Predicting the distribution of deepwater snappers in the western and central Pacific Ocean

Deepwater snappers are a significant resource for many Pacific Island countries and territories (PICTs) where they have supported important domestic and export markets for decades. Rapid expansion in deepwater snapper fisheries occurred during the 1970s but was soon followed by declines only two decades later, mainly due to lower catch rates, unreliable access to export markets, and a shift towards tuna longlining, which was more profitable at the time.

Recently, there has been interest in re-developing deepwater snapper fisheries in the Pacific in recognition of the limited potential for further commercial development of shallow reef and lagoon fisheries in the region, and the perception that there are unexploited populations in more distant locations. However, policy-makers are approaching such expansion with caution because there is limited information on the extent of deepwater snapper habitat and the potential sustainable yields.

Across the western and central Pacific Ocean (WCPO), over 20 PICTs have: 1) active deepwater snapper fisheries, 2) participated in deepwater snapper fisheries historically, or 3) expressed some interest in developing this capacity. It is plausible that many of these nations are exploiting the same stocks, given the wide distribution of most target species, and the potential for substantial connectivity among deepwater snapper populations across large geographical areas. Collaboration among PICTs, based on a consensual mapping of deepwater snapper habitats, could provide the basis for better management of deepwater snapper resources in the region.

There are no resources available, however, to conduct the comprehensive surveys needed to create detailed maps of deepwater snapper habitat throughout the Pacific. In the absence of detailed maps, the distribution of deepwater snapper habitat can only be estimated from available data. This report describes a modelling approach that combines available fisheries and oceanographic data to predict the distribution of deepwater snappers in the WCPO.

Methods

Scientists in the Oceanic Fisheries Programme at SPC used state-of-the-art computer modelling techniques and existing fisheries and oceanographic data to identify which oceanographic factors are most influential in determining the distribution of deepwater snappers. These factors were then used to predict the potential distribution of deepwater snappers across the WCPO.

Fisheries data

There are at least 20 species of deepwater snappers in the Pacific Ocean. The most common species captured by deepwater fisheries are listed in Table 1. Information on where these species are present was collated from previous SPC research surveys and from New Caledonia and Tonga fisheries data. The less common species of deepwater snapper were not considered, including Tang's snapper (*Lipocheilus carnolabrum*), saddle-back snapper (*Paracaesio kusakarii*), cocoa snapper (*P. stonei*), yellowtail blue snapper (*P. xanthura*), Vanuatu snapper (*P. gonzalesi*), and Randall's snapper (*Randallichthys filamentosus*), because these species are only a minor component of the catch and there was insufficient location information available. The species were grouped by genus (i.e. *Etelis*, *Pristipomoides* and *Aphareus*) for all data because often the particular species was not recorded. Although the habitat preference of species within each of these groups may vary, previous research shows a similar depth preference among species within each group.

Table 1. List of deepwater snapper species commonly captured in the Pacific Ocean.

Species name	Common name
Etelis carbunculus	Ruby snapper
Etelis coruscans	Flame snapper
Etelis marshi	Pygmy ruby snapper
Etelis radiosus	Scarlet snapper
Pristipomoides multidens	Goldbanded jobfish
Pristipomoides zonatus	Oblique-banded snapper
Pristipomoides filamentosus	Crimson jobfish
Pristipomoides flavipinnis	Golden eye jobfish
Pristipomoides argyrogrammicus	Ornate jobfish
Pristipomoides sieboldii	Lavender jobfish
Pristipomoides auricilla	Goldflag jobfish
Pristipomoides typus	Sharptooth jobfish
Pristipomoides squamimaxillaris	Scalemouth jobfish
Aphareus rutilans	Rusty jobfish

Physical and oceanographic data

The distribution of deepwater snappers was considered to be most influenced by depth, slope and temperature. Global bathymetric data, available at a spatial resolution of 0.016° (~1.85 km^2), was used to determine the depth (m) and slope (%) of the ocean floor. Global temperature-at-depth data, available at a spatial resolution of 0.25° (~15 km^2), was used to determine the average temperature at 0–50 m and 50–100 m.

Distribution modelling

Species distribution models were used to predict the distribution of deepwater snappers. First, a subset of fisheries and oceanographic data was selected from New Caledonia and Tonga, where the most reliable fisheries data were available. These data were used in models to evaluate which oceanographic factors were most important in determining the distribution of deepwater snappers. The models used the depth, slope, and temperature information at each location where deepwater snappers were captured to evaluate how influential each variable was in predicting where deepwater snappers were captured.

Second, the full set of fisheries and oceanographic data was used in species distribution models to predict the distribution of deepwater snappers across the WCPO. Maps of predicted deepwater snapper habitat were generated for the three species groups: *Etelis*, *Pristipomoides* and *Aphareus*. The area and proportion of predicted habitat for each species group was then calculated for the exclusive economic zones (EEZs) of 32 countries, territories or island groups.

Results

Oceanographic factors

Depth was the best predictor of presence for all deepwater snapper species, while slope and temperature-at-depth were much poorer predictors (Fig. 1).

Habitat distribution across the WCPO

Maps of predicted distribution of deepwater snapper habitat across the WCPO are shown in Figure 2. There were strong regional patterns in the predicted distribution of suitable habitat for deepwater snappers, with large areas of suitable habitat predicted in some EEZs, and more limited habitat predicted in others.

The highest proportion of suitable habitat was predicted in South Pacific EEZs, between approximately 15°S and 25°S (Table 2). Over 70% of cells within Tonga's EEZ and at least 30% within the EEZs surrounding Fiji, Wallis and Futuna, Vanuatu, New Caledonia, and Matthew and Hunter were predicted to contain suitable habitat for all three deepwater snapper species groups.

In contrast, less than 5% of 0.25° cells within the EEZs surrounding Australia, Howland and Baker, Jarvis, and Nauru were predicted to contain suitable habitat for all three species groups (Table 2). It is important to note that suitable habitat area was calculated using the total area of 0.25° cells within which suitable habitat was predicted, so it potentially overestimates the area of actual suitable habitat area (i.e. the area of suitable habitat in the cell may be much smaller).

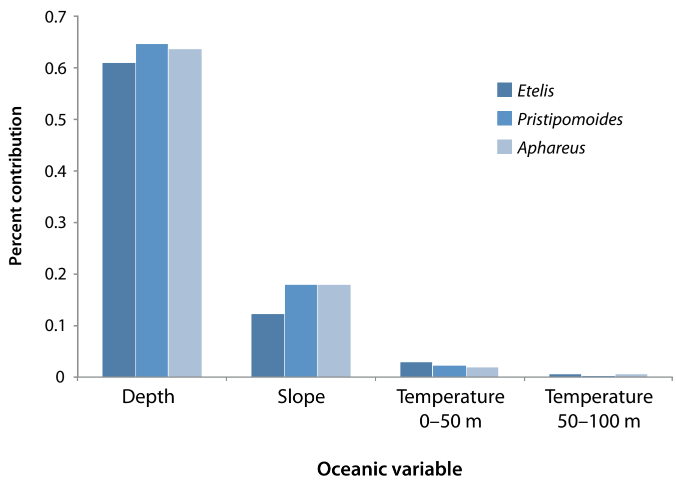

Figure 1. Relative contribution of oceanographic variables to model predictions of the presence of Etelis, Pristipomoides *and* Aphareus.

Table 2. Potential area ('000s km²) and proportion (prop) of suitable habitat of deepwater snapper species within the exclusive economic zones (EEZs) of 32 countries, territories and island groups from models at 0.25° spatial resolution. Note that potential area was calculated using the total area of 0.25° cells within which suitable habitat was identified and, therefore, provides an upper bound for actual habitat area. Estimates of unexploited biomass were available for the EEZs of 23 countries and territories (Dalzell and Preston 1992).

Country or territory	*Etelis*		*Pristipomoides*		*Aphareus*		Estimated unexploited biomass (t)
	area	prop	area	prop	area	prop	
American Samoa	18.5	0.04	23.1	0.06	30.8	0.07	-
Australia*	733.1	0.04	817	0.04	832.4	0.05	-
Cook Islands	85.5	0.04	139.4	0.07	244.9	0.12	413
East Timor	10.8	0.11	39.3	0.42	55.4	0.59	-
Federated States of Micronesia	90.1	0.03	301.9	0.10	410.4	0.14	1489
Fiji	714.6	0.50	828.6	0.58	914.1	0.64	4092
French Polynesia	429.7	0.08	571.4	0.11	662.3	0.12	3427
Guam	13.9	0.06	47.7	0.21	95.5	0.42	22
Howland and Baker	0.8	0.00	12.3	0.29	21.6	0.05	-
Indonesia*	224.1	0.03	834.7	0.11	1271.4	0.16	-
Jarvis	0	0.00	0	0.00	9.2	0.03	-
Kiribati (Gilbert Islands)#	44.7	0.04	91.6	0.09	97.8	0.09	731
Kiribati (Northern Islands)#	33.1	0.02	91.6	0.06	135.5	0.08	731
Kiribati (Phoenix Islands)#	23.1	0.03	57.8	0.08	64.7	0.09	731
Marshall Islands*	42.4	0.02	172.5	0.08	274.1	0.13	1108
Matthew and Hunter	90.1	0.38	84.7	0.35	67	0.28	-
Nauru	1.5	0.50	1.5	0.50	3.1	0.01	3
New Caledonia	517.5	0.41	504.4	0.40	471.3	0.37	1089
Niue	26.2	0.08	24.6	0.07	50.8	0.15	70
Northern Mariana Islands*	9.2	0.01	23.9	0.03	43.1	0.05	236
Palau	10	0.02	32.3	0.05	50.1	0.08	162
Palmyra	4.6	0.02	35.4	0.12	44.7	0.15	-
Papua New Guinea	363.5	0.13	736.2	0.25	944.9	0.33	4881
Philippines	110.1	0.05	194.1	0.09	276.5	0.12	-
Pitcairn Islands	51.6	0.05	53.9	0.05	46.2	0.05	11
Samoa	22.3	0.16	37	0.27	41.6	0.30	190
Solomon Islands	205.6	0.12	463.6	0.28	606	0.36	1711
Tokelau	15.4	0.04	39.3	0.11	64.7	0.18	99
Tonga	528.3	0.72	551.4	0.75	557.5	0.76	1125
Tuvalu	97	0.13	177.9	0.23	249.5	0.33	224
Vanuatu	250.3	0.35	301.1	0.42	345	0.48	980
Wallis and Futuna	127.1	0.48	147.9	0.56	153.2	0.58	102

* = partially covered by the present model
\# = biomass estimate derived from all three EEZ areas

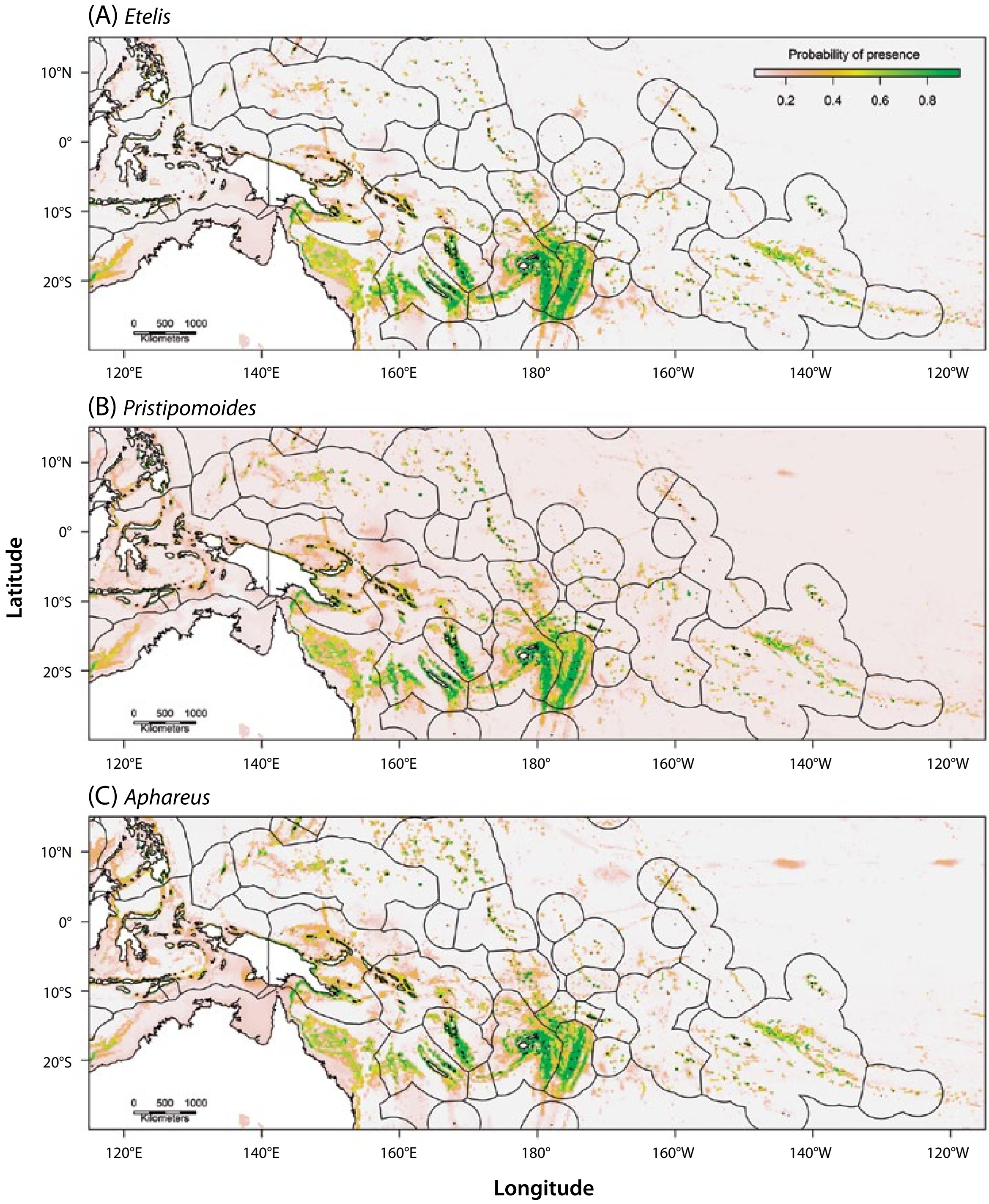

Figure 2. Predicted distribution of Etelis *(A),* Pristipomoides *(B) and* Aphareus *(C) in the western and central Pacific Ocean.*

The amount of predicted habitat also varied among species groups, with the proportion of cells predicted to contain suitable habitat highest for *Aphareus* and lowest for *Etelis* in almost all EEZs (Table 2).

Rudimentary assessments of deepwater snappers in the Pacific Islands region provide preliminary estimates of unexploited biomass for 23 PICTs based on data from depletion experiments and estimates of the length of the 200-m isobaths within each country (Dalzell and Preston 1992). The relationship between estimated unexploited biomass for each country and predicted habitat area from this study is positive (Fig. 3), supporting the assertion that opportunities for significant development of deepwater snapper fisheries are likely to be limited in PICTs where predicted habitat area is low.

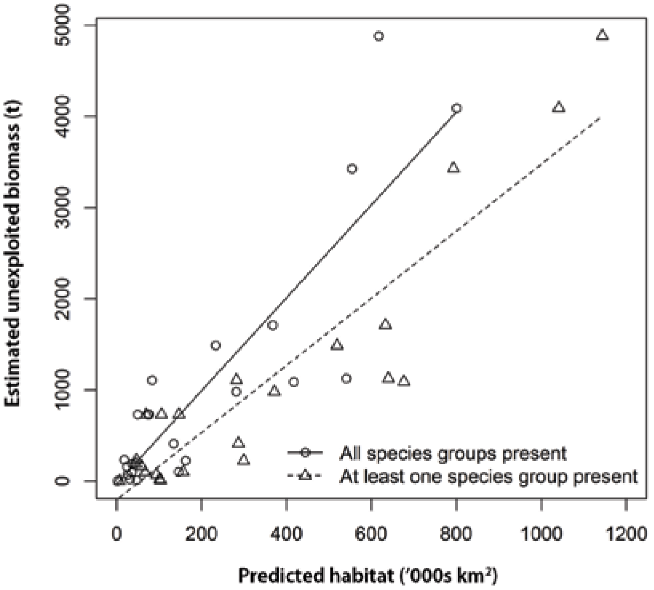

*Figure 3. Relationship between estimated unexploited biomass (source: Dalzell and Preston 1992) and predicted suitable habitat of deepwater snapper within the EEZs of 23 Pacific Island countries (estimates of unexploited biomass were not available for all countries — see Table 2). Each data point represents an EEZ, and data are shown for predicted habitat when all three species groups (*Etelis, Pristipomoides, Aphareus*) and at least one species group were predicted to be present within an EEZ.*

Conclusions

✓ The maps of deepwater snapper habitat provide a useful baseline for the development of monitoring programmes and spatial management plans for deepwater snappers.

✓ Opportunities for development of deepwater snapper fisheries are likely to be limited for many countries and territories north of approximately 15°S due to the relatively small area of predicted habitat for the three main deepwater snapper species groups.

✓ The predicted habitat does not consider abundance, and so it will be necessary to obtain information on the local abundance of deepwater snapper species to estimate potential yields. However, the relationship between estimated unexploited biomass and predicted habitat area is positive, suggesting that opportunities for significant development of deepwater snapper fisheries are likely to be limited in countries and territories where predicted habitat area is low.

✓ The larger area of predicted habitat for *Aphareus* and *Pristipomoides* compared with *Etelis* might indicate greater potential for exploitation of these species. However, *Aphareus* and *Pristipomoides* are usually found in lower abundance than *Etelis* and often fetch a lower market price.

✓ The accuracy and precision of predicted deepwater snapper habitat from the models are only as good as the available oceanographic data. The resolution of these data is very coarse (0.25°) and much of the Pacific Ocean remains unsurveyed. Bathymetric data have been estimated from satellite data for unsurveyed areas.

✓ Detailed bathymetric surveys will be required if more accurate and precise habitat information is desired for deepwater snapper or other resources.

References

Dalzell P. and Preston G.L. 1992. Deep reef slope fishery resources of the South Pacific: A summary and analysis of the dropline fishing survey data generated by the activities of the SPC Fisheries Programme between 1974 and 1988. Inshore Fisheries Research Project, Technical document no. 2. South Pacific Commission, Noumea, New Caledonia.

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