The abundance of invertebrates and plankton at and around seamounts make them important feeding grounds for many species of fish, such as this deep sea *Lepidion* spp.

Image courtesy of Dr Brian Bett, SOC (IDSOC)

OASIS participating institutions and key contacts

Universidad de Las Palmas de Gran Canaria, Spain
Javier Aristegui
jaristegui@dbio.ulpgc.es

Southampton Oceanography Centre, UK
Dave Billett
dsmb@soc.soton.ac.uk

Universität Hamburg, Germany
Project coordinator Bernd Christiansen
bchristiansen@uni-hamburg.de

World Wide Fund for Nature, UK/Germany
Stephan Lutter
lutter@wwf.de
Sabine Christiansen
christiansen@wwfneap.org

Friedrich-Alexander Universität Erlangen, Germany
Andre Freiwald
freiwald@pal.uni-erlangen.de

Instituto do Mar/Departamento de Oceanografia e Pescas, Universidade dos Açores, Portugal
Ricardo Santos
ricardo@notes.horta.uac.pt

Universität Rostock, Germany
Barbara Springer
bmspringer@web.de

National University of Ireland, Galway, Ireland
Martin White
martin.white@nuigalway.ie

University of Liverpool, UK
George Wolff
wolff@liverpool.ac.uk

www.rrz.uni-hamburg.de/OASIS

OASIS

OASIS' position statement

Seamounts are underwater offshore mountains rising from the abyssal plains in all oceans. Special current conditions create a unique environment at each seamount and provide the basis for an abundance of fish and invertebrates, making the waters important breeding and feeding grounds for vast numbers of pelagic and demersal fish. Many species at seamounts grow very slowly and some fish reproduce first at the age of 30 years and more and reach a maximum age of over 100 years. Due to their isolated locations in the open ocean, seamounts have been found to host a high level of endemism and local populations of fish. These factors make seamount ecosystems very sensitive to disturbance from human activities.

As seamounts are rich in fish and other natural resources, they provide lucrative fishing grounds and potential mining sites for metals, etc. Plummeting fish stocks in shallower waters now push fishing fleets further out at sea, and offshore seamount fish stocks are already being exploited by several northeast Atlantic fleets. Due to lack of governance of the high seas, management of seamounts in international waters is non-existent, causing the destruction of habitats and decline in fish populations.

The dragging of trawls over seamounts and the removal of large parts of resident fish populations have negative consequences for the biodiversity of seamounts and other underwater environments in various parts of the world. In New Zealand, for example, there is evidence of decline in fish stocks associated with seamount fishing, and in the northeast Atlantic, large areas of cold water coral reefs have been destroyed by trawling. When unregulated, even smaller-scale fishing can disturb these sensitive environments, such as in the Azores, where artisanal fishing at seamounts has caused the decline in important fish stocks.

Today, due to lack of well-funded research, little is known of seamount ecosystems in the northeast Atlantic, as well as of the impact of human activities upon these unique oceanic ecosystems. The OASIS project (OceAnic Seamounts: an Integrated Study), funded by the European Commission, is the first European seamount study integrating physical, biogeochemical and biological research.

Sustainable fisheries are dependent upon well-functioning ecosystems. In order to ensure a sustainable fishery and viable fishing communities, an ecosystem-based management approach is crucial for seamounts and other important oceanic ecosystems, regulating human activities and ensuring a sustainable exploitation of marine resources. One of the scopes of OASIS is therefore to produce comprehensive and science-based management guidelines for seamounts in deep sea areas.

Finally, until we know more about these fragile ecosystems and the long-term impacts of fishing and other human activities, we in the OASIS group believe that it is necessary to apply the precautionary principle to seamounts to ensure their necessary protection and management.

Image courtesy of Dr Brian Bett, SOC (IDSOC)

The OASIS project aims to yield important knowledge that can be used to design effective management plans for seamounts. Here, scientists are processing a sample at sea.

Printed on recycled paper

OASIS

Yielding knowledge on

Seamounts -
hidden oases in the deep ocean

Seamounts are offshore mountains rising steeply more than 1,000 metres above the abyssal plain. Standing isolated or as part of a chain of undersea elevations, their summits do not break the ocean surface. The hard substrates on the tops and flanks are made up of ancient volcanic rock and crusts rich in precious minerals. Tens of thousands of seamounts are estimated to exist world-wide – most still undescribed by science.

The OASIS project (OceAnic Seamounts: an Integrated Study) is the first European scientific seamount study integrating physical, biogeochemical and biological research. Its primary goal is to assess the ecosystem at and around two chosen seamounts. The scientific knowledge gained here will be integrated in ecosystem models and applied to developing concepts for seamount conservation. Further, site-specific management plans for potential seamount marine protected areas will be developed and presented to stakeholders. OASIS involves scientists and institutions from several west European countries.

A research project supported by the European Commission under the Fifth Framework Programme and contributing to the implementation of the Key Action "Sustainable Marine Ecosystems" within the Energy, Environment and Sustainable Development Contract no: EVK3-CT-2002-00073-OASIS

Seamounts host a large number of animals living attached to their rocky slopes. These are hydroids living at shallow depth.

Image courtesy of Dr Brian Bett, SOC (Ellison Bett)

Complex current patterns – the key to abundance

Like oases in the open ocean, seamounts host a wealth of marine life. This stems from their large size and shape, having complex effects on oceanic water circulation and often leading to the upwelling of nutrient-rich water from the surrounding deep ocean, or the trapping of organisms and organic particles in circular currents. This enhances the nutritional basis for a community of fish and invertebrates substantially different from that of the surrounding waters. Very isolated seamounts boast a high proportion of species that are unique to one place, so-called endemic species. Seamounts are also thought to act as stepping stones for the spreading of oceanic and continental shelf species across the ocean basins, otherwise prevented by large distances of deep open ocean.

Sea lilies and stony corals

Little is known about the invertebrate fauna of Atlantic seamounts. But we do know that seamounts often host vast numbers of animals attached to the hard bottom and feeding by trapping organic particles and plankton. Corals can be particularly abundant, with horny, stony and black corals present where currents are strong. Other invertebrates, such as sponges, hydroids, sea squirts, sea lilies, sea cucumbers and shrimp, provide ample food and diverse habitats for fish and other animals. The summit, if protruding into the light-penetrated surface waters, may be covered in seaweeds and crust-forming coralline algae. These riches make the waters at and around seamounts important feeding grounds for migrating turtles and whales and large predatory fish like swordfish and tuna, as well as for many deep-water fish.

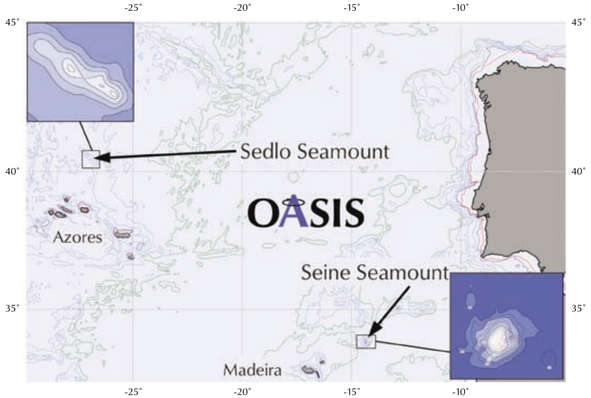
Due to enhanced food concentrations, many invertebrates, such as these deep water shrimps, find food and shelter at seamounts.

Image courtesy of Dr Brian Bett, SOC (Ellison Bett)

Hundred year-old fish

In environments where food is scarce, such as in the deep open ocean, evolution promotes the development of large, slow-growing and late-maturing species. Thus, many deep-water fish reach the age of over 30 years, some even living up to 150 years and reproducing first at about 30. Usually, these species are spread in low numbers across large distances of open ocean. During parts of their life cycle, they come together in huge quantities at seamounts, for example to spawn. Orange roughy (*Hoplostethus atlanticus*) and alfonsinos (*Beryx* spp.) are such fish. These cyclical aggregations make seamounts attractive fishing grounds for pelagic and demersal fisheries. But their life cycles make these fish very vulnerable to large-scale fishing activities, and entire populations can rapidly be fished down even by artisanal fishing.

The study sites



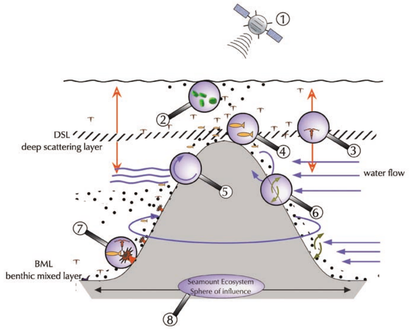
The Seine Seamount northeast of Madeira and the Sedlo Seamount north of the Azores are the OASIS project's study sites.

Seamount	Sedlo	Seine
Location	40°25'N/26°55'W	33°50'N/14°20'W
Summit depth	600 m	170 m
Features	Summit below winter mixed-depth layer, but within range of vertically migrating fauna.	Summit reaches well into winter mixed-depth layer.
Human impact	Surveyed but not exploited, hosting a population of orange roughy.	Undoubtedly exploited by deep-sea commercial fisheries.

Image courtesy of Dr Brian Bett, SOC (DNERC RSU)

The OASIS team makes use of research ships with sophisticated scientific equipment to investigate the secrets of seamounts and their surroundings. This is RRS Charles Darwin.

Schematic picture of seamount
Due to their size and shape, seamounts both affect the surrounding waters and make up an entire ecosystem of their own. OASIS aims to study the seamount ecosystem and has divided the work into five thematic areas. The numbers in the figure refer to some of the tasks to be undertaken, explained briefly in the text below.



OASIS in depth

OASIS' activities have been divided into five work areas, each focusing on one programme objective.

Objective 1: *To identify and describe the physical forcing mechanisms affecting seamount systems*
This objective addresses the hydrographic processes controlling the circulation, mixing and exchange of water in the vicinity of seamounts.
The tasks comprise: detailed mapping by swath bathymetry and review of known hydrography of study sites ⑤; 3-D current field measurements; satellite imagery of sea surface temperature and ocean colour ①; measurements of the benthic mixed layer structure and vertical turbulent diffusion; and process modelling.

Objective 2: *To assess the origin, quality and dynamics of particulate organic material within the water column and surface sediment at seamounts*
The organisms below the light-penetrated zone depend, with a few exceptions, on organic material produced at the ocean surface. Several processes affect the nutritional value of the organic matter for organisms living at or close to the seafloor. During its descent to the seafloor the material is altered in many ways, for example by ingestion and egestion by pelagic animals, microbial degradation or aggregate formation. And within the benthic mixed layer, sedimentation and resuspension strongly influence the availability of organic matter as food source for deep-living animals.
The tasks include: measurement of primary production ②, export production and water column remineralisation rates; determination of organic matter composition, provenance and quality; and the influence of kilometre-scale seafloor topography on particulate material fluxes in benthic mixed and nepheloid layers ⑥.

Objective 3: *To describe aspects of the biodiversity and the ecology of seamount biota, and assess their dynamics and the maintenance of their production*
Seamounts often host stocks of commercially valuable species. Several hypotheses exist regarding how these stocks are maintained. This objective will address the major fauna groups (zooplankton, micronecton, benthos and fish) at seamounts and their interactions, with special emphasis on the bottom mixed layer fauna.
The tasks comprise: determination of the interaction of the deep scattering layer with seamount topography ③; dynamics of the benthic mixed layer community and of standing stocks and distribution of benthos on and around seamounts ⑦; investigation of seamount fish and fisheries ④ and trophic pathways in seamount communities.

Objective 4: *Modelling the trophic ecology of seamount ecosystems*
Here, the growing body of information is synthesized in a continuously updated conceptual ecosystem model, which will provide a common platform for presenting the project's primary scientific results. In addition, all OASIS data will feed into a mass-balanced model. The resulting concepts will then be used in the development of an "offshore marine protected areas tool box" as well as site-specific management plans for the investigated seamounts ⑧.

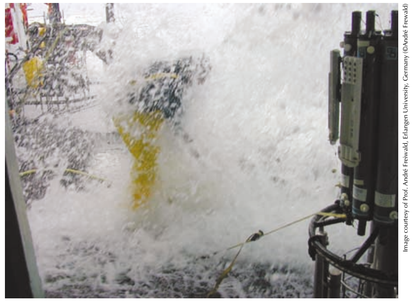


Image courtesy of Prof. Andrei Ferrari, GeL Erlangen University, Germany (Dr.Dirk Fenzel)

Objective 5: *Application of scientific knowledge to practical conservation*
Appropriate scientific advice is critical to the development of marine conservation policy, and the design of scientifically sound and practicable management plans are essential to the implementation of protected areas. In order to succeed in conserving the marine environment, policy-makers and advisers, as well as other stakeholders, need easy-to-use products. By drawing upon the scientific results of the project, OASIS will act as an interface to practitioners and will use the project's results to provide such products.
The tasks also comprise: public information and education; dissemination of scientific results; and organisation of workshops for stakeholders and decision-makers.

A series of cruises are carried out during the OASIS project's three years.

The new frontier for exploitation

The lack of governance of the high seas leads to the unregulated exploitation at oceanic features. As seamounts are rich in fish and other natural resources, they are turning into the new frontier for fisheries and extractive industries.

Seamount fisheries – turning oases into deserts

Due to dwindling fish stocks on the continental shelves, an increasing number of highly sophisticated fishing vessels target fish even at the most remote seamounts – with devastating consequences. Pelagic and demersal fisheries locally reduce the abundance of target fish and bycatch to commercial extinction – then moving on to the next fishing ground. When predators are fished down, otherwise predation-regulated animal groups are given more space and the entire ecosystem may thus change. Bottom trawling also physically destroys the benthic fauna and the habitats they form. In the northeast Atlantic, intensive trawling is estimated to have destroyed half of the known cold water coral reefs along the European continental margin – only bare rock and coral rubble remains.

Due to their sensitive nature, seamount communities recover from disturbances only over long time – if at all – by the sporadic recolonisation from nearby seamounts and areas along the continental shelves. Where distances are too large, excessive removal of seamount species and destruction of their habitats may lead to their local extinction.

Metals draw mining interest

Investigations are under way to explore the potential for mining the hard crusts covering seamount rock. Two centimeters of crust may have taken ten million years to accumulate. Locally, these crusts are very rich in cobalt, but also in other valuable metals. Such seamounts are potentially lucrative areas for the mining industry. But mining would destroy the crust upon which bottom-dwelling fauna is attached, and release silt and toxic metals bound in the crust, affecting the entire ecosystem both at exploited seamounts and downstream.

Precaution until we know more

There are still extensive gaps in our knowledge of seamount ecosystems, and of how human activities and climate change affect them. But as exploitation of seamount resources is growing rapidly, we must urgently increase our knowledge and develop legal and practical tools for conserving as much of these vulnerable and fragile ecosystems as possible. All coastal states share the responsibility to cooperate and ensure the conservation of biological diversity in international waters, and to apply the precautionary principle to marine resource use. This means that until we know more about these deep sea treasures, we must set aims for their conservation and management that minimise the risk of damage to non-target fauna and habitats – under all circumstances.

ISVWG (Lamandine, SYSKESN)

Most records of cold water corals are from offshore banks at depths between 100 and 1500 m. Due to their three-dimensional structure they provide a multitude of niches for many other animals.