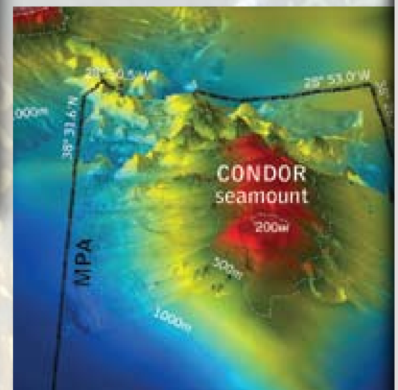
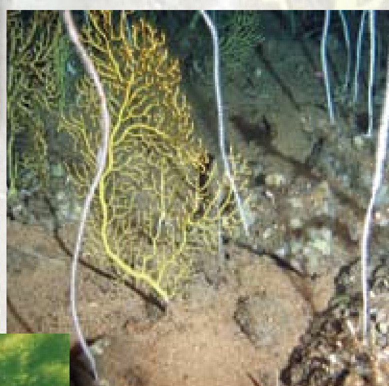
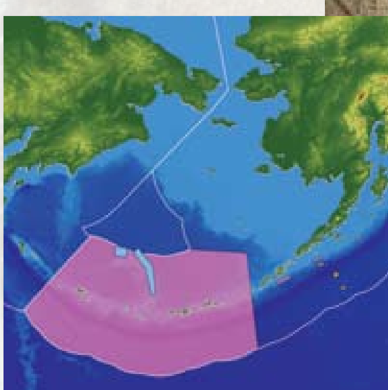


Can We Protect Seamounts for Research?

A CALL FOR CONSERVATION

BY TELMO MORATO, TONY J. PITCHER, MALCOLM R. CLARK, GUI MENEZES, FERNANDO TEMPERA, FILIPE PORTEIRO, EVA GIACOMELLO, AND RICARDO S. SANTOS





ABSTRACT. Extractive processes such as fishing and mining are degrading seamount ecosystems considerably, raising serious concerns about the impacts of these practices on global ocean biodiversity and key fluxes. Despite the data collected to date, we remain ignorant of the quantitative details of many of these issues. To address this limitation, we call for the closure of selected seamounts for research purposes. These research seamounts will act as baselines for recovery, and should be earmarked for monitoring and fundamental research. We describe an innovative bio-observatory at Condor Seamount in the Azores as one possible model.

INTRODUCTION: SEAMOUNTS IN TROUBLE

It is now well recognized that many seamounts around the world are in deep trouble, mainly due to the overexploitation of their fish resources, damage to sessile habitat-building organisms caused by destructive fishing gear (see Box 6 on page 123 of this issue [Pitcher et al., 2010]), and developing mining activities that may operate on a significant number of seamounts and affect as much as 20% of each seamount's surface area (Hein et al., 2009). Growing awareness of the threats posed to seamounts and their ecological roles in maintaining biodiversity, marine food webs, and larval settlement has resulted in calls for the protection and management of seamount habitats and their associated biodiversity at global, regional, and national levels (e.g., Probert et al., 2007; Santos et al., 2009).

For example, seamounts have become priority habitats under the Convention on Biological Diversity[1] (CBD, 2009), and the United Nations General Assembly (UNGA) and its advisory bodies have discussed seamount conservation. This treaty and these discussions led to the adoption of UNGA resolution A.61/L.38, which calls upon fisheries management organizations to locate vulnerable marine ecosystems, including seamounts, hydrothermal vents, sponge aggregations, and cold-water coral grounds, and declare bottom fishing closures until conservation and management measures that prevent significant adverse impacts have been established. This UN resolution was a major breakthrough for a precautionary approach to management in areas beyond national jurisdiction. However, the distribution and species composition of many of these biotopes remain unknown, and thus substantial additional research is urgently required to identify vulnerable ecosystems and ensure their proper management.

Two northeastern Atlantic high-seas initiatives are worth noting, both led by intergovernmental organizations: the North East Atlantic Fisheries Commission (NEAFC) and the Oslo-Paris Convention for the Protection of the Marine Environment of the Northeast Atlantic (OSPAR)[2]. NEAFC deals strictly with fisheries on the high seas, while OSPAR deals with the marine environment, with no mandate for fisheries. In 2002, NEAFC created an area to protect juvenile fish in Rockall Banks waters, and in 2004 banned bottom fishing in a large area on the Reykjanes Ridge (the northern part of the Mid-Atlantic Ridge) and on four seamounts adjacent to the ridge. In 2007, NEAFC prohibited bottom fishing in five areas in the Rockall-Hatton Bank area to protect deep-water corals, and in 2009 adopted measures that closed 330,000 km^2 to bottom fisheries in five areas of the Mid-Atlantic Ridge (NEAFC, 2009). In 2004, OSPAR included seamounts, together with other deep-sea habitats such as *Lophelia* reefs, deep-sea sponge aggregations, and mid-ocean ridges with hydrothermal vents, on a list of priority habitats in need of protection (OSPAR, 2004) and selected sites for a network of Marine Protected Areas (MPAs) both within Exclusive Economic Zones (EEZs) and in the high seas. In 2008 and 2009, six high-seas MPAs were proposed under OSPAR (information available through the OSPAR Secretariat: http://www.ospar.org); they are more or less coincident with those of NEAFC. However, in that same year, several European countries submitted claims for extended continental shelves beyond 200 nautical miles. Iceland, Ireland, and Portugal claimed a large part of the areas under the NEAFC agreement and those being considered by OSPAR for the high-seas components of the network of MPAs. The new framework is creating, for the first time, a dual jurisdiction in huge areas of the northeastern Atlantic Ocean, with the water column under international jurisdiction, and the seafloor and subseafloor, with their concomitant biotic and mineral resources, under national jurisdictions. Elsewhere, there have been a number

[1] The Convention on Biological Diversity (CBD) is an international treaty established by the United Nations during the Earth Summit in Rio de Janeiro, Brazil, in 1992, aiming to preserve biological diversity around the world.

[2] OSPAR is the Oslo-Paris Convention, the mechanism by which 15 governments of the western coasts of Europe, together with the European Community, cooperate to protect the marine environment of the Northeast Atlantic Ocean.

of initiatives to promote conservation of seamount ecosystems (see Box 6 on page 123 of this issue [Pitcher et al., 2010]; Probert et al., 2007), including closure of some seamount areas from any extractive activities, establishment of precautionary fishing limits, or banning of bottom trawls.

Although these initiatives have resulted in a number of seamounts now being conserved in some form, the percentage of the world's seamounts being scientifically monitored and effectively managed is still exceptionally low (Probert et al., 2007). Moreover, it is clear that there are profound gaps in scientific knowledge of seamount ecosystem functioning that are, at the same time, limiting the quality of the advice and serving as an excuse for the lack of management actions (Pitcher et al., 2007).

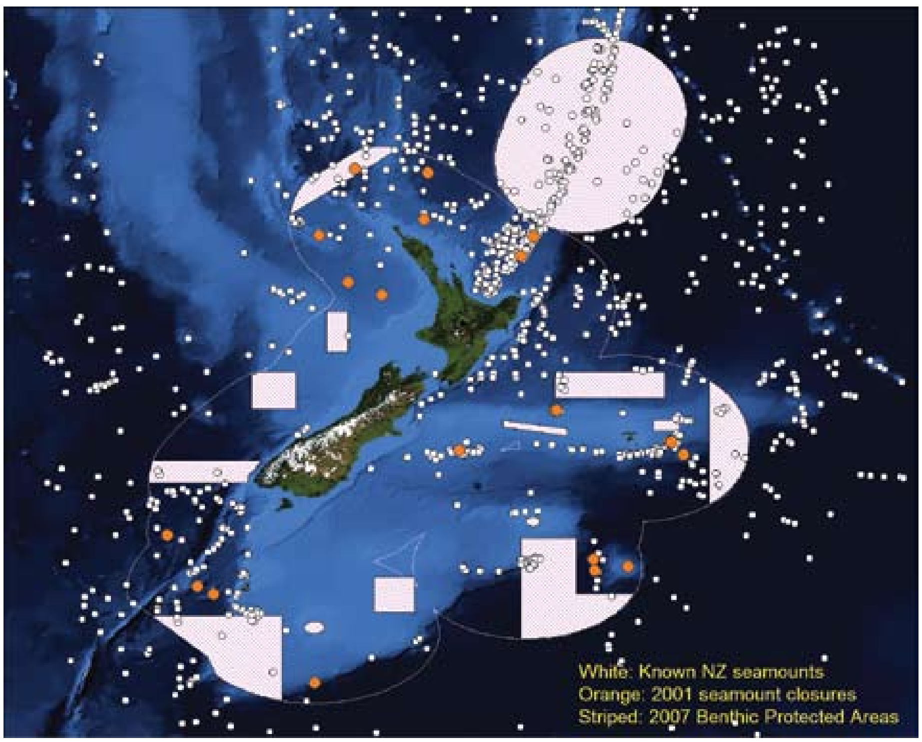


Figure 1. Distribution of seamount features in the New Zealand region (white dots), showing those protected from bottom trawling in 2001 (orange dots) and in 2007 as part of Benthic Protected Area closures (striped regions). The thin line marks the New Zealand Exclusive Economic Zone. Shallow water is the lighter blue.

SEAMOUNT CONSERVATION INITIATIVES

New Zealand

New Zealand is an example where focused seamount research has led to more effective seamount management and the implementation of spatial conservation measures. There are at least 600 seamounts, knolls, and pinnacles known within New Zealand's EEZ: research programs have surveyed over 50 of these features since 1999, describing biodiversity, ecological "values," and risks from human activities. In 2001, a draft "Seamount Management Strategy" closed 19 seamounts to all bottom trawling and dredging (Brodie and Clark, 2003). This area was expanded in 2007 with 17 new "Benthic Protected Areas" (BPAs) covering 1,200,000 km^2, about 30% of the EEZ (Figure 1). Included in the initial closures was a small cluster of seamounts off the east coast of New Zealand. This area, colloquially known as the "Graveyard," has small seamounts that

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are similar in physical characteristics, in close proximity, yet with fishing histories ranging from unfished to heavily fished (see Spotlight 7 on page 146 of this issue [Clark et al., 2010a]). Initial research trawling, and a subsequent photographic survey in 2001, revealed extensive cold-water corals on unfished seamounts that were highly vulnerable to bottom trawling (Clark and O'Driscoll, 2003; Clark and Rowden, 2009). Two of these unfished seamounts were protected, as well as one that had previously been heavily trawled. The latter closure was done purposely to learn what develops on a seamount once trawling stops. "Graveyard" sampling and photographic surveys in 2001, 2006, and 2009 enable comparisons of changes over time and confirm strong contrasts between fished and unfished areas. Concurrently, some taxa appear to be relatively resilient to trawling, or able to recolonize bare areas in a relatively short time (Clark et al., 2010b).

The Azores

In the Azores, there is a long history of conservation of seamount ecosystems since the 1980s (Figure 2) when the bank encompassing the Formigas islets and Dollabarat reef was designated the first European offshore marine reserve (Santos et al., 1995). More recently, there have been some multidisciplinary research programs aimed at the conservation of local seamount ecosystems (Morato et al., 2008a), including the Oceanic Seamounts: An Integrated Study

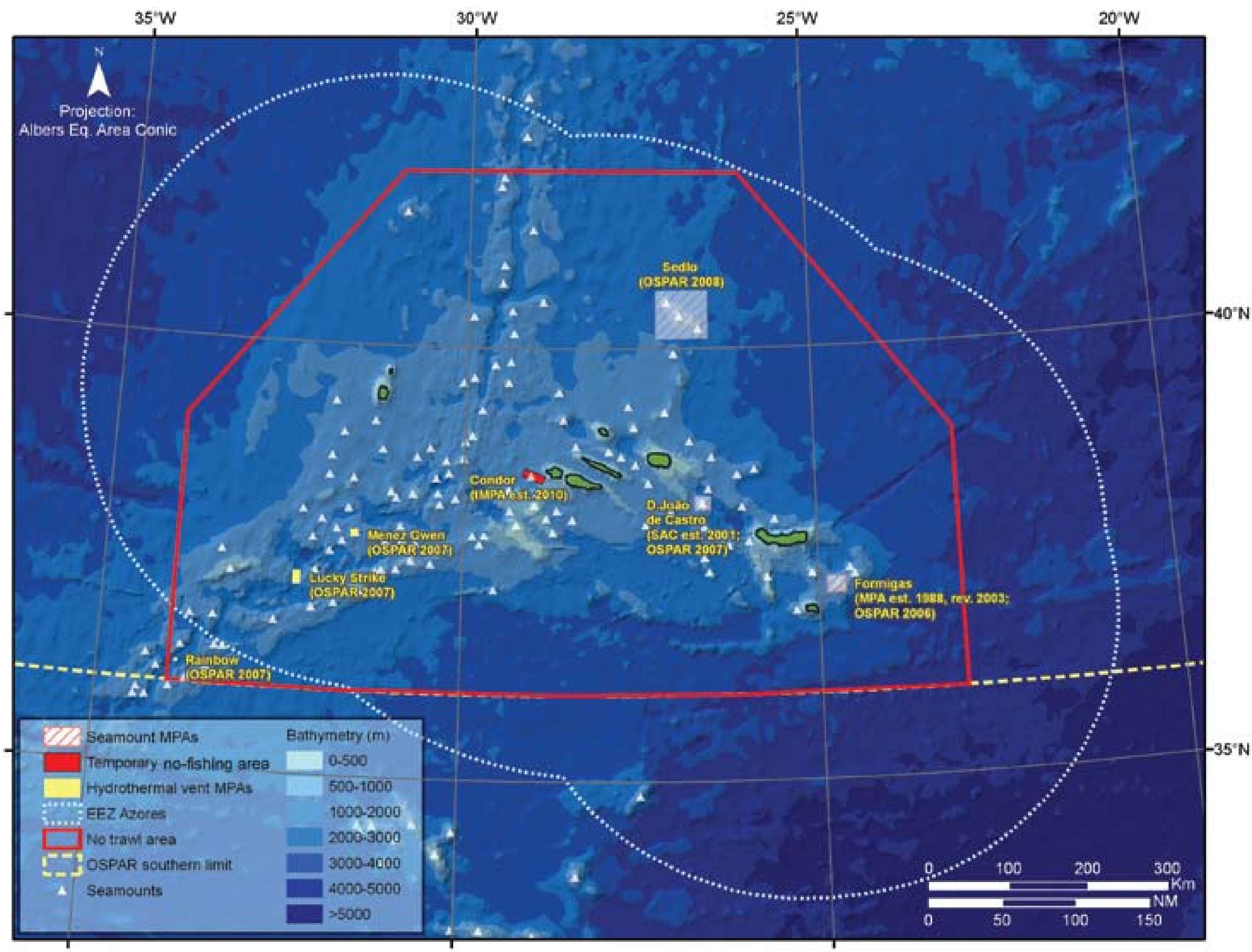

Figure 2. Locations of seamount Marine Protected Areas (MPAs) and deep-sea habitats of conservation importance in the Azores region. *Graphics: R. Medeiros ©ImagDOP*

(OASIS) project (Christiansen and Wolff, 2009, and http://www1.uni-hamburg.de/OASIS/) that led to the proposal of Sedlo Seamount as an offshore marine protected area (Santos et al., 2009). Research efforts have led to the discovery of new species and biotopes, such as a new deep-sea oyster considered to be a "living fossil" (e.g., Wisshak et al., 2009a, 2009b) and deep-sea coral gardens and sponge aggregations at Condor Seamount (Braga-Henriques et al., 2006; Tempera et al., 2009), and have helped to raise awareness of the need to protect seafloor habitats. Some of the scientific evidence about the ecological importance of seamounts in the Azores (e.g., Morato et al., 2008b) has been successfully passed on to the small-scale fishing community and has been used in the fishery management decision-making process (Santos et al., 2009). An example is the Azores regulation that prohibited deep-sea trawling, which recently became an EC regulation (see Probert et al., 2007). This policy option was taken with the knowledge that there would be no access to some fish stocks such as orange roughy, which is abundant around some seamounts (Menezes et al., 2009), and whose presence in the Azores has been well known since the nineteenth century, given that the species' holotype was collected in the Azores (Santos et al., 1997). Because the Azores is characterized by small, close-knit communities, communication is much faster and more effective as compared to larger places such as mainland Portugal. Cooperative relationships have developed since the early 1980s among the local fishing communities, the Azores administration, and the University of the Azores, facilitating discussion of different management scenarios for local ecosystems, and leading in 2009 to the agreement to designate Condor Seamount as a temporary no-fishing area with the aim to conduct integrated scientific studies on the biodiversity and functioning of seamounts.

> "THESE RESEARCH SEAMOUNTS WILL ACT AS BASELINES FOR RECOVERY, AND SHOULD BE EARMARKED FOR MONITORING AND FUNDAMENTAL RESEARCH."

Gulf of Alaska Seamounts

Seamounts in the central North Pacific have long been known as good fishing grounds for several bottom fish species (Sasaki, 1986). Since the 1960s, Japanese and former Soviet Union distant-water fleets have targeted these seamounts. Reports of these highly valued catches prompted the first US investigation of nine major seamounts, and their associated fishery resources, in the Gulf of Alaska in 1979 (Hughes, 1981). The US North Pacific Fishery Management Council has since developed an extensive suite of MPAs to conserve fish habitat and minimize impacts of fishing on vulnerable species such as crabs. Presently, about 62% of the Gulf of Alaska (i.e., over 950,000 km^2) has been closed to bottom trawling and other fishing gear. Explorations of the Gulf of Alaska seamounts in 1999, 2002, and 2004 revealed very rich demersal assemblages of fish and invertebrates and new species of corals and sponges (Hoff and Stevens, 2005; Stone and Shotwell, 2007), which raised awareness of the need to protect seafloor habitat. As a consequence, the Council has established several MPAs where all bottom-tending fishing gear is prohibited, including 16 Gulf of Alaska seamounts covering an area of about 18,000 km^2 (Figure 3).

New England Seamounts

The New England Seamounts are a 1200-km-long chain of about 30 volcanic peaks in the North Atlantic within the US EEZ, extending from Georges Bank to the eastern end of the Bermuda Rise (Figure 4; see Spotlight 4 on page 104 of this issue [Shank, 2010]). This seamount chain has not been extensively fished, and recent explorations revealed very rich and diverse benthic communities, many new distributional records, and a new species of gorgonian coral (Moore et al., 2003; Stiles et al., 2007). In 2007, two New England Seamounts (Bear and Retriever) were recognized as Habitat Areas of Particular Concern (HAPC) by the New England and Mid-Atlantic fishery management councils (United States). Despite the lack of commercial fishing activities, the councils are developing management measures that could protect the two seamounts from deep-sea bottom trawling in the future (Stiles et al., 2007).

SEAMOUNT RESEARCH AND UNDERSTANDING

A simple scoring technique can provide an Ecosystem Evaluation Framework (EEF) for a seamount (Pitcher et al., 2007). The EEF can highlight what attributes are known and unknown, what threats might exist and, where known, what levels of function the seamount has in the local ecosystem (see Box 6 on page 123 of this issue [Pitcher et al., 2010]). The overall impression from many such EEF examples is how little is actually known about the vast majority of seamounts. Hence, seamount scientists face a major challenge because seamount ecosystems remain seriously data-limited. Many seamount scientists (see Census of Marine Life on Seamounts, http://censeam.niwa.co.nz/science and the Seamount Biogeosciences Network, http://earthref.org/events/SBN/2009/) feel strongly that, in order to improve our global understanding of these ecosystems, research should aim to clarify the main factors that drive seamount community structure, diversity, and endemism at the scale of seamount chains, whole seamounts, and individual habitats within seamounts. Linked to this greater insight would be an understanding of the key processes that cause differences among seamounts, and between seamount and non-seamount regions. At the same time, we should develop capacities for understanding the resilience of seamount communities, the consistency of biodiversity patterns from microbial to megafaunal levels, and the structure of the food web and the energy fluxes through the different trophic levels (see Cochonat et al., 2007). This knowledge should lead to a better

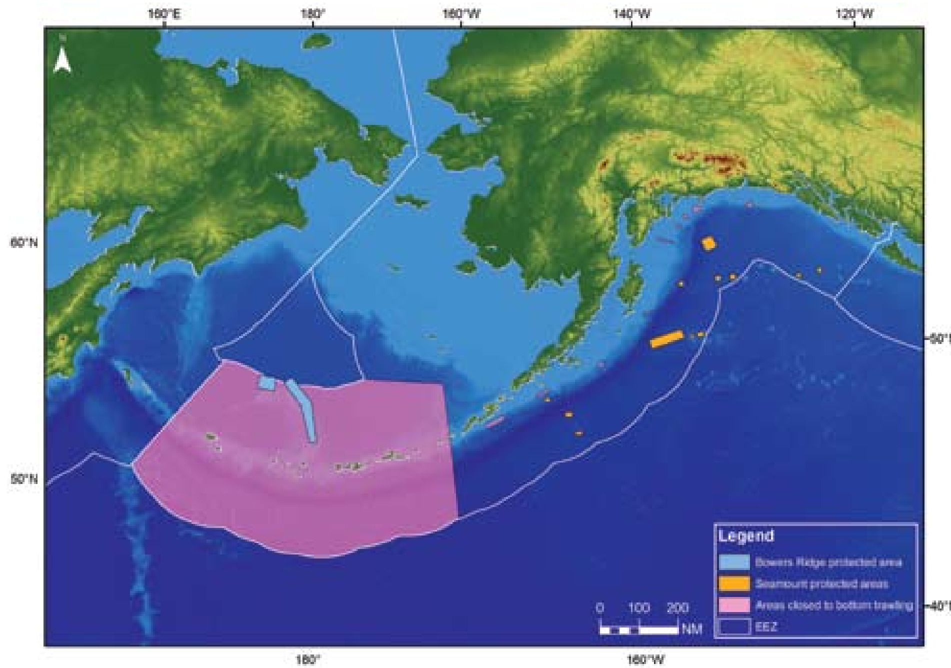

Figure 3. Location of the Gulf of Alaska seamount protected areas encompassing 16 features and covering an area of about 18,000 km^2. *Adapted from http://savecorals.com/gulf/maps.html, courtesy of Oceana. Graphics: R. Medeiros ©ImagDOP*

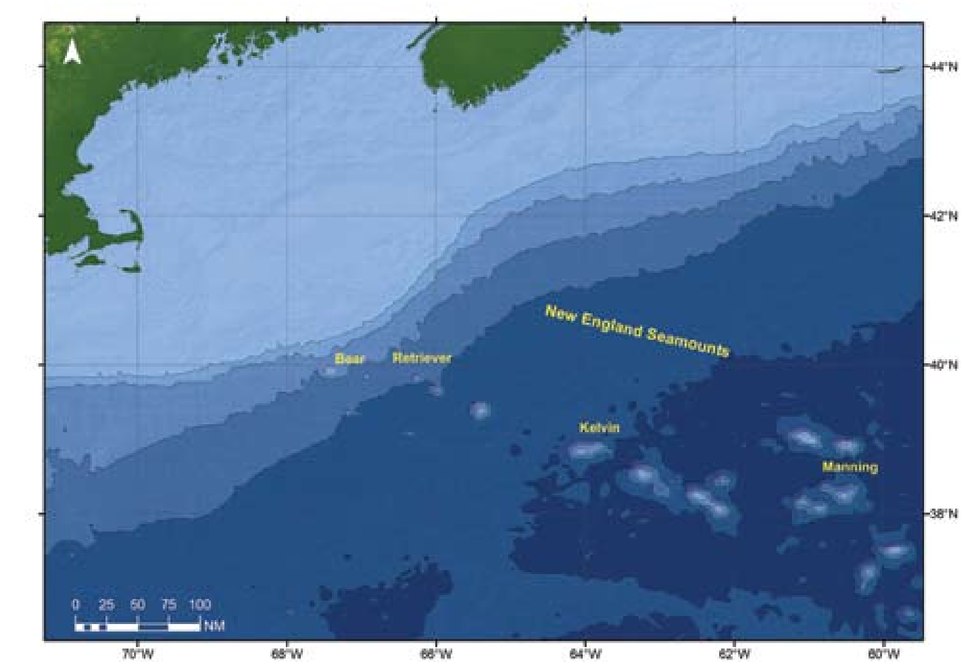

Figure 4. Location of the New England Seamount chain in the North Atlantic, extending from Georges Bank to the eastern end of the Bermuda Rise. *Graphics: R. Medeiros ©ImagDOP*

understanding of the impacts of fisheries activities on seamount community structure and function, and more effective advice on management measures that must be implemented globally, regionally, and locally. Research is thus crucial for reporting on the effects of management measures already implemented for some seamounts (Santos et al., 2009).

THE CONDOR SCIENTIFIC OBSERVATORY, AZORES, PORTUGAL

Well-managed seascapes represent the basis for achieving sustainable development of harvested marine resources and preventing biodiversity loss. Hence, there is a need to establish a common set of requirements for effective environmental monitoring of seamount areas. In particular, long-term multidisciplinary research concurrent with the development of ecological ecosystem models are essential to understand the structure and function of seamount communities and to allow continuous adaptive management advice. In particular, in situ observations need to be made so that temporal variability on scales of hours to years can be detected and measured. Seamount observatories could yield information on many different ecosystem aspects, such as ocean current dynamics and biophysical coupling, spatial and temporal variability of seamount organisms, seasonal and interannual variability of food supply, and recovery from fishing impacts.

Condor Seamount, located southwest of Faial Island in the Azores archipelago (Figure 5) has been used for decades as a fishing ground by local artisanal bottom fisheries, but has recently been proposed as a temporary no-fishing area to permit the installation of the first scientific underwater seamount observatory of its kind. The observatory will allow unique interdisciplinary monitoring and experimental studies. This elongated, flat-topped seamount is about 14 nautical miles long and supports rich assemblages of deep-sea corals, abundant sponges, sea urchins, crabs, and commercial fishes[3] (Figure 6). The CONDOR project (http://www.condor-project.org/) was launched in 2008 with the goal of implementing the Condor scientific observatory. Diverse equipment is being deployed to obtain long-term oceanographic and biological data along with continuous remote-sensing data (Figure 7). Different sampling strategies and technologies will be used to improve knowledge on connectivity, trophodynamics, and biodiversity, providing an integrated field-based study of Condor Seamount ecosystem structure and functioning.

The Condor observatory will undoubtedly increase knowledge of the oceanographic and biological patterns and processes associated with the seamount. Moreover, the closure of the seamount to bottom fisheries activities will allow assessment of fisheries impacts and further analysis of the recovery of fished populations. Research conducted at the Condor observatory will enhance the quality of advice for managing seamount areas and promote general public awareness of marine conservation and sustainable development.

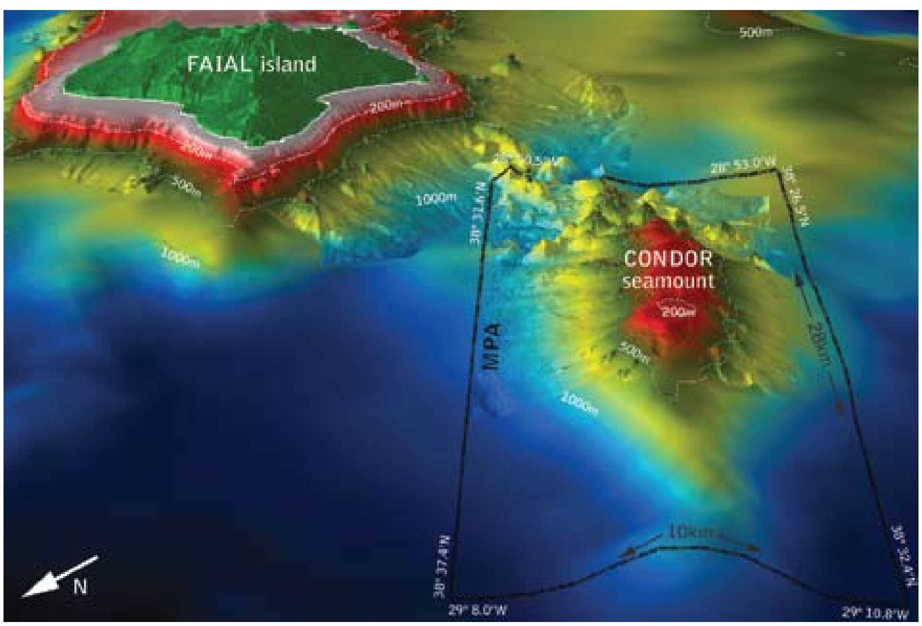

Figure 5. Perspective (2x vertical exaggeration) of Condor Seamount to the southwest of the Azorean island of Faial, Portugal, showing the limits of the temporary no fishing area that will allow installation of the Condor Seamount scientific observatory. Pink and red shades indicate shallow water. *Graphics: F. Tempera ©ImagDOP. Bathymetry data credits: EMEPC, DOP-UAz, Project STRIPAREA/J. Luís/UAlg-CIMA, Lourenço et al., 1998*

[3] A short video about Condor Seamount is available at http://www.horta.uac.pt/temp9/IMAR-Azores_coral_gardens_at_Condor_Seamount.divx.

FUTURE DIRECTIONS: A CALL FOR RESEARCH CLOSURES

Of the four examples of seamount closures described above, only one is specifically earmarked for research. Closed areas aimed at conservation measures only have an unfortunate history of reversal when governments change (Rosenberg et al., 2006; Rosenberg, 2009); a research argument may be more robust because of the unarguable need for long-term data, although this argument can apply only to relatively small areas. The innovative Condor Seamount observatory in the

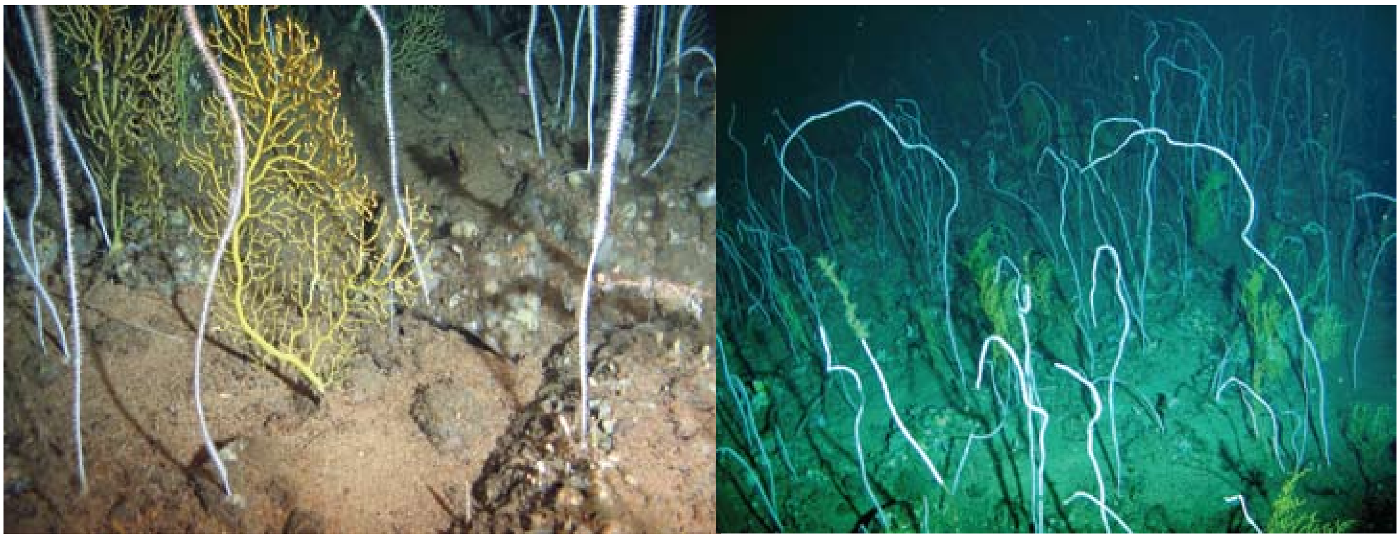

Figure 6. Deep-sea gorgonian assemblages dominated by *Viminella flagellum* (whip coral) and *Dentomuricea* sp. (yellow gorgonian) are a common feature at the top of Condor Seamount. *Photo credits: Gavin Newman ©Greenpeace*

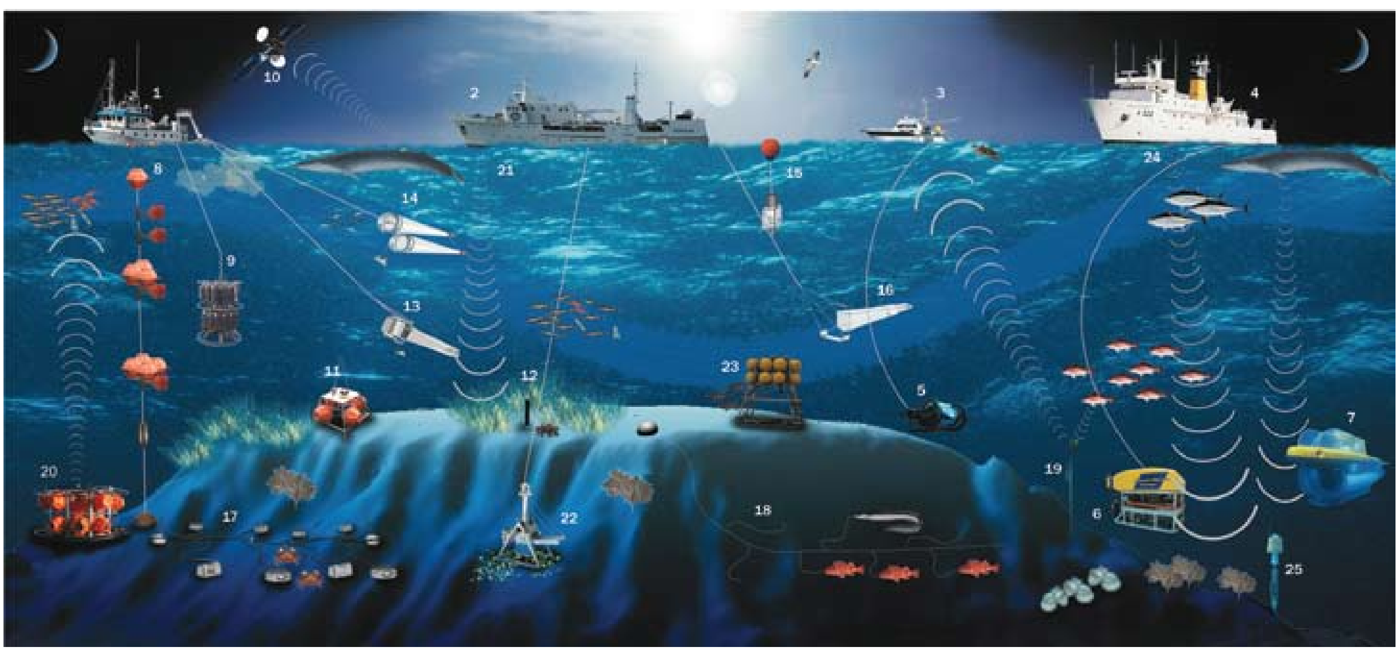

Figure 7. Scheme of the Condor Seamount scientific observatory in the Azores. Equipment and main platforms in use and planned to be used include: several research vessels (1–4), two remotely operated vehicles (5, 6), a manned submersible (7), oceanographic instruments (8–12), biological sampling gear (13–16), fishing gear (17, 18), telemetry instruments (10, 19), acoustic instruments for biomass estimations (20, 21), sediment sampling (22), other imagery instruments (23), seafloor mapping (24), and animal sounds recording (25). Components of the figure are illustrative and not to scale. *Graphics: F. Porteiro and E. Giacomello © ImagDOP*

Azores can serve as a model for other seamount "research closures" aimed at increasing knowledge and research opportunities, and because of the way in which it is protected from further fishing and exploitation. Ideally, such closed seamounts will be in locations that already have a reasonable amount of quantitative information so that changes resulting from closure can be detected; this requirement rules out a large number of seamounts that have been only cursorily examined. Unfortunately, some long-lived benthic communities' recovery time after disturbance might be quite long and thus difficult to quantify with short-term temporary closures (Waller et al., 2007). Seamounts close to land or the continental shelf are often better documented because of their ease of access, but proximity to regular fishing ports may mean that such seamounts are harder to close than remote offshore sites. The perceived impacts on fishers' livelihoods can trigger effective political lobbying against the closure. Nevertheless, closing seamounts for research may be easier to support politically than the formal creation of MPAs, which have been shown to be vulnerable to all kinds of political lobbying from special interest groups (Ballentine and Langlois, 2008). These cognitive aspects of marine spatial management need more careful study and analysis (Lam, in press). At Condor Seamount, informal agreements with the fishing community about its closure have been more effective, because it would be impossible to enforce compliance without enormous expense. Moreover, active support from the respected science community will likely encourage public support and compliance from fishers. Hence, here we urge marine scientists to join our call for seamount closures for research.

"...WE URGE MARINE SCIENTISTS TO JOIN OUR CALL FOR SEAMOUNT CLOSURES FOR RESEARCH."

ACKNOWLEDGMENTS

Seamount research in the Azores forms part of a set of larger projects on conservation of seamounts and other ocean pelagic and deep-sea habitats such as CORALFISH (FP7 ENV/2007/1/213144), CORAZON (FCT/PTDC/MAR/72169/2006), CONDOR (EEA Grants - PT0040/2008), MADE (FP7 KBBE/2007/1/210496), HERMIONE (FP7 ENV/2008/1/226354), TRACE (FCT PTDC/MAR/74071/2006), MICROCON (FCT PTDC/MAR/105486/2008), and SEAMOV (FCT PTDC/MAR/108232/2008). The Portuguese Task Group for the Extension of the Continental Shelf (EMEPC) is acknowledged for conducting multibeam surveys of opportunity on Condor Seamount and sharing the data. Joaquim Luís (University of Algarve-CIMA) is acknowledged for sharing complementary bathymetric data for western Faial collected under Project STRIPAREA (POCI/CTE-GIN/59653/2004).

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