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The Performance of Antillean Wire Mesh Fish Traps Set on Coral Reefs in Northern Papua New Guinea

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Abstract

Sustained fishing with Antillean style S-shaped and arrowhead wire mesh fish traps was undertaken on and around coral reefs in northern Papua New Guinea. Catches by weight and numbers versus soak time conformed to asymptotic curves with maxima after five days immersion. Moonphase affected catch rates, with highest catches over the period of full moon. Over 30 different families of fish were taken by the traps, but in both trap designs, catches were dominated by surgeonfish (Acanthuridae). Other dominant components of the catch were groupers (Serranidae), emperors (Lethrinidae) and parrotfish (Scaridae).

Introduction

The coral reefs of Papua New Guinea (PNG) are some of the most varied and extensive structures of their type in the world. Away from the estuarine Gulf of Papua on the south coast, coral reefs flourish around most of the mainland and around all of the PNG islands to the east. Dalzell and Wright (1986) stated that the estimated reef area of PNG is about 4 million ha and that current fish yields from coral reefs amounted to only 2.3 $kg \cdot ha \cdot year^{-1}$. Munro and Williams (1985) have suggested that finfish yields of 30-50 $kg \cdot ha \cdot year^{-1}$ from coral reefs are sustainable although much greater yields of 69-355 $kg \cdot ha \cdot year^{-1}$ have been reported from reefs in American Samoa (Wass 1982) and the Philippines (Alcala 1981; Alcala and Luchavez 1981).

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Throughout PNG most fishers use only seine and gill nets, handlines and spears. The use of fish traps on coral reefs in PNG is not common as it is in parts of Southeast Asia and the Caribbean. Portable fish traps or pots made from materials such as cane and string plaited from plant fiber, have been traditionally deployed on shallow coral reefs in PNG by subsistence fishers (Sibange 1984). However, the use of these types of portable fish trap is not common. Further, there are no accounts of the use of traps fabricated from materials such as chicken wire and mangrove sticks, similar to those found in the Caribbean Islands, being deployed on coral reefs in PNG.

Development effort employing alternative gears and fishing techniques commenced in PNG after 1980 in an attempt to expand the range of species exploited in the coastal zone. Examples of these initiatives were the experimental fishing trials and stock surveys of the fish resources of the deep reef slope (Sundberg and Richards 1984) and the trials with shallow water fish aggregating devices for artisanal troll fishing (Frusher 1988). Contemporary with these developments was a program of experimental fishing to investigate the performance of Caribbean (or Antillean) type fish traps on coral reefs in PNG. Specific objectives of the study were to: (1) report on average catch rates experienced through a program of sustained fishing with Antillean style traps; (2) determine the species composition of the catch taken by these traps and compare it to artisanal catches from the same location; (3) evaluate the performance of two simply constructed Antillean traps; (4) investigate the factors that influence the dynamics of trap catch rates and observe if the asymptotic catch model proposed for trap catches in the Caribbean is applicable to the same gear deployed on South Pacific coral reefs; and (5) investigate the biology of the principal coral reef species taken by trap fishing.

In this paper we report on the results of objectives 1 to 4. Studies on the biology of the dominant species in the catch have been reported in part by Dalzell (1989).

Materials and Methods

All trap fishing took place in Kavieng Harbour, PNG, at either the Nusalik Reef or in waters adjacent to the Fisheries Laboratory, in close proximity to the Hospital Reef (Fig. 1).

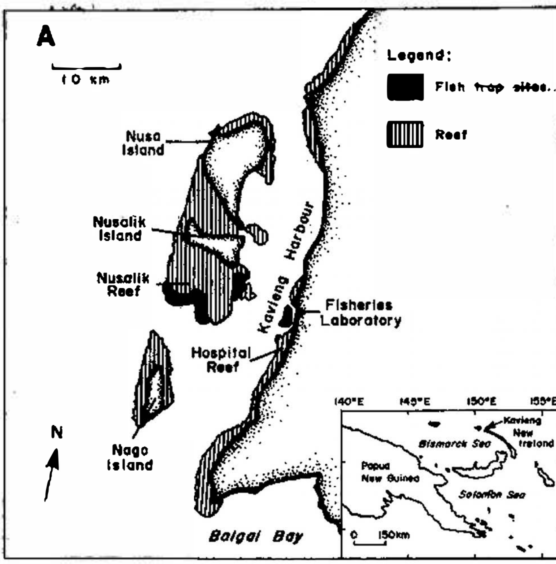

Fig. 1. Kavieng Harbour showing coral reefs and fish trapping sites.

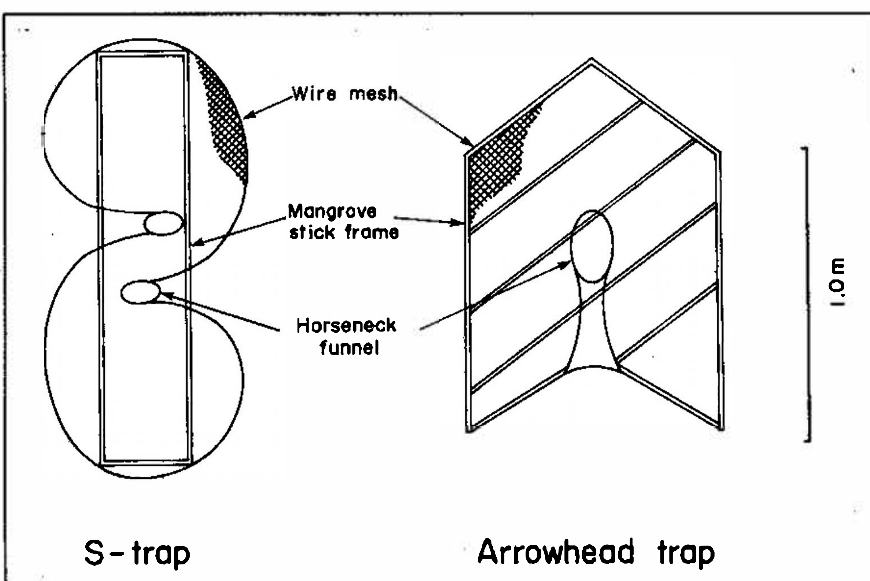

Fig. 2. Two designs of Antillean wire mesh fish traps deployed on Kavieng Harbour reefs.

Fish traps were constructed from galvanized chicken wire and mangrove sticks (Fig. 2). Initially, modified Cuban S-traps (Munro 1983) were deployed at the reef sites from February 1984 to August 1985. The S-traps were 1.5 m long, 0.9 m wide and 0.45 m deep and were constructed from a double layer of 2.5 cm (max. aperture 3.3 cm) mesh, 0.9-mm gauge chicken wire overlaid by a layer of 5.0 cm (max. aperture 6.5 cm) mesh, 1.6-mm gauge wire. The 2.5-cm mesh wire was too weak to withstand the rigors of trap hauling and shark attack without the support of the thicker and larger mesh wire. Two horseneck funnels (Munro 1983) were set diagonally opposite each other in the traps and had maximum and minimum elliptical diameters of 0.2 and 0.1 m, respectively.

Arrowhead traps, which were first deployed between June 1984 and February 1986, were constructed with only the 5.0-cm mesh, and were 1.3 m long, 0.9 m wide and 0.65 m deep. A single horseneck funnel mounted at the rear of the trap had maximum and minimum elliptical apertures of 0.25 and 0.16 m, respectively. Sketches of both types of traps are shown in Fig. 2.

Ten S-traps were set along the western slope of Nusalik Reef at depths of 3-13 m. Eight arrowhead traps were set in the same location but at depths of 5-20 m. The distance between the S-traps varied between 10 and 50 m and for the arrowheads, between 50 and 100 m. Three arrowhead traps were also set on the inner slope of the Nusalik Reef at similar depths and distance apart. Three arrowhead traps were maintained in the waters adjacent to the laboratory and Hospital Reef (Fig. 2) at depths of 10-20 m. All traps were baited every two weeks with cow limb bones, split to expose the bone marrow. The catches from the different traps at various soak times were sorted to species and the lengths and weight of individual fishes were recorded.

Traditional fishing sites are jealously guarded in PNG and permission for the authors to fish on Nusalik Reef with fish traps was sought from the Chief of the island. An agreement was reached where all fish, after measurements were made and specimens collected, were returned to the islanders. They in turn agreed to ensure no one tampered with the fish traps, which can be a problem in work of this kind. The traps near the Hospital Reef were marked by submerged yellow floats since initial trials with surface floats showed that the possibility of loss of gear and catch by theft was very high if the trap locations were obvious.

Results

Catch Rates

A total of 91 sets or 4,500 trap days (= no. of traps x days soaked) were made with the S-traps resulting in a catch of 634 kg comprising 2,643 fish. A total of 90 sets or 6,000 trap days were made with the arrowhead traps resulting in a catch of 1,275 kg or 2,259 fish. A minimum of at least five sets were made for most immersion periods between 1 and 11 days. Only a few sets were made for soak times greater than 11 days and these are not considered here. The greatest number of sets were made for soak times of 5, 6 and 7 days.

Plots of mean catch versus soak time are shown in Figs. 3-4. Catch by numbers in S-traps increased to a maximum at soaks of 4-5 days. Soaks greater than 5 days did not produce any increase in catch. A similar observation was noted for catches in arrowhead traps. The average maximum number of fish caught per trap in each instance was about four, although the standard errors about

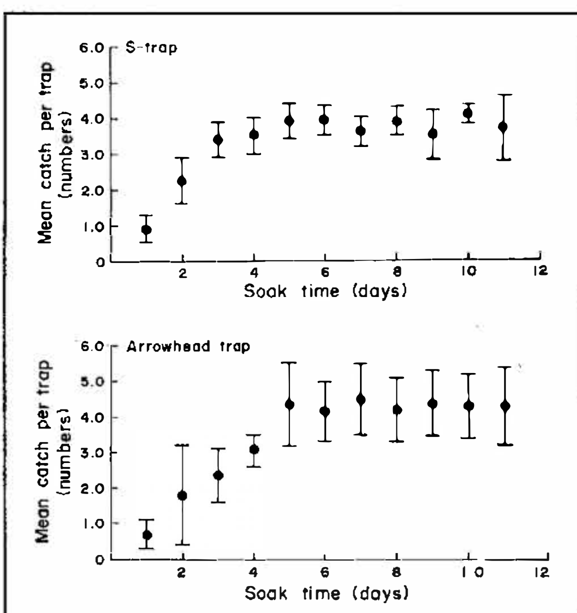

Fig. 3. Mean catch rate in numbers versus soak time for S and arrowhead traps on Kavieng Harbour reefs. Vertical bars represent standard errors about the mean.

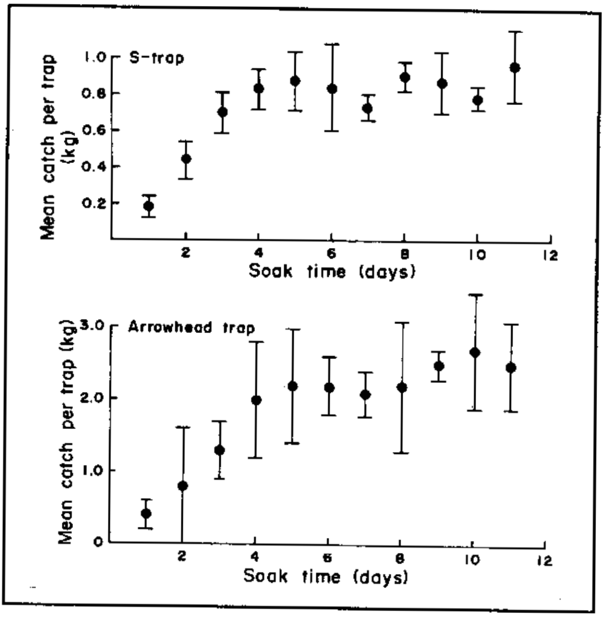

Fig. 4. Mean catch rate in weight versus soak time for S and arrowhead traps on Kavieng Harbour reefs.

the mean were quite large and there was considerable variation in mean catch per trap by both weight and numbers. Catch rates by weight for S- and arrowhead traps similarly reached maxima at soaks of 4-5 days. The mean catch of arrowhead traps oscillated around a mean of 2.3 kg/trap while for S-traps, the mean catch rate was 0.85 kg/trap after the plateau was achieved.

The effect of moonphase on trap catches was investigated using the mean catch per trap for 5, 6 and 7 day soaks. Catches were assigned to the four moonphases of the lunar calendar, new moon (NM), first quarter (FQ), full moon (FM) and last quarter (LQ). The criteria for inclusion in a given moonphase were as follows. The soak time was divided in two, then rounded up if necessary and added to the date the traps were set. If this fell within 3 days of specific moonphase, then it was assigned to that lunar quadrant. The few catches that fell equidistant between moonphases were assigned randomly to either phase. The plots of mean catch rate versus moon phase for both trap designs are shown in Figs. 5-6. Despite the large variation in catch rates for similar soak times, catch rates in each instance were markedly higher over the period of the full moon.

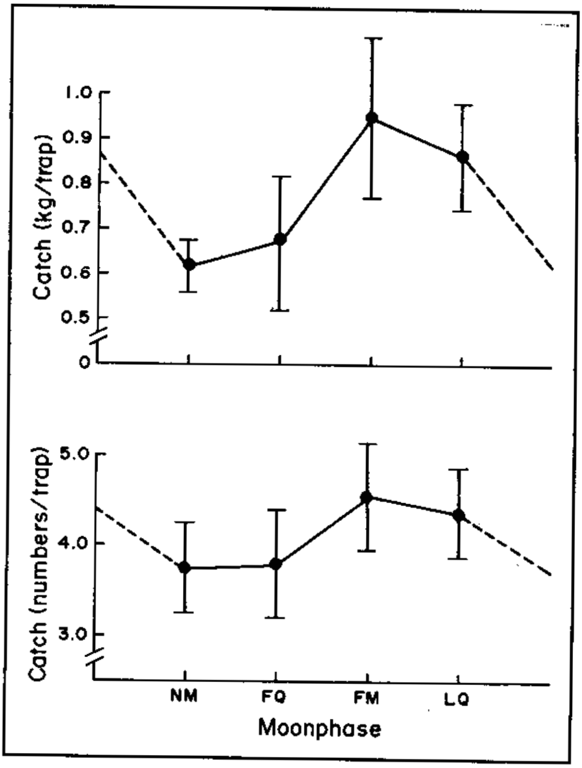

Fig. 5. Catch rates by weight and numbers versus moonphase for S-traps on Kavieng Harbour reefs.

Munro (1974) showed that catches of fish traps could be described by a simple exponential model of the form:

$$C_s = C_\infty (1 - e^{-Rs})$$

where C_s is catch at soak time s, C_∞ is the asymptotic catch and R is the coefficient of the probability of retention (r) of any fish contained in a trap. A measure of abundance of fish from trap catches can be determined from:

$$A = pC_s/r (1 - e^{-Rs})$$

where p is the probability of escapement, A is availability or theoretical daily rate at which fish enter a trap, and $r = 1 - p = e^{-R}$. Estimation of A for the same trap type at different locations may provide a measure of fish abundance.

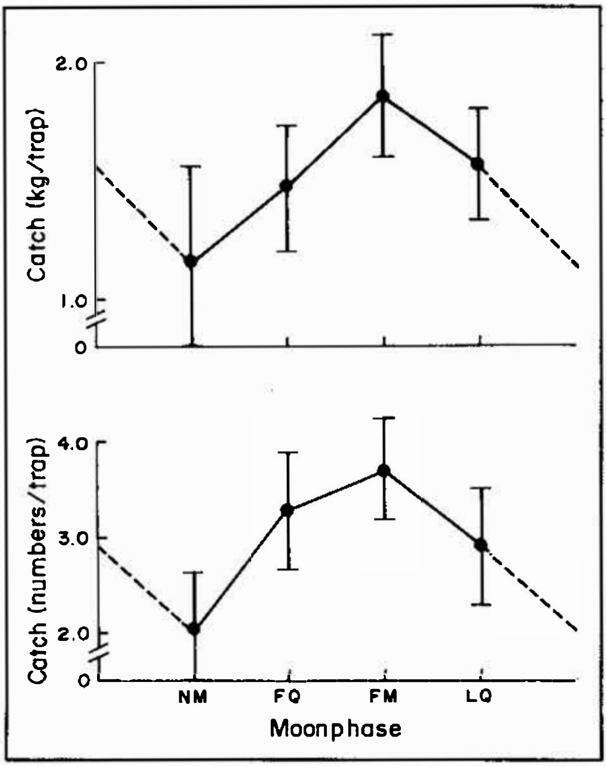

Fig. 6. Catch rates by weight and numbers versus moonphase for arrowhead traps on Kavieng Harbour reefs.

The model of Munro (1974) is easily fitted to catch and soak data following similar linearization procedures used for growth curves (Ricker 1975) and iteration of C_∞ to give the best fit. A summary of the results of fitting the model to the data for arrowhead and S-traps is given in Table 1. The asymptotic catches by numbers for each type of trap are similar, as are the availabilities computed from the model. The theoretical daily rate of ingress for both designs of trap is 1.5-1.9 fish per day. The asymptotic catch in kg of the arrowhead traps was nearly three times that of the S-traps and the availability was correspondingly higher. The larger funnels of the arrowhead traps permitted entry of larger fishes. Although the availabilities and C_∞ by number of traps were similar, the average weight of fish retained by arrowhead traps was greater.

Catch Composition

The catch compositions by numbers of arrowhead and S-traps are presented in Table 2. In both instances, catches were dominated by surgeonfish (Acanthuridae). These were followed by the emperors (Lethrinidae), groupers (Serranidae), parrotfish (Scaridae) and jacks (Carangidae) in the arrowhead traps and by emperors, parrotfish, groupers and goatfish (Mullidae) in the S-traps. The five families in both instances accounted for 64-75% of the trap catches. Similarly, in each instance, one species of surgeonfish accounted for nearly all the catches of Acanthuridae. In the S-traps, the dominant surgeon-

Table 1. Estimates of asymptotic catch (C_∞), coefficient of retention (R), probability of retention (r), probability of escapement (p) and availability (A) for S- and arrowhead traps set in Kavieng Harbour, Papua New Guinea.

Traps	Catch	C_∞	R	r	p	A
S-trap	Number	4.11	0.38	0.69	0.32	1.89
	Weight (kg)	0.97	0.35	0.71	0.29	0.38
Arrowhead	Number	4.78	0.28	0.76	0.24	1.47
	Weight (kg)	2.77	0.26	0.77	0.23	0.80

fish species was *Acanthurus nigricauda* and for the arrowheads, *A. xanthopterus*. Common species for other families were *Epinephelus microdon* (Serranidae), *Scarus ghobban* (Scaridae) and *Lethrinus obsoletus* (Lethrinidae).

A total of 116 and 176 species of fish were captured by arrowhead and S-traps, respectively. Only one species of cartilaginous fish, the stingray *Dasyatis khulii*, was taken by the traps. As might be expected, most species captured were strongly reef-attached. However, the arrowhead traps also caught substantial numbers of pelagic fishes in the form of juvenile trevallies (Carangidae).

Discussion

Our results are the first corroboration of the model proposed by Munro (1974) for fish traps in the Caribbean, and show that catches of similar Antillean designs of trap deployed on Pacific coral

Table 2. Catch composition (in numbers) by family and number of species in catches of arrowhead and S-traps in Kavieng Harbour, Papua New Guinea.

		Percentage of catch		No. of species	
Family name	Common name	Arrowhead	S-trap	Arrowhead	S-trap
Acanthuridae	Surgeonfish	27.6	41.1	7	14
Serranidae	Grouper	7.3	6.8	12	16
Lethrinidae	Emperor	14.3	11.1	11	14
Scaridae	Parrotfish	7.3	9.3	10	18
Lutjanidae	Snapper	3.5	4.1	14	12
Carangidae	Trevally	7.3	0.05	5	4
Nemipteridae	Bream	5.3	2.3	3	8
Mullidae	Goatfish	4.5	6.4	6	8
Balistidae	Triggerfish	2.5	4.1	3	5
Siganidae	Rabbitfish	4.7	2.8	8	10
Tetraodontidae	Pufferfish	1.6	0.5	4	5
Haemulidae	Sweet lips	1.8	0.02	3	1
Pomacanthidae	Angelfish	1.6	0.2	1	3
Chaetodontidae	Butterflyfish	3.4	3.3	10	13
Dasyatidae	Stingray	0.7	0.002	1	1
Labridae	Wrasse	0.9	1.5	2	9
Scorpaenidae	Butterfly cod	0.9	0.5	1	2
Ostraciidae	Boxfish	0.4	0.0	2	1
Syanaecidae	Stonefish	0.2	0.0	1	0
Holocentridae	Squirrelfish	0.2	2.6	4	13
Aluteridae	Filefish	0.1	0.4	1	1
Diodontidae	Porcupinefish	1.1	0.02	3	1
Zanclidae	Moorish idol	0.4	1.3	1	1
Ephipidae	Batfish	0.3	0.0	2	0
Platycephalidae	Flathead	0.03	0.3	1	1
Pomacentridae	Damselfish	0.0	0.4	0	8
Centropomidae	Sea perch	0.0	0.4	0	1
Theraponidae	Grunter	0.05	0.0	1	0
Gerridae	Silver biddy	0.0	0.0	0	1
Muraenidae	Moray eel	0.0	0.1	0	3
Coridae	Wrasse	0.0	0.4	0	1

reefs approach an asymptote. Catches are maximized after a soak period of 5 days for both S- and arrowhead traps. The daily probabilities of retention of the traps used here ranged from about $r = 0.70$ to 0.76, compared with $r = 0.88$ for S- and Z-traps used in Jamaica (Munro 1983). This may be due to the high proportion in the catch of fish such as surgeonfish, parrotfish and other strongly reef-attached species which are used to maneuvering through small holes and passages in the coral and are thus able to exit more easily from the traps. Further experimentation, possibly with other trap designs or funnel shapes, might decrease the chances of fish escaping from traps and hence increase the catch rate at optimum soak times.

Munro et al. (1971) reported that ingress and hence catch rates of fish traps set in Port Royal Harbour, Jamaica, were greatest during the new and full moon periods. The second and fourth lunar quadrants correspond to the period when tidal amplitudes are lowest and Munro et al. (1971) noted that the variations in catch rates through the lunar month result from a depression in catch rates when tidal currents reach their minimum velocity. Like Port Royal Harbour, the tidal amplitude at Kavieng Harbour is greatest at the first and third (new and full moon) quadrants (Ridgeway 1989; pers. comm.). However, our results show only a single peak in catch rates at full moon during the lunar month. The reasons for this dissimilarity are unknown and may result from the different species assemblages at the two locations, the interaction of tides with other physical properties of the environment or for other complex ecological reasons not obvious from the data.

Further comparisons between the results obtained here with those from fish trapping in the Pacific and elsewhere are difficult to make due to differences in trap design, deployment and methods used to estimate catch parameters. Munro (1983) quotes average catches of 1.92 kg/trap for Z- and S-traps in the shallow inshore waters of Jamaica after a 7-day soak period. Over the same period the mean catches from the S- and arrowhead traps used here were about 0.85 and 2.20 kg/trap. The availabilities by weight for traps in Kavieng Harbour ranged from 0.38 kg/day for S-traps to 0.80 kg/day for arrowhead traps. For the S- and Z-traps set in inshore Jamaican waters, Munro estimated an availability of 0.44 kg/day, while Felfoldy-Ferguson (1988) gives a range of 0.64-1.00 kg/day for Z-trap catches from the inshore waters of Tonga (10-35 m depth), although that author gives no details of catch rates.

Kulbicki and Mou-Tham (1987) set Z-traps baited with trash fish inside the barrier reef lagoon of New Caledonia at around 50 m and for soaks between 9 and 24 hours achieved average catch rates of 3.40 kg/trap. Catch rates were not affected by soak time, although the traps were not set for more than 24 hours. Unlike trap fishing in PNG and Tonga, catches were composed entirely of carnivorous fishes. Catches of fish from the outer reef slope of New Caledonia and Vanuatu in baited Z-traps employed in water between 50 and 430 m also contained only carnivorous species and catch rates over the average soak time of 24 hours ranged from 7.40 to 8.90 kg/trap (SPC 1985; Blanc 1987).

The subject of effective bait was not addressed in this study other than the placing of a piece of cow limb bone in the traps on average every two weeks. Munro (1974) suggests that ingress into a trap is largely a function of stock density within the area in which a trap is set, but that bait in a trap increases the rate of ingress of fish attracted to the bait. When the bait is completely consumed, the rate of ingress of these fishes might be expected to fall to levels equivalent to those observed in unbaited traps. Most of the marrow and tissue around the bones disappeared within a few days, yet the traps continued to fish successfully when bait was exhausted. The large number of herbivores and coral feeders in the catch, such as surgeonfishes, parrotfishes and butterflyfishes, suggests that fish entering the traps might not be primarily motivated by the search for food, but possibly for refuge.

Logistical problems prevented extension of this work beyond Kavieng Harbour, thus there is great scope for replication of this work elsewhere in PNG. Wright and Richards (1985) reported on the commercial artisanal catches of fish from the Tigak Islands, of which the islands of Kavieng Harbour form the eastern margin. The catch composition from this region is dominated principally by mullets, trevallies, snappers, emperors and groupers, which collectively formed about 70% of the catch. This is due to the predominant use of seine nets and handlines by Tigak Island fishers. Fish traps are very efficient at catching those species such as surgeonfishes and parrotfishes that do not normally take baited hooks. Thus, although the catches of the traps used in this study are relatively modest, they suggest that such gear may still be a useful adjunct to fishers in PNG (and the South Pacific) by expanding the range of fishes that may be exploited by commercial and subsistence reef fishing.

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