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# Deepwater biodiversity of the Kermadec Islands Coastal Marine Area

Jennifer Beaumont, Ashley A. Rowden and Malcolm R. Clark

Cover: Dive PV616: an extensive, dense bed of the bivalve *Gigantidus gladius* with associated predatory *Sclerasterias* asteroids at a diffuse hydrothermal vent site.

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# CONTENTS

Abstract	1
<hr/>	
1. Introduction	2
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1.1 Background	2
1.2 Previous seamount and vent studies in the region	3
1.3 Project objective	4
2. Methods	4
<hr/>	
2.1 Study area and sites	4
2.2 Data sources and selection	4
2.3 Description of selected data	5
2.3.1 MFish scientific onboard observer programme	5
2.3.2 TAN0205 direct samples and still images	6
2.3.3 KOK0505 and KOK0506 video and still images	9
2.4 Data analysis	12
2.4.1 Scientific observer data	12
2.4.2 Direct samples	12
2.4.3 Still images	12
2.4.4 Video	13
3. Results	14
<hr/>	
3.1 Scientific observer data	14
3.1.1 Species composition	14
3.1.2 Species distributions	15
3.2 TAN0205 direct samples	16
3.3 TAN0205 still images	16
3.3.1 Hard substrate	17
3.3.2 Coarse substrate	18
3.3.3 Soft substrate	19
3.4 KOK0505 and KOK0506 still images	19
3.4.1 Hard substrate	19
3.4.2 Coarse substrate	20
3.4.3 Soft substrates	20
3.5 KOK0505 and KOK0506 video footage	21
3.5.1 Macauley: Dive PV616	22
3.5.2 Macauley: Dive PV617	23
3.5.3 Macauley: RCV-150, ROV dive 312	24
3.5.4 Giggenbach: Dive PV618	24
3.5.5 Giggenbach: Dive PV619	24
3.5.6 Giggenbach: Dive PV 620	25
3.5.7 Wright: Dive PV621	25
3.5.8 Comparison of assemblage composition among seamounts	26

4.	Discussion	27
4.1	Limitations of the data	27
4.2	Assemblage composition and distribution patterns	27
4.3	Significance of the study area	28
4.3.1	Uniqueness and rarity	29
4.3.2	Special importance for life-history stages of species	29
4.3.3	Importance for threatened, endangered or declining species and/or habitats	29
4.3.4	Vulnerability, fragility, sensitivity or slow recovery	29
4.3.5	Biological productivity	30
4.3.6	Biological diversity	30
4.3.7	Naturalness	30
4.4	Threats	31
5.	Recommendations	32
6.	Acknowledgements	32
7.	References	33
Appendix 1		36
	Taxa list, for each seamount, for TAN0205 direct samples	36
Appendix 2		48
	Taxa list for TAN0205 still images	48
Appendix 3		49
	Pisces V and ROV dives	49
Appendix 4		56
	Taxa list for all Pisces V and ROV dives	56

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## Abstract

The Kermadec region to the north of New Zealand, including the Kermadec Islands, has been noted as a 'key biodiversity area' for a variety of marine fauna. However, there has been limited scientific research at water depths below 100 m. The New Zealand Department of Conservation is undertaking a project to define the natural character of the region's Coastal Marine Area (CMA), which includes the foreshore, seabed and coastal habitats. In addition, the project aims to identify natural assemblages that could be vulnerable to human disturbance. A variety of datasets held by the National Institute for Water and Atmosphere (NIWA) on the deepwater benthic biodiversity in the CMA and the surrounding area were analysed to contribute to our understanding of the character of the marine biological environment. Data from the scientific observer programme on fishing vessels, direct sampling, and seabed imagery from several seamounts and hydrothermal vents in the northern Kermadec area were analysed. Quantitative analysis revealed little or no difference in faunal assemblage composition among seamounts for direct sample and still image data. However, video data indicated that assemblage composition was largely different between Macauley, Giggenbach and Wright seamounts. This pattern is partly explained by the differences in water depth among these seamounts. A provisional assessment of the biological or ecological significance of the study area indicates that the Kermadec region satisfies a number of the criteria of the Convention on Biological Diversity for identifying such areas. Potential threats to seabed marine life in the area include disturbance from fishing, mining and pollution, and advection of invasive species by shipping. Small-scale, localised impacts may result from some kinds of scientific sampling.

Keywords: Kermadec Islands, seamounts, hydrothermal vents, biodiversity, fish, invertebrates

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# 1. Introduction

## 1.1 Background

The Kermadec Ridge is a prominent feature of New Zealand's underwater topography, extending from the outer Bay of Plenty northwards to Tonga (Fig. 1). It lies on the junction between the Pacific and Indo-Australian tectonic plates, where active subduction results in numerous submarine volcanoes that occur along an arc west of the ridge (e.g. de Ronde et al. 2001; Wright et al. 2006). The region is also interesting from an oceanographic perspective (as described in Sutton et al. 2012). For example, the Kermadec Ridge forms the western boundary of the deep South Pacific Ocean region and the resultant deep current that occurs below 2000 m is the South Pacific component of the global thermohaline circulation—an important part of the global climate system (Sutton et al. 2012).

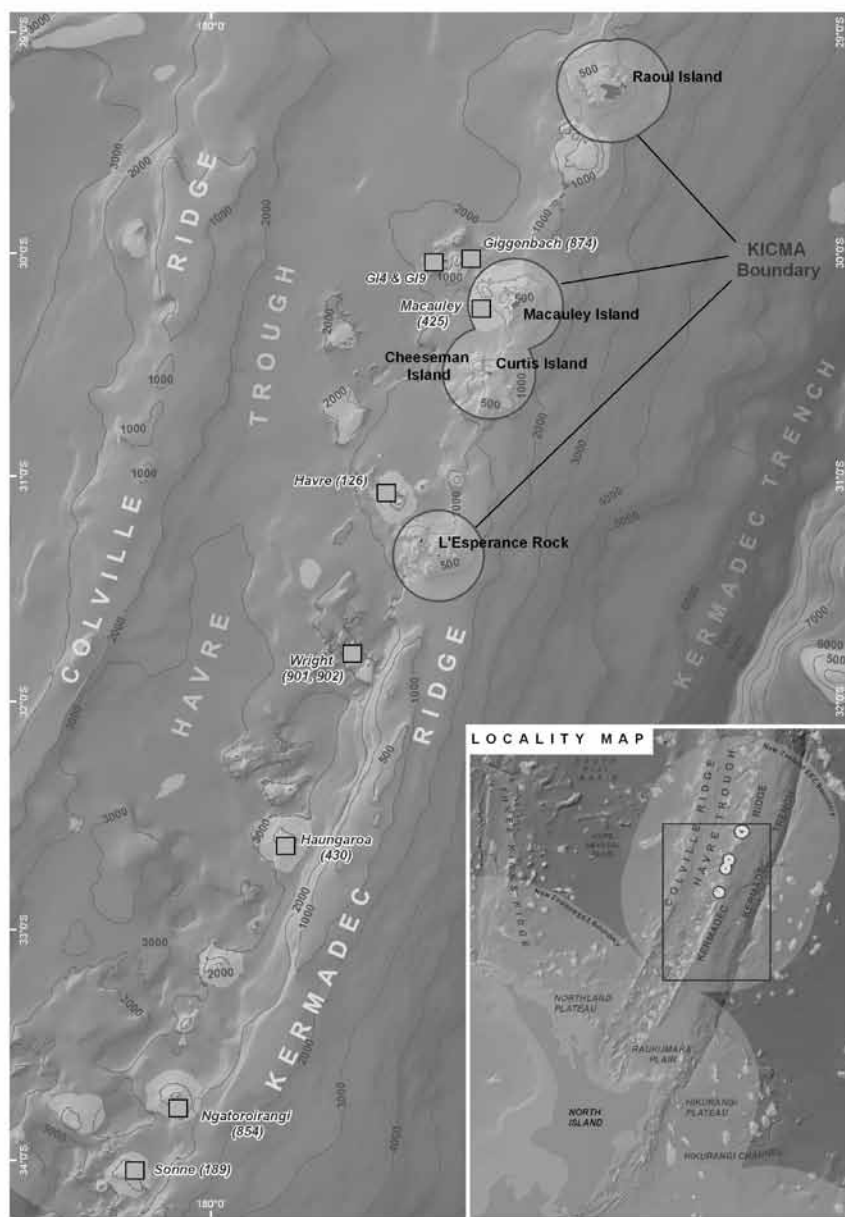


Figure 1. Bathymetric map of the northern Kermadec Ridge area showing the Kermadec Islands Coastal Marine Area (KICMA; black boundaries). The seamount sites included in this study are marked with squares and labelled with a name and seamount register ID number.

Knowledge of the nearshore shallow marine fauna of the Kermadec Islands, which emerge from the ridge, is reasonably good (e.g. Schiel et al. 1986; Cole et al. 1992; Brook 1998, 1999). The ecological significance of the islands and their surrounding waters was recognised in 1990 with the establishment of the Kermadec Islands Marine Reserve. The Kermadec region has been noted as a 'key biodiversity area' for a variety of marine fauna (Arnold 2004), and in 2007, the New Zealand government included the Kermadecs on its list of potential World Heritage Areas, which is a precursor for approval of that status by the UNESCO World Heritage Committee.

The Minister of Conservation is developing a Regional Coastal Plan for the Coastal Marine Area (CMA<sup>1</sup>) of the Kermadec Islands. In support of this, the Department of Conservation (DOC) is undertaking a project to define the natural character of the CMA, and identify natural assemblages that could be vulnerable to human disturbance. This project includes summarising aspects of bathymetry, geology, water column processes, the marine biological environment, terrestrial-marine linkages, protected species information, and an evaluation of human activities.

The Kermadec Islands CMA includes a large area offshore from the islands themselves that extends to depths of about 2500 m. However, there has been limited scientific research at depths below 100 m in the area, even though, in some places, such depths are close to the islands because of the steepness of the islands' structures. Recent scientific surveys in the deeper water around the islands, and further south on the Kermadec Ridge, have tended to concentrate on geological aspects, but biological samples have also been taken. In particular, biological sampling has focused on documenting the biodiversity of seamounts and associated hydrothermal vents.

## 1.2 Previous seamount and vent studies in the region

Kamenev et al. (1993) reported on Russian studies of a small number of vent sites in relatively shallow waters at the southernmost end of the Kermadec Volcanic Arc, noting that only a few vent-specific species were found at these locations. In 1998, a joint German and New Zealand expedition revisited the vicinity of the previously explored sites and also located sites of active venting on Brothers Volcano (Stoffers & Wright 1999). The biological information gained from this expedition is, in the main, yet to be formally analysed or reported upon (but some information is given in Wright et al. 2002).

The National Institute for Water and Atmosphere (NIWA), funded by the former Foundation for Research, Science and Technology and the former Ministry of Fisheries (MFish)<sup>2</sup>, sampled Brothers, Rumble III and Rumble V seamounts in 2001, and Whakatane, Otara, Nukuhou, Tuatoru, Rungapapa, Mahina and Tumokemoke seamounts in 2004. Clark & O'Shea (2001) and Rowden et al. (2003) presented preliminary results of the 2001 survey, recording over 300 macroinvertebrate species, of which at least 5% were undescribed for the New Zealand region. They found differences within and between seamounts; for example, Rumble V had two and three times more species than Rumble III and Brothers, respectively. Genetic studies of the vent mussel species revealed significant differences between the populations found at different seamounts (Smith et al. 2004). Rowden & Clark (2010) have presented preliminary results from the 2004 survey, recording over 500 macroinvertebrate species, of which 17% and 20% of bryozoan and sponge species, respectively, are undescribed for the New Zealand region. Differences were evident in the estimated number of species recorded for each seamount—Mahina and Nukuhou had the highest estimated number of species, Tumokemoke the least.

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<sup>1</sup> The CMA includes the foreshore, seabed and coastal water of which the seaward boundary is the outer limits of the territorial sea (a distance of 12 nautical miles from the land) and the landward boundary is the line of mean high water springs (refer to Fig. 1).

<sup>2</sup> The Foundation for Research, Science and Technology is now part of the Ministry of Business, Innovation & Employment (MBIE) and the Ministry of Fisheries is part of the Ministry for Primary Industries (MPI).

Two other international expeditions (the Japanese-New Zealand SWEEPVENTS Cruise in 2004 and the New Zealand-American Submarine Ring of Fire Expedition in 2005) have also sampled seamounts on the Kermadec Arc. Preliminary reports suggest that vent communities differed between seamounts, and the communities had both similarities and differences to other western Pacific vent communities (Rowden & Clark 2005).

Biological studies on Brothers and Rumble II seamounts have also been conducted as part of an exploratory minerals programme by Neptune Minerals Ltd. Community composition varied between sites and level of venting activity (Clark & Stewart 2005). Survey work with a remote-operated vehicle on Rumble II in 2007 was based on inactive sites and corals dominated the fauna on the chimney structures (Clark 2007). More recent research has been carried out between 2010 and 2012 in programmes including the Kermadec ARc MinerAls (KARMA) Programme, Oceans 20/20, Vulnerable Deep Sea Communities and with Neptune Minerals Ltd.

### 1.3 Project objective

Although there have not been many biological surveys in the Kermadec Islands CMA, NIWA collections and databases hold samples, photographic imagery and data from the above and other surveys that have not been fully processed and analysed. This material and these data provide valuable information for DOC's aim to define the natural character of the deepwater biodiversity of the CMA. Thus, the objective of the present study was to examine and analyse these data in order 'to describe the deep-water (>100 m) benthic invertebrate and fish assemblages of the Kermadec Islands Coastal Marine Area'. In addition, NIWA was asked subsequently by DOC to evaluate whether the CMA was a 'significant area' for deep-water fauna, to assess the threats posed by human activities and to make recommendations for future research in the area.

## 2. Methods

### 2.1 Study area and sites

The Kermadec Islands CMA is a relatively small area, encompassing just one seamount for which data were available (Fig. 1). In order to provide a more comprehensive summary of the biological assemblages at depths greater than 100 m in the Kermadec region, the study area for the project was extended to include seamounts associated with the northern Kermadec Ridge area. This extended range encompassed nine different seamounts for which data were available: Sonne, Ngatoroirangi, Haungaroa, Wright, Havre, Macauley, GI4, GI9 and Giggenbach (Fig. 1).

### 2.2 Data sources and selection

Six data sources were identified for the Kermadec Islands CMA and wider northern Kermadec Ridge area (Table 1). The type and quality of data available varied considerably. Some datasets were suitable for quantitative analysis (data from TAN0205 and KOK scientific cruises), some for qualitative analysis (data from the scientific observer programme) and some were deemed to be unsuitable for analysis as part of this study (e.g. historical records, which included samples taken by the HMS *Challenger* and various New Zealand Oceanographic Institute surveys).



Table 1. Data sources used within this study.

DATA SOURCE	TYPE OF DATA AND METHOD OF COLLECTION	QUANTITY AVAILABLE FOR ANALYSIS
Scientific observer programme	Fish: drop-, long-, hand-line	37 taxa from 284 line sets (4 areas)
Historical NZOI & miscellaneous data*	Macroinvertebrates: various direct gears	301 taxa from 119 stations
TAN0205 scientific cruise	Macroinvertebrates: sled and/or dredge	420 taxa from 41 stations (6 sites)
	Macrofauna: still images from tow camera	57 taxa from 14 stations (8 sites)
KOK0505&0506 scientific cruises	Macrofauna: direct collection by submersible	32 taxa from 21 stations (3 sites)
	Macrofauna: video and still images from submersible and Remote Operated Vehicle (ROV)	113 taxa from 7 dives (3 sites)

\* Data were unsuitable for analysis.

## 2.3 Description of selected data

### 2.3.1 MFish scientific onboard observer programme

Various research and commercial fishery databases were searched, and all records extracted for the area of interest. No trawl data were found, and the only dataset used was the MFish observer records from the *obs\_lfs* database held at NIWA, Wellington. These records were obtained by scientific observers placed onboard fishing vessels to monitor their fishing activities and any seabird or marine mammal bycatch. A total of 284 catch records were extracted, comprising

280 from drop- or dahn-lines, 3 from bottom long-lines and 1 from a handline. All data were combined, although it should be noted that the overall species composition reflected mainly the selectivity of drop-lines relative to the other methods where sample sizes were very small.

The distribution of sampling records is shown in Fig. 2. There are four 'clusters' of data: one each north and south of Raoul Island, and then two further south, one near Macaulay Island, and one south of Curtis Island. The sets were targeted mainly at bass groper, bluenose and kingfish.

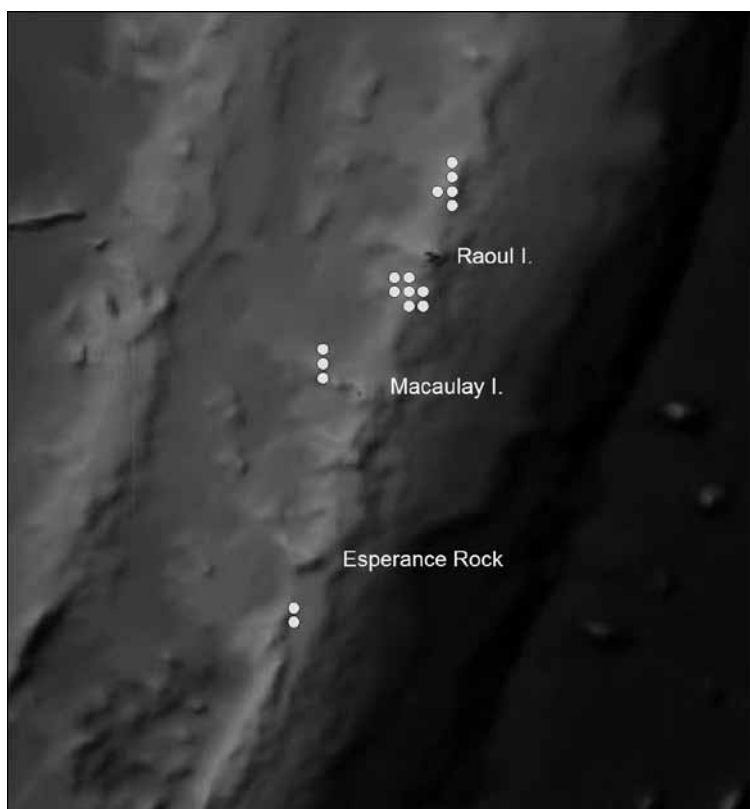


Figure 2. Location of sampling stations for MFish scientific observer data in the study area.

### 2.3.2 TAN0205 direct samples and still images

The TAN0205 scientific cruise was undertaken on the RV *Tangaroa*. Samples of macroinvertebrate fauna were recovered, using a sled and/or dredge, from 41 stations on six seamounts (Giggenbach, Macauley, Havre, Haungaroa, Ngatoroirangi, Sonne) in the study area.

A total of 300 images was captured from 14 stations on eight seamounts in the study area (in addition to the above-listed seamounts, G14 and G19 were visited). A Teledyne Benthos camera system was mounted in a rigid frame and took seafloor photographs when lowered to within 2 m of the bottom. However, many of these photos were very dark and, because they were mostly in black and white, faunal identification was difficult. As a result, only 115 of these images were suitable for analysis, as summarised in Table 2.

The locations of TAN0205 stations are plotted in Figs 3–9 and depths are given in Table 3.

Table 2. Summary of the 115 still images from the TAN0205 scientific cruise available for analysis.

SEAMOUNT	NO. OF TOWS	NO. OF IMAGES/TOW	TOTAL NO. OF IMAGES
Sonne	2	7,28	35
Ngatoroirangi	1	6	6
Haungaroa	2	8,5	13
Havre	3	1,2,8	11
Macauley	3	11,6,8	25
Giggenbach	1	9	9
G14	1	6	6
G19	1	12	12

Table 3. Seamounts, station numbers, and start and finish depths of TAN0205 camera stations.

SEAMOUNT	STATION NUMBER	DEPTH AT START (m)	DEPTH AT FINISH (m)
Sonne	17	1060	1050
Sonne	18	1050	1126
Ngatoroirangi	26	793	405
Haungaroa	41	1219	1222
Haungaroa	42	730	1196
Havre	52	996	1522
Havre	53	1400	1400
Havre	54	1134	1522
Macauley	59	305	989
Macauley	61	511	828
Giggenbach	69	99	643
G14	70	944	1253
G19	71	885	1303
Macauley	79	342	639

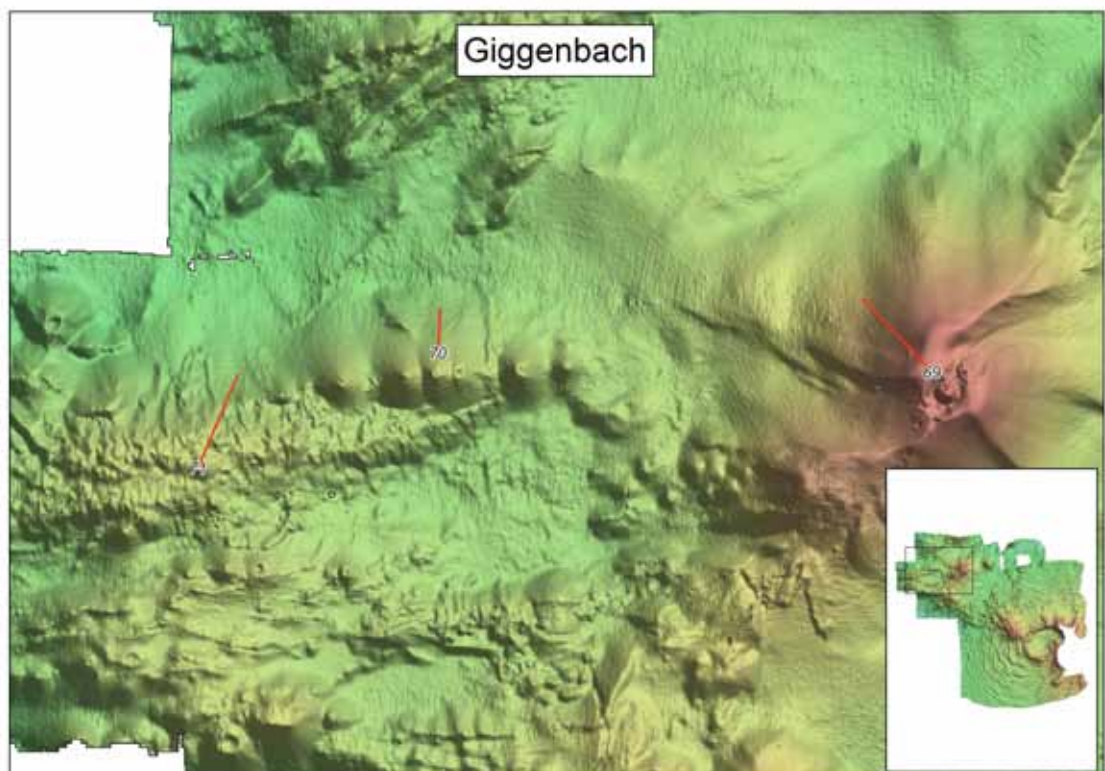


Figure 3. TAN0205 stations on Giggenbach seamount. Start and finish depths of these stations are given in Table 3.

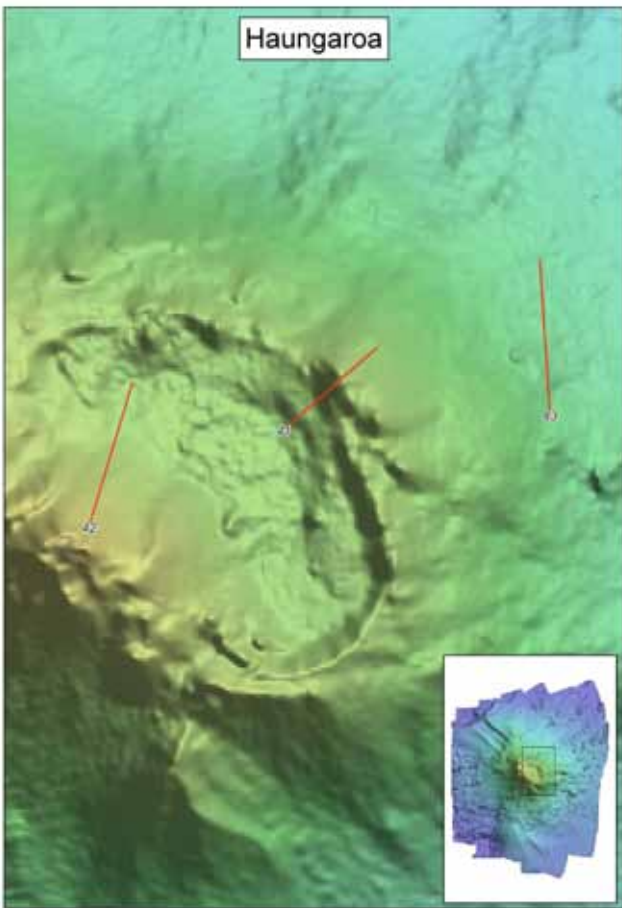


Figure 4. TANO205 stations on Haungaroa seamount. Start and finish depths of these stations are given in Table 3.

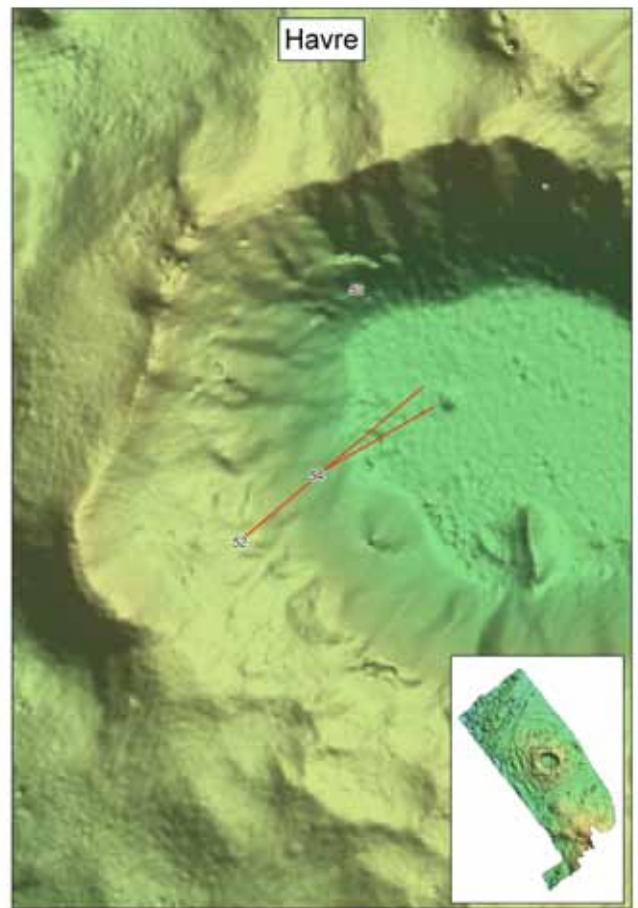


Figure 5. TANO205 stations on Havre seamount. Start and finish depths of these stations are given in Table 3.

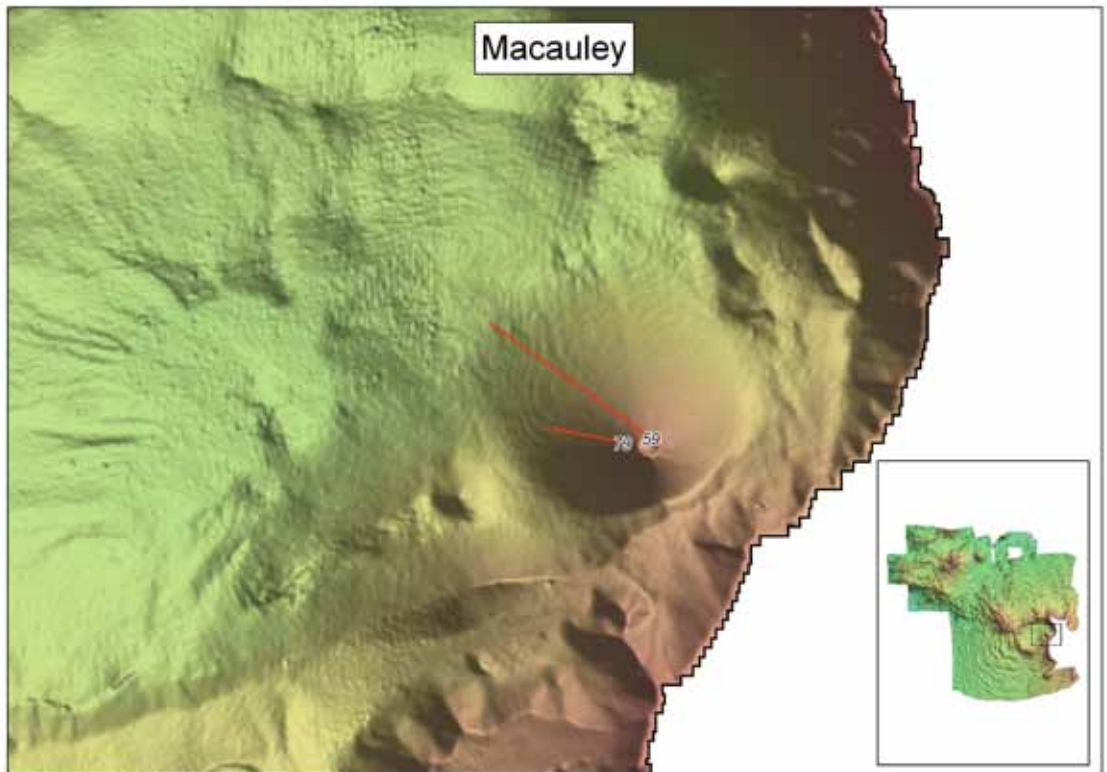


Figure 6. TANO205 stations on the northeastern area of Macauley seamount. Start and finish depths of these stations are given in Table 3.

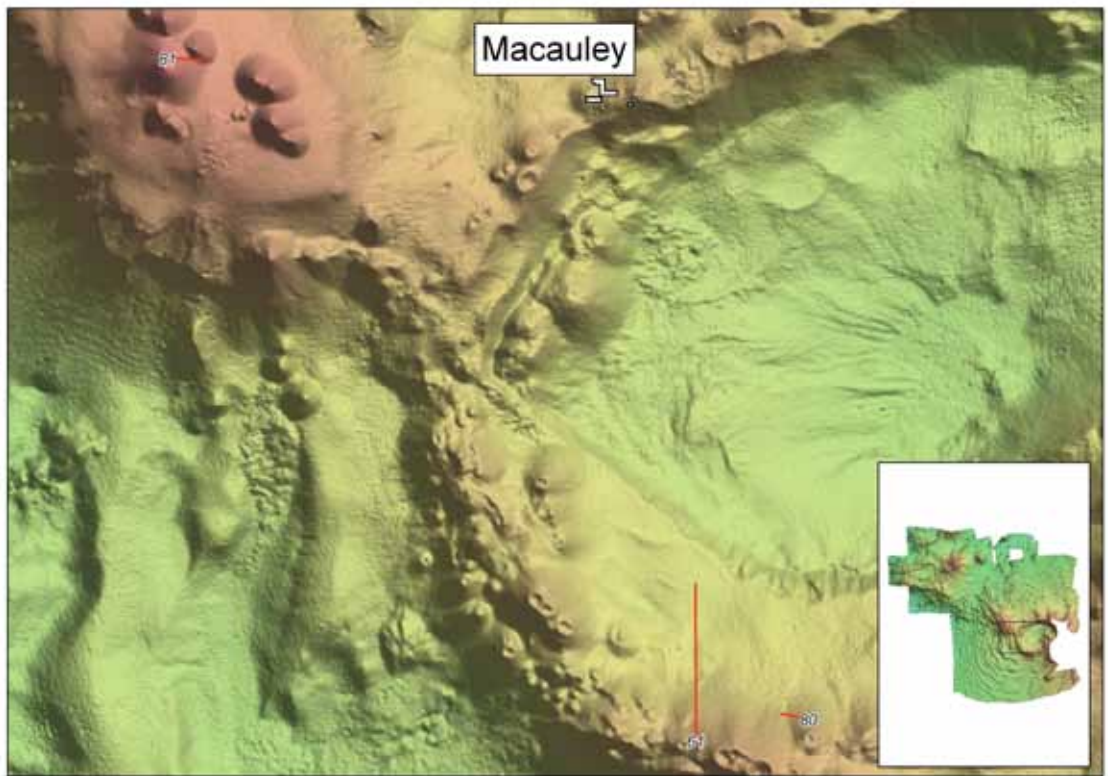


Figure 7. TANO205 stations on the southwestern area of Macauley seamount. Start and finish depths of these stations are given in Table 3.

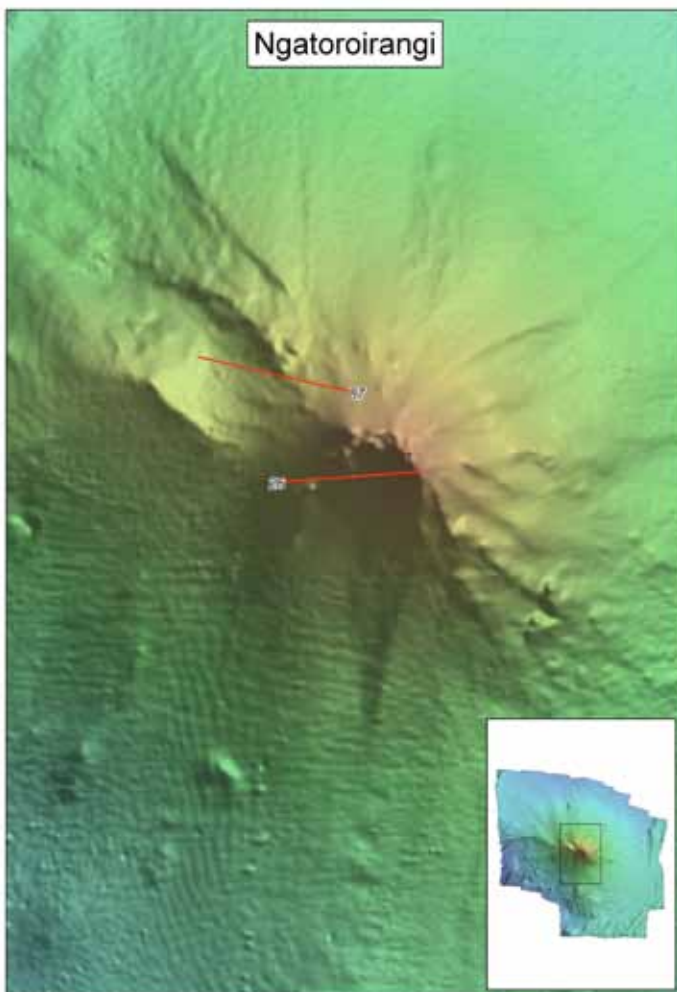


Figure 8. TANO205 stations on Ngatoroirangi seamount. Start and finish depths of these stations are given in Table 3.

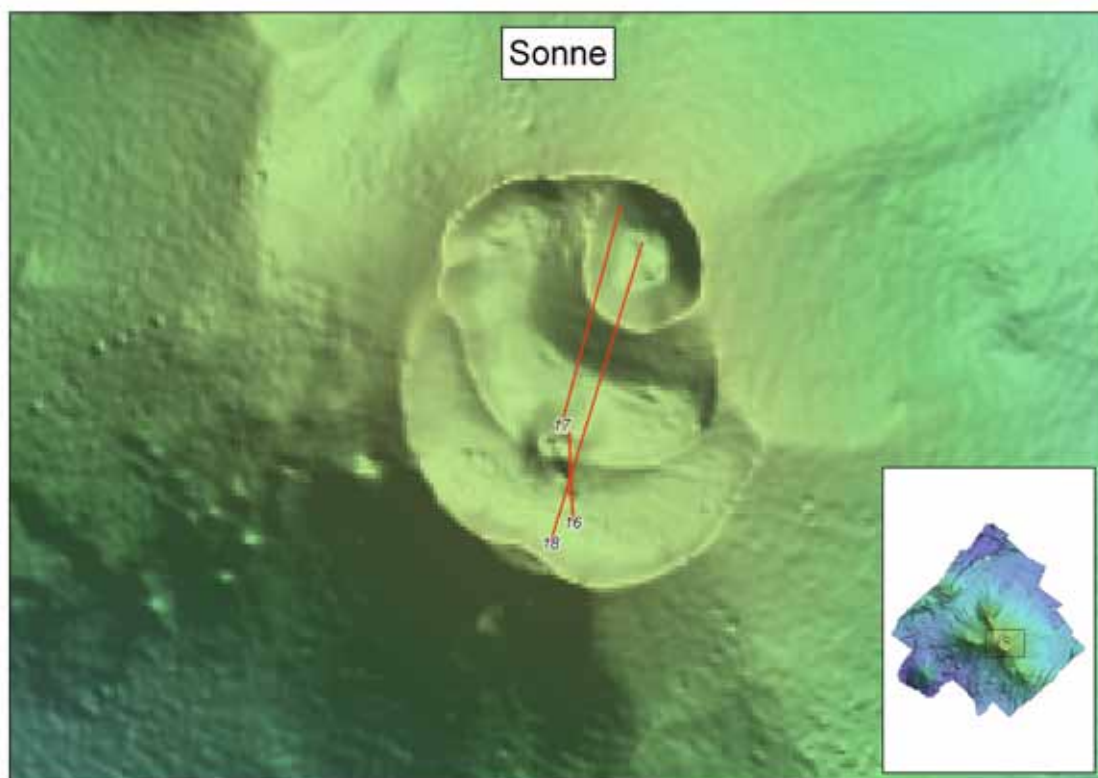


Figure 9. TAN0205 stations on Sonne seamount. Start and finish depths of these stations are given in Table 3.

### 2.3.3 KOK0505 and KOK0506 video and still images

In 2005, a series of Pisces V submersible and Remote Operated Vehicle (ROV) dives were conducted on seamounts in the study area from the RV *Ka'imikai-o-Kanaloa* (KOK). Both video footage and still images were obtained.

The volcanic cone on the eastern caldera wall of Macaulay seamount (Macauley Cone) was the target of two Pisces V submersible dives (616 and 617). The southern caldera rim of Macauley was also observed using a ROV (dive 312). The main volcanic cone in the centre of the Giggenbach seamount was observed by three Pisces V dives (618, 619 and 620). In particular, an active hydrothermal vent site was explored in great detail on the northeast side of the main cone. Pisces V dive 621 on Wright seamount targeted the eastern caldera, starting to the south and moving up onto a central cone. The dives' tracks on each seamount can be seen in Figs 10–13. The depths of each dive are given in Table 4.

A total of 4900 images was collected by the Pisces V submersible on Macauley, Giggenbach and Wright seamounts. However, many of these images were taken in very poor lighting and were, therefore, unable to be analysed. Further, because the still camera on Pisces V automatically took images every 15 seconds, many images were of the same location when the submersible stopped to investigate an area in detail. Only one image from each location was analysed to avoid repetitive sampling. As a result, only 366 images were suitable for analysis.

A total of 42 hours of video footage was recorded on the Pisces V and ROV dives on Macauley, Giggenbach and Wright seamounts. The video recorder on the Pisces V dives was sometimes manually operated to focus on areas of specific interest.

Data used from the KOK0505 and KOK0506 voyages are summarised in Table 5.

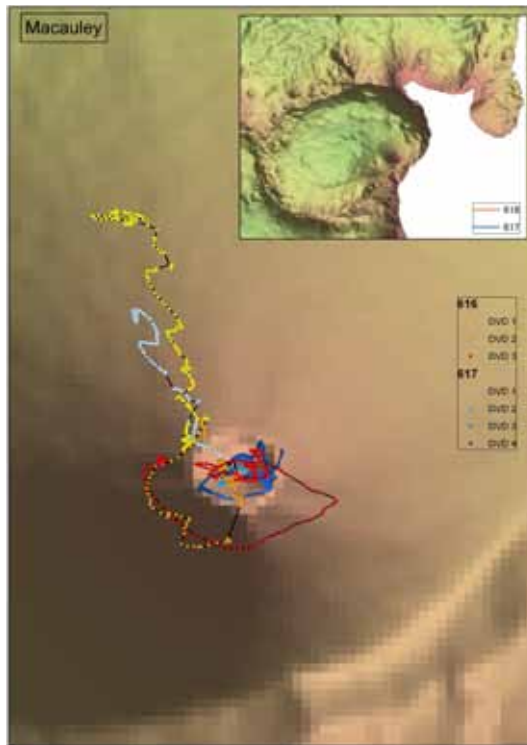


Figure 10. Submersible tracks for dives 616 and 617 on Macauley seamount.

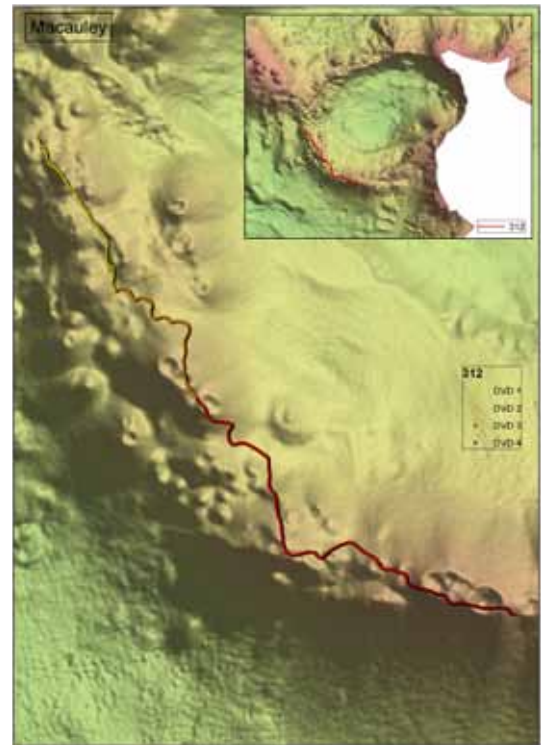


Figure 11. Ship's navigation file during ROV dive 312 on Macauley seamount.

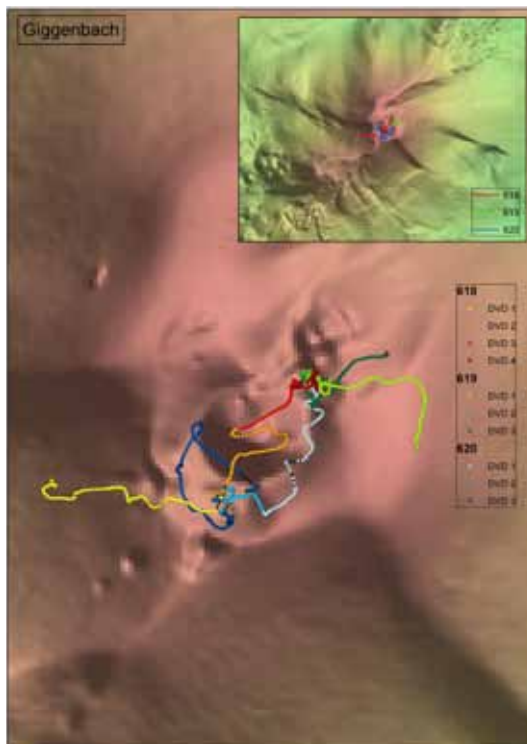


Figure 12. Submersible tracks for dives 618, 619 and 620 on Giggenbach seamount.

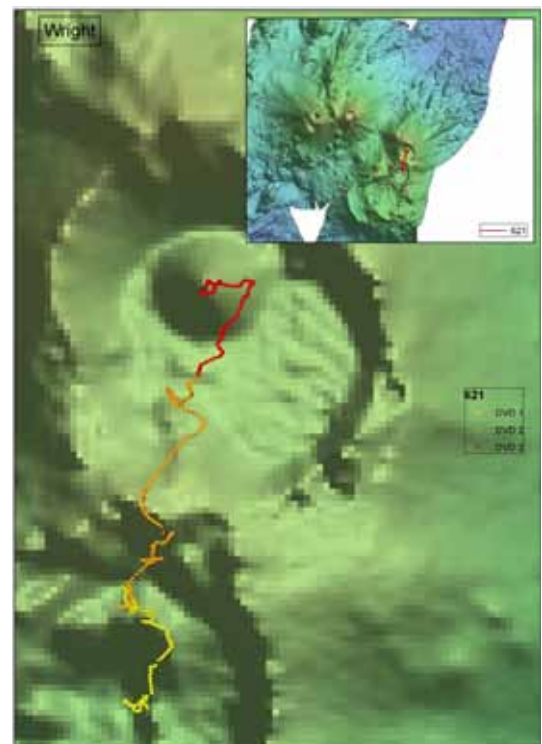


Figure 13. Submersible track for dive 621 on Wright seamount.

Table 4. Minimum and maximum depths of Pisces V dives, taken from the Pisces V dive logs. Depth information for ROV dive 312 was generated from bathymetry data within a GIS.

SEAMOUNT	DIVE ID	DVD NUMBER	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)	MID-DEPTH (m)
Macauley	616	1	284	521	403
		2	248	337	293
		3	257	337	397
		Overall	248	251	385
	617	1	284	360	322
		2	332	338	335
		3	260	337	299
		4	282	290	286
		Overall	260	360	210
	RCV312	1	564	661	613
		2	548	661	605
		3	455	723	589
		4	396	450	423
Overall		396	723	560	
Giggenbach	618	1	164	276	220
		2	83	191	137
		3	143	168	156
		4	161	166	164
		Overall	83	276	180
	619	1	119	168	144
		2	171	184	178
		3	110	164	137
		Overall	110	184	147
	620	1	175	186	181
		2	178	191	185
		3	140	165	152
		Overall	140	165	153
Wright	621	1	1155	1306	1231
		2	1000	1158	1079
		3	1031	1178	1105
		Overall	1000	1178	1089

Table 5. Data summary from KOK0505 and KOK0506.

SEAMOUNT	NO. VIDEO TRANSECTS	TOTAL TIME OF PISCES V VIDEO (hr)	TOTAL TIME OF ROV VIDEO (hr)	NO. STILL IMAGE TRANSECTS	NO. STILL IMAGES ANALYSED
Macauley	3	13.63	3.5	2	157
Giggenbach	3	19.25	-	2	137
Wright	1	5.98	-	1	70

## 2.4 Data analysis

As a result of the variation in gear types used, and the distribution and number of samples available, the different data sources were analysed independently. It should be noted that the best information was available from seamount sites, particularly those areas associated with active hydrothermal venting.

### 2.4.1 Scientific observer data

The scientific observers recorded detailed catch composition information for each of the observed long-line sets. These records were checked for consistency of taxonomic nomenclature, and updated where species names had changed. Checks were also made for likely data-entry mistakes (e.g. very high catch weights or numbers) before analysis. Each set was treated separately as each deployment was in a different location. Most lines were thought to have similar numbers of hooks, so no attempt was made to standardise effort, and the total catch from each station was summarised.

### 2.4.2 Direct samples

Macroinvertebrates sampled by the sleds and dredges were identified to species or putative species with the aid of microscopy and taxonomic keys. Data on presence/absence of macroinvertebrate species were compiled prior to analysis. Data were analysed using PRIMER v6, a suite of computer programs for multivariate analysis (Clarke & Gorley 2001; Clarke & Warwick 2001; and see references therein for the routines mentioned below). A ranked triangular similarity matrix for sample data was constructed using the Bray-Curtis similarity measure (excluding the two samples with only one species). In order to visualise the pattern of assemblage composition for the seamount samples, the similarity matrix was subjected to non-metric multidimensional scaling (nMDS) to produce an ordination plot. A one-way analysis of similarities (ANOSIM) test was carried out to test for differences in assemblage composition between seamounts. The species contributing to the dissimilarity between samples from different seamounts were investigated using the similarity percentages procedure SIMPER. The relationships between multivariate assemblage composition and depth (mid-depth) of sled or dredge tow were investigated using the BIOENV procedure (if any difference in assemblage composition among seamounts was apparent).

### 2.4.3 Still images

Still images were analysed for faunal and substrate information using Image J software. It was not possible to quantify faunal abundances in still images because of a lack of scaling information on each image and parallax error (distortion due to the camera's focal axis not being parallel to the substrate). This meant that it was difficult to make comparisons between images, stations or seamounts. However, it was possible to identify many taxonomic groups and these were ranked using a relative abundance scale, SACFOR (Table 6). Estimates of percentage cover were made for the different substrate size classes present in each image. The substrate classes used were: bedrock, boulders, cobbles, pebbles, gravel, sand, muddy sand and mud. These size classes were differentiated using the Wentworth scale (Table 7).

Faunal data from the still images were analysed, as for the direct samples, using routines in PRIMER. Analysis of faunal data was carried out using a relatively low resolution of identification owing to the poor quality of many images and the difficulties of accurate identification. This was particularly true of many of the fish species. In order to avoid bias towards the easily identifiable species, data were summarised by broad classes for multivariate analysis—for example, 'cartilaginous fish' included all sharks and rays and 'pelagic fish' included fish species such as kingfish, tarakihi etc. Analysis of data was conducted separately for images dominated by hard substrates (bedrock, boulders and cobbles), coarse substrate (gravel and pebbles), and soft substrates (sand, muddy sand and mud). Data were analysed as both presence/absence data and using the SACFOR scale. Although coarse groupings were often used for multivariate analysis, many species were identified to the lower taxonomic levels.



Table 6. SACFOR abundance scale (scale taken from JNCC 2009).

S = Super abundant, A = abundant, C = common, F = frequent, O = occasional, R = rare.

PERCENTAGE COVER	SIZE OF ORGANISM (m <sup>2</sup> )						DENSITY	DENSITY
	CRUST/ MEADOW	MASSIVE /TURF	<1 cm	1–3 cm	3–15 cm	>15 cm		
>80	S		S				>1/0.001 m <sup>2</sup> (1 x 1 cm)	>10000
40–79	A	S	A	S			1–9/0.001 m <sup>2</sup>	1000–9999
20–39	C	A	C	A	S		1–9/0.01 m <sup>2</sup> (10 x 10 cm)	100–999
10–19	F	C	F	C	A	S	1–9/0.1 m <sup>2</sup>	10–99
5–9	O	F	O	F	C	A	1–9	
1–5	R	O	R	O	F	C	1–9/10 m <sup>2</sup> (3.16 x 3.16 m)	
<1		R		R	O	F	1–9/100 m <sup>2</sup> (10 x 10 m)	
					R	O	1–9/1000 m <sup>2</sup> (31.6 x 31.6 m)	
						R	<1/1000 m <sup>2</sup>	

Table 7. Size classes used to classify substrata from video and still images, based on the Wentworth scale (Wentworth 1922).

SUBSTRATUM	DESCRIPTION
Bedrock	Could be further divided into sheet or pillow lava, tallus, breccia in volcanic situations
Boulders	Discrete separate units >25 cm at longest dimension
Cobbles	6–25 cm
Pebbles	0.4–6 cm
Gravel	Up to 0.4 cm
Sand	Course sediment, may have ripples or waves
Mud	Fine and silty, typically with burrows and/or visible invertebrate tracks

#### 2.4.4 Video

DVDs of video footage were rendered as .mpg files using Sony Vegas video editing software before being analysed using OFOP software (Greinert 2009). The quality of the video footage was such that identification of fauna was mainly to major group. These data were recorded together with an assignment of substrate type using the same classes as for the still images.

In principle, OFOP should allow the submersible and ROV navigation files to be linked to video footage in order to obtain spatial information for the biological and substrate observations. Unfortunately, there were incompatibility issues between the KOK video and/or navigation files and OFOP, which meant that it was not possible to match precise spatial information with the faunal and substrate data. As a result, each dive was analysed according to the DVD number (three or four DVDs were recorded per dive) (see Figs 10–13) to allow some spatial information to be attributed to the faunal and substrate data.

As for the direct samples and still images, routines in PRIMER were used to compare the faunal assemblages on seamounts using presence/absence data on the species and faunal groups identified for each submersible or ROV dive.

## 3. Results

### 3.1 Scientific observer data

#### 3.1.1 Species composition

A total of 37 species or groups of fish was identified by the observers (Table 8). The main species by weight (each having a catch total over 1 t) were bluenose (*Hyperoglyphe antarctica*), kingfish (*Seriola lalandi*), bass groper (*Polyprion americanus*), spiny dogfish (*Squalus acanthias*), king tarakihi (*Nemadactylus* sp.) and convict groper (*Epinephelus octofasciatus*).

Table 8. Summary of species (common name, species name, MFish code) and total catch weight (kg) from the MFish observer database.

COMMON NAME	SPECIES	CODE	CATCH (kg)
Alfonsino	<i>Beryx splendens</i> & <i>B. decadactylus</i>	BYX	1
Bass groper	<i>Polyprion americanus</i>	BAS	3442
Bluenose	<i>Hyperoglyphe antarctica</i>	BNS	5506
Bronze whaler	<i>Carcharhinus brachyurus</i>	BWH	60
Carpet shark	<i>Cephaloscyllium isabellum</i>	CAR	
Catshark	<i>Apristurus</i> spp.	CSH	13
Common warehou	<i>Seriolella brama</i>	WAR	35
Convict groper	<i>Epinephelus octofasciatus</i>	CGR	1084
Deepwater dogfish	Various	DWD	38
Dwarf scorpionfish	<i>Scorpaena papillosa</i>	RSC	3
Galapagos shark	<i>Carcharhinus galapagensis</i>	CGA	380
Hapuku	<i>Polyprion oxygeneios</i>	HAP	138
Kingfish	<i>Seriola lalandi</i>	KIN	5213
King tarakihi	<i>Nemadactylus</i> sp.	KTA	1238
Luciosudus	<i>Luciosudus</i> sp.	LUC	1
Mandarin shark	<i>Cirrhigaleus barbifer</i>	MSH	21
Moray eel	Muraenidae (Family)	MOR	1
Northern spiny dogfish	<i>Squalus griffini</i>	NSD	513
Orange wrasse	<i>Pseudolabrus luculentus</i>	OWR	1
Parrotfish	Scaridae (Family)	POT	2
Pink maomao	<i>Caprodon longimanus</i>	PMA	2
Rattails	Macrouridae (Family)	RAT	1
Rays	Several families (e.g. Torpedinidae)	RAY	10
Red snapper	<i>Centroberyx affinis</i>	RSN	121
Ribaldo	<i>Mora moro</i>	RIB	4
Rig	<i>Mustelus lenticulatus</i>	SPO	19
Ruby snapper	<i>Etelis coruscans</i>	ETE	4
Rudderfish	<i>Centrolophus niger</i>	RUD	
Seaperch	<i>Helicolenus</i> spp.	SPE	7
Shovelnose spiny dogfish	<i>Deania calcea</i>	SND	22
Spiny dogfish	<i>Squalus acanthias</i>	SPD	1568
Swollenhead conger	<i>Bassanago bulbiceps</i>	SCO	30
Tarakihi	<i>Nemadactylus macropterus</i>	TAR	236
Trevally	<i>Pseudocaranx dentex</i>	TRE	333
Warehou	<i>Seriolella labyrinthica</i>	SEL	270
Yellow-banded perch	<i>Acanthistius cinctus</i>	YBP	3
Yellow moray eel	<i>Gymnothorax prasinus</i>	MOY	1
Unidentified		UNI	6

### 3.1.2 Species distributions

The main target species had differing distributions of catch (Fig. 14). Bluenose were caught mainly at the southern stations, with a catch rate of up to 840 kg/set. Catches of this species around Raoul Island were generally low. Bass groper were caught throughout the sampling area, but catches north of Raoul Island were small. Kingfish and convict groper were taken at the three northern sites, but maximum catch rates of both species were considerably lower than for bluenose and bass groper.

Geographic differences in species composition are also seen in Fig. 15, where the main species are plotted as a percentage of the total catch in the four 'clusters' of data mentioned in section 2.3.1. Effort varied between the four areas, and so actual catch weights are not presented.

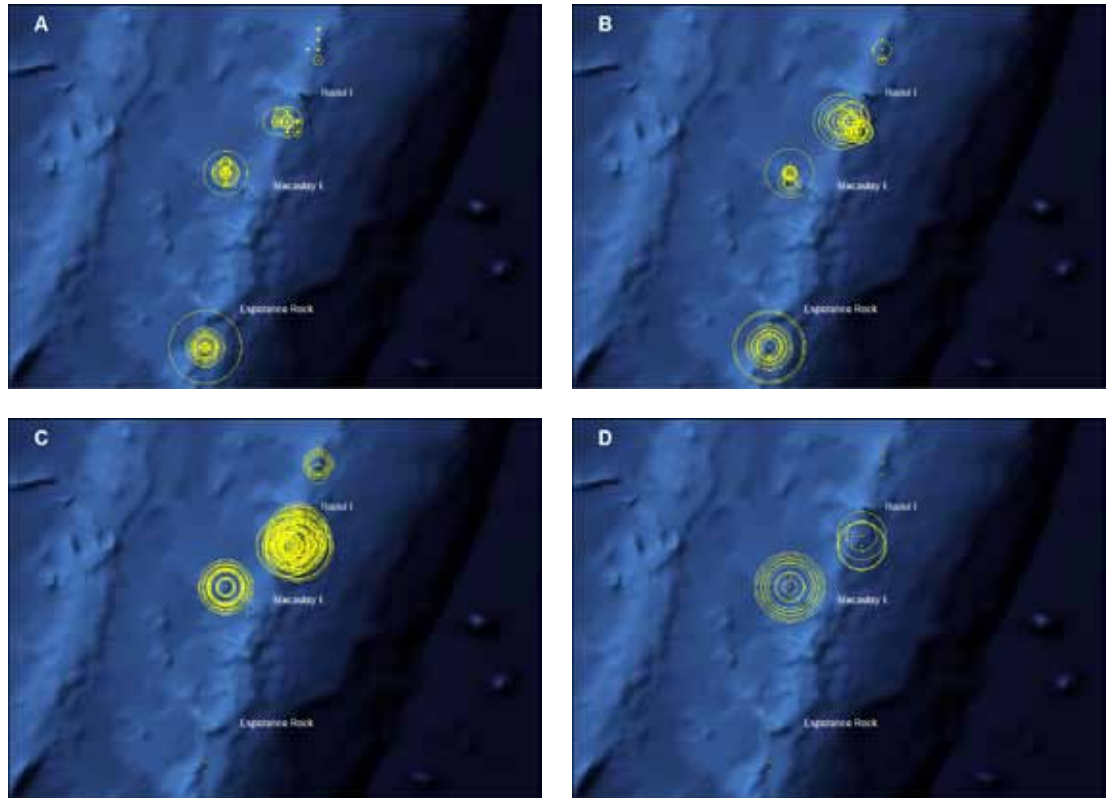


Figure 14. Catch rates (kg/set of a line) for the main target species: A. Bluenose (*Hyperoglyphe antarctica*) (maximum circle size is 840 kg). B. Bass groper (*Polyprion americanus*) (maximum circle size 330 kg). C. Kingfish (*Seriola lalandi*) (maximum circle size 150 kg). D. Convict groper (*Epinephelus octofasciatus*) (maximum circle size 140 kg).

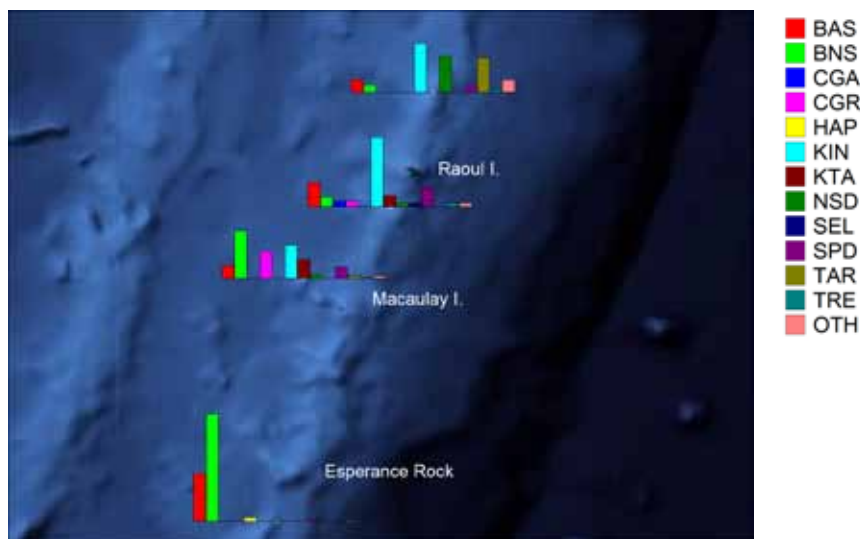


Figure 15. Catch composition in the four areas. Species codes are given in Table 7.

The northern area was dominated by kingfish, northern spiny dogfish and tarakihi, with the other species being relatively minor bycatch. Just south of Raoul Island, the fish assemblage consisted largely of kingfish, with bass groper and northern spiny dogfish. The fish assemblage in the area to the southwest comprised bluenose, convict groper and kingfish, while the southern area had lower diversity, with catches dominated by bluenose and bass groper.

### 3.2 TANO205 direct samples

Over 400 putative species were recorded from the samples collected on the six seamounts within the study area (Appendix 1). The number of species per sample ranged from 1 to 82, while the mean number of species per sample was: Giggenbach—8 ( $n = 5$ ), Macauley—27 ( $n = 7$ ), Havre—14 ( $n = 8$ ), Haungaroa—15 ( $n = 8$ ), Ngatoroirangi—18 ( $n = 6$ ) and Sonne—12 ( $n = 7$ ). Taking into consideration the different number of samples from each seamount, these results suggest that there is little difference in the number of species sampled from each seamount, with the exception of Macauley, which appears more species rich.

The nMDS plot of samples from the TANO205 survey, excluding one outlier sample from Macauley seamount (the single sample of hydrothermal vent fauna), illustrates that there is relatively little apparent difference in assemblage composition among seamounts (a lack of clustering indicates little or no variability; Fig. 16). The formal ANOSIM test confirmed that there is only a very small, yet statistically significant, difference in assemblage composition ( $R = 0.18, p < 0.001$ ).

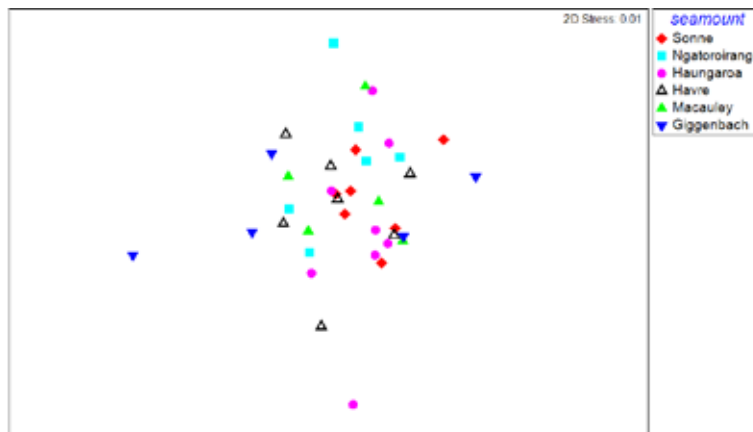


Figure 16. nMDS plot of Bray-Curtis similarities of presence/absence data from TANO205 sled and dredge samples.

### 3.3 TANO205 still images

The number of distinct taxa identified to the lowest possible level per taxonomic group in still images from each seamount is shown in Fig. 17. Overall taxa diversity was relatively low (57 taxa), although noticeably more taxa were observed at some seamounts (Ngatoroirangi—13, G19—15, Macauley—11) than others (Sonne—5, Haungaroa—6, Havre—4, Giggenbach—5, G14—5). A species list is given in Appendix 2.

The characterising fauna of assemblages, and the differences in assemblage composition between seamounts and locations on seamounts, were determined according to the dominant substrate type, as described below.

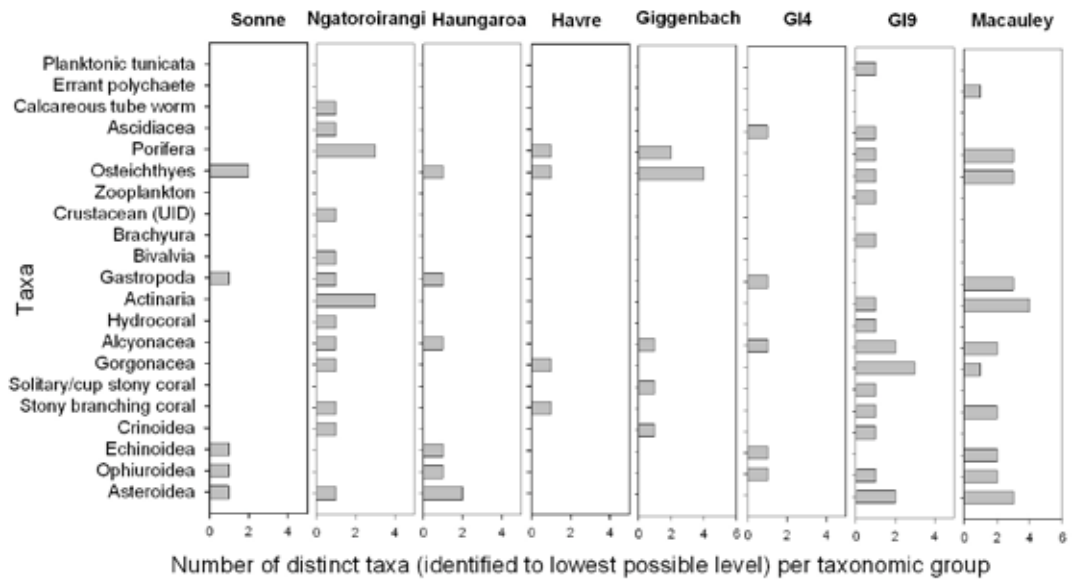


Figure 17. Graph showing the taxonomic diversity of fauna observed in the TAN0205 still images from each seamount.

### 3.3.1 Hard substrate

Images dominated by hard substrate were characterised by the presence of gorgonians, echinoids, ophiuroids, benthic fish, alcyonaceans, gastropods and asteroids (characterising taxa were identified here, as later, using SIMPER). There was little variability in assemblage composition among seamounts (as illustrated by the lack of clustering in the nMDS ordination plot, Fig. 18). Formal ANOSIM tests showed there to be very little difference between the faunal assemblages on seamounts for either the presence/absence data or the SACFOR data ( $R$  values  $< 0.15$ ,  $p < 0.01$ ). The largest significant difference in assemblage composition between individual seamounts, as revealed by pairwise comparison, was between Ngatoroirangi and G19 seamounts ( $R = 0.44$ ,  $p < 0.05$ ). While no detailed depth information was available for each image, the mid-depth (between start and finish depths) of each station was used as an overlay on the nMDS plot. There was no apparent relationship between depth and faunal assemblage pattern (Fig. 19).

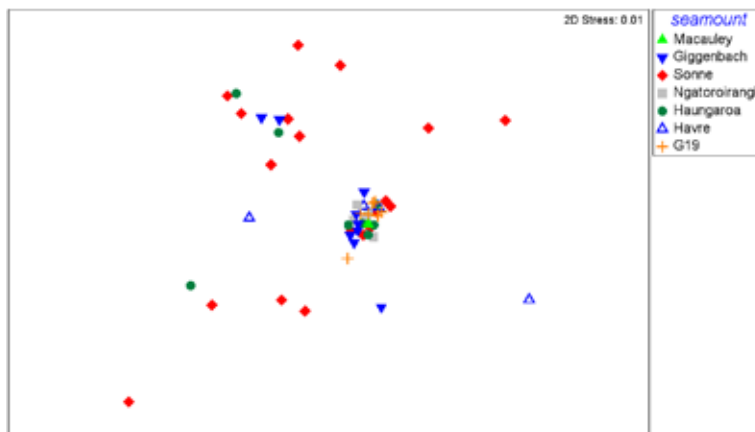


Figure 18. nMDS plot of Bray-Curtis similarities of SACFOR abundance data from TAN0205 images dominated by hard substrates (bedrock, boulder, cobble).

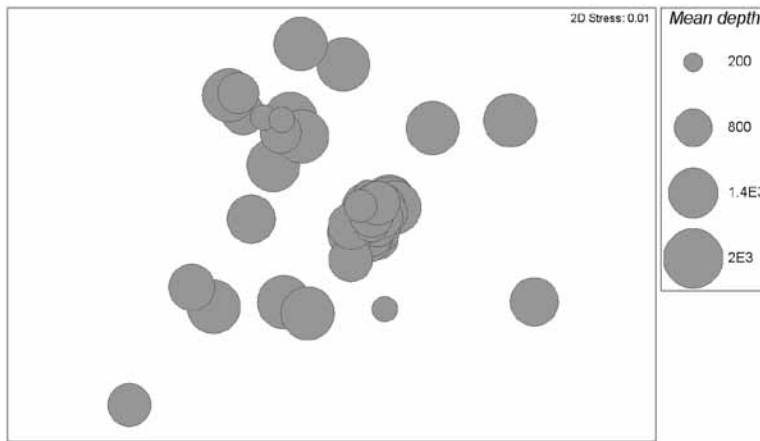


Figure 19. nMDS plot of Bray-Curtis similarities of SACFOR data from TAN0205 images (dominated by hard substrates) with depth overlaid as a bubble plot.

### 3.3.2 Coarse substrate

Images dominated by coarse substrate were characterised by the presence of ophiuroids, asteroids, gastropods and anemones. No apparent clustering was seen within the nMDS plot in Fig. 20 suggesting little variability in assemblage composition among seamounts. ANOSIM tests showed there to be no significant differences between stations ( $R$  values negative,  $p > 0.05$ ) for either presence/absence data or SACFOR data. Again, no obvious relationship was present between depth and faunal assemblage pattern (Fig. 21).

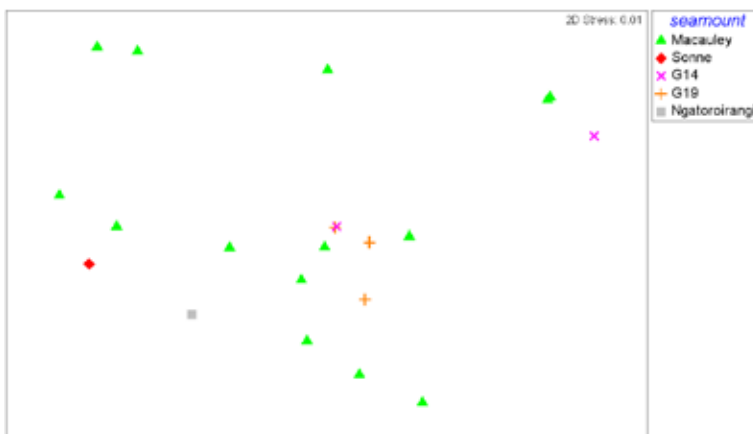


Figure 20. nMDS plot of Bray-Curtis similarities of SACFOR abundance data from TAN0205 images dominated by coarse substrates (pebble, gravel).



Figure 21. nMDS plot of Bray-Curtis similarities of SACFOR data from TAN0205 images (dominated by coarse substrates) with depth overlaid as a bubble plot.

### 3.3.3 Soft substrate

Images dominated by soft substrate were characterised by benthic fish, ophiuroids, echinoids and asteroids. As for the hard substrate data, the nMDS plot (Fig. 22) and ANOSIM tests (for both presence/absence and SACFOR data) revealed that there was effectively no difference in assemblage composition among seamounts ( $R$  values  $< 0.1$ ,  $p < 0.05$ ). No obvious relationship was present between depth and faunal assemblage pattern (Fig. 23).

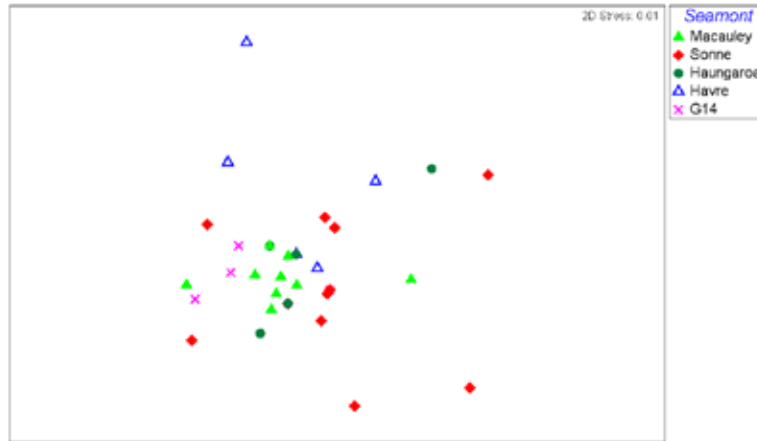


Figure 22. nMDS plot of Bray-Curtis similarities of SACFOR abundance data from TAN0205 images dominated by soft sediments (sand, mud, muddy sediment).



Figure 23. nMDS plot of Bray-Curtis similarities of SACFOR data from TAN0205 images (dominated by soft sediments) with depth overlaid as a bubble plot.

## 3.4 KOK0505 and KOK0506 still images

### 3.4.1 Hard substrate

Images dominated by hard substrate were characterised by the thermophilic tongue fish (*Symphurus* sp.), crabs, *Vulcanidas insolatus* (von Cosel & Marshall 2012) (a vent mussel), asteroids, cup corals, benthic fish, gastropods, pelagic fish, hydroids and anemones. There was little variation in community assemblage composition on hard substrates between dives or seamounts (Fig. 24). The ANOSIM tests (for both presence/absence and SACFOR data) indicated that there were only very small, yet statistically significant, differences in the composition of assemblages on the three study seamounts ( $R$  values = 0.1,  $p < 0.01$ ).

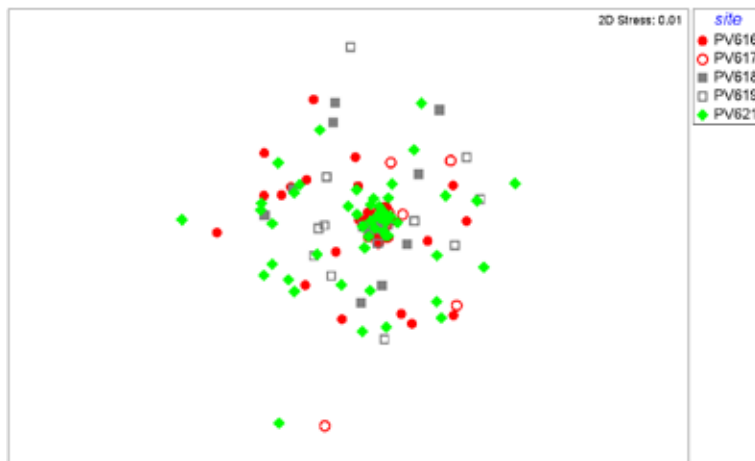


Figure 24. nMDS plot of Bray-Curtis similarities of SACFOR abundance data from images dominated by hard substrates (bedrock, boulders, cobbles). Circles = Macauley, squares = Giggenbach and diamonds = Wright.

### 3.4.2 Coarse substrate

Images dominated by coarse substrate were generally characterised by the presence of different coral taxa, benthic fish and anemones. No apparent differences were seen in faunal assemblage composition associated with coarse substrates between dives or seamounts (Fig. 25). The ANOSIM tests (for both presence/absence and SACFOR data) confirmed that there was no statistically significant difference in the assemblage composition for this substrate type among the study seamounts ( $R$  values  $< 0.1$ ,  $p > 0.05$ ).

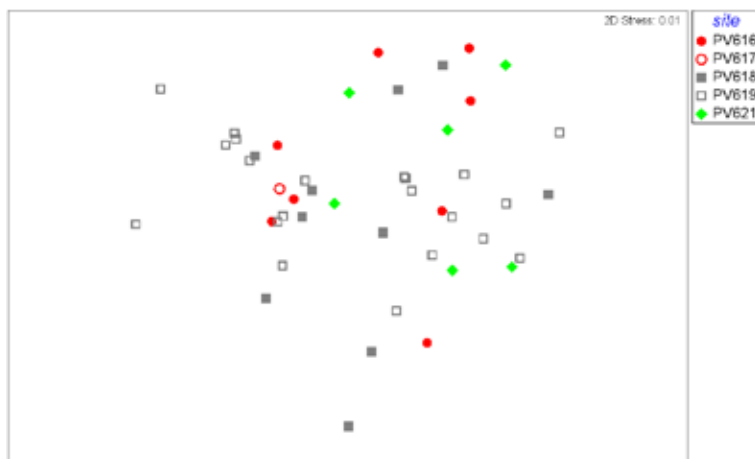


Figure 25. nMDS plot of Bray-Curtis similarities of SACFOR abundance data for images dominated by coarse substrates (pebbles, gravel). Circles = Macauley, squares = Giggenbach and diamonds = Wright.

### 3.4.3 Soft substrates

Images dominated by soft substrate were generally characterised by the tongue fish and *V. insolatus*. The nMDS plot illustrated that there was little apparent difference in the composition of faunal assemblages associated with soft substrates between dives or seamounts on Macauley and Giggenbach (soft substrate did not dominate any images from Wright seamount) (Fig. 26). The ANOSIM tests (for both presence/absence and SACFOR data) indicated that there was only a very small difference in composition ( $R$  values  $< 0.15$ ,  $p < 0.05$ ).



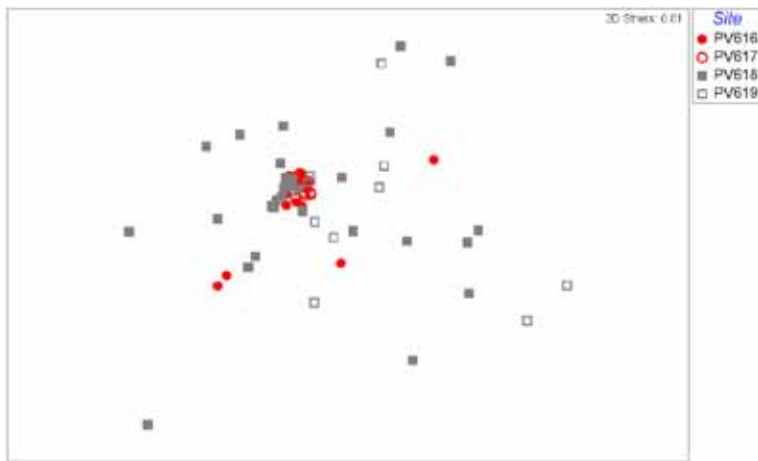


Figure 26. nMDS plot of Bray-Curtis similarities of SACFOR abundance data for images dominated by soft sediments (sand, mud, muddy sediment). Circles = Macauley, squares = Giggenbach. There were no images dominated by soft sediments at Wright seamount.

### 3.5 KOK0505 and KOK0506 video footage

The numbers of distinct taxa identified to the lowest possible level per taxonomic group in the video images from each dive and seamount are shown in Fig. 27. Overall diversity appeared to be high (102 taxa), with some indications of relatively high taxonomic distinctness. It can be seen that, for all dives on all the seamounts studied, bony fish had the greatest species richness. However, there were apparent differences both within and between the different seamounts. For example, more taxa were present on Macauley (dives 616, 617 and 312) than on Giggenbach (dives 618, 619 and 620). The highest number of taxa represented was recorded for dive 312 on Macauley ( $n = 33$ ), whereas dive PV620 on Giggenbach had the least taxa ( $n = 6$ ), though it is important to

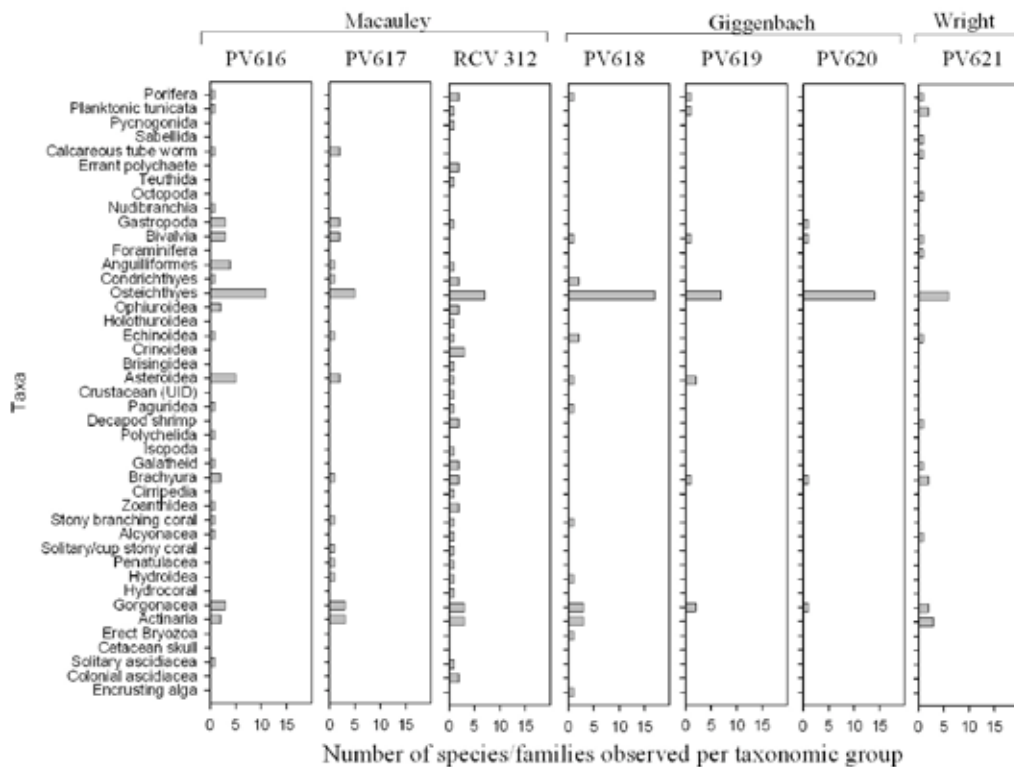


Figure 27. Graph showing the taxonomic diversity of fauna observed on each Pisces V and ROV dive at each of Macauley, Giggenbach and Wright seamounts.

note that the amount of video footage analysed varied between seamounts (see Table 5). The assemblage composition of individual dives is discussed in detail below, before the results of the comparison of the assemblage composition among seamounts are presented.

A detailed description of all Pisces V and ROV dives is given in Appendix 3. A full list of taxa for each dive is given in Appendix 4.

### 3.5.1 Macauley: Dive PV616

The area of Macauley surveyed on dive PV616 had a mixture of hard bedrock, breccia, sandy substrate and areas of bacterial mat (Fig. 28). Faunal assemblages on hard substrate generally had a low fish and invertebrate abundance and diversity (see Figs 29 & 30). However, some dense beds of the vent mussels *Gigantidas gladius* and *V. insolatus* were observed, particularly in soft sediment areas, together with large numbers of predatory asteroids (probably *Sclerasterias mollis* and *S. eructans*). One of the more notable observations was that of a deep sea blind lobster (*Polycheles enthrix*), sitting exposed on some breccia. This species is not often observed, particularly not away from the soft sediments in which it is usually partially buried (Shane Ahyong, NIWA, pers. comm. 2009).

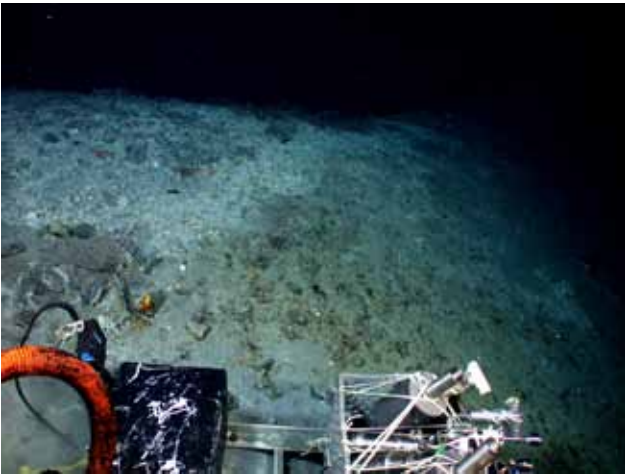


Figure 28. Dive PV616: on top of the caldera ridge. Mixed sediment (cobbles, pebbles and soft sediment) often with a layer of bacterial mat. Some tongue fish (*Symphurus* sp.) and the occasional asteroid were present.

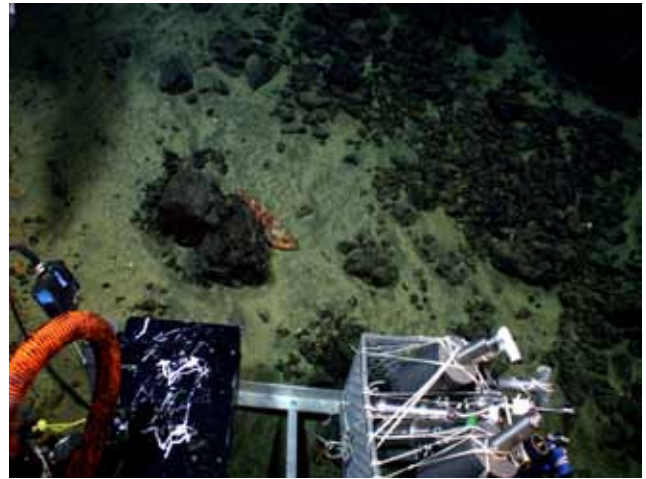


Figure 29. Dive PV616: the area is barren with respect to visible faunal life—with the exception of a sea perch (*Helicolenus* sp.).

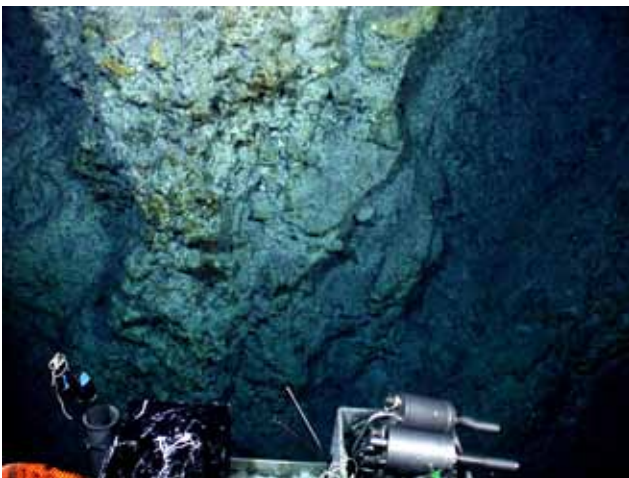


Figure 30. Dive PV616: a wall of hard substratum. Very little encrusting or mobile faunal life was observed on these structures.

Active hydrothermal vent sites were seen, together with elemental sulphur deposits. Tongue fish (probably *Symphurus thermophilis* (Munroe & Hashimoto 2008) and *Xenograpsus ngatama* (a crab) were associated with these active vents.

### 3.5.2 Macauley: Dive PV617

Areas of non-active hydrothermal venting were relatively barren of fauna (Fig. 31). However, some dense beds of *G. gladius* and associated asteroids (*Sclerasterias*), together with patches of *V. insolatus*, were observed (Fig. 32). Fish diversity was relatively low. Of note were two sightings of coffin fish (*Chaunax* sp.).

Some very large areas of active hydrothermal venting were observed on this dive. The dominant benthic fauna in these areas comprised the tongue fish and *X. ngatama* (Fig. 33). Large areas of vertical or near vertical walls with very low faunal diversity and biomass were also seen (e.g. Fig. 34).



Figure 31. Dive PV617: this frame grab from video footage shows how barren much of the hard substrate was in this dive.



Figure 32. Dive PV617: an extensive, dense, bed of the bivalve *Gigantidus gladius* with associated predatory *Sclerasterias* asteroids.

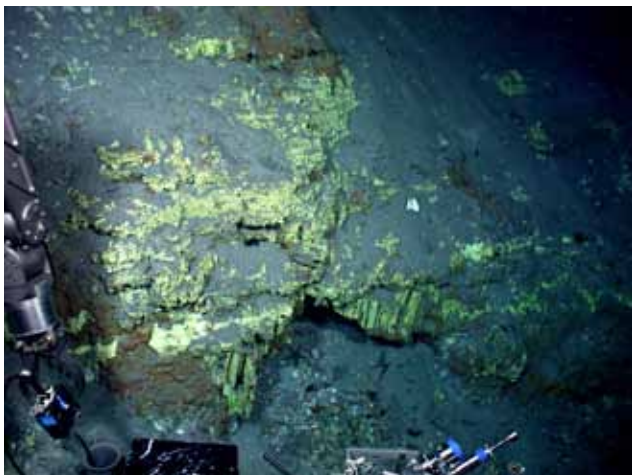


Figure 33. Dive PV617: interesting formations of sulphur deposits interspersed with hard substrate and soft sediments. Note the presence of a few asteroids, tongue fish (*Symphurus* sp.) and *Xenograpsus* crabs.



Figure 34. Dive PV617: hard substratum mostly barren of encrusting life with the exception of a few tube worms and some *Vulcanidas insolatus*. The fish is a bass (*Polyprion maeone*).

### 3.5.3 Macauley: RCV-150, ROV dive 312

The seabed in this area of Macauley was dominated by hard substrata, irregular outcrops of bedrock with some boulders and some gravel, although there were a few soft sediment areas. On occasions, there were unusual sheet-plate bedrock formations (Fig. 35). No active hydrothermal venting was observed.

An unidentified stalked crinoid was by far the most numerous organism observed on this dive, sometimes in large, very dense patches (Fig. 36). Faunal (invertebrate) diversity was high and included numerous scleractinian corals, gorgonians and 'armless' brisingid seastars. Fish diversity was low. Unusual observations included a large red-orange squid (probably a member of *Ommastrephidae*) and a shark egg case (probably from a catshark, *Apristurus* sp.). Also of note was a broken up cetacean skull, possibly of a rough-toothed dolphin (*Steno bredanensis*; to be confirmed; Anton van Helden, Te Papa Tongarewa, pers. comm., 2009).



Figure 35. Dive 312: a frame-grab from video footage showing unusual plate-like sediment formations. This substrate was relatively barren of visible faunal life with the exception of a few cnidarians (mostly cup corals and gorgonians).



Figure 36. Dive 312: this frame-grab from video footage shows an area of hard substrate supporting a dense population of an unidentified stalked crinoid.

### 3.5.4 Giggenbach: Dive PV618

This dive had some quite distinct areas with respect to topography and biology. There were large areas of bedrock, sometimes lava-like, and often with a soft-sediment overlay as well as extensive areas of sand (possibly ash deposits) with ripples present. The faunal assemblage in these areas was dominated by gorgonians and a wide variety of fish. Active and/or diffuse hydrothermal vent sites (sometimes bubbling) were associated with bacterial mat, *V. insolatus* and predatory asteroids (*Sclerasterias* spp.) (Fig. 37). An unidentified crab (possibly *X. ngatama*) was also observed at one vent site. There was also an area of large (>2 m tall) chimneys with very little sessile or invertebrate life but with an abundant fish life.

In the shallower depths of the Giggenbach cone, which consisted of cobble habitat covered in a coralline alga, there was a high density of fish. At the top of the cone, in 75–100 m depths, there were very large numbers of many different fish species (Fig. 38).

### 3.5.5 Giggenbach: Dive PV619

Fish dominated the fauna on this dive on Giggenbach seamount. Active, bubbling, hydrothermal vent sites were a big feature of dive PV619. These areas often had associations with *X. ngatama*, *V. insolatus* and bacterial mat. Areas of just bacterial mat were also regularly observed. The diversity of invertebrates observed on this area of Giggenbach was relatively low.

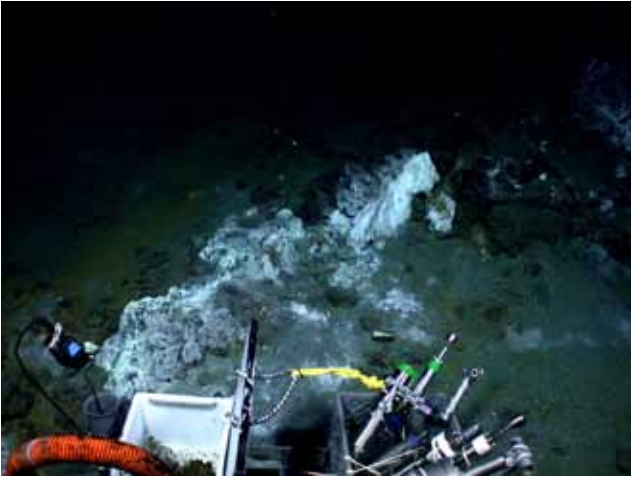


Figure 37. Dive PV618: an active hydrothermal vent site with associated bacterial mat and *Vulcanidas insolatus*.



Figure 38. Dive PV618: towards the summit of Giggenbach cone. Large numbers of kingfish (*Seriola lalandi*), pink maomao (*Caprodon longimanus*) and two-spot demoiselles (*Chromis dispilus*) were present. The hard substrate (cobbles/boulders) was covered in a layer of pink coralline algae.

### 3.5.6 Giggenbach: Dive PV 620

The area of Giggenbach observed on dive 620 was dominated by soft sediments as well as a few cobble-boulder habitat areas. Active hydrothermal areas, sometimes bubbling, were often associated with a bacterial crust and/or *V. insolatus*. Of note was a large pit area with numerous chimneys.

Fish dominated the fauna on dive 620 and fish abundance in the vicinity of the chimneys was especially high (Fig. 39). Unusual faunal observations included a pair of bandfish (*Cepola* sp.) living in burrows in a soft-sediment area. This was a new record for the Kermadec Ridge area.

### 3.5.7 Wright: Dive PV621

The area of Wright observed on dive PV621 was dominated by hard substrate, mostly of bedrock with topography including steep slopes, ridges and pillow formations. Some cobble and sandy areas were also seen. Much of the substrate appeared barren of fauna (Fig. 40). However, the faunal assemblage, when present, was dominated by fish (eels and grenadiers) and anemones.

Faunal observations of note included a few large vestimentiferan tubeworms (indicative of hydrothermal venting, although no active vents were seen) together with numerous saddle



Figure 39. Dive PV620: a frame-grab from video of small chimney-like structures in an expanse of soft sediment. Pink maomao (*Caprodon longimanus*) were shoaling around the structures.

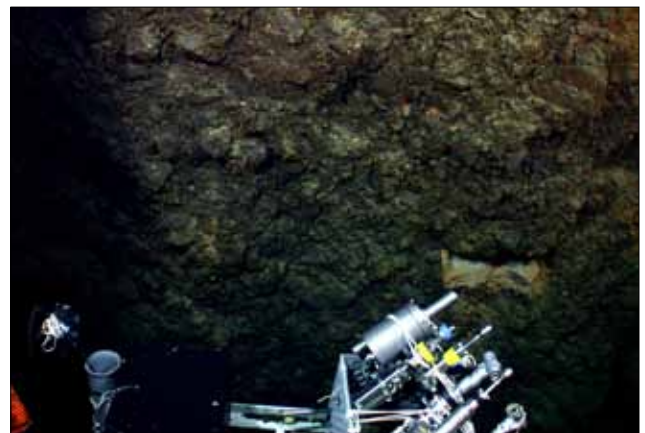


Figure 40. Dive PV621: a wall of hard substrate mostly barren of encrusting life.

oysters attached to rock (Fig. 41), a large octopus (probably of the family Octopodidae), and a giant anglerfish (thought to be *Sladenia* sp.). This was a new record for both New Zealand and the Kermadec Ridge area.

As the submersible moved up the slope to the summit of the cone, the seafloor changed from hard bedrock (often in pillow formations) to a thick bacterial mat apparently devoid of macrofauna (Fig. 42). Some diffuse active hydrothermal venting was also observed in this area.

### 3.5.8 Comparison of assemblage composition among seamounts

The nMDS plot in Fig. 43 shows the relationship between the composition of the different faunal assemblages (presence/absence) as determined from the video recordings made during the Pisces V and ROV dives on Macauley, Giggenbach and Wright seamounts. The difference in assemblage composition among seamounts was relatively large and statistically significant (ANOSIM:  $R = 0.625$ ,  $p < 0.01$ ). The largest pairwise differences in assemblage composition were between Giggenbach and Wright seamounts ( $R = 0.98$ ), then Giggenbach and Macauley ( $R = 0.58$ ), with differences between Macauley and Wright seamounts being the least ( $R = 0.43$ ). A BIOENV analysis revealed a significant correlation between overall assemblage pattern and mid-depth of each dive ( $p = 0.60$ ,  $p < 0.01$ ). This relationship can be visualised in Fig. 44 where the values of mid-depth has been overlaid onto the nMDS plot.

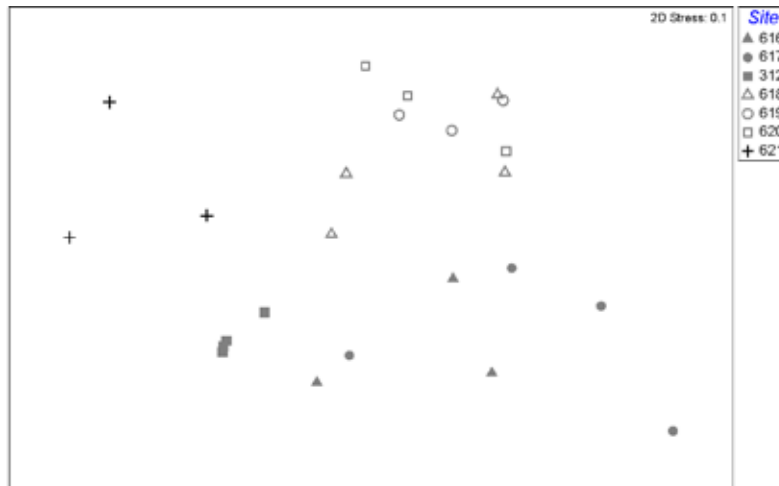


Figure 43. nMDS plot showing the relationship between OFOP (video) data for sites and seamounts. Solid grey = Macauley, open grey = Giggenbach and black cross = Wright.



Figure 44. nMDS plot showing the relationship between submersible and ROV dives and seamounts with mid-depth overlaid.

## 4. Discussion

The present study has compiled information, from a variety of sources, on the fish and invertebrate fauna associated with the seabed in the deeper waters of the Kermadec Islands CMA and surrounding area. Primarily, these data are from seamount features, some of which are sites of hydrothermal venting. The objective of the present study was to examine and analyse these data in order to describe the composition of the deep-water biotic assemblages. However, the types of analyses possible and the amount of relevant information obtained were limited by the quantity and quality of data available.

### 4.1 Limitations of the data

For the reasons outlined in sections 2.3.2, 2.3.3 and 2.4.3 (Methods), only some of the available data were suitable (albeit still with limitations). To avoid repetition, the reasons for excluding images will be only listed here:

- Poor quality of the still images (too dark; water turbid owing to the camera gear contacting the seabed), particularly those of the TAN0205 dataset
- Repeat images of the same area of seabed
- A lack of scaling information on each image
- Parallax error

These issues meant that obtaining quantitative data was a challenge, although by ranking organisms using a relative abundance scale (SACFOR), some quantitative information was retained. Lastly, whilst spatial coverage on each seamount was greater in the KOK surveys than for the TAN0205 survey, there was a bias (because of the focus of the survey) towards areas of hydrothermal venting. Thus, the sampling tools and strategies were not ideal for the purpose of providing a fully comprehensive description of the faunal assemblages in the study area, nor for appreciating the spatial variability in the composition of these assemblages (including any small-scale differences in composition with changes in water depth). In addition, data were not analysed in a way that currently allows for direct comparisons to be made with the results of previous analyses of seamount assemblages elsewhere in the region (e.g. Rowden et al. 2003).

### 4.2 Assemblage composition and distribution patterns

Where possible, data were subjected to quantitative analyses using multivariate statistical techniques. These analyses indicated very small or no differences in faunal assemblage composition based on direct sample or still image-derived data from the TAN0205 and KOK0505/0506 surveys. However, analysis of video-derived data from the KOK surveys showed there to be large and significant differences between the assemblages on Macauley (inside the CMA), Giggenbach and Wright seamounts, which can be largely explained by differences in depth among the seamounts. Giggenbach was the shallowest seamount surveyed, with video obtained from a depth range of 83–276 m. Data for Macauley was recovered from a depth range of 248–723 m, while data for Wright was obtained from the greatest depths, of 1000–1306 m. It is, therefore, surprising that the differences in assemblage composition were not also apparent from still image data from the KOK surveys. This finding is most likely a consequence of the coarse resolution of taxonomic identification together with a low number of useable images within each of the substrate subgroups for the still image datasets, resulting in low power for the statistical tests (see 4.1: Limitations of the data, above). Differences in invertebrate assemblage composition among seamounts and vents (associated with the Kermadec Ridge) found at different depths have been noted previously from analyses of preliminary data derived from both direct samples

and seabed imagery (Rowden et al. 2003; Rowden & Clark 2005). The small differences in assemblage composition among the seamounts sampled by the TANO205 survey probably relates to the fact that, even though there were some relatively shallow and deep stations, across all seamounts, the majority of samples were taken from a similar depth range (c. 700–1500m).

The qualitative examination of relative composition of fish species from the scientific observer programme reflected catches taken on long-lines. Hence, the compiled data cannot be considered representative of overall fish diversity or relative abundance. Most fish species recorded in the observer dataset are well-known from northern waters, and have a relatively wide distribution. However, the catches indicated latitudinal differences along the Kermadec Ridge, with bluenose becoming less prominent in northern regions, where kingfish become more abundant. This trend corresponds with published summaries of New Zealand fish distributions (Anderson et al. 1998), with bluenose becoming less abundant in northern New Zealand waters, near the species' northern limits. The observed increase in species like convict groper as boats moved north similarly reflects a latitudinal gradient in distribution, and may also relate to lines being set near shallow features nearer the main Kermadec Islands, where groper are common. Fish diversity appeared to be higher in the three northern sampling areas compared to the southern-most ones, but the small sample size makes it difficult to draw firm conclusions.

The spatial differences and similarities in the assemblage composition of fish and invertebrates revealed by the present analyses have implications for the environmental management of the study area (e.g. the appropriate size and depth range for a protected area). Whilst at least certain components of the deep-water fauna and habitats—such as vents—that exist in the study area are likely to be sensitive to human disturbance (see below), assessing the potential for recovery from disturbance is currently difficult because of a lack of knowledge (about, for example, growth rate, longevity and recruitment potential of dominant species). Such a recovery assessment may be unnecessary, at least in the near future, because bottom trawling is currently prohibited in the area (which is encompassed by a Benthic Protected Area), and seabed mining for polymetallic deposits is unlikely to progress to full-scale commercial extraction for at least a decade (see below).

### 4.3 Significance of the study area

Many sets of criteria have been developed to identify 'significant' biological or ecological areas. In the marine context, the latest to be published is that produced for the Convention on Biological Diversity (CBD) (CBD Secretariat 2009). The criteria of this scheme, developed to identify significant areas in need of protection in open ocean waters and deep-sea habitats, are: (1) uniqueness and rarity; (2) special importance for life-history stages of species; (3) importance for threatened, endangered or declining species and/or habitats; (4) vulnerability, fragility, sensitivity, or slow recovery; (5) biological productivity; (6) biological diversity; and (7) naturalness. The CBD has also developed 'guidance for selecting areas to establish a representative network of marine protected areas' in association with the significance criteria. The properties required for such a network and for components of marine protected areas (MPAs), in addition to containing ecologically and biologically significant areas, are: representativity; connectivity; replicated ecological features; adequate and viable sites (CBD Secretariat 2009).

DOC has no set criteria for defining significance in a marine context. There are criteria for defining significance in the terrestrial environment, which exist through environment case law (D. Young, DOC, pers. comm. 2009). In total, these terrestrial criteria are largely synonymous with the CBD significance criteria and the associated MPA selection guidance. Thus, given that the CBD scientific criteria and guidance have international status, are likely to be used widely, are designed to be relevant to deepwater assemblages, and are, presumably, the set of criteria and guidance most relevant to New Zealand's response to the CBD—the New Zealand's Biodiversity Strategy (Anon. 2000), it seems most prudent to use them to evaluate the ecological or biological significance of the study area.



Using information and the results of the analysis from the present study, and the definition notes for the CBD criteria (see tables in CBD Secretariat 2009), it is possible to formally assess the ecological or biological significance of the deep-water areas of the Kermadec Islands and adjacent region. Below is a preliminary and brief assessment, which can act as a provisional guide to the significance of the study area until such a time that a more exhaustive assessment is completed. Some notes are also included regarding the required MPA network properties and components as stipulated by the CBD. Note also that in 2010 the Pew Environment Group held a symposium 'DEEP' which reviewed the state of knowledge of the entire Kermadec region from the deep sea to the marine and terrestrial environments (Pew 2010)

#### **4.3.1 Uniqueness and rarity**

Whilst rarity is not a particularly useful criterion in the deep-sea context (rarity is a common feature of most deep-sea inhabitants), there are species and, possibly, communities that are unique to the area. For example, the mussel *G. gladius* (von Cosel & Marshall 2003) has, to date, not been found outside the Kermadec Ridge region. Other invertebrate species are also apparently endemic to the region (e.g. Buckeridge 2000, 2009; Glover et al. 2004; Webber 2004; McLay 2007; Ng & McLay 2007; Ahyong 2008; Schnabel 2009). A few offshore fish species are also thought to be endemic to the region, including a vent-associated eelpout (*Pyrolycus moelleri*) (Anderson 2006), a spiny dogfish (*Squalus raoulensis*) (Duffy & Last 2007) and a moray eel (*Anarchias supremus*) (McCosker & Stewart 2006). The specific identity of the species of tongue fish found in the region is still being evaluated by genetic studies. It may prove different from *Symphurus thermophilis*, which has a widespread distribution—being found along vents of the Kermadec Ridge to the Marianas Arc (Munroe & Hashimoto 2008). The level of endemism for deepwater fish is likely to be underappreciated because of the difficulties associated with sampling small and cryptic species.

A preliminary assessment of the overall composition of vent assemblages suggests that these communities are unique to the region (Rowden & Clark 2005). In terms of whether the area contains what the CBD criteria call 'distinct habitats or ecosystems', deep-water hydrothermal vents and the chemosynthetic ecosystem they support have, to date, been found (in the New Zealand region) only associated with seamounts of the Kermadec Volcanic Arc and, until their relationships to vent faunas elsewhere are much better understood, they must be considered special on a world scale.

#### **4.3.2 Special importance for life-history stages of species**

Populations of those species (such as vent mussels and worms) that rely upon the particular biotic and abiotic conditions that exist at hydrothermal vents, and that are physiologically constrained, can survive and thrive as adults only at these habitats. As already noted, hydrothermal vents and a suite of specialised species occur, in the New Zealand marine context, only in the Kermadec region.

#### **4.3.3 Importance for threatened, endangered or declining species and/or habitats**

According to DOC's latest threat classification list (Hitchmough et al. 2007), at least one species found in the study area is classified as threatened—the mussel *G. gladius* ('range restricted'). This species is associated with hydrothermal vents which are, as already noted, a habitat of particular regional importance for this species.

#### **4.3.4 Vulnerability, fragility, sensitivity or slow recovery**

While the area does contain species such as corals that are 'functionally fragile (susceptible to degradation and depletion by human activity or by natural events) or with slow recovery', it does not (in a New Zealand context) contain what this CBD criterion calls 'a relatively high proportion' of these species. However, hydrothermal vents and seamounts can, according to this criterion, be considered sensitive habitats which, as already noted, occur in relatively high proportion in the study area.

#### 4.3.5 Biological productivity

Hydrothermal vents elsewhere are known to support communities with comparatively high natural biological productivity (Van Dover 2000), and observations of abundant fauna, with large body sizes, associated with vents (particularly vent mussels) on the seamounts in the study area indicate that the Kermadec vents are also highly productive. Vent-related productivity is important for sustaining populations of 'background' species that are found in the vicinity of vent habitats (Van Dover 2000). Observations at Kermadec vents of relatively dense populations of asteroids (e.g. *Sclerasterias* spp.), crabs (*Paralomis* sp.) and fish (e.g. tongue fish, eelpout) suggest that at least these organisms are probably reliant to some extent on vent productivity. Seamounts are often cited as areas of enhanced biological productivity (Rogers 1994), but this generalisation is now being increasingly questioned, even though there is little doubt that certain invertebrate and fish species can form aggregations on seamounts (see review by Pitcher et al. 2007).

#### 4.3.6 Biological diversity

Data from the present study are not particularly suited for assessing whether or not the area contains, in the words of this CBD criterion, 'comparatively higher diversity of ecosystems, habitats, communities, or species, or has higher genetic diversity'. Studies spanning New Zealand's Exclusive Economic Zone (EEZ) that have evaluated the diversity of particular marine biota indicate that some faunal assemblages of the study area are comparatively diverse (e.g. bryozoan assemblages, Rowden et al. 2004), though others are not diverse (e.g. fish assemblages, Leathwick et al. 2006).

#### 4.3.7 Naturalness

The study area is currently subjected to a very low level of human-induced disturbance. The Kermadec Islands CMA itself has been protected from human disturbance since the designation of the Kermadec Islands Marine Reserve in 1990 (e.g. fishing and mining are prohibited). The study area in general is sufficiently remote to have largely avoided the attention of fishers using trawls, although long-lining has evidently occurred. Since 2007, the study area has been protected from bottom trawling by the implementation of Benthic Protection Areas (BPAs), one of which encompasses 620 500 km<sup>2</sup> around the Kermadec Islands. However, other forms of trawling and fishing are allowed within BPAs. Scientific sampling has clearly taken place in the deeper water of the CMA (under permit) and the adjacent region. The deployment of submersibles, ROVs or towed cameras create either no or minimal disturbance. The use of sampling gear that has prolonged contact with the seabed, such as dredges and sleds, does generate local disturbance. These sampling dredges or sleds are approximately 1 m wide and are typically towed for 15–20 minutes at low speeds over distances of hundreds of metres. The number of dredge and sled tows undertaken in the study area is currently less than a hundred. Parts of the study area (though not the CMA itself) are included in an area permitted for mining exploration by a mineral company. To date, exploration for massive sulphide deposits that contain a variety of metals of commercial value has been undertaken on only two seamounts south of the study area (Brothers, Rumble II). Full-scale commercial extraction of these polymetallic deposits is unlikely to occur for at least a decade. Thus, the study area has 'near natural structure, processes and functions'.

The study area can, according to the CBD scheme, be deemed an ecologically or biological significant area. That is, the CBD's guidance notes indicate that only one of the above criteria need be met to achieve the distinction of being 'significant'. With respect to the CBD's guidance for selecting areas to establish a representative network of MPAs, the study area, as well as being a significant area (as a whole and not just the CMA—which is already part of a collection of New Zealand MPAs), could be a candidate for inclusion in a large-scale MPA network, for the following reasons:

- It is centrally located in, and represents a relatively large proportion of, a wider deep-water biogeographical area ('New Zealand Kermadec lower bathyal province', UNESCO 2009) for benthic fauna (e.g. hermit crabs, Forest & McLay 2001)
- Some of its fauna are connected via larval dispersal or species exchanges, or have functional linkages to other areas that are already protected (e.g. see Miller et al. (2006), who found that there was no geographic variation in the genetic population structure of the stony coral *Solenosmilia variabilis* in the southwest Pacific—this coral occurs on protected Tasmanian seamounts)
- It contains multiple examples of particular ecological features (e.g. there are numerous seamounts and vent sites throughout the area)
- The area as a whole, if protected, is most likely to be of sufficient size to ensure the viability and integrity of the feature(s) for which it is selected (i.e. the study area covers an area of >200 000 km<sup>2</sup>).

## 4.4 Threats

As already mentioned in section 4.3, the main threats to the study area (but not the CMA itself, because of the legal protection already afforded this area by the designation of the marine reserve) are from fishing and potential mining.

Fishing, either so-called 'off bottom' trawling or long-lining, which are both allowed within the Kermadec BPA, are a potential threat to marine life in the area. Allowable trawling will obviously remove fish species and, where the trawl inadvertently makes contact with the seabed, could remove larger invertebrate species and disturb habitat (including hydrothermal vents). Long-lining will similarly remove target species and has the potential to remove larger invertebrates during recovery of the line and bottom weight. The consequences of these sorts of threats to the assemblages found on seamounts are reviewed in Clark & Koslow (2007).

Exploratory marine mining practices, such as the drilling of test holes and removal of discrete geological samples to assess the potential value of seafloor massive sulphides are thought to have only localised effects on seabed fauna (Consalvey 2007). However, the prospect of commercial-scale mining in the deep sea poses a potentially significant threat to seabed assemblages (Glover & Smith 2003), primarily through the physical disturbance of the seabed associated with the removal of crustal material, particularly if this activity is in the vicinity of active hydrothermal vents. As already noted, no exploratory mining investigations have yet taken place in the study area and commercial-scale mining in the Kermadec region (which will most probably take place south of the study area) is not likely to occur in the immediate future. The International Seabed Authority has published guidelines for exploratory sampling in High Seas Areas under its jurisdiction (ISA 2007), and these have been noted by minerals exploration companies with permits in the New Zealand EEZ.

Scientific sampling is relatively uncommon in the study area; however, when it takes place, it does present a localised threat to the biota. Obviously, direct sampling by dredge and sled removes organisms from their environment, and the passage of the gear can physically disturb the seabed. Of particular concern is the direct sampling of hydrothermal vents by such gear because vent sites are relatively small (covering from under tens to hundreds of square metres) and can include fragile structures such as chimneys and crusts, as well as relatively dense concentrations of vent organisms such as alvinocarid shrimp and bathymodiolid mussels. Scientific sampling is not often listed as a threat to marine life either because the scale is relatively inconsequential (compared with bottom trawling) or because it is considered necessary in order to obtain biodiversity information that will assist in the management of the oceans. However, in the case of Kermadec hydrothermal vents, uncontrolled scientific sampling using direct gears has the potential to be a small-scale, localised threat (e.g. ISA 2007, Chapter 18).

Another potential threat to marine life in the study area could arise from shipping, although the consequences of this threat to deepwater assemblages are more difficult to envisage than for shallow and inshore assemblages. Nonetheless, it is worth mentioning briefly the threat issues that relate to shipping. Ships utilising shipping lanes that transit the study area could, in the event of damage to their hulls, leak fuel or liquid cargo such as crude oil. In such an event, these toxic substances could pose a threat to marine life. In addition, ships can act as inadvertent carriers of invasive species, either on their hulls or in their ballast water. It is conceivable that hull-borne invasive species could become detached in the study area or that ballast organisms could be discharged with ballast water. If invasive species are so released into the area and they find suitable habitat, populations of these species may become established. The consequences of the presence of invasive species in the New Zealand marine environment are considered in Cranfield et al. (1998).

## 5. Recommendations

In light of the findings of this study, the following recommendations are made:

- Based on the limited information available to this study, the best interpretation is that the study area is ecologically significant and suitable for inclusion in a large-scale network of MPAs.
- Biological surveys are required to better document the biodiversity of deepwater habitats in the Kermadec Islands region, and elsewhere in the vicinity of the Kermadec Ridge. These surveys should employ systematic sampling strategies that enable robust comparisons between habitats (such as seamounts), which can then establish levels of faunal variability throughout the region.
- Because of the sensitivity of some of the habitats in the region (particularly hydrothermal vents), wherever possible, non-destructive sampling techniques should be used. This means that, seabed imagery, obtained by towed cameras, submersibles and ROVs, should be considered the primary means by which to determine the composition of seabed assemblages. Although direct sampling will be needed to determine the identity of some species and to collect material for genetic and microbial studies, it should be kept to a minimum in the vicinity of hydrothermal vents.
- For the purposes of future management, a more thorough evaluation of the ecological or biological significance of the study area should be undertaken, and a more comprehensive assessment of the threats be carried out (including their relative importance).
- Because marine mining is likely to be a future activity in the region, research is required to evaluate the potential impacts of mining on seabed assemblages (including those of hydrothermal vents).

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# Appendix 1

## Taxa list, for each seamount, for TAN0205 direct samples

PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT						
						SONNE	NGATOROI- RANGI	HAUNGA- ROA	HAVRE	GIGGEN- BACH	MACAULEY	
Annelida	Polychaeta	Eunicida	Eunicidae	<i>Eunice</i>	<i>Eunice</i> sp. 1	+		+				
Annelidat	Polychaeta	Eunicida	Onuphidae	[Onuphidae]	<i>Onuphidae</i> sp. 4				+			
Annelida	Polychaeta	Eunicida	Onuphidae	[Onuphidae]	<i>Onuphidae</i> sp. 1	+		+				
Annelida	Polychaeta	Eunicida	Onuphidae	<i>Hyalinoecia</i>	<i>Hyalinoecia</i> sp. 1		+					
Annelida	Polychaeta	Eunicida	Onuphidae	<i>Nothria</i>	<i>Nothria</i> sp. B	+			+			
Annelida	Polychaeta	Phyllocladida	Glyceridae	<i>Glyceria</i>	<i>Glyceria lapidum</i>			+				
Annelida	Polychaeta	Phyllocladida	Polynoidea	[Polynoidea]	<i>Polynoidea</i> sp. 8							+
Annelida	Polychaeta	Phyllocladida	Polynoidea	<i>Harmothoe</i>	<i>Harmothoe</i>	+						
					<i>macrolepidota</i>							
Annelida	Polychaeta	Sabellida	Serpulidae	[Serpulidae]	<i>Serpulidae</i> sp. A							+
Annelida	Polychaeta	Sabellida	Serpulidae	[Serpulidae]	<i>Serpulidae</i> sp. E					+		
Annelida	Polychaeta	Sabellida	Serpulidae	[Serpulidae]	<i>Serpulidae</i> sp. C				+			
Annelida	Polychaeta	Sabellida	Serpulidae	[Serpulidae]	<i>Serpulidae</i> sp. D				+			
Annelida	Polychaeta	Sabellida	Serpulidae	[Serpulidae]	<i>Serpulidae</i> sp. F		+		+			+
Annelida	Polychaeta	Sabellida	Serpulidae	<i>Placostegus</i>	<i>Placostegus</i> sp.		+		+			
Annelida	Polychaeta	Scolecida	Maldanidae	<i>Notoproctus</i>	<i>Notoproctus</i> sp. A					+		
Annelida	Polychaeta	Spionida	Chaetopteridae	<i>Spiochaetopterus</i>	<i>Spiochaetopterus</i> sp.		+					
Brachiopoda	[Brachiopoda]	[Brachiopoda]	[Brachiopoda]	[Brachiopoda]	<i>Brachiopoda</i> sp. 1							+
Brachiopoda	[Brachiopoda]	[Brachiopoda]	[Brachiopoda]	[Brachiopoda]	<i>Brachiopoda</i> sp. 2							+
Bryozoa	Gymnolaemata	Cheilostomata	Arachnopusiidae	<i>Arachnopusia</i>	<i>Arachnopusia perforata</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Arachnopusiidae	<i>Briarachnia</i>	<i>Briarachnia robusta</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Beanidae	<i>Beania</i>	<i>Beania plurispinosa</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Beanidae	<i>Beania</i>	<i>Beania discodermiae</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Beanidae	<i>Beania</i>	<i>Beania magellanica</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Bifaxariidae	<i>Diplonotos</i>	<i>Diplonotos</i> sp. "acutus"				+			+
Bryozoa	Gymnolaemata	Cheilostomata	Bitectiporidae	<i>Metropierella</i>	<i>Metropierella triangula</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Bitectiporidae	<i>Parkermavella</i>	<i>Parkermavella</i> sp.							+
					"biaviculata"							
Bryozoa	Gymnolaemata	Cheilostomata	Bitectiporidae	<i>Parkermavella</i>	<i>Parkermavella</i> sp.		+					+
					"septemspinosa"							
Bryozoa	Gymnolaemata	Cheilostomata	Buffonellodidae	<i>Buffonelloides</i>	<i>Buffonelloides granulosa</i>		+					+
Bryozoa	Gymnolaemata	Cheilostomata	Bugulidae	<i>Cornucopina</i>	<i>Cornucopina</i> sp.						+	

Continued on next page



PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT						
						SONNE	NGATOROI- RANGI	HAUNGA- ROA	HAVRE	GIGGEN- BACH	MACAULEY	
Bryozoa	Gymnolaemata	Cheilostomata	Bugulidae	<i>Cornucopina</i>	<i>Cornucopina geniculata</i>			+				
Bryozoa	Gymnolaemata	Cheilostomata	Bugulidae	<i>Himantozoom</i>	<i>Himantozoom</i> sp.			+				
Bryozoa	Gymnolaemata	Cheilostomata	Calloporidae	<i>Amphiblestrum</i>	<i>Amphiblestrum alcimum</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Calloporidae	<i>Callopora</i>	<i>Callopora</i> sp.		+					
Bryozoa	Gymnolaemata	Cheilostomata	Calloporidae	<i>Corbulella</i>	<i>Corbulella translucens</i>		+					
Bryozoa	Gymnolaemata	Cheilostomata	Calloporidae	<i>Crassimarginatella</i>	<i>Crassimarginatella</i> sp. "vicaria"							+
Bryozoa	Gymnolaemata	Cheilostomata	Calloporidae	<i>Crassimarginatella</i>	<i>Crassimarginatella</i> <i>spathulata</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Calloporidae	<i>Ellisina</i>	<i>Ellisina bathyalis</i>		+					
Bryozoa	Gymnolaemata	Cheilostomata	Calloporidae	<i>Marssonopora</i>	<i>Marssonopora</i> <i>kernadecensis</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Candidae	<i>Notoplites</i>	<i>Notoplites</i> sp.		+					
Bryozoa	Gymnolaemata	Cheilostomata	Cellariidae	<i>Cellaria</i>	<i>Cellaria tenuirostris</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cellariidae	<i>Cellaria</i>	<i>Cellaria immersa</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cellariidae	<i>Euginoma</i>	<i>Euginoma</i> sp. "pinnata"		+					
Bryozoa	Gymnolaemata	Cheilostomata	Cellariidae	<i>Stomhypselosaria</i>	<i>Stomhypselosaria</i> sp.		+					
Bryozoa	Gymnolaemata	Cheilostomata	Celleporidae	<i>Galeopsis</i>	<i>Galeopsis polyporus</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Celleporidae	<i>Galeopsis</i>	<i>Galeopsis pentagonus</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Celleporidae	<i>Lagenipora</i>	<i>Lagenipora</i> sp.		+					
Bryozoa	Gymnolaemata	Cheilostomata	Celleporidae	<i>Osthimosia</i>	<i>Osthimosia</i> sp.							+
Bryozoa	Gymnolaemata	Cheilostomata	Celleporidae	<i>Osthimosia</i>	<i>Osthimosia virgula</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Celleporidae	<i>Richbunea</i>	<i>Richbunea incomposita</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Chaperidae	<i>Chaperia</i>	<i>Chaperia multispinosa</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Chaperidae	<i>Chaperiopsis</i>	<i>Chaperiopsis cervicornis</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Chaperidae	<i>Chaperiopsis</i>	<i>Chaperiopsis splendida</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Chaperidae	<i>Icelozoon</i>	<i>Icelozoon</i> sp. "cervicornis"							+
Bryozoa	Gymnolaemata	Cheilostomata	Chorizoporidae	<i>Chorizopora</i>	<i>Chorizopora spicata</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cleidochasmatidae	<i>Yrbozoon</i>	<i>Yrbozoon ringens</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Crepidacanthidae	<i>Crepidacantha</i>	<i>Crepidacantha</i> sp. "disjuncta"							+
Bryozoa	Gymnolaemata	Cheilostomata	Crepidacanthidae	<i>Crepidacantha</i>	<i>Crepidacantha bracebridgei</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cribriliinidae	<i>Figularia</i>	<i>Figularia huttoni</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cribriliinidae	<i>Figularia</i>	<i>Figularia carinata</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cribriliinidae	<i>Figularia</i>	<i>Figularia pelmatifera</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cribriliinidae	<i>Klugerella</i>	<i>Klugerella gordoni</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Cribriliinidae	<i>Membraniporella</i>	<i>Membraniporella</i> sp.							+
Bryozoa	Gymnolaemata	Cheilostomata	Cribriliinidae	<i>Membraniporella</i>	<i>Membraniporella figularioides</i>		+					

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PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT						
						SONNE	NGATOROI- RANGI	HAUNGA- ROA	HAVRE	GIGGEN- BACH	MACAULEY	
Bryozoa	Gymnolaemata	Cheilostomata	Phidoloporidae	Rhynchozoon	<i>Rhynchozoon paa</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Phidoloporidae	Rhynchozoon	<i>Rhynchozoon</i> sp.							+
Bryozoa	Gymnolaemata	Cheilostomata	Phidoloporidae	Stephanollona	<i>Stephanollona longispinata</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Quadricellariidae	Quadricellaria	<i>Quadricellaria bocki</i>			+				
Bryozoa	Gymnolaemata	Cheilostomata	Romancheinidae	Escharella	<i>Escharella bersoni</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Schizoporellidae	Chiastosella	<i>Chiastosella longaevitae</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Schizoporellidae	Escharina	<i>Escharina waiparaensis</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Schizoporellidae	Escharina	<i>Escharina pesanseris</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Smittinidae	Hemismittoidea	<i>Hemismittoidea</i> sp.		+					
Bryozoa	Gymnolaemata	Cheilostomata	Smittinidae	Hemismittoidea	<i>Hemismittoidea hexaspinosa</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Smittinidae	Parasmittina	<i>Parasmittina</i> sp.							+
Bryozoa	Gymnolaemata	Cheilostomata	Steginoporellidae	Steginoporella	<i>Steginoporella magnifica</i>							+
Bryozoa	Gymnolaemata	Cheilostomata	Steginoporellidae	Steginoporella	<i>Steginoporella</i> sp. <i>lineata</i>							+
Bryozoa	Stenolaemata	Cyclostomata	Arnectocymidae	Entalophorecia	<i>Entalophorecia</i> sp.		+					+
Bryozoa	Stenolaemata	Cyclostomata	Diaperoeciidae	Diaperoecia	<i>Diaperoecia</i> sp.							+
					<i>brevicaulex</i>							
Bryozoa	Stenolaemata	Cyclostomata	Diaperoeciidae	Harmelinopora	<i>Harmelinopora</i> sp.							+
Bryozoa	Stenolaemata	Cyclostomata	Diastoporidae	Eurystrotos	<i>Eurystrotos</i> sp.		+					+
Bryozoa	Stenolaemata	Cyclostomata	Diastoporidae	Eurystrotos	<i>Eurystrotos ridleyi</i>							+
Bryozoa	Stenolaemata	Cyclostomata	Lichenoporidae	Disporella	<i>Disporella</i> sp.		+					+
Bryozoa	Stenolaemata	Cyclostomata	Oncousoeciidae	Stomatopora	<i>Stomatopora</i> sp.							+
Bryozoa	Stenolaemata	Cyclostomata	Tubuliporidae	Reptotubigera	<i>Reptotubigera philippae</i>							+
Cnidaria	Anthozoa	Actiniaria	[Actiniaria]	[Actiniaria]	<i>Actiniaria</i> sp. 1					+		
Cnidaria	Anthozoa	Actiniaria	[Actiniaria]	[Actiniaria]	<i>Actiniaria</i> sp. 3		+					
Cnidaria	Anthozoa	Actiniaria	[Actiniaria]	[Actiniaria]	<i>Actiniaria</i> sp. 5					+		
Cnidaria	Anthozoa	Actiniaria	[Actiniaria]	[Actiniaria]	<i>Actiniaria</i> sp. 2		+					+
Cnidaria	Anthozoa	Actiniaria	[Actiniaria]	[Actiniaria]	<i>Actiniaria</i> sp. 4		+			+		+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	? <i>Antipathes</i>	? <i>Antipathes</i> sp.		+					
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Antipathes	<i>Antipathes cf. gracilis</i>							+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Antipathes	<i>Antipathes cf. strigosa</i>							+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Antipathes	<i>Antipathes</i> sp. 1							+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Antipathes	<i>Antipathes cf. ulex</i>							+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Antipathes	<i>Antipathes cf. aperta</i>							+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Aphanipathes	<i>Aphanipathes</i> sp. 2							+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Aphanipathes	<i>Aphanipathes</i> sp. 1							+

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PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT										
						SONNE	NGATOROI- RANGI	HAUNGA- ROA	HAVRE	GIGGEN- BACH	MACAULEY					
Cnidaria	Anthozoa	Antipatharia	Antipathidae	Bathypathes	Bathypathes sp.											
Cnidaria	Anthozoa	Antipatharia	Antipathidae	<i>Parantipathes</i>	<i>Parantipathes cf. tenuispina</i>	+										+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	<i>Parantipathes</i>	<i>Parantipathes cf. columnaris</i>											+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	<i>Parantipathes</i>	<i>Parantipathes cf. helichosticha</i>											+
Cnidaria	Anthozoa	Antipatharia	Antipathidae	<i>Stichopathes</i>	<i>Stichopathes cf. variabilis</i>	+										+
Cnidaria	Anthozoa	Scleractinia	[Scleractinia]	[Scleractinia]	<i>Scleractinia</i> sp. 2 indet.		+									+
Cnidaria	Anthozoa	Scleractinia	[Scleractinia]	[Scleractinia]	<i>Scleractinia</i> sp. 1 indet.		+									+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Caryophyllia</i>	<i>Caryophyllia lamellifera</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Caryophyllia</i>	<i>Caryophyllia diomediae</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Caryophyllia</i>	<i>Caryophyllia rugosa</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Caryophyllia</i>	<i>Caryophyllia cf. ambrossia</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Caryophyllia</i>	<i>Caryophyllia scobinosa</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Conotrochus</i>	<i>Conotrochus brunneus</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Deltocyathus</i>	<i>Deltocyathus formosus</i>	+										+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Goniocorella</i>	<i>Goniocorella dumosa</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Solenosmilia</i>	<i>Solenosmilia variabilis</i>											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Stephanocyathus</i>	<i>Stephanocyathus coronatus</i>	+										+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Trochocyathus</i>	<i>Trochocyathus</i> sp.											+
Cnidaria	Anthozoa	Scleractinia	Caryophylliidae	<i>Vaughanella</i>	<i>Vaughanella multipalifera</i>											+
Cnidaria	Anthozoa	Scleractinia	Dendrophylliidae	<i>Balanophyllia</i>	<i>Balanophyllia</i> sp.											+
Cnidaria	Anthozoa	Scleractinia	Dendrophylliidae	<i>Eguchipsammia</i>	<i>Eguchipsammia japonica</i>											+
Cnidaria	Anthozoa	Scleractinia	Dendrophylliidae	<i>Eguchipsammia</i>	<i>Eguchipsammia fistula</i>											+
Cnidaria	Anthozoa	Scleractinia	Dendrophylliidae	<i>Enallopsammia</i>	<i>Enallopsammia rostrata</i>											+
Cnidaria	Anthozoa	Scleractinia	Flabellidae	<i>Flabellum</i>	<i>Flabellum cf. hoffmeisteri</i>											+
Cnidaria	Anthozoa	Scleractinia	Flabellidae	<i>Flabellum</i>	<i>Flabellum lowekeyesi</i>											+
Cnidaria	Anthozoa	Scleractinia	Flabellidae	<i>Flabellum</i>	<i>Flabellum ?messum</i>											+
Cnidaria	Anthozoa	Scleractinia	Flabellidae	<i>Polymyces</i>	<i>Polymyces wellsi</i>											+
Cnidaria	Anthozoa	Scleractinia	Fungiacyathidae	<i>Fungicyathus</i>	<i>Fungicyathus</i> sp.	+										+
Cnidaria	Anthozoa	Scleractinia	Guyniidae	? <i>Stenocyathus</i>	? <i>Stenocyathus</i> <i>vermiformis</i>											+
Cnidaria	Anthozoa	Zoanthinaria	Epizoanthidae	<i>Epizoanthus</i>	<i>Epizoanthus</i> sp.	+										+
Cnidaria	Anthozoa	Alcyonacea	Clavulariidae	<i>Telestula</i>	<i>Telestula</i> sp. 2											+
Cnidaria	Anthozoa	Alcyonacea	Nephtheidae	[Nephtheidae]	<i>Nephtheidae</i> sp. 1											+
Cnidaria	Anthozoa	Alcyonacea	Nephtheidae	[Nephtheidae]	<i>Nephtheidae</i> sp. 3											+
Cnidaria	Anthozoa	Alcyonacea	Nephtheidae	[Nephtheidae]	<i>Nephtheidae</i> sp. 4											+
Cnidaria	Anthozoa	Alcyonacea	Nephtheidae	[Nephtheidae]	<i>Nephtheidae</i> sp. 2											+

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PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT						
						SONNE	NGATOROI- RANGI	HAUNGA- ROA	HAVRE	GIGGEN- BACH	MACAULEY	
Crustacea	Cirripedia	Verrucomorpha	Verrucidae	[Verrucidae]	Verrucidae sp. 2A				+			
Crustacea	Cirripedia	Verrucomorpha	Verrucidae	[Verrucidae]	Verrucidae sp. 6				+			
Crustacea	Cirripedia	Verrucomorpha	Verrucidae	[Verrucidae]	Verrucidae sp. 7				+			
Crustacea	Cirripedia	Verrucomorpha	Verrucidae	[Verrucidae]	Verrucidae sp. 9			+				
Crustacea	Cirripedia	Verrucomorpha	Verrucidae	[Verrucidae]	Verrucidae sp. 8			+				
Crustacea	Decapoda	Anomura	Chirostylidae	Urotychus	Urotychus sp. 1				+			
Crustacea	Decapoda	Anomura	Chirostylidae	Urotychus	Urotychus sp. 2				+			
Crustacea	Decapoda	Anomura	Chirostylidae	Urotychus	Urotychus sp. 3				+			
Crustacea	Decapoda	Anomura	Galatheididae	Munida	Munida sp. 1		+					
Crustacea	Decapoda	Anomura	Galatheididae	Munida	Munida sp. 4				+			
Crustacea	Decapoda	Anomura	Galatheididae	Munida	Munida sp. 6							+
Crustacea	Decapoda	Anomura	Galatheididae	Munidopsis	Munidopsis sp. 1		+					
Crustacea	Decapoda	Anomura	Galatheididae	Munida	Munida sp. 5			+				
Crustacea	Decapoda	Anomura	Galatheididae	Munida	Munida sp. 3							+
Crustacea	Decapoda	Anomura	Galatheididae	Munidopsis	Munidopsis sp. 2		+					
Crustacea	Decapoda	Anomura	Galatheididae	Alainius	Alainius sp. 1			+				+
Crustacea	Decapoda	Anomura	Galatheididae	Munida	Munida sp. 2							+
Crustacea	Decapoda	Anomura	Galatheididae	Munida	Munida sp. 7			+				
Crustacea	Decapoda	Anomura	Lithodidae	Paralomis	Paralomis sp.							
Crustacea	Decapoda	Anomura	Paguridae	[Paguridae]	Paguridae sp. 2		+					
Crustacea	Decapoda	Anomura	Paguridae	[Paguridae]	Paguridae sp. 3							+
Crustacea	Decapoda	Anomura	Paguridae	[Paguridae]	Paguridae sp. 1		+					
Crustacea	Decapoda	Anomura	Parapaguridae	Parapagurus	Parapagurus sp.			+				
Crustacea	Decapoda	Anomura	Parapaguridae	[Parapaguridae]	Parapaguridae sp. 2			+				
Crustacea	Decapoda	Anomura	Parapaguridae	[Parapaguridae]	Parapaguridae sp. 3			+				
Crustacea	Decapoda	Brachyura	[Brachyura]	[Brachyura]	Brachyura indet. sp. 1							+
Crustacea	Decapoda	Brachyura	[Brachyura]	[Brachyura]	Brachyura indet. sp. 2							+
Crustacea	Decapoda	Brachyura	[Brachyura]	[Brachyura]	Brachyura indet. sp. 3			+				
Crustacea	Decapoda	Brachyura	Goneplacidae	Carcinoplax	Carcinoplax sp. 1							+
Crustacea	Decapoda	Brachyura	Goneplacidae	Carcinoplax	Carcinoplax sp. 2							+
Crustacea	Decapoda	Brachyura	Goneplacidae	Trachycarcinus	Trachycarcinus sp. 3			+				
Crustacea	Decapoda	Caridea	Alpheidae	Vexillipar	Vexillipar sp.							+
Crustacea	Decapoda	Caridea	Crangonidae	Pontophilus	Pontophilus gracilis				+			
					?juncus							
Crustacea	Decapoda	Caridea	Nematocarcinidae	Nematocarcinus	Nematocarcinus sp. 1				+			
Crustacea	Decapoda	Caridea	Oplophoridae	Oplophorus	Oplophorus sp.			+				
Crustacea	Decapoda	Caridea	Oplophoridae	Acanthephyra	Acanthephyra quadrispinosa							+

Continued on next page

PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT							
						SONNE	NGATOROI- RANGI	HAUNGA- ROA	HAVRE	GIGGEN- BACH	MACAULEY		
Crustacea	Decapoda	Caridea	Pandalidae	[Pandalidae]	Pandalidae sp.				+				
Crustacea	Decapoda	Caridea	Pandalidae	Heterocarpus	Heterocarpus sp.								+
Crustacea	Decapoda	Caridea	Pandalidae	?Hymenopenaeus	?Hymenopenaeus sp.								+
Crustacea	Decapoda	Caridea	Rhynchocinetidae	Rhynchocinetes	Rhynchocinetes balssi								+
Crustacea	Decapoda	Caridea	Styloclastidae	Styloclastus	Styloclastus discissipes								+
Crustacea	Decapoda	Palinura	Polycheilidae	[Polycheilidae]	Polycheilidae sp.								+
Crustacea	Isopoda	Sphaeromatidea	Serolidae	Acutiserolis	Acutiserolis sp.								+
Crustacea	Isopoda	Valvifera	Austrarcturellidae	Austrarcturella	Austrarcturella sp.								+
Echinodermata	Asteroidae	Brisingida	[Brisingida]	[Brisingida]	Brisingida sp.	+							
Echinodermata	Asteroidae	Brisingida	Novodniidae	Novodnia	Novodnia sp.	+							
Echinodermata	Asteroidae	Forcipulatida	Asteriidae	Asteriid	Asteriid sp. B								+
Echinodermata	Asteroidae	Forcipulatida	Asteriidae	Asteriid	Asteriid sp. A								+
Echinodermata	Asteroidae	Forcipulatida	Labidiasteridae	Coronaster	Coronaster sp.								+
Echinodermata	Asteroidae	Forcipulatida	Benthopectinidae	Benthopecten	Benthopecten sp.								+
Echinodermata	Asteroidae	Notomyotida	Benthopectinidae	Cheiraster	Cheiraster ?ludwigi								+
Echinodermata	Asteroidae	Notomyotida	Benthopectinidae	Plutonaster	Plutonaster hikurangi								+
Echinodermata	Asteroidae	Paxillosida	Asteriidae	Nepanthia	Nepanthia sp.								+
Echinodermata	Asteroidae	Valvatida	Goniasteridae	Mediaster	Mediaster arcuatus								+
Echinodermata	Asteroidae	Valvatida	Goniasteridae	Mediaster	Mediaster gartreli								+
Echinodermata	Asteroidae	Valvatida	Goniasteridae	Mediaster	Mediaster sp.								+
Echinodermata	Asteroidae	Valvatida	Goniasteridae	Pilsburiaster	Pilsburiaster aoteanus								+
Echinodermata	Asteroidae	Valvatida	Goniasteridae	[?Bourgueticinida]	[?Bourgueticinida] sp.								+
Echinodermata	Crinoidea	Comatulida	[Comatulida]	Comatulida	Comatulida sp.								+
Echinodermata	Crinoidea	Comatulida	Charitometridae	[Charitometridae]	Charitometridae sp.								+
Echinodermata	Crinoidea	Comatulida	Charitometridae	Charitometra	Charitometra basicurva								+
Echinodermata	Crinoidea	Comatulida	Charitometridae	Charitometra	Charitometra incisa								+
Echinodermata	Crinoidea	Comatulida	Charitometridae	Strotometra	Strotometra ornatissimus								+
Echinodermata	Crinoidea	Comatulida	Comasteridae	[Comasteridae]	Comasteridae sp.								+
Echinodermata	Crinoidea	Comatulida	Pentametrocrinidae	Pentametrocrinus	Pentametrocrinus semperi								+
Echinodermata	Crinoidea	Comatulida	Thalassometridae	[Thalassometridae]	Thalassometridae sp. B								+
Echinodermata	Crinoidea	Comatulida	Thalassometridae	[Thalassometridae]	Thalassometridae sp. A								+
Echinodermata	Crinoidea	Hyocrinida	Ptilocrinus	Ptilocrinus	Ptilocrinus sp.								+
Echinodermata	Crinoidea	Isocrinida	[Isocrinidae]	[Isocrinidae]	Isocrinidae sp.								+
Echinodermata	Crinoidea	Isocrinida	Isocrinidae	Hyalocrinus	Hyalocrinus naresianus								+
Echinodermata	Crinoidea	Isocrinida	Isocrinidae	Histocidaris	Histocidaris sp. B								+
Echinodermata	Echinoidea	Cidaroida	Cidaridae	Phyllacanthus	Phyllacanthus imperialis								+
Echinodermata	Echinoidea	Cidaroida	Cidaridae	Stylocidaris	Stylocidaris sp.								+
Echinodermata	Echinoidea	Cidaroida	Cidaridae	?Echinocyamus	?Echinocyamus sp.								+
Echinodermata	Echinoidea	Glypeasteroida	Fibulariidae										+

PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT							
						SONNE	NGATOROI-RANGI	HAUNGA-ROA	HAVRE	GIGGEN-BACH	MACAULEY		
Echinodermata	Echinoidea	Diadematoidea	Aspidodiadematae	<i>Aspidodiadema</i>	<i>Aspidodiadema tonsum</i>	+		+	+				
Echinodermata	Echinoidea	Echinoidea	Echinidae	<i>Gracilechinus</i>	<i>Gracilechinus multidentatus</i>	+			+				
Echinodermata	Echinoidea	Echinothuroidea	Echinothuridae	? <i>Araeosoma</i>	? <i>Araeosoma</i> sp.			+					
Echinodermata	Echinoidea	Pedinoidea	Pedinoidea	<i>Caenopedina</i>	<i>Caenopedina</i> sp.	+							+
Echinodermata	Echinoidea	Salenioida	Saleniidae	<i>Salenocidaris</i>	<i>Salenocidaris hastigera</i>	+							
Echinodermata	Holothuroidea	[Holothuroidea]	[Holothuroidea]	[Holothuroidea]	<i>Holothuroidea</i> sp. A	+							
Echinodermata	Holothuroidea	[Holothuroidea]	[Holothuroidea]	[Holothuroidea]	<i>Holothuroidea</i> sp. B	+							
Echinodermata	Holothuroidea	[Holothuroidea]	[Holothuroidea]	[Holothuroidea]	<i>Holothuroidea</i> sp. C			+					
Echinodermata	Holothuroidea	[Holothuroidea]	[Holothuroidea]	[Holothuroidea]	<i>Holothuroidea</i> sp. D	+							
Echinodermata	Holothuroidea	[Holothuroidea]	[Holothuroidea]	[Holothuroidea]	<i>Holothuroidea</i> sp. E	+							
Echinodermata	Holothuroidea	[Holothuroidea]	[Holothuroidea]	[Holothuroidea]	<i>Holothuroidea</i> sp. F	+				+			
Echinodermata	Holothuroidea	[Holothuroidea]	[Holothuroidea]	[Holothuroidea]	<i>Paracaudina</i> sp.								
Echinodermata	Ophiuroidea	Euryalinea	[Euryalinea]	[Euryalinea]	<i>Euryalinea</i> sp.			+					
Echinodermata	Ophiuroidea	Euryalinea	Asteronychidae	<i>Asteronyx</i>	<i>Asteronyx loveni</i>		+						
Echinodermata	Ophiuroidea	Euryalinea	Asteroschematidae	<i>Asteroschema</i>	<i>Asteroschema horridum</i>				+				
Echinodermata	Ophiuroidea	Euryalinea	Asteroschematidae	<i>Asteroschema</i>	<i>Asteroschema tubiferum</i>			+					+
Echinodermata	Ophiuroidea	Euryalinea	Asteroschematidae	<i>Asteroschema</i>	<i>Asteroschema bidwillae</i>			+					
Echinodermata	Ophiuroidea	Euryalinea	Asteroschematidae	<i>Ophiocreas</i>	<i>Ophiocreas oedipus</i>	+							
Echinodermata	Ophiuroidea	Ophiurida	[Ophiurida]	[Ophiurida]	<i>Ophiurida</i> sp.		+						
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	? <i>Amphioplus</i>	? <i>Amphioplus</i> sp.		+						
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	<i>Amphiura</i>	<i>Amphiura</i> sp. A	+				+			
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	<i>Amphiura</i>	<i>Amphiura</i> sp. C	+							+
Echinodermata	Ophiuroidea	Ophiurida	Amphiuridae	<i>Amphiura</i>	<i>Amphiura</i> sp. B	+				+			
Echinodermata	Ophiuroidea	Ophiurida	Hemieuryalidae	<i>Amphigyptis</i>	<i>Amphigyptis clausa</i>	+				+			
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	? <i>Ophioprium</i>	? <i>Ophioprium</i> sp.		+						+
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	[Ophiacanthidae]	[Ophiacanthidae] sp.								+
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophiacantha</i>	<i>Ophiacantha rosea</i>				+				
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophiacantha</i>	<i>Ophiacantha</i> sp. B	+				+			
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophiacantha</i>	<i>Ophiacantha</i> sp. A	+				+			
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophiocamax</i>	<i>Ophiocamax</i> sp.		+						+
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophiolebes</i>	<i>Ophiolebes</i> sp.		+						
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophiomyces</i>	<i>Ophiomyces</i> sp.		+						
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophioplinthaca</i>	<i>Ophioplinthaca</i> sp.		+						
Echinodermata	Ophiuroidea	Ophiurida	Ophiacanthidae	<i>Ophioplinthaca</i>	<i>Ophioplinthaca chelys</i>		+						
Echinodermata	Ophiuroidea	Ophiurida	Ophiactidae	<i>Ophiactis</i>	<i>Ophiactis profundus</i>		+						+
Echinodermata	Ophiuroidea	Ophiurida	Ophiactidae	<i>Ophiactis</i>	<i>Ophiactis abyssicola</i>	+							
Echinodermata	Ophiuroidea	Ophiurida	Ophiactidae	<i>Ophiactis</i>	<i>Ophiactis</i> ab. var. <i>cuspidata</i>	+							
Echinodermata	Ophiuroidea	Ophiurida	Ophiocomidae	<i>Clarkcoma</i>	<i>Clarkcoma bollonsi</i>								+



PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT									
						SONNE	NGATOROI- RANGI	HAUNGA- ROA	HAVRE	GIGGEN- BACH	MACAULEY				
Echinodermata	Ophiuroidea	Ophiurida	Ophiocomidae	<i>Ophiopsila</i>	<i>Ophiopsila</i> sp.		+								
Echinodermata	Ophiuroidea	Ophiurida	Ophioleucidae	? <i>Ophiostriatus</i>	? <i>Ophiostriatus</i> sp. B	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophioleucidae	<i>Ophiernus</i>	<i>Ophiernus vallinicola</i>	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophioleucidae	<i>Ophioluce</i>	<i>Ophioluce brevispinum</i>				+						
Echinodermata	Ophiuroidea	Ophiurida	Ophiomixidae	<i>Astrogymnotes</i>	<i>Astrogymnotes thomasinae</i>										+
Echinodermata	Ophiuroidea	Ophiurida	Ophiomixidae	<i>Ophiogeron</i>	<i>Ophiogeron edentulatus</i>	+		+							+
Echinodermata	Ophiuroidea	Ophiurida	Ophiomixidae	<i>Ophiomyxa</i>	<i>Ophiomyxa</i> sp.										+
Echinodermata	Ophiuroidea	Ophiurida	Ophiomixidae	<i>Ophioscolex</i>	<i>Ophioscolex</i> sp.	+		+							+
Echinodermata	Ophiuroidea	Ophiurida	Ophionerecidiae	<i>Ophiochiton</i>	<i>Ophiochiton fastigatus</i>	+		+							+
Echinodermata	Ophiuroidea	Ophiurida	Ophionerecidiae	<i>Ophiochiton</i>	<i>Ophiochiton</i> sp.				+						+
Echinodermata	Ophiuroidea	Ophiurida	Ophionerecidiae	<i>Ophiochiton</i>	<i>Ophiochiton lentus</i>			+							+
Echinodermata	Ophiuroidea	Ophiurida	Ophionerecidiae	<i>Ophionereis</i>	<i>Ophionereis fusca</i>									+	+
Echinodermata	Ophiuroidea	Ophiurida	Ophionerecidiae	<i>Ophioplax</i>	<i>Ophioplax</i> sp.									+	+
Echinodermata	Ophiuroidea	Ophiurida	Ophiothrichidae	<i>Ophiothrix</i>	<i>Ophiothrix oliveri</i>										+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	? <i>Ophiurolepis</i>	? <i>Ophiurolepis</i> sp. A	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	? <i>Ophiurolepis</i>	? <i>Ophiurolepis</i> sp. B	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	? <i>Stegophiura</i>	? <i>Stegophiura</i> sp.										
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Amphiophiura</i>	<i>Amphiophiura</i> sp. C	+		+							
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Amphiophiura</i>	<i>Amphiophiura improba</i>	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Amphiophiura</i>	<i>Amphiophiura urbana</i>					+					
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Amphiophiura</i>	<i>Amphiophiura</i> sp. A	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Amphiophiura</i>	<i>Amphiophiura</i> sp. B	+									+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Anthophiura</i>	<i>Anthophiura</i> sp.	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Dictenophiura</i>	<i>Dictenophiura</i> sp.	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiomusium</i>	<i>Ophiomusium lymani</i>	+									+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiomusium</i>	<i>Ophiomusium scalare</i>	+									+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiopyrgoides</i>	<i>Ophiopyrgoides</i> sp. A										
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiopyrgoides</i>	<i>Ophiopyrgoides</i> sp. B										+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiosphalma</i>	<i>Ophiosphalma</i> sp. B										+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiosphalma</i>	<i>Ophiosphalma</i> sp. A										+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiozonella</i>	<i>Ophiozonella stellata</i>	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiura</i>	<i>Ophiura</i> sp. X	+									+
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiura</i>	<i>Ophiura</i> sp. A	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiuroglypha</i>	<i>Ophiuroglypha</i> cf. <i>rugosa</i>										
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiuroglypha</i>	<i>Ophiuroglypha</i> sp.	+									
Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae	<i>Ophiuroglypha</i>	<i>Ophiuroglypha irrorata</i>	+									
Mollusca	Bivalvia	Arcoida	Arcidae	<i>Barbatia</i>	<i>Barbatia</i> sp. 1										+
Mollusca	Bivalvia	Arcoida	Arcidae	<i>Bentharca</i>	<i>Bentharca</i> sp. 1	+									+

PHYLUM	CLASS	ORDER	FAMILY	GENUS	TAXON	SEAMOUNT						
						SONNE	NGATOROI-RANGI	HAUNGA-ROA	HAVRE	GIGGEN-BACH	MACAULEY	
Mollusca	Bivalvia	Arcoida	Arcidae	<i>Samacar</i>	<i>Samacar</i> sp. 1		+					+
Mollusca	Bivalvia	Arcoida	Limopsidae	<i>Limopsis</i>	<i>Limopsis</i> sp. 1		+	+				+
Mollusca	Bivalvia	Pholadomyoidea	Euciroidae	<i>Euciroa</i>	<i>Euciroa</i> sp. 2				+			
Mollusca	Bivalvia	Pholadomyoidea	Verticordiidae	<i>Spinospella</i>	<i>Spinospella ericia</i>				+			
Mollusca	Bivalvia	Poromyoidea	Poromyidae	<i>Cetomya</i>	<i>Cetomya</i> sp. 1		+					
Mollusca	Bivalvia	Pterioidea	Limidae	<i>Lima</i>	<i>Lima</i> sp. 1							+
Mollusca	Bivalvia	Pterioidea	Spondyliidae	<i>Spondylus</i>	<i>Spondylus occidentis</i>							+
Mollusca	Bivalvia	Veneroidea	Chamidae	<i>Chama</i>	<i>Chama</i> sp. 1							+
Mollusca	Bivalvia	Veneroidea	Semelidae	<i>Abra</i>	<i>Abra</i> sp. 1		+					+
Mollusca	Bivalvia	Veneroidea	Lucinidae	<i>Bathyaustriella</i>	<i>Bathyaustriella thionipta</i>							+
Mollusca	Gastropoda	Littorinimorpha	Capulidae	<i>Cerithioderma</i>	<i>Cerithioderma</i> sp. 1		+					
Mollusca	Gastropoda	Littorinimorpha	Cassidae	<i>Oocorys</i>	<i>Oocorys sulcata</i>			+				
Mollusca	Gastropoda	Littorinimorpha	Ficidae	<i>Thalassocyon</i>	<i>Thalassocyon tui</i>		+					
Mollusca	Gastropoda	Littorinimorpha	Triviidae	<i>Trivellona</i>	<i>Trivellona valerieae</i>		+					
Mollusca	Gastropoda	Neogastropoda	Columbellidae	<i>Mitrella</i>	<i>Mitrella</i> sp. 1							
Mollusca	Gastropoda	Neogastropoda	Fasciolaridae	<i>Fusinus</i>	<i>Fusinus chrysoodomoides</i>			+				
Mollusca	Gastropoda	Neogastropoda	Mitridae?	[Mitridae?]	Mitridae? sp. 1		+					
Mollusca	Gastropoda	Neogastropoda	Muricidae	<i>Coralliophila</i>	<i>Coralliophila</i> sp. 1			+				
Mollusca	Gastropoda	Neogastropoda	Nassaridae	<i>Nassarius</i>	<i>Nassarius epharmillus</i>		+					
Mollusca	Gastropoda	Neogastropoda	Turridae	[Turridae]	<i>Turridae</i> sp. 23		+					
Mollusca	Gastropoda	Neogastropoda	Turridae	[Turridae]	<i>Turridae</i> sp. 24		+					
Mollusca	Gastropoda	Neogastropoda	Turridae	<i>Pontiothauma</i>	<i>Pontiothauma</i> sp. 1				+			
Mollusca	Gastropoda	Opisthobranchia	[Opisthobranchia]	[Opisthobranchia]	<i>Opisthobranchia</i> sp. 1		+					
Mollusca	Gastropoda	Ptenoglossa	Epitonidae	<i>Opalia</i>	<i>Opalia</i> sp. 1		+					
Mollusca	Gastropoda	Vetigastropoda	Trochidae	<i>Solarrella</i>	<i>Solarrella</i> sp. 2				+			
Mollusca	Gastropoda	Vetigastropoda	Trochidae	<i>Calliotropis</i>	<i>Calliotropis</i> sp. 6			+				
Nemertea	[Nemertea]	[Nemertea]	[Nemertea]	[Nemertea]	Nemertea sp.							
Pantopoda	Pycnogonida	[Pycnogonida]	[Pycnogonida]	[Pycnogonida]	<i>Pycnogonida</i> sp. 1			+				
Pantopoda	Pycnogonida	[Pycnogonida]	[Pycnogonida]	[Pycnogonida]	<i>Pycnogonida</i> sp. 2			+				
Pantopoda	Pycnogonida	[Pycnogonida]	[Pycnogonida]	[Pycnogonida]	<i>Pycnogonida</i> sp. 3				+			
Porifera	Demospongiae	'Lithistida'	Neopeltidae	<i>Neopelta</i>	<i>Neopelta</i> n. sp. 1							+
Porifera	Demospongiae	'Lithistida'	Phymatellidae	<i>Neoaualaxinia</i>	<i>Neoaualaxinia</i> n. sp. 1							
Porifera	Demospongiae	'Lithistida'	Pleromidae	<i>Pleroma</i>	<i>Pleroma menoui</i>		+					+
Porifera	Demospongiae	Astrophorida	Ancorinidae	<i>Stelletta</i>	<i>Stelletta</i> cf. <i>phialimorpha</i>		+					+
Porifera	Demospongiae	Astrophorida	Ancorinidae	<i>Stelletta</i>	<i>Stelletta</i> n. sp. 2		+					
Porifera	Demospongiae	Astrophorida	Ancorinidae	<i>Stelletta</i>	<i>Stelletta</i> n. sp. 5		+					
Porifera	Demospongiae	Astrophorida	Geodiidae	<i>Geodinella</i>	<i>Geodinella vestigifera</i>							+
Porifera	Demospongiae	Hadromerida	Suberitidae	<i>Pseudosuberites</i>	<i>Pseudosuberites</i> n. sp. 1							+

Continued on next page



# Appendix 2

## Taxa list for TAN0205 still images

PHYLUM	CLASS	ORDER	FAMILY	GENUS	SPECIES	SEAMOUNT							
						SONNE RANGI	NGATOROI- HAUNGA- ROA	HAVRE	GIGGEN- BACH	GI4	GI9	MACAULEY	
Echinodermata	Asteroidea	Valvatida	Goniasteridae	<i>Zoroaster</i>	<i>Zoroaster</i> sp.		+						+
Echinodermata	Asteroidea			<i>Mediaster</i>	<i>Mediaster sladeni</i> unidentified							+	+
Echinodermata	Asteroidea				unidentified		+					+	+
Echinodermata	Ophiuroidea				Unidentified large pink					+			+
Echinodermata	Ophiuroidea				Unidentified, large pink		+						+
Echinodermata	Echinoidea				Unidentified, dark red					+			+
Echinodermata	Echinoidea				Stony coral			+				+	+
Cnidaria	Hexacorallia/ Anthozoa	Scleractinia			Soft coral		+		+				+
Cnidaria	Octocorallia/ Anthozoa	Alyonacea			Unidentified anemone							+	+
Cnidaria	Hexacorallia/ Anthozoa	Actinaria	Hormathiidae										+
Cnidaria	Hexacorallia/ Anthozoa	Actinaria			Large purple anemone ( <i>Boloceroidea</i> sp.?)		+						+
Cnidaria	Hexacorallia/ Anthozoa	Actinaria		Boloceroidea?	Unidentified anemone. Small, bright yellow								+
Mollusca	Gastropoda		Ranellidae		Ranellidae spp.								+
Mollusca	Gastropoda			Aeneator	<i>Aeneator recens</i>								+
Chordata	Actinopterygii	Gadiformes	Moridae	Lepidion?	Probably <i>Lepidion</i> sp.								+
Chordata	Actinopterygii	Gadiformes	Macrouridae	Trachyrincus?	Grenadier (probably <i>Trachyrincus</i> sp.)								+
Porifera	Demospongiae				Unidentified yellow sponge							+	+
Porifera	Demospongiae		Corallistidae		Large white errant polychaete with yellow parapodia								+
Porifera	Hexactinellidae		Euplectellidae?										+
Annelida	Polychaeta												+

# Appendix 3

## Pisces V and ROV dives

### A3.1 Macauley

#### Dive PV616

Substrate at the first part of dive PV616 was relatively barren with respect to macrofaunal life (see Figs 29 & 30). Of the fauna that was observed, the occasional small stony coral colony on hard substrate was most common. There were also very occasional sightings of seafans and whip corals.

Few fish were observed in this first section of the dive. There was a fleeting glimpse of a small shark at the start of the dive (probably a northern spiny dogfish), a snipe fish (*Centriscomps humerosus*), a cucumber fish (*Chlorophthalmus* sp.), sea perch (*Helicolenus* sp.) and an unidentified iridescent green eel. Abundance and diversity of invertebrate fauna were also low, with occasional sightings of unidentified galatheid and pagurid crustaceans and the occasional urchin (probably either of Echinothuriidae or Phormosomatidae). One of the more notable observations was that of a deep sea blind lobster (*Polycheles enthrix*), sitting exposed on some breccia. This species is not often observed, particularly not away from soft sediments where it is usually partially buried (Shane Ahyong, NIWA, pers. comm. 2009).

Towards the end of DVD1, faunal biomass increased with the presence of dense beds of the vent mussels *Gigantidas gladius* and *Volcanidas insolatus*, particularly in soft sediment areas, together with large numbers of predatory asteroids (probably *Sclerasterias mollis* and *S. eructans*). There were also some scattered patches of the bivalve *Bathyaustriella thionipta* (Lucinidae) and the occasional gastropod, as well as a tarakihi (*Nemadactylus macropterus*).

No obvious hydrothermal venting activity was recorded on the video footage; however, the tongue fish (probably *Symphurus thermophilis* (Munroe & Hashimoto 2008)), often seen in the vicinity of active venting, was recorded on several occasions and in particularly high numbers towards the end of DVD1, which depicted substrates covered in a layer of bacterial mat.

The second section of the dive (recorded on DVD2) began on the rim of a crater where there was sandy substrate and areas of bacterial mat (Fig. 28). Numerous tonguefish were present in this area. Faunal assemblages on hard substrate were composed of small anemones, zoanthid anemones and gastropods. Patches of sulphur crust were also present on the hard substrates

(Fig. 45). Dense beds of *V. insolatus* were observed (Fig. 46), sometimes associated with large numbers of *Sclerasterias* asteroids. Fish species included bass (*Polyprion maeone*), a moray eel, kingfish (*Seriola lalandi*), sea perch and large numbers of tongue fish. Of note was an area with pinnacles and large boulders with large numbers of at least two different types of trumpet shell gastropods (Ranellidae). Soft-sediment-dominated assemblages included *Sclerasterias* spp., tongue fish, *V. insolatus*, members of Echinasteridae and small numbers of *Bathyaustriella thionipta*.

Images of active hydrothermal vent sites were seen, together with elemental sulphur deposits. Tongue fish and *Xenograpsus ngatama* (a crab) were associated with these active vents.

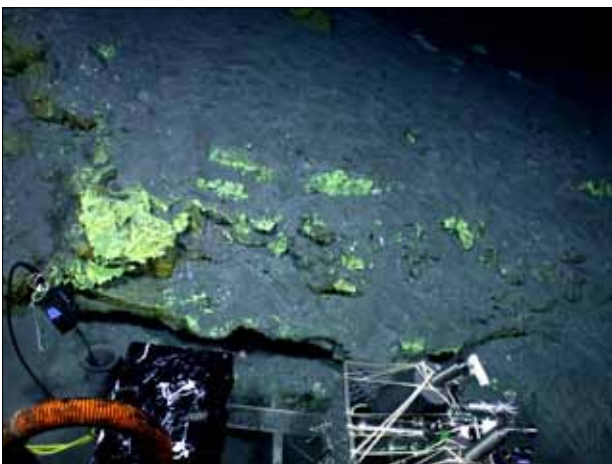


Figure 45. Dive PV616: yellow sulphur deposits were present within an expanse of soft sediment. Note the numerous tongue fish and occasional *Xenograpsus* crabs.



Figure 46. Dive PV616: a dense patch of *Vulcanidas insolatus* attached to hard substratum on Macauley.



Figure 47. Dive PV616: no visible encrusting fauna was observed on this chimney.

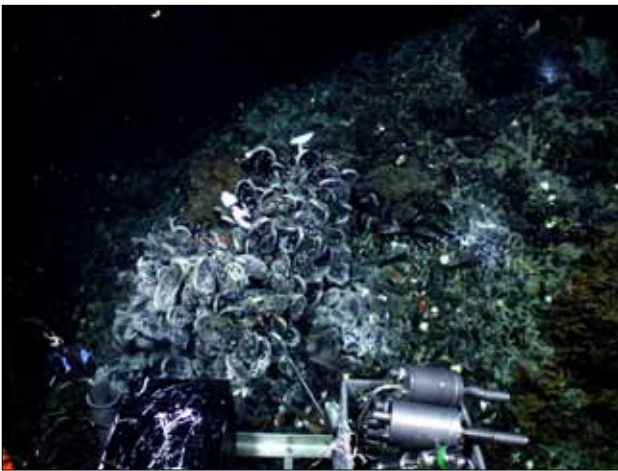


Figure 48. Dive PV616: as was often the case in the presence of hydrothermal activity, these *Vulcanidas insolatus* were covered in a bacterial mat.

The final section of dive 616 (recorded on DVD3) began near Marker 9 at an active hydrothermal vent site with numerous *X. ngatama* and tongue fish present. Sulphur crust was also observed. A vertical wall was seen which, with the exception of occasional areas of bacterial mat, had very little fauna associated with it. A sulphur chimney was also apparently barren of encrusting life (Fig. 47). Elsewhere, the faunal assemblages on hard substrata were dominated by dense beds of *V. insolatus*, with the occasional anemone and gastropod. In terms of fish, there were frequent sightings of sea perch, and occasional bass groper and kingfish, half-banded perch (*Hypoplectordes* sp.) and two species of unidentified small reef fish. Active hydrothermal vent sites continued to be recorded on this section of the dive, with bacterial mat, *V. insolatus* and *X. ngatama* present

(e.g. Fig. 48). Towards the end of the dive, the substrate became dominated by fine sediments, with faunal assemblages comprising dense beds of *Gigantidas gladius* together with large numbers of *Sclerasterias* asteroids. Tongue fish were observed towards the end of the dive.

### Dive PV617

Dense beds of *G. gladius* and associated asteroids (*Sclerasterias* spp.) dominated the benthic fauna on the first section of the dive (recorded on DVD1; Fig. 32), together with patches of *V. insolatus*. The dive started in an area relatively barren of fauna, but DVD1 revealed occasional hydroids, solitary corals, stony corals, gorgonians and anemones on hard substrate (Fig. 31). Fish species observed include a dogfish (possibly a northern spiny dogfish), snipe fish, at least two individual coffin fish (*Chaunax* sp.) and sea perch. This section of the dive ended in an area of hydrothermal venting with the tongue fish and *X. ngatama* present.

The second section of the dive (recorded on DVD2) was dominated by hydrothermal venting areas, some very large. Their dominant benthic fauna comprised the tongue fish and *X. ngatama*. A sulphur crust wall was investigated, but no obvious macrofaunal life was associated with it. Other hard substrate areas supported the occasional asteroid and solitary coral. This section of dive was in the area of Marker 9, also visited during dive PV616.

An active hydrothermal venting site (in the vicinity of Marker 9), with large areas of sulphur crust together with tongue fish, *X. ngatama* (Fig. 33) and the occasional kingfish and bass groper, was seen at the start the third section of the dive (on DVD3). Much of this part of the dive was focused

on vertical or near-vertical walls, recording the occasional small tube worm (serpulids), asteroid (*Sclerasterias* spp.), a couple of species of gastropod, *V. insolatus* (some individuals with tube worms on their shells), bass groper and a moray eel (e.g. Fig. 34).

The final section of the dive (DVD4) began at a wall with patches of sand overlay on its ledges. Fauna on the wall included tongue fish, *V. insolatus*, large numbers of asteroids (*Sclerasterias* spp.) and the occasional small calcareous tube worm. The submersible then moved up onto the rim of the Macauley caldera, where *V. insolatus* dominated the fauna with some *G. gladius* and occasional gastropods. No obvious active hydrothermal venting was noted on this section of the dive.

### ***RCV-150, ROV dive 312***

An unidentified stalked crinoid was by far the most numerous organism observed in the first section of this dive (recorded on DVD1), with some large very dense patches of it observed (Fig. 36). There were also numerous scleractinian corals, gorgonians and 'armless' brisingid seastars. Anemones, sea pens, alcyonaceans, stylasterids and solitary stony corals were also frequently observed. This section of the dive was dominated by hard substrates—irregular outcrops of bedrock with some boulders and some gravel—although there were a few soft sediment areas. No active hydrothermal venting was observed in this area.

The second section of the dive (recorded on DVD2) was also dominated by stalked crinoids, scleractinian corals and gorgonians, with anemones and stylasterids being recorded frequently. The occasional unidentified galatheid crustacean was also seen. Fish species observed included a nettostomatid eel, sea perch, dogfish, slender smoothhound (*Gollum attenuatus*) and patterned grenadier (*Coelorinchus mystax*). As with the area recorded on DVD1, this area was dominated by hard substrata though there were some large areas of gravel and sand. Unusual observations included a large red-orange squid (probably a member of Ommastrephidae) and a shark egg case (probably from a catshark, *Apristurus* sp.).

The third section of the dive (on DVD3) was dominated by scleractinians and gorgonians, with frequent observations of anemones and stalked crinoids. There were also reasonable numbers of soft corals, brisingids, asteroids and small unidentified crustaceans. Fish species included the patterned grenadier, nettostomatid eels, sea perch and a deep sea cod (*Lepidion schmidti*). Also of note was a broken up cetacean skull, possibly of a rough-toothed dolphin (*Steno bredanensis*; to be confirmed; Anton van Helden, Te Papa, pers. comm. 2009). This section of the dive was also dominated by hard substrates, with large areas of cobbles and gravel as well as some bedrock areas. However, there were also large areas of soft sediment. No active hydrothermal vents were recorded.



Figure 49. Dive 312: a slender smoothhound (*Gollum attenuatus*) sits on a hard substrate with a sessile fauna dominated by cup corals, stalked crinoids and brisingids.

The final section of the dive (recorded on DVD4) was again dominated by hard substrate. Occasionally, there were unusual sheet-plate bedrock formations (Fig. 35). Benthic faunal assemblages were dominated by scleractinians, gorgonians, brisingids, a stalked crinoid and fish such as sea perch and patterned grenadier as well as occasional bass groper, unidentified eels, cucumber fish and snipe fish (e.g. Fig. 49). Anemones were also observed frequently. No active hydrothermal vents were recorded.

## A3.2 Giggenbach

### Dive PV618

The first section of PV618 (recorded on DVD1) had a faunal assemblage dominated by many different types of fish and a large number of gorgonians (mostly *Primnoella* sp.). Fish identification was challenging, as the submersible did not get close to the fish. However, large numbers of pink maomao (*Caprodon longimanus*) and half-banded perch were recorded, there were occasional sightings of red snapper (*Centroberyx affinis*), and a scorpaenid and at least two other unidentified reef-dwelling fish were recorded. Active hydrothermal vents were observed, although no *V. insolatus*, tongue fish or *X. ngatama* were observed nearby. However, areas of bacterial mat were frequently recorded. The dive had started on an extensive flat area with a soft substrate and the occasional area of boulder and rubble, and had moved up-slope and then into a crater. Overall, the substrate here was dominated by bedrock, which was sometimes lava-like. The bedrock often had a soft-sediment overlay. There were also extensive sandy patches (possibly ash deposits) with ripples present.

The second section of the dive (on DVD2) had a fauna dominated by fish as well as a few hydroids and gorgonians. This section of dive began at an active hydrothermal vent with sulphide chimneys, iron crust and bacterial mat nearby. A second active vent was located, this one bubbling, with *V. insolatus* occurring at the vent site together with a bacterial mat (Fig. 37) (Marker 10 was placed here by the submersible). Fish life here included some small fish (probably half-banded perch) and a convict grouper.

The submersible then explored an area with some large (>2 m) chimneys, which had very little sessile or invertebrate life but abundant fish life, including pink maomao, convict grouper and tarakihi.

As the submersible ascended the Giggenbach cone into shallower depths, the density of fish became greater and included species such as pink maomao, tarakihi, red snapper, splendid perch (*Callanthias* spp.), kingfish, leatherjackets (*Parika scaber*), a banded butterfly fish (a member of Chaetodontidae) and many unidentified small fish (of at least two species). At the top of the cone, in 75–100 m depths, there were very large numbers of pink maomao and two-spot demoiselles (*Chromis dispilus*) together with kingfish, red snapper, convict grouper, tarakihi, Galapagos sharks (*Carcharhinus galapagensis*) and short-tailed stingrays (*Dasyatis brevicaudata*) (Fig. 38). The hard substrate here (cobbles) was covered in a coralline alga with some large hydroid colonies attached. There also appeared to be some diffuse hydrothermal venting in the area, although no specific venting site was seen.

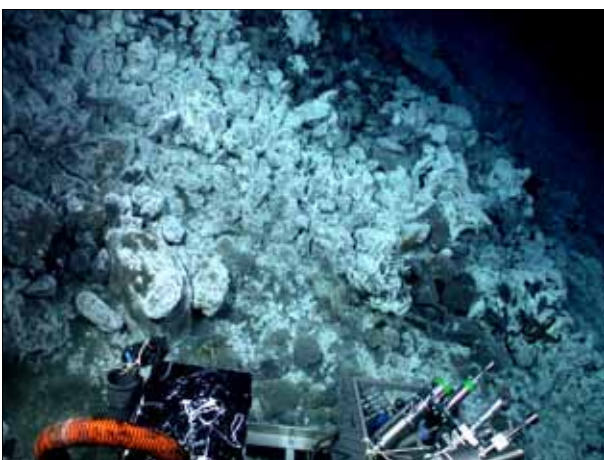


Figure 50. Dive PV618: a large number of *Vulcanides insolatus* covered in bacterial mat. Note also the predatory asteroids (*Sclerasterias* sp.) and the unidentified flatfish in the foreground (sp. 2).

The third section of this dive (on DVD3) started in relatively shallow depths on top of the volcanic cone. The fauna was dominated by fish species that included pink maomao, kingfish, tarakihi and convict grouper. A diffuse hydrothermal vent site with *V. insolatus* and associated bacterial mat was observed, with nearby convict grouper and tarakihi. A large area of the empty valves of *V. insolatus* was seen, followed by an extensive mussel bed, further up-slope, covered with a bacterial mat. A few predatory asteroids (*Sclerasterias* spp.) were also observed amongst the mussels. The submersible then arrived on the top of a ridge, which supported dense patches of mussels, together with tarakihi and convict grouper (Figs 50 & 51). Another diffuse hydrothermal vent site was seen towards the end of this section of the dive. Convict grouper were present here in relatively





Figure 51. Dive PV618: a convict grouper (*Epinephelus octofasciatus*) against a background of cobbles, pebbles and soft sediment, most of which is covered in a bacterial mat.

slope. The whole area was almost devoid of fauna with the exception of a few *V. insolatus* on the wall near the vent site. There were occasional sightings of convict grouper (a group of six was seen) and a very few unidentified small reef fish.

### Dive PV619

Fish again dominated the fauna on this dive on Giggenbach seamount. The first section of dive (recorded on DVD1) began on the outer rim of the caldera, where sediments were a mixture of gravel, muddy sediment (possibly ash deposits), pebbles and cobbles. Areas of bacterial mat were regularly observed, as were lots of small, unidentified, shoaling fish, possibly splendid perch. As the submersible moved towards the west (towards Marker 12), a huge field of dead *V. insolatus* was observed. Tarakihi, convict grouper, a flatfish (species 2) and a few live mussels were also seen. This section of dive ended back at Marker 12, at the active hydrothermal vent site (Fig. 52).



Figure 52. Dive PV619: an extensive area of active hydrothermal venting, including bubbling.

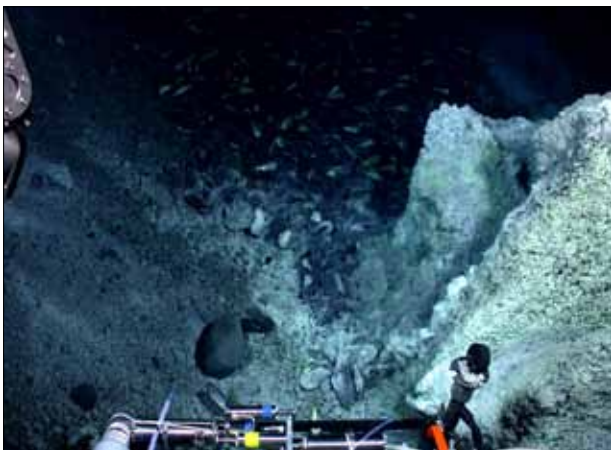


Figure 53. Dive PV619: an active hydrothermal vent area with associated *Vulcanidas insolatus* and bacterial mat.

high numbers (a group of four fish was seen). An unidentified small crab was also seen in an active hydrothermal vent, possibly *X. ngatama*. In the vicinity of this vent site were some *V. insolatus* and bacterial mat as well as some unidentified flatfish (species 2).

The final section of the dive (recorded on DVD4) started at a very active hydrothermal vent area, with a lot of bubbling (Marker 12). The temperature was recorded to be 205° C. The vent site was an extensive area (> 30 m wide) of sulphur crust on a slope-wall, with some small patches of pumice on the

second section of this dive (on DVD2) was also very much associated with active hydrothermal vent sites, and started in the vicinity of Marker 12. *X. ngatama* were observed at the vent site. The submersible then moved over a pumice slope to a dense bed of dead *V. insolatus* (with open valves). Some live examples were found along with many empty valves at a hydrothermal vent site (not bubbling) in the bottom of a pit (Fig. 53). Bacterial mat was also observed here. The submersible then surveyed the rest of the pit area, where many convict grouper, tarakihi, flatfish (species 2) and some unidentified small reef fish were observed.

The final section of the dive (on DVD3) began in another section of the pit with numerous flatfish (species 2) and a few patches of unidentified small reef fish on the slope. The submersible passed a wall with a few live mussels, bacterial mat and convict grouper. This area was directly above the active vent at Marker 12, and lots of bubbles were visible. As the submersible moved away from the active vent site, it passed over gravely areas together

with areas of muddy sediment and areas of cobble and bacterial mat. Gorgonians (mostly *Primnoella* spp.), numerous small unidentified reef fish (including some perch and a species of wrasse-like fish), some pink maomao and tarakihi dominated this final section of dive.

### Dive PV620

Muddy sediments (possibly ash) with areas of cobble characterised this first section of the dive (recorded on DVD1), with sessile fauna dominated by gorgonians (mostly *Primnoella* spp.). Of particular note in this area were a couple of bandfish (*Cepola* sp.), which was a new record for the Kermadec Ridge area. Cobble-boulder habitat, which was composed of tallus and broken-up pillows, later in this section of dive had a fish fauna that included convict grouper,



Figure 54. Dive PV620: a convict grouper (*Epinephelus octofasciatus*) in the foreground with some bedrock and cobbles in the background. The hard substrate was mostly barren of visible encrusting life.

abundant red snapper, splendid perch, half-banded perch, pink maomao and a large shoal of a unidentified small fish (skinny, yellowish fish) (Fig. 54). There were also significant areas of fine sediment supporting the occasional gorgonian as well as fish such as butterfly fish (Chaetodontidae, possibly Lord Howe coralfish (*Amphichaetodon howensis*)). The submersible then moved up a slope covered in a bacterial crust where some active hydrothermal venting was observed, before proceeding on to a sandy-fine sediment slope where bacterial mat, tarakihi and pink maomao were observed. This section of the dive ended at areas of vertical wall with patches of bacterial mat and a few unidentified fish (wrasse-like in shape).

The second section of the dive (on DVD2) began in an area with lots of deep pits and holes, and vertical walls and steep slopes of a sandy, ash-like substrate. The submersible was then in transit for a time so no biological observations were possible. Then an area of chimneys was encountered, having a small, active hydrothermal vent site, with associated bubbling, on a flat seabed of soft sediment. A few individuals of *V. inslatus*, with bacterial mat, and some half-banded perch and pink maomao were present. After that, a large pit area with numerous chimneys was located. Fish life here included pink maomao, tarakihi, convict grouper, half-banded perch and splendid perch (Fig. 39). The submersible then moved further up-slope, where the occasional butterfly fish as well as pink maomao and tarakihi were seen.

The faunal assemblage was relatively sparse in the final section of the dive (on DVD3). The occasional kingfish and pink maomao were the only fish identified in the first part of this section as the submersible was in transit. The submersible stopped briefly on a slope of fine, ash-like sediment where flatfish (species 2) and some gastropod shells were present. The dive ended back at an active hydrothermal vent area (Marker 12; see above).

## A3.3 Wright

### Dive PV621

The first section of this dive (recorded on DVD1) was dominated by hard substrate, mostly of bedrock with some cobble areas, although some sandy areas were encountered towards the end. Much of the substrate appeared barren of fauna (Fig. 40). However, the faunal assemblage, when present, was dominated by eels (including synaphobranchid eels) and anemones (a hormathid and an unidentified, small, species of anemone). A deep sea cod, probably *Lepidion microcephalus*, was seen on top of a ridge. Empty shells of *V. inslatus* were seen in many areas, but no live mussels were found. In particular, there was a pile of empty shells under a large boulder, as if discarded by a predator. Foraminiferan turf was observed in some areas. Of note was an area

at the end of this section of dive where there were a few large vestimentiferan tubeworms (indicative of hydrothermal venting, although no active vents were seen), together with numerous saddle oysters attached to rock (Fig. 41).

Hard substrate again dominated the second section of this dive (on DVD2), often on a steep slope or ridges and with pillow formations. The faunal assemblage was dominated by grenadiers (including species of *Coryphaenoides*), with the occasional unidentified eel. Crabs (including *Chaceon bicolor*) and unidentified shrimps were seen sporadically. Of note was a giant angler fish (thought to be *Sladenia* sp.), the sighting being a new record for both New Zealand and the Kermadec Ridge area. There were also areas of steep and gentle slope formed of a thick bacterial crust. This substrate was devoid of macrofauna.

The final section of this dive (on DVD3) was also dominated by hard substrate but with large areas of thick bacterial mat or bacterial crust. The faunal assemblage here was relatively sparse and dominated by grenadier fish (mostly species of *Coryphaenoides* but also of *Trachyrincus*). A large octopus (probably of the family Octopodidae), some unidentified shrimps and eels (including conger eels) were also sighted. As the submersible moved up the slope to the summit of the cone, the seafloor changed from hard bedrock (often in pillow formations) to a thick bacterial mat (Fig. 42). Some diffuse active hydrothermal venting was also observed in this area. The bacterial mat continued up onto a ridge (where Marker 13 was placed).

# Appendix 4

## Taxa list for all Pisces V and ROV dives

The CMA includes the foreshore, seabed and coastal water of which the seaward boundary is the outer limits of the territorial sea (a distance of 12 nautical miles from the land) and the landward boundary is the line of mean high water springs (refer to Fig. 1).

PHYLA	CLASS	ORDER	FAMILY	GENUS	SPECIES	COMMENTS	MACAULEY				GIGGENBACH			WRIGHT	
							616	617	312	618	619	620	621		
Rhodophyta	Rhodophyceae	Corallinales	Corallinaceae	(Corallinaceae)	Corallinaceae sp.1						y				
Chordata (Urochordata)	Asciacea	(Asciacea)	(Asciacea)	(Asciacea)	Asciacea sp.1	Unidentified solitary ascidian	+		+						
Chordata (Urochordata)	Asciacea	(Asciacea)	(Asciacea)	(Asciacea)	Asciacea sp.2	Unidentified colonial ascidian			+						
Bryozoa	Gymnolaemata?	(Gymnolaemata?)	(Gymnolaemata?)	(Gymnolaemata?)	Gymnolaemata? sp.1	Bryozoans (small, thin, flustrid-like)					+				
Cnidaria	Hydrozoa	Anthoathecata	Stylasteridae	(Stylasteridae)	Stylasteridae sp.1				+						
Cnidaria	Hydrozoa	Hydroida	(Hydroida)	(Hydroida)	Hydroida spp.			+			+				
Cnidaria	Hexacorallia/ Anthozoa	Scleractinia	Caryophylliidae	<i>Desmophyllum</i> or <i>Caryophyllia</i> ?	<i>Desmophyllum</i> or <i>Caryophyllia</i> sp.			+							
Cnidaria	Hexacorallia/ Anthozoa	Actiniaria	Hormathiidae	(Hormathiidae)	Hormathiidae sp. 1				+						+
Cnidaria	Hexacorallia/ Anthozoa	Actiniaria	Boloceroiidae?	(Boloceroiidae?)	Boloceroiidae? sp.1	Large purple anemone					+				
Cnidaria	Hexacorallia/ Anthozoa	Actiniaria	(Actiniaria)	(Actiniaria)	Actiniaria sp.1		+	+			+				+
Cnidaria	Octocorallia/ Anthozoa	Gorgonacea	Primnoidae	<i>Callogorgia</i>	<i>Callogorgia</i> sp.		+	+			+				+
Cnidaria	Octocorallia/ Anthozoa	Gorgonacea	Primnoidae	<i>Primnoella</i>	<i>Primnoella</i> sp.		+	+			+		+		+
Cnidaria	Octocorallia/ Anthozoa	Gorgonacea	(Gorgonacea)	(Gorgonacea)	Gorgonacea spp.		+	+			+		+		+
Cnidaria	Alcyonaria/ Anthozoa	Pennatulacea	(Pennatulacea)	(Pennatulacea)	Pennatulacea sp.1										
Cnidaria	Alcyonaria/ Anthozoa	Alcyonacea	(Alcyonacea)	(Alcyonacea)	Alcyonacea sp.1		+	+							+
Cnidaria	Hexacorallia/ Anthozoa	Scleractinia	Flabellidae	<i>Flabellum</i>	<i>Flabellum</i> sp.1						+				

Continued on next page

PHYLA	CLASS	ORDER	FAMILY	GENUS	SPECIES	COMMENTS	MACAULEY				GIGGENBACH			WRIGHT
							616	617	312	618	619	620	621	
Cnidaria	Hexacorallia/ Anthozoa	Scleractinia	Caryophyllidae	<i>Caryophyllia</i>	<i>Caryophyllia</i> sp.1		+	+	+					
Cnidaria	Hexacorallia/ Anthozoa	Scleractinia	(Scleractinia)	(Scleractinia)	Scleractinia sp.1		+	+	+					
Cnidaria	Hexacorallia/ Anthozoa	Zoantharia	Zoanthidae	(Zoanthidae)	Zoanthidae sp.1		+							
Cnidaria	Hexacorallia/ Anthozoa	Zoantharia	Zoanthidae	(Zoanthidae)	Zoanthidae sp.2	Crab with zoanthidea anemone			+					
Crustacea	Cirripedia	(Cirripedia)	(Cirripedia)	(Cirripedia)	Cirripedia sp.1	Barnacles			+					
Crustacea	Cirripedia	(Cirripedia)	(Cirripedia)	(Cirripedia)	Cirripedia sp.2	Stalked barnacles			+					+
Crustacea	Decapoda	Brachyura	Geryonidae	<i>Chaceon</i>	<i>Chaceon bicolor</i>									+
Crustacea	Decapoda	Brachyura	Xanthidae	<i>Medaeops</i>	<i>Medaeops serenei</i>		+							+
Crustacea	Decapoda	Brachyura	Varunidae	<i>Xenograpsus</i>	<i>Xenograpsus ngatama</i>		+	+		(+)	+	+		
Crustacea	Decapoda	Brachyura	(Brachyura)	(Brachyura)	Brachyura sp.1	Unidentified long-legged crab			+					
Crustacea	Decapoda	Brachyura	(Brachyura)	(Brachyura)	Brachyura sp.2				+					+
Crustacea	Decapoda	Anomura	Galatheididae	(Galatheididae)	Galatheididae sp.1		+		+					+
Crustacea	Decapoda	Polychelida	Polychelidae	<i>Polycheles</i>	<i>Polycheles enthrix</i>		+		+					
Crustacea	Decapoda	Anomura	Paguridae	(Paguridae)	Paguridae sp.1		+		+					
Crustacea	Decapoda	Penaeoidea	Aristeidae?	(Aristeidae?)	Aristeidae? sp.1	Shrimp with very long antennae—probably Aristeidae)			+					
Crustacea	Decapoda	(Decapoda)	(Decapoda)	(Decapoda)	Decapoda sp.1	Unidentified shrimp			+					+
Echinodermata	Asteroidea	(Asteroidea)	(Asteroidea)	(Asteroidea)	Asteroidea sp.1								+	
Echinodermata	Asteroidea	Spinulosida	Echinasteridae	(Echinasteridae)	Echinasteridae sp.1		+							
Echinodermata	Asteroidea	Valvatida	Goniasteridae	<i>Mediaster</i>	<i>Mediaster</i> sp.		+		+					
Echinodermata	Asteroidea	Forcipulatida	Asteridae	<i>Sclerasterias</i>	<i>S. mollis</i> and/or <i>S. eructans</i>		+	+						
Echinodermata	Asteroidea	Velatida	Solasteridae	(Solasteridae)	Solasteridae sp.1								+	
Echinodermata	Asteroidea	(Asteroidea)	(Asteroidea)	(Asteroidea)	Asteroidea sp.1		+	+	+					
Echinodermata	Asteroidea	Forcipulatida	Zoroasteridae	(Zoroasteridae)	Zoroasteridae sp.1		+							
Echinodermata	Asteroidea	Brisingida	(Brisingida)	(Brisingida)	Brisingida sp.1				+					
Echinodermata	Crinoidea	(Crinoidea)	(Crinoidea)	(Crinoidea)	Crinoidea sp.1				+					
Echinodermata	Crinoidea	(Crinoidea)	(Crinoidea)	(Crinoidea)	Crinoidea sp.2				+					
Echinodermata	Echinoidea	(Echinoidea)	(Echinoidea)	(Echinoidea)	Echinoidea sp.1	Unidentified stalked crinoid			+					
Echinodermata	Echinoidea	Echinothioida	Echinothuriidae	(Echinothuriidae or Phormoso matidae)	Echinothuriidae or Phormoso matidae spp.		+	+	+					+
Echinodermata	Echinoidea	Cidarida	Cidaridae	Goniocidaris	<i>Goniocidaris parasol</i>				+					
Echinodermata	Holothuroidea	(Holothuroidea)	(Holothuroidea)	(Holothuroidea)	Holothuroidea sp.1				+					

PHYLA	CLASS	ORDER	FAMILY	GENUS	SPECIES	COMMENTS	MACAULEY			GIGGENBACH			WRIGHT
							616	617	312	618	619	620	
Echinodermata	Ophiuroidea	Euryalida	Gorgonocephalidae	<i>Asterothorax</i>	<i>Asterothorax waitei</i>		+		+				
Echinodermata	Ophiuroidea	(Ophiuroidea)	(Ophiuroidea)	(Ophiuroidea)	Ophiuroidea sp.1		+		+				
Chordata	Actinopterygii	Perciformes	Chaetodontidae	<i>Amphichaetodon?</i>	<i>Amphichaetodon howensis?</i>					+			+
Chordata	Actinopterygii	Perciformes	Cepolidae	<i>Cepola</i>	<i>Cepola</i> sp.	Bandfish. A new record for Kermadec Ridge							+
Chordata	Actinopterygii	Perciformes	Polyprionidae	<i>Polyprion</i>	<i>Polyprion maeone</i>		+		+				+
Chordata	Actinopterygii	Perciformes	Serranidae	<i>Epinephelus</i>	<i>Epinephelus octofasciatus</i>						+		+
Chordata	Actinopterygii	Perciformes	Serranidae	<i>Hypoplectrodes</i>	<i>Hypoplectrodes</i> sp.		(+)		+				+
Chordata	Actinopterygii	Perciformes	Serranidae	<i>Caprodon</i>	<i>Caprodon longimanus</i>				+				+
Chordata	Actinopterygii	Perciformes	Carangidae	<i>Seriola</i>	<i>Seriola lalandi</i>		+		+				+
Chordata	Actinopterygii	Perciformes	Callanthidae	<i>Callanthias</i>	<i>Callanthias</i> spp.		+		+		(+)		+
Chordata	Actinopterygii	Perciformes	Cheilodactylidae	<i>Nemadactylus</i>	<i>Nemadactylus macropterus</i>		+		+				+
Chordata	Actinopterygii	Perciformes	Pomacentridae	<i>Chromis</i>	<i>Chromis dispilus</i>						+		
Chordata	Actinopterygii	Aulopiformes	Chlorophthalmidae	<i>Chlorophthalmus</i>	<i>Chlorophthalmus</i> sp.		+						+
Chordata	Actinopterygii	Gadiformes	Macrouridae	<i>Coryphaenoides?</i>	<i>Coryphaenoides serrulatus?</i>								
Chordata	Actinopterygii	Gadiformes	Macrouridae	<i>Trachyrhynchus?</i>	<i>?Trachyrhynchus</i> sp.								+
Chordata	Actinopterygii	Gadiformes	Macrouridae	<i>Coelorinchus</i>	<i>Coelorinchus mystax</i>					+			+
Chordata	Actinopterygii	Gadiformes	Macrouridae	(Macrouridae)	Macrouridae sp.1					+			+
Chordata	Actinopterygii	Gadiformes	Moridae	<i>Lepidion</i>	<i>Lepidion microcephalus?</i>								+
Chordata	Actinopterygii	Gadiformes	Moridae	<i>Lepidion</i>	<i>Lepidion schmidti</i>					+			
Chordata	Actinopterygii	Lophiiformes	Chaunacidae	<i>Chaunax</i>	<i>Chaunax</i> sp.				+				
Chordata	Actinopterygii	Lophiiformes	(Lophiiformes)	(Lophiiformes)	Lophiiformes sp.1					+			+
Chordata	Actinopterygii	Lophiiformes	Lophiidae	<i>Sladenia?</i>	<i>?Sladenia</i> sp.	Giant angler fish. A new record for New Zealand and Kermadec Ridge							+
Chordata	Actinopterygii	Beryciformes	Berycidae	<i>Centroberyx</i>	<i>Centroberyx affinis</i>						+		+
Chordata	Actinopterygii	Tetraodontiformes	Monacanthidae	<i>Parika</i>	<i>Parika scaber</i>					+			
Chordata	Actinopterygii	Scorpaeniformes	Scorpaenidae	(Scorpaenidae)	Scorpaenidae sp.1		+			+			
Chordata	Actinopterygii	Scorpaeniformes	Sebastidae	<i>Helicolenus</i>	<i>Helicolenus</i> sp.		+			+			
Chordata	Actinopterygii	Syngnathiformes	Centriscidae	<i>Centriscops</i>	<i>Centriscops humerosus</i>		+			+			
Chordata	Actinopterygii	Pleuronectiformes	Cynoglossidae	<i>Symphurus</i>	<i>Symphurus thermophilus?</i>		+			+			



PHYLA	CLASS	ORDER	FAMILY	GENUS	SPECIES	COMMENTS	MACAULEY			GIGGENBACH			WRIGHT
							616	617	312	618	619	620	
Annelida	Polychaeta	Canalipalpata	Sabellidae	(Sabellidae)	Sabellidae sp.1	Vestimentifera							+
Annelida	Polychaeta	(Polychaeta)	(Polychaeta)	(Polychaeta)	Polychaeta sp.1	Errant polychaete			+				
Annelida	Polychaeta	(Polychaeta)	(Polychaeta)	(Polychaeta)	Polychaeta sp.2	Unidentified with branched tentacle			+				
Arthropoda	Pycnogonida	Pantopoda	(Pantopoda)	(Pantopoda)	Pantopoda sp.1				+				
Chordata	Thaliacea	Salpida	(Salpida)	(Salpida)	Salpida sp.1				+		+		+
Porifera	Demospongiae	(Demospongiae)	(Demospongiae)	(Demospongiae)	Demospongiae sp.1	Yellow spikey sponge				+			
Porifera	Porifera	(Porifera)	(Porifera)	(Porifera)	Porifera sp.1				+				+
Porifera	Hexactinellida	(Hexactinellida)	(Hexactinellida)	(Hexactinellida)	Hexactinellida sp.1								
Crustacea					Zooplankton	Numerous zooplankton (shrimps)			+				
Chordata	Mammalia	Cetacean	Dephniidae	<i>Steno?</i>	<i>Steno bredanensis?</i>	Delphinid skull (possibly Rough-toothed dolphin, <i>Steno bredanensis</i> )			+				
Chordata	(Skull bones)				Skull bones								
UID						Red fuzz (algae?) on chimney					+		
Foraminifera	(Foraminifera)	(Foraminifera)	(Foraminifera)	(Foraminifera)	Foraminiferan turf						+		+
Bacterial mat					Bacterial mat						+		+