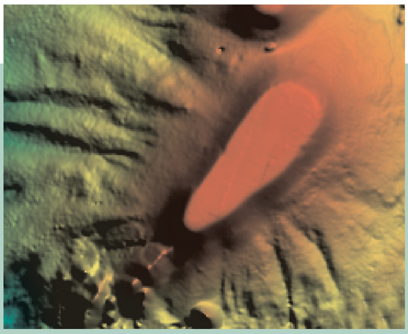
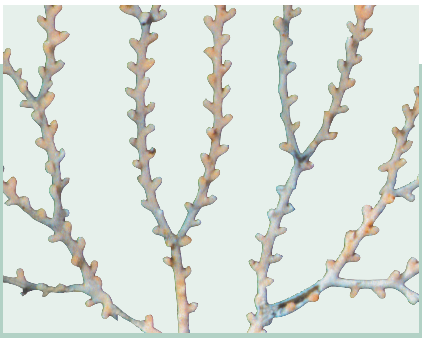
Assessment of the conservation values of the Norfolk Seamounts area

A component of the Commonwealth Marine Conservation Assessment Program 2002-2004





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Australian Government
Department of the Environment and Heritage

CSIRO

Report to the Department of the Environment and Heritage
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Summary

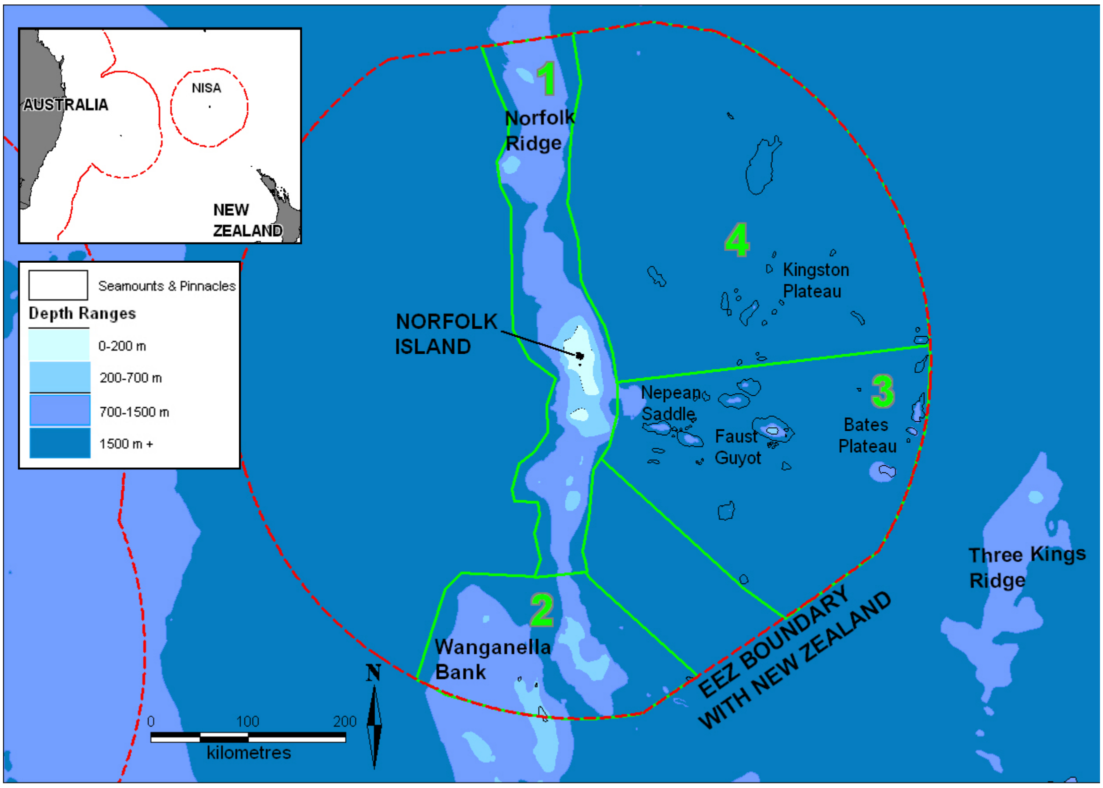
The Minister for the Environment and Heritage, on 26 September 2001, announced plans to assess the conservation values of 11 unique marine areas in Australian Commonwealth waters (DEH 2004 a). Two were assessed within the framework of the South East Regional Marine Planning process in 2002 (Butler *et al* 2002 a and b). The Norfolk Island Seamounts area (NISA) is the third, and was nominated for assessment based on an expectation that it supported a high diversity of endemic fauna. CSIRO was asked to provide a summary of the relevant and available data for the area, together with expert opinions, and come to a balanced conclusion regarding the question "Does the NISA possess biodiversity values worthy of protection?"

The assessment of the conservation values is done in accordance with the identification criteria outlined in Guidelines for identification of MPAs detailed in the Strategic Plan of Action for the NRSMPA (Appendix 1). Reporting focuses on the components specified by that plan (Appendix 2):

Does the NISA represent one or more ecosystems within a recognised bioregion, and to what degree? The NISA area lies within a distinct regional-scale bioregion, the "Norfolk Island Province", meaning its ecosystems have different components to those in all other provinces within the Australian Marine Jurisdiction. Initial data for the NISA, together with more extensive data from an adjacent seamount area (Norfolk Ridge), show biological communities are particularly rich and diverse, characterised by high levels of endemism (species found nowhere else), and are comprised of a remarkably high number of species and genera that are new to science. These patterns are consistent with the high natural values – specialised ecosystems with characteristic and rich biodiversity – reported for seamounts globally.

Seabed (benthic) and water column (pelagic) communities on individual seamounts vary with depth, meaning that deep and shallow seamounts have different conservation values. Full representativeness requires a seamount or cluster of seamounts to span four key depth ranges: near surface (less than 200 m deep), ~200 to 700 m, ~700 to 1,500 m, and deeper than 1,500 m. Four NISA sub-regions containing seamounts are provisionally differentiated on their present-day patterns of oceanographic circulation and seabed topography. Sub-region 3, the area of shallow and deep seamounts to the east/southeast of Norfolk Island

encompassed by the Norfolk Eddy, has the greatest potential to maximise conservation benefits for NISA seamounts. A second sub-region (sub-region 1, the Norfolk Ridge around Norfolk Island), contains the only known NISA seabed shallower than 200 m – the continental shelf around Norfolk Island. Although this is not part of a seamount ecosystem, the biological components of this shallow shelf area need to be included in an MPA to fully represent the natural values of the Norfolk Island Province (and see Reserve Design below).



Summary Figure The Norfolk Island Seamounts Area (NISA) showing four sub-regions containing seamounts (outlined in green) differentiated on the basis of geomorphology, bathymetry and oceanography. Map inset shows location of NISA. Legend shows (1) depth ranges important for biodiversity distributions and (2) outlines of seamounts and pinnacles (following Harris *et al.* 2003).

Will the NISA add to the representativeness of the NRSMPA, and to what degree?

Recently collected (NORFANZ) survey data confirmed strong differences between the faunas of seamounts in the Norfolk Island Province and the Tasmanian Province off southern Tasmania – Australia's only other MPA containing seamounts. Because the Norfolk Island Province has no existing MPAs covering seamounts, including a representative group or groups of its seamounts will add new and iconic natural values to the NRSMPA.

Will the NISA add to the coverage of the full range of ecosystems recognised at an appropriate scale and within and across each bioregion, and add to the comprehensiveness of the NRSMPA? Within the very large NISA area, the appropriate scale for conserving seamount ecosystems may be a major seamount cluster (or ridge system) if this proves to be the dominant scale of species endemism. Whole features (including some of the surrounding seabed and water column), that collectively span four key depth ranges – near surface (less than 200 m deep), ~200 to 700 m, ~700 to 1,500 m, and deeper than 1,500 m) – are required. Components of two sub-regions (1 and 3) are needed to comprehensively conserve the natural values of seamount ecosystems in the provincial scale bioregion of which the NISA area is part (and see Reserve Design below).

Including a representative group or groups of seamounts from the NISA area will add to the comprehensiveness of the NRSMPA by conserving biodiversity and habitats that are iconic, unique and not protected elsewhere in the Australian Marine Jurisdiction (AMJ).

Does the NISA area contribute to the maintenance of essential ecological processes of life-support systems? Seamounts are widely documented as supporting specialised ecosystems with characteristic and rich biodiversity, and unique or important ecological processes. Specific details of ecological processes are not known for the NISA area, but can be confidently inferred to be similar to better-known seamounts in broadly similar environments outside the AMJ.

Does the NISA area contain habitat for rare or endangered species? Seamounts are characterised by a diverse emergent benthic fauna that differs to faunas of the surrounding (flat) deep sea floor which are dominated by burrowing forms (and see Productivity below). Seamount faunas include habitat-forming corals that, over very long periods of time, build matrix-like ‘reefs’ used by a variety of benthic animals for shelter and attachment. It can be confidently inferred from better-known seamounts elsewhere that a wide variety of pelagic animals take advantage of increased productivity in the water column above and around seamount habitat in the NISA area. These will include listed and/or protected whales and turtles. The Norfolk Island Province, that bounds the NISA area, is home to six endangered species (three albatrosses, southern giant petrel, blue and southern right whales), and 12 vulnerable species (six albatrosses, three petrels, humpback whale, and green and leatherback turtles).

Does the NISA area contain areas on which species or other systems are dependent, e.g. contain nursery or juvenile areas or feeding, breeding or resting areas for migratory species? As well as being characterised by rich biodiversity, the NISA seamounts are adjacent to the New Caledonian section of the Norfolk Ridge which is known to support an archaic benthic fauna (sponges, hydroids, crinoids, molluscs and echinoderms) similar to the original fauna inhabiting the margin of Gondwana. These include some groups thought to have become extinct. It is hypothesised that the Norfolk Ridge – a contiguous feature at depths of 1,000 to 2,000 m connecting New Zealand, Norfolk Island and New Caledonia with seamounts and other elevated features at 500-1,000 m depth – may provide stepping stones in transoceanic dispersal of plankton and planktonic larvae of benthic species. Therefore the NISA area may contribute to preserving genetic diversity of modern and relict groups of animals.

Does the NISA area contain areas on which species or other systems are dependent, e.g. contain nursery or juvenile areas or feeding, breeding or resting areas for migratory species? Ten listed bird species (Australasian gannet, sooty tern, grey ternlet, red-tailed tropicbird, masked booby, two species of shearwater and three species of petrel) breed in the Norfolk Island Province, and several listed and/or protected migratory birds, whales and turtles move through the NISA area. It is expected that these species forage in near surface NISA waters and take advantage of increased productivity in the water column around and above seamounts.

Does the NISA area contain one or more areas which are a biologically functional, self-sustaining ecological unit? Individual seamounts or clusters of seamounts may represent self-sustaining ecological units. It is hypothesized that higher levels of endemism may be found on NISA seamounts of sub-region 3, the Nepean Saddle, Bates Plateau and South Norfolk Basin region that lie under the Norfolk Eddy, based on the potential for the retention of larvae in the eddy which is coherent to depths of 1,500 m.

Is the NISA area rated, or has the potential to be listed, on the world or a national heritage list or declared as a Biosphere Reserve or subject to an international or national conservation agreement? A key finding from a conference on the governance of high seas biodiversity conservation (DEH 2005) identified seamounts as a high priority for biodiversity conservation in both the national and international (high seas) context. The conservation values of the NISA area are expected to be as important as those of the

Tasmanian Seamounts Area which has been nominated for Australia's Commonwealth Heritage List and is being assessed by the Australian Heritage Council in 2006.

The NISA area is ideally located to form a component of a bi-lateral Tasman Sea conservation initiative with New Zealand (that could include a high seas area).

Does the NISA area contain unique species, populations, communities or ecosystems, or unusual or unique geographical features? Existing data show the NISA contains many unique elements, and this is consistent with the finding for better studied seamounts in adjacent regions (New Caledonia and New Zealand). Initial results from the NORFANZ survey already confirm new species of fishes, octopus, squat lobsters, prawns, krill, seaspiders, brittlestars, and hydroids.

Some seamounts of the adjacent Norfolk Ridge in the New Caledonian EEZ support an archaic benthic invertebrate fauna (sponges, hydroids, crinoids, molluscs and echinoderms) similar to the original fauna inhabiting the margin of Gondwana and this includes some groups thought to have become extinct in the Upper Jurassic. One species of the 'living fossil' sponge family Lithistidae was collected in the NISA area during the NORFANZ survey, and it is probable that other relict species occur there.

Known NISA seamounts have varied morphology and depth range, but are mostly larger and less regular than the conical volcanic cinder cones protected in the Tasmanian Seamounts Reserve.

Do the species, populations, or communities of the NISA area have a natural biological productivity? Seamounts profoundly influence water currents moving around them by rectifying and substantially amplifying flows in their vicinity, and have been described as oases of increased productivity in the otherwise nutrient-poor open ocean. Enhanced flows of food-rich waters past seamounts provide a consistent food source for filter-feeders, resulting in seamount benthic communities being dominated by emergent, filter-feeding fauna. Accelerated currents, which produce vortices where prey organisms are concentrated, lead to aggregations of higher level predators such as fishes. Seamounts may also enhance local productivity by intersecting the 'deep scattering layers' of plankton and small fishes, crustaceans and squids that live in the upper 1,000 m of the water column of the open ocean.

NISA seamounts are characterised by emergent fauna and are known to support ‘seamount’ fishes (billfishes and tunas alfonsino, ‘seabass’, and orange roughy). Some NISA seamounts peak within the depth range (less than 1,000 m from sea surface) required to intersect the open ocean’s ‘deep scattering layers’. It is expected that a wide variety of listed and/or protected migratory birds, whales and turtles take advantage of increased productivity in the water column around and above seamounts in the NISA area.

Thus, while details of productivity are not known for the NISA area, its seamounts can be confidently inferred to be oases of increased productivity because they are mostly surrounded by large expanses of deep open ocean (~3,000 m depth).

Are the NISA ecosystems and/or communities vulnerable to natural processes? Seamounts of the NISA area represent a deep ocean system likely only to be disturbed naturally by seismic events. However, the emergent benthic fauna, consisting largely of fragile, slow-growing and long-lived species, is vulnerable to anthropogenic processes, particularly mechanical disturbance from bottom fishing.

Does the NISA area capture important biogeographic qualities? The NISA area lies within a distinct regional-scale bioregion, the “Norfolk Island Province”, meaning its ecosystems have different components to those in all other biogeographic provinces within the AMJ. It lies at the extreme eastern margin of the AMJ, spanning a region of complex oceanography that may enhance the diversity and uniqueness of the NISA fauna through influences by the tropical southern Coral Sea, warm temperate northern Tasman Sea, and the persistent, stationary Norfolk Eddy.

How much has the NISA area been protected from, or not been subjected to, human induced change? NISA seamounts have a variable, but generally low, history of bottom fishing activity – the highest potential threat to its natural values. Soviet and Japanese fishing occurred prior to the establishment of the Australian EEZ, but the precise locations of fishing activity are not known. Since 2000, a small amount of bottom trawling has occurred to the north and east of the Norfolk Ridge and Wanganella Bank. Most NISA seamounts are expected to be little impacted or pristine at this time, but the area is being considered for further exploratory bottom fishing.

Are the existing data sufficient for MPA design and performance assessment? Existing data are sufficient for MPA design but not performance assessment. Although the NISA region encompasses a very large area that is incompletely mapped, a similar lack of data in other regions, e.g. the South East Region, has not been a barrier to MPA development. Key decisions on suitable boundary placement to effectively capture a range of identified biodiversity values in NISA can be made with confidence using existing information.

The first step in performance assessment – detailed inventory of individual seamounts and fauna – would be provisional, but conservative (additional information would almost certainly elevate performance rating). Assessment could commence by 1) compiling a regional scale database of seamount features using the NIWA template for seamounts in New Zealand's EEZ (in which variables to evaluate include depth at peak and at base, base area, Chlorophyll *a* concentration above the peak and distance to continental margin), and 2) fully analysing the NISA benthic fauna including making comparison with museum collections and current literature for fauna from adjacent regions (New Caledonia, New Zealand, and southern Australia). Additional survey, similar in some ways to the NORFANZ survey but designed to answer specific questions relevant to performance assessment, could then add substantially to knowledge of the NISA area's natural values, and showcase its inclusion in the NRSMPA.

What are key features for reserve design within the NISA area? Four NISA sub-regions containing seamounts are provisionally differentiated here on their present-day patterns of oceanographic circulation and seabed topography (see Summary Figure). Sub-region 3, the area of shallow and deep seamounts to the east/southeast of Norfolk Island encompassed by the Norfolk Eddy has the greatest potential to maximise conservation benefits due to: (1) the relatively high number of defined individual seamounts; (2) the shallow depths of some seamounts that will be characterized by different faunas to deep seamounts (one peaking at 600 m, and several peaking at ~1,000 m); (3) the possibility of higher levels of endemism on seamounts of the Nepean Saddle, Bates Plateau and South Norfolk Basin region that lie under the Norfolk Eddy (based on the potential for the retention of larvae since the eddy is coherent to depths of 1,500 m); and (4) the pristine state of many seamounts that have not been bottom trawled. Importantly, however, sub-region 1, (the Norfolk Ridge around Norfolk Island), contains the only known NISA seabed shallower than 200 m – the continental shelf around Norfolk Island – and this needs to be included to ensure Provincial-level comprehensiveness.

Global data on seamounts indicate that conservation of seamount ecosystems may require protection at the scale of a major seamount cluster or ridge system. Thus, a large single area extending from Norfolk Island to the Australian EEZ boundary to the east and southeast, to encompass continental shelf, seamounts on the Norfolk Ridge, and the key (shallow and deep) seamounts of the Nepean Saddle, Bates Plateau and South Norfolk Basin region, including the Faust Guyot (Summary Figure), would effectively conserve biodiversity values in this NISA area, and more broadly, the Norfolk Province, and in so doing would provide an iconic addition to Australia's NRSMPA. The location of this area close to the EEZ boundary shared with New Zealand is also ideally located for a single bi-lateral MPA that could span the adjacent high seas overlaying the northern part of the Three Kings Ridge.

Background

On 26 September 2001 the Minister for the Environment and Heritage announced plans to assess the conservation values of 11 unique marine areas in Australian Commonwealth waters (DEH 2004 a). The conservation assessments are intended to provide information on whether the Government should proceed with conservation measures for any of the areas, such as declaring new marine protected areas (DEH 2004 b).

The 11 study areas were divided into three groups:

- the Bass Strait sponge beds and Blue Whale aggregation site in the South East were assessed within the framework of the South East Regional Marine Planning process in 2002 (Butler *et al* 2002 a and b). The South-east Regional Marine Plan was launched in May 2004.
- eight areas to be assessed in the context of future Regional Marine Plans in order to avoid duplication and to increase efficiency - Eucla Canyon, Gulf of Carpentaria seagrass beds, Heywood Shoals, Naturaliste Plateau, Pea Shoals, Sea Angel Bank, Swan Canyon and Wallaby Plateau.
- the Norfolk Seamounts area was to be assessed separately in the same way as the Bass Strait sponge beds and Blue Whale aggregation site, because data relevant to the Norfolk Seamount Conservation Values Assessment was acquired during a recent biodiversity survey ('NORFANZ', Clark *et al.* 2003; Williams *et al.*, 2006).

This report concerns the Norfolk Seamounts area.

Scope of the Conservation Values Assessments (CVAs)

In summary, CSIRO was asked by the Department of the Environment and Heritage (DEH) to provide a succinct summary of the relevant and available data for each study area (Bass Strait sponge Beds, Blue Whale Aggregation site and Norfolk Seamounts area) and come to a balanced conclusion regarding the question "*Does the area possess biodiversity values worthy of protection?*" For example, does the area offer special/ significant values in terms of providing for (among other things):

- the special needs of rare, threatened or depleted species and threatened ecological communities;

- the conservation of special groups of organisms (e.g. species with complex habitat requirements, or migratory species, or species vulnerable to disturbance);
- centres of endemism, natural refugia for flora and fauna;
- recreational, aesthetic, educational or cultural needs; and
- a scientific reference site.

CSIRO was asked to include expression (with explanation) of the degree of confidence in the conclusions, and the necessity for any further information, and if appropriate to include conclusions about any specific sub-regions identified.

CSIRO was asked to identify and describe any areas of high conservation value in each of the areas and to provide an assessment of the conservation values of the areas in accordance with the identification criteria as outlined in *Guidelines for identification of MPAs detailed in the Strategic Plan of Action for the NRSMPA* (see Appendix 1) and to report on the components specified in Appendix 2, to the extent possible given available data. CSIRO was expected to consult with individuals and institutions with expertise and research interests in these areas and to make appropriate arrangements to access all available information and expertise, in liaison with DEH.

It is not the role of the initial conservation values assessment to recommend what protection measures may be appropriate, to provide information relevant to reserve design issues, or to deal with reserve management issues. Similarly, while the assessment may provide information regarding current uses and threatening processes it does not aim to provide a Social and Economic Impact Assessment. Should the Minister decide to pursue conservation measures for the area (such as an MPA), a detailed social and economic impact assessment would be developed as a subsequent stage of the process, in conjunction with an analysis of the conservation benefits, design and management of the proposed conservation measures.

The Norfolk Seamounts area – original outline

In the Minister's announcement (DEH 2004 a), the 'Norfolk seamount marine area' was described as: *"Large seamounts, including one 50km long, rising from 3,000m to 700m below sea level, expected to support a high diversity of endemic fauna."*

A document developed in the process of identifying the 11 areas announced by the Minister for the Environment and Heritage gave a more detailed description of the Norfolk Seamounts area (A. Hobday, CSIRO Marine Research pers. comm.):

Box 1: Original description of the Norfolk seamounts area

Norfolk Island – Seamounts to East

Marine domain: **NORFOLK**

Geographic location: Norfolk Island lies in the Tasman Sea approximately midway between New Caledonia and New Zealand.

Description of area (including unique values or any values of ecological importance):

Norfolk Island is a volcanic edifice on the southern part of the Norfolk Ridge, a feature that extends northwards to New Caledonia. The Ridge is a 'ribbon' of continental crust that, together with the Lord Howe Rise, separated from the Australian continent by rifting and seafloor spreading during the Late Cretaceous. In many places it appears to comprise several kilometres of sedimentary section (with volcanics) that have been folding and buckled during the Late Cainozoic, due to NE-SW directed crustal shortening, along the current plate boundary to the NE.

It is flanked by ocean basins about 3,000 m deep – the New Caledonia Basin to the west and the Norfolk Basin to the east. These have been assumed to be oceanic crust, though there is some evidence to suggest the New Caledonia Basin may be floored by a highly extended continental basement.

A recent survey of diversity and endemism of the benthic seamount fauna from the 6 seamounts along the Norfolk Ridge obtained 516 species of fish and macro invertebrates. 36 % of species from the Norfolk Island ridge seamounts were new to science and not known from sampling the ocean seafloor and are therefore potential endemics.

The research also revealed little overlap in community composition in the deep sea between seamounts sharing the same habitat type, at similar latitude and depth, and only 1,000 kilometres [apart]. It is believed that many taxa adapted to seamount conditions limit their dispersal to maintain their populations, because of the generally small size of seamounts, the considerable distance between them and their unique oceanographic environment. The seamounts of the Norfolk Ridge appear to be isolated marine systems and provide an exceptional opportunity to examine evolution and specialisation in the deep sea.

Current data/knowledge:

There is bathymetric and recent swath data in the region; some seismic profiles.

Vulnerability (known or potential threats):

Due to their highly localised distributions, seamount communities are extremely vulnerable to the impacts of fishing: their limited fixed habitat, the extreme longevity of many species and the apparently limited recruitment between seamounts all compound the uncertainty of recovery, from trawling activities in particular.

Given the pristine status of the Norfolk ridge seamount and increasing threats to its biodiversity values from potential exploratory fishing (trawling?) activities, we consider this area is a candidate conservation zone.

Condition:

Probably pristine - we understand that given the relative recent mapping of the Norfolk Seamount that it has previously not been targeted by the fishing industry. When AGSO were last surveying in the area they reported there were no signs of fishing activity for the days in which they were exploring.

Current / Potential uses:

Interest from operators targeting tuna and like species. Developmental finfish fishery (line and trawl methods) likely to be conducting restricted exploration in this area in the near future.

The Norfolk Ridge has some potential for petroleum, particularly in the area of the Taranui Sea Valley that lies to the south, at an offset of the Norfolk and West Norfolk Ridge systems. A thick folded sedimentary section is evident on seismic data from that area.

Large area classified as remote frontier petroleum province. Some interest in exploration. Scheduled for release pre-2005.

The Norfolk Island Seamounts Area (NISA) – definition

Neither of the above descriptions is, however, detailed enough to clearly delimit the geographical area to be assessed. In discussion with DEH, it was decided that the region to be considered in this CVA was comprised of the seamounts within the Australian Exclusive Economic Zone (EEZ) around Norfolk Island (Figure 1). Thus, the primary seamount features within the study area are the Norfolk Ridge, the seamounts to the east of Norfolk Island, and the Wanganella Bank Region south of the New Caledonia Basin (Figure 1). The inshore area, as defined by the AFMA Inshore Fishery box (AFMA 2004 a), and the abyssal plains surrounding seamount areas, are excluded from the present CVA (Figure 1).

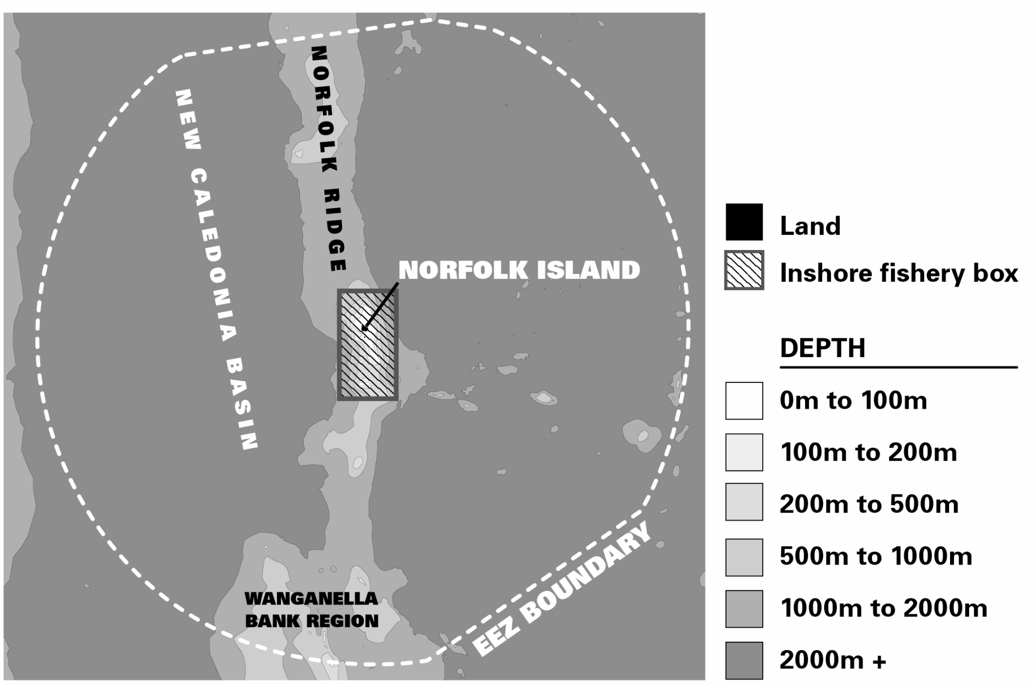


Figure 1. Map showing the Australian EEZ around Norfolk Island (AMBIS boundary record), coarse scale bathymetry, and the AFMA Inshore Fishery box (excluded from the present CVA). The focus of the CVA is on features that rise above the 2,000 m isobath (medium to light grey areas).

Methods

This report is the result of a desktop study, and presents relevant data and information currently available for the Norfolk Seamounts area. Conservation values were assessed for the NISA area as defined in the previous section and depicted in Figure 1. A regional context for interpreting the fauna of the NISA, using the criteria listed in Appendix 1 and 2, was provided by examining complementary data from adjacent regions, mostly seamounts in the Coral Sea (Lord Howe Rise and New Caledonia), parts of the Norfolk Ridge north of New Zealand, and SE Australia (Tasmania).

Stakeholder engagement and data collation

CSIRO Marine and Atmospheric Research (CMAR) initiated contact with a wide range of potential data holders and potential stakeholders with an introductory letter explaining the background to the present CVA, and drawing attention to the project web-site[1] where regular up-dates of the work were posted. In addition, all participants of the recent NORFANZ survey were contacted to ask for their co-operation in interpreting data from that survey as well as for any additional data and expert advice on seamount fauna. These letters, and the stakeholders and researchers contacted, are shown in Appendix 3. We also published a ‘call for information’ in the *Norfolk Islander* (Oct 2, 2004), the local weekly newspaper of Norfolk Island, in order to reach the wider population of the area. This resulted in an opportunity to provide information explaining our project and extending our call for information for a general meeting of the Norfolk Island Flora and Fauna Society.

The letters, web-site and calls for information generated interest in the study, especially from people from Norfolk Island. However, few data were available for the offshore region that constitutes our study area; Table 1 summarises the data received and included in this report.

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[1] Address of the Norfolk Seamounts CVA web-site: http://www.marine.csiro.au/norfolkseamountscva/)

Table 1 Data sets received from various external sources

Data received	Custodian	Acronym
Registered vessel movement	Australian Maritime Safety Authority	AMSA
Fish records from the Norfolk Island EEZ	Australian Museum	
Commercial fisheries records (demersal & pelagic)	Australian Fisheries Management Authority	AFMA
Bathymetry	Geoscience Australia	GA
Species distribution on seamounts	SeamountsOnline (Stocks 2004 a)	
Geomorphological features	National Oceans Office and Geoscience Australia	NOO & GA
Survey data NORFANZ	National Oceans Office and CSIRO Marine and Atmospheric research	NOO & CMAR
Data made available for analysis at the workshop		
Species distribution on seamounts (from MUSORSTOM surveys)	Istitute du recherche pour le développement – B. Richer de Forges	IRD
MUSORSTOM survey stations	IRD web-site	
Database on regional distribution of ophiuroids	Museum Victoria – T. O'Hara	MV
New Zealand seamounts biodiversity study – data from 2 surveys	National Institute of Water and Atmospheric Research – A. Rowden	NIWA
Sponge data from New Caledonian seamounts	Queensland Museum – M. Schlacher-Hoenlinger	QM

In December 2004 the project hosted a small workshop to facilitate the exchange and discussion of available seamount biological data from Australia, New Zealand and New Caledonia. A workshop setting was considered to be an effective way to discuss the context of the available data, such as the reliability of the taxonomic identifications. Appendix 4 contains the list of participants, agenda and a summary of the two-day meeting.

Data analysis

Willcox *et al.* (2001) noted that despite a relatively large volume of data being available for parts of the Norfolk Ridge, Lord Howe Rise and on the Tasmanian Seamounts, compared to seamounts in other parts of the world, there was "*inadequate understanding of biogeographic relationships on which to base a comprehensive, adequate and representative network of MPAs*". Since that report, additional data have become available:

initial results of the NORFANZ survey (aimed at identifying and comparing the biodiversity of the southern and central Norfolk Ridge and the Lord Howe Rise) (Clark *et al.* 2003; Williams *et al.*, 2006); a national demersal and pelagic bioregionalisation for the Australian marine jurisdiction (undertaken by the NOO, GA and CMAR in partnership) (Heap *et al.* 2005; Lyne and Hayes 2005); and early results from NIWA surveys of seamounts in the New Zealand EEZ funded by the New Zealand Ministry of Fisheries (e.g. Clark 2000; Rowden *et al.* 2003; 2004). New information from these sources has been considered here to the extent possible; details of some faunal analysis are provided in Appendix 5.

Findings

Physical Environment

The setting for the study area is the Australian EEZ around Norfolk Island which is situated 1,676 kilometres north east of Sydney at 29°02' S; 167°57' E. The Territory of Norfolk Island comprises Norfolk, Philip and Nepean Islands, with a combined area of 3,727 hectares (GA 2004). It lies on the Norfolk Ridge in the south-eastern Coral Sea, on the north-eastern edge of the Tasman Front (see Physical Oceanography section) which forms the boundary between the Coral and Tasman Seas (*sensu* Tilburg *et al.* 2002; Condie *et al.*2003) (Figure 2).

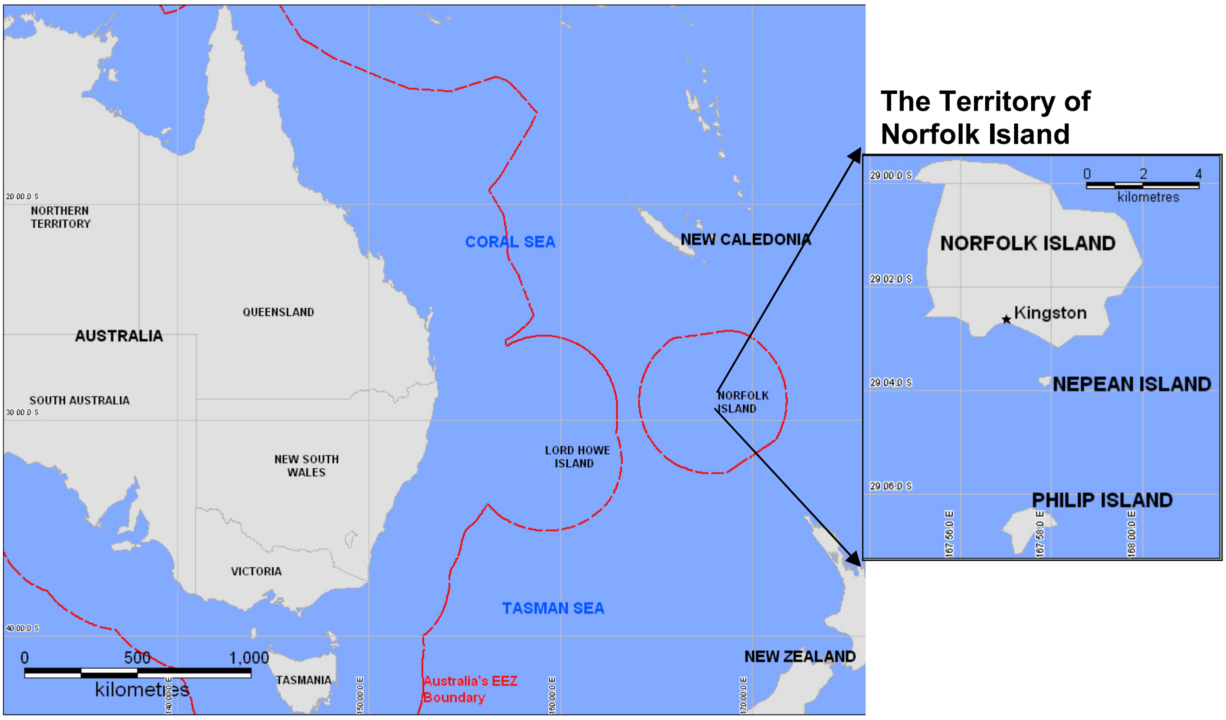


Figure 2 Location of the Territory of Norfolk Island in relation to Australia, New Caledonia and New Zealand. Also shown are the Coral Sea and Tasman Sea and the Australian Exclusive Economic Zone (EEZ) boundary as defined by AMBIS.

The Norfolk Ridge system bounds the eastern flank of the New Caledonia basin. It is a complex series of ridges and basins that extends some 1,600 km from the northern tip of New Zealand to New Caledonia (Mauffret *et al.* 2001) (Figure 3). It was once part of the old coastline of Gondwana, so most of it has existed in one form or another for over 70 million years (Stevens 1980; Eade 1988 a). The Norfolk Ridge proper lies to the north of Norfolk Island (Mauffret *et al.* 2001), while to the south the system is comprised of the West Norfolk Ridge, Wanganella Basin, Reinga Basin, and both Reinga and South Maria Ridges (here collectively called the Wanganella Bank region). These two parts of the Norfolk Ridge are separated by a northwest-trending scarp of the Vening Meinesz Fracture Zone. Mauffret *et al.* (2001) described the Norfolk Ridge proper as steep-sided, about 70 km in width, and "*having its western flank punctuated by a chain of seamounts (Norfolk Seamount Chain) that are prominent in the satellite gravity and related predicted bathymetry data sets*". Norfolk, Philip and Nepean Islands are the only exposed portions of the Norfolk Ridge.

The Australian Marine Jurisdiction around the Territory of Norfolk Island, and thus our study area, is bounded by the 200 nm Exclusive Economic Zone (EEZ, under Australia's territorial control). From a biological and physical point of view, the area can be divided into an ‘inshore’ area surrounding the island and extending to the continental shelf edge (200 m isobath), and an ‘offshore’ area – the EEZ beyond the 200 m isobath. Only the ‘offshore’ area was relevant to this study; the ‘inshore’ area was approximately defined by the inshore fishery box described by AFMA (2004 a) (i.e. an area of 67 x 40 nautical miles that includes all the continental shelf and upper continental slope) and not considered by this assessment.

The primary large-scale geological features of the study area include: to the west, the southern part of the New Caledonia Basin; to the east, part of a complex region which includes the North and South Norfolk Basins separated by the Nepean Saddle, Kingston and Bates Plateaus (that extend to the Three Kings Ridge and other features beyond our focus area, e.g. Mauffret *et al.* 2001); and centrally, a large portion of the Norfolk Ridge system (Figure 4).

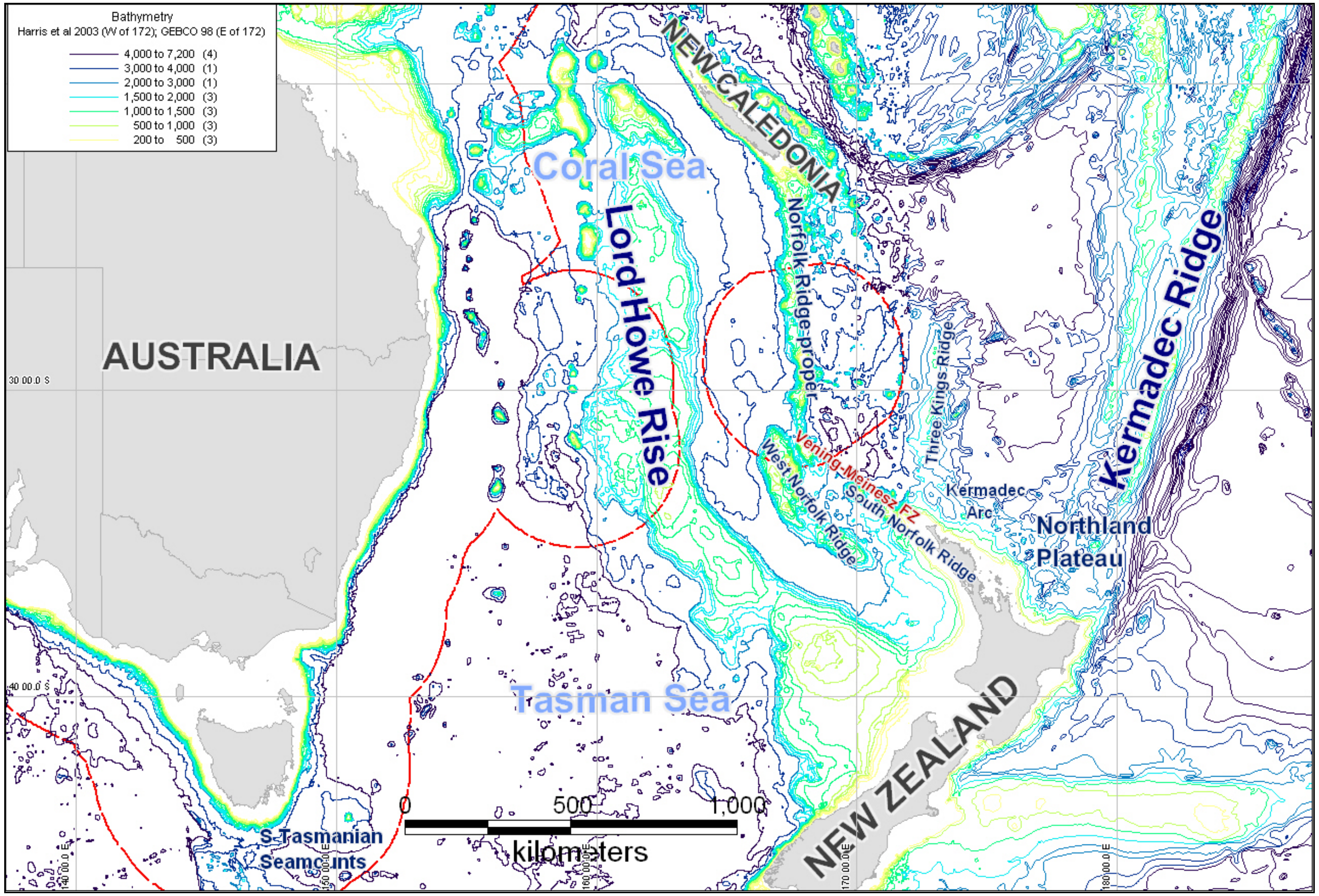


Figure 3 Regional bathymetry map showing the main geographical features of interest in the Tasman and Coral Seas Bathymetry of and main geographical features of interest in the Coral and Tasman Seas. Data from Harris *et al.* (2003) for the region west of 172º E, and GEBCO 97 Bathymetry for east of 172º E. Note, GEBCO 97 bathymetry does not cover depth shallower than 200 m.

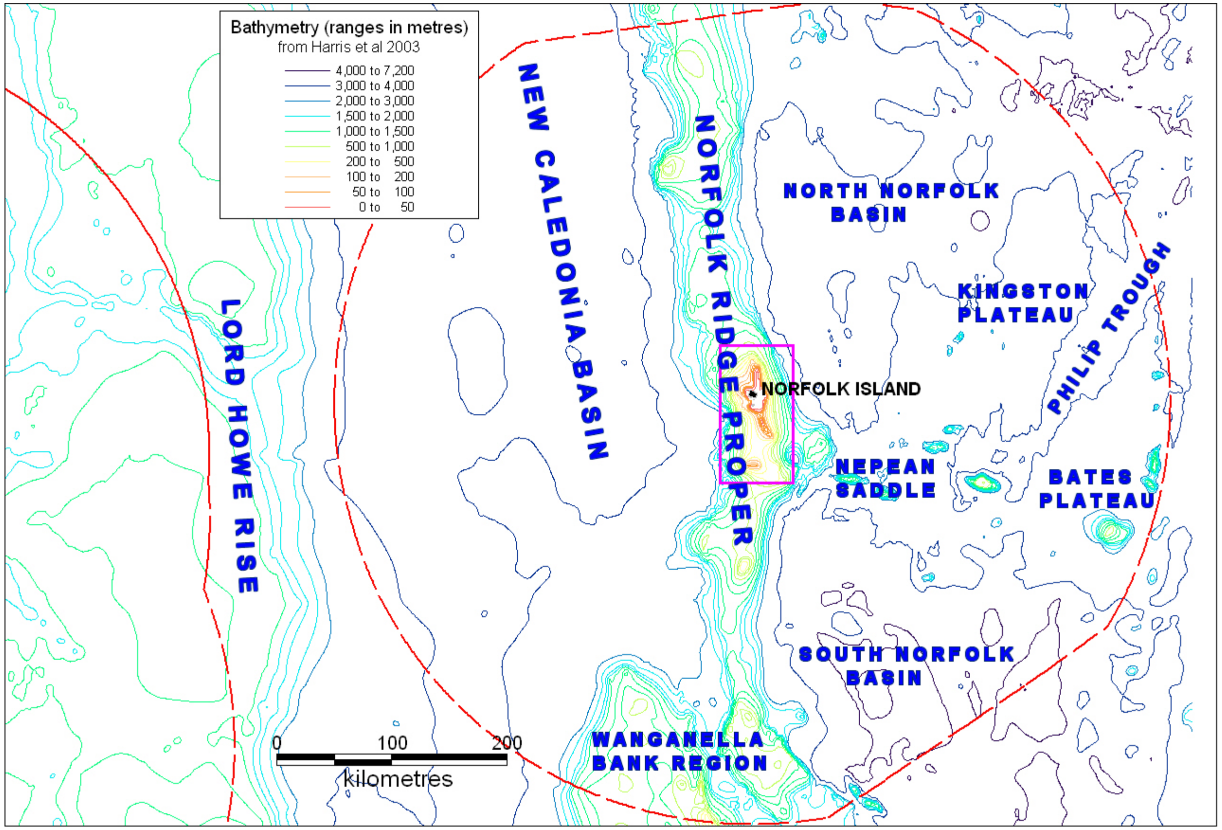


Figure 4 Close-up of the bathymetry of and the main geographical features in Australia's EEZ region surrounding Norfolk Island (data from Harris *et al.* 2003).

Bathymetry

The bathymetry of the entire Australian jurisdiction has been mapped and described by Harris *et al.* (2003) as a base data-set for the National Oceans Office's (NOO) Regional Marine Planning process. Figure 3 shows the regional map of the bathymetry in the Coral and Tasman Seas; Figure 4 zooms in to the area of this assessment.

The area between the Norfolk and Three Kings Ridges was mapped and described using multibeam bathymetry in an Australia/France collaborative seafloor mapping survey (FAUST-2) (see Mauffret *et al.* 2001). FAUST-2 delivered detailed maps and descriptions of the seafloor of the Nepean Saddle, and the Kingston Plateau, and identified Faust Guyot (see next section). However, bathymetry data for the remainder of the Norfolk region is particularly sparse (Harris *et al.* 2003). The bathymetric maps shown in Figures 3 and 4 have been created using, where available, swath mapping surveys and extrapolation from ship-track data, but the data has also been supplemented with data from the grid of predicted bathymetry from satellite altimetry (Harris *et al.* 2003). On the NORFANZ survey, additional swath mapping of target areas was completed. This information has not been added into the bathymetry maps of Harris *et al*. (2003) used here.

The shelf surrounding Norfolk Island is the only shallow region (depth less than 200 m) within the Norfolk Island EEZ. The NISA area appears to be entirely in deep waters of more than 200 metres depth. Seamounts are often defined as isolated structures that rise sharply up from the surrounding seafloor for at least 1000 metres (e.g. Wilson and Kaufmann 1987; Rogers 1994). The regions identified in the definition of the NISA area can be clearly distinguished in Figure 4, where closely spaced isobaths indicate a sharp rise in relief delineating the Norfolk Ridge, Wanganella Bank region and seamounts to the east of Norfolk Island, on the Neppean Saddle and Bates Plateau. The highest peaks in the NISA area are at 400 m below the sea surface on the Norfolk Ridge, south of Norfolk Island. The Wanganella Bank Region reaches its shallowest point at 600 m, while the seamounts to the east peak at depths of between 1000 m and 600 m below the sea surface.

Above we cited Mauffret *et al.* (2001) description of a series of seamounts to the west of the Norfolk Ridge as the *Norfolk Seamount Chain* – a feature identified on the basis of satellite gravity data from Sandwell and Smith (1997). Bernardel *et al.* (2002) described satellite-derived gravity as a valuable tool in identifying the location of both large-scale bathymetric features and deep-sea large-scale crustal features. However, distinct hills or seamounts along the western flank of the Norfolk Ridge are not shown in the more recent bathymetry maps created by Harris *et al.* (2003). Multibeam sonar mapping completed during the NORFANZ survey (Sites 3, 4 and 5) confirmed the existence of seamounts of a variety of size and morphology (see section below), but also that at least one seamount predicted by gravity-anomaly data did not exist (Williams *et al.*, 2006).

Geomorphology

The major geomorphic features of Australia's entire EEZ have been classified, described and mapped at a coarse spatial scale for the National Oceans Office (Harris *et al.* 2003). An extract from these maps shows the geomorphic features in the Norfolk Island EEZ (Figure 5). Those of interest to the present CVA are seamounts/ guyots and pinnacles which were defined by the Intergovernmental Oceanographic Commission (2001) as follows:

Seamount: A discrete (or group of) large isolated elevation(s), greater than 1,000 m in relief above the sea floor, characteristically of conical form.

Guyot: A seamount having a comparatively smooth flat top; also called a tablemount (at some time in geological history these have been above sea-level when their peaks eroded)

Pinnacle: Any high tower or spire-shaped pillar of rock, or coral, alone or cresting a summit.

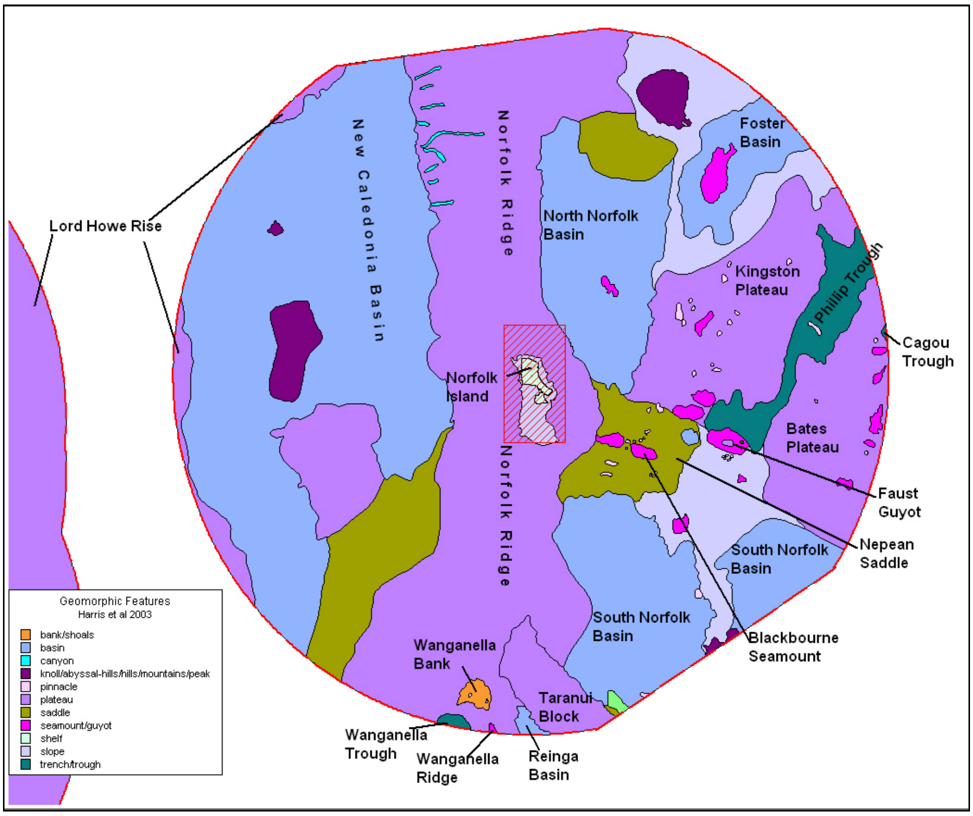


Figure 5 Map of the geomorphic features of the Norfolk Island EEZ, including their names where available (from Harris *et al* 2003)

On this basis, the distribution of seamounts in the NISA area (Figure 5) can be seen to include the cluster of seamounts and pinnacles to the east/ southeast of Norfolk Island situated on the Nepean Saddle and the Kingston and Bates Plateaus, with two more deep seamounts (peak depth 3,000 m below sea surface) to the northeast, one in each of the North Norfolk and the Foster Basins (Figure 5). These are primarily large structures, apparently 10s of km across the base. While Harris *et al*. (2003) did not identify any seamounts or pinnacles, sensu stricto, on the Norfolk Ridge or in the Wanganella Bank region, we have included these two regions in the assessment since their seafloors have elevated features and may act as a north-south conduit for seamount associated species distribution between New Caledonia and New Zealand. The presence of smaller seamounts on the western flank of the Norfolk Ridge was confirmed by the new data from the NORFANZ survey (Figure 8) but the total numbers and distribution remain to be verified.

The definition of what constitutes a seamount is blurred in the broader biological literature. Wilson and Kaufmann (1987) included guyots, large plateaus, submarine mountains (both isolated and in ridges) and some banks in their review of “seamount” biota, whereas Rogers

(1994) described three basic shapes: conical, elliptical and elongate. The conical shape is likely to include pinnacles since Rogers (1994) did not distinguish these. The Tasmanian seamounts protected in the *Tasmanian Seamounts Reserve*, (where the fauna were described by Koslow *et al.* 2001), were classified by Harris *et al.* (2003) as pinnacles. For the purposes of this study, we have not differentiated between seamounts, guyots and pinnacles since biodiversity conservation issues are to be found on the broad class of these elevated submarine structures.

The geomorphic definition of ‘seamounts’ and its ecological significance were discussed in the workshop held as part of this project. It was apparent that the seamount features studied in the four survey regions considered during the workshop (NORFANZ, New Caledonia, northern New Zealand and southern Tasmania) varied greatly in overall depth, height and morphology (Figures 6 to 8). The southern Tasmanian seamounts (Figure 6) are small conical ‘cinder cones’ and were identified as pinnacles by Harris *et al.* (2003), while the seamounts studied in New Caledonia (by B. Richer de Forges and co-workers at IRD, Figure 7) are flat-topped guyots with tops of several square kilometres and steep sides. Selected data from New Zealand provided by A. Rowden of NIWA indicated the seamounts on the Northland Plateau were similar in shape to the New Caledonian seamounts, while seamounts on the Kermadec Arc have narrower tops (see Rowden 2003; 2004). A range of seamount types were mapped during NORFANZ survey including features with steep topography on the Norfolk Ridge and on the Lord Howe Rise, some of which are outcrops of the ridge rather than isolated seamounts (Figure 8).

In addition to the differences in shape, the substratum types of the seamounts in the NISA area appear to be generally different from seamounts on the Norfolk Ridge inside the New Caledonian EEZ. Substrata on the New Caledonian seamounts are limestone and old coral (B. Richer de Forges, IRD, pers. comm.) while the substrata of seamounts on the Norfolk Ridge inside the Norfolk Island EEZ were volcanic rock (Williams *et al*., 2006.). Hinson (1990) also described the seabed on the northern and central Norfolk Ridge as hard volcanic rock which made trawling difficult.

Beyond noting these regional differences, no attempt has been made here to classify the morphology, structure, size, or sediments of the seamounts to enable more detailed comparison. To facilitate further assessment, a regional scale database of seamount features should be compiled using the NIWA template for seamounts in New Zealand’s EEZ.

Variables to evaluate include depth at peak and at base, base area, Chlorophyll *a* concentration above the peak and distance to continental margin (A. Rowden, NIWA, pers. comm.).

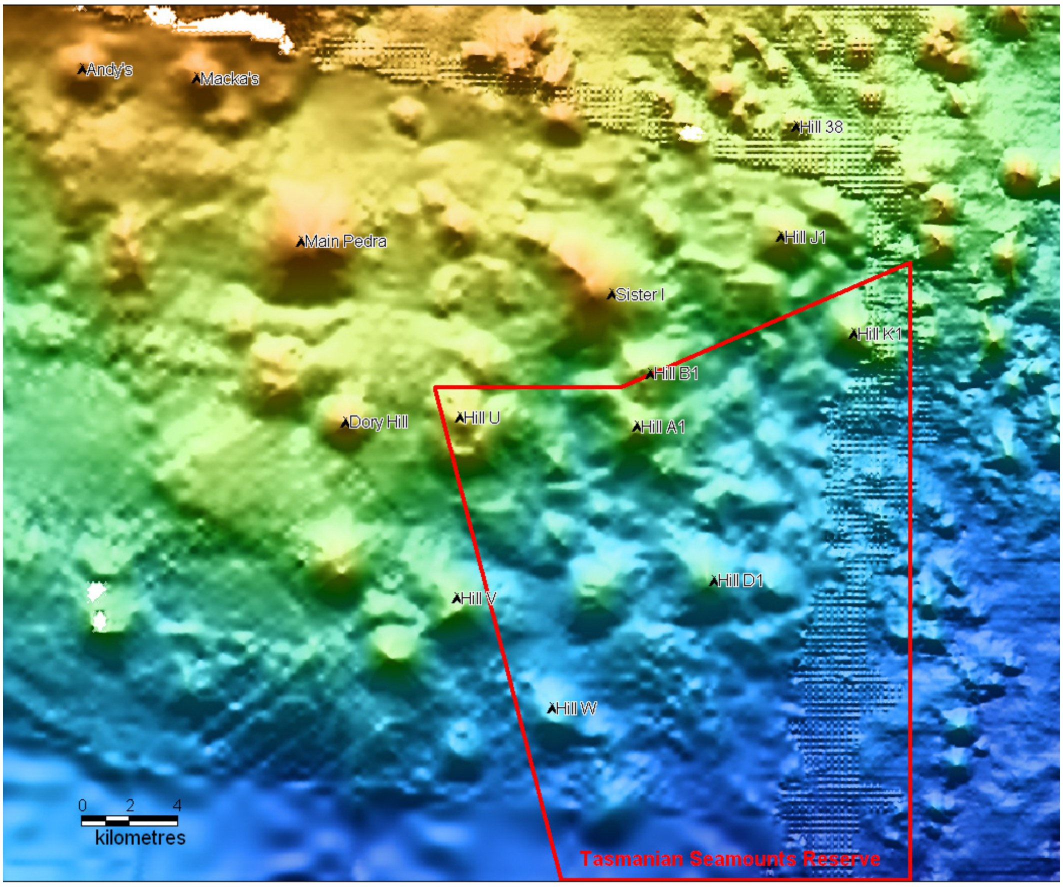
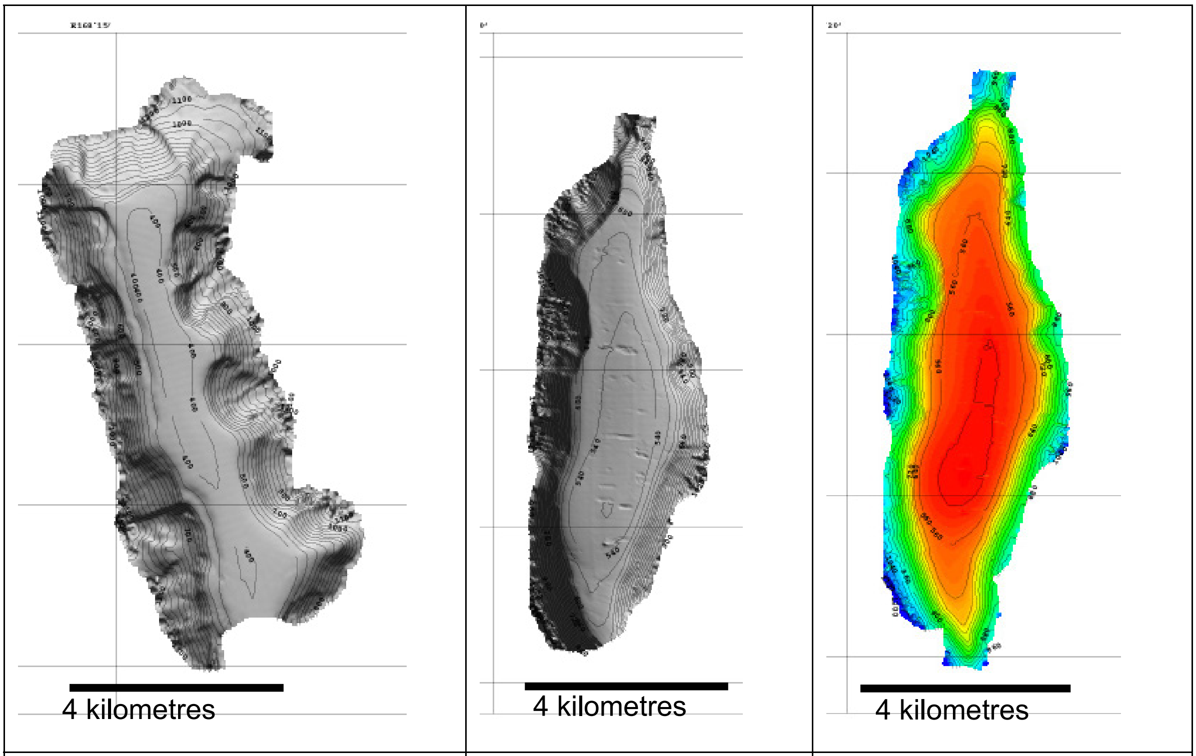


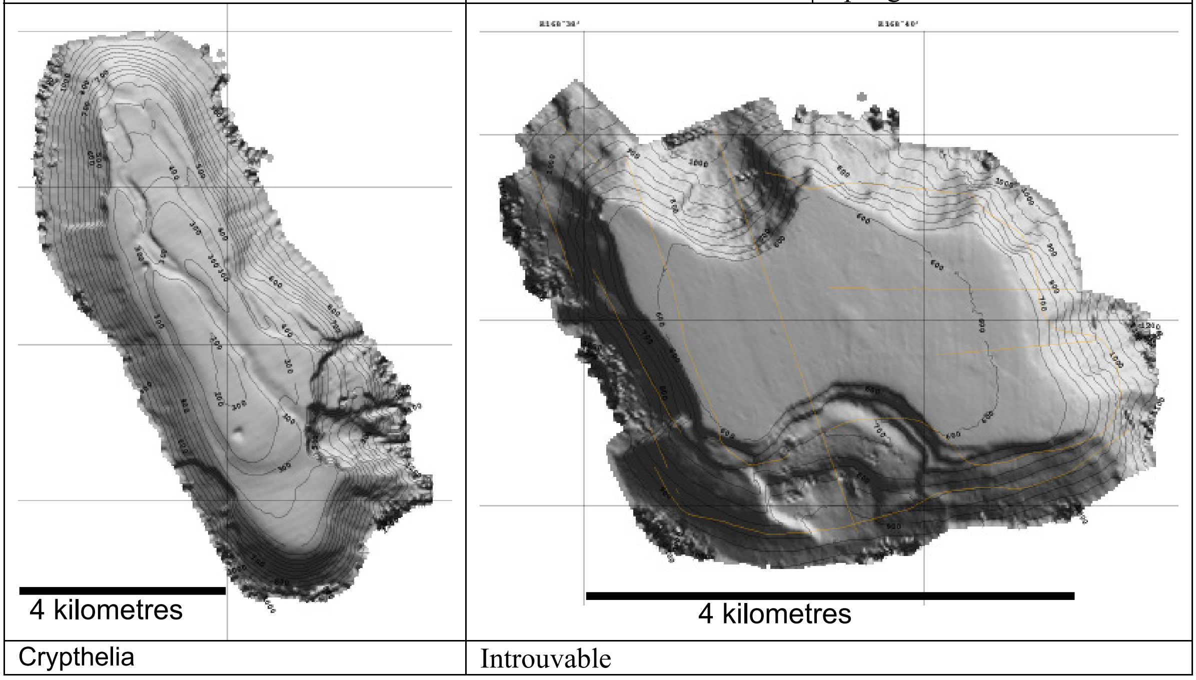
Figure 6 'Southern Tasmanian Seamounts'. Swath map of some of the 45 pinnacles identified to the south of Tasmania by Harris *et al* (2003). The seamounts sampled by CSIRO in 1998 are identified by name; the Tasmanian seamounts Reserve boundaries are also included. Swath data kindly provided by Geoscience Australia (GA). (Vertical exaggeration 5x)



Jumeau East

Brachiopode

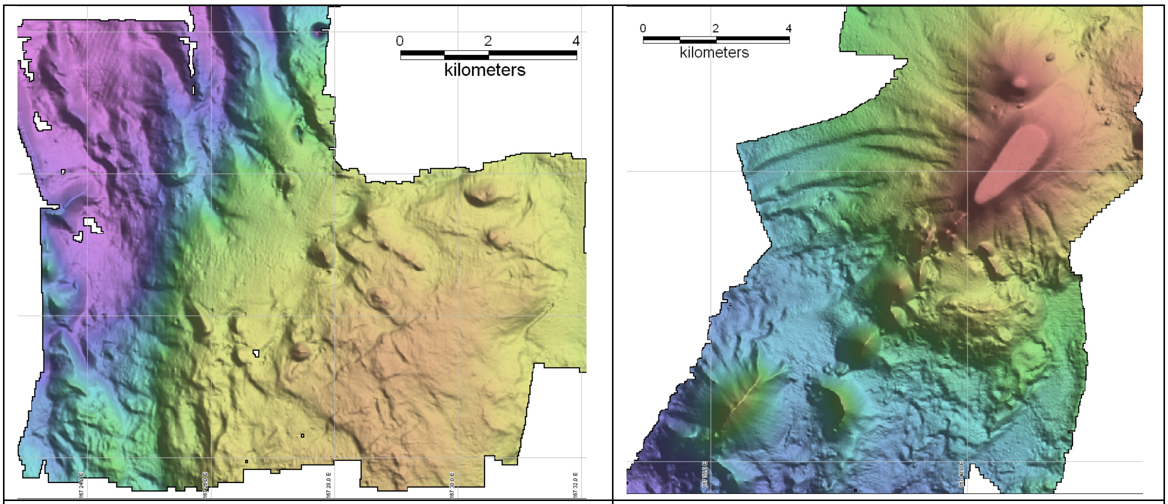
Eponge



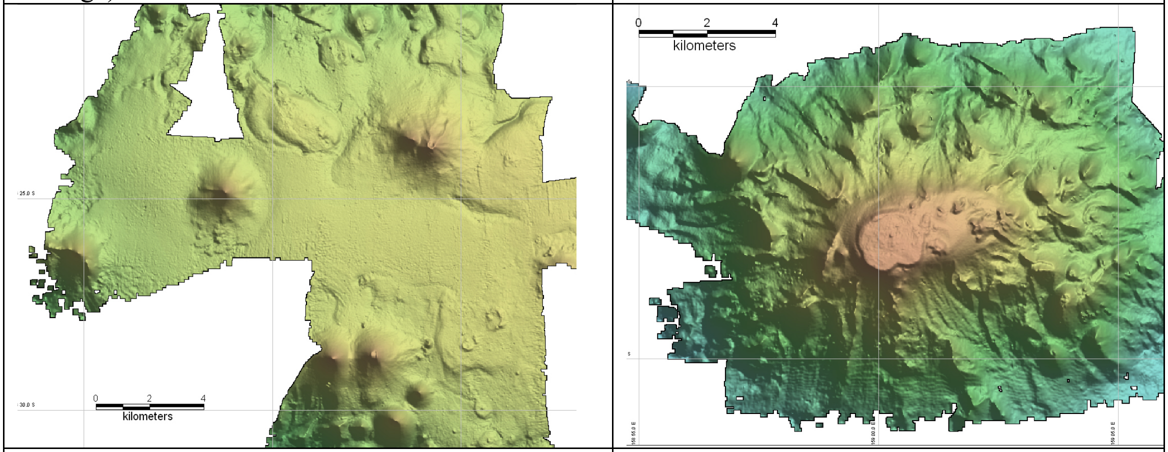
Crypthelia

Introuvable

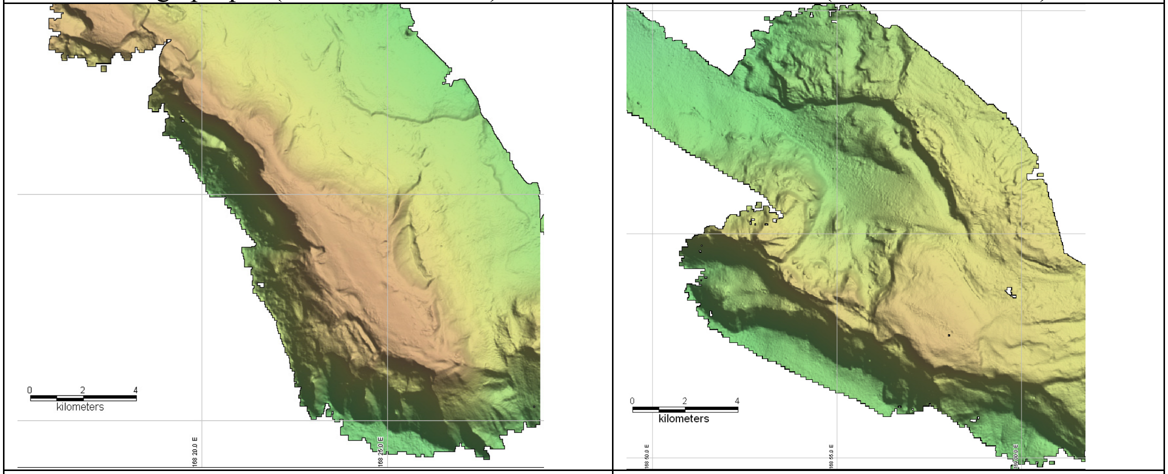
Figure 7 New Caledonian seamounts on the Norfolk Ridge. Swath and bathymetry maps of five of the ten seamounts in the New Caledonian EEZ studied by Dr. B. Richer de Forges of IRD. (Kindly provided by Dr. B. Richer de Forges of the Institute du Recherche pour le Development (IRD)). (Vertical exaggeration: 1x)



Norfolk Ridge proper (NORFANZ Site 3) (edge of ridge) | Norfolk Ridge proper (NORFANZ Site 4)



Norfolk Ridge proper (NORFANZ Site 5) | Lord Howe Rise (NORFANZ Site 6)



West Norfolk Ridge (NORFANZ Site 12) | West Norfolk Ridge (NORFANZ Site 13)

Figure 8 Seamounts on the Norfolk Ridge and Lord Howe Rise. Swath maps of six of the 14 features studied on the NORFANZ survey (NORFANZ unpublished data). (Vertical exaggeration: 5x)

Physical oceanography

Currents, Fronts and Eddies

The boundary between the Coral and the Tasman Seas is formed by the Tasman Front (*sensu* Tilburg *et al.* 2002; Condie *et al.*2003). The oceanographic significance of the Tasman Front is less related to the rather small change in water mass properties between the warmer Coral Sea and the cooler Tasman Sea, but rather that it marks the path of the separated components of the East Australian Current (EAC) (Condie *et al*. 2003). The EAC is a western boundary current that follows Australia's eastern coastline from 18º S to about 35º S (Boland and Church 1981; Ridgway and Dunn 2003). A portion of the EAC separates from the Australian coast near Sugarloaf point (NSW) forming the Tasman Front as it meanders westwards (Stanton 1981), creating the boundary between the Coral Sea to the North and the Tasman Sea to the south (*sensu* Tilburg *et al.* 2001; 2002). The western boundary current along New Zealand's coastline, the East Auckland Current (EAUC), is formed by the reattachment of a part of the Tasman Front flow to New Zealand's east coast (Stanton 1981; Tilburg 2001; Ridgway and Dunn 2003).

The deep water of the Coral Sea at depths relevant to seamount studies (i.e. greater than 600 m) is part of the Antarctic Intermediate Water mass. This mass has one major arm that supplies the Eastern South Pacific Ocean before spreading westwards through the Coral Sea to join the EAC from the north and exit the area along the path of the EAC (Tomczak and Godfrey 1994). Along this path this arm opposes a second, southern arm of Antarctic Intermediate Water that enters the Tasman Sea on a direct route from the Polar Front (Tomczak and Godfrey 1994).

The finer scale structures of the EAC system were examined by Ridgway and Dunn (2003) who identified four quasi-permanent eddies that appear to be associated with abrupt topography: (I) the Norfolk Eddy, (II) North Cape Eddy, (III) East Cape Eddy, and (IV) Wairarapa Eddy (Figure 9). The first three are associated with the eastern margin of the Norfolk Ridge, the Three Kings Rise and the southern margin of the Kermadec Ridge (Ridgway and Dunn 2003). The fourth appears to be associated with the Ritchie Banks and the Wairarapa Orange Roughy grounds, to the North of the Chatham Rise. These quasi-permanent eddies are persistent, stationary features unlike the well studied and documented warm-core eddies shed by the EAC off the south eastern coast of Australia (e.g. Brandt 1981; Nilsson and Cresswell 1981).

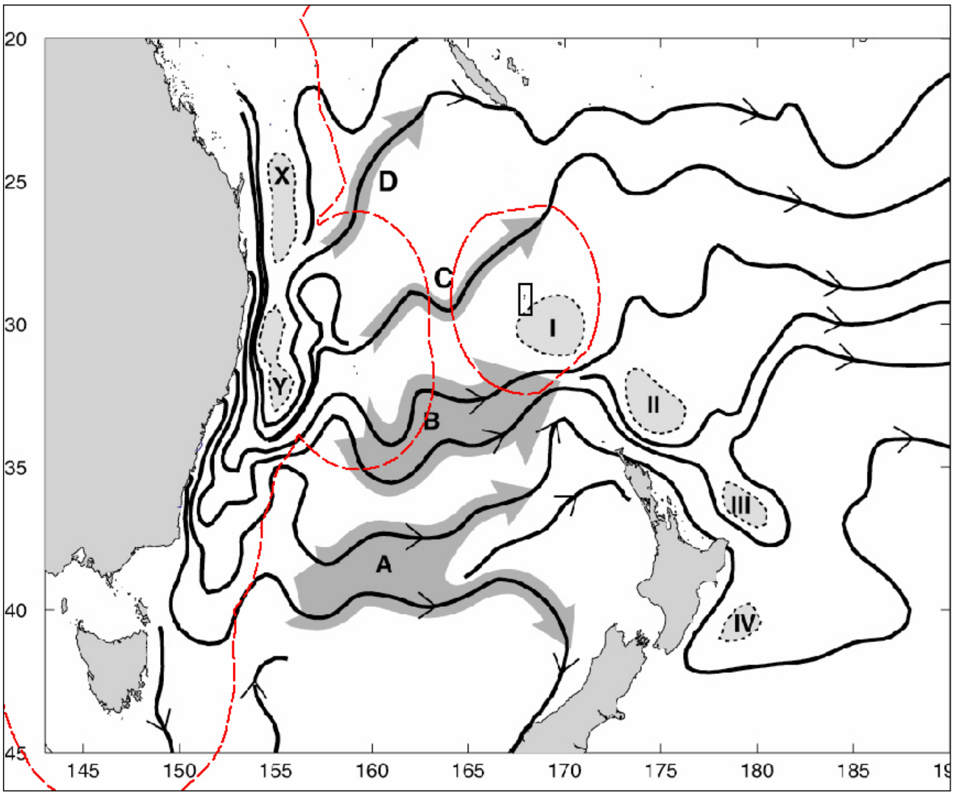


Figure 9 A schematic summary of the individual surface currents and eddies within the Tasman Sea. Figure 7 of Ridgway and Dunn (2003) with the Australian EEZ (AMBIS) and the Norfolk Inshore Fishery Box (AFMA) overlaid. The four components of the separating EAC flow are denoted by A, B, C, and D. Note that B represents the flow associated with the Tasman Front. The four quasi-permanent eddies surrounding New Zealand are I, Norfolk Eddy; II, North Cape Eddy; III, East Cape Eddy and IV, Wairarapa Eddy. X and Y are two anticyclonic recirculation cells associated with the EAC flow within the Tasman Abyssal basin.

While the North Cape, East Cape and Wairarapa Eddies have been described and studied before, the Norfolk Eddy had not been recognised prior to Ridgway and Dunn’s (2003) work. The Norfolk Eddy has, within the thermocline, a temperature and salinity signature of more than 1 ºC and 0.05 psu respectively, and is still evident as a coherent feature at 1,500 m depth (Ridgway *et al.* 2002). Depth-averaged steric height derived from the temperature (*T*) and salinity (*S*) fields in the CSIRO Atlas of Regional Seas (CARS) is shown in Figure 10. In this representation, the first three quasi-permanent eddies can be seen clearly; the Wairarapa eddy is not as distinct.

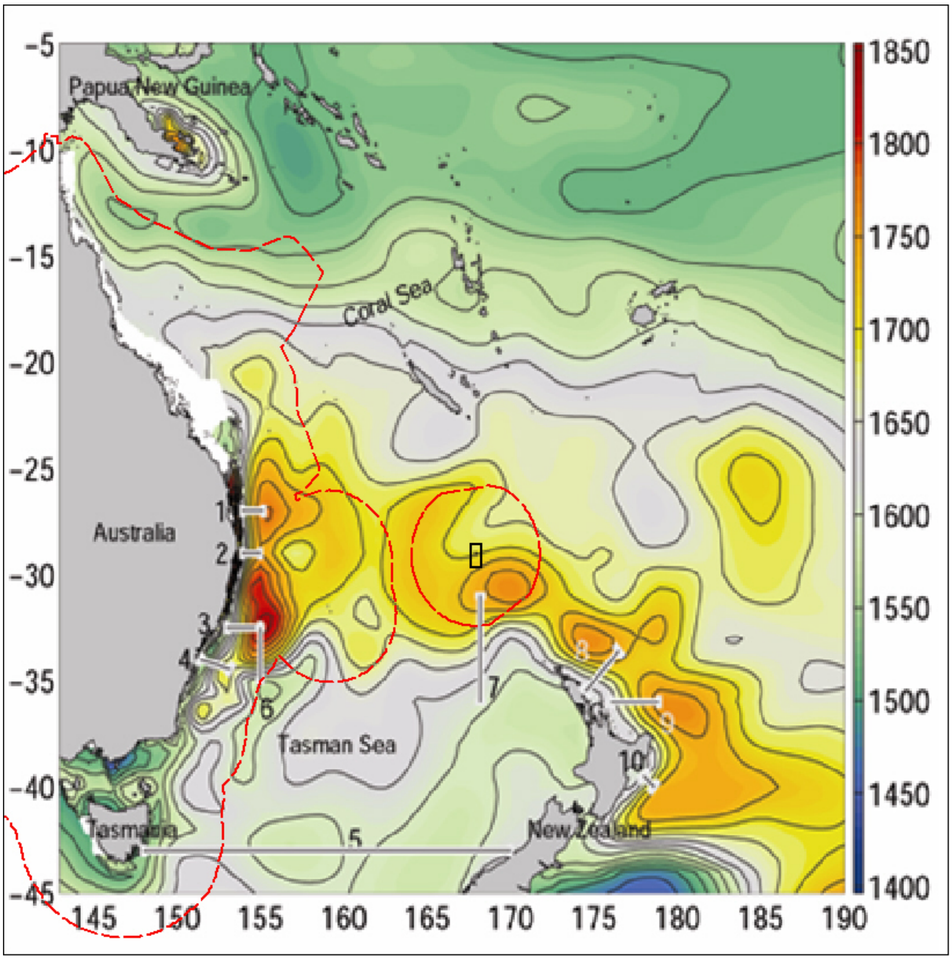


Figure 10 The depth averaged steric height (or mass transport function $P_{0/2000}$) derived from the *T* and S fields in the CARS atlas. Figure 3 of Ridgway and Dunn (2003) with the Australian EEZ (AMBIS) and the Norfolk Inshore Fishery Box (AFMA) overlaid. The contour interval is 25 m^2. The sections 1-10 are not discussed here.

The East Cape and Wairarapa Eddies have been described as a potential mechanism for the retention of rock lobster larvae, supporting the rich lobster fishery on the south-east coast of New Zealand’s North Island (Chiswell and Roemmich 1998).

The Norfolk Eddy encompasses the seamounts and pinnacles described by Harris *et al.* (2003) to the east-southeast of Norfolk Island (Figure 10), while the deeper seamounts and pinnacles to the northeast are influenced by lower steric heights (Figure 11). Model predictions show that flow fields have the potential to constrain species geographic ranges even when suitable habitat outside that range is abundant, and that they may function as one-way or two-way barriers to range extension (Gaylord and Gaines, 2000). As the Norfolk Eddy is coherent to depths of 1,500 m it may be inferred that there is a high potential for the retention of larvae from seamounts of the Nepean Saddle, Bates Plateau and South Norfolk Basin region, and the possibility that this may lead to higher levels of endemism in the area under the eddy. The seamounts of Foster Basin, North Norfolk basins, Kingston Plateau and Phillip Trough are likely habitats to a different larval pool.

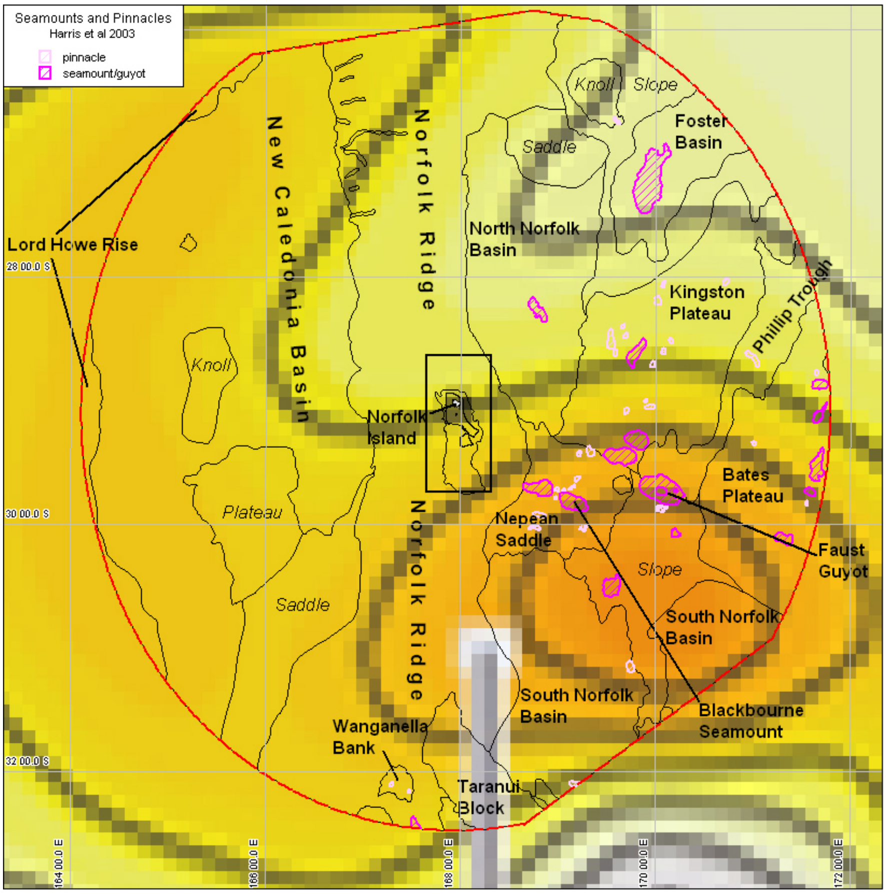


Figure 11 Close-up of Figure 10, showing the Norfolk Eddy in relation to the Norfolk island EEZ and the geomorphic features identified by Harris *et al.* (2003). Seamounts and pinnacles were thematically mapped (dark and light pink, respectively); all other geomorphic features are outlined and labelled by name (bold) or feature type (*italics*).

Productivity

Our study area is situated within a band of annual mean sea-surface chlorophyll-*a* concentrations between 0.1 and 0.2 mg m^{-3}, as pictured by Tilburg *et al.* (2002; Figure 1). The Coral Sea and, in particular, the EAC are nutrient poor and thus chlorophyll levels are low in that region (Tilburg *et al*. 2002). In contrast, the productivity in the Tasman Sea is higher with spring and autumn blooms of phytoplankton occurring regularly in the western part. These blooms are a result of vertical mixing of the water column by eddies that spin off the EAC south of its separation from the Australian coast (Tilburg *et al*. 2002).

The East Cape Eddy has been described as a mechanism for nutrient retention which leads to spring and autumn blooms of phytoplankton and is followed by peak biomass of salps in the region (Bradford *et al.* 1982). This eddy, similar to the Norfolk Eddy, is generated by the sharp topographic relief (Bradford *et al* 1982; Ridgway and Dunn 2003). Thus, there is a possibility that the Norfolk Eddy supports similarly increased productivity. Unfortunately, the Tilburg *et al*. (2002) illustration is too broad to show such a trend and we found no productivity studies that focus on the NISA area.

Distinct sub-regions within the assessment area

On the basis of physical data, the NISA area can be subdivided by large-scale geomorphology, bathymetry and oceanography into four sub-regions containing seamounts: (1) the centrally located Norfolk Ridge proper, (2) the Wanganella Bank region in the south, (3) an area of shallow and deep seamounts to the east/southeast of Norfolk Island (encompassed by the Norfolk Eddy) and (4) scattered deep seamounts in an area to the northeast of Norfolk Island (outside the Norfolk Eddy). In the context of ecosystem and biodiversity distributions, there are likely to be important, but as yet unknown, ecological characteristics of individual seamounts or clusters of seamounts such as depth range and size that vary within each of these broadly defined subregions.

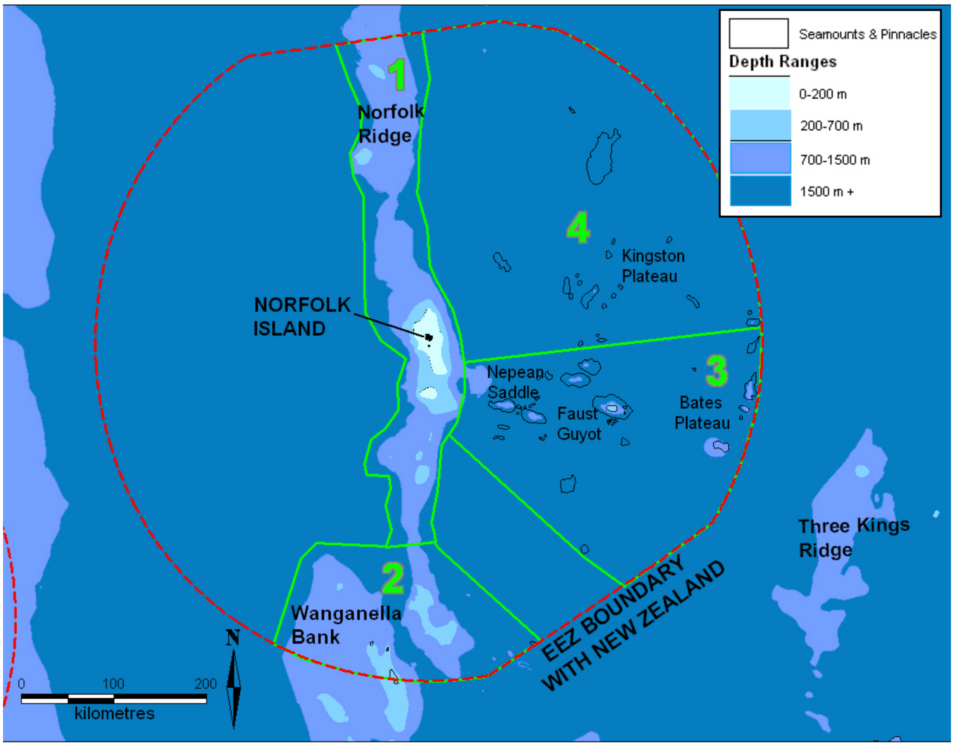


Figure 12 The Norfolk Island Seamounts Area (NISA) showing four sub-regions containing seamounts (outlined in green) differentiated on the basis of geomorphology, bathymetry and oceanography. Legend shows (1) depth ranges important for biodiversity distributions and (2) outlines of seamounts and pinnacles (following Harris *et al.* 2003)

Biological Environment

Bioregionalisation

Norfolk Island Region

Bioregions represent broad landscape patterns that are the result of the interplay between a range of factors including geology, climate and biota (Gouldthorpe and Gilfedder 2002). The process of 'bioregionalisation' is designed to provide ecologically meaningful '*boundaries and the framework for biodiversity or conservation management and the integrated, multiple-use management of other specific human activities or uses*' (IMCRA Technical Group 1998).

The IMCRA Technical group (1998) provided an interim marine and coastal bioregionalisation of Australia (IMCRA). In that assessment, Norfolk Island was classed as one of three sub-provinces within the wider "Norfolk Province" – (NorfP *a*) Norfolk Island, (NorfP *b*) Lord Howe Island, and (NorfP *c*) Elizabeth and Middleton Reefs (IMCRA Technical Group 1998). The Norfolk Province was described as a "*well defined subtropical province with a strong mix of both tropical Indo-Pacific species and warm temperate species from Australia and New Zealand*" with a significant component of endemics. The inshore fauna of Norfolk Island was described as resembling that of Australia's Central Eastern Province, while the offshore fauna on the submarine ridges was believed to share close affinities with New Caledonia and New Zealand (IMCRA Technical group 1998).

The National Oceans Office, in partnership with Geoscience Australia and CSIRO Marine and atmospheric Research, is currently determining both a benthic and pelagic bioregionalisation for Australia's EEZ. This process will extend IMCRA by incorporating more data – especially from offshore areas and work completed since 1998 – and by using more sophisticated spatial analyses. The detailed results of this process were only released a publicly at the end of this CVA project. The benthic regionalisation has classified the area of the Norfolk Island EEZ as a distinct benthic biogeographic province and has formally identified it as PV21 – the Norfolk Island Province (Heap *et al.* 2005); the pelagic regionalisation includes Norfolk Island in the Level 1b_P13 – the Coral Sea Circulation region (Lyne and Hayes 2005).

In the NOO national bioregionalisation process, *benthic* provinces (= Level 1 habitats) are defined as 'large biogeographic regions based on broad-scale distribution of fauna' (Heap *et al.* 2005). In most cases, benthic provinces were identified by statistical analyses but this was not possible for the offshore island territories (Heap *et al.* 2005). Characterisation of the Norfolk Island Province relied mostly on expert evaluation of the distributions of deep-water fish assemblages, and on geomorphic features in isolation where no fish data was available (i.e. > 2,000 m) (Heap *et al.* 2005). However, differences between the fauna of this province and faunas from continental Australia, the other ridges in the Coral/Tasman Seas, and from New Zealand and New Caledonia, will need to be quantified and characterised by taxonomic experts in order to confirm the classification of Norfolk Island Province (P. Last, CSIRO Marine Research, pers. comm.).

Level 1 habitat in the corresponding draft *pelagic* regionalisation refers to Oceanic Zones – a series of zonal circulatory processes that are driven by a combination of winds, solar forcing, air/sea moisture exchange and geostrophy (Lyne and Hayes 2005). The substructure, including depth structure of the Oceanic Zones, is described as bands of water types comprising a series of zonal core water masses, transitional water masses and fronts referred to as Level 1b (Lyne and Hayes 2005). The Coral Sea Circulation region (Level 1b_P13) contains the East Australian Current waters and its associated eddy fields. This current is the western boundary current in the south Pacific ocean: it leaves the Australian coast at about 34°S to flow around the northern end of New Zealand and down its east coast (East Auckland Current) (Lyne and Hayes 2005).

In summary, the benthic fauna in the marine region surrounding Norfolk Island is recognised as being different from other regions within the Australian Marine Jurisdiction at a provincial scale, but quantitative analysis of a broader geographical range of data covering a greater variety of fauna is required to confirm and add detail to this classification. The bioregional structure of the pelagic realm, and its influence on the benthic fauna, is not yet known; however, ocean features at a range of hierarchical levels down to individual eddy structure (especially the Norfolk Eddy) are likely to be relevant to the distribution of biodiversity in the NISA.

Norfolk Island Seamounts Area

Butler *et al.* (2001) used the term 'seamount faunal biogeographic provinces' to define the spatial extent of seamount-associated fauna and ecosystems. They may be comprised of individual seamounts, seamount clusters or entire ridge systems, depending on the level of species endemism. Seamounts are, in general, unique deep-sea environments that have diverse, specialised faunas characterised by high levels of endemism (Rogers 1994; Koslow and Gowlett-Holmes 1998, Richer de Forges *et al.* 2000; Willcox *et al.* 2003; Stocks 2004 b). Thus, isolated seamounts or clusters of oceanographically connected seamounts can act as isolated 'islands' that foster speciation and endemism over millennia (Wilson and Kaufmann 1987). However, they may also provide stepping-stones, along ridges or oceanographic currents, in transoceanic dispersal of plankton and planktonic larvae of benthic species (Wilson and Kaufmann 1987; Christiansen *et al.* 2000).

It cannot be determined whether the four NISA sub-regions, differentiated primarily on their physical characteristics, represent separate 'seamount faunal biogeographic provinces' – and see notes below under MPA criteria.

List of species

Characteristics of seamount biota

The striking difference between invertebrate communities from seamounts and those from non-elevated deep sea habitats, such as the continental slopes or abyssal plains, is the prevalence of filter-feeding emergent epifauna rather than deposit-feeding infauna (Rogers 1994; Stocks 2004 b). Wilson and Kaufmann (1987) reviewed data collected from seamounts in 11 regions world-wide. They report that Cnidarians (including corals), molluscs (gastropods and bivalves) and arthropods (crustacea) made up the most widely distributed invertebrate phyla in their study; with sponges and protists also abundant. In a more recent overview of the invertebrate fauna of 171 seamounts world-wide, Stocks (2004 b) lists crustacea and anthozoa (corals and anemones) as the major taxonomic groups. Gastropods, bivalves, echinoids (sea urchins), ophiuroids (brittle stars), asteroids (sea stars), polychaetes and hexactinellids (glass and related sponges) are also commonly recorded from seamounts (Stocks 2004 b).

Many dominant fish species associated with seamounts have different physiological and ecological characteristics from most deep-sea fishes. For example, most deep-sea fishes at continental slope depths (200-1,500 m) are pelagic and generally have greatly reduced bone and musculature, being either eel-like to maintain a minimal profile as they move through the water, or blob-like ambush predators with lures, well developed dentition, exceptionally large gape and highly distensible stomachs to reduce their need for mobility and agility (Koslow 1997). In contrast, dominant species on seamounts include orange roughy (*Hoplostethus atlanticus*) and deepwater oreos (Family Oreosomantidae), deep-bodied perciform fishes characterised by bony skeletons and firm flesh of high protein and lipid content (Koslow 1997). Their aggregating behaviour around seamounts makes them the target of commercial fishing operations.

A similar summary to Stocks' (2004 b) for seamount fishes by Froese and Sampang (2004) included 535 species (365 demersal/ benthopelagic and 170 pelagic) from 60 seamounts world-wide. Although only a small percentage of all known fish species is represented on seamounts (2%), the checklist represents 25% of taxa at Family level and 47% of taxa at the level of Order indicating that fish communities on seamounts are phylogenetically very diverse. The complete checklist of seamounts fishes may be found in the Appendices of Froese and Sampang (2004).

Checklists of taxa

Relative to other world oceans, the seamounts of the south-western Pacific are viewed as well surveyed (Richer de Forges *et al* 2000; Willcox *et al*. 2001). However, survey work has been highly concentrated, with surveys completed in the Coral and Tasman Seas focused around New Caledonia (Crosnier 1990, 1991 a, 1991 b, 1997, 2000) and to the north of New Zealand (Clark 1988; 1999; 2000; Clark *et al.* 1999; 2000; Clark and O'Driscoll 2003; Rowden *et al.* 2003; 2004). Closer examination showed that the seamounts in the Norfolk Island EEZ region are very poorly sampled (details in Appendix 5), with only a few samples provided by one biological survey. This was the 'NORFANZ' survey (Clarke *et al.* 2003; Williams *et al*., 2006) that collected material from three sites on the Norfolk Ridge and one on the Wanganella Bank within the NISA area. A **complete** checklist of species generated from these samples is given in Appendix 6; it is comprised of 546 benthic macro-invertebrates and 251 benthic fishes. Thus, in both the global and western Pacific contexts, the Norfolk Seamounts area encompasses a very large region whose benthic fauna is poorly represented in museum collections and in the current literature.

Key species

Key species in the context of this assessment fall into several categories: listed and protected species known to occur in the region; those with special biodiversity values (e.g. endemic or rare); those that distinguish the seamounts in the Norfolk Island area from seamounts elsewhere in the Australian marine jurisdiction (e.g. the Lord Howe Rise and southern Tasmania); and those of commercial value.

Listed and protected species

Sixty-one species occurring within the EEZ region of Norfolk Island are covered by one or more provisions of *the Environment Protection and Biodiversity Conservation (EPBC) Act* (*EPBC Act* 1999): 25 sea bird species, two turtles, one pipe fish, and 33 cetaceans (Appendix 6). The pipefish may be excluded from the present assessment as its distribution is limited to shallow waters surrounding Norfolk Island and thus to the excluded inshore fishery zone. The *EPBC Act* (1999) includes three types of listings: listed marine species, threatened marine species, and listed migratory marine species (Appendix 6). Listed marine species cover all the species in the Appendix 6 list, with the exception of two vulnerable bird species (*EPBC Act* 1999) and the cetaceans which are listed under their own category. ‘Threatened’ marine species cover eighteen of the sixty species; 6 are classed as endangered (three albatross species, southern giant petrel, blue and southern right whale), the remaining 12 are classed as vulnerable (six albatross species, three petrel species, humpback whale, green and leatherback turtle). The listed marine migratory species cover 14 birds, 2 turtles, and 8 cetaceans. Since our study area only covers deep-sea environments, our main concern with species listed under the *EPBC Act* (1999) is their potential connection to seamount-related productivity. The presence code in Appendix 6 indicates that only ten of the listed species, all birds, were shown to breed, and thus also forage, in the Norfolk EEZ and one additional bird, Tristan’s Albatross, ‘may forage’ in the region. The remaining species were classed as ‘*species or species habitat likely to occur in the region’* (*EPBC Act* 1999).

Additional bird and a cetacean species are also potentially linked to seamount-related productivity are listed, together with their source, in Table 2.

Table 2 Additional species not listed on the EPBC web site

Scientific Name	Common name	Source
Seabirds		
Sterna fuscata	Whale Bird	http://www.deh.gov.au/parks/norfolk/index.html)
Gygis alba	White Tern	http://www.deh.gov.au/parks/norfolk/index.html)
Anous stolidus	Common Noddy	http://www.deh.gov.au/parks/norfolk/index.html)
Anous minutus	Black Noddy	http://www.deh.gov.au/parks/norfolk/index.html)
Cetaceans		
Indopacetus pacificus	Longman’s Beaked Whale	P. Stevenson and M. Christian pers. comm. (unconfirmed sightings)

Endemic and rare species

A major problem in assessing endemism and rarity in this fauna, and that of the deep sea generally, is the lack of *species-level identifications*. Good progress has been made in identifying species in the NORFANZ collections in the <2 years since the survey (Williams *et al*., 2006), but it is not yet possible to produce a reliable list of endemic species from the seamounts within this study area. This will be an ongoing and step-wise process, with progress on individual taxa dependent, firstly, on the availability of an expert to undertake the work, and then their opportunity (time and funding) to implement it. For example, an authorative treatment of the squat lobsters (see below and Figure 13) was independently funded and completed at the same time this assessment was undertaken, while many other taxa have no foreseeable opportunity for upgrade.

It is important to note that while the taxonomic resolution of many groups (e.g. fishes) in faunal collections from individual surveys in the Coral and Tasman Seas region is of species-level taxa, for most groups they are described only as coded 'operational taxonomic units' or OTUs. For example, there are 113 species-level taxa of glass sponges (class Hexactinellida) coded with numbers between 6 and 144. This enables estimation of 'species richness' – the numbers of species-level taxa present – but does not permit comparison of species lists between surveys (e.g. Appendices 4 and 5) because there is no consistency in the nomenclature of the coded OTUs. To achieve this requires using taxonomic descriptions already published in the scientific literature, and often side-by-side comparison of specimens by experts. This process typically takes a period of many years, but until the coded identifications are reconciled between surveys, species distributions, and therefore endemicity, cannot be reliably evaluated.

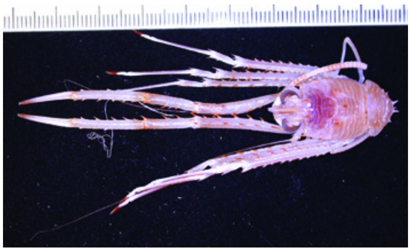
The NORFANZ data set does, however, enable **within**-survey comparison of macro-invertebrate and fish collections. Thus, the Norfolk Island region seamount collections can be compared to those from seamounts on the Lord Howe Rise. In addition, the fishes and ophiuroids can be further compared to collections from the eastern or western Tasman Sea and to southern Tasmania because the between-survey taxonomy has been completed (ophiuroids by Dr Tim O'Hara of Museum Victoria and some groups of fishes by the NORFANZ participants collectively). Spot endemics (species with apparently very restricted distributions) were numerous: from the total collection of 331 macro-invertebrate and 101 fish species collected **exclusively** within the NISA area, 316 invertebrate and 74 fish species-level taxa were recorded at only one station, while 14 and 19 respectively were found only at two stations – these species/ OTUs are identified in Appendix 6. A high proportion of species confirmed to be new to science in the NORFANZ collections were collected, although not exclusively, from the NISA area: 26 of the 66 new invertebrate species, and 17 of the 29 new fish species reported by Williams *et al.* (2006).

A few of the many examples of rare species from the NORFANZ collections (in the above sense of 'spot endemics') are highlighted here to illustrate this aspect of conservation value. Among the sponges (Phylum Porifera), one species from each of the highly specialised group of rare carnivorous sponges of the Family Cladorhizidae and the 'living fossils'

(Family Lithistidae), were collected on the Norfolk Ridge. Eight species of squatlobsters (family Galatheidae – Figure 13), including four of the nine new species of *Munida* described from the NORFANZ survey, are among the species recorded exclusively from the NISA area. Ahyong and Poore (2004) described the genus *Munida* as relatively restricted in its distribution, a significant exception to the usually wide-ranging genera of squatlobsters. Four of the twelve new species of seaspiders (Phylum Pycnogonida) that were discovered in the NORFANZ survey were reported from the NISA (Williams *et al*., 2006); three were collected exclusively on the Wanganella Bank region and one on the Norfolk Ridge proper (Appendix 6).

Invertebrate systematic studies have shown that some Norfolk Ridge seamounts in the New Caledonian EEZ support benthic sponges, hydroids, crinoids, molluscs and echinoderms with direct relationships to the Mesozoic fauna of ancient Tethys, some previously thought to have become extinct in the Upper Jurassic (Richer de Forges 1990). This archaic benthic invertebrate fauna is similar to the original fauna inhabiting the margin of Gondwana. It may be expected that seamounts on the Norfolk Ridge within this study area support a similar fauna.


Paramunida labis


Agononida eminens

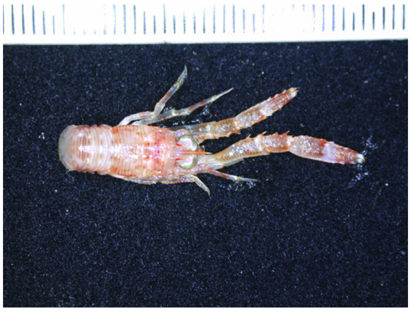

Munida curvirostris

No photo taken

Leiogalathea laevirostris


Munida sp nov 4


Munida sp nov 5


Munida sp nov 7

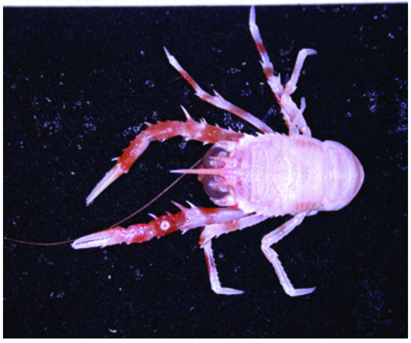

Munida sp nov 8

Figure 13 Photographs of squatlobster species sampled exclusively within the NISA during the NORFANZ survey, including four species of *Munida* newly described from these samples.

Commercial species

Commercial fishes in the Norfolk Seamounts Region include pelagic species such as billfishes and tunas as well as demersal species such as alfonsino, ‘seabass’, and orange roughy. A comprehensive list of all retained species from the AFMA-controlled pelagic fisheries and the Norfolk Island Demersal Finfish Fishery (NIODFF) is provided in Appendix 6. An additional group of species that could potentially become commercially important are the precious deep water benthic corals – with ‘black’, ‘gold’, ‘pink’, ‘red’ and ‘bamboo’ forms. Some of these corals were recorded by the NORFANZ survey on the Norfolk Ridge: black (Order Antipatharia), gold (Family Chrysogorgiidae) and bamboo (*Lepidisis spp*. and *Keratoisis spp*.) (Appendix 6). Black corals have also been observed ‘snagged’ by fishing lines in the Norfolk Island region (M. Christian, local fishing operator, pers. comm.).

Abundance and distribution

Animal abundance is reported as being generally higher on and over seamounts than on the surrounding deep seabed (Rogers 1994; Dower and Fee 1999; Stocks 2004 b). While little can be said about this in relation to the seamounts of the NISA area based on the few samples taken during the NORFANZ survey, there is no indication that this generality would not apply similarly. However, it can be expected that there will be differences in the abundance of particular animal groups in sub-regions, on individual seamounts, and, at least for mobile animals, between seasons. For example, Hinson (1990) reported only sparse ‘growth’ on the bottom of the northern and central part of the Norfolk Ridge, but a significant amount of ‘benthos and bottom growth’ on the southern part of the Norfolk Ridge and the Wanganella Bank region. The abundance of commercially valuable fish is uncertain in the region; the demersal fishery that operated in the Norfolk Island EEZ over an experimental period of three years did not produce commercially significant yields (AFMA 2003), and further uncertainties as noted in the section below.

Life history and behaviour

Invertebrate faunas of seamounts are characterised by sessile and emergent forms including groups such as the habitat-forming corals that are extremely long-lived (Stocks 2004 b). Stocks (2004b) reported that some deep-sea coral species found on seamounts had been aged at hundreds and possibly thousands of years old, making them, in the words of

Willcox *et al* (2001), “some of the longest-lived animals on earth”. Age and dating studies have shown that long-lived species (macro-corals and habitat-forming sponges living for 100’s of years) may be the dominant elements of seamount benthic communities (Grandperrin *et al.* 1997; Richer de Forges 1990).Both of these qualities render seamount communities vulnerable to any disturbance of the sea-floor.

The biology of seamount fishes is very poorly known in general (Froese and Sampang 2004). The commercially targeted species characteristically associated with seamounts tend to aggregate in large numbers on seamount peaks and slopes (Koslow 1997). Similar to the corals, they are generally long-lived, slow growing animals (Fenton *et al.* 1991; Smith *et al.* 1995; Koslow1997), with probably high recruitment variability (Leaman and Beamish 1984, Clark 1995). A relatively well known example is the orange roughy (*Hoplostethus atlanticus*) which is thought to be very long-lived (> 100 years, maturity at 22-40 years), and to have exceptionally low natural mortality (M = 0.045-0.064 year-1) and slow growth rates (K = 0.055-0.070 year-1); in addition, they spawn large eggs and have low fecundity (Branch 2001). Froese and Sampang (2004) report some of the oldest fish species occur on seamounts – yelloweye rockfish (*Sebastes ruberrimus*) and sablefish (*Anoploma fimbria*), aged to 118 and 114 years old, respectively.

Key processes

Seamounts profoundly influence water currents moving around them by rectifying and substantially amplifying flows in their vicinity. Thus the normally sluggish deepwater flows (< 5 cm sec$_{-1}$) may increase to 20-30 cm sec^{-1} over seamounts (Butler *et al*. 2001). As a consequence, many seamounts are swept clear of fine sediments, exposing rocks and cobbles that provide a firm substrate to which epifauna can attach and anchor (Glover and Smith 2003). Enhanced flows of food-rich waters past seamounts provides a consistent food source for filter-feeders (*sensu* Stocks 2004 b) and results in seamount benthic communities being dominated by emergent, filter-feeding epifauna (Rogers 1994; Stocks 2004 b). Seamounts may also enhance local productivity by interacting with the plankton and micronekton that comprise the ‘deep scattering layers’ of the upper 1,000 m of the water column of open ocean. Thus, shallow seamounts that peak within ~1,000 m of the sea surface may continuously *intersect* layers of deep scattering organisms of the lower mesopelagic zone (e.g. >500 m depth, *sensu* Williams and Koslow 1997). Seamounts may also *intercept* diel vertical migrating species. Following their night-time ascent to feed in near surface waters they can become trapped on descent in relatively shallow depths above seamounts, where they are more vulnerable to predation during daylight hours (Rogers 1994). In addition, Butler *et al*. (2001) report that prey organisms may become physically aggregated where accelerated currents flow past seamounts and shed vortices downstream, as noted at fronts and convergences elsewhere (e.g. Olson and Backus 1985). These processes may lead to dense aggregations of higher level predators such as fishes that exploit the accumulation of life near seamounts. These include commercially valuable pelagic fishes (Boehlert 1986; Sasaki 1986; Rogers 1994) and benthopelagic species such as orange roughy (Koslow 1997). Fishing operations in the Australian pelagic fishery for tuna and billfishes are usually carried out in relation to oceanographic features or features of the seabed topography, particularly seamounts (J. Young, CMAR, pers. comm.).

Rectifying flows over seamounts may also create Taylor columns, or anticyclonic gyres (Roden 1986), which generate upwelling that may enhance local primary productivity if the upwelling penetrates the euphotic zone. However, the strength and persistence of Taylor columns, and their contribution to production at higher trophic levels, depends on a number of factors and they do not appear to be a regular feature of most seamounts (Butler *et al.* 2001).

Discrete biological units within assessment area

The NORFANZ survey data showed distinct biological communities associated with depth zones for macro-invertebrates and fishes in the NISA area (Williams *et al*., 2006). This is consistent with widely reported patterns for deep water invertebrates (e.g. the entire NORFANZ data set) and fishes (e.g. Last *et al*., 2005). NORFANZ survey data also showed latitudinal differences within the NISA area between the Norfolk Ridge proper and the Wanganella Bank region. However, few samples were taken, and because the Wanganella bank has been trawled relatively heavily, a pristine fauna may be being compared to a degraded one.

Physical features, which may act as large spatial-scale surrogates for biodiversity distributions, indicate the study area can be considered as four distinct sub-regions based on large-scale geomorphology, bathymetry and oceanography: (1) the centrally located Norfolk Ridge proper, (2) the Wanganella Bank region in the south, (3) an area of shallow and deep seamounts to the east/southeast of Norfolk Island (encompassed by the Norfolk

Eddy) and (4) scattered deep seamounts in an area to the northeast of Norfolk Island (outside the Norfolk Eddy). There is not a validated sub-division within NISA in respect to biological units, but is useful for reserve design purposes by using one reliable parameters (depth zone) and degree of naturalness (anthropogenic impacts).

Special locations

Few known seamounts in the NISA area peak in less than 700 m from the sea surface. As the composition of biological communities is strongly correlated with depth, they may be the only seamounts with a shallow (upper continental slope) faunal component. Shallow seamounts are needed to properly capture representativeness in an MPA, especially by including those without impact from bottom fishing. Based on existing mapping, shallow seamounts include one on the Norfolk Ridge, which appears to peak at 400 m depth, and, to the east of Norfolk Island, the Faust Guyot which peaks at 600 m depth and others on the Nepean Saddle, Bates Plateau and South Norfolk Basin region which peak in ~1,000 m depth. There are insufficient survey data to identify special locations elsewhere.

MPA identification criteria

Willcox *et al.* (2001) report that despite the relative data richness on parts of the Norfolk Ridge, Lord Howe Rise and on the Tasmanian Seamounts, there *was inadequate understanding of biogeographic relationships on which to base a comprehensive, adequate and representative network of MPAs.* In the meantime, additional work has been done to fill in some of these gaps: the 2003 NORFANZ survey aimed to identify and compare the biodiversity of the southern and central Norfolk Ridge and the Lord Howe Rise (Clark *et al.* 2003; Williams *et al*., 2006); a national demersal and pelagic bioregionalisation is being undertaken by the NOO, GA and CMAR in partnership (Heap *et al.* 2005; Lyne and Hayes, 2005); and the New Zealand Ministry of Fisheries is funding a large biodiversity project to examine biodiversity on seamounts in the New Zealand EEZ (e.g. Clark 2000; Rowden 2003; 2004).

Representativeness

Seamounts of the Norfolk Island EEZ area were initially selected as an “iconic” area because they were believed to be areas of high diversity and specialised fauna. Thus, as well as being representative in the sense used by the ANZECC TFMPA (1999) in discussing the establishment of a Comprehensive, Adequate and Representative (CAR) system of MPAs for Australia, the NISA is also being assessed as having special natural values.

The NISA area lies within a distinct regional-scale bioregion, the "Norfolk Island Province", meaning its ecosystems have different components to those in all other provinces within the Australian Marine Jurisdiction. Initial data for the NISA, together with more extensive data from an adjacent seamount area (Norfolk Ridge), show biological communities are particularly rich and diverse, characterised by high levels of endemism (species found nowhere else), and are comprised of a remarkably high number of species and genera that are new to science. These patterns are consistent with the high natural values – specialised ecosystems with characteristic and rich biodiversity – reported for seamounts globally.

Seabed (benthic) and water column (pelagic) communities on individual seamounts vary with depth, meaning that deep and shallow seamounts have different conservation values. Full representativeness requires a seamount or cluster of seamounts to span four key depth ranges: near surface (less than 200 m deep), ~200 to 700 m, ~700 to 1,500 m, and deeper than 1,500 m. Four NISA sub-regions containing seamounts are provisionally differentiated on their present-day patterns of oceanographic circulation and seabed topography. Sub-region 3, the area of shallow and deep seamounts to the east/southeast of Norfolk Island encompassed by the Norfolk Eddy, has the greatest potential to maximise conservation benefits for NISA seamounts. A second sub-region (sub-region 1, the Norfolk Ridge around Norfolk Island), contains the only known NISA seabed shallower than 200 m – the continental shelf around Norfolk Island. While this is not part of a seamount ecosystem, its biological components need to be considered in an MPA to fully represent the natural values of the Norfolk Island Province.

Recently collected (NORFANZ) survey data confirmed strong differences between the faunas of seamounts in the Norfolk Island Province and the Tasmanian Province off southern Tasmania – Australia's only other MPA containing seamounts. Because the Norfolk Island Province has no existing MPAs covering seamounts, including a representative group or groups of its seamounts will add new and iconic natural values to the NRSMPA.

Comprehensiveness

Within the very large NISA area, the appropriate scale for conserving seamount ecosystems may be a major seamount cluster (or ridge system) if this proves to be the dominant scale of species endemism. Whole features (including some of the surrounding seabed and water column), that collectively span four key depth ranges – near surface (less than 200 m deep), ~200 to 700 m, ~700 to 1,500 m, and deeper than 1,500 m) – are required. Components of two sub-regions are needed to comprehensively conserve the natural values of seamount ecosystems in the provincial scale bioregion of which the NISA area is part.

Including a representative group or groups of seamounts from the NISA area will add to the comprehensiveness of the NRSMPA by conserving biodiversity and habitats that are iconic, unique and not protected elsewhere in the Australian Marine Jurisdiction (AMJ).

Ecological importance

Defining the ecological importance of the seamounts in the Norfolk Island Province is difficult on the basis of the limited data available, but it can be inferred from studies elsewhere. Seamounts in adjacent regions (southeastern Australia, New Caledonia and New Zealand) have diverse, specialised faunas characterised by high levels of endemism (Rogers 1994; Koslow and Gowlett-Holmes 1998, Richer de Forges *et al*. 2000; Willcox *et al.* 2003; Stocks 2004 b).

In certain locations, seamounts may provide stepping stones in transoceanic dispersal of plankton and planktonic larvae of benthic species (Wilson and Kaufmann 1987; Christiansen *et al.* 2000). This is hypothesised for the Norfolk Ridge where at depths of 1,000 to 2,000 m it is a contiguous feature connecting New Zealand, Norfolk Island and New Caledonia, while at 500-1,000 m its seamounts and other elevated features form a series of stepping stones. These elevated features form a considerable area of relatively shallow seabed, and provide large areas of accessible and diverse habitat (Richer de Forges 1990).

Limited biodiversity research, including initial results from the NORFANZ survey, show that, at least in some localities, the Norfolk Ridge supports marine communities that are particularly rich and diverse, are characterised by high levels of endemism, and are comprised of a remarkably high number of species and genera that are new to science (e.g. Grandperrin and Lehodey 1992; Lehodey *et al.* 1993; Séret 1997; Williams *et al*. 2006).

Ten listed bird species breed in the Norfolk Island EEZ region and several migratory species including birds, whales and turtles move through the area (*EPBC Act* 1999). It may be expected that these listed and/or protected species forage in the study area and take advantage of increased productivity in the water column around and above seamounts (*sensu* Rogers 1994).

International / national importance

High levels of endemicity and large faunal differences are found between seamount chains in the Tasman and Coral Seas (Richer de Forges *et al*. 2000), and the physical structure of seamounts (seamounts vs. guyots vs. pinnacles, and with different substratum types) also varies between regions (e.g. Figures 6-8 this report). Seamount faunas are vulnerable to the direct physical impacts of bottom contact fishing (Koslow *et al.* 2001), and there is ongoing expansion and development of seamounts fishing over much of the world's oceans (Butler *et al*. 2001). Many seamounts exist in international waters. Collectively, these factors indicate that seamounts should be a high priority for biodiversity conservation in both the national and international (high seas) context. This was a key finding from a conference on the governance of high seas biodiversity conservation (DEH 2005a).

Available data indicate that conservation of seamount environments will need to be managed on the scale of the seamount faunal biogeographic provinces (Butler *et al*. 2001), and that this may require protection at the scale of major seamount cluster and ridge systems if this proves to be the dominant scale of species endemism (Richer de Forges *et al*. 2000). Further research is required to assess this hypothesis, with research in the Indian and western Pacific Oceans given the highest priority, based on the concentration of seamounts and seamount-based fisheries in those areas (Butler *et al.* 2001). Thus, the NISA area (under Australian jurisdiction) is important for its prospective contribution both to Australia's NRSMPA and as a component of a broader Tasman Sea and western pacific conservation initiative that may include the high seas.

Uniqueness

While additional taxonomic work is needed to better determine the uniqueness of the seamount fauna of Norfolk Island Province in the regional setting of the coral and Tasman Seas, initial indications are that it contains many unique elements, and this is consistent with the finding for seamounts in adjacent regions (Richer de Forges *et al*. 2000). Analysis of data from the NORFANZ survey found that the macro-invertebrate fauna of the southern Coral Sea – on the Norfolk Ridge proper and on the northern Lord Howe Rise – differed from the fauna situated in the path of the Tasman Front – on the Lord Howe Plateau, and on the West and South Norfolk Ridge (Williams *et al*., 2006). However, analysis of the only taxonomically comprehensive regional data-set – for the ophiuroids (brittlestars) collated by Dr T. O'Hara – showed strong differences from southern Tasmanian seamounts but no significant difference from the Lord Howe Rise (Appendix 5).

Productivity

Seamounts have been described as oases of increased productivity in the otherwise nutrient-poor open ocean (Dower and Fee 1999; Glover and Smith 2003; Stocks 2004 b). Reasons for this difference include the profound influence of seamount topography on water currents and the interception of mesopelagic vertical migrators such as micronektonic fishes and zooplankton from the 'deep scattering layers' (e.g. Butler *et al.* 2001). Thus, seamounts may be swept clear of fine sediments, exposing rocks and cobbles that provide a firm substrate for attached epifauna, and may be bathed in food-rich waters and provide regions of locally accelerated currents that provide a consistent and relatively rich food source for filter-feeders (*sensu* Stocks 2004 b). Enhanced supply of food may lead to dense aggregations of emergent habitat-forming epifauna that in turn provides shelter and food for other animals. Enhanced benthic productivity, in combination with the intersection of deep scattering layers, aggregates large fishes in commercial quantities that are exploited by pelagic and bottom contact fishing (and see section on Key processes).

Vulnerability

The Norfolk Seamounts are deep ocean systems likely only to be disturbed naturally by seismic events. They are, however, vulnerable to anthropogenic processes that are discussed below.

Biogeographic importance

The NISA is situated within what is recognised as a distinct biogeographic province (the Norfolk Island Province, Heap *et al.* 2005), meaning its ecosystems have different components to those in all other biogeographic provinces within the AMJ. It lies at the extreme eastern margin of the AMJ, spanning a region of complex oceanography that may enhance the diversity and uniqueness of the NISA fauna through influences by the tropical southern Coral Sea, warm temperate northern Tasman Sea, and the persistent, stationary Norfolk Eddy.

Naturalness

The condition of the region was described as unfished and pristine, cited in the Section 'original outline' (Box 1). This description, produced prior to 2001, appears not to have taken account of fishing activities (see following section). P. Stevenson (DEH and ex park-ranger of Norfolk Island) indicated that, in the late 60's/early 70's, the area was heavily fished by Japanese trawlers. However, his account was unclear about the exact area of fishing. Was fishing restricted to the shelf/slope around Norfolk Island (i.e. the inshore fishing zone) or did the Japanese boats also target the tops of adjacent seamounts? Japanese Fisheries Agency data cited by Sasaki (1986) indicated that most of the experimental fishing effort by the Japanese trawlers was restricted to depths shallower than 200 m. Thus, only the shelf surrounding Norfolk Island appears to have been affected by the Japanese exploratory trawling.

Commercial trawling in the offshore region of the Norfolk Island EEZ was established in 2000, under AFMA management, on a three year exploratory basis – the Norfolk Island Offshore Demersal Finfish Fishery (NIODFF) (AFMA 2000). One regional restriction was imposed on this fishery: the trawl effort in the Wanganella Bank region was restricted to a certain number of days (AFMA 2000). Most effort of this fishery was concentrated on the Norfolk Ridge, in the north, near the boundary of the inshore fishery box, and on the Wanganella Bank. A few operators also fished on some of the seamounts to the east of the Norfolk Ridge. However, there has been no intensive fishing effort on these seamounts as far as we can establish. Seabed images of the Wanganella Bank region from the NORFANZ survey show what appear to be the marks made by bottom trawl fishing gear in several locations, confirming disturbance of seamounts in that area.

In conclusion, some seamounts and ridges in the NISA area are more natural and pristine than others. A fine spatial scale analysis of the distribution of fishing effort data is needed to clearly distinguish between pristine and potentially impacted sites as part of a process to identify candidate areas for conservation.

Current and potential uses and existing management regimes

Fisheries

The fisheries of Norfolk Island are concisely described by AFFA (2004 a). The local fishery off Norfolk Island is, in general, restricted to the region of the 'Inshore Fishery Box' (Figure 1), and thus not of concern to our assessment. However, there had been some international fishery activity in the region around the Norfolk Ridge prior to the declaration of the Australian Exclusive Economic Zone (EEZ) in 1979. More recently (since 2000) the Australian Fisheries Management Authority (AFMA) has managed the offshore region surrounding Norfolk Island as an exploratory fishery (see details below).

Demersal finfish

Large-scale demersal trawl-fisheries over seamounts began in 1967 when Soviet trawlers first exploited stocks of the pelagic armorhead (*Pseudopentaceros wheeleri*) in the North Pacific Ocean. Shortly after that (1969), Japanese trawlers commenced exploratory trawling on seamounts first in the North Pacific and later in the South Pacific (Sasaki 1986). Sasaki (1986) reported that the area surveyed by Japanese trawlers in the South Pacific extended over a broad sector between latitude 10º-30º S and Longitude 155º E-145º W. In the eastern part of this area, overlapping the NISA, they found that the species caught at 200-300 m were very similar to the Emperor Seamounts and the northern Hawaiian Ridge in the North Pacific, with the exception of pelagic armorhead and alfonsino (*Beryx splendens*) which were scarce in the South Pacific (Sasaki 1986). The seabed of Kermadec Ridge was too rough for intensive trawling. At Norfolk Ridge, however, the CPUE at 100-200 m depth – i.e. on the shelf surrounding Norfolk Island – was 4.6 metric tonnes per hour during initial exploratory trawling (Fisheries Agency of Japan 1977, *cited in* Sasaki 1986). Of the dominant species, seabass *Caprodon longimanus* (Günther), (called 'longfin perch' in Australia), appeared to have high commercial value (Sasaki 1986). This discovery of commercial seabass stocks on the Norfolk Ridge in January 1976 lead to a year of intensive trawling which decimated the fish stocks. The experimental trawls in January 1976 yielded 1.7 metric tonnes of seabass; by December the yield was only 0.2 metric tonnes. During that year the area was fished by a 2,500-GT class trawler that harvested 1,000 metric tonnes of fish in 47 trawling days, reducing the stock to probably one-sixth of its initial size (Fisheries Agency of Japan 1977 *cited in* Sasaki 1986).

There was no commercial demersal fishery in the region from the declaration of the Australian Fishing Zone (AFZ) in 1979 (AFFA 2004b) until 2000. In May 2000, AFMA released an exploratory management report after receiving numerous requests to undertake both trawling and demersal line fishing off Norfolk Island (AFMA 2000). In the exploratory management report AFMA (2000) stated that, from the evidence collected at that point, resources off Norfolk Island – and particularly waters near the Wanganella Bank region – did not appear to be able to sustain a large scale trawl fishery. It was uncertain at the time of that report if seamounts to the east and south-east of Norfolk Island would hold commercially viable resources. AFMA expected that target species would be alfonsino (*Beryx spp.*) and orange roughy (*Hoplostethus atlanticus*) for the trawl sector, and temperate basses (families Serranidae, Centrolophidae, Polyprionidae) for the demersal line fishery (AFMA 2000).

The exploratory Norfolk Island Offshore Demersal Finfish Fishery (NIODFF) was operating during the calendar years of 2001 to 2003, after which period a draft review was published (AFMA 2003). Two trawl and five line (demersal longline, dropline and trotline) exploratory fishery permits were issued for the fishery that required a minimum effort of 50 days over three years per permit. In total 10 line and 4 trawl trips were undertaken; 97 vessel days were spent in the fishery over the three years. This was well below the expected effort of 350 days. Much of the first year in the fishery was spent searching. The spatial distribution of the fishing effort concentrated mainly on the Norfolk Ridge, particularly in the region of the Wanganella Bank, and to the north of Norfolk Island. A few shots were taken from seamounts to the east of Norfolk Island but the area remained largely unfished. Lines were set between 150 m and 350 m depth, trawl shots extended to between 750 m and 1,075 m depth. While it is possible, from the data collected by AFMA, to identify individual seamounts on and off the Norfolk Ridge where fishing and particularly trawling has occurred, these details are confidential and cannot be released in this report.

A total of 82 tonnes of fish were caught and retained by the NIODFF fishery during the three years in which the exploratory fishery operated, of which around ~70 tonnes were caught inside the NISA area. 99% of these were caught by various demersal lining methods and less than 1% by trawling. The main species, accounting for 70% of the total retained catch are, from line operations, hapuku/bass groper (*Polyprion* spp.), blue eye trevalla (*Hyperoglyphe antarctica*) and jackass morwong (nominally *Nemadactylus macropterus*); and from trawl operations, alfonsino (*Beryx splendens*), orange roughy (*Hoplostethus atlanticus*) and school shark (*Galeorhinus galeus*). The entire list of total retained catch from the NISA study area, only, over the three year period, by species, is given in Appendix 6.

AFMA found that management costs exceeded gross value of production by 280% (AFMA 2003) and proposed four options for the future of the NIODFF. The AFMA Board is considering a Management Plan for exploratory fishing in the NIODFF for a period of 5 years.

Pelagic finfish

Three AFMA-managed pelagic fisheries extend into the Norfolk Island EEZ: the ‘Skipjack and Tuna Fishery’, the ‘Eastern Tuna and Billfish Fishery’, and the ‘Southern Bluefin Tuna Fishery’ (AFMA 2004 a) The Eastern Tuna and Billfish Fishery (ETBF) is taking the bulk of the catches in the region, while the Skipjack Fishery is at its extreme southern limit. Only limited fishing catches are reported from our study area; most of the catches are from the Norfolk Ridge and Wanganella Bank region (Figure 14). For this representation we combined the data from the three fisheries, but only included vessels that recorded some fishing in the NISA area; we also applied the ‘5-boat rule’, masking any grid cells where we had records from less than five vessels.

The species which were caught within the Norfolk Island EEZ and retained in these fisheries are listed in Appendix 6.

The eastern Australian longline-fishery targets mainly swordfish, yellowfin tuna and bigeye tuna. As mentioned under ‘Ecological importance’, J. Young (CMAR, pers. comm.) observed that fishing in this fishery is usually carried out in relation to oceanographic features or features of the seabed topography, particularly seamounts.

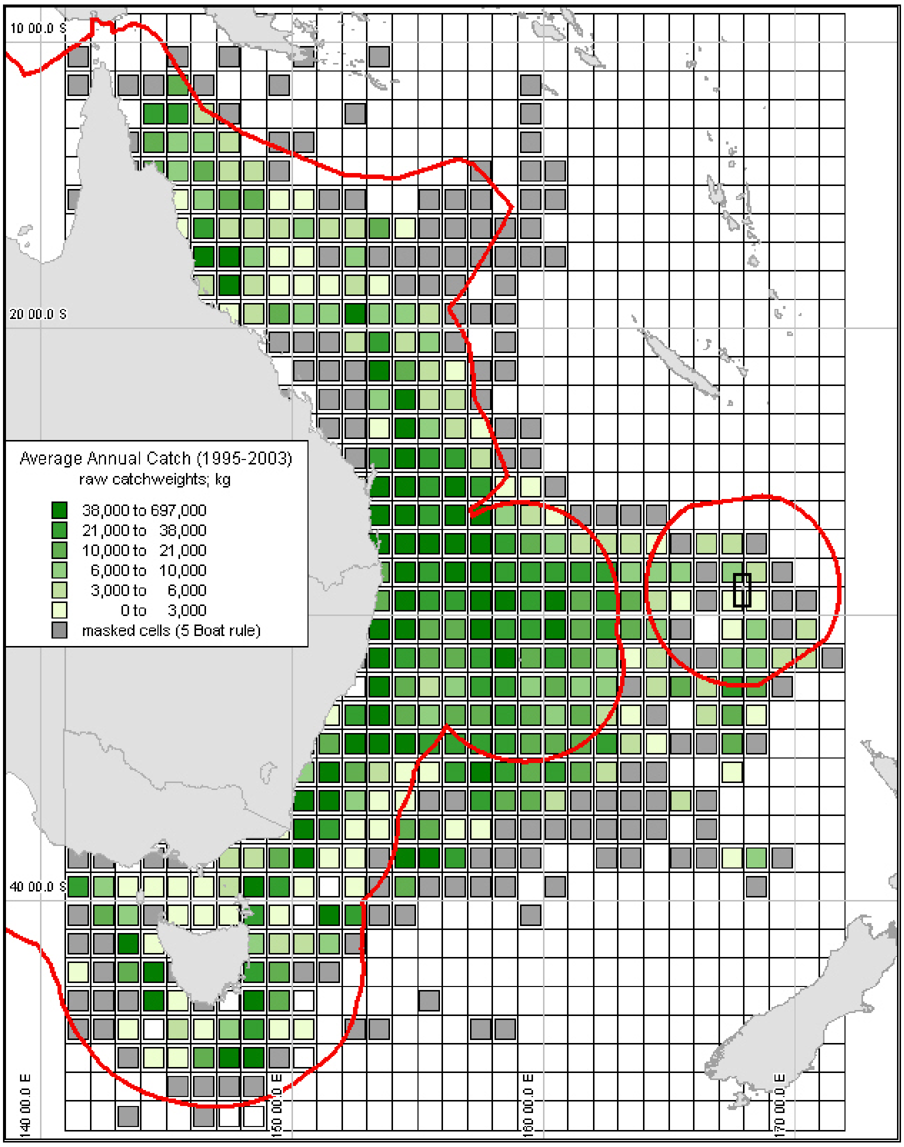


Figure 14 Average annual catch in the combined pelagic fisheries under AFMA management that extend to the Norfolk Island EEZ. Data from 1995 to 2003 was combined and an annual average catch per 10 minute grid-cell was calculated. Cells with records from less than five vessels were masked (5 Boat rule). The black box surrounding Norfolk Island represents the Norfolk Island inshore fishery area.

Squid

There is no local squid fishery within the Norfolk Island EEZ. However, there are some concerns among locals that there are fishers targeting squids in the region. People from Norfolk Island report that they *"used to be able to see the bright lights of the boats from shore at night. Although, this is less common now, the local fishermen say they are still out there, just out of sight of the island"* (M. Christian, pers. comm.). Local concern is that an unchecked squid fishery in the Norfolk Island region might be the cause of low breeding success they observed in some seabirds (M. Christian pers. comm.) – although we note that this may not be substantiated by scientific understanding.

There is no squid fishery, nor any foreign fishing, authorised for the Norfolk EEZ, with the closest managed squid fishery being the Southern Squid Jig Fishery, under AFMA management, which does not extend to the Norfolk Island EEZ (AFMA 2004 a). AFMA managers are aware of the concerns of people on Norfolk Island and actively engage with the local fishing community through meetings, encouraging the reporting of any suspicious activities. AFMA reported in a September 2004 open meeting with Norfolk Island Fishers, that in the past twelve month there had been an increased number of surveillance flights which have included coverage of the NI EEZ – and noted no illegal fishing vessels. (D. Johnson, AFMA, pers. comm.).

Precious corals

Precious corals – black, gold, pink, red and bamboo corals – are commercially harvested from seamounts in the vicinity of Hawaii. Precious coral fisheries can be viable, if they are well managed, allowing only selective, low-impact harvesting of mature corals in a similar way as is done in Hawaii (Grigg 2001). Black corals are harvested from depths of only 30-100 m in Hawaiian waters but they are known to occur in deeper waters on seamounts e.g. southern Tasmania (e.g. Koslow and Gowlett-Holmes 1998). Gold, bamboo and some pink corals are also recorded from Australian seamounts.

The NORFANZ survey found black corals (families unidentified) and gold corals (Chrysogorgiidae) on both the Norfolk Ridge and Lord Howe Rise; bamboo coral (Isididae) on the Norfolk Ridge System only (Williams *et al.*, 2006). The gold and bamboo corals had 3 and 2 species respectively that were only found inside the NISA area (Appendix 6). The Norfolk Island Flora and Fauna Society' museum collection has some black coral on display that had been entangled in some deep set fishing line in the Island's vicinity (M. Christian, pers. comm.). However, at this time there is no fishery for precious coral in the Norfolk Island region, and no local tradition in using those corals in crafts or arts (M. Christian, pers. comm.).

Minerals and Petroleum

There are no current acreage releases in the Norfolk Island EEZ (Department of Industry, Tourism and Resources 2004).

Bernardel *et al.* (2002) describe the hydrocarbon potential of the Norfolk area, interpreting their own results and summarising literature, such as geophysical studies (seismic reflection, seismic refraction, magnetics and gravity) collected by the Mobile Oil Company and Bundesanstalt für Geowissenschaften und Rohstoffe, that covered the southern and central areas of the Norfolk Ridge (Eade 1988 b; Bernardel *et al.* 2002). They describe a potential for hydrocarbon deposits in the New Caledonia Basin. The North and South Norfolk Basins are described as having similar sedimentary sequences, but other factors are expected to limit the generation of similar quantities of hydrocarbons.

Little is currently known about mineral resources (i.e. extractable mineral deposits) of the region (Bernardel *et al.* 2002). Mauffret *et al.* (2001) described large amounts of manganese crusting and iron coating from the three dredge samples taken on the Faust-2 survey. Bernardel *et al.* (2002) interpret this as a possibility of Mn/Fe nodule fields in the areas of low slope in the general region of the dredge sites (i.e. on the north and north-eastern part of the Three Kings Ridge and in the Cagou Trench. No description of mineral deposits is given for the Norfolk Ridge region.

Tourism and recreation (non-fishing)

The Norfolk Tourism office, and tour and charter operators from Norfolk Island reported that no tourism activities such as yacht races, whale watching, charter diving etc. presently occur outside the Norfolk Inshore Fishery Box.

Cruise ships, in general, do not regularly call at Norfolk Island, due to the underdeveloped and exposed nature of port facilities (Transam Argosy 2004 a) – for example, passengers have to be transported ashore using the ship's inflatable boats. Since 1992, only 11 cruise ships have visited Norfolk Island. Three ships paid the Island multiple visits in that time period; the *Arkona* and the *Europa* visited twice and the *Clipper Odyssey* made seven calls to Norfolk Island, the last in November 2004 (Transam Argosy 2004 b).

Maritime transport

Shipping movements in the Australian search and rescue area (S&R) are monitored by the Australian Maritime Safety Authority (AMSA – Safety). This area stops at approximately longitude 163º E, just outside the Lord Howe EEZ; the Norfolk Island EEZ, due to historical and practical considerations, is covered by New Zealand's S&R area (L. Murray pers. comm.). Thus, only minimal ship movements are recorded in the Norfolk Island EEZ (Figure 15). We have contacted Maritime Safety Authority New Zealand for similar data but did not receive a response in time for inclusion of such maps.

Norfolk Island is reliant on shipping transport for cargo and fuel. Transam Argosy Pty., the Norfolk Island agency for several shipping services, reports that cargo ships and tankers pay regular visits to Norfolk Island, coming from Australia, New Zealand and Fiji (Transam Argosy 2004 c) (Figure 15).

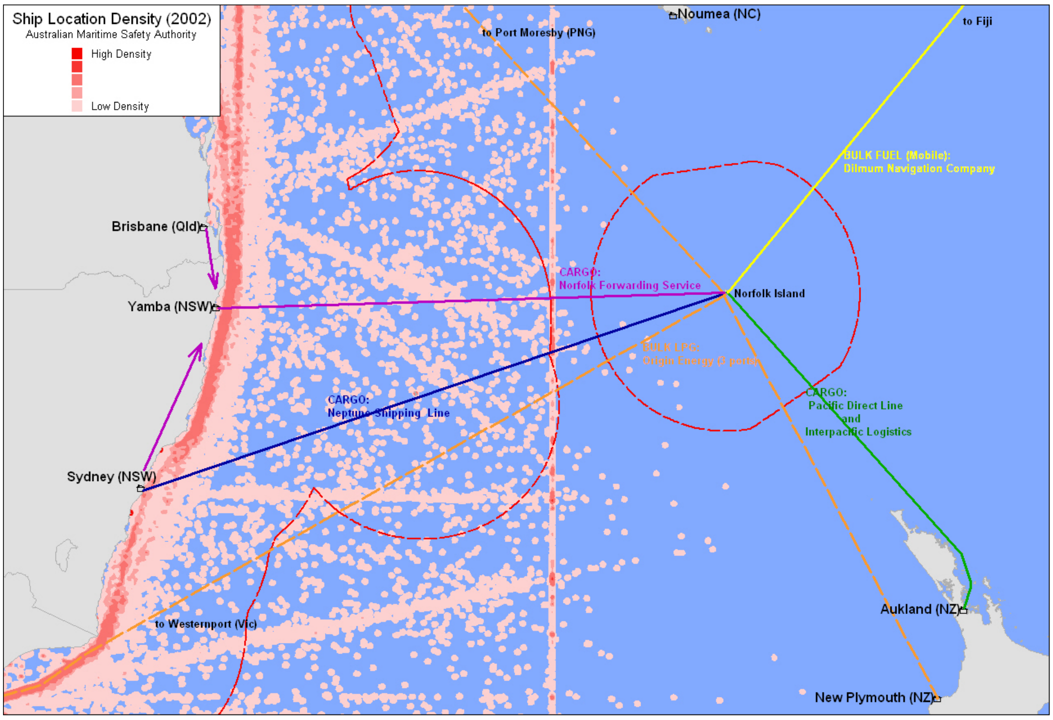


Figure 15 Ship location density (2002) as displayed in Figure 41 of the National Marine Atlas (NOO 2004 a) and the regular shipping connections to Norfolk Island. Data sources: Australian Maritime Safety Authority (AMSA), Origin Energy and Transam Argosy (2004 c).

Cargo

Cargo is transported from Australia and New Zealand by two shipping and two forwarding services. *Neptune Shipping Line* and *Pacific Direct* operate on a monthly basis from Sydney and Auckland, respectively. *Inter Pacific Logistics* is a forwarding service operating from New Zealand and the *Norfolk Forwarding Service* makes monthly trips between Yamba – the depot for freight from Brisbane and Sydney – and Norfolk Island (Figure 15). All these services are under the agency of Transam Argosy Pty (Transam Argosy 2004 c).

Ships that transport cargo to and from Norfolk Island anchor about 1 km offshore, unloading and loading onto lighters which are towed ashore by motorised launches. This is necessary because of the rugged coastline and lack of sheltered anchorage. Lighterage operations take place at either Cascade on the northern coastline, or Kingston (Sydney Bay) on the southern coastline, depending on the direction of the wind and swell (Transam Argosy 2004 a).

Tankers

Bulk LPG and fuel (petrol, jet fuel and diesel) are regularly transported to Norfolk Island. Bulk LPG is shipped approximately bimonthly from one of three ports – Westernport (Vic), new Plymouth (NZ) or Port Moresby (PNG) – on the way to other destinations in the Pacific Islands, using two vessels operated by Origin Energy (P. Israel, pers. comm.) (Figure 15). Fuel is shipped from Fiji using two vessels operated by Dilmum Navigation Company, chartered by Mobil (Transam Argosy 2004 a). The tankers anchor in Ball Bay, on the eastern coastline of Norfolk Island and discharge by pumping through floating pipelines to bulk storage tanks ashore (Transam Argosy 2004 a).

Indigenous interests/ values

When Norfolk Island was discovered by Captain Cook, in 1774, it was uninhabited by humans, although there is some archaeological evidence of Polynesian or Melanesian presence predating Cook’s arrival (DOTARS 2004 a). Thus, Norfolk Island, when first documented, had no indigenous inhabitants.

The Island was offered to the people of Pitcairn Island by the British crown in 1856, as a new homeland, and almost half of Norfolk Island’s population today are descendents of the Pitcairn Islanders. These people speak both English and a distinctive traditional language passed down from the Bounty mutineers and their Tahitian wives. Their unique heritage is also reflected in the traditional foods and cooking styles, arts and crafts and community activities still practised on the Island (DOTARS 2004 a).

In 1994, according to Norfolk Island's Society of Pitcairn Descendants, *"the Pitcairners of Norfolk Island formally declared that they are the indigenous people of Norfolk Island"*. (Norfolk Island's Society of Pitcairn Descendants 2004). However, not all residents of Norfolk Island support this view and it has not been accepted by Australia's Human Rights and Equal Opportunity Commission. *'Instead the Commission considered they [the Descendents of the Pitcairn Islanders] constituted a Minority under international law and were entitled to the rights and protections afforded Minorities by international treaties and conventions*' (DOTARS 2004 a).

Our contact in the Norfolk Island's Society of Pitcairn Descendants did not raise any specific concerns of Pitcairn Descendents in relation to our study.

Legislation/ management arrangements

Norfolk Island Governance

In 1914 Norfolk Island became an Australian Territory under the authority of the Australian Commonwealth and was governed by an Administrator appointed by the Federal Government and supported by a locally appointed or elected advisory council, until 1979. Since the enactment of the *Norfolk Island Act 1979*, Norfolk Island has had its own Legislative Assembly and has enacted a separate body of laws to govern activities on the Island. Federal legislation does not automatically extend to the Territory unless expressed to do so (see the section on Government). Federal Government Agencies are required to consult with the Norfolk Island Government prior to the extension of Federal laws to the Territory (DOTARS 2004 b).

DOTARS (2004 b) summarises the relationship between the Federal Government and the Norfolk Island Government as one of partnership and mutual obligation. Among other things, the Federal Government is committed to defend the Territory, protect the individual rights of its residents, encourage its sustainable development, ensure that its environment and cultural heritage are preserved and protected, and to look after its interests locally and internationally. In return, the Federal Government looks to the Norfolk Island Government for good governance, probity, law and order, appropriate standards of corporate and financial regulation, consumer protection and compliance with international obligations.

Management of the marine environment

In November 1979 Australia declared the Australian fishing zone (AFZ) and in 1994 the economic exclusion zone (EEZ) which both include the area of sea from the coast out to 200 nautical miles offshore and also includes the waters surrounding the offshore territories of the Cocos, Christmas, Norfolk, Macquarie, Heard and McDonald Islands (AFFA 2004 b). The AFZ and the EEZ differ in that, while the AFZ relates only to the use or protection of fisheries, the EEZ relates to all types of resources in the zone (e.g. fish, oil, gas, minerals, etc.) (AFFA 2004 b). Thus, the marine resources around Norfolk Island fall under federal jurisdiction. The National Oceans Office published a list of *treaties/conventions and 'soft law' that may impact on Australia's management of the marine environmen*t on a web-link (NOO 2004 b).

The legal focal point for the present assessment is legislation regarding environmental protection; in particular, legislation aimed at biodiversity issues. In Commonwealth waters, these are addressed in the *Environment Protection and Biodiversity Conservation Act* 1999 (*EPBC Act* 1999). This Act makes provisions for environmental impact assessment and strategic environmental assessment. In relation to biodiversity conservation, it provides protection for nationally threatened native species, internationally protected migratory species, cetaceans and other marine species and protected areas. Thus, proposed actions that are likely to have a significant impact upon listed threatened native species or ecological communities are subject to environmental impact assessment and approval processes (NOO 2002 a; Butler *et al.* 2002 a; 2002 b). None of the organisms that constitute seamount communities are currently listed as endangered or of national environmental significance; neither are seamount communities in general classified as threatened ecological communities (DEH 2004 c). However, a report on biodiversity conservation in the deep sea considers seamounts as one of the principal habitat types in need of further research and protection (Butler *et al.* 2001).

The fisheries in Norfolk Island's EEZ are to be managed by AFMA. Pelagic Fisheries regulated by AFMA have operated since at least 1995 within Australia's EEZ, extending into the region around Norfolk Island. The demersal fishery in the region is still in an exploratory phase. In 2000 AFMA issued two trawl and five line exploratory fishery permits for the Norfolk Island Offshore Demersal Finfish Fishery (NIODFF) (AFMA 2004 a). These were valid for three years, until December 2003, after which a review took place (AFMA 2003). The AFMA Board is considering a Management Plan for exploratory fishing in the NIODFF for a period of 5 years. Details of the fishery and its management are described in the fisheries section (p. 40 this report).

The Inshore Fishery, delimited by a box of approximately 67 x 40 nautical miles, and excluded from the present assessment (e.g. see Figures 2 and 3), includes all shelf waters surrounding Norfolk Island (AFMA 2004 a). The local fishers operate almost exclusively within this box and have managed the fisheries under self-regulation, using restrictions such as size limits and closures of spawning areas (Bates, pers. comm.; AFFA 2004 a). The local fishers are not strictly operating on a commercial level today. Thirty years ago fish were commercially processed in a local fish-factory; however, the commercial fishing and the factory were abandoned because of increased damage to the reefs (D. Bates, pers. comm.). In its April 2003 Board Newsletter, AFMA (2004 b) stated that it will refuse two applications to commercially fish in Norfolk Island inshore waters. It was considered *consistent with a precautionary approach not to allow any commercial fishing activities in inshore waters in addition to the local fishing activity* (AFMA 2004 b). AFMA, in consultation with other Commonwealth Government departments, and with the Norfolk Island Government, is currently working to formalise management arrangements for this fishery (AFMA 2004 a).

Scientific/ educational value

Stocks (2003) summarised the scientific and educational value of seamounts as excellent case studies for understanding marine biodiversity patterns: seamounts vary greatly in their biodiversity, can have a high degree of endemism, may be centres of speciation, and may act as "stepping stones" for the dispersal of coastal species. In addition, they are fragile ecosystems that must be managed carefully and with good scientific information in order to prevent habitat damage, and are areas of high production that support commercially important fisheries and coral mining.

Scientists have studied seamounts over the last 30 years but considerable gaps in the knowledge of these features remain (Dower and Fee 1999). The recent NORFANZ survey provided some insights into the scientific values of seamounts on the Norfolk Ridge and Lord Howe Rise: of the 1,621 and 591 macro-invertebrate and fish species collected, 66 macro-invertebrates and 29 fishes are confirmed as new to science, while large fractions of both the macro-invertebrates and micro-invertebrates are expected to be new or rare (Williams *et al*., 2006). This and other seamounts studies in the area have highlighted the current lack of taxonomists and taxonomic descriptions for the animals collected to match the needs of those who study biodiversity (Williams *et al.* 2006; Rowden and Clark 2005).

Current and potential impacts on natural values

The natural values of seamount communities are largely defined by high species richness and high rates of endemism (Richer de Forges *et al.* 2000), the presence of a diverse emergent epibenthic fauna that differs to faunas of the deep sea floor (Stocks 2004 b), and long-lived species, including deep-sea fishes (Koslow 1997).

Twelve broad categories of disturbance were identified to define impacts in the South-east Marine Region (NOO 2002 b). Seamounts in that region were identified as being affected by mechanical disturbance, biological interactions, and, potentially, by nuclear radiation, but not by chemical changes. All other disturbances, including marine contaminants, were classed as ‘unknown if the disturbance has an effect on seamounts in the South-east Marine Region’. Seamounts of the Norfolk Island Province will be similarly affected by mechanical disturbance from fishing, and by biological interactions that stem from fishing impact; however, the severity of such impacts is likely to be less than SE Australia based on the current low levels of fishing effort and the rugged seabed topography characterising areas of the Norfolk Ridge (see Williams *et al*. 2006). The distribution of impacts is unclear. Most immediately, those from fishing will be local to the seamounts being fished; other biological processes such as connectivity (i.e. the exchange of animals between seamounts including larval advection) may be affected more broadly, but nothing is known about such processes in this area. Climate change was identified as another source of impact on natural values (Butler *et al*. 2002 b) that could affect filter-feeder communities through its influence on current patterns and flow regimes in the ocean. All other disturbances, including marine contaminants, are unknown.

Mechanical disturbance

The main current source, and future potential source, of mechanical disturbance in the Norfolk Seamounts area is fishery activity. Bottom contact by demersal fishing gears has been shown to adversely affect large sessile epibenthic organisms (van Dolah *et al.* 1987, Kaiser *et al.* 1998, Engel and Kvitek 1998, Pitcher *et al.* 2000; Gianni 2004). The emergent epibenthic fauna, consisting largely of fragile, slow-growing species, is a principal natural value of seamounts (Stocks 2004 b) and it is these communities that are most susceptible to gear impact damage (Koslow *et al.* 2001; Butler *et al.* 2003; Gianni 2004). Demersal fishing gears range from trawls, drop lines and bottom-set lines targeting demersal fishes, to tangle nets used to target precious corals.

Another potential source of mechanical disturbance on seamounts is collection of animals in the commercial 'biodiscovery' context. As discussed by Butler *et al.* (2002 b), sponges and bryozoans produce chemicals that deter predation and have antifouling and other ecological benefits to the sessile organism. These may be of interest to humans for pharmaceutical or other uses. However, the development of new techniques in biodiscovery research has greatly reduced the quantities required for initial discovery of bioactive compounds (Hooper *et al.* 1998; Munroe *et al.* 1999; Quinn *et al.* 2002) and harvesting of wild populations is generally no longer considered a viable option (J. Hooper, Queensland Museum pers. comm. *in* Butler *et al.* 2002 b).

Dredging for mineral resources such as polymetallic nodules and manganese crusts may have the potential to cause severe local impacts. However, we have no knowledge of such enterprises having been undertaken in the deep sea.

Biological interactions

Impacts on the biological interactions of seamount fauna may follow mechanical disturbances. In addition to direct impacts on epibenthic organisms and connectivity, discussed above, fisheries remove seamount-specific fish species which are particularly vulnerable to over-exploitation due to their slow growth-rates, the long time they take to reach maturity and their long life-span (Koslow *et al*. 2000; NOO 2002 b).

Contaminants

The most frequent sources of contaminants, or marine debris, in general, are plastics and other synthetics (NOO 2002 b) discarded from ships or washed offshore from terrestrial sources. Contaminants also include chemicals such as heavy metals, hydrocarbons and wastes (garbage, galley wastes, etc.) and sewerage. In the Norfolk Seamounts area, being off shore and deep (>300 m), shipping can be considered as the principal *potential* source of contaminants – but there is no evidence that contamination has occurred. Fuel tankers anchor in Ball Bay, on the eastern coastline of Norfolk Island, and discharge fuel supplies by pumping through floating pipelines to bulk storage tanks ashore, but this seems an unlikely threat to seamounts in the deep ocean which are mostly at considerable distances from the island. The effects of other contaminants on seamount ecosystems are largely unknown. It may be speculated that lost nets, ropes and other debris that sinks to the seafloor may cause mechanical damage if they get snagged on corals or other epibenthos.

Climate change

Climate change, as described by Butler *et al.* (2002 b), may cause increased temperatures, as well as changes in current regime. Global warming is a result of increasing levels of greenhouse gases (CO_2, CH_4, and N_2O) in the atmosphere. This increase is attributed largely to human activities such as use of fossil fuels, land-use changes, and agriculture (Houghton *et al.* 1995). Temperature changes may affect marine biota directly and indirectly (Denman *et al.* 1995), however, it is beyond the scope of this work to comment on this source of impact.

Discussion

Seamounts and their natural values

Seamounts are elevated features of the deep seabed that are generally defined as being large, steep-sided, characteristically of conical form, and rising over 1,000 m in height. They may be single isolated features or exist in isolated groups, or may be part of a larger seabed feature such as a ridge. For the purposes of this study we have not differentiated between seamounts of different size or morphology (i.e. guyots and pinnacles) since biodiversity conservation issues are common to the broad class of these elevated submarine structures.

Studies worldwide show the natural values of seamounts are largely defined by characteristics of the benthic fauna: high species richness and high rates of endemism (Richer de Forges *et al*. 2000), the presence of a diverse emergent epibenthic fauna that differs to faunas of the surrounding (flat) deep sea floor (Stocks 2004 b), and long-lived benthic species including some deep-sea fishes (Koslow 1997). Some seamounts of the Norfolk Ridge in the New Caledonian EEZ support an archaic benthic invertebrate fauna (sponges, hydroids, crinoids, molluscs and echinoderms) similar to the original fauna inhabiting the margin of Gondwana and this includes some groups thought to have become extinct in the Upper Jurassic (Richer de Forges 1990). There is also a pelagic fauna associated with seamounts that includes characteristic species. Dominant among these are commercially valuable fishes including a suite of pelagic and benthopelagic species such as orange roughy (Boehlert 1986; Sasaki 1986; Rogers 1994; Koslow 1997) that are often widely distributed, but highly aggregated around seamounts.

These natural ecological values are explained by several factors, generally related to the profound influence seamounts exert on the water currents moving around them. Seamount substrata are often swept clear of sediments providing anchorage points for emergent epifauna; in addition, the enhanced flows of food-rich waters past seamounts provide a consistent food source for filter-feeders (Rogers 1994; Stocks 2004 b). Seamounts may also enhance local productivity by entrapping plankton and micronekton in local current flows and vortices which can lead to dense aggregations of higher level predators. These include fishes in commercial quantities, which exploit the accumulation of life near seamounts (see section on Key processes).

The Norfolk Island Seamounts Area in the national and regional context

The known seamounts of the NISA area include large structures, 10s km across the base, in a cluster to the east/ southeast of Norfolk Island, with two more, deeper seamounts to the northeast. In addition, there are smaller elevated features on the Norfolk Ridge and Wanganella Bank. However, precise bathymetry data is sparse in the Norfolk Island region (Harris *et al.* 2003), with the exception of the Neppean Saddle and Kingston Plateau that were mapped in detail during the Faust-2 survey (Mauffret *et al.*2001). New mapping data from the NORFANZ survey confirmed the presence of small seamounts on the western flank of the Norfolk Ridge (Williams *et al*., 2006.) but the total numbers, sizes, depth ranges and distribution remain to be fully verified.

The physical structure of known seamounts (seamounts, guyots and pinnacles) varies between regions of the Coral and Tasman seas (e.g. Figures 6-8 this report). It is noteworthy that seamount features studied in the four survey areas considered by this assessment (NORFANZ, New Caledonia, northern New Zealand and southern Tasmania) varied greatly in overall depth, height and morphology, and possibly substratum type. To facilitate further assessment, e.g. for MPA planning in the NISA area, a regional scale database of seamount features should be compiled using the NIWA template for seamounts in New Zealand's EEZ. Variables to evaluate include depth at peak and at base, base area, Chlorophyll *a* concentration above the peak and distance to continental margin (A. Rowden, NIWA, pers. comm.).

Relative to other world oceans, the seamounts of the south-western Pacific are viewed as well surveyed (Richer de Forges *et al* 2000; Willcox *et al*. 2001). However, survey work has been very concentrated, with surveys completed in the Coral and Tasman Seas being focused around New Caledonia (>20 surveys) and to the north of New Zealand (including an ongoing survey program). Seamounts in the NISA area and Norfolk Island EEZ region as a whole are very poorly sampled, with only a few samples provided by the 'NORFANZ' survey (Clarke *et al.* 2003; Williams *et al*., 2006). Thus, in both the global and western Pacific contexts, the NISA area encompasses a very large region that is incompletely mapped and whose benthic fauna is poorly represented in museum collections and in the current literature relative to adjacent regions (New Caledonia, New Zealand, and southern Australia).

Conservation values of seamounts in the Norfolk Island Seamounts Area

Determining the uniqueness of the seamount benthic fauna of the seamounts in the NISA area and defining its ecological importance is difficult because of the limited data available. However, limited biodiversity research, including initial results from the NORFANZ survey, shows that, at least in some localities, the Norfolk Ridge supports marine communities that are particularly rich and diverse, are characterised by high levels of endemism, and are comprised of a remarkably high number of species and genera that are new to science (e.g. Grandperrin and Lehodey 1992; Lehodey *et al.* 1993; Séret 1997; Williams *et al*. 2006). Importantly, a high proportion of species *confirmed* to be new to science in the NORFANZ collections were collected exclusively from the NISA area (Williams *et al.* 2006). These include four fishes, four seaspiders, an octopod, four species of squat lobsters, two species of prawns, one species of krill, two species of brittlestars, and six species of hydroids.

Important characteristics can also be inferred from studies of seamounts in adjacent regions (southeastern Australia, New Caledonia and New Zealand) which are known to have diverse, specialised faunas characterised by high levels of endemism (Rogers 1994; Koslow and Gowlett-Holmes 1998, Richer de Forges *et al.* 2000; Willcox *et al.* 2003; Stocks 2004 b). Those findings show that some seamounts of the Norfolk Ridge in the New Caledonian EEZ support an archaic benthic invertebrate fauna (sponges, hydroids, crinoids, molluscs and echinoderms) similar to the original fauna inhabiting the margin of Gondwana and this includes some groups thought to have become extinct in the Upper Jurassic (Richer de Forges 1990).

Evaluation of the biological data from the Tasman and Coral Sea region (NORFANZ, New Caledonia, northern New Zealand and southern Tasmania, Appendix 5) showed that data from only one faunal group (the brittlestars provided by Dr Tim O'Hara of Museum Victoria) was sufficiently developed (consistent species identifications and collection gear across surveys) to permit a detailed regional analysis. Multi-species distributions showed strong differences between the faunas of the NISA area and the southern Tasmanian seamounts but no significant difference to the Lord Howe Rise. Fauna and morphology of the southern Tasmanian seamounts were significantly different from all other regions examined (Appendix 5).

Ten listed bird species (Australasian gannet, sooty tern, grey ternlet, red-tailed tropicbird, masked booby, two species of shearwater and three species of petrel) breed in the Norfolk Island EEZ region and several migratory species, including birds, whales and turtles, move through the area. Among the migratory species are many endangered or vulnerable species of albatross and petrels, the endangered southern right and blue whales, as well as the vulnerable green and leatherback turtles. It is expected that these listed and/or protected species forage in the study area and take advantage of increased productivity in the water column around and above seamounts (*sensu* Rogers 1994).

So, while additional taxonomic work is needed to better define the key properties, particularly endemism, of benthic biodiversity of the NISA area in the regional setting of the Coral and Tasman Seas, the initial findings are that it contains many endemic, rare, relict and previously unknown elements, a pattern consistent with the finding for seamounts in adjacent regions (Richer de Forges *et al*. 2000). None of the organisms that constitute benthic seamount communities are currently listed as endangered or of national environmental significance, neither are seamount communities in general classified as threatened ecological communities (DEH 2004 c). However, a review of biodiversity conservation in the deep sea considers seamounts as one of the principal habitat types in need of further research and protection (Butler *et al.* 2001).

Threats to conservation values of the NISA

The main current source, and future potential source, of impact on the benthic biodiversity values of in the NISA area is mechanical disturbance from bottom fishing activity – principally demersal trawling, and to a lesser extent drop lines and bottom-set lines targeting demersal fishes. There is also the possibility of tangle nets being used to target precious corals. The emergent epibenthic fauna of seamounts, consisting largely of fragile, slow-growing, long-lived species, is a principal natural value (Stocks 2004 b) and it is these components that are most susceptible to gear impact damage (Koslow *et al.* 2001; Butler *et al.* 2003; Gianni 2004). Fishing activities at the surface, or restricted to the water column above seamounts, such as pelagic long-lining for tunas and billfishes, and shipping, pose minimal threats to benthic conservation values of the seamounts in the NISA.

There appear to be good prospects for locating seamounts in the NISA in pristine condition. Only the continental shelf (<200 m depth) surrounding Norfolk Island appears to have been affected by Japanese exploratory trawling (Sasaki 1986). Commercial bottom trawling by Australian vessels in the Norfolk Island Offshore Demersal Finfish Fishery (NIODFF) was established in 2000, under AFMA management, but there have been only low levels of effort concentrated on the Norfolk Ridge, in the north, near the boundary of the inshore fishery box, and on the Wanganella Bank, and some effort on seamounts to the east of the Norfolk Ridge. A fine spatial scale analysis of the distribution of fishing effort data would be needed to clearly distinguish between pristine and potentially impacted sites, but these details are confidential and cannot be released in this report. The NIODFF is currently closed, but the AFMA Board is considering a Management Plan for exploratory fishing in the NIODFF for a period of 5 years

Factors for future conservation planning

Protection of biodiversity in the Australian marine environment will be by establishing a network of marine protected areas (MPAs): Australia's National Representative System of MPAs – the NRSMPA. In simple terms this means reserving areas that reflect the biodiversity of particular marine ecosystems (representative), of sufficient size and spatial distribution to ensure their ecological viability (adequate), for the full range of ecosystems (comprehensive). For candidate MPA areas to be well-designed, and for the network to be comprehensive, adequate and representative, ecosystems need to be defined at the appropriate scales. Because marine ecosystems may not be well known, clearly bounded by lines on maps or exist at repeated spatial scales, physical 'habitats' are used as surrogates to define them. A hierarchical framework of habitats is being used by data analysts and conservation planners in Australia to provide an agreed classification and a common language for this purpose (e.g. Williams *et al.*, in press). At the first (coarsest) level, regional-scale biological zones – 'large biogeographic regions' or 'provinces' are delineated (defined as being different to each other) by broad-scale distributions of fauna (e.g. Heap *et al.* 2005). Habitats at progressively finer scales are nested within this scheme at a series of lower levels, and provide the basis to define 'bioregions' at any level.

In this framework, seamounts are habitat (ecosystem) units at the third level. Thus, seamounts present in one province are considered to be different from seamounts in a different province. For many marine regions, habitat distributions (as a proxy for ecosystem and biodiversity distributions) are known only down to the third level, and this determines the spatial resolution at which MPA planning and design for large areas has to operate. This is the case for the better known southeastern Australian area where the MPA network is being implemented at the time of writing (DEH 2005b), and also applies to the NISA area.

Thus, in order to answer the question, "does the NISA area contain biodiversity values worthy of protection", it is necessary to define two properties. First, whether the area has high natural values, and second, to determine if, and to what extent, they contribute to representativeness and comprehensiveness in the NRSMPA, i.e. whether those values occur and are protected elsewhere. The limited data available shows the seamount ecosystems in the NISA area *are* characterised by the high natural values documented for seamounts in various areas of the world's oceans – by supporting specialised ecosystems with characteristic and rich biodiversity, and unique or important ecological processes (e.g. Butler *et al.* 2001; Glover and Smith 2003; Stocks 2004 b).

To understand whether they contribute to representativeness and comprehensiveness in the NRSMPA, they need to be considered in the context of Australia's bioregions – defined in a process termed 'bioregionalisation'. The benthic bioregionalisation for Australia (Heap *et al.* 2005) has classified the area of the Norfolk Island EEZ as a distinct benthic biogeographic province: the “Norfolk Island Province”. Because this province contains no MPAs covering seamounts, the NISA area must be viewed as representing unique ecosystems. The NISA area encompasses several seamounts of varying size, depth range and morphology, and while the details of their individual conservation values are not yet known, each will represent one or more finer-scale ecosystems within the Norfolk Island Province. Inclusion of any individual seamount or group(s) of seamounts in the NRSMPA would therefore add to the representativeness and comprehensiveness of the NRSMPA by conserving biodiversity and habitats that are unique and not protected elsewhere in the Australian Marine Jurisdiction.

Although it is beyond the scope of this assessment to provide information on reserve design, data show the NISA area can be sub-divided on physical and, to some extent, biological characteristics, and therefore some initial conclusions can be made on the relative suitability of sub-regions for maximising conservation benefits. Physical data show the NISA can be considered as four sub-regions containing seamounts: (1) the centrally located Norfolk Ridge proper, (2) the Wanganella Bank region in the south, (3) an area of shallow and deep seamounts to the east/southeast of Norfolk Island (encompassed by the Norfolk Eddy) and (4) scattered deep seamounts in an area to the northeast of Norfolk Island (outside the Norfolk Eddy). Latitudinal differences in macro-invertebrate communities between the Norfolk Ridge proper and the Wanganella Bank region within the NISA area is supported by data from the NORFANZ survey – although as is noted below, the Wanganella bank has been trawled relatively heavily and so a pristine fauna may be being compared to a degraded one.

Important ecological characteristics of individual seamounts or clusters of seamounts include depth range and size. In particular, the distribution patterns of macroinvertebrates and fishes in the NISA area, based on the NORFANZ data, are mostly strongly related to depth. Numerous studies elsewhere (e.g. Last *et al*., 2005) show that distinct biological communities are associated with the depth zones of the continental shelf (< 200 m), the upper continental slope (~200-700 m), the mid-continental slope (~700-1,500 m) and deeper depths. Furthermore, diversity was observed to decline markedly below 1,400 m on the Tasmanian seamounts, with the important habitat forming coral (*Solenosmilia variabilis*) not found below 1,400 m depth (Koslow *et al*., 2001). Thus, a highly important criterion for maximising the biodiversity represented in a reserve is to select seamount(s) than reach to well into the depth range of the continental slope (200-1,500 m from sea surface), ideally to at least 700 m from sea surface, and if possible to less than 200 m from sea surface. Presently there are insufficient data to assess the structure and biological variation between individual NISA seamounts, and a key step in the design process will be to produce a database of individual NISA seamount features (using the NIWA template) that includes depth at peak and at base, base area, Chlorophyll *a* concentration above the peak and distance to continental margin.

Of the four NISA sub-regions, the northeastern sub-region 4 appears the least prospective for biodiversity conservation due to the relative scarcity of known seamounts, and their great depth – the shallowest appears to peak at about 1,400 m depth, while most peak at depths around 3,000 m. The Wanganella Bank, area 2, appears to have few true seamounts and is an area with relatively high bottom fishing activity. Sub-regions 1 and 3 are most prospective, with sub-region 1, (the Norfolk Ridge around Norfolk Island), containing the only known NISA seabed shallower than 200 m – the continental shelf around Norfolk Island. This is not strictly a seamount ecosystem, and, following consultation with DEH, was not analysed for this report. However, to fully represent the natural values of the Norfolk Island Province, components of this area are needed.

Sub-region 3, the area of shallow and deep seamounts to the east/southeast of Norfolk Island encompassed by the Norfolk Eddy has the greatest potential for four reasons: (1) the relatively high number of defined individual seamounts; (2) the shallow peaks of seamounts (one peaking at 600 m, and several peaking at ~1,000 m); (3) the possibility of higher levels of endemism on seamounts of the Nepean Saddle, Bates Plateau and South Norfolk Basin region that lie under the Norfolk Eddy (based on the potential for the retention of larvae as the eddy is coherent to depths of 1,500 m); and (4) the pristine state of many that have not been trawled.

Available data indicate that conservation of seamount environments will need to be managed on the scale of ‘seamount faunal biogeographic provinces’ (Butler *et al.* 2001), and that this may require protection at the scale of major seamount cluster and ridge system if this proves to be the dominant scale of species endemism (Richer de Forges *et al*. 2000). Further research is required to assess this hypothesis, with research in the Indian and western Pacific Oceans given the highest priority, based on the concentration of seamounts and seamount-based fisheries in those areas (Butler *et al.* 2001).

The location of NISA sub-region 3, and some of the prominent seamounts within it, is close to the EEZ boundary shared with New Zealand. A large single area extending from Norfolk Island to the Australian EEZ boundary to the east and southeast, to encompass continental shelf, seamounts on the Norfolk Ridge, and the key (shallow and deep) seamounts of the Nepean Saddle, Bates Plateau and South Norfolk Basin region, would provide an iconic addition to Australia's NRSMPA. It is also ideally located for a single bi-lateral MPA that could also span the adjacent high seas overlaying the northern part of the Three Kings Ridge.

Conclusion

Initial results from the recent NORFANZ survey show the NISA contains many unique elements, and this is consistent with the finding for better studied seamounts in adjacent regions (New Caledonia and New Zealand). Initial results already confirm new species of fishes, octopus, squat lobsters, prawns, krill, seaspiders, brittlestars, and hydroids.

Survey data also confirmed strong differences between the faunas of seamounts in the Norfolk Island Province and the Tasmanian Province off southern Tasmania – Australia's only other MPA containing seamounts. Because the Norfolk Island Province has no existing MPAs covering seamounts, including a representative group or groups of its seamounts will add new and iconic natural values to the NRSMPA.

Including a representative group or groups of seamounts from the NISA area will add to the comprehensiveness of the NRSMPA by conserving biodiversity and habitats that are iconic, unique and not protected elsewhere in the Australian Marine Jurisdiction (AMJ).

The conservation values of the NISA area are expected to be as important as those of the Tasmanian Seamounts Area which has been nominated for Australia's Commonwealth Heritage List and is being assessed by the Australian Heritage Council in 2006.

Seamounts of the NISA area represent a deep ocean system likely only to be disturbed naturally by seismic events. However, the emergent benthic fauna, consisting largely of fragile, slow-growing and long-lived species, is vulnerable to anthropogenic processes, particularly mechanical disturbance from bottom fishing. However, most NISA seamounts are expected to be little impacted or pristine.

The NISA area encompasses a very large region that is incompletely mapped, and there is presently insufficient data to completely assess the total numbers, key features (e.g. depth range) and distribution of individual seamounts within the NISA area. A regional scale database of seamount features should be compiled to aid the MPA design process. A focussed survey, similar in some ways to the NORFANZ survey but designed to answer specific questions relevant to performance assessment, would add substantially to knowledge of the NISA area's natural values, and showcase its inclusion in the NRSMPA.

Global data on seamounts indicate that conservation of seamount ecosystems may require protection at the scale of a major seamount cluster or ridge system. A large single area extending from Norfolk Island to the Australian EEZ boundary to the east and southeast, to encompass continental shelf, seamounts on the Norfolk Ridge, and the key (shallow and deep) seamounts of the Nepean Saddle, Bates Plateau and South Norfolk Basin region, would provide an iconic addition to Australia's NRSMPA. The location of this area close to the EEZ boundary shared with New Zealand is also ideally located for a single bi-lateral MPA that could span the adjacent high seas overlaying the northern part of the Three Kings Ridge

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Appendix 1

FROM: ***Guidelines for establishing the National Representative System of Marine Protected Areas.*** **(ANZECC TFMPA 1998). Criteria to be used as a basis for the identification and selection of MPAs**

IDENTIFICATION

Representativeness

Will the area:

- represent one or more ecosystems within an IMCRA bioregion, and to what degree;
- add to the representativeness of the NRSMPA, and to what degree.

Comprehensiveness

Does the area:

- add to the coverage of the full range of ecosystems recognised at an appropriate scale and within and across each bioregion;
- add to the comprehensiveness of the NRSMPA.

Ecological importance

Does the area:

- contribute to the maintenance of essential ecological processes of life-support systems;
- contain habitat for rare or endangered species;
- preserve genetic diversity, i.e. is diverse or abundant in species;
- contain areas on which species or other systems are dependent, e.g. contain nursery or juvenile areas or feeding, breeding or resting areas for migratory species;

- contain one or more areas which are a biologically functional, self-sustaining ecological unit.

International or national importance

- is the area rated, or have the potential to be listed, on the world or a national heritage list or declared as a Biosphere Reserve or subject to an international or national conservation agreement.

Uniqueness

Does the area:

- contain unique species, populations, communities or ecosystems;

- contain unusual or unique geographical features.

Productivity

- Do the species, populations, or communities of the area have a natural biological productivity.

Vulnerability assessment

- Are the ecosystems and/or communities vulnerable to natural processes.

Biogeographic importance

- Does the area capture important biogeographic qualities.

Naturalness

- How much has the area been protected from, or not been subjected to, human induced change.

Appendix 2

Information to be compiled for each area.

Note, all of this information is to be assembled / interpreted ***to the extent possible***. In some cases, there may be no relevant information.

1. A Description of the Physical Environment

(a) Bathymetry – To a resolution required to identify biophysical values

(b) Geomorphology

(c) Oceanography

(d) Distinct sub-regions within the assessment area

2. A Description of the Biological Environment

a) Comprehensive list of taxa to lowest practical taxonomic rank.

b) Full list of species that are of known ecological, commercial, cultural or recreational importance (to be referred to below as key species, where the term key simply means species of interest or special concern).

c) Abundances and distributions of key species

d) Behaviour and life history of known key species, e.g. breeding, feeding, migratory paths, etc. as they relate to the area.

e) Key processes such as trophic relationships and species interdependence including any known functional linkage with other communities/systems or areas outside the assessment area

f) Definition of discrete biological units (ecosystems / habitats / communities / assemblages / systems) within assessment area

g) If specific locations are found within the general area studied for the conservation values assessment as having particularly high biophysical values or other features of specific interest these locations should be identified and described.

3. Address to the extent possible each MPA Identification Criterion

(see attachment C – Appendix 1)

a) Representativeness

b) Comprehensiveness

c) Uniqueness;

d) Naturalness;

e) Ecological importance;

f) Biogeographic importance;

g) International or national importance;

h) Productivity; and

i) Vulnerability.

4. Current and Potential Uses and Existing Management Regimes

Provide information, to the extent possible, on the following

(a) Fisheries – Complete information on commercial, charter, amateur and traditional fisheries including:

- catch composition and distribution of fisheries
- catch quantities including bycatch of non-commercial species;
- main fishing methods and boat types;
- number of non-commercial and commercial operators using the area;

(b) Minerals and petroleum –exploitable minerals present, potential petroleum and mineral reserves, any exploration leases granted, seismic activity, location of any wells etc

(c) Tourism and recreation (non fishing) - types of use/activity, visitation rates, seasonal use patterns, number of commercial operators

(d) Maritime transport – locations of shipping lanes and volumes of traffic

(e) Indigenous interests/values.

(f) Describe the legislation and management arrangements (both domestic and international) relevant to each of the uses above and or to the assessment area generally.

(g) Scientific and education values – such as ongoing projects, exploration, and relevance for future local and regional users.

5. Current and Potential Impacts on Natural Values

The report should identify natural processes and anthropogenic *processes* that may impact on the biophysical values of the assessment area. For example, the report should identify/list any existing and potential pressures from human impacts such as physical, chemical and or biological processes that impact on biophysical values such as the disturbance of seagrass habitat, heavy metal contamination and predation by introduced pests. Similarly the risk and associated impact of storm events, global warming and natural predators, etc., should be described.

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Appendix 3

Form letter to potential stakeholders and data holders

CSIRO Marine Research

GPO Box 1538 Hobart TAS 7001 Australia
Castray Esplanade Hobart Tasmania
Telephone (03) 6232 5222 Int +61 3 6232 5222
Facsimile (03) 6232 5000 Int +61 3 6232 5000
Web site: http://www.marine.csiro.au
Chief: Dr Tony Haymet

9 June 2004

To Stakeholders

Dear Stakeholder

The Department of the Environment and Heritage has established a work program with CMR to develop a Conservation Values Assessment (CVA) for the 'Norfolk Seamounts' region. The purpose of this assessment is to decide if the area contains biodiversity values worthy of protection[1].

This letter is aimed at informing you of the Conservation Values Assessment work we are undertaking on the Norfolk Seamounts region; as well as to call for information and/or data you or your organisation might be holding.

Information collected for the Assessment will include a description of the physical environment, a description of the biological environment, current and potential uses and existing management regimes, as well as current and potential impacts on natural values. The assessment will also attempt to address, where possible, the identification criteria proposed for the development of the National Representative System of Marine Protected areas[2] such as representativeness, comprehensiveness, uniqueness, naturalness and ecological importance. For this assessment we also intend to draw on data from seamounts and similar features in neighbouring regions for comparison and interpretation.

In an earlier part of the work program, CMR identified sources of information that could benefit the CVA. Your organisation may already have been contacted as part of this information gathering process in 2003. For the current project, we are now seeking your assistance to access data and information that may assist in the assessment of the Norfolk Seamounts region.

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[1] http://www.deh.gov.au/coasts/mpa/commonwealth/establish/about.html#identify
[2] http://www.ea.gov.au/coasts/mpa/nrsmpa/index.html

I appreciate you may have conditions to meet before data/information is released to us, and I would anticipate that some personal contact is required to see what may be necessary. Can I request that you nominate the contact details of the person within your agency that has the authority to act on your agency's behalf. A member of the project team, either Donna Hayes or Franzis Althaus, will then contact your nominated representative to identify what data and information is currently held by you, which may be available for use in this assessment process.

If you believe your organisation has relevant information and/or data can you please respond **before June 30, 2004**, so we have sufficient time to directly contact your nominated representative to arrange the inclusion of your information in the CVA. If you are interested in keeping informed about the status of the CVA process, we will be posting regular updates on our web site[3].

Could you please address any correspondence or enquiries to Franzis Althaus (e-mail: franzis.althaus@csiro.au; phone (03) 6232 5059) or Donna Hayes (e-mail: donna.hayes@csiro.au; phone (03) 6232 5014).

I look forward to hearing from you.

Yours sincerely

Alan Williams

Project Leader

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[3] http://www.marine.csiro.au/norfolkseamountscva (under construction, available by end of June)

Table A3-1 List of potential data holders and stakeholders in the Norfolk seamounts area contacted in the initial mail-out

Stakeholder groups	Organisation	Acronym	Organisation contact
Commonwealth and Local Government	Department of the Environment and Heritage	DEH	Hilary Sullivan Emma Campbell
	Member of the 10th Legislative Assembly of Norfolk Island	MLA	Ivens Buffett (Minister for Land and the Environment) Fred Howe
	Norfolk island administration	NIA	Peter Davison Grant Tambling
	Norfolk Island Park Manager	DEH	Brook Watson Paul Stevenson (ex-manager)
	Department of Transport and Regional Services	DoTaRS	Trudy McInnis
	Department of Agriculture, Fisheries and Forestry	DAFF	Neil Garbutt Beth Cameron Norm Kelly
	Australian Fisheries Management Authority	AFMA	Dave Johnson
	National Oceans Office	NOO	Sally Troy Alicjia Mosbauer
Defence	Australian Department of Defence		Colin Trinder
	Australian Hydrographics Services	AHS	Michael Andrews
Maritime transport	Association of Australian Ports and Marine Authorities	AAPMA	Sue Blackwell
	Australian Maritime Safety Authority	AMSA	Lisa Holman Lyn Murray
	Australian Shipowners Association	ASA	Angela Gillham
	Shipping Australia		Martin Orchard
Indigenous community	Norfolk Island's society of Pitcairn Descendants		Ric Robinson
Commercial fisheries (offshore)	Norfolk Island Offshore Demersal Finfish Fishery	NIODFF	Letter forwarded to stakeholders through AFMA
	Australian Seafood Industry Council	ASIC	Russ Neal
	Austral Fisheries		Martin Exel
	Ocean Fresh		Joe Pirrello
	Petuna Sealord		Les Scott
Inshore fisheries / recreation / tourism	Norfolk Island Tourism		Bruce Walker
	Advance Fishing		Darren Bates
	Bounty Divers		Jack Marges
	Charter Marine		
	Norfolk Fishing		Ian Kenny

Stakeholder groups	Organisation	Acronym	Organisation contact
	Norfolk Fishing Frenzy		Kim Friend
	Norfolk Island Fishing Club		Steve Nutley Ken Nobbs
Minerals / Petroleum	Australian Petroleum Production and Exploration Association Limited	APPEA	Barry Jones
	Minerals Council of Australia	MCA	Michael Bissell
	Apache Energy		Myles Hyams
	BHP Billiton		
	Chevron Texaco		
	Duke Energy		
	ESSO		
	Origin Energy		
	SANTOS		
	Woodside Energy		
Conservation groups/ NGOs	Australian Conservation Foundation	ACF	Chris Smythe
	Australian Marine Conservation Society	AMCS	Kate Davey (National coordinator)
	DEH - Coast care		Melissa Bradbury (NSW) Tanya Ashworth (Qld)
	Greenpeace		Quentin Hanich Carmen Gravatt
	Humane Society International	HSI	Lizzie Bowman
	Marine and Coastal Community Network	MCCN	Margaret Harlow
	Ocean Watch		
	Project Jonah		Pam Eiser
	SeaNet		Emma Bradshaw
	Whale and Dolphin Conservation Society	WDCS	Margi Prideau Michelle Grady Sarah Dolman
	World Wildlife Fund Australia	WWF	Margret Moore
Scientific/education	Australian Antarctic Division	AAD	Barry Barker- birds
	Australian Institute of Marine Sciences	AIMS	
	Australian Marine Science Association	AMSA	Chris Smalley
	Australian Oceanographic Data Centre	AODOC	Martin Rutherford
	Bureau of Rural Sciences	BRS	Richard Tilzey
	Census of Marine Life	CoML	Karen Stocks
	CSIRO Marine Research	CMR	Tony Koslow Peter Last Alastair Graham Brian Griffiths

Stakeholder groups	Organisation	Acronym	Organisation contact
	Department of the Environment and Heritage	DEH	Astrida Mednis (NI cetacean data)
	GA		Peter Harris Neville Exon George Bernardel
	National Institute of Water and Atmospheric Research (NZ)	NIWA	Ashley Rowden
	National Oceanographic Data Center	NODC	
	Southern Cross Uni	SCU	Prof Leon Zann
	University of the Sunshine Coast	USC	Dr. Thomas Schlacher
	University of Tasmania	UTas	Tony Crawford

Form letter to managers and participants in the NORFANZ survey

CSIRO Marine Research

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Web site: http://www.marine.csiro.au
Chief: Dr Tony Haymet

9 June 2004

Dear «FirstName»

I write to let you know that your work on the NORFANZ biological collections will make a direct contribution to a Conservation Values Assessment (CVA) for the 'Norfolk Seamounts' region being undertaken by CSIRO Marine Research (CMR) for the Department of the Environment and Heritage. The purpose of the assessment is to determine if the region contains biodiversity values worthy of protection[1]. The assessment will assist DEH to decide whether an area within the Norfolk Seamounts region will be included in Australia's National Representative System of Marine Protected Areas (NRSMPA).

Information collected for the Assessment will include a description of the physical environment, a description of the biological environment, current and potential uses and existing management regimes, as well as current and potential impacts on natural values. The assessment will also attempt to address, where possible, the identification criteria proposed for the development of the NRSMPA[2] such as representativeness, comprehensiveness, uniqueness, naturalness and ecological importance. For this assessment we also intend to draw on data from seamounts and similar features in neighbouring regions for comparison and interpretation.

In addition to your contribution to the NORFANZ project, I would be very interested to hear if you have any additional data, comments or suggestions for the CVA. Also, if you are interested in keeping informed about the status of the CVA process, the project team will be posting regular updates on our project web site[3].

With thanks

Yours sincerely

Alan Williams (Project Leader)

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[1] http://www.deh.gov.au/coasts/mpa/commonwealth/establish/about.html#identify

[2] http://www.ea.gov.au/coasts/mpa/nrsmpa/index.html

[3] http://www.marine.csiro.au/norfolkseamountscva (under construction, available by end of June)

Table A3-2 List of participants/managers of the NORFANZ project contacted

Organisation	Acronym	Name
Australian Museum		Shane Ahyong Penny Berents Jim Lowry Mark McGrouther John Paxton Helen Stoddart
Museum Victoria		Di Bray Martin Gomon Laura Holmes Mark Norman Tim O'Hara Mark O'Loughlin Gary Poore David Staples Robin Wilson
National Oceans Office	NOO	Vicki Nelson
NSW Fisheries		Ken Graham
Museum & Art Gallery of the Northern Territory	NTM	Phil Alderslade Richard Wilan
Queensland Museum		Bill Dall Peter Davie John Hooper Pat Mather
Coral Reef Research Foundation (Palau)		Michael Dawson
California Academy of Sciences (USA)		Tomio Iwamoto
Ministry of Fisheries (NZ)	Mfish	Jacqui Burges
National Institute of Water and Atmospheric Research (NZ)	NIWA	Malcom Clark Dennis Gordon Anna Lörz Don McKnight Peter McMillan Don Robertson
Museum of New Zealand Te Papa Tongarewa (NZ)	Te Papa	Andrew Stewart Bruce Marshall Clive Roberts Rick Webber
Museum national d'Histoire Naturelle (F)		Bernard Séret
Istitute du recherche pour le développement (previously ORSTOM) (F)	IRD	Bertrand Richer de Forges

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Appendix 4

Norfolk Seamounts CVA – Workshop — AGENDA

Dates: Monday December 13 and Tuesday December 14, 2004

Location: Cove Room, Block 1, Level 1; CSIRO Marine Laboratories

Chair: Alan Williams (Tel. 0419 146 109)

Objectives: 1. Biogeographic importance: does the area capture important biogeographic qualities?

2. Uniqueness: does the area contain unique species, populations, communities or ecosystems?

Participants: Ashley Rowden (NIWA), Bertrand Richer de Forges (IRD), Peter Davie (QM), Thomas Schlacher (USC), Tim O'Hara (MV), Tony Koslow (CMR); Emma Campbell (DEH)

Project team: Alan Williams, Dianne Furlani, Franzis Althaus, Karen Gowlett-Holmes

Day 1 Monday December 13, 2004

9:00	Meet at Reception area, CSIRO Marine Research Labs
9:15	Welcome and background (AW) Short overview from each participant on the regional/ faunal data-sets, including ideas on approaches to analysis and addressing the aims of the workshop (video projector/ o/h projector/ slide projector available)
10:30-10:45	Morning tea
	Discussion of analytical approaches in the context of the data available
12:30-13:30	Lunch
	Discussion of analytical approaches in the context of the data available; data analysis and interpretation
15:30-15:45	Afternoon tea
	Taking stock and plan for Day 2
17:00	End of day 1

18:45 Dinner at Gondwana Restaurant, Battery Point

Day 2 Tuesday December 14, 2004

9:00	Reconvene workshop
	Data analysis and interpretation
10:30-10:45	Morning tea
	Data analysis and interpretation
12:30-13:30	Lunch
	Wrapping up analyses and interpretations
15:00-15:15	Afternoon tea
	Summing up workshop outcomes and results
16:00	End of Workshop

Norfolk Seamounts CVA – Workshop — OUTCOMES

Introductory comments

We limited our discussions to benthic macro-invertebrates. Although fish are an important factor in the description of the conservation values of the region, they form only a small relatively well worked-up part of the fauna and as such were not considered in the workshop discussions.

Main discussion points

- Terminology:
  - → simple, clear, well defined
  - → report needs to provide clarity
  - → difference between physical/political boundaries needs to be clear
- Must be clear about original MPA questions. What is being asked? Why?
- Relict species and archaic fauna to be noted where known. Important factor for biodiversity protection.
- Analysis for final report to include number of species.
- Limitations of data, and how best to deal with this:
  - → species lists incomplete
  - → context unsure eg subsampling, confidence in ID's, different gears
- How to characterise seamount within or between areas:
  - → differences between shapes, depths, etc.
  - → use of environmental variables including geomorphology from swathmaps
  - → scaling of seamount height to depth of water column (eg Taylor column)
  - → depth of deep scattering layer
  - → value of course depth classifications as opposed to just depth of sample
- Consistency in classification of species between datasets
  - → eg benthic, benthopelagic, pelagic, etc
- What spatial separation can our data support?
  - → meaningful ways to split our data sets – what scale/division to use
  - → how to deal with differences in sampling effort/intensity
  - → importance of latitudinal gradient
  - → which metrics best suited

- How to deal with data ownership issues
- Need to qualify the data matrix to give meaning to any analysis
  - → Depth, gear, effort, sampling intensity, etc

Data descriptions

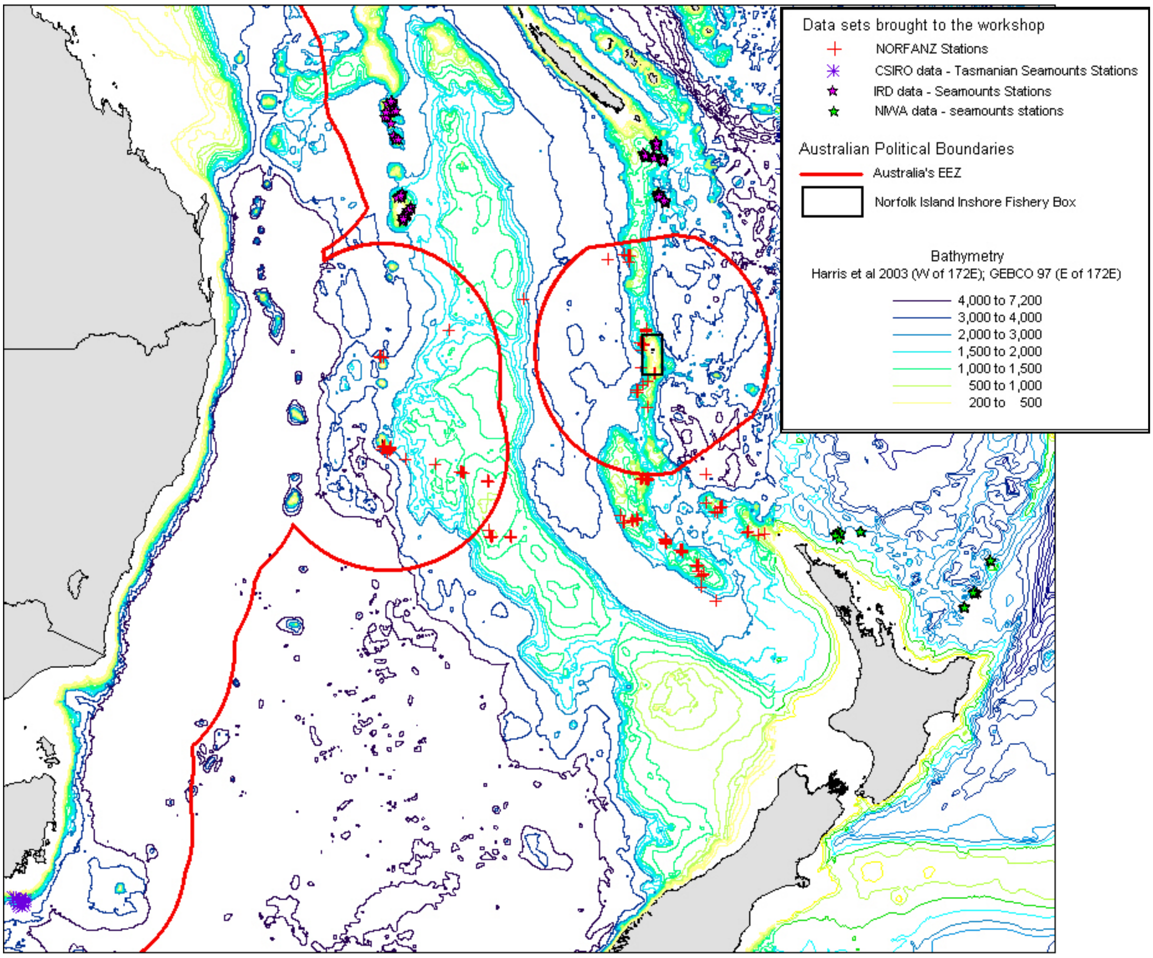

Figure A4-1 Geographical distribution of data sets brought to the workshop

Survey Data

<u>NORFANZ data</u>

- Physical
  - → Norfolk Ridge system, Lord Howe Rise,
  - → Covers 14 sites chosen based on abrupt features
  - → Sites include seamounts, ridge edges, plateaus
  - → Samples cover range of depths at each site

- Taxonomy
  - → Incomplete identification
  - → Often to OTU only
- High resolution groups
  - → sponges, octocorals, decapod crustacean (penaeids), pycnogonids, ophiuroids, octopods
- Gear
  - → CSIRO-Sebs (epibenthic sled), orange roughy trawl, beam trawl, midwater trawl, ratcatcher, NIWA sled, rockdredge
- Data limitations
  - → Samples lack comprehensive coverage
  - → Data is <u>not</u> quantitative
- IP: CSIRO, NIWA NOO, MFish,

<u>CSIRO data: Tasmanian seamounts data</u>

- Physical
  - → 14 pinnacles south of Tasmania, 6 within a reserve
  - → Samples cover range of depths at each: top, slope and bottom
  - → ~ 3 samples per site
- Taxonomy
  - → High taxonomic-resolution species-list available for entire cruise
- High resolution groups
  - → Decapods, ophiuroids, molluscs (cephalopod, bivalve)
- Gear
  - → CSIRO-Sebs, traps, drop lines
  - → CSIRO-Sebs used at each site
- Data limitations
  - → Prior trawl damage at pinnacle summit for some sites
  - → Data best treated as a cluster, not as individual seamounts
  - → Except for well treated groups, cannot be reconciled station by station
- IP: CSIRO, DEH

IRD (MUSORSTOM) data

- Physical
  - → Norfolk Ridge system (inside New Caledonian EEZ- Stylaster, Kaimon Maru, Jumeau Est, Jumeau Ouest, Azteque, Eponge), and seamounts of Lord Howe rise (Nova, Argo, Capel)
  - → Tabletop seamounts (i.e. differ in shape to others)
  - → Limestone sediments
  - → Top of seamounts vary from 250 to 800m below sea level
  - → Top of seamounts sampled only
  - → Norfolk Ridge system northern groups all close (~30km), southern group more widely spaced (~130km)
  - → Oceanography not well documented for individual seamounts
  - → Proposed fishery reserve encompasses the Norfolk Ridge seamounts within New Caledonia EEZ
- Taxonomy
  - → Variable treatment from fully identified species through to shipboard OTU's
  - → Archaic species "living fossils" within sponges, brachiopods and crinoids
  - → Some very long lived species eg >200yrs corals, >340yrs crinoids
  - → Trophic diversity noted in sponges and echinoderms through C and N signatures
- High resolution groups
  - → Molluscs, sponges (not hexactinellids), decapod crustaceans (penaeid, anomurans), ophiuroids
- Gear
  - → Beam trawl, Warren dredge, (few Charcol dredge samples)
- Data limitations
  - → No seamount-slope samples; no depth stratification
  - → Geology of seamounts unknown, but different to Lord Howe
- IP: IP: IRD, MNHN, CNRS, University Pierre & Marie CURIE

New Zealand seamounts data

- Physical
  - → Data of two regions brought to the workshop: TAN107, southern Kermadec Arc, and KAH0204, Northland Plateau
  - → Northland Plateau and southern Kermadec Arc seamounts are classed as different types according to the variables included in the NZ database
  - → Samples of 3 seamounts in each region

- Taxonomy
  - → Variable levels of identification
- High resolution groups
  - → Bryozoans, asteroids, sponges
- Gear
  - → Epibenthic sled, smaller than CSIRO-Sebs, larger than Warren Dredge
- Data limitations
  - → No depth stratification of samples
- IP: NIWA, MFish
- General comments on New Zealand Seamounts Project
  - → New Zealand data base identifying over 800 seamounts; for 400 of these a 13-variable description is available (variables include depth at peak and at base, base area, Chlorophyll *a* concentration above the peak; distance to continental margin)

Collated data-sets

Ophiuroid data (Tim O'Hara, MV)

- Ongoing biogeography project: "The biogeography and taxonomy of Ophiuroidea from the Coral and Tasman Seas"
- Data description
  - → Large database of a wide geographic range and covering a long time-frame
  - → Collation of ophiuroid records throughout Coral Sea and Tasman Sea, including data from IRD, New Zealand, Tasmanian Seamounts and NORFANZ
  - → Abundance data (some subsampling to be aware of)
  - → Data identified by geographical location (lat/long); seamounts not specified
  - → Overall sample coverage is sparse
  - → Collection effort/gears not standardised
  - → Currently few endemics (possibly sampling related or cryptic species)
  - → Genetics needed to separate potential taxonomically cryptic species
- Interpretation
  - → Large differences between Tasmanian and New Caledonian ophiuroid faunas (only 5% overlap, based on a 1° latitudinal grid)
  - → Evident longitudinal/latitudinal and bathymetric gradients
- IP: T. O'Hara (MV)

Decapod crustacean NORFANZ data (Peter Davie QM)

- Ongoing work on NORFANZ decapod crustacean data
- Data description
  - → Crabs: many rare and many new species; new records for Australia; high proportion of endemics
  - → Penaeids: not all benthic (only ~10 species, mostly shallow)

Sponge data IRD and NORFANZ (Thomas Schlacher)

- Statistical trial analyses of sponge distributions for separate data sets – IRD
- Interpretation
  - → Deeper sites showed less endemism; shallower sites were more site-specific
  - → Geographic separation (S vs. N on NC Norfolk Ridge) only important at depth <100 m
  - → Species richness decreases with increasing depth
  - → Confounding factors for analysis:
    - ➢ Spot-endemism (singletons)
    - ➢ Different gears used
    - ➢ Different bottom types
- IP: QM (Schlacher-Hoenlinger), NIWA

Considerations between data sets:

- Species lists incomplete
- Taxonomy incomplete and not reconciled between studies/areas
- Most consistently treated groups:
  - → Ophiuroids
  - → Sponges (excluding Hexactinellids)
- Context unsure e.g. subsampling, confidence in identifications
- Different gears/gear selectivities
- Different forms of data
- Different bottom types

- Limitations of background geomorphology
- Varying definitions of features

Analyses of regional patterns

During the workshop we identified ophiuroids and sponges as two groups that were treated consistently enough between surveys/data-sets to allow for pooling the data for analyses of regional patterns. Other groups that were consistently treated but that are not yet finalised enough to be available for analyses are bryozoans (ID's in progress now), benthic penaeids, and fishes.

A large portion of the workshop was spent on amalgamating data sets from different studies and regions and examining analytical methods that may be used to identify regional patterns of species distribution between seamounts and/or sites. Ashley Rowden and Thomas Schlacher worked principally on the sponge data from NORFANZ, IRD (seamounts on the Norfolk Ridge) and New Zealand; Tim O'Hara, with assistance from Dianne Furlani, and Franzis Althaus on the ophiuroid data in Tim's database.

The details of the reconciled data sets and the methodologies, data manipulation and analytical results are presented in detail in Appendix 5.

Questions considered:

- → What patterns emerge?
- → Are patterns driven by particular species/taxa?
- → What is the relative strength of physical factors (depth, geography, geomorphology, latitude)?
- → Relative influence of species numbers, overlaid by numbers of samples.

Statistical methods explored

PRIMER:

- Multi-Dimensional scaling plots of the data matrix were examined for patterns by
  - → depth
  - → latitude
  - → inside/outside Norfolk Island's EEZ on the Norfolk Ridge
  - → by geographic region / ridge systems

- BIO-ENV was used to identify the physical variables that drive patterns

OTHER STATISTICS CONSIDERED

- Taxonomic Distinctness analysis (in PRIMER)
- Lennon's B-SIM analysis was considered because it is not sensitive to differences in sampling effort
- Collectors curves – sample-based rarefaction curves
- Species rarefaction curves – individual-based rarefaction curves; only possible for **ophiuroid** data because abundance data is necessary for this analysis

Results in short (for details see Appendix 5)

Ophiuroid data

- The data in Tim O'Hara's database for the Tasman/Coral Seas has been restricted to data from sled-dredges and from seamounts only to eliminate confounding factors
- Data included originated from NORFANZ, IRD, Tasmanian Seamounts, as well as other surveys not described here
- 36 seamounts/seamount sites were used covering the South-Tasmanian seamounts, seamounts on and to the east of the Lord Howe Rise, and seamounts on the Norfolk Ridge system (Figure A4-2)
- 113 species from 132 samples were included
- Clustering in a 2D-MDS (more detail in Appendix 5):
  - → Tasmanian Seamounts cluster closely;
  - → Some seamounts flanking Lord Howe Rise and other to the west of Lord Howe Rise cluster relatively closely;
  - → Seamounts on the northern Norfolk Ridge studied in IRD surveys are scattered, mostly among the NORFANZ sites.
  - → Depth ranges separate clearly
- BIO-ENV
  - → Location (Lat/Long) and average depth appear to be the most important factors determining the difference between seamounts in respect of the ophiuroid data,

while species richness appears not to be a good measure. This may be due to the high percentage of spot-endemics (i.e. species with a single occurrence record): 47% (53).

- ANOSIM by Ridge:
  - → Tasmanian Seamounts are significantly different from the other regions; no other significant differences were observed.

Sponge data

- Reconciliation of NORFANZ, IRD (Norfolk) and New Zealand sponge data required exclusion of all Hexactinellids and some other species, where identification in each study is to species level, but the taxonomy is not reconciled
  - → Reduction of 500 OTUs to 179 species
- 27 sites were considered spread over the Norfolk Ridge system, the Northland Plateau, Kermadec Arc and few NORFANZ sites on the Lord Howe Rise
- The resulting data matrix was considered too sparse for meaningful statistical analysis

The problem of the sparse data matrix could potentially be solved by additional taxonomic work. In particular, reconciling the Hexactinellid sponge identifications between the three data sets, such that this group could be included in statistical analyses, would be an invaluable addition to the data.

Norfolk Seamounts CVA – Workshop — RECOMMENDATIONS

- Reconcile taxonomy of high resolution groups between studies/areas (e.g.. sponges – Hexactinellids; other groups – e.g. squat lobsters)
- High resolution taxonomy is essential for analyses, particularly if metrics that are not sensitive to sampling effort (e.g. Taxonomic Distinctness (Clarke and Warwick 2001)) are to be used
- Examine gear effects within and between studies – can they be quantified, corrected for?

- Detailed classification/description of the seamounts is needed – this would provide abiotic factors to examine differences in seamount faunas against
- Validate phylum/taxonomic group absence using visual techniques, both in combination with sampling gears and in areas where gears cannot be used
- Substratum types are known to make a difference to the fauna; but it is impossible to sample the sediments of entire seamounts. Extensive swath-mapping of all seamounts to be compared would assist determination of differences in substratum types.
- Analyses comparing fauna of seamounts and nearby continental slopes might be necessary in order to compare different deep-sea habitats.
- Pure richness measures (i.e. number of species sampled) are not informative due to high percentages of spot-endemics; collectors curves might be more useful.
- Particular consideration of differences between Norfolk Ridge and Lord Howe Rise — which is more “iconic”?

Conclusions

During the workshop it was remarked several times that the Tasman and Coral Seas are probably the most comprehensive and detailed studied in the world, in respect to seamount and other deep sea faunas. It will take decades to work through all the collected material in detail. However, with the current status of macro-invertebrate taxonomy of many groups only very limited regional analyses of combined data sets from various surveys are possible.

Tim O’Hara’s bioregionalisation project represents such a study. He has to date collated and reconciled a large data base of ophiuroid species distribution throughout the region by visiting the collections of the various data contributors and verifying and reconciling the specimen identifications. His work is still ongoing, with conclusion expected in 2006.

A similar effort for sponges and potentially some crustacean groups which have been worked on intensively in Australia, New Caledonia and New Zealand would be possible within a reasonable time frame.

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Appendix 5 — Faunal distribution in the Coral and Tasman Seas — Regional Data Analysis

Authors (alphabetically): Althaus F.[1]; Furlani, D. [1]; O'Hara, T.[2]; Rowden, A.[3]; Schlacher, T.[4]; Williams, A. [1]
Affiliation: [1] CSIRO Marine Research; [2] Museum Victoria; [3] NIWA; [4] Queensland Museum

Background

Willcox *et al*. 2001 report that despite the relative data richness on parts of the Norfolk Ridge, Lord Howe Rise and on the Tasmanian Seamounts, there "*was inadequate understanding of biogeographic relationships on which to base a comprehensive, adequate and representative network of MPAs".* The data Willcox *et al* (2001) are referring to are from the extensive deepsea surveys undertaken by MUSORSTOM (now IRD) and from the CSIRO survey of the southern Tasmanian Seamounts.

Additional work has been done, since the release of the Willcox *et al.* (2001) report, to fill in some of the identified gaps: the NORFANZ survey was aimed at identifying and comparing the biodiversity of the southern and central Norfolk Ridge and the Lord Howe Rise; a national demersal and pelagic bioregionalisation is being undertaken by the NOO, GA and CMR in partnership; and the New Zealand Ministry of Fisheries is funding a large biodiversity project undertaken by NIWA, looking at seamounts in the New Zealand EEZ. In addition, T. O'Hara is in the process of compiling a comprehensive database of ophiuroids from the Coral and Tasman Seas, for an ophiuroid bioregionalisation project. However, these surveys and projects are still ongoing and thus, results are not yet published.

We organised a workshop with key people involved in seamounts studies in the Coral and Tasman Seas to obtain their expert opinion/impression on the faunal distributions in the region and, if possible, to gain insights into preliminary results from their respective studies. Furthermore, at the workshop we aimed at pooling data sets from the various studies for an analysis of regional patterns in the fauna distribution on seamounts in the Coral and Tasman Seas.

Methods

Regional distribution of surveys and data sets

As mentioned above, deepsea fauna and, in particular, seamounts in the Coral and Tasman Seas have been examined in a series of surveys. The spatial distribution of the stations sampled in these surveys is visualised in Figure A5-1. Additional data from a variety of sources may be available for the chain of seamounts that lies between the Australian shelf and the Lord Howe Rise.

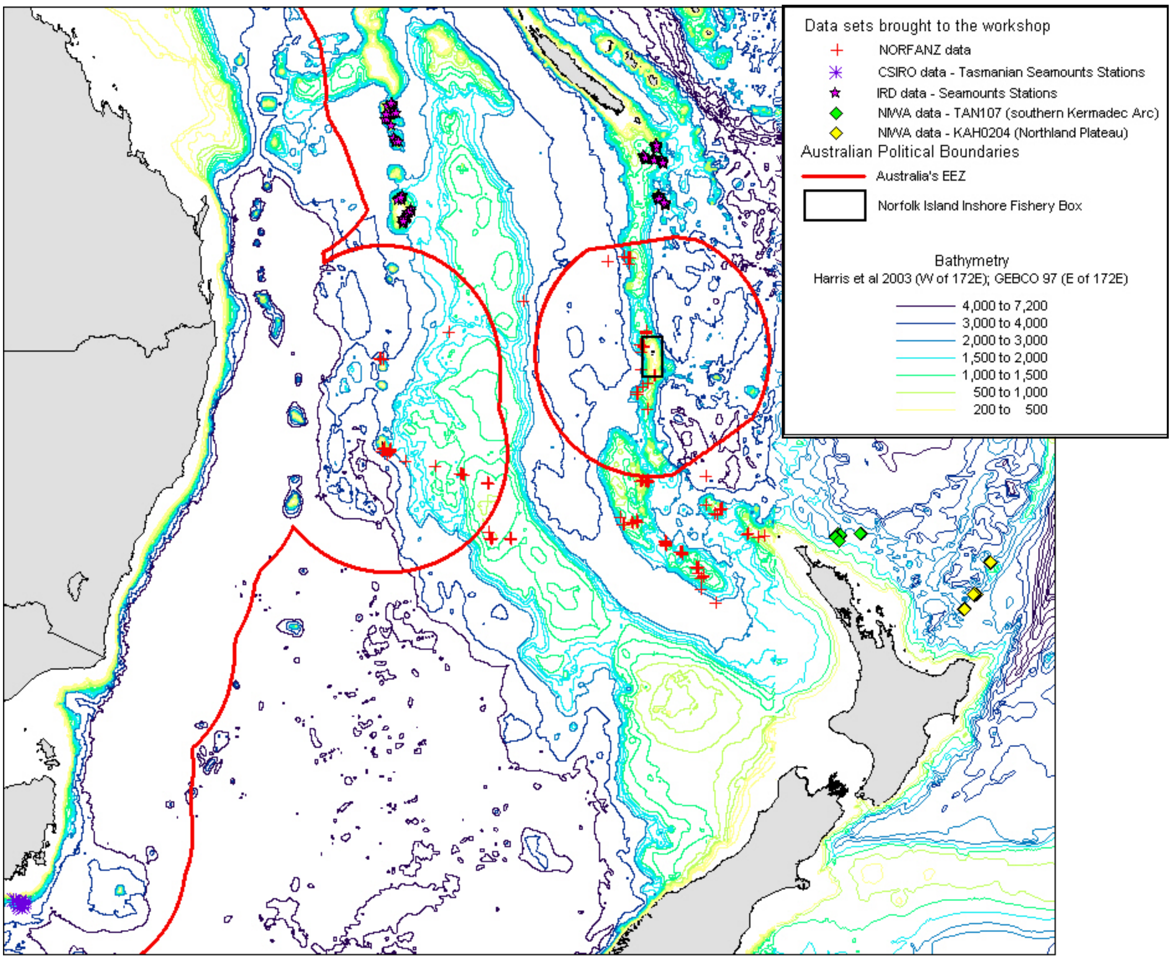

Figure A5-1 Geographical distribution of data sets brought to the workshop

Comparing the sampling protocols, gears and species coverage of the different surveys, we found that only a limited group of taxa were consistently treated and identified to species – or, where the taxonomy is not finalised, putative species – between surveys. These are fish (which we did not discuss at the workshop), ophiuroids, sponges, and, although not yet available, bryozoans and benthic penaeids.

Regional data available for analyses

Ophiuroids

T. O'Hara had compared and checked ophiuroid identifications and collated distribution data from all current and historical surveys and projects in the region, with the exception of data from New Zealand which will be added to the database at a later stage. Thus his database consists of species level identification of all ophiuroids historically collected in the Coral and Tasman Seas including background information such as sampling gear, location, depth, date etc. At the time of the workshop data from New Zealand had not yet been inspected and checked in detail and thus had not yet been added to the database. Most of the data included in analyses originated from NORFANZ (NOO, CMR, MFish, NIWA) and from IRD surveys; but also includes some New Zealand material that has been published by D. McKnight (formerly NIWA), and data from earlier CSIRO surveys by the research vessels Soela, Franklin and Southern Surveyor, as well as some other surveys (e.g. from the Russian boat Dmitry Mendeleev).

Sponges

The sponge data of the Coral and Tasman Seas were not comprehensively databased. Instead, the sponge data brought to the workshop stems from three separate data sources: (1) NORFANZ (NOO, CMR, MFish, NIWA); (2) Norfolk 1 – IRD survey data of New Caledonian seamounts on the Norfolk Ridge (Schlacher-Hoenlinger); and (3) TAN107 (southern Kermadec Arc) and KAH0204 (Northland Plateau) (NIWA).

Sponges collected in the NORFANZ and Norfolk 1 were processed, and classified to species or putative species (morphotypes with many having unique species names/registration numbers) at the Queensland Museum; sponges collected in TAN107 and KAH0204 were similarly processed, and classified to species or putative species (morphotypes with many having unique species names/registration numbers) at NIWA. T. Schlacher and A. Rowden brought the Queensland Museum and the NIWA data, respectively, to the workshop. In order to achieve as comprehensive as possible coverage of the sponge distribution in the region they combined the three datasets. However, this necessitated the exclusion of species where identifications had a potential for ambiguity which resulted in the removal of all calcareous sponges and hexactinellids. Thus, the data set was reduced to only demosponges that have unique species identification.

It must be stressed that the removal of hexactinellids – a group that consists mostly of deeper water species – will severely constrain the reliability of any interpretations of the pattern revealed by analysis of this dataset.

Data conditioning

Collection Gears

Various gears were employed on the different surveys; demersal and beam trawls, sleds/dredges. The only sampling gears that were consistently used in the region were a variety of sleds or dredges. NORFANZ used the CMR-designed epibenthic sled 'Csiro-Sebs' (Lewis 1999) and the 'NIWA sled'; the Tasmanian Seamounts survey used the 'Csiro-Sebs' sled; IRD used a Charcol dredge and later a Warren Dredge; and NIWA used the 'NIWA sled' – we refer to these sampling gears as sled-dredges from here onward. Beam trawls had been used in the IRD surveys and selectively on the NORFANZ survey (only on soft bottom); however, this gear type was not used on the two New Zealand surveys.

We limited our analyses to samples from sled-dredges only, in order to achieve comparability between data-sets. This was necessary because no information on comparative gear performance on seamounts is available to date.

Sample aggregation

Samples, and thus species, were aggregate for each individual seamount because the number of individual sled-dredges on seamounts is highly variable and thus precludes analysis of spatial variation within seamounts. Furthermore, at least for the sponge data, most demosponges have highly localised distributions (i.e. single stations or spot-endemics), introducing high variation in assemblage composition on a spatial scale much smaller than is of interest to this analysis.

The main data sets we used came from seamounts surveys. Thus, samples were intrinsically associated with seamount locations and names (Figure A5-2). T. O'Hara's data base was queried by seamount location. Where we only had a point location for a seamount we included data from a radius of approximately 10 km.

For each seamount physical attributes such as average sampling depth and location were recorded (Table A5-1).

For comparison between sub-regions the seamounts were assigned to ridges (Table A5-1) based on (a) bathymetric continuity within a ridge and (b) distinct breaks in relief and depth between ridges, and to distinct regions with clusters of seamounts, such as the southern Tasmanian seamounts or the chain of seamounts between Australia's continental margin and the Howe Rise (Figure A5-3). These ridges and regions are collectively called 'Ridge' from here onward. The Norfolk Ridge system was divided along the Vening Meinesz Fracture Zone into the 'Norfolk Ridge proper' and the 'West Norfolk Ridge'. The South Norfolk Ridge is, strictly speaking, an extension of the New Zealand shelf from the North Cape. The Lord Howe Rise was considered to encompass the seven seamounts along its immediate north-western flank – only one seamount, N9, is strictly situated on the Lord Howe Rise. Finally, the region labelled 'West of Lord Howe Rise' refers to a row of seamounts running centrally between the Australia's continental margin and the Lord Howe Rise.

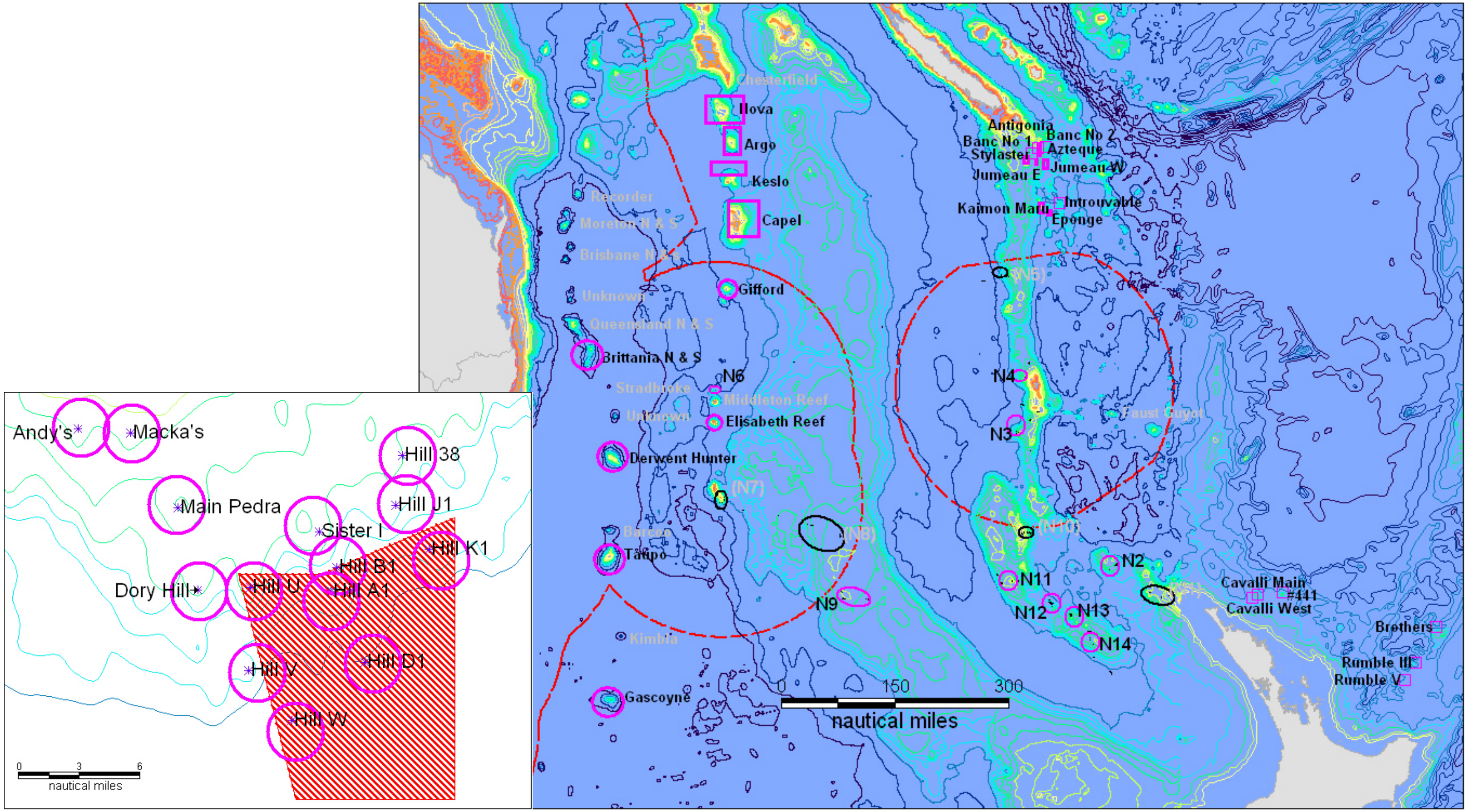

Figure A5-2 Location, name and extent of seamounts in the Coral and Tasman Seas. Seamounts outlined in pink with black labels were included in analyses of the sponge and/or the ophiuroid data. Inset map: location of the southern Tasmanian Seamounts (only Ophiuroid data available)

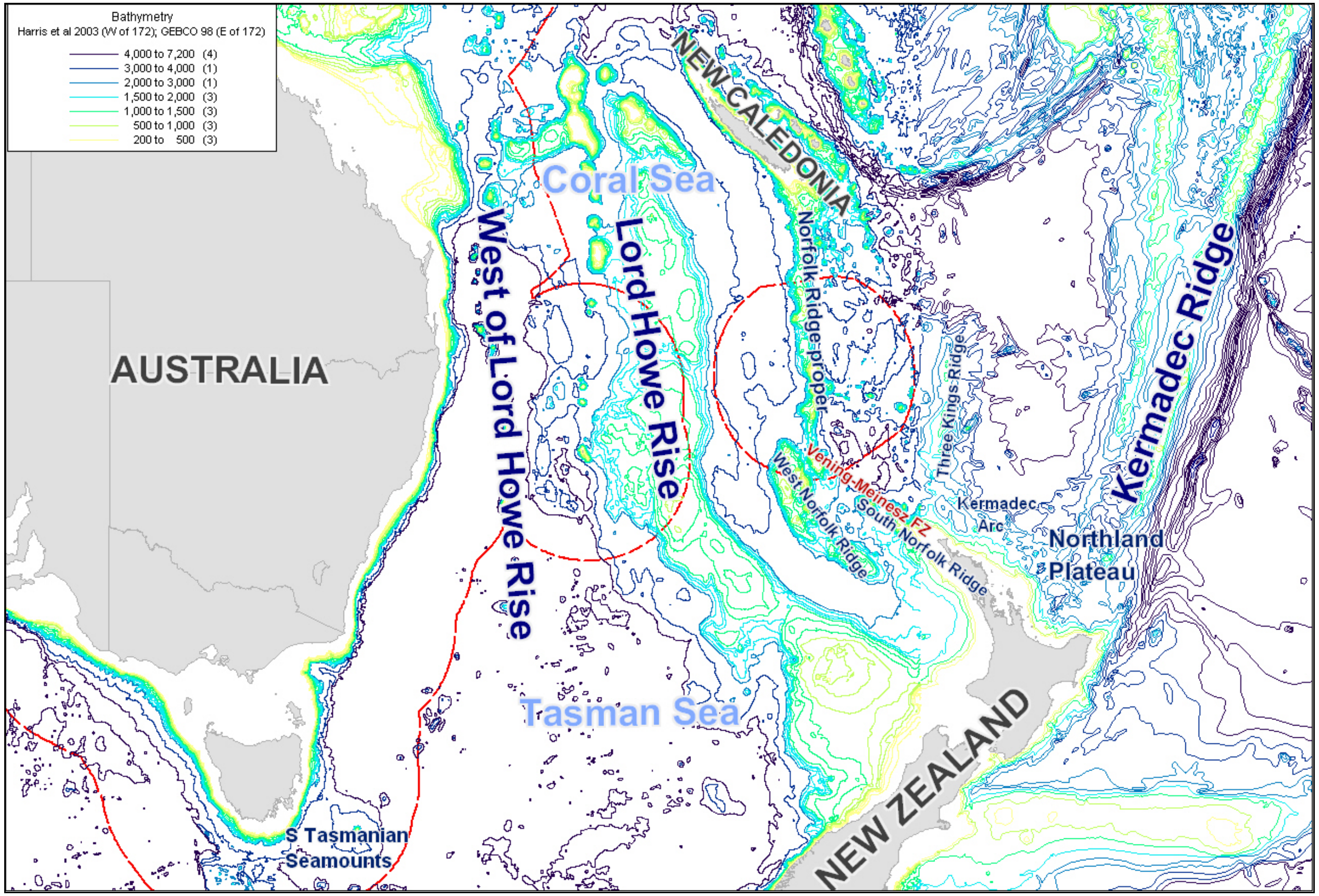

Figure A5-3 Geographically defined 'Ridges' – ridges and regions with clusters of seamounts used for combining seamounts by geographically defined are

Table A5-1 Seamounts in the coral and Tasman seas that were sampled for ophiuroids and/or sponges

Ridge	Seamount Name	Latitude (ºS)	Longitude (ºE)	Avg. sample depth (m)	Ophiuroid data # of Samples (sled-dredge)	Sponge data # of Samples
Tas seamounts	38	44.22	147.36	1220	2	-
Tas seamounts	A1	44.33	147.27	1325	2	-
Tas seamounts	Andys	44.19	146.98	836.7	3	-
Tas seamounts	B1	44.31	147.28	1320.5	3	-
Tas seamounts	D1	44.39	147.31	1795.8	2	-
Tas seamounts	Dory Hill	44.33	147.12	1163.3	3	-
Tas seamounts	J1	44.26	147.35	1229	3	-
Tas seamounts	K1	44.29	147.39	1412.5	2	-
Tas seamounts	Macka’s	44.20	147.04	721. 7	3	-
Tas seamounts	Main Pedra	44.26	147.10	790.5	1	-
Tas seamounts	Sister 1	44.28	147.26	1055.5	2	-
Tas seamounts	U	44.33	147.18	1166.5	2	-
Tas seamounts	V	44.39	147.18	1511.3	3	-
Tas seamounts	W	44.44	147.23	1765	1	-
West of Lord Howe Rise	Britannia	28.31	155.54	422	2	-
West of Lord Howe Rise	Derwent Hunter	30.81	156.26156	288	1	-
West of Lord Howe Rise	Taupo	33.18	156.17	132	3	-
West of Lord Howe Rise	Gascoyne	36.62	156.20	144	2	-
Lord Howe Rise	Nova	22.08 to 22.75	158.83 to 159.92	364.3	9	-
Lord Howe Rise	Argo	22.83 to 23.5	159.33 to 159.83	289	3	-
Lord Howe Rise	Kelso	23.67 to 24	159 to 159.99	328	1	-
Lord Howe Rise	Capel	24.62 to 25.	159.47 to 160.33	317.1	15	-
Lord Howe Rise	Gifford	26	159	337.5	1	-
Lord Howe Rise	N6	29.25 to 29.2	158.98 to 159.1	718.2	5	4
Lord Howe Rise	Elizabeth Reef	29.95	159.08	535	2	-
Lord Howe Rise	N9	34.23 to 34.01	162.59 to 163.33	617.5	3	1
Norfolk Ridge proper	Banc No 1	23.46	167.85	353	-	5
Norfolk Ridge proper	Banc No 2	23.30	168.25	236	-	3
Norfolk Ridge proper	Antigonia	23.34	168.03	378	-	2
Norfolk Ridge proper	Azteque	23.25 to 23.53	168.03 to 168.12	289.4	7	-
Norfolk Ridge proper	Stylaster	23.55 to 23.72	167.63 to 167.8	583.2	3	3

Ridge	Seamount Name	Latitude (ºS)	Longitude (ºE)	Avg. sample depth (m)	Ophiuroid data # of Samples (sled-dredge)	Sponge data # of Samples
Norfolk Ridge proper	Jumeau E	23.62 to 23.85	168.18 to 168.33	410	8 (excluded from analyses)	1
Norfolk Ridge proper	Jumeau W	23.62 to 23.75	167.97 to 168.05	277.6	6	1
Norfolk Ridge proper	Introuvable	24.66	168.65	583	-	4
Norfolk Ridge proper	Kaimon Maru	24.65 to 24.92	168.07 to 168.22	284.5	12	1
Norfolk Ridge proper	Eponge	24.85 to 24.98	168.3 to 168.42	574.8	3	1
Norfolk Ridge proper	N4	29.04 to 28.47	167.57 to 167.79	1050	0 (samples from other gears only)	1
Norfolk Ridge proper	N3	30.62 to 29.69	167.45 to 168.05	636. 7	3	3
West Norfolk Ridge	N11	33.82 to 33.61	166.9 to 167.48	272.5	1	2
West Norfolk Ridge	N12	34.41 to 34.25	168.36 to 168.44	378	1	2
West Norfolk Ridge	N13	34.63 to 34.56	168.89 to 168.97	804.5	2	2
South Norfolk Ridge	N2	33.55 to 33.26	169.72 to 170.25	851.2	6	2
Kermadec Arc	#441	34.05	174.81	781	-	5
Kermadec Arc	Cavalli Main	34.10	174.11	461	-	12
Kermadec Arc	Cavalli West	34.17	173.96	769	-	7
Northland Plateau	Brothers	34.87	179.06	1430	-	13
Northland Plateau	Rumble III	35.74	178.51	627	-	26
Northland Plateau	Rumble V	36.14	178.20	647	-	14

Objectives

1. Assess whether ophiuroid/sponge assemblages of seamounts differ between ridges in terms of species composition (i.e. beta-diversity or similarity/dissimilarity).
2. Identify whether depth and geographic position relate to patterns derived from spatial analysis of ophiuroid/sponge assemblage composition.
3. Examine whether ophiuroid/sponge assemblage on seamounts located within the Norfolk Ridge EEZ differ from those on mounts elsewhere on the Norfolk Ridge.

Numerical analysis approach

Spatial patterns in assemblage composition were derived following routine methods outlined by Clarke and Warwick (Clarke 1993; Clarke and Warwick 1997). In essence, beta-diversity was calculated by standard Bray-Curtis on presence/absence data (also referred to as Dice-, Sorensen- or Coefficient of Community – C –; e.g. Richer de Forges *et al.* 2000) and patterns in similarities depicted by non-metric multidimensional scaling (MDS). Relationships between environmental variables and biological patterns were explored with the BIO-ENV routine, and differences in similarities between a priori defined site groups (e.g. between ridges) were tested with ANOSIM (Analysis of Similarities). All methods used are routinely available in the PRIMER software package (Clarke and Gorley 2001).

Results

The ophiuroid and sponge datasets are analysed separately.

Ophiuroids

Evaluation of data adequacy

The ophiuroid data-set contains data from all surveys in the Coral and Tasman Sea region. All species identifications contained in this data-set were checked and confirmed by T. O'Hara, the ophiuroid expert who compiled the data.

For our purposes we restricted the data-set to samples from seamounts only. Ophiuroid samples were collected from 37 seamounts (Table A5-1) covering the South-Tasmanian seamounts, seamounts on and to the east of the Lord Howe Rise, and seamounts on the Norfolk Ridge system (Figure A5-2). By restricting the gear type to sled-dredges only we effectively reduced the number of seamounts included to 36; one seamount sampled on the NORFANZ survey, N4, had no ophiuroid samples taken with sled-dredges. Twenty-nine species – 20% of the 142 species recorded from seamounts in the region – were excluded from further analyses due to the gear restriction. In total 132 samples covering 113 species were included in the analyses. The numbers of samples, species and specimens taken with sled/dredge gear from each seamount are listed in Table A5-2; a complete species list, including their distribution over seamounts on each ridge is given in Table A5-3.

Table A5-2 Summary of the ophiuroid data matrix by seamount, including the ridge attributed to each seamount

Ridge	Seamount Name	Number of Sled/Dredge Samples	Number of Species	Number of Specimens
Tas seamounts	38	2	16	119
Tas seamounts	A1	2	10	70
Tas seamounts	Andy’s	3	14	74
Tas seamounts	B1	3	21	201
Tas seamounts	D1	2	10	60
Tas seamounts	Dory Hill	3	13	510
Tas seamounts	J1	3	21	251
Tas seamounts	K1	2	19	259
Tas seamounts	Macka’s	3	7	23
Tas seamounts	Main Pedra	1	3	9
Tas seamounts	Sister 1	2	18	460
Tas seamounts	U	2	16	199
Tas seamounts	V	3	25	1078
Tas seamounts	W	1	1	6
West of Lord Howe Rise	Britannia	2	8	71
West of Lord Howe Rise	Derwent Hunter	1	3	6
West of Lord Howe Rise	Gascoyne	2	5	23
West of Lord Howe Rise	Taupo	3	3	12
Lord Howe Rise	Argo	3	1	17
Lord Howe Rise	Capel	15	17	70
Lord Howe Rise	Elizabeth Reef,	2	7	15
Lord Howe Rise	Gifford	1	2	3
Lord Howe Rise	Kelso	1	1	3
Lord Howe Rise	N6	5	12	55
Lord Howe Rise	Nova	9	15	144
Lord Howe Rise	N9	3	7	12
Norfolk Ridge proper	Azteque	7	14	41
Norfolk Ridge proper	Esponge	3	3	5
Norfolk Ridge proper	Jumeau W	6	6	9
Norfolk Ridge proper	Kaimon Maru	12	10	31
Norfolk Ridge proper	Stylaster	3	7	13
Norfolk Ridge proper	N3	3	3	3
West Norfolk Ridge	N11	1	6	29
West Norfolk Ridge	N12	1	2	3
West Norfolk Ridge	N13	2	8	76
South Norfolk Ridge	N2	6	15	589

Table A5-3 Comprehensive list of the ophiuroid species included in the analyses. Also given are the number of seamounts (# SM) each species is recorded for in total and by Ridge.

	All Ridges	Southern Tasmanian seamounts	West of Lord Howe Rise	Lord Howe Rise	Norfolk Ridge proper	West Norfolk Ridge	South Norfolk Ridge
Species Name	# SM	# SM	# SM	# SM	# SM	# SM	# SM
Total number of seamounts per ridge	36	14	4	8	6	3	1
Amphiophiura bakeri	1						1
Amphiophiura distincta	1				1		
Amphiophiura insolita	1						1
Amphiophiura ornata	1						1
Amphiophiura sp D	1			1			
Amphiophiura urbana	1						1
Amphioplus jarum	1			1			
Asteroschema igloo	1				1		
Astroboa granulatus	1			1			
Astrobrachion adhaerens	1			1			
Astroceras compar	1				1		
Astroceras elegans	1				1		
Astrothrombus rugosus	1				1		
Astrothrombus vecors	1						1
Bathypectinura heros	1			1			
Clarkcoma bollonsi	1		1				
Gorgonocephalus pustulatum	1	1					
Ophiacantha cornuta	1			1			
Ophiacantha dallasi	1				1		
Ophiacantha fidelis	1						1
Ophiacantha longidens	1			1			
Ophiacantha pentagona	1				1		
Ophiacantha serrata	1				1		
Ophiacantha sp MoV 4536	1	1					
Ophiactis macrolepidota	1				1		
Ophiernus adspersus	1			1			
Ophiochiton sp MoV 4887	1						1
Ophiocypris megaloplax	1		1				
Ophiodera neglecta	1			1			
Ophiolimna antarctica	1					1	
Ophiomastus sp A	1				1		
Ophiomedea discrepans	1		1				
Ophiomitrella granulosa	1					1	
Ophiomitrella parviglobosa	1				1		
Ophiomitrella suspectus	1						1
Ophiomoeris nodosa	1				1		
Ophiomusium asperum	1			1			
Ophiomusium sp A	1			1			
Ophionereis sp MoV 4888	1				1		

	All Ridges	Southern Tasmanian seamounts	West of Lord Howe Rise	Lord Howe Rise	Norfolk Ridge proper	West Norfolk Ridge	South Norfolk Ridge
Species Name	# SM	# SM	# SM	# SM	# SM	# SM	# SM
Ophiophrixus confinis	1			1			
Ophiophycis johni	1		1				
Ophioplax lamellosa	1			1			
Ophiopristis dissidens	1				1		
Ophiopristis procera	1			1			
Ophiopsammus aequalis	1				1		
Ophiopsammus assimilis	1		1				
Ophiopsammus yoldii	1			1			
Ophioscolex sp. MoV 2721	1	1					
Ophiosphalma armigerum	1		1				
Ophiothrix vexator	1				1		
Ophiozonoida sp (tubercles)	1		1				
Ophiura micracantha	1			1			
Ophiurolepis accomodata	1	1					
Amphiura sp 2 (Lord Howe Rise)	2		2				
Asteronyx loveni	2	2					
Asteroporpa reticulata	2				2		
Ophiactis definita	2			2			
Ophiocamax vitrea	2				2		
Ophiomusium luetkeni	2			2			
Ophiomyces delata	2			2			
Ophiura flagellata	2	2					
Stegophiura sp 2	2			2			
Amphiophiura confecta	2			1	1		
Asteroporpa australiensis	2		1			1	
Asteroschema bidwillae	2					1	1
Ophiactis plana	2	1	1				
Ophiocreas mortenseni	2			1		1	
Ophiomusium lymani	2	1		1			
Ophiostriatus bispinosus	2			1	1		
Renetheo felli	2			1		1	
Ophiacantha sp MoV 4537	3	3					
Ophiura jejuna	3	3					
Asteroporpa indicus	3			1	2		
Ophiacantha fuscina	3				2	1	
Ophiohamus nanus	3			1	2		
Ophioleuce brevispinum	3			2		1	
Ophioplinthaca defensor	3	2		1			
Ophiothrix lepidus	3		2	1			
Ophiomitra leucorhabdota	3		1	1	1		
Ophiomyxa brevirima	3			1		1	1
Ophiothrix aristulata	3	1		1			1
Amphioplus sp MoV 2722 (Seamount)	4	4					

	All Ridges	Southern Tasmanian seamounts	West of Lord Howe Rise	Lord Howe Rise	Norfolk Ridge proper	West Norfolk Ridge	South Norfolk Ridge
Species Name	# SM	# SM	# SM	# SM	# SM	# SM	# SM
Ophiacantha sp MoV 4532	4	4					
Ophiocten hastatum	4	4					
Ophiomisidium irene	4	4					
Amphiophiura pertusa	4			2		1	1
Ophiomusium scalare	4				2	1	1
Ophiocamax applicatus	5	5					
Ophiomitrella sp MoV 2732	5	5					
Ophiura irrorata	5	5					
Ophiurid sp MoV 2733 (Seamount)	5	5					
Ophiopallas paradoxa	5			3	2		
Astrothorax waitei	5	3			1		1
Ophioleuce seminudum	5			2	2	1	
Ophiocreas sibogae	5	2			1	1	1
Ophiacantha sp MoV 2780	6	6					
Ophiotreta valenciennesi	6		1	3	2		
Ophiomoeris obstricta	6		1	3	1	1	
Ophiacantha sp MoV 2731	7	7					
Ophiacantha vepratica	7	7					
Dictenophiura platyacantha	7		2	5			
Ophiacantha spectabilis	8	8					
Ophiomitrella conferta	8	8					
Ophiurothamnus clausa	8	7				1	
Ophiacantha vivipara	9	9					
Ophiolimna sp cf bairdi (Seamount)	9	9					
Ophiura sp MoV 2728 (Seamount)	9	9					
Ophiacantha yaldwyni	10	10					
Ophioplinthaca plicata	10	9		1			
Ophiacantha densispina	11	11					
Ophiacantha rosea	13	12		1			
Ophiactis abyssicola	15	12		1	1	1	
Ophiomyxa australis	16	10	1	3	2		

Some seamounts have only a single species recorded (Table A5-2), but these seamounts were not affected by the restriction in gear type; furthermore, multiple specimens of the single species were recorded. Thus we are confident that this was not an artefact of the data-treatment in this analysis.

A high percentage of species (47%) were recorded from a single seamount (Table A5-3, Figure A5-4); these species can be called spot-endemics. However, given the relatively sparse data coverage for each seamount, it is impossible to determine if these species are truly endemic to a particular seamount.

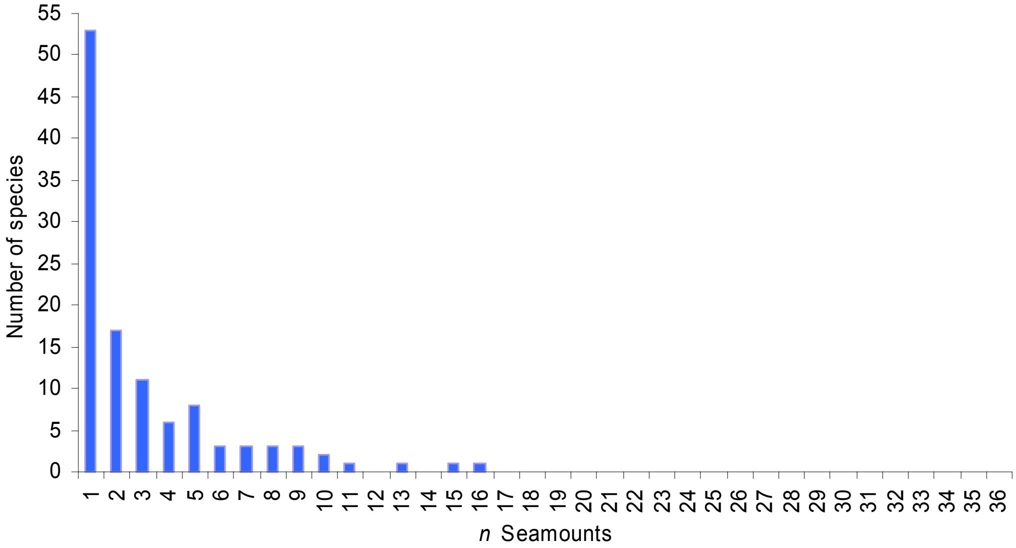

Figure A5-4 Bar-graph representation of the number of ophiuroid species common to *n* seamounts (*n* = 1, 2, 3, … 36)

The distribution of the 113 species over the six Ridges is shown in Table A5-3; Figures A5-5a and b below show the break-down of these species into species shared between two or more seamounts/Ridges and species unique to each seamount/Ridge. Most Ridges have approximately equal amounts of unique and shared species, with the exception of the Tasmanian Seamounts that have a higher proportion (70%); and the West Norfolk Ridge that had no unique species. Interestingly, the high proportion of unique species on the Tasmanian Seamounts as a group is not reflected in the individual seamounts which, collectively, have the lowest number of species unique to an individual seamount.

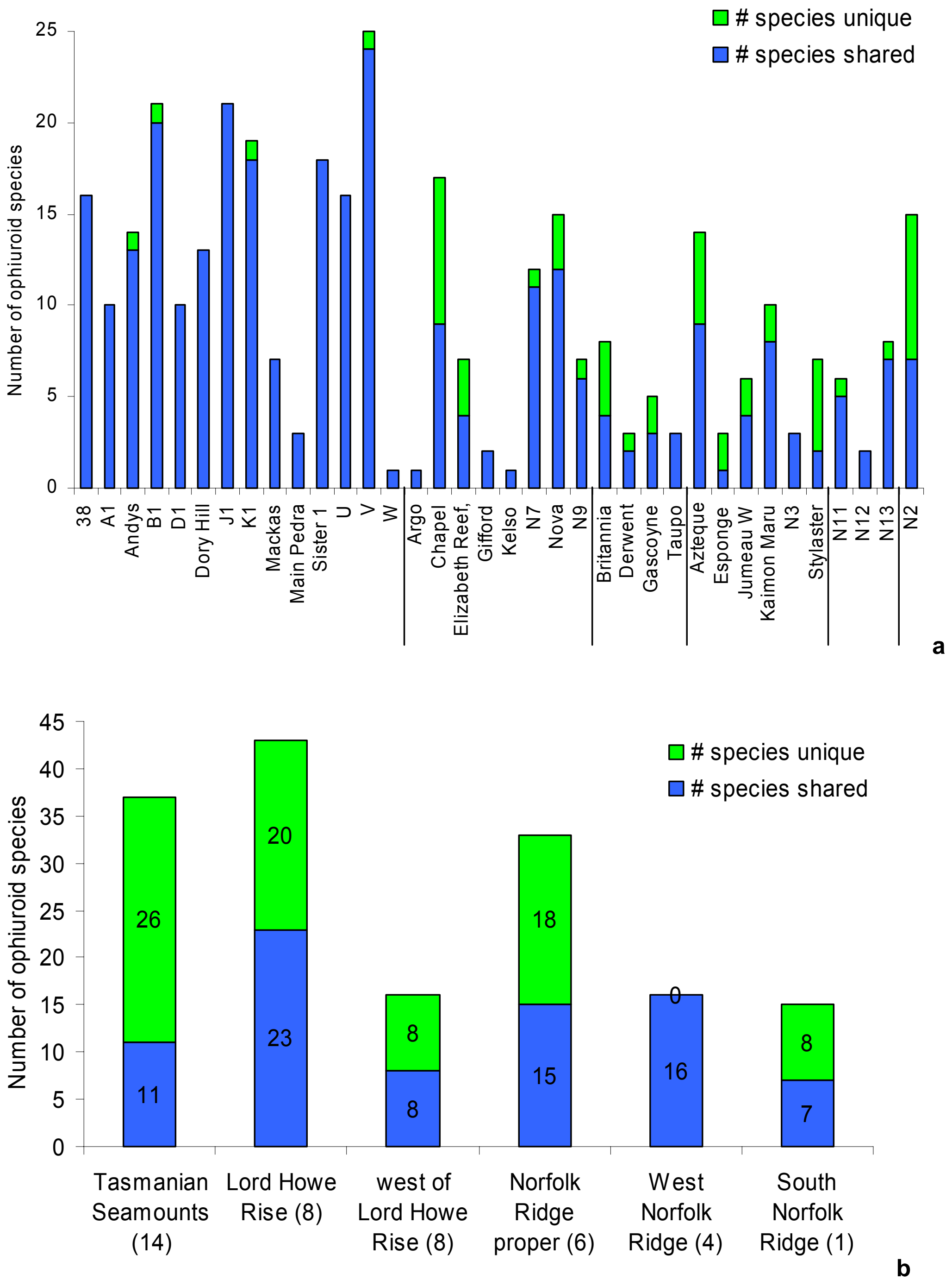

Figure A5-5 Distribution of shared and unique species over (a) the individual seamounts and (b) the Ridges. For (a) the vertical lines on the x-axis demarcate the different Ridges – these are ordered in the same sequence as in (b). For (b) the number of species is given on each bar and the number of seamounts included in each Ridge is given in brackets

Statistical analyses

Multi-dimensional scaling (MDS) in two dimensions was used to examine the spatial patterns of the ophiuroid data. The analysis has a low stress (0.1), indicating that two dimensions are adequate to visualise the patterns.

The MDS plots were coded by ridge and by sample depth range (Figures A5-6 and A5-7, respectively). The fourteen southern Tasmanian seamounts cluster very tightly; a second tight cluster is formed by three seamounts on the western flank of the Lord Howe Rise, and two from West of Lord Howe Rise: Argo, Kelso and Gifford; and Taupo and Gascoyne. The seamounts grouped in this cluster are all shallow (<340 m – Table A5-1), species poor (<=5 species) and poorly sampled (<=3 samples) (Table A5-2). The seamounts sampled on the NORFANZ trip and in the IRD surveys cluster loosely between the two tight clusters (Figure A5-6). Depth does clearly separate the seamounts from each other (Figure A5-7).

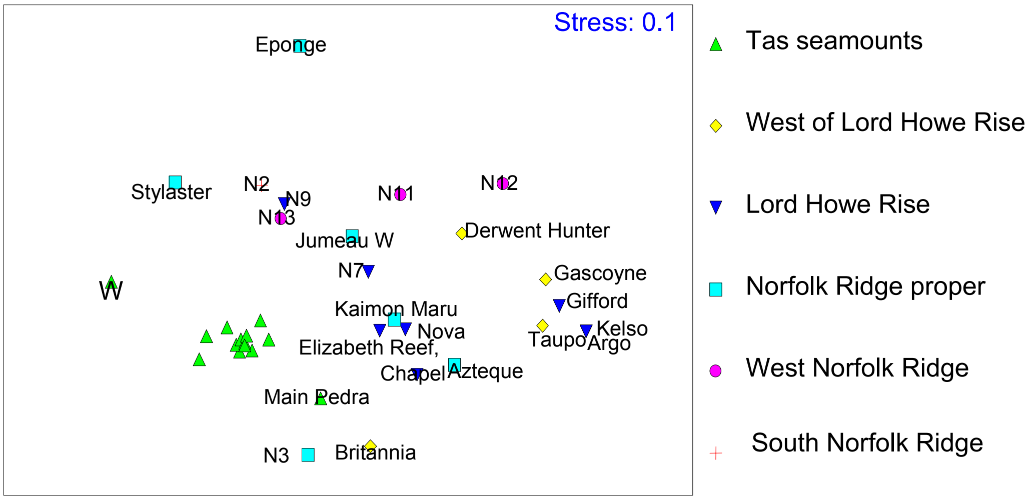

Figure A5-6 2D-MDS representation of the distribution patterns of ophiuroid species on seamounts in the Coral and Tasman Seas, coded by ridge and labelled with the seamount name (most of the southern Tasmanian seamounts are not labelled to simplify the graphic)

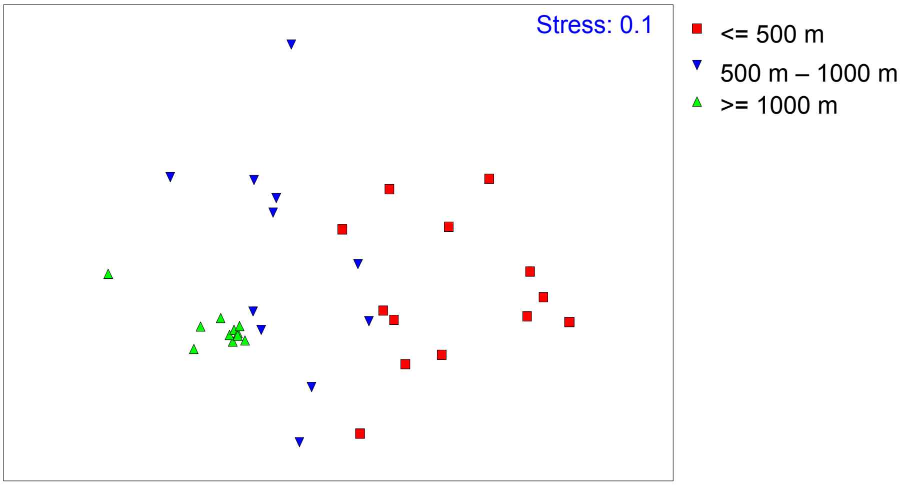

Figure A5-7 2D-MDS representation of the distribution patterns of ophiuroid species on seamounts in the Coral and Tasman Seas, coded by depth range (based on average sampling depth)

The dendrogram of a cluster analysis of the data shows that the tight clusters recognised in Figure A5-6 have within-group similarity of more than 37% (Figure A5-8). The Tasmanian Seamounts cluster shows Andy's and Macka's – with the shallowest in that group being ~800 m (Table A5-1) — as separate from the other seamounts (Figure A5-8). The second cluster shows a gradual addition of the seamounts from the south to the north (Figures A5-2 and A5-8).

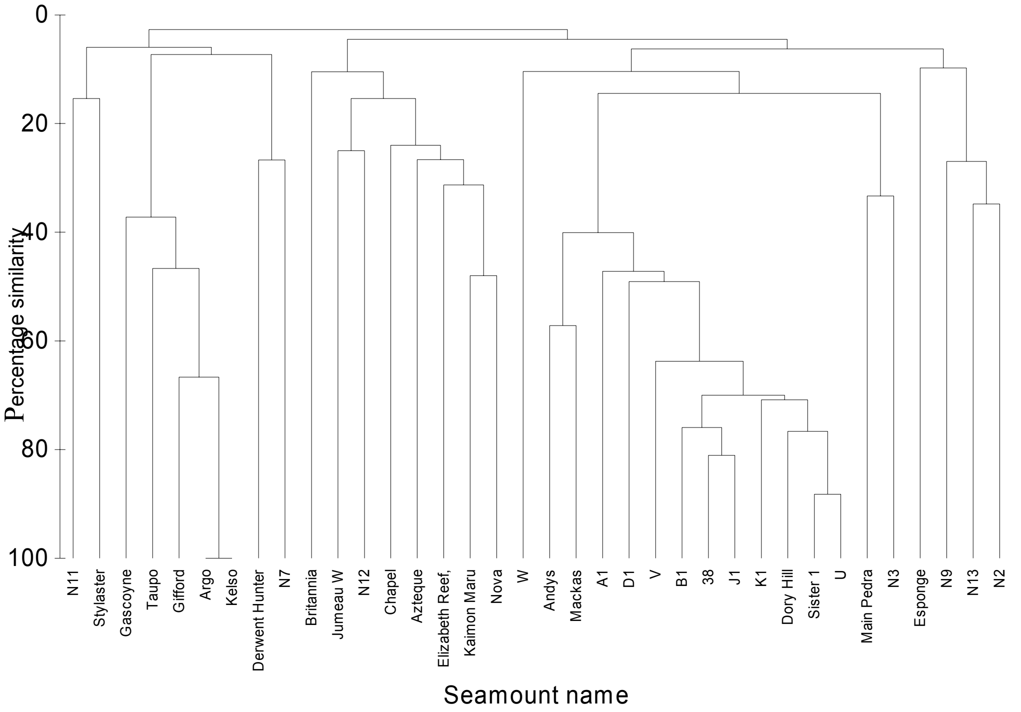

Figure A5-8 Dendrogram of a cluster analysis of the distribution patterns of ophiuroid species on seamounts in the Coral and Tasman Seas.

The BIO-ENV procedure in PRIMER is used to match environmental to biotic patterns. It calculates correlations (ρ) between two similarity matrices, one based on the biotic samples, the other based on combinations of environmental attributes of the samples considered at steadily increasing complexity – i.e. *k* variables at the time (*k*=1, 2, 3,..., *v*) (Clarke and Warwick 1997). Here we only have five abiotic variables: location (latitude and longitude), average sampling depth, number of samples per seamount, and number of species per seamount. The five best results are listed in Table A5-4; we also included the correlation values achieved by each individual abiotic variable.

Clearly the geographic location, especially longitude, and average depth of the seamount, are the most important factors determining the difference between seamounts with respect to the ophiuroid fauna. Species richness and the number of samples per seamount do not contribute to the differences between seamounts.

Table A5-4 Results from the BIO-ENV process comparing the distribution patterns of ophiuroid species on seamounts in the Coral and Tasman Seas with 5 abiotic variables relating to the seamounts.

Correlation value (ρ)	Number of variables included	Variables
5 Best Results		
0.457	3	Degrees longitude, Degrees latitude, Average sampling depth
0.447	2	Degrees longitude, Average sampling
0.426	2	Degrees longitude, Degrees latitude
0.419	1	Degrees longitude
0.410	2	Degrees latitude, Average sampling depth
Correlation with each variable		
0.419	1	Degrees longitude
0.398	1	Degrees latitude
0.366	1	Average sampling depth
0.068	1	Number of species per seamount
0.044	1	Number of samples per seamount

We tested the differences between ridges using the ANOSIM routine (Clarke and Warwick 1997). This routine compares the similarities between samples in the triangular similarity matrix underlying the MDS, calculating a test statistic *R* derived from the average of all rank similarities *within* a ridge and the average rank similarities *between* ridges. *R* falls between -1 and 1, being equal to 1 if '*all replicates within a site are more similar to each other than any replicates from different sites'* (Clarke and Warwick 1997). Negative values occur if replicates between sites are more similar than replicates within sites. The null hypothesis that the similarities between and within sites are on average the same is accepted if *R* is zero.

Tasmanian Seamounts are significantly different from the other regions; no other significant differences were observed (Table A5-5). Comparisons with the South Norfolk Ridge are of limited value: only one seamount was sampled on this ridge.

Table A5-5 Results of a global and a pairwise ANOSIM test of the ophiuroid species on seamounts in the Coral and Tasman Seas by ridge.

Groups	*R* Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Global Test	0.646	0.1	n/a	999	0
Tas Seamounts, Lord Howe Rise	0.775	0.1	319770	999	0
Tas Seamounts, Norfolk Ridge proper	0.79	0.1	38760	999	0

Groups	*R* Statistic	Significance Level %	Possible Permutations	Actual Permutations	Number >= Observed
Tas Seamounts, West of Lord Howe Rise	0.911	0.1	3060	999	0
Tas Seamounts, West Norfolk Ridge	0.859	0.3	680	680	2
Tas Seamounts, South Norfolk Ridge	0.939	6.7	15	15	1
Lord Howe Rise, Norfolk Ridge proper	0.239	3	3003	999	29
Lord Howe Rise, West of Lord Howe Rise	0.067	26.5	495	495	131
Lord Howe Rise, West Norfolk Ridge	0.176	13.3	165	165	22
Lord Howe Rise, South Norfolk Ridge	0.433	11.1	9	9	1
Norfolk Ridge proper, West of Lord Howe Rise	0.242	4.8	210	210	10
Norfolk Ridge proper, West Norfolk Ridge	-0.105	71.4	84	84	60
Norfolk Ridge proper, South Norfolk Ridge	0.011	57.1	7	7	4
West of Lord Howe Rise, West Norfolk Ridge	0.222	17.1	35	35	6
West of Lord Howe Rise, South Norfolk Ridge	0.5	20	5	5	1
West Norfolk Ridge, South Norfolk Ridge	-0.667	100	4	4	4

We considered substetting our data to seamounts from the Norfolk Ridge only, and compare seamount within the Norfolk Island EEZ to seamounts on the same ridge, outside the EEZ, in order to address objective 3. However, examination of the data showed that only three species of ophiuroids (*Asteroporpa reticulata, Ophiactis abyssicola, Ophiocamax vitrea*) were recorded from sled catches on the only seamount site (N3) inside the EEZ boundary. Each of these species has been recorded from one other seamount on the Norfolk Ridge System: *Asteroporpa reticulata* from Kaimon Maru (Norfolk Ridge proper); *Ophiactis abyssicola* from N13 (West Norfolk Ridge); and *Ophiocamax vitrea* from Azteque. No statistical analyses were done.

Sponges

Evaluation of data adequacy

Data from 27 seamounts spread over the Norfolk Ridge system, the Northland Plateau, Kermadec Arc and a few NORFANZ sites on the Lord Howe Rise were included (Table A5-1). However, exclusion of samples obtained with gears other than sleds or dredges led to large reductions in spatial coverage for the Norfolk 1 and the NORFANZ data-set. The former was reduced to 57%; the latter to 38% of original number of samples (Table A5-6). All data from NZ were collected with sled-dredges. This constraint to a single gear type also strongly lowered the number of species potentially available for further analysis: 69% of species were retained from the New Caledonian set and 50% from the NORFANZ set.

Table A5-6 Numbers of samples and sponge species represented in three data-sets broken down into samples from sled-dredges for inclusion into analyses and samples taken with other gears

Data Set	Number of Samples			Number of Species		
	Full Set	**Sled-dredges**	**Other gear**	**Full Set**	**Sled-dredges**	**Other gear**
NORFANZ	72	27 (38%)	45	286	142(50%)	184
Norfolk 1 (New Caledonian Mounts, Schlacher-Hoenlinger)	42	24 (57%)	18	118	81(69%)	67
New Zealand – KAH0204	24	24 (100%)	0	74	74 (100%)	0
New Zealand – TAN0107	53	52 (100%)	0	11	11 (100%)	0

Unlike the ophiuroid data-set, where data from different surveys had been pooled and species identifications cross-checked, here we had to amalgamate three separate data sets. Combining the three data-sets necessitated the exclusion of any ambiguous species identifications. This was unavoidable in the face of unresolved taxonomic affinity of some classes of sponges – in particular hexactinellids and calcareous sponges – and as cross-checking of specimens was not possible. This resulted in a reduction of the initial data matrix by 60% from 299 species to only 179 species with unambiguous identification. The effect of this reduction on individual seamounts is summarised in Table A5-7.

Table A5-7 Number of species remaining per area after conditioning of combined data set to single gear type and unique species ids.

Ridge	Seamount Name	Number of pooled of Samples	Number of unambiguous species in combined data set
Lord Howe Rise	N6	4	27
Lord Howe Rise	N9	1	1

Ridge	Seamount Name	Number of pooled of Samples	Number of unambiguous species in combined data set
Norfolk Ridge proper	Banc No 1	5	14
Norfolk Ridge proper	Banc No 2	3	18
Norfolk Ridge proper	Antigonia	2	10
Norfolk Ridge proper	Stylaster	3	4
Norfolk Ridge proper	Jumeau E	1	4
Norfolk Ridge proper	Jumeau W	1	21
Norfolk Ridge proper	Introuvable	4	5
Norfolk Ridge proper	Kaimon Maru	1	5
Norfolk Ridge proper	Eponge	1	7
Norfolk Ridge proper	N4	1	2
Norfolk Ridge proper	N3	3	1
West Norfolk Ridge	N11	2	16
West Norfolk Ridge	N12	2	2
West Norfolk Ridge	N13	2	1
South Norfolk Ridge	N2	2	3
Kermadec Arc	#441	5	7
Kermadec Arc	Cavalli Main	12	11
Kermadec Arc	Cavalli West	7	16
Northland Plateau	Brothers	13	1
Northland Plateau	Rumble III	26	1
Northland Plateau	Rumble V	14	3

This cut in species numbers is probably too severe to still reflect the original biological structure contained in the data**.** We already stressed in the methods section that the exclusion of hexactinellids – a group that consists mostly of deeper water species – may constrain the reliability of the data interpretation; the reduction in species caused by their exclusion exacerbates this problem. In fact, several seamounts now contain but a single species record: this is most certainly not a true reflection of the sponge fauna found on a seamount (i.e. we would be very surprised to find several seamounts harbouring but a single sponge species). The consequence for any further analysis of this data structure is that a single species does not comprise a “community” or “assemblage” and any further evaluation of biological pattern in assemblage structure is simply not a sensible approach.

In order to illustrate that spatial analysis of communities is no longer sensible we used the pooled data set in a cluster analysis based on Bray-Curtis similarity (Figure A5-9). The patterns seen here are an artefact of the data matrix reduction and should under no circumstances be taken to represent geographic patterns and/or affinities of any kind.

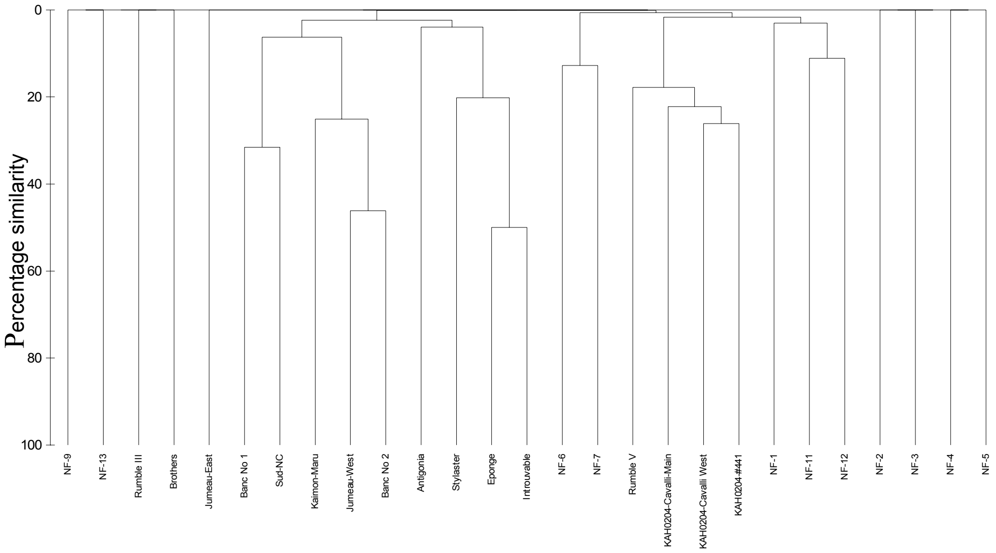

Figure A5-9 Dendrogram representation of the results of a cluster analysis of a sponge data-set pooled from three sources: NORFANZ, Norfolk 1 and two NIWA surveys. To ensure compatibility between data sets the data matrix needed to be reduced so heavily, that analysis of communities is no longer sensible. This graph is shown here only for the purpose of illustrating this point – it should under no circumstances be taken to represent geographic patterns and/or affinities of any kind.

Discussion

Data treatment and data adequacy

The seamount fauna of the Coral and Tasman Seas is extensively surveyed; but to achieve regional data coverage for analyses it is necessary to combine data-sets from various surveys. Many of the surveys in the region are quite recent and much of the collected material has not yet been fully studied and described – it will be decades before all the material will be worked through in detail. In order to meaningfully combine data from several surveys into one analysis to points need to be addressed: (1) collection methods and gear selectivity issues needs to be addressed; and (2) samples need to be treated consistently between surveys.

Sampling methods and gears may vary within as well as between surveys. Every gear has its selectivity and while it may be assumed that sled-dredges of only slightly different design sample similarly, it is not recommended to make such assumptions between different gears such as sled-dredges and beam or otter trawls. Gear effects within, as well as between surveys would need to be studied, and if possible, quantified and corrected for, if several gear types were to be included in combined data-sets. In the absence of any such study we had to limit the samples to a single gear type that was consistently used: sled dredge, which reduced the data available for analysis considerably.

The second point, consistent treatment of samples, relates to factors, such as have samples been sorted for the same faunal groups, and have these groups been identified to the same taxonomic level? With the current status of macro-invertebrate taxonomy we found that only fishes (which we did not discuss at the workshop), ophiuroids, sponges, bryozoans and benthic penaeids were treated consistently enough between surveys to allow for data-sets to be combined. The identifications of fishes, benthic penaeids and bryozoans of the NORFANZ survey has not yet been finalised, thus we had data of two of these groups available: ophiuroids and sponges.

The ophiuroid data collected in the region had already been collated by T. O'Hara for a bioregionalisation project. Thus, all species identification contained in the combined data-set had been checked and confirmed by him. This was not the case for the sponge data. Even though all sponges collected in each of the three surveys that were to be combined had been identified to described or putative species, it was impossible to reconcile putative species between data-sets held at the Queensland Museum and at NIWA without physically comparing sample specimens. This was particularly the case for two classes of sponges: the hexactinellids and the calcareous sponges which were collectively excluded from our combined data-set. Thus, in an attempt of combining the sponge data from three surveys — without being able to cross-check specimens, to reconcile the taxonomy between surveys — we reduced the data matrix to the extent of making it meaningless for statistical analyses. This problem could potentially be solved by additional taxonomic work. In particular, reconciling the hexactinellid sponge identifications between the three data sets, such that this group could be included in statistical analyses, would be an invaluable addition to the data.

Regional patterns in the distribution of ophiuroid species

Regional analyses of the ophiuroid data-set showed that the ophiuroid species composition of the southern Tasmanian Seamounts were clearly different from seamounts on any of the other ridges included here. They also had collectively the highest proportion of unique species, but the lowest number of unique species per individual seamount. Thus the Tasmanian Seamounts have many species in common that are not represented elsewhere.

The second tight cluster of seamounts did not reflect our definition of the Ridges; it clustered two seamounts from 'West of Lord Howe Rise' with three from the north-western flank of the Lord Howe Rise. The five seamounts in this cluster are all species-poor and with the exception of Gascoyne (the southern-most of the group) had no unique species. The other seamounts in the two Ridges, on the other hand are very different from each other, with up to 50% unique species; this cluster may reflect sampling depth more than a regional affinity.

The high percentage of unique species in samples confounded the analysis. From the data available here it is not possible to determine if these species were truly unique or even endemic to a particular seamount, or if they had been present, but not collected in other areas. We suggest, for future surveys, to use visual techniques in combination with the sampling gear to validate absence of taxonomic groups such as ophiuroids. Even though species cannot be identified from *in* situ photographs or videos, at the level of order or phylum such techniques would also augment the analysis and descriptions of relative gear performance.

Geographic location and depth were identified by the BIO-ENV procedure as the most important factors in cluster separation. The southern Tasmanian Seamounts, which form the main cluster separated in the analysis, are deeper than the other seamounts we examined. In addition, the Tasmanian Seamounts lie in the path of the southern arm of the Antarctic Intermediate waters that enters the Tasman Sea from the south on a direct path from the Polar Front, while most of the other seamounts considered in this analysis lie in the path of the second arm of the Antarctic Intermediate Water (Tomczak and Godfrey 1994). This second arm supplies the Eastern South Pacific Ocean, before spreading westward into the

Coral Sea, then joining the East Australian Current (EAC) from the north and leaving the area along the EAC path (Tomczak and Godfrey 1994). Within the second cluster a north-south trend of decreasing similarity could be observed. The BIO-ENV analysis was limited to very few abiotic factors. A detailed physical description of the seamounts included in the analyses could have added considerably to the interpretative power of this procedure.

We aimed at comparing the seamounts inside the Norfolk Island EEZ with other seamounts on the 'Norfolk Ridge proper', or on the whole Norfolk Ridge system to answer the question: are seamounts in the study area of the Norfolk Seamounts Conservation Values Assessment different from seamounts in the region. Unfortunately the area defined by the Norfolk Island EEZ was the most data poor of all regions; only one seamount sample with ophiuroid data (N3) was inside this zone. Samples from N3 were very species poor and we found that the three species sampled in this location were also recorded once each from three separate seamounts on the Norfolk ridge System.

Conclusion

The regional analyses of seamount fauna in the Coral and Tasman Seas that are possible at this stage are very limited, despite the large number of surveys that were undertaken in this region. Large portions of the collected material are still awaiting classification by expert taxonomists. High resolution taxonomy is a cornerstone of analyses of community structures or regional patterns — the species composition of two regions, areas or samples cannot be compared if the species are not identified. More projects that examine and compare specimens held in collections of different organisations, like the bioregionalisation of ophiuroids done by T. O'Hara, are necessary to enable a regional understanding of species distributions and ecological patterns. In particular for phyla like the hexactinellid sponges where the status of taxonomic knowledge is incomplete and many specimens can only be identified to putative species, direct comparison of specimens is necessary in order to reconcile the classification of these putative species such that there is no ambiguity between data-sets.

Gear selectivity was expected to be another confounding factor when data from several surveys are to be combined. T. Schlacher showed in an analysis on a single survey which employed several gears that the effect of gear selectivity needs to be addressed. We did not have the time to determine if gear selectivity would influence species distribution patterns, but to avoid any potential problems we limited our analyses to a single gear type. This factor will need to be studied in detail for surveys and gears used in the region for the immediate need of describing the faunal distribution. On a more general level, gears and their selectivity need to be considered in the planning of future surveys in order to make the collected data more compatible. Also examining gear performance in situ, using visual techniques such as cameras, would add considerable value to the catch data.

A detailed description of all seamounts including their peak and base depth, an indication of steepness (e.g. ratio of height to base area), and a description of the shape (conical, flat-topped, elongated etc.), would be an invaluable addition to the data. Such a description would provide abiotic factors to examine differences or similarities between seamount faunas against. Extensive swath-mapping of surveyed seamounts would assist with the collection of this information; in addition, such data may be used for interpretation of the underlying sediment structure which is known to have a great influence on the fauna.

During the workshop it was noted several times that the Tasman and Coral Seas are probably the most comprehensive and detailed studied in the world, in respect to seamount and other deep sea faunas. The wealth of information contained in the collections of surveys that were undertaken since the mid 1980's is immense. However, more work, especially reconciliation and/or detailed study of macro-invertebrate taxonomy, is necessary in order to understand the distribution and community structure of the seamount fauna in the Coral and Tasman Seas.

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Appendix 6

Species collected in the study area by the NORFANZ survey

The NORFANZ survey covered areas of the Norfolk Ridge system as well as the Lord Howe Rise. The species list presented here represents the four study sites that are located inside the Norfolk Seamounts CVA area. The sites are site N3, N4, N5 on the Norfolk Ridge proper and N10 in the Wanganella Bank region. Also indicated are: species is new to science (√: confirmed new species); if a species was collected on the Norfolk Ridge proper or in the Wanganella Bank region (√: present); if a species was **exclusively** collected within the Norfolk Seamounts CVA area, we included the number of samples it occurred in.

(NORFANZ – Species List: 10pp)

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Phylumcode	Phylum	Family	Species-identification	new to science	Unique to the NISA Study area (# samples)	NNR	Wanganella
10	Porifera	Acarnidae	Zyzzya sp. 3912		1	√	
10	Porifera	Ancorinidae	Stelletta sp. 1			√	
10	Porifera	Ancorinidae	Stelletta sp. 7		1	√	
10	Porifera	Aphrocallistidae	Aphrocallistes beatrix			√	√
10	Porifera	Azoricidae	Leiodermatium sp. 1		1	√	
10	Porifera	Calcarea	Calcarea sp 65		1		√
10	Porifera	Calcarea	Calcarea sp 66		1	√	
10	Porifera	Calcarea	Calcarea sp 83		1	√	
10	Porifera	Calcarea	Calcarea sp 87		1	√	
10	Porifera	Chalinidae	Cladocroce sp. 1			√	
10	Porifera	Chalinidae	Haliclona (Reniera) sp. 1		1		√
10	Porifera	Chalinidae	Haliclona (Reniera) sp. 2		1	√	
10	Porifera	Cladorhizidae	Chondrocladia pulvinata		1	√	
10	Porifera	Class	Hexactinellida -MF150		1	√	
10	Porifera	Coelosphaeridae	Lissodendoryx (Acanthodoryx) sp. 3924		1	√	
10	Porifera	Crambeidae	Monanchora sp. 3435		1	√	
10	Porifera	Crambeidae	Monanchora sp. 3928		1	√	
10	Porifera	Crellidae	Crella (Yvesia) sp. 3929		1	√	
10	Porifera	Dendoricellidae	Pyloderma sp. 3930		1	√	
10	Porifera	Desmoxyidae	Parahigginsia phakelloides		1	√	
10	Porifera	Farreidae	Farrea cf. occa			√	
10	Porifera	Farreidae	Farrea sp. 2		1	√	
10	Porifera	Halichondriidae	Axinyssa sp. 2		1	√	
10	Porifera	Halichondriidae	Halichondria (Halichondria) sp. 2		1	√	
10	Porifera	Halichondriidae	Halichondria (Halichondria) sp. 4		1	√	
10	Porifera	Halichondriidae	Halichondriidae - undifferentiated		2	√	
10	Porifera	Halichondriidae	Topsentia sp. 1		1	√	
10	Porifera	Hexachnellid	Hexachnellid MF131		1	√	
10	Porifera	Hexachnellid	Hexachnellid MF158			√	
10	Porifera	Hexactinellid	Hexactinellid MF134		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 102		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 103		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 107			√	
10	Porifera	Hexactinellida	Hexactinellida sp 114		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 117		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 121		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 124 & sp 31		2	√	
10	Porifera	Hexactinellida	Hexactinellida sp 126		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 127		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 136		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 141		2	√	
10	Porifera	Hexactinellida	Hexactinellida sp 144		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 17		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 20		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 23		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 26		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 27		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 32		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 36		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 6		1	√	
10	Porifera	Hexactinellida	Hexactinellida sp 7		1	√	
10	Porifera	Hyalonematidae	Hyalonema (Hyalonema) sp 1			√	
10	Porifera	Irciniidae	Irciniidae		1	√	
10	Porifera	Irciniidae	Psammocinia sp. 2		2	√	
10	Porifera	Lithistid	Lithistid sponge MF113		1	√	
10	Porifera	Microcionidae	Clathria (Clathria) sp. 3913		1	√	
10	Porifera	Microcionidae	Clathria (Clathria) sp. 3917		1	√	
10	Porifera	Mycalidae	Mycale (Mycale) sp. 1		1	√	
10	Porifera	Mycalidae	Phlyctaenopora (Barbozia) sp. 3945		1	√	
10	Porifera	Neopeltidae	Homophymia sp 1		1	√	
10	Porifera	Niphatidae	Niphates sp. 2		1	√	
10	Porifera	Pachastrellidae	Pachastrella sp. 3889		1	√	
10	Porifera	Pachastrellidae	Poecillastra sp. 3885		1	√	
10	Porifera	Petrosiidae	Petrosia sp. 2		1	√	
10	Porifera	Petrosiidae	Petrosia sp. 6			√	
10	Porifera	Petrosiidae	Xestospongia sp. 1		1	√	
10	Porifera	Petrosiidae	Xestospongia sp. 4		1	√	
10	Porifera	Petrosiidae	Xestospongia sp. 6		1	√	
10	Porifera	Petrosiidae	Xestospongia sp. 7		1	√	
10	Porifera	Phellodermidae	Echinostylinos sp. 3933		1	√	
10	Porifera	Phellodermidae	Echinostylinos sp. 3935		1	√	
10	Porifera	Phloeodictyidae	Aka sp. 1		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 10		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 12		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 13		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 15		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 16		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 17		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 2		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 3		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 7		1	√	
10	Porifera	Phloeodictyidae	Oceanapia sp. 8		1	√	

Phylumcode	Phylum	Family	Species-identification	new to science	Unique to the NISA Study area (# samples)	NNR	Wanganella
10	Porifera	Phloeodictyidae	Oceanapia sp. 9		1	√	
10	Porifera	Phloeodictyidae	Pachypellina sp. 1		1	√	
10	Porifera	Phloeodictyidae	Pachypellina sp. 3			√	
10	Porifera	Plakinidae	Plakortis sp. 1		1	√	
10	Porifera	Pleromidae	Pleroma menoui			√	
10	Porifera	Podospongiidae	Podospongia sp. 3897		1	√	
10	Porifera	Polymastiidae	Spinularia australis			√	
10	Porifera	Raspailiidae	Aulospongus sp. 3918		1	√	
10	Porifera	Siphonophorida	Siphonophorida tettilidae MF139		1	√	
10	Porifera	Spirastrellidae	Spirastrella sp. 3896		1	√	
10	Porifera	sponge	Hexactinellida		1	√	
10	Porifera	Spongiidae	Spongia sp. 1			√	
10	Porifera	Spongiidae	Spongia sp. 2			√	
10	Porifera	Tetillidae	Craniella sp. 3879		1	√	
10	Porifera	unidentified	unidentified sp. 75		1	√	
11	Hydrozoa / Cnidaria		Anemone		1	√	
11	Hydrozoa / Cnidaria		Anemone - orange white			√	
11	Hydrozoa / Cnidaria		Anemone #19				√
11	Hydrozoa / Cnidaria		Anemone #4		1	√	
11	Hydrozoa / Cnidaria		Anemone (purple)		1	√	
11	Hydrozoa / Cnidaria		Anemone sp. 8 & White anemone			√	√
11	Hydrozoa / Cnidaria		Anemones				√
11	Hydrozoa / Cnidaria		Antipatharian (bottle brush)			√	√
11	Hydrozoa / Cnidaria		Antipathidae - undifferentiated		1	√	
11	Hydrozoa / Cnidaria		Black coral			√	
11	Hydrozoa / Cnidaria		Black coral - bottle brush			√	
11	Hydrozoa / Cnidaria		Black coral - bushy tree				√
11	Hydrozoa / Cnidaria		Black coral feather			√	
11	Hydrozoa / Cnidaria		Black coral-broom			√	
11	Hydrozoa / Cnidaria		Cirrhipathes sp - spiral			√	
11	Hydrozoa / Cnidaria		Cirripathes sp2			√	
11	Hydrozoa / Cnidaria		Clavulariidae (?New Genus)	√	1	√	
11	Hydrozoa / Cnidaria		Deltocyathus sp		1	√	
11	Hydrozoa / Cnidaria		Dendrophylliidae			√	
11	Hydrozoa / Cnidaria		elongate sea pen		1	√	
11	Hydrozoa / Cnidaria		Flabellum			√	
11	Hydrozoa / Cnidaria		Flabellum sp			√	
11	Hydrozoa / Cnidaria		Flabellum sp7		1		√
11	Hydrozoa / Cnidaria		Jellyfish 1				√
11	Hydrozoa / Cnidaria		Orange trumpet coral - solitary coral			√	
11	Hydrozoa / Cnidaria		Order Actinaria - undifferentiated				√
11	Hydrozoa / Cnidaria		Order Hydroida - undifferentiated			√	√
11	Hydrozoa / Cnidaria		Order Scleractinia - undifferentiated			√	
11	Hydrozoa / Cnidaria		Pennatula sp Pennuatulidae		1	√	
11	Hydrozoa / Cnidaria		Primnoidae (pink)		1	√	
11	Hydrozoa / Cnidaria		red anemone			√	
11	Hydrozoa / Cnidaria		Scyphozoa - all spp.				√
11	Hydrozoa / Cnidaria		solitary coral			√	√
11	Hydrozoa / Cnidaria		Solitary coral sp11		1		√
11	Hydrozoa / Cnidaria		solitary coral sp8				√
11	Hydrozoa / Cnidaria		Stephanocyathus sp			√	
11	Hydrozoa / Cnidaria		Stylasteridae - undifferentiated			√	
11	Hydrozoa / Cnidaria		Stylasteridae sp2			√	
11	Hydrozoa / Cnidaria		Stylasteridae sp3		1	√	
11	Hydrozoa / Cnidaria		Zoanthids		1	√	
11	Hydrozoa / Cnidaria		Zooanthid			√	√
11	Hydrozoa / Cnidaria	Acanthogorgiidae	Acanthogorgia sp. 1		1	√	
11	Hydrozoa / Cnidaria	Acanthogorgiidae	Acanthogorgia sp. 2		1	√	
11	Hydrozoa / Cnidaria	Acanthogorgiidae	Acanthogorgia sp. 5		1	√	
11	Hydrozoa / Cnidaria	Acanthogorgiidae	Acanthogorgia sp. 8		1	√	
11	Hydrozoa / Cnidaria	Acanthogorgiidae	Anthogorgia sp. 1			√	
11	Hydrozoa / Cnidaria	Alcyoniidae	Anthomastus sp. 1			√	
11	Hydrozoa / Cnidaria	Anthoptilidae	Anthoptilum n. sp. 1	√		√	
11	Hydrozoa / Cnidaria	Chrysogorgiidae	Chrysogorgia sp. 1 & sp. 2			√	
11	Hydrozoa / Cnidaria	Chrysogorgiidae	Chrysogorgia sp. 3		1	√	
11	Hydrozoa / Cnidaria	Chrysogorgiidae	Chrysogorgia sp. 6		1		√
11	Hydrozoa / Cnidaria	Chrysogorgiidae	Isidoides armata			√	
11	Hydrozoa / Cnidaria	Chrysogorgiidae	undifferentiated		2	√	
11	Hydrozoa / Cnidaria	Clavulariidae	Clavulariidaen. gen.n. sp. 1	√	1	√	
11	Hydrozoa / Cnidaria	Clavulariidae	ClavulariidaeTelestulan. sp. 1	√	1	√	
11	Hydrozoa / Cnidaria	Ellisellidae	Nicella sp. 1		1	√	
11	Hydrozoa / Cnidaria	Ellisellidae	Nicella sp. 2		1	√	
11	Hydrozoa / Cnidaria	Ellisellidae	Nicella sp. 3		1	√	
11	Hydrozoa / Cnidaria	Ellisellidae	Verrucella sp. 1		1	√	
11	Hydrozoa / Cnidaria	Ellisellidae	Viminella sp. 1		1	√	
11	Hydrozoa / Cnidaria	Ellisellidae	Viminella sp. 2		1	√	
11	Hydrozoa / Cnidaria	Isididae	Isididaen. gen.n. sp. 1	√		√	
11	Hydrozoa / Cnidaria	Isididae	Keratoisis sp. 4			√	
11	Hydrozoa / Cnidaria	Isididae	Lepidisis sp. 1		1	√	
11	Hydrozoa / Cnidaria	Isididae	Lepidisis sp. 3			√	
11	Hydrozoa / Cnidaria	Isididae	Lepidisis sp. 6			√	
11	Hydrozoa / Cnidaria	Isididae	Lepidisis sp. 7		1	√	

Phylumcode	Phylum	Family	Species-identification	new to science	Unique to the NISA Study area (# samples)	NNR	Wanganella
11	Hydrozoa / Cnidaria	Isididae	Lepidisis undifferentiated			√	
11	Hydrozoa / Cnidaria	Nephtheidae	Dendronephthya sp. 2		1		√
11	Hydrozoa / Cnidaria	Nephtheidae	Scleronephthya cf. macrospiculata			√	
11	Hydrozoa / Cnidaria	Nidaliidae	Chironephthya sp. 1	√	1	√	
11	Hydrozoa / Cnidaria	Nidaliidae	Chironephthya sp. 2 (incl orange, pink, violet)			√	
11	Hydrozoa / Cnidaria	Nidaliidae	Chironephthya sp. 4		1	√	
11	Hydrozoa / Cnidaria	Nidaliidae	Chironephthya sp. 5		1	√	
11	Hydrozoa / Cnidaria	Nidaliidae	Chironepthya sp. 3		1	√	
11	Hydrozoa / Cnidaria	Pennatulidae	Pennatula sp. 1			√	
11	Hydrozoa / Cnidaria	Plexauridae	Astrogorgia sp. 1		1	√	
11	Hydrozoa / Cnidaria	Plexauridae	Astrogorgia sp. 2		1	√	
11	Hydrozoa / Cnidaria	Plexauridae	Villogorgia sp. 1		1	√	
11	Hydrozoa / Cnidaria	Plexauridae	Villogorgia sp. 2		1	√	
11	Hydrozoa / Cnidaria	Plexauridae	Villogorgia sp. 3		1	√	
11	Hydrozoa / Cnidaria	Plexauridae	Villogorgia sp. 4		1	√	
11	Hydrozoa / Cnidaria	Primnoidae	Narella sp. 1		1	√	
11	Hydrozoa / Cnidaria	Primnoidae	Perissogorgia colossus		1	√	
11	Hydrozoa / Cnidaria	Primnoidae	Thouarella sp. 1		1	√	
11	Hydrozoa / Cnidaria	Primnoidae	Thouarella sp. 3	√	1	√	
11	Hydrozoa / Cnidaria	Primnoidae	Thouarella sp. 4		1	√	
11	Hydrozoa / Cnidaria	Protoptilidae	Protoptilum n. sp. 1	√	1	√	
11	Hydrozoa / Cnidaria	Pteroeididae	Gyrophyllum sibogae			√	
11	Hydrozoa / Cnidaria	Pteroeididae	Pteroeides sp. 1		1		√
11	Hydrozoa / Cnidaria	Umbellulidae	Umbellula sp. 1		2	√	
15	Chaetognath / Piapulida		Pogonophora?		1	√	
15	Chaetognath / Piapulida		Priapulid sp1			√	√
15	Chaetognath / Piapulida		Priapulid sp3		1		√
17	Sipuncula		Sipunculan		1	√	
17	Sipuncula		Sipunculan sp1		1	√	
19	Brachiopoda		Sipunculid sp2		1	√	
20	Bryozoa		Bryozoa		1	√	
20	Bryozoa		Bryozoa - undifferentiated			√	√
20	Bryozoa		Bryozoan		1	√	
20	Bryozoa		Bryozoan		1	√	
20	Bryozoa		Bryozoan- Adeonidae			√	
20	Bryozoa		Fenestrate bryozoan - Phidoloporidae			√	
20	Bryozoa		Red bryozoan - Candidae		1	√	
22	Annelida		Amphinomidae			√	
22	Annelida		Amphinomidae sp2		1		√
22	Annelida		Amphinomidae sp3		1		√
22	Annelida		Aphroditidae - undifferentiated		1	√	
22	Annelida		Chaetopterid tubes		1		√
22	Annelida		Class Polychaeta - undifferentiated			√	√
22	Annelida		Nereididae - undifferentiated			√	
22	Annelida		Onuphidae				√
22	Annelida		Onuphidae - undifferentiated			√	
22	Annelida		Polychaete			√	
22	Annelida		Polychaete - Polynoidae			√	
22	Annelida		Polychaete - Serpulid 2		1	√	
22	Annelida		Polychaete sp12		1		√
22	Annelida		Polychaetes (covered in sand) sp11		1		√
22	Annelida		Polychaetes in sponge		1	√	
22	Annelida		Polynoidae - undifferentiated			√	
22	Annelida		Serpulid tube		1	√	
22	Annelida		Serpulidae - undifferentiated			√	
23	Mollusca (non-Gastropoda)		Bivalve		1	√	
23	Mollusca (non-Gastropoda)		Cardiidae		2	√	√
23	Mollusca (non-Gastropoda)		Class Bivalvia			√	
23	Mollusca (non-Gastropoda)		Class Scaphopoda			√	
23	Mollusca (non-Gastropoda)		Cuspidaria sp1			√	√
23	Mollusca (non-Gastropoda)		Cuspidaria sp2			√	√
23	Mollusca (non-Gastropoda)		Limidae sp 1			√	
23	Mollusca (non-Gastropoda)		Malleus sp		1	√	
23	Mollusca (non-Gastropoda)		Mytilidae -green sp1				√
23	Mollusca (non-Gastropoda)		order Teuthoidea - undifferentiated		1	√	
23	Mollusca (non-Gastropoda)		Pectinidae Chlamys sp		1	√	
23	Mollusca (non-Gastropoda)		Propriamussidae sp2			√	
23	Mollusca (non-Gastropoda)		Pteria penguin		1	√	
23	Mollusca (non-Gastropoda)		Pteria sp		1	√	
23	Mollusca (non-Gastropoda)		Scaphopoda		1	√	
23	Mollusca (non-Gastropoda)		Spondyus sp		1	√	
23	Mollusca (non-Gastropoda)	Chiroteuthidae	Chiroteuthis cf imperator			√	
23	Mollusca (non-Gastropoda)	Cranchiidae	Galiteuthis pacifica			√	
23	Mollusca (non-Gastropoda)	Cranchiidae	Galiteuthis sp. 1			√	
23	Mollusca (non-Gastropoda)	Cranchiidae	Teuthowenia sp. 2		1		√
23	Mollusca (non-Gastropoda)	Enoploteuthidae	Abraliopsis undifferentiated				√
23	Mollusca (non-Gastropoda)	Histioteuthidae	Histioteuthis bonnellii				√
23	Mollusca (non-Gastropoda)	Histioteuthidae	Histioteuthis miranda			√	√
23	Mollusca (non-Gastropoda)	Mastigoteuthidae	Mastogoteuthis cordiformis			√	√
23	Mollusca (non-Gastropoda)	Mastigoteuthidae	Mastogoteuthis magna				√
23	Mollusca (non-Gastropoda)	Octopodidae	Scaeurgus sp. 1	√	1	√	
23	Mollusca (non-Gastropoda)	Ommastrephidae	Nototodarus sloani				√

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23	Mollusca (non-Gastropoda)	Ommastrephidae	Ornithoteuthis volatalis				√
23	Mollusca (non-Gastropoda)	Onychoteuthidae	Onychoteuthis sp. 1				√
23	Mollusca (non-Gastropoda)	Onychoteuthidae	Onykia robsoni			√	
23	Mollusca (non-Gastropoda)	Spirulidae	Spirula spirula				√
24	Mollusca (Gastropodaa)		Buccinidae		1		√
24	Mollusca (Gastropodaa)		Callistomidae		2	√	√
24	Mollusca (Gastropodaa)		Class Gastropoda			√	√
24	Mollusca (Gastropodaa)		Conus sp1		1		√
24	Mollusca (Gastropodaa)		Corralinophilinae		1	√	
24	Mollusca (Gastropodaa)		Eulimidae		1	√	
24	Mollusca (Gastropodaa)		Eulimidae sp5		1		√
24	Mollusca (Gastropodaa)		Fasciolariinae		1	√	
24	Mollusca (Gastropodaa)		Fissurellidae				√
24	Mollusca (Gastropodaa)		Gastropod				√
24	Mollusca (Gastropodaa)		Gastropod Fasciolarinae Bucccinidae		1	√	
24	Mollusca (Gastropodaa)		Gastropod-naticiform-vanikoridae?		1	√	
24	Mollusca (Gastropodaa)		Mitridde sp1				√
24	Mollusca (Gastropodaa)		Muriadae Trophoninae sp1				√
24	Mollusca (Gastropodaa)		Nassariidae		1	√	
24	Mollusca (Gastropodaa)		Pterynotus sp		1	√	
24	Mollusca (Gastropodaa)		Rouellidae sp3		1		√
24	Mollusca (Gastropodaa)		Segunziidae - Gastropod			√	√
24	Mollusca (Gastropodaa)		Trochidae		1	√	
24	Mollusca (Gastropodaa)		Trochidae - undifferentiated		1		√
24	Mollusca (Gastropodaa)		Turridae - undifferentiated		1		√
24	Mollusca (Gastropodaa)		Turridae #3		1	√	
24	Mollusca (Gastropodaa)		Turridae #4		2	√	√
24	Mollusca (Gastropodaa)		Turridae sp1			√	
24	Mollusca (Gastropodaa)		Turridae sp2		1	√	
24	Mollusca (Gastropodaa)		Xenophora sp		1	√	
24	Mollusca (Gastropodaa)		Xenophora sp2		1		√
24	Mollusca (Gastropodaa)	Aglajidae	Melanochlamys sp. 1		1		√
24	Mollusca (Gastropodaa)	Arminidae	Armina sp. 1		1	√	
24	Mollusca (Gastropodaa)	Dendrodorididae	Doriopsilla sp. 1		1	√	
24	Mollusca (Gastropodaa)	Dorididae	Austrodoris sp. 1		1		√
24	Mollusca (Gastropodaa)	Nudibranch	Nudibranch		1	√	
24	Mollusca (Gastropodaa)	Philinidae	Philine angasi		2	√	√
24	Mollusca (Gastropodaa)	Pleurobranchidae	Pleurobranchaea maculata		1	√	
25	Echinodermata		Anserapoda sp1		1		√
25	Echinodermata		Antedonidae - undifferentiated			√	
25	Echinodermata		Aspidodiadema sp.			√	
25	Echinodermata		Aspidodiadema tonsum		1	√	
25	Echinodermata		Asterodiscides truncatus		1		√
25	Echinodermata		Asteroid #2		1	√	
25	Echinodermata		Asthenosomatidae			√	
25	Echinodermata		Astroceramus sp nov		1	√	
25	Echinodermata		Astromesites sp		1	√	
25	Echinodermata		Astropecten polyacanthus		1		√
25	Echinodermata		Bathycrinid stem			√	
25	Echinodermata		Brisingiidae- Asteroid			√	√
25	Echinodermata		Class Echinoidea - undifferentiated			√	√
25	Echinodermata		Class Holothuroidea - undifferentiated				√
25	Echinodermata		Crinoid			√	
25	Echinodermata		Crinoid		1	√	
25	Echinodermata		Cucumoriidae		1		√
25	Echinodermata		Dermechinus horridus				√
25	Echinodermata		Diadema palmeri			√	
25	Echinodermata		Dytaster sp			√	
25	Echinodermata		Echinoid (regular) sp14		1		√
25	Echinodermata		Echinothunidae sp2		1	√	
25	Echinodermata		Echinothuridae uniden sp2		1	√	
25	Echinodermata		Fibulariidae (echinoid)				√
25	Echinodermata		Gracilechinus multidentatus				√
25	Echinodermata		Heart urchins		1	√	
25	Echinodermata		Henricia sp			√	
25	Echinodermata		Henricia sp3				√
25	Echinodermata		Histocidaris sp1			√	
25	Echinodermata		Holothurian		1	√	
25	Echinodermata		Holothurian (round pelagic gel cover sp12)				√
25	Echinodermata		Holothurian sp2			√	
25	Echinodermata		Holothurian sp25		1		√
25	Echinodermata		Holothurian sp3		1	√	
25	Echinodermata		irregular urchin		1	√	
25	Echinodermata		irregular urchin		1	√	
25	Echinodermata		Large irregular urchin		1	√	
25	Echinodermata		Lovenia sp1		1		√
25	Echinodermata		Ludia sp		1	√	
25	Echinodermata		Mediaster sp			√	
25	Echinodermata		Ophidiosteridae		1	√	
25	Echinodermata		Ophiuroid- Amphiophiura sp		1	√	
25	Echinodermata		Paxillosida		1	√	
25	Echinodermata		Pectinastor sp			√	

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25	Echinodermata		Peronella sp1				√
25	Echinodermata		Persephonaster sp1				√
25	Echinodermata		Phormosoma sp1				√
25	Echinodermata		Phyllacanthus sp1		1		√
25	Echinodermata		Sand dollar		1	√	
25	Echinodermata		Small seastar (long arm)		1	√	
25	Echinodermata		Solasteridae			√	
25	Echinodermata		stalked crinoid			√	
25	Echinodermata		Tosia sp1				√
25	Echinodermata		Zoroaster sp			√	√
25	Echinodermata	Amphiophiura	Amphiophiura sp2		1		√
25	Echinodermata	Amphiophiura	Amphiophiura sp2				√
25	Echinodermata	Amphiophiura	Amphiophiura sp4				√
25	Echinodermata	Amphiophiura	Amphiophiura sp5				√
25	Echinodermata	Amphiuridae	Amphioplus sp. MoV 4890	√		√	√
25	Echinodermata	Amphiuridae	Amphiura sp. 2		1		√
25	Echinodermata	Amphiuridae	Ophiocentrus sp. 1		1		√
25	Echinodermata	Astrobrachion	Astrobrachion sp1		1	√	
25	Echinodermata	Class	Class Ophiuroidea - undifferentiated			√	
25	Echinodermata	Gorgonocephalidae	Asteroporpa (Asteroporpa) australiensis			√	
25	Echinodermata	Gorgonocephalidae	Asteroporpa (Austromoana) reticulata		1	√	
25	Echinodermata	Gorgonocephalidae	Gorgonocephalidae		1	√	
25	Echinodermata	Hemieuryalidae	Ophiomoeris obstricta			√	
25	Echinodermata	Ophiacantha	Ophiacantha sp2		1	√	
25	Echinodermata	Ophiacanthidae	Ophiocamax sp. MoV 4884	√	1	√	
25	Echinodermata	Ophiacanthidae	Ophiocamax vitrea			√	
25	Echinodermata	Ophiacanthidae	Ophiolimna antarctica				√
25	Echinodermata	Ophiacanthidae	Ophiolimna perfida		1	√	
25	Echinodermata	Ophiacanthidae	Ophiomitrella sp. MoV 4885	√		√	
25	Echinodermata	Ophiachs	Ophiachs sp2			√	
25	Echinodermata	Ophiactidae	Ophiactis abyssicola			√	√
25	Echinodermata	Ophiactidae	Ophiactis definita			√	
25	Echinodermata	Ophiactidae	Ophiactis sp. T1	√	1	√	
25	Echinodermata	Ophiodermatidae	Ophiodermatidae		1	√	
25	Echinodermata	Ophioleucidae	Ophiernus adspersus			√	
25	Echinodermata	Ophioleucidae	Ophiopallas paradoxa		1	√	
25	Echinodermata	Ophiomusium	Ophiomusium sp2		1		√
25	Echinodermata	Ophiomyxa	Ophiomyxa sp			√	
25	Echinodermata	Ophiomyxidae	Ophiomyxa brevirima				√
25	Echinodermata	Ophiotrichidae	Ophiothrix (Acanthophiothrix) lepidus			√	
25	Echinodermata	Ophiotrichidae	Ophiothrix (Acanthophiothrix) purpurea		1	√	
25	Echinodermata	Ophiotrichidae	Ophiothrix sp. 1		1	√	
25	Echinodermata	Ophiuridae	Amphiophiura pertusa			√	
25	Echinodermata	Ophiuridae	Amphiophiura turgida			√	√
25	Echinodermata	Ophiuridae	Ophiomusium simplex		1		√
25	Echinodermata	Ophiuridae	Ophiozonella bispinosa		1	√	
25	Echinodermata	Ophiuridae	Ophiozonoida picta				√
25	Echinodermata	Ophiuridae	Ophiuridae - undifferentiated				√
25	Echinodermata	Ophiuridae	Ophiuridae sp		1	√	
25	Echinodermata	Ophiuroid	Ophiuroid		1	√	
25	Echinodermata	Ophiuroid-	Ophiuroid- Amphiophiura sp			√	
27	Crustacea (Copepods/Barnacles/Ostracods)		Barnacle sp13		1		√
27	Crustacea (Copepods/Barnacles/Ostracods)		Barnacles			√	
27	Crustacea (Copepods/Barnacles/Ostracods)		Barnacles (ex Histiocidarus spines)			√	
27	Crustacea (Copepods/Barnacles/Ostracods)		Cirriped		1	√	
27	Crustacea (Copepods/Barnacles/Ostracods)		Cirriped			√	
27	Crustacea (Copepods/Barnacles/Ostracods)		Cirriped on sponge		1	√	
27	Crustacea (Copepods/Barnacles/Ostracods)		Class Cirripedia - undifferentiated			√	
27	Crustacea (Copepods/Barnacles/Ostracods)		Ostracoda sp1		1		√
27	Crustacea (Copepods/Barnacles/Ostracods)		Parasitic copepod sp3 (in slickhead)		1		√
27	Crustacea (Copepods/Barnacles/Ostracods)		Scalpellidae spD		1		√
27	Crustacea (Copepods/Barnacles/Ostracods)		Subclass Copepoda - undifferentiated				√
28	Crustacea (Malacostraca)		Gnathophausia ingens				√
28	Crustacea (Malacostraca)		Isopod sp2		1	√	
28	Crustacea (Malacostraca)		Isopod sp3		1	√	
28	Crustacea (Malacostraca)		Isopoda		1	√	
28	Crustacea (Malacostraca)		Isopopd sp9		1		√
28	Crustacea (Malacostraca)		Lophogastridae - undifferentiated				√
28	Crustacea (Malacostraca)		Mysidae - undifferentiated				√
28	Crustacea (Malacostraca)		Neognathophausia sp2				√
28	Crustacea (Malacostraca)		Syciona Sp2		1	√	
28	Crustacea (Malacostraca)	Acanthephyra	Acanthephyra quadrispinosa				√
28	Crustacea (Malacostraca)	Acanthephyra	Acanthephyra sp				√
28	Crustacea (Malacostraca)	Acanthephyra	Acanthephyra sp2				√
28	Crustacea (Malacostraca)	Alpheidae	Alpheidae sp1		1	√	
28	Crustacea (Malacostraca)	Alpheidae	Alpheidae sp2			√	
28	Crustacea (Malacostraca)	Ampeliscidae	Ampelisca sp. 1				√
28	Crustacea (Malacostraca)	Amphipod	Amphipod		1	√	
28	Crustacea (Malacostraca)	Aristeidae	Aristaeomorpha foliacea			√	√
28	Crustacea (Malacostraca)	Aristeidae	Aristeus mabahissae			√	√
28	Crustacea (Malacostraca)	Aristeidae	Aristeus virilis		1	√	
28	Crustacea (Malacostraca)	Aristeidae	Austropenaeus nitidus				√

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28	Crustacea (Malacostraca)	Axiidae	Axiidae		1	√	
28	Crustacea (Malacostraca)	Benthesicymidae	Benthesicymus investigatoris				√
28	Crustacea (Malacostraca)	Benthesicymidae	Benthesicymus urinator howensis				√
28	Crustacea (Malacostraca)	Benthesicymidae	Gennadas gilchristi				√
28	Crustacea (Malacostraca)	Benthesicymus	Benthesicymus sp1			√	
28	Crustacea (Malacostraca)	Carid	Carid - Benthesicymus sp2		1	√	
28	Crustacea (Malacostraca)	Carid,	Carid, unidentified 2		1	√	
28	Crustacea (Malacostraca)	Chirostylidae	Chirostylidae sp2			√	
28	Crustacea (Malacostraca)	Chirostyllidae	Chirostyllidae		2	√	√
28	Crustacea (Malacostraca)	Corophiidae	Corophiidae undifferentiated			√	
28	Crustacea (Malacostraca)	Crangonidae	Crangonidae spB		1	√	
28	Crustacea (Malacostraca)	Crangonidae	Crangonidae spC		1		√
28	Crustacea (Malacostraca)	Crangonidae	Crangonidae spD		1		√
28	Crustacea (Malacostraca)	Cyclodorippidae	Krangalangia spinosa		3	√	√
28	Crustacea (Malacostraca)	Cyphocaridae	Cyphocaris n. sp. 518	√			√
28	Crustacea (Malacostraca)	Cyphocaridae	Cyphocaris faurei		1		√
28	Crustacea (Malacostraca)	Dorippidae	Ethusina sp. 1			√	
28	Crustacea (Malacostraca)	Euphausiidae	Euphausia monacantha			√	
28	Crustacea (Malacostraca)	Euphausiidae	Euphausia recurva				√
28	Crustacea (Malacostraca)	Euphausiidae	Euphausia similis			√	√
28	Crustacea (Malacostraca)	Euphausiidae	Thysanopoda orientalis			√	√
28	Crustacea (Malacostraca)	Eurytheneidae	Eurythenes n. sp. 1	√			√
28	Crustacea (Malacostraca)	Galatheidae	Agononida nielbrucei				√
28	Crustacea (Malacostraca)	Galatheidae	Paramunida labis		1	√	
28	Crustacea (Malacostraca)	Galatheidae	Munida curvirostris		2	√	
28	Crustacea (Malacostraca)	Galatheidae	Agononida eminens		1	√	
28	Crustacea (Malacostraca)	Galatheidae	Munida sp nov 4	√	1	√	
28	Crustacea (Malacostraca)	Galatheidae	Munida sp nov 5	√	1	√	
28	Crustacea (Malacostraca)	Galatheidae	Munida sp nov 7	√	1	√	
28	Crustacea (Malacostraca)	Galatheidae	Munida sp nov 8	√	1	√	
28	Crustacea (Malacostraca)	Galatheidae	Leiogalathea laevirostris		1	√	
28	Crustacea (Malacostraca)	Gennadas	Gennadas sp1			√	
28	Crustacea (Malacostraca)	Gennadus	Gennadus sp2		1	√	
28	Crustacea (Malacostraca)	Glyphocrangon	Glyphocrangon cf formosa	possibly √		√	
28	Crustacea (Malacostraca)	Haliporoides	Haliporoides sp?	√	1		√
28	Crustacea (Malacostraca)	Hemisquillidae	Hemisquilla australiensis		1		√
28	Crustacea (Malacostraca)	Heterocarpus	Heterocarpus sibogae		1	√	
28	Crustacea (Malacostraca)	Heterocarpus	Heterocarpus sp Cariid prawn		2	√	
28	Crustacea (Malacostraca)	Homolidae	Homolochunia kullar		1	√	
28	Crustacea (Malacostraca)	Homologenus	Homologenus sp			√	
28	Crustacea (Malacostraca)	Infraorder	Infraorder Caridea - undifferentiated		1	√	
28	Crustacea (Malacostraca)	Ischyroceridae	unidentified sp. 1		1		√
28	Crustacea (Malacostraca)	Lanceolidae	Megalanceola stephenseni				√
28	Crustacea (Malacostraca)	Latreilliidae	Latreillia sp. 1			√	
28	Crustacea (Malacostraca)	Leucosiidae	unidentified sp. 1		3	√	√
28	Crustacea (Malacostraca)	Lysianassidae	?Hippomedon n. sp. 522	√	1		√
28	Crustacea (Malacostraca)	Majidae	Achaeus sp. 1		1		√
28	Crustacea (Malacostraca)	Majidae	Chlorinoides sp. 1		1		√
28	Crustacea (Malacostraca)	Majidae	Crytomaia sp. 1		1		√
28	Crustacea (Malacostraca)	Majidae	Cyrtomaia hispida			√	
28	Crustacea (Malacostraca)	Majidae	Macropodia sp. 1		1	√	
28	Crustacea (Malacostraca)	Majidae	Platymaia maoria				√
28	Crustacea (Malacostraca)	Majidae	Platymaia sp. 1			√	√
28	Crustacea (Malacostraca)	Majidae	unidentified sp. 1		1	√	
28	Crustacea (Malacostraca)	Majidae	unidentified sp. 2		1	√	
28	Crustacea (Malacostraca)	Majidae	unidentified sp. 3		1	√	
28	Crustacea (Malacostraca)	Majidae	unidentified sp. 4		1	√	
28	Crustacea (Malacostraca)	Majidae	unidentified sp. 5		1	√	
28	Crustacea (Malacostraca)	Majidae	unidentified sp. 6		1	√	
28	Crustacea (Malacostraca)	Majidae	Vitjazmaia latidactyla				√
28	Crustacea (Malacostraca)	Nematocarcinus	Nematocarcinus sp1				√
28	Crustacea (Malacostraca)	Nematocarcinus	Nematocarcinus sp2				√
28	Crustacea (Malacostraca)	Odontodactylidae	Odontodactylus hawaiiensis		1	√	
28	Crustacea (Malacostraca)	Oedicerotidae	unidentified sp. 3		1		√
28	Crustacea (Malacostraca)	Oedicerotidae	unidentified sp. 4		1		√
28	Crustacea (Malacostraca)	Oedicerotidae	unidentified sp. 5		1		√
28	Crustacea (Malacostraca)	Oplophoridae	Oplophoridae shrimp		1	√	
28	Crustacea (Malacostraca)	Oplophorus	Oplophorus spinosus				√
28	Crustacea (Malacostraca)	Paguridae	Paguridae sp8				√
28	Crustacea (Malacostraca)	Pandalidae	Pandalidae - undifferentiated				√
28	Crustacea (Malacostraca)	Pandalidae	Pandalidae spA		1	√	
28	Crustacea (Malacostraca)	Pandalidae	Pandalidae spB		1	√	
28	Crustacea (Malacostraca)	Pandalidae	Pandalidae spC		1	√	
28	Crustacea (Malacostraca)	Pandalidae	Pandalidae spJ				√
28	Crustacea (Malacostraca)	Pandalidae	Pandalidae spK		1		√
28	Crustacea (Malacostraca)	Pandalidae	Pandalidae spL		1		√
28	Crustacea (Malacostraca)	Panguroidma	Panguroidma		1	√	
28	Crustacea (Malacostraca)	Paraemonidae	Paraemonidae spB		1	√	
28	Crustacea (Malacostraca)	Parapaguridae	Parapaguridae sp11				√
28	Crustacea (Malacostraca)	Parapaguridae	Parapaguridae sp14		1		√
28	Crustacea (Malacostraca)	Parapaguridae	Parapaguridae sp15		1		√
28	Crustacea (Malacostraca)	Parapaguridae	Parapaguridae sp2			√	√

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28	Crustacea (Malacostraca)	Parapaguridae	Parapaguridae sp4			√	
28	Crustacea (Malacostraca)	Parapagurus	Parapagurus sp5		1	√	
28	Crustacea (Malacostraca)	Pasiphaea	Pasiphaea cf barnardi			√	√
28	Crustacea (Malacostraca)	Pasiphaea	Pasiphaea sp			√	
28	Crustacea (Malacostraca)	Pasiphaea	Pasiphaea spA (decapod)				√
28	Crustacea (Malacostraca)	Pasiphaea	Pasiphaea spE				√
28	Crustacea (Malacostraca)	Pasiphaeidae	Pasiphaeidae - undifferentiated			√	
28	Crustacea (Malacostraca)	Pasiphea	Pasiphea spC				√
28	Crustacea (Malacostraca)	Penaeoidea	Penaeoidea and Caridea - undifferentiated		1	√	
28	Crustacea (Malacostraca)	Phoxocephalidae	unidentified sp. 1		1		√
28	Crustacea (Malacostraca)	Phoxocephalidae	unidentified sp. 2		1		√
28	Crustacea (Malacostraca)	Pilumnidae	unidentified sp. 1		1	√	
28	Crustacea (Malacostraca)	Plesionika	Plesionika spp			√	√
28	Crustacea (Malacostraca)	Polychelidae	Pentacheles laevis			√	√
28	Crustacea (Malacostraca)	Polychelidae	Polycheles enthrix			√	
28	Crustacea (Malacostraca)	Polychelidae	Polycheles suhmi				√
28	Crustacea (Malacostraca)	Pontophilus	Pontophilus sp1		1	√	
28	Crustacea (Malacostraca)	Pontophilus	Pontophilus sp2		1	√	
28	Crustacea (Malacostraca)	Portunidae	Ovalipes molleri			√	√
28	Crustacea (Malacostraca)	Processidae	Processidae spB		1	√	
28	Crustacea (Malacostraca)	Processidae	unidentified sp. 1		1		√
28	Crustacea (Malacostraca)	Scyllaridae	Ibacus brucei		1		√
28	Crustacea (Malacostraca)	Sergestes	Sergestes spA (decapod)				√
28	Crustacea (Malacostraca)	Sergestes	Sergestes spE		1	√	
28	Crustacea (Malacostraca)	Sergestidae	Sergestes cf.curvatus		1	√	
28	Crustacea (Malacostraca)	Sergestidae	Sergestidae - undifferentiated			√	
28	Crustacea (Malacostraca)	Sicyoniidae	Sicyonia parafallax				√
28	Crustacea (Malacostraca)	Solenocendae	Solenocendae spC		1	√	
28	Crustacea (Malacostraca)	Solenocera	Solenocera spA		1	√	
28	Crustacea (Malacostraca)	Solenoceridae	Hadropenaeus lucasii				√
28	Crustacea (Malacostraca)	Solenoceridae	Haliporoides sibogae				√
28	Crustacea (Malacostraca)	Solenoceridae	Hymenopenaeus n. sp. 1	√		√	√
28	Crustacea (Malacostraca)	Solenoceridae	Hymenopenaeus neptunus				√
28	Crustacea (Malacostraca)	Solenoceridae	Hymenopenaeus obliquirostris				√
28	Crustacea (Malacostraca)	Solenoceridae	Hymenopenaeus undifferentiated		1		√
28	Crustacea (Malacostraca)	Solenoceridae	Solenocera comata		1		√
28	Crustacea (Malacostraca)	Solenoceridae	Solenoceridae - undifferentiated		1	√	
28	Crustacea (Malacostraca)	Solenoceridae	Solenoceridae spB		1	√	
28	Crustacea (Malacostraca)	Stylodactylidae	Stylodactylidae - undifferentiated		2	√	
28	Crustacea (Malacostraca)	Stylodactylus	Stylodactylus sp		1	√	
28	Crustacea (Malacostraca)	Suborder	Suborder Gammaridea - unidifferentiated		1	√	
28	Crustacea (Malacostraca)	Systellaspis	Systellaspis debilis			√	
28	Crustacea (Malacostraca)	Systellaspis	Systellaspis sp1 Carid oplophoridae			√	
28	Crustacea (Malacostraca)	Uroptychus	Uroptychus sp		1	√	
33	Pygnogonida	Ammotheidae	Ascorhynchus sp. 2	√	1	√	
33	Pygnogonida	Ammotheidae	Bathyzetes sp. 1	√	1		√
33	Pygnogonida	Colossendeidae	Rhopalorhynchus sp. 1	√	1		√
33	Pygnogonida	Pallenopsidae	Pallenopsis (Pallenopsis) sp. 1	√	1		√
33	Pygnogonida	Pycnogonid	Pycnogonid 3		1	√	
33	Pygnogonida	Pycnogonid	Pycnogonid sp2		1	√	
33	Pygnogonida	Pycnogonids	Pycnogonids sp1		1	√	
35	Ascidia	Ascidian	Ascidian		1	√	
35	Ascidia	Pyrosome	Pyrosome - red salp		1	√	
36	Hemichordata		Hemichordata sp1		1		√
37	Vertebrata - Pisces	Acropomatidae	Synagrops japonicus		2	√	
37	Vertebrata - Pisces	Alepocephalidae	Alepocephalidae - undifferentiated				√
37	Vertebrata - Pisces	Alepocephalidae	Alepocephalus antipodianus			√	√
37	Vertebrata - Pisces	Alepocephalidae	Alepocephalus australis			√	√
37	Vertebrata - Pisces	Alepocephalidae	Alepocephalus longirostris			√	
37	Vertebrata - Pisces	Alepocephalidae	Conocara werneri				√
37	Vertebrata - Pisces	Alepocephalidae	Mirognathus normani		1		√
37	Vertebrata - Pisces	Alepocephalidae	Narcetes lloydi		2	√	
37	Vertebrata - Pisces	Alepocephalidae	Rouleina attrita			√	√
37	Vertebrata - Pisces	Alepocephalidae	Talismania longifilis				√
37	Vertebrata - Pisces	Alepocephalidae	Xendoermichthys sp		1		√
37	Vertebrata - Pisces	Alepocephalidae	Xenodermichthys copei				√
37	Vertebrata - Pisces	Ammodytidae	Ammodytoides sp A		2		√
37	Vertebrata - Pisces	Apogonidae	Epigonus denticulatus				√
37	Vertebrata - Pisces	Argentinidae	Glossanodon sp		1		√
37	Vertebrata - Pisces	Aulopidae	Hime sp nov	√	2		√
37	Vertebrata - Pisces	Balistidae	Parika scaber		2		√
37	Vertebrata - Pisces	Bathyclupeidae	Bathyclupea gracilis?		2	√	√
37	Vertebrata - Pisces	Bathyclupeidae	Bathyclupea gracilis? (deep body)		1	√	
37	Vertebrata - Pisces	Bathyclupeidae	Bathyclupea gracilis? (slender body)		1	√	
37	Vertebrata - Pisces	Bathylagidae	Bathylagus sp.A				√
37	Vertebrata - Pisces	Bathypteroidae	Bathypterois filiferus		2	√	
37	Vertebrata - Pisces	Bathypteroidae	Bathypterois longifilis				√
37	Vertebrata - Pisces	Berycidae	Beryx decadactylus			√	
37	Vertebrata - Pisces	Berycidae	Centroberyx spA			√	
37	Vertebrata - Pisces	Bothidae	Bothidae, Achiropsettidae, Paralichthyidae - undif		1		√
37	Vertebrata - Pisces	Bothidae	Lophonectes sp NFZ1		4		√
37	Vertebrata - Pisces	Bothidae	Psettina spA		1	√	

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37	Vertebrata - Pisces	Caproidae	Antigonia sp 1 (big)		4	√	
37	Vertebrata - Pisces	Caproidae	Antigonia sp 2 (small)		2	√	
37	Vertebrata - Pisces	Carangidae	Pseudocaranx dentex		1		√
37	Vertebrata - Pisces	Carangidae	Seriola lalandi		1	√	
37	Vertebrata - Pisces	Carangidae	Trachurus declivis		4		√
37	Vertebrata - Pisces	Carangidae	Trachurus novaezelandiae		2		√
37	Vertebrata - Pisces	Carapidae	Carapidae		2	√	√
37	Vertebrata - Pisces	Carapidae	Eurypleuron owasianus		1	√	
37	Vertebrata - Pisces	Caulophrynidae	Caulophryne jordani		1		√
37	Vertebrata - Pisces	Cetomimidae	Cetomimidae spA		1	√	
37	Vertebrata - Pisces	Chaetodontidae	Amphichaetodon howensis			√	
37	Vertebrata - Pisces	Champsodontidae	Champsodon guentheri		1	√	
37	Vertebrata - Pisces	Chauliodontidae	Chauliodus sloani			√	√
37	Vertebrata - Pisces	Chaunacidae	Chaunax flammeus cf				√
37	Vertebrata - Pisces	Cheilodactylidae	Nemadactylus sp (king)	√			√
37	Vertebrata - Pisces	Chiasmodontidae	Chiasmodon niger				√
37	Vertebrata - Pisces	Chiasmodontidae	Kali macrodon		1		√
37	Vertebrata - Pisces	Chimaeridae	Chimaera sp NFZ1				√
37	Vertebrata - Pisces	Chimaeridae	Hydrolagus sp A (var NZ)	√			√
37	Vertebrata - Pisces	Chlorophthalmidae	Chlorophthalmus albatrossis			√	
37	Vertebrata - Pisces	Chlorophthalmidae	Paraulopus cf novazeelandiae		1	√	
37	Vertebrata - Pisces	Chlorophthalmidae	Paraulopus legandi		1	√	
37	Vertebrata - Pisces	Chlorophthalmidae	Paraulopus okamurai			√	√
37	Vertebrata - Pisces	Chlorophthalmidae	Paraulopus spA (not Gomon)		1	√	
37	Vertebrata - Pisces	Congridae	Congridae - undifferentiated		1		√
37	Vertebrata - Pisces	Cynoglossidae	Symphurus sp		1	√	
37	Vertebrata - Pisces	Cynoglossidae	Symphurus sp C				√
37	Vertebrata - Pisces	Diodontidae	Allomycterus pilatus				√
37	Vertebrata - Pisces	Emmelichthyidae	Emmelichthys nitidus		3		√
37	Vertebrata - Pisces	Evermannellidae	Evermannella balbo			√	
37	Vertebrata - Pisces	Gempylidae	Diplospinus multistriatus			√	
37	Vertebrata - Pisces	Gempylidae	Promethichthys prometheus		1	√	
37	Vertebrata - Pisces	Gempylidae	Rexea antefurcata			√	√
37	Vertebrata - Pisces	Gempylidae	Rexea solandri		1		√
37	Vertebrata - Pisces	Gobiesocidae	Kopua? sp A		1	√	
37	Vertebrata - Pisces	Gonorynchidae	Gonorynchus greyi				√
37	Vertebrata - Pisces	Gonostomatidae	Gonostoma bathyphilum				√
37	Vertebrata - Pisces	Gonostomatidae	Gonostoma elongatum			√	
37	Vertebrata - Pisces	Grammicolepididae	Grammicolepis brachiusculus			√	
37	Vertebrata - Pisces	Halosauridae	Aldrovandia affinis				√
37	Vertebrata - Pisces	Halosauridae	Halosaurus pectoralis			√	
37	Vertebrata - Pisces	Hexanchidae	Heptranchias perlo		2	√	√
37	Vertebrata - Pisces	Hoplichthyidae	Hoplichthys citrinus		1	√	
37	Vertebrata - Pisces	Hoplichthyidae	Hoplichthys gilberti		1	√	
37	Vertebrata - Pisces	Idiacanthidae	Idiacanthus atlanticus			√	
37	Vertebrata - Pisces	Labridae	Bodianus spA		1	√	
37	Vertebrata - Pisces	Labridae	Bodianus unimaculatus			√	
37	Vertebrata - Pisces	Lutjanidae	Pristipomoides filamentosus			√	
37	Vertebrata - Pisces	Lutjanidae	Pterocaesio sp A		1	√	
37	Vertebrata - Pisces	Macrorhamphosidae	Macrorhamphosus scolopax		3		√
37	Vertebrata - Pisces	Macrorhamphosidae	Notopogon xenosoma			√	
37	Vertebrata - Pisces	Macrouridae	Bathygadus cottoides			√	√
37	Vertebrata - Pisces	Macrouridae	Bathygadus spongiceps			√	√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus acanthiger				√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus celaenostomus				√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus cookianus				√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus innotabilis				√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus kermadecus		4	√	
37	Vertebrata - Pisces	Macrouridae	Caelorinchus maurofasciatus				√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus melanobranchus		1		√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus mycterismus				√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus sp NFZ3	√			√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus sp nov 1	√	1	√	
37	Vertebrata - Pisces	Macrouridae	Caelorinchus spathulatus		3	√	√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus supernasutus			√	√
37	Vertebrata - Pisces	Macrouridae	Caelorinchus trachycarus				√
37	Vertebrata - Pisces	Macrouridae	Cetonurus globiceps				√
37	Vertebrata - Pisces	Macrouridae	Coryphaenoides dossenus				√
37	Vertebrata - Pisces	Macrouridae	Coryphaenoides grahami				√
37	Vertebrata - Pisces	Macrouridae	Coryphaenoides mcmillani				√
37	Vertebrata - Pisces	Macrouridae	Coryphaenoides rudis				√
37	Vertebrata - Pisces	Macrouridae	Coryphaenoides serrulatus				√
37	Vertebrata - Pisces	Macrouridae	Coryphaenoides striaturus				√
37	Vertebrata - Pisces	Macrouridae	Coryphaenoides subserrulatus				√
37	Vertebrata - Pisces	Macrouridae	Gadomus aotaenus				√
37	Vertebrata - Pisces	Macrouridae	Gadomus colletti			√	
37	Vertebrata - Pisces	Macrouridae	Hymenocephalus gracilis			√	
37	Vertebrata - Pisces	Macrouridae	Hymenocephalus megalops				√
37	Vertebrata - Pisces	Macrouridae	Hymenocephalus nascens			√	√
37	Vertebrata - Pisces	Macrouridae	Macrouridae - undifferentiated				√
37	Vertebrata - Pisces	Macrouridae	Malacocephalus laevis				√
37	Vertebrata - Pisces	Macrouridae	Mesobius antipodum				√

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37	Vertebrata - Pisces	Macrouridae	Nezumia coheni			√	√
37	Vertebrata - Pisces	Macrouridae	Nezumia namatahi				√
37	Vertebrata - Pisces	Macrouridae	Nezumia propinqua			√	√
37	Vertebrata - Pisces	Macrouridae	Sphagemacrurus richardi				√
37	Vertebrata - Pisces	Macrouridae	Squalogadus modificatus			√	
37	Vertebrata - Pisces	Macrouridae	Trachonurus gagates			√	√
37	Vertebrata - Pisces	Macrouridae	Trachonurus sp NFZ 1		2		√
37	Vertebrata - Pisces	Macrouridae	Ventrifossa atherodon		1	√	
37	Vertebrata - Pisces	Macrouridae	Ventrifossa johnboborum			√	
37	Vertebrata - Pisces	Macrouridae	Ventrifossa macropogon		1	√	
37	Vertebrata - Pisces	Macrouridae	Ventrifossa paxtoni		1	√	
37	Vertebrata - Pisces	Macrurocyttidae	Zenion sp B		1		√
37	Vertebrata - Pisces	Malacosteidae	Malacosteus niger			√	
37	Vertebrata - Pisces	Malacosteidae	Malacosteus sp A			√	√
37	Vertebrata - Pisces	Melamphaidae	Melamphaidae - undifferentiated			√	
37	Vertebrata - Pisces	Melamphaidae	Scopeloberyx microlepis		1		√
37	Vertebrata - Pisces	Melamphaidae	Scopelogadus beanii				√
37	Vertebrata - Pisces	Melanostomiidae	Bathophilus abarbatus			√	
37	Vertebrata - Pisces	Melanostomiidae	Leptostomias sp A			√	
37	Vertebrata - Pisces	Melanostomiidae	Thysanactis sp. A		1	√	
37	Vertebrata - Pisces	Moridae	Antimora rostrata				√
37	Vertebrata - Pisces	Moridae	Halargyreus johnsonii				√
37	Vertebrata - Pisces	Moridae	Lepidion microcephalus				√
37	Vertebrata - Pisces	Moridae	Lepidion schmidti				√
37	Vertebrata - Pisces	Moridae	Melanonus gracilis				√
37	Vertebrata - Pisces	Moridae	Melanonus zugmayeri				√
37	Vertebrata - Pisces	Moridae	Mora moro				√
37	Vertebrata - Pisces	Moridae	Physiculus luminosa cf			√	
37	Vertebrata - Pisces	Moridae	Tripterophycis gilchristi				√
37	Vertebrata - Pisces	Mugiloididae	Parapercis sp A			√	
37	Vertebrata - Pisces	Mugiloididae	Parapercis sp B		1		√
37	Vertebrata - Pisces	Mugiloididae	Parapercis sp NFZ1		1		√
37	Vertebrata - Pisces	Myctophidae	Diaphus adenomus			√	
37	Vertebrata - Pisces	Myctophidae	Diaphus similis?		1	√	
37	Vertebrata - Pisces	Myctophidae	Diaphus sp		1	√	
37	Vertebrata - Pisces	Myctophidae	Diaphus watasei		2	√	√
37	Vertebrata - Pisces	Myctophidae	Hygophum proximum		1		√
37	Vertebrata - Pisces	Myctophidae	Lampanychus cf festivus				√
37	Vertebrata - Pisces	Myctophidae	Lampanyctus festivus			√	
37	Vertebrata - Pisces	Myctophidae	Nannobrachium cf atrum		1	√	
37	Vertebrata - Pisces	Nemichthyidae	Avocettina sp			√	√
37	Vertebrata - Pisces	Nemichthyidae	Nemichthys scolopaceus			√	
37	Vertebrata - Pisces	Neoscopelidae	Neoscopelus macrolepidotus			√	√
37	Vertebrata - Pisces	Nettastomatidae	Venefica sp				√
37	Vertebrata - Pisces	Nomeidae	Cubiceps caeruleus		1		√
37	Vertebrata - Pisces	Nomeidae	Cubiceps pauciradiatus		1	√	
37	Vertebrata - Pisces	Notacanthidae	Notacanthus sexspinus				√
37	Vertebrata - Pisces	Notosudidae	Scopelosaurus sp 1			√	
37	Vertebrata - Pisces	Ogcocephalidae	Halicmetus sp A (longtail) cf		1	√	
37	Vertebrata - Pisces	Ogcocephalidae	Halieutaea sp E1 (E black edge, low spine)		1	√	
37	Vertebrata - Pisces	Ogcocephalidae	Malthopsis sp NFZ1		1	√	
37	Vertebrata - Pisces	Oreosomatidae	Allocyttus verrucosus			√	√
37	Vertebrata - Pisces	Ostraciidae	Polyplacapros tyleri				√
37	Vertebrata - Pisces	Pentacerotidae	Pentaceros decacanthus			√	
37	Vertebrata - Pisces	Pentacerotidae	Zanclistius elevatus		2		√
37	Vertebrata - Pisces	Percophidae	Acanthaphritis grandisquamis		1	√	
37	Vertebrata - Pisces	Percophidae	Percophidae gen spA		1	√	
37	Vertebrata - Pisces	Platycephalidae	Onigocia pedimacula		1	√	
37	Vertebrata - Pisces	Psychrolutidae	Psychrolutes sp B				√
37	Vertebrata - Pisces	Psychrolutidae	Psychrolutes spC				√
37	Vertebrata - Pisces	Rajidae	Dipturus innominata				√
37	Vertebrata - Pisces	Rajidae	Dipturus innominata (var pale)		1		√
37	Vertebrata - Pisces	Rajidae	Notoraja sp C (NFZ)	√			√
37	Vertebrata - Pisces	Rajidae	Notoraja sp D (NFZ)	√			√
37	Vertebrata - Pisces	Rhinochimaeridae	Harriotta raleighana?		1	√	
37	Vertebrata - Pisces	Scorpaenidae	Helicolenus barathri				√
37	Vertebrata - Pisces	Scorpaenidae	Helicolenus barathri cf				√
37	Vertebrata - Pisces	Scorpaenidae	Neomerinthe sp B		1	√	
37	Vertebrata - Pisces	Scorpaenidae	Phenacoscorpius sp A			√	
37	Vertebrata - Pisces	Scorpaenidae	Scorpaena n sp (bul MS)	√		√	
37	Vertebrata - Pisces	Scorpaenidae	Scorpaena onaria (Tasman Sea form)		2	√	
37	Vertebrata - Pisces	Scorpaenidae	Setarches sp (longimanus cf)		2	√	
37	Vertebrata - Pisces	Scyliorhinidae	Apristurus sp A (freckled)	√		√	√
37	Vertebrata - Pisces	Scyliorhinidae	Apristurus sp B (bigfin)	√			√
37	Vertebrata - Pisces	Scyliorhinidae	Apristurus sp E	√			√
37	Vertebrata - Pisces	Scyliorhinidae	Apristurus sp E cf	√		√	
37	Vertebrata - Pisces	Scyliorhinidae	Apristurus sp G (herklotsi?)	√			√
37	Vertebrata - Pisces	Scyliorhinidae	Apristurus sp G (herklotsi?)?	√	1		√
37	Vertebrata - Pisces	Scyliorhinidae	Apristurus sp G cf	√	1		√
37	Vertebrata - Pisces	Scyliorhinidae	Cephaloscyllium sp NFZ1		1		√
37	Vertebrata - Pisces	Scyliorhinidae	Mustelus sp.NFZ1		1		√
37	Vertebrata - Pisces	Serranidae	Callanthias australis				√

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37	Vertebrata - Pisces	Serranidae	Caprodon sp C		2		√
37	Vertebrata - Pisces	Serranidae	Chelidoperca lecromi		1	√	
37	Vertebrata - Pisces	Serranidae	Epinephelus ergastularius		1	√	
37	Vertebrata - Pisces	Serranidae	Hypoplectodes sp A		1	√	
37	Vertebrata - Pisces	Serranidae	Lepidoperca magna			√	
37	Vertebrata - Pisces	Serranidae	Plectranthias spA			√	
37	Vertebrata - Pisces	Serranidae	Synagrops philippinensis		1		√
37	Vertebrata - Pisces	Serrivomeridae	Serrivomer sp A			√	
37	Vertebrata - Pisces	Serrivomeridae	Serrivomer spB (black)			√	
37	Vertebrata - Pisces	Serrivomeridae	Serrivomeridae - undifferentiated		1	√	
37	Vertebrata - Pisces	Squalidae	Centroscyllium kamoharai			√	
37	Vertebrata - Pisces	Squalidae	Centroscymnus coelolepis (var NZ)				√
37	Vertebrata - Pisces	Squalidae	Centroscymnus crepidater				√
37	Vertebrata - Pisces	Squalidae	Centroscymnus plunketi cf		1	√	
37	Vertebrata - Pisces	Squalidae	Centroscymnus sp NFZ1 (cf owstoni)				√
37	Vertebrata - Pisces	Squalidae	Dalatias licha				√
37	Vertebrata - Pisces	Squalidae	Deania calcea				√
37	Vertebrata - Pisces	Squalidae	Deania quadrispinosa cf			√	√
37	Vertebrata - Pisces	Squalidae	Etmopterus baxteri		1		√
37	Vertebrata - Pisces	Squalidae	Etmopterus lucifer				√
37	Vertebrata - Pisces	Squalidae	Etmopterus molleri				√
37	Vertebrata - Pisces	Squalidae	Etmopterus sp B	√		√	√
37	Vertebrata - Pisces	Squalidae	Squalus sp B (eastern highfin)	√		√	
37	Vertebrata - Pisces	Squalidae	Squalus sp B (non SAROA)				√
37	Vertebrata - Pisces	Squalidae	Squalus sp NFZ1		1		√
37	Vertebrata - Pisces	Sternoptychidae	Argyripnus iridescens				√
37	Vertebrata - Pisces	Sternoptychidae	Argyropelecus aculeatus			√	
37	Vertebrata - Pisces	Sternoptychidae	Argyropelecus hemigymnus			√	
37	Vertebrata - Pisces	Sternoptychidae	Argyropelecus sp			√	
37	Vertebrata - Pisces	Sternoptychidae	Polyipnus kiwiensis				√
37	Vertebrata - Pisces	Sternoptychidae	Polyipnus parini				√
37	Vertebrata - Pisces	Sternoptychidae	Polyipnus sp		1	√	
37	Vertebrata - Pisces	Sternoptychidae	Polyipnus tridentifer		1		√
37	Vertebrata - Pisces	Stomiidae	Stomias boa boa				√
37	Vertebrata - Pisces	Synaphobranchidae	Diastobranchus capensis			√	√
37	Vertebrata - Pisces	Synaphobranchidae	Synaphobranchus affinis			√	√
37	Vertebrata - Pisces	Synaphobranchidae	Synaphobranchus kaupi				√
37	Vertebrata - Pisces	Synodontidae	Synodus doaki		1	√	
37	Vertebrata - Pisces	Synodontidae	Synodus rubromarmoratus cf		2		√
37	Vertebrata - Pisces	Tetraodontidae	Canthigaster callisterna				√
37	Vertebrata - Pisces	Tetraodontidae	Canthigaster callisterna?		1	√	
37	Vertebrata - Pisces	Tetraodontidae	Sphoeroides pachygaster		2		√
37	Vertebrata - Pisces	Tetraodontidae	Torquigener spA		1		√
37	Vertebrata - Pisces	Torpedinidae	Torpedo macneilli				√
37	Vertebrata - Pisces	Trachichthyidae	Hoplostethus atlanticus				√
37	Vertebrata - Pisces	Trachichthyidae	Hoplostethus mediterraneus				√
37	Vertebrata - Pisces	Triakidae	Mustelus sp NFZ2		1		√
37	Vertebrata - Pisces	Trichiuridae	Benthodesmus elongatus			√	
37	Vertebrata - Pisces	Trichiuridae	Benthodesmus tuckeri				√
37	Vertebrata - Pisces	Trichiuridae	Lepidopus caudatus				√
37	Vertebrata - Pisces	Triglidae	Pterygotrigla andertoni		1		√
37	Vertebrata - Pisces	Triglidae	Pterygotrigla pauli				√
37	Vertebrata - Pisces	Triglidae	Pterygotrigla spA		1	√	
37	Vertebrata - Pisces	Uranoscopidae	Kathetostoma sp		7		√
37	Vertebrata - Pisces	Uranoscopidae	Uranoscopus sp A		1	√	
37	Vertebrata - Pisces	Veliferidae	Metavelifer multiradiatus				√
37	Vertebrata - Pisces	Zeidae	Zenopsis nebulosus				√
37	Vertebrata - Pisces	Zeidae	Zeus faber		1		√
37	Vertebrata - Pisces	Zoarcidae	Melanostigma gelatinosum		1		√

Species listed under the *EPBC Act* (1999)

Marine species occurring in the region of the Norfolk Island EEZ ,listed under the *EPBC Act* (1999), and including species listed as threatened – giving their current status – and migratory. 'Pres. code' refers to the type of presence in the area: 1 Species or species habitat likely to occur within area; 2 Foraging may recorded within area; 3 Breeding recorded within area.

Scientific Name	**Common Name**	**Listed Marine Species**	**Threatened Species (status)**	**Migratory Marine Species**	**Pres. code**
Birds					
Diomedea amsterdamensis	Amsterdam Albatross	Listed	Endangered	Migratory	1
Diomedea antipodensis	Antipodean Albatross	Listed	Vulnerable	Migratory	1
Diomedea dabbenena	Tristan Albatross	Listed	Endangered	Migratory	2
Diomedea exulans	Wandering Albatross	Listed	Vulnerable	Migratory	1
Diomedea gibsoni	Gibson's Albatross	Listed	Vulnerable	Migratory	1
Fregetta grallaria grallaria	White-bellied Storm-Petrel (Tasman Sea/Australasia)	N/A	Vulnerable	N/A	1
Macronectes giganteus	Southern Giant-Petrel	Listed	Endangered	Migratory	1
Macronectes halli	Northern Giant-Petrel	Listed	Vulnerable	Migratory	1
Morus serrator	Australasian Gannet	Listed	N/A	N/A	3
Phaethon rubricauda	Red-tailed Tropicbird	Listed	N/A	N/A	3
Procelsterna cerulea	Grey Ternlet	Listed	N/A	N/A	3
Pterodroma cervicalis	White-necked Petrel	Listed	N/A	N/A	3
Pterodroma neglecta neglecta	Kermadec Petrel (western)	N/A	Vulnerable	N/A	1
Pterodroma nigripennis	Black-winged Petrel	Listed	N/A	N/A	3
Pterodroma solandri	Providence Petrel	Listed	N/A	Migratory	3
Puffinus assimilis	Little Shearwater	Listed	N/A	N/A	3
Puffinus pacificus	Wedge-tailed Shearwater	Listed	N/A	Migratory	3
Sterna fuscata	Sooty Tern	Listed	N/A	N/A	3
Sula dactylatra	Masked Booby	Listed	N/A	Migratory	3
Thalassarche bulleri	Buller's Albatross	Listed	Vulnerable	Migratory	1
Thalassarche cauta	Shy Albatross	Listed	Vulnerable	Migratory	1
Thalassarche chlororhynchos	(Atlantic) Yellow-nosed Albatross	Listed	N/A	N/A	1
Thalassarche eremita	Chatham Albatross	Listed	Endangered	N/A	
Thalassarche impavida	Campbell Albatross	Listed	Vulnerable	Migratory	1
Thalassarche melanophris	Black-browed Albatross	Listed	N/A	Migratory	1
Fishes					
Halicampus boothae	Booth's Pipefish	Listed	N/A	N/A	1
Reptiles					

Scientific Name	**Common Name**	**Listed Marine Species**	**Threatened Species (status)**	**Migratory Marine Species**	**Pres. code**
*Chelonia mydas **	Green Turtle	Listed	Vulnerable	Migratory	1
*Dermochelys coriacea **	Leathery/Leatherback Turtle	Listed	Vulnerable	Migratory	1
Cetaceans					
Balaenoptera acutorostrata	Minke Whale	Cetacean	N/A	N/A	1
Balaenoptera bonaerensis	Antarctic/Dark-shoulder Minke Whale	Cetacean	N/A	Migratory	1
Balaenoptera edeni	Bryde's Whale	Cetacean	N/A	Migratory	1
Balaenoptera musculus	Blue Whale	Cetacean	Endangered	Migratory	1
Berardius arnuxii	Arnoux's Beaked Whale	Cetacean	N/A	N/A	1
Caperea marginata	Pygmy Right Whale	Cetacean	N/A	Migratory	1
Delphinus delphis	Common Dolphin	Cetacean	N/A	N/A	1
*Eubalaena australis **	Southern Right Whale	Cetacean	Endangered	Migratory	1
Feresa attenuata	Pygmy Killer Whale	Cetacean	N/A	N/A	1
Globicephala macrorhynchus	Short-finned Pilot Whale	Cetacean	N/A	N/A	1
Globicephala melas	Long-finned Pilot Whale	Cetacean	N/A	N/A	1
Grampus griseus	Risso's Dolphin, Grampus	Cetacean	N/A	N/A	1
Kogia breviceps	Pygmy Sperm Whale	Cetacean	N/A	N/A	1
Kogia simus	Dwarf Sperm Whale	Cetacean	N/A	N/A	1
Lagenodelphis hosei	Fraser's/Sarawak Dolphin	Cetacean	N/A	N/A	1
Lagenorhynchus obscurus	Dusky Dolphin	Cetacean	N/A	N/A	1
Lissodelphis peronii	Southern Right Whale Dolphin	Cetacean	N/A	N/A	1
*Megaptera novaeangliae **	Humpback Whale	Cetacean	Vulnerable	Migratory	1
Mesoplodon bowdoini	Andrew's Beaked Whale	Cetacean	N/A	N/A	1
Mesoplodon densirostris	Blainville's/Dense beaked Whale	Cetacean	N/A	N/A	1
Mesoplodon grayi	Gray's Beaked/Scamperdown Whale	Cetacean	N/A	N/A	1
Mesoplodon layardii	Strap-toothed/Layard's Beaked Whale	Cetacean	N/A	N/A	1
Mesoplodon mirus	True's Beaked Whale	Cetacean	N/A	N/A	1
Orcinus orca	Killer Whale, Orca	Cetacean	N/A	Migratory	1
Peponocephala electra	Melon-headed Whale	Cetacean	N/A	N/A	1
Physeter macrocephalus	Sperm Whale	Cetacean	N/A	Migratory	1
Pseudorca crassidens	False Killer Whale	Cetacean	N/A	N/A	1
Stenella attenuata	Spotted Dolphin, Pantropical Spotted	Cetacean	N/A	N/A	1

Scientific Name	Common Name	Listed Marine Species	Threatened Species (status)	Migratory Marine Species	Pres. code
	Dolphin				
Stenella coeruleoalba	Striped Dolphin, Euphrosyne Dolphin	Cetacean	N/A	N/A	1
Stenella longirostris	Long-snouted Spinner Dolphin	Cetacean	N/A	N/A	1
Steno bredanensis	Rough-toothed Dolphin	Cetacean	N/A	N/A	1
Tursiops truncatus s. str.	Bottlenose Dolphin	Cetacean	N/A	N/A	1
Ziphius cavirostris	Cuvier's/Goose beaked Whale	Cetacean	N/A	N/A	1

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Commercial species

Norfolk Island Offshore Demersal Finfish Fishery (NIODFF)

Fish species retained in the Norfolk Island Offshore Demersal Finfish Fishery caught inside the NISA area by total estimated catch weight.

Scientific Name	Common name	Total Retained catch (kg) by trawl and line methods
Polyprion spp	Hapuku and Bass Groper-NSW	31660
Hyperoglyphe antarctica	Blue Eye Trevalla	10610
Nemadactylus macropterus	Jackass morwong	7258
Seriola lalandi	Yellowtail Kingfish	4336
Polyprion oxygeneios	Temperate ocean bass (Hapuku)	3755
Nemadactylus sp.	King morwong	3327
Squalus megalops	Piked spurdog	3100
Lutjanus spp.	Sea perch	1105
Galeorhinus galeus	School Shark	914
Pseudocaranx dentex	Silver trevally	850
Centroberyx gerrardi	Bight redfish	640
Pentacerotidae	Boarfish	619
Centroberyx affinis	Redfish	458
Helicolenus sp.	Ocean perch	324
Isurus oxyrinchus	Shortfin Mako	287
Beryx splendens	Alfonsino	265
Unknown/mixed Species	OTHER	220
Sparidae - undifferentiated	Breams	220
Mustelus antarcticus	Gummy shark	170
Etelis carbunculus	Sea perch/snapper (N'thwest ruby fish)	120
Gnathanodon speciosus	Golden trevally	100
Carangidae - undifferentiated	Trevallies and jacks	85
Hoplostethus atlanticus	Orange roughy	80
Epinephelus ergastularius and Epinephelus septemfa	Bar rock cod	60
Squalus mitsukurii	Greeneye Spurdog	50
Pseudopentaceros richardsoni	Richardson's boarfish	40
Seriolella brama	Blue warehou	25
Mora moro	Ribaldo	22.2
other sharks	Other sharks	12
Rexea solandri	Gemfish	12
Lutjanus johnii	Fingermark seaperch (Golden snapper)	10
Centrophorus moluccensis	Endeavour dogfish	10
Chimaeridae - undifferentiated	Shortnose chimaeras	5
Diretmichthys parini	Black (Parin's) spinyfin	3
Macruronus novaezelandiae	Blue grenadier	1.8

Scientific Name	Common name	Total Retained catch (kg) by trawl and line methods
	TOTAL	70754

Pelagic Fisheries (combined)

Fish species caught within the Norfolk Island EEZ, and retained in the combined pelagic fisheries under Australia's management.

Scientific Name	Common Name
Beryx splendens	Alfonsino
Centroberyx affinis	Redfish
Centroberyx gerrardi	Bight Redfish
Diretmichthys parini	Parins Spinyfin - Black Roughy
Etelis carbunculus	Sea perch/snapper OR Northwest Ruby Fish
Genypterus blacodes	Pink ling
Gnathanodon speciosus	Golden Trevally
Helicolenus percoides	Reef Ocean Perch
Hoplostethus atlanticus	Orange Roughy
Hyperoglyphe antarctica	Blue Eye Trevalla
Isurus oxyrinchus	Shortfin Mako
Lutjanus johnii	Golden Snapper - Fingermark Seaperch
Lutjanus spp.	Sea Perch
Macruronus novaezelandiae	Blue Grenadier
Mora moro	Ribaldo
Nemadactylus macropterus	Jackass Morwong
Nemadactylus sp.	King Morwong
Neocyttus rhomboidalis	Spiky Oreo
Pentacerotidae	Boarfish
Polyprion oxygeneios	Hapuku
Polyprion spp	Hapuku and Bass Groper-NSW
Pseudocaranx dentex	Silver Trevally
Pseudopentaceros richardsoni	Richardson's Boarfish
Rexea solandri	Gemfish
Seriola lalandi	Yellowtail Kingfish
Seriolella brama	Blue Warehou

Appendix 7

Twelve categories of possible disturbance to marine ecosystems identified by NOO (2002b)

Disturbance Category	Description
Chemical change	Changing the concentration or properties of compounds naturally occurring in the ocean, such as changes to salinity, nutrients, and dissolved oxygen
Contaminants	Introducing substances that are not normally found in the marine environment
Temperature change	Changing the marine environment's natural temperature range
Mechanical change	Removing or changing structural (biological and physical) components of the ecosystem
Nuclear radiation	Introducing radioactive isotopes into the marine environment
Electromagnetic radiation	Introducing radiation that consists of electromagnetic waves
Noise	Increasing the level or amount of sound in the marine environment beyond its natural range
Biological interaction	Removing or damaging organisms
Introduced pathogens	Introducing disease-producing organisms to the marine environment, either from terrestrial or marine sources
Introduced marine species	Introducing species that do not occur naturally or historically
Turbidity/light	Changing the extent to which light penetrates the water column
Artificial light	Introducing a source of light that would not naturally occur in the marine environment