INTRODUCTION AND SUMMARY OF METHODS AND RESULTS FROM THE TROPICAL STOCK ASSESSMENT WORKSHOP

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A 3-week workshop was convened to assist fishery scientists from selected Pacific island countries in analyzing their research and commercial catch and effort data on deepwater snappers. Workshop participants came from the Cook Islands, Fiji, Kingdom of Tonga, Papua New Guinea, Solomon Islands, Tuvalu, Vanuatu, and Western Samoa. The ultimate objectives of the analyses were to estimate the maximum sustainable yield (MSY) and the fishing effort that achieves the MSY for deepwater snappers in each country. As a simplifying step, all analyses treated this multispecies resource as a single group by combining all species.

Since the deepwater snapper fisheries in all of the Pacific islands represented at the workshop are undeveloped or very recently developed, no long-term time series of catch and effort data are available to apply to production models. An alternate approach estimates unexploited exploitable standing stock (N_0) from the depletion of an area, typically a small seamount or island, and then estimates MSY as a fraction of the unexploited exploitable biomass (B_0; Polovina and Ralston 1986). To estimate N_0 from a depletion or intensive fishing study, two analytical models are used. If the depletion has occurred during a short time period so that the number of fish added by recruitment or removed by natural mortality is a minimal part of the population, then the Leslie model (Ricker 1975) is used. This model estimates catchability (q) and N_0 by regressing catch (expressed in numbers of fish) per unit effort (CPUE), against the cumulative number of fish caught. However, if the period covered by the depletion is long enough so that recruitment and natural mortality may have a significant impact on the population, then the Allen model (Sainsbury 1984) is used to estimate catchability (q) and N_0. The Allen model requires an estimate of natural mortality (M); it estimates q and mean recruitment (R) by regressing catch on two variables: effort and the product of effort with adjusted cumulative catch. Generally when the period covered by the depletion study is less than 9 months, then the Leslie model is used; when the period exceeds 9 months, then the Allen model is used. For the depletion and MSY analyses, whenever an estimate of M is required, two values (M = 0.25/year and 0.50/year) are used to represent a range from the published literature on deepwater snappers (Ralston 1987).

Once estimates of N_0 are obtained from either the Leslie or Allen model, they are adjusted for the habitat area of the depletion site by dividing N_0 by the length (in nautical miles) of the 200 m isobath. The estimates of N_0 are converted to B_0 by multiplying N_0 by mean fish weight.

Estimates of MSY are computed with three approaches: the Gulland method, which estimates MSY as $0.5MB_0$; the Pauly method, which estimates MSY as $2.3(w)^{-0.26}$, where w is the mean (in grams) of the asymptotic weight and the weight at the onset of sexual maturity (Pauly 1983); and a method based on the Beverton-Holt equation in which MSY is estimated as a fraction of B_0 with the fraction as a function of parameters, including M/K, where K is the von Bertalanffy growth constant, and age at recruitment to the fishery (t_r) (Beddington and Cooke 1983). The parameter M/K is estimated at 2.0, based on estimates for M and K for deepwater snappers from the literature (Ralston 1987). The estimated age at recruitment to the fishery is 3 years for Vanuatu and 4 years for all of the other study areas. For each country, an MSY estimate is computed as the product of the MSY range per nautical mile of 200 m isobath and the total length of the 200 m isobath.

Fishing mortality (F) is estimated from catchability, which is estimated from the depletion analyses for each country. The value of q from each depletion analysis is multiplied by the length of 200 m isobath to obtain a standardized q. The mean of all standardized q values from within a country is multiplied by the total fishing effort and then divided by the total length of the 200 m isobath to estimate annual F, which can be interpreted: When F equals M, then fishing effort is optimal to produce MSY; when F exceeds M, then fishing effort is excessive.

The results of 18 depletion analyses from the workshop are presented in Table 1. Table 2 presents a summary of the estimated unexploited exploitable biomass per nautical mile of 200 m isobath from the depletion analyses by seamount and island grouping. Except for a few outliers, most estimates of B_0 cluster around the median values of 2.7 metric tons (t)/nmi for seamounts and 0.7 t/nmi for islands. Since the seamounts are smaller than the islands and have a steeper slope, the difference in the estimates of B_0/nmi between seamounts and islands may, to some extent, be due to the concentration of biomass over the smaller habitat areas available at seamounts.

The ratios of MSY to B_0 by the Beverton and Holt, Gulland, and Pauly models have a range of about 10 to 30% (Table 3). For an M of 0.25, based on the Gulland estimate, a lower bound of MSY estimated at 9% B_0 is obtained. Conversely, using the Beverton and Holt equation and an M of 0.5 or using the Pauly method, which depends only on fish weight, estimates MSY at about 30% B_0. Thus, the range of 10 to 30% B_0 is estimated to include the true value of MSY.

Table 4 presents the MSY estimate for each country. For Tonga, current landings from the seamounts are almost twice the upper bound of the estimated MSY, and F is about equal to M. This result suggests that fishing effort is at the level which produces MSY and, once the fishery at the seamounts reaches its equilibrium level, the catches and CPUE will be substantially lower. However, if new seamounts are found, the higher catches may be sustained for a longer time. In Western Samoa, the

Table 1. *Summary of results of depletion analyses*

COUNTRY Area	Type	Principal Species	Nautical Miles of 200 meter isobaths	(Method) Number of Fish / nmi		Fish Mean Wgt (Kg.)	Unexploited Biomass / nmi (Tonnes)		Recruitment R/nmi/year	
MARIANAS		Pristipomoides zonatus		(Leslie)			(Leslie)			
Pathfinder Reef	Seamount	P. auricilla	3.00	1354		1.5	2.0			
		P. flavipinnis								
		Etelis carbunculus								
TONGA		P. filamentosus		(Allen)			(Allen)		(Number of fish)	
		P. flavipinnis		M=.25	M=.50		M=.25	M=.50	M=.25	M=.50
801	Seamount	Etelis coruscans	5.00	616	554	4.4	2.7	2.4	197	344
901	Seamount	E. carbunculus	6.80	614	351	4.4	2.7	1.5	137	202
903	Seamount		35.00	547	608	4.4	2.4	2.7	118	265
1004	Seamount		1.20	1927	1233	4.4	8.5	5.4	493	762
FIJI SEAMOUNTS		Etelis coruscans		(Leslie)			(Leslie)			
Taveuni	Seamount	E. carbunculus	3.10	333		7.5		2.5		
Napuka	Seamount		4.20	507		7.5		3.8		
Kadavu	Seamount		18.00	200		7.5		1.5		
Savusavu	Seamount		7.90	189		6.5		1.2		
GRID 147	Seamount		13.10	931		7.5		7.0		
FIJI SHELF										
Nasilai to Ovalau	Island		50.00	94		7.5		0.7		
Ovalau to MoonReef	Island		42.00	95		7.5		0.7		
MoonReef to Ellington	Island		40.00	75		7.5		0.6		
GRID 482	Island		40.00	73		7.5		0.5		
VANUATU									Recruitment	
		Etelis carbunculus		(Allen)			(Allen)		R/nmi/year - tonne	
		E. coruscans		M=.25	M=.50		M=.25	M=.50	M=.25	M=.50
Paama	Island	E. radiosus	28.00	1277	1100	1.8	2.3	1.1	0.30	0.37
Ambae	Island	Lutjanus malabarius	62.00	389	167	1.8	0.7	0.3	0.10	0.13
PAPUA NEW GUINEA		P. multidens		(Leslie)			(Leslie)			
Schoutten Islands	Island	P. filamentosus	33.00	121		2		0.2		
Kavieng	Seamount	E. carbunculus	0.25	416		2		3.3		
		Wattsia mosambitus								
		L. malabaricus								
		Paracaesia stonei								

Table 2. Length of 200m isobaths and Bo/nmi of 200m isobath for all depletion analyses

	Nautical Miles	Unexploited Biomass / nmi.
SEAMOUNTS		
Kavieng	0.25	3.30
1004	1.20	8.50
Pathfinder	3.00	2.00
Tavenui	3.10	2.50
Napuka	4.20	3.80
801	5.00	2.70
901	6.80	2.70
Savusavu	7.90	1.40
GRID 147	13.10	7.00
Kadavu	18.00	1.50
903	35.00	2.40
		2.70 = Median
ISLAND		
Paama	28.00	2.30
Schoutten Islands	33.00	0.20
MoonReef to Ellington	40.00	0.60
GRID 482	40.00	0.55
Ovalau to MoonReef	42.00	0.70
Nasilai to Ovalau	50.00	0.70
Ambae	62.00	0.70
		0.70 = Median

Table 3. Ratios of MSY to Bo for the three methods

	MSY/B M=.25	MSY/B M=.5
Gulland (1/2m)	0.13	0.25
		.
Beverton-Holt when m/k = 2		
age at recruitment = 3 years	0.06	0.18
age at recruitment = 4 years	0.09	0.28
Pauly (2.3w)^-.26		
Marianas	0.34	
Papua New Guinea	0.28	
Western Samoa	0.27	
Vanuatu	0.32	
Tonga	0.28	

Table 4. Estimates of MSY, 1988 Landings, and F for deepwater snappers at selected Pacific Island countries

COUNTRY	Estimated MSY (Tons/yr)	1988 Landings (Tons/yr)	1988 Estimated F (fishing mortality per year
TONGA	77 - 222	391	0.38
WESTERN SAMOA	17 - 50	25	(*)
FIJI current fishing area of 500 nmi of 200m habitat now being fished	70 - 200	300	0.12
FIJI potential fishing area of 3000 nmi	426 - 1280	0	0
PAPUA NEW GUINEA	170 - 270	0	0
VANUATU	113 - 190	40	.07

(*) No estimate of q available to estimate F deepwater snapper resource is already close to MSY, but some increase is possible. The fishery in Fiji is currently fishing only about 20% of the estimated 3,000 nmi of 200 m isobath. Thus, Fiji has the potential to increase catches if this unfished habitat has populations of deepwater snappers. However, if the fishery remains only within the habitat currently fished, catches will decline perhaps by 50%. The level of fishing effort may be a little lower than the level which produces MSY. Papua New Guinea has no appreciable landings of deepwater snappers, but a potential exists with MSY in the range of 170 to 270 t/year. Vanuatu's landings represent only one-third to one-fifth of the potential MSY, as indicated by the current landings and level of F; therefore, the potential exists for greater landings.

A point worth emphasizing is that the results from this workshop represent preliminary estimates of future MSY based on estimates of unexploited biomass and certain mathematical models that project the response of the populations to exploitation. The MSY estimates represent a sustainable equilibrium level, which is lower than the catches that can be obtained in the early stages of the fishery. As the fishery in each country develops, these preliminary estimates of MSY can be improved from a time series of catch and fishing effort data recorded by island.

This workshop also examined the utility of length-frequency data to estimate relative fishing mortality but found that size-frequency samples from the commercial catches do not provide very accurate indicators of fishing mortality, perhaps because of fish size and depth relationships and size-specific targeting by fishermen.

Finally, this workshop focused on the dynamics of the resource and did not consider the dynamics of the fishing operations. In some countries, market conditions and economics of other fisheries may limit fishing for deepwater snappers so that the MSY level is not achieved. In other instances, the distances from port to some of the deepwater snapper grounds may also limit fishing effort below the level resulting in MSY.

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