore (deep) circalittoral habitats with coarse sand may support populations of the interstitial polychaete *Hesionura elongata* with *Protodorvillea kefersteini*. Other notable species include the phyllodocid polychaete *Protomystides limbata* and the bivalve *Tellina (Moerella) pygmaea*. This biotope was reported in the offshore northern North Sea [2]. Relatively little data exists for this biotope.

Biotope Evaluation: Goods and Services
This biotope can provide habitat for shellfish and food for commercially important fish species. However,

regardless of the size of the biotope, the range of goods and services it can provide depends entirely on the species present and their life processes [3].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Can be impacted from offshore human activities, mainly trawl fishing, as well as dredging for gravels. In the past, dumping of solid wastes at sea could constitute an impact (currently prohibited in the EU).

Conservation and protection status

Included in the Council of Europe Bern Convention Res. No. 4 1996 as *Sublittoral soft seabed* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] Eleftheriou A, Basford DJ (1989) The macrobenthic infauna of the offshore northern North Sea. J Mar Biol Assoc UK, 69: 123-143

[3] Frid C, Paramor O (2006) Marine Biodiversity –the rationale for intervention: Building the evidence base for the Marine Bill. DEFRA report on www.defra.gov.uk.

Infralittoral fine sand

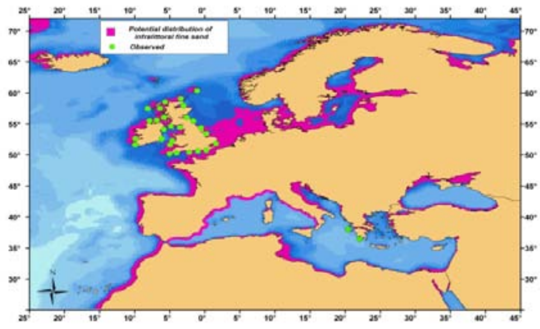
Compiled by Simone Mirto

Classification	Code	Title
EUNIS	A5.23	Infralittoral fine sand

Picture(s)

Not available

Biotope Distribution



Map of recorded and potential distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/maps/JNCCMNCR00001556.GIF

Biotope Requirements

Salinity: Full (30-35 ppt)
Wave exposure: Exposed, Moderately exposed, Sheltered
Tidal streams: Strong (3-6 kn), Moderately strong (1-3 kn), Weak (>1 kn), Very weak (negligible)
Substratum: Medium to very fine sand
Zone: Infralittoral
Depth Band: 0-5 m, 5-10 m, 10-20 m.

Biotope Description [1, 2]

Clean sands which occur in shallow water, either on the open coast or in tide-swept channels of marine inlets. The biotope typically lacks a significant seaweed component and is characterised by robust fauna, particularly amphipods (*Bathyporeia*) and robust polychaetes including *Nephtys cirrosa* and *Lanice conchilega* [1, 2].

Associated Biotopes at EUNIS Level 5:

A5.231: Infralittoral mobile clean sand with sparse fauna [1]. Medium to fine sandy sediment in shallow water, often formed into dunes, on exposed or tide-swept coasts often contains very little infauna due to the mobility of the substratum. Some opportunistic populations of infaunal amphipods may occur, particularly in less mobile examples in conjunction with low numbers of mysids such as *Gastrosaccus spinifer*, the polychaete *Nephtys cirrosa* and the isopod *Eurydice pulchra*. Sand eels *Ammodytes* spp. may occasionally be observed in association with this biotope (and others). This biotope is more mobile than SSA.NcirBat and may be closely related to LSa.BarSa on the shore. Common epifaunal species such as *Pagurus bernhardus*, *Liocarcinus depurator*, *Carcinus maenas* and *Asterias rubens* may be encountered and are the most conspicuous species present.

A5.232: Sertularia cupressina and Hydrallmania falcata on tide-swept sublittoral sand with cobbles or pebbles [1]. Shallow sands with cobbles and pebbles, exposed to strong tidal streams, with conspicuous colonies of hydroids, particularly *Hydrallmania falcata* and to a lesser extent *Sertularia cupressina* and *S. argentea*. These hydroids are tolerant to periodic submergence and scour by sand. Both diving and dredge surveys will easily record this biotope. *Flustra foliacea*, *Balanus crenatus* and *Alcyonidium diaphanum* may also occur on the more stable cobbles and pebbles, with *Urticina felina* and occasional *Lanice conchilega* present in the sand. Infaunal components of the other biotopes in the SSA or SCS complex may occur in this biotope as may elements of the '*Venus* ' associations; indeed, this biotope may be at one extreme of the spectrum of such associations and this biotope may be best considered an epibiotic overlay.

A5.233: Nephtys cirrosa and Bathyporeia spp. in infralittoral sand [1]. Well-sorted medium and fine sands characterised by *Nephtys cirrosa* and *Bathyporeia* spp. (and sometimes *Pontocrates* spp.) which occur in the shallow sublittoral to at least 30 m depth. This biotope occurs in sediments subject to physical disturbance, as a result of wave action (and occasionally strong tidal streams). The magelonid polychaete *Magelona mirabilis* may be frequent in this biotope in more sheltered, less tideswept areas whilst in coarser sediments the opportunistic polychaete *Chaetozone setosa* may be commonly found. The faunal diversity of this biotope is considerably reduced compared to less disturbed biotopes (such as FfabMag) and for the most part consists of the more actively-swimming amphipods. Sand eels *Ammodytes* spp. may occasionally be observed in association with this biotope (and others) and spionid polychaetes such as *Spio filicornis* and *S. martinensis* may also be present. Occasional *Lanice conchilega* may be visible at the sediment surface. Temporal variation: Stochastic recruitment events in the *Nephtys cirrosa* populations may be very important to the population size of other polychaetes present and may therefore create a degree of variation in community composition.

A5.234: Semi-permanent tube-building amphipods and polychaetes in sublittoral sand [1]. Sublittoral marine sand in moderately exposed or sheltered inlets and voes in shallow water may support large populations of semi-permanent tube-building amphipods and polychaetes. Typically dominated by *Corophium crassicorne* with other tube building amphipods such as *Ampelisca* spp. also common. Other taxa include typical shallow sand fauna such as *Spiophanes bombyx*, *Urothoe elegans*, *Bathyporeia* spp. along with various polychaetes including *Exogone hebes* and *Lanice conchilega*. *Polydora ciliata* may also be abundant in some areas. At the sediment surface, *Arenicola marina* worm casts may be visible and occasional seaweeds such as *Laminaria saccharina* may be present. As many of the sites featuring this biotope are situated near to fish farms it is possible that it may have developed as the result of moderate nutrient enrichment. The distribution of this biotope is poorly known and like the muddier SMU.AmpPlon, to which it is related, appears to have a patchy distribution. Temporal variation: It is possible that this biotope is a temporal or spatial variant of other more stable biotopes resulting from localised changes to sediment stability and organic status.

A5.235: Mediterranean communities of fine sands in very shallow waters [1]. These assemblages occur in very shallow water with seabottoms characterised by fine sands, usually with homogenous granulometry and of terrigenous origin. The characteristic species are: polychaete annelids: *Scolelepis* (= *Nerine*) *mesnili*, *Spiodecoratus*; bivalve molluscs: *Donax trunculus*, *D. semistriatus*, *Tellina tenuis*; decapod crustaceans: *Philocheras monacanthus*, *Portumnus latipes*; mysidaceans *Gastrosaccus mediterraneus*, *G. spinifer*; amphipods: *Bathyporeia* spp., *Pontocrates altamarinus*; isopod crustaceans: *Eurydice spiniger* and *Parachiridotea panousei.*

A5.236: Mediterranean communities of well sorted fine sands [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22]. This biocenosis often occupies vast areas along low coasts and in the bottoms of wide bays at depths 2 - 25 metres; sometimes it occupies vast areas along the coasts or in wide bays. The sediment is usually of homogeneous granulometry and terrigenous origin. Locally, the biocenosis of well sorted fine sands tolerates a slight lack of saltiness in the water near estuaries and surrounding some Mediterranean ponds. It thus presents a certain impoverishment, offset by the presence of some euryhaline species. When the wave action is too strong, the biocenosis can also be impoverished. Locally, the *Cymodocea nodosa* phanerogam can colonise certain areas, where it will constitute a local facies with epiflora. The fairly localized presence of some species (*Caulerpa prolifera*, *Halophila stipulacea*) also determines the forming of local facies. The characteristic species are: Polychaete annelids: *Sigalion mathildae*, *Onuphis eremita*, *Exogone hebes*, *Diopatra neapolitana;* bivalve molluscs: *Acanthocardia tuberculata* (=*Cardium tuberculatum*), *Mactra corallina* (=*stultorum*), *Tellina fabula*, *T. nitida*, *T. pulchella*, *Donax venustus;* gastropod molluscs: *Acteon tornatilis*, *Nassarius* (=*Nassa*) *mutabilis*, *Nassarius pygmaea*, *Neverita josephinia*; decapod crustaceans: *Macropipus barbatus*; amphipod crustaceans: *Ampelisca brevicornis*, *Hippomedon massiliensis*, *Pariambus typicus*; the isopod crustacean: *Idothea linearis;* echinoderms: *Astropecten* spp., *Echinocardium cordatum;* fishes: *Gobius microps*, *Callionymus belenus*. Association with *Halophila stipulacea* (also described under the EUNIS code A5.532): An association corresponding to the development as an epiflora of the *Halophila stipulacea* (Forsskål) Ascherson phanerogam species on sandy beds that are fairly much enriched with fine particles. The species has been sighted in the eastern Mediterranean (up to 50 metres down) and, more recently, on the coasts of Albania, Sicily and Greece, where it has been sighted up to 30 metres down. A species that is originally from the Indian Ocean.Its phytosociological name: the Giaccone 1968 association with *Halophiletum stipulaceae*. It can be associated with *Cymodocea nodosa*, *Caulerpa prolifera* and *Caulerpa racemosa*. The epiphytic flora has been described; it is very typical of the phanerogams, by and large fairly poor, probably related to the fairly frequent renewal of its leaves. The fauna is probably made up of species met with among the photophilous algae, found in most phanerogam meadows. The sediment fauna is the same as that of the biocenosis of well sorted fine sands. In Sicily, the species has been found mixed with *Caulerpa racemosa*.

A5.237: Pontic communities of well sorted fine sands. No further description available.

Biotope Evaluation: Goods and Services

The epi- and infauna of this biotope may be rich and diverse. It supports predatory fish and bird species, e.g. the sand eel is an important prey species for bird populations. The biotope has a role in maintaining the balance of the beaches. In some area and seasons, these infralittoral biotopes become important for fishery activities. They are reproduction and nursery grounds for certain species and may be also feeding and shelter areas for flatfishes.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

This biotope is directly subjected to anthropogenic activity on the littoral: dredged sediment disposal, shoreline development, pollution emissions, turbid water, etc. Such areas are subjected to accumulation and sedimentation of fine particles from watercourses or anthropogenic waste, as hydrodynamics are usually not strong enough to prevent this. The latter may result in smothering sea bed, altering the characteristics of the biotope, and hence the organisms dwelling there. The latter is of particular importance to fishing activities carried out in such areas. Physical disturbance on such biotopes may be caused directly and indirectly by fishing and aggregate dredging activities [23]. Fishing may affect the physical integrity of the sediment system through, e.g. scraping, digging or ploughing of the seabed, whilst dredging activities spoil disposal and aggregate extraction would affect the sediment and hydrographic regime through a variety of effects [24].

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (Council of Europe Bern Convention, 1996): *Sublittoral soft seabeds* (code 11.22).

References

[1] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010).
[2] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough:

www.jncc.gov.uk/MarineHabitatClassification
[3] Aliani S, Bianchi CN, Morri C (1995) Lineamenti del benthos dei mari toscani. Atti Soc Tosc Sc Nat, Mem, Serie A, Suppl 52: 77-92
[4] Bellan Santini D, Lacaze JC, Poizat C (1994) Les biocénoses marines et littorales de Méditerranée, synthèse, menaces et perspectives. Collection Patrimoines Naturels. Secrétariat de la Faune et de la Flore/MNHN 19: 1-246
[5] Dauvin JC, Bellan G, Bellan-Santini D, Castric A, Comolet-Tirman J, Francour P, Gentil F, Girard A, Gofas S, Mahe C, Noël P, De Reviers B (1994) Typologie des ZNIEFF-mer, liste des paramètres et des biocénoses des côtes françaises métropolitaines. 2ème Ed. Collection Patrimoines Naturels. Secrétariat de la Faune et la Flore/MNHN 12: 1-64
[6] Gamulin-Brida H (1967) The benthic Fauna of the Adriatic Sea. Oceanogr Mar Biol Ann Rev 5: 535-568
[7] Massè H (1972a) Contribution à l'étude de la macrofaune de peuplements des sables fins infralittoraux de côtes de Provence. Bul Soc Ecol 3(1): 11-20
[8] Massè H (1972b) Quantitative investigations of sand-bottom macrofauna along the Mediterranean north-west coast. Mar Biol 15: 209-220
[9] Massè H (1972c) Contribution à l'étude de la macrofaune de peuplements des sables fins infralittoraux de côtes de Provence. VII. Discussion, comparaison, et interpretation des données quantitatives. Téthys 4(2): 397-422
[10] Peres JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Méditerranée. Rec Trav Stat Mar Endoume, 31(47): 1-137
[11] Picard J (1965) Recherches qualitatives sur les biocénoses marines des substrats meubles dragables de la région de Marseille. Rec Trav St Mar Endoume, 52(36): 1-160
[12] Ros JD, Romero J, Ballesteros E, Gili JM (1984) Diving in blue water. The benthos: 233-295 in MARGALEF R. ed., Western Mediterranean. Oxford, Pergamon Press, 363p.
[13] Alongi G, Cormaci M, Pizzuto F (1992) La macroflora epifita delle foglie di *Halophila stipulacea* (Forssk.) Aschers. Del porto di Catania. Biologia Marina suppl. al Notiziaro SIBM 1: 287-288
[14] Cancemi G, Terlizzi A, Scipione MB, Mazzella L (1994) Il prato ad *Halophila stipulacea* (Forssk.) Aschers. Di Naxos (Sicilia): caratteristiche della pianta e del popolamento a fauna vagile. Biol Mar Med 1(1): 401-402
[15] Di Martino V (2001) Vegetali marini tropicali in Calabria e Sicilia. Distribuzione ed ecologia. 4th InternWorkshop on *Caulerpa taxifolia*. GIS Posidonie publ. pp 395-402
[16] Giaccone G, Alongi G, Pizzuto F, Cossu A (1994) La vegetazione marine bentonica del Mediterraneo: II Infralittorale e Circalittorale. Boll Acc Gioenia Sci Nat 27 (346): 111-157
[17] Haritonidis S, Diapoulis A (1990) Evolution of Greek marine phanerogam meadows over the last 20 years. Posidonia Newsletter 3(2): 5-10
[18] Harmelin JG (1969) Contribution à l'étude de l'endofaune de prairies d' *Halophila stipulacea* de Méditerranée orientale. Rec Trav Sta mar Endoume 45 (61): 305-316
[19] Ledoyer M (1966) Ecologie de la faune vagile des biotopes méditerranéens accessibles en scaphandre autonome. II. Données analytiques sur les herbiers de phanérogames. Rec Trav St mar Endoume 57(41): 135-164
[20] Rindi F, Maltagliati F, Rossi F, Acunto S, Cinelli F (1999) Algal flora associated with a *Halophilastipulacea* (Forsskål) Ascherson (Hydrocharitaceae, Helabiae) stand in the western Mediterranean. Oceanol Acta 22 (4): 421-429
[21] Zibrowius H (1993) Records of *Halophila stipulacea* from "Calypso" cruises in Greek and Turkish waters, 1955-1977. Posidonia Newsletter 4(2): 7-10
[22] Bellan-Santini D, Bellan G, Bitar G, Harmelin JG, Pergent G (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. Publication of Regional Activity Centre for Specially Protected Areas, United Nations Environment Programme, Action Plan for the Mediterranean. Available at http://www.rac-spa.org/
[23] MarLIN (2004) Biodiversity & Conservation: Habitats. Available online at: http://marlin.ac.uk/habitatimportance/habitatid/2004codes
[24] Elliot M, Nedwell S, Jones NV, Read SJ, Cutts ND, Hemingway KL (1998) Intertidal sand and mudflats & subtidal mobile sandbanks. In: *An overview of dynamic and sensitivity for conservation management of marine SACs*. Scottish Association for Marine Science for the UK Marine SACs Project

Infralittoral muddy sand

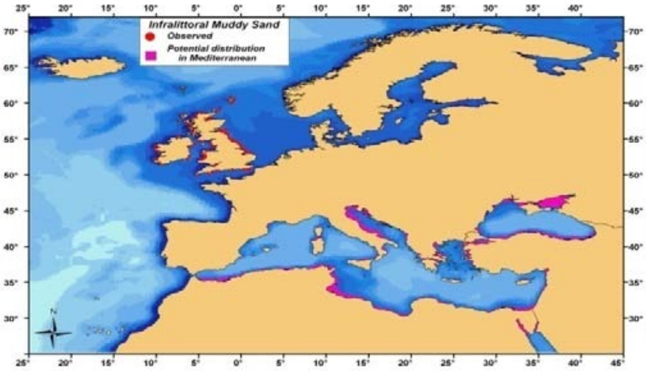
Compiled by Carlo Pipitone

Classification	Code	Title
NATURA 2000	1110	Sandbanks which are slightly covered by sea water all the time
EUNIS	A5.24	Infralittoral muddy sand

Picture(s)

Not available

Biotope Distribution



Map of recorded and potential distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00001559 (for UK and Ireland)

Biotope Requirements

Information compiled from [1]:
Salinity: full (30-35‰), variable (18-35‰)
Wave exposure: moderately exposed, sheltered
Tidal streams: moderately strong (1-3 kn), weak (>1 kn), very weak (negligible)
Substratum: fine to very fine sand with a silt fraction
Zone: infralittoral
Depth band: 0-5 m, 5-10 m, 10-20 m.

Biotope Description

Information compiled from [1]:
Non-cohesive muddy sand (with 5% to 20% silt/clay) in the infralittoral zone, extending from the extreme lower shore down to more stable circalittoral zone at about 15-20 m. This habitat supports a variety of animal-dominated communities, particularly polychaetes (*Magelona mirabilis*, *Spiophanes bombyx* and *Chaetozone setosa*), bivalves (*Fabulina fibula* and *Chamelea gallina*) and the sea-urchin *Echinocardium cordatum*. Most fish species occurring on pure sandy bottoms may well be found in this biotope; in the Mediterranean the most frequent families in this biotope are Sparidae, Mullidae, Bothidae, Gobiidae, Mugilidae, Triglidae, Callionymidae, and Labridae.

Associated Biotopes at EUNIS Level 5:
A5.241: Echinocardium cordatum and Ensis spp. in lower shore and shallow sublittoral slightly muddy fine sand [2]. Sheltered lower shore and shallow sublittoral sediments of sand or muddy fine sand in fully marine conditions, support populations of the urchin *Echinocardium cordatum* and the razor shell *Ensis siliqua* or *E. ensis*. Other notable taxa within this biotope include occasional *Lanice conchilega*, *Pagurus* and *Liocarcinus* spp. and *Asterias rubens*. This biotope has primarily been recorded by epifaunal dive, video or trawl surveys where the relatively conspicuous taxa *E. cordatum* and *Ensis* spp. have been recorded as characteristic of the

community. However, these species, particularly *E. cordatum* have a wide distribution and are not necessarily the best choice for a characteristic taxon. Furthermore, detailed quantitative infaunal data for this biotope is often rather scarce, possibly as a result of survey method as remote grab sampling is likely to under-estimate deep-burrowing species such as *Ensis* sp. Consequently, it may be better to treat this biotope as an epibiotic overlay which is likely to overlap a number of other biotopes. The precise nature of this infaunal community will be related to the nature of the substratum, in particular the quantity of silt/clay present. Infaunal species may include the polychaetes *Spiophanes bombyx*, *Magelona mirabilis*, *Nephtys cirrosa* and *Chaetozone setosa* and the amphipod *Bathyporeia* spp. This biotope is currently broadly defined and needs further consideration as to whether it should be placed at biotope or biotope complex level. It is likely that this biotope is part of a wider epibiotic sand /muddy sand community complex.

A5.242: Fabulina fabula and Magelona mirabilis with venerid bivalves and amphipods in infralittoral compacted fine muddy sand [2]. In stable, fine, compacted sands and slightly muddy sands in the infralittoral and littoral fringe, communities occur that are dominated by venerid bivalves such as *Chamelea gallina*. This biotope may be characterised by a prevalence of *Fabulina fabula* and *Magelona mirabilis* or other species of *Magelona* (e.g. *M. filiformis*). Other taxa, including the amphipod *Bathyporeia* spp. and polychaetes such as *Chaetozone setosa*, *Spiophanes bombyx* and *Nephtys* spp. are also commonly recorded. In some areas the bivalve *Spisula elliptica* may also occur in this biotope in low numbers. The community is relatively stable in its species composition; however, numbers of *Magelona* and *F. fabula* tend to fluctuate. Around the Scilly Isles numbers of *F. fabula* in this biotope are uncommonly low whilst these taxa are often found in higher abundances in muddier communities (presumably due to the higher organic content). Consequently it may be better to revise this biotope on the basis of less ubiquitous taxa such as key amphipod species although more data is required to test this. This biotope is considered to be part of the 'shallow *Venus* community' or 'boreal off-shore sand association' of previous workers. These communities have been shown to correlate well with particular levels of current induced 'bed-stress'. The 'Arctic *Venus* Community' and 'Mediterranean *Venus* Community' described to the north and south of the UK probably occur in the same biotope and appears to be the same biotope described as the *Ophelia borealis* community in northern France and the central North Sea. Sites with this biotope may undergo transitions in community composition. Other epibiotic biotopes may also overlay this biotope in some areas.

A5.243: Arenicola marina in infralittoral fine sand or muddy sand [2]. In shallow fine sand or non-cohesive muddy sand in fully marine conditions (or occasionally in variable salinity) a community characterised by the polychaete *Arenicola marina* may occur. This biotope appears quite faunally sparse. Those other taxa present however, include scavenging crustacea such as *Pagurus bernhardus* and *Liocarcinus depurator*, terebellid polychaetes such as *Lanice conchilega* and the burrowing anemone *Cerianthus lloydii*. Occasional *Sabella pavonina* and frequent *Ensis* spp. may also be observed in some areas. The majority of records for this biotope are derived from epifaunal surveys and consequently there is little information available for the associated infaunal species. It is possible that this biotope is an epibiotic overlay on other sublittoral sandy biotopes. At certain times of the year a diatom film may be present on the sediment surface.

A5.244: Spisula subtruncata and Nephtys hombergii in shallow muddy sand [2]. In shallow non-cohesive muddy sands, in fully marine conditions, a community characterised by the bivalve *Spisula subtruncata* and the polychaete *Nephtys hombergii* may occur. The sediments in which this community is found may vary with regard silt content but they generally have less than 20% silt/clay and in some areas may contain a degree of shell debris. Other important species in this community may include *Abra alba*, *Fabulina fabula* and *Mysella bidentata*. In addition, *Diastylis rathkei*, *Philine aperta* (in muddier sediments), *Ampelisca* spp., *Ophiura albida*, *Phaxas pellucidus* and occasionally *Bathyporeia* spp., may also be important, although this is not clear from the data available. In areas of slightly coarser, less muddy sediment *Spisula solida* or *S. elliptica* may appear occasionally in this biotope. Abundances of *Spisula subtruncata* in this biotope are often very high and distinguish it from other closely related biotopes. Extensive areas of this community to the north east of the Dogger Bank were recorded in the 1950s, but these seem to have declined since then. More information is required with regard the status of this biotope. In some areas this biotope may be a temporal variant or other sublittoral sandy biotopes.

A5.245: Turritella in muddy sands*.*No further description available.

A5.246: Ervillia castanea beds in infralittoral sand*.* No further description available.

A5.247: Pontic thalassinid-dominated muddy sands with Upogebia pusilla*.* No further description available.

A5.248: Pontic muddy sands with Mya arenaria and Anadara inaequivalvis*.* No further description available.

Biotope Evaluation: Goods and Services

Even though this biotope does not support generally high-biodiversity communities, its benthic fauna may provide food for several commercially important fish species and also host invertebrate populations important to fisheries (e.g. *Chamelea gallina, Tapes* spp.). This biotope may be important as feeding area for marine birds and as nursery for coastal fish (especially Sparidae in the Mediterranean).

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Infralittoral muddy sands may be severely impacted from coastal human activities, when these involve dumping or discharge of solid or liquid wastes at sea: dredged sediment disposal, industrial plants, agriculture, aquaculture farms, building activities, coastal urban centres can affect directly or indirectly this biotope. Also fishing in general, and the use of bottom-towed fishing gears in particular (which is prohibited at this depth range in the Mediterranean), impact this biotope. Small benthic invertebrates of the infauna are sometimes collected as bait by recreational fishermen.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (1996): *Sublittoral soft seabeds* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

Circalittoral fine sand

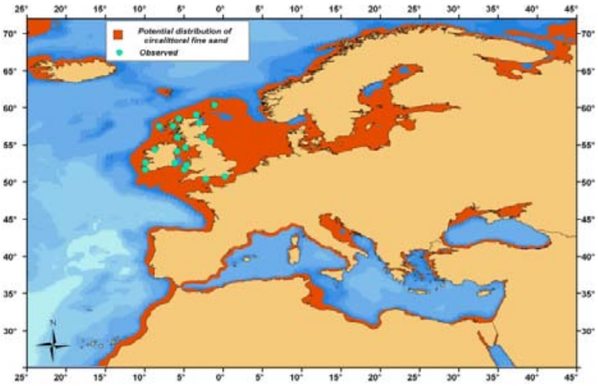
Compiled by Tomas Vega Fernandez

Classification	Code	Title
EUNIS	A5.25	Circalittoral fine sand

Picture(s)

Not available

Biotope Distribution



Map of recorded and potential distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00000321 (for UK and Ireland)

Biotope Requirements [1]

Salinity: full (30-35 ppt), variable (18-35 ppt)
Wave exposure: moderately exposed, sheltered, very sheltered
Tidal streams: weak (>1 kn), very weak (negligible)
Substratum: clean fine sands
Zone: circalittoral
Depth band: 10-20 m, 20-30 m, 30-50 m, 50-100 m, >100 m.

Biotope Description [1]

Clean fine sands with less than 5% silt/clay in deeper water, either on the open coast or in tide-swept channels of marine inlets in depths of over 15-20 m. The biotope may also extend offshore and is characterised by a wide range of echinoderms (in some areas including the pea urchin *Echinocyamus pusillus*), polychaetes and bivalves. This biotope is generally more stable than shallower, infralittoral sands and consequently supports a more diverse community. Most frequent taxa are *Cerianthus lloydii*, *Lanice conchilega*, *Pagurus bernhardus*, *Asterias rubens*, *Amphiura filiformis* and *Ophiura albida*.

Associated Biotopes at EUNIS Level 5:

A5.251: Echinocyamus pusillus, Ophelia borealis and Abra prismatica in circalittoral fine sand [1]. Circalittoral and offshore medium to fine sand (from 40 m to 140 m) characterised by the pea urchin *Echinocyamus pusillus*, the polychaete *Ophelia borealis* and the bivalve *Abra prismatica*. Other species may include the polychaetes *Spiophanes bombyx*, *Pholoe* sp., *Exogone* spp., *Sphaerosyllis bulbosa*, *Goniada maculata*, *Chaetozone setosa*, *Owenia fusiformis*, *Glycera lapidum*, *Lumbrineris latreilli* and *Aricidea cerrutii* and the bivalves *Thracia phaseolina* and *Tellina (=Moerella) pygmaea* and to a lesser extent *Spisula elliptica* and *Timoclea ovata*. This biotope has been found in the central and northern North Sea.

A5.252: Abra prismatica, Bathyporeia elegans and polychaetes in circalittoral fine sand [1]. In circalittoral and offshore medium to fine sands between 25m and 100m a community characterised by the bivalve *Abra prismatica*, the amphipod *Bathyporeia elegans* and polychaetes such as *Scoloplos armiger*, *Spiophanes bombyx*, *Aonides paucibranchiata*, *Chaetozone setosa*, *Ophelia borealis* and *Nephtys longosetosa* may be found. Crustacea such as the cumacean *Eudorellopsis deformis* and the opheliid polychaetes such as *Ophelia borealis*,

Travisia forbesii or *Ophelina neglecta* are often present in this biotope and the brittlestar *Amphiura filiformis* may also be common at some sites. This biotope has been reported in the central and northern North Sea [2, 3].
A5.253: Medium to very fine sand, 100-120 m, with polychaetes *Spiophanes kroyeri, Amphipectene auricoma, Myriochele sp., Aricidea wassi* and amphipods *Harpinia antennaria*. No further description available.

Biotope Evaluation: Goods and Services

This biotope is a source of sand for beach replenishment and other uses. It also provides habitat and food for commercially important fish species, as well as nursery areas for some of them.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	X		
Raw materials		X	
Air quality and climate regulation			X
Disturbance and natural hazard prevention			X
Water quality regulation / Bioremediation of waste			X
Cognitive benefits			X
Leisure, recreation and cultural inspiration			X
Feel good or warm glow			X
Photosynthesis and primary production			X
Nutrient cycling		X	
Reproduction and nursery areas	X		
Maintenance of biodiversity		X	

Sensitivity to human activities

Can be impacted from coastal human activities, mainly trawl fishing as well as sand mining activities which alter sea bed structure and biodiversity. In the past, it could be impacted by dumping of solid wastes (currently prohibited in the EU).

Conservation and protection status

Included as *Sublittoral sands* in EUNIS, therefore in the Council of Europe Bern Convention Res. No. 4 1996 as *Sublittoral soft seabed* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] Eleftheriou A, Basford DJ (1989) The macrobenthic infauna of the offshore northern North Sea. J Mar Biol Ass UK 69: 123-143

[3] Künitzer A, Basford D, Craeymeersch JA, Dewarumez JM, Dörjes J, Duineveld GCA, Eleftheriou A, Heip C, Herman P, Kingston P, Niermann U, Rachor E, Rumohr H, de Wilde PAJ (1992) The benthic infauna of the North Sea: species distribution and assemblages. ICES J Mar Sci 49: 127-143

Circalittoral muddy sand

Compiled by Carlo Pipitone

Classification	Code	Title
EUNIS	A5.26	Circalittoral muddy sand

Picture(s)
Not available

Biotope Distribution
Not available

Links to Available Maps
http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00001203 (for UK and Ireland)

Biotope Requirements [1]
Salinity: full (30-35‰)
Wave exposure: exposed, moderately exposed
Tidal streams: moderately strong (1-3 kn), weak (>1 kn), very weak (negligible)
Substratum: fine to very fine sand with a fine silt fraction
Zone: circalittoral
Depth band: 10-20 m to 30-50 m.

Biotope Description [1]
Circalittoral non-cohesive muddy sands with the silt content of the substratum typically ranging from 5% to 20%. This biotope is generally found in water depths of over 15-20m and supports animal-dominated communities characterised by a wide variety of polychaetes, bivalves such as *Abra alba* and *Nucula nitidosa*, and echinoderms such as *Amphiura* spp., *Ophiura* spp. and *Astropecten irregularis*. Other frequent species are the polychaetes *Scoloplos armiger*, *Spiophanes bombyx*, *Chaetozone setosa*, the decapod *Pagurus bernhardus*, the bivalve *Fabulina fabula*, and the echinoderm *Asterias rubens*. In similar Mediterranean circalittoral biotopes many fish species occur, belonging to families Mullidae, Merlucciidae, Sparidae, Centracanthidae, Bothidae, Soleidae, Gobiidae, Triglidae. These circalittoral biotopes tend to be more stable than their infralittoral counterparts and as such support a richer infaunal community.

Associated Biotopes at EUNIS Level 5:
A5.261: Abra alba and Nucula nitidosa in circalittoral muddy sand or slightly mixed sediment [1]. Non-cohesive muddy sands or slightly shelly/gravelly muddy sand characterised by the bivalves *Abra alba* and *Nucula nitidosa*. Other important taxa include *Nephtys* spp., *Chaetozone setosa* and *Spiophanes bombyx* with *Fabulina fabula* also common in many areas. The echinoderms *Ophiura albida* and *Asterias rubens* may also be present. This biotope is part of the *Abra* community. Numbers of adult *Abra alba* can exceed 1000 m^{-2}.
A5.262: Amphiura brachiata with Astropecten irregularis and other echinoderms in circalittoral muddy sand [1]. In shallow, circalittoral non-cohesive muddy sand (typically less than 20% silt/clay) with full or low salinity, abundant populations of the brittlestar *Amphiura brachiata* may occur with other echinoderms such as *Astropecten irregularis*, *Asterias rubens, Ophiura ophiura* and *Echinocardium cordatum*. Other infaunal species typically include *Mysella bidentata, Lanice conchilega* and *Magelona filiformis*. This biotope is likely to form part of the non-cohesive/cohesive muddy sand communities, which make up the 'off-shore muddy sand association' described by other workers. It is possible that in some areas this biotope forms an epifaunal overlay which may cover a range of biotopes in years of good recruitment but does not develop into a settled or established community.

Biotope Evaluation: Goods and Services

The rich epi- and infauna of this biotope make it important in supporting predator communities such as mobile macrofauna and demersal fishes, some of which are commercially targeted by specific fisheries.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Sea bed structure of certain circalittoral soft biotopes subjected to human activities displayed pronounced changes over the years; macrobenthic communities appeared to be less numerous and more homogeneous. The main factor that can explain these differences is the grain-size of the sediments which has shown large changes: a strong decrease in the mud fraction and increase in the fine sand fraction. These sedimentary changes were linked with human activities: increase in bottom trawling effort that induces the resuspension of fine mud particles and the homogenization of sediments over large areas, and decrease in terrigenous particulate fluxes due to human activities on the shoreline and in coastal waters [2].

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (1996): *sublittoral soft seabeds* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] Hily C, Le Loc'h F, Grall J, Glémarec M (2008) Soft bottom macrobenthic communities of North Biscay revisited: Long-term evolution under fisheries-climate forcing. Est Coast Shelf Scie 78: 413-425

Mediterranean communities of superficial muddy sands in sheltered waters

Compiled by Simone Mirto

Classification	Code	Title
EUNIS	A5.28	Mediterranean communities of superficial muddy sands in sheltered waters

Picture(s)
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements
Stage: Infralittoral
Nature of substratum: Muddy sand
Bathymetrical distribution: 1-3 metres
Position: Open sea
Hydrodynamics: Weak
Salinity: Normal, slight lack of salt possible
Temperature: Normal

Biotope Description [1, 2, 3, 4, 6]
A biotope located in protected coves, in a sheltered environment, where fine sedimentation can happen that gives a muddy-sandy sediment sometimes mixed with a small amount of gravels. Its depth is usually around 1 metre, rarely more than 3 metres. These shallow areas receive very variable environmental conditions and may present facies with epiflora or major developments of filtering or burrowing species. These environmental variations are linked to fairly strong sedimentation conditions, to climatic conditions, with great differences in temperature between winter and summer and even during the same day, to the possibility of rainwater runoff or ground water seepage, and to anthropic action.
The presence of this biotope can be seen behind a *Posidonia* barrier reef, a scenario that now only exists very rarely in certain countries.
The muddy sands in sheltered waters can sometimes be confused with the lagoon and estuary muddy sands and muds and with the euryhaline and eurythermal lagoon biocenosis, but in both cases these habitats are present in markedly more desalinated environments. Confusion is only possible in rare geomorphological situations: the entrance of a lagoon and a watercourse emptying into a shallow bay.
Characteristic/indicator species are: Polychaete annelids: *Phyloaricia foetida*, *Paradoneis lyra*, *Heteromastus filicornis*; Bivalve molluscs: *Loripes lacteus*, *Paphia* (=*Tapes*) *aurea*, *Tapes decussates*; Gastropod molluscs: *Cerithium vulgatum*, *C. rupestre*; Decapod crustaceans: *Upogebia pusilla*, *Clibanarius erythropus*, *Carcinus mediterraneus*; Sipunculid: *Golfingia vulgare*.

Associated Biotopes at EUNIS Level 5:
A5.281: Facies with Callianassa tyrrhena and Kellia corbuloides [5]. This facies of superficial muddy sands in sheltered waters is characterised by the dominance of the ghost shrimp *Callianassa tyrrhena* and the bivalve mollusc *Kellia corbuloides*.
A5.282: Facies with fresh water resurgences with Cerastoderma glaucum and Cyathura carinata [6]. This facies, typical of fresh water springs, is characterised by the bivalve molluscs *Cerastoderma glaucum* and *Cyathura carinata*.
A5.283:Facies with Loripes lacteus, Tapes spp. [6]. This facies is characterised by the bivalve molluscs *Loripes lacteus* and *Tapes* spp.

A5.284: Association with Caulerpa prolifera on superficial muddy sands in sheltered waters [5]. This facies is characterised by the green alga *Caulerpa prolifera* and occurs in the warmest areas.
A5.285: Facies of hydrothermal oozes with Cyclope neritea and nematodes.These facies are characterised by the gastropod *Cyclope neritea* and some species of nematodes. The facies are present between 3 - 15 metres depth with high hydrothermal activity [6]. Other associated organisms that have been reported from this biotope include the decapod *Callianassa truncata* and a suite of sulphur-resistant species, such as the annelids *Limnodriloides pierantonii* and *Capitella aff. capitata* [7].

Biotope Evaluation: Goods and Services

An environment where birds can feed. Certain facies are exploited either for molluscs (e.g. *Paphia aurea = Tapes aureus*), whose market value for consumption is great, or for fishing bait (*Upogebia*, *Marphysa*, *Arenicola*, *Perinereis cultrifera*, etc). It is a very productive environment, mainly because of very intense phytoplanktonic and microphytobenthic developments. The productive capacity is often exploited by humans (fishing for clams and cockles, or collecting bait).

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

This biotope is subjected to various threats, among which physical disappearance as a practice of land reclamation, intense fishing for molluscs or bait (*Upogebia, Marphysa, Arenicola, Perinereis*), causing uncontrolled modification of the sedimentary bed, accumulation of detritus and pollutants because the water is insufficiently renewed and because of strong sedimentation at certain periods and in certain sectors. Moreover increased eutrophication takes place at sites for shellfish farming (*Mytilus galloprovincialis*), and destruction of the biotope by eliminating the natural or artificial barriers to facilitate the movement of water or of boats. Cleaning up of waste (either carried by the sea or terrigenous) has to be done with care to avoid biotope destruction. These areas must be given protective management with a refusal of any development that involves filling in or hydraulic modification. In the Mediterranean, facies with *Cymodocea nodosa, Caulerpa prolifera* and *Zostera noltii* enjoy legal status and an array of legal devices that protect all marine phanerogams.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (Council of Europe Bern Convention, 1996):

Sublittoral soft seabeds (code 11.22).

References

[1] Bellan Santini D, Lacaze JC, Poizat C (1994) Les biocénoses marines et littorales de Méditerranée, synthèse, menaces et perspectives. Collection Patrimoines Naturels. Secrétariat de la Faune et de la Flore/MNHN 19: 1-246

[2] Dauvin JC, Bellan G, Bellan-Santini D, Castric A, Comolet-Tirman J, Francour P, Gentil F, Girard A, Gofas S, Mahe C, Noël P, De Reviers B (1994) Typologie des ZNIEFF-mer, liste des paramètres et des biocénoses des côtes françaises métropolitaines. 2ème Edit. Collection Patrimoines Naturels. Secrétariat de la Faune et la Flore/MNHN 12: 1-64

[3] Peres JM (1967) The Mediterranean benthos. Oceanogr Mar Biol Ann Rev 5. 449-533

[4] Peres JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Méditerranée. Rec Trav Stat Mar Endoume 31(47): 1-137

[5] Bellan-Santini D, Bellan G, Bitar G, Harmelin JG, Pergent G (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. Publication of Regional Activity Centre for Specially Protected Areas, United Nations Environment Programme, Action Plan for the Mediterranean. Available at http://www.rac-spa.org/

[6] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

[7] Bianchi CN (2009) Priority habitats according to the SPA/BIO protocol (Barcelona Convention) present in Italy. Identification sheets. III. 2. 3. 7. Facies of hydrothermal vents with *Cyclope neritea* and nematodes. Biol Mar Medit, 16(1): 106-110

Infralittoral sandy mud

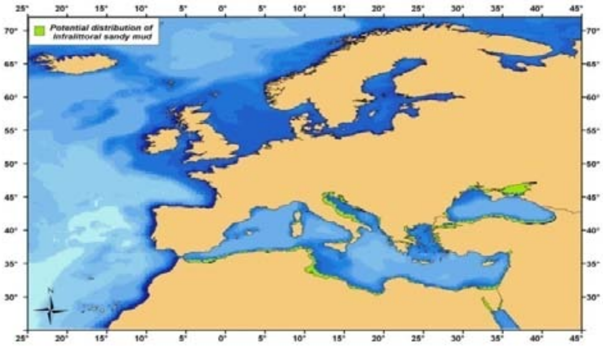
Compiled by Carlo Pipitone

Classification	Code	Title
NATURA 2000	1110	Sandbanks which are slightly covered by sea water all the time
EUNIS	A5.33	Infralittoral sandy mud

Picture(s)

Not available

Biotope Distribution



Map of potential distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002092 (for UK and Ireland)

Biotope Requirements [1]

Salinity: full (30-35‰), variable (18-35‰)
Wave exposure: sheltered, very sheltered, extremely sheltered
Tidal streams: moderately strong (1-3 kn), weak (>1 kn), very weak (negligible)
Substratum: mud with a fine to very fine sand fraction
Zone: infralittoral
Depth band: 0-5 m, 5-10 m, 10-20 m.

Biotope Description

Infralittoral, cohesive sandy mud, typically with over 20% silt/clay, in depths of less than 15-20 m. This biotope is generally found in sheltered bays or marine inlets and along sheltered areas of open coast. Typical species include a rich variety of polychaetes including *Melinna palmata*, tube building amphipods (*Ampelisca* spp.) and deposit feeding bivalves such as *Macoma balthica* and *Mysella bidentata*. Sea pens such as *Virgularia mirabilis* and brittlestars such as *Amphiura* spp. may be present but not in the same abundances as those found in deeper circalittoral waters. Other frequent species are the sea anemone *Sagartiogeton undatus* and the polychaete *Nephtys hombergii* [1]. Fishes that can be found in this biotope include species of families Bothidae, Triglidae, Mullidae, and Callionymidae.

Associated Biotopes at EUNIS Level 5:

A5.331: Nephtys hombergii and Macoma balthica in infralittoral sandy mud [1] develops on organically enriched near-shore shallow sandy muds and muds, and sometimes mixed sediments, between 5 and 20 m depth. It may be characterised by the presence of the polychaete *Nephtys hombergii* and the bivalve *Macoma balthica*. *Abra alba* and *Nucula nitidosa* may also be important although they may not necessarily occur simultaneously or in high numbers. Other taxa include *Spiophanes bombyx*, *Lagis koreni*, and *Echinocardium cordatum.* In some areas *Scoloplos armiger* and *Crangon crangon* may also be present. The community appears to be quite stable and the substratum is typically rich in organic content. This community has been included in the 'Boreal Offshore Muddy Sand Association' and is also described by several other authors. A similar community may occur in deep water in the Baltic. This biotope may occur in slightly reduced salinity estuarine conditions where *Mya* sp. may become a significant member of the community. This community may occur in small patches or swathes in shallow waters parallel to the shore or in shallow nearshore depressions or trenches where finer material accumulates e.g. off the Suffolk coast. This biotope is known to occur in patches between Denmark and the western English Channel.

A5.332: Sagartiogeton undatus and Ascidiella aspersa in infralittoral sandy mud [1]. Sheltered sublittoral mud or sandy mud in shallow water with relatively few conspicuous species may be characterised by the anemone *Sagartiogeton undatus* in low numbers and the tunicate *Ascidiella aspersa*. Other taxa may include *Carcinus maenas*, *Pagurus bernhardus* and terebellid polychaetes. The burrowing anemone *Cerianthus lloydii* may also be found occasionally. The status of this biotope is uncertain at present as it is not known whether it is an impoverished, disturbed or epifaunal variant of other sheltered, shallow mud biotopes or if the areas in which it has been recorded have been incompletely surveyed.

A5.333: Mysella bidentata and Abra spp. in infralittoral sandy mud [1]. Cohesive sandy mud in very sheltered areas at 0-20 m depth, sometimes with a small quantity of shells in shallow water may contain the bivalves *Mysella bidentata* and *Abra* spp. (typically *A. alba* and *A. nitida*). Other characteristic taxa may include *Scoloplos armiger*, *Mya* sp., and *Thyasira flexuosa*. Tube building amphipods are also characteristic of this biotope in particular *Ampelisca* spp. and Aoridae such as *Microprotopus maculatus*. This biotope is generally found in sheltered marine inlets or sealochs.

A5.334: Melinna palmata with Magelona spp. and Thyasira spp. in infralittoral sandy mud [1]. In infralittoral cohesive sandy mud at 5-20 m depth, in sheltered marine inlets, and occasionally variable salinity environments, dense populations of the polychaete *Melinna palmata* may occur, often with high numbers of *Magelona* spp. and the bivalve *Thyasira flexuosa*. Other important taxa may include *Chaetozone gibber, Nephtys hombergii, Galathowenia oculata, Euclymene oerstedii, Ampelisca tenuicornis, Ampharete lindstroemi*, *Abra alba* and *Phoronis* sp. In addition the polychaete *Aphelochaeta* spp. and the gastropod *Turritella communis* may be common or abundant in some areas. At the sediment surface visible taxa may include occasional *Virgularia mirabilis*, and mobile epifauna such as *Pagurus bernhardus.* This biotope is characteristic in many southern UK marine inlets and in some areas e.g. Plymouth Sound during high levels of recruitment when *M. palmata* often occurs in abundances between 500 to 1000 per m^2 moderate numbers of the species often 'overspill' into adjacent biotopes. In many areas this biotope is found on or near the boundary between euryhaline and polyhaline waters and in such areas moderately high numbers of *Aphelochaeta* spp. are often recorded. Numbers of *M. palmata* tend to vary considerably from year to year presumably due to recruitment and/or adult mortality.

A5.335: Ampelisca spp., Photis longicaudata and other tube-building amphipods and polychaetes in infralittoral sandy mud [1]. Sublittoral stable cohesive sandy muds in full salinity occurring over a wide depth range may support large populations of semi-permanent tube-building amphipods and polychaetes. In particular large numbers of the amphipods *Ampelisca* spp. and *Photis longicaudata* may be present along with polychaetes such as *Lagis koreni*. Other important taxa may include bivalves such as *Nucula nitidosa*, *Chamelea gallina, Abra alba* and *Mysella bidentata* and the echinoderms *Echinocardium cordatum* and *Amphiura brachiata*. In some areas polychaetes such as *Spiophanes bombyx* and *Polydora ciliata* may also be conspicuously numerous. This community is poorly known, appearing to occur in restricted patches. In some areas it is possible that it may develop as a result of moderate organic enrichment. A similar community in mud has also been reported in the Baltic which is characterised by large populations of amphipods such as *Ampelisca* spp., *Corophium* spp. and *Haploops tubicola*. Some researchers consider these biotopes to be part of a wider muddy sand community which varies temporally depending on changes in sediment deposition and recruitment as was reported in areas of Red Wharf Bay off the Welsh coast.

A5.336: Capitella capitata in enriched sublittoral muddy sediments [2]. The polychaete *Capitella capitata* is a widely-occurring, opportunist species complex that is particularly associated with organically enriched and polluted sediments where it may be superabundant. In very polluted/disturbed areas only *Capitella*, nematodes and occasional *Malacoceros fuliginosus* may be found whilst in slightly less enriched areas and estuaries species such as *Tubificoides*, *Cirriformia tentaculata*, *Pygospio elegans* and *Polydora ciliata* may also be found. In some areas, high numbers of the polychaete *Ophryotrocha* may also be present. *C. capitata* may become established as a result of anthropogenic activities such as fish farming and sewerage effluent but may also occur with natural enrichment as a result of, for example, coastal bird roosts. This biotope may also occur to some extent in the intertidal and in estuaries. It typically occurs in marine inlets, embayments or estuaries where organic enrichment allows *C. capitata* to outcompete other taxa, although the species may also occur in enriched muddy coastal sediments and also offshore where there is a high organic input from adjacent oil drilling platforms.

Biotope Evaluation: Goods and Services

This biotope does not include high-diversity communities, but it can provide food for several commercially important shallow-water fish species.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Infralittoral sandy muds may be severely impacted from coastal human activities, when these involve dumping or discharge of solid or liquid wastes at sea: dredged sediment disposal, industrial plants, agriculture, aquaculture farms, building activities, coastal urban centres can affect directly or indirectly this biotope. Fine sediments can trap pollutants for a long time, especially in sheltered areas.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (1996): *sublittoral soft seabeds* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

Infralittoral fine mud

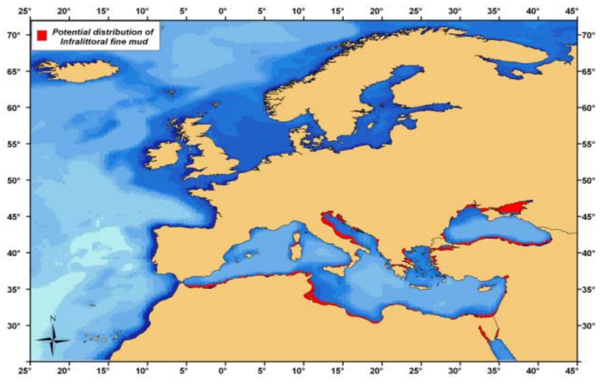
Compiled by Carlo Pipitone; Revised by Argyro Zenetos

Classification	Code	Title
EUNIS	A5.34	Infralittoral fine mud

Picture(s)

Not available

Biotope Distribution



Map of potential distribution

Links to Available Maps

http://www.jncc.gov.uk/marine/habitats/habitat.aspx?habitat=JNCCMNCR00001561 (for UK and Ireland)

Biotope Requirements [1]

Salinity: full (30-35‰), variable (18-35‰)
Wave exposure: sheltered, very sheltered, extremely sheltered
Tidal streams: weak (>1 kn), very weak (negligible)
Substratum: Mud (occasionally with shells or stones)
Zone: infralittoral
Depth band: 0-5 m, 5-10 m, 10-20 m.

Biotope Description [1]

Shallow sublittoral muds, extending from the extreme lower shore to about 15-20 m depth in fully marine or near marine conditions, predominantly in extremely sheltered areas with very weak tidal currents. Such biotopes are found in sealochs and some rias and harbours. Populations of the lugworm *Arenicola marina* may be dense, with anemones, the opisthobranch *Philine aperta* and synaptid holothurians also characteristic in some areas. The extent of the oxidised layer may be shallow with some areas being periodically or permanently anoxic. In these areas bacterial mats may develop on the sediment surface. Infaunal records for this habitat complex are limited encompassing only one biotope. They are therefore not representative of the full suit of infaunal species found in this biotope.

Associated Biotopes at EUNIS Level 5:
A5.341: Cerastoderma edule with Abra nitida in infralittoral mud [2]. Sheltered shallow sublittoral muds and gravelly muds in marine embayments, inlets or harbours may contain populations of the edible cockle *Cerastoderma edule* with *Abra nitida*. Other taxa may include the gastropod *Hydrobia ulvae*, cirraltulid polychaetes such as *Caulleriella* spp. and other polychaetes including *Hediste diversicolor* and *Aphelochaeta marioni*. Available data for this biotope in the UK are limited to parts of Southampton Water, Chichester Harbour and also in the Wash. The species list given here may therefore be far from complete. It is not known at this stage whether this biotope is a sublittoral extension of intertidal cockle beds or whether it exists independently of intertidal populations of *C. edule*.
A5.342: Arenicola marina in infralittoral mud [2]. In very shallow, extremely sheltered, very soft muds

Arenicola marina may form very conspicuous mounds and casts. This biotope may also contain synaptid holothurians such as *Labidoplax media* and *Leptosynapta bergensis* or *L. inhaerens*. However these species may be under recorded (possibly due to periodicity in feeding) and are not considered characteristic of this biotope. Other conspicuous fauna may include *Carcinus maenas*, *Asterias rubens* and *Pagurus bernhardus* whilst the turret shell *Turritella communis* may also be present in some areas. This biotope typically occurs in waters shallower than about 5 m in sheltered basins of sealochs and lagoons that may be partially separated from the open sea by tidal narrows or rapids. Sediment surfaces may become covered by a diatom film at certain times of the year.

A5.343: Philine aperta and Virgularia mirabilis in soft stable infralittoral mud [2]. Physically very stable muds, occasionally with small stones, with a high proportion of fine material (typically greater than 80%) may contain the opisthobranch *Philine aperta* and the seapen *Virgularia mirabilis*. These muds typically occur in shallow water down to about 12-15 m where significant seasonal variation in temperature is presumed to occur. This biotope is restricted to the most sheltered basins in, for example, sealochs. Although most records suggest full salinity conditions are prevalent, some sites may be subject to variable salinity. *P. aperta* is the most characteristic species of this biotope, occurring in high densities at many sites, whilst *V. mirabilis*, a species found more widely in muddy sediments, appears to reach its highest densities in this shallow mud but may not be present in all examples of this biotope. Other conspicuous species found in this shallow muddy biotope include *Cerianthus lloydii*, *Pagurus bernhardus*, *Sagartiogeton* spp. and *Hydractinia echinata*. Burrowing crustacean megafauna, characteristic of deeper mud, are rare or absent from this shallow sediment although the Norway lobster *Nephrops norvegicus* may sometimes be recorded. This biotope has been primarily recorded on the basis of its epifauna and conspicuous infauna. Little data exists on the infaunal component of this biotope but it may include *Nephtys* spp., spionid polychaetes, *Ampelisca* spp. and the bivalves *Nucula* spp., *Thyasira flexuosa*, *Mysella bidentata* and *Abra* spp. In the south of Great Britain, the polychaete *Sternaspis scutata* is also characteristic of this biotope. This polychaete is rare in Great Britain. Indeed, this southern variant of the biotope is very restricted in the UK to Portland Harbour but is known to occur further south in the Gulf of Gascony and the Mediterranean; in the Mediterranean a community of sticky muds with *V. mirabilis* and *Pennatula phosphorea* occurs as a facies of the circalittoral biocoenosis of coastal terrigenous muds [3]. It is possible that this biotope is a temporal variant of other sublittoral muddy biotopes. The key species *P. aperta* may be highly variable from year to year. The sediment may also be covered by a diatom film at certain times of the year.

A5.344: Ocnus planci aggregations on sheltered sublittoral muddy sediment [2]. Dense aggregations of the holothurian *Ocnus planci* on various substrata, typically muddy but occasionally with stones or shells, in sheltered conditions such as sealochs. *Philine aperta* also characterises this biotope but is present in lower abundances than in biotope A5.343. Other associated species vary but are typical of very sheltered muddy habitats and include the ophiuroids *Ophiura* spp. and *Ophiothrix fragilis*. *Melanella alba*, which parasitises holothurians, has been found in large numbers at one site.

A5.345: Astarte crenata beneath high salinity cold polar water [2]. No further description available.

A5.346: Oligochaetes in mobile mud [2]. No further description available.

Biotope Evaluation: Goods and Services

This biotope does not seem to offer particular goods and services due to its low-diversity community.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒

Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Infralittoral fine muds may be severely impacted from coastal human activities, when these involve dumping or discharge of solid or liquid wastes at sea: industrial plants, agriculture, aquaculture farms, building activities, coastal urban centres can affect directly or indirectly this biotope. Fine sediments can trap pollutants for a long time, especially in sheltered areas.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (1996): *sublittoral soft seabeds* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010).

[3] Peres JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec Trav Stat Mar Endoume 31: 1-137

Circalittoral sandy mud

Compiled by Carlo Pipitone

Classification	Code	Title
EUNIS	A5.35	Circalittoral sandy mud

Picture(s)

Not available

Biotope Distribution

Not available

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00002094 (for UK and Ireland)

Biotope Requirements [1]

Salinity: full (30-35‰)
Wave exposure: exposed, moderately exposed, sheltered, very sheltered
Tidal streams: moderately strong (1-3 kn), weak (>1 kn), very weak (negligible)
Substratum: mud with a significant fine to very fine sand fraction
Zone: circalittoral
Depth band: 5-10 m to 50-100 m.

Biotope Description [1]

Circalittoral, cohesive sandy mud, typically with over 20% silt/clay, generally in water depths of over 10 m, with weak or very weak tidal streams. This biotope is generally found in deeper areas of bays and marine inlets or offshore from less wave exposed coasts. Sea pens such as *Virgularia mirabilis* and brittlestars such as *Amphiura* spp. are particularly characteristic of this biotope whilst infaunal species include the tube building polychaetes *Lagis koreni* and *Owenia fusiformis*, and deposit feeding bivalves such as *Mysella bidentata* and *Abra* spp. Fish families frequently occurring in this biotope include Mullidae, Merlucciidae, Gadidae, Gobiidae, Bothidae, Soleidae, Triglidae.
Variants of this biotope occurring where the sedimentary rhythm is altered (by e.g. trawling) may belong to the biocoenosis of unstable soft bottoms described by Peres & Picard [2].

Associated Biotopes at EUNIS Level 5:
A5.351: Amphiura filiformis, Mysella bidentata and Abra nitida in circalittoral sandy mud [1]. Cohesive sandy mud off wave exposed coasts with weak tidal streams can be characterised by super-abundant brittlestar *Amphiura filiformis* with *Mysella bidentata* and *Abra nitida*. This community occurs in muddy sands in moderately deep water and may be related to the 'off-shore muddy sand association' described by other workers and is part of the infralittoral etage described by Glemarec. This community is also characterised by the sipunculid *Thysanocardia procera* and the polychaetes *Nephtys incisa*, *Phoronis* sp. and *Pholoe* sp., with cirratulids also common in some areas. Other taxa such as *Nephtys hombergii*, *Echinocardium cordatum*, *Nucula nitidosa*, *Callianassa subterranea* and *Eudorella truncatula* may also occur in offshore examples of this biotope.
A5.352: Thyasira spp. and Nuculoma tenuis in circalittoral sandy mud [1]. Circalittoral cohesive sandy muds with small quantities of gravel, off sheltered or moderately exposed coasts may support populations characterised by *Thyasira* spp. and in particular *Thyasira flexuosa*. Other characteristic taxa may include *Nuculoma tenuis* and *Goniada maculata* while, in some areas, *Rhodine gracilior*, *Mysella bidentata*, *Abra alba*, *Harpinia antennaria* and *Amphiura filiformis* may be abundant in parts of this biotope. Whilst moderately diverse, animal abundances are often low and it is possible that the biotope is the result of sedimentary disturbance, e.g. from trawling.
A5.353: Amphiura filiformis and Nuculoma tenuis in circalittoral and offshore muddy sand [3]. In cohesive and non-cohesive sandy mud, off moderately exposed coasts in deep water dense populations of *Amphiura filiformis* with the bivalve *Nuculoma tenuis* may occur. This biotope may be part of the *Amphiura filiformis* dominated infralittoral etage and part of the 'off-shore muddy sand association' described by other workers. Other species

characteristic of this biotope may include the echinoderms *Ophiura albida* and *Echinocardium flavescens* and the bivalve *Mysella bidentata*. *Phaxas pellucidus*, *Owenia fusiformis* and *Virgularia mirabilis* may also be present. At the sediment surface the hydroid *Sertularia argentea* may be present although only at very low abundances. Variations of this biotope exist in the northern North Sea and it is possible that more than one entity exists for this biotope.

A5.354: Virgularia mirabilis and Ophiura spp. with Pecten maximus on circalittoral sandy or shelly mud [3]. Circalittoral fine sandy mud may contain *Virgularia mirabilis* and *Ophiura* spp. A variety of species may occur, and species composition at a particular site may relate, to some extent, to the proportions of the major sediment size fractions. Several species are common to most sites including *V. mirabilis* which is present in moderate numbers, *Ophiura albida* and *O. ophiura* which are often quite common, and *Pecten maximus* which is usually only present in low numbers. *V. mirabilis* is usually accompanied by occasional *Cerianthus lloydii*, *Liocarcinus depurator* and *Pagurus bernhardus*. *Amphiura chiajei* and *A. filiformis* may occur in some examples of this biotope. Polychaetes and bivalves are generally the main components of the infauna, although the nemerteans *Edwardsia claparedii*, *Phoronis muelleri* and *Labidoplax buski* may also be widespread. Of the polychaetes *Goniada maculata*, *Nephtys incisa*, *Minuspio cirrifera*, *Chaetozone setosa*, *Notomastus latericeus* and *Owenia fusiformis* are often the most widespread species whilst *Myrtea spinifera*, *Lucinoma borealis*, *Mysella bidentata*, *Abra alba* and *Corbula gibba* are typical bivalves in this biotope. This biotope is primarily identified on the basis of its epifauna and may be an epibiotic overlay over other closely related biotopes. Such sediments are very common in sealochs, often occurring shallower than the finest mud or in somewhat more exposed parts of the lochs.

A5.355: Lagis koreni and Phaxas pellucidus in circalittoral sandy mud [3]. In stable circalittoral sandy mud dense populations of the tube building polychaete *Lagis koreni* may occur. Other species found in this biotope typically include bivalves such as *Phaxas pellucidus, Mysella bidentata* and *Abra alba* and polychaetes such as *Mediomastus fragilis*, *Spiophanes bombyx, Owenia fusiformis* and *Scalibregma inflatum*. At the sediment surface easily visible fauna include *Lagis koreni* and *Ophiura ophiura*. *Lagis koreni* is an important source of food for commercially important demersal fish, especially dab and plaice. In some areas e.g. Liverpool Bay, this biotope has exhibited cyclical behaviour with the community periodically switching from one biotope to another - possibly in relation to dredge spoil disposal along with other environmental and biological factors. Both *Lagis koreni* and *Phaxas pellucidus*, are capable of tolerating sudden increases in the deposition of sediment and often dominate such areas following such an event. Indeed it is likely that the two biotopes are merely different aspects of the same community as *Lagis koreni* is often recorded with high densities of *Abra alba*. Densities of mature populations of *L. koreni* may exceed 1000 m^{-2}.

Biotope Evaluation: Goods and Services

A variety of species may occur in this biotope, which includes a rich epi- and infauna and species composition at a particular site may relate, to some extent, to the proportions of the major sediment size fractions. Greater quantities of stones and shells on the surface may give rise to more sessile epibenthic species, some of which are important in the diets of many commercially fish and invertebrate predators [4].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒

Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Circalittoral biotopes are unlikely to be subject to human impacts related to coastal alteration as compared to shallower biotopes, and the fine sediments on which this biotope typically exists is not targeted for seabed extraction. However, due to the relatively stable conditions existing in these biotopes, in case of serious disturbance, they may show slow recovery.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (1996): *sublittoral soft seabeds* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] Peres JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec Trav Stat Mar Endoume 31: 1-137

[3] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

[4]MarLIN (2004) Biodiversity & Conservation: Habitats. Available online at: http://marlin.ac.uk/habitatimportance/habitatid/2004codes

Circalittoral fine mud

Compiled by Carlo Pipitone

Classification	Code	Title
EUNIS	A5.36	Circalittoral fine mud

Picture(s)

Not available

Biotope Distribution

Not available

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00000322 (for UK and Ireland)

Biotope Requirements [1]

Salinity: full (30-35‰), variable (18-35‰)
Wave exposure: moderately exposed, sheltered, very sheltered, extremely sheltered
Tidal streams: weak (>1 kn), very weak (negligible)
Substratum: mud
Zone: circalittoral
Depth band: 10-20 m to 30-50 m.

Biotope Description [1]

Sublittoral muds, occurring below moderate depths of 15-20 m, either on the open coast or in marine inlets such as sealochs. The seapens *Virgularia mirabilis* and *Pennatula phosphorea* are characteristic of this biotope complex together with the burrowing anemone *Cerianthus lloydii* and the ophiuroid *Amphiura* spp. The relatively stable conditions often lead to the establishment of communities of burrowing megafaunal species, such as *Nephrops norvegicus*. This biotope resembles the facies of sticky muds with *Virgularia mirabilis* and *Pennatula phosphorea* (EUNIS code A5.392), which develops in the Mediterranean at greater depth than in the Atlantic and hosts commercially important fish like Triglidae, Merlucciidae, Sparidae, Soleidae, Lophiidae. *Nephrops norvegicus* in the Mediterranean occurs at 10-50 m in northern and central Adriatic and on bathyal muds between 200 and 600 m in the western Mediterranean: this species seems linked more to the nature of substratum rather than to other factors [2].

Associated Biotopes at EUNIS Level 5:
A5.361: Seapens and burrowing megafauna in circalittoral fine mud [1]. Plains of fine mud at depths greater than about 15 m may be heavily bioturbated by burrowing megafauna; burrows and mounds may form a prominent feature of the sediment surface with conspicuous populations of seapens, typically *Virgularia mirabilis* and *Pennatula phosphorea*. The burrowing crustacea present typically include *Nephrops norvegicus*, which is frequently recorded from surface observations although grab sampling may fail to sample this species. Indeed, some forms of sampling may also fail to indicate seapens as characterising species. This biotope also seems to occur in deep offshore waters in the North Sea, where densities of *Nephrops norvegicus* may reach 68 per 10 m^{-2}, and the Irish Sea. The burrowing anemone *Cerianthus lloydii* and the ubiquitous epibenthic scavengers *Asterias rubens*, *Pagurus bernhardus* and *Liocarcinus depurator* are present in low numbers in this biotope whilst the brittlestars *Ophiura albida* and *O. ophiura* are sometimes present, but are much more common in slightly coarser sediments. Low numbers of the anemone *Pachycerianthus multiplicatus* may also be found, and this species, which is scarce in the UK, appears to be restricted to this biotope. The infauna may contain significant populations of the polychaetes *Pholoe* spp., *Glycera* spp., *Nephtys* spp., spionids, *Pectinaria belgica* and *Terebellides stroemi*, the bivalves *Nucula sulcata*, *Corbula gibba* and *Thyasira flexuosa*, and the echinoderm *Brissopsis lyrifera*. These soft mud habitats occur extensively throughout the more sheltered basins of sealochs and voes and are present in quite shallow depths (as little as 15 m) in these areas probably because they are very sheltered from wave action.
A5.362: Burrowing megafauna and Maxmuelleria lankesteri in circalittoral mud [3]. In circalittoral stable mud distinctive populations of megafauna may be found. These typically include *Nephrops norvegicus*, *Calocaris*

macandreae and *Callianassa subterranea*. Large mounds formed by the echiuran *Maxmuelleria lankesteri* are also frequent in this biotope. The seapen *Virgularia mirabilis* may occur occasionally in this biotope but not in large abundance. Infaunal species may include *Nephtys hystricis*, *Chaetozone setosa*, *Amphiura chiajei* and *Abra alba*.

A5.363: Brissopsis lyrifera and Amphiura chiajei in circalittoral mud [3]. Mud in deep offshore, or shallower stable nearshore, waters can be characterised by the urchin *Brissopsis lyrifera* and the brittle star *Amphiura chiajei*. Where intense benthic dredge fishing activity occurs, populations of the indicator species *B. lyrifera* may be depressed, although broken tests may still remain. Low numbers of the seapen *Virgularia mirabilis* may be found in many examples of this biotope. In addition, in certain areas of the UK such as the northern Irish Sea, this community may also contain *Nephrops norvegicus* and can consequently be the focus for fishing activity. Infaunal species in this community include the polychaetes *Nephtys hystricis*, *Pectinaria belgica*, *Glycera* spp. and *Lagis koreni* and the bivalves *Myrtea spinifera* and *Nucula sulcata*. This community is the 'Boreal Offshore Mud Association' and '*Brissopsis-chiajei*' communities described by other workers.

A5.364: Silty sediments > 140 m with polychaetes Lumbrineris fragilis, Levinsenia gracilis and amphipod Eriopisa elongata [3]. No further description available.

A5.365: Spiochaetopterus beneath high salinity Atlantic water [3]. No further description available.

A5.366: Macoma calcarea in deep-water soft clayey mud [3]. No further description available.

Biotope Evaluation: Goods and Services

The epi- and infauna of this biotope may be rich and diverse. The relatively stable conditions often lead to the establishment of communities of burrowing megafaunal species, and when large populations of species like Norway lobster *Nephrops norvegicus* occur, these circalittoral fine muds become important to bottom trawl fisheries.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Due to the circalittoral nature of this biotope, it is less subjected to human impacts as compared to shallower ones. Its deeper parts might be under the pressure of certain fishery activities though, mainly dredging and trawling. Due to the relatively stable conditions existing in these biotopes, in case of serious disturbance, they may show slow recovery.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (1996): *sublittoral soft seabeds* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] Relini G, Bertrand J, Zamboni A (1999) Synthesis of the knowledge on bottom fishery resources in central Mediterranean (Italy and Corsica). SIBM, Genova, pp 868

[3] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

Deep circalittoral mud

Compiled by Carlo Pipitone

Classification	Code	Title
EUNIS	A5.37	Deep circalittoral mud

Picture(s)
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements [1]
Salinity: full (30-35‰)
Wave exposure: very sheltered, extremely sheltered
Tidal streams: weak (>1 kn), very weak (negligible)
Substratum: mud with a sandy fraction
Zone: circalittoral
Depth band: 50-100 m, 100-200 m.

Biotope Description [2]
In mud and cohesive sandy mud in the offshore circalittoral zone, typically below 50-70 m, a variety of faunal communities may develop, depending upon the level of silt/clay and organic matter in the sediment. Communities are typically dominated by polychaetes but often with high numbers of bivalves such as *Thyasira* spp., echinoderms and foraminifera.

Associated Biotopes at EUNIS Level 5:
A5.371: Ampharete falcata turf with Parvicardium ovale on cohesive muddy sediment near margins of deep stratified seas [2]. Dense stands of *Ampharete falcata* tubes which protrude from muddy sediments, appearing as a turf or meadow in localised areas. These areas seem to occur on a crucial point on a depositional gradient between areas of tide-swept mobile sands and quiescent stratifying muds. Dense populations of the small bivalve *Parvicardium ovale* occur in the superficial sediment. Other infauna in this diverse biotope includes *Lumbrineris scopa*, *Levinsenia* sp., *Prionospio steenstrupi*, *Diplocirrus glaucus* and *Praxillella affinis* although a wide variety of other infaunal species may also be found. Both the brittlestars *Amphiura filiformis* and *A. chiajei* may be present together with *Nephrops norvegicus* in higher abundance than other circalittoral biotopes. Substantial populations of mobile epifauna such as *Pandalus montagui* and smaller fish also occur, together with those that can cling to the tubes, such as *Macropodia* spp. A similar turf of worm tubes formed by the maldanid polychaete *Melinna cristata* has been recorded from Northumberland. *Nephrops* trawling may severely damage this biotope and it is possible that such activity has destroyed examples of this biotope in the Irish Sea.
A5.372: Foraminiferans and Thyasira spp. in deep circalittoral soft mud [2]. In deep water and soft muds of Boreal and Arctic areas, a community dominated by foraminiferans and the bivalve *Thyasira* sp. (e.g. *T. croulinensis* and *T. pygmaea*) may occur. Foraminiferans such as *Saccammina*, *Psammosphaera*, *Haplophragmoides*, *Crithionina* and *Astorhiza* are important components of this community with dead tests numbering thousands per m^2 and sometimes visible from benthic photography. It is likely that a community dominated by *Astorhiza* in fine sands in the Irish Sea may be another distinct biotope. Polychaetes, e.g. *Paraonis gracilis*, *Myriochele heeri*, *Spiophanes kroyeri*, *Tharyx* sp., *Lumbrineris tetraura*, are also important components of this biotope. These communities appear to have no equivalent on the continental plateau further south but are known from the edge of the Celtic Deep in the Irish Sea. The benthos in these offshore areas has been shown to be principally Foraminifera and similar, rich communities may exist in Scottish sealochs. Communities from yet deeper (northern) waters at the extremes of the North Sea may be reminiscent, although dissimilar to this one reflecting a higher proportion of silt/clay. A fully Arctic version of this biotope has also been described although it should be noted that authors have considered this Boreal foraminiferan community to be part of a

'Boreal Deep Mud Association'.
This community typically occurs in water deeper than 100 m in the northern North Sea and have been referred to as 'Foraminifera communities' by other workers.
A5.373: Styela gelatinosa, Pseudamussium septemradiatum and solitary ascidians on sheltered deep circalittoral muddy sediment [2]. This biotope is known only from deep water in Loch Goil (Clyde sealochs) in fine mud at 65 m with terrigenous debris. Large numbers of solitary ascidians, including *Styela gelatinosa*, *Ascidia conchilega*, *Corella parallelogramma* and *Ascidiella* spp., are characteristic of this biotope together with the bivalve *Pseudamussium septemradiatum*. Terebellid worms, the bivalve *Abra alba* and the polychaete *Glycera tridactyla* may also occur. It is possibly an ice age relict biotope.
A5.374: Capitella capitata and Thyasira spp. in organically-enriched offshore circalittoral mud and sandy mud [2]. In circalittoral and deep offshore mud and sandy mud adjacent to oil or gas platforms, organic enrichment from drill cuttings leads to the development of communities dominated by *Capitella capitata*, an opportunist especially associated with organically enriched and polluted sediments. The bivalves *Thyasira flexuosa* or *T. sarsi* may also be found in moderate numbers at some sites. Other taxa may be present in low numbers in areas of less severe enrichment including *Pholoe inornata*, *Lagis koreni*, *Philine scabra*, *Anaitides groenlandica*, *Mediomastus fragilis* and *Paramphinome jeffreysii*.
A5.375: Levinsenia gracilis and Heteromastus filifirmis in offshore circalittoral mud and sandy mud [2]. In deep offshore mud and sandy mud a community characterised by the polychaetes *Levinsenia gracilis* and *Heteromastus filiformis* may occur. Other important taxa may include *Paramphinome jeffreysii*, *Nephtys hystricis* and *N. incisa*, *Spiophanes kroyeri*, *Orbinia norvegica*, *Terebellides stroemi*, *Thyasira gouldi* and *T. equalis*. Burrowing megafauna such as *Calocaris macandreae* may also be found in this biotope. This biotope has been found in the central and northern North Sea. A similar community, dominated by *L. gracilis* but accompanied by *Glycera* spp (particularly *Glycera rouxii*) and *Monticellina dorsobranchialis*, has also been reported from the Irish Sea. This Irish community also contains *Calocaris macandreae*, *Mediomastus fragilis*, *Tubificoides amplivasatus*, *Nephtys incisa*, *Ancistrosyllis groenlandica*, *Nucula sulcata*, *Litocorsa stremma* and *Minuspio* sp. and it is not known at present whether this represents a separate biotope or whether it is a geographic variant of a wider *Levinsenia* biotope. This biotope has been found in the central and northern North Sea and may also occur in the Irish Sea.
A5.376: Paramphinome jeffreysii, Thyasira spp. and Amphiura filiformis in offshore circalittoral sandy mud [2]. Deep, offshore cohesive sandy mud communities characterised by the polychaete *Paramphinome jeffreysii*, bivalves such as *Thyasira equalis* and *T. gouldi* and the brittlestar *Amphiura filiformis*. Other taxa may include *Laonice cirrata*, the sea cucumber *Labidoplax buski* and the polychaetes *Goniada maculata*, *Spiophanes kroyeri* and *Aricidea catherinae*. *Amphiura chiajei* may be occasional in this biotope as may *Philine scabra*, *Levinsenia gracilis* and *Pholoe inornata*. This biotope may comprise the *Amphiura* dominated components of the 'off-shore muddy sand association.
A5.377: Myrtea spinifera and polychaetes in offshore circalittoral sandy mud [2]. Deep, offshore habitats with cohesive sandy mud (>20% mud) may support communities characterised by infaunal polychaetes and the bivalve *Myrtea spinifera*. Polychaetes typically include *Chaetozone setosa*, *Paramphinome jeffreysii*, *Levinsenia gracilis*, *Aricidea catherinae* and *Prionospio malmgreni*. The bivalves *Thyasira* spp. and *Abra nitida* may also be found as may seapens, such as *Pennatula phosphorea*. Other biotopes contain *Myrtea spinifera* in lower numbers but these biotopes are generally sandier. This biotope has been recorded in the northern North Sea but may also exist in the Irish Sea.
A5.378: Baltic muddy bottoms of the aphotic zone. No further description available.

Biotope Evaluation: Goods and Services

The epi- and infauna of this biotope may be rich and diverse and may serve as food for several demersal fish species.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒

Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Deep circalittoral biotopes are less subjected to human impacts if compared to shallower biotopes, however they are vulnerable to effects from trawling activities. Due to the relatively stable conditions existing in these biotopes, in case of serious disturbance, they may show slow recovery.

Conservation and protection status

Listed as endangered natural habitat type in the Resolution no. 4 (1996): *sublittoral soft seabeds* (code 11.22).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

Mediterranean communities of muddy detritic bottoms

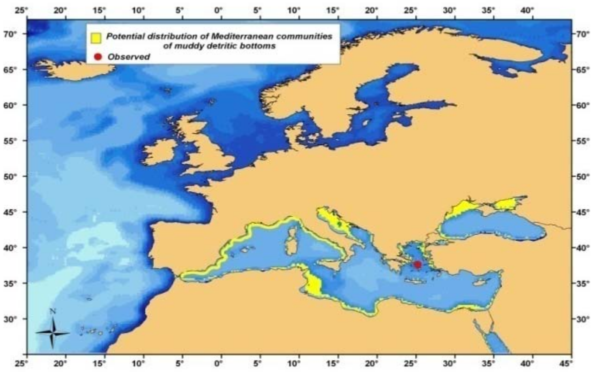
Compiled by Tomas Vega Fernandez

Classification	Code	Title
EUNIS	A5.38	Mediterranean communities of muddy detritic bottoms

Picture(s)

Not available

Biotope Distribution



Map of potential and observed distribution

Links to Available Maps

Not available

Biotope Requirements [1]

Salinity: full (30-35 ppt)
Wave exposure: very sheltered
Tidal streams: very weak (negligible)
Substratum: mud, sand, debris
Zone: circalittoral
Depth band: 50-100 m, > 100 m.

Biotope Description

This biocenosis develops in areas where a detritus bottom is covered with mud formed by terrigenous deposits from rivers. The sediment is a very muddy sand or sandy mud, or even a rather compacted mud, rich in shell debris or volcanic fragments (scoriae); sedimentation is slow enough to allow the development of sessile epifauna. Gravel, sand and mud are mixed in varying quantities, but mud always predominates [2]. The most characteristic taxa are the actinian *Eloactis mazeli*, the bivalve *Tellina serrata*, the polychaete *Leiocapitella dollfusi* and the isopod *Cirolana neglecta* [3].

<u>Associated Biotopes at EUNIS Level 5</u>:

A5.381: Facies with Ophiothrix quinquemaculata [2, 3]. This facies is exclusive to the muddy detritic biocenosis and is characterised by an unusual community of the brittlestar *Ophiothrix quinquemaculata* (Ophiuroidea). This species may be extremely dense at places, constituing up to 90% of the assemblage. Water movement must be enough to maintain particulate food suspended.

Biotope Evaluation: Goods and Services

Detritic biotopes inhabited by Mediterranean communities display substrata with predominance in bioclastic elements and usually exhibit relatively low species richness [3]. However, the nature of detritic formation could be diverse depending on the characteristics of surrounding substratum that may support specific decapod crustacean assemblages [4].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☒	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Characteristic flora and fauna that are highly sensitive to disturbances colonize detritic bottoms in the Mediterranean Sea; coastal areas are exposed to important levels of anthropogenic disturbance, mainly pollution (including changed sedimentation regimes) [5]. However, in years of high anthropogenic disturbance the general abundance of the macrofauna is decreased, but due to the elasticity of the system communities present a cyclic structure [4].

Conservation and protection status

Included in the Council of Europe Bern Convention Res. No. 4 1996 as sublittoral soft seabed. Included in the Barcelona Convention (1998) as *Biocoenosis of the muddy detritic bottom* (code IV.2.1).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough: www.jncc.gov.uk/MarineHabitatClassification

[2] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

[3] Pérès JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec Trav Stat Mar Endoume 31: 5-137

[4] Garcia JE, Manjon-Cabeza ME (2002) An infralittoral decapod crustacean community of southern Spain affected by anthropogenic disturbances. *J Crustac Biol* 22 (1): 83-90

[5] Klein JC, Verlaque M (2009) Macroalgal assemblages of disturbed coastal detritic bottoms subject to invasive species. *Est Coast Shelf Scie* 82 (3): 461-468

Mediterranean communities of coastal terrigenous muds

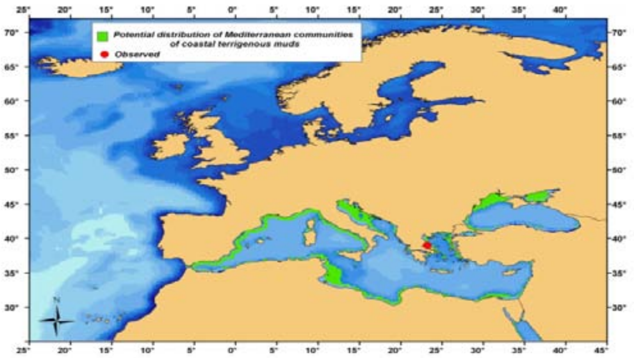
Compiled by Tomas Vega Fernandez; Revised by Carlo Pipitone

Classification	Code	Title
EUNIS	A5.39	Mediterranean communities of coastal terrigenous muds

Picture(s)

Not available

Biotope Distribution



Map of potential and observed distribution

Links to Available Maps

Not available

Biotope Requirements [1]

Salinity: full (30-35 ppt)
Wave exposure: sheltered, very sheltered
Tidal streams: weak to nonexistent; the appearance of facies can depend on certain currents
Substratum: mud, often of fluvial origin.
Zone: circalittoral
Depth band: from 30 m to 100 m.

Biotope Description [1, 2]

Mud sediment with a variable fraction of clay, almost always of fluvial origin. According to the clay content and to the silting rate, coastal terrigenous muds may be soft (mainly fluvial sediment with fast silting rate) or sticky (terrigenous sediment with slow silting rate). Motile epibenthic species, as well as fragments of mollusc shells, or other hard fragments occur only where the sediment is sufficiently firm (sticky mud).
According to their relationship with the sediment, several different species are characteristic of this biotope [1, 2]. Among infaunal species, the polychaetes *Sternaspis scutata, Lepidasthenia maculata*, *Phyllodoce lineata*, *Nereis longissima*, *Nephthys hystricis*, *Goniada maculata* and *Pectinaria belgica*; the bivalves *Cardium paucicostatum*, *Thyasira croulinensis*, *Mysella bidentata*, *Abra nitida* and *Thracia convexa*; the gastropod *Turritella communis*; the holothurians *Oerstergrenia (=Labidoplax) digitata*, *Trachythyone elongata* and *Trachythyone tergestina*; the crustacean *Aegaeon cataphractus*. Among pivoting species, the cnidarians *Virgularia mirabilis*, *Veretillum cynomorium* and *Pennatula phosphorea.* Among the epifauna, the polychaete *Aphrodite aculeata*; the decapod *Medorippe lanata*; the holothurian *Stichopus regalis*. Among sessile species, the cnidarian *Alcyonium palmatum*, the bivalve *Pteria hirundo* and the ascidian *Diazona violacea*. Several fish species may be very abundant, like e.g. *Mullus barbatus*, *Cepola macrophthalma*, *Dalophis imberbis*, *Lophius budegassa*, *Pagellus erythrinus*, *Arnoglossus* spp. and some gobiids.

Associated Biotopes at EUNIS Level 5:
A5.391: Facies of soft muds with Turritella tricarinata f. communis [3]. This facies is characterised by the presence of the gastropod *Turritella communis* which can constitute up to 95% of the assemblage (which is

made by molluscs to a large extent).
A5.392: Facies of sticky muds with Virgularia mirabilis and Pennatula phosphorea [3]. This facies is characterised by the soft corals *Virgularia mirabilis* and *Pennatula phosphorea* on sticky muddy bottoms, and quite often *Veretillum cynomorium* too. A facies dominated by the holothurian *Labidoplax digitata* may be recognized on soft reduced mud in the vicinity of river outlets [1]. Sticky muds sufficiently firm to support large debris - mainly mollusc shells - may host a facies characterized by sessile species growing on the debris like *Alcyonium palmatum*, *Pteria hirundo* and *Diazona violacea*. Also the large-sized holothurian *Stichopus regails* may be abundant in this facies [1].

Biotope Evaluation: Goods and Services

This biotope provides habitat and food for commercially important fish species, notably the red mullet (*Mullus barbatus*) as well as flatfishes.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Rather stable conditions prevail in this biotope [4]. However, it is impacted by human activities, mainly trawl-fishing, while in the past it could be also impacted by dumping of solid wastes which is currently prohibited in the EU.

Conservation and protection status

Included in the Council of Europe Bern Convention Res. No. 4 1996 as “sublittoral soft seabed” [3].

References

[1] Pérès JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec Trav Stat Mar Endoume 31: 5-137
[2] Peres JM (1982) Major benthic assemblages. Mar Ecol 5: 373-522
[3] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)
[4] Koulouri P, Dounas C, Arvanitidis Ch, Koutsoubas D & Eleftheriou A (2006) Molluscan diversity along a Mediterranean soft bottom sublittoral ecotone. *Scient Mar* 70(4): 573-583

Infralittoral mixed sediments

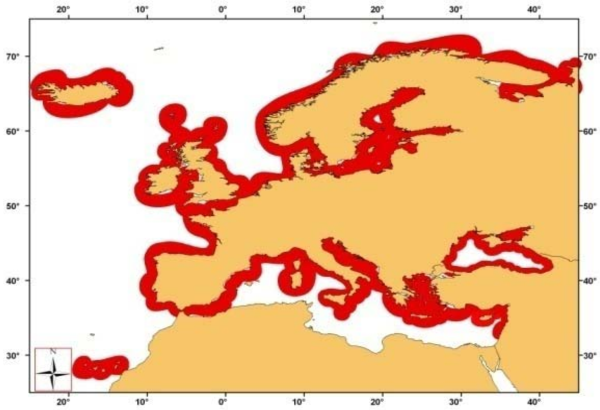
Compiled by Ibon Galparsoro, Ángel Borja and Marta Pascual; Revised by Argyro Zenetos

Classification	**Code**	**Title**
NATURA 2000	1140	Sandbanks which are slightly covered by sea water all the time
EUNIS	A5.43	Infralittoral mixed sediments

Picture(s)

Not available

Biotope Distribution



Map of potential distribution

Links to Available Maps

http://www.jncc.gov.uk/Marine/biotopes/biotope.aspx?biotope=JNCCMNCR00001565

Biotope Requirements

Shallow mixed (heterogeneous) sediments in fully marine or near fully marine conditions. With moderate to very sheltered wave exposure and strong to weak tidal streams. It supports various animal-dominated communities, with relatively low proportions of seaweeds. The habitat may include well mixed muddy gravelly sands or very poorly sorted mosaics of shell, cobbles and pebbles embedded in mud, sand or gravel [1].

Biotope Description

Due to the quite variable nature of the sediment type, a widely variable array of communities may be found, including those characterised by bivalves, polychaetes and file shells. This has resulted in many species being described as characteristic of this biotope all contributing only a small percentage to the overall similarity [1].

<u>Associated Biotopes at EUNIS Level 5:</u>

A5.431: Crepidula fornicata with ascidians and anemones on infralittoral coarse mixed sediment. Medium-coarse sands with gravel, shells, pebbles and cobbles on moderately exposed coasts may support populations of the slipper limpet *Crepidula fornicata* with ascidians and anemones. *C. fornicata* is common in this biotope though not as abundant as in the muddier estuarine biotope CreMed to which this is related. Anemones such as *Urticina felina* and *Alcyonium digitatum* and ascidians such as *Styela clava* are typically found in this biotope. Bryozoans such as *Flustra foliacea* are also found along with polychaetes such as *Lanice conchilega*. Little information is available with regard to the infauna of this biotope but given the nature of the sediment the infaunal communities are liable to resemble those in biotopes from the SCS habitat complex. As with FluHyd this biotope could be considered a superficial or epibiotic overlay but more data is required to support this [1].

A5.432: Sabella pavonina with sponges and anemones on infralittoral mixed sediment. Muddy gravelly sand with pebbles off shallow, sheltered or moderately exposed coasts or embayments may support dense populations of the peacock worm *Sabella pavonina*. This community may also support populations of sponges such as *Esperiopsis fucorum*, *Haliclona oculata* and *Halichondria panicea* and anemones such as *Sagartia* *elegans*, *Cerianthus lloydii* and *Urticina felina*. Hydroids such as *Hydrallmania falcata* and the encrusting polychaete *Pomatoceros triqueter* are also important. This biotope may have an extremely diverse epifaunal community. Less is known about its infaunal component, although it is likely to include polychaetes such as *Nephtys* spp., *Harmothoe* spp., *Glycera* spp., syllid and cirratulid polychaetes, bivalves such as *Abra* spp., Aoridae amphipods and brittlestars such as *Amphipholis squamata* [1].

A5.433: Venerupis senegalensis, Amphipholis squamata and Apseudes latreilli in infralittoral mixed sediment. Sheltered muddy sandy gravel and pebbles in marine inlets, estuaries or embayments with variable salinity or fully marine conditions, support large populations of the pullet carpet shell *Venerupis senegalensis* with the brittlestar *Amphipholis squamata* and the tanaid *Apseudes latreilli*. This biotope may be found at a range of depths from 5 m to 30 m although populations of *V. senegalensis* may also be found on the low shore. Other common species within this biotope include the gastropod *Calyptraea chinensis*, a range of amphipod crustacea such as *Corophium sextonae* and *Maera grossimana* and polychaetes such as *Mediomastus fragilis*, *Melinna palmata*, *Aphelochaeta marioni*, syllids and tubificid oligochaetes. Many of the available records for this biotope are from southern inlets and estuaries such as Plymouth Sound and Milford Haven but *V. senegalensis* has a much wider distribution and it should be noted that northern versions of this biotope may a have a much lower species diversity than reported here [1].

A5.434: Limaria hians beds in tide-swept sublittoral muddy mixed sediment. Mixed muddy gravel and sand often in tide-swept narrows in the entrances or sills of sealochs with beds or 'nests' of *Limaria hians*. The *Limaria* form woven 'nests' or galleries from byssus and fragments of seaweeds so that the animals themselves cannot be seen from above the seabed. *Modiolus modiolus* sometimes occurs at the same sites lying over the top of the *Limaria* bed. Other fauna associated with this biotope include echinoderms (*Ophiothrix fragilis*, *Ophiocomina nigra* and *Asterias rubens*), *Buccinum undatum*, mobile crustaceans (e.g. *Pagurus bernhardus*), *Alcyonium digitatum* and hydroids such as *Plumularia setacea*, *Kirchenpaueria pinnata* and *Nemertesia* spp. Sometimes red seaweeds such as *Phycodrys rubens* occur if the beds are in shallow enough water [1].

A5.435: Ostrea edulis beds on shallow sublittoral muddy mixed sediment. Dense beds of the oyster *Ostrea edulis*can occur on muddy fine sand or sandy mud mixed sediments. There may be considerable quantities of dead oyster shell making up a substantial portion of the substratum. The clumps of dead shells and oysters can support large numbers of *Ascidiella aspersa* and *Ascidiella scabra*. Sponges such as *Halichondria bowerbanki* may also be present. Several conspicuously large polychaetes, such as *Chaetopterus variopedatus* and terebellids, as well as additional suspension-feeding polychaetes such as *Myxicola infundibulum* and *Sabella pavonina* may be important in distinguishing this biotope, whilst the Opisthobranch *Philine aperta* may also be frequent in some areas. A turf of seaweeds such as *Plocamium cartilagineum*, *Nitophyllum punctatum* and *Spyridia filamentosa* may also be present. This biotope description may need expansion to account for oyster beds in England [1].

Biotope Evaluation: Goods and Services

Due to the variable nature of the seabed a variety of communities can develop which are often very diverse, including those characterised by bivalves, polychaetes, and file shells. The mixed sediment areas represent perhaps the most biodiverse of the sediment habitats in certain areas, and the combination of epifauna and infauna can lead to species rich communities. Many species in the biotope are likely to provide a food source for fishes, however, there is no evidence that any of the species in this biotope are exploited commercially [2].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☒	☐

Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

The biotope is impacted by increased wave exposure and is vulnerable to substratum loss due to anthropogenic activities taking place in shallow areas.

Conservation and protection status

Council of Europe Bern Convention Res. No. 4 1996. *Sublittoral soft seabeds*. Code: 11.22

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) EUNIS habitat classification

[2] MarLIN (2004) Biodiversity & Conservation: Habitats. Available online at: http://marlin.ac.uk/habitatimportance/habitatid/2004codes

Circalittoral mixed sediments

Compiled by Ibon Galparsoro, Marta Pascual and Ángel Borja

Classification	Code	Title
NATURA 2000		
EUNIS	A5.44	Circalittoral mixed sediments

Picture(s)

Not available

Biotope Distribution

Not available

Links to Available Maps

(UK distribution)
http://www.jncc.gov.uk/Marine/biotopes/biotope.aspx?biotope=JNCCMNCR00000323)
Other maps available at: www.jncc.gov.uk

Biotope Requirements

Fully saline circalittoral mixed (heterogeneous) sediment habitats in the circalittoral zone (generally below 15-20 m). It could range between moderately exposed, sheltered, and very sheltered from wave exposure. Tidal streams range from moderately strong (1-3 kn), up to very weak (negligible). It includes well mixed muddy gravelly sands or very poorly sorted mosaics of shell, cobbles and pebbles embedded in or lying upon mud, sand or gravel. Due to the variable nature of the seabed a variety of communities can develop which are often very diverse [1].

Biotope Description

The biotope is often characterised by some of the fauna which occurrs under *L. hyperborea* forest, depending on the wave exposure, current, and sand scour conditions. The soft-coral *Alcyonium*, large sponges (*Pachymatisma johnstonia* and *Cliona celata*) and hydroids (e.g. *Tubularia indivisa*), characterise vertical rock and tide swept habitats. Wave exposed habitats are characterised by the jewel anemone *Corynactis viridis*, cup coral *Caryophyllia smithii*, feather star *Antedon bifida*, and a range of bryozoans, anemones, sponges and hydroids. Current swept and sand scoured biotopes are usually characterised by hydroids (e.g. *Flustra foliacea*, *Sertularia* spp.), bryozoans, anemone *Urticina felina*, barnacles (e.g. *Balanus crenatus*), and calcareous tubeworms (e.g. *Pomatoceros triqueter*). Solitary ascidian species, brachiopods, and sponges characterize more wave and current sheltered conditions, such as occur in deeper waters. Some species may form particular biotopes, such as reefs of the honeycomb worm *Sabellaria spinulosa*, beds of mussls (i.e. *Mytilus edulis*, *Musculus discors*, *Modiolus modiolus*) and brittlestars (e.g. *Ophiothrix fragilis*, *Ophiocomina nigra*) [2].
A wide range of infaunal polychaetes, bivalves, echinoderms and burrowing anemones such as *Cerianthus lloydii* are often present in such biotopes and the presence of hard substrata (shells and stones) on the surface enables epifaunal species to become established, particularly hydroids such as *Nemertesia* spp. and *Hydrallmania falcata*. The combination of epifauna and infauna can lead to species rich communities. Coarser mixed sediment communities may show a strong resemblance, in terms of infauna, to biotopes within the A5.1. However, infaunal data for this biotope is limited to that described under the EUNIS code A5.443, and so are not representative of the infaunal component of this biotope [1] .

Associated Biotopes at EUNIS Level 5 and 6:
A5.441: Cerianthus lloydii and other burrowing anemones in circalittoral muddy mixed sediment. Circalittoral plains of sandy muddy gravel may be characterised by burrowing anemones such as *Cerianthus lloydii*. Other burrowing anemones such as *Cereus pedunculatus*, *Mesacmaea mitchellii* and *Aureliania heterocera* may be locally abundant. Relatively few conspicuous species are found in any great number in this biotope but typically they include ubiquitous epifauna such as *Asterias rubens*, *Pagurus bernhardus* and *Liocarcinus depurator* with occasional terebellid polychaetes such as *Lanice conchilega* and also the clam *Pecten maximus*. *Ophiura albida* may be frequent in some areas, and where surface shell or stones are present ascidians such as *Ascidiella aspersa* may occur in low numbers [1].

Associated sub-biotope:

A5.4411: Cerianthus lloydii with Nemertesia spp. and other hydroids in circalittoral muddy mixed sediment. In sheltered muddy sandy gravel with appreciable quantities of surfacial cobbles, pebbles and shells a community similar to ClloMx may develop with frequent *Cerianthus lloydii* and other burrowing anemones. However, the pebbles and cobbles embedded in the sediment are colonised by hydroids and in particular *Nemertesia antennina* and *N. ramosa*. Other hydroids may include *Kirchenpaueria pinnata* and *Halecium halecinum* whilst ascidians such as *Ascidiella aspersa* or *Corella parallelogramma* may also be present locally. *Pecten maximus* and *Pomatoceros triqueter* may also be frequent in certain areas [1].

A5.442: Sparse Modiolus modiolus, dense Cerianthus lloydii and burrowing holothurians on sheltered circalittoral stones and mixed sediment. Pebbles and cobbles on mud or muddy gravel in sealochs with frequent *Cerianthus lloydii* and occasional *Modiolus modiolus*. Large burrowing holothurians may include *Psolus phantapus*, *Paracucumaria hyndmani*, *Thyonidium commune*, *Thyone fusus* and *Leptopentacta elongata*. Many of these species only extend their tentacles above the sediment surface seasonally and are likely to be under recorded by epifaunal surveys. Other more conspicuous characterising taxa include *Pagurus bernhardus*, *Asterias rubens*, and *Buccinum undatum*. This biotope is well developed in the Clyde sealochs, although many examples are rather species-poor. Some examples in south-west Scottish sealochs have greater quantities of boulders and cobbles and therefore have a richer associated biota (compared with other sheltered *Modiolus* bed biotopes such as ModHAs). Examples in Shetland are somewhat different in having the cucumber *Cucumaria frondosa* amongst sparse *Modiolus* beds and a slightly different balance in abundance of other species; for example the brittlestar *Ophiopholis aculeata* is more abundant in these far northern examples in the voes and narrows [1].

A5.443: Mysella bidentata and Thyasira spp. in circalittoral muddy mixed sediment. In moderately exposed or sheltered, circalittoral muddy sands and gravels a community characterised by the bivalves *Thyasira* spp. (often *Thyasira flexuosa*), *Mysella bidentata* and *Prionospio fallax* may develop. Infaunal polychaetes such as *Lumbrineris gracilis*, *Chaetozone setosa* and *Scoloplos armiger* are also common in this community whilst amphipods such as *Ampelisca* spp. and the cumacean *Eudorella truncatula* may also be found in some areas. The brittlestar *Amphiura filiformis* may also be abundant at some sites. Conspicuous epifauna may include encrusting bryozoans *Escharella* spp. particularly *Escharella immersa* and, in shallower waters, maerl (*Phymatolithon calcareum*), although at very low abundances and not forming maerl beds.

A5.444: Flustra foliacea and Hydrallmania falcata on tide-swept circalittoral mixed sediment. This biotope represents part of a transition between sand-scoured circalittoral rock where the epifauna is conspicuous enough to be considered as a biotope and a sediment biotope where an infaunal sample is required to characterise it and is possibly best considered an epibiotic overlay. *Flustra foliacea* and the hydroid *Hydrallmania falcata* characterise this biotope; lesser amounts of other hydroids such as *Sertularia argentea*, *Nemertesia antennina* and occasionally *Nemertesia ramosa*, occur where suitably stable hard substrata is found. The anemone *Urticina feline* and the soft coral *Alcyonium digitatum* may also characterise this biotope. Barnacles *Balanus crenatus* and tube worms *Pomatoceros triqueter* may be present and the robust bryozoans *Alcyonidium diaphanum* and *Vesicularia spinosa* appear amongst the hydroids at a few sites. *Sabella pavonina* and *Lanice conchilega* may be occasionally found in the coarse sediment around the stones. In shallower (i.e. upper circalittoral) examples of this biotope scour-tolerant robust red algae such as *Polysiphonia nigrescens*, *Calliblepharis* spp. and *Gracilaria gracilis* are found. Situation: This biotope is found around most coasts, although regional differences are seen where one or two similarly scour-tolerant species such as *Styela clava* and *Crepidula fornicata* (Solent) occupy the hard substrata [1].

A5.445: Ophiothrix fragilis and/or Ophiocomina nigra brittlestar beds on sublittoral mixed sediment. Circalittoral sediment dominated by brittlestars (hundreds or thousands m^{-2}) forming dense beds, living epifaunally on boulder, gravel or sedimentary substrata. *Ophiothrix fragilis* and *Ophiocomina nigra* are the main bed-forming species, with rare examples formed by *Ophiopholis aculeata*. Brittlestar beds vary in size, with the largest extending over hundreds of square metres of sea floor and containing millions of individuals. They usually have a patchy internal structure, with localized concentrations of higher animal density. *Ophiothrix fragilis* or *Ophiocomina nigra* may dominate separately or there may be mixed populations of the two species. *Ophiothrix* beds may consist of large adults and tiny, newly-settled juveniles, with animals of intermediate size living in nearby rock habitats or among sessile epifauna. Unlike brittlestar beds on rock, the sediment based beds may contain a rich associated epifauna. Large suspension feeders such as the octocoral

Alcyonium digitatum, the anemone *Metridium senile* and the hydroid *Nemertesia antennina* are present mainly on rock outcrops or boulders protruding above the brittlestar-covered substratum. The large anemone *Urticina felina* may be quite common. This species lives half-buried in the substratum but is not smothered by the brittlestars, usually being surrounded by a 'halo' of clear space. Large mobile animals commonly found on *Ophiothrix* beds include the starfish *Asterias rubens*, *Crossaster papposus* and *Luidia ciliaris*, the urchins *Echinus esculentus* and *Psammechinus miliaris*, edible crabs *Cancer pagurus*, swimming crabs *Necora puber*, *Liocarcinus* spp., and hermit crabs *Pagurus bernhardus*. The underlying sediments also contain a diverse infauna including the bivalve *Abra alba* [1].

A5.446: Sandy mixed sediment with Alcyonidium diaphanum. No further description available.

Biotope Evaluation: Goods and Services

The presence of benthic invertebrates in this biotope increases habitat complexity through the creation of tubes and burrows [3, 4, 5, 6]. Few marine sedimentary habitats have been well sampled and it has been argued that the biological diversity of these biotopes is often under represented, since it appears to support a relatively diverse and abundant benthic fauna [7]. Particularly, the high densities of infaunal polychaete and bivalve species that exist here [1], have been attributed to the relatively low rate of natural physical disturbance and the heterogeneity of the habitat [8].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

These structures are easily destroyed by physical disturbance. Human activities which result in disturbance to the surface layers of this biotope are likely to adversely affect this service as they will affect the invertebrates which form the physical structures (e.g. tubes and burrows). Physical disturbances (e.g. scraping/smothering disturbances) are likely to affect the biomass and species composition of the invertebrates in this biotope and therefore adversely affect productivity.

Conservation and protection status

Included in the Council of Europe Bern Convention Res. No. 4 1996 as *Sublittoral soft seabeds.*

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB. 2004. Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough. www.jncc.gov.uk/MarineHabitatClassification

[2] Wilson JG (ed) (2005) The Intertidal Ecosystem: The Value of Ireland's Shores, 25-37. Dublin: Royal Irish Academy pp 1-24

[3] Aller RC (1988) Benthic fauna and biogeochemical processes in marine sediments: the role of burrow structures. In: Blackburn TH, Sorensen J (eds) Nitrogen recycling in coastal marine environments, London: John Wiley and Sons Ltd, pp 301- 338

[4] Callaway R (2006) Tube worms promote community change. Mar Ecol Prog Ser 308: 49-60

[5] Lenihan HS, Peterson CH (1998) How habitat degradation through fishery disturbance enhances impacts of hypoxia on oyster reefs. Ecol Appl 8: 128-40

[6] Widdicombe S, Austen M, Kendall M, Warwick RM, Jones MB (2000) Bioturbation as a mechanism for setting and maintaining levels of diversity in subtidal macrobenthic communitites. Hydrobiol 440: 369-77

[7] Snelgrove PVR (1998) The biodiversity of macrofaunal organisms in marine sediments. Biodiv Conserv 7: 1123-32

[8] Etter RJ, Grassle JF (1992) Patterns of species diversity in the deep sea as a function of sediment particle size diversity. Nature 360: 576- 78

Deep circalittoral mixed sediments

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1110	Sandbanks which are slightly covered by sea water all the time
EUNIS	A5.45	Deep circalittoral mixed sediments

Picture(s)

Not available

Biotope Distribution

Not available

Links to Available Maps

http://www.jncc.gov.uk/marine/biotopes/biotope.aspx?biotope=JNCCMNCR00001867
http://www.marlin.ac.uk/habitatpreferences.php?habitatid=63&code=1997

Biotope Requirements

Mud and sandy muddy mixed sediments with gravelly sand and stones or shell in the offshore lower circalittoral at depth 20-100 m around UK and Ireland. In the Black Sea this biotope occupies offshore shelf at depth range 55-140 m and is characterized by decreased dissolved oxygen and increased salinity compared to the coastal habitats; the sediment is mud mixed with shells and shell fragments with an upper layer (2-4 cm) consisting only of ample *Modiolula phaseolina* shells.

Biotope Description

This biotope may cover large areas of the offshore continental shelf. Such biotopes are often highly diverse with a high number of infaunal polychaete and bivalve species. Animal communities in this biotope are closely related to offshore gravels and coarse sands and in some areas populations of the horse mussel *Modiolus modiolus* may develop in these biotopes [1]. Such biotopes are often highly diverse with a high number of infaunal polychaete and bivalve species.
In the Black Sea the horse mussel *Modiolula phaseolina* is the dominant characterizing species [3, 4, 5]. Unlike the Atlantic region decreased species richness is observed in this biotope in the Black Sea in relation to deteriorated oxygen conditions with increasing depth [4, 5, 6]. Higher salinity (18.5 ppt) of deeper waters makes possible the development of small echinoderms that occur only in this biotope in the Black Sea.

In the Atlantic area only one biotope at EUNIS Level 5 was described:
A5.451: Polychaete-rich deep Venus community in offshore mixed sediments. This biotope corresponds to the 'Deep *Venus* Community ' and the 'Boreal Off-Shore Gravel Association ' as defined by other workers [1 and references therein] and is a major biotope around UK and Ireland. In offshore circalittoral slightly muddy mixed sediments, a diverse community particularly rich in polychaetes with a significant venerid bivalve component may be found [1]. The predictable environmental conditions in which the biotope occurs allow a stable and mature benthic community with high diversity and evenness to develop. The biotope is dominated by suspension feeders. Venerid bivalves, e.g. *Clausinella fasciata* and *Timoclea ovata*, make up the majority of the biomass, along with other slow growing, robust bivalve species, such as *Glycymeris glycymeris* and *Astarte sulcata*, and faster growing species, such as *Spisula elliptica*. Other suspension feeders include the burrowing cephalochordate *Branchiostoma lanceolatum*, and the epifaunal tube building polychaete *Hydroides norvegica*. Although bivalves dominate the biomass, polychaetes are very numerous. The tube building species *Lanice conchilega* and *Owenia fusiformis* deposit feed on suspended particles trapped by the fluctuations in hydrodynamic regime around their tubes. *Scoloplos armiger* and *Chaetazone setosa* are burrowing deposit feeders and *Notomastus latericeus* is an infaunal detritivore. The bivalves are predated by starfish, especially *Astropecten* sp., with the larger, thick shelled venerids being more resistant to predation than the thinner shelled *Spisula* spp. Bivalves are predated by boring gastropods, e.g. *Polinices* sp. and flatfish *Spisula* spp. in

particular are predated by the plaice *Pleuronectes platessa*. Some examples of this biotope may have abundant juvenile *Modiolus modiolus*.

A5.452 (proposed new insertion/optional numbering): Pontic deep circalittoral mud with shelly gravel with Modiolula phaseolina. This biotope constitutes the deepest community of aerobic macrofauna in the Black Sea and occupies large areas (40%) of the North-western and Western Black Sea shelf [3, 4, 5]. The biotope is characterized by bulk of dead shells and shelly detritus of the horse mussel *Modiolula phaseolina*, hypoxia and increased salinity in comparison to the coastal biotopes. Apart from the dominant species *Modiolula phaseolina* the characteristic fauna includes the anthozoan *Pachycerianthus solitarius,* the sponges *Sycon ciliatus* and *Suberites carnosus*, the polychaetes *Terebellides stroemi* and *Notomastus profundus,* the echinoderms *Amphiura stepanovi* and *Leptosynapta inhaerens,* the tunicates *Eugyra adryatica, Ctenicella appendiculata* and *Ciona intestinalis* [3, 4, 5, 6, 7, 8]. Significant species richness decrease becomes clearly perceptible, especially below 100 m depth in relation to hypoxic conditions, where gradually macrofauna disappears and only meiofauna comprising mainly nematodes is present.

Biotope Evaluation: Goods and Services

The biotope is probably an important source of food for opportunistic predatory fish and benthic scavengers. The substratum of the biotope is exploited in aggregate extraction, which would remove considerable quantities of sediment [2]. In the Black Sea mud with *Modiolula phaseolina*, particularly in its upper range, is feeding ground for the great sturgeon, turbot and whiting [4].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Deep circalittoral biotopes are less subjected to human impacts if compared to shallower biotopes, however deep soft bottom sediments are vulnerable to effects from trawling activities. The impact of human-induced eutrophication is perceptible even in such offshore areas in the Black Sea, reflected in decreased species richness, decline in *Modiolula* population abundance and biomass and shift of the lower limit of the biotope from 130 m in the 1960s to 100 m in the 1990s [5].

Conservation and protection status

Included in the Council of Europe Bern Convention Res. No. 4 1996 as *Sublittoral soft seabeds*. Part of this biotope may also be classified as habitat type 1110 under the EC/92/43 Habitats Directive.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The Marine Habitat Classification for Britain and Ireland Version 04.05 JNCC, Peterborough, www.jncc.gov.uk/MarineHabitatClassification

[2] Rayment WJ (2008) Venerid bivalves in circalittoral coarse sand or gravel. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme [on-line]. Plymouth: Marine Biological Association of the United Kingdom [cited 17/03/2010] http://www.marlin.ac.uk/habitatsbasicinfo.php?habitatid=63&code=1997

[3] Marinov T (1990) The zoobenthos from the Bulgarian Sector of the Black Sea. Publishing house of the Bulgarian Academy of Sciences, Sofia, pp 195 (in Bulgarian)

[4] Zaitsev YP, Alexandrov BG (1998) Black Sea Biological Diversity: Ukraine. Black Sea Environmental Series, vol.7. United Nations Publications, NY, pp 351

[5] Petranu A (1997) Black Sea Biological Diversity: Romania. Black Sea Environ Ser 4. United Nations Publications, NY, pp 314

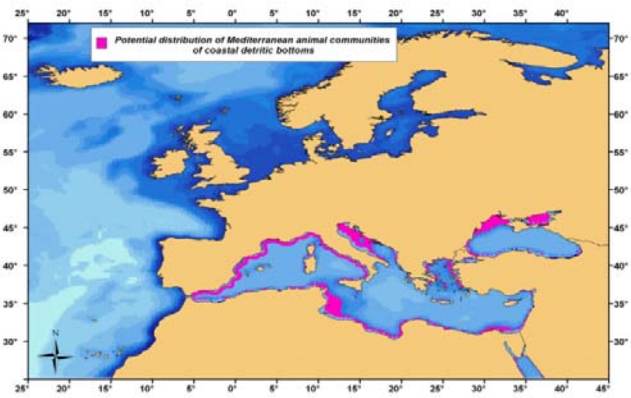
Mediterranean animal communities of coastal detritic bottoms

Compiled by Tomas Vega Fernandez; Revised by Argyro Zenetos

Classification	Code	Title
EUNIS	A5.46	Mediterranean animal communities of coastal detritic bottoms

Picture(s)
Not available

Biotope Distribution



Map of potential distribution

Links to Available Maps
Not available

Biotope Requirements [1]
Salinity: full (35-36 ppt)
Wave exposure: low
Tidal streams: weak to nonexistent; the appearance of facies can depend on certain currents
Substratum: organogenous gravel with a sandy-muddy filling in big bays and open sea
Zone: circalittoral
Depth band: from 30 to 100 m.

Biotope Description [1, 2]
These communities occur on a substratum whose nature varies widely and depends largely on the typology of the nearby coast and of nearby infralittoral formations. Substrata are typically organogenous gravels and coarse sands. Sometimes gravels and sands can be originated from predominant local rocks, but also shell debris from various molluscs, branched bryozoans, equinoderms, or dead and more or less corroded *Melobesiae* spp. The interstices between these various components are partially filled by a greater or lesser proportion of sand and mud of heterogeneous granulometry and of mixed origin: terrigenous and organogenous. The muddy portion is usually less than 20%, but various more or less muddy types exist. Fragmentation of the debris is not due to the always weak hydrodynamics, but to the action of organisms that attack the limestone (*Cliona* spp., *Polydora* spp., lithophagous Pelecypoda, etc. However, the regular or intermittent existence of bottom currents has frequently been stressed.
Several dozen species belonging to many groups of the phytobenthos and zoobenthos can be considered as characteristic of this particularly rich biocenosis. These include the following:
Phytobenthos: *Cryptonemia tunaeformis,* the multi-branched calcareous rhodophytes (*Phymatholithon calcareum*, *Mesophyllum coralloides*, *Lithothamnion fruticulosum*), and *Peyssonnelia* spp.
Zoobenthos: *Bubaris vermiculata*, *Suberites domuncula* (sponges); *Sarcodyctyon catenatum* (cnidarians); *Astropecten irregularis*, *Peltaster placenta*, *Genocidaris maculata*, *Luidia ciliaris*, *Ophioconis forbesi*, *Psammechinus microtuberculatus*, *Paracucumaria hyndmani* (echinoderms); *Limaria loscombi*, *Palliolum incomparabile*, *Flexopecten flexuosus*, *Laevicardium oblungum*, *Acanthocardia echinata*, *Tellina donacina*,

Melanella polita, *Turritella triplicata* (molluscs); *Hermione hystrix*, *Petta pusilla* (polychaetes); *Conilera cylindracea*, *Paguristes oculatus*, *Anapagurus laevis*, *Ebalia tuberosa*, *Ebalia edwardsi* (crustaceans); *Molgula oculata*, *Microcosmus vulgaris*, *Polycarpia pomaria*, *Polycarpia gracilis* (ascidians).
A certain number of these species can give rise to facies with epiflora and epifauna. Given the heterogeneity of the sediment, some species can be abundant in the biocenosis of the coastal detritic bottom. These are indicators of more particular environmental conditions. Here is meant, for example, the gravellicolous (*Echinocyamus pusillus*, *Spatangus purpureus*, *Astarte fusca*), the mixticolous (*Parricardium minimum*, *Timoclea ovata*, *Dentalium inaequicostatum*), the sabulicolous (*Philine aperta*), or species with a wide ecological distribution in loose substrata.

Associated Biotopes at EUNIS Level 5:
A5.461: Facies with Ophiura texturata [3, 2]. This facies is characterised by the high abundance of the Echinoderm *Ophiura texturata* that reach densities up to 2 individuals/m^2. Pelecypod larvae are highly abundant.
A5.462: Facies with Synascidies [3, 2]. This facies is characterised by the frequent presence of tunicate colonial ascidians or "Synascidies". It is rich in species, particularly ascidians.
A5.463: Facies with large Bryozoa [2]. This facies is characterised by the frequent presence of big colonies of arborescent bryozoans, unattached or fixed to small substrata.

Biotope Evaluation: Goods and Services

These bottoms occupy a considerable area on the continental shelf throughout the Mediterranean. The biotope is characterized by high specific diversity [1]. Influenced by various environmental factors, it develops many facies linked to the – sometimes luxuriant – expansion of particular species. Several commercial fish species (notably the stripped mullet *Mullus surmulletus*) live and feed in this bottoms, and *Spicara flexuosa* has been observed to dig nets and to spawn there (D'Anna & Badalamenti, pers. com.).

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities [1]

Subject to considerable threat by different human activities that cause the muddying of the continental shelf. The main causes of this overall effect are discharges of non-purified urban waste, major construction work in the maritime field, and leaching from soil devoid of vegetation cover due to fire. This hypersedimentation finally increases the expansion of other circalittoral detritic bottoms. Worse still, these additions of fine particles are usually loaded with various pollutants, particularly in wastewater, pollutants which act directly on the characteristic species of the biocoenosis. The most harmful induced effects cause many facies to disappear (Lithothamnia, big bryozoans, ascidian beds, etc.), species with a wide ecological distribution to become gradually dominant, beds to undergo a generalised monotonization, biodiversity to be lost, and exploitable living resources to dwindle.

Conservation and protection status [3]

Included in the Council of Europe Bern Convention Res. No. 4 1996 as *Sublittoral soft seabed*. Included in the Barcelona Convention (1998) as *Biocenosis of the coastal detritic bottom* (code IV.2.2).

References

[1] Pergent G (coord) Bellan-Santini D, Bellan G, Bitar G, Harmelin J-G, Pergent G (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. UNEP RAC-SPA
[2] Pérès JM, Picard J (1964) Nouveau manuel de bionomie benthique de la Mer Méditerranée. Rec Trav Stat Mar Endoume 31: 5-137
[3] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

Mediterranean communities of shelf-edge detritic bottoms

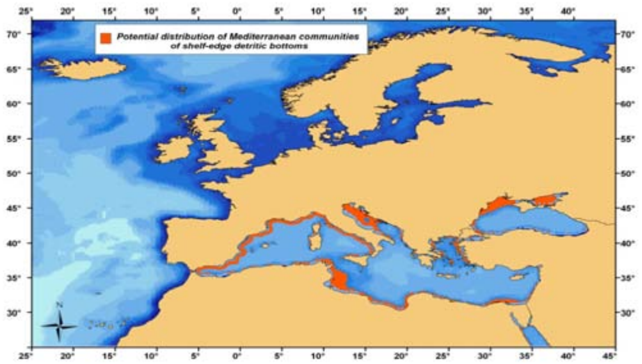
Compiled by Tomas Vega Fernandez; Revised by Argyro Zenetos

Classification	Code	Title
EUNIS	A5.47	Mediterranean communities of shelf-edge detritic bottoms

Picture(s)

Not available

Biotope Distribution



Map of potential distribution

Links to Available Maps

Not available

Biotope Requirements [1]

Salinity: full (35-36‰)
Wave exposure: extremely sheltered
Tidal streams: moderately strong (1-3 kn), weak (>1 kn), very weak (negligible)
Substratum: coarse sand, gravel and debris
Zone: circalittoral
Depth band: 80-130 m.

Biotope Description [1]

These communities are present in detritic bottoms of coarse sands and gravels likely of fluvial origin, with a substantial fraction of biogenic materials as dead shells, bryozoans and coral skeletons. The following species are characteristic and exclusive: the scaphopod *Antalis panorma*, the bivalves *Pseudamussium clavatum* and *Pinna rudis*, the echinoderms *Leptometra phalangium*, *Ophiura carnea* and *Thyone gadeana*, the amphipod *Haploops dellavallei*. Non-exclusive species also present are *Holothuria forskali* and the teleost *Gobius quadrimaculatus*. Some times the following species can also be found: the bivalve *Venus casina*, the irregular sea urchin *Spatangus purpureus*, the crinoid *Leptometra phalangium* and the brittle star *Ophiacantha setosa*.

Associated Biotopes at EUNIS Level 5:
A5.471: Facies with Neolampas rostellata [1, 2]. This facies is characterised by the high abundance of the sea urchin *Neolampas rostellata*. It appears in bottoms of fine gravels, mostly derived from broken shells, with little mud.
A5.472: Facies with Leptometra phalangium [1, 2]. This facies is characterised by the high abundance of the crinoid *Leptometra phalangium*.

Biotope Evaluation: Goods and Services

This biotope does not include high-diversity communities, but it can provide habitat and food for several commercially important fish species.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Infralittoral sandy muds may be severely impacted from coastal human activities, mainly trawl fishig. In the past, dumping of solid wastes could constitute an impact (currently prohibited by the EU).

Conservation and protection status

Included in the Council of Europe Bern Convention Res. No. 4 1996 as *Sublittoral soft seabed* (code 11.22). Included in the Barcelona Convention (1998) as *Biocenosis of shelf-edge detritic bottom* (code IV.2.3) [2].

References

[1] Pergent G (coord) Bellan-Santini D, Bellan G, Bitar G, Harmelin J-G, Pergent G (2002) Handbook for interpreting types of marine habitat for the selection of sites to be included in the national inventories of natural sites of conservation interest. UNEP RAC-SPA.

[2] EUNIS biodiversity database: http://eunis.eea.europa.eu/index.jsp (last visited: April 2010)

Maerl beds

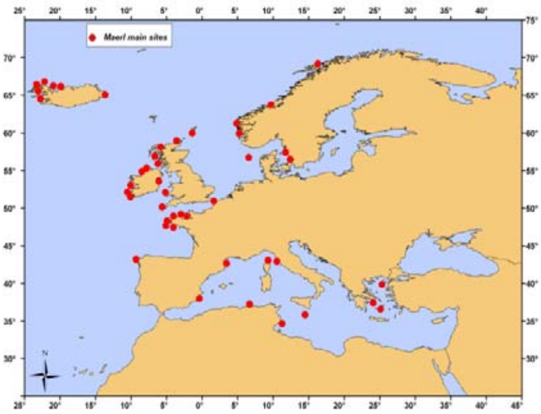
Compiled by Maria Salomidi

Classification	Code	Title
NATURA 2000	1110	Sandbanks which are slightly covered by sea water all the time
EUNIS	A5.51	Maerl beds

Picture(s)


Rhodolithes collected from Aegean Sea, Greece (Photo HCMR)

Biotope Distribution



Links to Available Maps

http://data.nbn.org.uk/habitat/map.jsp?HABITAT=NBNSYS0000019608
http://www.ukmarinesac.org.uk/communities/maerl/m1_2.htm

Biotope Requirements

Maerl beds are biogenic complexes primarily constructed by sciaphilous calcareous red algae in sedimentary bottoms, from the shallow infralittoral down to more than 100m depth in extreme oligotrophic conditions. They generally occur in deep, moderate to moderately strong tide- or current-swept fully saline environments.

Biotope Description

Beds of maerl in coarse clean sediments of gravels and clean sands, typically occur either on the open coast or in tide-swept channels of marine inlets (the latter often stony). In fully marine conditions the dominant maerl is typically *Phymatolithon calcareum* (A5.511), whilst under variable salinity conditions in some sealochs beds of *Lithothamnion glaciale* (A5.512) may develop [1]. Dead and alive maerl deposits may form banks (flat build-ups), their thickness ranging between a few centimetres and several meters [2].
The northern distribution of maerl beds is between Orkney Islands and southern Norway, while the southern limit is the Mediterranean and the Canary Islands [3].

Associated Biotopes at EUNIS Level 5:
A5.511: Phymatolithon calcareum maerl beds in infralittoral clean gravel or coarse sand (Pcal). Maerl beds characterised by *Phymatolithon calcareum* in gravels and sands. Associated epiphytes may include red algae such as *Dictyota dichotoma*, *Halarachnion ligulatum*, *Callophyllis laciniata*, *Cryptopleura elonga, Brongniartella byssoides* and *Plocamium cartilagineum*. Algal species may be anchored to the maerl or to dead bivalve shells amongst the maerl. Polychaetes, such as *Chaetopterus variopedatus*, *Lanice conchilega, Kefersteinia cirrata*, *Mediomastus fragilis*, *Chone duneri*, *Parametaphoxus fultoni* and *Grania* may be present. Gastropods such as *Gibbula cineraria*, *Gibbula magus*, *Calyptraea chinensis, Dikoleps pusilla* and *Onoba aculeus* may also be present. *Liocarcinus depurator* and *Liocarcinus corrugatus* are often present, although they may be under-recorded; it would seem likely that robust infaunal bivalves such as *Circomphalus casina*, *Mya truncata*, *Dosinia exoleta* and other venerid bivalves are more widespread than available data currently suggests. It seems likely that stable wave-sheltered maerl beds with low currents may be separable from SMP.Pcal having a generally thinner layer of maerl overlying a sandy /muddy substratum with a diverse cover of epiphytes but insufficient data currently exists on a national scale. Wave and current-exposed maerl beds, where thicker depths of maerl accumulate, frequently occur as waves and ridge / furrows arrangements. At some sites where *Pcal* occurs, there may be significant patches of maerl gravel containing the rare burrowing anemone *Halcampoides elongatus*; this may be a separate biotope, but insufficient data exists at present. Northern maerl beds in the UK do not appear to contain *L. corallioides* but in south-west England and Ireland *L. corallioides* may occur to some extent in *Pcal* as well as *Lcor*, where it dominates [1 and references within].
A5.512: Lithothamnion glaciale maerl beds in tide-swept variable salinity infralittoral gravel (Lgla). Upper infralittoral tide-swept channels of coarse sediment in full or variable salinity conditions support distinctive beds of *Lithothamnion glaciale* maerl 'rhodoliths'. *Phymatolithon calcareum* may also be present as a more minor maerl component. Associated fauna and flora may include species found in other types of maerl beds (and elsewhere), e.g. *Pomatoceros triqueter, Cerianthus lloydii, Sabella pavonina, Chaetopterus variopedatus, Lanice conchilega, Mya truncata, Plocamium cartilagineum and Phycodrys rubens. Lgla*, however, also has a fauna that reflects the slightly reduced salinity conditions, e.g. *Psammechinus miliaris* is often present in high numbers along with other grazers such as chitons and *Tectura* spp., *Hyas araneus, Ophiothrix fragilis, Ophiocomina nigra* and the brown seaweed *Dictyota dichotoma* are also typically present at sites. In Scottish lagoons this biotope may show considerable variation but the community falls within the broad description defined here. Situation: This biotope can often be found at the upper end of Scottish sealochs where the variable salinity may not be immediately obvious [1 and references within].
A5.513: Lithothamnion corallioides maerl beds on infralittoral muddy gravel (Lcor). Live maerl beds in sheltered, silty conditions which are dominated by *Lithothamnion corallioides* with a variety of foliose and filamentous seaweeds. Live maerl is at least common but there may be noticeable amounts of dead maerl gravel and pebbles. Other species of maerl, such as *Phymatolithon calcareum* and *Phymatolithon purpureum*, may also occur as a less abundant component. Species of seaweed such as *Dictyota dichotoma, Halarachnion ligulatum* and *Ulva* spp. are often present, although not restricted to this biotope, whereas *Dudresnaya verticillata* tends not to occur on other types of maerl beds. The sea-anemones *Anemonia viridis* and *Cerianthus lloydii*, the polychaetes *Notomastus latericeus* and *Caulleriella alata*, the isopod *Janira maculosa* and the bivalve *Hiatella arctica* are typically found in *SMP.Lcor* where as *Echinus esculentus* tends to occur more in other types of maerl. The seaweeds *Laminaria saccharina* and *Chorda filum* may also be present in some biotopes. *Lcor* has a south-western distribution in Britain and Ireland. Sheltered, stable, fully saline maerl beds in the north of Great Britain (where *L. corallioides* has not been confirmed to occur) may need to be described as an analogous biotope to *Lcor* [1 and references within].
A5.514: Lithophyllum fasciculatum maerl beds on infralittoral mud (Lfas). Shallow, sheltered infralittoral muddy plains with *Lithophyllum fasciculatum* maerl. This rarely recorded maerl species forms flattened masses

or balls several centimetres in diameter. *Lfas* may be found on mud and muddy gravel mixed with shell. Species of anemone typical of sheltered conditions may be found in association, for example, *Anthopleura ballii*, *Cereus pedunculatus* and *Sagartiogeton undatus*. Polychaetes such as *Myxicola infundibulum* and terebellids, also characteristic of sheltered conditions, may be present as may hydroids such as *Kirchenpaueria pinnata*. Occasional *Chlamys varia* and *Thyone fuscus* are present in all records of this biotope and red seaweeds such as *Plocamium cartilagineum*, *Calliblepharis jubata* and *Chylocladia verticillata* are often present [1 and references within].

A5.515: Association with rhodolithes in coarse sands and fine gravels under the influence of bottom currents. No further description available.

A5.516: Association with rhodolithes on coastal detritic bottoms. This association, characterised by "balls" of calcareous encrusting algae, occurs on coastal detritic bottoms [1 and references within].

Such associations with rhodoliths (A5.515 and A5.516) have been described from the Mediterranean Sea to co-occur with numerous other calcareous species, among which certain bryozoans (e.g. *Reptadeonella violacea, Mollia circumcinta*) and serpuloideans (e.g. *Pomatoceros triqueter, Serpula vermicularis*) were found to significantly contribute to the development of concretions [4, 5, 6].

Biotope Evaluation: Goods and Services

Maerl coralline algae are made up of about 80% of calcium carbonate and 10% of magnesium carbonate [3] and are thus inferred to be some of the largest stores of carbon in the biosphere [7]. When fossilized, such deposits can be used as stratigraphic markers and palaeoenvironmental indicators [7, 8]. Live and dead maerl deposits are being heavily and often unsustainably harvested (over 500,000 tons yearly) as a source of lime and trace elements for agricultural use, as water filtration agents, and as a natural anti-osteoporosis remedy [3, 7, 9, 10]. The complex nature of these biotopes creates a network of exceptional biological and functional diversity, hosting a large variety of associated organisms [2, 3, 6, 7], and providing shelter to many commercially important crustacean and fish species, among others [5, 7, 11].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☒	☐	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Being among the slowest-growing organisms (up to a few mm per year), coralline algae are exceptionally vulnerable to any mechanical disturbance such as dredging, trawling [7] and even net fishing [6, 11]. Other direct threats include habitat removal through offshore construction activities and the commercial extraction of maerl [7]. Increased sedimentation and turbidity, as a result of eutrophication, waste discharge, fish farming, construction works and nearby trawling pose also serious threats to both bioconstructors and associated fauna of this biotope [7, 12].

Conservation and protection status

Included in the Barcelona Convention as *Biocenosis of coarse sands and fine gravels mixed by the waves with association with rhodolithes* (III. 3. 1. 1) as well as *Biocenosis of coastal detritic sands- association with rhodolithes* (III. 3. 2. 2.). Two of the more common maerl-forming species, *Lithothamnion corallioides* and *Phymatolithon calcareum* are included in the Annex V of the EC/92/43 Habitats Directive [7]. In the UK, maerl beds are listed as a key habitat type within the Annex I category *Sand banks which are slightly covered by seawater at all times* in the JNCC interpretation of the Habitats Directive, and they are the subject of a Habitat Action Plan under the UK Biodiversity Action Plan [7]. In the Mediterranean, coralligenous and other calcareous bio-concretions (maerl included) became a special subject of an *ad hoc* UNEP-MAP Action Plan [6, 13]. Moreover, destructive fishing was recently prohibited over Mediterranean maerl beds according to the Council Regulation (1967/2006 EC). However, the lack of geospatial data on the distribution of these assemblages remains a major impediment for the substantial protection of these scarce and still poorly ecologically assessed biotopes.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The marine habitat classification for Britain and Ireland. Peterborough, JNCC

[2] Ballesteros E (2003) The coralligenous in the Mediterranean Sea: Definition of the coralligenous assemblage inthe Mediterranean, its main builders, its richness and key role in benthic ecology as well as its threats. Project for the preparation of a Strategic Action Plan for the Conservation of the Biodiversity in the Mediterranean Region (SAP BIO). UNEP-MAP-RAC/SPA: pp 87

[3] Lüning K (1990) Seaweeds. Their environment, biogeography, and ecophysiology. John Wiley and Sons Inc, NY, pp 527

[4] Rosso A, Sanfilippo R (2009) The contribution of bryozoans and serpuloideans to coralligenous concretions from SE Sicily. In: Pergent-Martini C, Brichet M (eds) UNEP-MAPRAC/ SPA (2009) Proceedings of the 1st Mediterranean symposium on the conservation of the coralligeous and other calcareous bio-concretions (Tabarka, 15–16 January 2009) RAC/SPA publication, Tunis

[5] Pérès J, Picard JM (1951) Notes sur les fonds coralligènes de la région de Marseille. Arch Zool Exp Gen 88(1): 24-38

[6] Sciberras M, Rizzo M, Mifsud JR, Camilleri K, Borg JA , Lanfranco E, Schembri PJ (2010) Habitat structure and biological characteristics of a maerl bed off the northeastern coast of the Maltese Islands (central Mediterranean). Mar Biodiv 39(4): 251-264

[7] Birkett DA, Maggs CA, Dring MJ (1998) Maerl (volume V). An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science, UK Marine SACs Project, pp 116

[8] Foster MS, Riosmena-Rodriguez R, Steller D, Woelkerling WJ (1997) Living rhodolith beds in the Gulf of California and their implications for paleoenvironmental interpretation. In: Johnson ME, Ladesma-Vásquez J (eds). Pliocene carbonates and related facies flanking the Gulf of California, Baja California, Mexico. Geological Society of America special paper no. 318

[9] Guiry MD, Blunden G (eds) (1991) Seaweed resources in Europe: uses and potential. Chichester, UK: John Wiley & Sons

[10] Blunden G, Binns WW, Perks F (1975) Commercial collection and utilisation of maerl. Econ Bot 29: 140-145

[11] Georgiadis M, Papatheodorou G, Tzanatos E, Geraga M, Ramfos A, Koutsikopoulos C, Ferentinos G (2009) Coralligene formations in the eastern Mediterranean Sea: Morphology, distribution, mapping and

relation to fisheries in the southern Aegean Sea (Greece) based on high-resolution acoustics, J Exp Mar Biol Ecol 368(1): 44-58
[12] Hall-Spencer J, White N, Gillespie E, Gillham K, Foggo A (2006) Impact of fish farms on maerl beds in strongly tidal areas, Mar Ecol Prog Ser 326: 1-9.
[13] Agnesi S, Annunziatellis A, Casese ML, Di Nora T, La Mesa G, Mo G, Pergent-Martini C, Tunesi L (2009) Analysis on the coralligenous assemblages in the Mediterranean Sea: a review of the current state of knowledge in support of future investigations. In: Pergent-Martini C, Brichet M (eds) UNEP-MAPRAC/SPA (2009) Proceedings of the 1st Mediterranean symposium on the conservation of the coralligeous and other calcareous bio-concretions (Tabarka, 15–16 January 2009). RAC/SPA publication, Tunis

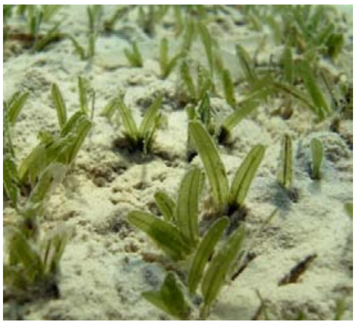
Sublittoral seagrass beds

Compiled by Maria Salomidi; Revised by Valentina Todorova

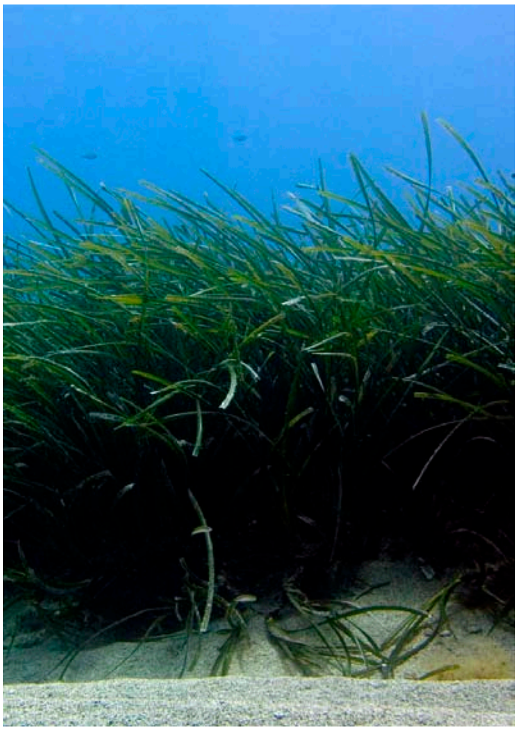
Classification	Code	Title
NATURA 2000	1120	Posidonia beds
NATURA 2000	1110	Sandbanks which are slightly covered by sea water all the time
EUNIS	A5.53	Sublittoral seagrass beds

Picture(s)

Cymodocea nodosa beds in a shallow bay, Aegean Sea, Greece (Photo by Maria Salomidi)

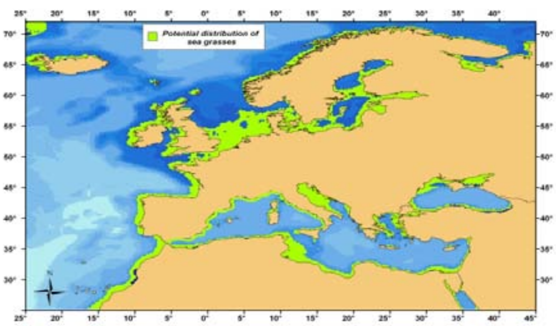


Halophila stipulacea, Aegean Sea, Greece (Photo by Maria Salomidi)



Posidonia oceanica beds in Saronikos Gulf, Greece (Photo by Yiannis Issaris)

Biotope Distribution



Map of potential distribution of seagrass beds

Links to Available Maps

http://bure.unep-wcmc.org/imaps/marine/seagrass/viewer.htm
http://data.nbn.org.uk/habitat/map.jsp?HABITAT=NBNSYS0000019601
http://natura2000.ecologie.gouv.fr/habitats/HAB1120.html#carto (France)
http://lifeposidonia.caib.es/user/carto/cos_en.htm (Balearics)
ftp://ftp.scn.minambiente.it/Cartografie/Natura2000/SIC_Marini_RelazioneFinale/SIC_Allegato10_Fig.3_habitat_1120.jpg (Italy)
http://biodiversity.eionet.europa.eu/article17/habitatsummary/?group=Y29hc3RhbCBoYWJpdGF0cw%3D%3D&habitat=1120&region=MMED (NATURA 2000)

Biotope Requirements

Seagrasses are mostly found in sheltered to extremely sheltered environments, in variable to fully saline conditions (10-45 ppt), forming extensive meadows on sandy to muddy bottoms [1]. Both salinity and temperature tolerance differs between species but, generally, *Zostera* species can tolerate much lower values than *Cymodocea nodosa* and *Posidonia oceanica* (the latter species being the most stenohaline of all four). Seagrasses depth distribution (reportedly 0-60 m) may also range significantly between species and regions, with their upper limit being mostly regulated by exposure, and their lower limit by light penetration [2, 3]. Additionally to nutrient uptake from the water column, seagrasses can also take up nutrients from the sediment, a fact that contributes much to their enhanced ability to survive in nutrient-poor environments compared to other primary producers [3].

Biotope Description

Seagrasses are marine flowering plants, widely recognized as ecosystem engineers due to their high potential to modify marine environments in terms of sediment stability, hydrodynamics, nutrient regime, food web structure and biodiversity [1, 4].
According to the EUNIS Classification System, seagrasses comprise all "*beds of submerged marine angiosperms in the genera Cymodocea, Halophila, Posidonia, Ruppia, Thalassia and Zostera"*. However, only *Cymodocea, Posidonia* and *Zostera* are native in European waters, while the genus *Ruppia* has been doubted as a true seagrass by some authors [5, 6].
The Black Sea vascular plants comprise 4 genera with 6 species: *Zostera marina, Z. noltii, Ruppia maritima, R. cirrhosa, Zannichellia palustris* and *Potamogeton pectinatus*) [7, 8, 9, 10]. Recent reviews refer to the first four of those as seagrasses, while *Zannichellia* and *Potamogeton* are regarded as seagrass associates [11]. The classification of the Black Sea bottom vegetation distinguishes five monodominant or mixed associations of seagrasses [8].

Associated Biotopes at EUNIS Level 5:
A5.531 Cymodocea beds: Formations of *Cymodocea nodosa* of the Atlantic shores of southern Iberia, northwestern Africa and the Macaronesian Islands. This species occurs only in the Mediterranean and the adjacent Atlantic coasts, as north as the southern coasts of Portugal. It can be found from shallow subtidal areas to very deep waters (50-60m), from muddy to sandy sediments and within a wide salinity range, from estuarine to hypersaline environments [5, 12]. *Cymodocea* beds are characteristic habitats for seahorses (*Hippocampus* spp.), and also particularly important for various fish species' juvenile stages [5, 12].
Associated sub-biotopes:
A5.5311: Macaronesian Cymodocea beds.
A5.5312: Lusitanian Cymodocea beds.
A5.5313: Mediterranean Cymodocea beds. (Also in association with *Caulerpa prolifera* or *Halophila stipulacea*). A preferred biotope for the Mediterranean seahorses *Hippocampus guttulatus* and *H. hippocampus.* The fish species *Lithognathus mormyrus* and *Xyrichthys novacula* are also common encounters.

A5.532 Halophila beds: Deep water colonies of *Halophila* spp. or *Thalassia* spp. of the Mediterranean and the Macaronesian Atlantic. Both *Halophila* and *Thalassia* are tropical seagrass genera. In the last century, the species *Halophila stipulacea* has invaded the eastern Mediterranean basin via the Suez canal, wherefrom it has been gradually extending westernwards [13]. The genus *Thalassia*, however, has not as yet been reported in European waters.
Associated sub-biotopes:
A5.5321: Canary Island Halophila beds.
A5.5322: Mediterranean Halophila beds.

A5.533 Zostera beds in full salinity infralittoral sediments. According to EUNIS, this category comprises beds of seagrass (*Zostera marina* or *Ruppia* spp.) in shallow sublittoral sediments, which are generally found in extremely sheltered embayments, marine inlets, estuaries and lagoons, with very weak tidal currents. They may inhabit low, variable and full salinity marine habitats. Whilst generally found on muds and muddy sands they may also occur in coarser sediments, particularly marine examples of *Zostera* communities. In southern Spain extensive beds of *Zostera marina* occur in open bays of the Mediterranean coast (Malaga & Granada) at 8-17 m depth which are probably the deepest in Europe along with those of the Black Sea [14]. 147 molluscan species have been registered as associated with *Zostera marina* beds [15]. The Black Sea eelgrass beds occur at depths between 0.2 – 17 m in bays and gulfs with normal salinity 17-19 ppt, in coastal salt lakes and occasionally in river estuaries and deltas with annual salinity range 0.3–14% [8, 11]. Eelgrass beds provide shelter to 115 macroalgae [8], 70 macrobenthic invertebrates, 34 species of fish and 19 fish larvae such as rockfish, horsemackerel,

anchovy and surmullet, which spawn there also [16, 17].
Associated sub-biotopes:
A5.5331: Zostera marina/angustifolia beds on lower shore or infralittoral clean or muddy sand (distinction between *Z. marina* and *Z. angustifolia* species is not yet clear [5]). No further description available.
**A5.5332 (slightly modified): Mediterranean Zostera noltii beds*. (Black Sea *Z. noltii* beds are proposedly inserted under a new EUNIS code: see *A5.5336).
*A5.5333: Association with Zostera marina in euryhaline and eurythermal environment.*No further description available.
*A5.5334: Mediterranean Zostera hornemanniana beds.*No further description available.
**A5.5335 (proposed new insertion/optional numbering): Black Sea Z. marina beds* are monodominant or mixed associations that occur at depth 0.5-17 m, with biomass and density maxima at 1-3 m in summer, and projection coverage 80-100% [8, 11].
**A5.5336 (proposed new insertion/optional numbering): Black Sea Z. noltii beds* are monodominant or mixed associations that occur at depth 0.2-10 m, with biomass and density maxima at depths to 1 m in summer, and projection coverage 20-60% [8, 11].

A5.534: Ruppia and Zannichellia communities. Some consider the genus *Ruppia* to belong to the group of seagrasses, but others suggest that species of this genus are not true seagrasses because they do not occur in oceanic water with consistently high salinity [5, 6].
Associated sub-biotopes:
*A5.5341: Middle European Ruppia and Zannichellia communities.*No further description available.
A5.5342: Tethyan marine Ruppia communities. No further description available.
*A5.5343: Ruppia maritima in reduced salinity infralittoral muddy sand.*No further description available.
**A5.5344 (proposed new insertion/optional numbering): Black Sea Ruppia beds are mixed associations with Potamogeton and Zannichellia*, less common than eelgrass beds but in some locations may occupy vast areas, at depths between 0.2-2 m within a wide range of salinity 11–19 ppt [8].
**A5.5345 (proposed new insertion/optional numbering): Black Sea Zannichellia beds mixed with Zostera noltii and Ruppia spp.* occur at depths between 0.2-1 m in strongly dilute salinities (9–11 ppt) but also in places with normal Black Sea salinity (≈18 ppt) [8].

A5.535: Posidonia beds. This biotope is characterised by the marine angiosperm *Posidonia oceanica*, a species endemic and characteristic of the infralittoral zone of the Mediterranean Sea and the adjacent NE Atlantic coasts. It can form extensive underwater meadows on sandy bottoms (though occasionally, small *Posidonia* patches can also be found growing over rock) from the surface and even up to 50 metres depth. This angiosperm is the building basis of thriving and complex communities *–aka Posidonietum oceanicae-* that live on the plant's leaves, rhizomes, adjacent sediments, and even dead "mattes" or beach cast detritus.
P. oceanica healthy meadows can host over 100 species of algae (e.g. *Hydrolithon* sp., *Pneophyllum* sp., *Peyssonnelia* spp., Corallinaceae, *Rhodymenia* spp.), 44 species of hydroids (e.g. *Monotheca posidoniae*, *Sertularia* spp.), 90 species of bryozoa (e.g. *Electra posidoniae*, *Margaretta cereoides*), 185 species of molluscs (e.g *Pinna nobilis, P. rudis, Arca noae*), 120 species of Crustacea*,* more than 182 species of Polychaeta *(e.g. Platynereis dumerlii* and *Syllis* spp.), at least 15 species of sponges (e.g. *Axinella* spp*., Clathrina* spp*., Sycon* spp.), and dozens of Echinoderms (like *Echinocardium* and *Spatangus* spp*., Asterina pancerii, Centrostephanus longispinus*, *Antedon mediterranea)* of which at least 16 described species of Holothuria [18]. The *Posidonietum* community is also known to host many fish species, either resident (e.g. *Gobius* spp., *Labrus* spp., *Symphodus* spp., *Diplodus* spp., *Sarpa salpa*, *Coris julis, Chromis chromis, Opeatogenys gracilis, Syngnathus typhle* and the endangered *Hippocampus* spp*.*) or at least during their juvenile stages [18]. The marine turtles *Chelonia mydas* and *Caretta caretta* have also been described as associated fauna.
Based on their demographic and other ecological aspects, *Posidonia* meadows can be further discriminated in four distinct sub-biotopes [19]:
A5.5351: Ecomorphosis of striped Posidonia oceanica meadows.
A5.5352: Ecomorphosis of "barrier-reef" Posidonia oceanica meadows.
A5.5353: Facies of dead "mattes" of Posidonia oceanica without much epiflora.
A5.5354: Association with Caulerpa prolifera (but various other similar associations, either with *the green alga Caulerpa racemosa* or the seagrasses *Cymodocea nodosa, Zostera noltii and Halophila stipulacea* are also common).

****A5.536 (proposed new insertion/optional numbering): Black Sea Potamogeton pectinatus beds mixed with***

Zostera marina, Z. noltii. and Ruppia cirrhosa. This biotope occurs at depth 0.5-3 m in salinities of 11-18 ppt [8].

Biotope Evaluation: Goods and Services

Seagrass ecosystems rank among the most productive biomes on earth [4, 20], supporting exceptionally high biomass and an average net production of ca 400 g C m^{-2} yr^{-1} [4].
Healthy and extensive seagrass meadows provide habitat, shelter, food source and nursery grounds for a large variety and abundance of marine organisms [18, 23]. Apart from their significant contribution in enhancing local biodiversity, oxygenating waters and sediments and cycling nutrients, seagrasses are also known to constitute important trophic links to their adjacent marine or terrestrial ecosystems by exporting an average 24.3% of their net production [2]. Although seagrass primary production accounts for some 1% of the total primary production in the oceans, seagrasses are responsible for 12% (or about 27 Tg C $year^{-1}$) of the total amount of carbon stored in ocean sediments, playing thus a significant role in the regulation of the global carbon cycle [21, 22].
Seagrass leaf canopies control the transparency of the water column by favouring retention of suspended particles, and protect shorelines by attenuating the wave energy. Shoreline protection is further enhanced by dense networks of rhizomes that stabilize sublittoral sediments, and detached (withered) leaves which cushion beaches from wave erosion [21, 22].
Due to their slow growth rates, strict ecological requirements and overall sensitivity, seagrasses are generally considered as indicators of environmental quality [18, 22]. Moreover, species with vertical and long lived rhizomes act as long-term logs of environmental information, offering an insight to past episodes of disturbance, and levels of persistent contaminants (radioactive/ synthetic chemicals, heavy metals, etc) [18].
Although seagrasses had been quite familiar and directly used by past coastal communities (eg. dry leaves for packing/filling material, roof insulation/covering, bedding, soil amendment, animal feeding etc) [23], their high ecological value is little comprehended by the public today. A first appraisal ofthe value of the services their ecosystems provide, yielded a minimum estimate of 15837 € ha^{-1} y^{-1}, which is two orders of magnitude higher than the estimate obtained for croplands [22].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☒	☐	☐
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Increasing human population and subsequent urbanization and industrialization of the coastal zone has been widely recognized among the most serious threats that seagrass ecosystems face today. In the course of the last two decades, the estimated loss of seagrass from direct and indirect human impacts amounts to 33,000 km^2, or 18 % of the documented seagrass area [24], with a global loss rate at 2-5% $year^{-1}$ (4 to10-fold greater than the one estimated for tropical forests) [21]. Given the slow growth rate of all European seagrasses (and especially so for *P. oceanica*) [23] such losses can be regarded as virtually irreversible, as recovery may take centuries once the cause of disturbance is eliminated [18, 21].

Human activities that pose serious direct or indirect threats to seagrasses, are both numerous and multifold, and comprise excess nutrient and organic supplies to coastal waters (domestic, agriculture and aquaculture effluents), mechanical damage from fishing activities, coastal engineering and anchoring; disruption of the sedimentation/erosion balance along the coast, proliferation of invasive species (*Caulerpa taxifolia*, *C. racemosa*), and human-induced salinity changes [2, 8, 18, 21, 23, 25].

Conservation and protection status

Seagrasses are recognized as priority species/habitat types for conservation efforts in international (e.g. Rio Convention, Barcelona Convention, Bern Convention, EU Habitats Directive, EU Water Framework Directive) and national frameworks [11, 24]. More recently, the EU Fisheries Regulation 1967/2006 prohibited trawling (beach seines) over *Posidonia oceanica* beds in the Mediterranean. However, paucity of sufficient data on seagrass distribution and quality status hinders the effective implementation of management policies. Moreover, legal protection against seagrass losses is only possible where disturbance derives from proximal causes, while difficulties of assigning responsibility for more diffuse impacts (e.g. eutrophication) constitute major barriers to conservation [2].

References

[1] Hemminga MA, Duarte CM (2000) Seagrass Ecology. Cambridge Univ. Press, Cambridge

[2] Duarte CM (2002) The future of seagrass meadows. Environm Conserv 29(2): 192-206

[3] Greve TM, Binzer T (2004**)** Which factors regulate seagrass growth and distribution? In: Borum J, CM Duarte, D Krause-Jensen and TM Greve (eds) European seagrasses: an introduction to monitoring and management. The M&MS project, European union

[4] Costanza R, d'Arge R, Groot RD, Farber S, Grasso M, Hannon B, Limburg K, Naeem S, O'Neill RV, Paruelo J, Raskin RG, Sutton P, van der Belt M (1997) The value of the world's ecosystem services and natural capital. Nature 387: 253–260

[5] Borum J, TM Greve (2004) The four European seagrass species. In: Borum J, CM Duarte, D Krause-Jensen and TM Greve (eds) European seagrasses: an introduction to monitoring and management. The M&MS project, European union

[6] Den Hartog C (1970) The Seagrasses of the World. North Holland Publ. Co., Amsterdam

[7] Kalugina-Gutnik A (1975) Phytobenthos of the Black Sea. Naukova Dumka, Kiev, pp 246 (in Russian)

[8] Milchakova NA (1999) On the status of seagrass communities in the Black Sea. Aquat Bot 65: 21–32

[9] Petrova-Karadzhova V (1982) Stocks distribution of the eelgrasses *Zostera marina* and *Zostera nana* along the Bulgarian Black Sea coast. Proc Inst Fish, XIX: 97-106 (in Bulgarian with English summary)

[10] Todorova V (in press) Sublittoral seagrass beds. In: Biserkov V (eds) Red Data Book of Republic of Bulgaria, vol. 3, Natural Habitats, pp 368

[11] Milchakova NA, Phillips RC (2003) Black Sea Seagrasses. Mar Pollut Bull 46: 695–699

[12] Gambi MC, Barbieri F, Bianchi CN (2009) New record of the alien seagrass *Halophila stipulacea* (Hydrocharitaceae) in the western Mediterranean: a further clue to changing Mediterranean Sea biogeography. Mar Biodiv Rec2: e84

[13] Verdiell-Cubedo D, Oliva-Paterna FJ, Torralva-Forero M (2007) Fish assemblages associated with Cymodocea nodosa and Caulerpa prolifera meadows in the shallow areas of the Mar Menor coastal lagoon. Limnetica, 26 (2): 341-350

[14] Moreno D, Guirado J (2003) Nuevos datos sobre la distribucion de las fanerogamas marinas en las provincias de Almerva y Granada (SE Espapa). Acta Bot Malacitana 28: 105-120

[15] Rueda JL, Salas C (2008) Molluscs associated with a subtidal Zostera marina L. bed in southern Spain: Linking seasonal changes of fauna and environmental variables. Estuar Coast Shelf S 79(1): 157-167
[16] Gordina AD, Beloivanenko TT (1976) The diversity of species and the numbers of fish eggs and larvae in *Zostera* and *Phyllophora* biocenoses. Biologiya Morya36: 40–50 (in Russian)
[17] Makkaveeva EB (1976) The dynamics of mass species populations of eelgrass biocenoses. Biologiya Morya36: 25–40 (in Russian)
[18] Díaz-Almela E, Duarte CM (2008) Management of Natura 2000 habitats. 1120 **Posidonia* beds (*Posidonion oceanicae*). European Commission
[19] UNEP/MAP (1999) Draft reference classification of marine habitat types for the Mediterranean region. Eleventh Ordinary Meeting of the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution and its Protocols, Malta, 27-30 October 1999, UNEP(OCA)/MED IG.12/5, Athens, 1999
[20] Duarte CM, Chiscano CL (1999) Seagrass biomass and production: a reassessment. Aquat Bot 65: 159–174
[21] Duarte C, Gattuso J-P (2008) Seagrass meadows. In: Cutler J. Cleveland (eds) Encyclopedia of Earth (Washington, DC: Environmental Information Coalition, National Council for Science and the Environment). [First published in the Encyclopedia of Earth December 11, 2006; Last revised September 21, 2008; Retrieved March 15, 2010] http://www.eoearth.org/article/Seagrass_meadows
[22] Terrados J, Borum J (2004) Why are seagrasses important? – Goods and services provided by seagrass meadows. In: European seagrasses: an introduction to monitoring and management. The M&MS project, European union
[23] Marbà N, Duarte CM, Alexandre A, Cabaço S (2004) How do seagrasses grow and spread? In: European seagrasses: an introduction to monitoring and management. The M&MS project, European union
[24] Duarte CM, Marbà N, Santos R (2004) What may cause loss of seagrasses? In: European seagrasses: an introduction to monitoring and management. The M&MS project, European union
[25] Langmead O, McQuatters-Gollop A, Mee LD, Friedrich J, Gilbert AJ, Gomoiu MT, Jackson EL, Knudsen S, Minicheva G, Todorova V (2009) Recovery or decline of the Black Sea: A societal choice revealed by socio-ecological modelling. Ecol Model 220 (21): 2927-2939

Sublittoral polychaete worm reefs on sediment

Compiled by Marijn Rabaut

Classification	**Code**	**Title**
NATURA 2000	1170	Reefs
NATURA 2000	1110	Sandbanks which are slightly covered by sea water all the time
EUNIS	A5.61	Sublittoral polychaete worm reefs on sediment

Picture(s)

Photos by Marijn Rabaut

Biotope Distribution

Not available

Links to Available Maps

http://images.google.be/imgres?imgurl=http://www.jncc.gov.uk/marine/biotopes/maps/JNCCMNCR00001112.GIF&imgrefurl=http://www.jncc.gov.uk/marine/biotopes/biotope.aspx%3Fbiotope%3DJNCCMNCR00001112&usg=__lp5iegZsEDQpVWANb6nPthEOv3Q=&h=400&w=300&sz=11&hl=nl&start=39&sig2=D_-zC58_JqPQgP6UA1bLsA&um=1&itbs=1&tbnid=N3vaFjY_mXtDKM:&tbnh=124&tbnw=93&prev=/images%3Fq%3DSabellaria%26start%3D21%26um%3D1%26hl%3Dnl%26sa%3DN%26ndsp%3D21%26tbs%3Disch:1&ei=p_egS8fUE9u_-Qb7mJGpDA

http://www.marlin.ac.uk/speciesinformation.php?speciesID=4277#

http://www.marlin.ac.uk/speciesfullreview.php?speciesID=3633

http://www.marlin.ac.uk/speciesfullreview.php?speciesID=4278

Biotope Requirements

Sublittoral tube worm reefs are found in mixed sediments found under a variety of hydrographic conditions [1]. Fine sediments with relatively high mud content are preferred. The reef builders itself realize state changes of the abiotic environment [2]. The trapping of the sediment is a physical process by which dense tube aggregations change the hydrodynamics on a small geographical scale. This stabilization and formation of an emergent structure is probably the most important causative factor to attract the associated benthos as a consequence of a so-called skimming flow (*i.e.* a decrease of current velocity at the sediment-water interface). This effect was shown not only to be the direct implication of the tubes changing the local hydrodynamics, but reinforcing alternative processes caused by the production of mucus, presence of bacteria, benthic diatoms etc. may explain the stabilizing impact of relatively low density aggregations [3-5].

Despite the fact that *S. alveolata* [6], *S. spinulosa* [7, 8] and *L. conchilega* occur in turbid marine waters, there seems to be an upper tolerance limit of particulate matter in suspension above which the reef builders weaken. Although more individuals of the reef are filter feeding with increasing suspended particulate matter, the clearance rates of individual *S. alveolata* are adversely affected [6].

Biotope Description

Polychaetes that aggregate in high densities and change their direct physical and biological environment are referred to as reefs on sediment. They play an important role in the structural composition or stability of the seabed and provide a wide range of niches for other species to inhabit. Consequently, polychaete worm reefs often support a diverse flora and fauna [1].

Associated Biotopes at EUNIS Level 5:

A5.612: Sabellaria alveolata on variable salinity sublittoral mixed sediment. *Sabellaria alveolata* is a filter feeding species commonly occurring along the European coasts [6, 9, 10]. Reefs occur mainly on the bottom third of the shoreline (i.e. intertidally) and in the shallow subtidal [7]. Nevertheless, the biotope has been described under EUNIS A5.61 category. The unique nature of the diverse assemblages found on bioconstructions of the ecosystem engineer *S. alveolata* is not related to the presence of particular species but it is rather owing to the juxtaposition of species belonging to surrounding communities [9]. Moreover, biodiversity decreases again when very high densities are reached (so called ‘platform-reefs’) [9, 11]. *Sabellaria alveolata* is reported to build reefs that reach regularly 50 cm thickness [7].

A5.611: Sabellaria spinulosa on stable circalittoral mixed sediment.*Sabellaria spinulosa*, is found almost entirely in the subtidal [7]. A clear structuring function on the benthic species composition was suggested [7 and references therein], though no unique species have been found [12]. The elevations created by dense aggregations are significant and reach large dimensions (*S. spinulosa* was found to reach 10-15 cm [12] and has been reported to grow up to 60 cm high [7].

A5.613: Serpula vermicularis reefs on very sheltered circalittoral muddy sand. Large clumps (mini 'reefs') of the calcareous tubes of *Serpula vermicularis*, typically attached to stones on muddy sediment in very sheltered conditions in sealochs and other marine inlets.

****A5.614 (proposed new insertion/optional numbering): Lanice conchilega reefs.*** This species is a well-known and widely distributed tube dwelling polychaete in soft bottom marine environments [13]. The physiology, the tube structure [2, 14], the hydrodynamic influence [15-17], the ecosystem-engineering influence on faunal abundance, the species richness and the species composition [13, 18, 19] as well as the occurrence of *L. conchilega* aggregations [20, 21] have been documented. The aggregations produce clearly defined microhabitats which alternate with areas without *L. conchilega*, generating a surface structure of gentle mounds and shallow depressions. This ‘seascape’ can be visualized using side scan sonar imagery [22]. For the macrobenthic community, the habitat modifying capacity of *L. conchilega* has been suggested to lie in the creation and regulation of safe havens for species, in influencing the interactions between local species and in changing the physical environment [13, 18]. Therefore, the species has been described as an important ecosystem engineer. Its effect on biodiversity has been described extensively [13, 17, 19, 20, 23-25]. *Lanice conchilega* has the capacity to double the biodiversity in the richest soft-sedimented macrobenthic habitat of the Belgian part of the North Sea (BPNS) (*i.e.* the *Abra alba – Kurtiella bidentata* community *sensu* Van Hoey *et al.* [26]). Furthermore, several studies describe in detail how *L. conchilega* affects the abiotic environment [27, 28]. Recently, the species has been defined as a true reef builder [29].

Biotope Evaluation: Goods and Services

Marine biogenic structures that reach a few centimetres into the water column can have a profound effect on the structure and functioning of marine ecosystems. These systems are heavily used by a variety of taxa, including post-settlement juveniles of commercially important fish species [30]. Furthermore, food availability can be an important factor explaining flatfish distribution in the nursery [31] and can even override abiotic habitat preferences [32]. It has been suggested that flatfish species actively select for a tube mat biotope built up by *Chaetopterus* sp. and *L. conchilega* [33, 34, 35] and clusters of *L. conchilega* constitute a large feeding area for 0-group flatfishes like *Pleuronectes platessa* and *Solea solea* [36].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☐	☒

Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

In general, anthropogenic influences can strongly modify the engineering community by removing autogenic ecosystem engineers through e.g. bottom trawling [37]. The phenomenon of ecosystem engineers in relation to fisheries activities is largely understudied [38 and references therein], given the importance of structure (both abiotic and biotic) to fisheries productivity and the declines of so many species resulting from fishing pressure. The loss of habitat structure generally leads to lower abundance (biomass) and often to declines in species richness [39]. Therefore, the impact of fisheries on marine ecosystem engineers is considered as a potentially serious problem because engineering activity influences both biological diversity and ecosystem functioning. Dubois *et al*. [9] state that degraded areas are more and more widespread in *S. alveolata* reefs either directly because of destructive manual fishing methods or indirectly through the impact of shellfish aquaculture. The anthropogenic activities cause a reduction in new recruit densities leading to significant damage to both the structure and the associated fauna of the system [10, 40]. Holt *et al*. [7] review the impact of bottom fisheries on *S. spinulosa*. The disappearance of the species in some areas in the Wadden Sea has been suggested as a good indicator for fishing intensity. Large areas in the North Sea with *S. spinulosa* reefs have been reported to disappear due to fisheries activities and commercial shrimp fisheries are known to search for *S. spinulosa* upon which they trawl for shrimps ([7] and references therein). Vorberg [41] found in a one-off experimental disturbance with a shrimp beam trawl that in the short-run, the reef structure itself does not disappear as the natural growth and capacity for repair is such that they can rebuild destroyed parts of their dwellings within a few days. The author indicates, however, that trawling in the medium to long-term can have consequences for the integrity of the reefs in the event of intensive fishing. For *L. conchilega*, the reef structure itself appears to be relatively resistant to fisheries impact [42] while the associated reef fauna experience an immediate impact [43]. In the event of intensive beam-trawling, the reef structure will eventually disappear [42]. As such, beam trawl impacts on subtidal reefs seem to be similar. However, for both reef systems there is not enough detailed knowledge on the natural development processes in the reef to interpret the significance of the various abiotic and biotic factors and it is therefore still difficult to predict the recovery capacity (*i.e.* the elasticity) of the different reef systems.

Conservation and protection status

It is not only necessary to value the function of ecosystem engineers in their environment but also to recognize the consequences of their anthropogenically induced degradation. Therefore, ecosystem engineers merit increased scientific and conservation emphasis, because of the fundamental role that they play in shaping habitat and the dependent communities from microbes to predators [38]. While traditional conservation efforts are focusing on charismatic species, the species that are the most critical in retaining community and ecosystem integrity and function are the ecosystem engineers that provide stress amelioration and associational defenses, and these should be the primary target of modern conservation efforts [44]. The value of polychaete worm reefs on sediment lies in their numerous links to different ecosystem levels, in their apparently important function in the ecosystem and in their implications for biodiversity (*i.e.* its effect on the niche breadth of several species).

Bouma *et al*. [37] indicate that coastal sediments in temperate locations are strongly modified by ecosystem engineers that shape the coastal sea and landscape and control particulate and dissolved material fluxes. The modifying effect is often most pronounced if several individuals manage to establish together and as such synergistically succeed in modifying the environment [37]. *Sabellaria alveolata*, *Sabellaria spinulosa* and *Lanice conchilega* have all the potential, when occurring in massive densities, to classify as reefs under the EU Habitats Directive (i.e. habitat type 1170). These biotopes are vulnerable to physical disturbance such as beam trawling. Given their important function within soft-sediment biotopes, these reefs are in need for stringent conservation measures.

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The marine habitat classification for Britain and Ireland version 04.05. In: Joint Nature Conservation Committee Report, Peterborough, UK www.jncc.gov.uk/MarineHabitatClassification Accessed 15 March 2010

[2] Jones SE, Jago CF (1993) In situ assessment of modification of sediment properties by burrowing invertebrates. Mar Biol 115: 133-142

[3] Fager EW (1964) Marine sediments: Effects of a tube-building polychaete. Science 143: 356-358

[4] Eckman JE, Nowell ARM, Jumars PA (1981) Sediment destabilization by animal tubes. J Mar Res 39: 361-374

[5] Murray JMH, Meadows A, Meadows PS (2002) Biogeomorphological implications of microscale interactions between sediment geotechnics and marine benthos: A review. Geomorphology 47: 15-30

[6] Dubois S, Barillé L, Cognie B (2009) Feeding response of the polychaete *Sabellaria alveolata* (Sabellariidae) to changes in seston concentration. J Exp Mar Biol Ecol 376: 94-101

[7] Holt TJ, Rees EI, Hawkins SJ, Seed R (1998) Biogenic Reefs. An overview of dynamic and sensitivity characteristics for conservation management of marine SACs. Scottish Association for Marine Science (UK Marine SACs Project), Volume IX

[8] Davies AJ, Last KS, Attard K, Hendrick VJ (2009) Maintaining turbidity and current flow in laboratory aquarium studies, a case study using *Sabellaria spinulosa*. J Exp Mar Biol Ecol 370: 35-40. doi: 10.1016/j.jembe.2008.11.015

[9] Dubois S, Retière C, Olivier F (2002) Biodiversity associated with *Sabellaria alveolata* (Polychaeta: Sabellariidae) reefs: Effects of human disturbances. J Mar Biol Ass UK 82: 817-826

[10] Dubois S, Commito JA, Olivier F, Retière C (2006) Effects of epibionts on *Sabellaria alveolata* (L.) biogenic reefs and their associated fauna in the Bay of Mont-Saint-Michel. Estuar Coast Shelf S 68: 635-646 doi: 10.1016/j.ecss.2006.03.010

[11] Porras R, Bataller JV, Murgui E, Torregrosa MT (1996) Trophic structure and community composition of polychaetes inhabiting some *Sabellaria alveolata* (L.) reefs along the Valencia Gulf Coast, Western Mediterranean. Mar Ecol-Pubblicazioni Della Stazione Zoologica Di Napoli I 17: 583-602

[12] Hendrick VJ, Foster-Smith RL (2006) *Sabellaria spinulosa* reef: A scoring system for evaluating 'reefiness' in the context of the Habitats Directive. J Mar Biol Ass UK 86: 665-677

[13] Rabaut M, Guilini K, Van Hoey G, Vincx M, Degraer S (2007) A bio-engineered soft-bottom environment: The impact of *Lanice conchilega* on the benthic species-specific densities and community structure. Estuar Coast Shelf S 75: 525-536 doi: 10.1016/j.ecss.2007.05.041

[14] Ziegelmeier E (1952) Beobachtungen über den Röhrenbau von *Lanice conchilega* (Pallas) im Experiment und am natürlichen Standort. Helgoländ Wiss Meer: 108–129

[15] Eckman JE (1983) Hydrodynamic processes affecting benthic recruitment. Limnol Oceanogr 28: 241-257

[16] Heuers J, Jaklin S, Zühlke R, Dittmann S, Günther CP, Hildebrandt H, Grimm V (1998) A model on the distribution and abundance of the tube-building polychaete *Lanice conchilega* (Pallas, 1766) in the intertidal of the Wadden Sea. Ver Ges Oekol 28: 207–215

[17] Dittmann S (1999) Biotic interactions in a *Lanice conchilega*-dominated tidal flat. In: Dittmann S (ed) The Wadden Sea ecosystem: Stability properties and mechanisms, pp 153-162

[18] Van Hoey G, Guilini K, Rabaut M, Vincx M, Degraer S (2008) Ecological implications of the presence of the tube-building polychaete *Lanice conchilega* on soft-bottom benthic ecosystems. Mar Biol 154:1009-1019. doi: 10.1007/s00227-008-0992-1

[19] Callaway R (2006) Tube worms promote community change. Mar Ecol Prog Ser 308: 49-60

[20] Carey DA (1987) Sedimentological effects and palaeoecological implications of the tube-building polychaete *Lanice conchilega* Pallas. Sedimentol 34: 49-66

[21] Hartmann-Schröder G (1996) Annelida, Borstenwürmer, Polychaeta. Gustav Fischer

[22] Degraer S, Moerkerke G, Rabaut M, Van Hoey G, Du Four I, Vincx M, Henriet JP, Van Lancker V (2008) Very-

high resolution side-scan sonar mapping of biogenic reefs of the tube-worm *Lanice conchilega*. Remote Sens Envir 112: 3323-3328. doi: 10.1016/j.rse.2007.12.012

[23] Féral P (1989) Biosedimentological implications of the polychaete *Lanice conchilega* (Pallas) on the intertidal zone of two Norman sandy shores (France). Bull Soc Géol France 5: 1193-1200

[24] Zühlke R, Blome D, Heinz van Bernem K, Dittmann S (1998) Effects of the tube-building polychaete *Lanice conchilega* (Pallas) on benthic macrofauna and nematodes in an intertidal sandflat. Senck marit 29: 131-138

[25] Van Hoey G (2006) Spatio-temporal variability within the macrobenthic *Abra alba* community, with the emphasis on the structuring role of *Lanice conchilega*. PhD thesis, Ghent University (UGent)

[26] Van Hoey G, Degraer S, Vincx M (2004) Macrobenthic community structure of soft-bottom sediments at the Belgian Continental Shelf. Estuar Coast Shelf S 59: 599-613. doi: 10.1016/j.ecss.2003.11.005

[27] Forster S, Graf G (1995) Impact of irrigation on oxygen flux into the sediment: Intermittent pumping by *Callianassa subterranea* and "piston-pumping" by *Lanice conchilega*. Mar Biol 123: 335-346

[28] Braeckman U, Provoost P, Gribsholt B, Middelburg J, Soetaert K, Vincx M, Vanaverbeke J (accepted) Experiments on the role of macrofauna functional traits and density in biogeochemical fluxes and bioturbation. Mar Ecol Prog Ser

[29] Rabaut M, Vincx M, Degraer S (2009) Do *Lanice conchilega* (sandmason) aggregations classify as reefs? Quantifying habitat modifying effects. Helgol Mar Res 63: 37-46. doi: 10.1007/s10152-008-0137-4

[30] Watling L, Norse EA (1998) Disturbance of the seabed by mobile fishing gear: A comparison to forest clearcutting. Conserv Biol 12: 1180-1197

[31] Beyst B, Cattrijsse A, Mees J (1999) Feeding ecology of juvenile flatfishes of the surf zone of a sandy beach. J Fish Biol 55: 1171-1186.

[32] Phelan BA, Manderson JP, Stoner AW, Bejda AJ (2001) Size-related shifts in the habitat associations of young-of-the-year winter flounder (*Pseudopleuronectes americanus*): Field observations and laboratory experiments with sediments and prey. J Exp Mar Biol Ecol 257: 297-315

[33] Rees EIS, Bergmann M, Galanidi M, Hinz H, Shucksmith R, Kaiser MJ (2005) An enriched Chaetopterus tube mat biotope in the eastern English Channel. J Mar Biol Assoc UK 85: 323-326

[34] Shucksmith R, Hinz H, Bergmann M, Kaiser MJ (2006) Evaluation of habitat use by adult plaice (*Pleuronectes platessa* L.) using underwater video survey techniques. Journal of Sea Research 56:317-328. doi: 10.1016/j.seares.2006.06.001

[35] Rabaut M, Van De Moortel L, Vincx M, Degraer S (2010) Biogenic reefs as structuring factor in *Pleuronectes platessa* (Plaice) nursery. J Sea Res 64: 102-106

[36] Amara R, Laffargue P, Dewarumez JM, Maryniak C, Lagardere F, Luczac C (2001) Feeding ecology and growth of O-group flatfish (sole, dab and plaice) on a nursery ground (Southern Bight of the North Sea). J Fish Biol 58: 788-803

[37] Bouma T, Olenin S, Reise K, Ysebaert T (2009) Ecosystem engineering and biodiversity in coastal sediments: Posing hypotheses. Helgol Mar Res 63: 95-106

[38] Coleman FC, Williams SL (2002) Overexploiting marine ecosystem engineers: Potential consequences for biodiversity. Trends Ecol Evol 17: 40-44

[39] Airoldi L, Balata D, Beck MW (2008) The Gray Zone: Relationships between habitat loss and marine diversity and their applications in conservation. J Exp Mar Biol Ecol 366: 8-15. doi: 10.1016/j.jembe.2008.07.034

[40] Dubois S, Comtet T, Retière C, Thiebaut E (2007) Distribution and retention of *Sabellaria alveolata* larvae (Polychaeta : Sabellariidae) in the Bay of Mont-Saint-Michel, France. Mar Ecol Prog Ser 346: 243-254. doi: 10.3354/meps07011

[41] Vorberg R (2000) Effects of shrimp fisheries on reefs of *Sabellaria spinulosa* (Polychaeta). ICES J Mar Scie 57: 1416-1420

[42] Rabaut M (2009) *Lanice conchilega*, fisheries and marine conservation: Towards an ecosystem approach to marine management. Ghent University (UGent), PhD thesis, 350 pp

[43] Rabaut M, Braeckman U, Hendrickx F, Vincx M, Degraer S (2008) Experimental beam-trawling in *Lanice conchilega* reefs: Impact on the associated fauna. Fisheries Research 90:209-216. doi: 10.1016/j.fishres.2007.10.009

[44] Crain CM, Bertness MD (2006) Ecosystem engineering across environmental gradients: Implications for conservation and management. Bioscie 56: 211-218

Sublittoral mussel beds on sediment

Compiled by Marijn Rabaut

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A5.62	Sublittoral mussel beds on sediment

Pictures

Not available

Biotope Distribution

Not available

Links to Available Maps

http://www.jncc.gov.uk/Marine/biotopes/biotope.aspx?biotope=JNCCMNCR00000374

Biotope Requirements

Found in a variety of habitats ranging from sheltered estuaries and marine inlets to open coasts and offshore areas they may occupy a range of substrata, although due to the stabilising effect such communities have on the substratum muddy mixed sediments are typical. A diverse range of epibiota and infauna often exists in these communities [1].

Biotope Description

Sublittoral mussel beds comprised of either the horse mussel *Modiolus modiolus* or the common mussel *Mytilus edulis*. These communities may be sublittoral extensions of littoral reefs or exist independently [1]. Moreover, surface topography of a soft-bottom mussel bed is fractal at a spatial scale relevant to hydrodynamic processes and habitat structure important for benthic organisms [2].

Field experiments were carried out to investigate the effects of mussels (*Mytilus edulis*) on fauna and on sediment characteristics [3]. In the first experiment mussels were removed from within an established mussel bed to create bare patches and in the second experiment mussels were transplanted to an adjacent bare sandflat. In the mussel removal experiment, mobile epibenthic crustaceans (predominately *Gammarus* spp. and *Jaera albifrons*) were markedly reduced in bare patches whereas infaunal species were much less affected. In the mussel transplant experiment, mobile epibenthic crustaceans (e.g. *Gammarus* spp. and *Jaera albifrons*) colonised mussel transplant plots, but were absent at all times from the adjacent sandflat sediments. The polychaetes *Eteone longa* and *Pygospio elegans* were both significantly reduced in mussel transplant plots, whilst *Capitella* spp. increased in numbers. Mussels clearly had marked effects on both the fauna and sediments probably through a combination of biodeposition and filtration by the mussels and the provision of a structurally complex habitat [3].

Biotope Evaluation: Goods and Services

Mussel beds could be used to dissipate wave energy and thereby protecting valuable salt marshes from erosion both in the Wadden Sea and in the Eastern Scheldt estuary. Mussel beds could also increase deposition in these areas by slowing down the flow [4]. Moreover, there are fisheries at a number of localities and they are often farmed: banks of small overcrowded mussels are moved to more favourable areas where growth is rapid. This mussel production is based on an extensive culture and depends entirely on natural resources for food, spat and space. In the main culture areas, production with existing techniques seems to have reached the system's carrying capacity. Spat availability can be an additional limiting factor, particularly in bottom culture. In many traditional mussel culture areas, new functions have developed, such as recreation and nature conservation, and therefore extension of mussel culture is now also space limited. Expansion of mussel culture in Europe takes place in areas like Scottish fjords, Ireland and Greece, and is planned in Norway. Further development of sustainable mussel culture in Europe has different requirements for traditional and for new areas [5].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☒	☐	☐
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Within a year of commencement of fisheries on a sublittoral mussel bed on sediment, a significant change in the species composition of the benthic community can occur, with a decrease in the number of species and in the total number of individuals. The abundance of carnivorous and deposit feeding benthic species increased, whilst the mussels outcompeted other benthic filter feeding organisms, preventing the settlement of these organisms by ingestion of the larvae, and removed other benthic organisms by physical smothering [6]. Mussel dredgers can damage this structure by either removing the entire bed or by making the structure more open and exposed to wave action [7]. A German study [8, 9] on the impact of fisheries on a few mussel beds in Lower-Saxony, indicated that even removal of a small percentage of mussels caused almost complete destruction of the beds within one year after the fisheries took place.

Conservation and protection status

It is not only necessary to value the function of ecosystem engineers in their environment but also to recognize the consequences of their anthropogenically induced degradation. Therefore, ecosystem engineers merit increased scientific and conservation emphasis, because of the fundamental role that they play in shaping habitat and the dependent communities from microbes to predators [10]. While traditional conservation efforts are focusing on charismatic species, the species that are the most critical in retaining community and ecosystem integrity and function are the ecosystem engineers that provide stress amelioration and associational defenses, and these should be the primary target of modern conservation efforts [11].
Within the EC/92/43 Habitats Directive, this biotope can be protected as “Reefs” (habitat type 1170).

References

[1] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) The marine habitat classification for Britain and Ireland version 04.05. In: Joint Nature Conservation Committee Report, Peterborough, UK www.jncc.gov.uk/MarineHabitatClassification Accessed 15 March 2010

[2] Commito JA, Rusignuolo BR (2000) Structural complexity in mussel beds: the fractal geometry of surface topography. J Exp Mar Biol Ecol 255: 133-152

[3] Ragnarsson SA, Raffaelli D (1999) Effects of the mussel *Mytilus edulis* L. on the invertebrate fauna of sediments. J Exp Mar Biol Ecol 241: 31-43

[4] Leeuwen van B (2008) Modeling mussel bed influence on fine sediment dynamics on a Wadden Sea intertidal flat, University of Twente

[5] Smaal AC (2002) European mussel cultivation along the Atlantic coast: production status, problems and perspectives. Hydrobiol 484: 89-98

[6] Smith J, Shackley SE (2004) Effects of a commercial mussel Mytilus edulis lay on a sublittoral, soft sediment benthic community. Mar Ecol Prog Ser 282: 185-191

[7] Nehls G, Thiel M (1993) Large scale distribution patterns of the mussel *Mytilus edulis* in the Wadden sea of Schleswig Holstein: do storms structure the ecosystem? Netherl J Sea Res 31: 181–187

[8] Herlyn M, Millat G, Michaelis H (1999) Einfluss der Besatzmuschelentnahme auf die Entwicklung eulitoraler Neuansiedlungen von *Mytilus edulis L*. im niedersächsischen Wattenmeer. NLÖ-Forschungsstelle Küste 9/1999: 27 pp

[9] Herlyn M, Millat G (2000) Decline of the intertidal blue mussel (*Mytilus edulis*) stock at the coast of Lower Saxony (Waddensea) and influence of mussel fishery on the development of young mussel beds. *Hydrobiol* 426: 203-210[10] Coleman FC, Williams SL (2002) Overexploiting marine ecosystem engineers: Potential consequences for biodiversity. Trends Ecol Evol 17: 40-44

11] Crain CM, Bertness MD (2006) Ecosystem engineering across environmental gradients: Implications for conservation and management. Bioscie 56: 211-218

Pontic Ostrea edulis biogenic reefs on mobile seabottom

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A5.64	Pontic *Ostrea edulis* biogenic reefs on mobile seabottom

Picture(s)
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements
The reefs occur along moderately exposed coasts of the Western Black Sea in clear marine waters, on rocky and mixed bottoms between 7 - 25 m depth.

Biotope Description
Unlike the flat oyster beds on the Atlantic, Mediterranean and Eastern Black Sea coast that represent clumps and layers of dead shells and life oysters attaining maximum height of 0.5-1 m above the surrounding mixed sediments [1, 2] the Pontic oyster reefs constitute massive erect biogenic structures attaining 7 m height, 30-50 m length and 10 m width, distinguished by high three-dimensional complexity and irregular, branching or netted shape with serrated margins [3, 4, 5]. The reefs are constructed mainly of aggregated *Ostrea edulis* shells, with calcareous tubes of *Sabellaria taurica* also present as cementing material. Oysters on the reefs are currently extinct, life oysters observed last in the 1970s (Klisurov pers. com.) thus the reefs have become functionally relic [1]. At present oyster reefs are colonised by blue mussels and sponges, overgrown by red (*Delesseria ruscifolia*) and brown (*Zanardinia typus*) sciaphilic algae, and abundantly populated by crabs (*Eriphia verrucosa*), a variety of blennies, gobies, scorpionfishes, and wrasses, and riddled with the boreholes of the bivalve *Petricola lithophaga*.
The biotope is considered unique of European marine waters.

Biotope Evaluation: Goods and Services
Recent oysters remain the most potent reef-builders among bivalves, being ecosystem engineers that create biogenic habitats important to biodiversity, benthic-pelagic coupling, and fishery production. *Ostrea edulis* is an active suspension feeder on phytoplankton, bacteria, particulate detritus and dissolved organic matter [1 and references therein]. Reefs of suspension feeding bivalves are important in nutrient cycling in estuarine and coastal ecosystems, transferring phytoplankton primary production and nutrients to benthic/fish secondary and tertiary production. The severe decline and probable extinction of oysters on the reefs has resulted loss in the ecosystem services provided by this biotope.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐

Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☒	☐	☐
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

The causes of *Ostrea edulis* local extinction in the Western Black Sea are currently unclear. In the Western Black Sea the oysters were never commercially fished, and recreational harvest was very limited, so overfishing can be ruled out as a cause of extinction. The possible causes responsible for the oyster's loss could be increased sedimentation and overall ecological degradation during the anthropogenic eutrophication period in the Black Sea in the second half of the last century. Generally, *Ostrea edulis,* being permanently fixed to the substratum and unable to burrow up through the deposited material, is known to be sensitive to smothering by increased sedimentation [1 and references therein]. Pathogens such as *Bonamia ostreae* that reached Europe via introduction of infected *O. edulis* from North America and brought about disease outbreaks occurring first in France in 1979 and spreading to neighbouring countries over the following decades could have reached and affected the Black Sea oyster populations too [3 and references therein]. The predatory pressure of the alien whelk *Rapana venosa* could have contributed as well [2, 6] although feeding experiments have shown that oysters are not preferred prey for *Rapana* [7].

Conservation and protection status

Since the 1980s severe decline of oyster populations has been reported for all habitats along the Black Sea coasts – both sedimentary bottoms and rocky reefs (PERELADOV, 2005). *Ostrea edulis* is included in the Black Sea Red Data Book as Endangered [8]. Being unique and important to marine biodiversity and food web maintenance in the coastal ecosystem, Pontic oyster reefs are of high conservation interest and measures for their rehabilitation are needed. However restoration programmes may be futile since recovery of oyster stocks is shown to be complicated and dependent on many factors, such as sufficient spawning stock density to ensure synchronous spawning and larval production, presence of adults and shell material to enhance settlement, hydrodynamic containment in a favorable environment, etc. Pontic oyster reefs qualify for Natura 2000 habitat type 1170 Reefs.

References

[1] Tyler-Walters H (2008) Ostrea edulis beds on shallow sublittoral muddy sediment. Marine Life Information Network: Biology and Sensitivity Key Information Sub-programme. Plymouth: Marine Biological Association of the United Kingdom [cited23/03/2010] http://www.marlin.ac.uk/habitatsbasicinfo.php?habitatid=69&code=1997

[2] Pereladov MV (2005) Modern status of the Black Sea Oyster population. Coastal hydrobiological investigations. VNIRO Proceedings, 144: 254-273

[3] Todorova V, Micu D, Klisurov L (2009) Unique Oyster reefs discovered in the Bulgarian Black Sea. Comptes Rendus de l'Academie bulgare des Sciences, 62(7): 871-874

[4] Micu D, Todorova V (2007) A fresh look at the western Black Sea biodiversity. MarBEF Newsletter No 7, pp 26-28

[5] Todorova V, Micu D, Panayotova M, Konsulova T (2008) Marine Protected Areas in Bulgaria - Present and Prospects, Steno Publishing House, Varna, pp 20

[6] Chuhchin VD (1984) Ecology of the gastropod molluscs of the Black Sea. Academy of Sciences of the USSR, Kiev, Naukova Dumka, pp 175 (in Russian)

[7] Ivanov AI, Rudenko VI (1969) Intensity of the rapa whelk (*Rapana thomassiana*) growth relative to size and season. Trudy AzCherNIRO, 26: 167-172 (in Russian)

[8] Dumont HJ (Ed) (1999) *Black Sea Red Data Book.* Published by the United Nations Office for Project Services, 413 pp. http://www.grid.unep.ch/bsein/redbook/index.htm

Organically-enriched or anoxic sublittoral habitats

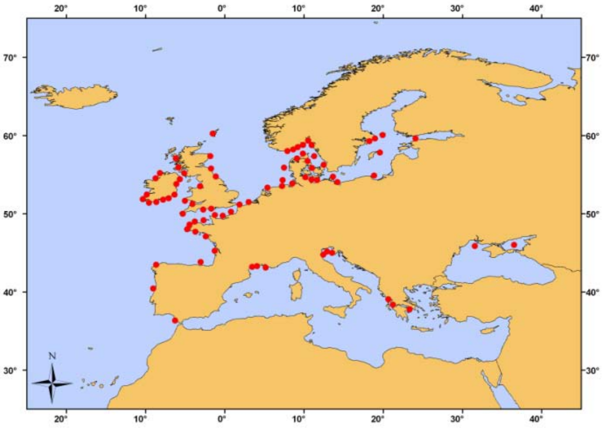
Compiled by Ibon Galparsoro, Marta Pascual and Ángel Borja

Classification	Code	Title
EUNIS	A5.72	Organically-enriched or anoxic sublittoral habitats

Picture(s)

Not available

Biotope Distribution



Map of recorded distribution

Links to Available Maps

www.jncc.gov.uk/MarineHabitatClassification/
http://rs.resalliance.org/2006/03/23/mapping-anoxic-zones-pt-2/

Biotope Requirements

Sublittoral soft seafloor with anoxic mud, often in areas with poor water exchange. In the open sea, a conspicuous bacterial mat could be present covering the surface. Fully saline (30-35 ppt) or variable (18-35 ppt); wave exposure: Sheltered, Very sheltered or Extremely sheltered; tidal streams: weak (>1 kn) or very weak (negligible).
The anoxia may be a result of natural conditions of poor water exchange, in some sea lochs, or anthropogenically, under fish farm cages or wastewater discharges due to nutrient and/or organic enrichment. The fauna is normally impoverished at such sites, with few elements of the infaunal communities present in other muddy biotopes [2]. The occurrence of this biotope is a classic response to excessive organic biodeposition in shallow coastal inlets with relatively low dispersive capacity [3]. The biotope is defined by a very slow recovery time of species under severe oxygen deficiency [4].

Biotope Description

Tight coupling has been demonstrated between gradual degradation of benthic habitats and faunal behaviour, species richness, abundance and biomass. There seems to be a critical oxygen level (normally <2 $ml.l^{-1}$) that forces changes in the benthic faunal successional stages leading to benthic community successional stages from equilibrium to virtually azoic conditions [5]. As normoxic conditions would return, pioneering stages would gradually recolonise the area [6].
Once the organically-enriched or anoxic sublittoral conditions are being reached, scavenging species such as *Asterias rubens* and *Carcinus maenas* are typically present (where the environment is not too anoxic) along with occasional *Arenicola marina;* in extreme conditions of anoxia little survives other than the *Beggiatoa*. The polychaete *Ophiodromus flexuosus* occurs in high densities at the interface between oxygenated and deoxygenated sediments (in Norwegian fjords) [1].

Associated Biotopes at EUNIS Level 5 and 6:
A5.721: Periodically and permanently anoxic sublittoral muds.
Associated sub-biotope:

A5.7211: Beggiatoa spp. on anoxic sublittoral mud. Sublittoral soft anoxic mud, often in areas with poor water exchange with the open sea, can have a conspicuous bacterial mat covering of *Beggiatoa* spp. The anoxia may be a result of natural conditions of poor water exchange in some sealochs (and many Scandinavian fjords) or artificially under fish farm cages from nutrient enrichment. The fauna is normally impoverished at such sites, with few elements of the infaunal communities present in other muddy biotopes. Scavenging species such as *Asterias rubens* and *Carcinus maenas* are typically present where the environment is not too anoxic along with occasional *Arenicola marina* but in extreme conditions of anoxia little survives other than the *Beggiatoa*. The polychaete *Ophiodromus flexuosus* occurs in high densities at the interface between oxygenated and deoxygenated sediments (in Norwegian fjords) [2]. Beggiatoa-dominated sublittoral mud are likely to be a seasonal phenomenon although not necessarily annual depending on the time of year of the survey and prevailing conditions such as temperature, nutrient inputs (whether natural or anthropogenic) and productivity [7].

Biotope Evaluation: Goods and Services

The Global International Waters Assessment (GIWA) regional assessments reported that dead zones have become increasingly common in the world's lakes, estuaries and coastal zones, with serious impacts on local fisheries, biodiversity and ecosystem functions. Extensive dead zones have been observed for many years in the Baltic Sea, Black Sea and Gulf of Mexico [1, 8]. The action of bio-turbation by benthic organisms, mainly through the construction of burrows, plays a significant role in nutrient cycling, the latter being affected by storage, internal cycling, processing and acquisition by marine benthic organisms, for example fish mineralize nitrogen and phosphorous via excretion [9]. Benthic animals from a wide range of phyla have developed different strategies in adapting to exposure to hypoxic/anoxic conditions resulting in survival for many weeks under adverse environmental conditions [10].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☐	☒	☐
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

This biotope could suffer from eutrophication problems due to nutrient input from human agricultural / sewage/ sanitation activities. The biotope is also sensitive to continental-marine organic matter input [11]. High disturbance could be caused by dredging activities or by trawling [12]. Megafauna play a significant role in bio-turbation, and as detailed earlier it is these organisms which are most vulnerable to trawling activity. Disturbance by the increasing aquaculture activities increment which leads to the increasing of fouling pests, toxic / noxious microalgae blooms, diseases, etc. [13, 14].

Conservation and protection status

There is a need to design more efficient monitoring programs to assess eutrophication effects in estuaries and determine the effectiveness of regulatory or management initiatives to reduce organic over-enrichment of seabeds.

References

[1] Díaz RJ, Rosenberg R (2008) Spreading Dead Zones and Consequences for Marine Ecosystems. Scie 321: 926-29

[2] Connor DW, Allen JH, Golding N, Howell KL, Lieberknecht LM, Northen KO, Reker JB (2004) Marine Habitat Classification for Britain and Ireland Version 04.05. JNCC, Peterborough. www.jncc.gov.uk/MarineHabitatClassification

[3] Cranford PJ, Hargrave BT, Doucette LI (2009) Benthic organic enrichment from suspended mussel (*Mytilus edulis*) culture in Prince Edward Island. Canada Aquacult 292(3-4): 189-96

[4] Powilleit M, Kube J (1999) Effects of severe oxygen depletion on macrobenthos in the Pomeranian Bay (southern Baltic Sea): a case study in a shallow, sublittoral habitat characterised by low species richness. J Sea Res 42(3): 221-34

[5] Díaz RJ, Rosenberg R (1995) Marine Benthic Hypoxia: A review of its ecological effects and the behavioural resposes of benthic macrofauna. Oceanogr Mar Biol: an Annual Review 33: 245-303

[6] Nilsson HC, Rosenberg R (2000) Succession in marine benthic habitats and fauna in response to oxygen deficiency: analysed by sediment profile-imaging and by grab samples. Mar Ecol Progr Ser 197: 139-149

[7] Ltd. ES (2006) Site Condition Monitoring: surveys of lagoons in the Vadills Lagoon Special Area of Conservation, July-August 2003. Scottish Natural Heritage Commissioned Report No. 209 (ROAME No. F02AA409c). Available online at: http://www.snh.org.uk/pdfs/publications/commissioned_reports/Report%20No209.pdf

[8] Rabalais NN, Díaz RJ, Levin LA, Turner RE, Gilbert D, Zhang J (2010) Dynamics and distribution of natural and human-caused hypoxia. Biogeoscie J1 - BG, 7: 585-619.

[9] Beaumont NJ, Tinch R (2003) Goods and Services related to the marine benthic environment. CSERGE Working Paper ECM 03-14 http://www.uea.ac.uk/env/cserge/pub/wp/ecm/ecm_2003_14.pdf:21

[10] Hagerman L (1998) Physiological flexibility; a necessity for life in anoxic and sulphidic habitats. Hydrobiol 376: 241-54

[11] Mojtahid M, Jorissen F, Lansard B, Fontanier C, Bombled B, Rabouille C (2009) Spatial distribution of live benthic foraminifera in the Rhone prodelta: Faunal response to a continental-marine organic matter gradient. Mar Micropaleont 70(3-4): 177-200

[12] Thrush SF, Dayton PK (2002) Disturbance to marine benthic habitats by trawling and dredging: Implications for marine biodiversity. Ann Rev Ecol System 33: 449-73

[13] Forrest BM, Keeley NB, Hopkins GA, Webb SC, Clement DM (2009) Bivalve aquaculture in estuaries: Review and synthesis of oyster cultivation effects. Aquacult 298(1-2): 1-15

[14] Kaiser MJ, Laing I, Utting SD, Burnell GM (1998) Environmental impacts of bivalve mariculture J Shellf Res 17(1): 59-66

Deep-sea artificial hard substrata

Compiled by Roberta Mifsud

Classification	**Code**	**Title**
EUNIS	A6.12	Deep-sea artificial hard substrata

Picture(s)

Not available

Biotope Distribution

Not available

Links to Available Maps

Not available

Biotope Requirements

Communities using artificial material as their hard substratum in the deep-sea (generally defined as waters deeper than 200m) are found wherever such material is available. The colonization of the artificial hard substrata in terms of abundance and type of organisms which settle depends on several factors including surface texture and complexity [1, 2, 3, 4, 5], surface colour [6, 7, 8], surface energy or surface wettability [9, 10, 11, 12] and composition [13, 14, 15]. How surfaces colonize is also affected by other parameters such as surface orientation [16, 17, 18] and position in relation to other marine surfaces / sediment [19, 20]. It is, therefore, evident that the process of colonization of artificial surfaces submerged in the marine environment is undoubtedly complex with a large number of factors influencing the settlement process and the development of epifaunal communities. In addition, the material from which an artificial reef is made also has the potential to have a significant affect on the way the surfaces of the reef are colonized by epifauna and flora that, in turn, will influence the eventual biodiversity of the system [21].

Biotope Description

Hard substrata in the deep sea are generally found in the form of habitat islands as they are usually discrete, insular habitats surrounded by an environment that poses diffulties for dispersal. The dispersal barrier for attached organisms is the vast areal extent of soft sediment on the deep-sea floor [22]. Such habitats in the deep sea encompass seamounts (e.g [23, 24]), hydrothermal vents (e.g. [25, 26]), rock outcrops [27], dropstones [28], manganese nodules [29, 22] as well as any other hard substratum of anthropogenic origin.

Although artificial substrata (a.k.a. artificial reefs) have been used deliberately in shallow waters with the aim of serving as a tool to protect habitats from trawling destruction, promote nature conservation, aid fisheries, as biofiltration structures [30] and/or in reef-to-rig conversions, such practices are very uncommon in deep seas. Communities living on artificial hard substrata in deeper waters are usually found on small-scale anthropogenic material deployed for experimental purposes, accidental ship wrecks or larger-scale infrastructure components such as underwater cables.

Invasion rates of hard substrata in deep water is usually high for opportunistic species, characterized as species with high reproductive rates, good dispersal ability, short generation time, and low competitive ability (e.g. [31]). In fact, the most common taxon recruiting artificial substrata are usually foraminifera, which are indeed considered opportunistic ([32, 33]) [22]. On the contrary of what is evidenced in shallow waters, deep-sea colonization does not exhibit temporal and spatial variation in recruitment, i.e. no difference was reported in artificial substrata deployed in four different locations during four different time periods [22].

Biotope Evaluation: Goods and Services

Although artificial substrata have been used deliberately in shallow waters with the aim of serving as a tool to protect habitats from trawling destruction, promote nature conservation, aid fisheries, as biofiltration structures or in rig-to-reef conversions, such practices are very uncommon in deep seas. Communities living on artificial hard substrata in deeper waters are usually found on small-scale anthropogenic material deployed for experimental purposes, accidental ship wrecks or larger-scale infrastructure components such as underwater cables. There is an attraction vs. production debate regarding artificial reefs [34, 35], where on one hand scientists see such structures as replacing lost habitat by allowing encrusting organisms to grow, providing cover, and hence enhancing the production of large fish. On the other hand, some elements of the conservation movement have come to regard artificial reefs with alarm, seeing them as merely fish aggregators that speed up the depletion of vulnerable large fish [36, 37].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

Communities inhabiting deep-sea artificial hard substrata are not particularly threatened from any human activities. However, there is some concern about the introduction of artificial hard substrata on the seabed which apart from positive effects might also have counter effects such as the increase in fishing effort and catch rates, boosting of the potential for overexploitation of stocks by increasing access to previously unexploited stock segments and increasing the probability of overexploitation by concentrating previously exploited segments of the stock [34]. Furthermore, while studies clearly show, for example, that increasing habitat structure and heterogeneity using artificial reefs can increase the local abundance of fish, it has not been conclusively demonstrated that the total fish yield for any body of water increases significantly as a result of structural modification, rather it may be that the artificial habitat tends to concentrate fish that were already present [38, 39, 40, 41].

Conservation and protection status

Communities inhabiting artificial hard substrata in the deep sea do not require any conservation as they are not exposed to any particular anthropogenic threats.

References

[1] Crisp DJ, Ryland JS (1960) Influence of filming and of surface texture on the settlement of marine organisms. Nature (Lond) 185: 119

[2] Bourget E, Deguise J, Daigle G (1994) Scales of substratum heterogeneity, structural complexity, and the early establishment of a marine epibenthic community. J Exp Mar Biol Ecol 181: 31-51

[3] Lemire M, Bourget E (1996) Substratum heterogeneity and complexity influence micro-habitat selection of Balanus sp and Tubularia crocea larvae. Mar Ecol Prog Ser 135: 77-87

[4] Walters LJ, Wethey DS (1996) Settlement and early post settlement survival of sessile marine invertebrates on topographically complex surfaces: the importance of refuge dimensions and adult morphology. Mar

Ecol Prog Ser 137: 161-171
[5] Bers AV, Wahl M (2004) The influence of natural surface topographies on fouling. Biofouling 20: 43-51
[6] Taki Y, Ogasawara Y, Ido Y, Yokoyama N (1980) Colour factors influencing larval settlement of barnacles, Balanus amphitrite subspp. Bull Jap Soc Sci Fish 46: 133-138
[7] James RJ, Underwood AJ (1994) Influence of color of substratum on recruitment of spirorbid tubeworms to different types of intertidal boulders. J Exp Mar Biol Ecol 181: 105-115
[8] Kon-ya K, Miki W (1994) Effects of environmental factors on larval settlement of the barnacle Balanus amphitrite reared in the laboratory. Fish Sci (Tokyo) 6: 563-565
[9] Rittschof D, Hooper IR, Schmidt AR (1986) Settlement of marine macroinvertebrate larvae on chemically defined surfaces. Am Soc Zool 26: A102
[10] Schmidt AR, Rittschof D, Hooper IR, Gerhart DJ, Hill L, Bonaventura J, Costlow JD (1987) Wettability affects settlement of barnacles and bryozoans in the field. Am Soc Zool 27: A42
[11] Rittschof D, Costlow JD (1989) Bryozoan and barnacle settlement in relation to initial surface wettability: a comparison of laboratory and field studies. Scient Mar 53: 411-416
[12] Roberts D, Rittschof D, Holm E, Schmidt AR (1991) Factors influencing initial larval settlement: temporal, spatial and surface molecular components. J Exp Mar Biol Ecol 150: 203-211
[13] McGuinness KA (1989) Effects of some natural and artificial substrata on sessile marine organisms at Galeta Reef, Panama. Mar Ecol Prog Ser 52: 201-208
[14] Anderson MJ, Underwood AJ (1994) Effects of substratum on the recruitment and development of an intertidal estuarine fouling assemblage. J Exp Mar Biol Ecol 184: 217-236
[15] Qiu JW, Thiyagarajan V, Leung AWY, Qian PY (2003) Development of a marine subtidal epibiotic community in Hong Kong: implications for deployment of artificial reefs. Biofouling 19: 37-46
[16] Todd CD, Turner SJ (1986) Ecology of intertidal and sublittoral cryptic epifaunal assemblages. I. Experimental rationale and the analysis of larval settlement. J Exp Mar Biol Ecol 99: 199-231
[17] Hurlbut CJ (1991) The effects of larval abundance, settlement and juvenile mortality on the depth distribution of a colonial ascidian. J Exp Mar Biol Ecol 150: 183-202
[18] Connell SD (1999) Effects of surface orientation on the cover of epibiota. Biofouling 14: 219-226
[19] Glasby TM, Underwood AJ (1998) Determining positions for control locations in environmental studies of estuarine marinas. Mar Ecol Prog Ser 171: 1-14
[20] Glasby TM, Connell SD (2001) Orientation and position of substrata have large effects on epibiotic assemblages. Mar Ecol Prog Ser 214: 127-135
[21] Brown CJ (2005) Epifaunal colonization of the Loch Linnhe artificial reef: Influence of substratum on epifaunal assemblage structure. Biofouling 21: 73-85
[22] Beaulieu SE (2001) Colonization of habitat islands in the deep sea: recruitment to glass sponge stalks. Deep-Sea Res I, 48: 1121-1137
[23] Mullineaux LS (1994) Implications of mesoscale flows for dispersal of deep-sea larvae. In: Young CM, Eckelbarger KJ (eds) Reproduction, Larval Biology, and Recruitment of the Deep-Sea Benthos. Columbia University Press, New York, pp 201-221
[24] Mullineaux LS, Mills SW (1997) A test of the larval retention hypothesis in seamount-generated flows. Deep-Sea Res I, 44: 745-770
[25] Lutz RA (1985) Dispersal of organisms at deep-sea hydrothermal vents: a review Hydrothermalism, biology and ecology symposium. Oceanol Acta, Paris, pp 23-29
[26] Hessler RR, Smithey Jr WM, Boudrias MA, Keller CH, Lutz RA, Childress JJ (1988) Temporal change in megafauna at the Rose Garden hydrothermal vent (Galapagos Rift; eastern tropical Pacific). Deep-Sea Res I, 35: 1681-1709
[27] Lissner AL, Taghon GL, Diener DR, Schroeter SC, Dixon JD (1991) Recolonization of deep-water hard substrate communities: potential impacts from oil and gas development. Ecolog Appl 1: 258-267
[28] Oschmann W (1990) Dropstones-rocky mini-islands in high-latitude pelagic soft substrate environments. Senckenbergiana maritima 21: 55-75
[29] Mullineaux LS (1987) Organisms living on manganese nodules and crusts: Distribution and abundance at three North Pacific sites. Deep Sea Res 34: 165-184
[30] Jensen A, Collins K, Lockwood P (2000) Current issues relating to artificial reefs in European Seas. In: Jensen A, Collins K, Lockwood P (eds) Artificial reefs in European seas. Kluwer Academic Publishers, Dordrecht, The Netherlands
[31] Grassle JF, Sanders HL (1973) Life histories and the role of disturbance. Deep-Sea Res 20: 643-659
[32] Lipps JH (1983) Biotic interactions in benthic foraminifera. In: Tevesz MJS, McCall PL (eds) Biotic Interactions in Recent and Fossil Benthic Communities. Plenum Press, New York, pp 331-376

[33] Kaminski MA, Grassle JF, Whitlatch RB (1988) Life history and recolonization among agglutinated foraminifera in the Panama Basin. Abhandlungen der Geologischen Bundesanstalt 41: 229-243

[34] Grossman GD, Jones GP, Seaman Jr. WJ (1997) Do artificial reefs increase regional fish production? A review of existing data. Fisheries. Special issue on artificial reef management 22: 17-23

[35] Pickering H, Whitmarsh D (1997) Artificial reefs and fisheries exploitation: A review of the "attraction versus production" debate, the influence of design and its significance for policy. Fish Res 31: 39-59

[36] Polovina JJ (1989) Artificial reefs: Nothing more than benthic fish aggregators. Reports of California Cooperative Oceanic Fisheries Investigations [REP. CCOFI.] 30

[37] Pitcher TJ, Seaman Jr W (2000) Petrarch's Principle: how protected human-made reefs can help the reconstruction of fisheries and marine ecosystems. Fish Fish 1: 73-81

[38] Bohnsack JA (1989) Are high densities of fishes at artificial reefs the result of habitat limitation or behavioural preference? Bulletin of Marine Science 44: 631-645

[39] Bohnsack JA (1991) Habitat structure and the design of artificial reefs. In: Bell SS, McCoy ED, Mushinsky HR (eds) Habitat Structure-The Physical Arrangement of Objects in Space. Chapman & Hall, London, pp 412-430

[40] Ryder RA, Kerr SR (1989) Environmental priorities: placing habitat in hierarchic perspective. Canadian Special Publication in Fisheries and Aquatic Science 105: 2-12

[41] Turner SJ, Thrush SF, Hewitt JE, Cummings VJ, Funnell G (1999) Fishing impacts and the degradation or loss of habitat structure. Fisheries Manag Ecol 6: 401-420

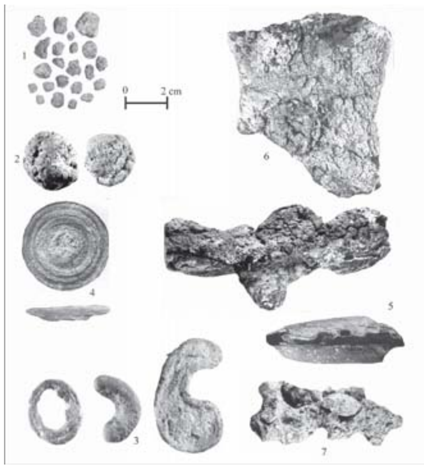
Deep-sea manganese nodules

Compiled by Roberta Mifsud

Classification	Code	Title
EUNIS	A6.13	Deep-sea manganese nodules

Picture(s)

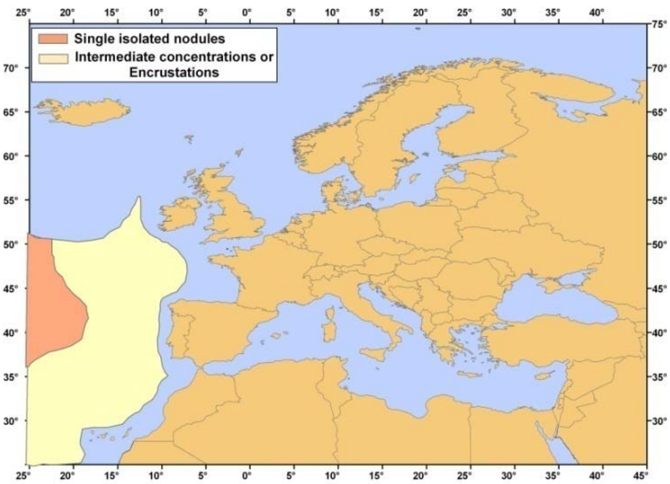
An abundant concretion field on the sea floor of the eastern Gulf of Finland (excerpted from [1]).
Courtesy of:
Zhamoida Vladimir, Ph.D., Department of Regional Geoecology & Marine Geology Russian Research Geological Institute (VSEGEI)



Typical ferromanganese concretions from the eastern Gulf of Finland: 1) buckshot concretions; 2) sphoeroidal concretions; 3) irregular concretions; 4) discoidal concretions; 5) concentric rings around erratic nuclei; 6) large flat concretions or crusts without erratic nuclei; 7) irregular crusts incorporating large amounts of clastic material (excerpted from [2]).

Biotope Distribution

Manganese deposits are found on the bottom of all oceans, but not in the Mediterranean and the Red Sea [4].



Distribution of ferromanganese oxide concentrations in the North Atlantic (adapted from [3]).

Links to Available Maps

http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0102-261X2000000300007

Biotope Requirements

The formation of manganese nodules and crusts takes place where a source of manganese is obtained via the following methods of formation: hydrogenetic, diagenetic, hydrothermal [5] and halmyrolitic [6]. Hydrogenetic deposits form from seawater in an oxidizing environment. Such nodules form by precipitation from the sea-water (with possible bacterial mediation) and their growth also comprehends early diagenetic formation.

Diagenetic deposits result from diagenetic processes (the process of chemical and physical change in deposited sediment during its conversion to rock) within the underlying sediments leading to upward supply of elements from the sediment column. Hydrothermal deposits precipitate directly from hydrothermal solutions in areas with high heat flow such as mid-ocean ridges, back-arc basins and hot spot volcanoes. These tend to be associated with hydrothermal sulphide deposits and iron oxihydroxide crusts. The important source of manganese in the pelagic environment is often related to hydrothermal activity association with global tectonic processes [5]. Halmyrolitic formation takes place when the source of metallic components is the seawater weathering of basaltic debris [6].

Manganese nodules are usually found in places where sedimentation rates are low, such as in red clay or siliceous ooze areas (where sedimentation rates are in the magnitude of 1 to 3 mm/103 years or less), where sedimentation is inhibited as a result of strong current scour or on seamounts where sedimentation is limited due to current action [3].

Another important factor for the nodule formation is the availability of suitable nuclei around which the ferromanganese oxide phases can accrete. These include fragments of altered volcanic rock (for example palagonite or pumice), sharks' teeth and whales' ear bones. Easily weathered nuclei better catalyze the oxidation of manganese, resulting in faster growth of the nodules [3].

The volume of ferromanganese oxides deposited is time-dependent. The length of time that has been available for the accumulation of nodules is related to sea-floor spreading rates, that is ferromanganese oxide encrustations increase in thickness as the sea floor gets older [3].

With regards to depth, Ehrlich [4] reported that manganese nodules have been found in all oceans from as low as 65 fathoms (118 m) deep and up till a depth of 3,125 fathoms (5,715 m). However, manganese nodules were found in shallower waters in Mecklenburg Bight (SW Baltic Sea) at depths of 20-25 m [7] and at greater depths (6,000 m) in the eastern North Pacific Ocean [8]. On the other hand, nodules are preferentially found on ocean floors that have a gentle topography and are rich in fine sediments (silts, clay) [9].

Biotope Description

Manganese nodules are mineral concretions, rich in manganese and iron oxides [4]. They appear in the form of small black-brown slightly flattened boulders with a diameter of between 5 and 10 cm and sometimes even larger. The density of nodules is 2g/cm^3, with typical water content of 30%, and porosity of 50% [6]. The great variability of conditions in the geological environment (topography, erosion by deep ocean currents and the model of regional deposition) has lead to differentiation of nodule beds and the recognition of 'nodule facies' [9]. The classification by AFERNOD [10] in [9] was based on a photographic study of the ocean depths associated with samples. Three main facies A, B and C were recognized using the following criteria: (1) distribution of nodules on the seabed; (2) estimated mean diameter; (3) sediment-nodule relationships and (4) presence or absence of barren areas [6]:

- Facies A is composed of 70-80% small nodules with complex irregular forms. Often includes (0-30%) nodule debris. Nodules stand proud of the sediment, are often accompanied by rock debris of volcanic origin, and are frequently associated with rock outcrops. Ferromanganese hydroxides are not well crystallised, and have a confused or laminate structure.
- In facies B most nodules are ovoid and often occur among the debris of ancient nodules. Their surface is smooth in texture, sometimes having small rounded lumps. They are distributed evenly on the bottom and the hydroxides are not well crystallised, having a laminated or badly organised structure.
- Facies C is composed of the largest nodules of all that have a conspicuous equatorial rim. They are found buried in sediment up to this line, and are often recovered from a bed of soft sediment that partly masks their appearance. They are homogeneously distributed on the seabed. Hydroxides are well crystallised but still exhibit similar laminar characteristics as A & B. The boundary between areas of facies B and facies C is not clearly defined, and occurs as a progressive transition [6].

The dominant taxon on manganese nodules is the agglutinating foraminifers. Mat-forming and tunnel-forming foraminifer taxa are generally more abundant and cover much more of the nodule surface than the familiar agglutinated tubular and chambered foraminifers [11]. Tubular and chambered foraminifer taxa, however, have been the focus of most studies of the role of eukaryotic organisms in nodule formation [e.g. 12, 13, 14]. Dudley and Margolis [15] found agglutinated tubular and chambered foraminifer tests in and on manganese nodules and suggested that the organisms might participate in nodule formation. Higher densities of foraminifer tests were found on rapidly accreting nodules than on slowly accreting ones, leading Dugolinsky [16] in [11] to postulate that population densities of agglutinated foraminifers may regulate nodule growth rates. A mechanism for biogenic growth of nodules has been proposed by Riemann [17], who noted that the stercomes (waste pellets) of agglutinated foraminifers contained manganese and suggested the foraminifers accumulate oxidized manganese, package it in stercomes and deposit it on the nodule. If foraminifers do participate in nodule formation, the high abundance and cover of the mat and tunnelforming taxa reported suggest that they may be more important tonodule growth than the more familiar chambered and tubular taxa [11]. On the other hand, the megafauna associated with manganese nodules is characterised by a dominance of cnidarians, echinoderms and sponges. Cnidaria consist principally of actinids and octocorallia while echinoderms are represented mostly by holothurians and crinoids [9].

Biotope Evaluation: Goods and Services

Assemblages of manganese nodules contribute substantially to overall levels of benthic diversity. Three microhabitats (raised surfaces, depressed surfaces, and nodule sides) and two surface textures (smooth and rough) are recognised. Most of the summit region of the nodules is occupied by raised microhabitats and have a smooth texture. These smooth, raised surfaces are usually the most colonized microhabitat of the nodules [18]. Manganese concretions can also be considered as natural metal ionic traps “cleaning” near- bottom waters of some toxic elements as the content levels of toxic metals (e.g. Pb, Zn, and Cu), originating from anthropogenic sources [1]. Although ferromanganese nodules have been recommended by some researchers as monitors of metal marine pollution, their utility for monitoring seems to be limited [19]. On average, manganese nodules contain about 25% manganese, but also minor constituents of copper, nickel and cobalt. These valuable metals are an important resource for the future. Already in the 1970s the Federal Institute for Geosciences and Natural Resources took part in the exploration of manganese nodules in the deep-sea. However, involved mining companies soon lost their interest as the prices for the valuable metals contained in manganese nodules rapidly declined, due to new resource findings on land in the 1980’s. Today, in view of the depleting land resources and the increasing industrial demand, manganese nodule resources are of interest again. The International Seabed Authority, which administers the resources of the deep-sea under the UN Law of the Sea, has already given licenses to contract partners from different countries. France, Japan, India, China, Korea, Russia, and Germany have been active in developing mining and processing technologies for deep sea manganese nodules [20]. But so far no such large-scale mining has started.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☐	☒
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☒	☐
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

The main threat to assemblages associated with deep-sea manganese nodules is nodule mining. The most direct effect of manganese-nodule mining will be on the bottom-dwelling communities, especially on fauna attached to the nodules, which will be destroyed [21, 22]. Other effects include the partial covering of surrounding epifauna by sediment blanketing, biochemical changes resulting in biotic responses, and changes in the existing depositional and decompositional biota-sediment processes [23, 24 and references therein]. However, the impact of the mining itself is very likely to be small compared with the potential environmental impact of processing nodules at sea, or in the coastal zone.

Conservation and protection status

Mining of manganese nodules is regulated by the Mining Code, which refers to the whole of the comprehensive set of rules, regulations and procedures issued by the International Seabed Authority to regulate prospecting, exploration and exploitation of marine minerals in the international seabed Area (defined as the seabed and subsoil beyond the limits of national jurisdiction). It states that prospecting shall not be undertaken if substantial evidence indicates the risk of serious harm to the marine environment.

References

[1] Zhamoida V, Grigoriev A, Gruzdov K, Ryabchuk D (2007) The influence of ferromanganese concretions-forming processes in the eastern Gulf of Finland on the marine environment. The Quaternary deposits of the Eastern Gulf of Finland. Geol S Fin 45: 21-32

[2] Grigoriev AG, Zhamoida VA, Glasby GP (2004) Distribution of radionuclides in ferromanganese cocnretions and associated sediments from the northern-eastern Gulf of Finland. Baltica 17: 63-70

[3] Glasby GP (1977) Marine Manganese deposits. Elsevier

[4] Ehrlich HL (1962) Bacteriology of Manganese Nodules. I. Bacterial Action on Manganese in Nodule Enrichments. Appl Microbiol 11: 15-19

[5] Rojkovic I, Aubrecht R, Misik M (2003) Mineral and chemical composition of manganese hardgrounds in Jurassic limestones of the Western Carpathians. Geol Carpath 54: 317-328

[6] Sutton G, Wheeler AJ, O'Leary E (2001) Current Status and RTDI Requirements in Respect of the Development of Irish Seabed Resources. University College Cork, Ireland

[7] Marcus MA, Manceau A, Kersten M (2004) Mn, Fe, Zn and As speciation in a fast-growing ferromanganese marine nodule. Lawrence Berkeley National Laboratory. LBNL Paper LBNL-55067.

[8] Amos AF, Roels OA (1977) Environmental aspects of manganese nodule mining. Mar Policy April 1977: 156-163

[9] Tilot V (2006) The polymetallic nodule ecosystem of the Eastern Equatorial Pacific Ocean. Vlanderen, Belgium

[10] Hein P, Voisset M (1978) Les nodules polymetalliques de la zone Clarion Clipperton: Facies and geochimie.

[11] Mullineaux LS (1987) Organisms living on manganese nodules and crusts: Distribution and abundance at three North Pacific sites. Deep Sea Res 34: 165-184

[12] Von Stackelberg U (1984) Significance of benthic organisms for the growth and movement of manganese nodules of the equatorial North Pacific. Geophys Mar Lett 4: 37-44

[13] Wendt J (1974) Encrusting organisms in deep-sea manganese nodules. In: Hsu KJ, Jenkyns HC (eds) Int Ass Sed pp 437-447

[14] Greenslate J (1974) Microorganisms participate in the construction of manganese nodules. Nat Phys Scie 249: 181-183

[15] Dudley WC, Margolis SV (1974) Iron and trace element concentration in marine manganese nodules by benthic agglutinated foraminifera. G. S. A. Abstracts with Programs

[16] Dugolinsky BK, Margolis SV, Dudley WC (1977) Biogenic influence on growth of manganese nodules. J Sed Petrol. 47: 428-445

[17] Riemann F (1983) Biological aspects of deep-sea manganese nodule formation. Oceanol Acta 6: 303-311

[18] Veillette J, Juniper SK, Gooday AJ, Sarrazin J (2007) Influence of surface texture and microhabitat

heterogeneity in structuring nodule faunal communities. Deep Sea Res I 54: 1936-1943

[19] Szefer P (2002) Metal pollutants and radionuclides in the Baltic Sea – an overview. Oceanologia 44: 129-178

[20] Sharma R (2010) First nodule to first mine-site: development of deep-sea mineral resources from the Indian Ocean. Curr Scie 99: 750-759

[21] Thiel H, Foell EJ, Schriever G (1992) Potential Environmental Effects of Deep-sea Mining. University of Hamburg [22] Thiel H, Schriever G, Bussau C, Borowski C (1993) Manganese nodule crevice fauna. Deep Sea Res I, 40: 419-423

[23] Ingole B, Ansari ZA, Rathod V, Rodrigues N (2001) Response of deep-sea macrobenthos to a small-scale environmental disturbance. Deep-Sea Res II 48: 3401-3410

[24] Raghukumar C, Lokabharathi PA, Ansari ZA, Nair S, Ingole BS, Sheelu G, Mohandass C, Nath BN, Rodrigues N (2001) Bacterial standing stock, meiofauna and sediment nutrient characteristics: indicators of benthic disturbance in the Central Indian Basin. Deep-Sea Res II 48: 3381-3399

Deep-sea biogenic gravels

Compiled by Roberta Mifsud

Classification	Code	Title
NATURA 2000	1110	Sandbanks which are slightly covered by sea water all the time
EUNIS	A6.22	Deep-sea biogenic gravels

Picture(s)
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements
Communities of biogenic gravel occupy a great variety of coarse sediments: from coarse sand to cobbles and boulders, with overlying biogenic fragments; percent gravel by weight is always > 50 % and often > 70 % [1]. Such communities are generally found near to and associated with communities of hard corals, seashell beds or brachiopods.
Such communities are by and large composed of fauna which is adapted to low light intensities and boulder substrata. For example, larvae of *Terebratulina* sp., the main component of the *Terebratulina* gravel community, actively seek cryptic sites (with low light intensity). Ascidians, which co-occur with brachiopods, have similar habitat preferences and are known to settle in cryptic habitats, such as cracks, crevices, and beneath rocks [2]. Thus, the patchy distribution of such communities with distinct boundaries is highly characterized by life history traits and strong control by substratum [3].

Biotope Description
Deep-sea biogenic gravel assemblages are generally composed of sessile suspension-feeding organisms including barnacles, tunicates, poriferans, epifaunal bivalves and tubiferous polychaetes. Free-living forms include many suspension-feeding echinoderms and carnivores (decapods, boring gastropods, polychaetes, echinoderms). Members of the megabenthic infauna are mostly small sized (< 30 mm) bivalves. Such communities are characterized by a number of species which are exclusive to biogenic facies, (such as *Ophiura sarsi*, *Chlamys islandica*, *Hiatella arcfica*, *Natica clausa*, *Margarites costahs*, *Calliostoma occidentale*, *Halocynthia pyriformis*, *Pandalus montagui* and *Lebbeus groenlandicus* for the biogenic gravel community on the eastern side of Georges Bank, NW Atlantic) [4]. An example of a biogenic gravel community is the *Terebratulina*-dominated (brachiopod) community typically occurring on gravel substrata with boulder-sized particles [3]. The composition of the community closely corresponds to rock-face subtype of Noble et al. [6], with brachiopods (mainly *Terebratulina septentrionalis*) and sponges as the best-represented taxa. Serpulid polychaetes (such as *Filograna implexa*, *Spirorbis* sp. and less often *Serpula vermicularis*) are also associated with brachiopods in this habitat dominated by suspension feeders. Even though this community can be found in relatively shallow waters (~90m) [3], this type of community has also been reported in deep water [6, 7]. The region occupied by the *Terebratulina* community may also include patches of scallop populations, especially on gravel lag [3].

Biotope Evaluation: Goods and Services
The heterogenous sediments of the biogenic bottom provide spatial refuges from predators and suitable microhabitats for invertebrates, especially juveniles. Sandy patches between gravel particles harbour infaunal bivalves. However, the biogenic bottom harbours a greater abundance of mobile polychaetes because of the increased bottom complexity [8]. Biogenic structures projecting above the seafloor might also affect deep-sea communities through their interactions with near-bottom flow by the disruption of local flow patterns, thereby altering particle deposition and erosion rates, as well as abundances of sedimentary microbes. These

hydrodynamic effects can increase local species' abundances through passive recruitment or through active migratory responses to hydrodynamic or food-enhancement cues [9].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

The main threat to deep-sea biogenic gravel communities is bottom fishing such as scallop dredging. Studies show that abundance, biomass and species diversity of benthic megafauna decrease at disturbed sites. Community composition is also affected. Disturbed sites also show higher evenness diversity, possibly because dredging prevents any species from becoming numerically dominant [8].

As a consequence, bottom fishing reduces the abundance of prey species that are important in the diets of demersal fish. Many of the species found in high abundances in undisturbed sites of deep-sea biogenic gravel communities are important in the diets of demersal fish species. Thus in dredged areas demersal fish must spend more time foraging, and juveniles will be exposed to increased predation risk [10].

Conservation and protection status

The National Research Council (NRC) committee that studied the effects of trawling and dredging on seabed biotopes recommended that a combination of effort reduction, gear modifications, and area closures be tailored to fit specific combinations of fisheries and habitats [11]. Effort reduction—the cornerstone of fisheries management— should result in commensurate decreases in bottom fishing disturbance [12]. Sensitive biotopes with long recovery times require the additional protection of area closures. There are some incentives and opportunities for "reduced-impact" fishing gears to operate within closed areas. However, bottom contact is required to catch species such as flatfish and scallops, and for these fisheries there is limited scope to reduce bottom impacts with gear modifications. Rotational harvest strategies may increase the yield-per-recruit of scallops by reducing the mortality of small scallops [13]. However, the rotation times that are being considered (3-5 years) are shorter than the recovery times of gravel habitats (~10 years). The result of a rotational harvest strategy on gravel habitats could be to maintain all the areas in a chronically disturbed state. During a temporary trawl closure in the North Sea, fishing effort was displaced outside a closed area, but then returned when the area was re-opened [14]. The net result was a more homogeneous distribution of fishing effort and increased effort in areas that formerly were less impacted by bottom gear. From a biotope perspective, it is preferable to keep fishing effort patchy [15] because repeated tows of the same area cause a diminishing mortality of benthic species and large areas remain unfished. Thus, permanently closed areas of gravel habitat are preferred over temporary or rotating closures to mitigate the effects of fishing on benthic communities. However, rotating closures of other kinds of habitats (e.g. those sandy and muddy habitats that recover more rapidly than gravel) might be an appropriate management strategy [10].

References

[1] Lough RG, Valentine PC, Potter DC, Auditore PJ, Bolz GR, Neilson JD, Perry RI (1989) Ecology and distribution of juvenile cod and haddock in relation to sediment type and bottoms currents on eastern Georges Bank. Mar Ecol Prog Ser 56: 1-12

[2] Svane I, Young CM (1989) The ecology and behavior of ascidian larvae. Oceanogr Mar Biol Annu Rev 27: 45–90

[3] Kostylev VE, Todd BJ, Fader GBJ, Courtney RC, Cameron GDM, Pickrill RA (2001) Benthic habitat mapping on the Scotian Shelf based on multibeam bathymetry, surficial geology and sea floor photographs. Mar Ecol Prog Ser 219: 121-137

[4] Thouzeau G, Robert G, Ugarte R (1991) Faunal assemblages of benthic megainvertebrates inhabiting sea scallop grounds from eastern Georges Bank, in relation to environmental factors. Mar Ecol Prog Ser 74: 61-82

[5] Noble JP, Logan A, R. WG (1976) The recent *Terebratulina* community in the rocky subtidal zone of the Bay of Fundy, Canada. Lethaia 9: 1–17

[6] Paine RT (1959) Maine records of the brachiopod *Terebratulina*. Maine Field Nat 15: 46-49

[7] Caddy JF (1970) Records of associated fauna in scallop dredge hauls from the Bay of Fundy. Fish Res Board Can Tech Rep 225

[8] Collie JS, Escanero GA, Valentine PC (1997) Effects of bottom fishing on the benthic megafauna of Georges Bank. Mar Ecol Prog Ser 155: 159-172

[9] Thistle D, Eckman JE (1990) The effect of a biologically produced structure on the benthic copepods of a deep-sea site. SO: Source Deep-sea Research 37: 541-554

[10] Collie JS, Hermsen JM, Valentine PC, Almeida FP (2005) Effects of Fishing on Gravel Habitats: Assessment and Recovery of Benthic Megafauna on Georges Bank. American Fisheries Society Symposium 41: 325-343

[11] NRC (2002) Effects of trawling and dredging on seafloor habitat, Washington, D.C.

[12] Hall SJ (1999) The effects of fishing in marine ecosystems and communities, Oxford, UK

[13] Myers RA, Fuller SD, Kehler DG (2000) A fisheries management strategy robust to ignorance: rotational harvest in the presence of indirect fishing mortality. Can J Fish Aquat Sci 57: 2357-2362

[14] Rijnsdorp AD, Piet GJ, Poos JJ (2001) Effort allocation of the Dutch beam trawl fleet in response to a temporarily closed area in the North Sea. ICES CM 2001 N:01

[15] Duplisea DE, Jennings S, Warr KJ, Dinmore TA (2002) A size-based model of the impact of bottom trawling on benthic community structure. Can J Fish Aquat Sci 59: 1785-1795

Communities of bathyal detritic sands with Gryphus vitreus

Compiled by Roberta Mifsud

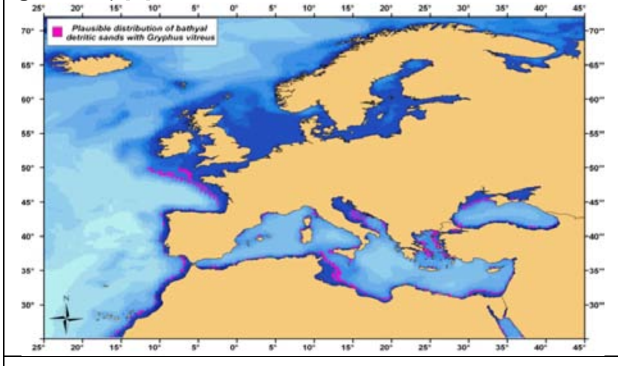
Classification	Code	Title
EUNIS	A6.31	Communities of bathyal detritic sands with *Gryphus vitreus*

Picture(s)

Thanatocoenosis on the *Gryphus vitreus* bottoms [1]
Copyright: Christian Emig (Carnets de Geologie christian.emig@free.fr)

Biotope Distribution

Gryphus vitreus is common in the Mediterranean and off the coasts of France, Portugal, and Spain [2]. This biocoenosis forms a more or less broad belt along the continental margin of the Mediterranean. It is bounded on the edge of the continental shelf (~ 100-120 m) by a circalittoral biocoenosis (mostly the coastal detritic biocoenosis) and on the continental slope by the bathyal mud biocoenosis (between 160 and 250 m according to the slope gradient) [3].



Links to available maps

Not available

Biotope Requirements

The ecological requirements of *G. vitreus*, a stenotopic species, are high hydrodynamic conditions (inducing a weak sedimentation, high nutrient supplies and sandy sediment with small hard substrata) and an annual constancy of temperature and salinity [1].

The hydrodynamic conditions, generally existent wherever this biocoenosis occurs in Corsica and along the coast of Provence are always more intense than in the surrounding biocoenoses, i.e. those of the coastal detritic (circalittoral) and the bathyal mud. A consequence of such bottom currents is a weak sedimentation, a high supply of nutrients, and the peculiar nature of the sediment (with small hard substrata) [1]. The named bottom currents are not only directly responsible for the extension and depth range of the *Gryphus vitreus* bathyal

detritic sand biocoenosis (BDS), but their direction and velocity, directly related to the physiography of the bottom, induce the distributional density zones of *Gryphus vitreus* [4].
Gryphus vitreus assemblages are mainly distributed on muddy-detritic and shelf-edge detritic communities, where the sediments consist of a mixture of gravel together with some sand, mud and many remnants from benthic organisms [5]. The substratum of the BDS is well-sorted sand (gravel, coarse and fine sand), clogged by a fine fraction which can reach 60%, and contains a large detritic proportion of small hard substrata of endogenous origin (fragments of mollusc and brachiopod shells, sponges, bryozoans, corals, gravels and pebbles) [6].
Quoting Fischer and Oehlert [7], Cooper [2] reports the depth range of *Gryphus vitreus* to be from 392 to 2,661 meters. However, the upper bathymetric limit of such communities in Corsica lies between 115 and 125 m (rarely, from 90 m) [8]. The horizontal distribution of *G. vitreus* varies from ~ 250 m to > 4 km, and is directly related to geomorphological and hydrodynamic variations resulting from local topography and/or geographical location [8].
Within this biocoenosis, the temperature varies between 12.5 and 14.5°C and the salinity between 37.5 and 38.5 g/l [9].

Biotope Description

Bathyal detritic sands with *Gryphus vitreus* (BDS) offer a high species richness and abundance when compared to the deep-sea silt zones (SZ) and detritic sands (DS): BDS contains double the number of species and four times the number of individuals supported by SZ, and three times more species and 5 times more individuals than DS [9]. *G. vitreus* might serve as prey for economically important species, especially when molluscs, which are more difficult to open, are scarce. Known predators of the brachiopod in the Mediterranean are polychaetes, naticid gastropods and decapods, especially the spiny lobster *Palinurus mauritanicus* which is of economical importance [10].

Biotope Evaluation: Goods and Services

The main threat to communities of bathyal detritic sands with *G. vitreus* is trawling and dredging. As in any other biotope where members of the community act as a secondary substratum, providing hard habitat islands where such a substratum is scarce, it will definitely be destroyed by bottom fishing with towed gears. Silting due to towed fishing gears affects *G. vitreus* biocoenosis and can cause its replacement by the bathyal mud biocoenosis, which always occurs below the former. Silting and the consequent decline of BDS may substantially affect lobster fisheries [11].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☒	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure and recreation	☐	☐	☒
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

The main threat to communities of bathyal detritic sands with *Gryphus vitreus* is bottom fishing, especially dredging and silting. As in any other biotope where members of the community act as a secondary substratum, providing hard habitat islands where such a substratum is scarce, it will definitely be destroyed by bottom fishing such as dredging and trawling. Silting affects *Gryphus vitreus* biocoenosis up to the extent that they will disappear and be replaced by the bathyal mud biocoenosis which always occurs below the former. The dead brachiopods could be fossilized in a bed of high density population (thanatocoenosis). Silting may also have indirect economical consequence. For example, silting off Ile-Rousse (NW Corsica) which is an intensive fishing zone will certainly affect lobster catches as these are occassional predators of *G. vitreus* [11].

Conservation and protection status

Communities of bathyal detritic sands are currently not protected by any legislation or regulation.

References

[1] Emig CC (1987) Offshore brachiopods investigated by submersible. J Exp Mar Biol Ecol 108
[2] Cooper GA (1981) Brachiopoda from the Gulf of Gascogne, France (Recent) Smithsonian contributions to paleobiology. Library of Congress Cataloging in Publication Data
[3] Emig CC (1989) Distributional patterns along the Mediterranean continental margin (upper bathyal) using *Gryphus vitreus* (Brachiopoda) densities. Palaeogeogr Palaeocl Palaeoecol 71
[4] Emig CC, Garcia-Carrascosa MA (1991) Distribution of *Gryphus vitreus* (Born, 1778) (Brachiopoda) on transect P2 (Continental margin, French Mediterranean coast) investigated by submersible. Sci Mar 55
[5] Peres JM (1985) History of the Mediterranean biota and the colonization of the depths. In: Margalef R (ed) Key Environments: Western Mediterranean. Pergamon Press, Oxford, pp 198-232
[6] Emig CC (1997) Bathyal zones of the Mediterranean continental slope: An attempt. Publ Espec Ins Esp Oceanogr 23: 23-33
[7] Fischer P, Oehlert DP (1891) Brachiopodes Expedition scientifique du Travailleur et du Talisman (1880-1883), Paris, pp 139
[8] Emig CC (1985) Distribution and synecology of *Gryphus vitreus* (Brachiopoda) bottoms in Corsica. Marine biology. Berlin, Heidelberg 90
[9] Laubier L, Emig CC (1993) The Mediterranean deep-sea benthic fauna. Ist Sci Ambientali Mar, Santa Margherita Ligure
[10] Delance JH, Emig CC (2004) Drilling predation on *Gryphus vitreus* (Brachiopoda) off the French Mediterranean coasts. Palaeogeogr Palaeocl Palaeoecol 208
[11] Emig CC (1989) Observations préliminaires sur l'envasement de la biocoenose à *Gryphus vitreus* (Brachiopoda), sur la pente continentale du Nord de la Corse (Méditerranée). Origines et conséquences. CR Acad Sci Paris 309: 337-342

Communities of deep-sea corals

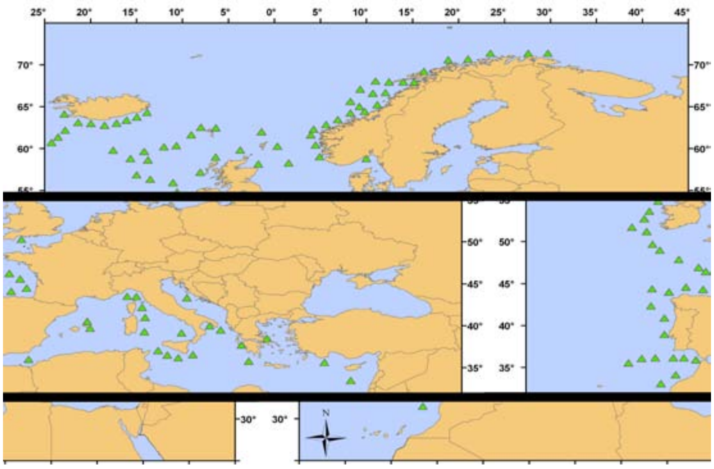
Compiled by Roberta Mifsud

Classification	Code	Title
EUNIS	A6.61	Communities of deep-sea corals

Picture(s)

Not available

Biotope Distribution



Map compiled from various sources [1, 2, 3]

Links to available maps

http://bure.unep-wcmc.org/marine/coldcoral/viewer.htm
http://data.nbn.org.uk/habitat/map.jsp
http://www.geohab.org/agenda2005.html#7

Biotope Requirements

Where *Lophelia*-reefs occur, they are unevenly distributed on the seafloor as individual (single) reefs or in groups (clusters). They are apparently scattered only in certain geographical regions, dependent either on water depth intervals, watermass properties, special currents, geological (substratum) conditions, or sea floor topography [4, 5].

Apparently depth is not the main environmental parameter influencing the distribution of deep-sea coral communities [6], *Lophelia* colonies grow at 40 m depth on the Tautraridge in Trondheimsfjorden, Norway[1]. Thus, such communities are better referred to as cold-water corals, whose distribution seems to be triggered by three main interrelated factors: topography, hydrodynamic regime, and substratum typology (hard vs. soft-bottom) [7].

Deep-sea coral reefs establish themselves at locations on the seafloor where there is a continuous and regular supply of concentrated food and nutrients [5]. Unlike their tropical and subtropical counterparts, deep sea corals do not obtain any energy directly from sunlight, but instead capture microscopic animals from the surrounding water [8].

The preferred substratum type of deep-water coral communities varies greatly. Many records of deep-sea coral mounds refer to indurated or rocky bottoms (e.g., [9, 10, 11]). Precipitous submarine topographies are often considered most suitable sites for deep coral growth [12]. However, some extant and subfossil deep coral mounds have been documented to develop on a somewhat gently-sloping, non-rocky seabed (e.g., [3, 13])[12]. On the other hand, Vertino *et al.* [7] reported that under the same bathymetric and hydrodynamic conditions, the local abundance of scleractinian corals seemed to increase with the increasing size of available hard substratum.

Studies of sediment lithology and stratigraphy carried out at Santa Maria de Leuca on the Apulian margin (Mediterranean) suggests the following succession phases prior to coral colonisation: (a) deposition of a glacial Pleistocene muddy unit; (b) onset of strong bottomc urrents, which cause bivalve orientation and sediment winnowing; (c) a somewhat prolonged non-depositional history causing progressive induration of the sediment exposed to seawater,eventually turning the sedimenti nto firm-ground; (d) first coral colonization of the firm-ground by *Caryophyllia;* (e) continuing non-deposition history, with dark coating of *Caryophyllia* corals; (f) second (modern) phase of colonization by *Madrepora* [14].

Lophelia pertusa is reported to tolerate temperatures between 4 and 13°C [15]. It can tolerate cooler waters for a short period of time and on the other extreme live *L. pertusa* and *Madrepora oculata* from mounds off Santa Maria di Leuca, Ionian Sea, thrive at temperatures of 13.8°C at 550 to 1,100 m depth [12]. Salinity values tolerated by *L. pertusa range* from as low as 32‰ in Scandinavian fjords [16] to at least 38.78‰ inthe Ionian Sea [12].

Freiwald et al. [6] conclude that the preferred locations of deep-water coral communities are found in areas where: a) the seasonal storm wave base does not affect the seabed; b) strong topographically guided bottom currents prevent deposition of sediments, thereby creating current swept hard substratum that facilitates colonization by habitat-forming corals. Generally, these grounds are pre-existing topographic highs of various scales that form obstacles in the current path: they can be boulder fields, moraine ridges, drumlins, the flanks of oceanicbanks, seamounts, sedimentary mounds and occasionally artificial substrata such as wrecks and oil rigs; c) the flow of water is funnelled through narrow passages such as straits (e.g. Strait of Gibraltar, channels, or fjord troughs (e.g. in Scandinavia) and submerged canyons and gullies; d) nearby nutrient-rich waters stimulate the development of high phyto- and zooplankton levels, providing a major food source for the coral communities.

Biotope Description

Deep-sea coral communities have a patch distribution [17] and the predominant species are the colonial *Lophelia pertusa* (Linnaeus, 1758) and *Madrepora oculata* to which the solitary *Desmophyllum cristagalli* is generally associated [18, 19, 20][2]. *Lophelia pertusa*, the reef-forming coral of the three, has a wide geographic distribution ranging from 55°S to 70°N, where water temperatures typically remain between 4-8°C. These reefs are generally subject to moderate current velocities (0.5 knots). The majority of records occur in the north-east Atlantic. The extent of *L. pertusa* reefs vary, with examples off Norway several km long and more than 20m high. These reefs occur within a depth range of 200->2000m on the continental slope, and in shallower waters in Norwegian fjords and Swedish west coast. In Norwegian waters, *L. pertusa* reefs occur on the shelf and shelf break off the western and northern parts on local elevations of the sea floor and on the edges of escarpments. The biological diversity of the reef community can be three times as high as the surrounding soft sediment [21], suggesting that these cold-water coral reefs may be biodiversity hotspots. *Lophelia* provides habitat for animals such as sponges, anemones,bryozoans, gorgonians, worms, fish, mollusks and crustaceans [8]. Characteristic species include other hard corals, such as *Madrepora oculata* and *Solenosmilia variabilis*, the redfish *Sebastes viviparous* and the squat lobster *Munida sarsi*. *L. pertusa* reefs occur on hard substrata; this may be *Lophelia* rubble from an old colony or on glacial deposits. For this reason, *L. pertusa* reefs can be associated with iceberg plough-mark zones. Areas of dead coral reef indicate the site supported coral reef habitat in the past and should be reported as this habitat type [22].

Biotope Evaluation: Goods and Services

Deep-sea coral communities are considered as biodiversity hotspots, representing patches of high diversity in a low diversity environment [23, 24, 25]. It is hypothesized that reefs may function as centres of spreading for associated fauna [1]. Deep-sea coral reefs are important for fisheries: fish aggregate on deep-sea reefs as they provide protection from currents and predators, nurseries for young fish, and feeding, breeding and spawning areas for numerous fish and shellfish species [6], including crustacea and fish species of economic interest, such as *Aristaeomorpha foliacea* and *Helicolenus dactylopterus* [2]. Furthermore, coral and sponge communities are a largely untapped resource of natural products with enormous potential as pharmaceuticals, nutritional supplements, enzymes, pesticides, cosmetics, and other commercial products [6]. Bathyal cold-water corals are being increasingly studied for paleoceanographic purposes, since their aragonitic skeletons serve as geochemical archives, providing useful insights into past water properties and circulation patterns [26 and references within]. Deep-sea coral reef communities also have what is known as a high existence value. This is the benefit of simply knowing marine biodiversity exists even if it is never utilized or experienced [27].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☐	☒

Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Documented and potential sources of threats to cold water corals are (1) commercial bottom trawling and other bottom fishing; (2) hydrocarbon exploration and production; (3) cable and pipeline placement; (4) bioprospecting and destructive scientific sampling; (5) other pollution; (6) waste disposal and dumping and (7) coral exploitation and trade [6]. The biggest human threat to deep-sea coral reefs is destructive fishing; bottom trawling in particular has pulverized these communities and ripped many of them from the seabed. Trawling directly kills the corals, breaks up the reef structure, and buries corals through increased sedimentation. Wounds in coral tissue and infection cause additional deaths in those that are not killed outright. Furthermore, bottom trawl activity alters the hydrodynamic and sedimentary conditions [2]. Another impact of trawling activity on the white coral reef is due to the suspension of sediments; in fact, coral species, like all suspension feeders, are particularly vulnerable to the effects of increased sedimentation [28]. Other fishing gears such as bottom long-lines and gillnets can also cause substantial damage to these communities [6]. However, Mediterranean deep-coral banks are not targeted and therefore are not deliberately impacted by any commercial fishing. On the contrary, they represent a type of bottom that trawlers try carefully to avoid in order not to damage their nets. Fishing-boat echo-sounders are capable of indicating the likely presence of coral mounds. The experience gained by the accidental entangling of nets with coral colonies has greatly reduced such accidents among commercial fishermen [3]. Drilling, oil and gas exploration, seabed extraction and mining directly crush and damage corals, and can affect their living conditions by increasing the amount of sand and grit in the water and altering essential currents and nutrient flows. Drilling muds and cuttings from oil and gas exploration can be toxic to corals, and are known to cause death and alter feeding behaviour in shallow water varieties. Drill cuttings also settle and build up into piles directly underneath oil platforms and can smother and kill corals, sponges and other animals that filter the seawater for food [6].

Conservation and protection status

Deep-sea coral reef communities are protected by several laws, regulations and conventions from several bodies worldwide. These include decisions made by the Council of Europe and the European Commission, the OSPAR Convention, ICES, the Convention on Biological Diversity, the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the United Nations General Assembly. Cold water corals are included in the list of vulnerable marine ecosystems, in a recent regulation issued by the Council of the European Union on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears [29]. This Regulation puts restrictions on fishing activities, requires special fishing permits and impact assessments, and contains provisions on unforeseen encounters with vulnerable marine ecosystems, area closures and an observer scheme for all vessels which have been issued a special fishing permit. [6] have made several recommendations regarding the conservation and sustainable management of deep-sea coral communities and stressed the need for proper information management and research, monitoring and assessment, specific regulations and measures, and international coordination and awareness. Since 1999, the Norwegian Ministry of Fisheries has banned trawl-fisheries on eight deep sea coral sites, namely the Sula Reef (1999), Iverryggen Reef (2000), the Røst Reef (2003), Tisler and Fjellknausene Reefs (2003), and Trænarevene, Breisunddjupet and an area northwest of Sørøya in Finnmark (2009). Similar measures were taken by the EU at the Darwin Mounds, off Scotland in 2004, and three more coral sites off Iceland in 2006, whereas numerous other sites around the Azores, Madeira and the Canary Islands have been proposed as candidates for protection [30, 31]. In 2006, the General Fisheries Commission for the Mediterranean has created the new legal category of “Deep-sea fisheries restricted area”, and recommended the banning of demersal fishery practices over the coral reef off Cape Santa Maria de Leuca (Italy) and the Eratosthenes Seamount (Cyprus) [30]. In the Mediterranean, GFCM (General Fishery Commission for the Mediterranean) and EU prohibited the use of towed dredges and trawlers at depths beyond 1,000 m [32(GFCM, 2005; EC, 2006), which potentially protects part of the Mediterranean deep-sea coral communities.

References

[1] Fosså JH, Mortensen PB, Furevik DM (2002) The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. Hydrobiologia 471: 1–12

[2] Tursi A, Mastrototaro F, Matarrese A, Maiorano P, D' Onghia G (2004) Biodiversity of the white coral reefs in the Ionian Sea (central Mediterranean). Chem Ecol 20: S107-S116

[3] Remia A, Taviani M (2005) Shallow-buried Pleistocene *Madrepora*-dominated coral mounds on a muddy continental slope, Tuscan Archipelago, NE Tyrrhenian Sea. Facies 50: 419–425

[4] Hovland M, Risk M (2003) Do Norwegian deep-water coral reefs rely on seeping fluids? Mar. Geol 198: 83-96

[5] Hovland M, Vasshus S, Indreeide A, Austdal L, Nilsen O (2002) Mapping and imaging deep-sea coral reefs off Norway, 1982-2000. Hydrobiologia 471: 13-17

[6] Freiwald A, Fossa JH, Grehan A, Koslow T, Roberts JM (2004) Cold Water Coral Reefs: Out of Sight-No Longer Out of Mind. UNEP WCMC Biodiversity Series [UNEP WCMC Biodiversity Ser.]. no. 22

[7] Vertino A, Savini A, Rosso A, Geronimoa ID, Mastrototaro F, Sanfilippoa R, Gaye G, Etiopef G (2009) Benthic habitat characterization and distribution from two representative sites of the deep-water SML Coral Mound Province (Mediterranean). Deep Sea Research Part II: Topical Studies in Oceanography 57: 380-396

[8] Roberts S, Hirshfield M (2003) Deep Sea Corals: Out of sight, but no longer out of mind. Oceana - Protecting the Worlds' Oceans

[9] Neumann AC, Kofoed JW, Keller G (1977) Lithoherms in the Straits of Florida. Geology 5: 4-10

[10] Newton CR, Mullins HT, Gardulski AF (1987) Coral mounds on the Western Florida Slope: unanswered questions regarding the development of deep-water banks. Palaios 2: 359-367

[11] Messing CG, Neumann AC, Lang JC (1990) Biozonation of deepwater lithoherms and associated hardgrounds in the Northeastern Straits of Florida. Palaios 5: 15–33

[12] Taviani M, Remia A, Corselli C, Freiwald A, Malinverno E, Mastrototaro F, Savini A, Tursi A (2005) First geo-marine survey of living cold-water *Lophelia* reefs in the Ionian Sea (Mediterranean basin). Facies 50: 409–417

[13] Roberts JM, Long D, Wilson JB, Mortensen PB, Gage JD (2003) The cold-water coral *Lophelia pertusa* (Scleractinia) and enigmatic seabed mounds along the northeast Atlantic margin: are they related? Mar Pollut Bull 46: 7–20

[14] Malinverno E, Taviani M, Rosso A, Violanti D, Villa I, Savini A, Vertino A, Remia A, Corselli C (2010) Stratigraphic framework of the Apulian deep-water coral province, IonianSea. Deep-Sea Research II 57: 345–359

[15] Freiwald A, Hühnerbach V, Lindberg B, Wilson JB, Campbell J (2002) The Sula Reef complex, Norwegian Shelf. Facies, 47: 179-200

[16] Stromgren T (1971) Vertical and horizontal distribution of *Lophelia pertusa* (Linne) in Trondheimsfjorden on the west coast of Norway. K. Nor. Vidensk. Selsk. Skr. 6: 1-9

[17] Wilson JB (1979) Patch development of the deep water *Lophelia pertusa* (L.) on the Rockall bank. J Mar Biol Assoc UK 59: 165-177

[18] Le Danois E (1948) Les Profondeurs de la Mer. Payot, Paris: 303

[19] Peres JM, Picard J (1964) Nouveau Manuel de Bionomie benthique de la mer Mediterranee. Rec Trav Stat Mar Endoume 31: 137

[20] Peres JM (1967) The Mediterranean benthos. Oceanogr Mar Biol 5: 449–533

[21] (ICES) ICftEotS Coral reefs in the North Atlantic?

[22] OSPAR (2004) Proposed amendments to the EUNIS classification of marine habitats (levels 2-4 only). Meeting of the Biodiversity Committee, Bruges, 16-20 February 2004, Annex 8. OSPAR Convention for

the Protection of the Marine Environment of the North-East Atlantic
[23] Henry LA, Roberts JM (2007) Biodiversity and ecological composition of macrobenthos on cold-water coral mounds and adjacent off-mound habitat in the bathyal Porcupine Seabight, NE Atlantic. Deep-Sea Res I, 54: 654-672
[24] Carlier A, Le Guilloux E, Olu K, Sarrazin J, Mastrototaro F, Taviani M, Clavier J (2009) Trophic relationships in a deep Mediterranean cold-water coral bank (Santa Maria di Leuca, Ionian Sea). Mar Ecol Prog Ser 397: 125-137
[25] Mastrototaro F, D'Onghia G, Corriero G, Matarrese A, Maiorano P, Panetta P, Gherardi M, Longo C, Rosso A, Sciuto F, Sanfilippo R, Gravili G, Boero F, Taviani M, Tursi A (2010) Biodiversity of the white coral bank off Cape Santa Maria di Leuca (Mediterranean Sea): An update. Deep-Sea Res II, 57, 412-430
[26] Lopez Correa M, Montagna P, Taviani M, Vendrell-Simòn B, McCulloch M (2010) Stable isotopes (d 18 O and d 13 C), trace and minor element compositions of recent scleractinians and last glacial bivalves at the Santa Maria di Leuca deep-water coral province, Ionian Sea. Deep-Sea Res II 57: 471-486
[27] Loomis JB, White DS (1996) Economic benefits of rare and endangered species: summary and meta-analysis. Ecol Econ 18: 197-206
[28] Rogers AD (1999) The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts from human activities. Int Rev Hydrobiol 84: 315–406
[29] EC (2008) Council Regulation on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears. Regulation 734/2008, OJ L 201
[30] Tudela S, Simard F, Skinner J, Guglielmi P (2004) The Mediterranean deep-sea ecosystems: an overview of their diversity, structure, functioning and anthropogenic impacts, with a proposal for their conservation. Málaga, IUCN, and Rome, WWF
[31] Hourigan TF (2008) The status of cold-water coral communities of the world: a brief update. p. 57-66. In: *Status of coral reefs of the world: 2008*, Wilkinson C (Ed) Townsville, Global Coral Reef Monitoring Network, Reef and Rainforest Research Centre
[32] GFCM (2005) Recommendation on the management of certain fisheries exploiting demersal and deepwater species, Rec. GFCM/2005/1
[33] EC (2006) Council Regulation concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Regulation 1967/2006, OJ L 409

Deep-sea sponge aggregations

Compiled by Roberta Mifsud

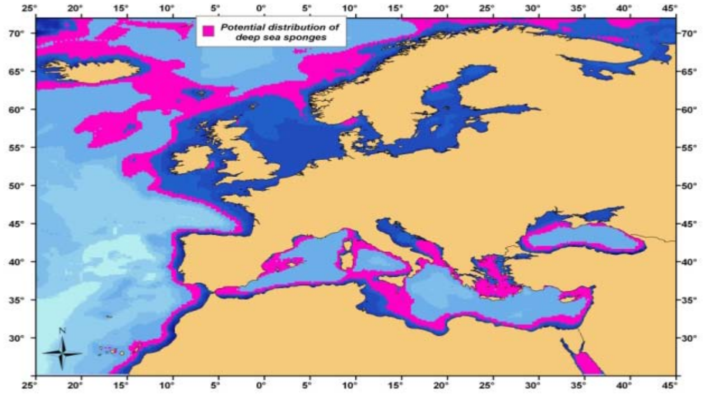
Classification	**Code**	**Title**
NATURA 2000	1170	Reefs
EUNIS	A6.62	Deep-sea sponge aggregations

Picture(s)

Paco Cárdenas and the *Jago* team: Jürgen Schauer and Karin Hissman. "Deep-sea sponge aggregation of *Geodia barretti.*" Picture taken in Northern Norway on board the submersible Jago (IFM/Geomar, Kiel) at a depth of 300 m. Online image. 20th April 2010.

http://www.uib.no/imagearchive/stort-hovedtekstbilde_Paco-sponges.jpg

Biotope Distribution



Distribution of the currently known populations of the hexactinellid sponge *Oopsacas minuta* and of the cladorhizid sponge *Asbestopluma hypogea*, all located in the Mediterranean [1].

Links to Available Maps

Not available

Biotope Requirements

A number of physical factors affect sponge assemblages. These include water flow rate [2], sedimentation [3], nutrient levels [4], depth [5, 6], light [7, 8], and habitat availability [3, 9, 10]. Deep-sea sponge aggregations occur between water depths of 250-1300 m [11], where the water temperature ranges from 4-10°C and there is moderate current velocity (0.5 knots). They may be found on soft substrata or hard substrata, such as boulders and cobbles which may lie on sediment. Iceberg plough-mark zones provide an ideal habitat for sponges because stable boulders and cobbles, exposed on the seabed, provide numerous attachment/settlement points. However, with 3.5 kg of pure siliceous spicule material per m^2 reported from some sites [12], the occurrence of sponge fields can alter the characteristics of surrounding muddy sediments [13].

Biotope Description

Deep sea sponge aggregations are principally composed of sponges from two classes: Hexactinellida (glass sponges) and Demospongia. Densities of occurrence are hard to quantify, but sponges in the class Hexactinellida have been reported at densities of 4-5 per m^2, whilst 'massive' growth forms of sponges from the class Demospongia have been reported at densities of 0.5-1 per m^2. Deep-sea sponges have similar habitat preferences to cold-water corals, and hence are often found at the same location. Research has shown that the dense mats of spicules present around sponge fields may inhibit colonisation by infaunal animals, resulting in a dominance of epifaunal elements [12]. Sponge fields also support ophiuroids, which use the sponges as elevated perches [13].

The predominant feeding mode on glass sponge stalks is suspension feeding. However, usually many trophic modes are represented. The stalks accumulate sinking particles like trees collecting snow on their branches. Pockets of sedimented detritus could support macrofaunal detrivores such as copepods and polychaetes. Also, mobile predators that may feed on the cnidarian colonies (icluding stenothoid amphipods and aplacophorans) or on the detrivores (including phyllodocid polychaetes) were found in the stalk communities [14].

Sponge aggregations collected at abyssal depths are usually species-rich and densely packed with organisms covering the primary substratum and attached to secondary substrata provided by other epifaunal organisms. The stalks provide hard substrata for passive suspension feeders above the soft sea floor and provided refuge and gathering sites for motile cryptofauna [14].

Biotope Evaluation: Goods and Services

Deep-sea sponge aggregations are directly related to increased abundance and richness of the macrofauna. Deep-sea sponges provide a structured habitat of increased complexity suitable for many invertebrates; they provide shelter to small epifauna, within the oscula and canal system, and an elevated perch for many species, such as brittlestars [15]. Deep sponge aggregations constitute an essential fish habitat, providing shelter and prey for both juvenile and adult fish [16]. Dense spicule mats deposited by sponges may have several effects on the benthic community, e.g. by providing a hard substratum that is suitable for colonisation by many epibenthic species, and support increased biomass of macrofaunal species [11]. Furthermore, sponge communities are a largely untapped resource of natural products with enormous potential as pharmaceuticals, nutritional supplements, enzymes, pesticides, cosmetics, and other commercial products [17]; many compounds obtained from deep-sea sponges are being tested in clinical trials for anti-cancer, anti-inflammatory, and other medical properties [18].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☒	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☒	☐
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☐	☒	☐

Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Having similar habitat preferences to cold-water corals, thus often being found in the same location [12], deep-sea sponge aggregations suffer from the same threats that deep-sea corals do (see the previous section on 'Communities of deep-sea corals – EUNIS A6.61' for more details). Deep-sea sponges are long-lived and slow-growing, and deep-sea sponge communities are likely to take many years to recover if damaged. Recovery of sponge aggregations is much slower in deep waters than it is in shallower, warmer waters [19]. Physical disturbance to the seabed, particularly by bottom trawling, is the greatest threat. A recent evaluation of the status of this habitat in the OSPAR area concluded that it is considered 'currently threatened as the likely rate of decline linked directly to human activity exceeds that which can be expected to regrow' [16].

Conservation and protection status

Deep-sea sponge aggregations are one of the five deep-sea habitats listed by OSPAR as threatened or declining. Within the Habitats Directive, this biotope can be protected under the habitat type 1170. In the UK, 'deep-sea sponge aggregations' is a priority habitat for conservation action [20]. Deep-sea sponge aggregations are often offered the same protection that deep-sea coral reef communities benefit from, both because these two community types are very often mentioned together in regulations and directives (e.g. [21]) and as they both benefit from the same conservation measures (see the previous section on 'Communities of deep-sea corals – EUNIS A6.61').

References

[1] Bakran-Petricioli T, Vacelet J, Zibrowius H, Petricioli D, Chevaldonne P, Rada T (2007) New data on the distribution of the 'deep-sea' sponges *Asbestopluma hypogea* and *Oopsacas minuta* in the Mediterranean Sea. Mar Ecol 28: 10-23

[2] Bell JJ, Barnes DKA (2000) A sponge diversity centre within a marine island. Hydrobiol 440: 55–64

[3] Konnecker G (1973) Littoral and benthic investigations on the West Coast of Ireland. I. The sponge fauna of Kilkieran Bay and adjacent areas. Section A: Faunistic and Ecological Studies. Proc R Ir Acad 73B: 450–472

[4] Storr JF (1976) Ecological factors controlling sponge distributions in the Gulf of Mexico and the resulting zonation. In: Harrison FW, Cowden RR (eds) Aspects of Sponge Biology. New York Academic Press, New York, pp 261–276

[5] Alvarez B, Diaz MC, Laughlin RA (1990) The sponge fauna on a fringing coral reef in Venezuela, I. Composition, distribution, and abundance. In: Rutzler K (ed) New Perspectives in Sponge Biology. Smithsonian Institution Press, Washington, DC, pp 358–366

[6] Witman JD, Sebens KP (1990) Distribution and ecology of sponges at a subtidal rock ledge in the central Gulf of Maine. In: Rutzler K (ed) New Perspectives in Sponge Biology. Smithsonian Institution Press, Washington, DC, pp 391–396

[7] Sara M, Pansini M, Pronzato R (1978) Zonation of photophilous sponges related to water movement in reef biotopes of Obhor Creek (Red Sea). In: Levi C, Boury- Esnault N (eds) Sponge Biology. Colloques internationaux du CNRS 291, pp 283–295

[8] Cheshire AC, Wilkinson CR (1991) Modelling the photosynthetic by sponges on Davies Reef, Great Barrier Reef. Mar Biol 109: 13–18

[9] Barthel D, Tendal OS (1993) The sponge association of the abyssal Norwegian Greenland Sea: species composition, substrate relationships and distributions. Sarsia 78: 83–96

[10] Bell JJ, Barnes DKA (2003) Effect of Disturbance on Assemblages: an Example Using Porifera. Biol Bull 205: 144-159

[11] Bett BJ, Rice AL (1992) The influence of hexactinellid sponge (*Pheronema carpenteri*) spicules on the patchy distribution of macrobenthos in the Porcupine Seabight (bathyal NE Atlantic) Ophelia 36: 217-226

[12] Gubbay S (2002) The Offshore Directory: Review of a selection of habitats communities and species in the North-East Atlantic. World Wildlife Fund

[13] OSPAR (2004) Proposed amendments to the EUNIS classification of marine habitats (levels 2-4 only). Annex 8. OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic. Meeting of the Biodiversity Committee, 16-20 February 2004, Bruges

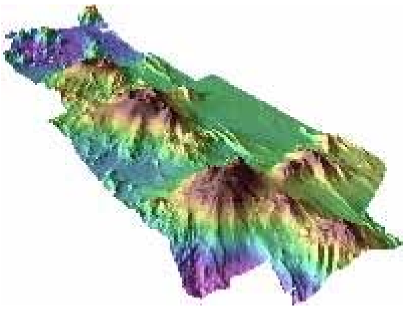
[14] Beaulieu SE (2001) Life on glass houses: sponge stalk communities in the deep sea. Mar Biol 138: 803 - 817
[15] Konnecker G (2002) Sponge Fields. In: Gubbay S (ed) Offshore Directory. Review of a selection of habitats, communities and species of the North-East Atlantic. WWF-UK. North-East Atlantic Programme
[16] OSPAR (2010) Background document for deep-sea sponge aggregations. Biodiversity Series. OSPAR Commission, Publ. Num. 485/2010, ISBN 978-1-907390-26-5[17] Freiwald A, Fossa JH, Grehan A, Koslow T, Roberts JM (2004) Cold Water Coral Reefs: Out of Sight-No Longer Out of Mind. UNEP WCMC Biodiversity Series [UNEP WCMC Biodiversity Ser.] no. 22
[18] Maxwell S, Ehrlich H, Speer L, Chandler W (2005) Medicines from the deep: the importance of protecting the High Seas from bottom trawling. Washington, Natural Resources Defense Council
[19] Freese JL (2001) Trawl-induced damage to sponges observed from a research submersible. *Marine Fisheries Review*, 63(3): 7-13.
[20] UKBAP (2008) UK Biodiversity Action Plan, Priority Habitat Descriptions. Brig, A. Maddock (Ed) http://www.ukbap.org.uk/UKPriorityHabitats.aspx
[21] EC (2008) Council Regulation on the protection of vulnerable marine ecosystems in the high seas from the adverse impacts of bottom fishing gears. Regulation 734/2008, OJ L 201

Seamounts, knolls and banks

Compiled by Stelios Katsanevakis

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A6.72	Seamounts, knolls and banks

Picture(s)



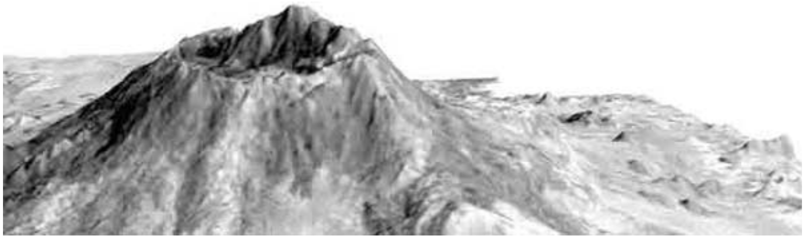
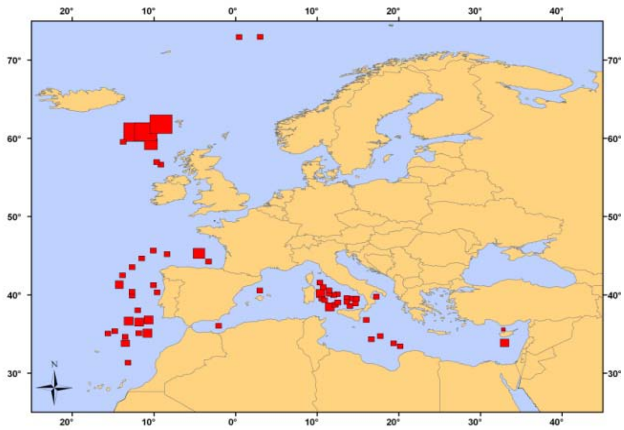


Image courtesy of CENSEAM, National Institute of Water and Atmospheric Research (NIWA), New Zealand http://censeam.niwa.co.nz/outreach/censeam_images

Biotope Distribution



Map of currently known distribution

Links to Available Maps

http://earthref.org/databases/SC/
http://seamounts.sdsc.edu/

Biotope Requirements

Seamounts, knolls and banks is a very broad classification and includes undersea topographic features rising from the seafloor at a great variety of depths and environmental conditions. They are generally deep biotopes usually found rising from a seafloor of 1,000–4,000 m depth and their summits reach hundreds to thousands of meters below the sea surface, although the summits of some seamounts may reach just a few meters below the sea surface.

Biotope Description

Seamounts are defined as undersea mountains of volcanic origin that rise steeply more than 1,000 m above the surrounding sea floor, do not emerge above the sea surface, and are of limited extent across the summit [1, 2]. Knolls are similar topographic features of lower height. Seamounts are typically conical with circular, elliptical or more elongate base and they may occur singly or in clusters, even forming chains that stretch over considerable parts of the ocean [1]. Seamounts often have a slope inclination of up to 60^{o} and thus form a distinctive setting in the deep abyssal plain. They are subject to vigorous currents and are associated with hard substrata such as bedrock, cobbles, boulders, gravel and coral rubble. Sediments are also common towards the base of the seamounts and on terraces or summits of flat-topped seamounts. Their relief has profound effects on the surrounding ocean circulation. At a large-scale they may deflect major ocean currents and at a small-scale they

cause the formation of trapped waves, the reflection, amplification and distortion of internal waves, the amplification of tidal currents and the formation of Taylor columns, which are eddies of water that are formed over seamounts and may become trapped or shed downstream. Taylor columns are associated with upwelling of nutrient-rich water from the deep ocean and may lead to increased productivity in the upper waters above or downstream of seamounts [1]. Data from satellite gravimetry suggest that tens of thousands of seamounts occur around the globe [3], with only few having been studied.
Seamount fauna is dominated by suspension feeders including gorgonian, scleractinian and antipatharian corals, sea anemons, sea pens, hydroids, bryozoans, sponges, ascidians and crinoids [1, 4, 5]. Densities of these species are often higher near the peaks or around the rim of the summit, as their distribution is largely dependent on locally induced currents. Corals may form deep cold-water reefs on seamounts that introduce additional complexity and provide a microhabitat of high biodiversity similar to the shallow-water tropical coral reefs. Gorgonians and whip corals may form high density beds that are associated with high densities of fish aggregations and may be important foraging areas for larger predators [1]. Hard substrata species of NE Atlantic seamounts are among others the corals *Dendrophyllia cornigera, Aulocyanthus atlanticus, Balanophyllia thalassae, Lophelia pertusa, Madrepora oculata*, and *Antipathes glabberima*, the gorgonian *Elisella flagellum*, sponges of the genus *Haliclonia*, and the sea urchin *Cidaris cidaris* [2, 6, 7]. The fauna of the sands and muds of the seamounts include various types of segmented and unsegmented worms, crustaceans, molluscs, echinoderms and ascidians [1, 5].
Seamounts are very important as habitat, feeding grounds and sites of reproduction for many deep or pelagic fish species. Many demersal or pelagic fish species such as redfish (*Sebastes* spp.), splendid alfonsino (*Beryx splendens*), orange roughy (*Hoplostethus atlanticus*), black scabbard fish (*Aphanopus carbo*), silver scabbard fish (*Lepidopus caudatus*), snipefish (*Macroramphosus* spp.), Atlantic horse mackerel (*Trachurus trachurus*), chub mackerel (*Scober japonicus*) and various shark species often form large aggregations in association with NE Atlantic seamounts [2, 8, 9].

<u>Associated Biotopes at EUNIS Level 5:</u>
A6.721 : Summit communities of seamount, knoll or bank within euphotic zone. No further description available.
A6.722 : Summit communities of seamount, knoll or bank within the mesopelagic zone(i.e. interacting with diurnally migrating plankton). No further description available.
A6.723 : Deep summit communities of seamount, knoll or bank (i.e. below mesopelagic zone). No further description available.
A6.724 : Flanks of seamount, knoll or bank. No further description available.
A6.725 : Base of seamount, knoll or bank. No further description available.

Biotope Evaluation: Goods and Services

Seamounts are hotspots of biodiversity in deep waters as their distinctive environment provides habitat for a great variety of benthic and pelagic species. Especially deep cold-water coral reefs or gorgonian and antipatharian beds associated with seamounts provide microhabitats of high biodiversity similar to the shallow-water tropical coral reefs. There is a high rate of speciation and endemism amongst seamount fauna [1, 4, 10]. Seamounts provide appropriate environmental conditions for the reproduction of many pelagic or demersal fish species. Orange roughy (*Hoplostethus atlanticus*), roundnose grenadier (*Coryphaenoides rupestris*), splendid alfonsino (*Beryx splendens*) and bulls-eye (*Epigonus telescopus*) are known to form spawning aggregations over NE Atlantic seamounts [2, 11]. Seamounts often maintain high standing stocks of demersal and pelagic fishes providing habitat, feeding grounds and sites of reproduction. The high abundance of commercially valuable fish and shellfish around seamounts has caused their intensive exploitation with long-lines, mid-water and deep bottom trawlers and static nets. Black scabbard fish (*Aphanopus carbo*), anglerfish (*Lophius piscatorius*), redfish (*Sebastes* spp.), slickhead (*Alepocephalus bairdii*), roundnose grenadier (*Coryphaenoides rupestrius*), various species of sharks, and also large pelagics such as tunas and swordfish are among the target species of commercial fisheries on seamounts in the NE Atlantic [2, 11[.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Fishing is by far the most significant threat to the biodiversity of seamounts. Seamounts are especially vulnerable to bottom trawling, which is highly destructive for the fragile habitat forming taxa such as corals [5, 12]. Strong differences in faunal composition have been reported between fished (by trawlers) and unfished seamounts; the coral cover has been almost completely removed from the fished seamounts [5, 12]. Deep cold-water corals are long-lived and slow growing and their recovery from trawling would be very slow; benthic community structure may never return to pre-fished state. Given the high levels of endemism of seamount benthic fauna, it is likely that unregulated fishing has already led to a substantial decline or depletion of the global population of some species. Many species of fish living around seamounts have a life history of slow growth and maturation rates and high longevity (e.g. orange roughy has a longevity of >100 years and matures at an age of ~20-30 years). These species may not withstand intensive fishing, which has already led to the collapse of many seamount fish stocks [2]. Many fish species are known to form spawning aggregations around seamounts and are therefore easily targeted by trawlers. Trawl fisheries around seamounts have a high proportion of discards. Mining activities on seamounts targeting ferromanganese crust and polymetallic sulphides is likely in the near future [13]; such exploratory mineral mining has already been conducted. Such activities will be destructive in the impacted area but also affect the surrounding seamount areas by substantially increasing the sediment load and turbidity of the downstream seawater affecting the entire benthic fauna, especially suspension feeders [1, 2].

Conservation and protection status

Seamounts are extremely vulnerable to fishing activities (esp. bottom trawling) and the habitats and biocommunities of many of them have already been seriously degraded. Seamounts have become priority biotopes under the OSPAR Convention and are included in the network of MPAs promoted by OSPAR. The United Nations General Assembly adopted in 2006 resolution 61/105 that calls for a precautionary approach and required the closure of bottom fishing activities by 31 December 2008 at all known and suspected vulnerable ecosystems, including seamounts, hydrothermal vents and cold-water corals, until conservation measures have been established to prevent significant adverse impacts. Seamounts are also likely to form part of the Natura 2000 network of protected areas and can be protected under the 1170 code (*Reefs*). In European territorial waters there are currently only few seamounts managed as MPAs or for which management plans have been developed [14]. A number of high seas areas are now closed to bottom fisheries, by Regional Fishery Management Organizations (RFMOs), in accordance with the United Nations General Assembly resolution

61/105. The 2010 OSPAR Ministerial Meeting took the significant step of adopting OSPAR Decisions establishing six MPAs in areas beyond national jurisdictions, including several seamounts, and OSPAR Recommendations on their initial management. However, outside the European territorial waters and Exclusive Economic Zones no adequate mechanisms exist yet for the effective surveillance and protection of these areas. In addition there are several issues that complicate the management of these areas: (1) the seabed and water column in these areas may be subject to different jurisdiction; in four of these MPAs Portugal manages the seabed as part of an UNCLOS outer limit continental extension; (2) OSPAR has no authority to control fishing activities, which are controlled by NEAFC (North East Atlantic Fisheries Commission); (3) OSPAR has no control on mining, which is covered by the International Seabed Authority; (4) OSPAR has no control on shipping, ruled by IMO (International Maritime Organization). OSPAR continues its liaison with other international competent authorities and relevant bodies to further develop the management framework for these sites. In the Mediterranean, GFCM and EU prohibited the use of towed dredges and trawlers at depths beyond 1,000 m [15, 16], which potentially protects part of the Mediterranean seamount biotopes.

References

[1] Rogers AD (2004) The biology, ecology and vulnerability of seamount communities. IUCN, Gland, Switzerland, pp 12

[2] Gubbay S (2003) Seamounts of the North-East Atlantic. WWF Germany, Frankfurt and Main, pp 38

[3] Kitchingman A, Lai S (2004) Inferences of potential seamount locations from mid-resolution bathymetric data. In: Morato T, Pauly D (eds) Seamounts: Biodiversity and fisheries. Fisheries Centre, University of British Columbia, Vancouver, pp 7-12

[4] Richer de Forges B, Koslow JA, Poore GCB (2000) Diversity and endemism of the benthic seamount fauna in the Southwest Pacific. Nature 405: 944-947

[5] Clark MR, Rowden AA (2009) Effect of deepwater trawling on the macro-invertebrate assemblages of seamounts on the Chatham Rise, New Zealand. Deep Sea Res I 56: 1540-1554

[6] Zibrowius H (1980) Les Scléractiniaries de la Méditerranée et de l'Atlantique nord oriental. Memoires de l'Institut Oceanographique Foundation Albert Ier, Prince de Monaco, 11, pp 247

[7] Piepenburg D, Mueller B (2002) Distribution of epibenthic communities on the Great Meteor Seamount (NE Atlantic) mirrors water-column processes. Abstracts from Theme Session on oceanography and ecology of seamounts – indications of unique ecosystems. ICES CM:2002/M:13

[8] Martins R, Ferreira C (1995) Line fishing for black scabbardfish (*Aphanopus carbo* Lowe, 1839) and other deep water species in the eastern mid-Atlantic to the north of Madeira. In: Hooper A.G. (Ed.) Deep-water fisheries of the North Atlantic oceanic slope. Kluwer Academic Publishers, London, pp 323-335

[9] Christiansen B, Martin B, Hirch S (2009) The benthopelagic fish fauna on the summit of Seine Seamount, NE Atlantic: composition, population structure and diets. Deep Sea Res II 56: 2705-2712

[10] Gad G (2009) Colonisation and speciation on seamounts, evidence from Draconematidae (Nematoda) of the Great Meteor Seamount. Mar Biodiv 39: 57-69

[11] Menezes GM, Rosa A, Melo O, Pinho MR (2009) Demersal fish assemblages off the Seine and Sedlo seamounts (northeast Atlantic). Deep Sea Res II, 56: 2683-2704

[12] Koslow JA, Gowlett-Holmes K, Lowry JK, O'Hara T, Poore GCB, Williams A (2001) Seamount benthic macrofauna off southern Tasmania: community structure and impacts of trawling. Mar Ecol Progr Ser 213: 111-125

[13] Sarma K, Ramana MV, Subrahmanyam V, Krishna KS (1998) Seamounts an additional tool to confirm the nature of the crust and to locate possible mineral resources from dredging. Mar Georesour Geotec 16(1): 41-51

[14] Santos RS, Christiansen S, Christiansen B, Gubbay S (2009) Toward the conservation and management of Sedlo Seamount: a case study. Deep Sea Res II 56(25): 2720-2730

[15] GFCM (2005) Recommendation on the management of certain fisheries exploiting demersal and deepwater species, Rec. GFCM/2005/1

[16] EC (2006) Council Regulation concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Regulation 1967/2006, OJ L 409

Oceanic ridges

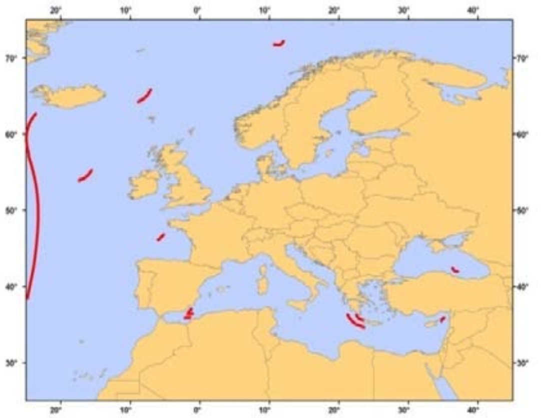
Compiled by Stelios Katsanevakis

Classification	**Code**	**Title**
NATURA 2000	1170	Reefs
EUNIS	A6.73	Oceanic ridges

Picture(s)

Not available

Biotope Distribution



Map of currently known distribution

Links to Available Maps

Not available

Biotope Requirements

The oceanic ridge systems are the most pronounced tectonic features on Earth rising 2,000–4,000 m from the ocean floor and sometimes reaching the surface, forming emergent islands, such as Iceland and Azores in the Mid-Atlantic Ridge (MAR). Mid-ocean ridges demarcate the boundary between two tectonic plates. These ridges extend as an almost continuous feature around the globe in the form of spectacular mountain ranges of volcanic basalts. This biotope includes all non-chemosynthetic systems and communities of oceanic ridges. Hydrothermal vents are treated separately (see EUNIS code A6.94: Vents in the deep sea).

Biotope Description

The main oceanic ridge of European interest is the Mid-Atlantic Ridge (MAR), which mainly lies in areas beyond national jurisdiction (except for some ridge islands such as Iceland and Azores), but other smaller ridges also exist both in the NE Atlantic and the Mediterranean Sea (see map). The MAR is a mid-oceanic ridge that extends from 87º N in the Arctic Ocean to Bouvet Island at 54º S in the Southern Ocean. Near the equator it is divided by a narrow submarine trench into the North Atlantic Ridge and the South Atlantic Ridge. The topography of the MAR has a profound impact on the circulation and hydrography in the North Atlantic [1]. Topographically, the Mid-Atlantic Ridge (MAR) is highly diverse, and prevailing currents show large variations over short distances [1]. Oceanic ridge biotopes range from shallow coastal waters around islands and seamounts to deep slopes and fractures at depths exceeding 4,000 m. Although generally hilly and rocky, the ridges also have sediment-covered plains and valleys. Oceanic ridges provide the main hard substratum and relatively shallow depths in otherwise sedimentary abyssal plains. Biological productivity is generally enhanced at ridges compared to the adjacent oligotrophic ocean basins, often because of local upwelling.

Aggregations of zooplankton and nekton have been observed in several locations of the MAR region [2, 3]. Aggregation of feeding cetaceans may be associated with the enhanced secondary production of oceanic ridges. In several locations of the MAR, aggregations of sperm (*Physeter macrocephalus*) and sei (*Balaenoptera borealis*) whales capitalize on secondary production maintained by enhanced primary production associated with the frontal processes in the upper part of the water column [4]. Other species of cetacean commonly observed along the MAR include pilot whales (*Globicephala melas*), short-beaked common dolphin (*Delphinus delphis*), white-sided dolphin (*Lagenorhynchus acutus*), and stripped dolphin (*Stenella coeruleoalba*) [5].

Oceanic ridges provide important habitats for many deep water fish such as the orange roughy and deepwater sharks. Oceanic ridges provide diverse habitats and wide depth ranges for demersal fish. Overall fish biomass and abundance of both demersal and pelagic fish in oceanic ridges general declines with depth [6, 7]. The rough topography of oceanic ridges with available hard bottoms and the elevated currents provide favorable conditions for sessile suspension feeders such as corals, hydroids, and sponges, which may occur in great abundance along oceanic ridges. In the MAR there is a high species richness of corals with at least 40 taxa, with *Lophelia pertusa* and *Anthomastus* sp. being the most common [8].

Associated Biotopes at EUNIS Level 5:
A6.731: Communities of ridge flanks. No further description available.
A6.732: Communities of ridge axial trough (i.e. non-vent fauna). No further description available.
A6.733: Oceanic ridge without hydrothermal effects. No further description available.

Biotope Evaluation: Goods and Services

Biological productivity is generally enhanced at ridges compared to the adjacent oligotrophic ocean basins, often because of local upwelling. Aggregations of zooplankton and nekton have been observed in several locations of the Mid-Atlantic Ridge (MAR) region [2, 3]. Aggregation of feeding cetaceans may be associated with the enhanced secondary production of oceanic ridges. In several locations of the MAR, aggregations of sperm (*Physeter macrocephalus*) and sei (*Balaenoptera borealis*) whales and other cetaceans capitalize on secondary production maintained by enhanced primary production associated with the frontal processes in the upper part of the water column [4, 5]. Oceanic ridges provide important and diverse habitats for many deep water fish such as the orange roughy and deepwater sharks. The rough topography of oceanic ridges with available hard bottoms and the elevated currents provide favorable conditions for sessile suspension feeders such as corals, hydroids, and sponges, which may occur in great abundance along oceanic ridges. In the MAR there is a high species richness of corals with at least 40 taxa, with *Lophelia pertusa* and *Anthomastus* sp. being the most common [8].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☒	☐
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☒	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

The main human activities conducted in the areas of oceanic ridges are fishing, shipping and the laying of communication cables. Fishing activities have the biggest impact on marine biodiversity around oceanic ridges

[8]. High Seas fishing has been conducted in the area of MAR since the 1970s and has led to overexploitation of several demersal deep sea fish species and extended damage to benthic biotopes because of bottom trawling [9].

Conservation and protection status

The areas beyond national jurisdiction of the North East Atlantic, including MAR, are covered by a regional seas agreement (the OSPAR convention) and by three regional fisheries management organisations: North East Atlantic Fisheries Commission (NEAFC), North Atlantic Salmon Conservation Organization (NASCO), and International Commission for the Conservation of Atlantic Tunas (ICCAT). Regional fisheries management organisations are recognized as the primary international vehicles for high seas fisheries governance in accordance with the United Nations Convention on Law of the Sea (UNCLOS) and the United Nations Fish Stocks Agreement (UNSFA). Their formal mandates extend solely to the regulation of fisheries, including wider environmental concerns (NEAFC) or more narrowly focused on the conservation and sustainable utilization of the target species involved (NASCO and ICCAT) [9]. The OSPAR commission pursues the establishment of a network of MPAs in the NE Atlantic with a broader scope that also applies to the MAR. The 2010 OSPAR Ministerial Meeting took the significant step of establishing six MPAs in areas beyond national jurisdictions, including sections of the MAR. However, there are several complications for the management of these MPAs (see previous section on 'Seamounts, knolls and banks - EUNIS A6.72').

References

[1] Søiland H, Budgell WP, Knutsen Ø (2008) The physical oceanographic conditions along the Mid-Atlantic Ridge north of the Azores in June–July 2004. Deep-Sea Res II 55: 29-44

[2] Opdal AF, Godø OR, Bergstad OA, Fiksen Ø (2008) Distribution, identity, and possible processes sustaining meso- and bathypelagic scattering layers on the northern Mid-Atlantic Ridge. Deep-Sea Res II 55: 45-58

[3] Gaard E, Gislason A, Falkenhaug T, Søiland H, Musaeva E, Vereshchaka A, Vinogradov G (2008) Horizontal and vertical copepod distribution and abundance on the Mid-Atlantic Ridge in June 2004. Deep-Sea Res II 55: 59-71

[4] Skov H, Gunnlaugsson T, Budgell WP, Horne J, Nøttestad L, Olsen E, Søiland H, Víkingsson G, Waring G (2008) Small-scale spatial variability of sperm and sei whales in relation to oceanographic and topographic features along the Mid-Atlantic Ridge. Deep-Sea Res II 55: 254-268

[5] Doksæter L, Olsen E, Nøttestad L, Fernö A (2008) Distribution and feeding ecology of dolphins along the Mid-Atlantic Ridge between Iceland and the Azores. Deep-Sea Res II 55: 243-253

[6] Bergstad OA, Menezes G, Høines ÅS (2008) Demersal fish on a mid-ocean ridge: distribution patterns and structuring factors. Deep-Sea Res II 55: 185-202

[7] Fossen I, Cotton CF, Bergstad OA, Dyb JE (2008) Species composition and distribution patterns of fishes captured by longlines on the Mid-Atlantic Ridge. Deep-Sea Res II 55: 203-217

[8] Mortensen PB, Buhl-Mortensen L, Gebruk AV, Krylova EM (2008) Occurrence of deep-water corals on the Mid-Atlantic Ridge based on MAR-ECO data. Deep-Sea Res II 55: 142-152

[9] Dotinga H, Molenaar EJ (2008) The Mid-Atlantic Ridge: a case study on the conservation and sustainable use of marine biodiversity in areas beyond national jurisdiction. IUCN, Gland, Switzerland

Abyssal hills

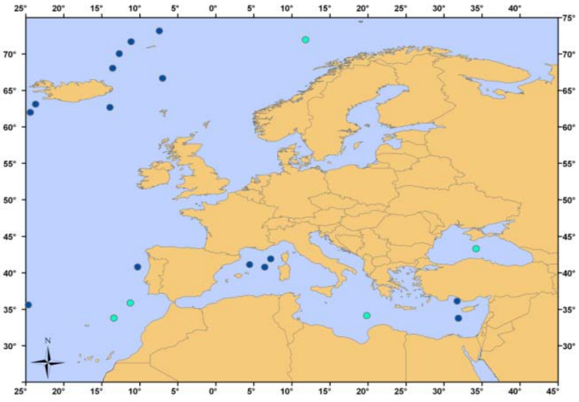
Compiled by Stelios Katsanevakis

Classification	Code	Title
NATURA 2000	1170	Reefs
EUNIS	A6.74	Abyssal hills

Picture(s)

Not available

Biotope Distribution



Map of currently known distribution

Links to Available Maps

http://www.marine-geo.org/portals/ridge2000/
http://www.ig.utexas.edu/research/projects/roughness_internalwaves/POgoff08.htm?PHPSESSID=def1b9

Biotope Requirements

A relatively low relief (a few meters to a few hundred meters) above the deep ocean floorat depths between 3,000 and 6,000 m. Characterized by absence of sunlight, constant low temperature, and great hydrostatic pressure.

Biotope Description

Abyssal plains are those parts of the ocean that begin at the edge of the continental margin and continue into the ocean depths. These plains, which are extremely level and may slope less than 1:1000, are the flattest places on earth and cover approximately one-half of the deep-ocean floor. The flatness of these plains is the result of the accumulation of a blanket of sediments, up to 5 kilometers thick, which overlies the basaltic rocks of the oceanic crust. Abyssal hills punctuate the relatively featureless plains. They are upthrown blocks of oceanic crust that form during extensional faulting of the seafloor as it spreads away from the mid-ocean ridge axis. These features cover a large geomorphic terrain characterizing >30% of the ocean floor and are the most common landforms on earth [1]. Axial faulting and volcanism are the primary mechanisms of abyssal hill formation [2]. The abyssal hills have relatively low relief as they rise from a few meters to a few hundred meters above the ocean floor of the abyssal plain.Because abyssal hills are bounded by active normal faults, they typically have steep cliffs or escarpments that expose cross sections of subseafloor basalt normally hidden beneath marine sediment [3]. These faults also penetrate ridge flank basement crust and may be natural conduits connecting ridge flank hydrothermal reservoirs to the ocean floor [4, 5]. Often covered with a blanket of unconsolidated pelagic sediments, these hills are usually extinct volcanoes or small formations of rock which were once extruded in molten form. Abyssal hills may often be found running parallel to mid-ocean ridges and may be found alone or in groups. In the North Atlantic the abyssal hills province is distributed along the basins which parallel the eastern and western flanks of the mid-Atlantic ridge and merge into the topography of the crestal region [6].
Our knowledge of the abyssal hill communities (and generally of the abyssal ocean floor) is limited. The food chain is based on the rain of organic matter from the shallow layers. Bacteria play an important role in deep-sea benthic food webs. The meiofauna graze on bacteria and play a major role in making energy available to larger benthic animals. Suspension feeders are rare and deposit feeders dominate. Animal density is generally very low

due to low availability of food.
Although there has been very little abyssal hill exploration, there is evidence (from two young abyssal hill localities) of episodic hydrothermal venting [5, 7]. However, very little is known about the characteristics of hydrothermal vents and mineral deposits in the abyssal hill terrain and the biological consequences. *Tevnia* worm tubes, galatheid crabs, shrimps, “dandelion” siphonophores, and mossy microbial floc have been reported from such sites [7]. A diverse hyperthermophilic microbial community (including groups within Crenarchaeota, Euryarchaeota, and Korarchaeota) was found in samples from East Pacific abyssal hills [3]. Benjamin and Haymon [7] stressed that “if young abyssal hills host widespread hydrothermal systems that are seismically rejuvenated by earthquakes at frequent (decadal time scale) time intervals, these systems may be important to deep-sea hydrothermal biota, allowing larva of hydrothermal vent animals to disperse across the mid-ocean ridge, as well as along the ridge crest”. However, our relevant knowledge remains limited and more research is needed.

Biotope Evaluation: Goods and Services

There is a lack of relevant knowledge. Although this is the most common marine biotope, it is the least explored and we know very little on the goods and services it provides or may provide in the future. Further research is needed especially on the role of abyssal hills to climate regulation, water quality regulation and the maintenance of deep water biodiversity.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☐	☒
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

There are no documented threats to abyssal hills due to human activities.

Conservation and protection status

There are no conservation or protection measures so far for abyssal hills biotopes.

References

[1] Macdonald KC, Fox PJ, Alexander RT, Pockalny R, Gente P (1996) Volcanic growth faults and the origin of Pacific abyssal hills. Nature 380: 125-129
[2] Tucholke BE, Lin J (1994) A geologic model for the structure of ridge segments in slow spreading ocean crust. J Geophys Res 99: 11937-11958
[3] Ehrhardt CJ, Haymon RM, Lamontagne MG, Holden PA (2007) Evidence for hydrothermal Archaea within the

basaltic flanks of the East Pacific Rise. Environ Microbiol 9: 900-912
[4] Yang J (2002) Influence of normal faults and basement topography on ridge-flank hydrothermal fluid circulation. Geophys J Int 151: 8387
[5] Haymon RM, Macdonald KC, Benjamin SB, Ehrhardt CJ (2005) Manifestations of hydrothermal discharge from young abyssal hills on the fast-spreading East Pacific Rise flank. Geology 33: 153-156
[6] Rona PA, Harbison RN, Bush SA (1974) Abyssal hills of the eastern central North Atlantic. Mar Geol 16: 275-292
[7] Benjamin SB, Haymon RM (2006) Hydrothermal mineral deposits and fossil biota from a young (o.1 Ma) abyssal hill on the flank of the fast spreading East Pacific Rise: evidence for pulsed hydrothermal flow and tectonic tapping of axial heat and fluids. Geochem Geophys Geosyst 7: Q05002

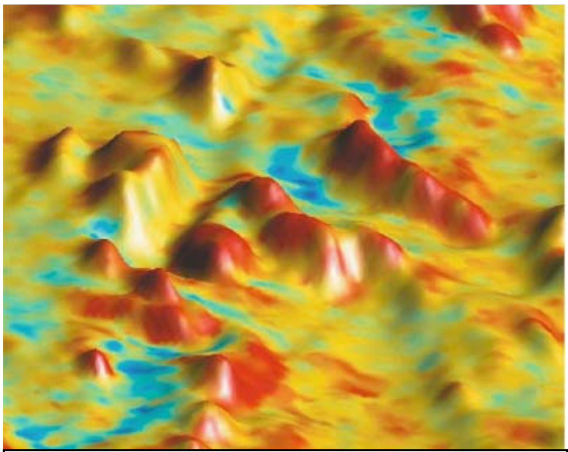
Cold-water coral carbonate mounds

Compiled by Stelios Katsanevakis

Classification	**Code**	**Title**
NATURA 2000	1170	Reefs
EUNIS	A6.75	Carbonate mounds

Picture(s)

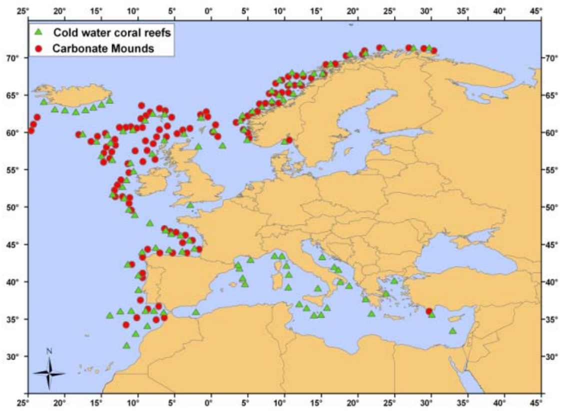
Graphical representation of cold water coral reef



Computer generated seafloor depicting carbonate mound formations

Image courtesy: Institute of Marine Research, Bergen, Norway (Dr Jan Helge Fosså)

Biotope Distribution



Map of currently known distribution

Links to Available Maps

http://www.springerlink.com/content/k8706q7447012j76/fulltext.pdf

Biotope Requirements

Cold-water corals that form carbonate mounds are largely restricted to oceanic waters and temperatures between 4º and 13ºC [1, 2]. Such conditions are generally found in relatively shallow waters (~50 to 1000 m) at high latitudes, and at great depths (up to 4000 m) beneath warm water masses at low latitudes [1]. Cold-water corals do not possess a symbiotic relationship with algae and therefore are not restricted to the photic zone. Cold-water corals are frequently reported from sites with locally accelerated currents (favourable for suspension feeding organisms) and high concentrations of suspended particulate organic material such as areas of the continental slope where internal tidal waves enhance seabed food supply [1, 2, 3]. *Lophelia pertusa* which is the most important framework-building cold-water coral can tolerate a wide range of salinities, which makes it adaptable in fjordic settings [4]. One constraint for the presence of cold-water coral carbonate mounds (hereafter called carbonate mounds) is the need for suitable substratum for initial coral attachment that can include dropstones or exposure of consolidated sediment [2].

Biotope Description

Biogenic cold-water coral reefs are frameworks produced by scleractinian corals that alter sediment deposition, provide structural habitat, and are subject to dynamic processes of growth and (bio)erosion [1]. Carbonate mounds are larger structures formed by successive periods of coral reef development, sedimentation and (bio)erosion and they may or may not support contemporary reefs (active or retired mounds respectively) [1]. Such mounds have a variety of shapes, and their size varies from small, low relief ovoid features a few meters high and tens of meters across to giant mounds that reach heights of 350 m and diameters of several kilometers [1, 2, 3]. Such giant mounds were formed over many thousands to millions of years; giant mounds occur in the Porcupine Seabight, Porcupine Bank, Rockall Bank and Hatton Bank in NE Atlantic [2]. The origin of carbonate mounds has been related either to hydrocarbon seepage [5, 6, 7, 8] or autogenic processes stimulated by high current speeds and food supply [1, 2, 3, 9]. There is little evidence for the former hypothesis, while recent evidence suggests that hydrodynamic conditions have a strong influence on mound growth and morphology [1, 2, 3]. However, some carbonate mounds may have been initiated by gas seepage and, once grown sufficiently, functioned independently of further seepage or even capped the initial seeps [2]. Carbonate mounds may have a sediment veneer, typically composed of carbonate sands, muds and silts. Coral reefs and mounds tend to cluster in “provinces”, where specific hydrodynamic and food supply conditions favor coral growth. Some of these provinces are characterized by old giant carbonate mounds established since the Late Pliocene/Pleistocene, e.g. the Porcupine Bank Canyon Mounds west of Ireland [3]. There is a strikingly larger number of records of cold-water scleractinians and carbonate mounds in the NE Atlantic than in the other oceans, possibly due to the greater depth of the aragonite saturation horizon (>2000 m in the NE Atlantic in comparison to 50–600 m in the N Pacific) [1].

Active carbonate mounds and cold-water coral frameworks in general are the most three-dimensionally complex habitats in the deep ocean, providing niche for many species such as fish, crustaceans, molluscs, echinoderms, sponges, bryozoans and polychaetes [1, 10, 11]. The main frame-building corals of European carbonate mounds are *Lophelia pertusa* and *Madrepora oculata* [1, 2]. In European Atlantic waters carbonate mounds are created mainly by *L. pertusa*. *M. oculata* seems to be more common in the Mediterranean. Other scleractinian coral species of carbonate mounds include *Desmophyllum cristagalli*, *Enallopsammia rostrata*, and *Solenosmilia variabilis* (10). More than 2800 species have been found living on *L. pertusa* reefs in the NE Atlantic [12]. Where cold-water corals (such as *L. pertusa*) are present on the mound summit, coral debris may form a significant component of the overlying substratum.

Biotope Evaluation: Goods and Services

Carbonate mounds are important palaeoclimatic archives due to their longevity over geological scales, cosmopolitan distribution, and banded skeletal structure [1]. Fossil records from carbonate mounds allow us to estimate past seawater temperatures and follow the ventilation history of the ocean and shifts in deep-ocean circulation patterns [1, 13, 14]. Active carbonate mounds are complex high diversity habitats in the deep ocean, providing niche for a great variety of species and great abundance of suspension feeders, grazers, scavengers and predators [1]. Carbonate mounds represent patches of high diversity in an environment of low diversity [15]. Their biodiversity may be comparable to that found on tropical shallow-water coral reefs, while there is evidence of high endemism [1]. Carbonate mounds provide fish habitat and are considered good fishing places for net and long-line fisheries.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☒	☐	☐

Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☒	☐	☐

Sensitivity to human activities

Bottom trawling is the most significant threat to carbonate mounds. Severe physical damage to the coral cover of carbonate mounds, from which recovery would take hundreds or thousands of years, has been reported in many areas [10, 15, 16]. Deep cold-water corals are long-lived and slow growing and their recovery from trawling would be very slow; benthic community structure may never return to pre-fished state. It has been estimated that between 30 and 50% of *L. pertusa* reefs in Norwegian waters are either damaged or impacted by trawling [15].

Global climate change is a serious potential threat for the cold-water coral ecosystems of carbonate mounds due to the acidification of the oceans, rising of sea water temperature and alteration of deep water circulation [1, 17, 18]. Modeling studies predict that depth of the aragonite saturation horizon will move shallower by several hundred meters, thereby turning current carbonate mound areas inhospitable for coral formation in the future [1, 17].

Small and highly localized impact has been reported due to hydrocarbon drilling activities and there is also potential risk due to future mining activities [1].

Conservation and protection status

Carbonate mounds are extremely vulnerable to fishing activities (esp. bottom trawling) and many of them have already been seriously damaged. Carbonate mounds are included in the OSPAR List of Threatened or Declining Species and Habitats and are included in the network of MPAs promoted by OSPAR. The UN General Assembly adopted in 2006 resolution A.61/L.38 that calls for a precautionary approach and required the closure of bottom fishing activities by 31 December 2008 at all known and suspected vulnerable ecosystems, including seamounts, hydrothermal vents and cold-water corals, until conservation measures have been established to prevent significant adverse impacts. Several nations worldwide such as Canada, Norway, UK and USA have closed areas with cold-water coral biotopes to bottom fishing.

References

[1] Murray Roberts J, Wheeler AJ, Freiwald A (2006) Reefs of the deep: the biology and geology of cold-water coral ecosystems. Science 312: 543-547

[2] Wheeler AJ, Beyer A, Freiwald A, de Haas H, Huvenne VAI, Kozachenko M, Olu-Le Roy K, Opderbecke J (2007) Morphology and environment of cold-water coral carbonate mounds on the NW European margin. Int J Earth Sci (Geol Rundsch) 96: 37-56

[3] Kenyon NH, Akhmetzhanov AM, Wheeler AJ, van Weering TCE, de Haas H, Ivanov MK (2003) Giant carbonate mud mounds in the southern Rockall Trough. Mar Geol 195: 5-30

[4] Rogers AD (1999) The biology of *Lophelia pertusa* (Linnaeus 1758) and other deep-water reef-forming corals and impacts fromhuman activity. Int Rev Hydrobiol 84: 315-410

[5] Hovland M (1990) Do carbonate reefs form due to fluid seepage? Terra Nova 2: 8-18

[6] Hovland M, Thomsen E (1997) cold-water corals – are they hydrocarbon seep related? Mar Geol 137: 159-164

[7] Henriet JP, De Mol B, Pillen S, Vanneste M, van Rooij D, Versteeg W, Croker PF, Shannon PM, Unnithan V, Bouriak S, Chachknine P, The Porcupine Belgica 97 Shipboard Party (1998) Gas hydrate crystals may help build coral reefs. Nature 391: 648-649

[8] Hovland M, Risk M (2003) Do Norwegian deep-water coral reefs rely on seeping fluids? Mar Geol 198: 83-96

[9] White M, Mohn C, de Stigter H, Mottram G (2005) Deep-water coral development as a function of hydrodynamics and surface productivity around submarine banks of the Rockall Trough, NE Atlantic. In: Freiwald A, Roberts JM (eds) Cold-water corals and ecosystems, Springer, Berlin Heidelberg New York, pp 503-514

[10] Hall-Spencer H, Allain V, Fosså JH (2002) Trawling damage to Northeast Atlantic ancient coral reefs. Proc R Soc Lond B 269: 507-511

[11] van Soest RWM, Cleary DFR, de Kluijver MJ, Lavaleye MSS, Maier C, van Duyl FC (2007) Sponge diversity and community composition in Irish bathyal coral reefs. Contrib Zool 76: 121-142

[12] HERMES project (Hotspot Ecosystems Research on the Margins of European Seas), FP6 European Research Project (http://www.eu-hermes.net)

[13] Goldstein SJ, Lea DW, Chakraborty S, Kashgarian M, Murrell MT (2001) Uranium-series and radiocarbon geochronology of deep-sea corals: implications for Southern Ocean ventilation rates and the oceanic carbon cycle. Earth Planet Sc Lett 193: 167-182

[14] Schröder-Ritzrau A, Mangini A, Lomitschka M (2003). Deep-sea corals evidence periodic reduced ventilation in the North Atlantic during the LGM/Holocene transition. Earth Planet Sc Lett 216: 399-410

[15] Fosså JH, Mortensen PB, Furevik DM (2002) The deep-water coral *Lophelia pertusa* in Norwegian waters: distribution and fishery impacts. Hydrobiologia 471: 1-12

[16] Wheeler AJ, Bett BJ, Billet DSM, Masson DG, Mayor D (2005) The impact of demersal trawling on northeast Atlantic deepwater coral habitats: the case of the Darwin Mounds, United Kingdom. Am Fish S S 41: 807-817

[17] Orr JC, Fabry VJ, Aumont O, Bopp L, Doney SC, Feely RA, Gnanadesikan A, Gruber N, Ishida A, Joos F, Key RM, Lindsay K, Maier-Reimer E, Matear R, Monfray P, Mouchet A, Najjar RG, Plattner GK, Rodgers KB, Sabine CL, Sarmiento JL, Schlitzer R, Slater RD, Totterdell IJ, Weirig MF, Yamanaka Y, Yool A (2005) Anthropogenic ocean acidification over the twenty-first century and its impact on calcifying organisms. Nature 437: 681-686

[18] Weaver PPE, Boetius A, Danovaro R, Freiwald A, Gunn V, Heussner S, Morato T, Schewe I, van den Hove S (2009) The Future of integrated deep-sea research in Europe: the HERMIONE project. Oceanography 22 (Special Issue): 178-191

Submarine canyons on the continental slope

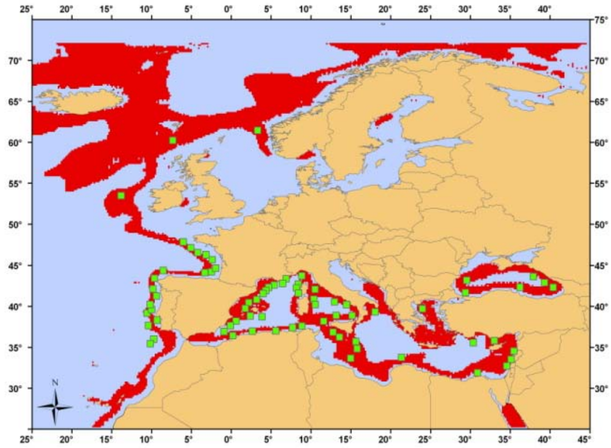
Compiled by Stelios Katsanevakis

Classification	Code	Title
EUNIS	A6.81	Canyons, channels, slope failures and slumps on the continental slope

Picture(s)

Not available

Biotope Distribution



Green dots represent known canyons. The red area represents potential biotope distribution (sea bottoms between 200 and 2,000 m depth)

Links to Available Maps

http://www.marine-geo.org/portals/ridge2000/

Biotope Requirements

Submarine canyons are deep incisions of the continental shelf and slope, with atypical topographic and hydrodynamic features that channel and concentrate large quantities of detritus and other organic matter. Their unique environmental conditions (habitat heterogeneity, high organic load, vertical fluxes, increased currents, episodic events such as slumps) create special benthic biotopes differing from adjacent slope areas and characterized by high local diversity of benthic and pelagic fauna.

Biotope Description

Submarine canyons are among the most spectacular features found along continental shelves and slopes and play an important role in the transport of sediments and organic matter from the shore to deep basins. Detritus and other materials are transported deeper through canyons by tidal currents and violent episodic events, including slumps and turbidity flows. Periodically intense currents, debris transport and organic aggregates, sediment slumps and turbidity flows are more likely to affect animals in canyons than in typical shelf and slope environments [1]. Submarine canyons may accumulate and transport unusually large quantities of macrophyte-detritus and other organic load [2, 3]. Therefore, conditions in canyons can lead to widespread organic enrichment, mainly because of transport along the sea floor rather than surfaced-derived particulate organic matter [1]. The most likely canyons to experience high levels of organic loading are those with shallow heads especially near marine macrophyte communities such as kelp forests, seagrass beds and estuaries [1, 3].
Submarine canyons are commonly found to contain distinct species assemblages, higher macro- and mega-faunal densities and/or biomass, and increased biodiversity than nearby non-canyon regions at similar depths [1, 3, 4, 5, 6]. Along the slopes of continental margins and islands, submarine canyons are recurrent sources of habitat heterogeneity and serve as ‘keystone structures’ for marine biodiversity [6]. The habitat heterogeneity of submarine canyons (in comparison to adjacent slope areas) may enhance biodiversity by providing refugia from predation, enhanced or alternative food resources, stress gradients, and substratum diversity [6]. However, many factors such as bottom geomorphology, oceanographic conditions, distance from shore,

orientation to currents, overlying production regime can result in different patterns of faunal enhancement between and within submarine canyons [6].
Canyon consumers potentially experience enhanced food supply through at least three mechanisms: suspension feeders may benefit from accelerated currents and increased abundance of prey [7, 8, 9]; demersal planktivores may exploit dense layers of zooplankton that become concentrated in canyons passively or actively (during downward vertical migration) [10], and detrivores may benefit by high sedimentation rates in canyons or through accumulation of macrophytic detritus [1, 2]. Several studies have found higher abundance of plankton and micronekton [11, 12, 13, 14, 15], and fish [3, 6, 15, 16] in canyons than nearby non-canyon areas. The significance of submarine canyons as deep-water coral biotopes has also been documented [9, 17].

Associated Biotopes at EUNIS Level 5:
A6.811: Active downslope channels (see general description).
A6.812: Inactive downslope channels (see general description).
A6.813: Along-slope channels. In general alongslope trending features show little disaggregation of sediment, and have moved by slow processes such as creep and shear failure. There is a lack of information on the biocommunity structure of such biotopes.
A6.814: Turbidites and fans. Sediments deposited by turbidity currents (gravity-driven suspensions of mud and water) and not by tractional or frictional flow are called turbidites. Turbidity currents may be caused by flood river discharges, storms, breaking of internal waves, and slope failure. Turbidites show a characteristic sequence of fining grain size and vertical disposition of sedimentary structures, which record the decrease in flow velocity. Turbidity currents can transport large volumes of sediments from the continental margin to the deep sea in a single event [18]. As sediment is deposited on the continental slope, the steepest part of the ocean, it is prone to sliding down onto the continental rise due to gravity. Deep-sea submarine fans are thick sedimentary bodies that develop seaward of a major sediment input. Such fans are similar to alluvial fans found on land near mountains and rivers. They have gradients similar to continental slopes, decreasing from the upper to the lower fan. They are supplied with sediment by one or more feeder channels, usually connected to slope canyons or canyon-channel systems [18]. In the Mediterranean, the major deep-sea submarine fans are the Rhone and Ebro fans in the western Mediterranean, and the Nile fan in the eastern Mediterranean [18].

Biotope Evaluation: Goods and Services

Submarine canyons can sustain enormous biomasses of infaunal megabenthic invertebrates over large areas [19]. Fish abundance is enhanced in canyons [3, 6, 15, 16], which are therefore regularly targeted by commercial and recreational fishermen exploiting bottom fish and invertebrates [6]. Some of the deep-water shrimp fishing grounds are located on the margin of submarine canyons [18]. Canyons may also focus the deposition of nekton carcasses, concentrating scavengers [20] and thus be hotspots of scavenger-based ecosystem services and enhanced fishery yields [6]. Canyons may serve as important nursery grounds for some fish and invertebrate species possibly due to increased structural diversity compared to adjacent slope areas (e.g., rock walls, boulders, and detritus patches) and increased availability of benthic or planktonic prey [3, 6]. Enhanced availability of food in canyons may be especially important for allowing demersal fish and benthic invertebrates to reproduce in otherwise oligotrophic regions [6]. Submarine canyons may harbour source populations in a 'source-sink system' providing larvae out to the surrounding slope and enhancing local and regional species density [6]. In the Catalan Sea (W. Mediterranean), the comparison of size distributions of the commonest species along the upper slope (e.g., *Merluccius merluccius*, *Trachyrhynchus trachyrhynchus*, and *Galeus melastomus*) between stations inside and outside of a submarine canyon, showed much lower mean weight values inside the canyon indicating that the canyon acted as a nursery area [16]. Mediterranean submarine canyons act as recruiting grounds and reservoirs of mature specimens of deep-water shrimp (such as *Aristeus antennatus* and *Aristaeomorpha foliacea*) [18]. Submarine canyons play a crucial role in the redistribution of carbon and anthropogenic materials derived from marine primary production and terrestrial runoff [21]. They are considered major pathways for the transportation and burial of organic carbon, acting as buffers for carbon storage; burial of organic carbon in marine sediments moderates atmospheric CO_2 levels on geological time scales [22].

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☒	☐	☐
Raw materials	☐	☐	☒
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☐	☒	☐
Cognitive benefits	☐	☐	☒
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☒	☐	☐
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Marine pollution seems to be an important threat to submarine canyons. Canyons receive anthropogenic materials derived from terrestrial runoff and have been considered as potential waste disposal sites [21]. For example, the Cassidaigne canyon near Marseilles has been used by the aluminum industry for damping its wastes ("red mud"). Marine litter (defined as any manufactured or processed solid waste material that enters the marine environment from any source) has been found to accumulate in high densities in submarine canyons [23] with significant impact to benthic fauna.

Conservation and protection status

There are no specific conservation or protection measures so far for submarine canyons. In the Mediterranean, GFCM and EU prohibited the use of towed dredges and trawlers at depths beyond 1,000 m [25, 26], which potentially partly protects the deeper part of some Mediterranean submarine canyons.

References

[1] Vetter EW, Dayton PK (1998) Macrofaunal communities within and adjacent to a detritus-rich submarine canyon system. Deep-Sea Res II 45: 25-54
[2] Harrold C, Light K, Lisin S (1998) Organic enrichment of continental shelf and deep-sea benthic communities by macroalgal drift imported from nearshore kelp forests. Limnol Oceanogr 43: 669-678
[3] Vetter EW, Dayton PK (1999) Organic enrichment by macrophyte detritus and abundance patterns of megafaunal populations in submarine canyons. Mar Ecol Prog Ser 186: 137-148
[4] Cartes JE, Company JB, Maynou F (1994) Deep-water decapod crustacean communities in the northwestern Mediterranean: influence of submarine canyons and season. Mar Biol 120: 221-229
[5] Gage JD, Lamont PA, Tyler PA (1995) Deep-sea macrobenthic communities at contrasting sites off Portugal, preliminary results: I Introduction and diversity comparisons. Int Rev Ges Hydrobio 80: 235-250
[6] Vetter EW, Smith CR, De Leo FC (2010) Hawaiian hotspots: enhanced megafaunal abundance and diversity in submarine canyons on the oceanic islands of Hawaii. Mar Ecol 31: 183-199
[7] Rowe GT (1971) Observations on bottom currents and epibenthic populations in Hatteras submarine canyon. Deep-Sea Res 18: 569-581
[8] Shepard FP, Marshall NF, McGloughlin PA (1974) Currents in submarine canyons. Deep-Sea Res 21: 691-706
[9] Reveillaud J, Freiwald A, van Rooij D, Le Guilloux E, Altuna A, Foubert A, Vanreusel A, Olu-Le Roy K, Henriet J-

P (2008) The distribution of scleractinian corals in the Bay of Biscay, NE Atlantic. Facies 54: 317-331
[10] Green CH, Wiebe PH, Burczynski J, Youngbluth MJ (1988) Acoustical detection of high-density semersal krill layers in the Submarine Canyons off Georges Bank. Science 241: 359-361
[11] Greene CH, Wiebe PH, Burczynski J, Youngbluth MJ (1992) Acoustical detection of high-density demersal krill layers in the submarine canyons off Georges Bank. Science 241: 359-361
[12] Cartes JE, Sardà F, Company JB, Lleonart J (1993) Day-night migrations by deep-sea decapod crustaceans in experimental samplings in the western Mediterranean Sea. J Exp Mar Biol Exol 171: 63-73
[13] Macquart-Moulin C, Patriti G (1993) Canyons sous-marins et advection vers le talus continental du plancton néritique. Oceanol Acta 16: 179-189
[14] Gili J-M, Pages F, Bouillon J, Palanques A, Puig P, Heussner S, Calafat A, Canals M, Monaco A (2000) A multidisciplinary approach to the understanding of hydromedousan populations inhabiting Mediterranean submarine canyons. Deep-Sea Res I 47: 1513-1533
[15] Brodeur RD (2001) Habitat-specific distribution of Pacific ocean perch (*Sebastes alutus*) in Pribilof Canyon, Bering Sea. Cont Shelf Res 21: 207-224
[16] Stefanescu C, Morales-Nin B, Massutí E (1994) Fish assemblages on the slope in the Catalan Sea (Western Mediterranean): influence of a submarine canyon. J Mar Biol Ass UK 74: 499-512
[17] Mortensen PB, Buhl-Mortensen L (2005) Deep-water corals and their habitats in The Gully, a submarine canyon off Atlantic Canada. In: Freiwald A, Roberts JM (eds) Cold-water corals and ecosystems. Springer, Heidelberg, pp 247-277Vetter EW (1995) Detritus-based patches of high secondary production in the nearshore benthos. Mar Ecol Prog Ser 120: 251-262
[18] Sardà F, Calafat A, Mar Flexas M, Tselepides A, Canals M, Espino M, Tursi A (2004) An introduction to Mediterranean deep-sea biology. Sci Mar 68(3): 7-38
[19] De Leo FC, Smith CR, Rowden AA, Bowden DA, Clark MR (2010) Submarine canyons: hotspots of benthic biomass and productivity in the deep sea. Proc Royal Soc *B* 277: 2783-2792[20] Vetter EW (1995) Detritus-based patches of high secondary production in the nearshore benthos. Mar Ecol Prog Ser 120: 251-262
[21] Weaver PPE, Billett D, Boetius A, Danovaro R, Freiwald A, Sibuet M (2004) Hotspot ecosystem research on Europe's deep-ocean margin. Oceanography 17: 132-143
[22] Masson DG, Huvenne VAI, De Stigter HC, Wolff GA, Kiriakoulakis K, Arzola RG, Blackbird S (2010) Efficient burial of carbon in a submarine canyon. Geol 38: 831-834[23] Galgani F, Leaute JP, Moguedet P, Souplet A, Verin Y, Carpentier A, Goraguer H, Latrouite D, Andral B, Cadiou Y, Mahe JC, Poulard JC, Nerisson P (2000) Litter on the Sea Floor Along European Coasts. Mar Pollut Bull 40: 516–527
[24] GFCM (2005) Recommendation on the management of certain fisheries exploiting demersal and deepwater species, Rec. GFCM/2005/1
[25] EC (2006) Council Regulation concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. Regulation 1967/2006, OJ L 409

Deep-sea trenches

Compiled by Stelios Katsanevakis

Classification	Code	Title
EUNIS	A6.82	Deep-sea trenches

Picture(s)

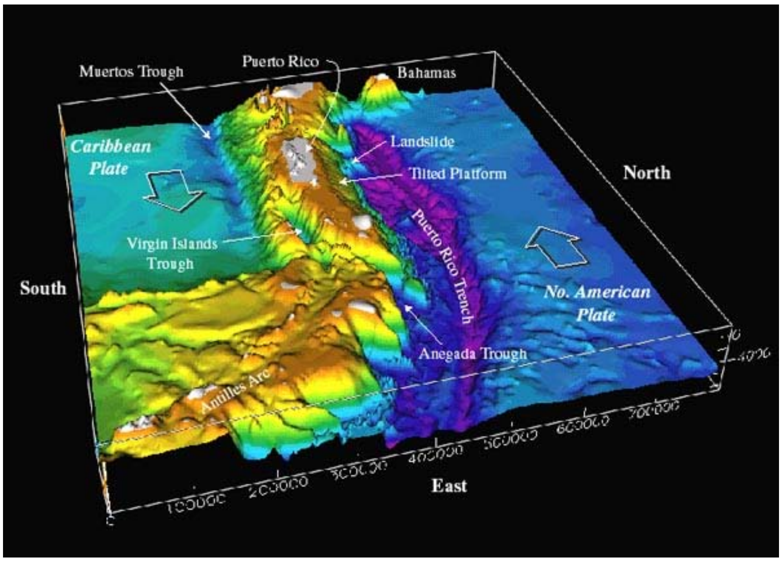
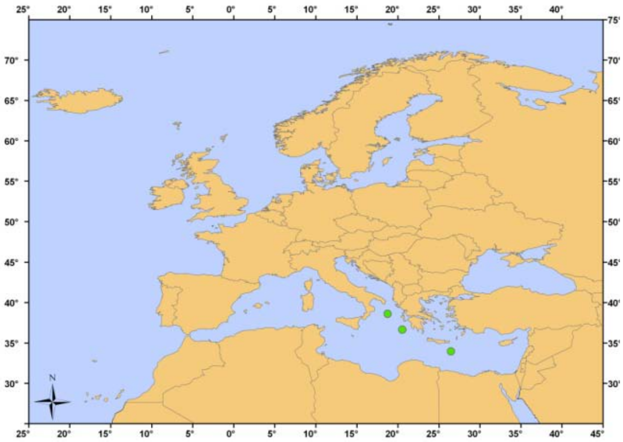


Image courtesy: USGS as found on OceanExplorer.noaa.gov

Biotope Distribution



Map of currently known distribution

Links to Available Maps

http://www.rrsjamescook.com/Oceanography%20-%20Trench.asp?Back=index.asp
http://www.marinebio.net/marinescience/02ocean/mgtectonics.htm
http://www.marine-geo.org/portals/ridge2000/

Biotope Requirements

Deep ocean trenches form slivers of narrow, elongate ocean floor that plunge from depths of 6,000 m to >10,000 m deep. They are the deepest areas of the ocean typically extending 3 to 4 km below the level of the surrounding oceanic floor. The greatest known ocean depth is in the Challenger Deep of the Mariana Trench, at a depth of 10,911 m below sea level. Deep-sea trenches are characterized by elevated hydrostatic pressures (600-1,100 atm), low temperatures (typically close to 2°C), currents that flow through and ventilate the trenches, geographical isolation, and spatio-temporal variation in food supply [1, 2].

Biotope Description

Trenches are a distinctive morphological feature that defines the natural boundaries between two converging lithospheric plates. Along convergent plate boundaries, plates move together at rates that vary from a few mm to over ten cm per year. A trench marks the position at which the flexed, subducting slab begins to descend beneath another lithospheric slab. Trenches are typically very narrow and their width generally does not exceed 40 km. Their slopes can be up to 45º or more, making trenches extremely difficult to sample remotely. Trenches are often characterised by the presence of turbidity currents, slides and collapses that can have catastrophic consequences on the local benthos. There are about 50,000 km of convergent plate margins, mostly around the Pacific Ocean—the reason for the reference “Pacific-type” margin—but they also exist in the eastern Indian Ocean, with relatively short convergent margin segments in the Atlantic Ocean and in the Mediterranean Sea (Hellenic trench, Pliny trench). Trenches are sometimes buried by sediments and lack bathymetric expression.

Surfaced-derived particulate organic matter (POM) and energy- and nutrient-rich carrion falls, such as the carcasses of marine mammals and fish, clearly play an important role in the supply of food to trench organisms [3, 4]. Patterns of food supply are very temporally and spatially variable and are affected by location, surface ocean and climatic processes, and the physical topography of the trench environment [2]. The steep slopes of trenches create a downward transport and subsequent accumulation of POM along the trench axis, differentiating trenches from the surrounding abyssal plains [2]. Higher microbial biomass has been measured in trenches than the surrounding abyssal plains (in some cases by an order of magnitude) and has been attributed to the entrapment of organic matter in the trenches [5]. Chemosynthetic bacterial communities have been discovered within trenches down to depths of >7000 m, providing localised resources for many specialized species [2, 6], but have received much less attention than the chemosynthetic communities associated with hydrothermal vents.

Trenches are accessible to some eurybathic abyssal fauna, e.g. grenadier fishes (Macrouridae) and natantial prawns (Benthesicymidae) but these are largely confined within 6,000–7,000 m [7, 8]. Of the 300 metazoan species documented from deep-sea trenches (based on sparse available data due to limited research), 58% were thought to be endemic to these biotopes [2]. A diverse array of metazoan species of fish, holothurians, polychaetes, bivalves, isopods, actinians, amphipods and gastropods have been recorded in deep-sea trenches [2, 9]. Special adaptations to high hydrostatic pressures and low temperatures are common to organisms living in deep trenches (e.g., the use of intracellular protein-stabilizing osmolytes and the increased use of unsaturated fatty acids in cell membrane phospholipids [10, 11, 12, 13]. Although the ‘carbonate compensation depth’ (at depths between 4,000–5,000 m in the Pacific or shallower towards higher latitudes), which is the depth at which calcium carbonate supply equals the rate of solvation, may form a physiological barrier to trench colonisation for some species, there are numerous examples of adaptations that overcome this potential limitation [2]. Scavenging amphipods represent a particularly conspicuous and ubiquitous component of trench fauna; some of them are adapted for burst of feeding activity followed by lengthy periods of digestion and fasting [2]. Gigantism, observed in many trench-dwelling crustaceans (amphipods, isopods, tanaids, and mysids) might be a response to ephemeral food resources, intense competition or predation [14].

Biotope Evaluation: Goods and Services

Deep-sea trenches are the deepest areas of the ocean typically extending 3 to 4 km below the level of the surrounding oceanic floor. A diverse array of metazoan species of fish, holothurians, polychaetes, bivalves, isopods, actinians, amphipods and gastropods have been recorded in deep-sea trenches, with many of them considered as endemic to these biotopes [2]. The deep-sea environment is also a source of unique microorganisms with great potential for biotechnological exploitation. Piezophilic (i.e. pressure loving) bacteria living in the deep sea have special features that allow them to live in this extreme environment, and it seems likely that further studies of these organisms will provide important insights into the origin of life and its evolution [15]. Research on piezophiles is expected to progress in two directions: (1) the exploration of high-pressure adaptation mechanisms of deep-sea organisms; and (2) the biotechnological applications of deep-sea organisms, as in the case of other extremophiles [16].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☐	☒
Raw materials	☐	☒	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒

Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☐	☒	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☐	☐	☒
Nutrient cycling	☐	☐	☒
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

There are no documented threats to deep-sea trenches due to human activities.

Conservation and protection status

There are no conservation or protection measures so far for deep-sea trenches.

References

[1] Johnson GC (1998) Deep water properties, velocities, and dynamics over ocean trenches. J Mar Res 56: 239-347

[2] Jamieson AJ, Fujii T, Mayor DJ, Solan M, Priede IG (2010) Hadal trenches: the ecology of the deepest places on Earth. Trends Ecol Evol 25: 190-197

[3] Stockton WL, De Laca TE (1982) Food falls in the deep sea: occurrence, quality, and significance. Deep-Sea Res 29: 157-169

[4] Britton JC, Morton B (1994) Marine carrion and scavengers. Oceanogr Mar Biol Annu Rev 32: 369-434

[5] Boetius A, Scheibe S, Tselepides A, Thiel H (1996) Microbial biomass and activities in deep-sea sediments of the Eastern Mediterranean: trenches are benthic hotspots. Deep-Sea Res I 43: 1439-1460

[6] Fujikura K, Kojima S, Tamaki K, Maki Y, Hunt J, Okutani T (1999) The deepest chemosynthesis-based community yet discovered from the hadal zone, 7326 m deep, in the Japan Trench. Mar Ecol Prog Ser 190: 17-26

[7] Jamieson AJ, Fujii T, Solan M, Matsumoto AK, Bagley PM, Priede IG (2009) Liparid and macrourid fishes of the hadal zone: *in situ* observations of activity and feeding behaviour. Proc R Soc B 276: 1037-1045

[8] Jamieson AJ, Fujii T, Solan M, Matsumoto AK, Bagley PM, Priede IG (2009) First finding of decapod crustacea in the hadal zone. Deep-Sea Res 56: 641-647

[9] Beliaev GM (1989) Deep-sea ocean trenches and their fauna. Nauka Publishing House, Moscow

[10] Hazel JR, Williams EE (1990) The role of alterations in membrane lipid composition in enabling physiological adaptation of organisms to their physical environment. Prog Lipid Res 29: 167-227

[11] Somero GN (1992) Adaptations to high hydrostatic pressure. Annul Rev Physiol 54: 557-577

[12] Pradillon G, Gaill F (2007) Pressure and life: some biological strategies. Rev Environ Sci Biotechnol 6: 181-195

[13] Samerotte AL, Drazen JC, Brand GL, Seibel BA, Yancey PH (2007) Correlation of trimethylamine oxide and habitat depth within and among species of teleost fish: an analysis of causation. Physiol Biochem Zool 80: 197-208

[14] Saint-Marie B (1992) Foraging of scavenging deep-sea lysianassoid amphipods. In: Rowe GT, Pariente V (eds) Deep-sea food chains and the global carbon cycle. Kluwer Academic Publishers, NATO ASI Ser C 360: 105–124

[15] Horikoshi K (1998) Barophiles: deep-sea microorganisms adapted to an extreme environment. Curr Opin Biotech 1(3): 291-295

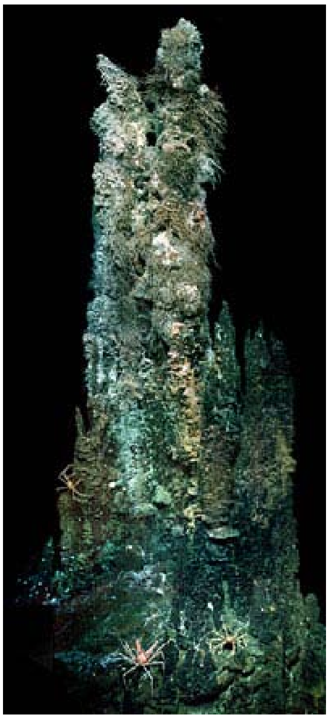
[16] Abe F, Horikoshi K (2001) The biotechnological potential of piezophiles. Trends Biotechnol 19: 102-108

Deep-sea hydrothermal vents

Compiled by Stelios Katsanevakis

Classification	**Code**	**Title**
NATURA 2000	1180	Submarine structures made by leaking gases
EUNIS	A6.94	Vents in the deep sea

Picture(s)



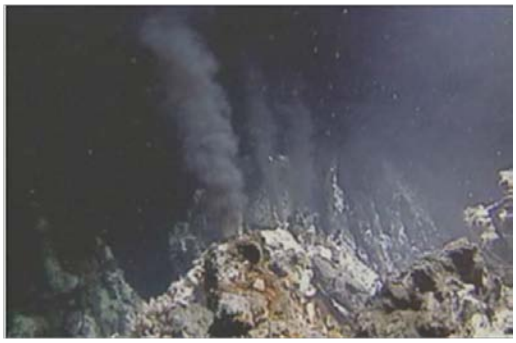
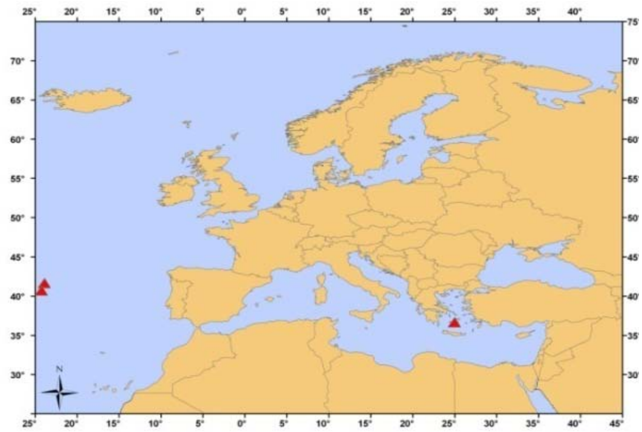


Image Courtesy: Woods Hole Oceanographic Institution

Biotope Distribution



Map of currently known distribution

Links to Available Maps

http://divediscover.whoi.edu/vents/world.html
http://www.divediscover.whoi.edu/ventcd/pdf/Tiveyocv34.pdf

Biotope Requirements

Deep-sea hydrothermal vents are observed in mid-oceanic ridges, fracture zones, subduction zones, back-arc basins, volcanic arcs, and active seamounts. Hydrothermal vents form when seawater reacts with the earth's magma, becoming superheated and taking on many minerals and compounds such as hydrogen sulphide that support rich biocommunities based on chemoautotrophic bacteria. Deep-sea hydrothermal vent fields cover relatively small areas of the seabed in water depths between 200 – 4000 m. The depth of 200 m corresponds to sharp changes in vent fauna and is considered as the limit between shallow-water and deep-water hydrothermal vents [1].

Biotope Description

Deep-sea hydrothermal vent communities were discovered in 1977 at 2,500 m depth on the Galapagos Spreading Centre during a dive of the manned deep-sea research vessel *Alvin*. Since then many hydrothermal vents have been located and studied over various geological and dynamic environments such as fast to slow-spreading mid-oceanic ridges, fracture zones, subduction zones, back-arc basins, volcanic arcs, and active seamounts. In such areas seawater may penetrate the upper levels of the Earth's crust through cracks and channels formed in cooling lava flows. Seawater is then heated to very high temperatures, reacts chemically with hot basalt in the Earth's crust and emerges at hydrothermal vents as superheated water containing compounds such as sulphides (especially hydrogen sulphide), dissolved minerals including iron, copper and zinc, nutrients, CO_2 and methane [2]. The temperature of the water coming out of the vents ranges from a modest 10-30 ºC (still much warmer than the 2-3 ºC ambient seawater) to ~400 ºC; because of the very high pressure, this superheated water does not boil [3]. Because heated water is more buoyant than cold seawater, it exits back into the ocean water. When it hits the cold ocean water, many of the minerals crystallize, creating black and white "smokers", "chimneys" and other mineral deposits [2].

Hydrothermal vents are oases of life on the barren deep-sea floor. These biotopes contain a huge diversity of chemoautotrophic bacteria, which form the core of the trophic structure around the vent. These bacteria can use the energy contained in hydrogen sulphide molecules to make organic matter (chemosynthesis). Other small or large animals (tubeworms, bivalves, limpets, barnacles, shrimp, crabs, gastropods) live off the chemosynthetic bacteria either eating them directly or harbouring them in their bodies (endosymbiotic or episymbiotic relationships) living off the organic compounds the bacteria produce [4]. It takes a high level of speciation to live in such extreme biotopes and thus many of the species recorded in hydrothermal vents are endemic to these biotopes [1, 5]. Deep-water hydrothermal vents have a short life span, usually on the order of years to decades and local communities can often be wiped out entirely, while new vents continuously spring up. Hence, special adaptations of vent fauna include the capability of long-distance dispersal (to colonize new distant vents) and *r*-selective traits such as high reproductive capacity and quick development once established [2, 6].

Hundreds of species have been discovered at the hydrothermal vents and the fauna varies widely between regions due to discontinuites of the ridges and hydrological barriers [7]. Six major hydrothermal provinces in the world ocean have been identified (northwest Pacific, southwest Pacific, northeast Pacific, northern east Pacific rise, southern east Pacific rise, and northern mid-Atlantic ridge) by multivariate analysis of vent faunal data [7]. The most distinct aspect of the Atlantic deep-water hydrothermal vents is the absence of any species of tubeworms, which have been the most popular vent species in the media. Characteristic vent species in the Atlantic include mytilids of the genus *Bathymodiolus*, the shrimps *Rimicaris exoculata, Mirocaris fortunata*, *Mirocaris keldyshi* and *Chorocaris chacei*, the crab *Segonzacia mesatlantica*, the gastropod *Protolira valvatoides* [4, 8, 9]. Submarine hydrothermal venting in the Mediterranean has mostly been described from shallow waters [10] and deep hydrothermal vents seem not to be common, e.g. in Santorini (Greece) [11], and there is no much available information on their biocommunities.

Associated Biotopes at EUNIS Level 5:
A6.941: Active vent fields. No further description available.
A6.942: Inactive vent fields. No further description available.

Biotope Evaluation: Goods and Services

Hydrothermal vents are oases of life on the barren deep-sea floor. These biotopes contain a huge diversity of chemoautotrophic bacteria, which form the core of the trophic structure around the vent. Other small or large animals (tubeworms, bivalves, limpets, barnacles, shrimp, crabs, gastropods) live off the chemosynthetic bacteria either eating them directly or harbouring them in their bodies (endosymbiotic or episymbiotic relationships) living off the organic compounds the bacteria produce [4]. It takes a high level of speciation to live in such extreme biotopes and thus many of the species recorded in hydrothermal vents are endemic to these biotopes [1, 5]. Hundreds of species have been discovered at the hydrothermal vents and the fauna varies widely between regions due to discontinuities of the ridges and hydrological barriers [7]. Deep-sea hydrothermal vents are important biological sources of thermophile and hyperthermophile bacteria that show a great potential for biotechnological applications [12, 13]. Microbial polysaccharides represent a class of important products of growing interest for many sectors of industry. Some bacteria originating from hydrothermal deep-sea vents were shown to biosynthesize innovative exopolysaccharides under laboratory conditions that are expected to find many applications in the near future due to their specific properties [12]. Extremophilic microorganisms from hydrothermal vents will provide a valuable resource not only for exploitation in novel biotechnological processes but also as models for investigating how biomolecules are stabilized when subjected to extreme conditions [12, 13]. Proposed uses for polymers produced exopolysaccharides from deep-sea hydrothermal vents include water treatment and removal of heavy metal pollutants, food-thickening agents, and clinical applications in the area of cardiovascular diseases and bone healing [13]. The relatively uniform reactions between seawater and seafloor basalt are considered to constitute a geochemical “flywheel” that stabilizes the ocean’s composition against variations in river input caused by long-term climatic and tectonic changes [14]. Some hypotheses about the origin of life on Earth centre on hydrothermal vents and their chemosynthetic based communities. Several important features of hydrothermal vents make it a good candidate for abiogenesis [2, 15). Such theories have important implications for extraterrestrial life, as similar conditions to those at deep-sea hydrothermal vents are expected to prevail on certain planets [2]. Thus, hydrothermal vents are natural laboratories that provide valuable information for our understanding of the origin of life.

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☐	☒
Raw materials	☒	☐	☐
Air quality and climate regulation	☐	☐	☒
Disturbance and natural hazard prevention	☐	☐	☒
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☒	☐	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☐	☒	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

There are no documented present threats to deep-water hydrothermal vents due to human activities, other than bottom fishing. Hydrothermal vents spew metal-rich fluids that settle out to form mineral-laden sediment beds. There is an ongoing discussion on mining the metalliferous deposits around hydrothermal vents and arguments that such mining can be environmental-free and sustainable [16]; however the consequences to these biotopes are unknown.

Conservation and protection status

The UN General Assembly adopted in 2006 resolution A.61/L.38 that calls for a precautionary approach and required the closure of bottom fishing activities by 31 December 2008 at all known and suspected vulnerable ecosystems, including seamounts, hydrothermal vents and cold-water corals, until conservation measures have been established to prevent significant adverse impacts. The 2010 OSPAR Ministerial Meeting took the significant step of establishing six MPAs in areas beyond national jurisdictions to protect seamounts and parts of the MAR; several areas with hydrothermal vents are included in these MPAs. However, there are several complications for the management of these MPAs (see previous section on 'Seamounts, knolls and banks - EUNIS A6.72').

References

[1] Tarasov VG, Gebruk AV, Mironov AN, Moskalev LI (2005) Deep-sea and shallow-water hydrothermal vent communities: two different phenomena? Chem Geol 224: 5-39

[2] Howe A (2008) Deep-sea hydrothermal vent fauna: evolution, dispersal, succession and biogeography. Macalester Rev Biogeogr 1: 1-20

[3] Rice T (2000) Deep ocean. The Natural History Museum, London

[4] Lutz RA, Kennish MJ (1993) Ecology of deep-sea hydrothermal vent communities: a review. Rev Geophys 31: 211-242

[5] van Dover CL (2000) The ecology of deep-sea hydrothermal vents. Princeton University Press, Princeton

[6] van Dover CL, German CR, Speer KG, Parson LM, Vrijenhoek RC (2002) Evolution and biogeography of deep-sea vent and seep invertebrates. Science 295: 1253

[7] Bachraty C, Legendre P, Desbruyères D (2009) Biogeographic relationships among deep-sea hydrothermal vent faunas at global scale. Deep-Sea Res 56: 1371-1378

[8] Gebruk AV, Chevaldonné P, Shank T, Lutz RA, Vrijenhoek RC (2000) Deep-sea hydrothermal vent communities of the Logatchev area (14º45'N, Mid-Atlantic Ridge): diverse biotopes and high biomass. J Mar Biol Ass UK 80: 383-393

[9] Desbruyères D, Biscoito M, Caprais J-C, Colaço A, Comtet T, Crassous P, Fouquet Y, Khripouno A, Le Bris N, Olu K, Riso R, Sarradin P-M, Segonzac M, Vangriesheim A (2001) Deep-Sea Res I 48: 1325-1346

[10] Dando PR, Stüben D, Varnavas SP (1999) Hydrothermalism in the Mediterranean Sea. Prog Oceanogr 44: 333–367

[11] Sigurdsson H, Carey S, Alexandri M, Vougioukalakis G, Croff K, Roman C, Sakellariou D, Anagnostou C, Rousakis G, Ioakim C, Gogou A, Ballas D, Misaridis T, Nomikou P (2006) Marine Investigations of Greece's Santorini Volcanic Field. Eos Trans AGU, 87(34): 337

[12] Guezennec J (2002) Deep-sea hydrothermal vents: A new source of innovative bacterial exopolysaccharides of biotechnological interest? J Ind Microbiol Biot 29: 204-208

[13] Mancuso Nichols CA, Guezennec J, Bowman JP (2005) Bacterial exopolysaccharides from extreme marine environments with special consideration of the Southern Ocean, sea ice, and deep-sea hydrothermal vents: a review. Mar Biotechnol 7: 253-271

[14] Edmond JM, von Damm KL (1992) Hydrothermal activity in the deep sea. Oceanus 35: 76-81

[15] Martin W, Russel MJ (2003) On the origins of cells: a hypothesis for the evolutionary transitions from abiotic geochemistry to chemoautotrophic prokaryotes, and from prokaryotes to nucleated cells. Phil Trans Roy Soc B 358: 59-85

[16] Ellis DV (2008) Mining the deep-sea vents: pollution and conservation issues. In: Hofer TN (ed) Marine pollution: new research. Nova Science Publishers, New York, pp 1-3

Pontic anoxic H_2S black muds of the slope and abyssal plain with anaerobic sulphate reducing bacteria and nematodes

Compiled by Valentina Todorova

Classification	Code	Title
EUNIS	A6.95	Pontic anoxic H2S black muds of the slope and abyssal plain, with anaerobic sulphate reducing bacteria and nematodes

Picture(s)

Not available

Biotope Distribution

Not available

Links to Available Maps

Not available

Biotope Requirements

The Black Sea is the largest anoxic water basin on Earth and its stratified water column comprises an upper oxic, middle suboxic and a lower permanently anoxic, sulfidic zone. The anoxic zone contains about 87% of the Black Sea water column and about 75% of its bottom [1] below the depth of 180-200 m [2]. Coccolith compact ooze covers the continental slope and the abyssal plain at depth below 180-200 m [3]. Permanently anoxic conditions and hydrogen sulfide accumulated as a by-product of anaerobic decomposition of organic matter, constant temperature of 8.5-9°C, constant salinity of 22-22.5 ppt are the principal environmental features in this biotope [2].

Biotope Description

It is debatable whether meiofauna can live in the noxious Black Sea bathyal and abyssal sediments. Zaitsev et al. [4] and Sergeeva [5, 6, 7, 8] reported the finding of an assortment of multi-cellular meiofauna comprising nematodes (*Cobbionema, Desmoscolex, Tricoma, Neochromadora, Chromadora, Monoposthia, Microlaimus, Eurystomina, Enoplus,* etc), harpacticoid crustaceans (*Ectinosoma, Laophontidae, Parastenhelia, Harpacticus*), ostracods, amphipods, kinorhynchans, and acarines, as well as protozoans - ciliates and foraminifers at depths between 400-2250 m. Additionally 20 peculiar forms allegedly “new to science” and “endemic of the deep” were found, which remained taxonomically unidentified [5, 6, 7, 8]. However more recently Zaitsev and Polikarpov [1] argued that there was no convincing scientific evidence that fauna found in deep sediments was viable. The authors suggested that the specimens retrieved were simply remains of the dead bodies of organisms living in the aerobic zone, which were transported through sedimentation, sediment sliding and water currents to the deep zone.

The deep Black Sea sediments are inhabited by anaerobic bacteria believed to be more active and diverse than anywhere else in the ocean. The most abundant bacterial population in the Black Sea belongs to the sulfate - reducing bacteria from *Desulfosarcina* / *Desulfococcus* group. Other functional groups include methane oxidizing archea, ammonium oxidizing anammox bacteria, chemoautotrophic sulfur-oxidizing bacteria, and photosynthetic purple and green sulfur bacteria.

Biotope Evaluation: Goods and Services

The deep anoxic Black Sea sediments are inhabited by anaerobic bacteria believed to be more active and diverse than anywhere else in the ocean. The most abundant bacterial population in the Black Sea belongs to the sulfate -reducing bacteria from *Desulfosarcina* / *Desulfococcus* group. Other functional groups include methane oxidizing archea, ammonium-oxidizing (anammox) bacteria, chemoautotrophic sulfur-oxidizing bacteria, and photosynthetic purple and green sulfur bacteria. The Black Sea harbours vast quantities of hydrogen sulfide. This noxious gas could be used as a renewable source of hydrogen gas to fuel a future carbon-free economy [9, 10, 11]. Total hydrogen sulfide production in the sediments of the Black sea is estimated at about 10,000 tons per day and this equates to potentially well over 500 tons of daily hydrogen gas production using various different decomposition methods [10]. The anammox bacteria were estimated to contribute up to 50% of oceanic nitrogen loss [11]. The anammox process is currently implemented in water treatment for the low-cost removal of ammonia from high-strength waste streams [11]. The major part of methane (>90%) that is produced in ocean sediments is consumed by microbes before it reaches the atmosphere. Therefore anaerobic oxidation of methane has a significant impact on climate regulation as methane is a 30 times stronger greenhouse gas compared to carbon dioxide [12].

Service	**High**	**Low**	**Negligible/ irrelevant/ unknown**
Food provision	☐	☐	☒
Raw materials	☒	☐	☐
Air quality and climate regulation	☒	☐	☐
Disturbance and natural hazard prevention	☒	☐	☐
Water quality regulation / Bioremediation of waste	☒	☐	☐
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☐	☒
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☐	☒

Sensitivity to human activities

Insufficient information.

Conservation and protection status

Deep sea biotopes in the Black Sea are not addressed by any legal provisions or management aimed at their conservation.

References

[1] Zaitsev YP, Polikarpov GG (2008) Recently Discovered New Biospheric Pelocontour Function in the Black Sea Reductive Bathyal Zone. J Black Sea/Mediterranean Environm 14: 151-165

[2] Oguz T (2008) General Oceanographic Properties: Physico-chemical and Climatic Featuers. In: Oguz T (Ed). State of the Environment of the Black Sea (2001 - 2006/7). Publications of the Commission on the Protection of the Black Sea Against Pollution (BSC) 2008-3, Istanbul, Turkey, pp 448

[3] Ross DA, Degens ET (1974). Recent sediments of the Black Sea. In: Degens, ET, Ross DA (Eds.) The Black Sea: Geology, Chemistry, and Biology. American Association of Petroleum Geologists, Tulsa, USA, pp 183–199

[4] Zaitsev YP, Antsupova LV, Vorobyova LV, Garkavaya GP, Kulakova II, Rusnak EM (1987) Nematoda in the Black sea deep-water part. Reports UkrAcad SciSerB 11: 77-79 (in Russian)

[5] Sergeeva NG (1988) On the finding of bottom invertebrates at great depths in the Black sea// III All-Union Conf. on Marine Biology (Sevastopol, Oct.18-20, 1988). Reports theses. Kiev, Nauk. Dumka, 246-247 (in Russian)

[6] Sergeeva NG (2000) Meiobenthos of the Black Sea Anaerobic Zone. Intern. Symp. The Black Sea Ecological Problems. Black Sea Strategic Action Plan Implementations (1996-2000). Odessa, SCSEIO, pp 258-262

[7] Sergeeva NG (2000) New data on life in the deep water hydrogen sulphide zone of the Black sea. In: Global monitorings ystem of the Black Sea: fundamental and applied aspects. MGIPress, Sevastopol, pp 138-146
[8] Sergeeva NG (2003) In: Arvanitidis C, Eleftheriou A, Vanden Berghe E, Appeltans W, van Avesaath PH, Heip CHR, Mees J, (eds) Electronic conference on 'Marine Biodiversity in the Mediterranean and the Black Sea' - Summary of discussions, 7-20 April, 2003. Flanders Marine Institute (VLIZ): Oostende, Belgium. iv, pp 74
[9] Inderscience (2009) Black Sea Pollution Could Be Harnessed As Renewable Future Energy Source. ScienceDaily. Available online at: http://www.sciencedaily.com/releases/2009/03/090316075849.htm (Last accessed March 26, 2010)
[10] Haklidir M, Tut FS, Kapkin Ş (2009) Possibilities of Production and Storage of Hydrogen in the Black Sea. Internat J Nucl Hydr Prod Appl 2 (1): 78 - 85
[11] Op den Camp HJM, Kartal B, Guven D, van Niftrik LAMP, Haaijer SCM, van der Star WRL, van de Pas-Schoonen KT, Cabezas A, Ying Z, Schmid MC, Kuypers MMM, van de Vossenberg J, Harhangi HR, Picioreanu C, van Loosdrecht MCM, Kuenen JG, Strous M, Jetten MSM (2006) Global impact and application of the anaerobic ammonium-oxidizing (anammox) bacteria. Biochem Socie Trans 34 (1), 174-178
[12] Treude T, Knittel K, Blumenberg M, Seifert R, Boetius A (2005) Subsurface Microbial Methanotrophic Mats in the Black Sea. Appl Envir Microb 71(10): 6375–6378

*Pontic anaerobic microbial biogenic reefs above methane seeps

Compiled by Valentina Todorova

Classification	Code	Title
NATURA 2000	1180	Submarine structures made by leaking gases
EUNIS	*A6.96	* Pontic anaerobic microbial biogenic reefs above methane seeps

Picture(s)
Not available

Biotope Distribution
Not available

Links to Available Maps
Not available

Biotope Requirements
Anaerobic conditions in deep Black Sea, methane seepage, sulfate present in sediments.

Biotope Description
Carbonate structures with methanogenic origin, associated with several centimetres thick microbial mats, occur in the Black Sea above methane seeps [1, 2, 3].

Carbonate structures of three different morphologies are observed: (a) *slabs*, (b) *caverns* - subsurface void chambers up to 20 cm^3 in size, and (c) *chimneys* with vertical orientation in the water column or *tubes* forming a subhorizontal network in the subsurface.

The three described carbonate types are interpreted as the result of three different mechanisms of fluid seepage and carbonate precipitation. The most prominent among these structures are the reef-like carbonate buildups up to 1 m in diameter and 4-meter-high covered by massive microbial mats that prosper at methane seeps in anoxic waters of the Black Sea shelf [2]. Strong ^{13}C depletions indicate an incorporation of methane carbon into carbonates, bulk biomass, and specific lipids. The mats mainly consist of densely aggregated methane oxidizing archaea (MOA) and sulfate-reducing bacteria (SRB). If incubated in vitro, these mats perform anaerobic oxidation of methane coupled to sulfate reduction. Anaerobic microbial consortia can generate both carbonate precipitation and substantial biomass accumulation. Syntrophic partners of the AOM consortium occur in structured aggregates: archaea are located in the center surrounded by the SRB.

Biotope Evaluation: Goods and Services
Carbonate structures with methanogenic origin, associated with several centimeters thick microbial mats, occur in the Black Sea above methane seeps. The major part of methane (>90%) that is produced in ocean sediments is consumed by microbes before it reaches the atmosphere. Therefore anaerobic oxidation of methane has a significant impact on climate regulation as methane is a 30 times stronger greenhouse gas compared to carbon dioxide [2]. The microbial reefs discovered in the Black Sea suggest how ancient oceans might have looked when oxygen was a trace element in the atmosphere, long before the onset of metazoan evolution, and provide a unique opportunity for scientific knowledge development regarding the biological cycling of carbon in an anoxic biosphere.

Service	High	Low	Negligible/ irrelevant/ unknown
Food provision	☐	☐	☒
Raw materials	☒	☐	☐
Air quality and climate regulation	☒	☐	☐

Disturbance and natural hazard prevention	☒	☐	☐
Water quality regulation / Bioremediation of waste	☐	☐	☒
Cognitive benefits	☒	☐	☐
Leisure, recreation and cultural inspiration	☐	☐	☒
Feel good or warm glow	☐	☒	☐
Photosynthesis and primary production	☒	☐	☐
Nutrient cycling	☒	☐	☐
Reproduction and nursery areas	☐	☐	☒
Maintenance of biodiversity	☐	☒	☐

Sensitivity to human activities

Available data remain insufficient but gas and oil drilling and extraction of gas-hydrates may lead to the physical destruction of this biotope.

Conservation and protection status

Microbial *bubbling reefs* are a subtype of Natura 2000 habitat type 1180 *Submarine structures made by leaking gases* listed under the Habitats Directive. These should receive adequate attention and Special Areas of Conservation should be designated in the Black Sea aimed at the conservation of this extraordinary natural biotope. The initial list of sites of Community importance for the Black Sea biogeographical region adopted by Commission Decision of 12 December 2008 does not include site with “bubbling reefs” over methane seeps.

References

[1] Mazzini A, Ivanov MK, Nermoen A, Bahr A, Bohrmann G, Svensen H, Planke S (2008) Complex plumbing systems in the near subsurface: Geometries of authigenic carbonates from Dolgovskoy Mound (Black Sea) constrained by analogue experiments. Mar Petrol Geol 25: 457–472

[2] Michaelis W, Seifert R, Nauhaus K, Treude T, Thiel V, Blumenberg M, Knittel K, Gieseke A, Peterknecht K, Pape T, Boetius A, Amann R, Joergensen BB, Widdel F, Peckmann J, Pimenov NV, Gulin MB (2002) Microbial reefs in the Black Sea fueled by anaerobic oxidation of methane. Scie 297: 1013-1015

[3] Treude T, Knittel K, Blumenberg M, Seifert R, Boetius A (2005) Subsurface Microbial Methanotrophic Mats in the Black Sea. Appl Environ Microbiol 71(10): 6375–6378