

NEW ZEALAND IMPLEMENTATION OF PROTECTION MEASURES FOR VULNERABLE MARINE ECOSYSTEMS IN THE SOUTH PACIFIC OCEAN

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ABSTRACT

*The Interim Measures for bottom fisheries adopted by the developing South Pacific RFMO require participants to limit bottom fishing to 'currently fished areas', and to prevent significant adverse impacts on vulnerable marine ecosystems in fished areas. The bottom trawl footprint mapped by New Zealand consists of 200 x 20 minute blocks trawled over the reference period 2002 - 2006, forming distinct fishing areas within which New Zealand flagged vessels reported 11,425 tows, primarily targeting orange roughy (*Hoplostethus atlanticus*). Effort levels and levels of past seabed impact differ substantially within these blocks, ranging from 'lightly' trawled (< 3 tows / block) to 'heavily' trawled (>50 tows / block), with a maximum of 1,417 tows in the most heavily trawled block on the Challenger Plateau. Effort data were used to stratify the bottom trawl footprint into three effort tiers, each comprising about one third of the footprint.*

This effort stratification was used as the basis for implementation of three-tiered management measures tailored to levels of past effort and impact. 62 'lightly trawled' blocks were closed to prevent further impact in these areas. 69 'moderately trawled' blocks were made subject to a move-on rule to require vessels to identify and move away from fishing positions which produce 'evidence of a VME'. 69 'heavily trawled' blocks were designated as Open to fishing, constraining future fishing effort primarily to these previously impacted areas. A further 20 blocks were closed to provide representative protection within the moderately and heavily trawled tiers and further closures may be established on the basis of benthic bycatch data.

In the absence of seabed biodiversity data upon which to base representative closures, biologically important physical factors, primarily depth range and topography, were used to select additional closures and to evaluate representivity of Closed areas in comparison with Open areas. Geospatial analyses are presented on the distribution of seabed depth within Open, Move-On and Closed blocks in each fishing area, and the depth and topographic representivity of closures in comparison with the overall SPRFMO Area is evaluated.

INTRODUCTION

Lying as it does on the 'Pacific Ring of Fire', New Zealand is closely surrounded by extensive volcanic underwater topographic features, ranging from the 10,000m deep Kermadec Trench in the north to the 4,000m high Macquarie Ridge in the South, and from the massive Lord Howe / Challenger plateaus in the west to the Louisville Seamount chain in the east. The FAO '*International Guidelines for the Management of Deep-Sea Fisheries in the High Seas*' list such features, particularly submerged edges and slopes; summits and flanks of seamounts, guyots, banks, knolls, and hills; canyons, trenches and hydrothermal vents, as features that potentially support species, groups or communities which are '*considered sensitive and potentially vulnerable to deep sea fisheries in the high seas, and which may contribute to forming vulnerable marine ecosystems (VMEs)*' (FAO 2008).

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UN General Assembly Resolution 61/105, of December 2006, requires that such areas on the high seas should be closed to bottom fisheries, unless adequate management measures have been put in place to prevent significant adverse impacts on VMEs. In response, participants negotiating the South Pacific RFMO (SPRFMO) adopted interim measures for high seas bottom fisheries in April / May 2007. These interim measures include limiting bottom fishing to within areas where such fishing is '*currently occurring*', and to prevent significant adverse impacts on VMEs in such fished areas (SPRFMO 2007a)³. New Zealand is implementing these interim measures through a series of sequential implementation steps. A number of the requirements of the interim measures were already satisfied through existing management systems for New Zealand fisheries (such as VMS requirements), while other measures have required further implementation of existing systems (such as increased observer coverage). Requirements to limit bottom fishery impacts to 'currently fished areas', and to prevent 'significant adverse impacts' in these areas, are being implemented through a combination of precautionary closures and a move-on rule.

New Zealand's implementation of the SPRFMO interim measures began with full observer coverage requirements in 2007, followed by conservation and management measures that came into effect in May 2008, in time for the 2008 high seas bottom trawling season in the form of conditions on the high seas fishing permits required by New Zealand flagged vessels fishing the high seas. The purpose of this paper is to describe the process whereby these measures were developed, present the information used to design these measures and evaluate the representivity of closed and move-on areas in terms of biologically important physical factors, in comparison with areas left open to fishing.

MAPPING THE NEW ZEALAND BOTTOM TRAWL FOOTPRINT

In terms of the Benthic Assessment Framework adopted at the 4th SPRFMO negotiation meeting in September 2007, 'currently fished' areas are defined in terms of a bottom fishing 'footprint' consisting of 20 minute (latitude x longitude) blocks trawled over the years 2002 - 2006 (SPRFMO 2007b). The New Zealand high seas bottom trawling footprint was mapped using high seas catch and effort data reported to the New Zealand Ministry of Fisheries on compulsory catch and effort returns over the 2002 - 2006 reference period. These returns report all bottom trawl tow start and end positions in latitude / longitude to the nearest minute. The resultant bottom trawl footprint consists of 200 x 20-minute blocks within which at least one trawl occurred over 2002 - 2006, comprising separate fishing areas on the Lord Howe Rise, Challenger Plateau, West Norfolk Ridge, Three Kings Ridge and Louisville Ridge (Figure 1).

A total of 11,145 bottom trawls were reported by New Zealand vessels in these 200 bottom trawl footprint blocks over 2002 - 2006. However, levels of historical fishing effort within these 200 bottom trawl footprint blocks differ substantially. 62 blocks were very lightly trawled, with < 3 tows per block and a combined total of 92 tows. With an average of zero tows per year, these blocks were classified as 'lightly trawled' over the period. At the other end of the scale, half the remaining blocks (69 blocks) sustained 10,533 tows, with > 50 tows (average 10 tows per year) per block, and a maximum total 1,417 tows per block reported over 2002-2006 in the most heavily trawled block on the Challenger Plateau. Within these blocks, designated as 'heavily trawled' for implementation purposes, 95% of the trawling effort occurred, 97% (8,957 t) of the New Zealand high seas orange roughy catch was made, much of the trawling was conducted on shallower features and seabed impacts will have been most concentrated (MFish 2008).

³ The SPRFMO Area is under negotiation, but for the purposes of the interim measures and this paper it is the high seas area south of the Equator, north of the CCAMLR Convention area, east of the SIOFA Convention Area and west of the areas of fisheries jurisdictions of South American States.

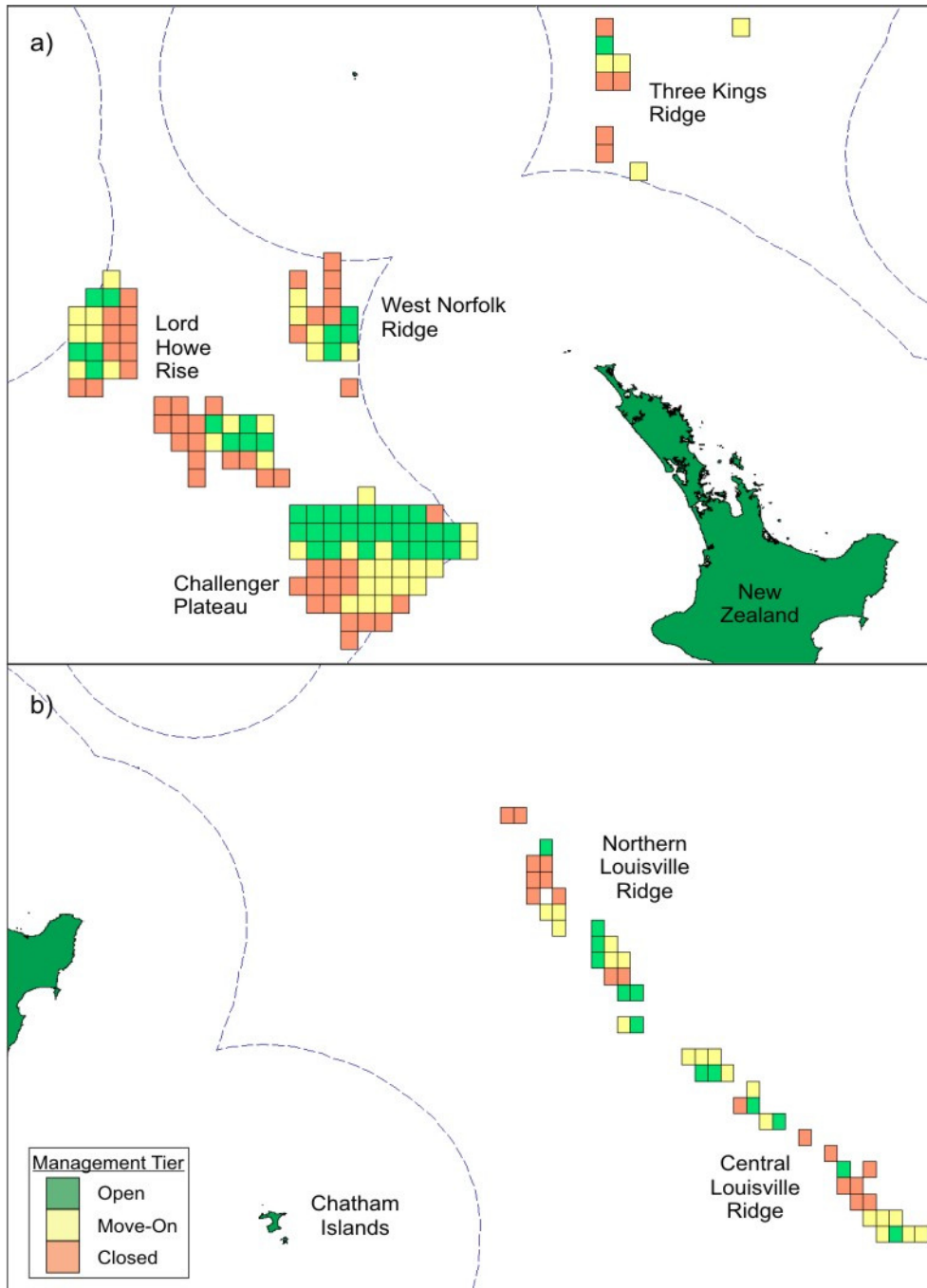


Figure 1. Geographic distribution of Open, Move-On and Closed New Zealand bottom trawl footprint blocks in a) The Lord Howe Rise, Challenger Plateau, West Norfolk Ridge and Three Kings Ridge areas, and b) The Northern and Central Louisville Ridge areas. (Southern Louisville Ridge footprint blocks are not shown).

In-between these effort extremes, the remaining 69 blocks supported 5% of the effort (559 tows) and 3% (265 t) of the orange roughy catch. Within these 'moderately trawled' blocks, many of the trawls were conducted on flatter areas adjacent to seamounts, and seabed impacts are expected to have been relatively low. The resulting effort stratification of the New Zealand bottom trawl footprint was used as the foundation for a three-tiered approach to implementation of the SPRFMO interim measures for protection of VMEs.

PREVENTION OF SIGNIFICANT ADVERSE IMPACTS ON VMEs

In terms of the SPRFMO interim measures for bottom fisheries, in addition to being restricted to fishing within the bottom trawl footprint, participants are required to close areas where VMEs are known or likely to occur, unless adequate management measures have been implemented to prevent '*significant adverse impacts*' on VMEs in such areas. Although significant adverse impacts were not defined, concerns focus on trawling impacts on underwater topographic features which support VMEs, particularly seamounts and biogenic habitat forming coldwater corals and sponge fields. In areas where presence of VMEs is unknown, participants are required to move 5nm away from sites where 'evidence of a VME' is encountered (Parker *et al.* 2009, this volume).

In implementing the interim measures, New Zealand's approach has been to tailor management measures to levels of past effort and impact in each of the three bottom trawl footprint effort tiers. Management and mitigation measures to give effect to the SPRFMO bottom fishery interim measures were developed in consultation with industry, environmental NGOs and other government departments concerned with benthic protection. Competing objectives or requirements were expressed by participants in these consultations:

- To protect all known or likely VMEs from any significant adverse impacts from bottom fishing operations.
- To provide access to adequate and suitable target areas to provide for a viable and sustainable deepwater trawl fishery.

The management approach taken, and described in this paper, attempts to balance these competing objectives, while fulfilling the interim measures. In doing so, given the difficulty of defining '*significant adverse impacts*', New Zealand has implemented measures which instead attempt to provide for '*adequate and representative protection*' from trawling impacts, and to do so at an ecosystem or regional area level, not at an individual feature level. The approach taken protects representative areas (in terms of what is known about their depth, seabed habitat and geographic distribution ranges) of benthic habitat and associated VMEs, characteristic of the various fishing areas, from significant adverse impacts at an ecosystem scale, while providing for fishing in limited areas that have previously been heavily fished.

Three-Tier Management Approach

New Zealand's three-tiered approach to implementing management and mitigation measures has been designed to provide adequate and representative protection to areas likely to support VMEs, with emphasis on protecting areas less impacted by past fishing effort, while constraining future fishing effort to areas already most impacted by past fishing. This has been done by adopting different approaches in each of the three effort tiers in the bottom trawl footprint. An overview of the key characteristics of the three effort tiers and the management measures implemented within each tier is shown in Figure 2 and a summary of the total number of blocks, and numbers closed within each fishing area, is shown in Table 1. Maps showing the geographic distribution of the New Zealand bottom trawl footprint blocks, indicating closure status of each block, is shown in Figure 1 for the Lord Howe Rise, Challenger Plateau, West Norfolk Ridge Three Kings Ridge, Northern and Central Louisville Ridge areas.

Table 1. Summary of the total number of blocks in each fishing area, and the number closed in each effort tier.

Fishing Area	Total Number of Blocks	Lightly Trawled Closed Blocks	Additional Closures: Mod & Heavy areas
Lord Howe North	22	8	2
Lord Howe South	23	12	2
Challenger Plateau	58	9	6
West Norfolk Ridge	17	6	2
Three Kings Ridge	10	4	1
Louisville North	24	7	3
Louisville Central	26	6	2
Louisville South	16	6	2
Other Areas	4	4	0
Total	200	62	20

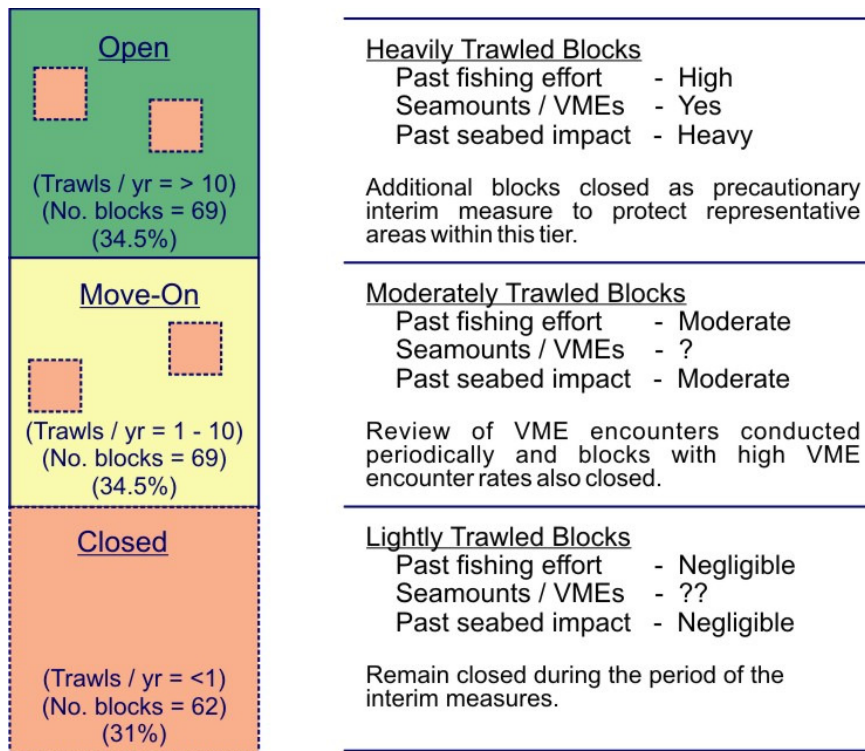


Figure 2. The three-tier past-effort classification system adopted by New Zealand as a basis for management of bottom trawling in the bottom trawl footprint.

- *Tier 1: Lightly Trawled Blocks*

The 62 lightly trawled blocks have been closed to further fishing. This reduces the footprint to a better approximation of the actual area ‘currently fished’, and protects these lightly trawled areas from further impact, while ensuring that effort is limited primarily to areas already impacted by previous fishing. A similar ‘approach to benthic protection has been adopted in other regions, such as the ‘open areas’ approach by the U.S.A. National Marine Fisheries Service for benthic habitat protection in the Aleutian Islands / Bering Sea

groundfish trawl fishery (NMFS 2008). An important purpose of that fishery management plan is to constrain fishing effort to seabed areas already impacted by past fishing, and prevent effort from expanding onto adjacent untrawled, or lightly trawled, areas. The approach taken by NMFS has been to close any area with ≤ 1 trawl per 100 km² over 1998 - 2005 to further fishing, with any area with > 1 trawl being designated the 'open' area for fishing. For comparison, the 20 minute blocks comprising the New Zealand bottom trawl footprint average 1,087 km² in area, ranging from 1,243 km² in the north to 898 km² in the south of the footprint, with blocks with < 4 trawls over 2002 - 2006 being closed.

- *Tier 2: Moderately Trawled Blocks*

Much of the fishing effort in the 69 moderately trawled (3 - 50 tows) blocks appears to have been exploratory fishing in areas adjacent to targeted seamount features, and it is largely not known whether VMEs occur in these blocks. The 'move on' rule has been applied in these blocks, using the rapid VME Identification Protocol described in Parker *et al.* (2009, in press). Vessels bringing up 'evidence of a VME' (as defined in that protocol) are required to move 5nm away from the position that hauling of the gear commenced for any particular tow, and not fish within 5nm of that position for the remainder of that fishing trip. 'Evidence of VMEs' in trawl bycatches in each tow is gathered by scientific observers under the 100% observer coverage requirements for high seas bottom trawling. These observers additionally collect detailed scientific benthic by-catch data, quantified and identified to lowest possible taxon. Data generated by trawls encountering evidence of a VME will be periodically reviewed, together with observer data on detailed benthic bycatch. Additional closures will be considered if consistent and significant evidence of VMEs is found in particular areas (see Parker *et al.* 2009 for details).

- *Tier 3: Heavily Trawled Blocks*

Much of the past fishing effort in the 69 'heavily trawled' (> 50 tows) blocks has been targeted on certain seamount features. These heavily trawled blocks account for most of the effort and catch over the 2002 - 2006 reference period. Given the existing evidence of the substantial impact of bottom trawling on fragile deepwater corals, it is likely that many VMEs in targeted fishing positions in these areas have already been significantly impacted. These blocks have been designated to be 'open' fishing areas. The 'move on' rule has not been applied in these blocks, in part to address the concern that such move-on provisions result in steady expansion of fishing effort onto adjacent, previously less impacted areas, and that it is preferable to constrain effort to existing trawled areas. Instead, 'adequate representative protection' of VMEs across the spatial scale of each of the distinct fishing areas is being implemented through the closure of the lightly trawled tier; implementation of the move-on rule (with the possibility of further closures if existence of VMEs is demonstrated), plus additional precautionary closures in the moderately and heavily trawled tiers.

- *Additional Block Closures*

While the heavily and moderately trawled blocks are, in principle, 'open' fishing areas, with a move-on provision in the moderately trawled blocks, there were concerns that closures implemented in the lightly trawled tier may not be adequately representative of the open areas, so that additional representative protection was required in the heavily and moderately trawled tiers. An additional 20 blocks (10% of the total footprint blocks), 9 in the moderately trawled and 11 in the heavily trawled areas, have therefore been closed. The 20 additional block closures were selected to be representative of the open areas in terms of depth range and topography, using high-resolution bathymetry provided by industry for the purpose of the consultations.

PRINCIPLES FOR EVALUATING REPRESENTIVITY OF SPATIAL CLOSURES

Adequate and representative area closures have been recognized as probably the most effective long-term VME protection measure by the SPRFMO Science Working Group (SPRFMO 2007c) and the FAO Technical Consultation on International Guidelines for the Management of Deepsea Fisheries in the High Seas (FAO 2008). Recent IUCN recommendations on protection of seamounts and deep sea VMEs recommend a minimum closure of 30% - 40% of such areas (Rogers *et al.* 2008). One of the main questions that arose during consultations and risk assessment on the three-tier management approach and proposed closures was whether Closed areas were representative of the Open areas in terms of likelihood of supporting VMEs, and whether these closures were sufficient to constitute 'adequate and representative protection' across the spatial scale of the bottom trawl footprint (MFish 2008).

Data on seabed biodiversity are lacking for most deep sea benthic areas, except for a few specifically surveyed seamount systems. In the absence of such data, a series of Pew Foundation sponsored workshops to develop guidelines for the design of MPA networks for seamounts and the Abyssal Nodule Province in the Pacific high seas (Clark 2008) has recommended stratification of such closures to represent at least the following 'biologically important factors' of importance to coldwater corals:

Biogeographic Zone: Reflecting oceanographic conditions (water masses) in large ocean areas, such as the Southwest Pacific Ocean.

Proximity / Connectivity: Being the distance between underwater topographic features (such as seamounts), and the relationship of seamount direction to current flow. These affect the abilities of fauna to disperse and colonize adjacent seamounts. The range indicating a separate feature has been proposed as 100km - 200km and Clark (2008) specifically recommend Close (<100km separation) and Distant (> 100km separation) as appropriate strata for precautionary conservation in the central Pacific region.

Summit Depth / Seabed Depth Range: Depth is a major determinant of species composition, particularly on deepsea seamount features with high elevation. Elevation above the abyssal plain (which typically lies at ~4000m deep in the South Pacific Ocean) is also a relative measure of seamount size. The following depth strata were adopted for the purposes of evaluating the New Zealand bottom trawl closures, modified slightly from those recommended by Clark (2008) to divide strata at 2,000m, the current maximum trawlable depth.

- 0 - 200 m - This stratum represents the protrusion of a seabed feature into the photic zone.
- 201 - 800m - This stratum represents the depth distribution range of the scattering layer, composed of vertically migrating animals, and the impact of these on the fauna that exists on seamount summits. 800m is the upper bathyal split proposed by Zezina (1997).
- 801 - 2,000 m - This stratum covers part of the 800 - 3,500m depth band recognized in the GOODs report (2008) as the lower bathyal biogeographic zone, as assigned by Zezina (1997) based on a global evaluation of brachiopods. The lower bathyal zone has been divided at 2,000m for the purpose of designing representative closures in the bottom trawl footprint.
- > 2,000m - This is the stratum below current trawling technology, and currently beyond impact by deepwater trawling.

Seabed Topography: Seabed topography is an indicator of seabed geology, and therefore of substratum suitability for supporting VME species. FAO (2008) specifically recognizes the following as being features that potentially support species, groups or communities which may contribute to forming VMEs:

- Submerged edges and slopes; summits and flanks of seamounts, guyots, banks, knolls, and hills; canyons, trenches and hydrothermal vents.

EVALUATION OF REPRESENTIVITY OF CLOSED AREAS

The four main biologically important factors identified above were used to stratify and evaluate representivity of the spatial closures within the New Zealand bottom trawl footprint.

- *Stratification by Biogeographic Zone*

Fishing areas in the Tasman Sea and in the SW Pacific Ocean can be considered, at most, to occupy two different bio-geographic zones. The requirement of stratifying representative benthic protection measures by biogeographic zone (Clark 2008) is automatically dealt with by stratifying closures between the fishing areas.

- *Stratification by Proximity / Connectivity*

Stratification of spatial closures across the fishing areas also addresses the recommendation to stratify spatial closures by proximity / connectivity. The Tasman Sea fishing areas are about 150km x 300km in size, with separation between them ranging from about 50km - 250km. The three areas along the Louisville Ridge are about 120km wide, but up to 1,200km long.

The distribution of closures across these fishing areas is shown in Figure 1 and summarised in Table 1. The lightly trawled block closures are distributed across all fishing areas, in inverse proportion to the level of past fishing effort in each area. A smaller proportion of the blocks have remained lightly trawled in heavily trawled areas such as the Challenger Plateau, and so a smaller proportion of blocks in that area (16%) have been closed. In contrast, a high proportion of blocks have been lightly trawled, and closed, in less trawled areas such as the West Norfolk Ridge (35% closed), Three Kings Ridge (40% closed) and Lord Howe Rise (44% closed). Lightly trawled block closures along the Louisville Ridge range from 23% of blocks for the most heavily trawled central area to 38% of blocks in the more lightly trawled southern area.

In contrast, additional closures in the moderately and heavily trawled tiers were intentionally distributed in proportion to the number of heavily trawled blocks in each area, to ensure proportional protection by these additional closures. The largest number of additional closures was therefore made in the Challenger area (six blocks), decreasing to one additional closure in the Three Kings Ridge area. Over the entire bottom trawl footprint, 31% of the blocks were closed due to being lightly trawled, with additional closures bring the total proportion closed to 41% (82 of the 200 blocks).

- *Stratification and Representivity by Depth Range*

Representivity by depth and topography were evaluated using seabed bathymetric data. During consultations with industry, additional block closures were specifically selected to be representative of open areas within each fishing area, based on high-resolution bathymetric industry data of trawled areas. Representivity of all closed areas in relation to the SPRFMO

Area was then evaluated using the 2008 global one minute resolution gridded bathymetry available from the General Bathymetric Chart of the Oceans (www.gebco.net). Data were extracted for the SPRFMO Area (0° - 60°S, 120°E - 70°W) and re-gridded at 3 minute resolution using MapInfo Vertical Mapper® to reduce the amount of data. Simple rectangular gridding (which averages nearby depths at the new grid resolution) was used to avoid introducing any further gridding artefacts. These re-gridded depth data were contoured using MapInfo® to produce closed contour regions at intervals of 200m from which areas by depth could be determined, split into regions which fall within the SPRFMO Area, and those which fall into Exclusive Economic Zones EEZs adjacent to the SPRFMO Area.

Histograms of the resulting 200m depth frequency distributions are compared in Figure 3 for EEZs and the SPRFMO Area. The seabed in the SPRFMO Area primarily covers the depth range 2,800m - 5,600m, with a strong mode at the depth of the abyssal plain from 4,000m - 4,600m. Many South Pacific countries have extensive deep areas within their EEZs and EEZ seabed depths cover a wider range than the SPRFMO Area, extending from the shore out to the 10,000m deep Kermadec Trench within the New Zealand EEZ. Notably, most of the South Pacific seabed in depths < 3,200m lies within EEZs, with most of the seabed in the trawlable depths < 2,000m lying on continental shelves and slopes within EEZs.

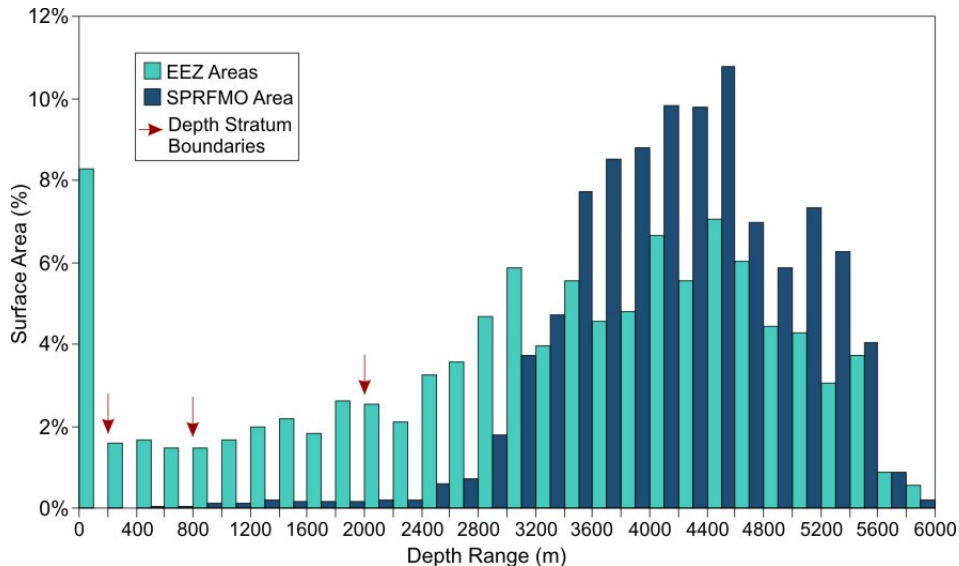


Figure 3. Depth frequency distributions (200m depth ranges) of the seabed in the SPRFMO Area, and in adjacent EEZs, showing boundaries (from Clark 2008) of the depth strata used for evaluating representivity of closed areas by depth.

Table 2 provides a summary of the estimated area within each of the recommended depth protection strata (Clark 2008), and the depth boundaries of these strata are indicated on Figure 3. Most EEZ and SPRFMO areas lie below trawlable depth, but there are substantial differences between the SPRFMO Area and EEZs in the trawlable depth ranges. Less than 1% of the SPRFMO Area is < 2,000m deep, whereas 23% of EEZs are shallower than 2,000m. Across the whole South Pacific, almost 100% of the 0m - 200m depth range lies within EEZs, as does 98% of the 200m - 800m range and 90% of the 800m - 2,000m range. Overall, 94% of the trawlable depth range of 0m - 2,000m lies within EEZs and coastal states clearly have an important role to play in protecting VMEs on seabed areas at trawlable depths within their EEZs.

Table 2. Estimated total sea surface area within various depth ranges in the SPRFMO Area and within adjacent EEZs.

Depth Range	Within EEZs		In SPRFMO Area	
	Area (km ²)	% Area	Area (km ²)	% Area
0 - 200	3,109,166	7.6%	552	0.001%
200 - 800	1,770,889	4.3%	43,101	0.1%
800 - 2,000	4,392,874	10.8%	497,305	0.9%
> 2,000	31,453,950	77.2%	53,309,911	99.0%
Totals	40,740,704	100%	53,850,868	100%

The distribution of areas < 2,000m deep within the SPRFMO Area is mapped in Figure 4. These areas are isolated and largely confined to the plateau and ridge areas of the Lord Howe / Challenger / West Norfolk area, and the scattered seamount chains forming the Louisville, Foundation, Salas y Gomez and Nazca Ridges. Figure 5 compares the bottom trawl footprint with the distribution of these < 2,000m deep areas. Although the bottom trawl footprint only covers 0.4% of the total SPRFMO Area, it covers all of the Area from 0m - 200m depth, 90% of the Area from 200m - 800m and 22% of the Area from 800m - 2,000m (Table 3). In total, footprint areas < 2,000m deep cover 28% of the SPRFMO Area < 2,000m deep. There is therefore a clear obligation on SPRFMO participants to protect VMEs that may occur in the high proportion of trawlable depth that lies within the bottom trawl footprint.

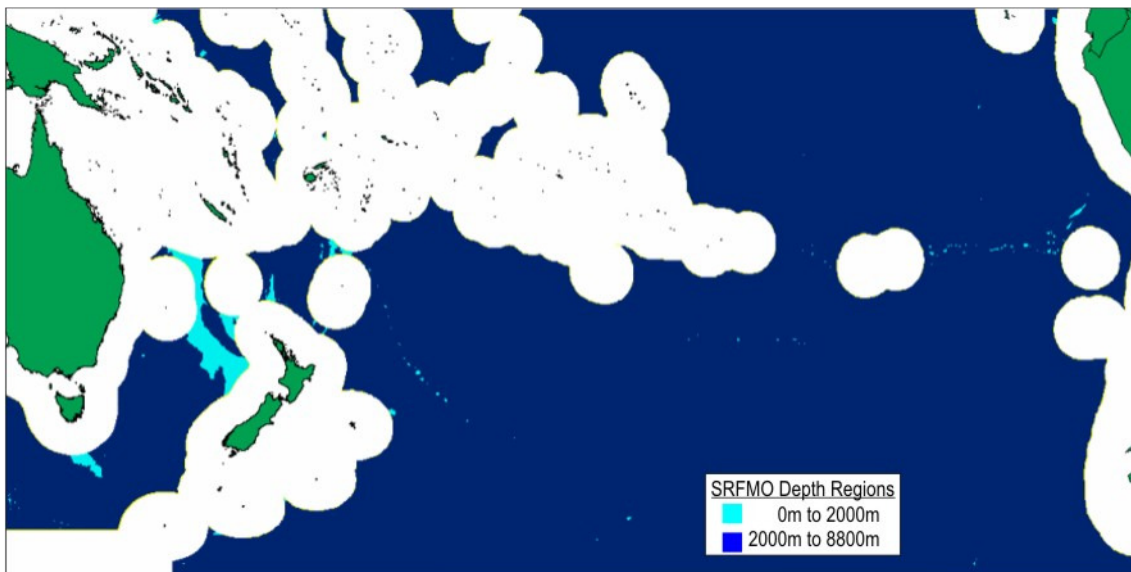


Figure 4. Map of the SPRFMO Area showing the proportion deeper than 2,000m (99% of the SPRFMO Area) and the area shallower than 2,000m (1% of the SPRFMO Area). Trawlable areas (< 2,000m depth) are largely confined to the South Tasman Rise, Lord Howe Rise, Challenger Plateau and the West Norfolk, Three Kings, Louisville, Foundation, Salas y Gomez and Nazca Ridges.

The distribution of depth ranges within each footprint block was evaluated using the original 1 minute GEBCO gridded bathymetry data, which provides ~400 evenly spaced depth grid points for each footprint block. Assuming each point within a block to represent an equal area of the footprint block concerned, the surface areas of each 200m depth range within each footprint block were calculated, to allow comparison with the SPRFMO Area.

Table 3. Proportion of the New Zealand bottom trawl footprint covering various depth strata within the SPRFMO Area.

Depth Range	SPRFMO Area (km ²)	Bottom Trawl Footprint Area (km ²)			Footprint Total
		Closed	Move-On	Open	
0 - 200	552	100.0%	0.0%	0.0%	100.0%
200 - 800	43,101	35.5%	40.0%	14.6%	90.0%
800 - 2,000	497,305	9.0%	4.9%	8.2%	22.0%
> 2,000	53,309,911	0.1%	0.0%	0.0%	0.1%
Totals	53,850,868	0.2%	0.1%	0.1%	0.4%

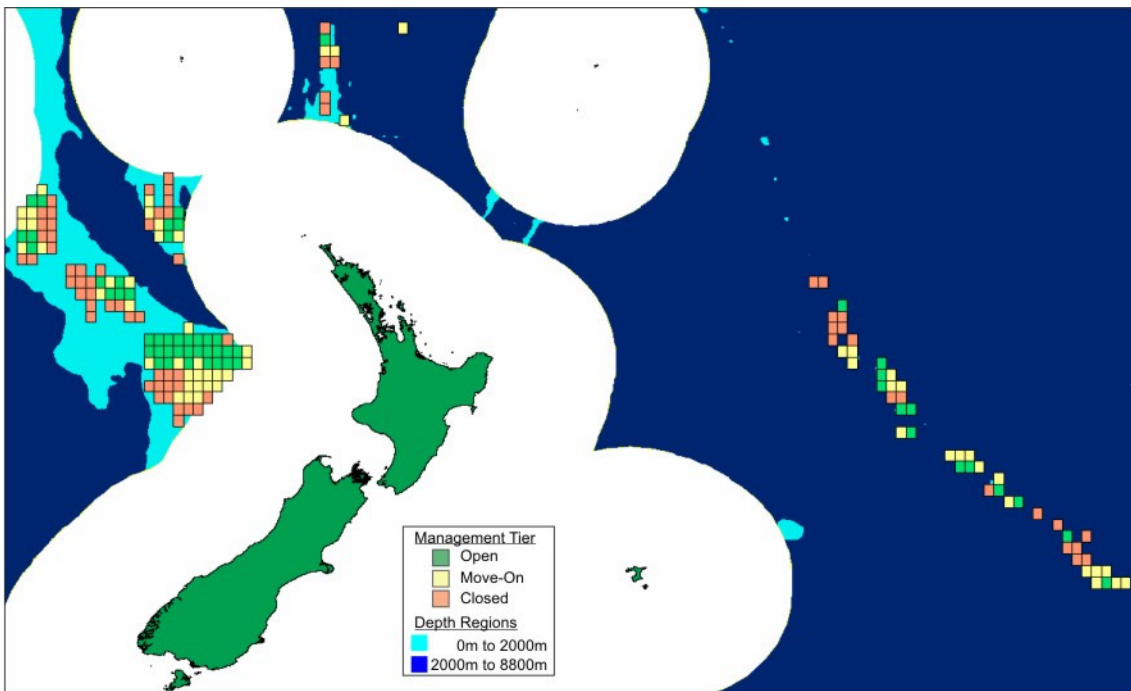


Figure 5. Portion of the SPRFMO Area covering the Lord Howe Rise, Challenger Plateau, West Norfolk Ridge, Three Kings Ridge, northern and central Louisville Ridge areas, showing the areas shallower and deeper than 2,000m, overlaid by the New Zealand bottom trawl footprint blocks in these areas, classified by management status.

The extent to which New Zealand has protected VMEs through spatial closures is shown in Table 3, which summarises the proportion of the footprint within each depth range which has been Closed, made subject to a Move-On rule, or left Open. All of the 0m - 200m depth range has been closed. 84% of the 200m - 800m depth and 63% of the 800m - 2,000m depth range have been closed or made subject to move-on. In addition, the entire depth range deeper than 2,000m is effectively 'closed' as a result of being beyond trawlable depths. These deep areas within the footprint have nonetheless been explicitly closed, as a result of falling within lightly trawled blocks. Overall, 68% of the 0m - 2,000m depth range and 71% of the total depth range within the footprint has been protected in some way, either by closure or by implementation of move-on provisions.

Histograms of seabed area by 200m depth range and closure status within each of the footprint fishing areas is shown in Figure 6. The percentage of each fishing area / depth stratum which has been protected in some way (either by precautionary closures or by implementation of a move-on rule) is further summarised in Figure 7, which shows the

percentage of each stratum protected in relation to 30% and 50% reference levels. The fishing areas differ in depth range, with plateau areas like the Lord Howe Rise and Challenger Plateau having narrower depth ranges than the ridge and seamount chain systems. Much of the footprint on these plateaus lies within the actively targeted trawl depth range of 400m - 1,600m (MFish 2008). Depths on the West Norfolk Ridge span the widest range, including most of the high seas area shallower than 200m and some areas deeper than 2,000m adjacent to the ridge itself. In contrast, most of the seabed in the Three Kings and Louisville Ridge areas lies below 2,000m, with limited areas of trawlable depth, particularly along the Louisville seamount chain.

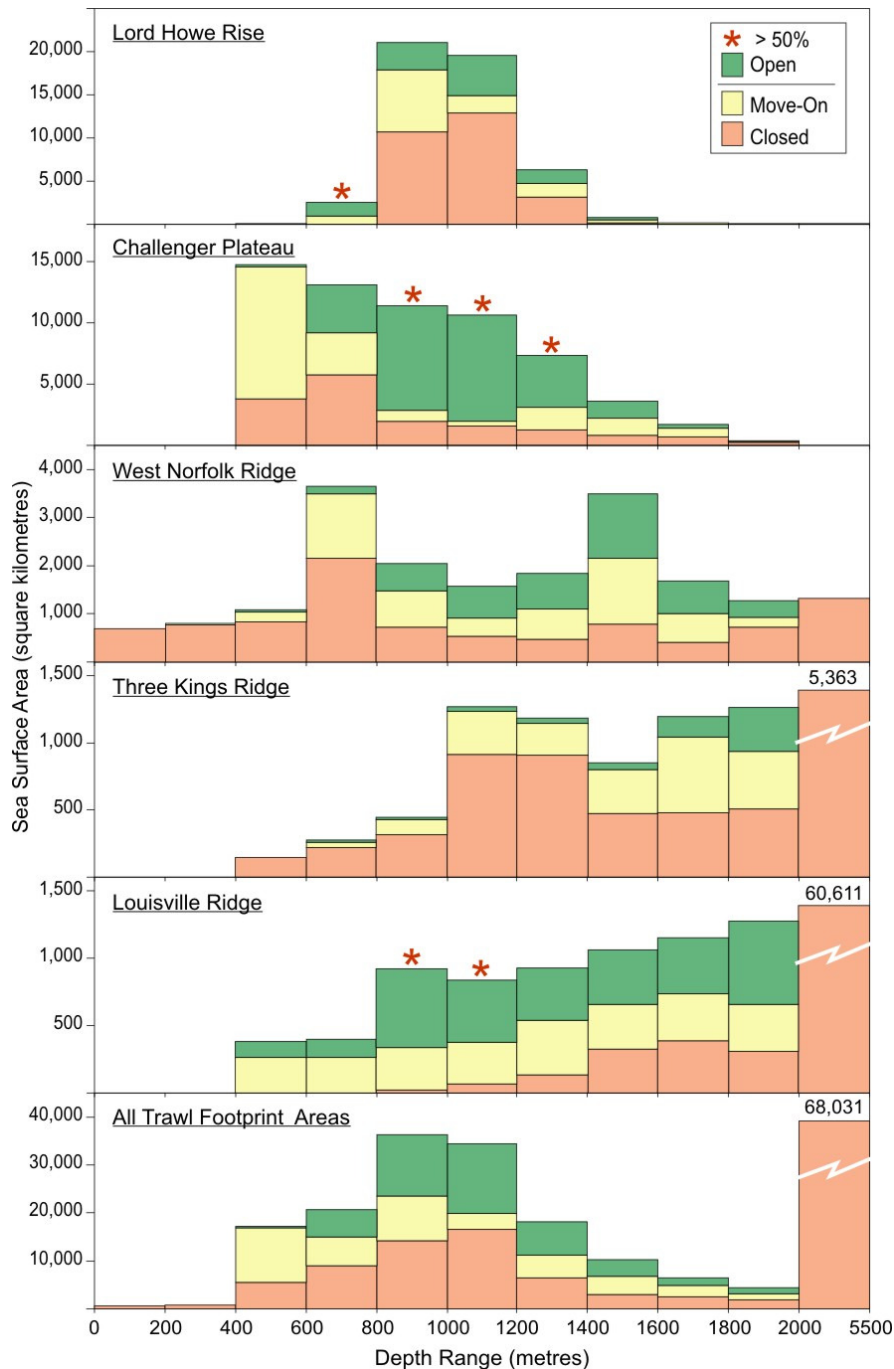


Figure 6. Depth-frequency histograms of the area of Closed, Move-On and Open blocks within the main fishing areas constituting the New Zealand bottom trawl footprint. (* indicates strata where less than 50% of the area has been protected by closure or move-on.)

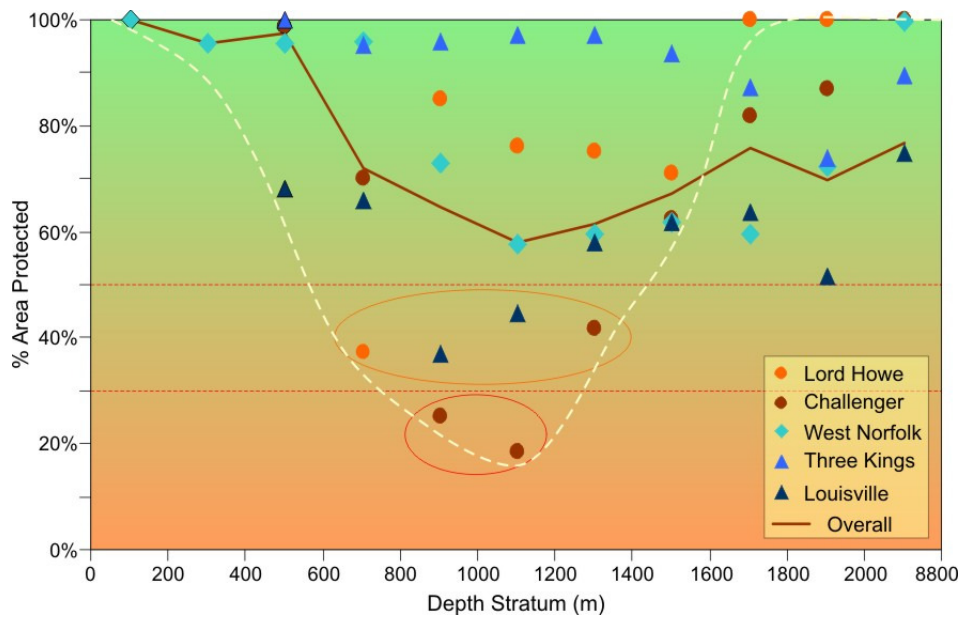


Figure 7. Plot showing the % of each fishing area / 200m depth stratum in the New Zealand bottom trawl footprint that has been protected, either by closure or by move-on provisions, in relation to reference levels of 30% and 50%. The solid line shows proportions protected by 200m depth range across the entire footprint. The dotted line shows the inferred distribution of fishing intensity by depth / area stratum.

Across the entire footprint, more than half of each 200m depth range has either been closed or made subject to a move-on provision, the least being 58% of the 1,000m - 1,200m depth range. However, the proportion of protected area by 200m depth range differs between fishing areas, depending on intensity of past fishing effort in each area. Most notably, 27% of the main targeted depth range of 800m - 1,400m on the Challenger Plateau has been protected, including less than 20% of the 1,000m - 1,200m depth range. 37% of the 600m - 800m depth range on the Lord Howe Rise and 41% of the 800m - 1,200m depth range on the Louisville Ridge have been protected. This is a direct consequence of the higher levels of past (2002 - 2006) fishing effort in these areas, and the management decision to leave such areas open to focus future trawling effort on those historically most impacted areas.

- *Stratification and Representivity by Topography*

Seamounts - Given the emphasis in UN General Assembly Resolution 61/105 (UNGA 2007), the SPRFMO interim measures and the FAO Deepwater Guidelines (FAO 2008) on protection of seamounts as features likely to support VMEs, an initial evaluation of the representivity of footprint closures in protecting topographic features was conducted using available data on distribution of seamounts in the South Pacific Ocean. Two data sets were used, the Kitchingman & Lai (2004) database of predicted seamounts, and the Allain *et al.* (2008) database of validated seamounts occurring within the SPRFMO Area.

Of the total 4,126 Kitchingman & Lai (2004) seamounts occurring in the South Pacific Ocean (0°-60°S, 120°E - 70°W), 2,541 (62%) occur within the EEZs of countries bordering the SPRFMO Area, and 1,585 (38%) within the SPRFMO Area. This is a consequence of the volcanic nature of the region, and the result that many South Pacific countries, particularly small Pacific island countries, have numerous seamounts within their EEZs. Coastal States consequently have an important role to play in protecting VMEs in the South Pacific region.

Within the SPRFMO Area itself, Allain *et al.* (2008) have validated the existence and positions of 1,450 seamount features. Of these, 97% lie outside the new Zealand bottom trawl footprint, 42 lie within the New Zealand bottom trawl footprint, and 18 (1.2%) lie within the Open footprint blocks.

General Seabed Topography - In addition to the GEBCO one minute bathymetric grid data, higher resolution (30 arc-second) data are available from Geoscience Australia (www.ga.gov.au) for the Tasman Sea region. These two data sets were used to generate highest available resolution bathymetric grid maps of the individual fishing areas using MapInfo Vertical Mapper®. Three-dimensional digital terrain surfaces draped with the New Zealand bottom trawl footprint were generated for each fishing area to facilitate visual comparison of topography of the Closed, Move-On and Open blocks in each area. Cross-sectional profiles across the various fishing areas were then used to evaluate the extent to which closed areas, and areas outside the bottom trawl footprint, are representative, in terms of depth range and seabed topography, of the areas left open to bottom trawling. Examples are presented here of two of the areas, to illustrate the process which was conducted for all areas (see MFish 2008).

- *Three Kings Ridge*

The Three Kings Ridge footprint area lies along the eastern edge of the Fiji Basin, and is surrounded by a large number of relatively isolated, steep, high profile seamounts (Figure 8). Most of the high profile and likely high biodiversity features in this area lie outside the footprint, and have remained untrawled, as has much of the ridge feature itself. Along the ridge area within the footprint, only one block remains open to fishing. The combination of closed, move-on and outside-footprint surrounding areas protect most of the shallower, high profile areas in the northern part of this area. The one additional block closure, plus one move-on block, afford complete protection of the southern part of this area, including the shallowest feature.

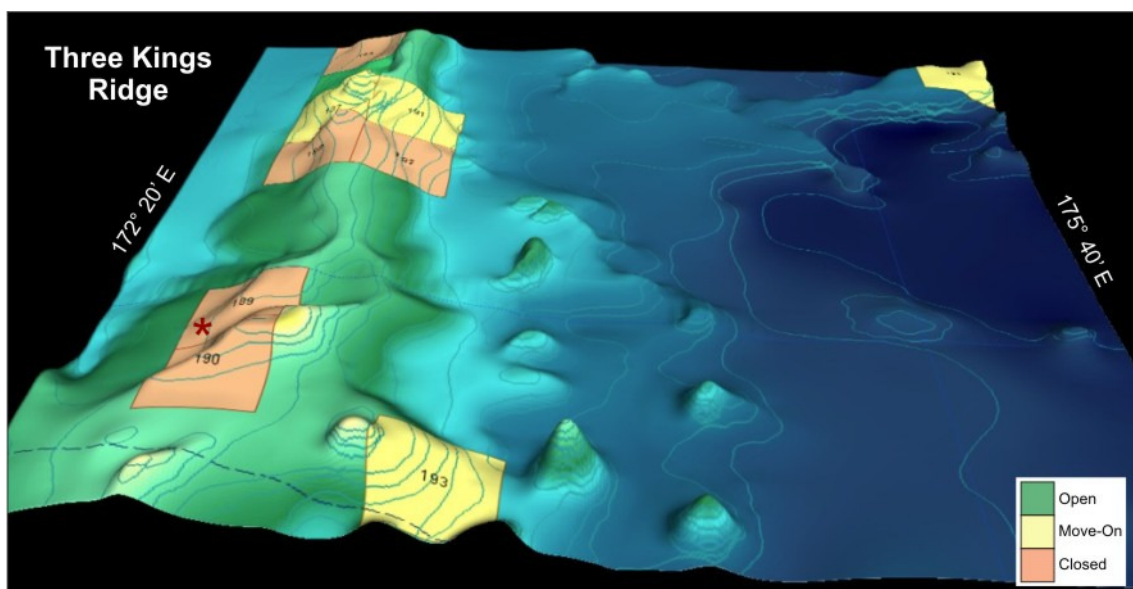


Figure 8. Three-dimensional seabed topography in the Three Kings Ridge fishing area showing the distribution of Open, Move-On and Closed bottom trawl footprint blocks, and ridge / seamount features outside the footprint. (* indicates additional closures of moderately and heavily trawled blocks.)

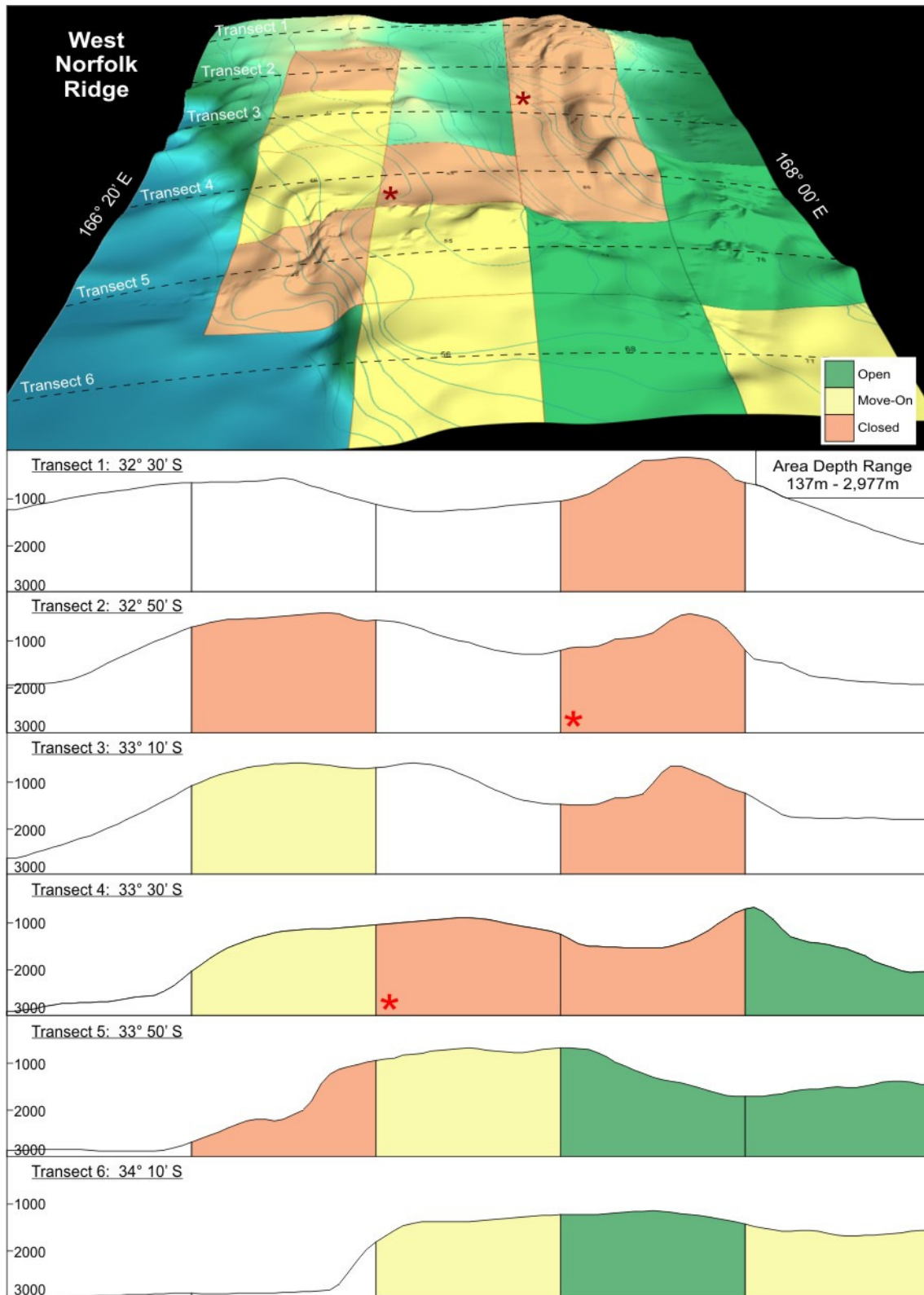


Figure 9. Three-dimensional seabed topography in the West Norfolk Ridge fishing area showing the distribution of Open, Move-On and Closed bottom trawl footprint blocks. Transects through the indicated block centre latitudes show the comparative profiles of Open, Move-On and Closed blocks, and of areas outside the footprint. Areas outside the footprint are unshaded. (* indicates additional closures of moderately and heavily trawled blocks.)

- *West Norfolk Ridge*

The West Norfolk Ridge is a complex, rugged and high profile area of hills, steep flanks and canyons, dominated by two parallel ridge features running roughly north-south (Figure 9). The shallowest and highest profile of these in the northeast of the area is a primary target area for bottom longline vessels targeting bluenose (*Hyperoglyphe antarctica*) and wreckfish (*Polyprion* species) on steep rocky features along this entire ridge. This area has remained relatively untrawled in the past, and one additional block closure has resulted in most of the eastern ridge being closed to trawling. Trawling has focussed on features on the southeast and central parts of the area. Cross-sectional profiles (Figure 8) show that the topography and depth range of the Open blocks are well represented by the eastern ridge closure, the move-on blocks covering the shallowest part of the central area, plus the additional block closure on the central canyon between the ridges. To the west, the southwest block closure protects a particularly steep flank area. Together with the move-on blocks, the entire high profile western flank is currently protected.

DISCUSSION

The mitigation measures to prevent significant adverse impacts from bottom trawling in the New Zealand bottom trawl footprint are the combination of closure of all lightly trawled blocks, the application of the move on rule in all moderately trawled blocks, plus additional precautionary closures of representative blocks in the moderately and heavily trawled areas, with the potential future closure of further blocks found to contain significant evidence of VMEs. Advantages of this approach are that representative trawled areas and un-impacted areas are closed to provide protection to likely VMEs from the outset, rather than relying entirely on a move-on rule and subsequent analyses before closing areas. The clear definition of open and closed areas provides certainty to industry and facilitates compliance. The approach also supports data collection as information on fishing impacts and regeneration rates can be monitored. The combination of limited footprint, representative precautionary closures and the move-on rule are intended to constitute adequate protection measures during the interim period. New Zealand will review its implementation of the interim measures in 2010, linked to the provision to potentially open new regions of the SPRFMO Area in 2010 on the basis of an assessment.

In the long term, however, effective protection of Pacific Ocean high seas benthic VMEs will probably require the establishment of a series of international spatial closures designed to protect adequate and representative areas of habitats and ecosystems, designed using:

- Benthic bycatch data from 100% observer coverage.
- Seabed biodiversity surveys, particularly in untrawled areas.
- Habitat suitability classification and niche factor analysis models.

Over the next few years, New Zealand will be evaluating these approaches to support international recommendations for representative spatial closures in the South Pacific Ocean.

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REFERENCES

- Allain, V. J-A. Kerandel, M. Clark (2008) Potential seamount location in the South Pacific RFMO Area: prerequisite for fisheries management and conservation in the high seas. Paper presented to the SPRFMO 5 Science Working Group Meeting, SPRFMO-V-SWG-05, 18 pp.
- Clark MR (2008) Report from the PEW workshop on design of marine protected areas for specific seamounts systems in international waters, 27-29 May, 2008. 11pp.
- FAO (2008) International Guidelines for the Management of Deep Sea Fisheries in the High Seas. Annex F of the Report of the Technical Consultation on International Guidelines for the Management of Deepsea Fisheries in the High Seas. Rome, 4–8 February and 25-29 August 2008 (in press).
- GOODs report (2008). Global Open Oceans and Deep-sea habitats (GOODs) bio-regionalisation.
- Kitchingman A., S. Lai (2004) Inferences on potential seamount locations from mid-resolution bathymetric data. In: Seamounts: Biodiversity and Fisheries (eds T Morato, D Pauly) UBC Fisheries Centre, 78, p. 261, Vancouver, B.C.
- MFish (2008) Bottom Fishing Activities by New Zealand Vessels Fishing in the High Seas in the SPRFMO Area during 2008 and 2009. New Zealand Ministry of Fisheries, SPRFMO Bottom Fishery Impact Assessment, 102 pp (incl. appendices)
- NMFS (2008) Environmental Assessment / Regulatory Impact Review / Final Regulatory Flexibility Analysis For Amendment 89 to the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area and Regulatory Amendments for Bering Sea Habitat Conservation. National Marine Fisheries Service EA-RIR-FRFA Report, 230 pp.
- Parker, SJ, AJ Penney, MR Clark (2009) Detection criteria for managing trawl impacts to vulnerable marine ecosystems in high seas fisheries of the South Pacific Ocean. *Mar. Ecol. Prog. Ser.* (this volume).
- Penney A, S Parker, J Brown, M Cryer, M Clark and B Sims (2008) New Zealand Implementation of the SPRFMO Interim Measures for High Seas Bottom Trawl Fisheries in the SPRFMO Area. Document *SPRFMO-V-SWG-09*, South Pacific Regional Fishery Management Organisation, Wellington, New Zealand
- Rogers AD, MR Clark, JM Hall-Spencer, KM Gjerde (2008) The science behind the guidelines: A scientific guide to the FAO draft international guidelines (December 2007) for the management of deep-sea fisheries in high seas and examples of how the guidelines may be practically implemented. IUCN, Switzerland, 2008.
- SPRFMO (2007a) SPRFMO III Report - Annex F: Interim measures adopted by participants in negotiations to establish South Pacific regional fisheries management organisation. Reñaca, Chile, 30 April – 4 May 2007.
- SPRFMO (2007b). SPRFMO IV Report - Annex C: Benthic Assessment Framework. Noumea, New Caledonia, 4- 7 September 2007.
- SPRFMO (2007c) Report of the Fourth Meeting of the SPRFMO Science Working Group. SPRFMO-IV, Noumea, New Caledonia, 4-7 September 2007.
- UNGA (2007) Resolution 61/105 Sustainable fisheries, including through the 1995 Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks, and related instruments. UNGA A/RES/61/105 Available at: http://www.un.org/Depts/los/general_assembly/general_assembly_reports.htm, 21pp
- Zezina, O. (1997). Biogeography of the bathyal zone. *Advances in Marine Biology*, 32: 389–426.