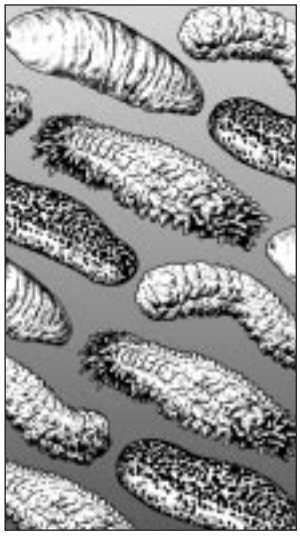
ISSN 1025-4943

Secretariat of the Pacific Community

BECHE-DE-MER

Number 10 — May 1998

INFORMATION BULLETIN



Editor and group coordinator: Chantal Conand, Université de La Réunion, Laboratoire de biologie marine, 97715 Saint-Denis Cedex, La Réunion, France. [Fax: +262 938166; E-mail: conand@univ-reunion.fr]. **Production:** Information Section, Marine Resources Division, SPC, B.P. D5, 98848 Noumea Cedex, New Caledonia. [Fax: +687 263818; E-mail: cfpinfo@spc.org.nc].
Printed with financial assistance from the Government of France.

Editorial

This 10th edition of the Bulletin gives us an opportunity to review the progress made in the 'sea-cucumber sector' information system in broad terms. After beginning in the tropical Pacific, the Bulletin has gradually acquired a wide international audience, while sea cucumber fisheries, often a source of conflict, have grown.

Readers, I would like to thank all those who have already contributed to the Bulletin, and ask that you take an active role in its improvement, as many of you have already indicated that the Bulletin is useful for you. I would be very interested in having your opinion on the following questions:

- Is the current presentation by section, i.e. 1) New Information, 2) Correspondence, 3) Publications, satisfactory?
- Which section should be given more space?
- In the 'New Information' section, parts on '*In situ* spawning observations' and 'Asexual reproduction through fission observations' have been introduced. This issue will for the first time include a part on 'Aquacultural information', with help from S. Battaglene at ICLARM. Are there any other new parts that you would like to see included?

Your suggestions and comments are both useful and necessary.

This Bulletin includes original articles on the resources of several different countries, including Malaysia (p. 2); Madagascar (p. 7–13); Sulawesi, Indonesia (p. 31); and Mozambique (p. 34). Many different aspects of the biology of asexual reproduction through fission (p. 15) and identifying specimens are discussed. And a contribution on the aquaculture of the species *Stichopus japonicus* (p. 24) will certainly meet the expectations of those interested in this activity.

Chantal Conand

Inside this issue

new info
beche-de-mer

The taxonomy and exploitation of sea cucumbers in Malaysia

by Mark Baine[1] *& Bobby Forbes*[1]

Introduction

In March 1996, Heriot-Watt University, Scotland and the Fisheries Research Institute, Malaysia were awarded funds from the UK Department of the Environment's Darwin Initiative to research the taxonomy, life history and conservation of sea cucumbers in Malaysia. Fishing is prohibited in designated Marine Parks, and these will provide ideal sites for the study of sea cucumber taxonomy and population dynamics.

Outside the Marine Parks there are no management measures in place for sea cucumber fisheries, and concern has been expressed at the possible overfishing of this resource, in particular the species *Stichopus variegatus* (curry fish) also known as 'Gamat'.

The project will also aim to identify fishing areas, collate information on catch and effort, provide population abundance estimates, determine the impact of existing fishing practices and recommend management measures as deemed appropriate.

Survey areas

The aim of the initial survey work was to cover geographically-distinct areas and establish species lists for these areas. Three areas were chosen for the initial survey phase. They are shown in Figure 1.

Pulau Pangkor – Sembilan Islands

Situated at the mouth of the Dindings River on the west coast of Peninsular Malaysia, the east coast of Pangkor is subject to heavy sediment loading. Sediment loading on the west coast of the island is less marked.

The Sembilan Islands can be found approximately 20 km to the south of Pulau Pangkor, and are outside the zone of riverine influence. Sediment loading is considerably reduced, resulting in the presence of a greater variety of large corals.

Payar Group – Langkawi

The Payar Group consists of three small islands designated as a Marine Park: Pulau Payar, Pulau Kaca and Pulau Lembu. Situated in the only 'clear-water zone' on the west coast of Malaysia, they are a popular location for day visitors from the tourist centre of Langkawi.

The Langkawi archipelago is located just south of the Thai border on the west coast of Malaysia. A major tourist destination, in recent years the area

1. International Centre for Island Technology (ICIT), Heriot-Watt University, Stromness, Isle of Orkney, Scotland
E-mail: mark@icit.emon.co.uk

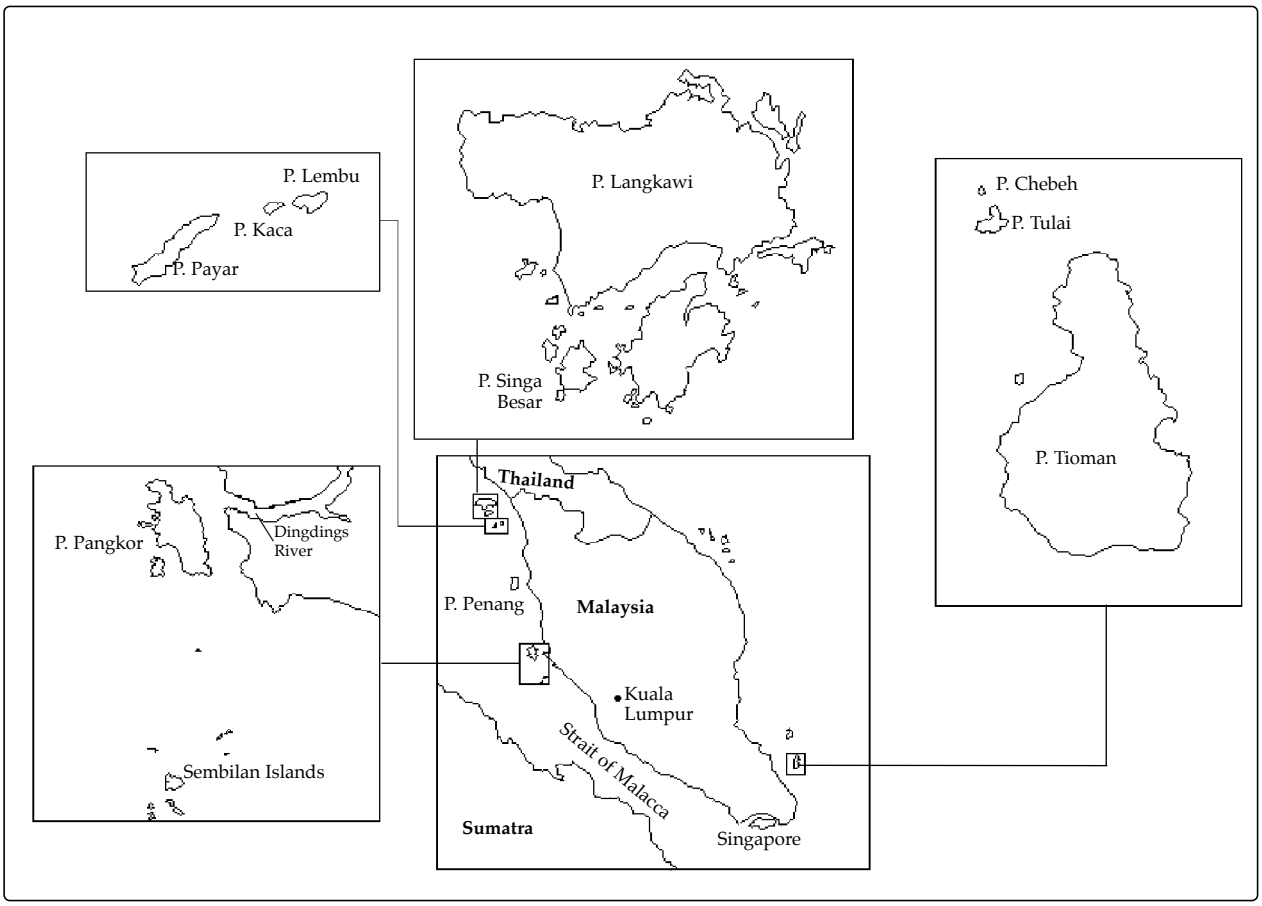


Figure 1

Maps showing the areas chosen for the initial survey phase

has undergone rapid development, with reclamation of coastal areas increasing. This in turn has resulted in increased sediment loading in the nearshore waters.

Pulau Tioman

Pulau Tioman, also designated a marine park, is situated on the east coast of Malaysia and is unaffected by runoff from rivers along that coast. It therefore exhibits much more diverse and developed coral communities. The east coast of the island is exposed to the annual monsoon season and is typical of a high energy environment, providing different habitats to those found on the west coast of the island.

Survey methodology

The major aim of the diving surveys in Phase I was to initiate the development of a taxonomic catalogue of the principal species found in Malaysian waters. Data gathering is being approached in three phases:

Phase I : Establish a species list
Phase II : Training courses in taxonomy and survey techniques
Phase III : Monitor permanent transects to provide extensive data on species distribution and population dynamics

Survey results

Table 1 (see next page) shows the initial results of Phase I surveys. There were, however, different degrees of effort employed at each area, although local knowledge tends to indicate that the greater number of species found on the east coast is more likely to be the result of a greater diversity of habitat types. Further Phase I surveys should determine whether this is true. In all, 17 species were identified to species level, with a further six species still to be identified.

Table 1: Species list and location

Species	Location				
	Pangkor	Sembilan	Tioman	Payar	Langkawi
Stichopus variegatus	x	x	x	x	x
Stichopus chloronotus			x	x	
Stichopus horrens				x	
Stichopus sp. 1			x	x	
Stichopus sp. 2			x		
Stichopus sp. 3				x	
Thelenota ananas			x		
Actinopyga echinites			x		
Actinopyga lecanora			x		
Actinopyga miliaris			x		
Bohadschia argus			x		
Bohadschia graeffei			x		
Bohadschia marmorata			x	x	
Holothuria atra	x	x	x	x	x
Holothuria coluber			x		
Holothuria edulis			x		
Holothuria impatiens			x		x
Holothuria hilla			x		
Holothuria leucospilota			x	x	x
Holothuria sp. 1		x			
Holothuria sp. 2			x		
Synapta recta			x	x	
Synapta sp. 1				x	

Fishery and trade statistics

In the early stages of this research, a limited number of sources have been identified for the collection of fishery statistics. These are presented below.

At this stage it is important to highlight inconsistencies in the definition of beche-de-mer. It appears from the Malaysian import and export statistics (Table 2) that beche-de-mer refers to sea cucumber and not merely dried sea cucumber. This unfortunately provides us with a confusing scenario, whereby the tonnage of dried sea cucumber has been presented in combination with salted sea cucumber and sea cucumber in brine. It also at present makes it very difficult to compare these statistics with other existing estimates.

If we take a closer look at the statistics for the third category, 'Beche-de-mer o/t fresh, chilled or frozen', one can immediately see the tremendous gulf between import and export figures. From the available statistics for this category, the major country of origin for the imports to Malaysia is Indonesia at 30 per cent (1994), 51 per cent (1993), 84 per cent (1992), 92 per cent (1991) and 94 per cent (1990), although in 1994 China overtook Indonesia at 37 per cent.

The major destination for exports in this category is Singapore at 61 per cent (1994), 70 per cent (1993), 42 per cent (1991) and 81 per cent (1990), apart from 1992 when Taiwan received 60 per cent of the exports.

The value of imports and exports to Malaysia between 1989 and 1994 (in Malaysian Ringgit and approximate US$ million equivalent [February 1997]) is presented in Table 3 (statistics supplied by FAO).

More detailed information exists for the state of Sabah, Malaysia. The local Fisheries Department have indicated that before the 1980s, the imports and exports of beche-de-mer were well over 100 t

Table 2: **Import and export of fishery commodities, statistics supplied by FAO (in tonnes)**

Year	Beche-de-mer live, fresh or chilled		Beche-de-mer frozen		Beche-de-mer o/t* fresh, chilled or frozen	
	Import	Export	Import	Export	Import	Export
1989	4.16	0.83	7.75	75.60	405.63	29.92
1990	11.68	0.36	5.75	45.31	413.72	79.55
1991	4.54	0.00	10.65	18.42	436.15	24.41
1992	4.65	0.00	6.68	23.48	388.61	49.15
1993	2.67	0.00	3.76	7.87	329.19	9.63
1994	10.39	0.00	24.15	16.45	643.32	13.06

* This category is also known as 'Dried, salted or in brine'.

Table 3: **Value of imports and exports of beche-de-mer (o/t fresh, chilled or frozen) in Malaysia**

Year	Beche-de-mer o/t fresh, chilled or frozen			
	Imports		Exports	
	Malaysian Ringgit (RM)	*US$m equivalent**	*Malaysian Ringgit (RM)*	*US$m equivalent**
1989	3 513 150	1.595	170 146	0.077
1990	2 631 940	1.195	575 002	0.261
1991	3 150 862	1.430	453 019	0.206
1992	2 660 313	1.208	284 050	0.129
1993	1 882 117	0.854	99 056	0.045
1994	2 442 040	1.109	156 849	0.071

* Feb. 1997 value

in certain years, most of the imports coming from the Philippines and Indonesia through barter trade. Local sea cucumber production at the time was erratic, and fluctuated according to overseas market demands. Good quality beche-de-mer was commanding around 17 RM per kilogram, with low grades fetching around 6 RM per kilogram. After the eighties (data is unavailable between 1982 and 1989) exports dropped to below 10 t per year with almost no records of imports between 1990 and 1995. The cost of the beche-de-mer, however, increased, with prices per kilo ranging from 17 RM to 160 RM.

The Fisheries Department has further indicated that there are six companies involved in the export of sea cucumbers from Sabah, the overseas market including Singapore, Taiwan, Hong Kong, China, Korea, Japan, Thailand and others. In addition, Sabah also supplies Sarawak and Semenanjung Malaysia. Local traders explain the reduction in imports to Sabah as a result of neighbouring countries developing and improving transportation and communication networks, enabling them to directly export to other countries rather than through Sabah.

The FAO have also supplied figures for the catch of sea cucumbers in Malaysia, which are given in Table 4 (see next page). In addition, Conand and Byrne (1993) presented details of imports and exports from the Singapore market. The authors have extrapolated the data for Malaysia and presented them in Table 5 (see next page). As noted earlier it is difficult to compare data from these varied sources, which may also have different interpretations of the definition of beche-de-mer.

As stated by Conand and Byrne (1993) the situation with respect to statistics is not helped by the fact that Malaysia is simultaneously an importer, exporter, producer and consumer. The above data is a result of our first tentative steps into this complex maze of trade. For the remainder of the research, we will seek to confirm these figures and elaborate on them, including the gathering of statistics from individual traders. This will hopefully enable us to understand in more detail the complexity of trading routes, and more importantly the level of sea cucumber catch within Malaysia.

Holothurian fisheries in Malaysia

To date, two islands with a history of sea cucumber fisheries have been visited. These were Pulau Pangkor and Pulau Langkawi, both on the west coast of Malaysia, and neither designated as marine parks. At this initial stage of the research, it was decided to informally talk with local fishermen and traders. Some interesting results were yielded.

Only one sea cucumber fisherman exists in Pangkor. He collects sea cucumbers at low spring tides, normally with several helpers. The products are used for local consumption, and occasionally visitors from peninsular Malaysia purchase them. He processes them in three ways, producing beche-de-mer; 'Gamat water' (boiled coelomic fluid) taken orally for an ailment such as an upset stomach; and 'Gamat oil' (sea cucumbers boiled in coconut oil) used externally for aches and pains etc. Greater detail of the levels of catch, effort, areas, population size, etc. will be obtained for the fishing activities in Pangkor as the research proceeds. Fished areas will also be compared with unfished areas.

The number of sea cucumber fishermen in the islands of Langkawi is open to a high degree of conjecture. During our visits to local traders, we were informed that these varied between 0 and 10 local fishermen. At present it is not clear how many fishermen there are, and this will be further clarified. The major trader in Langkawi informed us that in the 1930s–1940s, farmers from Langkawi visited the island of Adang, Thailand and upon arriving remarked upon the healthy appearance of local villagers. They were subsequently informed about the properties of the sea cucumber, and upon returning home, a fishery developed in Langkawi. As with many fisheries, demand grew, and fishermen and suppliers increased in numbers.

The product eventually became so popular that around the mid-1940s, Langkawi traders began to import sea cucumbers from Thai fishermen (known as the 'sea people'). According to local suppliers, over intensive-fishing practices in Langkawi were also having a negative impact on the local sea cucumber populations.

Traders in Langkawi still obtain Gamat from Adang fishermen. The major retailer in Langkawi informed us that every season (October – February) about 30 boats arrive with approximately 300 kg of dried Gamat (beche-de-mer) on each boat. This equates to around 9 t of dried Gamat in total, and if we use a 10 per cent conversion rate, it equates to around 90 t of fresh sea cucumber. Each boat also carries 100 tins of Gamat water.

This retailer marketed the Gamat water and also processed the dried Gamat into such items as lotions, oils, tablets and toothpaste. He processed 10–20 packs of tablets per day (each with

Table 4: **Sea cucumber catch data for Malaysia (t) (Source: FAO)**

Year	1982	1983	1984	1985	1986	1987	1988	1989*	1990*	1991*	1992	1993	1994	1995
Catch	430	435	367	1169	687	800	616	800	800	780				

* Unconfirmed

Table 5: **Imports and exports of sea cucumber from and to the Singapore Market (t) (calculated from Conand & Byrne, 1993)**

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Imports					426	294	394	253	154					
Exports					138	143	98	72	64					

1000 tablets) and around 10 tins of Gamat oil per day (rising to 20–30 in December in the local holiday season). He employs around 15 staff members and has indicated his wish to export to other countries including Britain. The amount of Gamat imported from Adang does, however, raise serious questions as to the health of similar sea cucumber populations in Thailand.

There are numerous other smaller market outlets in Langkawi for Gamat products such as beche-de-mer, soaps, oils, lotions, water, toothpaste, tablets and cosmetics. In these forms they are offered as cures for such ailments as upset stomachs, diarrhoea, aches and pains, cuts and inflammation, ulcers, chest pain, asthma, impotence, relief of soreness after giving birth and the general 'feel good factor'. It is not our intention to test the validity of these claims. However, the University of Malaya tested 23 species of sea cucumber in a recent study (Anon. 1995), and found that one species from the *Stichopus* genus possessed pain-killing properties (lending possible verification of the purported properties of *Stichopus variegatus*). Water-soluble extracts of an active compound, when tested on laboratory mice were found to be more effective than aspirin and morphine and 6–8 times safer. An oil-soluble extract, when taken orally, including human consumption, was also found to be very effective in the treatment and healing process of wounds. The medications have been manufactured into syrup, ointment, and cream and tablets, and are still on trial.

It is uncertain, at present, what part overfishing has played in the decline of local sea cucumber populations. In Langkawi, for example, the speculation is that overfishing has played a strong part in the decline of *Stichopus variegatus*. Other areas with established sea cucumber fisheries, such as the coastal waters of Sabah, will be surveyed and local fishermen and traders interviewed. It is thought that these waters may represent the main source of sea cucumber catches in Malaysia, and that Sabah itself may be an important centre for beche-de-mer trade. Over the period of research it is hoped that a clearer picture of market trading routes for sea cucumbers to and from Malaysia will be developed, with particular emphasis being placed on the trade in sea cucumbers that have originated in Malaysian waters.

Acknowledgements

The authors would like to thank Alister Wallbank from ICIT and all the staff at the Fisheries Research Institute, Penang and the Marine Parks Authority, in particular Dr Choo Poh Sze, Zaidnuddin Ilias and Sallehudin Jamon for their invaluable input to the study. This research is funded by the United Kingdom's Department of the Environment under the Darwin Initiative for the Survival of Species.

References

Anon. (1995). Sea cucumbers: medicinal properties of Malaysian species. TRAFFIC Bulletin. 15 (2). 59.

CONAND, C. & M. BYRNE. (1993). A review of recent developments in the world sea cucumber fisheries. Marine Fisheries Review 55(4). 1–13.

Sustainable management of the sea cucumber fishery sector in Madagascar

by C. Conand, M. De San, G. Refeno, G. Razafintseheno, E. Mara & S. Andriajatovo

The history of sea cucumber exploitation in Madagascar and the problems of over-fishing were discussed in Bulletin No. 9 (Conand et al., 1997). Several programmes are under way, and the main results and prospects are addressed in this article.

In Madagascar, after reaching significant tonnages (nearly 600 metric tonnes (t), which represents more than 6000 t fresh weight) in 1991 and 1994, official trepang exports are showing a significant decline (Rafalimanana, 1997).

Other current indicators of over-exploitation are declining quality, a decrease in product size and value, and strong competition between collectors.

The sustainable development goal in national policy will require the whole sector, which is characterised by a multiple-level fishery, to be restructured, and the professionals, who are becoming a partner of government so as to introduce a system of industry control of exploitation, to organise themselves (Conand, 1997a, 1997b; Conand et al., 1997).

The sea cucumber sector in Madagascar and the various players involved in sustainable management

In Madagascar, this sector comprises five main levels as in other countries (Conand, 1997a):

1. The resource in its environment (species and stock assessment).

2. Harvesting by fishermen, which is generally carried out by hand, at low tide on the reef flats, or by free-diving (or even by scuba-diving, which is illegal but difficult to control).

3. Processing of the sea cucumbers, which may be carried out by fishermen or other people in the villages. Beche-de-mer processing greatly reduces length (by about 50%) and weight (by about 90%); a clear distinction must therefore be made in the statistics between catch figures and those corresponding to production or export of trepang.

4. Several other intermediate levels, with a variety of operators, including collectors, exporters, the national and regional governments (Fisheries Departments, Customs, etc.).

5. Export of products to international market places, then import by the consumer countries.

Concerning the resource itself, various species are collected in most tropical sea-cucumber fisheries, but the diversity depends on ecological conditions. Traditionally, a dozen species of high and medium commercial value are harvested, but with the increase in international demand and the growing scarcity of the resource, fishermen are now collecting other less valuable species (Conand, 1997b). In Madagascar, more than twenty species are collected; identification work should go ahead on an urgent basis (scientific names and vernacular names) in order to avoid confusion (Conand, 1997 and IH-SM report, 1996). This taxonomic work is essential in order to be able to formulate the study protocols.

The national PRE/COI/UE programme co-ordinating body in Madagascar (CN-MAD), with European Union funds, has helped the efforts of the Fishery Ministry and the profession, through a pilot operation to implement the sustainable management of sea cucumber resources. In order to reduce over-exploitation of sea cucumbers (extremely heavy at the current time), shared management of this resource is being introduced, involving the organised profession (exporters, harvesters), the fisheries administration, the scientific research interests and local communities; these have yet to get more involved through the research of a better quality of product and a more selective fishery. This operation could be extended to other countries in the area and other resources in cases where commercial pressure has adversely affected management methods, as for example shark fishery for dried fins, which are exported to the same markets, often by the same exporters.

The National Association of Sea Cucumber Producers (ONET) has now been legally established and has held its general meeting and regional meetings. Objectives have been set.

Sustainable management requires that scientific knowledge about the fisheries biology of the various species be acquired as quickly as possible.

Current progress on the various programmes

Research is currently being carried out by the Institute of Fisheries and Marine Sciences (IH-SM) of the University of Toliara and the Centre for Oceanographic Research in Nosy Bé (CNRO).

At IH-SM, a programme funded by the World Bank—BM/ONE/IH-SM—is now being completed. It will provide an update on fisheries in the Toliara region. It will also yield interesting information about catches and their variability, both spatially and in terms of species. R. Rasolofonirina (1997) has completed a post-Master's-level thesis on the fishery, ecology and biology of two commercial species, *Bohadaschia vitiensis* and *Holothuria scabra versicolor*. His results represent the first in-depth information about these species, as common as they are, and their fishery (see article in this Bulletin).

At CNRO, the PATMAD programme included a sea cucumber (*Holothuria scabra*) component.

Within the environmental programme (PRE/COI/UE) of the IOC (Indian Ocean Commission), the pilot operation of the Madagascar national co-ordinating body (CN-MAD) has targeted the integration of participants and, through this mechanism, the implementation of sustainable management techniques for this resource. The regional environmental programme intends to support the implementation of the following objectives:

- study of the current status of the resource by professionals;
- formulation of a monitoring and joint management system for this resource; definition of simple assessment method for the resource and its fluctuation, which could be used by professionals;
- support for the creation of a quality management manual for this product; and
- sea cucumber farming experiments.

This entire process is being carried out as a joint Administration/ONET operation with the involvement of field participants (technical departments, communities, local governments) in order to show the favourable effect of involving the players in sustainable management of the resource.

Plan of action

The various stages of implementation of sustainable management of the sea cucumber resource are now clearly identified and relevant. They have been defined for Madagascar, but could easily be transferred to the other countries in the region where necessary. Joint management, as a preliminary stage, is now effective; ONET functions.

The plan of action has four main components for gradual implementation; they are presented in a more-or-less chronological order:

1. Assessment and monitoring of stocks

Over-exploitation was noted on the basis of subjective observations. It is now necessary to mobilise the means needed to monitor the resource. This will be done in collaboration with scientists.

2. Production and export statistics

The complexity of this fishery system emerges here. Various proposals can provide the answer for monitoring. Some activities are already in progress, such as the Fisheries Service's historical survey, and the IH-SM work for the south-west region. Here again, it is necessary to introduce systems to monitor the amounts of sea cucumbers caught, processed and exported. These systems will be implemented in collaboration with the various participants.

3. Quality manual

As its need has become clearly apparent, this will be a basic tool for improving the quality of products and so controlling poor exploitation (harvesting of juveniles). Its production must be considered to be a priority issue, and it could be used on a regional basis.

4. Farming

In spite of the scarcity of information, this is a way to remedy over-exploitation, particularly evident through fishing for juveniles (Conand, 1997b). It is now necessary to undertake a feasibility operation. If the experiment gives good results, one activity, which has been postponed for the moment, should be envisaged, that is creation of a hatchery to provide juveniles in sufficient numbers for farming. This could also be of regional interest.

Conclusion

It is thus clearly apparent that this pilot operation has stimulated the interest of the professional and the Fishery Administration and has already given tangible results. While the fishery is currently having problems world-wide (Conand, 1997b), Madagascar is one of the few countries where analysis of the 'fishery system' in its entirety has allowed a truly integrated activity to be planned; collaboration between the various participants is healthy and efficient.

This is in the context of a national industry, which, due to exports of processed products to international markets where they are re-exported to Asian consumers, is part of a world-wide 'sea cucumber system' of which various levels and participants are still inaccurately known. This system could be a good example of a multi-thematic and multi-disciplinary context of integrated management of a multi-specific resource. Better organisation has become necessary due to the urgency of activities needed to limit current over-exploitation. This will lead to sustainable protection of the resource and integrated management of the coastal zone. By providing a practical example of the relevance and efficiency of solving resource management problems, when there is very strong commercial pressure, through the industry itself, it could act as a model for the Indian Ocean region, as well as for other regions.

References

CONAND, C. (1997a). Are holothurian fisheries for export sustainable? Intern. Cong. Reefs, Panama, 2. 2021–2026.

CONAND, C. (1997b). Mise en oeuvre de la gestion durable de la ressource en holothuries. Report for GREEN/COI. 28 p. + 5 appendices.

CONAND, C., N. GALET-LALANDE, H. RANDRIAMIARANA, G. RAZAFINTSEHENO & M. DE SAN. (1997). Sea cucumbers in Madagascar: difficulties in the fishery and sustainable management. SPC Beche-de-mer Information Bull. No. 9. 4–5.

IH-SM. (1996). Etude de la pêcherie aux holothuries et propositions de mesures d'aménagement. Report of the first phase. Report IH-SM/BM/ONE. 25 p.

RAFALIMANANA, T. (1997). Résultats de l'enquête historique sur l'exploitation des holothuries à Madagascar. Minist. de la pêche, ONET, PRE/COI/UE. Report. 20 p.

RASOLOFONIRINA, R. (1997). Écologie, biologie et pêche de deux holothuries, *Bohadschia vitiensis* et *Holothuria scabra versicolor* dans la région de Toliara. D.E.A. IH-SM, Univ. de Toliara. 65 p.

Sea cucumber exploitation in the Toliara region of south-west Madagascar

by R. Rasolofonirina[1] & C. Conand[2]

Introduction

Sea cucumber harvesting is a traditional activity in Madagascar (Conand et al., 1997) and is very actively pursued in the south-west (Toliara). Several sources (e.g. Provincial Trade Department, Provincial Marine Fisheries Service) indicate that, between 1979 and 1986, exports fluctuated between 10 and 56 t. Data on recent exports show a very large increase, with volumes of more than 500 t. However, available data are insufficient to diagnose and analyse current over-exploitation, as the fishing sector is quite complex, and analysis at several different levels is needed (Conand, 1997a and 1997b).

For these reasons, a study was undertaken by the Fisheries and Marine Science Institute (IH-SM) to monitor fishing, fishery organisation, catches and marketing in two separate villages. The original results were reported in a post-Master's-level thesis (Rasolofonirina, 1997).

Methods

Two villages near Toliara, Ankembé and Besakoa, were selected for comprehensive monitoring by researchers and scientists over an eight-month period (Figure 1).

Each day, sea cucumber harvesters were asked to answer questions on total fishing time, the number of working fishermen, fishing sites, etc.

Catches were sampled before processing (i.e. cooking and drying), in order to determine the exact species, the number of specimens for each species and the corresponding weights. From these data, average catch sizes and fishing effort, on a tidal or monthly basis, and catch per unit effort (CPUE) could be calculated. Finally, the marketing circuit was determined through surveys carried out in both villages and in Toliara.

Results

The results show how fishing was organised in each village, as well as the fishing effort, catches and corresponding CPUEs for the villages concerned. The marketing circuit is also described.

Organisation

Harvesting is done by hand, during low spring tides only, on the reef flats. To reach the main reef, fishermen cross the lagoon in dug-out, outrigger canoes propelled by sail or paddles. When they visit the fringing reef, which is accessible on foot, they sometimes bring canoes along in order to continue fishing after low tide has ended.

Family members (or the whole family) go fishing in the morning, and come back in the afternoon. Each village fishes in the closest part of the reef to them: the northern section for Besakoa and the central or southern section for Ankiembe.

The work is divided up among the members of the family; for example, the father prepares and drives the boat, everyone present takes part in harvesting, and after returning home, the women take care of processing and selling the catch.

The time needed to get to the main reef is comparable for both villages—from 30 to 60 minutes depending on the weather. At the fishing site, each person collects sea cucumbers (see Figure 2 on page 13) and other reef resources (e.g. octopus, shellfish, crabs, shrimps) in a jute bag or a bucket. On the fringing reef, fishermen work in groups of two or three, mainly in the sea grass areas.

Sea cucumber fishing in the Toliara region is therefore mainly done on foot at low tide. Free diving (mask only) is very infrequently used, and only when there are neap tides. Fishing with diving suits or trawls is not a practice in this region, although these techniques are used elsewhere.

Fishing effort

Table 1 summarises the monthly averages calculated for the villages of Ankiembe and Besakoa, in terms of fishing days (or trips) and fishing hours per trip.

1. IH-SM, Université de Toliara
2. Laboratoire d'Écologie Marine, Université de La Réunion

Harvesting was done during the spring tide, with the number of monthly fishing days varying from 10 to 20 in each village, for an overall average of 15 days.

Collection usually lasted for three to six hours; it varied with the tide amplitude, but did not show any seasonal variations; collection time seems to have increased in Ankiembe during the study period.

The number of fishermen per month (Table 2) was significantly higher in the village of Besakoa (an average of 254 over the eight-month study) than in Ankiembe (143 on average).

The relative percentages of men, women and children also differed (Table 2). In Ankiembe, women represented the largest share (55% on average), while men and children accounted for 23 and 22 per cent respectively. In Besakoa, men had the highest share (60%), followed by women

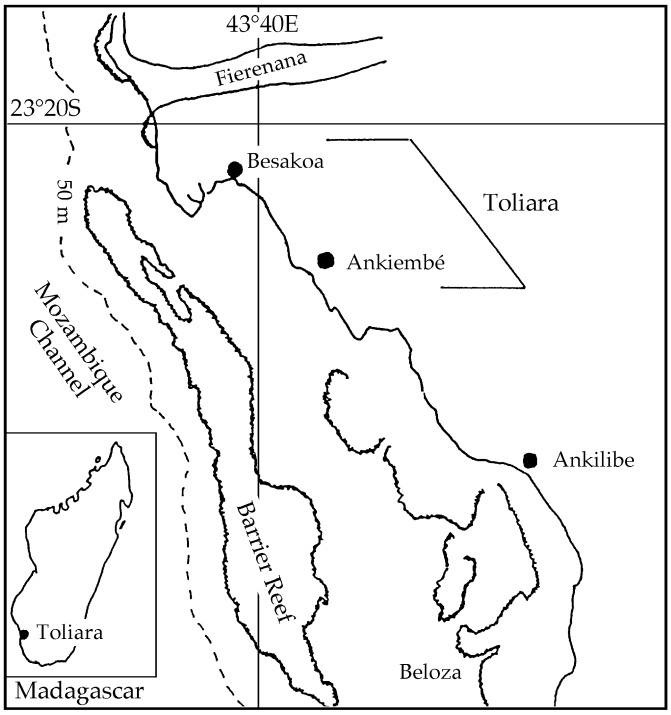


Figure 1

Location of the villages and the traditional fishing areas

Table 1: **Monthly averages in terms of the number of sea cucumber fishing days (trips) and the average length of these trips, for the villages of Ankiembé and Besakoa**

Month	Number of days	Mean duration (h)
Ankiembe		
Nov. 95	20	2.8
Dec. 95	17	3.2
Jan. 96	21	3.8
Feb. 96	12	3.7
Mar. 96	13	4.5
Apr. 96	13	4.1
May 96	13	4.6
Jun. 96	10	4.8
Mean	**15**	**3.9**
Besakoa		
Nov. 95	17	3.4
Dec. 95	13	4.7
Jan. 96	16	3.8
Feb. 96	13	4.5
Mar. 96	12	5.6
Apr. 96	20	5.8
May 96	17	5.4
Jun. 96	14	4.8
Mean	**15**	**4.7**

Table 2: **Monthly distribution of the overall number and categories of fishermen, for the villages of Ankiembé and Besakoa**

Month	Number of fishermen			
	Men	Women	Children	Total
Ankiembe				
Nov. 95	29	111	81	221
Dec. 95	31	102	39	172
Jan. 96	40	130	84	254
Feb. 96	20	74	20	114
Mar. 96	26	35	2	63
Apr. 96	28	71	13	112
May 96	49	60	7	116
Jun. 96	35	51	8	94
Mean	**32**	**79**	**32**	**143**
Besakoa				
Nov. 95	100	74	20	194
Dec. 95	158	87	55	300
Jan. 96	76	40	27	143
Feb. 96	109	39	6	154
Mar. 96	81	34	0	115
Apr. 96	272	139	43	454
May 96	278	106	38	422
Jun. 96	159	63	24	246
Mean	**154**	**73**	**27**	**254**

at 29 per cent, whereas children only accounted for 11 per cent. Finally, the fishing season was slightly different in each village, with effort higher during the hot season in Ankiembe and the reverse being true in Besakoa.

Catches and CPUEs

Table 3 shows monthly catches and the corresponding catch per unit effort (in terms of fresh sea cucumber weight), calculated by fishing days (CPUE 1), or by fishing time (CPUE 2).

Catches are presented in the form of monthly totals: 1) the number of specimens and 2) weight of fresh sea cucumber.

In Ankiembe, monthly catches averaged about 900 kg, or 3600 sea cucumbers. A net decrease occurred during the study, with catches dropping from 2000 kg to only 200 kg during the final months. The average monthly CPUE per day also went from 9 to 2 kg and the CPUE per hour dropped from 4 to 0.4 kg.

In Besakoa, monthly catches averaged about 1700 kg, around 13 000 sea cucumbers; in contrast to Ankiembe, there was a gradual increase in average monthly catches here, with catches going from 400 kg to 4000 kg. The average monthly CPUE per day went from 2 kg to 10 kg, and the CPUE per hour from 0.5 kg to 2 kg.

Table 3: **Monthly catches (in number of sea cucumbers and in fresh weight) and average monthly CPUE (in kg), calculated by fisherman per day (CPUE 1) and by fisherman per hour (CPUE 2).**

Month	Catch		CPUE 1*	CPUE 2*
	Number	Weight (kg)	(kg/day)	(kg/hour)
Ankiembe				
Nov. 95	8 432	2 168	9.33	4.10
Dec. 95	7 648	1 910	9.81	3.29
Jan. 96	6 674	1 745	5.71	1.37
Feb. 96	2 277	540	4.88	1.46
Mar. 96	530	128	1.73	0.40
Apr. 96	1 281	347	2.94	0.82
May 96	1 147	303	2.48	0.54
Jun. 96	810	202	2.01	0.42
Mean	**3 600**	**918**	**4.86**	**1.55**
Besakoa				
Nov. 95	10 271	404	1.69	0.54
Dec. 95	12 083	624	1.99	0.42
Jan. 96	5 437	319	2.17	0.59
Feb. 96	5 666	706	3.97	0.99
Mar. 96	2 820	334	2.74	0.50
Apr. 96	22 993	4 511	9.47	1.73
May 96	35 156	4 726	9.57	1.77
Jun. 96	12 150	2 566	11.8	2.23
Mean	**13 322**	**1 774**	**5.43**	**1.10**

* Monthly means

Marketing

The catches were sold in one of two ways:

- the fishermen processed the catches themselves when they returned from fishing and then waited until the end of the tidal period to sell all the products processed during that period;
- the fishermen sold the fresh catch to collectors/processors who took care of processing; these collectors bought the fresh product either by sea cucumber or by bucket.

In both villages, products then went to exporters in Toliara, who exported them directly to international markets, or first sent them to operators in Antananarivo, where they were then exported.

Discussion

The first conclusion is that sea cucumber fishing continued to go ahead throughout the survey, which took place both during the hot and cold seasons. The results demonstrate the importance of sea cucumber fishing to the villages of southwest Madagascar.

Fishermen harvest sea cucumbers whenever tidal conditions are favourable, that is for about 15 days a month. Each trip takes up most of the day when the time needed to reach the fishing area and come back again is taken into account. The sea cucumbers then have to be processed after the fishermen get home. The number of fishermen is significant in both villages but the differences in terms of the relative percentages of men, women and children between the two villages have not yet been analysed, and merit further research.

Total catches are large, especially at Besakoa. It is important to verify, through selective studies,

whether the opposing trends in catches and CPUEs between the two villages can be confirmed.

The specific composition of catches will be addressed in another document, but two species, *Bohadschia vitiensis* and *Holothuria scabra versicolor* have been the object of an in-depth study (Rasolofonirina, 1997). In Ankiembe, they account for a significant part of the catches, but this is not the case in Besakoa. An ecological study of the reefs visited by fishermen should allow these differences to be explained.

There were, then, some clear differences between the two villages for the various criteria studied; these differences require more information about the anthropology of the villages in order to be interpreted.

Intensive fishing of sea cucumbers, as is now carried out, will render these resources increasingly scarce. Juveniles are often harvested, and this will have very negative effects on stock. In addition, fishermen often overturn coral heads and break them, thereby damaging the surrounding environment. Implementation of sustainable management methods will take place through actions involving the various participants in the fishing sector, from the fisherman to the exporter (Conand et al., 1997). Education of fishermen should be accompanied by training in processing methods so as to obtain a better price for the products, and by development of this fishery through limiting access and taking steps to reconstitute stocks.

References

CONAND, C. (1997a). Are holothurian fisheries for export sustainable? Intern. Cong. Reefs, Panama, 2. 2021–2026.

CONAND, C. (1997b). Gestion durable de la filière holothuries à Madagascar. Séminaire international sur les récifs coralliens, Octobre 1997, Nosy-Bé, Madagascar. 7 p.

CONAND, C., N. GALET-LALANDE, H. RANDRIAMIARANA, G. RAZAFINTSEHENO & M. DE SAN. (1997). Sea cucumbers in Madagascar: difficulties in the fishery and sustainable management. SPC Beche-de-mer Information Bull., 9: 4–5.

RASOLOFONIRINA, R. (1997). Biologie, écologie et pêche de deux espèces d'holothuries *Bohadschia vitiensis* et *Holothuria scabra versicolor* au Grand Récif de Tuléar. DEA memoir, IH-SM, Univ. de Toliara.

Figure 2

Collection at low tide on Toliara Barrier reef (photo F. Conand)

Laamu atoll mariculture project: Low profile cage for retaining sea cucumbers

by Norman Reichenbach, Yoosuf Nishar* & Ahmed Shakeel**

For grow-out studies on sea cucumbers, a cage was designed that 1) did not need to have netting above the water level during high tides (low profile), and 2) could easily be scaled-up to encompass as large an area as needed. A low profile cage was desired because of the strong currents in the reef flat area in which we were working. If the cage netting needed to be above the water level during high tides, the cage would have to be more than 2 m high. This height of netting would require an excessive amount of support to withstand the currents.

Two low profile cage styles were constructed. In both cage styles the plastic netting (1/2 inch (12.7 mm) mesh) was buried about 10 cm into the substrate, and then protruded about 30 cm above the substrate. The top of the netting was curled down over a rerod stake (8 to 10 mm diameter) so that the top looked like an inverted 'V' with the interior part of the 'V' being about 10 to 15 cm above the substrate (Fig. 1). The rerod simply provided support for the netting, and was placed at various intervals along the netting depending upon the strength of the current in the area where the cage was placed. In most areas, an interval of 0.5 to 1 m was adequate. The netting was attached to the rerod using cable ties and rope. The inverted 'V' was used to see if a sea cucumber crawling up the side of the netting might get wedged into this 'V' and then just crawl back down the netting to the substrate. Such events were observed several times.

The 'V' had to be tight enough so that the animal could not rotate through the 'V', and then crawl around and then out of the cage. This completed the first cage style. The second cage style simply added copper foil along the inner edge of the inverted 'V' to see if this would help retain the animals.

The low profile cages retained juvenile *Holothuria fuscogilva* and *H. nobilis,* but not *Stichopus chloronotus*, *S. variegatus*, *Actinopyga mauritiana* and *Thelenota ananas*. These later species climbed readily, and were able to avoid getting wedged into the inverted 'V'. In contrast, *H. fuscogilva* and *H. nobilis* did get wedged into the inverted 'V', and were retained at a level of about 95 per cent. The addition of copper foil did not improve retention rates for *H. fuscogilva* and *H. nobilis,* nor did it help retain the other species tested.

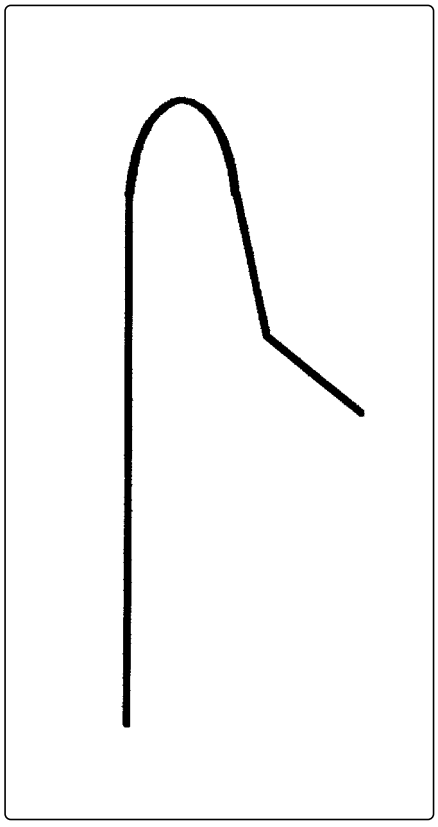


Figure 1

Rerod stake design for low profile cages

* Oceanographic Society of Maldives, P.O. Box 2075, Malé, Republic of Maldives
E-mail: normreich@juno.com

Fission in a population of *Stichopus chloronotus* on Reunion Island, Indian Ocean

by C. Conand, J. Armand*, N. Dijoux* & J. Garryer**

Introduction

Although *Stichopus chloronotus* is found throughout the tropical Indo-Pacific region, this species has not yet been studied in depth. In New Caledonia, it is mainly found on outer reef flats and upper zones of outer slopes at depths of less than 12 m (Conand, 1989). On the Australian Great Barrier Reef, it has a similar distribution, with higher densities on the outer reef flat than on the inner reef flat (Franklin, 1980). It only feeds between 11 a.m. and 7 p.m., and at night hides under dead coral or large debris (Uthicke, 1994).

As for sexual reproduction, two spawning periods have been observed in Australia, in November and March (Franklin, 1980). Asexual reproduction through fission was observed for the first time in Australia by Harriot (1980) and Franklin (1980) and the seasonal nature and the extent of this event were recently studied by Uthicke (1997).

This study conducted in La Réunion presents fission and regeneration rates for a main population of *Stichopus chloronotus* as well as the morphology and anatomy of specimens in the process of regeneration. The results are compared to those for the population of another reef where fission was not observed. These two strategies are linked to population density and specimen size.

Materials and methods

Observations were carried out in October 1996 and in April and July 1997 at the main 'Trou d'eau' station, located on the Saint Gilles/La Saline fringing reef on the west coast of the island. The back reef, where the population was located, forms a channel and consists mainly of deposits of biological detritus and an accumulation of dead coral, coral sand and basalt boulders; sea urchins (*Echinometra mathaei, Stomopneustes variolaris, Diadema setosum*) and cowry shells were also observed there. The *Stichopus* were observed grouped together on coral heads; the quadrats where there were no specimens consisted primarily of sand with very little coral.

During each observation, data were collected in 20 marked quadrats, each one square metre in size. All the specimens of *Stichopus chloronotus* found were collected. This count allowed assessment of distribution and average density for the species at this site, comparison of these parameters to those observed elsewhere and assessment of fission and regeneration rates.

The various categories of specimens were defined as had already been done for other species (Conand & De Ridder, 1990; Conand et al., 1997). In the case of *Stichopus chloronotus*, only three categories of specimen were observed with any frequency, these being normal specimens (N) and two types of specimen in the process of regenerating (Ap) and (Pa). Ap are those specimens corresponding to the anterior part after fission which are regenerating their posterior part. Pa specimens are those corresponding to the posterior part after fission which are regenerating their anterior part.

The first task carried out in each quadrat was to identify the various categories of specimens. Measurements of the total length of each specimen were taken using a measuring tape; the regenerated part was also measured and specimens were weighed.

Several specimens of each category were then collected at the 'Trou d'eau' site for dissection. Measurements were taken at two separate stages:

- on fresh animals after relaxation using magnesium chloride:
  - **Lt:** total length, ± 0.5 cm along the back from mouth to anus;
  - **Lr:** length of the regenerated part, ± 0.1 cm;
  - **Wt:** total weight of the specimen, ± 0.5 g; and
  - **Wd:** drained weight after the coelomic liquid had been drained off, ± 0.5 g;

* Marine Ecology Laboratory, University of La Réunion, France

- on specimens preserved in Bouin:
  Li: length of the digestive tube, ± 0.5 cm;
  Lg: length of the gonads, ± 0.5 cm;
  Wif: weight of the full digestive tube, ± 0.5 g;
  Wie: weight of the empty digestive tube, ± 0.5 g;
  Wg: weight of the gonads, ± 0.1 g;
  We: weight of the tegument, ± 0.5 g;

These measurements made it possible to calculate both digestive tube contents: Wi f–e = Wif – Wie, and gonad-index: RGS = Wg (Pg) * 100/We.

At the supplementary 'Étang Salé' station, a fringing reef located further to the south, sampling conducted in February 1997 made it possible to calculate the density and structure (in weight) of a second population. No specimens in the process of fission or regeneration were observed there.

Results

Presentation of the two populations studied

At the 'Trou d'eau' station, the population was composed of a mixture of normal specimens and specimens in the process of regenerating after fission.

Table 1 presents the figures and percentages for each category on the three sampling dates. The average density was 3.7 individuals per square metre (m^2). On average, normal specimens made up 83 per cent of the sample, while specimens in the process of regeneration were divided between 9 per cent for those which were regenerating their anterior part and 7 per cent for those regenerating their posterior part. Specimens in the process of regeneration were more numerous in October (24%) than in April (11%) or July (13%).

Figure 1 shows the weight distribution for both normal specimens and those in the process of regeneration at this station on the three observation dates. Normal specimens weighed up to 140 g and the weight distributions showed two modes, one at 25 g and the other at 65 g, whereas specimens in the process of regeneration had only one modal weight at 15 g.

At 'Étang Salé', the population consisted only of normal specimens, which were quite large in size (Figure 2), that is, between 55 and 265 g. The density there was low, at 0.17 per m^2.

Comparative anatomy of the various specimen categories

Comparison between normal specimens and the two categories of specimens in the process of regeneration led to a better understanding of the dynamics of regenerating the main organs. It was then possible to infer when feeding and reproduction (in particular) began again after fission.

Observation of eight normal specimens (Table 2 and Figure 3 B, see next pages) showed that at the 'Trou d'eau' study site, *Stichopus chloronotus* had an average length of 17.3 cm, and an average overall open weight of 66.3 g.

The tegument of *Stichopus chloronotus* is green, thick, smooth and has a tendency to disintegrate rapidly. The weight of the tegument (muscle included) (We) averaged 39.6 g, and it was 3 mm thick. The muscles of normal specimens were characterised by five longitudinal muscular bands that were attached from the peripharyngeal calcareous ring up to the cloaca. Each muscular band had an

Table 1 : Distribution of the various categories of specimen at 'Trou d'eau' for the three sampling dates

Date	Total no.	Normal	A + Ap	P + Pa	F	S
30.10.1996	78	59	9	10	0	19
01.04.1997	53	47	1	5	0	6
15.07.1997	93	81	6	6	0	12
Total	224	187	16	21	0	37
% of total		83 %	7 %	9 %	0 %	17 %
Mean	74.7	62.3	5.3	7.0	0.0	12.3
S. d.	20.2	17.2	4.0	2.6	0.0	6.5

F: Specimens in the process of fission; S: Specimens having completed fission (A + Ap + P + Pa)

average width of 5.5 mm and was attached to the tegument in its median part.

Stichopus chloronotus is a detritus-feeder species which uses its twenty oral tentacles (averaging 4.8 mm in length) to collect food. The digestive tract had a thin wall and formed three loops. The average length of the digestive tract was 302.4 mm, with an empty weight of 2.3 g.

Using these data, it was possible to estimate the amount of food consumed by specimens at the time of harvest. This varied between 0.4 g and 9.0 g with an average of 4.6 g. The transverse vessel linked the first loop to the second. The *rete mirabile* was located on the second loop.

Water vascular system: the turgescence of the oral tentacles comes from the 20 vesicles of the oral podia situated in pairs around the peripharyngeal calcareous ring. The average length of the vesicles of the oral podia was 22.4 mm. The Polian vesicle, situated under the peripharyngeal calcareous ring, measured 15 mm.

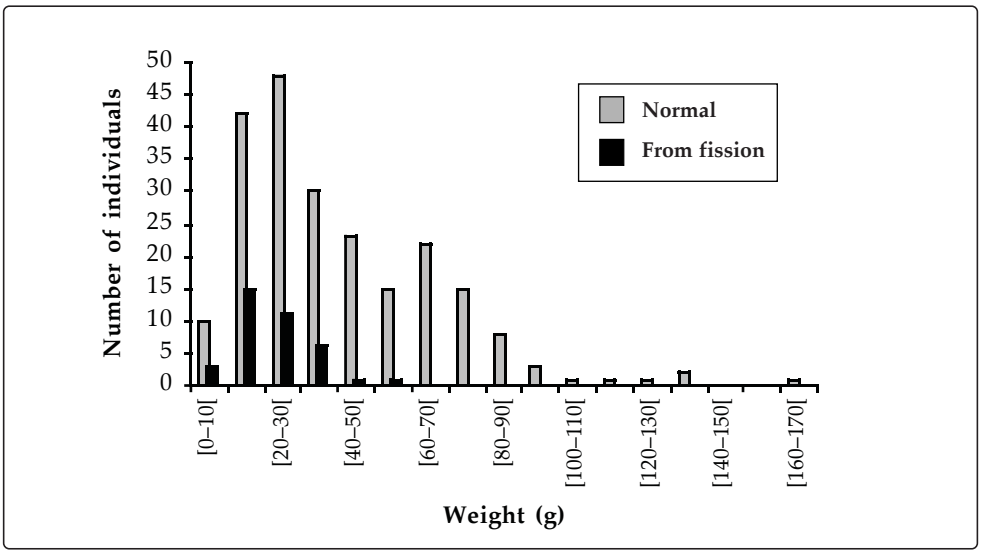


Figure 1

Weight distribution of normal specimens and those resulting from fission at 'Trou d'eau'

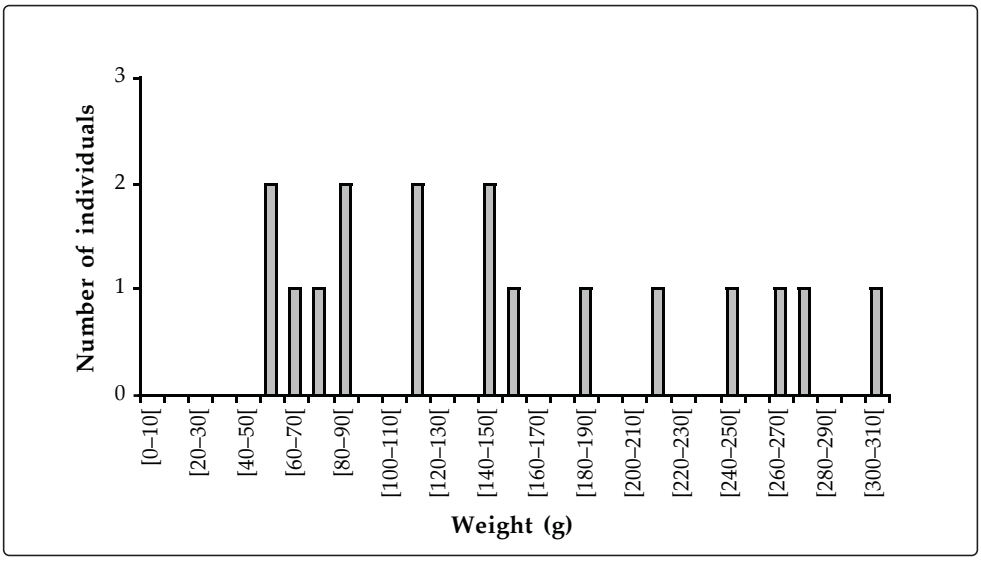


Figure 2

Weight distribution of specimens at 'Étang Salé'

Table 2: Parameters of normal individuals (N) [1]

	Wt (g)	Wd (g)	We (g)	Lt (mm)	Wi f (g)	Wi e (g)	Wi f–e (g)	Li (mm)	Wg (g)	Lg (mm)	RGS
N 20	94.60	85.50	53.88	18.00	6.38	3.30	3.08	343.00	0.70	114.00	1.30
N 21	63.80	55.50	39.69	14.20	-	-	-	237.00	0.11	26.00	0.28
N 22	92.00	89.60	42.25	18.40	11.70	2.69	9.01	310.00	0.93	120.00	2.20
N 23	85.00	83.20	53.08	17.70	10.16	2.37	7.79	299.00	0.56	126.00	1.06
N 24	66.10	63.60	32.66	16.00	9.67	1.96	7.71	323.00	0.21	4.50	0.64
N 26	55.20	53.70	31.70	18.00	2.36	1.97	0.39	250.00	0.17	112.00	0.54
N 27	43.30	41.30	27.10	17.50	3.30	1.48	1.82	230.00	0.02	34.00	0.07
N 28	60.30	58.10	36.36	18.50	4.77	2.23	2.54	370.00	0.03	84.00	0.08
Mean	70.04	66.31	39.59	17.29	6.91	2.29	4.62	295.25	0.34	77.56	0.77
S. d.	17.30	16.48	9.15	1.38	3.37	0.54	3.19	48.18	0.32	45.55	0.68
Var.	299.23	271.51	83.75	1.89	11.39	0.29	10.19	2320.94	0.10	2074.59	0.46

Table 3: Parameters of anterior individuals regenerating the posterior (Ap) [1]

	Wt (g)	Wd (g)	We (g)	Lt (cm)	Wi f (g)	Wi e (g)	Wi f–e (g)	Li (mm)	Wg (g)	Lg (mm)	RGS	Lr (cm)
Ap 1	51.00	48.00	28.27	-	0.79	0.47	0.32	143.50	0.03	20.00	0.11	1.50
Ap 3	42.60	36.60	22.82	12.50	0.98	0.40	0.58	128.00	0.04	33.00	0.18	2.50
Ap 4	40.00	33.00	21.99	11.50	0.80	-	-	174.50	0.04	2.20	0.18	1.50
Ap 7	26.60	23.50	15.74	9.00	0.17	-	-	127.00	0.02	21.00	0.13	1.20
Ap 11	18.80	18.10	11.06	7.80	0.56	0.37	0.19	122.50	0.02	11.00	0.18	1.10
Ap 12	28.30	24.80	14.02	9.80	-	-	-	160.00	0.02	19.00	0.14	1.80
Ap 15	5.00	4.90	2.98	4.50	0.18	0.15	0.03	67.00	-	-	-	1.40
Ap 16	13.70	12.60	7.88	8.10	0.29	0.27	0.02	172.00	0.03	18.00	0.38	1.80
Ap 17	14.30	12.40	7.68	7.40	0.33	0.18	0.15	129.00	0.02	5.00	0.26	0.30
Mean	26.70	23.77	14.72	8.83	0.51	0.31	0.22	135.94	0.03	16.15	0.19	1.46
S. d.	14.45	12.82	7.83	2.34	0.29	0.12	0.19	30.82	0.01	9.21	0.08	0.56
Var.	208.76	164.48	61.24	5.49	0.09	0.01	0.04	949.75	0.00	84.91	0.01	0.32

Table 4: Parameters of posterior individuals regenerating the anterior (Pa) [1]

	Wt (g)	Wd (g)	We (g)	Lt (cm)	Wi f (g)	Wi e (g)	Wi f–e (g)	Li (mm)	Wg (g)	Lg (mm)	RGS	Lr (cm)
Pa 2	30.10	24.20	13.16	9.80	0.12	0.11	0.01	89.00	0.01	3.00	0.08	1.10
Pa 8	22.80	18.60	11.49	8.50	0.08	0.07	0.01	86.00	0.01	7.00	0.09	1.20
Pa 9	15.60	12.20	8.49	7.50	0.06	-	-	59.00	-	-	-	1.30
Pa 10	21.60	19.80	12.62	7.80	0.11	0.10	0.01	96.00	-	-	-	0.40
Pa 13	13.00	12.50	8.34	7.60	0.16	0.16	0.00	122.00	-	-	-	1.60
Pa 14	8.50	8.40	5.69	6.30	0.16	0.16	0.00	101.00	-	-	-	1.10
Pa 18	19.40	11.80	7.86	8.30	-	-	-	118.00	-	-	-	1.40
Mean	18.71	15.36	9.66	7.97	0.12	0.12	0.01	95.86	0.01	5.00	0.08	1.16
S. d.	6.57	5.18	2.58	0.99	0.04	0.04	0.00	19.65	0.00	2.00	0.01	0.35
Var.	49.12	26.81	6.64	0.99	0.00	0.00	0.00	386.12	0.00	4.00	0.00	0.12

1. Wt: total weight; Wd: drained weight; We: eviscerated weight; Lt: total length; Wi f: full intestine weight; Wi e: empty intestine weight; Wi f–e: intestine contents weight; Li: intestine length; Wg: gonad weight; Lg: gonad tubule length; RGS: gonad index; Lr: regenerated length

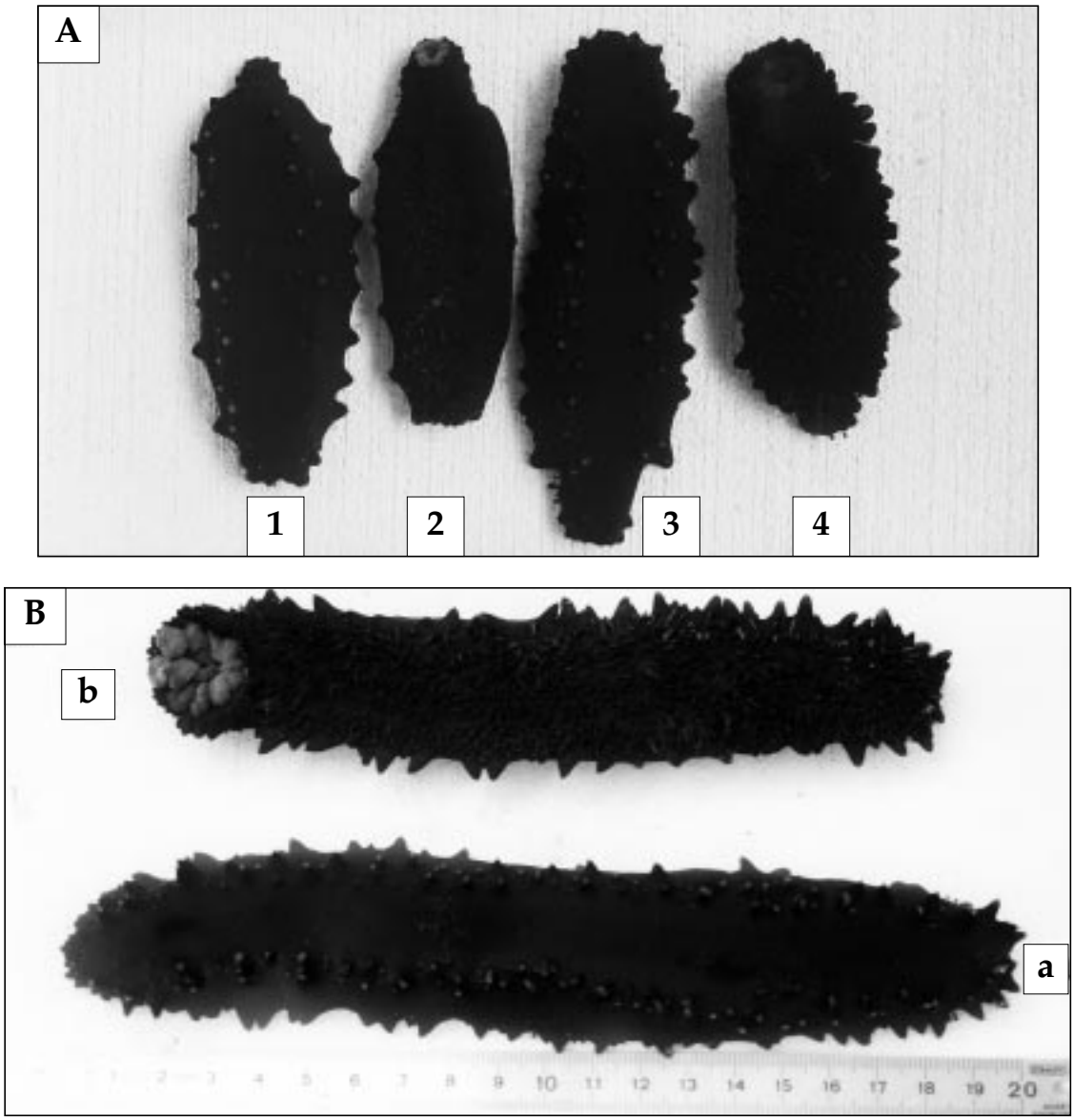


Figure 3

Stichopus chloronotus

Photo A: regenerating specimens: 1 & 2: Pa; 3 & 4: Ap.
Photo B: normal specimens: a: dorsal side; b: ventral side.

The genital glands were in the form of two tufts situated on either side of the dorsal mesentery, and were attached by the gonadal base. The gonads were in the form of branched tubules. The average weight of the gonads was 0.3 g. The gonad index was between 0.08 and 2.2. The average length of the gonads was 77.6 mm. No difference was observed between male and female gonads.

The respiratory system was formed from two branched tubes called respiratory trees, on the right and left, which opened into the cloaca and extended into the coelomic cavity. The left respiratory tree was intertwined with the *rete mirabile*, while the right respiratory tree was attached to the tegument by the mesentery.

Several specimens in the process of regenerating their anterior part (Pa) or posterior part (Ap) are shown in Figure 3 A.

Specimens in the process of regenerating their posterior part (Ap) are presented in Table 3 and Figure 4 (see next page).

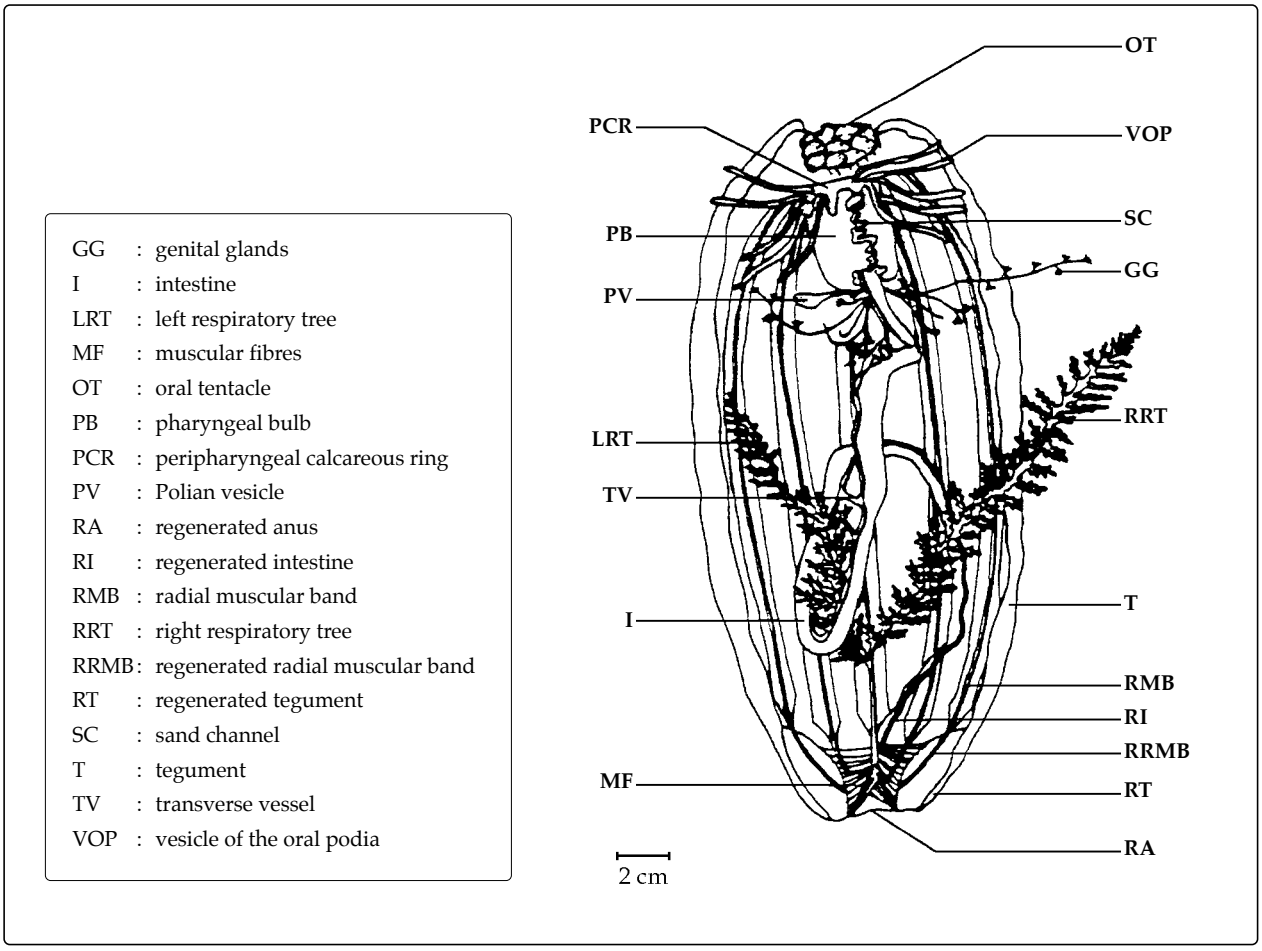


Figure 4

Anatomy of an Ap specimen

Ap specimens in the process of regeneration had an average length of 8.8 cm, or half that of normal specimens, and an average total open weight of 23.7 g. From an anatomical point of view, only the posterior part changed.

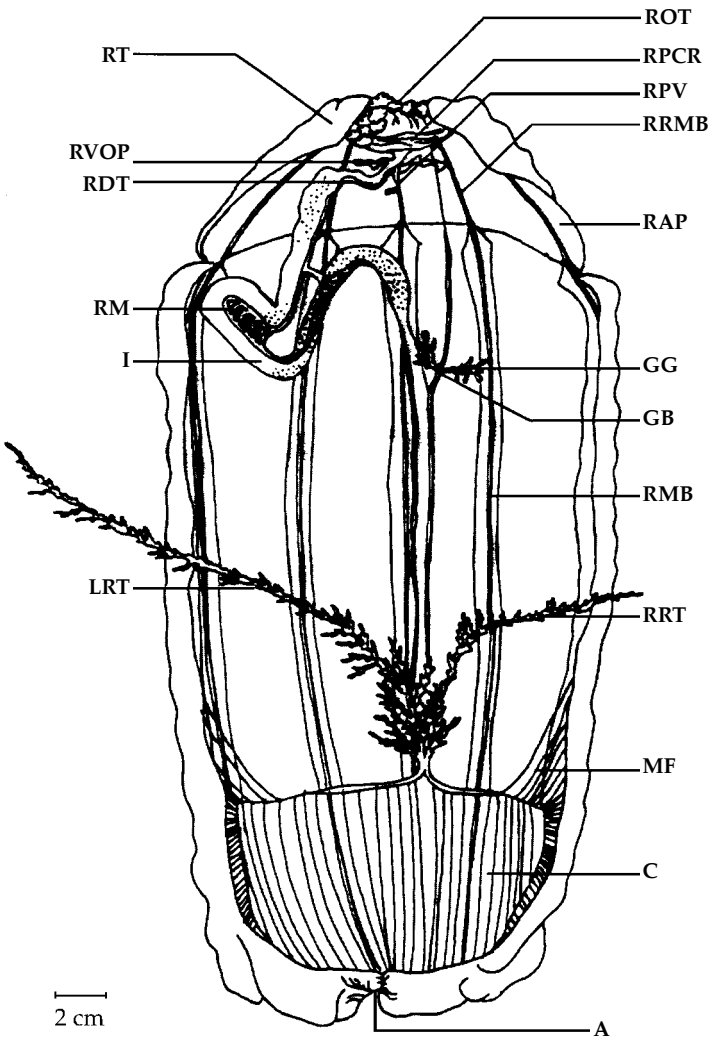
The regenerated tegument appeared lighter after fixation in Bouin. A fold separating the regenerated part from the anterior part was observed. The thickness of the tegument varied in three areas: the 'normal' part near the mouth measured 3 mm, the tegument near the fold measured 6 mm and the regenerated tegument measured 1 mm. The length of the regenerated tegument when retracted averaged 1.5 mm, while the original tegument averaged 7.4 cm. Moreover, a lack of papillae and a difference in the size of the tube feet between the regenerated part (0.5 to 1 mm) and the original part (2 mm) could be observed. The muscles also regenerated. In fact, the muscles in the anterior part had a width of 5.5 mm, while they only measured about 1.5 mm in the regenerated part. They were, then, thinner and they were attached to the tegument at the cloaca.

Ap specimens are characterised by regeneration of the posterior part of the digestive tract and the anus. The transverse vessel and an under-developed *rete mirabile* could be seen.

The average length of the digestive tract was 135.9 mm, with an empty weight of 0.3 g. According to data, the quantity of sand ingested into the digestive track of Ap individuals (0.2 g) was much less than in normal specimens. The presence of sand in the digestive track indicated that the specimen had sufficiently regenerated to allow normal feeding.

Gonads were present, but were not very developed. The gonadal base appeared to be barely formed. The average length of the genital glands was 16.1 mm, with a gonad-index varying between 0.11 and 0.38. It is thought that either these specimens had not reached sexual maturity or the gonads had regressed after fission.

In general, the respiratory trees observed in Ap specimens had a normal appearance. Fission seemed to have occurred behind these organs.



A	:	anus
C	:	cloaca
GB	:	gonadal base
GG	:	genital glands
I	:	intestine
LRT	:	left respiratory tree
MF	:	muscular fibres
RAP	:	regenerated anterior part
RDT	:	regenerated digestive tract
RM	:	*rete mirabile*
RMB	:	radial muscular band
ROT	:	regenerated oral tentacles
RPCR	:	regenerated peripharyngeal calcareous ring
RPV	:	regenerated Polian vesicle
RRMB	:	regenerated radial muscular band
RRT	:	right respiratory tree
RT	:	regenerated tegument
RVOP	:	regenerated vesicle of oral podia

Figure 5

Anatomy of a Pa specimen

Specimens in the process of regenerating their anterior part (Pa) are shown in Table 4 (page 18) and Figure 5.

Pa specimens in the process of regeneration had an average length similar to that of Ap specimens, that is 8.0 cm; and they weighed between 8.5 and 30.1 g.

As with Ap specimens, the colour of the regenerated tegument was lighter. On average, the regenerated part measured 1.2 cm and had regenerated tube feet measuring 1.25 mm on its ventral surface but no papillae on the dorsal surface. The regenerated mouth had a diameter of 6.5 mm. The thickness of the tegument varied between 0.5 mm and 0.75 mm, and the muscles averaged 0.75 mm. A folded area separated the original part from the regenerated one. The original part had an average length of 6.8 cm. The thickness of the tegument was 2.5 mm and the thickness of the muscles was 4.5 mm. On the ventral surface, tube feet measured about 2.5 mm.

The regeneration of Pa specimens involved various changes. The peripharyngeal calcareous ring was barely visible. The Polian vesicle had regenerated, but was small in size (about 6 mm). The three loops of the digestive track were formed and were very thin. The presence of the transverse vessel was noted in certain Pa specimens, and the *rete mirabile* was present but very under-developed. The amount of sand ingested by specimens

was almost nil. This small quantity, 0.01 g, leads to the supposition that the digestive track was not yet functional.

Depending on the stage of regeneration, the reproductive system varied; in two specimens, barely-formed gonadal bases were observed, while gonads were absent in five other specimens. The respiratory trees appeared more transparent than those of normal specimens, and were much less thick. None of the specimens had a left respiratory tree intertwined with the *rete mirabile*.

Discussion

Stichopus chloronotus is one of the most common sea cucumber species in La Réunion, together with *H. leucospilota*, *H. atra* and *Synapta maculata*. Studies have already been carried out on *Stichopus chloronotus* in the South Pacific, but this is the first one to be conducted in La Réunion.

In La Réunion, population density reached 3.15 specimens per m^2 at the 'Trou d'eau' station. This figure is high in comparison with densities observed in New Caledonia, since they did not exceed 0.5 specimens per m^2 there (Conand, 1989), and those observed on the Great Barrier Reef, from 0.02 to 1.2 specimen per m^2 (Franklin, 1980; Uthicke, 1994 and 1997). Moreover, *S. chloronotus* was located on the back reef at 'Trou d'eau', while generally it is a species found on the outer reef flats, but the very narrow width of the reef may provide an explanation for this distribution.

According to Franklin (1980), sexual maturity occurs at the age of one year, when specimens reach a weight of 70 g. Gonads are whitish in colour in both sexes. The spawning period takes place in spring and in autumn (Franklin, 1980).

The average size of specimens varies according to the population studied, from 30 to 170 g on the Great Barrier Reef (Uthicke, 1994) and 50 and 150 g respectively for the two populations in La Réunion.

Despite the fact that the sample size in La Réunion was insufficient to demonstrate seasonal variations in fission rates, it would appear that, as on the Great Barrier Reef (Uthicke, 1997), fission was higher in July (cool season).

There was a marked contrast in La Réunion between the population of 'Trou d'Eau', with its high density, small specimens and high fission rate, and the 'Étang Salé' one, where fission was non-existent, the density low and the size relatively large. These results confirm those of Uthicke for the Great Barrier Reef (1997), where fission rates were correlated to population density.

The results obtained about fission and regeneration of this species are primarily related to frequency of regeneration rates.

During our study, no specimens in the process of fission were observed. The regeneration rate (%R = (Ap+Pa)/2T*200) was 18.6 per cent for the population considered in October. Fission varied according to species; most of the time it was due to a constriction which led to a tear in the tegument, digestive tract and muscles. Fission occured at about 52 per cent of the total length in this species, since Ap specimens were slightly larger than Pa ones. In *H. atra*, fission occured at 45 per cent of the total length (Conand & De Ridder, 1990) and in *H. leucopsilota*, fission occured at 22 per cent of the total length (Conand, Morel & Mussard, 1997).

As for weights, it was seen that for specimens in the process of regeneration, the weights Wt, Wd and We were about half those for normal specimens. This could be explained by the fact that Ap and Pa specimens do not feed during regeneration and by the lysis of the organs following fission until such time as the digestive organs again become functional.

In *Stichopus chloronotus*, the mortality of Ap specimens was slightly higher than that of Pa, as their numbers were lower. According to Doty's theory in 1997, mortality in Ap specimens is higher than in Pa ones in *H. atra*. According to Conand, Morel and Mussard (1997), mortality of specimens resulting from fission in *H. atra* is much higher than mortality of A and P specimens in *H. leucopsilota*.

Study of the anatomy of the two types of specimens undergoing regeneration, when compared to that of normal specimens, allowed a better understanding of the process of regeneration. The differentiation between the normal part and the regenerated part was marked on the external morphology by a small ring, which indicated a regenerated anus or mouth, narrower than the rest of the body. The tegument, as well as the width of the muscles and their attachments marked the area being regenerated and they converged towards the anus (Ap) or the mouth (Pa).

Generally, in Ap specimens, changes covered about a third of the specimens and were evident in the regenerated part only. In the specimens observed, the anus had already formed, and was strengthened to a certain degree by muscular fibres.

Pa specimens showed more changes than Ap specimens. In fact, in this case, it was the anterior part, or mouth which had to be regenerated. Depending on the stage observed, a peripharyngeal calcareous ring may have been observed, the

rete mirabile may have been absent or under-developed, and the transverse vessel may or may not have existed. The respiratory trees were present, but were not as developed as in normal specimens. One Pa specimen was observed with a respiratory tree that seemed to have been regenerated as it was much more transparent and thinner than the old one. The gonads were three times smaller than those of Ap specimens.

The anatomical study also allowed a better understanding of the resumption of feeding and reproduction in specimens resulting from fission.

Concerning feeding during regeneration, the quantity of material ingested averaged 0.22 g for Ap specimens and 0.01 g in Pa specimens. This indicated to us that digestive system activity was much more significant in Ap specimens. This could be explained by the fact that Ap specimens regenerate their anus and thus keep their buccal system intact. The average length of the digestive tract was greater in Ap specimens (135.94 cm) than in Pa specimens (95.86 cm). This ratio shows that the digestive tract of Ap specimens was on average 1.42 times greater than that of Pa specimens.

Finally, concerning reproduction, the gonads of Ap specimens were longer (16.15 mm) than those of Pa specimens (5 mm); but in comparison to normal specimens (78.10 mm), the average length of the gonads in the Ap specimens was 15 times smaller. It is supposed that the gonads break, leaving in place the gonadal base, which then regenerates. The gonad-index indicated that the gametes regenerate quicker in Ap specimens (0.19) than in Pa specimens (0.08).

Conclusion

This study on the asexual reproduction and regeneration of *Stichopus chloronotus* has made it possible for the anatomy of the species and the parameters for regeneration to be recorded in detail. This adds to the knowledge gained from the studies on *H. atra* and *H. leucospilota* in La Réunion, and indicates that fission is frequent there. A study under way on *H. atra* is aimed at quantifying the long-term consequences of this event on population dynamics, and to verify if it is determined by human disturbances which are particularly pronounced in La Réunion.

References

BOYER, C., S. CAILASSON & K. MAIRESSE. (1995). Asexual reproduction in *Holothuria atra* on a reef of Reunion Island in the Indian Ocean. SPC Beche-de-mer information Bulletin No.7: 7–9.

CONAND, C. (1988). Comparison between estimations of growth and mortality of two stichopodid holothurians: *Thelenota ananas* and *Stichopus chloronotus* (Echinodermata: Holothuroidea). Proc. 6th Int. Coral Reef Symp., Townsville. 2: 661–665.

CONAND, C. (1989). Les holothuries Aspidochirotes du lagon de Nouvelle-Calédonie: biologie, écologie et exploitation. Études et Thèses, ORSTOM, Paris. 393 p.

CONAND, C. (1990). The fishery resources of Pacific island countries. Part 2. Holothurians. FAO Fisheries Technical Paper 272.2. 143 p.

CONAND C. (1996). Asexual reproduction by fission in *Holothuria atra*: Variability of some parameters in populations from the tropical Indo-Pacific. Oceanologica Acta 19. 3: 209–216.

CONAND, C. & C. DE RIDDER. (1990). Reproduction asexuée par scission chez *Holothuria atra* (Holothuroidea) dans des populations de platiers récifaux : 71–76. **In:** Echinoderm Research. De Ridder et al. (eds). Balkema, Rotterdam. 343 p.

CONAND, C., C. MOREL & R. MUSSARD. (1997). A new study of asexual reproduction in holothurians: Fission in *Holothuria leucospilota* populations on Reunion Island in the Indian Ocean. SPC Beche-de-mer Information Bulletin No. 9: 5–11.

FRANKLIN, S.E. (1980). The reproductive biology and some aspects of the population ecology of the holothurians *Holothuria leucospilota* (Brandt) and *Stichopus chloronotus* (Brandt). Ph. D. Thesis, University of Sydney.

HARRIOT, V. (1982). Sexual and asexual reproduction of *Holothuria atra* Jäeger at Heron Island reef, Great Barrier Reef. Australian Museum Memoir, 16: 53–66.

UTHICKE, S. (1994). Distribution patterns and growth of two reef flat holothurians, *Holothuria atra* and *Stichopus chloronotus*. **In:** Echinoderms through time: Proceedings of the 8th International Echinoderm conference. D. David, A. Guille, J.P. Feral, & M. Roux (eds), A.A. Balkema. Rotterdam. 569–576.

UTHICKE, S. (1997). The seasonality of asexual reproduction in *Holothuria atra*, *Holothuria edulis* and *Stichopus chloronotus* (Holothuroidea: Aspidochirotida) on the Great Barrier Reef. Mar. Biol.

Technical development in seed production of the Japanese sea cucumber, *Stichopus japonicus*

by Siro Ito[1] *& Hitoshi Kitamura*[2]

Introduction

The sea cucumber *Stichopus japonicus* is a commercially-important species in Japan as a raw food, contrary to in China. There are three varieties of this sea cucumber: green, red, and black. The former two inhabit the sandy mud bottom of the bay, and are of great commercial importance. The other one can be found both in the open sea and on rocky shores. In Saga Prefecture, located on the northwest part of Kyushu Island, Southern Japan, the commercial catch of *Stichopus japonicus* has gradually decreased from 196 metric tonnes (t) in 1971 to 23 t in 1995 (wet weight). In the whole of Japan, the catch quantity has also decreased from 10 000 t in 1971 to 7000 t in 1995.

For the promotion of starting stock of the sea cucumber, the Sea Farming Center in Saga Prefecture has been producing 500 000 to 1 000 000 juveniles (10–20 mm in body size) per year since 1993. After metamorphosis from larvae, the juveniles grow up to 10–20 mm in size within the first three months, and grow up to an average of about 80 mm (max. 150 mm) size within one year. A protocol for the mass production of juveniles has been developed recently by the Center. Methods of brood stock management and culture of periphytic diatoms have been improved. Periphytic diatoms play two important roles: as a biological cue for the induction of larval metamorphosis, and as a suitable primary food for the juveniles.

Outline of juvenile production

Seed production usually begins with the catch of adult sea cucumbers from the sea in January. These animals are then reared for about three months. Propagation of periphytic diatoms on corrugated plates is also started in February. They are cultured at a density of more than one million cells/cm^2 within two months. In April, the induction of spawning of brood stocks is carried out, and larvae are cultured to a viable stage for about two weeks. After metamorphosis on the plates, the juveniles feed on periphytic diatoms and grow up to 10–20 mm body size within the first three months. These animals are shipped out to be released directly in the sea from July to August.

Brood stock management

Investigation into the maturation of natural sea cucumbers along the coast of the prefecture indicated that the spawning season lies within the March – May period (Fig. 1). As a result, about 100 adult sea cucumbers (300 g each) are caught in January and reared in a 2 t tank with the sea mustard, *Undaria pinnatifida*, at ambient temperature (12–18°C) to control the maturation. In April, the gonad index and the oocyte size in major axis are measured in random sampling to estimate the timing of the spawning induction (Fig. 2). When the gonad index and the oocyte diameter are more than 20 and 140 μm, respectively, spawning should be induced by heating the sea water (+ 5°C) of the tank (Fig. 3). From another investigation, it was found that the optimum density of spermatozoon for insemination is at 5–10 x 10^4 spermatozoon/ml or 1–2 x 10^3 spermatozoon per ovum.

Diatom culture

There are three important steps in propagating the periphytic diatoms on corrugated plates (40 x 32 cm), usually started in February in 15 t tanks (about 1000 plates each) (Figure 4, reprinted from Ito & Kitamura, 1998). The first is the enrichment with the addition of the nutrient salts (ammonium sulphate, superphosphate, Clewat32, and sodium

1. Saga Prefectural Fisheries Research and Development Center, Ashikari 2753-2, Saga 849-03, Japan
2. Faculty of Fisheries, Nagasaki University, Bunkyo 1-14, Nagasaki 852, Japan
E-mail: kitamura@nagasaki-u.ac.jp

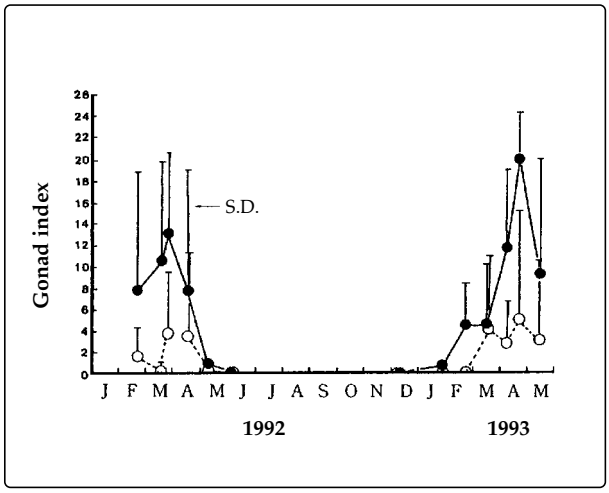


Figure 1

Seasonal changes in gonad index of the sea cucumber *Stichopus japonicus*

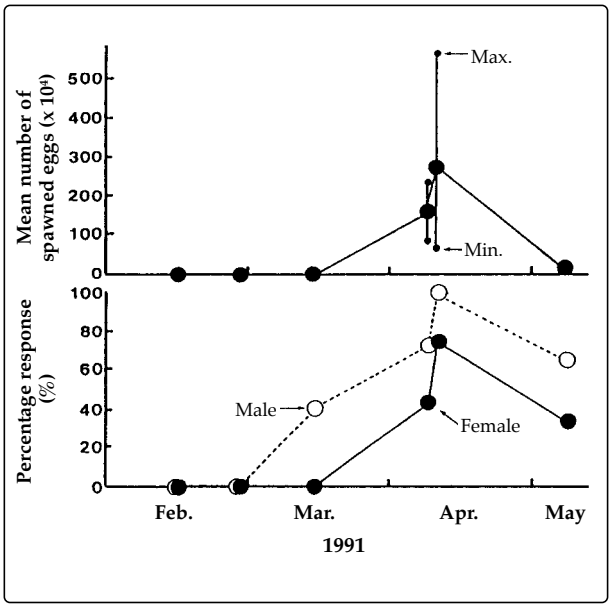


Figure 3

Percentage response of spawning and mean number of spawned eggs per female of the sea cucumber

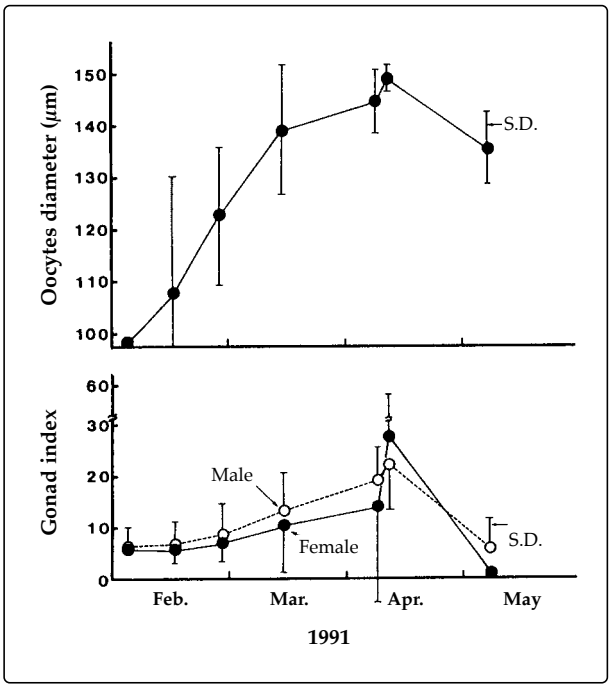


Figure 2

Changes in gonad index and oocyte diameter of the sea cucumber

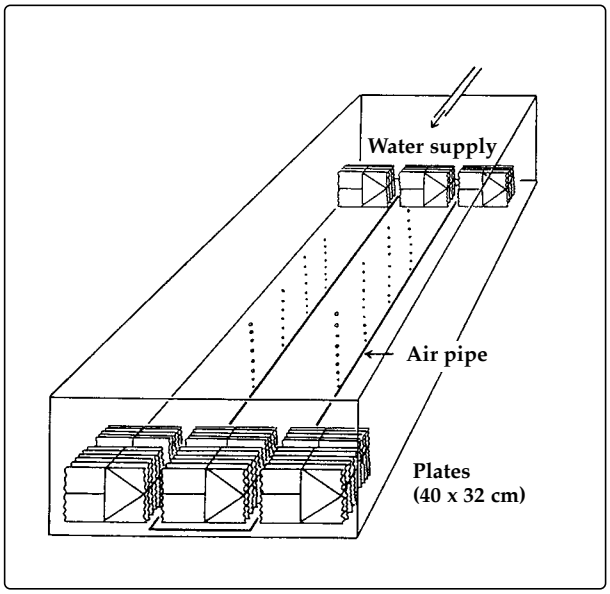


Figure 4

The schematic view of diatom culture in the 15 t tanks

silicate) in the tank under controlled light intensity. Light penetration is controlled by a black mesh sheet placed over the tanks. About 70 per cent of sunlight is shut-off on fine days and 50 per cent during cloudy or rainy days. The second step is washing with high-pressure sea water and reversing the plates once or twice a week. This method can significantly remove the larger diatoms that grow on the plates, thus making the smaller and highly adhesive diatoms dominant, which accelerates the propagation rate of the diatoms. And the last step is the elimination of copepods, which feed on diatoms, using the pesticide trichlorfon (0.5–1.0 ppm). As a result, we can culture small periphytic diatoms, such as *Navicula*, *Amphora*, *Achnanthes*, and *Nitzschia* at a density of more than one million cells/cm² on the plates within two months (see Figure 5, next page, reprinted from Ito & Kitamura, 1998).

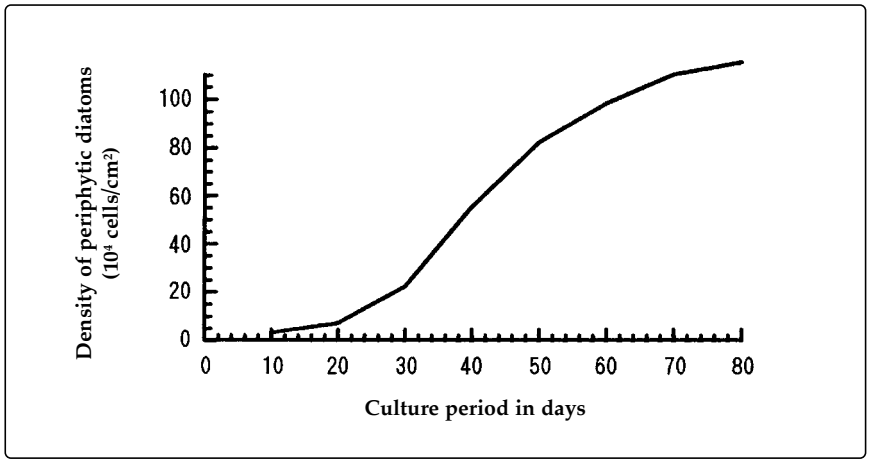


Figure 5

The typical propagation of the periphytic diatoms on the plates

Larval rearing and spat collection

After fertilisation, larvae of the sea cucumber are cultured to doliolaria larvae (Imai & Inaba, 1950) at 20°C by feeding the planktonic diatom, *Chaetoceros gracilis*, for about two weeks (Figures 6 and 7, reprinted from Ito & Kitamura, 1998). The larvae gradually increase in size through the 9th day. On the 11th day, body size of auricularia larvae reaches its maximum size, 900 μm. After that, body size falls to about 500 μm, and they grow up to doliolaria larvae. The induction of metamorphosis should be carried out at the stage of doliolaria. The metamorphosis of doliolaria larvae to juvenile is accelerated by the higher density of periphytic diatoms, and the density should be more than 200 000 cells/cm² to induce more than 50 per cent of larval metamorphosis (Ito, 1994) (Figure 8, reprinted from Ito & Kitamura, 1998). Periphytic diatoms are suitable primary food for the juveniles of this animal as for sea urchins (Tani & Ito, 1979; Kitamura et al., 1993) and abalones (Kawamura & Kikuchi, 1992).

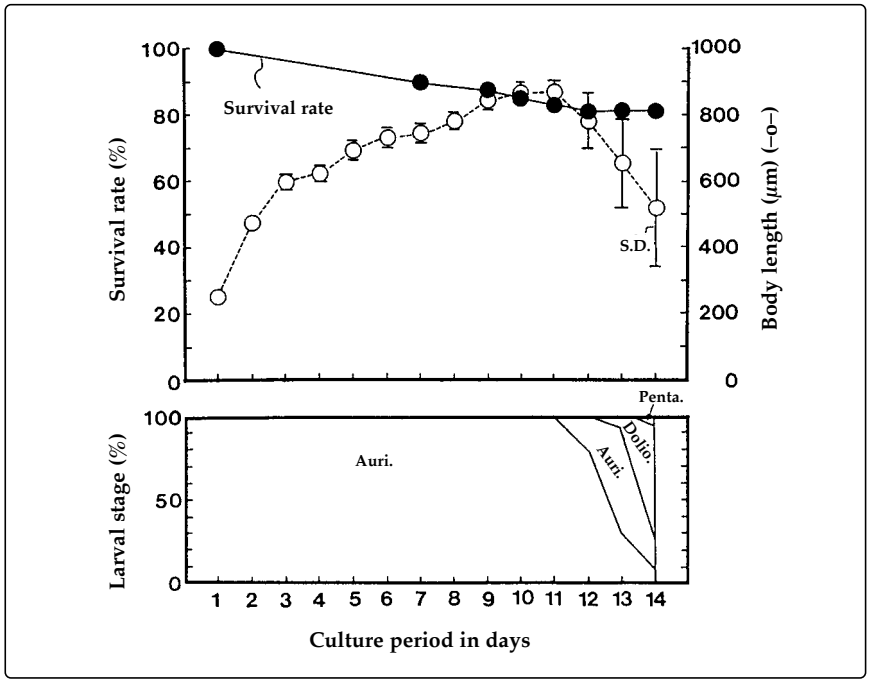


Figure 7

Growth of the larvae and percentage of each larval stage of the sea cucumber

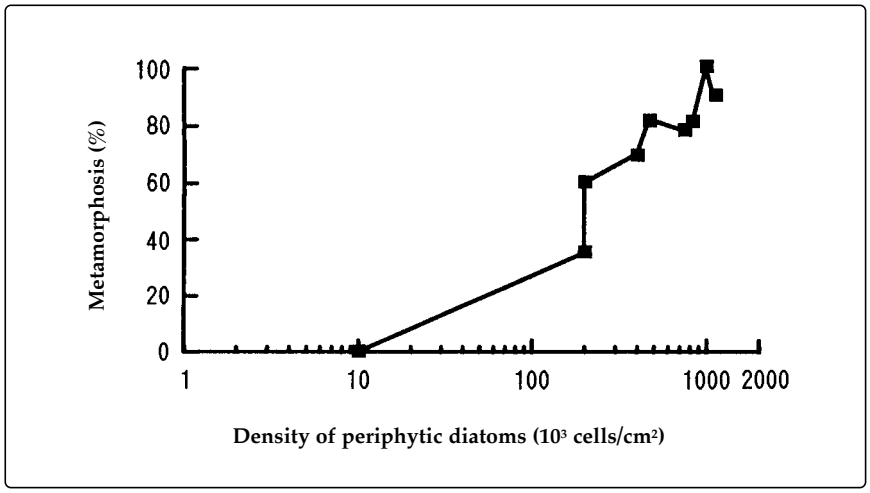


Figure 8

Relationship between the density of diatoms and the metamorphosis ratio

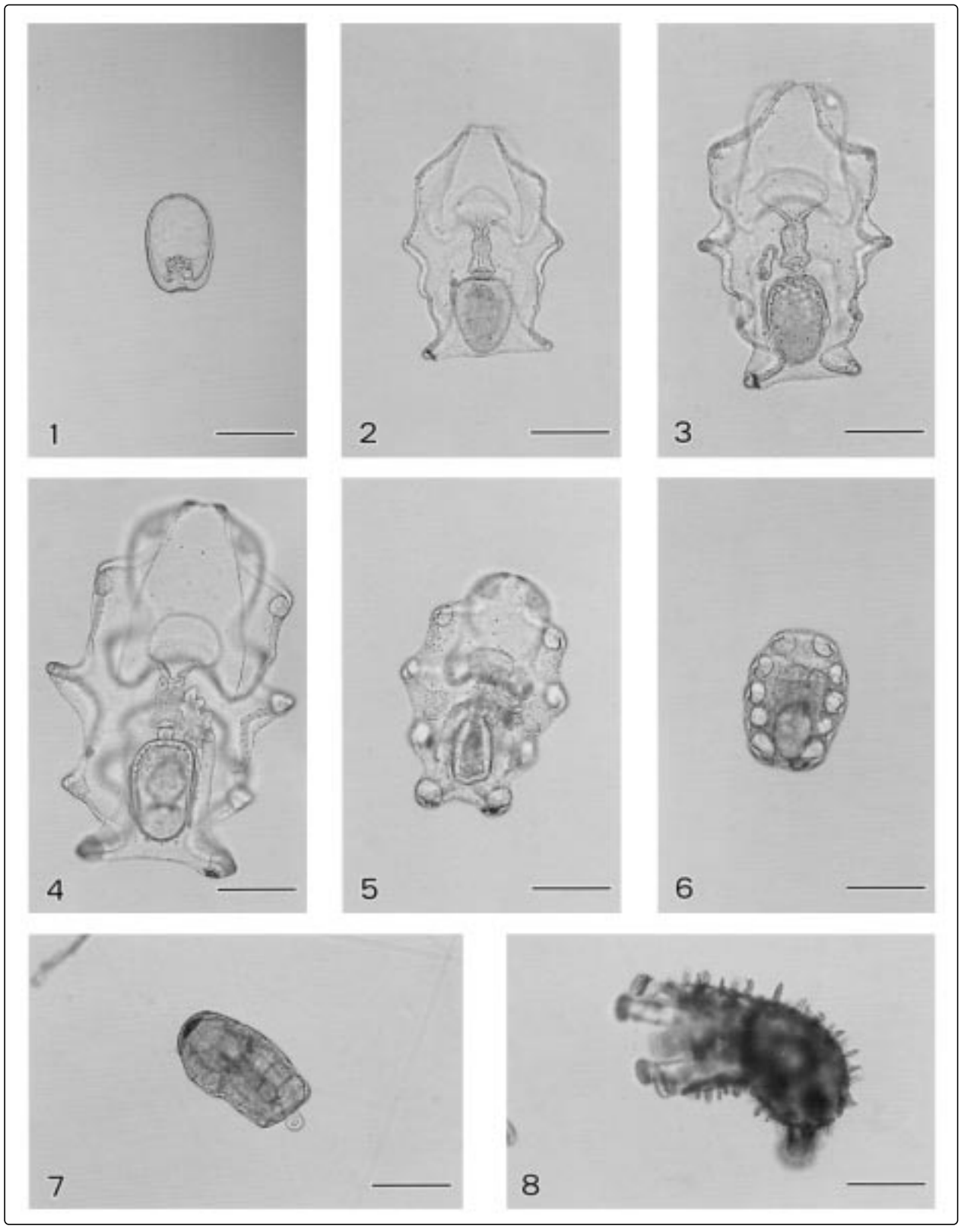


Figure 6

Photographs of the growth stages of larvae of the sea cucumber

1. One-day-old after artificial fertilisation, bar indicates 200 μm
2. Younger auricularia larva (ear-shaped-larva), 3-day-old
3. Auricularia larva, 7-day-old
4. Auricularia larva, 9-day-old, about 900 μm
5. Older auricularia larva, 11-day-old
6. Doliolaria larva (barrel-shaped-larva), 14-day-old
7. Pentacutula larva (five-tentacle larva), 15-day-old; this larva can attach substrata by tentacles
8. Juvenile of the sea cucumber after twenty days from the fertilisation

Rearing of juveniles

After induction of metamorphosis on the plates in April, juveniles feed on periphytic diatoms for about 3 months growing up to 10–20 mm body size in 15 t tanks at 18–26°C (Fig. 9). During this period of juvenile culture, periphytic diatoms are maintained by enrichment with the addition of nutrient salts and by elimination of copepods by the trichlorfonic chemical as mentioned above. It is important to reduce the juvenile density by the addition of other plates to the tank. From July to August, these animals are shipped out to be released directly in the sea. A few of the juveniles are transferred to a diked pond with sandy mud bottom, and they grow up to an average of 80 mm (max. 150 mm) in one year (Fig. 10).

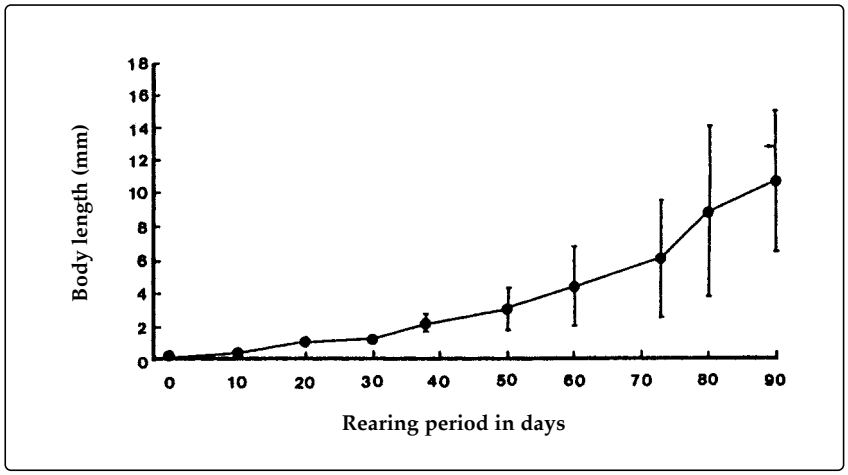


Figure 9

Growth of the juvenile sea cucumber on corrugated plates in the 15t tanks

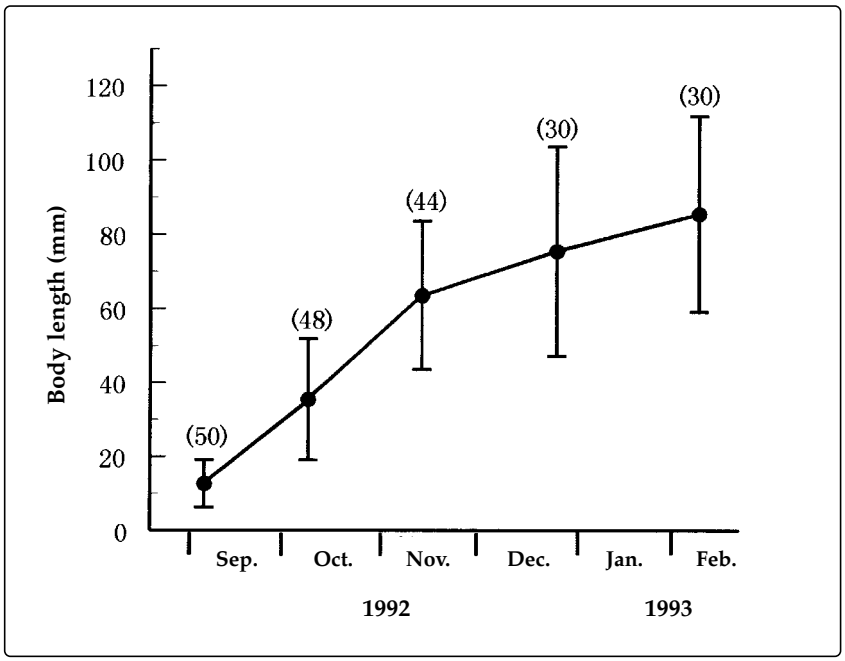


Figure 10

Growth of the sea cucumber in the diked pond

References

IMAI, T. & D. INABA. (1950). On the artificial breeding of Japanese Sea-Cucumber, *Stichopus japonicus* Selenka. Bull. Inst. Agricul. Res. Tohoku University. 2.

ITO, S.(1994). Studies on the technological development of the mass production for sea cucumber juvenile, *Stichopus japonicus*. Bulletin of Saga Prefectural Sea Farming Center, 4: 1–87.

ITO, S. & H. KITAMURA. (1998). Induction of larval metamorphosis in the sea cucumber *Stichopus japonicus* by periphytic diatoms. Hydrobiologia. 358 (in press).

KAWAMURA, T. & S. KIKUCHI. (1992). Effects of benthic diatoms on settlement and metamorphosis of abalone larvae. Suisanzoshoku. 40: 403–409.

TANI, Y. & Y. ITO. (1979). Effects of benthic diatoms on settlement and metamorphosis of the sea urchin, *Pseudocentrotus depressus*. Suisanzoshoku. 27: 148–150.

KITAMURA, H., S. KITAHARA & H.B. KOH. (1993). The Induction of Larval Settlement and Metamorphosis of Two Sea Urchins, *Pseudocentrotus depressus* and *Anthocidaris crassispina*, by Free Fatty Acids Extracted from the Coralline Red Alga *Corallina pilulifera*. Marine Biology, 115: 387–392.

Photo-identification of *Stichopus mollis*

by Lesley Raj
University of Otago, New Zealand

This note outlines the preliminary result of a photo-identification study, which began in December 1996 and is continuing. Holothurians lack obvious hard parts, and therefore cannot be aged directly. The most obvious way to study growth rate would be by some method of tagging or marking individuals for identification (Gentle, 1982; Conand, 1990). These processes are difficult however due to the animals' ability to rapidly regenerate damaged tissue and expel foreign objects embedded in the body wall (Gentle, 1990; Conand, 1990). The main objective of the study is to determine if characteristic markings, for example warts and spots, on individual *Stichopus mollis* can be used as a means of identification.

Site

A site was chosen in Elizabeth Basin, Doubtful Sound, Fiordland (Fig. 1). It was selected for many reasons, the first being the presence of *Stichopus mollis* in sufficient numbers to allow for re-identification of individuals during recurring visits to the site.

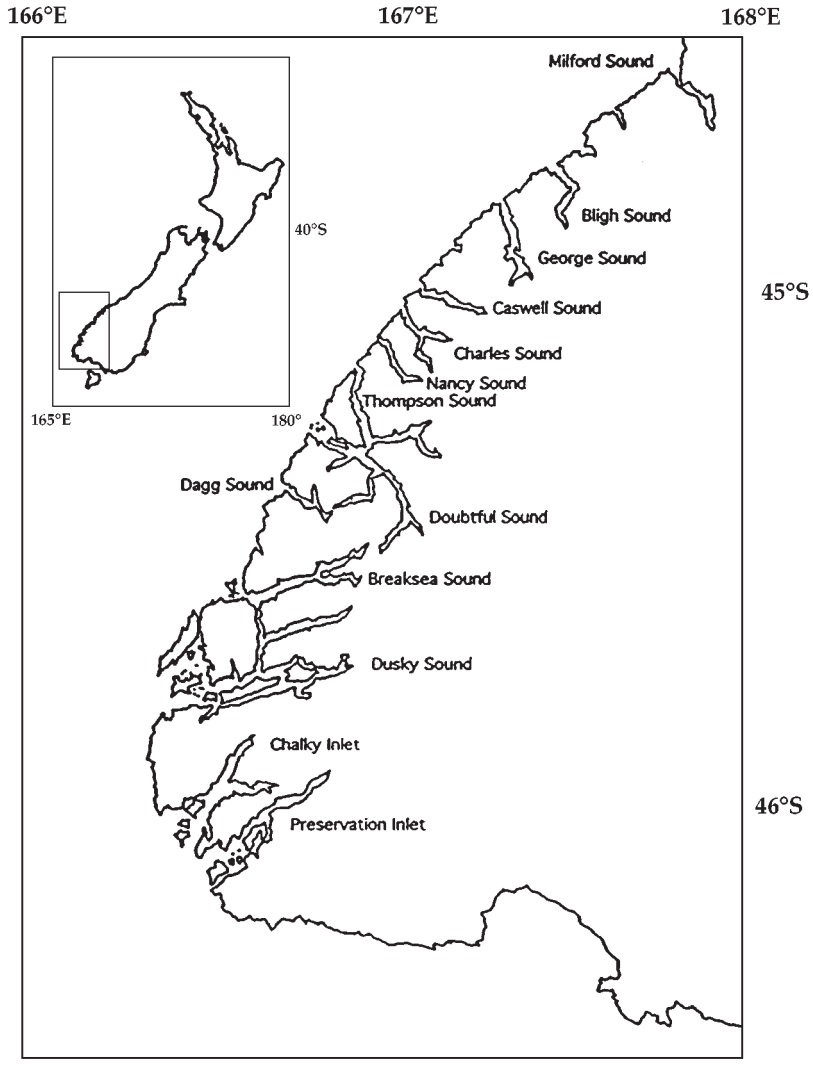


Figure 1

South-western new Zealand showing Doubtful Sound and the other major fiords (from Stewart, 1995, p. 52)

The nature of this study requires divers to be down for a period of up to 60 minutes. Maximum depth at Elizabeth Basin is 15 m, which allows a long and safe bottom time when diving to photograph the animals.

The area is enclosed by natural boundaries: a rock wall, a vertical face and a shallow beach. These act as a natural barrier to animals trying to move into or out of the area, again increasing the chances of re-photographing individuals for identification and growth studies.

There is no fishery yet in New Zealand for *Stichopus mollis*, so there should be no loss of holothurians through fishing. Due to the remoteness of Doubtful Sound, no losses due to disturbance by other divers were expected.

Methods

A dive buddy and I swim transects from the shallowest point of the study site, along the rock wall. We move towards the vertical cliff, photographing any *Stichopus mollis* within 5 m of the transect line. Once we reach the end of the transect, at which the depth is approximately 15 m, we move across 5 m and swim back towards the beach, again pho-

tographing any *S. mollis* we pass. This process is repeated until the camera film is finished, or the transects completed.

Total length is the only measurement that can be taken underwater, and is therefore the only feasible estimate for field use (Sewell, 1990). At each individual *Stichopus mollis*, my dive buddy holds or places a ruler beside the animal for the photograph. The photographs are generally taken from above to give a dorsal view of the animal. Generally, visibility at this site is good, ~20 m. Special care is taken to ensure the animals are not touched by the divers or the ruler, to make sure the animals are photographed in a 'resting' state.

The photographs for each month are placed into one of four groups according to the individuals' visual characteristics: 1) spots, 2) stripes, 3) monocolour and 4) obvious, unique patterns. Then the photos between months can be compared and any matching patterns or characteristics indicate the re-identification of individuals. These animals' length measurements can then be taken from the ruler in the photo and their growth calculated.

Results and discussion

Up until the end of September 1997, seven individuals have been positively identified due to their characteristic markings (Fig. 2).

Stichopus mollis appear to have characteristic warts and spots that remain constant for a period of at least 18 weeks. The sequence of these natural markings allow re-identification of individuals from a wild population.

This method of tracking holothurians is non-invasive, and does not restrict the individuals feeding or movement. Photo-identification is therefore favourable when studying growth and movement, as there are no external variables to consider, for example thinning of tegument (Lokani, 1992).

Photo-identification is only useful for identifying holothurians which have naturally occurring markings. Stewart (1993) was able to readily identify *Holothuria scabra* from photographs due to their characteristic large body wrinkles (these animals were kept in enclosures).

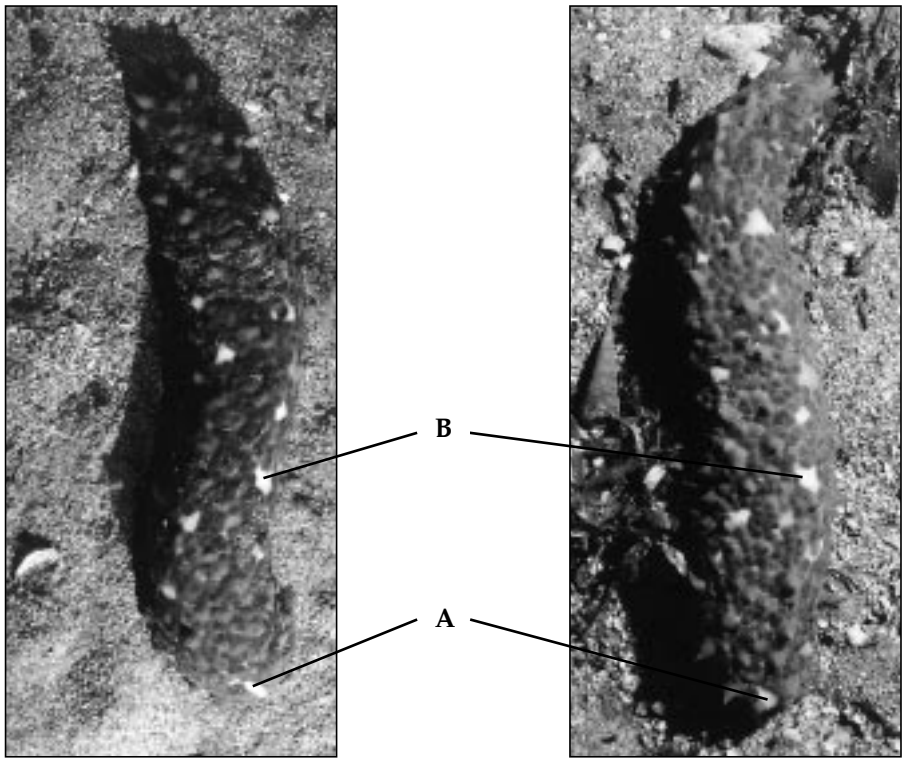


Figure 2

The same individual *Stichopus mollis* with photos taken 13 weeks apart (A and B are characteristic spots)

The process of matching photographs is time consuming and tedious. If a computer programme existed, similar to a police fingerprint database, photos would be an efficient means of identifying holothurians. However, this study does prove photo-identification can be used as a means of re-identifying holothurians for growth measurements.

Acknowledgements

The study is funded by the University of Otago, New Zealand. Travel assistance is provided by 'Fiordland Travel' and film supplied at a discounted price by 'Agfa'.

References

CONAND, C. (1990). The fishery resources of Pacific island countries. Part 2: Holothurians. FAO Fisheries Technical Paper, No. 272.2 : 143 p.

GENTLE, M.T. (1982). Unpublished report on population biology of beche-de-mer in Fiji. South Pacific Commission, Noumea, New Caledonia.

GENTLE, M.T. (1990). Ecology and resource potential of commercial beche-de-mer. South Pacific Commission, Noumea, New Caledonia.

LOKANI, P. (1992). First results of an internal tag retention experiment on sea cucumber. SPC Beche-de-mer Information Bulletin No.4: 9–12.

SEWELL, M.A. (1990). Aspects of the ecology of *Stichopus mollis* (Echinodermata: Holothuroidea) in north-eastern New Zealand. New Zealand Journal of Marine and Freshwater Research, 24: 97–103.

STEWART, B.G. (1993). Evidence for a marked decline of beche-de-mer populations in the Suva and Beqa areas of Fiji, and a preliminary description of a method of identifying beche-de-mer individuals based on characteristic body wrinkles. The University of the South Pacific Marine Studies Technical Report 1. 20 p.

Preliminary notes on the exploitation of holothurians in the new Wakatobi Marine National Park, Sulawesi, Indonesia

by Abigail Moore [1]

Introduction

The remote Wakatobi or Tukang Besi islands are situated in the south-east of Sulawesi (Indonesia) in the area of greatest tropical marine biodiversity (Tomascik et al., 1997). They are inhabited by two separate ethnic and cultural groups: the Bajo, or sea-gypsies, who live almost exclusively by the exploitation of marine resources at a very low subsistence level; and the land-based islanders, who are mainly farmers and traders. There are also large numbers of vessels from other parts of Indonesia, and even other countries exploiting the area.

Fishery background

Holothurians are mainly exploited by the Bajo, but also collected by anyone, anywhere if seen in the course of other activities, including by the crews of many vessels just passing through. The area has a long history of beche-de-mer exploitation, but there is no separate 'holothurian fishery' as such.

Holothurians form an important part of a multi-species invertebrate fishery (WWF, 1994), which is often also combined with fin-fish exploitation, as reported in other Indo-Pacific areas (Trinidad-Roa, 1987; Conand, 1997). The product is largely marketed through Chinese traders in Bau-Bau, the nearest town of any size, or to visiting Bugis or Chinese traders en-route to Surabaya.

As one of the few cash-earning commodities in what is still predominantly a barter economy, 'trepang' are more important to the local community than their actual value might suggest.

1. BSc, MSc student at Hull University, UK. E-mail: abigailmoore@hotmail.com

Species and uses

The main species exploited are: *Holothuria scabra,* by far the most prized and expensive; *Thelenota ananas* and, to a lesser extent, *T. anax*; *Actinopyga echinites, A. lecanora, A. mauritiana* and *A. miliaris*; *Boadschia marmorata*; *Stichopus variegatus* and *S. Chloronotus*; *Holothuria nobilis* and *H. fuscopunctata*; *H. atra, H. edulis* and *H. leucospilota*.

The last three are a fairly recent addition, due to an increasing demand for low-value species (Richards et al., 1994). It was interesting to note that *H. leucospilota* seems to occur in two varieties: pure black, and black with white fringes to the tentacles and white tips to the podia and papillae. Are these in fact two varieties of one species or two species? The white-tipped ones are twice as valuable.

Holothurians are mostly collected for trade only, and are prepared along substantially similar lines to those described in Conand (1990), though sometimes there is room for improvement. The majority are prepared in the villages, by a few local traders. However, in the calm season, the catch is often cooked and dried on-site in remoter areas. Wood is initially taken along, then collected from as close as possible to the harvest site. The main source of fuel in both cases is mangrove wood—a potential environmental problem.

A few individuals may be eaten raw in times of hunger and low market prices, though never *H. scabra,* which is too valuable, or *H. atra*, used locally for 'obat' (which can mean 'medicine', either in the western sense, or as in 'medicine man', for warding off evil or as a charm).

Those most commonly eaten, and viewed as a 'hard times food', are small holothurians which are not dried or traded, and which I have failed so far to identify. The local name is 'buntulaha'. They are long and thin, about 1 to 1.5 cm diameter, tubular, diameter constant except for conical tips, both extremities looking very similar. Length varies from 7 to 15 cm, but diameter does not seem to vary with length (personal observation and local sources). They all live buried in the sand flats, and are abundant—if you know how to find them. Buntulaha are eaten raw: first the outer spicules are removed by scraping the tegument, like preparing a new carrot, then they are split longitudinally and the insides removed. The tegument is then cleaned in sea-water and cut into pieces. It has the taste and texture of oyster-flavoured chewing-gum!

Fishing methods and timing

Local exploitation occurs year-round on reef-flats close to the villages or sheltered from the prevailing winds. The main collection seasons are October to December and April to May, when the winds are usually light, and trips can be made to the further reefs. There is some tradition as to which of the outlying areas are exploited by which village, though this is not always adhered to, and outsiders in any case do not comply with any such restrictions.

Collection methods include:

- reef-flat gleaning at low tide (mainly women and children), by local people
- collection by free-diving, using home-made goggles, by day or more usually by night (nulu), mainly from small canoes, predominantly by local people
- hookah, including that on boats mainly engaged in lobster or other fisheries; boats and often also crews are frequently from outside the area.

Fishing vessels:

- Most local boats are still dug-out canoes, with sail and paddle, though increasingly motorised with small long-shaft outboards called 'katintin', which can cope with the appalling fuel quality (fuel is often mixed with kerosene as well as dirt and water).
- The larger traditional sailing boats, the Sope and Lambo models, are often used to go further away, including to various illegal fishing activities in Northern Australia, and are increasingly motorised.
- There is also a growing fleet of pure motor boats, called 'Johnson', ranging from smallish open skiffs to larger vessels (7 m keel not uncommon) with a cabin, in which whole families can go to the offshore reefs for days or weeks at a time. Inboard diesel engines tend to be Chinese—relatively cheap but very noisy and polluting. As well as local crafts, large numbers of boats of many types (bait-fish, live-fish, chilled fish, lobster etc.) from many areas come and go, often using cyanide, bombs and hookah, for which they are the main culprits, though locals are also sometimes guilty of destructive practices.

Problems in the fishery

There has been a dramatic decline of most nearshore resources in recent years (Majors, 1996), including holothurians. Local collectors and merchants all agree that there are problems. It is get-

ting harder to find 'trepang', and those brought in are smaller.

Specimens I saw awaiting preparation, or already prepared, were much smaller than I would have expected from the literature on the species involved. Many would have been below minimum spawning size (where this is known), and below recommended legal minimums where these exist in other holothurian fisheries (Uthicke, 1996; Conand, 1997). My personal observation is that, even since my first visit to the area in 1995, it is harder to find holothurians.

Closure of the fishery without provision of other options would undoubtedly cause hardship, and in such a remote area would probably be unenforceable. Smuggling is part of the culture anyway!

Mariculture attempt

A small pen was tried here in 1996, but specimens either escaped or failed to grow. A Bajo visitor from an island just to the North said that in his village, juveniles are brought in by local fishermen, but instead of being killed immediately, are placed in a pen and have been successfully reared to adult size. This has reportedly been done with no special feeding, and with a mixture of species. Planks were sunk into the substrate to a depth of about 20 cm to prevent escape, and the pens were big. He said that it took 3 months to 1 year between capture and market readiness.

It seems that pens on sea-grass or on bare sand were equally successful, but that depth was important, as if they dry out or the water is too shallow, they stop feeding and also burrow, tending to escape more. Maybe the pen size is crucial, or the design, or the siting. . . further investigation seems necessary.

Conclusion

There is a general opinion locally that conservation measures are necessary, in particular that the juveniles need to be left to grow. One village has agreed to avoid harvesting juveniles as a community decision. Significantly, this is one of the better-off villages, with more alternative sources of income. With the support of the local communities, local and other NGOs involved in the area, the Marine Park, relevant authorities and local businesses, it should be possible to work out and implement suitable measures, as has been the case in similar situations elsewhere (e.g. McManus et al., 1988).

Because it is not a case of a few people solely dedicated to holothurian fisheries, for whom alternative livelihoods could perhaps be found, but rather of most members of a community relying on the resource as a small but significant part of their survival kit, solutions are unlikely to be simple.

References

CONAND, C. (1990). The fishery resources of Pacific island countries. Part 2: Holothurians. FAO Fisheries Technical Paper, No. 272.2 : 143 p.

CONAND, C. (1997) Are holothurian fisheries for export sustainable? Intern. Cong. Reefs, Panama, 2: 2021–2026.

MAJORS, C. (1996). Wakatobi fisherfolk development programme, Yayasan Bajo Sejahtera. 1–2.

MCMANUS, J.W., E.M. FERRER & W.L. CAMPOS. (1988). A village-level approach to coastal adaptive management and resource assessment. **In:** Proc. 6th Int. Coral Reef Symp. Townsville. Vol 2: 381–385.

RICHARDS, A.H., L.J. BELL & J.D. BELL. (1994). Inshore fisheries resources of Solomon Islands. Mar. Pol. Bul. Vol. 29, Nos 1–3: 90–98.

TOMASCIK, T., A.J. MAH, A. NONTJI & M.K. MOOSA. (1997). The Ecology of the Indonesian Seas Part II. Periplus, Singapore. 1387 p.

TRINIDAD-ROA, M.J. (1987). Beche-de-mer fishery in the Philippines. NAGA October 1987. 15–17.

UTHICKE, S. (1996). Beche-de-mer: a literature review on holothurian fishery and ecology, AIMS. 45 p.

WWF. (1994). Proposed projects: community-based management in Tukang Besi Islands. WWF Jakarta. 13–14

A summary about holothurians in Mozambique

by Rabia Abdula [1]

Mozambique is located in southern Africa between latitudes 10°20'S and 26°50'S with an area of nearly 786 000 km² (Figure 1). This country has one of the largest maritime coast in Africa—around 1430 nautical miles—and all the shoreline is bathed by the Indian Ocean (Fisher et al., 1990).

Sea cucumbers are known in Mozambique as 'magajojo' and they are distributed throughout the coast. Capture and processing were introduced by Chinese people in the 1950s.

Fishing areas (Figure 2) are located north (Cabo Delgado and Nampula Provinces) and south (Inhambane and Maputo Provinces).

The principal commercial species captured in Mozambique are: *Holothuria scabra*, *Holothuria nobilis*, *Holothuria fuscogilva*, *Actinopyga echinites*, *Holothuria atra* and *Actinopyga mauritiana*. There are other species occurring in Mozambique waters such as *Actinopyga lecanora*, *Stichopus chloronotus*, *Stichopus variegatus*, *Synapta oceanica* and *Holothuria hilla* for which catch levels are not known, and a few more that are unidentified.

The fishery is artisanal, and is basically 'hand catch'. In the North Provinces (Cabo Delgado and Nampula) the collectors use home-made snorkelling equipment, diving down to depths of 10 to 15 m. In the south (Inhambane Province) the collectors use ready-made snorkelling equipment. There is no information about collectors using scuba for this fishery.

In 1990, the catch registered was 500 t (Dioniso & Munguambe, 1993), 700 t in 1993 (DNP, 1995), 6 t in 1995 and 54 t in 1996 (DNP, 1997). Unfortunately, it is difficult to know if the discrepancy in the catch values is due to irregular registration in the provinces or to over-exploitation.

There are few studies about this resource in Mozambique. The ones available have mainly focused on the economic feasibility of the fishery, and the general biological environment around Inhaca Island. The stocks of *H. scabra* and *H. nobilis* have been drastically decreasing, probably as a result of an intensive exploitation. Actually, in Inhambane Province, fishing for holothurians is forbidden until re-establishment of the resource.

Figure 1

Location of Mozambique in Africa

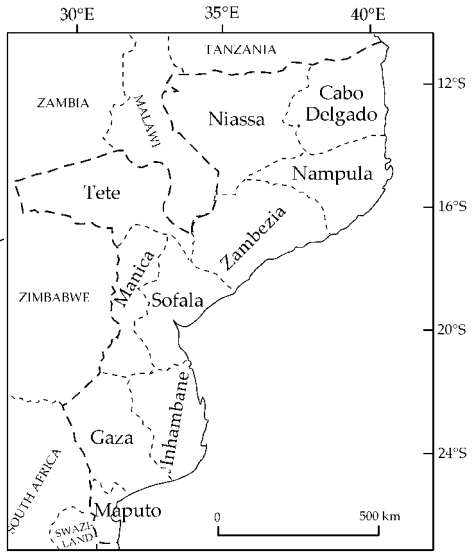


Figure 2

Map of Mozambique showing the provinces boundaries

1. Biologist, Instituto de Investigacao Pesqueira, Maputo, Mozambique, Av. Mao Tse Tung, 389 CP 4603, Maputo, Mozambique. E-mail: Rabia@magumba.uem.mz

In Mozambique, the commercial species are processed as described below (Fisher et al., 1990):

1) Holothurians are opened with a longitudinal slash on the ventral face and then boiled in sea water for one-and-a-half hours.
2) They are buried in the sand (or put in a wooden box, particularly in the Southern region), for one night.
3) They are pressed to remove their skins and internal organs, cleaned, boiled again, dried and finally put out to dry in the sun.

Sea cucumbers are not part of the diet of Mozambicans. In Mozambique this resource is only for sale. The collectors sell the holothurians to Mozambican and foreign enterprises or single traders acting as intermediaries. The prices vary from region to region, and sea cucumbers are mainly exported to South Africa and Asia.

References

ABDULA, R. (1995). Relatorio de viagem a Ilha da Inhaca. Instituto de Investigacao Pesqueira. Maputo. (Unpub.).

ABDULA, R. & F. ATANASIO. (1995). Relatorio de viagem a Provincia de Nampula. Instituto de Investigacao Pesqueira. Maputo. (Unpub.).

DIONISO, E. & F. MUNGUAMBE. (1993). Estado actual de Exploracao de Outros recursos pesqueiros. Seminario sobre os Recursos pesqueiros em Moçambique. Instituto de Investigacao Pesqueira (IIP); Maputo 33 p. (Unpub.).

DIRECCAO NACIONAL DE ADMINISTRACAO PESQUEIRA (DNP). (1995). Estatistica de Pesca (1994–1996). Maputo. 284 p.

DIRECCAO NACIONAL DE PESCAS (DNP). (1997). Relatorio Anual, 1996. Maputo.

FISHER, W., L. SOUSA, C. SILVA, A. FREITAS, J.M. POUTIER, W. SCHEIDER, T.C. BORGES, J.P. FE RALE & A. MASSINGA. (1990). Quia de Campo para Identificacao das Epecies Commerciais Marinhas e de Aguas Salobras de Moçambique. Roma. 424 p.

Aquaculture section

Prepared by S. Battaglene, ICLARM – Solomon Islands

News from the Pacific

1. Ban on the taking and sale of sandfish in the Solomon Islands

There is increasing interest in both the harvest and the management of beche-de-mer in the Pacific region. The price of valuable species like sandfish and white teatfish has risen considerably over the last 12 months. For example, in the Solomon Islands, over 17 new buyers, mainly Chinese, visited in November 1997. Many buyers are now sending boats out to collect animals for central processing, depriving Islanders of much of the profit. The increased demand has seen many stocks overfished. The Solomon Island Government has responded by placing a ban on the collection and sale of sandfish.

2. Progress on the culture of sandfish in the Solomon Islands

A summary of our research over the last 12 months was presented to the Third International Larval Biology meeting in Melbourne, Australia, held from 13–16 January 1998 (see Abstracts Section, this issue).

3. Less progress with white teatfish culture

White teatfish were successfully spawned and the auricularia reared by two programmes in the Pacific in 1997. We achieved this at the ICLARM Coastal Aquaculture Centre in October, but could not rear the larvae past the doliolaria stage. Similar progress was reported in Kiribati by the Japanese-funded Overseas Fishery Co-operation Foundation. Reasons for the failure of larvae to settle remain unclear. Opportunities to spawn white teatfish are restricted by the short spawning season—October to November. Further research is planned in 1998.

In situ spawning observations

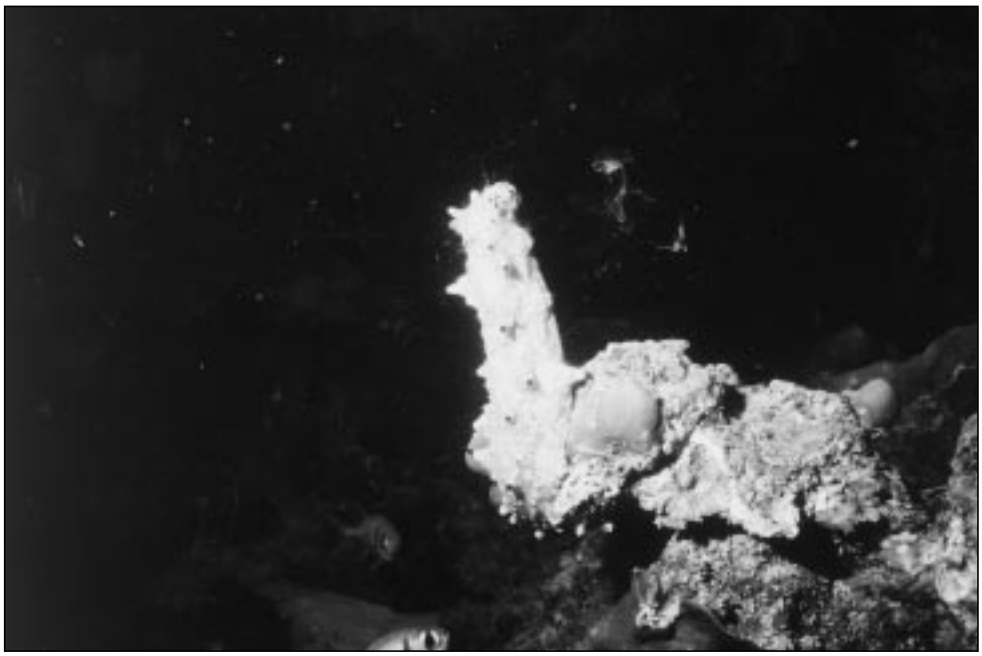
In situ spawning observations provide very important information about the biology of the reproduction of the species, for example behaviour, season, initiating factors.

Observation from French Polynesia

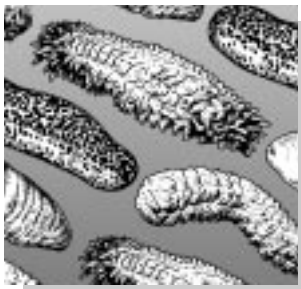
Name of observer: C. Jardin , Director SNC PAE TAI-PAE UTA
Date: 27/01/97
Time: 3 p.m.
Tide: –
Moon: FM + 4
Site: Rangiroa, northern area
Surroundings: sand
Depth: 5 m
Species: *Bohadschia vitiensis*
Number of specimens of this species displaying spawning behaviour: 1 in the middle of several others.

Observation and photograph from the Seychelles

Name of observer: Patrick Durville (Marine Ecology Laboratory, University of La Reunion)
Date: 3/11/97
Time: 5 p.m.
Tide: –
Moon: NM
Site: Ile Aride
Surroundings: Coral
Depth: 15 m
Length of observation: 5 min.
Species: undetermined
How many specimens of this species displayed spawning behaviour? 1 only
Did other species display this behaviour? No
Indicate whether it was possible to determine if the specimens were male or female: male specimen (sperm clearly visible).



***In situ* observation of a male spawning**



abstracts, publications, workshops & meetings
beche-de-mer

Are holothurian fisheries for export sustainable?

by C. Conand
Lab. Écologie marine, Univ. de La Réunion, 97715 Saint-Denis, France.

Source: Paper presented at the International Congress on Reefs, Panama, 2 : 2021–2026.

Holothurian fisheries have a very long history and the increase in the catches could be interpreted as a sign of sustainibility. A dozen Indo-Pacific coral reef species constitute the major part of world catches of these export fisheries, which are yet poorly documented and generally not rationally managed. From different sets of statistics (captures, processing, national exports by producers or imports by consumers, international markets in Hong Kong and Singapore) the main characteristics and the recent trends are analysed. The annual world captures are around 120 000 t, valued over US$ 60 million. It appears also that new fisheries have developed in many non-traditional fishing areas, such as Mexico and the Galapagos. The main life-history traits of the species, though showing variety, could explain that they constitute fragile stocks. With the increasing market demand, biological over-exploitation occurs well before economic over-exploitation. Effective collaborative management is needed. Development of information exchange is now in progress through the *Beche-de-mer Bulletin* published by the South Pacific Commission.

Potential of the tropical Indo-Pacific sea cucumber, *Holothuria scabra*, for stock enhancement

by Stephen C. Battaglene & Johann D. Bell
ICLARM, Coastal Aquaculture Centre, PO Box 438, Honiara, Solomon Islands

Submitted to 'Proceedings first international Symposium on Stock Enhancement and Sea Ranching' Bergen, Norway 8–11 September.

Sea cucumbers processed into 'beche-de-mer' are a valuable source of income for many poor communities in the Indo-Pacific. Increasing demand from China has seen most stocks of high-value species over-fished. The ability to sustain or increase the yield of tropical sea cucumbers by stock enhancement is being assessed in a number of countries including, Ecuador, India, Maldives, Marshall Islands, and Solomon Islands. Sea cucumbers appear suitable for enhancement because they are: restricted to inshore habitats, low on the food chain, relatively sedentary and easy to harvest. Among the tropical sea cucumbers, sandfish, *Holothuria scabra*, appears to be an especially good candidate for stock enhancement because it is of high value, is easy to propagate, and grows rapidly at high densities on simple, low-cost diets. Our preliminary rearing trials indicate that the juveniles could be ready for release into the wild at two months of age and 20 mm in total length. However, before effective and responsible strategies for releasing sandfish can take place, we need to understand their ecology and population genetics. Methods also need to be developed to mark the juveniles so that the success of experimental releases can be assessed.

Induction of larval metamorphosis in the sea cucumber *Stichopus japonicus* by periphytic diatoms

by S. Ito & H. Kitamura.

Source: *Hydrobiologia* (in press).

The mass production of juvenile seeds of the sea cucumber, *Stichopus japonicus* has been recently developed by the Sea Farming Centre of Saga Prefecture. Methods for the culture of periphytic diatoms have been improved. There are three important steps in propagating the diatoms. The first step is the enrichment, with the addition of the nutrient salts, under controlled light intensity. The second step is washing with high pressure seawater and reversal of the plates. The last step is elimination of copepods, which feed on diatoms, using a pesticide. Small periphytic diatoms such as *Mavicula*, *Amphora*, *Achanthes*, and *Nitzschia* are easily cultured at a density of more than one million cells per cm^2, and these diatoms are able to include larval metamorphosis and serve as a food source for juvenile sea cucumbers.

Predation on holothurians: a literature review

by Patrice Francour
Laboratoire de Biologie Marine et d'Écologie du Benthos and GIS Posidonie, Faculté des Sciences de Luminy, 13009 Marseille, France

Source: *Invertebrate Biology*, 116(1): 52–60.

In the literature, 69 references altogether have reported 76 predators on holothurians. In terms of the number of predatory species, the most important predators are fishes (26 species), seastars (19 species), and crustaceans (17 species). Seastars are the predators most often cited as regularly ingesting large quantities of holothurians. Toxicity seems to be an effective defence against a generalised predator but, against a specialist on holothurians, escape by swimming movements or shedding of a piece of body wall are the only behaviours that occasionally end with a successful escape. Escape behaviours may be a factor in providing the apparent size refuge from predators. Impacts of predators on holothurian populations have rarely been reported or evaluated, and predation on the earliest life stage is unknown.

Note on *Synaptula recta* Semper, 1868 (Echinodermata, Holothuroidea, Synptidae) new to Pakistan waters

Source: *Pakistan J. Zool.*, vol. 29(1), 92–94, 1997.

Synaptula recta Semper, 1868 is widely distributed in the Indo-West-Pacific region. It was previously not known from Pakistan (northern Arabian Sea). These specimens now recorded from the region fill the gap in the distribution of the species. The specimen is briefly described and illustrated.

Reproduction, spawning induction, development and larval rearing of the tropical sea cucumber sandfish, *Holothuria scabra*, Jaeger 1833

by Stephen C. Battaglene, Christain Ramofafia & J. Evizel Seymour
ICLARM, Coastal Aquaculture Centre, PO Box 438, Honiara, Solomon Islands, E-mail: ICLARM@welkam.solomon.com.sb

Presented at the Third International Larval Biology meeting, Melbourne, Australia 13–16 Jan. 1998.

Sea cucumbers, processed into 'beche-de-mer', are a valuable source of income for many coastal communities in the developing nations of the Indo-Pacific. Increasing demand from China has caused overfishing of stocks of the high-value species. ICLARM is exploring the possibility of restoring depleted populations of tropical sea cucumbers by stock enhancement. Sandfish *Holothuria scabra*, is considered the best candidate for stock enhancement because it is of high value, widely distributed, relatively easy to culture, and grows rapidly at high densities on simple, low-cost diets. In the Solomon Islands, individual mature sandfish are present in the wild population year-round with peak reproduction in May and November. Approximately 10 per cent of mature sandfish can be induced to spawn by elevating sea water tempera-

ture 3 to 5°C. Four batches of sandfish eggs totalling 19 million fertilised eggs were produced from the Coastal Aquaculture Centre hatchery in the first 12 months of operation. Optimal egg densities for static incubation were 0.1 egg/ml. Larvae were cultured at densities of 0.1 to 4 larvae/ml using batch exchange of water. Larvae grew and developed better on *Chroomonas* sp. than other algae species tested. Although, large scale rearing is undertaken using combinations of *Chaetoceros muelleri* (*gracilis*), *Chaetoceros calcitrans, Chaetoceros simplex*, *Chroomonas* sp., Tahitian *Isochrysis* sp., and *Pavlova salina*. Feeding density started at 20 000 cells/ml at Day 2 and increased to 40 000 cells/ml by Day 14. Settlement of sandfish pentacula started from Day 10 to 14. A combination of fresh micro-algae and commercial dried micro-algal products 'Algamac 2000' and 'Livic' were fed from Day 10. Survival to settlement ranged between <1 and 35 per cent depending on initial stocking density and other husbandry factors. Larval survival and growth increased with successive batches as rearing protocols and rearing systems were refined. Experiments are continuing to establish the best combination of micro-algae for larval growth and survival. The batches of settled juveniles were detached from settlement plates using 1–0.5% KCl at Day 21 and transferred to outdoor concrete rearing tanks. Over 150 000 juveniles, some as large as 150 mm, have been produced.

Recruitment in the Holothurian *Cucumaria frondosa* in the Gulf of Maine

by Dorothy E. Medeiros-Bergen & Erika Miles

Source: *Invertebrate Reproduction and Development*, 31: 1–3 (1997). 123–133.

The sea cucumber *Cucumaria frondosa* spawns in the spring, in the Gulf of Maine, USA. The larvae remain pelagic for several weeks prior to recruitment to the benthos. In western Gulf of Maine, a previous study showed that juvenile *C. frondosa* occur exclusively inside mussel beds; adults are absent from the region. In the present investigation, recruitment and juvenile abundance in the field were examined from 1993–1995. A study conducted in the spring of 1993 in the Maine-New Hemishire coastal waters indicated that recruitment of *C. frondosa* to mussel beds was high. In the fall of 1994, no recuits were present on the benthos; juveniles were more abundant in coralline algae than in mussel beds or kelp holdfasts. In 1995, recruitment and juvenile abundance monitored over the recruitment season revealed that recruitment was highest in June. Toward the end of June and during early July, recruitment was significantly higher in mussel beds than in coralline algae and kelp holdfasts. In June, a 2 day intensive field study indicated that recruits were significantly more abundant in the mussel beds than coralline algae. Mussel beds may enhance early survival by providing a refuge from predation. A potential predator on new recruits are large nereid worms.

Seasonality of asexual reproduction in *Holothuria (Halodeima) atra*, *H. (H.) edulis* and *Stichopus chloronotus* (Holothuroidea:Aspidochirotida) on the Great Barrier Reef

by S.Uthicke

Source: *Marine Biology* (1997) 129: 435–441

Asexual reproduction by fission was monitored for 18 months in populations of *Holothuria (Halodeima) atra, H. (H.) edulis* and *Stichopus chloronotus* on three nearshore fringing reefs and one midshelf reef in the Great Barrier Reef. Fission in *S. chloronotus* occurred exclusively between March and October, with a peak value of 31 per cent recently divided individuals in one population in July. *H. atra* showed a similar pattern, with maxima of between 16 and 26 per cent from May to July. In *H. edulis*, asexual reproduction occurred only between March and July, with a maximum of 17 per cent recently divided individuals in March. Fission rates (43%) for *S. chloronotus* were found in a dense population on Great Palm Island. The lower-density midshelf reef population exhibited comparatively lower annual fission rates (19%). About 24 per cent of *H. edulis* undergo fission each year. Annual fission rate and population density were positively correlated in the four populations of *S. chloronotus* and *H. atra* studied rarely exhibit asexual reproduction, the major exception being the echinoderms (Emson & Wilkie, 1980). Transverse fission in aspidochirotide holothurians has been reported for six *Holothuria* species (Crozier, 1917; Deichmann, 1922; Bonham & Held, 1963; Harriott, 1980) and two *Stichopus* species (Harriott, 1980). On the southern section of the Great Barrier Reef (GBR), fission has been observed in *H. atra, H. edulis, S. chloronotus* and *S. horrens* on Heron Island (Harriot, 1980). Fission products of the first three species are frequently observed on nearshore fringing reefs and midshelf reefs in the central section of the GBR (Uthicke, 1997). *H. atra* and *S. chloronotus* are the most abundant holothurian species on the reef flats of the GBR (Harriot, 1980; Hammond et al., 1985; Uthicke, 1994), whereas *H. edulis*

is more abundant in deeper water of the fore-reef area (Uthicke, unpublished data). In several populations of *H. atra,* asexual reproduction is the main means of population size-maintenance (Ebert, 1978; Chao et al., 1993). Seasonal fluctuations in fission frequency were reported for *H. atra* (Harriot, 1982; Conand, 1989 and 1996) and *H. parvula* (Emson & Mladenov, 1987). Chao et al. (1993) were the first to demonstrate that *H. atra* has a distinct seasonal periodicity, with a peak activity between July and September in Taiwanese populations; no information on fission periodicity of *H. edulis* and *S. chloronotus* is available.

In this investigation, asexual reproduction of *Holothuria atra*, *H. edulis* and *Stichopus chloronotus* was monitored for 18 months on several reefs of the GBR to determine the seasonality of fission, spatial differences in fission frequency and the proportion of the populations reproducing by fission.

Results of the Rumphius Biohistorical Expedition to Ambon (1990). Part. 4. The Holothurioidea (Echinodermata) collected at Ambon during the Rumphius Biohistorical Expedition.

by C. Massin

Source: *Zool. Verh. Leiden* 307, 23-12-1996: 1–53, figs 1–35.

During the Rumphius Biohistorical Expedition (4 Nov. – 14 Dec. 1990) 52 specimens representing 27 holothurian species were collected. All the species are described, figured and discussed systematically. Six species are new to the fauna of Ambon; two of these are new to the fauna of Indonesia, and two are new species: *Afrocucumis stracki* and *Chiridota smirnovi*. The holothurian fauna of Ambon is now represented by 59 species.

Ammonium excretion by holothurians enhances production and turnover of benthic diatom communities

by S. Uthicke [1, 2] and D.W. Klumpp [2]
1. Institut fuer Hydrobiologie und Fischereiwissenschaft, 22959 Hamburg, Germany
2. Australian Institute of Marine Science, PMB No. 3, Townsville MC Qld 4810, Australia

Source: *Proc. 8th Int. Coral Reef Symp*. 1: 873–876. 1997

In this paper the effects of holothurian excretion products on microphytobenthos communities dominated by benthic diatoms are examined. Production and biomass of these communities was measured in treatments with elevated ammonium levels and compared to control aquaria with low nutrient levels. Elevation in ammonium level was produced by excretion of holothurians. Even slightly increased ammonium levels (1.1 mmol NH_4 above the background level) led to a 31 per cent increase in total pigment concentrations (chl. a + phaeopigment), but chlorophyll a as indicator for living biomass was not enhanced. Area specific production increased 34 per cent within 8 days in the enhanced treatments. The nutrient enhancement led to significantly higher maximum gross production (P_{max}), initial slope (a) and daily net-production, but did not alter the saturation point (I_k) and the compensation point (I_c).

Growth of juvenile *Actinopyga mauritiana* (Holothuroidea) in captivity

by Christain Ramofafia, Timothy P. Foyle & Johann D. Bell
International Centre for Living Aquatic Resources Management, Coastal Aquaculture Centre, P.O. Box 438, Honiara, Solomon Islands

The growth of juvenile (less than 10 g) *Actinopyga mauritiana* was examined at three different levels of stocking biomass; low (26 g/m^2), medium (130 g/m^2), high (260 g/m^2), and two 'feeding regimes' (removing or not removing faeces from grow-out tanks) for 12 months. Growth was monitored monthly using 'fresh weights', which were taken after maximum contraction and expulsion of cloacal water. Mean growth was highest at low stocking biomass (10.4 g fresh weight per month ± 1.49 S.E.), but ceased once total biomass reached 250–300 g/m^2. Growth at medium stocking biomass was much reduced compared to that at low biomass, and reduced growth at high levels, was due to overgrazing of suitable algal food. Leaving faeces in grow-out tanks increased growth significantly once algal food became limiting indicating that fae-

ces can provide supplementary nutrition for *A. mauritiana* in captivity, probably via greater availability of bacteria. We conclude that juvenile *A. mauritiana* caught from the wild have potential for culture if individuals are stocked initially at around 26 g/m^2.

Ovarian Development in the Class Holothuroidea: a Reassessment of the 'Tubule Recruitment Model'

By M.A. Sewell[1], P.A. Tyler[2], C.M. Young[1], and C. Conand[3]

1. Department of Larval Ecology, Harbour Branch Oceanographic Institution, 5600 U.S. 1 North, Fort Pierce, Florida 34946;
2. Department of Oceanography, University of Southampton, Southampton SO17 IBJ, United Kingdom;
3. Laboratoire de Biologie Marine, Université de La Réunion, 97715 Saint-Denis Cedex, La Réunion, France

The 'tubule recruitment model' for the development of the holothurian gonad was proposed (a) to connect the stages of oogenesis with ovarian morphology in holothurians throughout the reproductive season and (b) to emphasise the potential for the holothurian ovary as a model system for cytological and biochemical study of echinoderm oogenesis. To reassess the evidence for this model, we have examined published accounts and unpublished observations on gonad development in holothurians from both temperate and tropical habitats, in shallow water and in the deep sea. A very limited number of species were found to conform to the predictions of the tubule recruitment model. The patterns of gonad development vary substantially in holothurians, even at the individual level, and with taxonomic position, geographical location, and habitat. The tubule recruitment model can be applied to only a small subset of holothurians, specifically those in the families Stichopodidae and Holothuridae that have gonad morphology similar to that of *Parastichopus californicus*. However, the tubule recruitment model is invalid for many other aspidochirotes, and does not have wider applicability within the class Holothuroidea. To recognise unifying patterns of reproduction and to assist in the development of robust theory (Giese et al., 1987). An example is the 'tubule recruitment model' proposed by Smiley (1988) to describe gonad development in the class Holothuroidea (phylum Echinodermata). This conceptual model, based on a careful and impressive study of ovarian development in the aspidochirote sea cucumber *Parastichopus californicus*, was proposed to connect the stages of oogenesis with the ovarian morphology of holothurians throughout the reproductive season (Smiley, 1988, 1994; Smiley et al., 1991), and to accentuate the usefulness of the holothurian ovary as a model system for cytological and biochemical study of echinoderm oogenesis (Smiley, 1988, 1990, 1994; Smiley et al., 1991).

Since the tubule recruitment model was first published, several studies have documented apparent exceptions to the model. Moreover, our own work with a variety of holothurians from throughout the world, and from depths ranging from the intertidal zone to the deep sea, casts additional doubt on the broad applicability of the model. Here we re-examine both the published literature and our own unpublished data to test the applicability of the tubule recruitment model to the class Holothuroidea in general, and particularly to the aspidochirote holothurians.

Other noteworthy publications

BALLMENT, E., S. UTHICKE, L. PEPLOW & J. BENZIE. (1997). Techniques for enzyme electrophoretic analysis of the holothurians, *Holothuria atra* and *Stichopus chloronotus* (Holothuroidea: Aspidochirotida). AIMS Report, Number 27, 1997.

BATTAGLENE, S.C. & J.E. SEYMOUR. (in press). Detachment and grading of the tropical sea cucumber sandfish, *Holothuria scabra*, juveniles from settlement substrates. Aquaculture.

CHAMBERS, M.R. (1989). A survey of the beche-de-mer of Vanuatu. **In:** T. Done & K.F. Navin (Eds), The marine resources of Vanuatu (165 p.), Australian Institute of Marine Science, Townsville: 107–114.

FORBES, R. & M. BAINE. (eds.) (1988). A Field Guide to the Sea Cucumbers of Malaysia (Working Document). Pub. Heriot-Watt University. 42 p. *(International Centre for Island Technology, Heriot-Watt University, Stromness, Orkney, Scotland, and Institut Penyelidikanan, Jobatan Perikanan Malaysia, Pulau Pinang, Malaysia. The final guide will be available soon. Orders to Mark Baine: Mark@icit.demon.co.uk; fax +44 1856 851349)*

GRIFFIN, N. (1997). Sea cucumbers in the frame, report on the uses for this Asian delicacy, now being caught off North America. Seafood International, September 1997. 75.

LAMBERT, P. (1996). *Psolidium bidiscum*, a new species of sea cucumber from the northeast Pacific Ocean (Echinodermata: Holothuroidea) . Can. J. Zool 74: 20–31.

LAMBERT, P. (in press). Sea cucumbers of British Columbia – Including southeastern Alaska and Puget Sound. University of B.C. Press. Vancouver.

RASOLOFONIRINA, R. (1997). Écologie, biologie et pêche de deux espèces d'holothuries aspidochirotes *Bohadschia vitiensis* et *Holothuria scabra versicolor* au Grand Récif de Toliara. DEA de l'Université de Toliara (Madagascar), 1997.

SEWELL, M.A. (1996). Mortality of pentactulae during intraovarian brooding in the apodid sea cucumber *Leptosynapta clarki*. Biol. Bull. 190: 188–194.

SEWELL, M.A., A.S. THANDAR & F.-S., CHIA. (1995). A redescription of *Leptosynapta clarki* Heding (Echinodermata: Holothuroidea) from the northeast Pacific, with notes on changes in spicule form and size with age. Canad. J. Zool. 73: 469–485.

Workshops and meetings

'Friends of the echinoderms'

Regional echinoderm meeting to be held at The Wallops Island Marine Science Consortium, Wallops Island, Virginia, USA, from 16–19 August 1998.

Contact:

Thomas Scott Klinger, Ph.D.
Professor at the Department of Biology
and Vice President for Academics Marine Science
Consortium, Inc.
Bloomsburg University
400 East Second Street
Bloomsburg, PA 17815–1301
USA

Phone: +1 717 389 4118
Fax: +1 717 389 3028
E-mail: tklinger@bloomu.edu

Fifth European Conference on Echinoderms

Milano, 7–12 September 1998
University of Milano, Department of Biology 'Luigi Gorini'

Contact:

M. Daniela Canadia Carnevali, Chair, 5th ECE
Dipartimento di Biologia 'Luigi Gorini'
Universita degli Studi di Milano
Via Celoria, 26, 20133 Milano, Italy

Phone: +39 2 26604465
Fax: +39 2 26604462
E-mail: cndmdn@imiucca.csi.unimi.it

Organising committee:

Chair: M. Daniela Candia Carnevali

Members: Francesco Andrietti
Francesco Bonasoro
Erminio Giavini
Giulio Lanzavecchia
Giulio Melone

Pre-registration form (To receive the Second Circular)

5th European Conference on Echinoderms
Milano, 7–12 September 1998

Name:
Address:
Telephone:
Fax:
E-mail:

For organisational reasons please answer the following questions (preliminary survey only):

- I plan to present a contribution in the form of:
  an oral contribution; a poster.
- My contribution relates to the following topic:
  Functional Biology; Physiology; Reproductive Biology; Developmental Biology; Paleontology; Ecology; Behaviour.
- If possible, I would like to stay in a:
  university residence; hotel.

Send your pre-registration form to:

Prof. M. Daniela Canadia Carnevali
Dipartimento di Biologia 'Luigi Gorini'
Universita degli Studi di Milano
Via Celoria 26
20133 Milano
Italy

Date for next International Echinoderm Conference

Dear fellow echinodermologists

Those of you who were at the San Francisco meeting, and attended the general meeting at the end of the conference, will remember that we decided that the next international conference would be held at the University of Otago, Dunedin, New Zealand in late January or early February, 1999.

Although February is not ideal for those teaching in academic institutions in the Northern hemisphere, it is the best timing for a conference in New Zealand. As it is just before the start of our academic year, all the necessary University facilities, lecture theatres, halls of residence etc., will be open and available, and the weather is generally pleasant in southern New Zealand in February (I anticipate that most people travelling to New Zealand will wish to spend some time enjoying the spectacular scenery in this part of the world before or after the conference).

Since deciding on February 1999, however, I have had a letter from Maria Daniela Canadia Carnevali, the organiser of the next European echinoderm conference, to be held from 6–11 September 1998, in Milan. Daniela is very concerned that the European and New Zealand conferences have been scheduled so close together and feels that many people, especially those from Europe, will be unable to obtain the funding to attend both meetings.

Since receiving Daniela's letter I have consulted several members of the organising committee for the next IEC, and other potential participants from the USA, UK and Europe. All agree that it would be better to have a greater gap between the two meetings, and so I have decided to postpone the New Zealand conference for one year. The date of the next IEC therefore becomes early February of the year 2000. I apologise for this change of dates, however I would like as many people as possible to come to New Zealand and enjoy our southern hospitality.

I will send out further notices at least a year, or possibly longer, before the conference, and if there is sufficient interest I will set up an information page on the Web.

8 June 1997

Mike Barker
Conference Organiser, IEC 2000
Department of Marine Science
Portobello Marine Laboratory
P.O. Box 8
Portobello, Dunedin
New Zealand
Phone: +64 3 4781820
Fax: +64 3 4781825
E-mail: mike.barker@stonebow.otago.ac.nz

correspondence
beche-de-mer

From: Rabia Abdula

Instituto de Investigacao Pesqueira (IIP), Av. Mao Tse Tung No. 389, C. Postal 4603, Maputo, Mozambique
Phone: 258 1 490307; Fax: 258 1 492112

With the co-ordination of the Eduardo Mondlane University (Mozambique), I will be conducting study on the reproduction and growth of *H. scabra* at Inhaca island (Mozambique). We have some problems with the methodology to be used; can you please suggest an appropriate methodology for this study? I have also been unable to find someone to give me a short course about holothurians; could you please send me some addresses of institutions that study holothurians? Regards.

From: Kriton Glenn

E-mail: glenn@basins.anu.edu.au

Date: 20 June 1997

At the 8th Coral Reef Symposium, I met people working on holothurians, and I would like to get some information about eating habits. I am hoping that someone can assist me. Also, I would like to get some information on the international trade of holothurians. Is there any data on this and where could I find it? I am working on Ashmore Reef on the north-west shelf of Australia for my thesis. This reef is protected by Australia from Indonesian fishermen, but they still poach the Trepang. My study is on the sediments of the reef and the pressures that affect them. When I was looking at the forams, I noticed an 'etching' that was non-preferential and all over the foraminifera. I am also trying to get this reef listed as a genetic bank by the United Nations, as it has the highest species diversity of sea snakes in the world. Additionally, it has a very high species diversity of fish and corals.

From: Mark Baine

E-mail: mark@icit.demon.co.uk

Date: 9 October 1997

Subject: Corruption in Galapagos. Forwarded from gdavis@fcdarwin.org.ec

Date: 29 September 1997

There were two articles of interest this weekend concerning the auction of the boat *Magdalena*, which was used for the illegal transport of sea cucumbers and was seized earlier this year. One article was in *El Universo* on 27 September; the other, in *El Comercio* on the same date, is longer and translates into English as follows:

'Allegation: In the case of the boat *Magdalena Galapagos*: the people accuse the Second Judge'

Protests against corruption have reached the Galapagos Islands. Representatives of all the associations of workers and professionals in the archipelago marched against the Second Civil Judge, Alberto Avellan. The people accuse him of irregularities that range from extortion, bribery, and abuse of trust to corrupt practice in the management of the judgement on the embargo of the boat *Magdalena*, detained when it was being used to transport sea cucumbers to the continent. A report by members of the Navy and park wardens of the National Park indicates that it was carrying 40 000 sea cucumbers. Its six crew members were also detained for investigations on 6 March 1997.

The boat was going to be auctioned on 19 September, according to a decision issued in April by the judge of the first instance, Eliecer Cruz, director of the Galapagos National Park, in a Forestry law suit initiated at the beginning of this year. Nevertheless, accepting the appeal presented by the ex-owners of the boat, Avellan suspended the auction of the boat. The astonishment in the populace grew when it learned of the accusation by the legal advisor of the Galapagos National Park, Patricio Carrion, who stated that the judgement left the Second Civil Court in the hands of the lawyer Luz Maria Pico Diaz, defence lawyer for the owners of the boat.

This was confirmed by means of a police operation requested by Carrion over the weekend. During this operation, Pico was surprised within the office of the Notary Public of the Canton of Santa Cruz, together with Jose Rivadeneira and Etelvina Pozo, owners of the boat, working on the computer of the Notary, Marco Montalvo, with the judgement in their hands. There is an accusation, number 418-97, addressed to the president of the Higher Court in Guayaquil, asking for Avellan's removal. With regard to the lawyer Luz Maria Pico Diaz, she was removed previously as a criminal judge in Guayaquil by the Supreme Court of Justice due to various improprieties.

From: Rabindra Singh (Mr)

Biology Department, University of New Brunswick, P.O. Box 5050, Saint John, N.B. Canada E2L 4L5
Phone: +506 648 5629/5565, Fax: +506 648 5650

I have been in touch with you before to request reprints of your papers. I am in the final stages of my Ph.D. and I am thinking of applying for a Natural Science and Engineering Research Council of Canada scholarship/fellowship to study in a foreign laboratory. I am wondering if there are research projects that you may have, or are aware of, on echinoderm research. I have been studying feeding in the northern sea cucumber *Cucumaria frondosa*, but I am willing to expand my research area to other interesting projects. Any info you can share will be appreciated.

From: Jennifer Carter

Northern Territory University in Darwin, Australia; E-mail: j_carter@gis.ntu.edu.au

Jennifer has started a Ph.D. programme investigating 'Aspects of sandfish ecology in the Top End (Australia): implications for harvesting by Aboriginal communities'.

This project primarily involves surveying parts of the northern Australian coastline for sandfish abundance and distribution for stock assessment. In the past some 1700 to 1900 Aboriginal people of northern Australia were involved in the collection of trepang to supply Macassan (from what is now Sulawesi) traders who sailed to northern Australian waters every wet season (November to March in Darwin). Many communities are interested in resuming this activity to help attain partial economic independence. Survey methods involve intertidal walks, boat transects and an underwater video camera. The water is very murky, and a small beam trawl will probably also be used to assist with obtaining results in the more turbid areas. Sediment samples have been taken, which will be analysed for particle size and input into a GIS, along with other parameters such as distance to mangroves, reefs, freshwater outflow etc. (with remote sensing and GIS modelling) in an attempt to characterise habitats.

Sandfish are currently being fished by non-Aboriginal fishers and the project will also probably involve biomass dynamics modelling of fishers log-book data (providing I obtain their permission) to get an idea

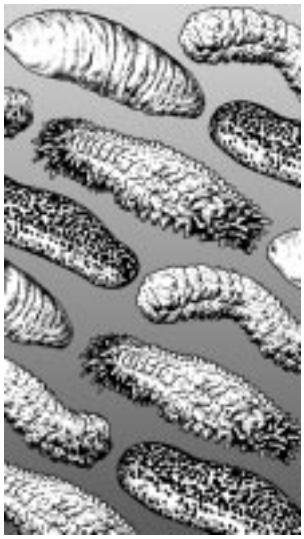
of sustainability and to relate what has happened in areas that have been fished to the densities I obtain in other areas. Hopefully this research will help to develop sustainable use strategies.

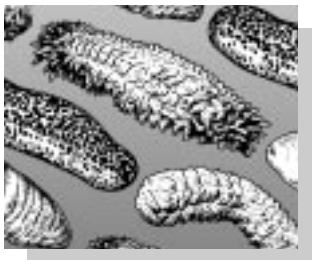
From: Heather Galley (*Secretary and Treasurer*)

Queensland East Coast Beche-de-mer Industry Association, P.O. Box 262, Bundaberg, QLD 4670, Australia
Fax: +61 7 4126 8111, Email: hjg@ozemail.com.au

Would you be so kind as to advise what the prerequisites for becoming a member of PIMRIS are, whether our association could in fact join and what the membership fees are.

Mr Garry Preston recently addressed a meeting of our Association in Cairns, North Queensland and presented some excellent publications, namely *SPC Beche-de-mer Information Bulletin,* Number 9 - March 1997, a publication by the South Pacific Commission; and FAO Fisheries Technical Paper 272.2, Part 2, Holothurians. If at all possible we would like to avail our association of the first eight issues of the bulletin and would appreciate your advice as to where we would obtain same. We would also like to convey our congratulations on your publication and our appreciation for the information it contains. So little is available in Australia, and our members were most interested in and very keen to obtain personal copies of these publications.





new members
beche-de-mer

Francisco Alonso Solis-Marin
Laboratorio de Sistematica y Ecologia de Equinodermos
Instituto de Ciencias del Mar y Limnologia
Universidad Nacional Autonoma de Mexico
Mexico
Phone: +52 622 58 02
Fax: +52 616 07 48 or 616 27 45
E-mail: fasolis@mar.icmyl.unam.mx

William Allison (Bill)
Ma. Maadheli
Majeedhee Magu
Male 20-03
Maldives
E-mail: lintel@dhivehinet.net.mv
(Organisation: Lintel & Fashan)

Dr Jim T. Luong-Van
Faculty of Science
School of Biological and Environmental Sciences
Casuarina Campus, Buiding 40
Darwin 0909, Northern Territory
Australia
Phone: +61 8 89 46 6718
Fax: +61 8 89 46 6690
E-mail: jluongva@darwin.ntu.edu.au

ARC DE MER NV
Kalmansputtewegel 14
9940 Ertvelde-Evergem
Belgium
Phone: +32 9 3430998
E-mail: mosselman@innet.be

ARC DE MER LANKA (PVT) LTD
Tappa Watta
Talarambe
Kamburugamuwa
Sri Lanka
Phone: +94 41 26037
E-mail: wvillems@sri.lanka.net

Professor Michael Thorndyke
Director of Research
School of Biological Sciences
Royal Holloway, University of London
Egham, Surrey TW20 0EX
United Kingdom
Phone: +44 1784 443766
Fax: +44 1784 470756
E-mail: m.thorndyke@rhbnc.ac.uk

Kumiko Okamoto
Department of Fisheries and Marine Resources
P.O. Box 1066
Lelu
Kosrae, FM96944
Federated States of Micronesia
Phone: +691 370 3031
Fax: +691 370 3362
E-mail: kumiko@mail.fm

Professor Hitoshi Kitamura,
Faculty of Fisheries, Nagasaki University
Bunkyo-machi
Nagasaki 852
Japan
Phone: +81 958 47 1111 (ext. 3152)
Fax: +81 958 44 3516
E-mail: kitamura@net.nagasaki-u.ac.jp

Ginny Eckert
Department of Ecology
Santa Barbara
California, 93106 9610
USA
E-mail: eckert@lifesci.ucsb.edu

Patrick Bryan
Fisheries Supervisor
Division of Fish and Wildlife
POB 10007
Saipan, MP 96950
Northern Mariana Islands

Adelaida K. Semesi
Centre of Environment and Development
Studies, Noragric
P.O. Box 5001
N-1432 AS
Norway

Dr Ron Johnstone
Sida Marine Program
Zoology Dept.
Stockholm University
10691 Stockholm University
Sweden
Tel: +46 8 164002
Fax: +46 8 167715
E-mail: Ron.Johnstone@Zoologi.su.se

Clive Migosi Anguenyl
KMFRI
P.O. Box 81651
Mombasa
Kenya

Dr Yunus D. Mgaya
University of Dar Es Salaam
Dept. of Zoology and Marine Biology
P.O. Box 35064
Dar Es Salaam
Tanzania

Saleh S. Osman
Ministry of Agriculture
P.O. Box 159
Zanzibar
Tanzania

Dr M. Miosera
Institute of Marine Science
P.O. Box 668
Zanzibar
Tanzania

A.T. Kamukum
Fisheries Officer
Kunduchi Marine Fisheries Institute
P.O. Box 60091
Dar Es Salaam
Tanzania

G.C. Mahika
Fisheries Research Officer
Tafiri
P.O. Box 9750
Dar Es Salaam
Tanzania

Serge Andrianjatovo
Président de ONET
III R 603 Tsimbazaza
101 Antananarivo
Madagascar

Address change:

Jean-François Hamel & Annie Mercier
Société d'exploration et de valorisation de l'environnement (SEVE)
1003 Chemin de la Montagne
Orford (Québec)
Canada J1X 3W3
Phone/fax: +1 819 843 7005
E-mail: seve@sympatico.ca

PIMRIS is a joint project of 5 international organisations concerned with fisheries and marine resource development in the Pacific Islands region. The project is executed by the Secretariat of the Pacific Community (SPC), the South Pacific Forum Fisheries Agency (FFA), the University of the South Pacific (USP), the South Pacific Applied Geoscience Commission (SOPAC), and the South Pacific Regional Environment Programme (SPREP). Funding is provided by the Canadian International Development Agency (CIDA) 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.