Proc 8th Int Coral Reef Sym 2:2027–2032. 1997

SUSTAINABILITY AND MANAGEMENT OF REEF FISHERIES IN THE PACIFIC ISLANDS

P. Dalzell and T.J.H. Adams

South Pacific Commission, BP D5, Noumea, New Caledonia

ABSTRACT

Subsistence fishing on coral reef organisms has persisted in the South Pacific for several millennia. Human population densities in some locations were higher prior to European contact and thus subsistence fisheries harvests were probably greater than at present, and could have significant impacts on near shore sedentary resources such as molluscs. Assessment of the sustainable limits of coral reef fin-fish fisheries are confounded by the difficulties in recording catch and effort from fisheries with diverse range of gears and species in landings. Estimates of observed reef-fish yields in 43 locations in the South Pacific range from 0.3 to 64 t/km^2 per year (mean = 7.7 t/km^2). Examples are presented of surplus production yield curves, based largely on spatial indexes of fishing intensity, for individual Pacific Islands and for the Pacific as a whole. The results from these different curves suggest that the maximum sustainable yields (MSYs) for reef fin-fishes in the Pacific Islands range from 6-20 t/km^2/yr, with a global MSY of about 16 t/km^2/yr. The maintenance of sustainable yields from Pacific reefs will depend mainly on whether human populations continue to grow unchecked over the next 30 years and dietary intakes remain unchanged.

INTRODUCTION

Historically, Pacific islanders have relied for a large part of their protein requirements on fish and in particular on fishes from coral reefs and lagoons. Although the diet of Pacific islanders has become more varied during this century, reef fisheries continue to be a major protein source and remain a key element in the food security of the Pacific Islands. Pacific Island societies have increasingly become more urbanized, with in many cases over 50 % of the national population residing in the capital cities. The average population growth rate for the region is 2.3 per cent or a net doubling time for the present population of 6.6 million people of 30 years. Apart from the large Melanesian islands, land is at a premium and even in some parts of Melanesia, pressure for usable land resources, whose area is constrained by the abrupt volcanic terrain, is acute. Fish and other seafood must therefore continue to play a major role in the nutrition of Pacific islanders, in particular the nearshore marine resources of coral reefs and lagoons.

Harvesting coastal fish and invertebrates is a common economic activity in many islands of the region with competition between commercial and subsistence sectors. The increasing wealth of East and Southeast Asia continues to generate stronger demand for the fisheries resources of the South Pacific, most recently for live reef fish. The twin threats of population growth and lucrative overseas markets will thus continue to increase fishing pressure on reef resources where exploitation has for the most part been moderate for many centuries. Clearly, it is important to try and assess how sustainable are the reef fisheries resources of the region, how high will be the demand for these resources and what can be done to manage these fisheries and ensure long term harvests. In this paper we attempt a synthesis of information from various historical and archaeological sources with more contemporary information from reef fisheries to indicate what conclusions may be inferred about the sustainability of Pacific reef fisheries.

HISTORICAL RECORD OF REEF FISHERIES EXPLOITATION

Humans first appeared in the Pacific from the west in the late Pleistocene, about 40,000 years BP (Before Present) as populations of hunter-gatherers moved through the Indonesian chain to Australia, the New Guinea mainland, the New Guinea Islands and probably the Solomon Islands (Bellwood 1980; Irwin 1992). Current evidence for the earliest settlement in the New Guinea Islands is 32,000 years BP in New Ireland and 28,000 years BP in Bougainville, at the northern end of the Solomon's chain. About 3,500 to 4,000 years BP, a second wave of migrants moved through Melanesia from Southeast Asia. These new migrants, were characterised by the manufacture of distinctively stamped and incised pottery known as Lapita (named from an excavation site in New Caledonia). Unlike the initial Australoid populations, they had developed the outrigger canoe and sails which made journeys over broader expanses of water much safer. The present descendants of this second wave of migrants, who populated much of the Pacific, demonstrate racial and linguistic affinities with contemporary East Asian mainland populations and speak related languages in a large single family termed collectively, Austronesian.

Archaeological excavations throughout much of the Pacific have been concerned mainly with gathering information on the Lapita civilisation which populated many of the Pacific Islands and the succeeding post-Lapita populations. Some sites in Papua New Guinea, however, have evidence of continual human occupation back to the late Pleistocene, a record extending over 30,000 years. A detailed review of the prehistory of the Pacific with respect to long term sustainability of reef fisheries resources will be presented by us elsewhere. For this paper we have summarised examples from various islands of the Pacific that illustrate the effects of long term subsistence exploitation of reef resources by Pacific populations prior to European contact (Table 1). In summary it appears that sedentary resources such as molluscs may have been very important following initial island colonisation and that sustained harvesting pressure both depleted stocks and caused significant shifts towards smaller younger individuals in exploited mollusc populations. There is little evidence, however, that long term subsistence exploitation of reef fin-fish has had any significant effects on reef fish populations.

Other influences, apart from fishing pressure, such as physical and environmental changes may affect patterns of exploitation through loss of suitable habitat, as is thought to be the case at Tikopia and Tongatapu (Table 1). Social changes may also have strongly influenced fishing patterns. A decline in inter-island communication between Aitutaki and the other Cook Islands led to a cessation of the importation of pearl oyster (*Pinctada margaritifera*) shell which is superior in quality to turban shell (*Turbo setosus*) for fish hook manufacture. Pearl oyster is not common in Aituaki lagoon while turban shell is found in abundance. The reliance of the Aitutaki population on the more fragile *Turbo* hooks is thought to be the reason for the increasing predominance of small lagoon species in the fish bone assemblage and the decline in larger snapper and groupers from the outer reef slope, and for a decline in line fishing in general in favour of netting and the use of stone fish traps.

CONTEMPORARY REEF FISHERIES

Reef fin-fish are presently thought to account for between 50-60 per cent of the total nearshore fisheries landings in the region (Dalzell and Adams 1994). We have assembled over 40 estimates of reef fin-fish yields from the South Pacific Islands based on published and unpublished sources (Table 2). We have standardised these yield estimates by basing them on the area of coral reef alone from navigational and hydrographic chart where these were not given by the sources

Table 1: Summary of the results of fish bone and mollusc shell assemblages in Pacific island archaeological sites

Location	Time period (yrs)	Comments	Source
Matenkupum (New Ireland, Papua New Guinea	32,000 BP	Earliest evidence of human capture of marine fish in world. Capture probably by fish traps, wiers and spears	Allen et al (1989)
Tongatapu (Tonga)	3,500-2,000 BP	Initial heavy exploitation of bivalve molluscs (*Anadara* spp & *Gafrarium* spp) due to a combination of fishing and environmental Mortality curves constructed from shells in middens show decrease in average size and age of *Gafrarium* spp through time	Spennenman (1987)
Mangaia (Cook Is)	980-330 BP	Significant increase in frequency of molluscan remains at about 500 years BP. Average size of gastropod *Turbo setosus* decreased by about 50 per cent between earliest layers in sequence and those in later years. No evidence of overfishing of reef fish populations based on bone assemblages, but possible overfishing of freshwater eel population	Kirch et al (1995) Butler (1993)
Tikopia (Solomon Is)	2,900-200 BP	Molluscs major source of food following colonisation. Mollusc populations reduced through fishing and agriculturally induced environmental changes	Kirch & Yen (1982)
Pari (Papua New Guinea)	2,000 BP-Present	Mollusc shells in middens reflect fishing pressure through time, with decrease in average size and age in population	Swadling (1977)
Mussau (Papua New Guinea)	3,500-350 BP	Fish bone assemblages in middens remain constant over four millenia, comprising mainly lethrinids, serranids and scarids	Kirch et al (1991)
Santa Cruz Is (Solomon Is)	3,200-2,600 BP	Mollusc shells in middens reflect fishing pressure through time, with decrease in average size and age in population	Swadling (1986)
Niutoputapu	2,800-200 BP	Fish bone assemblages in middens show long term exploitation of reef and lagoon species, similar to contemporary patterns of fishing	Kirch & Dye (1979) Kirch (1988)
Kapingamarangi & Nukuoro (Caroline Is)	1,050-500 BP	Fish bone assemblages reflect importance of reef and lagoon fish in diet despite cultural importance of pelagic fish such as rainbow runner (*Elegatis bipinnulatus*)	Leach & Davidson (1988)
Aitutaki (Cook Is)	2,000-1,000 BP	Breakdown in inter-island communication and trade leads to Shift in shell hook manufacture from imported pearl oyster (*Pinctada margaritifera*) to more fragile turban shell (*Turbo setosus*) reflected in greater exploitation of smaller lagoon fishes	Allen (1992)
Palau	1,300-100 BP	Fish bone assemblages suggets continuity in reef fish composition and fishing practices between pre-contact period and present	Masse (1986)
Papua New Guinea, Solomon Is, Fiji, Tonga	3,500-350	Comparison of fish bone assemblages suggests greater reliance on line fishing for reef carnivores in west Pacific, compared to net and spear fishing for reef herbivores/omnivores in east. Differences may possible reflect greater fishing pressure in east with reduction in reef carnivore populations	Butler (1984)

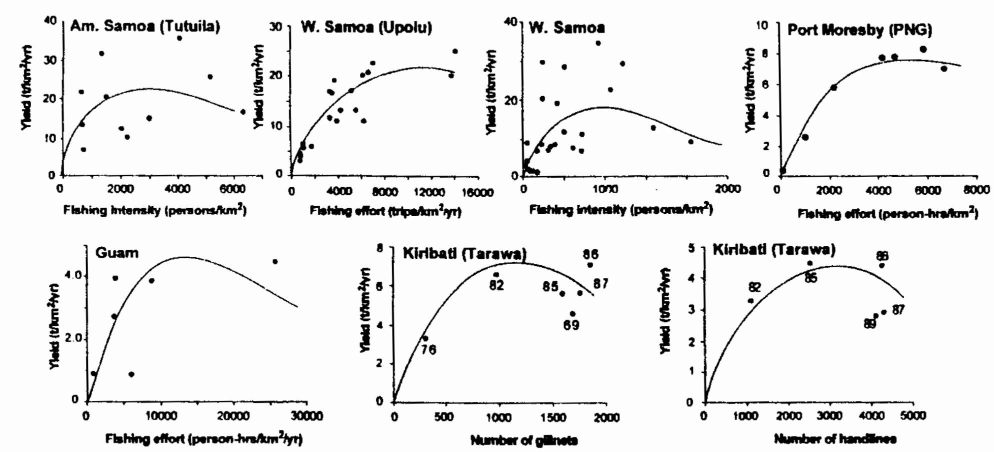

Fig. 1: Examples of surplus production models for reef and lagoon fisheries in the South Pacific Sources: Am. Samoa (Wass 1982), W. Samoa (Upolu) (Zann et al 1991), W. Samoa (King 1988), Port Moresby (PNG) (Lock 1986), Guam (Katnik 1982), Kiribati (Tarawa) (Yeeting and Wright 1989)

Table 2: Summary of reef areas, population densities and annual reef finfish yields for Pacific Islands

Country/ location	Island type[a]	Coral reef area (km^2)	Annual reef reef fish catch (t)	Human population (n)	Population density (n/km^2 of reef)	Annual reef fish yield (t/km^2 of reef)	Source
Guam	HIS	43.1	38.8	133,152	3,089.4	0.79	T. Pitlik, Guam, pers. comm.
Am. Samoa (Tutuila)	HIS	25.0	176.0	54,600	2,184.0	7.04	S. Saucerman, Am. Samoa, pers. comm.
Moorea	HIS	50.0	50.0	9,000	180.0	1.00	Arias-Gonzalez (1993)
FSM (Kosrae)	HIS	30.8	60.0	7,400	240.3	1.95	Smith (1992)
A. Sam (Tutuila)	HIS	3.6	61.3	7,182	1,995.0	17.03	Wass (1982)
Vanuatu	HIS	1,063.0	2,019.0	142,000	133.6	1.90	David and Cillauren (1989)
New Caledonia mainland	HIS	1,600.0	3,000.0	164,173	102.6	1.88	Anon (1994) and Kulbicki pers comm.
W. Samoa	HIS	220.0	1,935.0	105,323	478.7	8.80	Zann et al (1991)
Yap (Fed States of Micronesia)	HIS	131.0	226.3	6,646	56.5	1.73	Uwate (1987)
Koro (Fiji)	HIS	2.5	9.6	309	126.1	3.92	Bayliss-Smith (1985)
Uvea (Wallis & Futuna)	HIS	70.3	330.0	9,000	128.0	4.69	Anon (1994)
W. Manus (Papua New Guinea)	HIS	61.1	173.6	3,379	55.3	2.84	Chapau and Lokani (1986)
Tigak Is (Papua New Guinea)	HIS	143.7	39.0	683	4.8	0.27	Wright and Richards (1985)
Palau	HIS	450.0	1,057.0	15,000	33.3	2.35	Kitalong and Dalzell (1993)
Lakeba (Fiji)	HIS	5.9	26.2	365	61.8	4.43	Bayliss-Smith (1975)
Port Moresby (Pap. New Guin.)	HIS	116.0	524.0	5,447	47.0	4.52	Lock (1986)
Moala (Fiji)	HIS	42.6	434.5	2,118	49.7	10.20	Jennings and Polunin (1995)
Cokovata (Fiji)	HIS	29.6	242.7	833	28.1	8.20	Jennings and Polunin (1995)
Nukutuba (Fiji)	HIS	16.8	77.3	220	13.1	4.60	Jennings and Polunin (1995)
Ko Ono (Fiji)	HIS	103.9	270.1	580	5.6	2.60	Jennings and Polunin (1995)
Macuata& Bua (Fiji)	HIS	957.0	1,521.0	29,600	30.9	1.59	Ledua et al in prep
Nauru	COI	7.4	35.2	9,900	1,337.8	4.76	Dalzell and Debao (1994)
Niue	COI	6.2	58.0	2,200	354.8	9.35	Dalzell ey al (1993)
Tongatapu (Tonga)	COI	100.0	350.0	30,000	300.0	3.50	Tulua et al (1995)
Tamana (Kiribati)	COI	1.7	107.0	1,376	819.0	63.69	Anon (1991)
Niutao (Tuvalu)	COI	3.1	62.0	750	245.9	20.33	K. Belhadjali, pers. comm.
Kuria (Kiribati)	COI	13.0	176.4	985	75.7	13.55	Anon (1991)
Washington Is	COI	6.4	94.7	936	146.3	14.80	Anon (1985)
Tarawa (Kiribati)	ATO	129.0	3,304.0	28,800	223.3	25.61	Mees et al (1988)
Solomon Is Ontong Java	ATO	12.2	7.3	1,400	114.8	0.60	Bayliss-Smith (1975)
Ouvea (New Caledonia)	ATO	40.0	70.0	3,000	75.0	1.75	Kulbicki et al (1994)
Nanumea (Tuvalu)	ATO	20.5	25.6	976	47.6	1.25	Chambers (1984)
Funafuti (Tuvalu)	ATO	24.2	120.0	3,990	164.7	4.95	Rowntree (1992), Dalzell (unpub. dat.
Lamotrek (Caroline Is.)	ATO	8.8	18.8	278	31.6	2.14	Stevenson and Marshall (1974)
Aitutaki (Cook Is.)	ATO	50.0	154.0	2,000	40.0	3.08	Adams et al (in press)
Fakaofo (Tokelau)	ATO	18.5	71.9	700	37.8	3.89	Gillett and Toloa (1987)
Aranuka (Kiribati)	ATO	22.3	186.7	1,002	45.0	8.39	Anon (1991)
Butaritari (Kiribati)	ATO	87.6	1,235.0	3,786	43.2	14.10	Anon (1991)
Palmerston (Cook Is.)	ATO	16.8	23.0	66	3.9	1.37	Preston et al (1995)
Maiana (Kiribati)	ATO	84.7	989.0	2,184	25.8	11.67	Anon (1991)
Abemama (Kiribati)	ATO	67.9	1,690.0	3,218	47.4	24.90	Anon (1991)
Fr. Polynesia (Tikehau)	ATO	93.0	200.0	280	3.0	2.15	Caillart (1988)
Fanning Atoll (Kiribati)	ATO	32.3	60.0	1,309	40.5	1.86	Anon (1985)

a. HIS = high island, COI = coral island, ATO = atoll

cited in Table 2. Other authors have expressed reef fisheries yields using various combinations of reef, lagoon and shelf areas over a variety of depth ranges, which can make comparisons between different reefs difficult to interpret.

Our yield estimates ranged from 0.27 $t/km^2/yr$ to 63.7 $t/km^2/yr$, with a mean of 7.7 $t/km^2/yr$. The yield from Tamana in the Gilbert Islands of Kiribati is higher than maximum estimates recorded elsewhere of around 37 $t/km^2/yr$ in the Philippines (Alcala and Russ 1990). However, the Tamana estimate is based on raising short-term survey data to annual production rather than on a complete record of catch over a year. Such extrapolations assume that the catches during the period of observations are 'typical' but may instead represent seasonal peaks or troughs in the annual production of fish from the reef. Further, Tamana is a small coral island with no lagoon and a narrow fringing reef of 1.7 km^2, and both Arias-Gonzalez (1994) and Polunin et al (in press) noted a clear inverse relationship between reef fin-fish yields and reference areas in a number of studies conducted in the Pacific and Caribbean.

In the early 1970s Munro and Thompson (see Munro 1983) proposed a variation of simple equilibrium surplus production models (Schaefer 1954; Fox 1970) to circumvent the problems of determining maximum sustainable yield (MSY) from the multi-gear and multi species nearshore reef fishery in Jamaica. Spatial variation in fishing effort (in canoe numbers/km^2) was used with combined annual catches of all species expressed as yield per km^2 of reef or shelf area. Several authors have adopted this approach for Pacific Island reef fisheries, including both American and Western Samoa (Munro 1984, based on Wass 1982; King 1988; this study, based on Zann 1991), Papua New Guinea (Lock 1986), Guam (Katnick 1982) and these are summarised in Figure 1. Also included are two surplus yield curves that use inter-annual variation in fishing effort in terms of gear numbers for reef and lagoon catches in Tarawa Atoll (Yeeting and Wright (1989; Anon 1991), with the results expressed as yield per km^2 of reef.

The predicted MSYs from these simple models ranges from 4.5 - 20 $t/km^2/yr$. Yield estimates from both Western and American Samoa show close agreement with MSY in the region of 20 $t/km^2/yr$. The combined MSY of handline and gillnet fishing from Tarawa, if expressed solely on reef area amounts to 23 $t/km^2/yr$. Lower MSYs were predicted from both Guam and Port Moresby. These differences in MSY are not immediately evident from these data and may represent differences in sampling methodology, the area of fishing grounds defined by the authors, the target species in these fisheries, variations in fishing skills associated with the various islands and the differences in the index of fishing intensity, based on population densities, gear numbers, fishing trips and aggregated man-hours spent fishing.

Munro (1978) suggested that this type of approach might be used to construct a simple global surplus production model for Pacific reef yields, where fishing intensity for a given island or archipelago could be expressed as population density, as in the surplus production models described above. A simple Fox-type curve was fitted to the yield and population density data in Table 2 (Figure 2) through a linear regression of the natural logarithm of annual per-capita reef fish production (yield/density) versus density. This gave a predicted MSY of 16.4 t/km^2/yr at a population density of 581 people/km^2 ($r = 0.66$, $p < 0.001$, 41 df) (although a better fit to the data ($r = 0.78$, N= 41, $p < 0.001$) can be obtained with a double log transformation of annual per-capita production on density).

Clearly this a very simple model, and the estimated sustainable reef fin-fish yield can only be regarded as an initial indication of the upper limits of productivity. The various data used to construct the yield curve comes from a variety of different sources and methods and some of the annual yield estimates are extrapolations based on limited observations over shorter time periods. Further, reef fisheries are dynamic systems and the relationship between population density and yield is also contingent on a variety of other influences including island size and geomorphology, climate, oceanography and socio-economic factors, which have not been considered here but may form the basis of future reef fishery management investigations made by the South Pacific Commission.

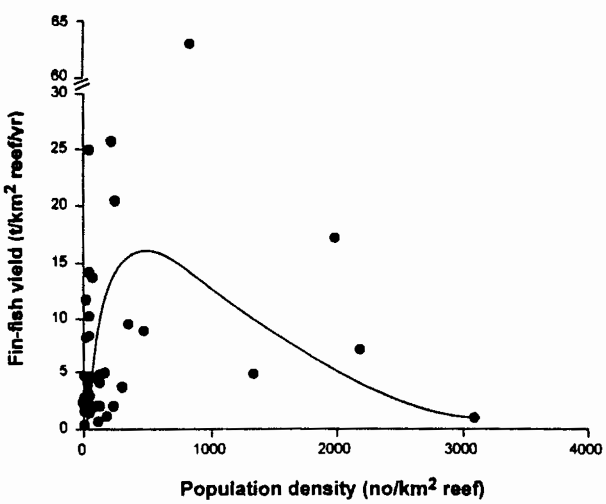

Fig. 2: Reef fin-fish yield versus human population density per unit reef area for selected Pacific Island locations.

CONCLUSIONS

This brief paper has tried to cover a wide spectrum of information on reef fisheries yields and their management and to indicate directions for future research. The conclusions that we have reached from our survey of various sources of information on Pacific reef fisheries are as follows:

1. Pacific reef fisheries are dynamic systems that have long been exploited by human populations. Evidence suggests that prehistoric subsistence exploitation could have marked effects on sedentary resources such as molluscs, forcing Pacific Island settlers to diversify their food base. The archaeological record with respect to fin-fish is more ambivalent and indicates the need for greater collaboration between fisheries biologists and the archaeological disciplines.

2. Finfish harvests from coral reefs are probably sustainable in the range of 10-20 t/km^2/year. However the estimates of sustainable yield are based on simple equilibrium surplus production models where equilibrium conditions may not apply. Further, the models assume that in a multispecies reef fish stock the various species react in an overall similar manner to exploitation but this is still far from understood and the results that are available are not consistent (Polunin and Jennings 1995). Some gears such as gill nets and spearfishing can under certain circumstances lead to rapid reduction in reef fish populations, but these appear to recover rapidly if fishing effort is reduced (Smith and Dalzell 1993)

3. The limits to fisheries exploitation in the past in small Pacific islands were based on an island's carrying capacity for human populations, which was primarily a function of the land area available and the volume of the root crop, taro (*Colocasia* spp and *Cyrtosperma* spp), that could be cultivated (Bayliss-Smith 1974, 1980). The impact of western civilisation on Pacific populations was initially disastrous in many locations leading to wholesale human population decline through disease, slavery and migration (McArthur 1967). Indeed it is likely that fish catches from reefs and lagoons declined in many locations in the Pacific during the 19th century as human populations were reduced. However in contemporary Pacific populations imported food stuffs, health care and the cash economy, promote population growth which then generates a higher subsistence demand for reef fish and invertebrates, even though these have been partially replaced in the diet. The limits of reef fisheries production in many parts of the Pacific are thus likely to be approached within the next 30 years if current population growth rates remain unchecked and if coastal fish remain the principal source of animal protein. The solutions to the question of the sustainable limits of Pacific Island reef fisheries (and coastal fisheries in general) will, however, not be found solely within the fisheries sector, but are part of the wider question concerning the carrying capacities for contemporary human populations in the Pacific Islands.

ACKNOWLEDGEMENTS

We are particular grateful to Dr. Peter Bellwood (Australian National University), Prof. Pat Kirch (University of California, Berkeley) and Dr. Virginia Butler (Portland State University, Oregon) for their help with understanding the prehistory of the Pacific and for sharing their knowledge about marine resource use by early Pacific islanders. We thank SPC Demographer Dr Gerald Haberkorn for help in obtaining Pacific Islands population figures.

REFERENCES

Adams TJH , Dalzell P, Bertram I, Matoto S, Terekia O, Tuara P (in press) The Aitutaki lagoon fishery. Integrated Coastal Fisheries Management Project Technical Document No 00, South Pacific Commission, Noumea

Alcala AC , Russ, GR (1990) A direct test of the effects of protective management on abundance and yield of tropical marine resources. J Cons Int Explor Mer 46: 40-47

Allen J, Gosden C, White JP (1989) Human Pleistocene adaptations in the tropical island Pacific: recent evidence from New Ireland, a Greater Australian outlier. Antiquity 63: 548-561

Allen, MS 1992 Temporal variation in Polynesian fishing strategies: the Southern Cook Islands in regional perspective. Asian Perspectives 31 (2): 183-204

Anonymous (1985) Report of a fisheries resource survey of the Northern Line Group of Kiribati. Ministry of Natural Resources, Fisheries Division, Tarawa

Anonymous (1991) Fisheries Division Annual Report: 1989. Kiribati Ministry of Natural Resources Development, Bikenibiu

Anonymous (1994a) Peches maritimes et aquaculture: les chiffres de 1992 et 1993. Service Territorial de la Marine Marchande et des Peche Maritimes, Noumea

Anonymous (1994b) Wallis et Futuna, Rapport Annuel 1993. Institut d'Emission d'Outre-Mer, Paris

Arias-Gonzalez JE (1993) Fonctionnement trophique d'un ecosysteme recifal: secteur de Tiahura. Ile de Moorea, Polynesie Francaise. Ph.D. Thesis, University of Perpignan pp 327

Arias-Gonzalez JE, Galzin R, Nielson J, Mahon R, Aiken K. (1994) Reference areas as a factor affecting potential yield estimates of coral reef fishes. Naga (the ICLARM Quarterly 17) (4): 37-40

Bayliss-Smith T, (1974) Constraints on population growth: the case of the Polynesian outlier atolls in the precontact period. Human Ecology 2 (4): 259-293

Bayliss-Smith T, (1975) The price of protein: marine fisheries in Pacific subsistence. Pacific Science Association, 13th Pacific Science Congress, Aug 18-30, University of British Columbia, Vancouver

Bayliss-Smith T (1980) Population pressure, resources and welfare: towards a more realistic measure of carrying capacity. In Brookfield HC (ed) Population environment and resources in tropical, islands: the case of eastern Fiji. MAB Technical Notes No. 13, UNESCO, Paris 61-93

Bellwood PS (1980) The peopling of the Pacific. Scientific American, 243 (5): 138-147

Butler VL (1993) Measuring effects of prehistoric predation and habitat alteration on fishes, Mangaia, Cook Islands. Society for American Archaeology Meeting, St Louis, Missouri

Butler VL (1994) Fish feeding behaviour and fish capture: the case for variation in Lapita fishing strategies. Archaeology in Oceania 29: 81-90

Caillart B (1988) Etude d'un pecherie artisanale de l'archipel des Tuamotu. Papeete. Oceanographie Notes et Documents 38, ORSTOM de Papeete: 1-85

Chambers A (1984) Nanumea. Canberra: Atoll Economy: Social Change in Kiribati and Tuvalu No. 6, Australian National University

Chapau MR , Lokani P (1986) Manus west coast fisheries resources survey. Research and Surveys Branch Unpublished Report, Department of Primary Industry, Port Moresby pp 88

Dalzell P , Adams T (1994) The present status of coastal fisheries production in the South Pacific islands. Working Paper 8, South Pacific Commission Twenty-Fifth Regional Technical Meeting on Fisheries 14-18 March 1994, New Caledonia

Dalzell P, Debao A (1994) Coastal fisheries production on Nauru. Noumea: Inshore Fisheries Research Project, Country Assignment Report, South Pacific Commission, New Caledonia pp 19

Dalzell P, Lindsay SR, Patiale H (1993) Fisheries resources survey of the island of Niue. Inshore Fisheries Research Project Technical Document. No. 3, South Pacific Commission, Noumea

David G, Cillauren E (1989) A survey of village subsistence fishing in Vanuatu. Port Vila: Notes and Documents on Oceanography 19, Mission ORSTOM de Port Vila: 11-25

Fox WW (1970). An exponential surplus-yield model for optimizing exploited fish populations. Transactions of the American Fisheries Society 99: 80-88

Gillett R , Toloa F (1987) The importance of small-scale tuna fishing: a Tokelau case study. In Doulman D (ed) Tuna Issues and Perspectives in the Pacific Islands Region. East-West Centre, Honolulu: 177-190

Irwin G (1992) The prehistoric exploration and colonisation of the Pacific. Cambridge University Press, Cambridge: 240 pp

Jennings S , Polunin NVC (1995) Comparative size and composition of yield from six Fijian reef fisheries. J Fish Biol 46: 28-46

Katnik SE (1982) Effects of fishing pressure on the reef flat fisheries of Guam. MSc thesis, University of Guam 62 pp

King M. (1988) Fisheries research and stock assessment in Western Samoa. Terminal Report TCP/SAM/8552, Food and Agriculture Organisation, Apia

Kirch PV, Steadman DW, Butler VL, Hather J, Weisler MI (1995) Prehistory and human ecology in Eastern Polynesia: excavations at Tangatatu rockshelter, Mangaia, Cook Islands. Archaeology in Oceania 30: 47-65

Kirch PV (1988) Niuatoputapu: the prehistory of a Polynesian chiefdom. Monograph No. 5, Thomas Burke Memorial Washington State Museum, Seattle

Kirch PV, Dye TS (1979) Ethno-archaeology and the development of Polynesian fishing strategies. Journal of the Polynesian Society 88 (1): 53-76.

Kirch PV, Yen DE (1982.) Tikopia: the prehistory of a Polynesian outlier. Bernice P. Bishop Museum, Bulletin No. 238, Hawaii

Kirch PV, Hunt TL, Weisler M, Butler V, Allen MS (1991) Mussau Islands prehistory, results of the 1985-86 excavations. Occasional Papers in Prehistory, No. 20, Department of Prehistory, Australian National University, Canberra: 144 163

Kitalong A, Dalzell P (1994) A preliminary assessment of the status of inshore coral reef fish stocks in Palau. Inshore Fisheries Research Technical Document, No. 6, South Pacific Commission, Noumea: pp 37

Kulbicki M, Bargibant G, Menou J-L, Mou-Tham G, Thollot P, Wantiez L, Williams J (1994) Evaluation des ressources en poissons du Lagon d'Ouvea: 3 ème partie: les Poissons. Conventions Sciences de la Mer, Biologie Marine No. 11, Centre ORSTOM de Noumea: pp 448

Leach, B.F, Davidson JM (1988) The quest for the Rainbow Runner: prehistoric fishing on Kapingamarangi and Nukuoro Atolls, Micronesia. Micronesica 21, 1-22

Lock JM (1986) Fish yields of the Port Moresby barrier and fringing reefs. DPI Technical Report 86/2, Department of Primary Industry, Port Moresby pp 17

Masse WB (1986) A millenium of fishing in the Palau Islands, Micronesia. In A. Anderson (ed). Traditional Fishing in the Pacific: Ethnographical and Archaeological Papers from the 15th Science Congress. Pacific Anthropological Records No. 37, Benice P. Bishop Museum, Hawaii 85-117

McArthur N (1967) Island populations of the Pacific. Australian National University Press, Canberra pp 381

Mees CC, Yeeting BM, Taniera T (1988) Small scale fisheries in the Gilbert Group of the Republic of Kiribati. Fisheries Division, Ministry of Natural Resource Development, Tarawa: pp 63

Munro, JL (1978) A method for the estimation of potential productivity of western Pacific reefs and lagoons. Working Paper 12, South Pacific Commission Tenth Regional Technical Meeting on Fisheries, 13 -17 March 1978, New Caledonia: pp 7

Munro JL (1984) Yields from coral reef fisheries. Fishbyte 2 (3): 13-15

Munro JL (ed) (1983) Caribbean coral reef fishery resources. ICLARM Studies and Reviews 7, International Centre for Living Aquatic Resources Management, Manila

Polunin NVC , Jennings S (1995) Multispecies responses of reef-fisheries to exploitation in the Indo-Pacific. Overseas Development Administration, Fisheries Management Science Programme, London

Polunin NVC., Roberts CM, Pauly D (in press) Developments in tropical reef fisheries management. In Polunin NVC and Roberts CM (eds) Reef Fisheries, Chapman and Hall, London

Preston GL, Lewis AD, Sims N, Bertram I, Howard N, Maluofenua S, Marsters B, Passfield K, Tearii T, Viala F, Wright A, Yeeting B (1995) The marine resources of Palmerston Island, Cook Islands. Inshore Fisheries Research Technical Document, No. 6, South Pacific Commission, New Caledonia

Rowntree JT (1992) PIMAR Tuvalu Fishing Project: The problem of marketing fish catch from the commercial fishing trials. Quarterly Progress Report, Tuvalu Bottomfish Project, Oct-Dec 1992, RDA International Inc, Placerville

Saucerman S , Kinsolving A (1995) Fisheries management and conservation in American Samoa. In Dalzell P and Adams TJH (eds) South Pacific Commission and Forum Fisheries Agency Workshop on the Management of South Pacific Inshore Fisheries, Manuscript Collection of Country Statements and Background Papers, Volumes I: 68-74

Schaefer, MB (1954) Some aspects of the dynamics of populations important to the management of marine fisheries. Bulletin of the Inter-American Tropical Tuna Commission 1: 25-56

Sims NA, Preston GL, Yeeting BM, Alfred A (1989) Pearl oysters in Christmas Island, Kiribati, and the potential for development of a pearl culture industry. Inshore Fisheries Research Project, Country Assignment Report, South Pacific Commission, Noumea

Smith AJ (1992) Federated States of Micronesia: Marine Resources Profiles. FFA Report 92/17. Forum Fisheries Agency, Honiara

Smith A, Dalzell P (1993) Fisheries resources and management investigations in Woleai Atoll, Yap State, Federated States of Micronesia. Inshore Fisheries Research Project Technical Document No. 4, South Pacific Commission, New Caledonia

Spennenman DHR (1987) Availability of shellfish resources on prehistoric Tongatapu, Tonga: effects of human predation and changing environment. Archaeology in Oceania 22: 81-96

Stevenson DK, Marshall N (1974) Generalisations on the fisheries potential of coral reefs and adjacent shallow-water environments. Proceedings of the Second International Coral Reef Symposium, Volume 1, University of Queensland, Brisbane: 147-156

Swadling P (1977) Central Province shellfish resources and their utilisation in the prehistoric past of Papua New Guinea. The Veliger , 19 (3): 293-302

Swadling P (1986) Lapita shellfishing: evidence from sites in the Reef/Santa Cruz Group, Southeast Solomons. In Anderson A (ed) Traditional Fishing in the Pacific: Ethnographical and Archaeological Papers from the 15th Science Congress. Pacific Anthropological Records No. 37, Benice P. Bishop Museum, Hawaii 137-148

Tulua S , Kava V, Matoto SV (1995) Inshore Fisheries Statistics Annual Report 1994. Ministry of Fisheries, Tonga

Uwate R (1987) A survey of village fishermen of Yap Proper: 1987. Colonia: Marine Resources Management Division, Yap State, Federated States of Micronesia

Wass RC (1982) The shoreline fishery of American Samoa: past and present. In Munro JL (ed) Marine and coastal processes in the Pacific: ecological aspects of coastal zone management, UNESCO, Jakarta: 51-83.

Wright A, Richards AH (1985) A multispecies fishery associated with coral reefs in the Tigak Islands, Papua New Guinea. Asian Marine Biology 2: 69 84

Yeeting B, Wright A (1989) A review of the status of fisheries resources in Tarawa Lagoon, Republic of Kiribati. Report No. 89/16, Forum Fisheries Agency, Honiara

Zann LP, Bell L, Sua, T (1991) The inshore fisheries resources of Upolu, Western Samoa: coastal inventory and database. Field Report No 5, Food and Agriculture Organisation and United Nations Development Project, Apia