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Recent observations of reef fishes at the Kermadec Islands Marine Reserve, New Zealand

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The Kermadec Islands have been identified as one of the few remaining pristine marine ecosystens left in the world. The Kermadec Islands Marine Reserve (MR) is the largest in New Zealand protecting species endemic to the archipelago and species not found elsewhere within the country. Reef fishes were surveyed for size and abundance at three sites around Raoul Island and the Meyer Islets and biomasses of trophic groups were calculated. Planktivores dominated trophic group abundance at all three sites. This research represents the first observations of all trophic groups of reef fishes since implementation of the Kermadec Islands MR in 1990.

Keywords: Kermadec Islands; marine reserve; reef fish; subtropical; trophic

Introduction

The isolated Kermadec Islands (29–31°S, 178°W), located 750 km northeast of Cape Reinga, represent the only true subtropical marine habitat in New Zealand. The volcanic Kermadec Island archipelago is composed of four main island groups; Raoul Island and surrounding Herald Islets in the north, Macauley and Haszard Islands, Curtis and Cheeseman Islands and the southernmost island group of L'Esperance and Havre Rocks (Fig. 1). Located between New Zealand (34°S) and Tonga (21°S), the Kermadec Islands harbour a mix of temperate and tropical species (Schiel et al. 1986; Francis et al. 1987; Francis 1991; Cole et al. 1992; Francis 1993; Brook 1998, 1999; Cole 2001; Gardner et al. 2006; Wicks et al. 2010). Sea surface temperature varies from 18° to 24°C seasonally (Francis et al. 1987). While corals are present, both coral reefs and macroalgal stands are absent at the Kermadec Islands (Schiel et al. 1986; Brook 1999).

During the time of initial studies by Francis et al. (1987) in 1984 and 1985, long-line fishing pressure in New Zealand was beginning to expand geographically following declines of hapuku (*Polyprion oxygeneios*) and bass (*Polyprion americanus*) stocks with fishing trips planned to the Kermadecs. Subsequently Francis submitted an application (1985) for a marine reserve (MR) to protect New Zealand's only subtropical marine ecosystem and the Kermadec Islands MR was designated in 1990. It is New Zealand's largest MR at 748,000 ha and extends 22 km seaward from all four island groups (Fig. 1). The Kermadec Islands MR protects species endemic to the Kermadec Islands as well as highly targeted commercial species in a region where recruitment occurs locally for some species (Francis et al. 1987). The Kermadec Islands have recently been identified by the

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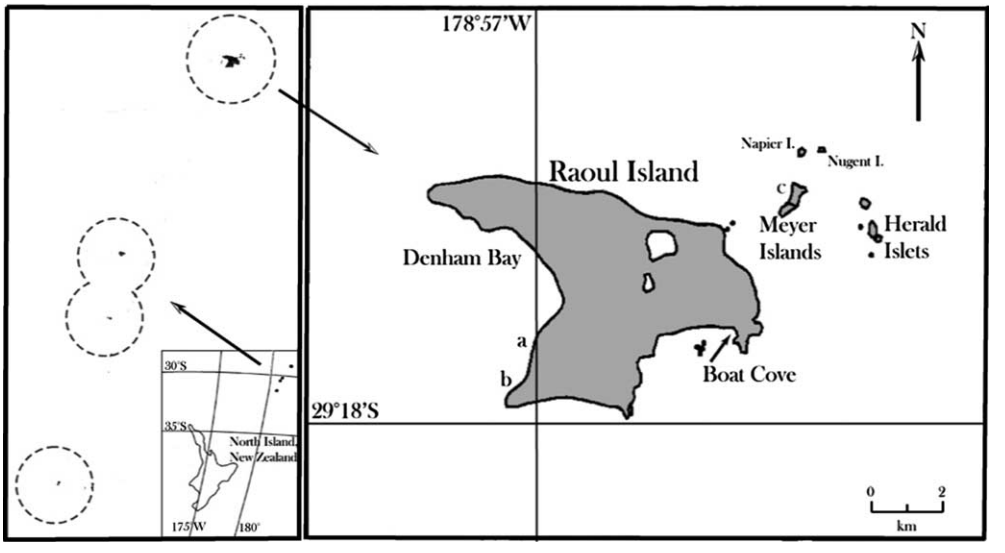

Figure 1 Kermadec Islands Marine Reserve boundaries (left panel, dotted lines), location of Kermadec Islands relative to New Zealand (insert) and map of Raoul Island and surroundings with survey locations (a = Denham 1; b = Denham 2; c = Meyer). Island groups in the left panel from north to south: Raoul Island and surrounding Herald Islets; Macauley and Haszard Islands; Curtis and Cheeseman Islands; L'Esperance and Havre Rocks. Kermadec Islands Marine Reserve map (left panel) modified with permission from the New Zealand Department of Conservation.

Census of Marine Life Project as one of 18 pristine sites that exist globally. Along with early species checklists, subtidal research at the Kermadec Islands has been limited because of geographic isolation. The aim of this study is to provide a snapshot of reef fish abundances and trophic structure at three sites around Raoul Island and the Meyer Islets. While Cole studied herbivorous fishes post-implementation of the Kermadec Islands MR (2001), this study represents the first observations of all reef fish species since implementation of the Kermadec Islands MR in 1990.

Methods

Fish size and abundance surveys were conducted using SCUBA over 5 days from 25 March until 29 March 2008, at three sites inside the Kermadec Islands MR. Two sites located on the south-western side of Raoul Island (south of Denham Bay and referred to as Denham 1, D1; Denham 2, D2) were approximately 2 km apart and a third site was sampled on the western side of the Meyer Islands (referred to as M; Fig. 1). Sample site availability was largely determined by the prevailing north-easterly winds, which limited access to other areas. Denham Bay is characterised by large boulders, rocks, cobble and sand with a gentle slope from the intertidal to subtidal zone (Brook 1998). The Meyer Islands are characterised by vertical walls with habitat features such as caves, overhangs and crevices (Brook 1998). All surveys were conducted on rocky reef substratum between 5 and 25 m in depth. Sea surface temperature was recorded as 24°C for all surveys in this study, which is the annual high.

Underwater surveys were undertaken utilising timed counts in a $5 \times 5\,m^2$ area from the sea floor to the surface, which was observed for 3 min (hereafter referred to as a 'station') in order to record both benthic and pelagic fishes.

Table 1 Mean individual species abundance with trophic group.

Family	Species	Common name	Denham 1		Denham 2		Meyer		Trophic Group
			$\bar{x}$	SE	$\bar{x}$	SE	$\bar{x}$	SE	
Carcharhinidae	*Carcharhinus galapagensis*	Galapagos reef shark	0.00	0.00	0.03	0.03	0.00	0.00	F
Aulostomidae	*Aulostomus chinensis*	Trumpetfish	0.00	0.00	0.00	0.00	0.15	0.15	F
Trachichthyidae	*Optivus elongatus*	Slender roughy	0.00	0.00	1.00	0.69	0.00	0.00	P
Serranidae	*Acanthistius cinctus*	Yellow-banded perch	0.00	0.00	0.26	0.09	0.00	0.00	F
	Aulacocephalus temmincki	Gold-ribbon grouper	0.00	0.00	0.58	0.47	1.85	1.53	I
	Epinephelus daemelii	Spotted black grouper	0.00	0.00	0.10	0.06	0.15	0.15	F
	Trachypoma macracanthus	Toadstool grouper	0.00	0.00	0.06	0.04	0.00	0.00	F
Carangidae	*Seriola lalandi*	Kingfish	0.00	0.00	0.10	0.05	0.15	0.10	F
Arripidae	*Arripis xylabion*	Northern kahawai	0.00	0.00	0.03	0.03	0.00	0.00	I
Mullidae	*Parupeneus spilurus*	Black-spot goatfish	0.00	0.00	0.19	0.10	0.23	0.17	I
Pempheridae	*Pempheris analis*	Bronze bullseye	0.00	0.00	0.77	0.63	0.00	0.00	P
Kyphosidae	*Kyphosus bigibbus*	Grey drummer	0.00	0.00	2.06	1.87	5.92	3.07	O
Girellidae	*Girella cyanea*	Bluefish	0.00	0.00	0.00	0.00	9.23	5.25	O
	Girella fimbriata	Caramel drummer	0.00	0.00	0.00	0.00	0.08	0.08	H
Scorpidae	*Labracoglossa nitida*	Blue knifefish	0.00	0.00	2.90	1.97	0.00	0.00	P
	Scorpis violaceus	Blue maomao	0.00	0.00	26.45	6.38	0.00	0.00	P
Microcanthidae	*Atypichthys latus*	Mado	0.00	0.00	2.71	1.10	0.00	0.00	O
Chaetodontidae	*Amphichaetodon howensis*	Lord howe coralfish	0.10	0.10	0.00	0.00	0.23	0.17	I
Cirrhitidae	*Notocirrhitus splendens*	Splendid hawkfish	0.00	0.00	0.03	0.03	0.00	0.00	I
Aplodactylidae	*Aplodactylus etheridgii*	Notch-head marblefish	0.10	0.10	0.03	0.03	0.00	0.00	H
Latridae	*Cheilodactylus ephippium*	Painted moki	0.00	0.00	0.03	0.03	0.00	0.00	I
	Cheilodactylus francisi	Masked moki	0.00	0.00	0.03	0.03	0.00	0.00	I
Pomacentridae	*Chromis dispilus*	Demoiselle	26.00	10.56	11.13	2.67	51.69	24.70	P
	Chrysiptera rapanui	Kermadec demoiselle	28.60	5.02	8.58	1.67	13.46	2.85	P
	Parma alboscapularis	Black angelfish	0.40	0.16	0.69	0.15	0.00	0.00	H
	Parma kermadecensis	Kermadec scalyfin	0.00	0.00	0.13	0.06	1.54	0.33	H
	Stegastes fasciolatus	Pacific gregory	2.30	0.30	3.13	0.77	0.00	0.00	H
Labridae	*Anampses caeruleopunctatus*	Blue-spotted wrasse	0.40	0.16	0.39	0.13	0.38	0.24	I
	Anampses elegans	Elegant wrasse	0.30	0.21	0.16	0.07	0.62	0.27	I
	Coris sandageri	Sandager's wrasse	1.10	0.41	0.32	0.09	1.46	0.50	I
	Notolabrus inscriptus	Green wrasse	0.10	0.10	0.29	0.16	0.08	0.08	I
	Pseudolabrus luculentus	Orange wrasse	10.30	3.48	2.03	0.45	7.31	2.14	I

Table 1 (*Continued*)

Family	Species	Common name	Denham 1 $\bar{x}$	Denham 1 SE	Denham 2 $\bar{x}$	Denham 2 SE	Meyer $\bar{x}$	Meyer SE	Trophic Group
	Thalassoma lutescens	Sunset wrasse	0.10	0.10	0.23	0.09	0.08	0.08	I
	Thalassoma trilobatum	Ladder wrasse	0.00	0.00	0.19	0.08	0.00	0.00	I
Blennidae	*Cirripectes alboapicalis*	White-dot blenny	0.10	0.10	0.00	0.00	0.00	0.00	H
	Plagiotremus tapeinosoma	Mimic blenny	4.40	2.27	5.84	1.41	2.38	1.21	F
Monacanthidae	*Thamnaconus analis*	Morse-code leatherjacket	0.30	0.15	0.03	0.03	0.15	0.10	I
Zanclidae	*Zanclus cornutus*	Moorish idol	0.00	0.00	0.00	0.00	0.15	0.15	O
Number of species			6.5	0.4	7.2	0.4	6.7	0.3	
Total abundance			74.6	15.3	68.9	6.9	97.4	26.3	
Total biomass (kg)			3.4	0.8	17.4	3.4	39.7	16.0	

H, herbivore; P, planktivore; O, omnivore; I, invertebrate feeder; F, fish and invertebrates; total number of species, total abundance and total biomass (kg) per station with standard error (SE) at each site. D1, Denham 1, $n = 10$; D2, Denham 2, $n = 32$; M, Meyer, $n = 13$.

This method was chosen to sample a range of depths with limited time. Individual fishes that were obviously attracted to the diver from outside the survey area were not recorded. Stations were separated by 20-m intervals and were sampled perpendicular to the shore to include a range of depths representative of nearshore subtidal rocky reef habitat at each site ($n = 10$ stations at D1; $n = 32$ stations at D2; $n = 13$ stations at M). Denham 1 was characterised by a shallow, gently sloping shelf; Denham 2 by a steeper sloping shelf; Meyer was characterised by steeper vertical walls rising from a deeper shelf. At each station, all fishes inside the survey area were identified, counted and visually estimated for size class to the nearest 5-cm interval. Fish species were assigned to one of five trophic groups; herbivores, omnivores, planktivores, benthic invertebrate feeders, and fish and invertebrate feeders (Francis 2001; Froese and Pauly 2005). Size–frequency data were converted into biomass using non-linear length to weight relationships for north-eastern New Zealand reef fishes as described by Taylor & Willis (1998) and Fishbase (Froese and Pauly 2005). A species accumulation curve was generated using data pooled across all three sites with PRIMER software using the bootstrap technique with 9999 permutations (Clarke & Gorley 2006).

Results

Thirty-eight species of fish were recorded in the timed counts and a further three species were sighted during the expedition; *Pterois volitans* (lionfish), *Canthigaster callisterna* (clown toado) and *Evistias acutirostris* (striped boarfish) (Table 1). These 41 observed fish species represented 36 genera, 23 families, seven orders and two classes. Of the 4220 fish counted during underwater surveys, the 10 most abundant species accounted for 93% of all fish (Fig. 2). The highest mean number of species per station was observed at D2 (7.2 ± 0.2 species; mean ± SE), whereas M showed the highest fish abundance

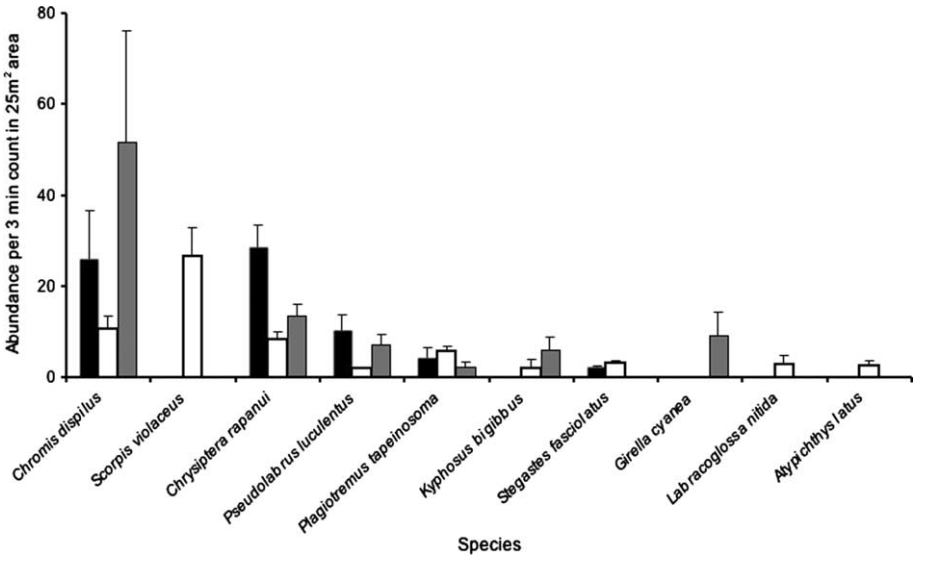

Figure 2 Abundance of 10 most frequently observed reef fish species (mean ± SE) at Kermadec Islands Marine Reserve survey sites (D1, Denham 1, black bars, $n = 10$; D2, Denham 2, white bars, $n = 32$; M, Meyer, grey bars, $n = 13$). Refer to Fig. 1 for location of survey sites.

and biomass per station (114.9 ± 28.5 individuals; 39.7 ± 16 kg respectively). The mean size of *Chromis dispilus* was larger at M (15 ± 2 cm; mean ± SE) than D1 and D2 (D1 = 7 ± 1 cm; D2 = 8 ± 2 cm). *Kyphosus bigibbus* showed greatest average size at M (31 ± 4 cm; D2 = 24 ± 5 cm; mean ± SE) and was not observed at D1. *Pseudolabrus luculentus* was larger at D2 (12 ± 1 cm; mean ± SE) than at D1 (8.8 ± 2 cm) and M (7.1 ± 1 cm). Planktivores were the most abundant trophic group at all sites, accounting for 71% of total observations, followed by invertebrate feeders (10%), omnivores (8%), fish and invertebrate feeders (7%) and herbivores (4%) (Fig. 3). Planktivores accounted for 47% of total biomass, followed by omnivores (35%), invertebrate feeders (8%), fish and invertebrate feeders (7%), and herbivores (3%; Fig. 3). The high biomass of omnivores observed at M was related to a high abundance of *Girella cyanea* (Fig. 3). Increased sampling effort of reef fishes would likely record new species, as a species accumulation curve did not reach an asymptote (Fig. 4).

Discussion

Observations of *Chromis dispilus* as the most abundant species followed by *Scorpis violaceus*, *Chrysiptera rapanui*, *Pseudolabrus luculentus*, *Plagiotremus tapeinosoma* and *Kyphosus bigibbus* are similar to observations by Schiel et al. (1986) and Cole et al. (1992). *Scorpis violaceus* was classified by Francis et al. (1987) as abundant and observed by Cole et al. (1992) at two of four sites surveyed, but was not observed by Schiel et al. (1986). In this study, *Scorpis violaceus* was observed at one of three sites, Denham 2. The high abundance of *Plagiotremus tapeinosoma* noted in my study was not reported by Schiel et al. (1986) nor by Cole et al. (1992), who recorded it as the 10th most abundant benthic fish out of 12, although Francis et al. (1987) reported it to be common, which may indicate that this species is only found at specific locations throughout the archipelago or that it varies in its distribution temporally.

Planktivores dominated trophic group abundance at all sites and accounted for almost

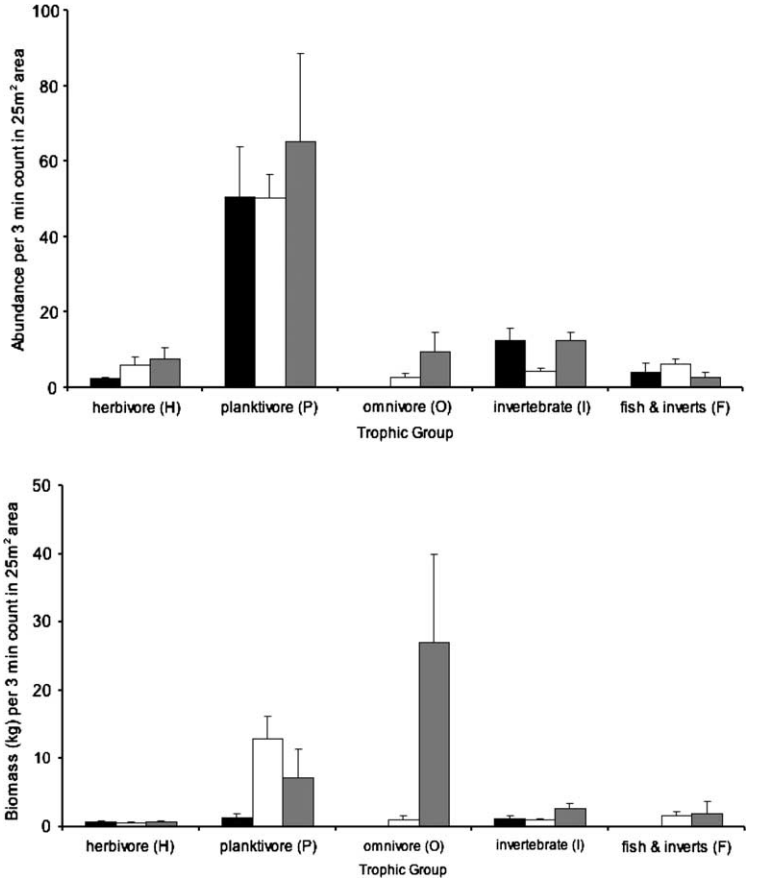

Figure 3 Abundance and biomass (kg) of reef fishes representing each trophic group (mean + SE) at Kermadec Islands Marine Reserve survey sites (D1, Denham 1, black bars, $n = 10$; D2, Denham 2, white bars, $n = 32$; M, Meyer, grey bars, $n = 13$). Refer to Fig. 1 for location of survey sites.

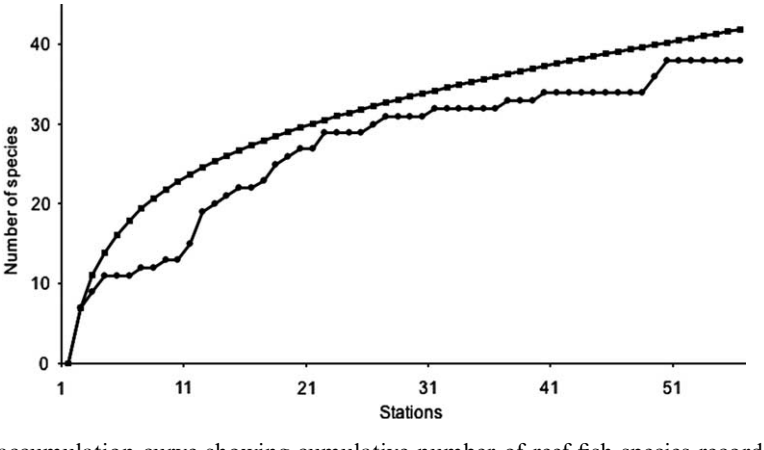

Figure 4 Species accumulation curve showing cumulative number of reef fish species recorded at Kermadec Islands Marine Reserve (data pooled across all three sites) within each station (circles) and generated using the Bootstrap technique with 9999 permutations (squares).

half of the biomass, while invertebrate feeders, herbivores, fish and invertebrate feeders and omnivores represented smaller proportions, suggesting that plankton is a major food source available to fishes of the Kermadec Islands. Omnivores accounted for a high biomass at M, in comparison with small biomasses at both D1 and D2, also suggesting that they are sensitive to differences among sites. Differences in size-class distributions may suggest that certain regions of the Kermadec Islands are preferentially used by juveniles and adults of some species, although species-specific factors have not been identified. Future observations will undoubtedly provide a greater understanding of spatial and temporal variability in reef fish assemblages at the Kermadec Islands MR.

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References

Brook FJ 1998. The coastal molluscan fauna of the northern Kermadec Islands, Southwest Pacific Ocean. Journal of the Royal Society of New Zealand 28: 185–233.

Brook FJ 1999. The coastal scleractinian coral fauna of the Kermadec Islands, southwestern Pacific Ocean. Journal of the Royal Society of New Zealand 29: 435–460.

Clarke, KR, Gorley RN, 2006. PRIMER v6: user manual/tutorial. Plymouth, PRIMER-E.

Cole RG 2001. Patterns of abundance and population size structure of herbivorous fishes at the subtropical Kermadec Islands and in mainland New Zealand. New Zealand Journal of Marine and Freshwater Research 35: 445–456.

Cole RG, Creese RG, Grace RV, Irving P, Jackson BR 1992. Abundance patterns of subtidal benthic invertebrates and fishes at the Kermadec Islands. Marine Ecology-Progress Series 82: 207–218.

Francis MP 1985. The Kermadec Islands. A marine reserve proposal. New Zealand Ministry of Agriculture and Fisheries, Fisheries Research Division Internal Report 29.

Francis MP 1991. Additions to the fish faunas of Lord Howe, Norfolk and Kermadec Islands southwest Pacific Ocean. Pacific Science 45: 204–220.

Francis MP 1993. Checklist of the coastal fishes of Lord Howe, Norfolk, and Kermadec Islands, Southwest Pacific Ocean. Pacific Science 47: 136–170.

Francis MP 2001. Coastal fishes of New Zealand: an identification guide. Third edition. Auckland, Reed Books.

Francis MP, Grace RV, Paulin CD 1987. Coastal fishes of the Kermadec Islands. New Zealand Journal of Marine and Freshwater Research 21: 1–13.

Francis MP, Randall JE 1993. Further additions to the fish faunas of Lord Howe and Norfolk Islands, Southwest Pacific Ocean. Pacific Science 47: 118–135.

Froese R, Pauly D 2005. FishBase: concepts, design and data sources. Los Baños, Laguna, Philippines, ICLARM (www.fishbase.org).

Gardner JPA, Curwen MJ, Long J, Williamson RJ, Wood AR 2006. Benthic community structure and water column characteristics at two sites in the Kermadec Islands Marine Reserve, New Zealand. New Zealand Journal of Marine and Freshwater Research 40: 179–194.

Schiel DR, Kingsford MJ, Choat JH 1986. Depth distribution and abundance of benthic organisms and fishes at the subtropical Kermadec Islands. New Zealand Journal of Marine and Freshwater Research 20: 521–535.

Taylor RB, Willis TJ 1998. Relationships amongst length, weight and growth of north-eastern New Zealand reef fishes. Marine and Freshwater Research 49: 255–260.

Wicks LC, Gardner JPA, Davy SK 2010. Spatial patterns and regional affinities of coral communities at the Kermadec Islands Marine Reserve, New Zealand—a marginal high-latitude site. Marine Ecology Progress Series 400: 101–113.