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EXECUTIVE SUMMARY

Rowden, A.A.; Clark, M.R.; O'Shea, S. (2004). Benthic biodiversity of seamounts on the Northland Plateau. ***Marine Biodiversity Biosecurity Report No. 5.*** **21 p.**

1) A research programme entitled "Seamounts: their importance to fisheries and marine ecosystems" is currently being carried out by NIWA with funding from the Foundation for Research, Science & Technology. Additional funding from the Ministry of Fisheries in 2002 enabled a survey of seamounts on the Northland Plateau to be extended, and further research on biodiversity to be undertaken.

2) Two seamounts (Cavalli and #441) were sampled using an epibenthic sled and camera frame. This report describes the benthic macro-invertebrate assemblage on these seamounts, and quantifies and compares biodiversity between seamounts surveyed.

3) A total of 396 macro-invertebrate species was recorded from 25 epibenthic sled stations. At least 17% of the species are considered to be undescribed for the New Zealand region. Species were distributed among 13 phyla, with 6 of the phyla containing over 90% of the taxa found. Taxonomic diversity varied within these major phyla.

4) No differences between seamounts were evident in the mean number of species recorded for each feature: Cavalli 'main', Cavalli 'west', and #441 had a mean number of species of 37.8, 58.2, and 47.2 per sample, respectively.

5) Analysis of photographic images confirmed the dominance of certain taxa as revealed by direct sampling, but also indicated compositional differences in taxonomic diversity between the two study seamounts.

6) Further sampling of other seamounts (using a combination of direct sampling and photographic techniques) and adjacent areas of hard substrate is required to improve assessments of biodiversity and endemism.

1. INTRODUCTION

1.1 Overview

In the New Zealand marine environment, seamounts are common and widely distributed features (Wright 1999), some of which are the focus of important commercial fisheries (Clark 1999). Having significant elevated seafloor topography (usually defined as over 1000 m), seamounts are of considerable scientific interest, often hosting unusual or unique assemblages and a biodiversity disproportionate to their size/area (Probert 1999). Seamounts are not only widely recognised as areas of high productivity, but are also regarded as fragile habitat (Rogers 1994) susceptible to disturbance from fishing (e.g., Koslow et al. 2001) and mining (e.g., Grigg et al. 1987). Within the New Zealand region, very little ecological research has been undertaken on seamounts and few studies have addressed the effects that human activities may have on their physical and biological integrity (Probert et al. 1997, Clark & O'Driscoll in press). A research programme entitled "Seamounts: their importance to fisheries and marine ecosystems" is currently being carried out by the National Institute of Water and Atmospheric Research (NIWA) with funding from the New Zealand Foundation for Research, Science & Technology (FRST) and the Ministry of Fisheries (MFish). This programme aims to describe and build an understanding of the role and dynamics of seamounts in the marine environment (Clark et al. 1999).

Since the mid 1990s, NIWA scientists have studied a variety of seamount habitats in New Zealand, including those of the Chatham Rise (Rowden et al. 2002) and the southern Kermadec volcanic arc (Rowden et al. 2003), and found species/taxonomic diversity to be high. However, sampling coverage of parts of New Zealand's Exclusive Economic Zone is very limited, and cannot provide good information on how macro-invertebrate assemblage composition and diversity varies throughout the New Zealand region.

The present study was designed to extend the previous work of NIWA, and to provide a more comprehensive description of the seamount assemblages on the Northland Plateau northeast of New Zealand's North Island. Owing to the potential synergies between the FRST-funded NIWA seamount programme and the goals of the MFish biodiversity programme, additional objectives were supported by MFish to expand the biodiversity research undertaken during a survey planned for this area. In this report, we present results from this work describing the benthic macro-invertebrate assemblage on two seamounts, one of which was afforded a degree of legal protection from anthropogenic disturbance nearly a year before the survey (Anon. 2001), and quantify and compare biodiversity among the seamounts surveyed.

1.2 Objectives

There were six aims in the project 'Additional Research on Biodiversity of Seamounts' (ZBD2001/10).

- To determine the macro-invertebrate assemblage composition on Cavalii seamount, and adjacent seamount #441, by photographic transects and epibenthic sled sampling.
- To determine the distribution of macro-invertebrate assemblages on the seamounts.
- To compare the macro-invertebrate species diversity of neighbouring seamounts.
- To evaluate and collect samples from suitable macro-invertebrate species for genetic analysis.
- To map bathymetry and habitat characteristics of the seamounts.
- To compare macro-invertebrate assemblage composition of the seamounts with nearby hard-bottom low relief (under 100 m) on the slope, if suitable areas can be located.

This report represents an initial analysis of some of the preliminary data that resulted from the study undertaken to achieve the project aims. More detailed analyses are planned, once faunal identification is more complete, and will be reported in a future publication(s).

2. METHODS

2.1 Study site

The study site was located 100 km east-northeast of North Cape of the North Island, on the Northland Plateau (Figure 1). The two seamounts studied were Cavalli seamount and a feature known as #441 (the reference number assigned to the feature in the NIWA seamounts database). Cavalli is a broadly circular feature that rises over 1000 m from a base depth of 1600 m and encompasses an area of 600 km^2. The seamount comprises three distinct peaks separated by small sea valleys. The 'main' peak of Cavalli occurs at a water depth of 461 m, and the smaller 'west' and 'south' peaks occur deeper at 769 m and 802 m, respectively. Seamount #441 lies about 65 km to the east of Cavalli, where it rises from a water depth of 2300 m to peak at 781 m, and has an area of 200 km^2. Both seamounts have been lightly fished (e.g., Cavalli has five recorded trawls (Clark et al. 2000)), and Cavalli seamount was closed to bottom trawling in 2001 (Anon. 2001).

2.2 Survey design

2.2.1 Epibenthic sled sampling

To allow for statistically valid comparisons between the associated fauna, a minimum of five random replicate epibenthic sled samples was desired for each of the two study seamounts. Sample stations were selected at random by a combination of random direction from the seamount peak and random depth down the slope. In addition, further random epibenthic sled samples were undertaken on the 'west' and 'south' peaks of Cavalli (i.e., sub-seamounts).

2.2.2 Photographic image sampling

The aim was to conduct at least four photographic transects arranged in a cross pattern centred on each seamount peak. Transects were to extend from the peak to 1000 m (the operational limit of the camera) down the flanks of the seamounts.

2.3 Field sampling

2.3.1 Epibenthic sled sampling

A small epibenthic sled (overall size 150 cm long, 50 cm high, and 100 cm wide), similar in design to a SEBS sled (Lewis 1999), was used for sampling seamount fauna between 14 and 19 April 2002. Macro-invertebrates were sampled by the sled mouth (100 cm wide by 40 cm high) and were retained in a net of 30 mm stretched mesh size that was covered in an anti-chaffing net of 100 mm stretched mesh size. A depth sensor was attached inside the frame to give both an accurate depth of the tow, and to help determine when the gear was on the bottom. Sleds were towed at each seamount station (Figure 2) up the slope at 1–1.5 knots for a target time of 15 minutes. Sled deployment was maintained as constant as possible between tows to enable robust comparisons of catch per tow. On recovery of each sled, the sample was sorted by hand and all macro-invertebrates recovered were identified (to at least major group), and retained (either fixed in formalin/alcohol or frozen) for subsequent analysis in the laboratory.

2.3.2 Photographic images

A still camera was mounted in a vertical-drop frame. The digital camera was a Minolta Dimage with wide-angle lens and zenon flash fitted 25 cm from and perpendicular to the base of the frame. The camera frame was towed down-slope (previous experience had identified up-slope tows as unsatisfactory) within 2–3 m of the seabed in order to achieve good-quality pictures. Camera frame height above bottom was monitored continuously using a specially adapted Furuno CN-22 net monitor, and supplied the information required to make the necessary adjustments to warp length. Tow speed was about 1 knot across the seabed. The camera was pre-set to take shots at either 1 or 2 minute intervals along the sample transects (Figure 2). The camera had limitations on numbers of images taken and stored, which necessitated its retrieval after 150 shots for the images to be downloaded from the camera's disk on to a computer.

2.4 Laboratory analyses

2.4.1 Epibenthic sled samples

Macro-invertebrates were identified to species or putative species (i.e., apparently morphological distinct organisms, sometimes also called operational taxonomic units) with the aid of microscopy and taxonomic keys, and enumerated when possible. After identification, samples were preserved in isopropyl alcohol/and or formalin and lodged in the biological collection, and records entered on to computer files at NIWA.

2.4.2 Photographic images

The locations of all still-camera stations (position of the camera frame, not the vessel) on the seamounts were calculated from the known depth of the frame at the time of each image capture and from the detailed bathymetric data collected along each transect. The digital image from each camera-frame station was analysed by eye and a standard assessment form detailing station information (station position, direction of transect, seabed depth, camera depth) was completed for image quality and organisms present. Digital images were viewed using Corel Photo-Paint and an initial assessment was made of image clarity, ranking each image as either 'good' or 'bad' (the latter category included those images which were over- or under-exposed). Individual and colonial organisms visible in the images were enumerated (count of individuals or apparent colonies) and assigned to the following taxonomic groupings: Porifera, Scleractinia, Alcyonacea, Antipatharia, Actiniaria, Anthothecata, Decapoda, Gastropoda, Ophiuroidea, Asteroidea, Crinoidea, Echinoidea, Holothuroidea, Polychaeta, and 'indeterminate macro-invertebrates'. All data were transferred to computer spreadsheets for analyses.

2.5 Data analysis

2.5.1 Epibenthic sled samples

Owing to the time required to fully identify the macro-invertebrates, a compositional analysis of the seamount assemblage (for the two seamounts combined) is necessarily restricted to a description based on those fauna identified to the taxonomic level of order. An analysis of variance (ANOVA) test was performed to test for statistically significant differences in the diversity of macro-invertebrate fauna between the (sub)seamounts sampled. The number of species sampled was the response variable, and 'seamount' was the random factor (significance level was set at $\alpha = 0.05$). To achieve a balanced design, data from five stations per (sub)seamount were used for the analysis, that is, the minimum number of successful stations achieved for a (sub)seamount (excluding Cavalli 'south' for which only one sample was recovered). For those (sub)seamount features for which more than five effective samples were taken, stations omitted from analysis were those that reduced the sample size variability for the seamounts to a minimum. Data were tested for departures from homogeneous variance before ANOVA to check that test assumptions were met. All analyses used the statistics software package NCSS.

2.5.2 Photographic image samples

Owing to the qualitative nature of the image record (seabed area of images not currently calculated), comparisons of taxonomic groupings between seamount assemblages were simply made by examining differences in the number of groupings recorded, and by noting representation of groupings on each seamount.

3. RESULTS

3.1 Sampling performance

3.1.1 Epibenthic sled samples

The epibenthic sled appeared to perform well for sampling seamount fauna. To effectively sample each of the two study seamounts, 32 random epibenthic sled deployments were made: Cavalli 'main' (14), Cavalli 'west' (9), Cavalli 'south' (3), and #441 (6). Of these deployments, macro-invertebrates were recovered from 11, 7, and 1 sample(s) on Cavalli 'main', 'west', and 'south', respectively; and all 6 samples taken on seamount #441 (total effective samples = 25). Data from these samples can be used to assess the assemblage diversity of the two seamounts as a whole.

Attempts were made to standardise the time/speed for each epibenthic sled tow, but occasional deviations occurred. The influence this variability might have on sample comparability was evaluated by relating the estimates of area sampled (distance along seabed x width of sled mouth) to the number of species sampled per effective epibenthic sled tow. Figure 3 shows that two samples were recovered from particularly small areas of the seabed and that the few species in these samples is likely to be a consequence of that. If these two small area samples are excluded, there is a lack of significant relationship between number of species sampled and the sample area (mean sample area per tow for these samples = 355 m^2 ± 33 1 SE). Hence variability in area sampled per sled tow will not invalidate comparisons of diversity between (sub)seamounts.

3.1.2 Photographic images

In the time available, it was possible to take 559 photographic images along 4 transects on each sampled feature, from close to the feature peaks to a maximum of 1020 m water depth. Sampling effort was unequal between (sub)seamounts: Cavalli 'main' was sampled with 236 images (total transect length, 26 km; water depth range, 470–1020 m), Cavalli 'west' by 76 images (total transect length, 4.2 km; water depth range, 780–950 m), Cavalli 'south' by 78 images (total transect length, 1.8 km; water depth range, 840–1020 m), and seamount #441 by 169 images (total transect length, 8.1 km; water depth range, 875–950 m). At times it proved difficult to maintain a steady flight of the camera frame at the desired height above the bottom. Overall, the quality of the photographic record varied, with 66% of images categorised as 'good'. Photographs classed as 'bad' were not used for obtaining macro-invertebrate data.

3.2 Biodiversity of seamount macro-invertebrate assemblage

3.2.1 Taxonomic diversity of assemblage

3.2.1.1 Epibenthic sled samples

There were 396 species in the 25 samples of macro-invertebrates from the two study seamounts. Of the total number of species recorded, 250 are currently identified to putative taxon level only, of which at least 67 species (17% of the total species sampled) represent previously undescribed taxa (including 6 probable undescribed genera) (assessment for Bryozoa only). Species were distributed among 13 phyla, with 6 of the phyla (Bryozoa, Cnidaria, Porifera, Echinodermata, Arthropoda, Mollusca) containing over 90% of the total number of taxa found.

The number and distribution of classes, orders, and species within the phyla (i.e., taxonomic diversity), varied considerably (Table 1). The most species-rich group, the Bryozoa (107 species), was represented by two classes, one of which contained 83% of the total number of species recorded for this phylum. This class, Gymnolaemata, contained only one order, as did the other bryozoan class Stenolaemata. In the next most speciose phylum, the Cnidaria (75 species), the distribution of species among taxonomic sub-groupings was different. Three classes represented this phylum (Anthozoa, Hydrozoa, Scyphozoa), and two were relatively order-rich with one containing six orders and the other at least four orders. Two of the anthozoan orders, Scleractinia and Alcyonacea, possessed equal numbers of species (18) that together accounted for nearly half of the taxa in this phylum. A similar number of species was found for the hydrozoan order Anthoathecata. The phyla Porifera and Echinodermata each had 52 species. However, the former phylum was represented by three classes, of which two possessed five orders each. Two orders in each of these particular order-rich classes (Demospongiae, Hexactinellida) dominated in terms of number of species. The 52 species of echinoderms were distributed between five classes, two of which were relatively order-rich (six or more orders). One order, the Ophiurida, which belonged to a class possessing only two representative orders, contained just over half of the species (27) sampled for this phylum. The Crustacea sampled were dominated by decapods (one of the two orders representing the class Malacostraca) that possessed 68% of the 44 species recorded for this phylum. All but one of the remaining crustacean representatives belonged to the order Thoracica. The other phylum well represented by sampling the study seamounts, the Mollusca, contained 39 species in four classes. Species were relatively evenly distributed among the orders possessed by these mollusc classes, apart from the orders Neogastropoda and Vetigastropoda, which contained eight and seven species (respectively).

Figure 4 illustrates the distribution of the seamount species within the most order-diverse or dominant classes of the major phyla.

3.2.1.2 Photographic images

From the 371 images that were of sufficient quality to observe the seabed, it was possible to identify and classify the macro-invertebrates into the chosen groupings for 176 photographic records (Table 2). Individuals belonging to the Porifera were the most frequently observed faunal organisms (occurring on 113 images) (Figure 5). Cnidarians were the next most frequently identifiable organisms, occurring in 109 images, of which the hydrozoan order Anthoathecata constituted 35% of the observations for this phylum. Records of cnidarians belonging to the class Anthozoa most often belonged to the orders Scleractinia (23%) and Actiniaria (19%) (Figures 6 & 7). Echinoderms occurred in 99 images, with the classes Ophiuroidea and Echinoidea (Figures 8) constituting the most numerous of all observations (43%, 35% of Echinodermata or 24%, 20% of total, respectively). Members of the Gastropoda, Polychaeta, and Decapoda were not so frequently observed on the seabed, occurring in only 13, 6, and 3 (respectively) of the images taken on the study seamounts.

3.2.2 Comparison of biodiversity between seamounts

3.2.2.1 Epibenthic sled samples

The mean diversity (expressed as number of species) for the two seamounts sampled on the Northland Plateau was 47.9 (± 7.02 1 SE). Mean diversity per (sub)seamount was 37.8 (± 9.45 1 SE) for Cavalli 'main', 58.2 (± 25.12 1 SE) for Cavalli 'west' and 47.2 (± 20.39 1 SE) for #441 (Figure 9). One-way ANOVA revealed that there was no significant difference in the number of species sampled between the (sub)seamounts studied (mean square =520.47, F-ratio = 0.27, $P > 0.10$).

3.2.2.2 Photographic images

The number of images in which macro-invertebrates could be identified differed between the (sub)seamounts, that is, sample size was 135, 54, 70, and 112 for Cavalli 'main', 'west', 'south', and #441, respectively. The number of taxon groupings observable in images was similar for those (sub)seamounts most intensively sampled, and predictably less for the one that received the least sampling effort. Of the 14 faunal classifications (excluding indeterminable macro-invertebrates) used for the analysis, 13 were noted for Cavalli 'main', 11 for Cavalli 'south', 11 for #441, and 6 for Cavalli 'west'. Macro-invertebrates were visible on a similar number of images for Cavalli 'main' and #441 seamounts (64 and 67, respectively), which allows for a reasonable comparison of the taxonomic compositions of the observable fauna. Two taxa were observed in relatively few of these images on Cavalli 'main' (percentage occurrence) and none on #441: Decapoda (3%) and Crinoidea (3%). One taxon, the Antipatharia, did not occur at all on Cavalli 'main' while occurring relatively frequently in images (13%) from #441. A larger unique percentage occurrence was demonstrated by the Scleractinia (39%) in photographic records from Cavalli 'main'. Certain taxa were 2–3 times more frequently observed on #441 than on Cavalli 'main'. These taxa were the Ophiuroidea (8 versus 19%), Anthoathecata (11 versus 31%) and Porifera (34 versus 85%). One taxon, the Echinoidea, which was observed in 44% of images on Cavalli 'main', was observed in only 8% of the same type of images from #441. Other taxonomic groupings were relatively equally represented on both seamounts. These taxa were: Polychaeta (3%), Holothuroidea (3%), Asteroidea (5%), Gastropoda (6–9%), Alyconacea (6–10%), and Actinaria (12–14%).

4. DISCUSSION

Three hundred and ninety six species of macro-invertebrate were recorded from the two seamounts in this study. At least 17% of the species (Bryozoa alone) recovered by the survey are considered to be undescribed for the New Zealand region. This estimate includes six genera new to science. However, because over half of all the taxa recorded have so far been identified to putative species only, the proportion of undescribed species/genera is probably much greater. Species were distributed among 13 phyla, with 6 of the phyla containing over 90% of the taxa found. Taxonomic diversity varied within these major phyla. No differences between seamounts (and sub-seamount feature) were evident in the mean number (per sled sample) of species recorded for each feature. However, images from the camera survey did reveal differences in the taxonomic composition of the fauna between the seamounts (and sub-seamount features)

Rogers (1994) in his review of global seamount studies found that only 597 invertebrate species had been recorded since direct sampling began at the end of the nineteenth century. The review also noted that there had been relatively little sampling effort on seamounts and that seamount-targeted studies were very few. However, a recent study in the southwest Pacific Ocean is broadly similar in scope and methodology to the one reported here. Sampling of seamounts in the Tasman Sea and southeast Coral Sea recorded more than 850 macrofaunal species, of which 16–36% were deemed both new to science and potentially endemic to seamounts (Richer de Forges et al. 2000). A number of geographic seamount groupings were sampled; sampling of seamounts on the Norfolk Ridge recorded 516 macrofaunal species, 4 seamounts on Lord Howe Rise produced 108 species records, and 297 species were found on 14 seamounts southeast of Tasmania. Different sampling effort was probably, in part, responsible for differences in species numbers observed between these seamount groupings, and it is most likely that the number of species present on these seamounts is far greater than the number recorded (Richer de Forges et al. 2000).

The present evaluation of macro-invertebrate biodiversity for two seamounts on the Northland Plateau appears to be broadly comparable with the study of Richer de Forges et al. (2000). However, the meaningfulness of making any direct comparisons is questionable, for diversity estimates for the Tasman/Coral Sea area were for two macrofaunal components (*both* invertebrates and fish) and these surveys used slightly different sampling gears and strategies than the present study. Nonetheless it is worth noting that the species number recorded appears to be relatively high for the present study considering the relatively small sampling effort and extent. That is, more species were recorded from 25 samples taken on the two present study seamounts than on the 4 Lord Howe Rise and 14 Tasmania seamounts that received a greater sampling effort (35 and 34 samples respectively). Whilst seamounts of the Norfolk Ridge were found to have just over 100 more species recorded than seamounts in the present study, this record is from six features that received over ten times as much sampling effort as afforded Cavalli and #441. That Cavalli and #441 support such relatively high numbers of macro-invertebrate species is contrary to *a priori* expectation, for according to species-area theory (*sensu* Gleason 1922) and the related island-biogeography theory (*sensu* MacArthur & Wilson 1963) (accepting that seamounts can be considered marine islands, *sensu* Hubbs 1959), a comparable survey undertaken for the least number of seamounts using the smallest number of samples would be expected to result in the lowest estimate of species number.

The only two specifically seamount-targeted studies available for making more direct, and possibly more meaningful, comparisons are recent surveys of the macro-invertebrate biodiversity of eight seamounts on the Chatham Rise (east of New Zealand) (Rowden et al. 2002) and three seamounts on the southern Kermadec volcanic arc (northeast of New Zealand) (Rowden et al. 2003). Both these, and the present study, used the same gear type, samples were of similar unit area, and the same sampling strategy was used. A comparative compositional analysis of the faunas of these studies and the present investigation has yet to be undertaken, but a comparison of the biodiversity descriptions is revealing in itself. A total of 414 macro-invertebrate species, distributed among 14 phyla (with 6 phyla containing over 90% of the total number of taxa), were recorded from 42 epibenthic sled stations on eight seamounts for the former survey (Rowden et al. 2002), whilst a total of 308 species (10 phyla, 5 phyla containing over 90% of the total number of taxa) were recorded from 52 samples on three seamounts for the latter survey (Rowden et al. 2003). Thus, the macro-invertebrate assemblage (in total) of Cavalli and #441 is similarly speciose and as taxonomically diverse as the assemblage of the seamounts of the Chatham Rise, whilst both are more diverse than the assemblage of the seamounts of the southern Kermadec volcanic arc. Again it should be noted that, because of the greater sampling effort/extent of the two earlier surveys, the diversity of the two seamounts on the Northland Plateau appears to be relatively high.

The proportion of undescribed species, and therefore an estimate of the species possibly endemic to study seamounts, was at least 5% and 15% for the southern Kermadec volcanic arc and Chatham Rise seamounts respectively. Estimates of seamount faunal endemism for the present study (17%) are thus similar to those made from the Chatham Rise survey and to those made for seamounts of the Tasman and Coral Sea (Richer de Forges et al. 2000). However, caution should be attached to any such comparison; any interpretation of the uniqueness of the seamount assemblages on the Northland Plateau requires a study that compares species composition of seamounts and similar substrata of low-relief slope throughout the New Zealand region.

No significant difference in diversity (mean number of species per sample) was detectable between Cavalli 'main', Cavalli 'west', and seamount #441. There was also no difference in species number between the eight study seamounts of the Chatham Rise survey (Rowden et al. 2002), which had a very similar range of mean number of species per sample per seamount (38–61) as that found for the present study (39–58). In contrast, the three study seamounts of the southern Kermadec volcanic arc had a lower mean range of number of species per sample per seamount (13–31), despite the positive influence that the more intensive sampling regime for these seamounts might have conveyed upon the number of species sampled (Rowden et al. 2003). It is likely that, in part, the reason for the lower number of species found on the Kermadec seamounts relates to the relatively young age and active substrate of these volcanic features.

In addition to diversity being evaluated by direct sampling using the epibenthic sled, a camera frame was also used to assess diversity of taxonomic groupings observable on recovered images. Analysis of camera images confirmed the dominance of certain taxa as revealed by direct sampling, but also indicated some additional useful methodological and biodiversity information. For example, the diversity of relatively large-bodied or colonial forms, such as members of the orders in the phyla Cnidaria and Echinodermata, compared reasonably well with that assessed by epibenthic sled samples. The proportion of the Porifera in direct samples was also apparent in the recovered images. Mobile and smaller-bodied organisms are not so readily observable on photographs of the seafloor, and indeed the apparently diverse (as revealed by the sled samples) mollusc taxa and decapod crustaceans were poorly sampled by the camera. The most striking limitation of the camera to assess the biodiversity of the study seamounts was its inability to effectively quantify the dominance and diversity of the Bryozoa, partly because of their smaller size, and partly because of a preference for living on the underside of rocks. However, analysis of the camera images did prove useful for revealing compositional differences in the macro-invertebrate assemblages on each of the seamounts. Of particular note were differences in the occurrence frequency of the Ophiuroidea, Anthoathecata, and Porifera (more frequently observed on #441) and the Echinoidea (more often imaged on Cavalli 'main'); and the seemingly unique presence of members of the Antipatharia on #441 and the Scleractinia on Cavalli 'main'. The existence of such compositional differences requires confirmatory data that will result from future planned analyses of sled-derived data. Only then should the question as to why such differences have been observed be addressed.

Despite concerns about the destructive nature of sampling using an epibenthic sled (particularly on protected seamounts), and the related attractiveness of using only camera/video-derived samples to study the biodiversity of seamounts, it should be remembered that the footprint of the direct sampling device used is relatively small (seamount:sample area km^2; Cavalli – 600:0.013, #441 – 200:0.002). In addition, it is currently not possible to identify even the major components of a macro-invertebrate assemblage from a photograph (in this instance, the cryptic Bryozoa). When an assemblage is largely or partly undescribed, as for New Zealand seamounts, recovery of specimens by direct sampling is imperative for a full assessment of biodiversity. The usefulness of combining sled and photographic sampling methods has already been demonstrated by seamount studies elsewhere (e.g., Raymore 1982, Kaufmann et al. 1989), yet this approach has only very recently been more frequently applied to studies of New Zealand's benthos.

In summary, the present study of the seamounts on the Northland Plateau has revealed a diverse assemblage of macro-invertebrates, composed of a number of relatively taxonomically diverse phyla. The extent of endemism for the seamount assemblage studied is (after identifications are complete) likely to be even higher than already indicated and, like the high diversity, broadly comparable to that found in a previous study of seamounts in the southwestern Pacific Ocean. However, we emphasise that, considering the relatively low sampling effort on the seamounts and similar-substrate/low-relief habitats in the region, further sampling would be required to substantiate indications of high diversity and endemism for these and other seamounts.

Seamount assemblages are considered fragile and vulnerable to disturbance from fishing (Probert 1999, Koslow et al. 2001, Clark & O'Driscoll in press), and to assess and manage the interactions of fishing with these communities we need to improve our understanding of the biodiversity of New Zealand's seamounts. Such studies should use a combination of sampling methods, including photographic techniques as well as direct sampling using epibenthic sleds. In particular, further sampling of features in the vicinity of the present study seamounts and those that extend eastwards to the seamounts of the Kermadec volcanic arc, and northwards in association with the Three Kings Ridge, are recommended to improve our understanding of regional patterns of seamount biodiversity.

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Table 1: Taxonomic composition of the macro-invertebrate assemblage from two seamounts on the Northland Plateau (total of 25 epibenthic sled samples).

Phylum	Class	Order	Number of species
Sarcomastigophora	–	–	1
Porifera	Demospongiae	Poecilosclerida	15
		Astrophorida	11
		Hadromerida	4
		Halichondrida	3
		Haplosclerida	1
	Hexactinellida	Hexactinosida	8
		Lyssacinosida	6
		Amphidiscosida	1
		Aulocalycoida	1
		Murrayonida	1
	Calcarea	Leucosolenida	1
Cnidaria	Anthozoa	Scleractinia	18
		Alcyonacea	18
		Antipatharia	9
		Actiniaria	6
		Zoanthiniaria	2
		Pennatulacea	1
	Hydrozoa	Leptoathecata	17
		-	2
		Anthothecata	1
	Scyphozoa	Coronatae	1
Annelida	Polychaeta	Phyllodocida	5
		Terebellida	4
		Sabellida	3
		Eunicida	2
		Spionida	1
		Scolecida	1
		Amphinomida	1
Sipuncula	–	–	1
Crustacea	Cirripedia	Thoracica	13
	Malacostraca	Decapoda	30
		Isopoda	1
Pycnogonida	–	–	1
Mollusca	Aplacophora	–	1
	Polyplacophora	Ischnochitonina	3
		Lepidopleurina	2
	Gastropoda	Neogastropoda	8
		Vetigastropoda	7
		Neotaenioglossa	4
		Littorinimorpha	3
		Ptenoglossa	2
		–	1
	Bivalvia	Pterioida	5
		Arcoida	3

Table 1: *(continued)*

Echinodermata	Ophiuroidea	Ophiurida	27
		Euryalinida	4
	Echinoidea	Cidaroida	5
		Echinoida	1
		Clypeasteroida	1
		Diadematoida	1
		Salenoida	1
		Pedinoida	1
	Asteroidea	–	1
		Forcipulatida	2
		Velatida	1
		Spinulosida	1
		Paxillosida	1
		Notomyotida	1
	Crinoidea	Comatulida	2
	Holothuroidea	–	2
Bryozoa	Gymnolaemata	Cheilostomata	89
	Stenolaemata	Cyclostomata	18
Brachiopoda	–	–	4
Nemertea	–	–	1
Hemichordata	Pterobranchia	Rhabdopleurida	1
Chordata	Ascidiacea	–	1

Table 2: *Allocation of taxonomic* groupings for photographic images recovered from two study seamounts on the Northland Plateau.

Phylum	Class	Order	Number of images
Porifera	–	–	113
Cnidaria	Anthozoa	Scleractinia	25
		Actiniaria	21
		Alcyonacea	15
		Antipatharia	10
	Hydrozoa	Anthoathecata	38
Crustacea	Malacostraca	Decapoda	3
Mollusca	Gastropoda	–	13
Annelida	Polychaeta	–	6
Echinodermata	Ophiuroidea	–	43
	Echinoidea	–	35
	Asteroidea	–	11
	Holothuroidea	–	8
	Crinoidea	–	2
'indet. macro-invertebrates'	–	–	8

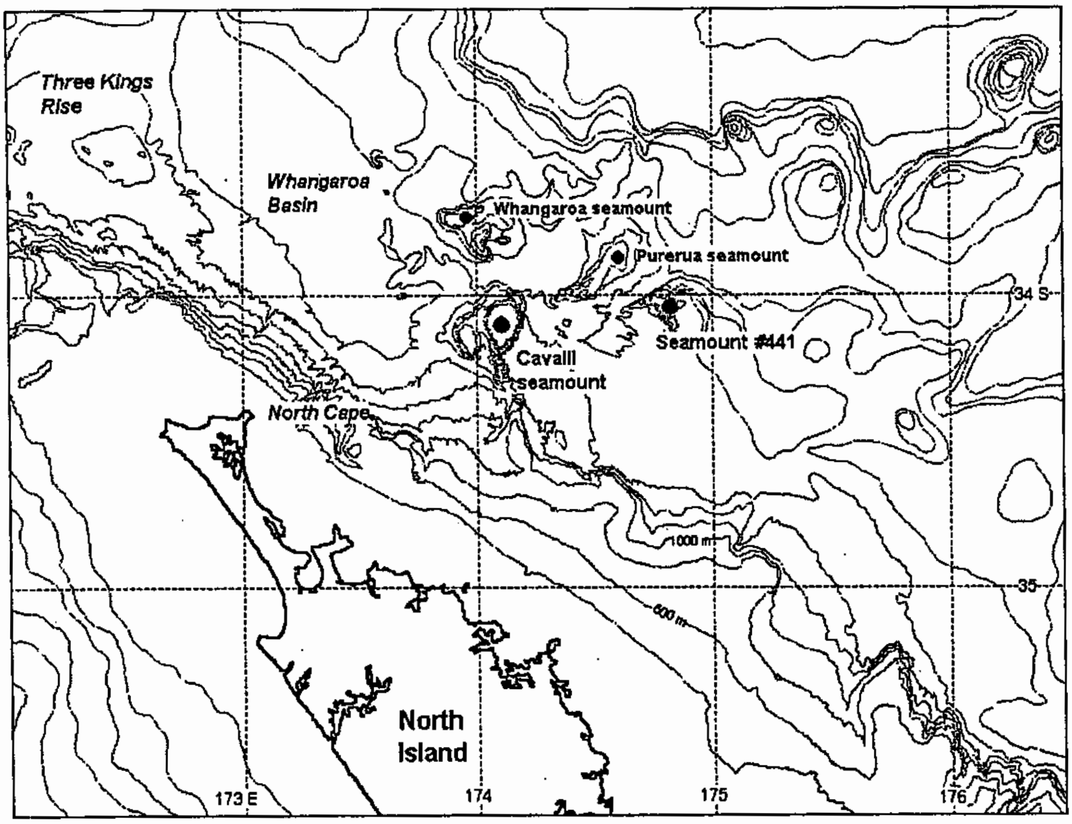

Figure 1: Location of the two study seamounts and adjacent features on the Northland Plateau, off the North Island, New Zealand.

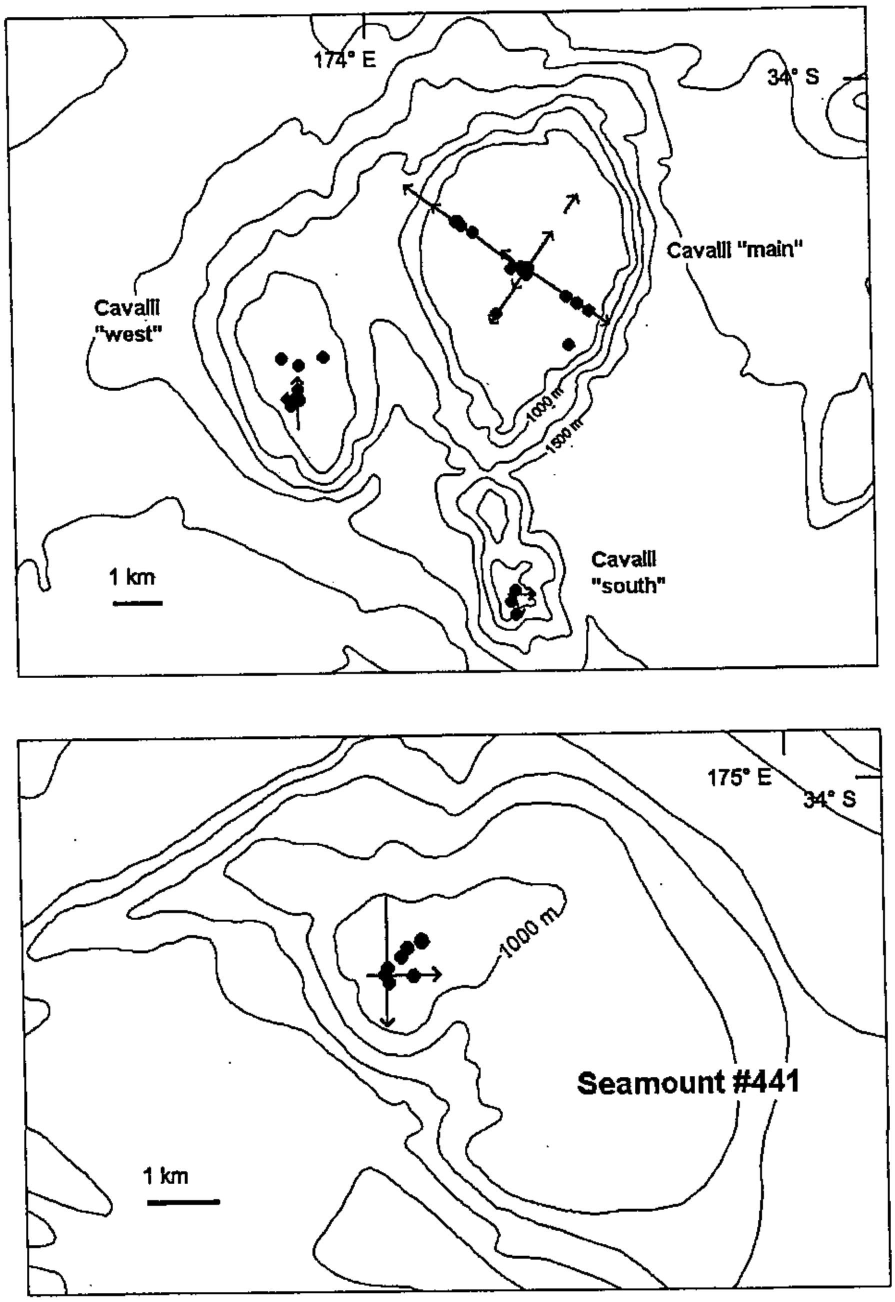

Figure 2: Distribution of epibenthic sled sample stations (crosses) and camera frame transects (lines) on Cavalli 'main', 'west', and 'south' and #441 seamounts (note drawings are not to the same scale).

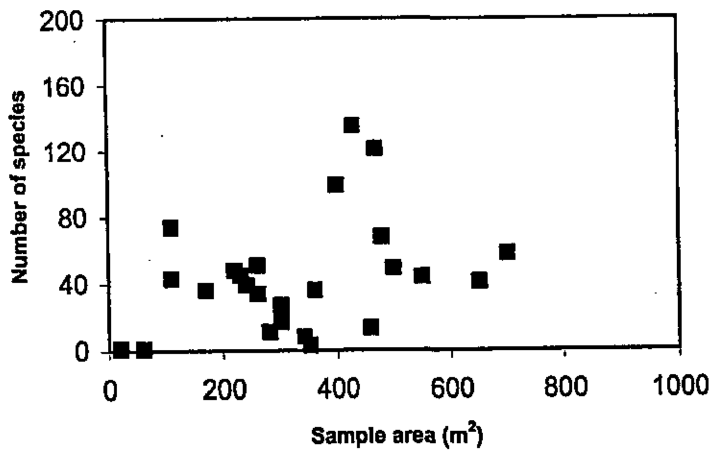

Figure 3: The relationship between the number of macro-invertebrate seamount species and the sample area of the epibenthic sled stations from the study seamounts on the Northland Plateau.

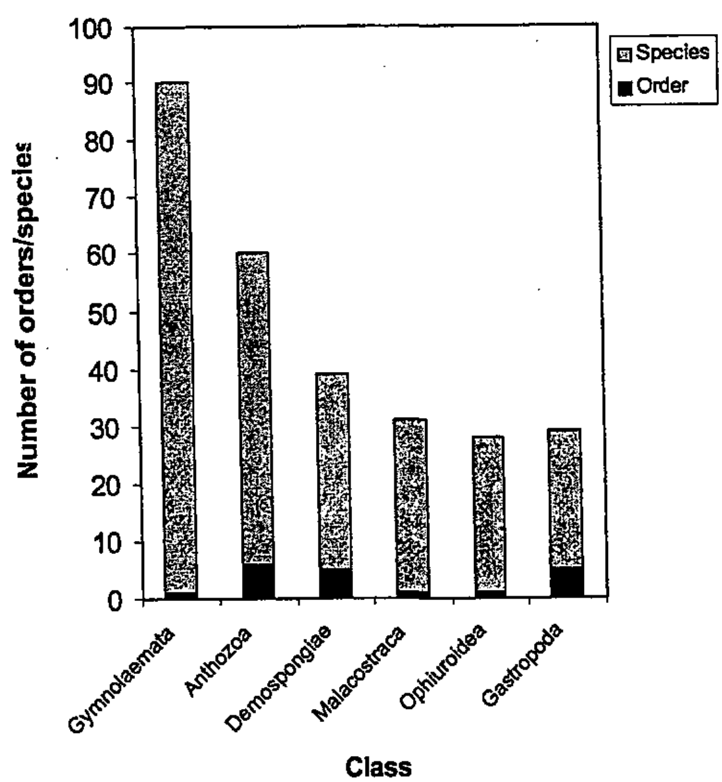

Figure 4: Taxonomic composition of the most order-diverse or dominant classes of the seamount macro-invertebrate assemblage sampled in the study seamounts on the Northland Plateau.

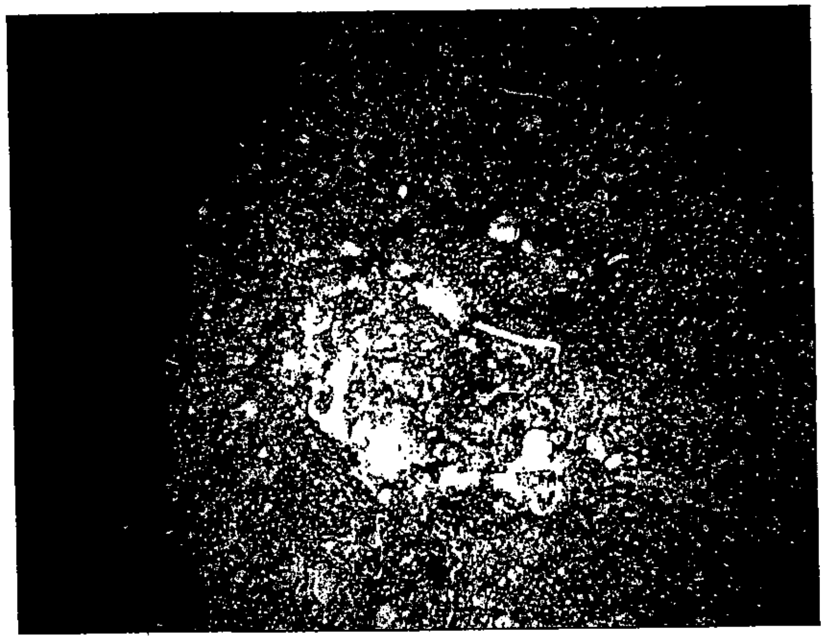

Figure 5: Photograph of seabed (Station 49-9965) showing individual colonies of the phylum Porifera.

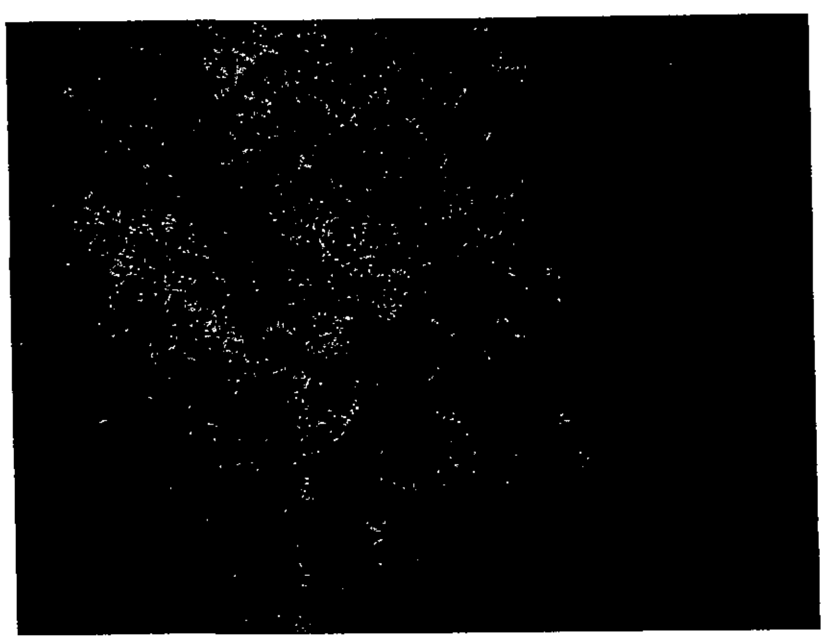

Figure 6: Photograph of the seabed (Station 10-9040) showing individuals of the order Scleractinia.

Figure 7: Photograph of the seabed (Station 25-9351) showing an individual of the order Actinaria

Figure 8: Photograph of the seabed (Station 26-9375) showing individuals of the class Echinoidea.

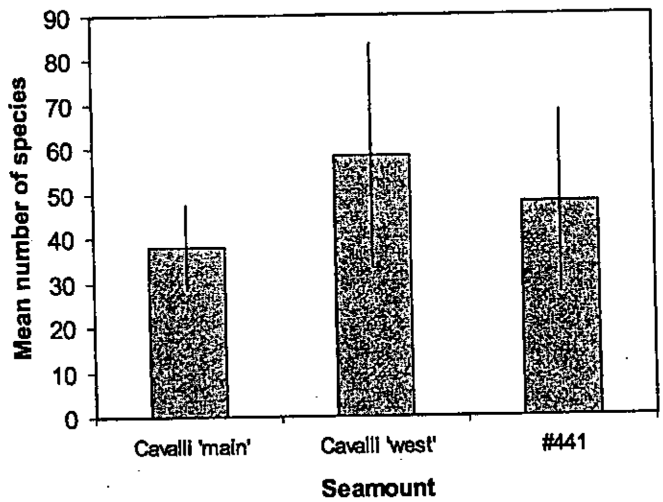

Figure 9: Mean number of macro-invertebrate species for (sub)seamounts sampled on the Northland Plateau (error bars = 1 SE).