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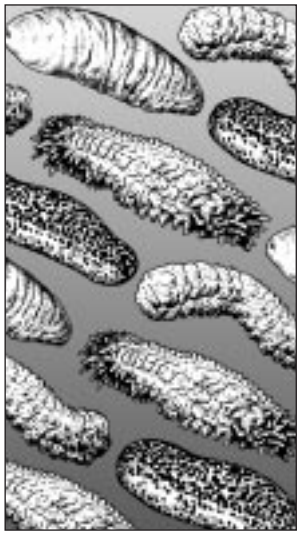

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Editorial

Dear readers,

Here is the 12th edition of the Bulletin which has been issued more quickly than usual as enough information had been received to advance its publication date.

I would like to take this opportunity 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.

The presentation is still by section, i.e. 1) New Information, 2) Publications, 3) Correspondence. Do you find this satisfactory?

- Which section should be given more space?
- In the 'New Information' section, how do you find the parts on 'In situ spawning observations' and 'Observations of asexual reproduction through fission'? Your contributions on these topics are important; would you have any related submission that could be included in the next issue?
- The column 'Aquaculture' has been continued thanks to the collaboration of S. Battaglene from ICLARM. Do you find it useful?
- Are there any other new parts that you would like to include?

Your suggestions and comments are both useful and necessary for the Bulletin's development.

Bulletin no. 12 includes an original article about international markets (p. 11). An important conference took place in Malaysia (p. 2). Many different aspects of the biology of marketable species and genetics, a new area, (p. 18) are also discussed.

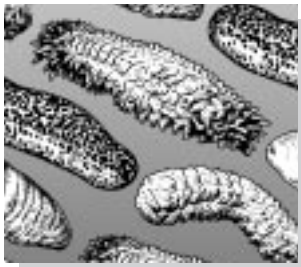
Previous issues of the Bulletin are now available on the SPC Web-site at http://www.spc.org.nc/coastfish (clik 'Newsletter' in the menu).

Inside this issue

The next International Echinoderm Conference will be held in New Zealand at the beginning of the year 2000. Its site is:
http://macintosh.otago.ac.nz/iec2000

The Echinoderms Newsletter is now also available at: http://www.nmnh.si.edu/iz/echinoderm

Chantal Conand



new info
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The Conservation of sea cucumbers in Malaysia, their Taxonomy, Ecology and Trade: International Conference

Bilik Mesyuarat (2nd Floor), Ministry of Agriculture, Wisma Tani, Jln. S. Salahuddin, 25 February 1999.

Agenda included the following presentations:

- Holothurian fisheries, an overview with emphasis on the SE Asian region (Professor Chantal Conand, Univ- Reunion, Reunion)
- Holothurian culture, An overview and future prospects (Dr. Stephen Battaglene, ICLARM, Solomon Islands)
- Holothurian fisheries and trade in Thailand (Dr. Somchai Bussarawit and Ms. Nalinee Thongtham, Phuket Marine Laboratory, Thailand)
- Reproductive biology in the population of Stichopus variegatus from the Johore Islands (Dr Zulfigar Yasin, Universiti Sains Malaysia)
- Species of sea cucumber in Pulau Besar Johor (Siti Zaamar et al., Universiti Sains Malaysia)
- The taxonomy and ecology of Holothurians in Malaysian waters (Mr Bobby Forbes, Heriot-Watt University, Scotland and Mr. Zaidnuddin Ilias, Fisheries Research Institute, Malaysia)
- Holothurian fisheries and trade in Malaysia (Dr. Mark Baine, Heriot-Watt University, Scotland and Ms. Choo Poh Sze, Fisheries Research Institute, Malaysia)
- Towards a Holothurian conservation and management strategy for Malaysia (Ms. Choo Poh Sze, Mr. Bobby Forbes, Dr. Mark Baine and Mr. Zaidnuddin Ilias)
- Expert Panel Presentation (Prof. Chantal Conand and Dr. Stephen Battaglene).

Expert panel presentation

by Pr C. Conand & Dr S. Battaglene

Concluding remarks presented at the end of the Conference

1. The presentations have shown that much progress has been achieved in a field where previous knowledge was very low. First looking at the 'sea cucumber fishery system' as a whole, it appears that the collaboration has been very effective between the different partners, scientists from the universities and the fishery departments. Further developments should tend towards a co-management involving also fishermen and traders. The 'sea cucumber fishery system' should be taken as an example of co-management for one particular resource of reef communities, and consequently be included in the various programmes focusing on reef monitor-

ing and rehabilitation. Some sea cucumber species could be taken as indicators of the state of the reef.

2. Major progress has been made on the taxonomy and ecology of sea -cucumbers in Malaysia, which is located within the highest biodiversity areas of the world. Despite the difficulties of their taxonomy, 37 species have been determined, a few others still remain to be identified or described if they appear as new to the science. A collection of underwater photographs of the sea cucumbers in their characteristic habitat has been constituted. With the increase of interest during the last decade given to biodiversity, sea-cucumbers appear as a group of macro-invertebrates where many large species, commun in shallow waters, are yet to be described.

3. Despite an important increase of interest during the last decade, by the scientific community, the managers and the users, it has appeared that further studies are needed on different aspects to enable sustainable exploitation of sea cucumbers. They should first focus on biology and ecology of the species, in Malaysia as well as on a regional basis, as there are many interactions with the neighbouring countries, Thailand and the Philippines for example. The life-history traits and the ecology of the populations of many of the commercial species are yet mostly undescribed in the region. Very little is known concerning recruitment, growth and mortality of most species; in general, these species appear as slow-growing and very vulnerable and constitute therefore fragile stocks. More research intended to quantify the population parameters is still necessary. Stock assessments are also needed, but the ressource seems to be already severely depleted although the situation is variable in the different zones in Malaysia. Solutions appropriate to each case have to be found.

4. As far as the trends in fisheries and trade are concerned, it appears that the number of producing countries has recently increased worldwide, both in tropical and temperate regions, but the tonnages are still incompletely recorded. The situation in Malaysia appears to be particularly difficult, the country been at the same time importer, consumer, producer and exporter. It remains important to better collect and standardise the statistics at the different levels of the 'holothurian system'. It is also important to emphasise the importance of the processing methods, to make the activity profitable. The recent conflicts appearing within, or between, several countries might be interpreted as signs of overexploitation of the resource, and of a high level of demand. The management has to be appropriate for each case. The question of fishery regulations has been debated; if fishery regulations are to be taken, it is very important to watch over their application. The present depletion of most stocks has been noticed.

5. Development of a regional network, dealing with the same set of species and fishery context, has been requested during the meeting; it can be achieved through e-mail, or other media. It will help to circulate the information on the different aspects of the subject.

Abstracts from papers presented during the Conference

World sea-cucumber exploitation and the market for trepang: an overview

Chantal Conand
Laboratoire d'Ecologie Marine, Université de La Réunion, Saint-Denis, France

Characteristics of the morphology, anatomy and biology of sea cucumbers, particularly the commercial species used to prepare *trepang* (or beche-de-mer) are presented as an introduction, before an overview of the complex 'fishery system'. The main world fisheries, tropical and temperate, traditional and contemporary and their recent catches are analysed. There is an increase of interest in this commercial resource, many recent fisheries witnessing conflicts in relation to conservation needs. The processed product generally passes from the producer country to the main world markets, Hong Kong, Singapore and Taiwan, before being imported to the consumer countries. From different indices, overexploitation is becoming more and more noticeable worldwide as the demand for *trepang* increases. Sustainable management should become a priority and regulations should be adapted for these fisheries. In conclusion, further studies should develop a greater understanding of the fisheries biology of the commercial species; stock assessments; improving available statistics on catches and markets; and the development of alternative measures for con-

servation based on mariculture techniques. Despite an increasing interest, these fields are poorly understood, yet they deserve more attention as their social value in small artisanal activities is high.

Culture of tropical sea cucumbers for the purposes of stock restoration and enhancement

Stephen C. Battaglene
International Center for Living Aquatic Resources Management, Coastal Aquaculture Centre (CAC), Honiara, Solomon Islands

Severe over-fishing of sea cucumbers has occurred in most countries of the tropical Indo-Pacific. The release of cultured juveniles is being examined at the ICLARM Coastal Aquaculture Centre in Solomon Islands as a means of restoring and, eventually, enhancing tropical sea cucumber stocks. Sandfish (*Holothuria scabra*) are the tropical species with the most potential for stock enhancement. Sandfish are of high value, widely distributed and relatively easy to culture in simple systems at low cost. This paper summarises what is known about the culture of *H. scabra* and compares it to that of the temperate species *Stichopus japonicus*. Sandfish live in high-nutrient environments at densities of hundreds per hectare. They have reproductive peaks in September and October, but can be induced to spawn year-round. Increases in water temperature and addition of powdered algae are effective ways of inducing spawning. *Chaetoceros muelleri* and *Rhodomonas salina* are two of the better micro-algae for feeding the larvae. Sandfish larvae are more robust and easier to rear than those of other tropical species. Larvae metamorphose into juveniles after 2 weeks at 28°C and settle on 'diatom-conditioned' plates. ICLARM has produced over 200,000 juveniles from six separate spawnings. Sandfish can be reared on hard substrates until they reach 20 mm in length and are then best transferred to sand substrates. Absolute daily growth rates for juvenile sandfish averaged 0.5mm day^{-1} ((0.03 s.e.) and ranged from 0.2 to 0.8 mm day^{-1}, depending on stocking density, light intensity and addition of powdered algae. Overall, there are good reasons to believe that sandfish can be produced cost-effectively for the purposes of restocking and stock enhancement. The potential for using cultured juveniles to manage fisheries for sea cucumbers now depends on the development of strategies to optimise the survival of juveniles released into the wild, and to evaluate commercial-scale releases.

Sea cucumber fisheries and trade in Thailand

Somchai Bussarawit & Nalinee Thongtham,
Phuket Marine Biological Center, Phuket, Thailand

Sea cucumbers are ecologically and commercially important. Used in the production of beche-de-mer (*trepang*), in Thailand they are collected both in the Gulf of Thailand and the Andaman Sea for local consumption and for the export market. The decrease of sea cucumbers in their natural habitat, however, has raised concern and prompted the Ministry of Agriculture and Cooperatives to request the Department of Fisheries for information on the present status of the sea cucumber fishery in Thailand. From the study, a list is provided of species diversity and commercial use of sea cucumbers found in Thai waters. Of the species occurring on sea grass, reef flats and reef slopes, the sea cucumbers used in the production of beche-de-mer are *Holothuria scabra*, *H. atra*, *H. leucospilota*, *Stichopus chloronatus*, *S. variegatus*, *Bohadschia marmorata*, and *B. argus*. Further research is necessary to study the taxonomy, biology and ecology of sea cucumbers in order to properly assess restocking and conservation in Thai waters.

Species of sea cucumber found in Pulau Besar, Johor, with special emphasis on the genus *Stichopus*

Siti Zaama Rizal Boss, Zufigar Bin Yasin & Aileen Tan Shau-Hwai
Unversiti Sains Malaysia, Pulau Pinang

A preliminary survey was completed in Pulau Besar, Johore to list the species of sea cucumber found in the island. Three genera and seven species of sea cucumber were found in the study area, with four species from the genus *Stichopus* yet to be identified. The characteristics taken into account for taxonomic consideration are presented in this paper. The number of species from the genus *Stichopus* is higher than the number of species from other genera of the same order. *Stichopus* is are considered the dominant genus in the study area.

The taxonomy and ecology of sea cucumbers in Malaysia

Bobby Forbes [1] *& Zaidnuddin Ilias* [2]
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During the period July 1996 to December 1998 six surveys were carried out in Peninsular Malaysia and Sabah in order to determine species presence, abundance and distribution. A total of 148 sites were surveyed and the biological habitats and relative abundance of sea cucumber species described at each. Thirty-seven species of sea cucumber have been described with a further six species requiring verification. Species abundance, although relatively high at most locations, displayed considerable patchiness. The *Stichopus horrens* was rare at Pulau Langkawi, the site of a traditional fishery and failed restocking trials. There were temporal variations in species abundance at two sites although it was unclear from the data if these were the result of a true seasonal variation.

Sea cucumber fisheries and trade in Malaysia

Mark Baine [1] *& Choo Poh Sze* [2]
1. *Heriot-Watt University, Orkney Islands, Scotland*
2. Institut Penyelidikan Perikanan, Pulau Pinang, Malaysia

Through an examination of existing statistical data on sea cucumber trade and qualitative discussion on historical and present fisheries (both communicated and observational), this paper provides an analysis of the current situation with respect to fisheries management, suggesting possible areas of future consideration in the development of a conservation and management plan for holothurians in Malaysia. There currently exists no countrywide regulation in this fishery. In the wake of purported overfishing of sea cucumber populations in Langkawi, supplies from Adang, Thailand ensure the maintenance of a healthy infrastructure for the trade and processing of sea cucumbers through Langkawi. Concerns are raised, however, for the long term sustainability of such cross-border links and potential knock-on effects. Pulau Pangkor, located off the west coast of Peninsular Malaysia supports a one-man fishery aimed at *Stichopus horrens*, which, although small in associated effort, does raise the question of permissibility with respect to juvenile catches. Sabah state, in north-east Borneo supports Malaysia's largest fishery, with current fishing levels requiring review and monitoring to determine the need for regulation and management. Existing trade statistics for Malaysia are erratic and at times confusing, requiring re-evaluation of the sub-categorisation of beche-de-mer and the classification of origin of catches. A more detailed monitoring programme for Sabah is required on top of the existing, recognisably under-achieving, landing surveys.

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Sea cucumber fisheries in Malaysia, towards a conservation strategy

by Mark Baine [1] *and Choo Poh Sze* [2]

Introduction

Baine and Forbes (1998) provided some background information to the UK Darwin Initiative funded research project into the taxonomy, life history and conservation of Malaysia holothurians, which began in April 1996. This research has been completed, the results now available within a set of conference proceedings (Baine 1999). Abstracts from the conference are presented on page 4 in this bulletin and include contributions from Thailand, from experts from ICLARM (Solomon Islands) and La Reunion University, and other Malaysian researchers.

The aim of this paper is to summarise the results and recommendations of the Darwin project group in terms of the existing fisheries in Malaysia and their future management. Malaysia presents us with three contrasting case studies.

Firstly, there is Pulau Langkawi, an island off the West Coast of Malaysia and close to the border of Thailand, where it enjoys strong sea cucumber trade links with the island of Adang (see Map 1).

Secondly, there is the low-effort fishery further down the West Coast in Pulau Pangkor.

Thirdly, we have the multi-species, multi-national fishery that exists along the entire coast of the state of Sabah in Northeast Borneo(Map 2).

Pulau Langkawi

A combination of over-intensive fishing practices in Langkawi, with a purported decline in *Stichopus* spp. (referred to locally as *gamat*), and a strong market demand, led to the regular importation of sea cucumbers from Adang, Thailand during the 1990s. Although little fishing is undertaken in Langkawi waters, the demand for the product from Thailand sees existing overfished sea cucumber populations under even more pressure. This is readily identified by the encroachment of fishers into Thailand's national parks, a worrying trait identified by Bussarawit and Thongtham (1999). The level of trade between these two islands is not clearly understood with no official statistics available but discussions with local traders have indicated that each season (approximately October–April) sees the arrival of at least the equivalent of around 90 tonnes of fresh sea cucumber. These are used not only for beche-de-mer but also in the production of oils, lotions, cosmetics and tablets. This level of trade in itself raises a number of serious questions. Questions of legality, stock health and future sustainability demand immediate attention if one is to avoid a potential future collapse of the fishery in Thailand. Langkawi traders are aware of the possible ramifications of such a collapse on their industry. Here are some possible scenarios if the situation persists:

- market demand in Langkawi is met elsewhere, most likely the under-utilised fishery in neighbouring Pulau Pangkor to the south;
- market demand in Langkawi is met from within through a programme of culture and restocking;
- a combination of the above;
- the sea cucumber processing and trade industry declines in Langkawi.

The Fisheries Departments of both Malaysia and Thailand, in collaboration, should cautiously address the ecological ramifications of trade relationships between these two islands. Much of the catch landed in Langkawi is illegal and should be phased out over a set period of time. This will help allow stocks in Thailand waters to recuperate, although a system of regulation for the Thailand fishery will need to be put in place. In the meantime every effort should be made to quantify landings from Thai fishers in terms of species and their processed nature. In the long-term, agreement could be reached whereby a Thailand fishery may supply a set percentage of the Langkawi market.

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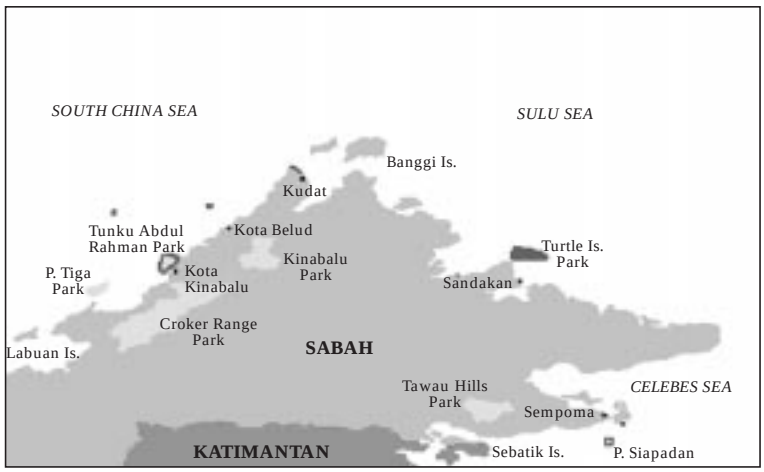
A survey of processors and traders in Langkawi should also be undertaken to produce a more detailed examination of the socio-economic importance of the industry in Langkawi.

In parallel with the above, research should be initiated into the potential for restocking Langkawi waters. This should be a joint University and Fisheries Department initiative which aims to assess the viability of supplying sea cucumbers to meet the market demand within Langkawi. The backing and involvement of processors and traders should be sought for such research, with the ultimate aim of transferring management of restocking programmes, if successful, to the community itself. It is important, however, to understand that there is a number of research prerequisites to the practical initiation of any stocking programme. For example, given the high degree of pollution in Langkawi and its as yet unquantified impact on the local environment, most notably water quality, it would be advisable to ascertain the availability of adequate food supplies for sea cucumber populations. One possibility, using Pulau Payar (a Marine Park found further south), is to identify the preferred food supply for natural populations. An assessment of their availability in Pulau Langkawi can then be undertaken, thus ensuring identification of those sites that would prove more congenial to the needs of a restocking programme.

Map 1. **Malaysia and South Thailand**



Map 2. **State of Sabah in Northeast Borneo**

It is possible that a future scenario will exist whereby the demand in Langkawi is supplied from three directions: from within through restocking initiatives, from Thailand in a trade agreement and from Pulau Pangkor as part of a managed fishery. Pulau Langkawi may yet prove to be the heart of a complex system of sea cucumber fisheries and trade in peninsular Malaysia.

It should therefore be approached as such, with careful handling of the issues and the implementation of a system of collaborative and proactive management.

Pulau Pangkor

Only one fisher targets sea cucumber populations (*Stichopus horrens*) at various sites in Pulau Pangkor, fishing by hand at low tide approximately five days in each month. He operates a submerged cage system in which he keeps up to 1000 individuals at a time. These sea cucumbers are mainly used for the collection of coelomic fluid (termed *gamat* water). Approximately 100 specimens are slit and drained to enable the production of one small bottle of this product, which is subsequently boiled. Sea cucumbers, once drained, are returned to the cage. Little is known about their survival rate after such stress. On

demand, the fisher also produces *gamat* oil and beche-de-mer, but this is not a common practice. His market is mainly local with some interest from peninsular Malaysia. This fisher appears to operate within a certain conservation ethic, however, he is unaware that a considerable portion of his catch is comprised of juveniles. Concern is levied at this, even at such low effort.

It is important that this is approached carefully and with sensitivity. Although not his sole income, the sea cucumber fishery is his main source of livelihood. It has been recommended that the Fisheries Research Institute (Institut Penyelidikan Perikanan), with input from the Universiti Kebangsaan Malaysia which has conducted related research in Pulau Pangkor, arrange a meeting with the resident fisher to discuss his targeting of *Stichopus horrens*, and to impress upon him the need to steer away from juvenile catches, thus realising long-term benefits.

If willing, the fisher will also be asked to record his catch in terms of date, weight, length, area fished and effort employed (hours fished). The Fisheries Research Institute would develop a self explanatory logbook system for this purpose. The fisher would be reassured that this is only for research and that his livelihood is not under threat. It has also been recommended that the logbook should be completed by the fisher against a background of stock assessments in the area. The combined data can then be used to determine the status of the fishery and its limits for expansion. This is considered important as there is always the risk that as supplies of sea cucumber from Adang to Pulau Langkawi become depleted or are prohibited, the market demand in Langkawi is met by increased pressure on the stock in Pangkor waters. Such stock surveys are necessary to ensure baseline information for the identification of sustainable yields. It is essential that the Pangkor fishery be monitored in line with developments in Langkawi.

Sabah

Sabah is the most significant state in Malaysia for sea cucumber fisheries. The Sabah fisheries department estimated landings at around 155 tonnes in 1995, although this is widely thought to be an underestimate. It is, however, an increase of 9.2% on the previous year's estimate. This information is collated as part of the national SMPP (Sistem Maklumat Pengurusan Perikanan) programme which is the only monitoring surveys undertaken on the state's sea cucumber fisheries as part of an overall approach to monitoring landings of all marine species. It is also unclear as to the origin of the catch. It is commonly thought that a significant proportion of the catch could be from Philippine waters. Sabah, with over 1600 km of coastline, employs no regulation on its sea cucumber fisheries, with little baseline information available on the health of the stocks, although observation does suggest a decline in some areas. There are four main fishing areas in Sabah: Kudat, Semporna, Sandakan and the West Coast (Kota Kinabalu and surrounding areas). The majority of fishing is undertaken by hand collection, free diving and trawl, the latter comprising an estimated 15% of the total catch.

Processing in Sabah is mainly a cottage-level industry involving families of collectors or middlemen (those who buy from fishers and sell the processed animal on to retailers or exporters). The dominant product from processing is beche-de-mer. A variety of species are targeted including prickly redfish (*Thelenota ananas*), teatfish (*Holothuria nobilis and H. fuscogilva*) and mainly sandfish (*Holothuria scabra*). The majority of the catch ends up in the export market, particularly when channelled through companies with factory level processing facilities.

A number of informal interviews with fishers was conducted during the course of the research. Common issues that arose included the decrease in catch compared with 3-5 years previous, an increase in effort and the lack of any community-based resource management. It must be stated that these informal interviews only relate to two island communities off Semporna in Southeast Sabah, namely Pulau Kulapuan and Bohey Dulang, and must certainly not be viewed as a widespread attitude.

In general Sabah is seen to present a host of problems in developing a workable strategy towards management of holothurian fisheries.

These include:

- the lack of Fisheries Department personnel to enforce management measures in the wide geographical area involved;
- the lack of incentive to divert manpower to this problem of limited economic importance in terms of the state's overall fishing industry;
- the lack of data relating to the origins of catch landed in Sabah, and resulting lack of clear indication statistically of which grounds are being heavily fished and what proportion of the catch originates from Philippine waters;
- the understanding that existing landing statistics are vastly underestimated and thus prove inadequately indicative;
- the above two points mean that there is little accurate baseline data available for future determination of the effects of regulation;

- the majority of the catch is undertaken by hand collection with localised cottage processing industries;
- the questions of implementability and acceptability of imposed regulations in areas where community management is dismissed; and which, against a background of a lack of true understanding of what the problems are from any regulatory body, is likely to lead to social and political repercussions.

It is therefore difficult to find an immediate solution to the problem of potential overfishing in Sabah waters. There are arguments for both a policy of strict regulation and one of no regulation, and it must be noted that the Fisheries Department has indicated its need of hard statistical data to convince it to develop a management plan for sea cucumber fisheries in Sabah. This is difficult to achieve, considering that the body that should be responsible for the collation of such statistical data is the Fisheries Department and that personnel resources and research/monitoring funds are tight given the current economic climate in Malaysia.

In recognising the difficulties facing Sabah Fisheries Department in allocating manpower to the gathering of data on sea cucumber fisheries, the research team has recommended the consideration of a minimium level of data collection. This could be achieved through the use of personnel in direct collation of data at landing ports (as is already practiced, but with increased scope) and/or through the voluntary participation of processors in a limited logbook scheme. The latter has its difficulties, particularly as much of the catch is processed at cottage industry level, which in many cases will go unrecorded. One does, however, feel that there will always be constraints on data collection in Sabah and additional conservative estimates may be required. Basic information that would be of use to future management of the fishery includes:

- catch location;
- species composition;
- method of collection;
- quantity;
- destination (where possible to avoid repetition of data from landings with that of processors).

Those processors willing to participate in a logbook scheme could record the details from their suppliers.

The situation in Sabah requires careful appraisal. If the state does not instigate a rigorous monitoring programme soon and persists in maintaining the open-access fishery that exists at present, there is a very real danger that in the next few years the situation will worsen to the point where regulation is rushed into place but too late.

Another issue in Sabah is the verve with which officials wish to install a programme of restocking (in itself an admission and realisation of the impending problem), and to this end research projects are underway. This drive has gathered momentum without the hard statistical data necessary to qualify the programme (data which, coincidentally, has been designated as of the utmost importance by the Fisheries Department in Malaysia). As things stand at present there will also be little background data available by which to measure the success of such a programme. In this instance it should be stated that a programme of restocking is not the sole answer to problems of holothurian fisheries management. It should complement a well-structured and effective management plan.

Concluding comments

This research culminated with the formation of the Malaysian Network for Holothurian Conservation and Sustainable Management (HCSM), a network comprising representatives from academia, fisheries and conservation sectors. There has been little collaboration between these different sectors over the years in addressing the problems facing sea cucumbers and their dependent industries. It is hoped that the spirit of co-operation that has developed with this research continues in the future.

Figure 1 (see next page) provides an overview of some of the issues that will need to be addressed by the HCSM. The Darwin research programme incorporated aspects of training in holothurian ecology and survey methodology which should be utilised to the full in learning more about the population dynamics of the many species that exist in Malaysian waters, particularly within the Marine Parks. Such ecological research can be complemented with an integrated approach to fisheries management in Malaysia and further afield in Southeast Asia where issues of illegal fishing and trade warrant future consideration. Depending on how circumstances develop within Malaysia, particularly in terms of the economy, it will be important for the HCSM, in its discussions and actions, to strike a balance between monitoring, regulation, research, culture and restocking. It will be difficult. A demanding task for the HCSM will be achieving prioritisation for sea cucumber research and regulation in such difficult economic times. This will need to be examined in terms of the nation's growing participation in biodiversity and biotechnology research and also with knowledge of the existence of external funding sources (including the EC pro-

gramme for scientific and technological co-operation with developing countries, the Darwin Initiative and others). Prioritisation is a large hurdle to overcome, but one must additionally not lose sight of the importance of participatory management in ensuring that any initiatives stand a chance of being successful. Inevitably there will be conflict between conservation and fishery interests. This should be anticipated and planned for.

Acknowledgements

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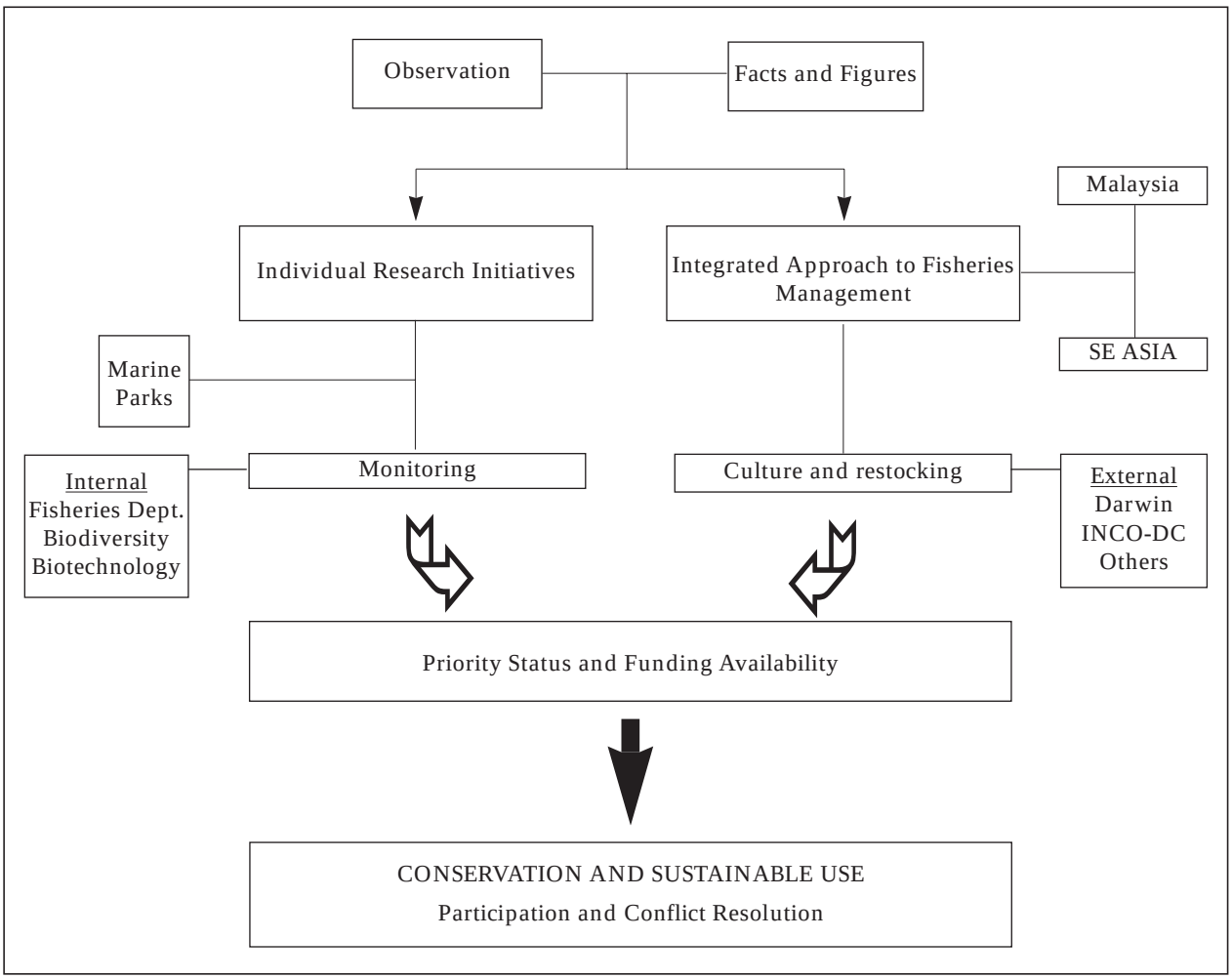

Figure 1. **A holistic approach to holothurian research and fisheries management**

The beche-de-mer trade in 1995/1996 and an assessment of exchanges between the main world markets

by S. Jaquemet[1] *& C. Conand*[1]

Introduction

The main sea cucumber markets

Hong Kong, Singapore and Taiwan are the main international beche-de-mer markets (Conand and Byrne, 1993). Hong Kong is the largest of the three and, since 1986, has imported more than 6,000 t and re-exported 3,500 t of sea cucumber annually, with import values amounting, on average, over the decade, to US$ 27 million ± 10 and re-export values to US$ 11 million ± 4. However, since 1994, imports have decreased in comparison to the early 1990s, while re-exports have risen, reaching 4,000 t in 1996 (Table 1). Hong Kong's main suppliers are Indonesia and the Philippine Islands, which together supply 40% of this market's imports. The Hong Kong market's biggest customer is China, which buys 80% of its re-exports.

Singapore is the second biggest market, but its annual imports (1100 t, i.e. a value of US$ 8.5 million ± 3.3) and re-exports (1000 t, i.e. a value of US$ 7.5 million ± 3.3) are well below Hong Kong's. Its main suppliers are Tanzania, Madagascar and Papua New Guinea; together, they account for 50% of import tonnage. Its major customers are Malaysia and, in particular, the Hong Kong and Taiwan markets.

Taiwan is third; it imports dry products (beche-de-mer) from Indonesia, Singapore and Japan and frozen products from the temperate fisheries of the North American continent. Its import tonnages are about 600 t per year for beche-de-mer and 450 t for frozen products, with respective values of US$ 3.5 and 1.8 million. There are also other smaller markets in many South-east Asian countries, which only supply the local trade (Ferdouse, 1999).

Two-way trade between the markets

Analysis of the trade statistics for the three markets reveals the existence of two-way trade in this commodity between the markets. Such exchanges can involve large tonnages and may distort actual trade statistics for these markets by causing some quantities to be counted several times. This type of trade had already been shown to exist (Conand & Byrne, 1993; Conand, 1998), but had never really been quantified in terms of worldwide beche-de-mer production.

Also, this analysis allowed an evaluation to be made of the reliability of these markets' trade statistics. Declared imports to one market from one of the other two should, in fact, be equivalent to the re-exports declared by the second or third towards the first.

This paper proposes first to present all trade between the three markets during the 1986–1996 period, in terms of both tonnages and values for the Hong Kong and Singapore markets, so as to track trade over the course of a decade and thereby determine the flow of goods and values which resulted from this trade. The trade's scale will then be compared to both a previously-assessed portion of 1995 world production (Jaquemet, 1999) and to the markets themselves.

Table 1: **Beche-de-mer trade for the three international markets in 1995 and 1996. T: tonnage, V: value in US$ million, i: imports, r: re-exports.**

	1995				1996			
	Ti	Vi	Tr	Vr	Ti	Vi	Tr	Vr
HONG KONG	5788	41.1	3907	15.5	5020	41.9	3976	18.1
SINGAPOUR	1051	13.2	759	11.5	1009	13.2	836	13.4
TAIWAN	715	4.0	34	0.6	592	3.4	25	0.5

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Method

The theoretically equivalent quantities were compared in order to evaluate the reliability of the data provided by these markets. To do this, Hong Kong's imports from Singapore markets and Singapore's re-exports to the Hong Kong market (and vice-versa) for the period 1986 to 1996 were compared by means of a Wilcoxon test. Taiwan's trade statistics were processed in the same manner in relation to data from the two other markets.

The beche-de-mer flow resulting from these exchanges was also determined for each market by calculating the differences between imports and re-exports to the other markets. This flow was then related to the market's imports and re-exports in order to estimate the extent of reciprocal trade between the markets in relation to their own activity and to world production. Values and per-kilo prices for trade between the Hong Kong and Singapore markets were also analysed so as to gain a better understanding of how important this trade was for these markets.

Results

In Table 2, data on trade between the Hong Kong, Singapore and Taiwan markets are presented in terms of import and re-export tonnages. As the Taiwan data were incomplete, the analysis mainly covers statistics from the Hong Kong and Singapore markets.

The largest amount of reciprocal trade involved the Hong Kong and Singapore markets. The statistics for these two markets did not show any significant differences (Wilcoxon at 5%) over the ten-year period between the quantities of beche-de-mer shipped to Hong Kong and those shipped to Singapore. In some years, however, there may have been significant differences between the tonnages declared by these two markets (Table 2). The differences between imports and re-exports for each market made it possible to determine that the flow resulting from this trade was positive in the Singapore-Hong Kong direction, at about 600 t per year, for the period 1986-1996.

Study of two-way traffic with the Taiwan market is more difficult, from that market's trade statistics. Many data were missing and comparison of these data to those from the other two markets showed significant differences. Study of trade between the Hong Kong and Singapore markets and knowledge of the trade statistics records in Taiwan showed that data from this market were much less carefully compiled than those from the other two markets and so were less reliable. Nevertheless, the differences in imports and re-exports between the other two markets and Taiwan were both positive, i.e. the beche-de-mer flow was towards the Taiwan market from both Singapore and Hong Kong. Over this 10-year period, Hong Kong re-exported mean annual quantities of about 250 t to Taiwan, while Singapore re-exported an average of 80 t.

In order to better understand trade between the Hong Kong and Singapore markets, it was useful to study the value of the products traded as well as per-kilo prices. These exchanges are presented in Table 3 for the 10 year period, 1986–1996.

The highest values occurred in trade involving re-exports to Hong Kong and matched the flow of beche-de-mer tonnages. For the Hong Kong market, the values of imports from Singapore represented on average 1/5 of total annual imports, while such re-exports accounted for less than 1/10 of total re-exports. For Singapore, 50% of re-export values came from trade with Hong Kong, while imports were only 5% of total annual imports. Per-kilo prices fluctuated from year to year but all increased over the decade. The highest per-kilo prices were found in re-exports to the Singapore market. The higher per-kilo prices for trade between Hong Kong and Singapore have to be considered in the light of the quality of the goods. Singapore only imported a small quantity of products from Hong Kong, but they were of high commercial value.

Discussion

Trade in these three markets in 1995 and 1996

Analysis of the Hong Kong trade statistics for 1995 and 1996 confirmed that market's position as world Leader. Import and re-export tonnages increased slightly in comparison to 1994, but remained below those of the early 1990's (Conand & Byrne, 1993). In contrast, these values have very clearly risen in recent years, as have per-kilo prices, which have quadrupled in 10 years for both imports and re-exports. This significant increase was the result of an increase in demand which supply was not able to match. Singapore's imports and re-exports also increased, in terms of both tonnage and value. Imports remained clearly below those of Hong Kong, but a constant increase in tonnages transiting through this market over the decade was observed. Since 1986, the Taiwan market has experienced relative stability in imports in comparison to the other two markets.

Reciprocal trade and world production in 1995

Study of the trade between the three international beche-de-mer markets brought about a better un-

Table 2: **Beche-de-mer exchanges (in tonnes) between the Hong Kong (HK), Singapore (SG) and Taiwan (TW) markets. *, ^: non significant difference of 5%.**

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
HONG KONG											
Imports from SG*	301	354	772	1041	1319	1308	943	756	920	695	552
Re-exports to SG^	136	100	132	55	69	111	48	62	55	39	80
Imports from TW	44	7	50	44	…	…	…	…	…	12	39
Re-exports to TW	272	327	…	…	…	…	…	…	…	364	217
SINGAPORE											
Imports from HK^	84	30	48	18	47	79	48	44	46	43	77
Re-exports to HK*	657	384	624	439	651	773	786	556	727	455	460
Imports from TW	…	201	…	3	5	3	8	0	5	10	11
Re-exports to TW	110	115	81	150	123	180	167	132	53	61	59
TAIWAN											
Imports from HK	…	6	0	6	12	5	3	7	…	1	0
Re-exports to HK	…	…	…	…	…	22	8	8	2	3	5
Imports from SG	9	2	18	36	71	149	55	34	20	30	22
Re-exports to SG	…	…	…	…	…	5	8	…	6	15	11

Table 3: **Reciprocal beche-de-mer trade between the Hong Kong and Singapore markets in terms of total values and per-kilo prices.**

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
HONG KONG											
Imports from SG											
Value (US$ 1000)	1533	2200	3430	3444	4986	4159	3594	3177	4927	4938	5871
Price per kilo (US$)	5.1	5.7	4.3	3.2	3.7	3.2	3.8	4.3	5.4	7.2	11.0
Re-exports to SG											
Value (US$ 1000)	1075	526	1016	419	712	1695	669	967	836	775	1086
Price per kilo (US$)	7.2	9.2	7.7	7.8	10.7	11.8	13.8	14.6	15.7	13.0	11.5
SINGAPORE											
Imports from HK											
Value (US$ 1000)	801	258	421	150	538	1239	692	713	590	350	780
Price per kilo (US$)	9.5	8.6	8.8	8.3	11.4	15.7	14.4	16.2	12.8	8.1	10.1
Re-exports to HK											
Value (US$ 1000)	1142	1932	3461	2305	3130	4859	4559	3883	4932	3794	4545
Price per kilo (US$)	2.2	5.0	5.5	5.3	4.9	6.3	5.9	6.9	6.7	8.3	9.9

derstanding of the role each plays in world trade. The significance of such exchanges in each market's trade in 1995 is summarised in Figure 1 (see next page) Tonnages corresponding to two-way trade are indicated in Figure 1; they have not been deducted from the markets' total imports and re-exports.

Assessment of world production in 1995 (Jaquemet, 1999) made it possible to determine that about 13,062 t of dry products were sold. Tonnages involved in reciprocal trade between markets in 1995 amounted to some 890 t, i.e. 7% of world production. The significance of this trade in terms of value is more difficult to estimate. If the US$ 60 million value proposed for 1994 (Conand, 1998) is taken as a reference figure, it is conceivable, given the development of trade tonnages, that the total value of trade in 1995 was at least US$ 80 million. In that case, total reciprocal trade between markets would account for about 10% of world val-

ues. This type of commerce, therefore, had only relative importance in the world beche-de-mer trade; it was, however, probably under-estimated as the tonnages and values reported by Taiwan were probably lower than the actual figures.

At the scale of these markets, two-way trade was more important, particularly for the Singapore and Taiwan markets.

In fact, Singapore shipped 72% of its re-exports to the Hong Kong market and 6% to Taiwan.

A total of 9.5% of Hong Kong imports came from the Singapore market and 8% of its re-exports headed for Taiwan.

Taiwan imported 42% of its beche-de-mer from Hong Kong and 6% from Singapore.

Sea cucumbers could in this way to be imported either for local consumption or for later re-exportation, depending on the market. Taiwan engaged in this trade with the other two markets in order to import products for domestic consumption. Singapore imported quantities exceeding domestic consumer demand from producing countries in order to be able to re-export a large proportion to Hong Kong. This market played a central role in trade. In fact, at their own scale, imports and re-exports with other markets only accounted for a small percentage of transiting tonnages. However, this did allow the re-export of high quality goods of high commercial value to Singapore.

Conclusion

Trade between the main international beche-de-mer markets only accounted for a small percentage of global trade, remaining at less than 10% of total market tonnages and values. The Hong Kong market played a central role in these exchanges and served as an intermediary between the Singapore and Taiwan markets which did very little direct trading. Comparison of the trade statistics of these markets also allowed it to be shown that there were problems with data reliability which hamper proper stock management.

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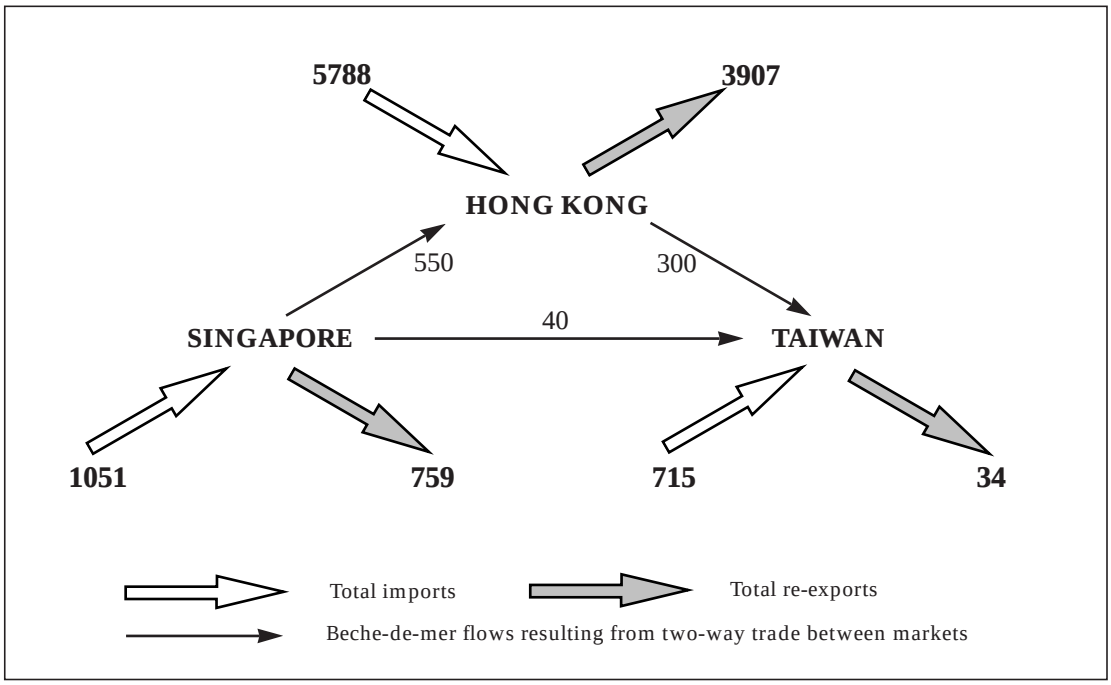

Figure 1. **Scale of two-way trade between markets**

Overview: Aspects of sea cucumber industry research and development in the South Pacific

by Andrew Morgan[1] *and Jeff Archer*[1]

Sea cucumbers are members of the class Holothuroidea (phylum Echinodermata), and are related to sea stars, brittle stars, basket stars and sea urchins. This class is divided further into six orders: the Dendrochirotida, Dactylochirotida, Apodida, Molpadida, Elasipodida and Aspidochirotida. Of the 1200 holothurians that have been described, 49 species (belonging to 36 genera) are present in New Zealand waters (Pawson 1970).

The international beche-de-mer fishery produces approximately 80,000 tonnes of raw sea cucumber each year from sources in the South Pacific and Asia (Conand & Sloan, 1989) for processing into beche-de-mer. During the period 1983–1990, a dramatic increase in the demand for beche-de-mer, coupled with a decline in total landings of sea cucumbers, prompted research into the fishery of the commercial species (Preston, 1993). This redefined the geographical parameters of the beche-de-mer industry and diverted some interest from the traditional species (mainly tropical or ancient northern fisheries), to the exploration of new, previously non-utilised, tropical and temperate species, for example; *Stichopus californicus* and *S. parvimensis* on the Washington coast, and *Cucumaria frondosa* on the East coast of Canada (see reviews by: Mottet, 1976; Sloan, 1984 and 1986; Conand & Sloan, 1989; Bradbury & Conand, 1991; Bradshaw *et al*., 1991; Conand & Byrne, 1993).

An extensive sea cucumber fishery off the Queensland coast and the Torres Strait region in Australia has a TAC (total allowable catch) of 500 tonnes annually. As one species is targeted and fished out, other species are sought, with the end result being the over exploitation of sea cucumbers. Presently, the main species being targeted is *Holothuria nobilis,* the black teatfish. Interest is growing in harvesting the white teatfsih, *Actinopyga echinties*, as the black teatfish becomes fished out. *Holothuria scabra*, the sandfish, is also heavily over-fished. It is a common occurrence for indigenous people from Papua New Guinea (PNG) to poach sea cucumbers situated in Australian waters in the area of Warrior Reef, Torres Strait.

More recently, interest has focused on the fishery potential of the Southern Hemisphere temperate sea cucumber *Stichopus mollis*. The New Zealand sea cucumber *S. mollis* forms a visible, yet relatively unstudied component of sub-tidal north-eastern New Zealand. An aspidochirote holothurian, *S. mollis* is perhaps one of the best known of the New Zealand sea cucumbers. Common in shallow water, it can be found on the rocky shores and sandy mud bottoms of many coastlines around this country and parts of southern and western Australia and Tasmania (Pawson, 1970). Currently, a small fishery exists from Kaikoura to Fiordland with an annual quota of just 15 tonnes. Due to the lack of research on population distribution and abundance, and interest from industry, this fishery has not been developed from its present status.

Regardless of the prevalence of *Stichopus mollis*, information on this species is scarce. Past work on *S. mollis* has been concerned primarily with its taxonomy and distribution (Pawson, 1970), and only a few publications provide information on biology or ecology. Since Dawbin's (1948 a and b) accounts of the aspects of regeneration after auto-evisceration, the only other published report on the biology of this species other than Archer (1996) is the investigation of gonad development and the reproductive cycle by Sewell (1987).

At present there are gaps in the knowledge regarding aspidochiote holothurian ecology, and biology (see review by Bakus, 1973). With interest growing in holothurian fisheries biology and ecology, and the major aquaculture project in the Solomon Islands acting as an epicentre for holothurian research in the South Pacific, there is now a continuous flow of publications appearing in scientific journals and fisheries and aquaculture magazines. Little is known about the timing of spawning, larval development and juvenile ecology of these animals. This has lead to problems in understanding the life history of these animals, for the management of natural populations in fishery and conservation terms. The lack of knowledge also forms a barrier to intensive hatchery-based activities.

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Culture

Efforts to develop hatchery techniques for the mariculture of commercially valuable species (Houkou Production Team, 1976; James *et al.*, 1988; Arakawa, 1990; James *et al.* 1994; Ramofafia *et al.*, 1995; Ito, 1995), and the utilisation of species with a lower market value (Conand & Sloan, 1989) have increased over the past five to ten years.

Over the past several years a hatchery and grow-out project has been undertaken at ICLARM (International Centre for Living Aquatic Resource Management) in the Solomon Islands, with the aim of restocking or enhancing populations of commercially valuable holothurians. The program is in the first five year stage of a fifteen year project and has so far proven successful in obtaining large amounts of seed of the sea cucumber *Holothuria scabra* and production of moderate amounts of both the surf redfish and prickly redfish (Battaglene, pers. comm.).

Researchers in Japan at the Saga and Aichi Prefectural Sea Farming Centres (Ito, 1995) have been culturing the sea cucumber *Stichopus japonicus* for a number of years and currently produce millions of juveniles that are released back into the natural population each year.

However, problems exist in finding these animals again and a number of factors have been implicated in causing this. Researchers in India (James *et al.*, 1994) have been producing small amounts of the sea cucumber *Holothuria scabra* for a number of years and biologists continue to refine seed production and grow-out.

A number of problems still exist with the logistics of culturing holothurians, as evidenced by the aquaculture efforts of Pacific Island nations, in areas such as broodstock management, maturation and conditioning, spawning, larval rearing, settlement, grow-out, harvesting, and fattening.

Currently, there are two proposals being put forward by people involved in the sea cucumber fishery in Queensland, Australia, to set up sea cucumber farms and add value by processing the body wall, gut and gonad, targeting the species *Holothuria scabra*, which has so far proved to be the easiest of the possible commercial holothurians to culture.

Marketing and processing

Known as beche-de-mer (*iriko* in Japanese, *hai-som* in Chinese, or *trepang* in Indonesian), the sea cucumber forms large, valuable and traditional fisheries in numerous South Pacific and Asian countries. The term beche-de-mer is given to the processed form of the sea cucumber (Bruce, 1983; Robertson *et al.*, 1987; Parish, 1978) and is consumed in a variety of ways.

In Japan and Korea the gutted body wall of their sea cucumber is consumed raw or pickled, and a specialised range of products are produced from the gonad, respiratory trees and viscera (Mottet , 1976; Conand & Sloan, 1989). *Konowata*, the fermented or pickled guts or intestines and *Kuchiko*, the prepared and dried sea cucumber gonads are considered a delicacy. *Konowata* is used in Japan as a 'nibly' with social drinks and is sold in small glass jars (65 g) for around AU$ 100. Intestines, which are currently wasted during processing, can account for 40 per cent of the wet weight of a sea cucumber. Both these products can fetch prices upwards of AU$ 1000 a kilo.

The muscle bands of some species are used as clam substitutes in Asia and the United States (Mottet, 1976), and the body wall has been consumed in dry tablet form. Even an extract of boiled skin is drunk as a tonic in Malaysia (Subasinghe, 1992). Only certain species are valued for beche-de-mer production, and are primarily composed of the aspidochirote sea cucumbers.

Currently, Ocean Quenst Pty. Ltd. and Reef Organics Ltd., Australia, are developing a complementary medicine substance (food supplement) product that has anti-inflammatory properties. Therapeutic products have been identified through analytical and laboratory trials. Market trials, label design and a range of flavours are being developed from several reef species. Some concerns still exist about the development of pharmaceutical products and issues concerning toxicology.

In New Zealand techniques have been developed and refined, at a factory managed by Rex Scaper, for processing the body wall of *Stichopus mollis*. It is difficult to obtain export prices on this animal as it is 'lumped' in with sea urchin export prices, which together appear to reach approximately AU$ 1 000 000 in export earnings annually.

The expansion of the sea cucumber fishery and development of value-added products would increase substantially the export value of *S. mollis*.

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Allozyme variation as a tool for beche-de-mer fisheries management: A study on *Holothuria scabra* (sandfish)

by Sven Uthicke[1] *& John Benzie*[1]

Introduction

Information on the biology and ecology of the Sandfish (*Holothuria (Metriatyla) scabra*) is sparse, although it is one of the most valuable beche-de-mer species. As do most aspidochirotide holothurians, it feeds on sediments. It prefers muddy substrates (Baskar, 1994) from which it selects fine particles rich in organic matter (Wiedemeyer, 1993). *Holothuria scabra* is one of the few species that prefers coastal areas to coral reefs (Conand, 1989) and is often found in intertidal seagrass beds. This species burrows into the sediment for a part of the day (Wiedemeyer, 1993; James *et al.*, 1994). Sexual reproduction via broadcast spawning occurs in the warm months in the southern hemisphere (Conand, 1989 and 1993a), although a secondary spawning peak has been observed in June in Moreton Bay, Australia (Harriott, 1980). Some information exists on the population size of this species in the Northern Territories (Vail, 1989), Moreton Bay (Harriott, 1980), Papua New Guinea (Shelley, 1981) and the Torres Strait (Long *et al.*, 1996).

Along the Queensland coast, the Sandfish occurs in two distinct colour morphs. One of these is nearly entirely black, with a dark grey ventral surface (hereafter referred to as Black Sandfish, Figure 1). The second is of creamy colour underneath and the dorsal surface is greyish green, with black stripes in wrinkles of the epidermis (hereafter referred to as Grey Sandfish, Figure 1). The Grey Sandfish fits the general descriptions of *H. scabra* (Conand, 1989; Anonymous, 1994) whereas the black colour morph may be one colour variety of *H. scabra var. versicolour*, as described by Conand (1989) from New Caledonia. The extent of interbreeding between the two varieties, and hence whether they should be treated as different fishery stocks is not known.

Both Sandfish varieties are also reported in deep subtidal areas from where they are caught as bycatch in the prawn trawl fishery. In contrast to the intertidal mudflats, Sandfish are currently not commercially fished in deep areas. During a stock assessment in the Northern Territories, Vail (1989) observed that animals from seagrass beds shallower than two meters are distinctly smaller than deep animals and suggested that seagrass beds are nursery areas for the Sandfish.

Allozyme markers are a useful tool to describe gene-flow and between populations of holothurians (Uthicke *et al.*, 1998; Uthicke *et al.*, 1999). With the aid of allozyme genetic markers developed in this study for the Sandfish, we aimed i) to determine whether black and grey individuals of *H. scabra* are one species or are simply colour morphs, and ii) to investigate whether deep populations may be sources of recruits for intertidal areas.

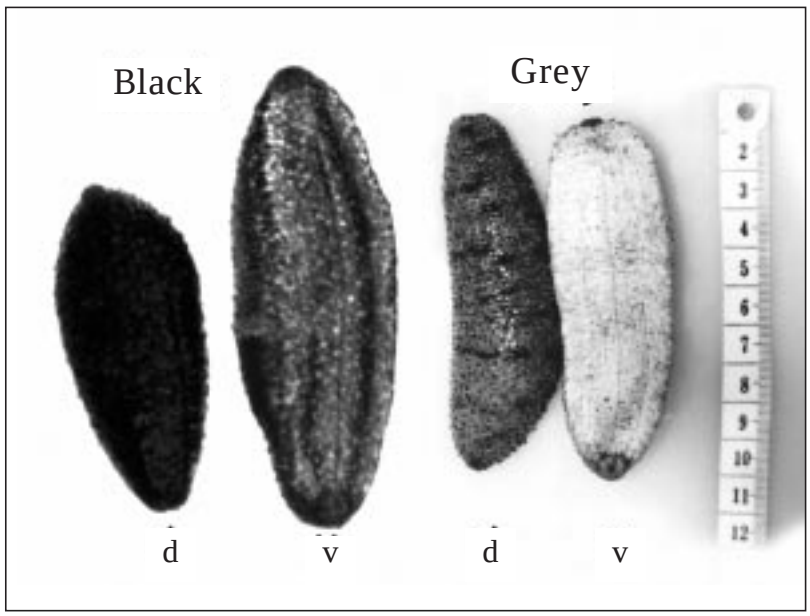

Figure 1. **Black and Grey Sandfish**

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Material and methods

Sampling strategy

Two shallow populations of the Sandfish were sampled in the area of Hervey Bay (Urangan; Tin Can Bay) in south Queensland (Figure 2). An additional intertidal population was sampled ca. 450 nautical miles (nm) north (Upstart Bay). Samples were taken during low tides by walking on the mud flats. Animals from a deep population (18–20 m) were obtained during three trawling shots (Figure 2) using commercial prawn trawling equipment.

The length of all animals was recorded to the nearest centimetre. During dissection, the presence or absence of gonads was noted and a subsample of the gut (cleaned from sediments) was snap frozen in liquid nitrogen for later analyses.

Allozyme electrophoresis

Approximately 250 mg of frozen gut tissue was homogenised in the same volume of Tris HCl buffer (100 mM Tris adjusted to pH 8.0 with HCl) prior to electrophoresis. Electrophoresis for all enzymes was performed on 12% horizontal starch gels. In an initial screening process, 21 enzyme systems which appeared promising in a previous screening of two other holothurian species (details in Ballment *et al.*, 1997) were tested for 5 individuals of each colour morph on three buffer systems. This screening identified 7 polymorphic enzymes [*PGM** (5 alleles), *GPI** (3 alleles) and *HK** (2 alleles), *MDH** (2 alleles), *PEP-1** (3 alleles), *PEP-2** (2 alleles), *PEP-3** (2 alleles)]. Statistical analyses were performed with standard genetical software packages as described for example in Uthicke *et al.* (1998).

Results

General characteristics of the populations

The proportions of the two colour varieties were different at different sites ranging from significantly more black individuals in the trawl shots to only grey individuals in Tin Can Bay (see Table 1 on next page). The individuals sampled from 18–20 m depth by trawling were distinctly larger than those in all shallow populations (Table 1). The size frequency distributions of all populations appeared unimodal and were similar between the black and grey colour morphs in each population (data not shown). Gonads were present in nearly all of the individuals from the subtidal population at Hervey Bay. In contrast, none of the animals in

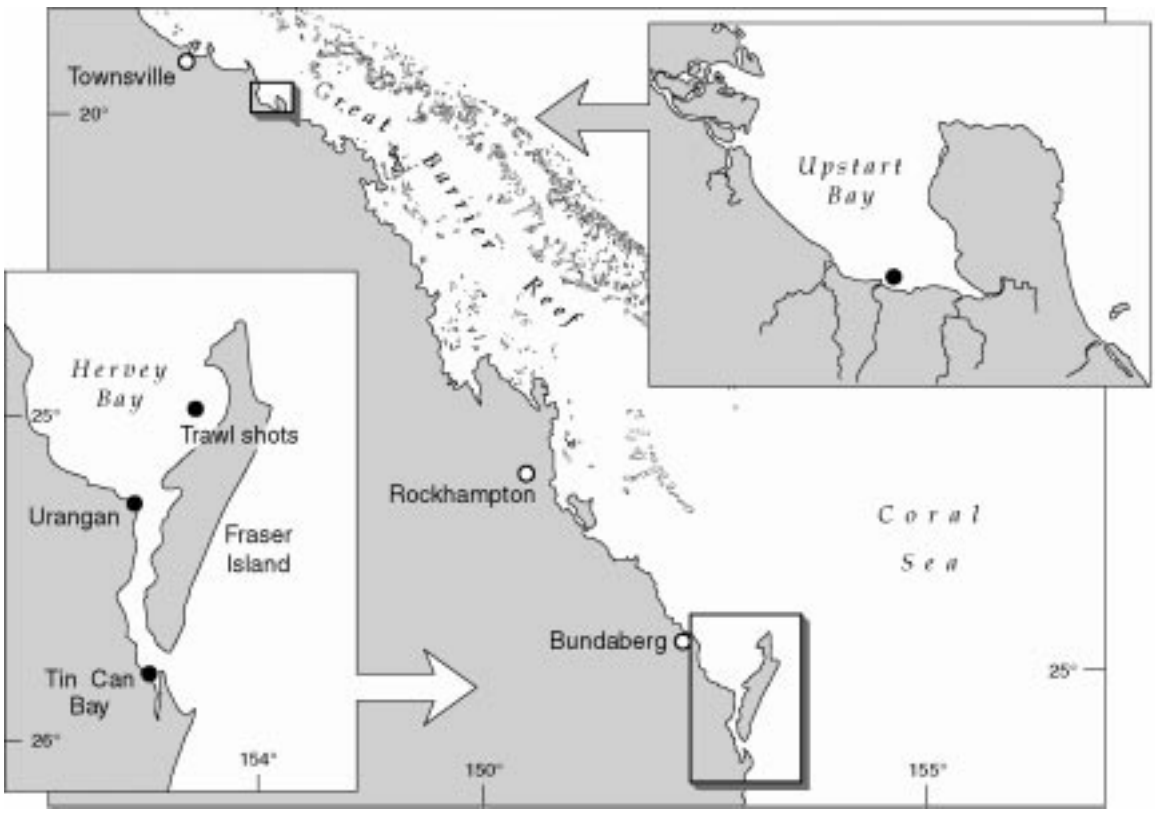

Figure 2. **Locality map of four sampling stations on the Queensland coast**

Table 1. **Average size (cm, standard deviation in parentheses), ratio of Black to Grey Sandfish (significant deviations from 1:1 ratio indicated, *: p < 0.05, NS: not significant) and the percentage of animals without gonads for 4 populations of *Holothuria scabra***

	Mean size	Black : Grey	Animals without gonads
Urangan	17.8 (2.5)	52: 48 NS	34%
Tin Can Bay	14.4 (1.8)	only grey, N = 17	53%
Upstart Bay	9.8 (1.5)	< 8 : 48 [1]	100%
Trawl shots	26.9 (4.0)	154 : 116*, [2]	12%

1. All black animals found were collected, but many more than 42 grey animals were present
2. Ratio only from shot 2 and 3

Table 2: **Probabilities (p) of exact test for differences in alletic frquencies between Black and Grey Sandfish at three populations in Queensland. No test is significant at p < 0.05 after corrections for multiple simultaneous tests**

Locus	Trawl shots	Urangan	Upstart Bay
*GPI**	1.000	1.000	0.660
*HK**	0.029	0.525	1.000
*MDH**	0.496	1.000	1.000
*PEP-1**	0.319	0.298	0.674
*PEP-2**	0.507	0.095	0.358
*PEP-3**	0.480	0.081	0.032
*PGM**	0.572	0.034	0.384
Total: χ^2	14.71	15.61	12.46
p	0.398	0.338	0.569

Table 3. **Pairwise FST values between four populations of Holothuria scabra. Values above the diagonal were derived from all 7 loci, those below the diagonal are derived from 6 loci (omitting PEP-3). Significance levels: *: p < 0.05; **: p < 0.01; ***: p < 0.001; ns: not significant.**

	Urangan	Trawl	Tin Can Bay	Upstart Bay
Urangan	-	0.005^{ns}	-0.006^{ns}	0.137^{***}
Trawl	0.006^{ns}	-	0.006^{ns}	0.172^{***}
Tin Can Bay	-0.015^{ns}	-0.003^{ns}	-	0.074^{***}
Upstart Bay	0.038***	0.081^{ns}	0.028^{ns}	-

Upstart Bay had detectable gonads. There appears to be a distinct correlation between the average animal size at each population and the number of animals with gonads (Table 1).

Population genetics

Genotype frequencies were not significantly different from those expected under Hardy-Weinberg equilibrium, irrespective of whether both colour morphs were analysed separately or pooled for each population with one exception (*PGM** showed significant heterozygote deficits at one population).

In the three populations where Black and Grey Sandfish occurred, we detected no difference in allelic frequencies between these two colour morphs.

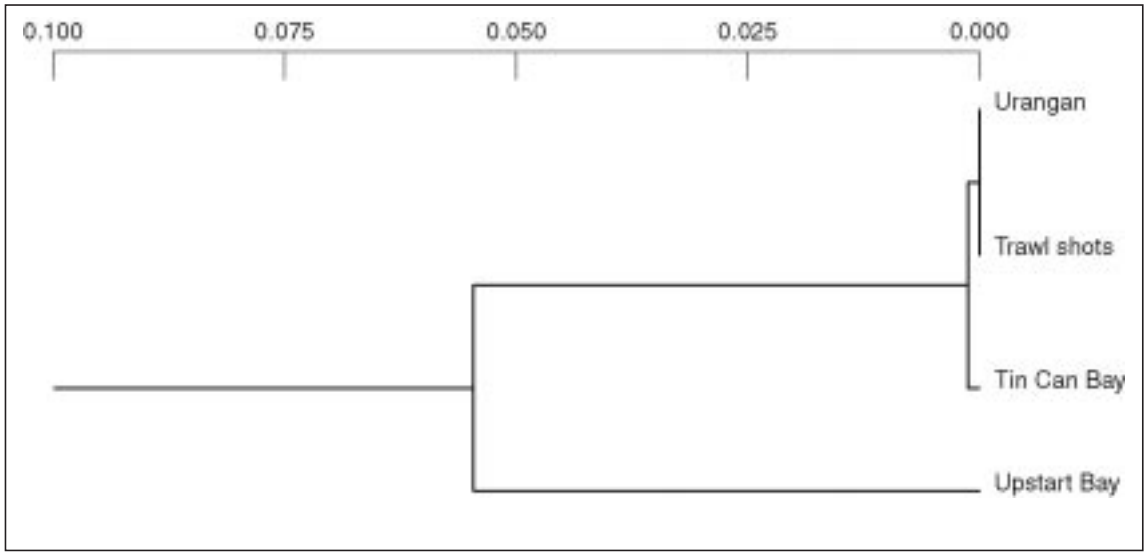

Figure 3. Dendrogram illustrating genetic relationships from four populations on the Queensland coast, using UPGMA cluster algorithm and Nei's unbiased genetic distance (Nei 1978)

(Table 2). We therefore pooled data from the two varieties at each population for subsequent analyses.

Several F_{ST} values for single loci and the mean (0.068) over all loci differed significantly from zero. Because the *PEP-3** locus showed extremely high values, we recalculated the average F_{ST} also without that locus. Although the value was lower (0.027), it was still significantly different from zero demonstrating significant differentiation among populations. F_{ST} values for single pairs of sampling stations revealed that there was no differentiation between the three southern populations near Fraser Island, but all of these show significantly restricted geneflow with the population in Upstart Bay (Table 3). Cluster analyses (Figure 3, cophenetic coefficient: 0.891) showed a similar trend. There was virtually no separation between the shallow population in Urangan and the trawled population, and the highest degree of separation was detected between the three southern populations and that of Upstart Bay.

Discussion

Black and Grey Sandfish

We detected no difference in allelic frequencies between the Black and Grey Sandfish colour morphs in any of the three populations in which they occurred together. The same alleles exist in both varieties and no fixed allele differences were detected. Genotype frequencies conformed to those expected under Hardy-Weinberg equilibrium, whether data for both colour morphs were pooled or kept separate. Additionally, Grey and Black Sandfish showed similar average lengths and length-frequency distributions at each population. Thus, there are no indications that Black and Grey Sandfish found off the Queensland coast are two separate species and we conclude that they are colour morphs of one species.

The factors causing this variation in colour is not known. It also remains unresolved why the colour morphs constitute varying proportions of the population, and whether the colour is environmentally or genetically determined. Although only 17 animals were sampled at Tin Can Bay it seems that the black variety is extremely rare at that location, and it also constitutes less than 10 % of the population in Upstart Bay. Thus, it appears that the high percentage of black individuals in Urangan and the trawl samples is a phenomenon specific to Hervey Bay.

Conand (1989) mentioned a colour variety of *H. scabra* in New Caledonia and tentatively termed this *H. scabra var. versicolour*. Although the coloration seems to be similar to the Black Sandfish investigated here, Conand noticed that the two varieties in New Caledonia occur in different areas, *H. scabra var. versicolour* being found in deeper habitats. There were also slight differences in spawning times between the two varieties (Conand, 1989 and 1993a), but the latter author concluded that the similar morphology of the calcareous ring and the spicules did not allow the erection of a new species. Colour seems to be a highly plastic feature in *H. scabra*. Apart from the variations observed in this study and in New Caledonia, specimens from India were reported to have yet another colour pattern, with a brown to black dorsal surface and white to yellow wrinkles (Sachithananthan 1994, see colour photography in

James *et al.*, 1994). It remains to be investigated whether differences in colour on a larger geographic scale represent species differences in *H. scabra.*

Deep and shallow populations

Neither the cluster analyses nor the variations of the F_{ST} values indicated any genetic subdivision between the deep population in Hervey Bay and the nearest shallow population in Urangan. Significant population subdivision was detected between the population in Upstart Bay and all southern populations. This allows sound inferences to be made concerning general levels of dispersal among populations.

It can be concluded that there is a large exchange of genetic material between deep and shallow populations. The higher number of large sized and sexually mature individuals in the deep area supports the hypothesis that there is a successive downward migration of growing individuals. In a study of a shallow population of *H. scabra* in Moreton Bay Harriott (1980) observed that all individuals had gonads. Since a fraction of the individuals from the seagrass beds in our study also had gonads, it can be assumed that spawning also takes place in the shallow areas.

James *et al.* (1994) reported that *Holothuria scabra* migrates to deeper areas for breeding, but does not mention how this was determined. It is a feature of many holothurian species that individuals in deeper areas are larger than shallow specimens (Conand, 1993b; Uthicke 1994), and the latter authors also suggested a migration to deeper areas during the life of these species.

Although we could show that the deep and shallow populations are closely linked, the genetic data alone cannot determine whether a migration of adults from shallow to deep water occurs. Similarly, the genetic data demonstrate that both deep and shallow populations derive recruits from the same larval pool. Presumably they both contribute to this pool but this requires other (non-genetic) research to confirm. Thus, the genetic data show that deep water animals could act as a source of recruits for the shallow water populations, but do not provide absolute proof that they do.

The occurrence of immature juveniles in all shallow populations supports the hypothesis that shallow seagrass beds are important settlement and nursery areas for *H. scabra* (Vail 1989).

This finds strong support from the samples at Upstart Bay, where all individuals were juveniles. If growth rates given by Shelley (1985) are used, it is possible that all of these animals had settled during the eight months prior to sampling. For sustainable management of the Sandfish stock it seems crucial to determine whether shallow seagrass beds are the only settlement area for juvenile *H. scabra*. If no juveniles can settle in the deep populations, this would indicate that these rely on recruitment of downward migrating adults. In that case, a careful management of the shallow populations and of the seagrass habitat *per se* is necessary to sustain both shallow and deep *H. scabra* populations.

The population at Upstart Bay was the only population that was genetically distinct from the other populations. This finding shows that the method developed is suitable to detect genetic distances, and it therefore confirms that the low degree of separation between deep and shallow southern populations is not simply due to methodological problems.

Since the population at Upstart Bay is approximately 450 nm further north, we assume that genetic differentiation of the Sandfish follows a separation-by-distance model. However, this has to be confirmed with a larger set of populations sampled.

In summary, both colour-morphs of the sandfish appear to belong to one species and it seems conservative to pursue the current practice to manage these together. Currently, deep populations of the Sandfish are not commercially fished, but a loss to these due to mortality caused by trawl-fishing cannot be excluded. These deep populations may constitute a buffer and a new source of recruits for the fished shallow populations. Due to the easy access by walking in the intertidal zone, shallow areas may be prone to overfishing if not appropriately managed.

We encountered two areas (Moon Point and Tin Can Bay) which were previously fished and now only contain very few animals. Although, apart from fishing also environmental factors may be the cause for reduced population size, this indicates that fished areas should be carefully monitored, especially because very few populations exist along the Queensland coast.

Acknowledgements

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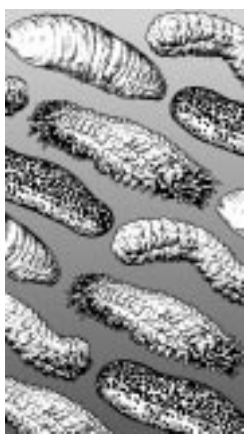

Recent trends in beche-de-mer exports from New Caledonia

by Régis Etaix-Bonnin[1]

The most representative data on beche-de-mer fishery developments in New Caledonia continue to be the export tonnage and value figures provided by the Customs Service.

This information has its limits, however, because it relates to an exported commodity, whereas customs records almost always concern imports. The possible resulting inaccuracies are much more likely to affect values than tonnages exported. In addition, customs commodity classifications do not distinguish between exported sea cucumbers by species, although different species have very different commercial values. The only useable data, therefore, are the aggregate export figures for the last five years, which are showned in Table 1.

It emerges from these data that, whereas apparent mean values have remained stable in the last two years, exported tonnages dropped sharply in 1998 (–31% compared to 1997 and –51% compared to 1994).

Although, as stated above, it is hazardous to rely only on export data, this slump could indicate excessive pressure on the resource.

This is one of the reasons why the Northern Province authorities in New Caledonia have commissioned a resource study, which could begin in the weeks to come. There are plans to conduct a similar study on trochus.

Table 1. **Beche-de-mer exports from New Caledonia**

	1994	1995	1996	1997	1998
Quantity (t)	79.8	48.0	49.2	56.5	39.1
Value (US$)*	1 131 910	1 004 340	784 430	1 181 920	791 500
Ave. price (US$/kg)	14.1	20.9	15.9	20.9	20.2

* For US$ 1.00 = 110 CFP

Some news on the Galapagos situation.

Sea cucumber fishery postponed

Puerto Baquerizo Moreno (Ivan Naula).

English translation from *El Universo*, 15 March 1999

The start of the fishery for sea cucumbers, scheduled for today, was postponed until 25 March by request of the presidents of the fishery cooperatives on the three islands, because they have not been able to purchase the fishing gear and other materials due to the bank holiday.

In a document, the directors of the cooperatives requested the postponement of the start of the sea cucumber fishery, because only today, with the reopening of the banks, will they be able to make the necessary transactions and withdrawals to buy the fishing gear.

Galapagos: The DAC could be involved: Sea cucumbers, a cargo was confiscated

English translation from *El Comercio,* 3 April 1999

The illegal fishing for sea cucumbers does not stop. On 31 March, 17 500 sea cucumbers were confiscated in the airport on Isabela Island (Galapagos). This was denounced by Yolanda Kakabadse, Minister of the Environment.

The incident could have greater implications, because it seems that personnel of the National

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Department of Aviation (*Direccion Nacional de Aviacion Civil* or DAC) took part in the illegal action. Inspectors of the Galapagos National Park observed that boxes and suitcases were being unloaded from a car belonging to the DAC and taken to a plane of the Air Force that was going to leave for Guayaquil.

Investigations began and it was shown that the cargo did not have the pre-checking seal, nor did it have an addressee indicated. The driver of the vehicle was Sargeant Braulio Bravo, of the DAC.

The Minister stated that, before the 1st of April, sea cucumber fishing was prohibited and that the confiscated sea cucumbers were already processed. She acknowledged that the Ministry authorized the opening of the sea cucumber fishery in Galapagos for two months, beginning the 1st of April. The objective: to evaluate the impact that the exploitation of this species could cause.

Soon new regulations would be announced, along with the names of the three sites in which it will be possible to undertake fishing activities. The Charles Darwin Research Station and the National Institute of Fisheries (*Instituto Nacional de Pesca*) will be in charge of the analysis of data. In addition, sea cucumber fishermen will be trained with regard to permitted size and quotas.

Fishing for sea cucumbers was officially closed in 1995, but the National Department of Fisheries (Direccion Nacional de Pesca) in Guayaquil continued to receive denunciations. The arguments given by the infractors: the activity took place before the moratorium.

The uncontrolled harvesting began in 1991 in the waters around Isabela Island, in the Bolivar Channel by Fernandina Island and in the zone of exclusion within the 40-mile limit.

A report by Traffic International, the program that monitors trade in wildlife, stated that, between 1992 and 1996, 80 metric tons of sea cucumbers, that is, more than four million individuals, were exported.

In addition, the trade structure had problems: a sea cucumber shipment left Galapagos and went to Piura (Peru), then entered Guayaquil to travel to Mexico or the United States and thence to Hong Kong and Taiwan.

Holothurian fishery in Washington (USA)

by Alex Bradbury [1]

Monday, 08 February 1999

Landings of sea cucumbers in the Washington State, from 1995 onward, have been:

- 1995: 529 metric tonnes
- 1996: 237 metric tonnes
- 1997: 227 metric tonnes
- 1998: 208 metric tonnes

The reason for the big drop in landings beginning in 1996 is simple: that is the year that treaty Indian tribes began receiving (legally) 50 per cent of the total statewide quota. But the Indian tribes are still not set up for diving, very few boats participate in the Indian fishery, so the 50 per cent of the quota assigned to Indian tribes is not taken, except for a few pounds. It is not legal for non-Indians to take the Indian 50 per cent, even if the Indians areunable to take their share. This may change in the future, as the Indians learn the fishery and buy diving equipment. Quotas themselves have remained relatively stable for 1996 and 1997 at 480 metric tonnes annually. But in 1998 we arbitrarily reduced the annual quota to 408 metric tonnes, a 15 per cent reduction simply because we are not doing any stock assessment and therefore do not know what is happening to the stocks.

Catch per unit effort (CPUE) trends in recent years (as kg per diver hour, from logbook data, non-Indian divers only) are as follows:

- 1995: 63 kg / hr
- 1996: 56 kg / hr
- 1997: 65 kg / hr
- 1998: 80 kg / hr

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aquaculture
beche-de-mer

News from ICLARM, Coastal Aquaculture Centre in the Solomon Islands

prepared by Stephen Battaglene

The sea cucumber project at the CAC is entering the last year of a five-year program to develop techniques for the mass-production of tropical sea cucumbers. Major achievements during the first five-year phase of the program include:

- Assessment of the reproductive cycle of sandfish. Results show that it spawns all year round with a peak in activity from September to November.
- The development of techniques for transporting sandfish and inducing them to spawn. Sandfish can be induced to spawn year-round.
- Demonstration that wild adult sandfish can be held, and conditioned to spawn, in land-based tanks.
- Establishment of an algal unit and identification of optimal micro-algal diets for larval rearing of sandfish.
- Development of hatchery systems for rearing larval sandfish through to settlement.
- Successful settlement, detachment and grading of juvenile sandfish in plate culture systems.
- Production of juvenile sandfish of up to 250 mm in length in land-based nursery systems.
- To date, seven successful hatchery trials have been conducted with sandfish, resulting in production of more than 200 000 juveniles.
- Assessment of ponds as a potentially cost-effective means of on-growing juvenile sandfish.

My colleagues, Dr Annie Mercier and Dr Jean-Francois Hamel provide further details of the ICLARM programs investigating tropical sea cucumbers. Both ICLARM, and the specialist Advisory Panel of Australian scientists to the project, are confident that the basic techniques now exist to produce juvenile sandfish in large numbers at reasonable cost for the purpose of restocking and stock enhancement. All parties involved in the project now feel that it is appropriate to proceed to the second phase of this strategic research, i.e., identification of strategies for optimizing the survival of released juveniles. ICLARM will be approaching donors over the next six months and hope to start the second phase in January 2000.

Unfortunately, the news from the Solomon Islands is not all good. There have been civil disturbances since the beginning of the year due to ethnic tension between two groups from the islands of Malaita and Guadalcanal. Long-held tribal differences and problems with land rights have seen a mass exodus of Malaitians from the capitol Honiara. A declared 'State of Emergency' last month precipitated the temporary closure of many businesses, schools and roads. The CAC located some 25 km from Honiara has had to curtail research until things return to normal, hopefully in the near future. In the meantime I have relocated back to Australia and will continue to write up the results of the study.

I can be contacted by e-mail at the following address: <sbattaglene@bigpond.com.au> or by post to: PO Box 354, Sandy Bay, Hobart, Tasmania, Australia 7006.

News prepared by J.-F. Hamel and A. Mercier

International collaboration for the study and restoration of *Holothuria scabra* populations in the Solomon Islands

by Annie Mercier and Jean-François Hamel

Society for the exploration and valuing of the environment (SEVE), 655 rue de la Rivière, Katevale (Québec), Canada J0B 1W0. Tel. & Fax: (819) 843-3466, E-mail: seve@sympatico.ca

Of the approximately 1400 sea cucumber species that live on sea floors all over the world, less than 20 possess all the physical characteristics that make them attractive to the major buyers. The Solomon Islands are blessed with all of the most prized species, including the white teatfish *Holothuria fuscogilva* and the sandfish *Holothuria scabra*, which currently hold the highest value on the market. Unfortunately, both species have been fished heavily by local populations, especially in recent years and the stocks are experiencing a drastic decline throughout the archipelago. While the demand for sea cucumber products increases insatiably, sizeable animals are also becoming difficult to find in many other areas, including the Philippines, India, Maldives, Papua New Guinea and Fiji.

The fact that the wholesale price for high value species of beche-de-mer has more than doubled over the last four years is good news for Pacific Islanders who often have few products they can trade for hard currency. But for them to benefit from this trade, the present beche-de-mer crisis must first be resolved.

Stock enhancement appears as one of the most promising avenues for increasing and stabilising sustainable sea cucumber harvests. The possibility of restoring populations of tropical sea cucumbers is in fact being assessed in a number of countries, including Ecuador, India, Kiribati, Maldives and Marshall Islands. However, proper seeding of natural habitats, which have been heavily depleted, with cultured juveniles requires long hours of laboratory and field testing.

In Solomon Islands, scientific researchers and villagers have pulled together to learn how to manage sea cucumber populations and build a future for the beche-de-mer industry. A research team from the International Centre for Living Aquatic Resources Management (ICLARM) based at the Coastal Aquaculture Centre (CAC) near Aruligo on Guadalcanal is currently working on a stock enhancement project. During the course of this project, ICLARM hopes to develop expertise in the ecology and rearing of valuable sea cucumber species and test whether it is possible to enhance sea cucumber stocks through release of hatchery produced juveniles.

Dr Stephen Battaglene, an aquaculture scientist from Australia, was appointed head of ICLARM's beche-de-mer project in Solomon Islands, funded by the Australian Centre for International Agricultural Research (ACIAR). His main objectives were to induce spawning of mature adults and develop cost-effective techniques to rear the larvae into juveniles hardy and large enough to survive release.

The research, focused on the sandfish and white teatfish, began in August 1996, when eggs obtained from ripe sandfish produced over 10 000 juveniles of 20 mm in size. Since then, Dr. Battaglene and his team have successfully produced numerous batches of young sea cucumbers and they have now produced over 200 000 juveniles. ICLARM has thus reared thousands of young sea cucumbers ranging from 1 to 250 mm, which were used in experiments aimed at determining the best way to grow them. Researchers were able to find out what was the most suitable food, substrate, rearing density, and salinity, for each of the species.

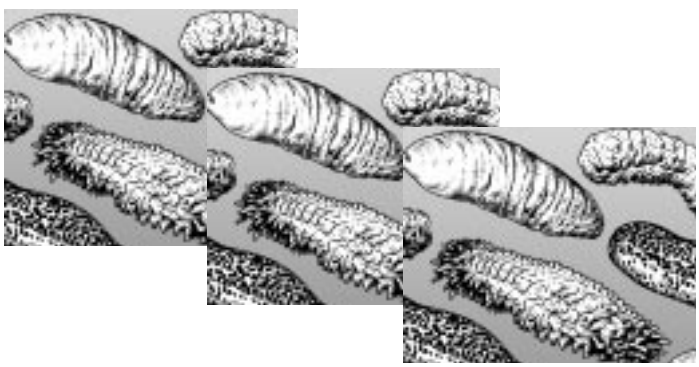
The second part of the beche-de-mer project was focused on the study of the juveniles' ecology, essentially to provide useful information about where and when the young should be released in the natural habitat. For this work, Dr Battaglene has sought our collaboration and a joint project was prepared by ICLARM and two Canadian institutions : Institut des Sciences de la Mer de Rimouski (ISMER; formerly INRS-Oceanologie) and the Society for the Exploration and Valuing of the Environment (SEVE). The three-year venture obtained financing from the Canadian International Development Agency under CGIAR-Canada Linkage Fund. Beginning in July 1998, our work focused on studying the behaviour, settlement, recruitment, distribution and migration of juvenile and adult *H. scabra*, both in the wild and under laboratory conditions.

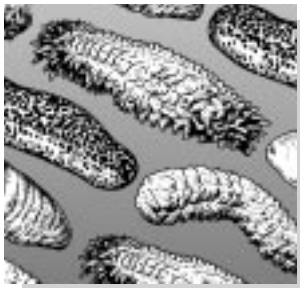
The residents of New Mala on the Vonavona lagoon in the Western Province know a great deal about the harvested and processing of sandfish. In fact, some parts of the lagoon have been severely overfished, a pattern that reflects what is happening throughout the nation. The villagers of New Mala agreed to stop sandfish collection and processing around their village to allow us to conduct part of our fieldwork in this area. Adult sandfish can reach 400 mm in size; they occur mostly on sand or mud in areas that are influenced by terrigenous inputs, often associated with seagrass beds and mangrove swamps. We spent a lot of hours scanning these habitats to study their spatial distribution and population structure. We eventually found out where the small juveniles occurred and investigated their migration patterns, preferred habitats and susceptibility to predation. During the first year, data were also gathered on the burrowing habits and daily activities of juvenile *H. scabra* (recently published in JEMBE 239: 125–156), as well as on their settlement preferences and recruitment in the field. For this, we had to find a way to identify newly-settled sea cucumbers collected from the wild. A study of ossicle change in *H. scabra* was thus conducted in collaboration with Dr Claude Massin from the Institut Royal des Sciences Naturelles de Belgique, allowing us to pinpoint the unique skeletal features of larvae and young specimens.

Another important member of the beche-de-mer team, Christain Ramofafia, is currently doing a Ph.D. on the reproductive ecology of valuable sea cucumber species under the supervision of Dr Maria Byrne in Australia. Originally from Malaita (Solomon Islands), Chris joined ICLARM five years ago as a research assistant. He has conducted three years of monthly field sampling during his study of *H. scabra*'s reproductive cycle. In doing so, he has allowed us to examine hundreds of individuals collected from different sites and to identify a new species of pea crab that lives encysted in the respiratory tree of *H. scabra* adults from a single bay in the Solomon Islands. The symbiont was named and described in collaboration with Dr Peter K.L Ng from the University of Singapore. We have also investigated its reproductive biology and invasive patterns. These results will be published shortly in Ophelia Vol. 51.

We are now in the final year of the joint Solomon Islands-Canada project, which is mainly dedicated to publishing the data and presenting them at symposia and conferences. The collaboration has been very productive and we hope that the knowledge gathered on adult and young *H. scabra*, aside from increasing our general knowledge of holothurian ecology, will provide useful tools to stock enhancement programs aimed at restoring the depleted sandfish populations in Solomon Islands and elsewhere.

Fortunately, the Government of Solomon Islands has recognised that stocks of sandfish have been fished down too far and that ICLARM's project represents a sustainable way of restoring and enhancing stocks of this species. Accordingly, the government has introduced legislation to ban the export of sandfish. However, all other species of beche-de-mer can still be sold. Other measures that could help to improve the resource management in Solomon Islands and elsewhere include establishing a minimum size limit for collection, upgrading the skills of processors to lower the proportion of rejected products and restrict collection to free diving only. Provided that all goes well, scientists are hoping to begin the restoration of sustainable sea cucumber stocks in the year 2000. If their work is successful and if the local communities and government join hands in this project, future generations of Solomon Islanders can look forward to improved and reliable harvests of beche-de-mer.





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

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Daily burrowing cycle and feeding activity of juvenile sea cucumbers *Holothuria scabra* in response to environmental factors

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This study investigated the daily activities of juvenile sea cucumbers *Holothuria scabra* Jaeger. All individuals exhibited daily burrowing and feeding rhythms in response to environmental factors. The cycle of the smallest juvenile, >10–40 mm, was linked to light: the juveniles began to burrow around sunrise and emerged close to sunset. Their burrowing activity was inhibited by continuous darkness. Juveniles >40–140 mm responded to changes in temperature; they emerged around midday. The maintenance of a constant warm temperature prevented them from burrowing. For all juveniles, time spent on the surface corresponded with feeding and periods of locomotion; while burrowed they remained stationary, did not feed and had a low intestinal transit. Organic matter content in the intestine was also found to vary with the daily cycle. Decreases in salinity from 35 to 30, 25 and 20‰ induced the burrowing of all juveniles within minutes, but they began to re-emerge after a few hours. Acclimation occurred most rapidly at salinity 30 ‰ and was slowest at salinity 20 ‰. Conversely, nearly 40% of the juveniles were unable to cope with a decrease to salinity 15‰. Juveniles of all sizes demonstrated a strong selectivity for sediment characteristics. In tow substrate selection experiments, their preference for sand with a grain size around 0.4 mm and for organically rich material was firmly expressed within an hour. The general behaviour of juvenile *H. scabra* reflects their ability to inhabit shallow sandy areas with high terrigenous inputs and variable environmental conditions.

Source: Journal of Experimental marine Biology and Ecology, 239 (199): 125–156

Mucus as a mediator of gametogenic synchrony in the sea cucumber *Cucumaria frondosa* (Holothuroidea: Echinodermata)

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The data presented here demonstrate that the sea cucumber *Cucumaria frondosa* secretes biologically active mucus that helps maintain gametogenic synchrony among conspecifics. Either a whole mature individual or a sample of its freshly collected mucus was able to initiate gametogenesis in conspecifics that were in the gametogenic recovery stage when other environmental conditions, including day length, were maintained constant. Similar results were obtained when the mucus was kept in seawater for less than 3 h prior to its use, whereas after 6 h in seawater, the mucus had lost its inducing properties. Laboratory experiments showed that the mucus was produced in lesser amount during late summer and autumn; the production rapidly increased in early January to reach a peak a few months before the June spawning, in 1992 and 1993. The increment of mucus production was concurrent with the initiation of gametogenesis. Synthesis of mucus was maximal in individuals having attained gametogenic maturity and minimum in individuals with less developed gonads. At first relatively stable in seawater, the mucus gradually lost its integrity within a period of 3–5 h, suggesting that the mucus may be carried over long distances by currents, thus allowing a transfer of information before its complete degradation. This phenomenon was observed in the field where streams of mucus could be followed by SCUBA divers as far as 20–30 m away from the secreting animals. The data presented here are the first evidence of the important role played by the mucus secretion during the gametogenic process of an echinoderm.

Source: J. Mar. Biol. Ass. UK (1999) 79: 121–129. printed in UK

Sediment patch selectivity in tropical sea cucumbers (Holothurioidea: Aspidochirotida) analysed with multiple choice experiments

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Source: Journal of Experimental Marine Biology and Ecology, 236 (1999): 69–87

Sea Cucumber (Beche-de-mer) Fishery Management Workshop

Queensland Fisheries Management Authority, Brisbane 8–9 December 1997

Proceedings , ISBN 07242 7025 6, edited by S.B. Damschke
Fisheries Research & Development Corporation
QFMA Queensland FisheriesManagement Authority

Sediment bioturbation and impact of feeding activity of *Holuthuria (Halodeima) atra* and *Stichopus chloronotus*, two sediment feeding holothurians, at Lizard Island, Great Barrier Reef

Sven Uthicke

In aquarium experiments and during field observations, *Holothuria* (*Halodeima*) *atra* (Jaeger, 1883) and *Stichopus chloronotus* (Brandt, 1835) consumed and average of 67 and 59 g dry wt of sediment individual^{-1}d^{-1}, respectively. A model calculation showed that a mixed population of both species on a reef flat near Lizard Island, GBR has a potential to rework about 4600 kg dry wt yr^{-1} 1000 m^{-2} which is approximately the weight of the upper 5 mm of sediment in this area. Gut content analyses showed no significant decrease in phy-

copigments (chlorophylls *a* and *c* and fucoxanthin) during gut passage. In both species the oesophagus pigment content was similar to the concentration in sediments directly in front of the individuals. However, pigment content in front of *S. Chloronotus* and in all gut segments of this species were significantly higher than the corresponding values in *H. atra* suggesting patch selectivity in the former species. Extremely low meiofauna contents in holothurian guts indicated that meiofauna play a negligible part in the nutrition of *H. atra* and *S. chloronotus*. In contrast, the ratio of living to dead diatoms was significantly lower in the guts of both holothurian species compared to the adjacent sediment, indicating digestion of the ingested diatoms. In aquarium experiments, feeding and bioturbation activity of both species significantly reduced microalgal biomass (measured as chlorophyll *a* concentrations) in sediments inoculated with diatoms or cyanobacterial mats.

Source: Bulletin of Marine Science, 64(1): 129–141, 1999.

Improving the conservation management of the commercial sea cucumber *Holothuria scabra* (Sandfish)

Sven Uthicke & John Benzie

Final report produced for the Australian Parks and Wildlife Service Project No. WCRCP-019. Australian Institute of Marine Science, Townsville, August 1998.

Evolution of exploitation in the Galapagos Islands: Ecuador's sea cucumber trade

M. Jenkings & T.A. Mulliken

For centuries, sea cucumbers have been a popular source of food, most notably in East Asian cuisine. In the 1980s, international trade in sea cucumbers for food increased dramatically. The fishery in Ecuador emerged at that time, comprising almost exclusively only one species *Isostichopus fuscus*; by 1991 the fishery for sea cucumbers along mainland Ecuador had been exhausted and the country's fishing effort focused on populations in the Galapagos Islands. Although exports of sea cucumber from Ecuador account for a tiny proportion of the world trade in this commodity, the impact of the fishery in that country threatens to affect the unique ecosystem of the Galapagos Islands. Attempts at localities fishing continued unabated. In March 1998, a special law was passed giving priority to the design of a management plan for the Galapagos fisheries which, at the time of writing, is nearing finalisation. Development of a rational management system with carefully controlled exports, rather than a complete ban, may reduce the risks of illegal fishing and processing of sea cucumbers.

Source: TRAFFIC Bulletin Vol. 17 No.3 (1999): 107–118

Sea cucumber (*Stichopus japonicus*) culture in Farming Fisheries Center, Okayama Prefecture

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The center for International Cooperation – The Ocean research Institute – The University of Tokyo. 1998. 29 p. + annexes.

Abstracts of papers presented at the 'Indigenous Island Aquaculture Session of the World Aquaculture Society Conference, Sydney, April 99'

Reproduction and development of sea cucumbers in the Solomon Islands: implications for beche-de-mer broodstock availability

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Tropical sea cucumber stocks have been severely overfished in many developing island nations. Overfished stocks can take over 50 years to recover and the release of hatchery-produced juveniles is being examined as a means of restoring stocks. Production of juveniles is dependent on the availability of good quality gametes. This study investigated reproduction of *Holothuria fuscogilva*, *H. scabra* and *Actinopyga mauritiana* in the Solomon Islands. The reproductive cycles of these species were documented by the gonad index (GI) method, gonad histology and spawning trials. *H. fuscogilva* and *A. mauritiana* had annual reproductive cycleS with breeding season in August to October, and October to January respectively. Although the GI of *H. scabra* peaked in September, spawning was evident year round. Spawning was induced by either thermal stimulation or by addition of dried algae, *Schizochytrium* sp., to holding tanks. Larval development in all three species is planktotrophic with development of auricularia into a non-feeding doliolaria stage. The pentacula stage marked the transition from a planktotrophic life style to a benthic mode of existence.

Progress in the production of tropical sea cucumbers *Holothuria scabra* and *Holothuria fuscogilva* for stock enhancement

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Stocks of tropical sea cucumbers have been overfished throughout much of the Indo-Pacific. The most valuable species have been exploited so heavily in some island nations that it may take 50 years for the stocks to recover. Release of juvenile sea cucumbers reared in hatcheries is increasingly being suggested as a way of restoring wild stocks, and then increasing yield through stock enhancement.

ICLARM has been evaluating the cost-effectiveness of producing juvenile sandfish, *Holothuria scabra*, and white teatfish, *H. fuscogilva*, for stock enhancement. Sandfish live in high-nutrient environments at densities of 100s per ha, whereas white teatfish live on coral reef slopes at densities of 10s per ha. Both species have reproductive peaks in September and October but sandfish can be induced to spawn year-round in the Solomon Islands. Increases in water temperature and addition of powdered algae are effective ways of inducing spawning. *Chaetoceros muelleri* and *Rhodomonas salina* are two of the better micro-algae for feeding the larvae of both species. However, the larvae of *H. scabra* are more robust and easier to rear than those of *H. fuscogilva*. Both species metamorphose into juveniles after two weeks at 28ºC and settle on 'diatom conditioned' plates.

Sandfish are relatively easy to rear and ICLARM has produced over 200 000 juveniles from six separate spawnings. In contrast, white teatfish are difficult to produce because larval survival is low and juvenile growth is slow. Sandfish can be reared on hard substrates until they reach 20 mm in length and are then best transferred to sand substrates. Absolute daily growth rates for juvenile sandfish averaged 0.5 mm day^{-1} (±0.03 s.e.) and ranged from 0.2 to 0.8 mm day^{-1}, depending on stocking density, light intensity and addition of powdered algae. The biology and ease of culture make *H. scabra* the better candidate for stock enhancement.

Summary of theses

Population structure of *Holothuria (Holodeima) atra* (Jäger, 1833) and *Stichopus chloronotus* (Brandt, 1835) (Holothuroidea: Aspidochirotida) and their role in nutrient recycling in coral reef ecosystems

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Holothurians are conspicuous members of many coral reef communities and often occur in high density and biomass. Although this implies that they may have important functions in these systems, information on their ecology in coral reefs is sparse. Several holothurians reproduce asexually by transverse fission and this may be important to maintain populations at high densities. I investigated whether this is true for two common species, *Holothuria atra* and *Stichopus chloronotus* on three nearshore reefs (Brook, Fantome and Great Palm Island) of the Great Barrier Reef (GBR), Australia. Amongst other organisms and non-living organic matter, benthic microalgae are a food source of sediment feeding holothurians. I tested the hypotheses that i) benthic microalgae productivity is limited by the availability of inorganic nutrients and that ii) the microalgae thus benefit from the presence of holothurians because the latter remineralise and excrete significant amounts of nutrients.

Densities of *Holothuria atra* (0.08 to 0.83 ind. m^{-2}) and of *Stichopus chloronotus* (0.11–1.67 ind. m^{-2}), and also the biomass values were high and remained relatively stable over the study period at each location. Asexual reproduction by transverse fission occurred in both *H. atra* and *S. chloronotus*. For both species, the annual fission rates at the nearshore reefs (43 to 76 %) were much higher than at a midshelf reef (9 to 19 %). Fission rates of *H. atra* and *S. chloronotus* in winter were significantly higher than during the other seasons. This was distinctly reflected in the weight-frequency distributions, and the median weight of the animals decreased in periods of high asexual reproduction. Population densities and annual fission rates were positively correlated in both species, and higher rates of asexual reproduction also correlated with a smaller average animal size.

Estimates of the level of asexual reproduction using population genetic parameters confirmed that this reproductive mode was more important at the nearshore reefs than at two midshelf reefs. The estimated maximum sexual input for both holothurian species at two nearshore reefs was between 32 and 67%, and between 74 and 87% at the midshelf reefs. Relatively low genetic variation between the sub-populations indicated that gene transfer between the reefs via sexually produced larvae does occur, probably unidirectional from the midshelf to the nearshore reefs. Large differences in genotype frequencies were detected between female and male individuals of both species, and sex-ratios were in most cases highly biased. A differential dispersal ability or mortality of female and male larvae are suggested as the most likely explanations for these phenomena.

Transverse fission was the most important means to maintain high densities and biomass of *Holothuria atra* and *Stichopus chloronotus*, and also had a strong impact on the population structure. There are indications that nearshore reefs are habitats with high food levels, and that therefore dense holothurian populations of small individuals can be sustained. The availability of sufficient food in combination with a restricted larval supply may be the main factor to promote asexual reproduction.

Organic carbon (~0.2% DW), nitrogen (~0.02% DW), bacterial numbers (~10^8 cells ml^{-1}), diatom numbers (~10^6 cells ml^{-1}), chlorophyll a (~1-3 µg g DW^{-1}) and phaeophytin (~1-3 µg g DW^{-1}) in the sediments of the nearshore reefs as indicators of the nutritional quality for holothurians were in a range previously reported for coral reefs. Average concentrations of all sediment parameters were lower in winter than in summer, albeit not always significantly so. Generally, the lowest values at the nearshore reefs were detected at Great Palm Island. A likely cause for this is that Great Palm Island is furthest from the mainland and thus least affected by terrestrial runoff.

Annual microbenthos community net production was 168 g C m^{-2}, with distinctly (50–60%) lower values in winter than in summer. A considerably higher gross production indicated that a large fraction of the primary production by the microalgae is directly consumed by benthic infauna. Small values of the photosynthetic efficiency (α) suggested nutrient-limitation of microalgal production.

As expected, inorganic water-column nutrient concentrations at the nearshore reefs were on a low level [0.06–0.91 µM dissolved inorganic nitrogen (DIN); 0.00–0.25 µM phosphate], whereas organic nutrients were higher [dissolved organic nitrogen (DON): ca. 3–10 µM; dissolved organic phosphorus (DOP): 0.02–0.21 µM]. Nutrient concentrations in the sediment-pore water were substantially higher (up to: 4.65 µM DIN; 0.85 µM phosphate; 0.50 µM DOP; 9.66 µM DON) than those in the water column. The latter were consistently lower at Great Palm Island than at the two other nearshore reefs.

For both *Holothuria atra* and *Stichopus chloronotus*, ammonium is the most important N-excretion product. Ammonium excretion rates were higher in the latter species and they were higher in summer than in winter for both species. Small amounts of phosphate were also released by both holothurian species. Area-specific ammonium excretion rates of the holothurians (1.6–15.9 µmol m^{-2} h^{-1}) were high and in a similar range as previously reported nutrient fluxes on coral reefs. Phosphate release rates were considerably lower (0.01–0.63 µmol m^{-2} h^{-1}).

Both ammonium excretion and respiration rates were reduced in fission products of *Stichopus chloronotus*, but not in those of *Holothuria atra*. Since even anterior sections of both species have normal (*H. atra*) or only slightly reduced (*S. chloronotus*) excretion rates, I suggested that intact organisms also excrete ammonium through the body-wall. Because approximately 25% of the body-wall is in direct contact with the sediment, the excreted nutrients are likely to be directly available to benthic microalgae. Compared to background levels in the water column, high ammonium concentrations were measured in water from the waterlungs (8–15 µM elevation) and directly behind (1.3–2.4 µM elevation) holothurians when water expulsions through the anus occur. This is a second important source of ammonium for the benthic microalgae.

Benthic microalgae exposed to waste water from tanks containing holothurians demonstrated an up to 37% enhanced production. Microalgae *in situ* exhibited also significantly enhanced (12%) production caused by a holothurian-mediated ammonium elevation of only ~0.1 µM. When nutrients were directly added, highest production rates were measured when both ammonium and phosphate concentrations were increased. These results clearly support the hypothesis that benthic microalgae in the study area are nutrient-limited and, therefore, nutrients derived from holothurian excretion may enhance microalgal production.

Microalgae production was increased in all aquaria in which holothurians were present, irrespective of whether microalgae were grazed or protected from grazing. There was a significant (negative) correlation between the amount of sediment consumed and the increase in chlorophyll a and phaeophytin concentrations in the sediment. Holothurians in their natural densities have an overall beneficial effect on benthic microalgal biomass and production.

For *Holothuria atra*, 29–46% of the carbon assimilated was used for respiration and 24 –44% of the assimilated nitrogen was released as ammonium. A similar amount of organic carbon was estimated to be allocated into growth, whereas the percentage of nitrogen used for biomass increase was distinctly higher (39–63%). Similar calculations for *Stichopus chloronotus* indicated a deficit of carbon and nitrogen, because selective feeding by this species on sediment patches rich-organic material could not be taken into account. In *H. atra* the relative amounts of organic carbon and nitrogen that are allocated into growth are inversely related to the concentrations of these compounds in the sediment. Hence, population growth and density of holothurians may be limited by food availability.

Both microalgal and holothurian organic carbon stocks were of a size that corresponded to 10% of the organic carbon pool in the upper sediment layer. The amount of nitrogen incorporated in holothurian biomass was distinctly larger (~ 30% of the sediment N pool). Holothurians may only supply ~ 1% of the microalgal N demand by excretion. However, this is distinctly more than the amount of N from the algal biomass that is consumed by these animals. Thus, most nutrients remineralised by the holothurians may originate from non-living organic matter. Maximum calculations for the amount of nutrients released from the interstitial water by bioturbation activity of the holothurians showed that this amount was insignificant.

In conclusion, the presence of holothurians in the densities observed stimulated the production of the microphytobenthos. Nutrients are tightly recycled within the benthic system and I propose that holothurians are members of a benthic recycling system with some similarity to the well-known planktonic microbial loop. However, a difference to the latter is that holothurians interact directly with many different components of the suggested benthic system, spanning several orders of magnitude in size. In addition to the direct recycling of nutrients by holothurians, I hypothesise that they also increase the overall performance of this recycling loop and thus indirectly promote remineralisation rates of the different components of this system.

Husbandry and spawning of the sea cucumber *Holothuria scabra* (Echinodermata: Holothuroidea).

by Andrew David Morgan
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Thesis submitted for the degree of Master of Science in Marine Science, University of Queensland, 20 Nov. 1998.

From July 1996 to December 1997 the reproductive cycle of male and female *Holothuira scabra* was monitored for a local population at Stradbroke Island, Moreton Bay (27º30' North, 153º24' East) Australia.

The gutted-weight gonad index peaked in November of both years while no obvious progression of oocyte size was noticed. Gametogenesis coincided with a period of body-wall weight loss from mid-winter (June) to mid-summer (December). During gametogenesis, mature oocytes were observed and were either reabsorbed or spawned, during, or prior to, the vitellogenic period from September to November. It was likely that stored nutrients in the body wall were used for gametogenesis during the latter part of winter and that in response to its environment, the production of ripe ova was regulated by phagolytic activity.

Animals collected from October 1996 to January 1997 were maintained at the natural temperature and light cycle existing at that time and subsisted on the detrital material contained in the sand in the holding tank, losing up to 40% of their wet weight over two months. The weight of animals continued to decline for a period of three months post-spawning, despite the addition of prawn and lucerne pellets to promote bacterial and fungal growth in the substrate. Animals collected during October 1997 were conditioned at 27°C and a 16:8 LD (light / dark) photoperiod. Diets provided to broodstock reduced the amount of weight loss, which reached approximately 10% after 1 month, compared to 20% for the controls. Animals were more active at night, produced more faeces in the control and blue-crab diet quadrats and spent a large proportion of time moving along the perimeter of quadrats, while movement across the substrate depended on the distribution of food. The degree of weight loss in captivity may depend on the interaction of diet, temperature and light and the effect these variables have on the coupling of feeding behaviour with the reproductive strategy of *H. scabra*.

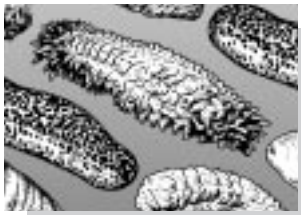
During the 1997 / 98 summer, between 1 to 5 weeks of captivity, 100% of animals were induced to spawn in four trials at dusk on or close to a new or full moon, using nine males and nine females contained in a 1.5 m^2 area and 20 to 30 cm of 1 µm filtered sea water, using a 3 to 5ºC temperature shock. *H. scabra* was induced to spawn in small numbers during the 1996 / 97 summer despite a marked degree of weight loss and all induced individuals spawned during the 1997 / 98 summer, irrespective of diet in captivity. No correlation was found between egg size and hatch rate, fecundity, fertilisation rate, weight or number of days in captivity, for females. The difference in fecundity between animals of similar size and mean fecundity in consecutive trials decreased the longer animals were held before spawning.

The hatch rate of eggs was reduced significantly for broodstock held for one month and was most likely affected by: i) The expiration of gonad nutrients for egg metabolism and the resulting use of yolk reserves to maintain egg viability once vitellogenesis was completed. ii) The use of gonad and egg nutrients for somatic metabolism when other nutrient sources ran out. Hatch rate and fecundity are important indicators of egg viability of broodstock maintained in captivity for an extended period.

It was found that in excess (40 and 80 x 10^3 cells / ml), and in the absence of the alga *Isocrysis galbana*, larval survival was less and growth and development was inhibited. In moderate amounts of algae (10 and 20 x 10^3 cells / ml) the percentage of growth, survival and development of larvae increased substantially. The instantaneous mortality rate (larvae / day) of larvae varied throughout development in all feeding regimes and between bowls within a treatment, but was least overall in moderate amounts of algae.

Meeting

The next international Echinoderm Conference will be held in New Zealand at the beginning of the year 2000. Its site is: http: / / macintosh.otago.ac.nz / iec2000



correspondence
beche-de-mer

From Yves Samyn (23 February 1999)

I'm still working at the Free University of Brussels, and doing my research on echinoderms (mainly systematics of eastern african holothurians and echinoids). I have also started working on a small paper for the *SPC Beche -de-mer Information Bulletin*:

The necessity for studying holothurians in the littoral waters of the Western Indian Ocean.

ABSTRACT – Aspidichorotid sea cucumbers (Echinodermata: Holothuroidea) are heavily fished in the littoral waters of Kenya and Tanzania, which results in plummeting populations. In order to conserve and manage these natural resources appropriate conservation and managementsplans have to be developped. This can only be done if high quality research on different levels broadens our understanding of the populations in question. This paper discusses some aspects of traditional and molecular biology which should help in the holothurian conservation in eastern Africa.

Yves Samin can be contacted by e-mail at: ysamyn@pop.vub.ac.be

From Dr Oscar Sosa Nishizaki

Unfortunately, I have to send you the news that German Perez Placencia has died last Sunday May 2, while he was doing a professional abalone diving survey at Cedros Island, in the southern part of the Baja California state. As maybe you know, he was working for the Regional Fisheries Center at Ensenada, Baja California from the National Institute of Fisheries of Mexico. And this survey was one of his duties. Also since last January, he started his graduate studies to get a Ph. D.degree under my direction, here at CICESE. That is why I was asked by his wife, Laura Veronica, to send this very tragic news. As you might imagine, she is going through a very hard time, and she and her 10 month-old daughter, Daniela, will move to Mexico City with her parents. I do not have the address right now. But if you are interested let me know to send it in our next communication.

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Note from the editor and the SPC Fisheries Information Section:
German had contributed to the Bulletin BDM #8 (p. 15): 'Beche de mer fishery in Baja California' and BDM 9 with an abstract on p. 29. We wish to join with the many others who offer sincere condolences to German's family. His death is a tragic loss.

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). This bulletin is produced by SPC as part of its commitment to PIMRIS. The aim of PIMRIS is to improve the availability of information on marine resources to users in the region, so as to support their rational development and management. PIMRIS activities include: the active collection, cataloguing and archiving of technical documents, especially ephemera ('grey literature'); evaluation, repackaging and dissemination of information; provision of literature searches, question-and-answer services and bibliographic support; and assistance with the development of in-country reference collections and databases on marine resources.

PIMRIS

Pacific Islands Marine Resources Information System