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BECHE-DE-MER

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NOTE FROM THE EDITOR

This issue of the bulletin contains original contributions on the various aspects of sea cucumber exploitation: fishing and marketing, research in ecology and biology, general information on publications and, as usual, questions by members.

Several contributions point out the difficulties encountered in trying to establish a rational management of these fisheries. Depletion of the natural stocks or indices of overfishing are shown in many western Pacific and Indian Ocean fisheries : Solomon Islands (see p. 2), Madagascar (p.10), Maldives (p.11).

The management of some temperate fisheries is also difficult according to biological as well as economic or social standpoints (Washington State p.15). The recent 'scandal' of the Galapagos has shown that sea cucumber fishing is so attractive that a clandestine, illegal fishery started up in 1992 in the Marine Reserve created in 1986 (pp. 14 and 21).

In the different countries concerned, the sea cucumbers are the goal of small-scale fisheries which do not attract enough attention or funding for them to be properly managed.

It is hoped that this issue will serve to circulate information and that members will give their comments and share their experiences to provide up-to-date information for the next issue.

Chantal Conand

Inside this issue

PIMRIS is a joint project of 4 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the South Pacific Commission (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific's Pacific Information Centre (USP-PIC), and the South Pacific Applied Geoscience Commission (SOPAC). Funding is provided by the International Centre for Ocean Development (ICOD) and the Government of France. This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ("grey literature"); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS
Pacific Islands Marine Resources Information System

B E C H E - D E - M E R

I N F O

Bohadschia argus

The beche-de-mer industry in the Solomon Islands: recent trends and suggestions for management

by Alexandra Holland,
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Introduction

Beche-de-mer is purchased from all provinces in the Solomon Islands. Processing is often done at the village level and involves the whole community. Processed beche-de-mer is usually traded at a local store for commodities and cash. The storekeeper contacts an exporter in Honiara once there is sufficient beche-de-mer to warrant collection. The storekeeper then trades the beche-de-mer with an exporter, for merchandise. The exporters grade the beche-de-mer, pack it in hessian sacks and ship it to Hong Kong, whenever there is sufficient cargo.

There are two major exporters of beche-de-mer in Honiara (Sunking Enterprises and Western Pacific Shells) and a few smaller companies. In the last few years, fishermen have been able to command a higher price for beche-de-mer, owing to increased competition between exporters. There are, however, two reasons why this situation may not persist. The first is that the government has introduced a tax of 10 per cent, effective from January 1993, for all beche-de-mer exports. Secondly, the exporters have stated that there has been a general decrease in beche-de-mer landings since 1991 (though no figures are as yet available from the Fisheries Division, Honiara). This has led some small marine export companies to divert their interests to other marine products.

In this paper, the features of the beche-de-mer industry in the Solomon Islands between 1982 and 1992 are examined. In particular, the species harvested; the relative importance of the fishery in each province; the value of the fishery; variation in catch of individual species; potential management strategies and the possibility of re-seeding to enhance the industry are described.

The information presented here was gathered from local indigenous knowledge, exporters and the Solomon Island Fisheries Division. At present, the Fisheries Division only records data on the total exports of beche-de-mer from each province. These data are used to summarise recent trends in the relative importance of the provinces and the value of production. The company records of one of the two major exporters of beche-de-mer in the Solomon Islands were used to describe the species composition of the catch, and recent annual variation in the exports of individual species.

Species of commercial value

In 1993, 22 species of sea cucumbers were exploited. Eighteen of these species are listed in Table 1. The other four species are snakefish, hongpay fish, stonefish (black) and ripplefish. Scientific names for these are unavailable. There is some discrepancy between exporters as to the name given to stonefish (black). One exporter names this species 'blackfish', though it is a different species from *Actinopyga*

Table 1: Eighteen species of sea cucumber harvested in the Solomon Islands

Scientific name	Common name
High-value species	
Holothuria (Microthele) fuscogilva	White teatfish (susufish)
Holothuria (Metriatyla) scabra	Sandfish
Holothuria (M.) scabra var versicolor	Sandfish
Thelenota ananas	Prickly redfish
Stichopus chloronotus	Greenfish
Stichopus variegatus	Curryfish
Medium-value species	
Actinopyga lecanora	Stonefish
Actinopyga mauritiana	Surf redfish
Bohadschia graffei *	Orangefish
Holothuria (Microthele) nobilis	Black teatfish
Actinopyga miliaris	Blackfish
Bohadschia marmorata *	Chalkfish
Bohadschia argus	Leopard fish
Low-value species	
Bohadschia vitiensis	Brown sandfish
Thelenota anax	Amberfish
Actinopyga echinites	Deep-surf fish
Holothuria (Halodeima) atra	Lollyfish
Holothuria fuscopunctata	Elephant's trunk fish
Holothuria edulis *	Pinkfish

* Species that have only been fished since 1988

miliaris. 'Black stone' is the name given to black teatfish by Hong Kong importers, so to avoid further confusion the unknown species will be called stonefish (black) in this review.

In 1988, only 15 species of beche-de-mer were exploited. The seven new species now being caught are of low to medium value (Table 1). The Hong Kong importers are now accepting species of lower value because there is an increasing demand for them in Asian markets, especially since China has entered international trade. The classification of species into categories of high, medium and low value is based on average price received from five Hong Kong importers (CIF) in 1993 (Table 2). Species of high value fetched more than US$ 10 per kg, those of medium value between US$5 and US $10 and the low-value species were sold for less than US$5 per kg.

The relative value of species has changed since the report by McElroy (1990). He recognised three species of high value; white teatfish, prickly redfish and black teatfish. The latter species has now slipped to tenth position (Table 2).

Table 2: Average annual price of the 21 species of beche-de-mer exported from the Solomon Islands between 1988 and 1993 (prices are the average of those offered by five Hong Kong exporters)

Common name	Grade	Number	1988	1989	1990	1991	1992	1993
					Price (US$/kg)			
High value species								
White teatfish	1	<5	12.9	13.0	22.9	22.9	25.3	25.3
	2	5 to 7	11.4	11.7	19.5	19.5	21.4	21.4
	3	8 to 10	9.6	8.2	10.6	14.3	14.3	14.3
Sandfish	1	<20	10.8	11.2	11.7	11.7	11.7	20.0
	2	21 to 40	6.8	8.1	8.6	8.6	8.6	12.0
	3	41 to 80	2.6	3.1	3.6	3.6	3.6	6.0
Prickly redfish		<10	7.5	7.5	10.6	11.9	13.6	13.9
Greenfish		<55	6	6	8.1	10.4	12.6	13
Stonefish (black)		20 to 120	3.4	4.2	6.8	7.6	9.1	11.7
Curryfish	1	<15	4.4	4.7	6.9	7.4	9.1	10.6
	2	15 to 30	3.8	4	6	8	10.1	11.7
Medium value species								
Stonefish		20 to 120	3.1	3.1	3.9	5.6	7.5	9.7
Surf redfish	1	20 to 30	3.8	4.3	6	6.9	8.4	9.1
	2	31 to 80	3.4	3.4	5.1	6.2	8.2	8.2
Orangefish	1	<100				5.2	7.5	9.1
	2	>100					7.1	7.1
Black teatfish	1	<10	8.3	8.3	8.3	8.8	9.1	8.4
	2	>10				2.9	5	8.4
Blackfish	1	<11	3.4	4.2	5.4	6.5	7.5	8.4
	2	>11	2.2	2.2	3.6	4.8	5.2	4.3
Chalkfish		<8			7.5	7.9	7.9	7.9
Leopardfish		<15	2.5	2.5	4	4.6	5.4	5.7
Low value species								
Brown sandfish	1	<18	1.9	1.9	2.5	4.4	4.8	4.7
	2	18 to 34	1.5	1.6	1.9	2.1	2.8	4.2
	3	35 to 80	1.1	1.1	1.9	2.1	2.8	4.2
	4	81 to 130	0.6	0.6	0.6	0.6	0.6	0.6
Amberfish		<8	2.3	2.7	2.7	3	4.3	4.3
Deep-surf redfish		<7	1.8	2.5	2.9	2.9	3.0	3.2
Hongpay fish		<45				3.0	3.0	3.2
Lollyfish	5"	<15	2.5	2.5	2.5	2.5	2.6	2.6
	3" to 5"	15 to 50	1.8	1.6	1.8	1.9	2.0	2.0
	2" to 3"	>51	0.8	0.9	1.0	1.2	1.3	1.3
Snakefish		<25				1.3	2.5	2.5
Elephant's trunkfish		<5	1.8	1.8	1.8	1.9	1.9	2.1
Pinkfish		<30				1.2	1.2	1.3

Apart from the fact that grades are based on the size of the animal and that Grade 1 brings the highest price, several other points emerging from Table 2 are:

— White teatfish and prickly redfish have consistently attracted a high price;

— Sandfish have almost doubled their value in the last two years;

— Grade 2 curryfish commanded a higher price than Grade 1 because the smaller animals do not fall apart as readily on boiling, thus rendering a higher quality product;

— Some species are not graded by size.

Relative importance of the provinces

The species composition of beche-de-mer caught from each province does not differ greatly. However, there are large variations in total catch among provinces, due mainly to differences in the ability of the local free-divers, and the extent of suitable habitat. A summary of the nature of each province, and the relative importance of its beche-de-mer fishery, is set out below.

Western Province

More than 30 per cent of the Solomon Islands' landmass and 21 per cent of its population is contained within this province. It consists of the New Georgia Islands, Choiseul and the Shortlands. Along with Malaita Province, the Western Province produces the majority of beche-de-mer in Solomon Islands. In recent years, at least 20 per cent of the beche-demer exported came from this region (Figure 1). In 1989, it yielded 58 per cent of total production. There are five large lagoons in the Western Province: Marovo; Roviana; Tetepare; Vella Lavella; Vonavona. All of the commercial species are caught in these lagoons.

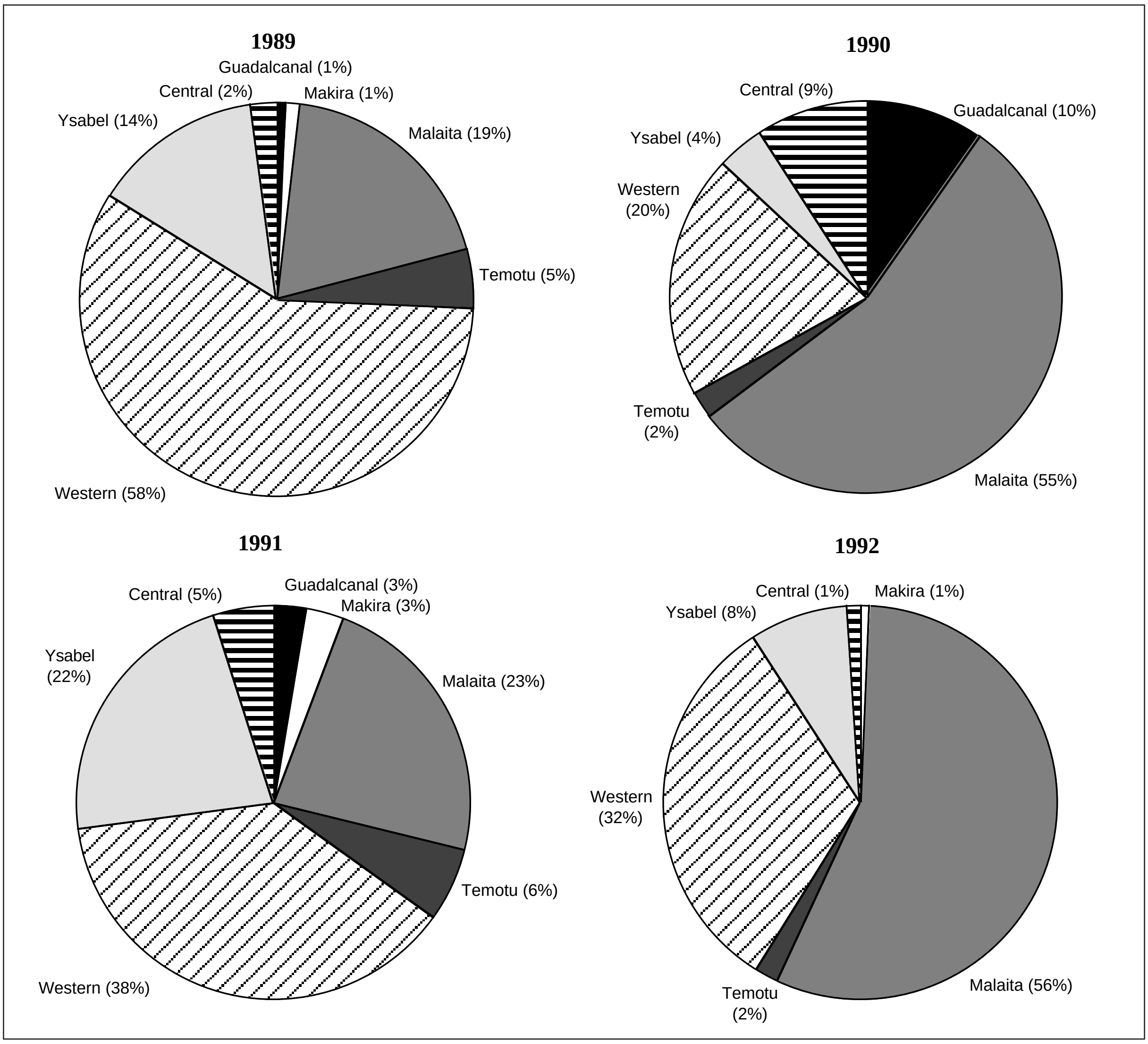


Figure 1: Percentage of beche-de-mer produced in each Province between 1989 and 1992

Other places, however, have a high abundance of a few species. For example, Choiseul produces a large amount of greenfish. Also, much of the white teatfish and brown sandfish come from Wagina where the fishermen use hookah to search for these species.

The Western Province is noted for its relatively high production of sandfish. This species prefers brackish water and is harvested mostly from the lagoons of Vonavona and Marovo, which receive a high run-off of freshwater.

Before the civil war in Bougainville, Papua New Guinea, production from the Western Province was enhanced by the catches of fishermen from the small islands around Bougainville. They would often trade beche-de-mer with people from the Shortlands and Choiseul. However, trade embargos imposed recently by the Papua New Guinea Government have decreased beche-de-mer trading, although the high value of the Kina still encourages some illegal transactions.

Malaita Province

The most important area for beche-de-mer in Malaita Province is Ontong Java, a large atoll lying 270 km north of the island of Ysabel. The atoll is 70 km long, 36 km wide and has two main islands, Luaniua and Pelau. Some features of this fishery have been reported previously by Crean (1977).

Ontong Java is still governed by chiefs, whose opinions and laws are respected. The chiefs allow beche-de-mer to be fished on 'even' years only. In these years, not all the species of beche-de-mer are fished. Usually the villagers concentrate on two species in particular. One of these is always white teatfish (called 'susufish' in Solomon Islands Pijin). The second species is chosen on the basis of its relative abundance. For example, greenfish were caught in 1990 and amberfish in 1992. The chiefs have acknowledged the need for management of the fishery and their system will persist whilst they hold power.

The people of Ontong Java were taught to process beche-de-mer by the Japanese prior to the Second World War (Crean, 1977). Most of the white teatfish processed is Grade A (1), because the animals have attained a larger size during the period when the fishery is closed; and the processing techniques are to a higher standard.

When the fishery at Ontong Java is open, the atoll produces the greatest quantities of white teatfish in the Solomons. The high catch can be attributed to two factors. First, the Polynesians who inhabit the atoll can free-dive far deeper than most Melanesians. Second, the large lagoon within the atoll is an ideal habitat for white teatfish.

In the years when Ontong Java is closed, most of the catch from this province comes from north Malaita, especially Lau Lagoon, and Tasman Island. In the case of Tasman Island, which belongs to Papua New Guinea, beche-de-mer is traded for commodities with the people from Ontong Java . In the even years of 1990 and 1992, Malaita Province produced over half of the beche-de-mer in the Solomon Islands (Figure 1). In the years when the Ontong Java fishery was closed, the percentage of beche-de-mer produced fell to around 20 per cent (Figure 1).

Ysabel Province

Most of the beche-de-mer is purchased in the north region of Ysabel, around Kia. In this region, there are many sheltered islands with sandy lagoons. Ysabel Province is the third largest producer of beche-de-mer (Figure 1). Much of the total catch of brown sandfish comes from this area.

Temotu Province

This remote province lies at the south-eastern border of Solomon Islands (Figure 1). It consists of three groups of islands: Santa Cruz, a group of high, volcanic islands; the Reef Islands, with their coral terraces and atolls; and the extinct volcanoes of the Duff Islands and also Utupua, Vanikolo and Tikopia.

Much of the beche-de-mer purchased from Temotu Province is from Utupua and Vanikolo. The fishery started in 1988 due to improved communication with Honiara and the increased demand for beche-de-mer. The majority of beche-de-mer processed in the Temotu Province is leopardfish, followed by brown sandfish. Exports ranged between 2 per cent and 6 per cent of the national total between 1989 and 1992 (Figure 1).

Central Province

The Florida (Nggela) Islands, Russel Islands, Savo, Rennel and Bellona make up this province. Most of the beche-de-mer produced here comes from lagoon habitats around Nggela and Russel Islands, although Indispensable Reef, an isolated atoll to the south, is also fished. With the exception of 1990, less than 5 per cent of the beche-de-mer produced in the Solomons came from the Central Province (Figure 1).

Guadalcanal Province

The north-east coast of Guadalcanal has alluvial plains with seagrass beds and shallow lagoons. The south coast has steep drop-offs and is largely inaccessible, due to bad anchorages and reefs. The majority of beche-de-mer is collected from the northern shore near Honiara. With the exception of 1990, when Guadalcanal produced 10 per cent of the beche-de-mer in Solomon Islands, catch has not exceeded 3 per cent and was negligible in 1992 (Figure 1).

Makira Province

Between 1988 and 1992, production of beche-de-mer from Makira did not exceed 3 per cent of the national total (Figure 1). This is due to the steep volcanic nature of the islands, which provide limited habitat for beche-de-mer.

Value of the fishery

Total exports of beche-de-mer from Solomon Islands increased from 17 t in 1982 to 622 t in 1991 (Figure 2). The increase in exports of beche-de-mer has been at the expense of other non-finfish, which declined from 731 t in 1986 to 180 t in 1991 (Figure 2). By 1991, beche-de-mer comprised 78 per cent of all non-finfish exports, and had a value of SI$ 7.6 million.

It is interesting to note that, despite the high value of beche-de-mer in 1991, it accounted for only 1.4 per cent of the total weight of fisheries products from the Solomon Islands in that year.

However, processed sea cucumbers average only 6.2 per cent of their initial weight (Preston, 1990). When the fresh weight of the beche-de-mer is calculated, the industry represented 20 per cent of all fisheries products in 1991.

The large increase in production of beche-de-mer between 1990 and 1991 can be attributed to four factors:

— There was a dramatic decrease in the catch of trochus (apparently due to the combined effects of overfishing and an increase in export duty). It fell from 92.4 per cent of the non-finfish exports in 1990 to 14.1 per cent in 1991. This caused a switch in fishing effort to beche-de-mer;

— Increased fishing for beche-de-mer in remote areas, e.g. Temotu Province;

— Decline in copra prices, inducing villagers to fish for beche-de-mer;

— Establishment of new marine export companies in some provinces. e.g. at Gizo in the Western Province.

The price of beche-de-mer per kg from the Solomon Islands, in terms of SI$, has been increasing due to the depreciation of the SI$. However, the average price of beche-de-mer in terms of US$ has changed little in the past decade. This is in contrast to the prices (US$) of individual species, e.g. white teatfish and sandfish, which have increased (Table 2). This trend is due to the higher proportions of low-value species in the catch in recent years (see below).

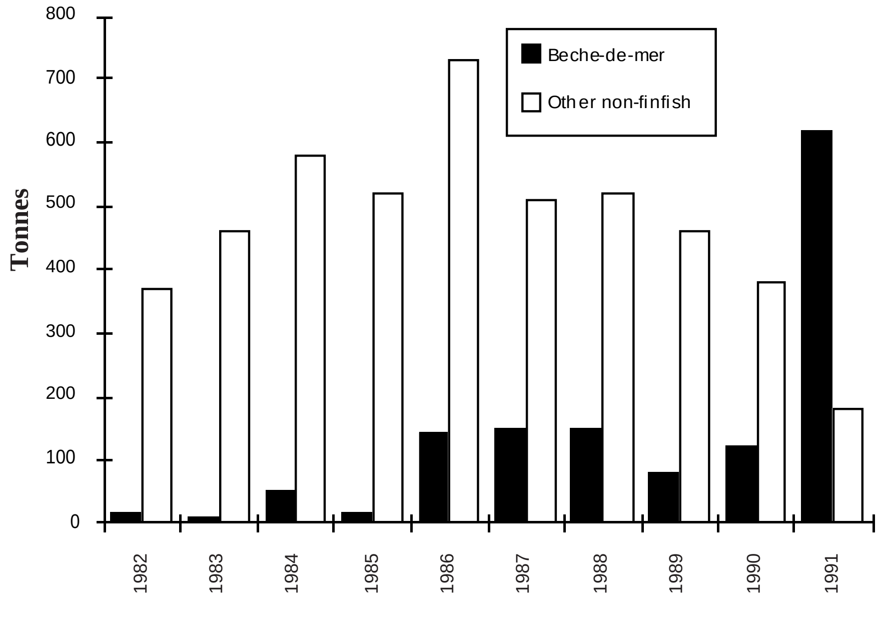


Figure 2: Importance of processed beche-de-mer and other non-finfish exports from the Solomon Islands between 1982 and 1991

Since 1988 the SI$ price per kg has fluctuated substantially from month to month. This undoubtedly reflects changes in the proportions of high- and low-value species exported each month. For example, in 1990, the average price of beche-de-mer was significantly positively correlated with the percentage of white teatfish, greenfish and prickly redfish, in the exports of Sunking Enterprises (Spearman Rank Correlation Coefficient $r_s = 0.63$, $p < 0.5$, $n = 9$).

There have been no apparent seasonal trends in the quantity of beche-de-mer exported, despite marked seasonality in the Hong Kong market (Van Eys & Philipson, 1989). However, with the exception of 1987 and 1989, exports were relatively high in November and / or December. This is because fishermen need to trade for money just prior to Christmas. Sea condition also dictates the collection of beche-de-mer. For example, exports between January and April 1990 were low following Cyclone Ofa in January of that year.

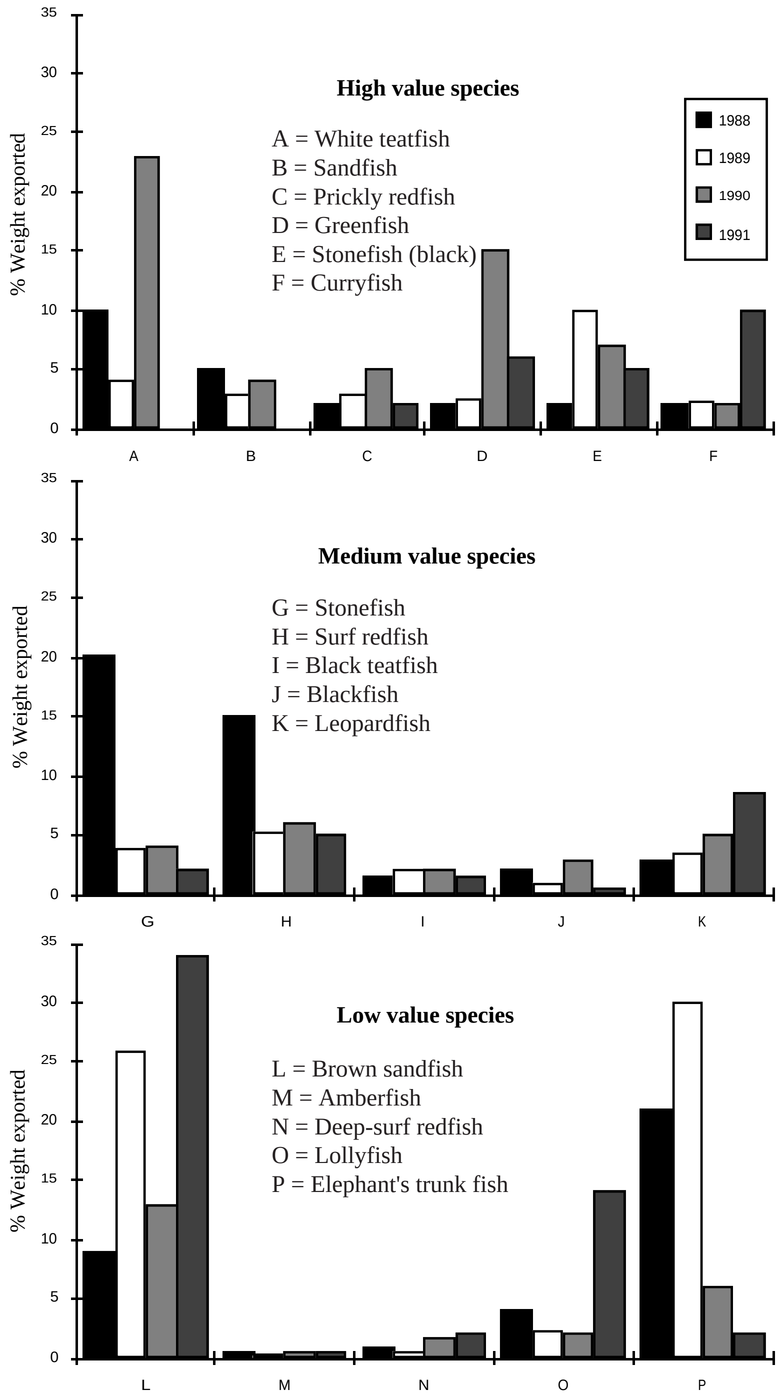


Figure 3: Annual variation in exports of the principal species of beche-de-mer harvested in the Solomon Islands between 1988 and 1991

Variation in catch among species and years

In recent years, there have been large variations in catches of different species of beche-de-mer (Figure3). The species caught in the greatest quantities were brown sandfish and elephant's trunk fish. These were previously described as being of negligible commercial value (Anon. 1979). Other species that were considered non-commercial until recently are the leopardfish (called tigerfish by exporters) and curryfish, both of which were caught in relatively high quantities (8-10 per cent of total catch) in 1991. Other species that were harvested in relatively high quantities were white teatfish, greenfish, stonefish and surf redfish. The reason why brown sandfish has dominated exports from Solomon Islands since 1989 is that the fisheries in Marovo Lagoon and Temotu were opened in 1988. Kia and Vonavona Lagoon also yielded high quantities of brown sandfish.

Production of each species also varied greatly among years (Figure3). In many cases this variation did not represent annual variability in the abundance of the animals. I have already pointed out why the catch of white teatfish is higher in even years. It is also interesting to note that when the Ontong Java fishery is closed, catches of brown sandfish increased dramatically. Surf-redfish exports were high in 1988, probably because fewer species were of commercial value at that time (Table 2).

The decrease in the highly valued sandfish after 1989 can also be attributed to factors other than natural variation in abundance, or over-fishing. The processing of this species to a high standard is complex (Anon, 1979) and a large proportion of the catch is rejected by exporters because of its poor quality. The difficulties in processing sandfish have led fishermen to collect other species, notably curryfish and lollyfish (Figure 3).

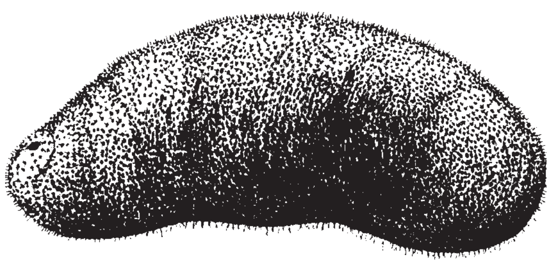
Recent data for 1992 reveal that beche-de-mer landings were in slight excess of 700 t (Fisheries Department statistics). However, in 1993 catches dropped substantially (although as yet no data are available) due to over-fishing which has led to a severe reduction of initial adult biomass. Additional income from logging royalties may have led to a decreased fishing effort for beche-de-mer, although this is speculative.

Management of the fishery

There are two self-imposed restrictions on the catch of beche-de-mer in Solomon Islands. One is the situation at Ontong Java, described earlier. The other is in Makira. There, the local population has experienced fish poisoning. They believe that the decrease in stocks of sea cucumbers has induced this problem, and that the fish are now 'eating the poisons' on the reef that were once consumed by sea cucumbers. The people of Makira have placed a moratorium on beche-de-mer fishing in certain areas to replenish the stocks.

Official data for use in management of the beche-de-mer fishery in Solomon Islands are limited. At present, the Fisheries Division only requires exporters to record the area where the beche-de-mer is caught, and the quantity and value of the processed beche-de-mer purchased there. It also requests information on the destination, quantity and value of the exports. A breakdown of the species, and proportions of the different grades for each species, can currently only be obtained from the private records of the exporters.

Optimal management will depend on reliable data on distribution, age and growth, fishing mortality, natural mortality, catch per unit of effort, fecundity and recruitment of each species. Because the fishery involves 22 species and is spread over a wide area, collection of such information is beyond the current resources of the Solomon Islands.



Official knowledge of the fishery could, however, be improved if the form used to record exports of beche-de-mer was modified to include data on the processed quantity of each grade for every species. Changes in the proportions of the grades and in the total quantity of the species could then be used to assess whether over-fishing is occurring.

Adams (1993) has recommended several measures for the management of beche-de-mer in the Solomon Islands (see *Beche-de-mer Information Bulletin #5*).

There are some other measures that could be introduced for the benefit of both the fishermen and the stocks of those species sold by grades. The first is a minimum size limit. As Grade 1 product fetches the best price, yield per recruit could be maximised by placing a minimum size limit corresponding to the size needed for Grade 1. If the size limit was above the length at first maturity, this would also contribute to the sustained production of propagules. Length at first maturity is already known for several species (Conand, 1981, 1990).

Fishermen may have difficulty following a size limit because many of them have no means of accurate measurement. One way this could be resolved for large species is only collecting animals that are at least as long as an adult fisherman's forearm. For smaller species, a common manufactured product could be used as a yardstick. For example, an animal should not be collected if it fits inside a 'Solomon Blue' tuna can. The exporters also have a role to play here. It is in their interest to sell Grade 1 product, therefore they could provide disincentives for harvesting lower grade animals.

The need for this type of management is not as crucial for white teatfish and brown sandfish as it is for some of the other species. More than 50 per cent of the white teatfish and brown sandfish exported in 1988 and 1991 was Grade 1. This was not the case for sandfish and lollyfish.

Curryfish, which fetches a higher price at a smaller size, could not be managed efficiently by a lower size limit. Its relatively high price, and the preference for smaller individuals, make it a possible candidate for aquaculture (see below).

The second way that management of the fishery could be improved is to upgrade the skills of processors through training. At present, a proportion of animals is rejected by purchasers due to decomposition caused by incomplete drying and improper storage.

Restricting collection to free-diving only, as recommended by Adams (1993), would limit the amount of time available to search for animals hidden away in the coral reef, and would prevent most fishing below 30m. This is a conservative method that should reduce recruitment over-fishing because up to half the stock of some species live at depths greater than 30m (Preston & Lokani, 1990).

Stock enhancement

A promising method of sustaining and maximising the catch of beche-de-mer from tropical areas is the reseeding of habitats with juveniles reared in hatcheries. Techniques are being developed for the propagation of beche-de-mer in captivity in Japan, Guam and Hawaii (see *BDM Information Bulletin #4* and *#5*). The techniques focus mainly on larval rearing (R. Richmond, pers. comm.) and reproduction by fission (Harriot, 1982). If juveniles can be produced economically, they could be released onto reefs for subsequent harvest. This will be a major thrust of future research at ICLARM's Coastal Aquaculture Centre near Honiara.

The viability of this option cannot be assessed without further research. Important questions that need to be answered are:

— Which species would be most suitable for aquaculture?

— What is the best method for tagging juveniles? (so as to distinguish which animals were produced in hatcheries)?

— At what size and density should the juveniles be released?

— Where should the juveniles be liberated to maximise their survival and recapture?

This report has identified at least two species with high values and particular habitat preferences that should be suitable for enhancement. One is white teatfish, which are unlikely to disperse from lagoonal atolls, like Ontong Java, if seeded there. The other is sandfish, which should remain in lagoonal areas of high freshwater run-off. Curryfish is also a candidate for reseeding or farming because of its relatively high value and the fact that it should be ready to harvest in a relatively short time.

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Fishing beche-de-mer in Madagascar

by Mark A. Irwing
Madex SARL
Mahajanga, Madagascar

I have been fishing, processing and marketing beche-de-mer for five years, the past two and a half years in Madagascar and previously in Mozambique. I by no means call myself an expert on the subject. I agree with William S. Sommerville of The Asil Group in New Zealand who wrote in his article of the last issue (see *Beche-de-mer Information Bulletin #5*), that one continues to learn daily in this fascinating and often frustrating business.

Madagascar is the fourth largest island in the world and has a coastline about 4,000 km long. While beche-de-mer can be found along the entire coastline, it is only fished on the leeward side of the island. I suspect the windward side is too dangerous for divers.

Species

There are many different species of beche-de-mer found around Madagascar: black teatfish, brown teatfish, white teatfish, sandfish, black sandfish, red sandfish, prickly redfish, curryfish, surf redfish, elephant trunk fish, greenfish, lollyfish.

Quality

We have found that, as the demand for beche-de-mer increases, so the quality supplied by the local fishing villages decreases. There were never such problems when I first started working in Madagascar. We and a few other processing companies still enforce strict quality control measures.

However, over the last 12 months, with an increase in demand, we have seen many illegal collectors enter the industry. They are doing it more harm than good, their only interest being to make a fast buck. They hardly carry any overheads and certainly don't give anything back to the industry.

These illegal collectors offer beche-de-mer fishing villages huge sums of money, almost double what we usually pay them (e.g. teatfish FMG20,000/kg or US$ 10/kg and sandfish FMG 35,000/kg or US$18/kg). This practice has caused traditional fishing villages to stop catching fish and start catching and processing beche-de-mer.

The fishermen try to speed up the process so as to make money more quickly, but in doing this they compromise the quality. Instead of doing two or three boilings they are only doing one.

Many are not burying the beche-de-mer in sand overnight. In some cases, instead of adding extra salt to a boiling, they are rubbing salt onto the body of the beche-de-mer, which causes holes to form on the bottom and sides.

Problems facing the industry in Madagascar

Being a third world country, Madagascar does not have the resources of infrastructure to handle the problems facing the beche-de-mer industry. These include:

—No closed fishing season such as those applied to other fishing industries;

—No limits on size, quantity or species;

—No educational workshops for local fishermen;

—Insufficient access to coastal villages.

—Manpower shortage and lack of motivation in Fisheries Departments;

— No visible aid organisations (e.g. UN, FAO).

Problems facing registered processing companies

These include:

—Competition from illegal collectors;

—Lack of help from the Department of Fisheries;

—Lack of active beche-de-mer organisation to help improve the beche-de-mer industry before it is too late.

Our company, for instance, will re-invest US$2 million in 1994/95 to improve the industry in Madagascar, but we need everybody to pull in the same direction, not just to think of the money that can be made out of these creatures. Let us implement ways of looking after these creatures that put the money into our pockets! Our aim is to improve all facets of the industry through:

— Better equipment;

— Better information on endangered species, on spawning, on life cycle, aquaculture;

— Educational workshops for local fishing villages;

— Creation of about 300 extra jobs;

— Improved social services for personnel: medical aid and pension, schools for children, housing and sports facilities.

We would gladly accept any advice or information on the above as well as encourage research parties to visit Madagascar in the future.

Estimated production in dry weight

The Department of Fisheries estimates production of all beche-de-mer at ±120 t / yr. My estimate is ± 300 t / yr, with ± 60 t wasted due to bad quality or small size (± 1-2cm).

Please send any enquiries or information to:

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MADEX SARL
Siège Social
1er étage
Immeuble Laza Boina
Quai Barriquand
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Mahajanga 401
Madagascar

Laamu Atoll Mariculture Project: mariculture of sea cucumbers — project summary

by N. Reichenbach, S. Holloway and A. Shakeel
Oceanographic Society of Maldives
Male, Republic of Maldives

The primary objective of our project, over an initial two-year period, is to demonstrate the feasibility of sustainable sea cucumber culture at village level in the Maldives, in order to provide a viable alternative to the rapidly declining sea cucumber fishery. Villagers who have been involved in this fishery will be encouraged to participate.

Culturing sea cucumbers will help reverse the present trend towards depletion of the natural stocks of marketable sea cucumber species and will help restore jobs and income provided by the fishery until recently. The project is sponsored by the Oceanographic Society of Maldives and endorsed by the Maldivian Ministry of Fisheries and Agriculture.

In the propagation of sea cucumbers we are considering both the sexual and asexual forms of reproduction. In November 1993, we began a screening experiment to examine which of several commercial species have potential for asexual propagation.

The species we are examining in our replicated field-pen trials include *Actinopyga mauritiana*, *A. miliaris*, *Holothuria fuscogilva*, *H. nobilis*, *Stichopus chloronotus*, *S. variegatus* and *Thelenota ananas*. We have induced animals in our pens to undergo binary fission and are currently measuring survivorship and individual growth / regeneration rates. Following this screening experiment we plan to determine the optimal density and the effect of food supplements on the growth and survivorship of asexually propagated animals.

In our evaluation of the sexual form of reproduction, we initiated, in December 1993, a 12-month study on the sexual cycle of three species of sea cucumber. The gonads of field-collected specimens of *A. mauritiana*, *H. fuscogilva* and *T. ananas* are being examined. The data collected will be used to assess the time and duration of spawning activity, fecundity and the weight at first sexual maturity. Upon determination of the spawning season for each species, trials on animal spawning and larval / juvenile rearing will be conducted in the laboratory.

Based upon the data collected from the experiments noted above we will select the 'best' species. Characteristics which will be considered in the selection of the best species will include biomass per unit area, survivorship and growth / regeneration rates in the asexual propagation trials, duration of spawning season, fecundity, larval and juvenile survivorship, marketability and price per kg.

Once the best species is selected, we will identify three Maldivian families to conduct pilot-scale operations. These operations will be part of the follow-up community-based mariculture development programme.

Spawning observations

A request for information on spawning behaviour of tropical holothurians was published in Beche-de-mer Information Bulletin #4. *For this issue we have received a list of observations (presented below) compiled by S. Uthicke in the Lizard Island (Australia) area and another observation on lollyfish spawning by Dr Johann Bell from ICLARM in the Solomon Islands.*

1. Spawning observations from Lizard Island area (compiled by Sven Uthicke, Institut für Hydrobiologie, Hamburg, Germany)

Date: 11/11/1992
Time: 18h00
Species: *Stichopus chloronotus*
Moon Phase: full + one
Remarks: 1 specimen spawned in Aquarium
Observer: S. Uthicke

Date: 12/11/92
Time: 18h00–18h30
Species: *Stichopus chloronotus*
Moon Phase: full + 2
Remarks: 8 individuals observed (≈15 per cent of observed specimens), sea grass bed off research station.
Observer: S. Uthicke

Date: 13/11/92
Time: 18h30
Species: *Stichopus chloronotus*
Moon Phase: full + 3
Remarks: 1 specimen, Mauros Reef
Observer: S. Uthicke

Date: 12/12/92
Time: 18h30
Species: *Stichopus chloronotus*
Moon Phase: full + 2
Remarks: 14 individuals spawned (≈ 20 per cent of observed individuals)
Observer: S. Uthicke

Date: 16/12/93
Time: 16h30
Species: *Holothuria fuscopunctata*
Moon Phase: 3/4 -1
Remarks: 2 individuals, North Direction Island
Observer: S. Uthicke

Date: 29/12/92
Time: 16h30
Species: *Bohadschia graffei*
Moon Phase: 1/4 -3
Remarks: 1 specimen, North Reef
Observer: S. Uthicke

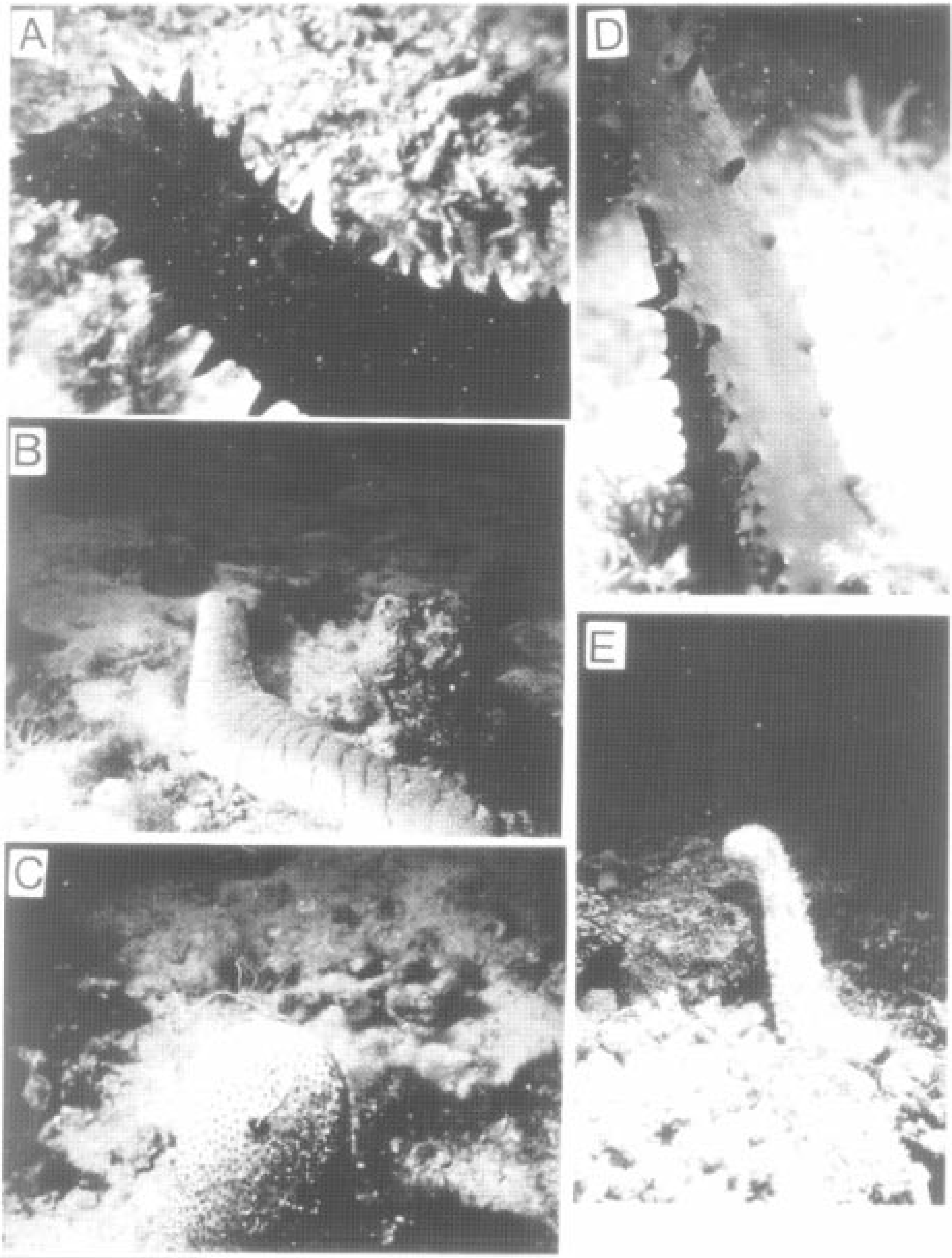
Date: 11/1/93
Time: 18h40
Species: *Stichopus chloronotus*
Moon Phase: full + 3
Remarks: 8 specimens spawned on reef flat, other days after full moon were checked, but no spawning occurred.
Observer: S. Uthicke

Date: 11-12/1/93
Time: ≈ 9h00 and 17h00 on both days
Species: *Holothuria coluber*
Moon Phase: full + 3
Remarks: Observer described spawning as very intensive, he claims that more than 50 per cent of population spawned each time.
Observer: Roland Knapp

Date: 25/11/92
Time: 17h30
Species: *Stichopus variegatus*
Moon Phase: new + 1
Remarks:
Observer: Bridgit Kerrigan

Date: 26/11/92
Time: 17h40
Species: *Stichopus variegatus*
Moon Phase: new + 2
Remarks: Watsons Bay, ca. 8m depth, individuals crawled on exposed places to spawn.
Observer: S. Uthicke

Date: 16/2/93
Time: 16h15
Species: *Bohadschia graffei*
Moon Phase: 3/4 + 2
Remarks: 4 individuals, South Reef
Observer: S. Uthicke



Holothurians spawning. A and D: *Stichopus chloronotus*; B and C: *Holothuria fuscopunctata*; E: *Bohadschia graffei* (photos: Sven Uthicke)

Date: 9/4/93
Time: 19h00
Species: *Stichopus chloronotus*
Moon Phase: full + 2
Remarks: 5 individuals, sea grass bed
Observer: S. Uthicke

General Remarks: only populations of *S. chloronotus* were generally observed for spawning (this means that they actually did not spawn in the months where no spawning was recorded) all observations on other species were made by coincidence.

Spawning of lollyfish (*Holothuria atra*) — communicated by Johann Bell

Species: *Holothuria atra*

Number: Three individuals (1 female & 2 males) out of a group of 15 animals held in a 75l fibreglass tank spawned at 12.00h on 14 October 1993. The tank was supplied with a system of flow-through seawater at 30°C.

Behaviour: Anterior half of the body elevated during spawning, with uniform swaying from side to side. Gametes were released from the genital papillae in strands of varying lengths. Gametes were negatively buoyant, sinking to the bottom of the tank or onto the animal itself. Eggs were pink and sperm were white. The release of gametes was moderately slow. Upon disturbance, gametes spilt from the strand into the water. The spawning period for each individual varied between 20 and 30 min.

Fertilisation: The average size of an unfertilised egg was 137µm. The two-cell division stage was reached after two hours. The four-cell stage began after four hours.

Moon Phase: 1 day before New Moon.

The sea cucumber should stay under

by Catherine Malaval
(Excerpt from an article published in* Liberation*, 25/01/94)

The holothurian, highly valued for its culinary virtues, especially in South-East Asia, is being over-fished.

The problem is that, like the earthworm on land, it plays an important ecological role on the sea floor.

Dried, rehydrated, tossed into a soup or cut into thin slices, it is a delicacy for the Chinese, who call it beche-de-mer or trepang. Served raw with soy sauce, it is also a favourite of the Japanese. This has been true for thousands of years, ever since the culinary qualities of the holothurian, or sea cucumber, were first discovered. Unfortunately this creature, whose soft body makes it at first glance quite repulsive, is today the target of a booming trade.

In tropical regions, 80,000 t are thought to be harvested each year, while another 12,000 t are estimated to be taken annually in temperate zones. Their destination: the big Singapore and Hong Kong markets. 'Over-exploitation is occurring almost everywhere. While it is true that we do not have as much information on the sea cucumber as we do on tunas or whales, the signs are unmistakable. Once an area is depleted, fishermen change location, and this process is being seen more and more frequently. The size at capture is also decreasing. Nowadays it rarely even reaches one metre', explained Chantal Conand, a biological oceanographer and senior lecturer at the University of La Réunion.

In short, the sea cucumber is highly sought after not only in Japan or China but also in all the other 'Chinatowns' around the world, such as those in Sydney or San Francisco. So much so that this animal, which once passed its days peacefully reclining on the ocean floor, is soon to become the subject of a study programme off the Galapagos Islands by the World Conservation Union (an international conservation organisation). It is already under surveillance in the Maldives. Researchers are hoping to develop a system of aquaculture without delay. This will not be possible without a full file on holothurians, a major task.

'Just knowing its growth rate poses a problem. Frankly, measuring a holothurian is like trying to measure an accordion!' claims Conand, who, from 1981 to 1984, conducted a study aimed at assessing the number of exploitable species, for ORSTOM in

New Caledonia. 'What's more, of the 1,200 species of holothurians, the 12 which are edible do not all have the same biology.' In general, it is known that a toxin, concentrated mainly in its skin, protects it from many predators and that it sometimes allows small fish such as Carapidae (messmate fish or pearlfish) to take shelter in its anus. Its method of reproduction is quite astonishing – both males and females, which are ordinarily content to lie flat, rear up like cobras and swing backwards and forwards while releasing their sexual cells.

Finally, the sea cucumber plays a very important role ecologically. As it moves forward, it ingests and turns over kilos of sediment from the ocean floor. 'If they were not around to stir up the sediment, it would become more stratified and there would be less oxygen. Less oxygen means that the sediment would be less healthy and thus there would be less food for other animals', explains Conand. In other words, the sea cucumber plays the same role on the seabed that the earthworm plays on land.

A useful but unlucky animal: large quantities must be harvested to supply enough to eat since, in fact, only 10 per cent of the animal, i.e., its thick skin, is eaten.

Sea cucumber dive fishery in Washington State: an update

by Alex Bradbury
Department of Fisheries
Washington State, USA

The commercial dive fishery for *Parastichopus californicus* in Washington State began in 1971, and was the subject of an article by C. Conand and A. Bradbury in *Beche-de-Mer Bulletin #3* (1991). This article updates the fishery information for the last three seasons (1991–1993) and summarises catch-and-effort data since 1983, the first year that harvest logbooks were required.

From 1971 to 1986, the fishery was open in all areas. Following signs of overfishing, Washington State Department of Fisheries implemented a rotational harvest from 1987 to 1992. State waters were divided into four areas, each fished for roughly six months followed by a closure of roughly three and a half years.

In 1993, it became apparent that two of the four harvest areas were not as productive as the other two, resulting in catch inequities and economic imbalance. The future of the rotational system was also questioned following legal decisions regarding harvest rights for native American Indian tribes. The rotational system was abandoned midway through the 1993 season, with the fishery returning to an all-State fishery. The pros and cons of rotational management are presently being analysed from biological, legal, and socioeconomic standpoints.

A summary of production and catch per unit of effort (CPUE) since 1983 is given in Figure 1. Catch figures prior to 1988 should be viewed with cau-

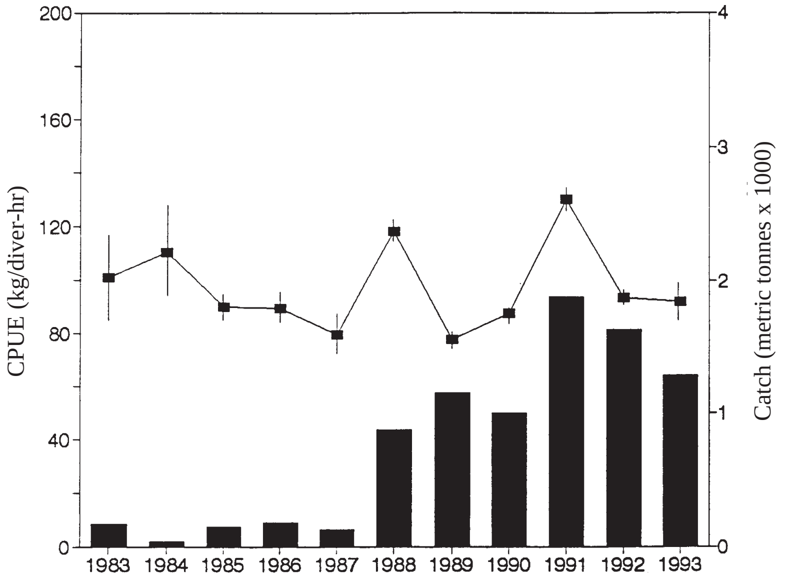


Figure 1. *Parastichopus* catch per unit of effort (line) and catch (bars) since 1983 in Washington State. Vertical bars through CPUE estimates are 95% confidence intervals derived from lognormalised data. Catch refers to tonnes of split, drained, and eviscerated sea cucumbers.

tion, however, due to underreporting. Since 1991, catch has been reduced by roughly 30 per cent with seasonal quotas. These quotas were implemented following signs that recovery of sea cucumber populations at several experimental sites was not sufficient to sustain the fishery at current levels.

State-wide CPUE shown in Figure 1 varies according to the harvest area being fished on the rotational system, but overall appears relatively stable. This apparent stability, however, may be deceptive. CPUE has declined significantly, for instance, in two of the four fishing areas over the past three seasons. Mean harvest depth has also increased significantly in all four areas since 1983, as divers search deeper waters for sea cucumbers. This trend appears to be stabilising recently; mean harvest depth has increased significantly in only one of four districts over the last two seasons.

Value per kg paid to divers at the dock has nearly tripled since 1990. Average price per kg in 1989 and 1990 remained at roughly US$ 1.32, increasing to US$ 2.03 in 1991 and to US$ 2.71 in 1992. Price during the 1993 season was US$ 3.51 per kg of slit, drained, and eviscerated sea cucumbers.

Several experimental sites have been established to determine the effect that fishing has on *Parastichopus* populations. One of these sites, Pulali Point, has been surveyed since 1989, during which time two fishing seasons have occurred. Prior to 1989, the area was seldom visited by commercial divers. During each visit to the site, biologists count all harvestable-sized *Parastichopus* within 12 transects, each transect measuring 83.6 m^2. Four depth zones are surveyed within the site, ranging from 7.6 m to 25.0 m.

Figure 2 shows that the 1990 fishery apparently resulted in a 70 per cent decline in density of harvestable-size animals. During the closed period, which lasted two years and nine months, density fluctuated seasonally (perhaps due to aggregation in the autumn and winter months). Surveys at the site will continue, and data are presently being analysed to estimate rates of mortality (both natural and fishing) and recruitment.

The eventual goal of this research is a yield model for the *Parastichopus* fishery in Washington State, Growth studies are also being carried out with this goal in mind, but these are complicated by several factors: most populations have unimodal size frequency distributions; very small animals are cryptic and apparently suffer high natural mortality; recruitment appears to be episodic in many areas; confined animals do not survive and grow well; and *Parastichopus* sheds conventional plastic tags within a few months.

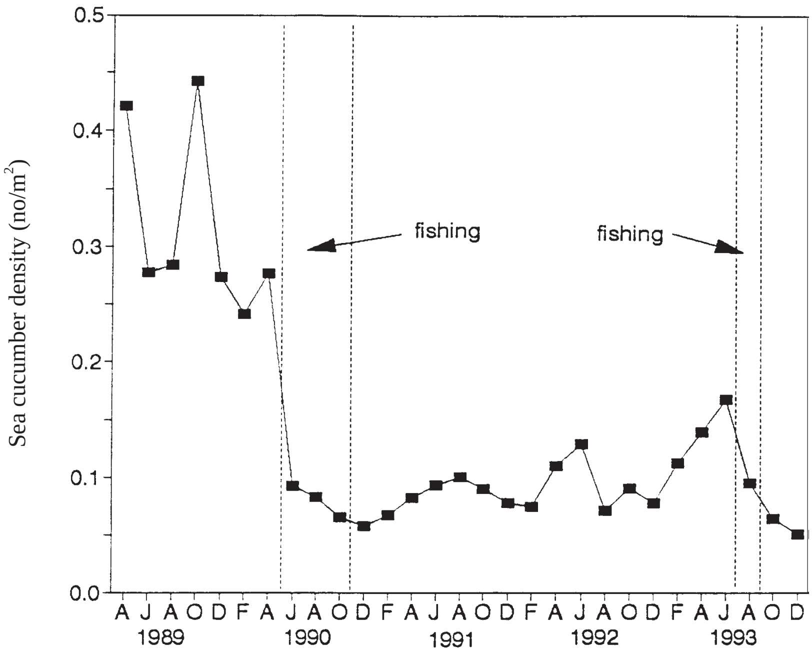


Figure 2. Density of harvestable-sized *Parastichopus* encountered within 12 transects at Pulali Point, Washington State

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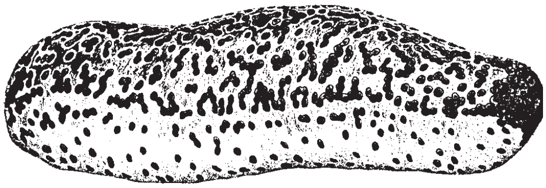
CORRESPONDENCE



Royal Hawaiian Sea Farms involved in research on sea cucumbers

Dale Sarver from Hawaii (Royal Hawaiian Sea Farms, Inc., P.O. Box 3167, Kailua-Kona, Hawaii 96745) sent a letter to Chantal Conand to ask for information on an Hawaiian sea cucumber species he intends to study. Extracts from this letter are reproduced below.

...I recently received number 5 issue of the Beche de Mer Information Bulletin. *It was a very good issue with lots of helpful information.*

We were successful in obtaining renewal for our sea cucumber research through the US Department of Agriculture Small Business Innovation Research program. So we will be working for at least another 2 years on growout techniques for Stichopus horrens *and possibly others.*

There is another Hawaiian species which we intend to look at. It is fairly common in places below 30 meters on fine sand and coral rubble. It gets to 30–40cm and is out feeding during the day. It is similar to S. horrens *but somewhat firmer, and does not 'melt' when disturbed or lifted out of the water. I have not been able to get a name for this animal. It looks like something in between a* Stichopus *and a* Thelenota, *and is orange/red. I have enclosed a photo of one which started spontaneously spawning in our tanks a few hours after collection (14:00hrs). It was a male and reared up in the typical position whilst spawning. It stimulated one other male to start spawning too, but the third one did not respond.*

We will be trying to spawn this species during the winter. I would be grateful if you could identify this animal for me. This species is interesting to us because it seems hardier in culture conditions, and people prefer it to the S. horrens *which is normally eaten here in Hawaii.*

Reply from Chantal Conand

'...Thank you very much for your letter and congratulations on the programme. I wish you much success. To identify the species, it is necessary to have spicules prepared. From the photo it looks of course like a stichopodid, but a scientific determination is needed for the species level. I have a few ideas but need the spicule plates from the dorsal and the ventral tegument. If you would like to prepare them and send them to me I shall probably be able to tell you the species.'

Samples sent by W.S. Sommerville for species identification

William S. Sommerville, Managing Director of Asil Group Ltd. (New Zealand) sent a letter and samples of beche-de-mer to Chantal Conand for species identification. Extracts from this letter are reproduced below.

Golden sandfish is a marketing name since buyers in Asia were calling it smooth sandfish and saying it was worth less than traditional sandfish. It is harvested in Tonga.

The snakefish name came from the Western Province in the Solomon Islands and it is used in Papua New Guinea as well. Sorry we do not have a Latin name.

Enclosed please find samples of the golden sandfish and snakefish.

I would certainly be interested to hear any comments you have on these species.

Reply from Chantal Conand

Thank you very much for the samples you sent me. The golden sandfish is easily determined from the sample as Holothuria scabra *var.* versicolor, *a variety of sandfish that I described in the FAO review.*

It has been exploited in New Caledonia and got very good prices at the beginning, but was rapidly overexploited (from the data on catch per unit of effort). Some taxonomists refer to it as H. scabra. *The snakefish is more difficult and will need a rigorous determination from alcohol-preserved specimens. Anyway it is of little value.*

Sea cucumber pen-culture project set up in the Republic of Maldives

Norman Reichenbach, from the Oceanographic Society of the Maldives, wrote the following letter to Chantal Conand.

'...I have recently read several of your papers on sea cucumbers. Your papers are of particular interest to me since I am working on a development project on pen culture of sea cucumbers in the Republic of Maldives. The project is jointly sponsored by two NGOs, the Oceanographic Society of the Maldives and the Canadian Association of International Community Development Agencies, and the Maldivian Government Ministry of Fisheries and Agriculture.

Holothuria nobilis *and* Thelenota ananas *are of particular interest to me since I will begin my pen culture research on these species. In your recent FAO publication "The fishery resources of Pacific Island countries. Part. 2: Holothurians" you indicated some publications in press that dealt with the above species. If these or other related papers are now available I would greatly appreciate reprints of these papers.*

Thank you for considering my request and I look forward to your reply. Please address all correspondence to the address for the Oceanographic Society of the Maldives (H. Giniraahiaage, P.O. Box 2075, Male, Republic of Maldives (via Singapore).'

Request for information on growth, migration and feeding of some tropical holothurians

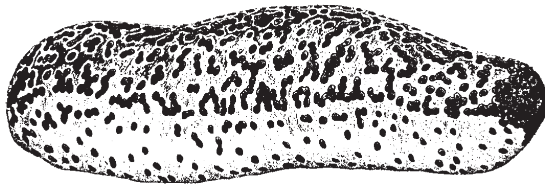
Paul Lokani, from the James Cook University of North Queensland, Townsville, Australia writes:

'...I am currently studying at the James Cook University of North Queensland, Townsville. This year, I am doing 1 year of study to qualify to do the Master of Science. I am enrolled with the Marine Biology Department. I would like to study growth, migration (using internal micro tags) and feeding in some species of commercial tropical holothurians. I will decide on the actual species as soon as I confirm which species have been studied.

I would like to know from you which species you studied for growth and migration and if I could have copies of the reports you have written on these. Would you know anybody else that have studied growth, migration and feeding in tropical holothurian species?'

B E C H E - D E - M E R

Abstracts, Publications Workshops and Meetings



Recent publications on tropical holothurians

Chao, S.M., C.P. Chen and P.S. Alexander (1993). Fission and its effect on population structure of *Holothuria atra* (Echinodermata: Holothuroidea) in Taiwan. *Mar. Biol.* 116: 109–115.

Conand, C. (1993). Ecology and reproductive biology of *Stichopus variegatus* an Indo-Pacific coral reef sea cucumber (Echinodermata: Holothuroidea). *Bull. Mar. Sci.* 52 (3): 970-981.

Conand, C. (1993). Reproductive biology of the characteristic holothurians from the major communities of the New Caledonia lagoon. *Mar. Biol.* 116: 439–450.

Lane, D. (1992). Biogeographical notes on the northward extension of the known latitudinal range for the tropical stichopodid sea cucumber, *Thelenota anax* H.L. Clark (Echinodermata: Holothuroidea). *Raffles Bulletin of Zoology*, 40 (2): 175–178.

Kerr, A., E. Stoffel and R. Yoon (1993). Abundance distribution of Holothuroids on a windward and leeward fringing coral reef, Guam, Mariana Islands. *Bull. Mar. Sci.* 52 (2): 780-791.

The following text summarises the results of a German 'Diplomarbeit' with the original title 'Untersuchungen zurkologie zweier sedimentfressender Holothurien, *Holothuria (Halodeima) atra* und *Stichopus chloronotus*, im Riffbereich um Lizard Island, Australien' (Ecology of two sediment-feeding Holothurians, *Holothuria (Halodeima) atra* (Ger, 1833) and *Stichopus chloronotus* (Brand, 1835), on reefs near Lizard Island, Australia), by Sven Uthicke, Institut für Hydrobiologie und Fischereiwissenschaft, Zeiseweg 9, 2000 Hamburg 50, Germany.

Populations of the two holothurian species were monitored during six consecutive months (November 1992 – April 1993) in three permanent transects (10 x 100 m) across a reef flat near Lizard Island, Great Barrier Reef. Each transect was subdivided into five zones. *H. atra* and *S. chloronotus* were the most abundant shallow-water holothurian species on the reefs around Lizard Island. On the transects and in other observed areas they nearly always co-occurred, but mostly one of the species clearly dominated the other. Along the transects both species showed distinct heterogeneous distribution patterns in abundances and average body size.

Potential nutrients for holothurians (measured as bacterial numbers, protein and chlorophyll a content) were determined in sediments of each zone of the transects. Although the nutritional value of the sediments was found to differ significantly between single zones, no correlations were found between these values and the distribution patterns of the holothurians. This suggests that nutrients were not a major limiting factor for the distribution of *H. atra* and *S. chloronotus* on the reef flat under study.

The bottom coverage with different substrata (Scleractinia, Alcyonaria, dead hard coral, coral rubble, pavement and sediment) was estimated along the transects. The coverage with coral rubble showed a significant negative correlation with the mean body weight of both holothurian species. This suggests that zones with a high percentage of coral rubble are habitats for juvenile holothurians. These zones are generally in the middle of the reef flat and are probably best suitable for larval settlement. It appears that individuals migrate towards the reef margins as they become larger.

The intensity of water movement in the zones was measured by the erosion of plaster-of-Paris cubes and showed a clear gradient along the transects as well as differences between the transects. The abundance and biomass of *S. chloronotus* decreased significantly in areas of high water-flow while *H. atra* appeared to be more adapted to these zones. Thus, the latter species was dominant in the more exposed zones while the former was more abundant in sheltered areas.

Temporal variations were observed in biomass and abundance of *H. atra* and *S. chloronotus*. The number of all *H. atra* in the transects increased from 296 to 345 during the observation period, while the biomass of this species was nearly constant. As no recruitment of juvenile *H. atra* could be observed, the increase of abundance is probably due to asexual reproduction by transverse fission. This assumption is supported by analyses of weight-frequency data. In contrast to *H. atra*, the abundance of *S.chloronotus* decreased from 279 in November to 227 in March; the biomass of this species showed a maximum in January. The decrease in abundance could be explained by a high mortality, probably due to strong winds and stronger current conditions which prevailed from the beginning of January until the end of the observation period. The overall mean abundance of *H. atra* on the transects was 10.7 individuals / 100m^2(biomass: 128 g / 100m^2) the abundance of *S. chloronotus* had a mean of 9.0 individuals / 100m^2 (biomass: 141 g / m^2).

An average growth rate of 12g / month during the observation period was calculated for *S. chloronotus* employing Modal Progression Analyses (MPA). As this species is known to have two distinct spawning periods in November and March, the approximate age of each cohort could be assessed assuming all individuals resulted from one of these spawning periods. Plotting the weight of these cohorts against their assumed age resulted in an annual growth rate smaller (70 / 80 g / year) than the growth rate that could be extrapolated from data of the observation period (12 x 12 g = 144 g / year). This suggests a strong seasonal variation in the growth of *S. chloronotus*. MPA could not be applied to obtain growth rates for *H. atra*. This was probably due to asexual reproduction of this species, as the weight-frequency data showed no clear modes.

The daily activity rhythm of the two species under study was examined in two 24 h cycles in aquarium experiments. Faecal pellets were collected every two hours to determine their dry weight. *H. atra* was feeding day and night with the same intensity, whereas *S. chloronotus* stopped feeding at night. These findings were supported by field observations. During their nightly resting phase, individuals of *S. chloronotus* tended to hide under dead corals or larger rubble. During the daytime, *S.chloronotus* covered distances of about 27.2 cm per hour, which was significantly 'faster' than *H.atra* (12.9 cm / hour). Grain-size analyses of faeces of both species showed that *S. chloronotus* (median: 424 µm) selected for much finer sediments than *H.atra* (median: 1102 µm). The former species was frequently found feeding on pavement or between coral rubble while the latter fed in more open areas. Hence, micro-habitat and grain-size selection appear to be important means of niche separation between the two species.

An average-sized individual of *H. atra* (129-125 g) consumed about 67 g of sediment (dry weight) per day, an average *S. chloronotus* (in November: 144 g) 59 g. Assuming the determined densities on the reef flat, the populations of both species would rework about 4600 kg sediment / year per transect (1000m ^{2}). This is approximately the weight of the upper 5 mm of sediment per 1000 m^2. Ten individuals of each species were sacrificed for analyses of gut contents. A sediment sample was taken directly in front of each specimen. No significant decrease in phycopigments (chlorophyll a and c, fucoxanthin) occurred during gut passage and the contents in the oesophagus were not higher than in the adjacent sediments. Pigment concentrations of sediments in front of *S. chloronotus* and in all gut segments of this species were significantly higher than the corresponding values in *H. atra*. From these observations I conclude that *S. chloronotus* is efficiently selecting for sediments rich in plant material. This selection does obviously not occur by taking up certain particles from a given sediment, but by carefully choosing the sediment spot to feed on. Meiofauna density in the ingested sediments of both holothurians species was significantly lower than in sediments near the holothurians. The ratio of living and dead diatoms was much smaller inside the intestines. This might indicate that at least a portion of the plant material ingested is digested as well.

Several aquarium experiments were conducted to examine the influence of holothurians on micro algae and bacteria in sediments. In a pilot experiment, bacterial concentrations in an aquarium with *S. chloronotus* and a control aquarium reached the same level (2,3-2,8 x 109 cells / ml) after 9 days. The bacterial population in an aquarium with *H. atra* reached this value after 14 days. A larger experiment showed that both species significantly reduced chlorophyll a concentrations in sediments compared to control aquaria. The reduction by *H.atra* was more distinct than by *S. chloronotus*. In further experiments both holothurian species were feeding intensively on sediments with cyano-bacterial mats, extinguishing these mats and preventing their development.

The review *New Scientist* of 11 December 1993 contained an article entitled 'The grub and the Galapagos', by Nigel Sitwell, on a clandestine fishery of *Isostichopus fuscus* that started in 1992. The exploitation was banned by the President of Ecuador, but there has been strong pressure by businessmen to revoke the ban. Scientists sent by IUCN reported that 'the sea cucumbers had been taken at a rate of 130,000 to 150,000 per day and predicted that if this continued, populations would be wiped out in the entire archipelago within three to four years'.

Sea cucumbers are still fished despite the ban. A new institution, 'The Presidential Advisory Commission of the Environment', has been created to examine the whole problem, take into account the conservationist opinion and the fishermen's interests and provide guidance. Charles Darwin Research Station is starting biological and ecological studies on holothurian populations.

Below is an abstract of a paper entitled ' Predictable and unpredictable spawning events: *in situ* behavioural data from free-spawning coral reef invertebrates', by Russ Babcock, Craig Mundy, John Keesing (Australian Institute of Marine Science, PMB No. 3, Townsville MC, QLD 4810, Australia) and Jamie Oliver (Great Barrier Reef Marine Park Authority, P.O. Box 1379, Townsville, QLD 4810, Australia), which was published in 1993 in *Invertebrate Reproduction and Development*.

We describe the spawning behaviour and some aspects of spawning periodicity in a diverse group of marine invertebrates, principally echinoderms, but including sponges, anthozoans, molluscs, and polychaetes. Our observations were made both opportunistically and on a systematic basis between 1978 and 1992 on the central and northern Great Barrier Reef.

Spawning was predictable in some of the species observed, for example *Bohadschia argus, Euapta godeffroyi,* and *Stichopus variegatus* (Holothuroidea), which exhibited regular lunar and diel periodicity. Others, such as *Holothuria coluber, Actinopyga lecanora,* and *Bohadschia graffei* (Holothuroidea), *Acanthaster planci* (Asteriodea), *Hyotissa hyotis* and *Arca* spp. (Bivalvia) exhibited no clear lunar or diel periodicity in spawning behaviours. Mass hetero-specific spawnings which involved several species, often from different phyla, were commonly observed.

The species participating were usually those with unpredictable spawning patterns. While the species involved were diverse, there were also occasions when spawning involved species from the same genera. Fertilisation rates were measured *in situ* for the predictable spawner *Bohadschia argus* and were found to vary between 0 and 96 per cent depending on the circumstances of the spawnings. Fertilisation rates for the unpredictable spawners showed similar variability; *Holothuria coluber* and *Actinopyga lecanora* ranged from 9 to 83 per cent.

Eighth International Echinoderm Conference

The 8th International Conference was held in Dijon, France, from 6 to 10 September 1993, with several hundred participants from all over the world. Presented here are summaries of the communications on tropical sea cucumbers and the abstracts on sea cucumbers from other regions. They are presently with the referees and will soon be published, when accepted, by Balkema, Rotterdam.

1. Communications on tropical species

The fishery of the sea cucumbers *Isostichopus fuscus* and *Parastichopus parvimensis* in Baja California, Mexico, by L.R.S. Castro, National Institute of Fishery, Ensenada Baja California, Mexico

These species have been harvested along the east and west coast since 1988. The annual catch values in fresh weight from 1988 to 1992 were: 420, 703, 1000, 1783 and 1277 t.

The processed products: whole – gutted and dried, boiled skin, semi-frozen and raw fresh muscle, are totally exported to China (route L.A. Ca. USA). The maximum sizes measured were up 435mm in *I.fuscus* and 310mm in *P. parvimensis*.

The animals are hand-harvested by divers in shallow waters up to 30m deep on rock reefs. Both species are known to suddenly disappear or reappear in known fishing grounds in relation to seasonal changes in sea water temperatures. They are surface deposit feeders with mud, sand and remains of macroalgae, shells and sea urchin spines in their guts.

The animals eject their viscera but this behaviour is more drastic with *P. parvimensis* because it seems less tolerant to sun and air exposure. Sexes are separate, spawning in both species occurs in summer; in autumn–winter there are very few animals with gonads, very poorly developed. The adult size is 220-240mm (TL).

Through direct visual assessment of densities with quadrats drawn randomly we found: 1.46, 0.38 and 0.33 animals/m^2 and 720, 2115.5 gr/m^2 at west coast side. Average ranges of the measurements of the animals sampled were: TL, 217-263; GL, 210; BL, 100-109; DL, 64-57 (mm). TW,522-720; GW, 365-378; BW, 102-129; DW, 18-20 (grs).

These are data from samples of commercial catches for both coasts. The resource studies are for management regulations and continue.

Sediment utilization, niche breadth and niche overlap of Aspidochirotida (Holothuroidea: Echinodermata) in the lagoon and reef flat of Heron Island, Great Barrier Reef, by T.S. Klinger, C.R. Johnson & J. Jell, Department of Biological and Allied Health Sciences, Bloomsburg University, USA and Departments of Zoology and Earth Sciences, University of Queensland, Australia.

Aspidochirotida are abundant deposit-feeders in the lagoon (0.17±0.53 ind./m^2; mean ± 1 SEM) and on the reef flat (0.68±0.06 ind./m^2) of Heron Island. Granulometry of sediment and faeces indicates minimal feeding-niche separation between species. Electivity (E) for grain sizes ranges from -0.74±0.14 to 0.43±0.19. Coarser grain sizes (-1.5 to -0.5 phi) tend to be excluded, and finer grain sizes (3.0 to 4.5 phi) included disproportionately in the diet. However, each species ingests all available sediment grain sizes and all species ingest each grain size in roughly the same proportions.

Niche breadth (FT) for all species ranges from 0.97±0.00 to 0.99±0.01 and niche overlap (L) for each species pair ranges from 0.78 to 1.15. Some spatial separation of species occurs. *Holothuria atra* and *Holothuria leucospilota* have aggregated distributions, with *H. atra* more common on the inner and *H. leucospilota* more common on the outer reef flat. In the lagoon, *H. atra* and *H. leucospilota* forage at a distance from coral patch reefs (1.7 to 3.0 m) while *Holothuria edulis, Stichopus chloronotus* and *Stichopus variegatus* forage nearer (0.7 to 1.3 m).

However, active exclusion is unlikely. Coefficients of association (C_7) for these species indicate random co-occurrence. *Holothuria impatiens* and *Stichopus horrens* are positively associated (C_7=0.34) reflecting their shared cryptic habitat. Total consumption by Aspidochirotida in the lagoon and reef flat (3.93 and 12.76 g/m^2/day, respectively) represents only a small fraction of the available surface sediment (0.06% and 0.22%, respectively). Available surface sediment is not a limiting resource and therefore competition between co-occurring deposit-feeding Holothuroidea is probably slight.

Echinoderms of the Houtman Abrolhos Islands, Western Australia and their relationship to the Leeuwin current, by L.M. Marsh, Western Australian Museum, Perth, Western Australia.

The Houtman Abrolhos Islands (28°18'-29°S, 113°36-114°E), lying 65-90km off the mid-west coast of Western Australia are the southernmost coral reefs in the Indian Ocean. They are influenced by the warm Leeuwin Current during autumn and winter and by cooler water during the summer, resulting in a juxtaposition of coral reefs and kelp beds which is reflected in the composition of the echinoderm fauna. Sixty-eight per cent of the 167 species of echinoderms are tropical species, 13 per cent are southern Australian temperate species and 15 per cent are endemic to the west coast of Australia, but no species are confined to the islands.

Population dynamics of two reef flat dwelling Holothurians, *Holothuria atra* and *Stichopus chloronotus*, by Sven Uthicke, Institüt für Hydrobiologie und Fischereiwissenschaften, Zeiseweg 9, 2000 Hamburg 50, Germany.

Population dynamics were studied in two species of aspidochirotes (*Holothuria (Halodeima) atra* Jaeger and *Stichopus chloronotus* Brandt) on a reef flat near Lizard Island, Great Barrier Reef. Populations of these species were monitored during six consecutive months (November 1992 – April 1993) in three permanent transects (10m x 100m). Each transect was subdivided into 10 quadrats. In these quadrats species abundance was recorded each month, individual wet weight (ww) every second month. Additionally the following physical parameters were determined in every quadrat: type of bottom coverage, water movement and water depth. As sediment parameters, bacterial biomass, chlorophyll a and protein content were measured.

The obtained mean growth rates were 10g ww / month for *S. chloronotus* and 5g ww / month for *H. atra*. The mean body weight of both species decreased significantly in quadrats with high coral rubble cover. This suggests juvenile holothurians grow up in this type of habitat and that they migrate out of this zone as they become larger.

Although the species are sympatric on the reef flat under study they occupy different micro-habitats and exhibit different feeding rhythms. *H. atra* is found mainly on bare sand, ingesting coarse sediment, while *S. chloronotus* feeds on smaller particles selected from coral rubble covered with filamentous algae. The former species feeds 24 hours a day and the latter only between 11 am and 7 pm.

No correlations were found between chemical sediment parameters and the abundance of either species. This suggests that the distribution of these species on the reef flat is not limited by food. Their distribution is, however, greatly influenced by water movement. The biomass and abundance of *S.chloronotus* are lower in areas of high flow while *H. atra* is more adapted to these zones. Hence, *H.atra* dominates the more exposed quadrats and *S.chloronotus* is the dominant species in sheltered areas.

2. Communications on holothurians

G.G. Foster, A.N. Hodgson. The distribution and reproduction of three sympatric species of intertidal holothurians from South Africa.

H.M. Moore, D. Roberts. Feeding in deep-sea holothurians.

P.M. O'Loughlin, T.M. Bardsley. Diversity and density in Antarctic holothurians (Echinodermata, Holothuroidea).

A.V. Smirnov. Holothurians of the order *Apopida*: system and phylogeny.

A.S. Thandar. A new species of the holothuroid genus *Phyllophorus* from South Africa.

A. Tuwo, C. Conand. Fecundity of three temperate holothurians with pelagic development.

P.M. O'Loughlin, J.N. Ortenburg. Brood-protecting and fissiparous cucumariids (Echinodermata, Holothuroidea).

M.A. Sewell. Mortality of Pentactulae during intraovarian brooding in the apodid sea cucumber *Leptosynapta clarki*.

3. Posters on holothurians

J.-F. Hamel, G. Desrosiers. Larval fixation and small scale migration of the sea cucumber *Cucumaria frondosa*.

Y. Liao, A.M. Clark. An introduction to the echinoderms of southern China.

C. Massin. Calcareous deposit variations in holothurians illustrated by Antarctic dendrochirotes (Echinodermata).

J.B. McClintock, M. Slattery, B. Gaschen, J. Heine. Reproductive mode and population characteristics of the Antarctic sea cucumber *Cucumaria ferrari*.

A.S. Thandar. Character divergence and cladistic relationships of the Southern African genera and subgenera of the family Holothuriidae.

The contributions will be published by BALKEMA (Rotterdam).

Welcome to new members

by J.P. Gaudechoux, South Pacific Commission, Noumea, New Caledonia

The SPC Beche-de-mer Special Interest Group is growing. We have received additional completed questionnaires from the individuals listed below. The previous lists of members are available in the first four issues of *SPC Beche-de-mer Bulletin*.

If you are on the list and your name and address are wrong, please send us a correction. If you are not on the list and would like to be, fill in the form enclosed with the bulletin or write to us for a new one.

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