PHILIPPINE CORAL REEF FISHERIES RESOURCES PART II. MURO-AMI AND KAYAKAS REEF FISHERIES, BENEFIT OR BANE?

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INTRODUCTION

Coral reefs are among the most highly productive and complex communities. Their exceptionally high primary productivity (Odum, 1971) is concurrent with the high secondary productivity in terms of fish (Brock, 1954; Randall, 1963; Talbot and Goldman, 1972; McCain and Peck, 1973). The high fish productivity on coral reefs forms the basis for important fisheries in many tropical countries (Stevenson and Marshall, 1974). In Sabah, reef fisheries were estimated to contribute 30% of the total fisheries production (Langham and Mathias, 1977). In the Philippines, Carpenter (1977) estimated that reef fisheries contribute at least 15% of the total fisheries production.

The *muro-ami* and *kayakas* Philippine reef fisheries are excellent examples of how the high secondary productivity of coral reefs can be transformed into substantial fisheries production. Although very effective in exploring the difficult-to-harvest reef fishes, these fishing methods are destructive to the habitat. This habitat debilitation is considered detrimental to the long term efficiency of reef fisheries. However, simple modifications can be made on both gears to eliminate their habitat debilitation while retaining their efficiency.

This paper reviews the *muro-ami* and *kayakas* fisheries in regard to their production capabilities and effects on the habitat. Some suggestions are made for increasing the long-term efficiency of the gears.

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GEAR DESCRIPTION

Muro-Ami

The *muro-ami, sinsoro-hapones* or *handok,* is a drive-in-net used exclusively on coral reefs. This Japanese fishing method was introduced to the Philippines by Okinawan fishermen before World War II. The movable net consists of a bag flanked by two long wings (Figure I). It is set on reefs 3 to 10 fathoms deep, with the mouth facing the current. Fish are driven into the net by a cordon of swimmers, each carrying a vertical scareline. The number of swimmers varies between 8 and 200 depending on the size of the operation. The vertical scareline often has short strips of light-colored plastic or coconut leaves tied perpendicular at intervals along its length. To offset the bouyancy of the scareline, a stone weight is tied at its end. The catch consists primarily of *Caesio* spp. and Acanthuridae (surgeon fish).

Kayakas

The *kayakas* is the Philippines' version of the *muro-ami.* The name, size, and certain operational details vary from region to region throughout the Philippines. In the Visayas, it is called the *bahan,* the *bahig-lukay, lukayan,* and *pukot likom-likom.* In Bicol, it is referred to as the *bahan.* In the Tagalog and Pangasinan regions, it is referred to as the *kayakas* or *kayakas-boholano.*

The *kayakas,* like the *muro-ami,* utilizes a movable net and a scareline (Figure II). It is also set on coral reefs but usually in depths not more than two fathoms. The scareline is horizontal and is made of coconut leaves (*kayakas* is the Tagalog word for coconut leaves). The net is usually supported with a bamboo frame. The scareline is laid out in a circular fashion with the opening of the net forming part of, and facing the inside of the circle. The scareline is constricted closer to the net opening by fishermen on a boat. Swimmers positioned along the length of the scareline aid in freeing the scareline when caught on the corals and rocks. When the scareline is constricted to the desired size about the opening of the net, swimmers congregate at the end farthest from the net. Armed with large rocks and long poles, the swimmers break up and overturn coral colonies. This is intended to drive the fish into the net by creating

noise and forcing fish from hiding places. Catch composition varies widely with Scaridae (parrotfish), Labridae (wrasses), Acanthuridae (surgeonfish) and Siganidae (rabbitfish) forming the bulk of the catch.

FISHERIES PRODUCTION OF *MURO-AMI* AND *KAYAKAS*

Commercial *muro-ami* operations have contributed substantially to Philippine fisheries production (Table I). Numerous small-scale *muro-ami* operations also exist which are classified under municipal fisheries. The numbers and production of these municipal *muro-ami* operations are difficult to ascertain from the data. Fisheries data analyzed from the Sulu Sea, Bohol Sea and Moro Gulf areas (South China Sea, 1975) suggest however, that municipal *muro-ami* fisheries contribute a large percentage to the reef fisheries production.

Except for three years, from 1965 to 1975, *muro-ami* registered the highest average annual production per unit vessel among commercial fisheries (Table II). This high production of the *muro-ami* fisheries does not appear to be due to an unusually high operating efficiency of the gear. The *muro-ami* operates under limitations similar to all fisheries such as seasonal variations in production (Fisheries Statistics of the Philippines) due to weather-induced operational difficulties. Variations in current velocity restrict the *muro-ami's* use to certain areas and tidal situations as it is difficult to set in areas with swift current. Normally, the *muro-ami* does not operate at night. During observations of the *muro-ami* operation using *SCUBA,* it became obvious that the gear is highly selective as most of the bottom-associated fishes ignored the scarelines.

Since the *muro-ami's* overall operating efficiency is not unusually high, its high production appears to be due to the inherent high productivity of coral reefs. Unlike the highly diverse trophic distribution normal to reef fish assemblages (e.g. Talbot and Goldman, 1972), the catch composition of the *muro-ami* is dominated by schooling or shoaling herbivores and planktivores. The ability to effectively exploit a portion of the lower trophic level reef ichthyofauna is perhaps the primary reason for this gear's success.

Data concerning the number of vessels and production of the *kayakas* are inadequate and therefore, its impact on total reef fisheries production cannot be determined. Observations of several *kayakas* operations at Apo Reef, Mindoro, from May to June, 1977, however provided sufficient data to estimate its production capabilities. The average *kayakas* operation observed, consisted of approximately a 7-ton mother vessel, four small boats used during actual operation, and 27 fishermen, produced 1.5 to 2.1 metric tons of chopped salted fish per day. This is comparable to the highly productive commercial operations of *muro-ami,* purse seine and otter trawl (Fisheries Statistics of the Philippines). The success of the *kayakas* fisheries may be attributed to its ability to harvest and market the lower trophic level, and smaller sized fishes.

EFFECTS OF THE *MURO-AMI* AND *KAYAKAS* ON THE HABITAT

The recent evolution in the use of the stone-weighted *muro-ami* scareline has touched off a conservation controversy. According to interviews with old-time fishermen, when the *muro-ami* was first introduced, the scareline's stone weight was relatively small and used only to offset the bouyancy of the rope. More recently, operators have directed their fishermen to use larger weights and to actively pound the substrate by lifting and dropping the scareline. This action is intended to drive fish into the net by creating noise and to force elusive fishes out from hiding.

Operators and some gear technologists contend that the destruction wrought by the *muro-ami* scareline weights is insignificant. To determine the amount of damage inflicted by *muro-ami* scareline weights, trials were undertaken to simulate the effect of the scareline weight on corals. Rocks similar to those used as weights for the scareline, weighing two, three, and four kilograms were dropped on corals in 10, 20 and 30 feet of water. The surface area of damaged coral was obtained by measuring the short and long diameter of the area struck. Tables III and IV respectively, summarize the coral growth forms used and the amount of damage done in these tests. The results show that considerable apparent damage by *muro-ami* weights can be done to branching, rose-like, and encrusting or plate-like corals but not to the massive or boulder corals.

The actual amount of damage on coral reefs caused by a *muro-ami* operation depends on the number of swimmers and the frequency of hits on the substrate by the scareline weights. The measurement of these variables on an actual *muro-ami* operation is difficult to determine due to the inaccessibility of the area of *muro-ami* operation and the questionable reliability of data gathered from *muro-ami* fishermen who know that they are being watched. For purposes of illustration however, some probable scenarios of *muro-ami* operation have been constructed and illustrated in Table V. Although aspects of the assumptions in Table V will vary with respect to differences in individual *muro-ami* operations and the places they operate, it is obvious that *muro-ami* operations cause considerable damage to coral reefs. The relationship of this damage to fisheries and ecological processes will be discussed later.

According to observations using face mask and snorkel during actual operations, the *kayakas* is also destructive to the habitat. The area disturbed by swimmers breaking corals during the final stages of each *kayakas* operation was estimated at 0.2 hectares. The actual percentage of coral cover destroyed in this area was difficult to measure. As a subjective comparison however, it appeared that on a per area basis, the *kayakas* operation did much more damage to the corals than the *muro–ami* operation.

During 14 days of observation of the *kayakas* operation at Apo Reef, Mindoro, in May and June 1977, there was an average of two *kayakas* operating daily. Each *kayakas* used an average of four sets of their gear per day. If the area disrupted by the *kayakas* is taken to be 0.2 hectares, the total area disrupted by the two *kayakas* operations at Apo Reef was 1.6 hectares per day.

DISCUSSION AND CONCLUSIONS

The coral destruction caused by the current *muro-ami* and *kayakas* operations made these highly productive fishing gears unattractive on the basis of long-term fisheries production. Talbot (1965) found a clear relationship between the quantity of fish and percentage of coral cover. Reef plankton, the food base for many commercially important reef fish, was found to be more abundant in terms of number and volume over living substrates than non-living substrates such as coral rubble or sand (Porter et al., 1977; Porter and Porter, 1977). It has already been established that after considerable disturbances, it requires decades for coral reefs to recover (Smith et al., 1973; Pearson, 1974; Johannes, 1976). Coral growth is generally a very slow process. For the massive coral *Montastrea annularis,* growth rates have been reported between 0.4 to 2.50± 1.08 cm/yr (Buddmeier and Kinzie, 1976). For the Pacific branching corals *Acropora* spp., growth rates have been reported between 8.5 and 22.58 cm/yr (Buddmeier and Kinzie, 1976).

The contention that both the *muro-ami* and the *kayakas* cause considerable damage to corals is supported by observations and experimentation. The cumulative damage to corals caused by repeated *muro-ami* and *kayakas* operations in the same place over a period of several years could substantially reduce coral cover and thus reduce the carrying capacity of the reef for fish.

When the calcareous skeleton of corals is broken, normally inaccessible biomass is made available, subsidizing the local food web. This biomass is readily consumed by fishes which are not normally known as coral feeders (authors' observations). One could argue then, that on a short term basis, the "pruning" of corals by the *muro-ami* and *kayakas* operation could help fish populations recover by increasing available food. This advantage should be considered cautiously though, as reduction in reef surface area via coral destruction could be more detrimental to reef fish assemblages than the advantage gained by a temporary increase in food availability.

Indeed, the major limiting factor to fish populations on reefs where food is normally abundant, is thought to be space (Randall, 1963; Smith and Tyler, 1972). The possibility that the reapportionment of organic production by the breaking of corals in the complex, stenotrophic structure of the reef community could be beneficial, is doubtful. Harvest pressure and coral destruction could produce a disadvantageous synergy by upsetting the trophic structure.

A close look at the *muro-ami* and *kayakas* operations reveal that coral destruction is not necessary for these gears to be effective. Simple modifications could be made to both gears which would reduce their habitat-debilitating effect, while not substantially decreasing their efficiency.

Although the main purpose of the *muro-ami* scareline weight is to offset the bouyancy of the rope, some say it is useful in herding

bottom fish into the net. While observing the operation using *SCUBA,* it appeared that most bottom fish ignored the scarelines. The only bottom fish caught were those nearest to the net.

The breaking of corals by the *muro-ami* weight appears more an unnecessary aberration rather than as an integral function of its operation and the scareline could be modified to be less destructive while retaining the gear's effectiveness. To offset the bouyancy of the scareline rope, smaller weights could be attached along its length. Double pendulum rocks could be tied along its length to serve as noise-makers as the scareline is lifted and dropped.

The breaking of corals during the *kayakas* operation also seems an unnecessary element in the operation. Very few fish are forced into the net by the actual act of breaking corals. The noise and the scareline itself were observed to be the major factors in driving the fish. The majority of fish caught by the *kayakas* are the schooling and shoaling herbivores and planktivores. Instead of breaking corals, swimmers could as effectively drive fish by using non-destructive noise makers.

A comparison of yearly *muro-ami* statistics raises questions concerning the need to apply management to reef fisheries. An inverse relation exists between the total production of commercial *muro-ami* and the number of commercial *muro-ami* vessels (Figure III). Although the number of vessels were most numerous from 1961 to 1963, these were the lowest years of total production. Similar inverse peaks appeared in 1966, 1967 and 1972. Peaks in the total production coincide with decreases in number of vessels in 1964, 1969 and 1973.

The number of commercial *muro-ami* vessels fluctuates widely from year to year suggesting that more vessels are fielded based on fortunes of previous years. The harvest capacity of the reefs may have been exceeded during the years of exceptional success. Thus, as more fishermen are attracted to *muro-ami* by the success of other *muro-ami* operators, they are met with overfished populations. This would explain the reason for decreased production despite increased effort. Years of highest production may be due to decreased harvest pressure in previous years in old fishing grounds, and/or the exploitation of new fishing grounds.

Table I. Production of commercial *muro-ami* fisheries, 1960-1975
(Fisheries Statistics of the Philippines)

YEAR	MURO-AMI PRODUCTION (Metric Tons)
1960	9,573
1961	9,362
1962	10,878
1963	11,622
1964	18,321
1965	14,160
1966	11,722
1967	10,246
1968	16,642
1969	19,307
1970	16,823
1971	17,894
1972	16,827
1973	26,475
1974	24,033
1975	18,992

Table II. Average annual production in metric tons of commercial fishing vessels per unit vessel, by gear used, 1960-1975
(Fisheries Statistics of the Philippines)

Gear . Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
Bagnet	84	76	78	99	122	118	112	111	171	145	146	116	160	51	67	64
Beach Seine	6	10	24	43	56	22	28	87	53	122	94	109	54	40	26	15
Gill net	3	14	9	23	100	5	1	14	32	16	25	25	47	35	55	20
Hook and line	61	60	76	76	70	79	85	80	113	96	94	92	56	81	128	99
Long Line	-	-	-	-	-	-	-	165	136	127	68	40	37	-	-	73
Muro-ami	*204	*195	*236	*242	*436	*179	*249	*277	366	*803	*647	*484	431	*716	650	*542
Purse Seine	7	12	11	34	57	171	114	230	*367	316	354	444	*465	495	732	537
Push net	-	-	-	-	-	-	-	-	-	-	-	-	-	179	4	2
tter Trawl	103	108	132	162	211	208	223	243	237	201	208	224	209	192	244	314
ound Haul Seine	44	66	73	94	97	63	83	99	219	62	44	40	57	73	60	54
ing Net	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	276

*Highest average annual production per unit vessel

Table III. The species of hard corals* per growth form used in testing the destructiveness of *muro-ami* rocks

Massive or Boulder	Table-like Branching	Other Branching	Encrusting or Plate-like	Rose-like
. Porites lobata	1. Acropora convexa	1. Pocillopora danae	1. Echinopora lamellosa	1. Montipora pulcherrima
	2. Acropora pectinata	2. Acropora brueggemanni	2. Turbinaria peltata	2. Montipora prolifera
	3. Acropora speciosa	3. Millepora elegans	3. Pachyseris gemmae	
		4. Pocillopora verrucosa	4. Montipora compressa (may also appear branching)	
		5. Heliopora coerulea		
		6. Seriatopora caliendrum		
		7. Acropora formosa		
		8. Millepora platyphylla		
		9. Millepora intricata		
		10. Porites nigrescene		
		11. Acropora humilis		

* Hard corals here include all calcareous Cnidarians

Table IV. Areas of stony coral damaged by dropping *muro-ami* type rocks from the surface to depths of 10, 20 and 30 feet

GROWTH FORM OF CORAL

ight of Rock (kg)	Area * Damaged	Boulder or Massive n=18 (cm²)	Table-like branching n=12 (cm²)		6n**	Other branching n=18 (cm²)		6n	Encrusting or Plate-like n=12 (cm²)		6n	Rose-like n=12 (cm²)		6n
	Median	Negligible	95.48			122.67			52.2			143.84		
2	Minimum	"	72.77	±	11.86	84.33	±	12.49	26.57	±	9.37	89.79	±	16.41
	Maximum	"	118.18	±	23.2	161.0	±	24.79	77.84	±	27.03	197.88	±	23.20
	Median	Negligible	197.05			176.1			151.61			204.62		
3	Minimum	"	118.18	±	45.29	103.96	±	8.43	77.84	±	6.58	118.18	±	11.86
	Maximum	"	275.91	±	107.0	248.23	±	15.51	225.37	±	22.34	291.06	±	29.91
	Median	Negligible	344.18			216.18			249.31			276.22		
4	Minimum	"	190.36	±	81.87	132.78	±	4.67	114.30	±	25.65	175.15	±	5.07
	Maximum	"	498.0	±	176.34	299.57	±	27.27	384.31	±	58.22	377.29	±	12.65

n = number of samples of each type of growth form tested

*Area damaged was computed by measuring the long and short diameters of the area damaged by the muro-ami type rocks. The minimum area damaged was computed by using the short axis as basis for computing the area of a circle. Maximum area damaged was computed similarly using the long axis. Median area damaged is the median of the maximum and minimum area damaged.

**6n Is the standard deviation of the areas of a circle computed using the long or short axis as the diameter according to the number of samples for each coral type.

Table V. Areas of damaged corals in one hectare during probable *muro-ami* operations*

Area of hard coral damaged (m^2)

Weight of Rock (kg)	Percent Hard Coral Cover 10%	20%	30%	40%	50%	60%	70%
2(M=103.55 cm^2)	23.30	46.60	69.90	93.2	116.5	139.8	163.10
3(M-182.35 cm^2)	41.03	82.06	123.09	164.12	205.15	246.17	287.20
4(M=271.47 cm^2)	61.1	122.16	183.24	244.32	305.4	366.49	427.57

*** Number of swimmers is assumed to be 50 per hectare (estimated from observing *muro-ami* operations). Each swimmer is assumed to strike the bottom 50 times in the hectare (estimated from underwater observations of *muro-ami* operations). The area of coral damaged per "hit" is the average of the median area damaged per coral growth form (from Table IV) of all growth forms excluding massive forms per rock size (=M). All growth forms except massive forms is assumed to be 90% of the stony coral cover.**

(50 swimmers x 50 strikes x M x 0.9 = 2250M)

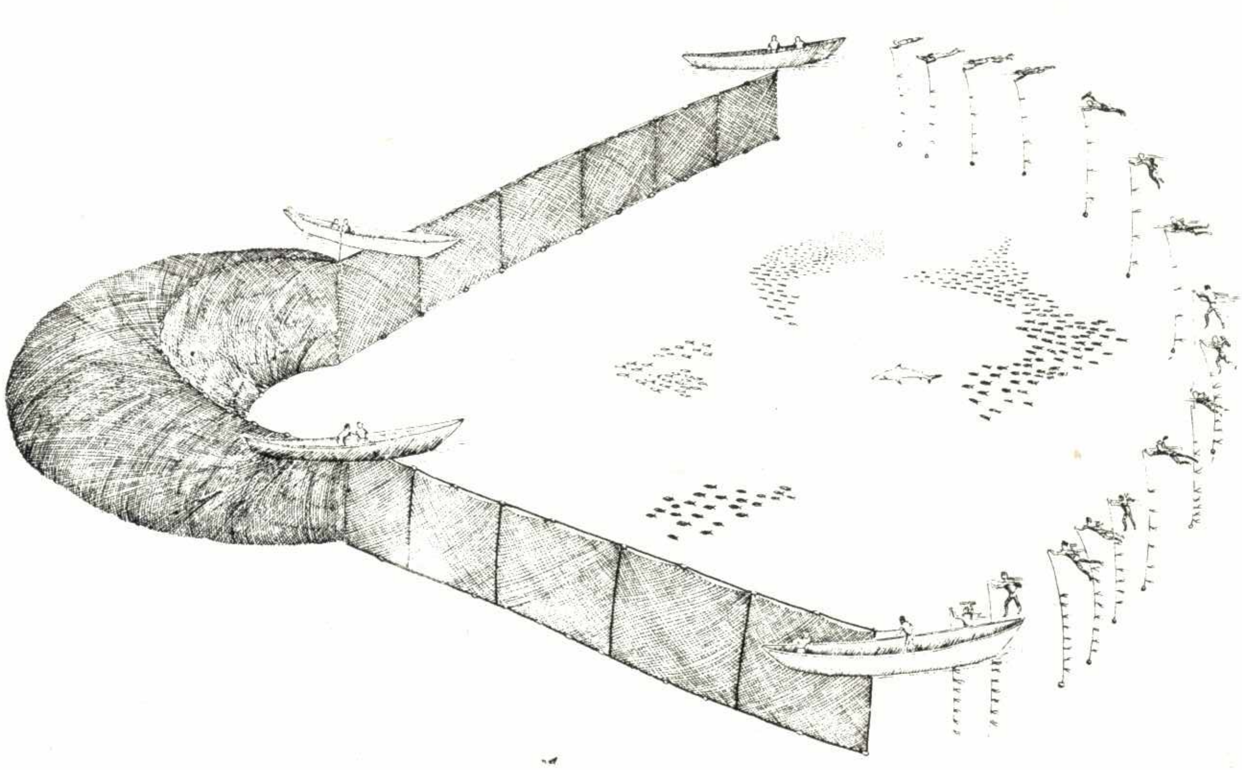

Figure I. *Muro-ami* operation

Figure II. *Kayakas* operation

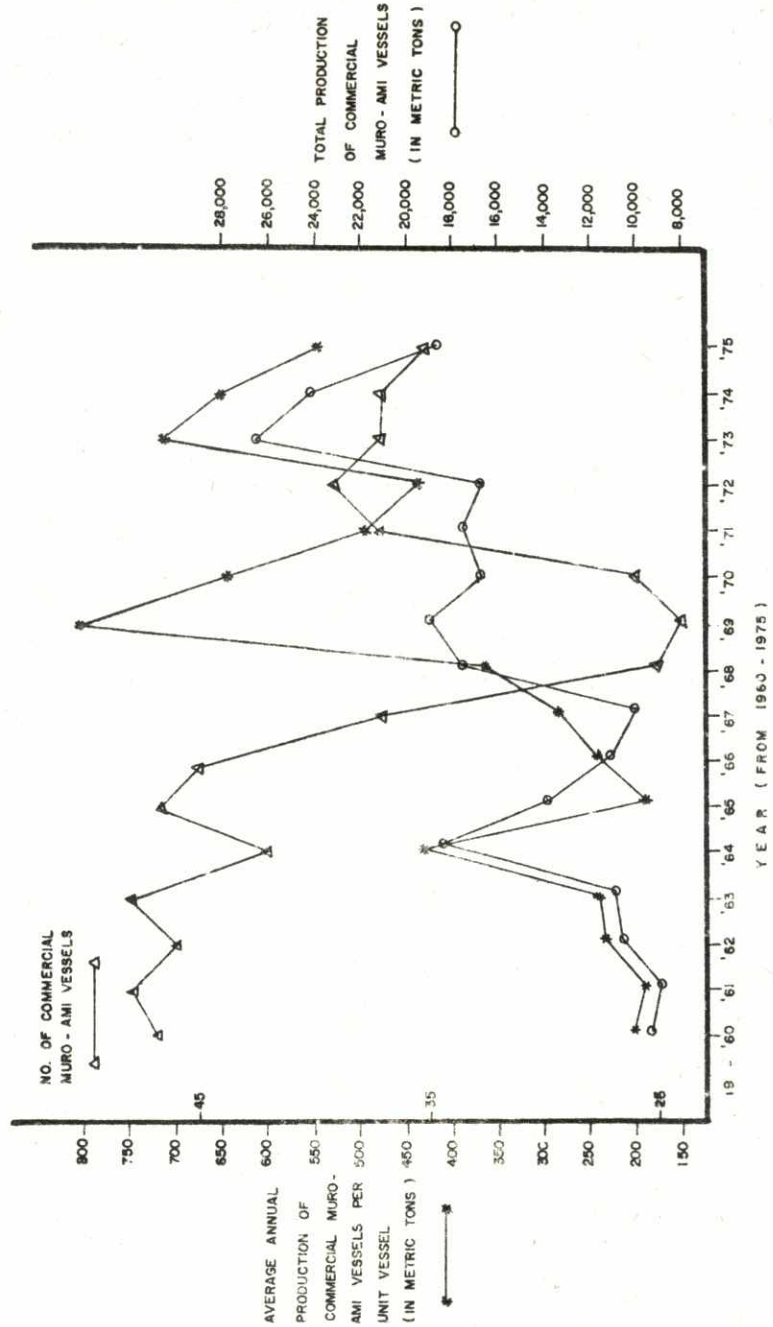

Figure III. *Muro-ami* statistics (1960-1975)