Management of beche-de-mer fisheries in the Western Province of Papua New Guinea

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Introduction

The tropical fisheries for beche-de-mer are centered in the rural coastal areas of the Asia-Pacific region (Conand, 1990). Africa and South America also support fisheries for beche-de-mer. One problem common among all beche-de-mer fisheries is the lack of management and overfishing.

Conand highlighted the need and requirements, both biological and fisheries-related, for the management of beche-de-mer fisheries, which has been elucidated in some parts of the South Pacific (Conand, 1990). The use of this information in the applied management of beche-de-mer fisheries in specific fisheries is limited. This information still need to be updated to suit the specific requirements of the stocks concerned for it to be used effectively in management.

There is currently insufficient knowledge to develop models for rational management of beche-de-mer fisheries (Conand, 1990). Management in Fiji (Adams, 1993), Tonga, Papua New Guinea (Lokani, unpub.) and Queensland lack biological knowledge of the local fisheries and stocks.

These are first steps in management, but they can only be useful if they are evaluated with their respective objectives and improved with the availability of new and updated fisheries and biological information. Banning the use of Scuba gear (e.g. Fiji, Maldives, Papua New Guinea, Tonga) has been justified as enabling the protection of broodstock existing in deeper waters. There is currently no scientific basis to suggest that the so-called broodstock in deeper waters actually produce significant recruits to the population, if at all. However, their existence is reassuring to the managers that something is being done.

The artisanal beche-de-mer fishery in the Western Province of Papua New Guinea needs both biological and fisheries information for it to be managed effectively. Current management of minimum size limit, gear restrictions (which applies to the whole of Papua New Guinea) and a one year closure, is inadequate. Minimum size limits and gear restrictions which were enforced quite effectively, did not prevent overfishing. Brief descriptions of the fisheries and ecological information form the basis of a management regime which is discussed in this paper. The management regime is being developed and has not yet been enforced.

Fisheries

The fisheries for beche-de-mer in Western Province, Papua New Guinea commenced in 1990. Fishing was greatest in the Warrior Reef complex. This was due in part to the limitation in reef growth along the coastline which has been restricted by freshwater run off from the Fly River, swamp lands and numerous streams along the coast. The fishery in Western Province is discussed here in the context of how it occurred and affected stocks in the Warrior Reef system.

Motorised banana boats, averaging 19 feet, made of fibreglass and driven by outboards, were the vessel commonly used by fishermen. Outrigger canoes driven by sail and outboards (Prescott, 1986) were also used. The vessels were used as transport and freight carriers from Daru to the Warrior Reef. Actual fishing involved walking on the reef flat during low tide and snorkelling, while hand collecting sea cucumber into old flour bags. The catch was landed in Daru the same day where it was processed, normally by assistants belonging to the family.

Catch composition and catch rates

Sandfish (*Holothuria scabra*) was the targeted species. It formed 100 per cent of the catch in 1990 and 1991, and dropped only because of depleted stocks (Lokani, pers. obs.) [table 1]. Other species harvested were principally of the genus *Actinopyga*. These could not be separated because fishermen identified them by one common name (table 1).

Table 1: Species composition of the Daru-based beche-de-mer fishery by year (in kg)

Species	1990	1991	1992	1993
Holothuria scabra	109,380	192,647	159,760	39,302
Actinopyga sp.	0	0	2,937	73,816
Total	109,380	192,647	162,697	113,118

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Increased production of *Actinopyga* species occurred in 1992 and 1993 corresponding to the drop in production of the main species of sandfish (table 1). Similar trends were experienced in the Tigak Islands and Fiji (Preston et al., 1988) where reduction in the high-value species production shifts effort to low-value species.

Table 2: Mean catch rates (dry weight) per fishing unit from May to August, 1991 (data compiled includes purchase record of 1 trader only)

Month	mean	n	std. err.	Total weight (kg)
May	10.63	222	1.42	2,361
June	19.14	127	2.82	2,431
July	5.93	95	0.64	564
August	10.80	56	11.96	595

Mean catch rates are based on the sale of products to a single trader ranged from 5 to 11 kg (table 2). Mean catch rate per boat in the Australian jurisdiction of the Warrior Reef by PNG fishermen was 491.66 kg (se=47.42, n=12). This is equivalent to 49.17 kg dry weight. Given the mean number of fishermen per boat was five per banana boat, each fishermen collected 9 kg of product. This catch rate fell within the range recorded in Table1.

To monitor catch and effort, it is proposed that traders will issue a standard receipt to the fishermen to enable the standard collection of catch-and-effort data when purchasing products.

YIELD

Estimated yield per hectare from the fisheries was relatively low when the fisheries commenced in 1990, increasing by almost 100% in 1991 (table 3). By the time the fisheries closed in 1993, yield had dropped to a low of 2 kg per hectare.

Yield estimate from a survey in December 1994 was a slight improvement from the 1993 yield. It is not known if this improvement was due to natural variations of the population or growth and therefore recovery of the population.

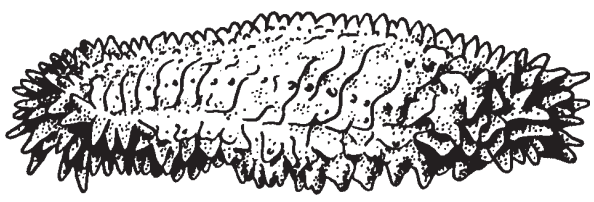


Table 3: Yield estimate for sandfish only, from 1990 to 1994

Year	Yield (kg/ha)	Source
1990	6	Fishery
1991	11	Fishery
1992	10	Fishery
1993	2	Fishery
1994	3	Fishery

BIOLOGY — PRELIMINARY RESULTS

Updating and improving knowledge on the biology and ecology of sandfish in the Warrior Reef for management purposes is the subject of a distribution and abundance, reproduction, growth and movement study which commenced in May 1994. Some of the preliminary analysis (representing data from May 1994 to December 1995) is presented here to support a preliminary management regime.

Distribution and abundance

In a survey by Lokani and Lari (unpublished), sandfish were found throughout the reef flat, with densities ranging from 0 to 2,562 bdm / hectare. Mean densities at Auwomaza and Wapa were 244 and 136 bdm / hectare respectively. There were no significant differences in densities at Auwomaza and Wapa, but significant differences were apparent for different zones (windward, mid-reef and leeward sites). Populations at both reefs had contagious distributions.

Size distribution at Auwomaza was bi-modal, with a mean size of 18 centimetres while that of Wapa was unimodal, with a mean size of 20 centimetres. The mean sizes at both reefs were relatively small, being good only for C- or D-sized processed products. The small size at both reefs is attributed to overfishing of the large-size products, which were obviously the target of fishermen (Lokani, pers. obs.).

Reproduction

The reproductive biology of sandfish in the Warrior Reef is being studied by observations and histological processing of the gonad tissue. Histological results are not ready for presentation here. One of the aims of the reproductive study is to determine the spawning season of sandfish.

Graphical display of the gonad index from May to December suggests spawning would occur around the December-to-February period.

At least six species of sea cucumber are known to reproduce asexually, however sandfish are not included in this group. Initial trials to induce fission in sandfish by constriction were successful after at least one week. Growth after two months was at least 2 cm for the anal portion growing the head portion. Proper experimentation of induced fission needs to be carried out.

Movement

Recruitment in sandfish is not known. Patterns of movement may shed light on recruitment patterns. Two movements are possible in sandfish: horizontal movement above the substrate and vertical movement associated with burrowing behaviour.

Mean speed of 12 centimetres per minute was achieved by sandfish. Preliminary analysis of orientation suggests that movement is not random and may be orientated towards specific areas. If this is common, then it may have a bearing on recruitment patterns where settlement is restricted to certain areas of the reef. It was common, for example, to find that where large sizes were common, smaller sizes were very rare.

MANAGEMENT

Management regulations currently exist in the form of size regulations, gear restrictions and permit requirements. These management measures were introduced in response to various resolutions passed by the National Fisheries Councils which called for the management of sedentary resources, of which beche-de-mer was one of the main fisheries. Management measures discussed below only relate to the objective of achieving maximum sustainable yield. A more comprehensive discussion of the management measures are discussed in Anon. (Undated).

Size Limit

The current size limit of 15 centimetres is based on the size at first sexual maturity as calculated by Shelly (1981) for populations at Bootless Bay in Port Moresby. This size limit will be reviewed as soon as the reproductive study is completed. This limit was enforced on the dry products which were inspected by Fisheries Officers at Daru just before export.

Size limit helps to maximise the economics of the fishery, but it depends on proper modelling. Sandfish are bought according to size, with the larger sizes being more valuable (Conand and Sloan, 1989; Conand, 1990; Lokani and Kubohojam, undated).

TAC

Total Allowable Catch (TAC) equivalent to the maximum-sustainable-yield level is desirable. Initial levels of the TAC will be set at levels to be determined by a simple criteria of:

1. TAC will be 90 per cent of the estimated yield.
2. Yield is calculated from 17 cm–plus sizes

The yield will be determined by visual census using line transects with the precision of the estimate initially set at 20 per cent. The percentage of the yield is initially suggested to offset any underestimate of the yield caused by survey methods and processing methods used.

It has been rightly stated by Conand and Sloan (1989) that diverse social organisations and coastal-area tenure systems make management measures of catch quotas, closures and licencing unrealistic where they exist. The Warrior Reef presents a unique opportunity to apply the catch quota in the form of a TAC together with closures and licensing, because none of the complications highlighted by Conand and Sloan (1989) would affect the fishery. There is a lobster dive fishery in the same reef which has existed since the 1970s.

Closure

Acting on pressure from the Australian authorities over the frequent illegal fishing by PNG fishermen on the Australian side of the Warrior Reef, the Minister for Fisheries imposed a three months closure on the fisheries. This was later extended to a full year until March the following year after a survey revealed that stocks were very low (see Mobiha, undated).

Use of a closed season is seen as an effective strategy to control effort and limit yield to sustainable yield levels. It is anticipated that the closed season will commence when the TAC is reached. Closure during the spawning season is desirable to maximise reproductive output.

Preliminary tests on diurnal movement related to burrowing behaviour suggest that more sea cucumber are exposed during spawning, thus making them more susceptible to fishing. High fertilisation success in *Cucumaria miniata* has been attributed to high population density (Sewell and Levitan,

1992). This has not been investigated in sandfish, but it is appealing that conservative measures are taken. Use of the closed season in China is associated with the spawning period (Conand & Sloan, 1989).

Gear restriction

Enforcement of a ban on underwater-breathing gear is unlikely to have an effect on the stocks of sandfish, as the depth distribution is relatively shallow. The deeper species of white teatfish and prickly redfish may require underwater-breathing gear, but this is unlikely to be attractive to the fishermen at present. Underwater-breathing gear in the form of hookah is currently being used in the lobster fishery on the same reef.

Permits and licensing

A licensing system is proposed for the buyers of beche-de-mer from the fishermen and boats. The number of licences issued to the fishermen will depend on the TAC level. Licences to the buyers will enable them to buy beche-de-mer in Western Province. They will still comply with the current requirements for an export permit for each shipment of export. A requirement of the licence will be issuing of receipts by the buyers.

It is proposed that boats fishing for beche-de-mer from the Warrior Reef will be licensed, with the limit on the size being boats 23-feet in length constructed of fibreglass. The licencing of boats is seen as making surveillance and minimising illegal fishing on the Australia side of the Warrior Reef. Papua New Guinea and Australia have a ratified treaty known as the Torres Strait Treaty, which includes provisions for joint management (e.g. lobster) and cooperation in surveillance activities.

Receipts

A simple log-book system in the form of receipts will be issued by the buyer of products as part of the licence. The receipts will be able to yield catch and effort information of individual fishermen and boats. Buyers need to issue receipts to the fishermen as proof of purchase or trade in any case. The idea of the receipts is to standardise the format and collect additional information on the fishery. By doing so, buyers and fishermen participate in monitoring activities that are there to help the fishery and themselves.

Reliable standard statistics on the fisheries (Conand and Sloan, 1989) are needed to make reliable assessment of the stocks. Conand (1990) could only get the co-operation of one trader in collecting fishery statistics, possibly because of the competition from other traders.

RESEARCH NEEDS

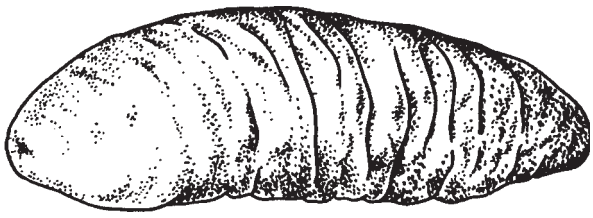
The possibility of enhancing and increasing yield through stock enhancement has not been investigated in sea cucumbers. Teleost fishes and sedentary organisms such as giant clams and trochus have been successfully reared and used for farming or restocking purposes. The three possible stock enhancement techniques that can be investigated are:

1. Relocation of recruits,
2. Induced fission,
3. Hatchery rearing.

Relocation of recruits and young recruits from areas of high abundance to areas of low abundance: This is a simple labour-intensive method that requires study. This study will need to investigate the growth rate at various levels of density. If growth is density-dependent, then the level of density with the highest growth may be taken as the starting density level for relocation. Relocation in the form of sea ranching was recommended by a review of the Maldives beche-de-mer fishery (Joseph, 1992).

Initial trials (Lokani, pers. obs.) on induced fission of sandfish are encouraging. Fission was successfully induced within a week of initial constriction with growth of about 2 cm of the mouth portion within a month. Investigation of induced fission needs to focus on various sizes and the rate of growth for fissiparous products. Similar directions of research for mariculture purposes were said to have been initiated in the Maldives (Reichenbach et al., 1994).

Hatchery rearing is well established in teleost fish, giant clams and trochus. Investigations into rearing sandfish or any other sea cucumber species are probably the best source of recruits for stock enhancement or culture. A cold-water species *Stichopus japonicus* has been successfully reared for stocking or culture purposes (Arakawa, 1990).



REFERENCES

ADAMS, T. (1993). Management of beche-de-mer (sea cucumber) fisheries. SPC Beche-de-mer Information Bulletin. (5):15–21.

ARAKAWA, K.Y. (1990). A handbook on the Japanese sea cucumber—its biology, propagation and utilization. 118p.

CONAND, C. & SLOAN, N. (1989). Echinoderm Fisheries for Echinoderms. **In**: Marine Invertebrate Fisheries. Ed. Caddy, Wiley and Sons. 687–663.

CONAND, C. (1989). The fishery resources of the Pacific Island countries. Part 2. Holothurians. FAO Fisheries Technical Paper, Rome. 272.2. 143 p.

JOSEPH, L. Review of the beche-de-mer (sea cucumber) fishery in the Maldives. Doc. no. BOBP / WP / 79 of the Bay of Bengal Programme. 34 p.

LOKANI, P. & RAY, L. (undated). Distribution and abundance of sandfish (*Holothuria scabra*) on the reef flat at Warrior Reef, Torres Strait Protected Zone, Papua New Guinea.

LOKANI, P. & KUBOHOJAM, G. (undated). Beche-de-mer processing and marketing in Papua New Guinea.

PRESCOTT, J. (1986). The fishery for green turtles, *Chelonia midas*, in Daru, with notes on their biology: a preliminary report. **In:** eds. Haines, A.K., G. C. Williams & D. Coates. Torres Strait Fisheries Seminar, Port Moresby, 11–14 February. 1985. 38–43.

PRESTON, G.L., V. VAKKAMOCE, P. LOKANI & F. VIALA. (1988). Exploitation of the sea cucumber, *Actinopyga miliaris* (blackfish, driloli) in Fiji. Inshore Fisheries Research Project Country Assignment Report. South Pacific Commission, Noumea. 12 p.

REICHENBACH, N., S. HOLLOWAY & A. SHAKEEL. (1994). Laamu Atoll Mariculture Project: mariculture of sea cucumbers – project summary. SPC Beche-de-mer Information Bulletin. (6): 11.

SEWELL, W.A. & D. R. LEVITAN. (1992). Fertilisation success during a natural spawning of the dendrochirote sea cucumber *Cucumaria miniata*. Bull. Mar. Sci. 51(2): 161–166.

Current management policies and problems of the inshore fisheries resources in Vanuatu — Sea cucumbers

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Sea cucumbers, or beche-de-mer, are seen as one of the major cash crops for many of the remote areas in the South Pacific. In Vanuatu, they are an important source of income locally and nationally. The end products are priced very highly in the South-East Asian Market because they are regarded as a delicacy.

The management of this resource has been very poor, as beche-de-mer harvesting is not a tradition in this country, and also because there has been very little scientific information available on which management can be based. The current legislation in Vanuatu concerning the exploitation of this species is based on a quota system. The Ministerial order of 1991 limits the export of dried beche-de-mer to an annual quota system. So far, records of annual exports of dried beche-de-mer from Vanuatu have been consistently well below the legal quota (Bell & Amos, 1993). This may mean that the quota could be well above the sustainable level of exploitation for the fishery. The reason for the low production could also be that the resource is not large enough to expand to meet the quota, or there is a lack of enthusiasm by the collectors and exporters to expand.

However, the Fisheries Department needs to conduct resource assessment surveys in order to determine appropriate exploitable levels of the stock available. Chambers (1989) recommended that the correct strategy with regard to beche-de-mer harvesting in Vanuatu would be to collect intermittently from sites which are large enough and support sufficient densities of commercial species in order for it them be economical.

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