

**Information describing seamount habitat relevant to the South
Pacific Regional Fisheries Management Organisation**

**DRAFT
21 April 2007**

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1. Overview

Seamounts are elevated seafloor features. The geological definition of a seamount is any feature greater than 1000 m in elevation from the seabed and of limited extent across the summit. Other underwater features with less than the 1000 m elevation are also usually referred to as seamounts by biologists due to the similarity in biological communities between such features and geologically defined seamounts. The biological definition of seamounts, which is any elevated seafloor feature above 250 m, will be used throughout this document.

Seamounts are associated with elevated levels of productivity and typically support unique biological communities with high levels of endemism.. Seamounts are an important habitat for commercial deepwater fish stocks such as cardinalfish, orange roughy, oreos, alfonsino and bluenose, which aggregate around these features for either spawning or feeding.

Seamounts are becoming increasingly vulnerable to fishing as technology has allowed the expansion of fishing fleets to venture beyond areas of national jurisdiction and onto the high seas. The predominant fishing method over seamounts is the bottom trawl. The effects of trawl gear have been well documented and, depending on the degree of contact with the bottom, these include effects such as scraping and ploughing of the seabed, sediment re-suspension, the destruction of non-target benthic animals, especially calcified structural forms like corals and sponges.

Very little is known about the interactions between the biological communities that inhabit seamounts and the level of dependence of the specific community components on one another. Bottom trawling is likely to have negative effects on the long-term sustainability of seamount habitats, and hence on associated components, including commercial fish populations, although the likely duration of these effects have not yet been properly quantified.

There are currently minimal management practices in place to protect the biodiversity on seamounts on the high seas in the South Pacific Ocean. Recently the United Nations General Assembly agreed to implement an ecosystem approach to fisheries management, and requires interim measures to avoid the adverse impacts of bottom trawling to be in place by December 2007 (UNGA Sustainable Fisheries Resolution 61/105).

2. Physical Description

Seamounts are elevated seafloor features that peak below sea level. Most seamounts are circular or elliptical (Epp & Smoot 1989), although very elongated seamounts do occur (Wessel & Lyons 1997) (Figure 1). Seamounts are often volcanic in origin, formed by volcanic activity over hotspots in the earths crust. Spreading of the seafloor away from these hotspots via plate tectonic movements means that seamounts often form in long chains or elongated clusters.

There are many definitions of seamounts. The geological definition of seamounts is any feature greater than 1000 m in elevation off the seabed and of limited extent across the summit (Epp & Smoot 1989). Other defined submarine features include knolls - an isolated elevation rising less than 1000 m from the seafloor and of limited extent across the summit; and, pinnacles - a smaller pillar-like elevation off the

seafloor. Biologists frequently refer to all of these features collectively as seamounts due to the similarities of biological communities on these features. This document, unless otherwise stated, will use the biological definition of a seamount, which is any elevated seafloor feature above 250 m.

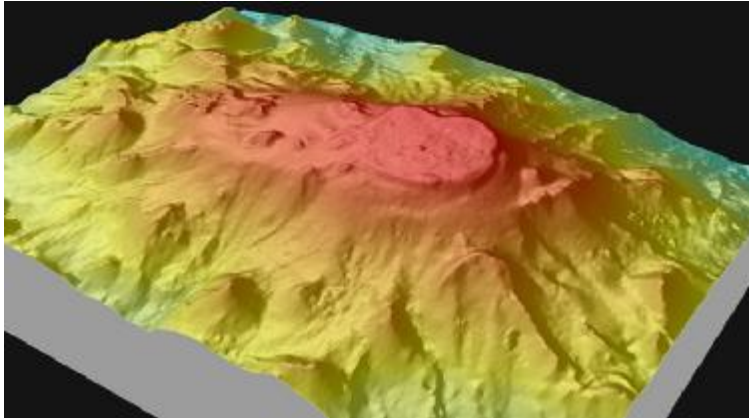


Figure 1: A multi-beam image of seamounts on the Lord Howe Rise.

2.1 Distribution

Seamounts are present in all ocean basins (Figures 2 & 3). It is difficult to estimate a precise number of seamounts, as this depends on the definition used and the resolution of the bathymetry map used.

Kitchingman & Lai (2004) estimated there to be at least 14 287 seamounts globally with elevation greater than 1 000 m, with 8 952 occurring in the Pacific Ocean. Kitchingman and Lai (2004) generated an estimate of the number of seamounts in the world's oceans by using two algorithms relying on the depth differences between adjacent cells of a digital global elevation map (ETOPO2). Allain *et al.* (2007) cross-checked Kitchingman and Lai's data set with other datasets to remove any atolls and islands there were incorrectly classified as seamounts and found that 713 (12%) were misclassified and that only 25% (1 537 seamounts) could be verified. Out of the 1 537 seamounts, a further 694 were multiple identifications of the same feature. The list of seamounts is therefore not yet definitive and more work needs to be done.

Previously, Wessel (1997) estimated a similar number of seamounts within the Pacific Ocean, 8 882 which were extrapolated by vertical gravity gradients using remote sensing data. An earlier study by Smith & Jordon (1988) estimated considerably more seamounts, with 30 000 seamounts greater than 1 000 m high in the Pacific Ocean, and between 600 000 and 1.5 million seamounts of all heights in the Pacific Ocean. Smith & Jordon (1988) derived seamount numbers by comparing wide-beam echogram counts, sea beam swath counts and counts from bathymetric maps.

The total area covered by seamounts in the South Pacific Ocean is unknown. However, it is thought that the majority of large seamounts occur in the Pacific Ocean (63%), with 52% of those on the high seas beyond areas of national jurisdiction (Kitchingman & Lai 2004).

Current trawlable depths range from 250 – 1500 m, which encompasses about 18% of seamounts estimated by Kitchingman & Lai (2004).

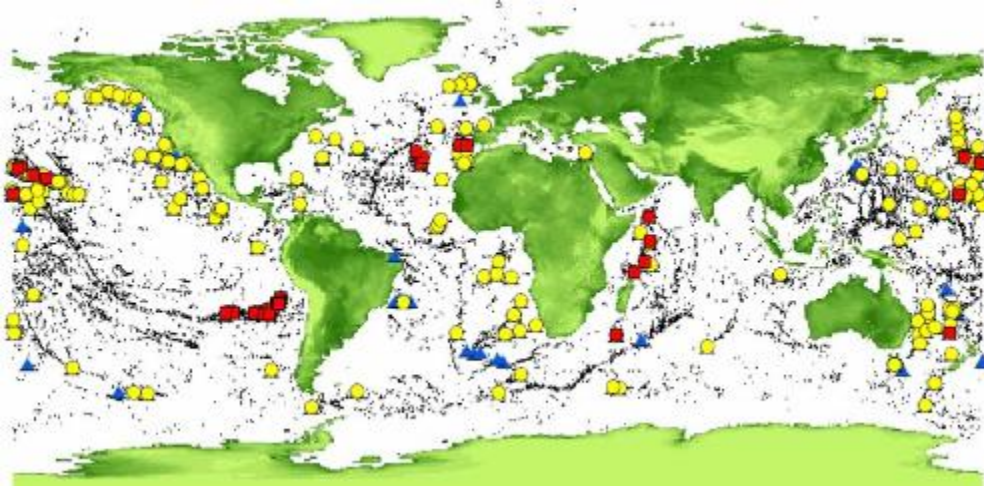


Figure 2: Global distribution of seamounts (seamount defined as > 1000 m and round or elliptical in shape). Source: Kitchingman & Lai (2004).

- = Predicted seamount locations (14 300) from Kitchingman & Lai 2004)
- ▲ = Sampled seamounts (but no available biological data)
- = Seamounts with some level of biological data
- = Seamounts that have received taxonomically broad sampling; sampling effort and relative abundances are known.

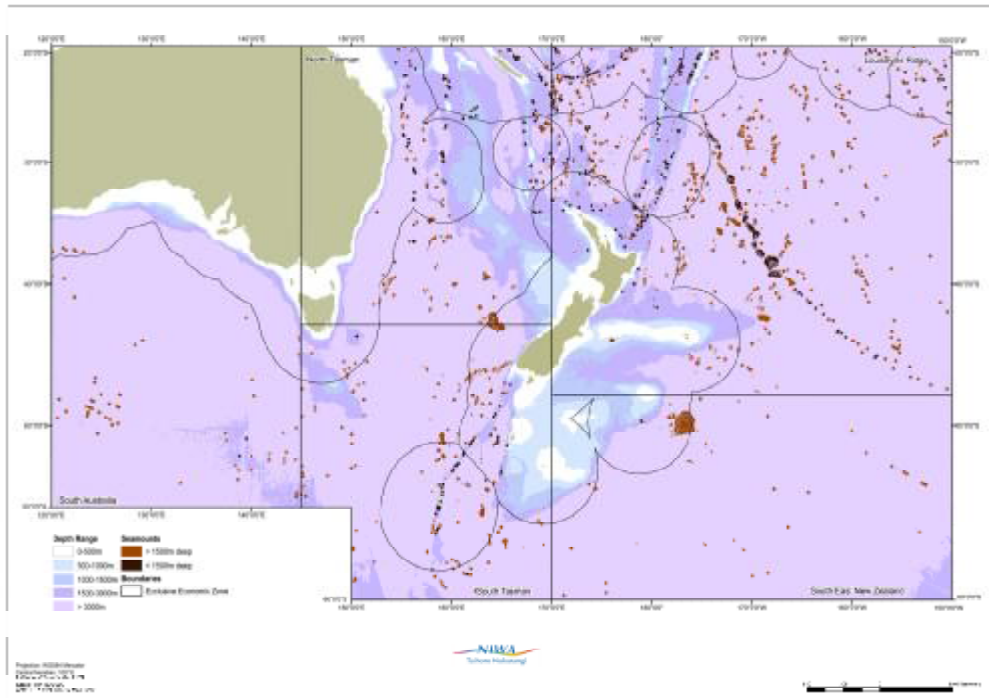


Figure 3: Seamount distributions within the southwest Pacific Ocean (seamount defined as any feature >1000 m. Seamounts positions derived from satellite altimetry data, e.g. as per Rowden et al. 2005).

NOTE: A figure similar to Figure 3 above is under preparation for the entire proposed South Pacific RFMO area.

2.2 Productivity

Seamounts affect ocean circulation; water movement in the deep sea is accelerated upon reaching the elevated surface of the seamount. This results in the up-welling of relatively cool, nutrient rich into nutrient poor surface water (Clark et al. 1999). This results in higher productivity over seamount localities (Clark et al. 1999). As a result, enrichment of bottom-associated communities and high abundances of demersal fishes has been regularly reported over seamounts.

3. Biological Description

Seamounts support unique biological communities, sometimes with high levels of endemism (Koslow et al. 2001). Although they appear to be geographically isolated, the large numbers of seamounts, often distributed as chains of seabed features may serve as stepping stones for dispersal across large open ocean basins, providing navigational features and pools of high productivity and food availability. In particular, the life-cycles of ocean basin species that are long-lived, with slow growth rates and typically low productivity are often associated with seamounts (Koslow 1996, Froese & Sampang 2004, Morato et al. 2004).

3.1 Associated Species

Due to the typically accelerated currents, the benthic communities on seamounts are generally dominated suspension feeders such as deep and cold water corals (Rogers 1994). Deeper seamounts, in particular, are dominated by cnidarian suspension feeders, including stony corals, gorgonian corals, black corals, sea anemones, sea pens and hydroids (reviewed in Rogers 2004; see also Koslow et al. 2001, Rowden *et al.* 2002). Other common suspension feeders typically found on seamounts include barnacles, bryozoans, polychaete worms, molluscs, sponges, basket stars, brittle stars and crinoids. There is also an associated mobile benthic fauna that includes echinoderms (sea urchins and sea cucumbers) and crustaceans (crabs and lobsters) (reviewed by Rogers 1994).

Soft sediments also accumulate on seamounts, with polychaete worms being the dominant inhabitant of these sediments. Marine protozoans are abundant on seamount sediments in the Pacific, Atlantic, and Indian Oceans (Clark *et al.* 1999).

Corals may form cold, deep water reefs on seamounts, adding high levels of biological structural complexity, and resultant high habitat diversity, to seamounts. These reefs provide food, habitat and shelter for a variety of other species, and are likely to be structurally important within the ecosystem (Krieger & Wing 2002). Strong associations between cold water corals and other species have been well documented. A recent review of direct dependencies of coral associated organisms has shown 114 species to be mutually dependant on cold-water corals¹ (Buhl-Mortensen & Mortensen 2004).

¹ In biology, mutualism is an interaction between two or more species where both species derive benefit.

Seamounts provide an important habitat for commercial deepwater fish stocks such as cardinalfish, orange roughy, oreos, alfonsino, ribaldo, southern boarfish, Patagonian toothfish and bluenose (Koslow 1996) which aggregate around these features for either spawning or feeding. Koslow (1996) investigated activity levels and life history patterns of deep sea fish and concluded that seamount associated fish are more highly specialised than other deep sea fish, being characterised by robust morphology, and strong locomotory ability. Their flesh has high protein and lipid content but low water content, they have substantially higher metabolic rates, late maturity, extended reproductive periods and extremely long life spans (in the order of 100+ years) (Koslow 1996). Current lists of fish species associated with seamounts are incomplete, but already list 535 fish species (Froese & Sampang 2004). Of those listed, 365 are demersal or benthopelagic and 170 are pelagic species. All are piscivorous (Froese & Sampang 2004) (see www.seamounts.sdsc.edu for fish species found associated with seamounts in the South Pacific Ocean).

Limited sampling of seamount-associated fauna has been conducted in the South Pacific Ocean. Biodiversity data for the world's sampled seamounts is available at (<http://seamounts.sdsc.edu>). As of May 2005 there are 1 289 records from 231 seamounts in all ocean basins. It is estimated that only 3-4% of seamounts have been sampled for invertebrates, and even this sampling has been conducted in an *ad hoc*, non-systematic and non-quantitative manner (Stocks 2004) (Figure 2). When using this database, it is therefore important to acknowledge that the data indicate 'presence only' at the time and place of sampling, and the absence of data does not necessarily mean that that species, or indeed a range of other un-detected species, does not occur on a seamount.

In 2003 a New Zealand research voyage (NORFANZ) sampled the benthic fauna and associated fish species on the Lord Howe Rise and the Norfolk Ridge. Results are still preliminary, but the survey has served to illustrate the costs and benefits of a project of this nature. In total, 590 fish species and 1 305 macro-invertebrate species were provisionally identified on board during the survey. A substantial increase in the number of macro-invertebrate species is envisaged as the collection of samples is further researched and will take researchers around the world several years to examine all of the material, especially the invertebrates, and to describe the unknown species. It is estimated that over 20% of the invertebrate species are likely to be either new records for the region, or new to science (Roberts & Clark 2006). For more detailed information about the species found at these locations see Clark *et al.* (1999). For more detailed information about the species sampled in the southeast Pacific Ocean see Parin *et al.* (1997).

Several studies have sampled and described the fauna associated with seamounts inside the New Zealand EEZ (see Rowden *et al.* 2002; Rowden *et al.* 2003; Rowden *et al.* 2004; Tracey *et al.* 2004). The degree of overlap in community structure inside and outside the New Zealand EEZ is unclear.

There is some evidence for an association of valuable highly-migratory pelagic species such as bigeye tuna, bluefin tuna, yellowfin tuna and swordfish with seamounts (Adam *et al.* 2003, Musyl *et al.* 2003, Campbell & Hobday 2003, Holland *et al.* 1999). It is thought that these pelagic fish primarily use seamounts for feeding grounds, but may also make use of such areas for spawning and nursery grounds, and possible as navigational markers.

There is evidence that seamounts also represent potentially important focal points for seabirds foraging in mid-ocean (Haney *et al.* 1995). Compared to adjacent waters seabird density and biomass within a 30 km radius centred on the Fieberling Guyot

seamount summit (in the eastern North Pacific), were 2.4 and 8 times higher respectively (Haney *et al.* 1995). The seabird aggregation observed was attributed to changes in the abundance and/or behaviour of pelagic organisms in the deep scattering layer over seamounts (Haney *et al.* 1995).

Links between benthic and pelagic systems on seamounts are assumed to exist, but there is little research on the subject. A study by Bulman *et al.* (2002) showed there was little link between the pelagic and benthic components through food web modelling on seamounts of East Tasmania. However, potential links between pelagic and benthic components of seamount ecosystems go further than food web modelling and include trophic, ontogenetic and mechanistic links related to chemical processes such as nutrient cycling. The scientific committee of the western and central Pacific Fisheries Commission are currently investigating the relationship between seamounts and pelagic fisheries (see Allain *et al.* 2006).

To date, seamount studies have been generally aimed at assessing the overall diversity of seamount communities and levels of endemism, and little is known about how species are distributed over seamounts at a regional and global scale.

3.2 Endemic Species

Research to date indicates that biodiversity on seamounts can be extremely high. The fauna of seamounts are typically highly unique and may have a limited distribution restricted to a single geographic region, a seamount chain or even a single seamount location (Rogers 2004, Koslow *et al.* 2001, Richer de Forges *et al.* 2000, Parin *et al.* 1997). Levels of endemism (species not found anywhere else) on seamounts are relatively high, compared to the deep sea. Between 31 and 36% of species from the Norfolk Ridge and Lord Howe Rise are endemic (Richer de Forges *et al.* 2002), ~35% on Tasmanian seamounts (Koslow *et al.* 2001), and 44% for fishes and 52% for bottom-living invertebrates on the Nasca and Sala-y-Gomez seamount chains (Parin *et al.* 1997) have been documented as endemic species.

Why seamount communities are characterised by high levels of endemism is uncertain, but is likely to have resulted from the physical isolation of seamounts, with limited larval dispersal and resultant genetic isolation leading to a high rate of speciation amongst seamount populations. In areas of the same habitat type within the deep sea, at similar latitudes and depth, ~1 000 km apart, little overlap in community composition has been observed (Richer de Forges *et al.* 2000).

Even within seamount groupings or ridge systems in parts of the southwest Pacific Ocean, low species overlap has been observed. Seamounts in clusters or along ridge systems therefore appear to function as 'island groups' or 'chains' leading to highly localised species distributions and speciation between groups or ridge systems (Richer de Forges *et al.* 2000). The fauna of the Nasca and Sala-y-Gomez seamount chains close to Chile in the Southeast Pacific are far more closely related to the Indo-Pacific fauna than to the Chilean coast species (Parin *et al.* 1997).

A major problem with seamount studies is that the large number of samples collected is often not studied due to time/ funding and specific taxonomic skill restraints. These issues combined with the discovery of a large number of species new to science can make it difficult to compare the biodiversity of different seamounts or of continental slope and seamounts.

4. Fishing Practices

4.1 Fishing Technology

The main bottom trawl fisheries occurring around seamounts are trawl fisheries for deepwater species (e.g. alfoncino, orange roughy). The deepwater fishing fleet comprises large factory trawlers (mainly >50 m) which process the catch on board, and smaller vessels (25 and 40 m) that land the fish whole. Because of the rough bottom types and steep terrain, trawl gear typically deployed on seamounts is robust with large steel or solid rubber bobbins on the ground-rope. This allows the gear to roll over the surface and to be less prone to jamming on protruding rocks, but also makes such trawls highly destructive to marine life.

Advances in electronic fishing equipment have been important in developing seamount fishing. Previously, gear loss in the fishery was substantial, and fish aggregations, once found, were difficult to relocate. Multi-beam sonar sounders have been used to locate and map seamount and other seabed features. Net monitors mounted on the headline give information on the performance of the trawl, when it is on the bottom, the depth, the opening of the net, the amount of fish being caught, and the roughness of the bottom. The most significant development has been the improved navigation systems, particularly as GPS satellite navigation, and more recently the declassification of the precision of GPS satellite position information. These improvements in technology have led to reductions in gear loss and more efficient fishing, and potentially more damage to marine life in areas now targeted by these fishing operations.

4.2 Fishing History

Compared to fisheries over the continental shelf, catch rates on seamounts typically decline rapidly once a fishery develops (Watson & Morato 2004), partially as an inevitable consequence of the slow growth and low productivity of commercially fished target species on seamounts. Since the early 80's, seamounts in the southwest Pacific have sustained high fishing pressure and have yielded large catches over a number of years. The number of seamounts exploited by deepwater fisheries on the high seas in the southwest Pacific has also increased dramatically over time.

In the South Pacific region, most fishing on seamounts is driven by the orange roughy fishery (see Clark & O'Driscoll 2003). Commercial fisheries for orange roughy occur on ridge systems and seamount chains in the Tasman Sea and southwest Pacific Ocean. Fisheries on the high seas in the South Pacific Ocean started on the "Westpac Bank" (which is close to the main fishing grounds on the SW Challenger Plateau) in the early-mid 1980s. Further exploration in the region resulted in discoveries of commercial fisheries on the Lord Howe Rise in 1987-88, Northwest Challenger Plateau in 1998-89, Louisville Ridge in 1993-94, South Tasman Rise in 1997-98, and West Norfolk Ridge in 2001-02. (These orange roughy fisheries are discussed in more detail in the orange roughy species profile.)

Seamount fisheries often start off intensely and then, as catches decrease on one seamount area, fishers move onto another seamount, resulting in a 'serial depletion' of stocks along the series of fished seamounts, and eventually an overall decline in catches from the area. The orange roughy fishery by New Zealand vessels on the Louisville ridge peaked in 1994-95 at over 11 000 t, and had declined to 1 419 t in the 2003-04 season.

The main seamounts that are fished by bottom trawl in the proposed SPRFMO region are described below:

Louisville Ridge

The Louisville Ridge is a chain of more than 60 seamounts extending for over 4 000 km southeast from the Kermadec Ridge. Fishing began in 1993-94 in the central part of the Ridge, and spread both northwest and southeast in subsequent years. The Louisville Ridge complex is mostly fished by New Zealand vessels, although vessels from Japan, China, Russia and Ukraine occasionally fish this area. Australian vessels have not fished on the Louisville Ridge since 2000. The number of tows on this area from New Zealand vessels in 2003-04 was 1 336 and this has steadily decreased to 581 tows in the 2005-06 year.

South Tasman Rise

Exploratory fishing for orange roughy on the South Tasman Rise by New Zealand and Australian vessels started in the late 1980's, and by 1997 a major fishery had developed. New Zealand vessels stopped fishing there in 2002. Australia is still currently active in these fishing grounds. However, catches are low and the number of tows has decreased from 67 in 2003-04 to 18 in 2005-06 (Clark unpublished).

Lord Howe Rise

Both Australian and New Zealand vessels fish the Lord Howe Rise. Effort has been relatively consistent by Australian vessels since 2003-04, with the number of tows staying at 21. Effort by NZ vessels has decreased from 207 tows in 2003-04 to 71 in 2005-06 (Clark unpublished)

NW Challenger

Fishing on the NW Challenger Rise is predominantly conducted by New Zealand flagged vessels. Effort increased to 1 007 tows in 2004-05, but dropped back down to 399 tows in 2005-06. Australian flagged vessels fishing effort went from 72 tows in 2003-04 to 1 tow in 2005-06 (Clark unpublished). Tow behaviour has changed, with longer tow duration covering larger areas of the flat bottom increasing, and hill fishing decreasing.

West Norfolk

Fishing on the West Norfolk Ridge is predominantly by New Zealand flagged vessels. Fishing effort continues to increase from 90 tows in 2003-04, to 33 tows in 2005-06 (Clark unpublished).

Some fishing for deep snappers using benthic dropline methods has occurred on the high seas in the South Pacific region, however, the extent of this fishing is unknown. Benthic-pelagic species such as those caught by dropline might be a link between the benthic and pelagic components of the ecosystem.

The deep sea lobster *Projasus parkeri* is also found on the Lord Howe Rise and has been commercially exploited, but detailed catch and effort data are unavailable. *Jasus caveorum* has been fished on the Foundation seamounts in the Southeast Pacific using pots.

Projasus bahamondei is a dominant megabenthic predator on the Nasca and Sala Y Gomez seamounts in the southeastern Pacific (Parin *et al.* 1997) but it is unknown whether these have been harvested or not.

4.3 Unregulated/ unreported fishing

There is no information available.

5. Impacts of Fishing

5.1 Habitat Damage

Fishing on seamounts is generally restricted to the relatively small areas that are accessible to current bottom trawl fishing gear. Therefore, when targeting aggregations of fish on a seamount, a large number of trawls occur repeatedly in the same areas. This causes repeated localised impact on the benthos and may prevent the recovery of these organisms (Clark *et al.* 1999). However, as noted above, fishing behaviour has changed over the last decade, especially on the NW Challenger Plateau. Tow duration has increased and there is preference to use long tows on flat bottom, rather than short tows on hill features. As a result, the area of habitat affected by trawl gear has increased substantially in such areas (Clark unpublished).

The impacts of heavy trawl gear have also been well documented for soft sediment habitats. Reported effects of trawling include scraping and ploughing of the seabed, sediment re-suspension and its smothering impact, and the destruction of non-target benthic animals, especially structurally complex organisms like deepwater corals and sponges (see Jones 1992, Dayton *et al.* 1995).

In the first year of the orange roughy fishery on the South Tasman Rise, large quantities of coral bycatch were taken. Observers estimated a bycatch of approximately 1.6 tonnes of coral for each hour of towing a trawl net during the 1997-98 fishing season (Anderson & Clark 2003). A total of 1 762 tonnes of coral was estimated by observers to have been brought up in the trawl nets in the 165 tows observed. Extrapolation estimated that over 10 000 tonnes of coral was taken in the first year of the fishery, not including coral that was damaged and not brought to the surface (Anderson & Clark 2003). Coral bycatch fell rapidly to ~100 t in the third year of fishing as attached organisms were progressively removed by repeated trawling (Anderson & Clark 2003).

Trawl operations appear to have significantly impacted heavily trawled seamounts where reef aggregate has been removed or turned to rubble. In a study by Koslow *et al.* (2001), the benthic biomass by-catch from unfished seamounts was 2-times higher than that from heavily fished seamounts. The number of species per sample was also 46% greater on the unfished seamounts (Koslow *et al.* 2001). Direct observation from photographic surveys out on fished and unfished seamounts in the south Pacific region show a very strong contrast in the distribution of coral species, with close to 100% coral cover on unfished seamounts, compared with only 2-3% coral cover on fished seamount areas (Clark & O'Driscoll 2003).

O'Driscoll & Clark (2005) constructed fishing effects indices for fished seamounts in New Zealand waters. The Challenger Plateau, Lord Howe Rise and the Louisville Ridge included within the proposed SPRFMO area fall within the top 50 list of highest fishing effects indices. However this index is derived from effort data, and not from actual measurements of biological seabed impacts. The actual biological impacts will depend on substrate type and community composition, in addition to fishing intensity. Further research is required to relate the intensity of fishing to actual quantitative estimates of impacts on benthic faunal communities.

5.2 Ecosystem Considerations

Deep water ecosystems are relatively stable through time, and typically support long-lived, low-productivity faunal assemblages, compared to many other ecosystems (Koslow & Gowlett-Holmes 1998). They are therefore potentially more sensitive to disruption than more productive or dynamic ecosystems due to the slow growth rates and high longevity. Information on rate of recovery of seamount communities is poorly known, as is life history information for the organisms that create these communities.

Deep water organisms associated with seamount ecosystems are long-lived, have slow growth rates and low levels of recruitment. Pink corals (*Corallium* spp.) are believed to live ~75 years, bamboo corals from South Tasmania are believed to live longer than 100 years (Koslow & Gowlett-Holmes 1998) and some black corals are believed to live even longer (Griggs 1993). Damage to these species may take decades or centuries to recover, if ever.

Stony corals are considered to be ‘ecosystem engineers’ that create, modify and maintain habitat for other organisms. Stony corals provide structural diversity and critical habitat for many other associated seamount species and are key indicator species for seamounts benthic communities. The destruction of corals therefore has cascade effects, resulting in markedly lower species diversity and biomass of bottom living fauna (Koslow *et al.* 2001, Clark *et al.* 1999, Clark & O’Driscoll 2003, Lack *et al.* 2003).

There is substantial overlap in the known distributions of stony corals and deepwater trawl fisheries on seamount features. Clark *et al.* (2006) have mapped the predicted areas of maximum vulnerability of communities living on seamounts to potential impacts by deepwater fishing activities in the alfonsino fisheries in 250m – 750m depth (Figure 4), and in the orange roughy fisheries in 750m – 1250m depth (Figure 5). Given the high levels of endemism of seamount fauna, it is likely that trawling activities have already reduced the distribution and abundance of associated benthic species, and caused a decline in biodiversity, on heavily fished seamounts.

6. Evaluation of anthropogenic risks to seamount ecosystems

No formal risk assessment of the impacts of fishing on and around seamounts has been carried out. However, the risk to seamount habitat from fishing appears high. Research investigating the effects of trawling in shallow water and on reef systems has shown that these shallower communities are adversely impacted by fishing. Given the low productivity and long generation times of deepwater organisms, it is likely that seamounts are being impacted to a greater degree by fishing activities.

Possible threats to seamounts from commercial fishing include: overexploitation of fish stocks, damage and non-recovery of habitat forming coldwater corals, decreased biodiversity and potential adverse cascade effects to pelagic species and seabirds.

Seamounts are also at risk from possible future mining for ferromanganese crust and poly-metallic sulphides (Griggs *et al.* 1987; Carter 1989; Sarma *et al.* 1998) which would have a direct physical impact in addition to indirect impacts on seabed associated communities in the area of exploitation.

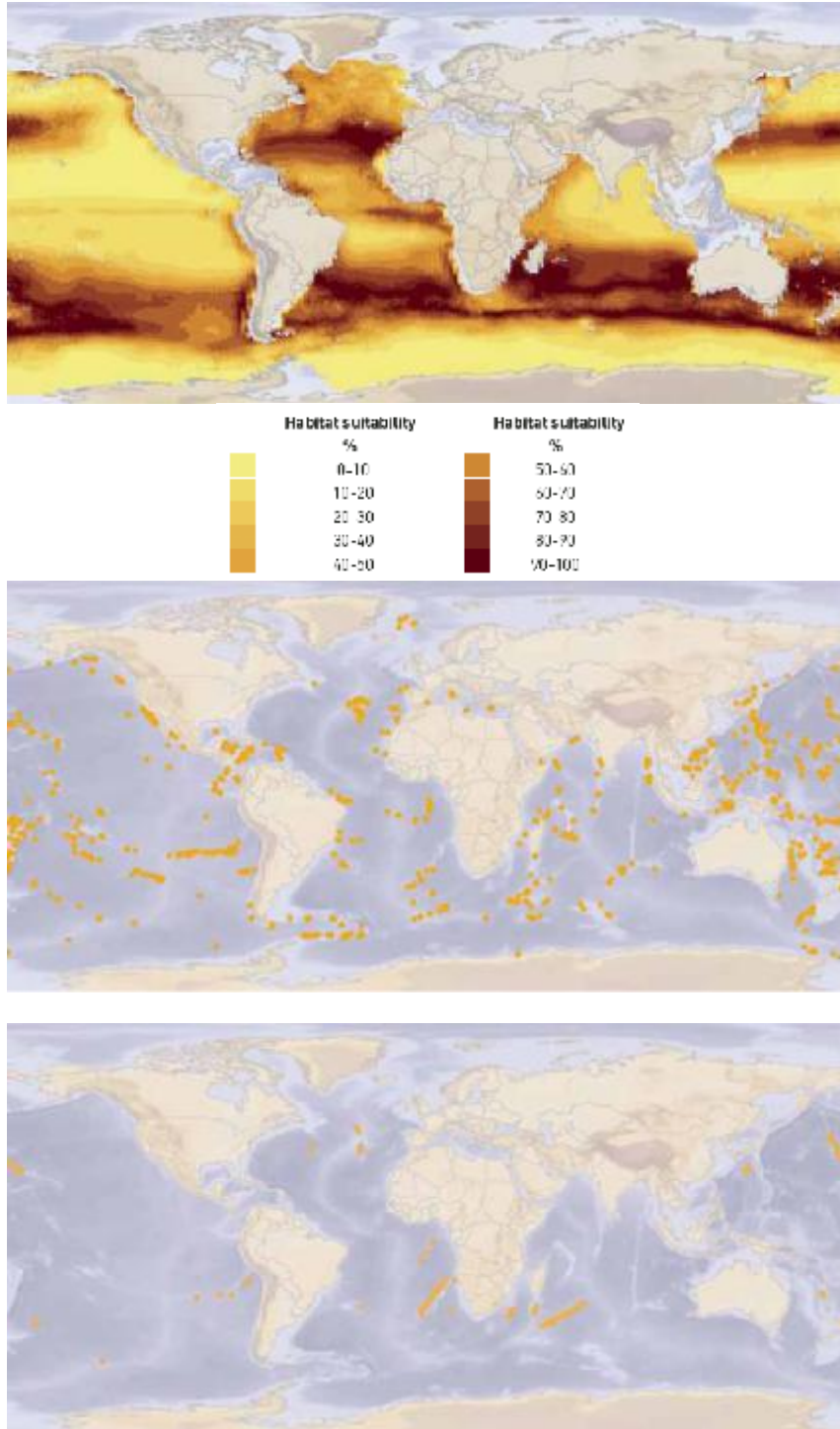


Figure 4: Main areas under risk from alfonsino seamount fisheries (250-750 m depth range). Top: Predicted habitat suitability for stony corals in 250-750 m depth. High percentage values indicate more suitable habitat. Middle: Distribution of high risk seamount summits in the 250-750 m depth range. Bottom: Seamounts with known historical alfonsino group catches (Taken from Clark *et al.* 2006).

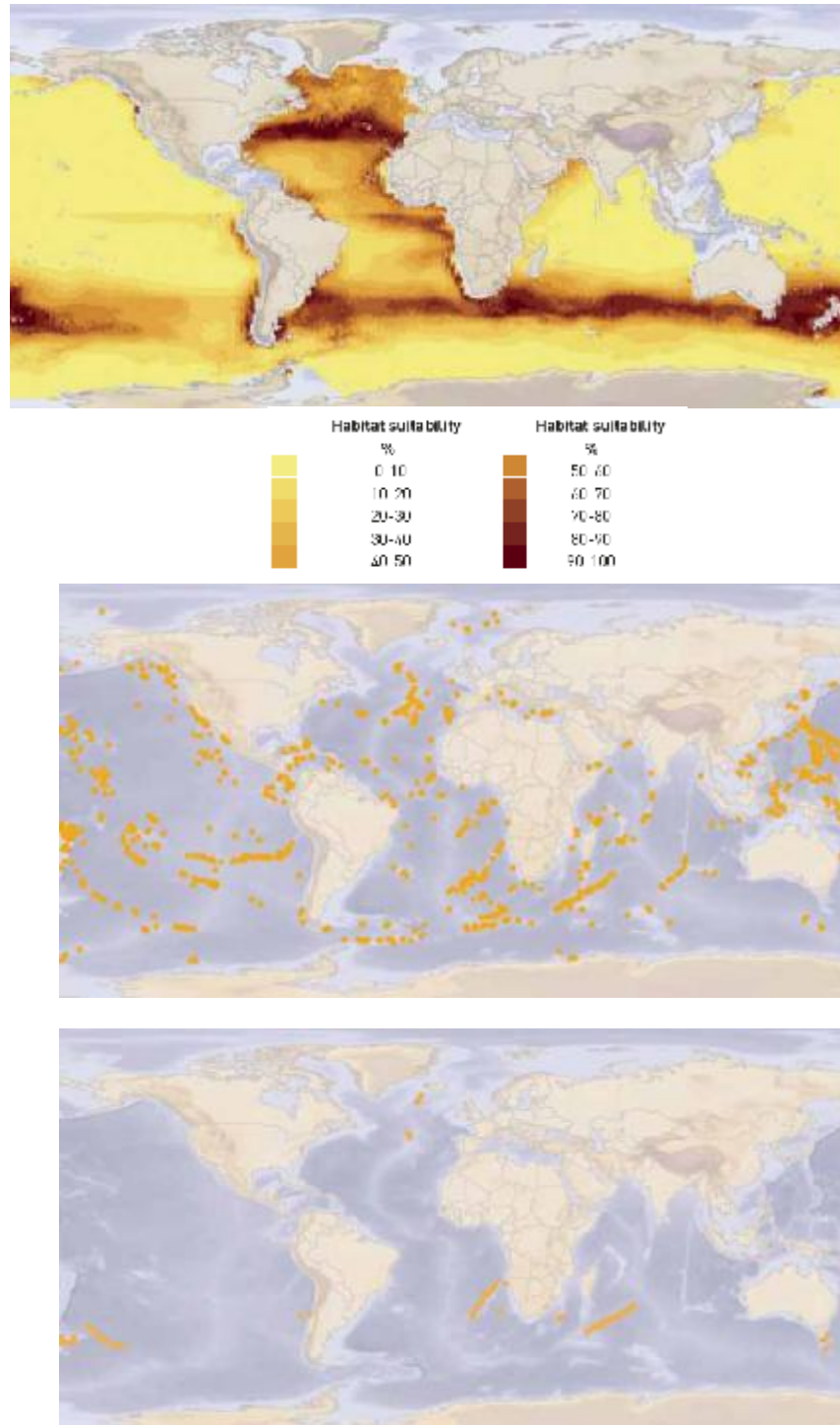


Figure 5: Main areas under risk from orange roughy seamount fisheries (750-1250 m depth range). Top: Predicted habitat suitability for stony corals in 750-1250 m depth. High percentage values indicate more suitable habitat. Middle: Distribution of high risk seamounts with summits in the 750-1250 m depth range. Bottom: Seamounts with known historical orange roughy group catches (Taken from Clark *et al.* 2006).

7. Management

7.1 Current management practices

There is currently only one management measure in place on the high seas to control access to seamount habitat under a memorandum of understanding between Australia and New Zealand. This agreement began in 1998 and includes strict management of the South Tasman Rise area in the western Tasman Sea. New Zealand vessels have not fished the South Tasman Rise since 2000/01. However, in 1999 and 2000, vessels registered in South Africa and Belize fished the region.

Negotiations at the 61st (2006) United Nations General Assembly (UNGA) achieved consensus on the following in regards to bottom trawling on the high seas (UNGA Resolution 61/105):

“i. In high seas unmanaged areas: States should either: adopt unilateral precautionary measures to ensure that bottom trawling does not result in significant adverse impacts on vulnerable marine ecosystems; or cease to authorise their fishing vessels. States are to make measures publicly available;

ii. In areas covered by RFMO’s: Precautionary measures to be implemented by 31 December 2008 to ensure that bottom trawling does not result in significant adverse impacts on vulnerable marine ecosystems, including area closures. Measures are to be made publicly available;

iii. In areas covered by RFMO under negotiation: interim measures on bottom trawling to be implemented by 31 December 2007 and to make these publicly available.”

All actions taken in terms of this resolution will be reviewed in three years (2009) at UNGA 64.

New Zealand, in 2001, closed 19 seamounts inside its EEZ (200nm) to all trawling operations. One of those seamount closures includes an area that straddles the EEZ limit and the area of that seamount on the high seas is closed to trawling by New Zealand flagged vessels as a condition of their high seas permit. The inclusion of fished and non-fished seamounts within the closure provided an opportunity for scientific research to investigate the impacts of bottom trawling on seamounts. The closed seamounts vary in size and depth and are located among four biogeographic zones in the New Zealand region, based on a classification using a combination of physical, oceanographic and hydrographic variables and chlorophyll-*a* as a measure of productivity. The selection process was based on the seamount classification scheme developed by Rowden *et al.* (2005). Three out of the twelve seamount classes only occur outside the New Zealand EEZ, associated with the Emerald Basin, Lord Howe Rise, and the Louisville Ridge (Rowden *et al.* 2005).

NOTE: Details of recent New Zealand BPA closures still to be included here.

Australia, in May 1999, protected several seamounts within their EEZ creating the Lord Howe Island Marine Park and the Tasmanian Seamounts Marine Reserve. The Tasmanian Seamounts Reserve is predominantly aimed at protecting benthic habitat and is closed to bottom trawling, while allowing pelagic long-lining in the upper

water column. The Lord Howe reserve is closed to all fishing. To determine the effectiveness of these reserves, Australia has put in place a performance assessment program and has developed performance indicators. Further proposals are currently being considered for several Seamount Protected Areas in Southeast Australia.

7.2 Management implications

There are two main options for minimising the impacts of bottom trawling on sensitive seamount habitats: 1) Gear restrictions that allows fishing with minimal adverse impacts; or, 2) Closure of areas to the bottom trawling method. Ecosystem modelling on the effects of pelagic fishing over protected benthos in the Tasmanian seamount reserve demonstrated that the pelagic fishing has no significant interaction with the benthos in the protected areas (Bulman *et al.* 2002) suggesting that option 2 could be acceptable.

If areas are to be closed, it is important to choose seamounts that are representative of the area in terms of biodiversity, and ideally that have been subjected to varying degrees of fishing effort. For example, the endemics of the Sala Y Gomez ridge are closer to the Atlantic fauna than to those of the eastern Pacific (Parin *et al.* 1997). Depth of summit has been identified as the most important physical factor in determining abundance and diversity of benthic communities (Clark *et al.* 2006).

The importance of seamounts in larger-scale patterns of biodiversity in the ocean is unknown, but there is the potential that impacts on seamounts may also impact connected ecosystems. It is known that migratory species such as tuna, marine mammals and seabirds congregate over seamounts (Hui 1985, Haney *et al.* 1995), indicating that seamounts can have some particular importance for species with much larger ranges.

8. Research

8.1 Ongoing Research

Census of Seamount Life (CenSeam) is an organisation of scientists with the stated mission to “determine the role of seamounts in the biogeography, biodiversity, productivity, and evolution of marine organisms, and to evaluate the effects of humans on seamounts.” Current research projects aim to answer the question: “What role do seamounts play in the biogeography, biodiversity, productivity, evolution of marine organisms, and what is their effect on the global, oceanic ecosystems?” This organisation acts on a global scale; current activities are further detailed at <http://www.coml.org/descrip/censeam.htm>.

New Zealand is currently funding several seamount projects. There are attempts to characterise seamount biodiversity, (macroinvertebrates in particular) on particular assemblages of seamounts, with the aim of extrapolating these macroinvertebrate assemblages to other seamounts. Projects also aim to compare and contrast seamounts on the North Chatham Rise, some of which are fished and some of which are now protected. This research focuses on linking acoustic habitat mapping to seabed biodiversity studies to generate deepwater community maps, and to evaluate the recovery rates of deepwater biodiversity impacted by fishing.

Future research already planned by New Zealand will use macroinvertebrate assemblage data to test the validity of the current physical seamount classification system.

8.2 Recommended Research

As noted by Clark *et al.* (2006), there are a number of shortcomings and gaps that need to be addressed in order to answer questions for policy makers, managers and scientists. These include the need for: better seamount location data, standardised biological sampling / collection methods, comparisons with other deep water habitats, assessment of the spatial scale of variability, and improving taxonomic resolution. In addition, more knowledge on recovery rates from trawling, a functional understanding of the ecosystem, increased genetic studies and better access to catch and effort data are required.

9. Additional Comments

None at this time.

10. References

- Adam, MS., Sibert, JR., Itano, D., Holland, KN. (2003) Dynamics of bigeye (*Thunnus obesus*) and yellowfin (*T. albacares*) tuna in Hawaii's pelagic fisheries: analysis of tagging data with a bulk transfer model incorporating size-specific attrition. *Fishery Bulletin* 101: 2154-228.
- Allain, V., Kerandel, J-A., Andrefouet, S., Magron, F., Clark, M., Muller-Karger, F. (2007) Location of seamounts in the Western and central Pacific Ocean (WCPO): screening and cross-checking of existing datasets. Abstract only.
- Allain, V., Kirby, D., Kerandel, J. (2006) Seamount Research Planning Workshop Report 20-21 March 2006. WCPFC-SC-2-2006/EB IP-5.
- Anderson, OF., Clark, MR. (2003) Analysis of the bycatch in the fishery for orange roughy, *Hoplostethus atlanticus*, on the South Tasman Rise. *Marine and Freshwater Research* 54: 643-652.
- Buhl-Mortensen, L., Mortensen, PB. (2004) Symbiosis in deep-water corals. *Symbiosis* 37: 33-651.
- Bulman, CM., Butler, AJ., Condie, S., Ridgway, k., Koslow, JA., He, X., Williams, A., Bravington, M., Stevens, Young, JW. (2002). A trophic dynamic model for the Tasmanian Seamounts Marine Reserve: Links between pelagic and deepwater ecosystems. CSIRO Marine Research Report.
- Campbell, R., Hobday, AJ. (2003) Swordfish-Environment-Seamount-Fishery interactions off eastern Australia. Report to the Australian Fisheries Management authority. pp. 1-97.
- Carter, L. (1989) New occurrences of manganese nodules in the southwestern Pacific Basin east of New Zealand. *New Zealand Journal of Marine and Freshwater Research* 23: 247-253.

- Clark, M. (unpublished) Descriptive analysis of orange roughy fisheries in the New Zealand region outside the EEZ to the end of the 2005-06 fishing year. ORH 2006/03. Fisheries Assessment report, Ministry of Fisheries.
- Clark, M., Tittensor D., Rogers, AD., Brewin, P., Schlacher, T., Rowden, A., Stocks, K., Consalvey, M. (2006) Seamounts, deep sea corals and fisheries: vulnerability of deep sea corals to fishing on seamounts beyond areas of national jurisdiction UNEP-WCMC, Cambridge, UK.
- Clark, M., O'Shea, S., Tracey, D., Glasby, B. (1999) New Zealand Region Seamounts: Aspects of their biology, ecology and fisheries. NIWA National Institute of Water and Atmospheric Research Ltd, Wellington, New Zealand.
- Clark, M., O'Driscoll, R. (2003) Deepwater fisheries and aspects of their impact on seamount habitat in New Zealand. *Journal of Northwest Atlantic Fishery Science* 31: 151-163.
- Dayton, PK., Thrush, SF., Agardy, MT., Hofman, RJ. (1995) Viewpoint: environmental effects of marine fishing. *Aquatic Conservation of Marine and Freshwater Ecosystems* 5: 205-232.
- Epp, D., Smoot, N. (1989) Distribution of seamounts in the North Atlantic. *Nature* 337: 254-257.
- Froese, R., Sampang, A. (2004) Taxonomy and biology of seamount fishes. In: Seamounts, biodiversity and Fisheries. Morato, T., Pauly, D. (eds). Fisheries Centre Research reports. 12(5): 78.
- Griggs, RW., Malahoff, A., Chave, EH., Landahl, J. (1987) Seamount benthic ecology and potential environmental impact from manganese crust mining in Hawaii. Pp. 379-390. In: Keating, BH., Fryer, P., Batiza, R., Boehlert, GW. (eds). Seamounts, islands and atolls. Geological Monograph 43: 405.
- Griggs RW. (1993) Precious coral fisheries of Hawaii and the U.S. Pacific Islands. *Marine Fisheries Review* 55(2): 50-60.
- Haney, JC., Haury, LR., Mullineaux, LS., Fey, CL (1995) Sea-bird aggregation at a deep North Pacific seamount. *Marine Biology* 123: 1-9.
- Holland, KN., Kleiber, P., Kajiura, SM. (1999) Different residence times of yellowfin tuna, *Thunnus albacares*, and bigeye tuna, *T. obesus*, found in mixed aggregations over a seamount. *Fishery Bulletin* 97: 392-395.
- Hui, CA., (1985) Undersea topography and the comparative distributions of two pelagic cetaceans. *Fishery Bulletin*. 83(3): 472-475.
- Jones JB. (1992) Environmental impact of trawling on the seabed: a review. *New Zealand Journal of Marine and Freshwater Resources* 26:59-67.
- Kitchingman, A., Lai, S. (2004) Inferences on potential seamount locations from mid-resolution bathymetric data. In: Seamounts, biodiversity and Fisheries. Morato, T., Pauly, D. (eds). Fisheries Centre Research reports. 12(5): 78.
- 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. *Marine Ecology Progress Series* 231: 111-125.
- Koslow, JA., Gowlett-Holmes, K. (1998) The seamount fauna off southern Tasmania: Benthic communities, their conservation and impacts of trawling. Final Report to Environment Australia and the Fisheries Research and development Corporation: Canberra.
- Koslow, JA, (1996) Energetic and life history patterns of deep-sea benthic, benthopelagic and seamount associated fish. *Journal of Fish Biology* 49A: 54-74.
- Krieger, KJ., Wing, BL. (2002) Megafauna associations with deepwater corals (*Primnoa* spp.) in the Gulf of Alaska. *Hydrobiologica* 471: 83-90.
- Lack, M., Short, K., Willock. (2003) Managing risk and uncertainty in deep-sea fisheries: lessons from orange roughy. TRAFFIC Oceania and WWF Endangered Species Programme, 73pp.
- Morato, T., Cheung, WWL., Pitcher, TJ. (2004) Vulnerability of seamount fish to fishing: fuzzy analysis of life-history attributes. In: Seamounts, biodiversity and Fisheries. Morato, T., Pauly, D. (eds). Fisheries Centre Research Reports. 12(5): 78.
- Musyl, ML., Brill, RW., Boggs, CH., Curran, DS., Kazama, TK., Seki, MP (2003). Vertical movements of bigeye tuna (*Thunnus obesus*) associated with islands, buoys, and seamounts near the main Hawaiian islands from archival tagging. *Fisheries Oceanography* 12(3): 152-169.
- O'Driscoll, RL., Clark, MR. (2005) Quantifying the relative intensity of fishing on New Zealand seamounts. *New Zealand Journal of Marine and Freshwater* 39: 839-850.
- Parin, NV., Mironov, AN., Nesis, KN. (1997) The Nasca and Sala-y-Gomez submarine ridges: an outpost of the Indo-west Pacific fauna in the Eastern Pacific. Pp. 145-242. In: Gebruk, AV., Southward, EC., Tyler, PA. (eds). *Biogeography of the Oceans. Advances in Marine Biology* 32: 147-242.
- Richer de Forges, B., Koslow, JA., Poore, GCB. (2000). Diversity and endemism of the benthic seamount fauna in the southwest Pacific. *Nature* 405: 944-974.
- Roberts, C., Clark, M. (2006) Biodiversity of the Norfolk ridge and Lord Howe Rise, Tasman Sea: results of the NORFANZ voyage, 2003. Final Research Report, Ministry of Fisheries.
- Rogers, AD. (2004) The Biology, Ecology and vulnerability of seamount communities. IUCN Report.
- Rogers, AD. (1994) The biology of seamounts. *Advances in Marine Biology* 30: 305-350.
- Rowden, AA., Clark, MR., Wright, IC. (2005) Physical characterisation and a

biologically focused classification of “seamounts” in the New Zealand region. *New Zealand Journal of Marine and Freshwater Research* 39: 1039-1059.

- Rowden, AA., Clark, MR., O’Shea, S. (2004) Benthic biodiversity of seamounts on the northland Plateau. *Marine Biodiversity and Biosecurity Report No. 5.*
- Rowden, AA., O’Shea, S., Clark, MR., McKnight, DG. (2003) Benthic biodiversity of seamounts on the southern Kermadec volcanic arc. *Marine Biodiversity and Biosecurity Report No. 3.*
- Rowden, AA., O’Shea, S., Clark, MR. (2002) Benthic biodiversity of seamounts on the northwest Chatham Rise. *Marine Biodiversity and Biosecurity Report No. 2.*
- Sarma, K., Ramana, MV., Subrahmanyam, V., Krishna, KS. (1998) Seamounts an additional tool to confirm the nature of crust and to locate possible mineral resources from dredging. *Marine Georesources and Geotechnology* 16(1): 41-51.
- Smith, DK., Jordon, TH. (1988) Seamount statistics in the Pacific Ocean. *Journal of Geophysical Research.* 93: 2899-2919.
- Stocks, K. (2004) Seamountsonline: an online resource for data on the biodiversity of seamounts. In: *Seamounts, biodiversity and Fisheries.* Morato, T., Pauly, D. (eds). *Fisheries Centre Research reports.* 12(5): 78.
- Tracey, D., Bull, B., Clark, MR., Mackay, KA. (2004) Fish species composition on seamounts and adjacent slope in New Zealand waters. *New Zealand Journal of Marine and Freshwater Research* 38: 163-182.
- Watson, R., Morato, T. (2004) Exploitation patterns in seamount fisheries: a preliminary analysis. In: *Seamounts, biodiversity and Fisheries.* Morato, T., Pauly, D. (eds). *Fisheries Centre Research reports.* 12(5): 78.
- Wessel, P., Lyons, S. (1997) Distribution of large Pacific seamounts from Geostat/ERS-1: Implications for the history of intraplate volcanism. *Journal of geophysical Research* 102(B10): 22459-22475.
- Wessel, P. (1997) Sizes and ages of seamounts using remote sensing: Implications for intraplate volcanism. *Science* 227: 802-805.