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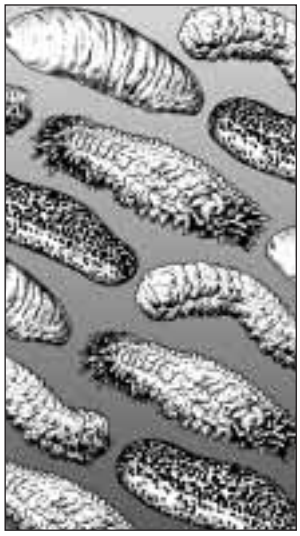

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Editorial

Welcome to the 15th issue of the Bulletin. The 'New Members' section on page 42 and the great number of hits on the Bulletin's web-pages (www.spc.int/coastfish/News/bdm/bdm.htm) are proof of the increasing interest raised by our publication. Thanks to all contributors who helped me in keeping the Bulletin alive and informative.

We start the 'New Information' section with an article on the Torres Strait beche-de-mer fishery (p. 2) followed by two articles on the different aspects of the biology of sea cucumbers sexual reproduction (p. 4 and p. 13). The 'Aquaculture News' column includes three original articles presenting new projects in Vietnam (p.17), Marshall Islands (p. 27) and New Zealand (p. 28).

Information on beche-de-mer prices is difficult to get. *INFOFISH Trade News* is one of the best sources of information for seafood market trends and we are thankful to them for allowing us to reproduce a table presenting beche-de-mer prices on the Asian markets (p. 31). We also thank the National Fisheries Authority (NFA) of Papua New Guinea for providing information on their beche-de-mer export prices (p. 30). Sharing information is the main aim of this bulletin and we encourage other fisheries departments from within and outside the Pacific region to follow NFA's example.

I draw again your attention to the '*Echinoderms Newsletter*' that is available on the Web (www.nmnh.si.edu/iz/echinoderm) and to the echinoderms forum that was created after the International Conference in Dunedin. You can subscribe by contacting sabine.strohr@nrm.se or by sending an e-mail to listserv@nrm.se and including on the first line of the message SUBSCRIBE ECHINODERM-L, your surname and first name, but no other text.

Chantal Conand

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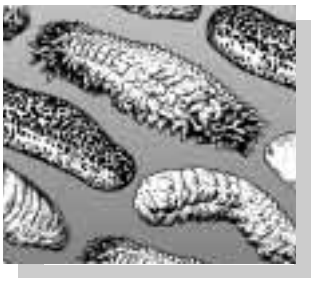

new info
beche-de-mer

The Torres Strait beche-de-mer (sea cucumber) fishery

Dallas D'Silva[1]

Brief history

The beche-de-mer fishery is an important commercial fishery for Torres Strait Islanders. There is no definite record of when beche-de-mer fishing began in Torres Strait but by the early 18th century it had become important to the economies of both Torres Strait and coastal Papua communities (Williams 1994). In the past, the fishery was based primarily on sandfish *(Holothuria scabra)*; however, harvesting of this species has since been discontinued. Current fishing effort focuses on surf redfish *(Actinopyga mauritiana)*, black teatfish *(Holothuria nobilis)*, white teatfish *(Holothuria fuscogilva)* and to a lesser extent, a couple of lower value species.

Management arrangements

Commercial and traditional fishing within the Australian section of the Torres Strait Protected Zone (TSPZ) is managed under the Commonwealth *Torres Strait Fisheries Act 1984* by the Protected Zone Joint Authority (PZJA). The PZJA is comprised of the Commonwealth and Queensland Ministers responsible for fisheries.

Fisheries resources of the TSPZ are managed in accordance with the provisions of the Torres Strait Treaty, ratified in 1985. The Treaty requires Australia and Papua New Guinea to cooperate in the conservation, management and optimum utilisation of resources of the region primarily for the benefit of traditional inhabitants of the two countries.

Management and licensing tasks are administered by the Australian Fisheries Management Authority (AFMA) and the Queensland Fisheries Service (QFS) based at Thursday Island and Brisbane, respectively. The Queensland Boating and Fisheries Patrol (QBFP) perform surveillance and enforcement duties from officers based on Thursday Island.

This fishery, in common with all other Torres Strait fisheries, has the policy that if an increase in fishing effort is allowed, then it must be reserved exclusively for Torres Strait Islanders.

Key management measures

Regulations implemented in the fishery include: limiting the method of collecting beche-de-mer to either hand, or hand-held, non-mechanical implements; a ban on the use of hookah gear; limiting Islander dinghies to less than 7 metres in length; and a competitive total allowable catch (TAC — measured in wet weight gutted) for commercial species and minimum size limits.

Current fishery trends

Fishing for beche-de-mer in Torres Strait is mainly by free diving from dinghies crewed by 2–3 fishers or by hand collection along reefs at low tide. Once collected, the animal is gutted, graded, cleaned, boiled, smoked and dried. This is a labour-intensive process usually carried out on processing vessels or at shore-based facilities.

1. Queensland Fisheries Service, GPO Box 46, Brisbane, Qld, 4001, Australia

Beche-de-mer are especially susceptible to overfishing because they are large, easily seen and collected, and do not require sophisticated fishing techniques (Skewes et al. 2000). As a result, the Torres Strait beche-de-mer fishery is subject to a suite of output and input controls aimed at preventing overfishing but also allowing Islanders to benefit from the use of beche-de-mer stocks.

A total of 148 traditional vessels are presently licensed for the fishery. One non-islander operator is licensed in the fishery with additional conditions that primarily involve the participation of islanders in those activities.

Overexploitation of sandfish

Sandfish is a high-value species occurring in relatively shallow waters and vulnerable to over-harvesting. The population on Warrior Reef has been subject to excessive levels of fishing effort during the early 1990s and 1995 in particular. A similar boom on the PNG side of the TSPZ preceded this in the late 1980s and early 1990s.

Following concerns of serious resource depletion and overexploitation of sandfish stocks on Warrior Reef, two independent fishery surveys were commissioned to assess the level of reduction in sandfish abundance from November 1995 to January 1996 and in January 1998. The collection of sandfish was primarily for export to Asia. Harvesting has been prohibited since early 1998, following recommendations from Commonwealth Scientific Industrial Research Organisation (CSIRO) researchers who surveyed the remaining stock on Warrior Reef, and determined it was approximately 80 per cent less than in November 1995. In 1995, the sandfish stocks were considered overexploited, therefore the subsequent reduction indicated a serious depletion (Skewes et al. 2000).

Sandfish stocks were regarded as being in a downward spiral, with progressively smaller breeding populations leading to smaller and smaller recruitments. The CSIRO survey also led to the introduction of severe management measures. Further fishing pressure on sandfish may have led to a total collapse of the stock and a continued closure was recognised as the only feasible strategy for rehabilitation.

Because the fishery had been closed for two years, it was decided that another survey should be carried out to determine if there had been any recovery in the population. This was recognised as a high priority by management agencies and Islander fishing representatives at a beche-de-mer workshop held on Thursday Island in July 1999.

CSIRO Division of Marine Research

Sandfish (*Holothuria scabra*)

A third survey of the sandfish population on Warrior Reef was undertaken by CSIRO in January 2000. The work revealed that sandfish stocks are still severely depleted with only a very slight recovery since the extremely low abundance recorded in 1998. The heavily depleted population was also confirmed by estimates of the standing stock, which suggest it is unlikely there are more than 100 tonnes of adult animals remaining on Warrior Reef. The present stock size is also very low compared to virgin biomass estimates of over 1600 tonnes (Skewes et al. 2000).

The findings from the most recent survey were noted by the PZJA at its meeting in April 2000 and the existing closure for sandfish has been continued. The PZJA referred the findings to the Beche-de-mer Fishery Working Group and requested the group to develop long-term management arrangements, including monitoring and enforcement for the fishery.

Recovery of sandfish stocks

Experience elsewhere in the Pacific indicates recovery of overfished sea cucumber stocks is a lengthy process, taking several years. This is because holothurians, like many other invertebrates are broadcast spawners, and fertilisation success is highly dependent on population density. Reduction of population densities by fishing may render remaining individuals incapable of successful reproduction.

The possibility of reseeding sandfish stocks on Warrior Reef is also being explored as a viable option to assist recovery. The fishery has several characteristics that make it suitable to reseeding and would benefit from recent work conducted by ICLARM in Solomon Islands where propagation techniques for sandfish have been investigated.

While reseeding may be a viable option to assist rehabilitation in future management agencies are more concerned with the effective sustainable management of other commercial species being fished at present.

Recent catch estimates

Combined log returns from individual islands indicate that 15 tonnes of prickly redfish, 23 tonnes of black and white teatfishes, and 12 tonnes of all other species were harvested during 1999. The 1998 catch included 80 tonnes of prickly redfish, 20 tonnes of teatfishes and 15 tonnes of all other species combined. The 1997 catch comprised 57 tonnes of prickly redfish, 29 tonnes of teatfishes and 29 tonnes made up of all other species combined. These figures are in wet weight and gutted.

Official figures for 1995 revealed the total harvest of sandfish was around 1000 tonnes. Industry estimates place the total catch between 1200 and 1400 tonnes wet weight, with all but approximately 50 tonnes being sandfish.

Status of other commercial species

The status of black and white teatfish, surf redfish and other lower value species remains unknown at present. It is possible these species may be the target of increased fishing pressure in future due to the growing export market demands for quality beche-de-mer.

References

Williams, G. 1994. Fisheries and Marine Research in Torres Strait. Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forest, Australia. 84 p.

Skewes, T., D. Dennis and C. Burridge. 2000. Survey of *Holothuria scabra* (sandfish) on Warrior Reef, Torres Strait, January 2000. CSIRO Division of Marine Research.

Sexual reproduction of *Stichopus chloronotus*, a fissiparous sea cucumber, on Reunion Island, Indian Ocean

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Introduction

Stichopus chloronotus is a holothurian of the order Aspidochirotes, family *Stichopodidae*, that is widely distributed across the tropical Indo-Pacific region. It is mainly found on reef flats and slopes with considerable hydrodynamic energy. The species' density is relatively low, but sometimes reaches up to several specimens per m^2 (Franklin 1980; Conand 1989; Uthicke 1994; Conand et al. 1998).

Similarly to nine other Aspidochirotes sea cucumbers, they can reproduce both sexually and asexually (Uthicke 1994, 1997, 2001; Conand et al. 1998). Their sexual reproduction has been studied in Australia (Franklin 1980) and Malaysia (Tan Shau-Hwai and Bin Yasin 2000). Asexual reproduction is achieved by transverse fission resulting in two animals that each regenerate the missing part (Uthicke 1997; Conand and Uthicke 1998; Conand et al. 1998).

The aim of this study was to describe the sexual reproduction cycle on Reunion Island. The results should provide a better understanding of the respective roles of sexual and asexual reproduction and facilitate the interpretation of population genetics (Uthicke et al. 1999 and 2001).

Materials and methods

Sites

The Trou d'Eau station is located on Reunion Island's west coast on the Saline-les-Bains reef complex that spans five kilometres. It is a fringing reef that is swept by the trade winds, but with little hydrodynamic activity. Most sampling was conducted on this site, which is a back reef forming a channel made up mainly of detrital coral sediment littered with large basalt blocks. Small amounts of brackish water well up into this 0.70-m deep area at the shoreline, providing algal cover for the substrate at certain times of the year.

Seawater surface temperature was selected as a reference parameter and recorded hourly throughout the study, ie from March to April 2001, using a

VEMCO minilog-T sensor set three metres deep at the Pointe des Galets harbour exit (F. Conand pers. corr.). The temperature curve throughout the study was obtained by five-day averages of hourly readings.

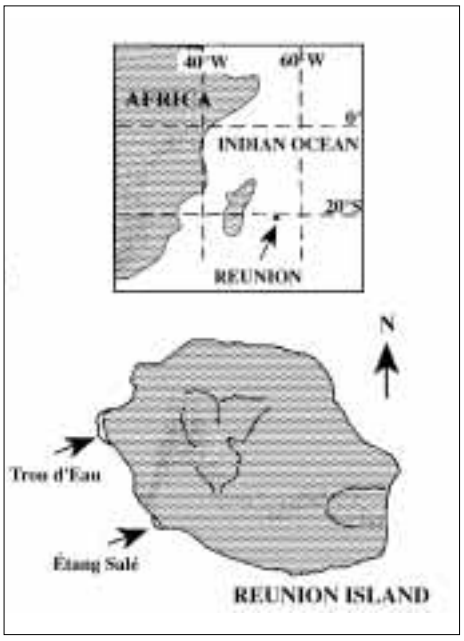

Figure 1. Sampling sites of *Stichopus chloronotus*

Sampling

Twenty adult specimens were collected monthly at the Trou d'Eau station from March 2000 to April 2001. They were selected from among the longest and heaviest category, so as to avoid any bias arising from the relation between size and the gonad index value (Franklin 1980). Such sampling based on a uniform size category is recommended for studying reproduction cycles. Small specimens were also sampled to determine the population's size at first sexual maturity. Further sampling was conducted at the Planch'Alizés station (Fig. 1), following early results, so as to obtain extra females.

Gonad dissection and processing

Specimens were anaesthetised in a 37 % magnesium chloride solution and dissected on arrival at the laboratory after a one-hour journey. The length to within 0.5 cm (Lt) and total weight to within 10^{-1} g (Wt) were measured for each specimen. The gonads were weighed to within 10^{-2} g (Wg) and fixed in formalin (10 %). Finally, the eviscerated weight (We) was obtained, which is more representative than the total weight that includes the coelomic fluid and digestive tract contents, which cause considerable variability (Conand 1989). The gonad index or GI follows the Conand (1989) calculation method. The monthly average (+/- standard deviation) was calculated and the patterns indicated maturity, spawning and sexual resting periods.

$$\mathbf{GI = (100 \times Wg) / We}$$

Stichopodidae gonads have two tufts of tubules located on either side of the mesentery. The tubules branch out distally and are joined at the base in a sac, which bulges out from the dorsal mesentery. Saccules, ie dilations developing during maturation, are generally observed in this family (Conand 1993a). This characteristic form is not found, however, in *S. chloronotus*, which has tubular distal tips.

The gonads' macroscopic and microscopic characters were determined using samples fixed in formalin. The lengths of gonad tubules were measured from the gonad base to the distal tip to within 5 mm (Lg). Tubule diameters were also measured (Dg). Both values were used to describe *S. chloronotus* maturity stages by comparing them with macroscopic gonad characteristics such as colour, morphology and consistency and by using other descriptive methods, such as gonad indices, microscopic observations and histological sections.

It was possible to determine the sex in females during advanced stages of maturation using a binocular magnifier, but it was generally necessary to resort to a microscope. Also, oocyte diameter distribution was established based on samples preserved in formalin and was used to determine maturity stage characteristics.

Atresia was related to undischarged germ cell disintegration. These germ cells were, therefore, observed as coloured clusters in several areas of the gonad tubule lumina. A new parameter was defined and used to determine the end of the sexual cycle, because the proportion of clusters increased as reproductive activity declined. A semi-quantitative value or atresia index was allocated to each specimen using the formalin samples.

- *no atresia* (0): no degenerative cell clusters observed anywhere in the gonad
- *low atresia* (1): small scattered coloured clusters mainly distributed at the tubules' distal tips
- *medium atresia* (2): much larger and more numerous clusters, still mainly concentrated in the distal tips. Clusters clearly visible to the naked eye.
- *high atresia* (3): clusters replaced by structures taking up the entire lumen volume in the gonad's main tubules. Some clusters remained in the distal tips of tubules that appeared fairly empty.

An atresia development curve was obtained and correlated with mean GI curves throughout the study.

Histological sections were prepared to provide more accurate descriptions of the observed maturity stages. Two stains were used, ie Trichrome and HPS (hematoxylin-phloxin-saffron).

Results

Sex ratio

Out of the entire year's sampling of 260 specimens, only 8 females were collected, giving a sex ratio of 97.3% males (Fig. 2). In the extra sample collected at Planch'Alizés, 5 of the 12 specimens obtained were female and 7 male, which was a more balanced sex ratio.

Gonad and gonad index study

Monthly mean GI variations (Fig. 3a) indicated several phases in the year. From March to late May, values remained fairly stable between 1.64 and 1.69. From late May onwards, a sharp GI fall was observed, reaching 0.83 ± 0.29 in July. A gradual return to the mean GI was then noted, followed by a maximum in early November at 3.22 ± 0.93, ie the first GI peak. Gonad indices subsequently fell slightly up until late December (2.41 ± 1.36). In January, GI rose very steeply again to reach a second peak in late January (4.58 ± 1.36). Values then gradually declined until late March (3.31 ± 1.10). Two peaks were therefore noted on the GI curve, ie around mid-November and late in January. Falling values coincided with the two spawning seasons (Conand 1989). Both peaks occurred in the warm season (Fig. 3b), when seawater temperatures were at their highest. GI values obtained for March (Fig. 3a) differed from one year to the next, however, with a mean GI in 2000 of 1.64 ± 0.45 and for March 2001 of 3.31 ± 1.10 (t = -6.27, 5% significant difference threshold).

An analysis of gonad tubule diameters indicated that this parameter generally followed the mean GI curve. From March to June, tubule diameters slowly narrowed at the same time as gonad indices dropped off for the first time. When gonad indices rose to their initial peak in mid-November, tubule diameters increased considerably. As with diameters, gonad tubule lengths also varied in line with the monthly GI curve. Average lengths dropped with the first GI trough and rose again with the first GI peak.

Providing a macroscopic description of gonads in terms of the maturity stage was more difficult than with other sea cucumber species (Conand 1989, 1993b). There was no major variation in appearance during the sexual cycle. The following phases were nevertheless identified: 1) a maturing stage; 2) a pre-spawning or ripe stage; and 3) a post-spawning stage (Fig. 4). No immature specimens were observed, other than in the extra sampling conducted to determine weight at first maturity.

With regard to atresia, the mean atresia index curve during reproduction (Fig. 3a) generally followed the opposite path to mean gonad indices. When the initial GI peak occurred in mid-November, atresia was falling sharply, reaching nil in late November. After rising steeply again in January, between the two spawning seasons, it declined once again. Mean atresia index increases occurred during GI falls, immediately after spawning.

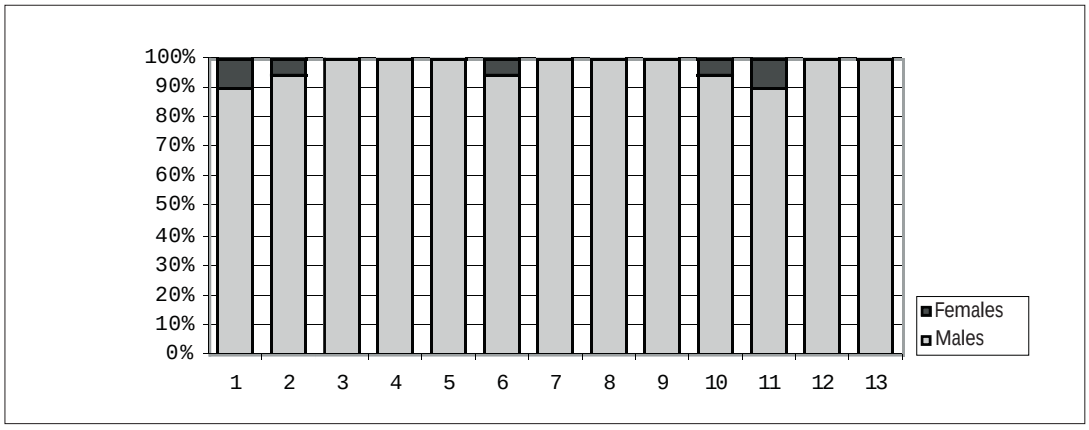

Figure 2. Monthly sex ratio in *Stichopus chloronotus* population from Trou d'Eau, La Reunion (monthly sample of 20 individuals, March 2000 – April 2001)

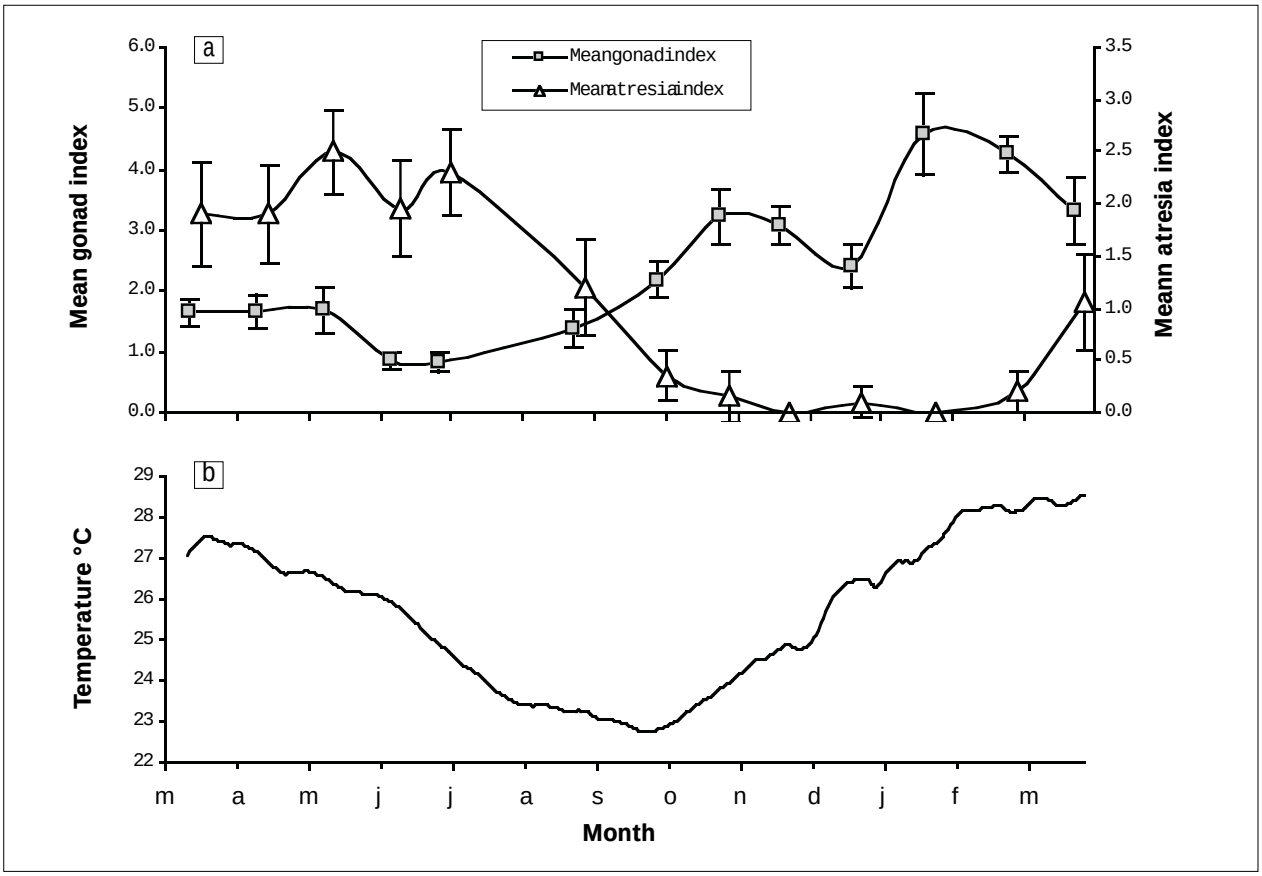

Figure 3. **Monthly variations of gonad index and atresia index (±SD) of *Stichopus chloronotus* and sea water temperatures (La Reunion)**

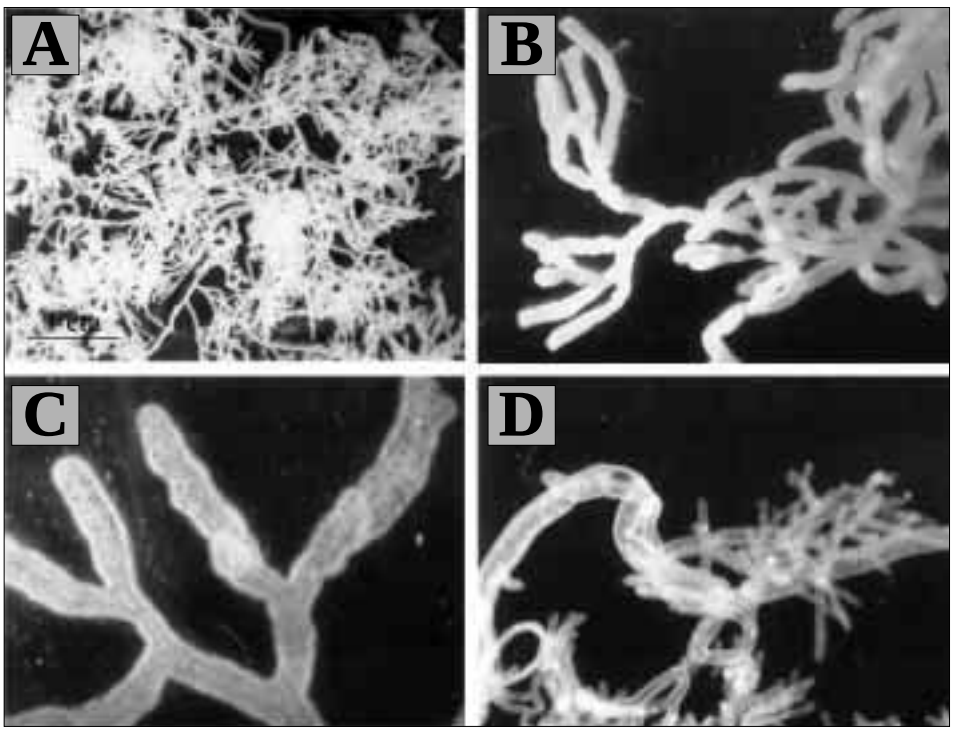

Figure 4. **Morphology of *Stichopus chloronotus* gonads.**
A: Testis. B: Mature testis tubule.
C: Mature ovarian tubule. D: Post spawning testis showing atresia.

The oocyte diameter frequency distribution based on formalin samples is presented for each stage in Figure 5. During the post-spawning stage (Fig. 5a), oocytes were distributed between 12 µm and 48 µm, the mode being 30 µm. During maturation (Fig. 5b), developing oocytes have diameters ranging from 36 µm to 78 µm, the average being 64 µm. The only three females collected during the spawning season (Fig. 5c) had oocytes measuring 30 to 114 µm with the mature oocyte mode being 84 µm.

A more accurate appreciation of these stages was obtained through the histological study. It provided a clearer distinction between immature and maturing specimens. Four maturity stages were described using the histological approach, ie 1) immature; 2) maturing; 3) pre-spawning or mature; and 4) post-spawning (Fig. 6). These stages are described in Table 1.

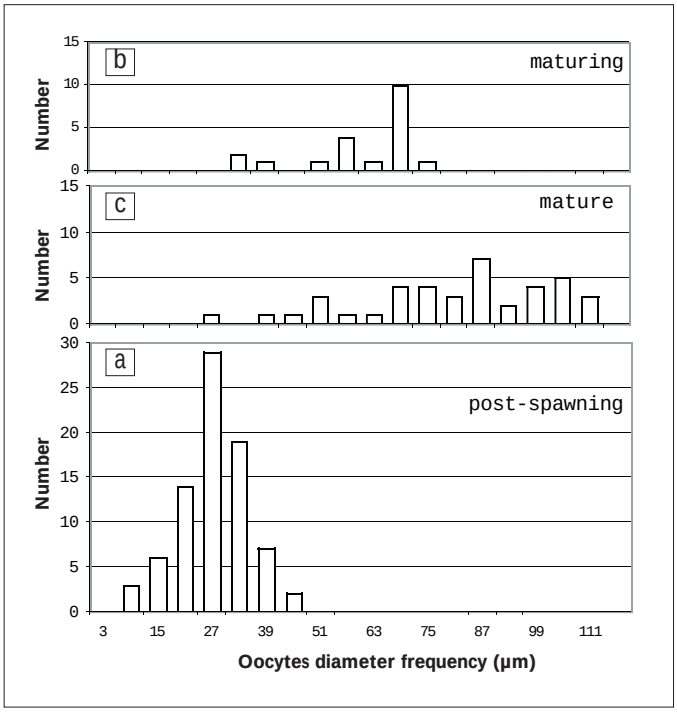

Figure 5. **Oocyte diameter frequency distributions of *Stichopus chloronotus***

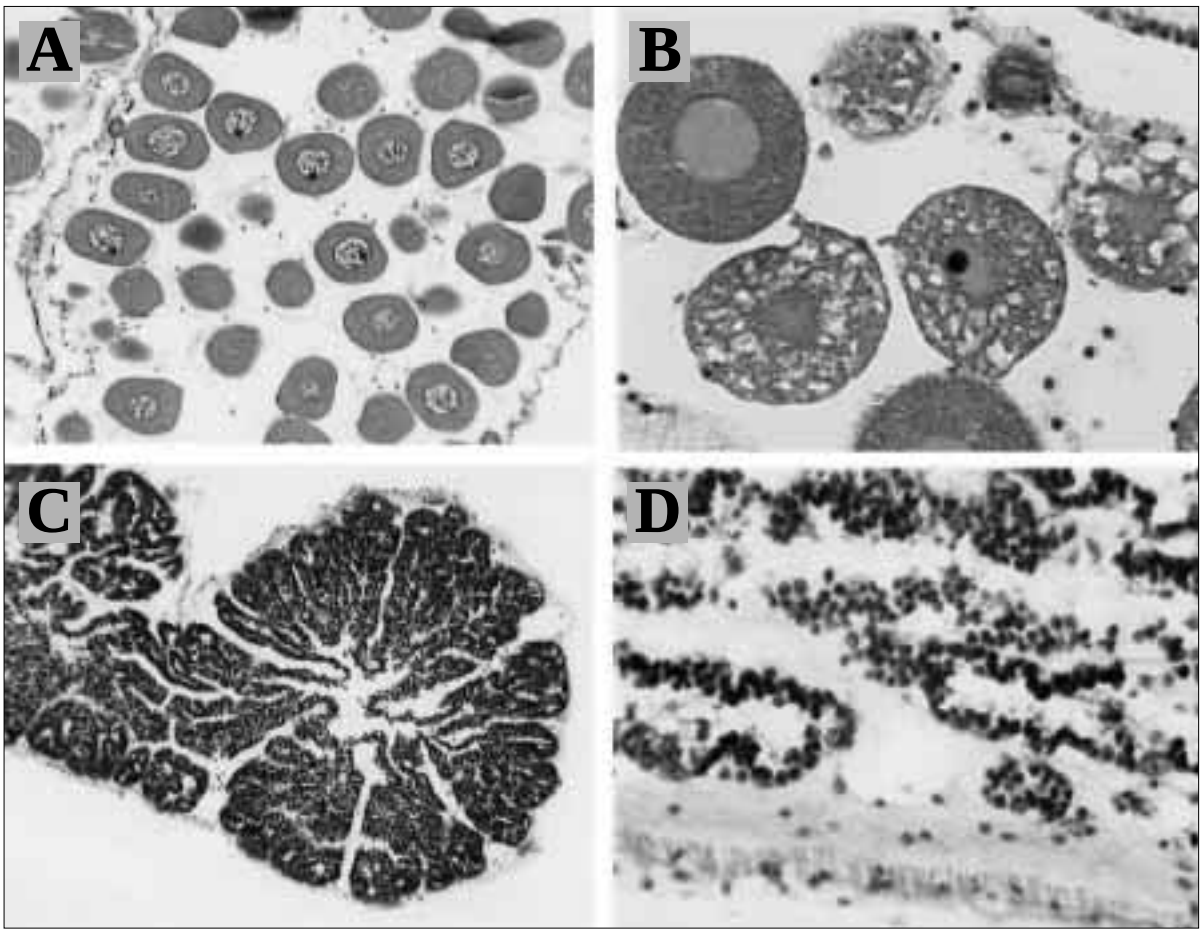

Figure 6. **Histological characteristics of *Stichopus chloronotus* gonads. A. Ovary, vitellogenis oocytes. B. Post spawning ovary with degenerating oocytes. C. Mature testis with spermatocytes and sperm. D. Post spawning testis.**

First maturity

First maturity was determined on the basis of 20 small specimens from the extra samples collected at Trou d'Eau (11/03/01). Weight at first maturity was estimated at 50 g. All specimens weighing more than 50 g proved to have gonads, while those weighing less did not.

Maturity stage variations during the yearly cycle

Figure 7 presents the proportions of specimens at each stage over time supported by the various methods. Most post-spawning specimens were observed from March to July and declined as maturing specimens increased from August to October. Pre-spawning specimens rose sharply in November and fell in December. They increased abruptly again in January and gradually waned in February and March. The cycle was therefore characterised by a minor initial spawning season in November, followed by the main season in February/March during the warm season.

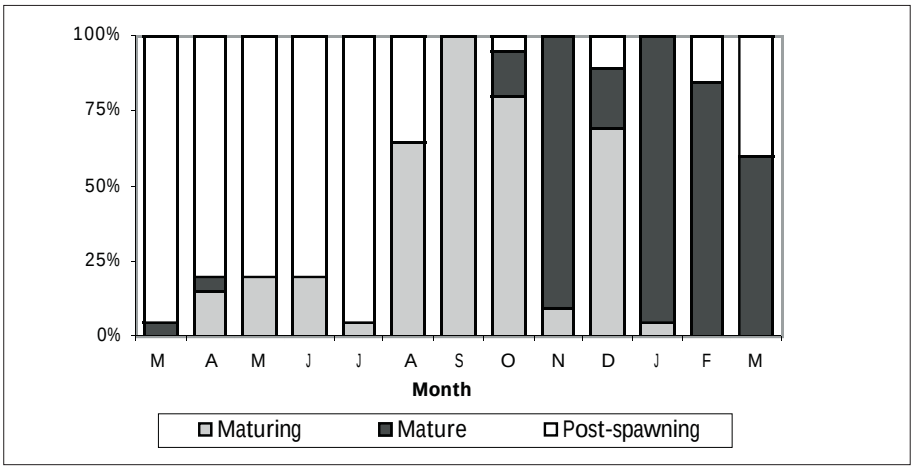

Figure 7. ***Stichopus chloronotus*'s reproductive cycle on Reunion Island**

Table 1. **Macroscopic and microscopic characteristics of *Stichopus chloronotus* gonads at different maturity stages**

Various stages	Gonad anatomical and macroscopic characteristics	Microscopic characteristics
Immature stage	Small tubules with little branching	Some sparse villi against tubule walls. Few germ cells.
Maturing stage	Whitish tubules already branching out considerably; villi clearly visible	**Males:** Increasing villi. Few germ cells in tubule lumina. **Females:** Oocytes tightly packed and filling entire tubule lumina. At this stage, oocytes measure 36 to 78 µm, the average being 64 µm.
Mature stage	Slight colour change from whitish to off-white and even creamy brown in both sexes. Tubules are bulging.	**Males:** Villi are less prominent and remain on walls. Maturing spermatocytes are clearly visible. Sperm appear in the form of thick granules in the tube lumina. **Females:** Oocytes are not attached to tubule walls, which still hold oogonia. At this stage, most oocytes are mature, measuring an average 84 µm with the largest reaching 114 µm. They have a very wide, clearly visible nucleus and an eccentric nucleolus.
Post-spawning stage	Tubules are more or less empty, but have residual, undischarged sperm or oocytes undergoing atresia (yellowish clusters)	More or less empty tubules are observed in both sexes. Undischarged cells and oocytes at various stages of deterioration are noted in females and atresia clusters in males.

Discussion

This study follows on from an analysis of asexual reproduction by fission in *Stichopus chloronotus* (Conand et al. 1998) and is the first on sexual reproduction on Reunion Island. It was conducted at the Trou d'Eau site, where there is a high fission rate. The site benefits from an upwelling of nutrient-rich water (Cuet 1989), which enables algae to develop and results in high organic-matter content in sediment. These conditions are highly conducive to settlement and proliferation by this species, which is a detritus feeder (Conand 1989; Uthicke 1997).

When using microscopic sex determination, a highly male-biased sex ratio of 0.97:0.03 was observed. This is unusual among other sea cucumber species in which the ratio is often close to 1:1 (Conand 1989; Hopper et al. 1998; Uthicke 1997; Hamel et al. 2001).

Other *S. chloronotus* populations studied in the past have displayed balanced sex ratios, ie in Australia (GBR) (Franklin 1980), Indonesia (Tan Shau-Hwai and Bin Yasin 2000) and Reunion Island (Planch'Alizés site) (Conand unpub. obs.). A comparable sex-ratio bias has, however, been described by Uthicke et al. (1999) on Great Palm Island (GBR). Only one female was observed out of 59 specimens.

There are four possible explanations for these results:

1) high adult female mortality;
2) a higher fission rate among males;
3) low female recruitment owing to high female mortality among larvae or juveniles; and
4) sex inversion during the life cycle at the planktonic larval or adult stages.

Weight distribution was identical among males and females, however, indicating that age and survival rates were also equally distributed across both sexes, which would exclude the first hypothesis. No differences in fission rates between the sexes have been observed either (Uthicke et al. 1999), which excludes the second hypothesis.

The fact that size is evenly distributed among both males and females and that no hermaphrodite specimens have been recorded is incompatible with the sex-inversion hypothesis at the adult stage. The heavy sex-ratio bias at Trou d'Eau can therefore be explained either by higher female mortality during recruitment or a differential dispersal ability according to sex, as on the GBR (Uthicke et al. 1999).

The reproductive cycle was described using standard methods. Average monthly GI data can differ depending on the species or site under consideration. The bimodal curve observed with *Stichopus chloronotus* on Reunion Island indicates a biannual reproductive strategy, which confirms previous studies on this species (Franklin 1980; Tan Shau-Hwai and Bin Yasin 2000). There is a significant difference between the peaks' average values (ie statistically significant at a threshold of 5%), which implies different reproductive activity rates at each spawning season. This has been observed before by various authors, namely Franklin (1980), with regard to *S. chloronotus*, as well as by Conand (1989 and 1993b) and Hamel et al. (2001) with regard to *Holothuria scabra*. Mean gonad indices for March 2000 (1.64 ± 0.45) and March 2001 (3.31 ± 1.10) differed significantly ($p = -6.27$ at a 5 % threshold).

Water temperatures in March 2001 exceeded the multi-year average by approximately 1° C. This prolonged warm season brought about a shift and/or extension of the reproductive cycle. This phenomenon has previously been observed by various authors, particularly Hopper et al. (1998), who demonstrated how temperature severely disrupted the reproductive cycle in *Actinopyga mauritiana*.

When values are compared with other authors', several similarities can be observed, such as two reproductive seasons and greater activity in the warm season, but so can a number of differences. Such comparisons can only be made in terms of general reproductive activity trends, however, as each author's selected gonad indices restrict the values than can be compared (total weight, open or eviscerated). The reproductive cycle described in Malaysia (Tan Shau-Hwai and Bin Yasin 2000), for example, appears to extend over a longer period than on Reunion Island. As there is a longer interval between the two reproduction peaks (Fig. 8), the end of the cycle occurs later. Also, an earlier peak has been recorded. The data obtained on the Great Barrier Reef (Franklin 1980) indicates the same interval between peaks as on Reunion Island (Fig. 8). Values are also too small to discern any difference in reproductive activity rates between the two spawning periods. The cycle on the Great Barrier Reef appears to last the same time as on Reunion Island, although the two reproductive cycles seem to occur at slightly different times.

Gonad morphology was examined from two angles: tubule diameter and tubule length. Data on tubule diameters indicated that they were widest during spawning, as observed by Franklin (1980). The longest tubule lengths were recorded during the high reproductive activity period. Tubules were present throughout the year in *S. chloronotus*

and there was no sexual resting phase. Oocyte diameter estimates were obtained from formalin-fixed specimens. An average diameter of 84 µm was obtained and the highest measurement, ie 114 µm, was recorded in the pre-spawning stage. These values are higher than Franklin's who worked on material fixed in Bouin's solution, which causes greater cell retraction than formalin.

The monthly atresia index variations indicated a close link with reproductive activity. The atresia index curve followed a generally opposite path to the GI curve's, with higher values occurring in April and August. This index was useful in corroborating other results.

The histological study confirmed the results obtained on the choice of the various stages using macroscopic observations. Although first maturity was estimated at 50 g in this study on the basis of only 20 specimens, this weight was consistent with Franklin's results (1980).

The proportion of specimens at each stage during the cycle effectively correlated with the GI curve and fairly accurately reflected the specimens' monthly development stages.

The description of *S chloronotus*'s reproductive cycle was therefore based on an integration of three different parameters, ie 1) variations in GI averages; 2) monthly variations in the average atresia index; and 3) monthly proportions of specimens in each stage.

Conclusions

Stichopus chloronotus's reproduction cycle at the Trou d'Eau, Reunion Island, site does not differ greatly from other populations' as previously studied on Australia's GBR (Franklin 1980) or in Malaysia (Tan Shau-Hwai and Bin Yasin 2000). As on other sites, the cycle covers a year and has two spawning seasons. The Conand et al. (1998) study conducted at the same station nevertheless demonstrated that this population was quite unusual in terms of the high densities recorded (3.7 specimens/m^2), low average specimen weights and asexual reproduction by fission. It should nevertheless be noted that spawning occurred in the warm season and fission in the cool. This study contributes new information to the quest to understand this population's adaptive strategies and will serve as a basis for assessing the respective roles played by both reproduction methods in population dynamics.

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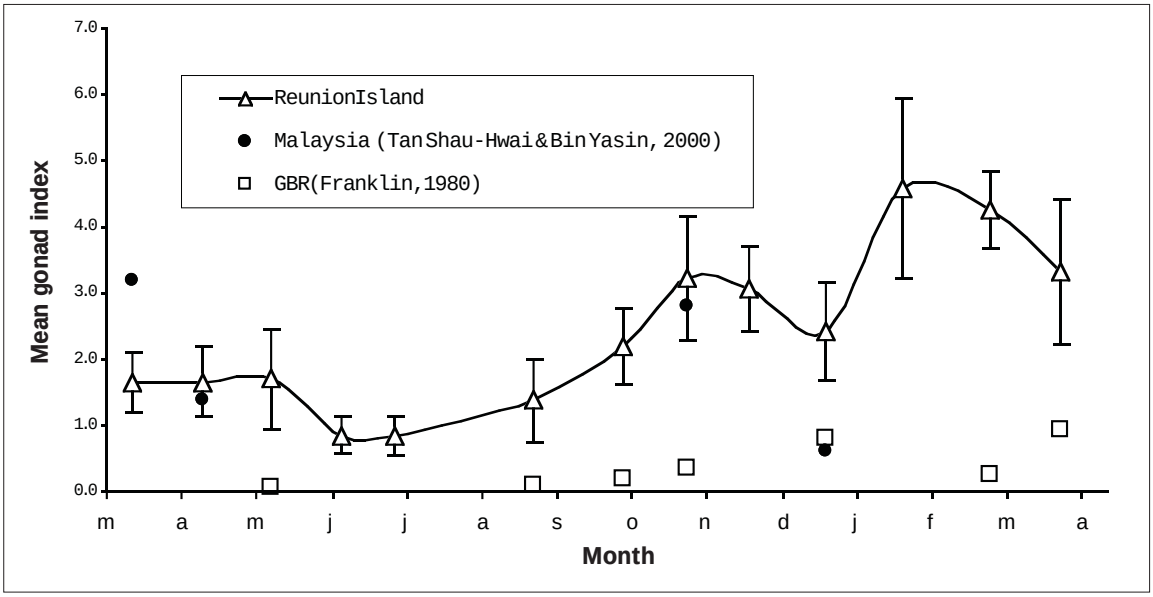

Figure 8. Comparison of the reproductive cycles (Gonad-indices) of *Stichopus chloronotus* between several countries

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Stichopus chloronotus

Assessment of the 'tubule recruitment model' in three tropical Aspidochirote holothurians

Christain Ramofafia[*1,2] *and Maria Byrne*[1]

Introduction

Holothurians have a single gonad comprising one or two tufts of elongate tubules. The tubules develop as a single cohort or as distinct cohorts that differ in age (Smiley et al. 1991). In species where the gonad development is uniform, the gametogenic state of tubules is similar across the entire gonad and all tubules have a uniform appearance. In species where the gonad has cohorts of tubules, gametogenesis is synchronous within cohorts but asynchronous across cohorts. Typically, the small-sized tubules are in an early gametogenic stage and the largest tubules are mature. In these gonads the tubules are recruited progressively from anterior to the posterior region of the gonad basis. Such progressive evolution of tubules has been described in detail for one species *Stichopus californicus* and has provided the basis for the 'tubule recruitment model' (TRM) for ovarian development in holothurians (Smiley and Cloney 1985; Smiley 1988, 1994; Smiley et al. 1991).

In a given annual reproductive cycle, the gonad of *S. californicus* is organised into three distinct cohorts (primary, secondary and fecund) of tubules. The primary tubules are attached to the anterior section of the gonad basis and contain previtellogenic oocytes. In the central region of the gonad the secondary tubules contain vitellogenic oocytes. The fecund tubules are attached to the posterior end of the gonad basis and contain only late vitellogenic oocytes. After spawning, these tubules are resorbed. In *S. californicus* it takes at least two years for recruiting tubules to become mature. Primary tubules appear in Year N and progressively develop into secondary tubules in Year N+1. Secondary tubules become the fecund tubules in Year N+2 (Smiley and Cloney 1985). It was suggested that this pattern of oocyte and ovary development might apply broadly across the Class Holothuroidea (Smiley and Cloney 1985).

Assessing the applicability of the TRM for Holothuroidea, Sewell et al. (1997) reported that gonad development in many species of the orders Dendrochirotida, Apoditida and Molpaditida does not conform to the model. Most holothuroids in these orders appear to possess ovaries with all their tubules at a similar stage of development. Although the TRM was based on an aspidochirote species, only the ovaries of *Holothuria forskali* (Order Aspidochirotida) have subsequently been found to conform to the predictions of the model (Tuwo and Conand 1992). Like *S. californicus*, *H. forskali* is a temperate holothuroid. Assessment of ovary development in several tropical aspidochirotids revealed that their ovaries do not develop according to the predictions of the model (Sewell et al. 1997). These include *Holothuria atra, H. floridana, H. mexicana, H. nobilis, Actinopyga echinites, Stichopus variegatus*, and *Thelenota ananas* (Conand 1981, 1982, 1993a,b; Engstrom 1980; Pearse 1968). Here, we describe gonad development in *H. fuscogilva, H. scabra* and *Actinopyga mauritiana*, in the Solomon Islands and assess the pattern of gonad tubule growth with respect to the TRM. Further descriptions of reproduction can be found for *H. fuscogilva*, in Conand (1981, 1989, 1993a), Ramofafia et al. (2000), for *A. mauritiana* in Conand (1989, 1993a), Hopper et al. (1998), Ramofafia et al. (2001), and for *H. scabra* in Ong Che and Gomez (1985), Conand (1989, 1993a).

Gonad morphology

Tubule organisation

The gonad of *H. fuscogilva*, *H. scabra* and *A. mauritiana* consisted of a single tuft of tubules arising from the gonad basis (Fig. 1A). No distinct cohorts of tubules were encountered. The organisation of the tubules around the gonad basis was radial with the gonad basis taking a central location (Fig. 1A). A single gonoduct runs through the gonad base to the external gonopore.

Tubule growth

After the summer spawning period of *H. fuscogilva* and *A. mauritiana* (August–December), new tubules appeared in March or April. These tubules subsequently developed and reached maturity in August

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(*H. fuscogilva*) or October *(A. mauritiana*). In *H. scabra,* gonad development was asynchronous and spawning appeared to be continuous. In *H. scabra* gonad development differed among individuals but the state of the tubules was similar across the gonad. In all three species the gonad tubules developed as a single cohort (Fig. 1A).

Gonad growth in all three species involved an increase in the size (length and diameter) of the tubules and in the number of tubule branches. Tubule size increased as the oocytes developed. Branching of tubules increased the volume of the gonad, increasing fecundity. Branching of tubules in all three species was always by bifurcation, which occurred once or twice on previously branched segments (Fig. 1B). The branches varied in length but the gametogenic stage was similar in the bifurcated branches (Fig. 1C). In *H. fuscogilva*, some short bifurcated tubules were observed. However, the gametogenic stage in these short tubules was similar to the tubules that were of greater length. Gravid ovaries in all three species occupied more than half the coelomic cavity, extending distally to the posterior region of the coelomic cavity, and generally had a wet weight ranging from 50 to 100 g. Gravid ovaries were usually packed with mature oocytes that were easily seen through the transparent ovary wall (Fig. 1C, D).

Spawning in all three species was not synchronous across the tubules. In the partly-spawned state, the ovaries had both spawned and unspawned tubules. Examination of squash preparations of spawned and unspawned tubules revealed the presence of phagocytes and degenerating oocytes indicating that many of the unspawned eggs were being resorbed. In spent ovaries, all tubules were reduced in size and appeared wrinkled (Fig. 1E). However, unspawned eggs may still be present and many of these were degenerating (Fig. 1F). In both *H. fuscogilva* and *A. mauritiana*, individuals lacking gonads were encountered. For these species it appears that total gonad resorption occurs in some post-spawned individuals each year. Individuals lacking gonads were rarely encountered in *H. scabra,* suggesting that total resorption of gonads in this species was rare.

Gametogenesis

Ovary histology indicated gametogenesis in *H. fuscogilva* and *A. mauritiana* was initiated in March or April with the presence of early oocytes in the germinal layer. In *H. scabra*, gametogenesis was asynchronous with individuals having gonads at different stages of maturity through the year. Despite this difference, the process of gametogenesis was similar in all three species with previtellogenic oocytes appearing along the germinal epithelium in recovery stage ovaries. As ovaries developed, vitellogenic activity was seen in growing ovaries with previtellogenic, early-, mid-, and late vitellogenic oocytes distributed through the gonadal tubules. Upon reaching the mature stage, fully-grown oocytes dominated the tubule. In all three species, histology revealed that previtellogenic oocytes were present along the germinal epithelium throughout development. Gametogenic renewal during the spawning period was seen in all three species but the frequency of occurrence was greater in *H. scabra* than *H. fuscogilva* and *A. mauritiana.*

Table 1. **Description of gonad tubule morphology in three tropical holothurians compared to the tubule recruitment model (TRM).**

	Species		
TRM features	*Holothuria fuscogilva*	*Holothuria scabra*	*Actinopyga mauritiana*
Distinct tubule cohorts	single cohort	single cohort	single cohort
Progressive tubule recruitment	no	no	no
No total tubule resorption	yes, occasional	absent	yes, occasional
No gametogenic renewal in post-spawning tubules	gametogenic renewal	gametogenic renewal	gametogenic renewal
Single generation of oocytes within tubules	overlapping generations of oocytes	overlapping generations of oocytes	overlapping generations of oocytes
Oocytes need more than one year to mature	oocytes matured in less than a year	oocytes may mature in less than a year?	oocytes matured in less than a year

Discussion and conclusion

For holothurian ovaries to conform to the TRM, the gonad must consist of distinct cohorts of tubules each containing gametes at the same stage of development (Smiley 1988). Recruitment in these ovaries shows a regular pattern of resorption of fecund tubules after spawning, followed by replacement by a cohort of vitellogenic tubules. Ovary development in *H. fuscogilva*, *H. scabra* and *A. mauritiana* from Solomon Islands differed from the TRM in a number of ways (Table 1). Clearly, they do not conform with the TRM described for *S. californicus* (Smiley 1988). Ovary development in *H. fuscogilva*, *H. scabra* and *A. mauritiana* from other tropical locations is similar to that described here (Conand 1993a; Hopper et al. 1998; Ong Che and Gomez 1985; Reichenbach 1999; Tuwo 1999). The increasing number of tropical aspidochirote species not conforming to the TRM leads us to agree with Frick et al. (1996) and Sewell et al. (1997) that the TRM is not the rule for holothuroid oogenesis.

Acknowledgements

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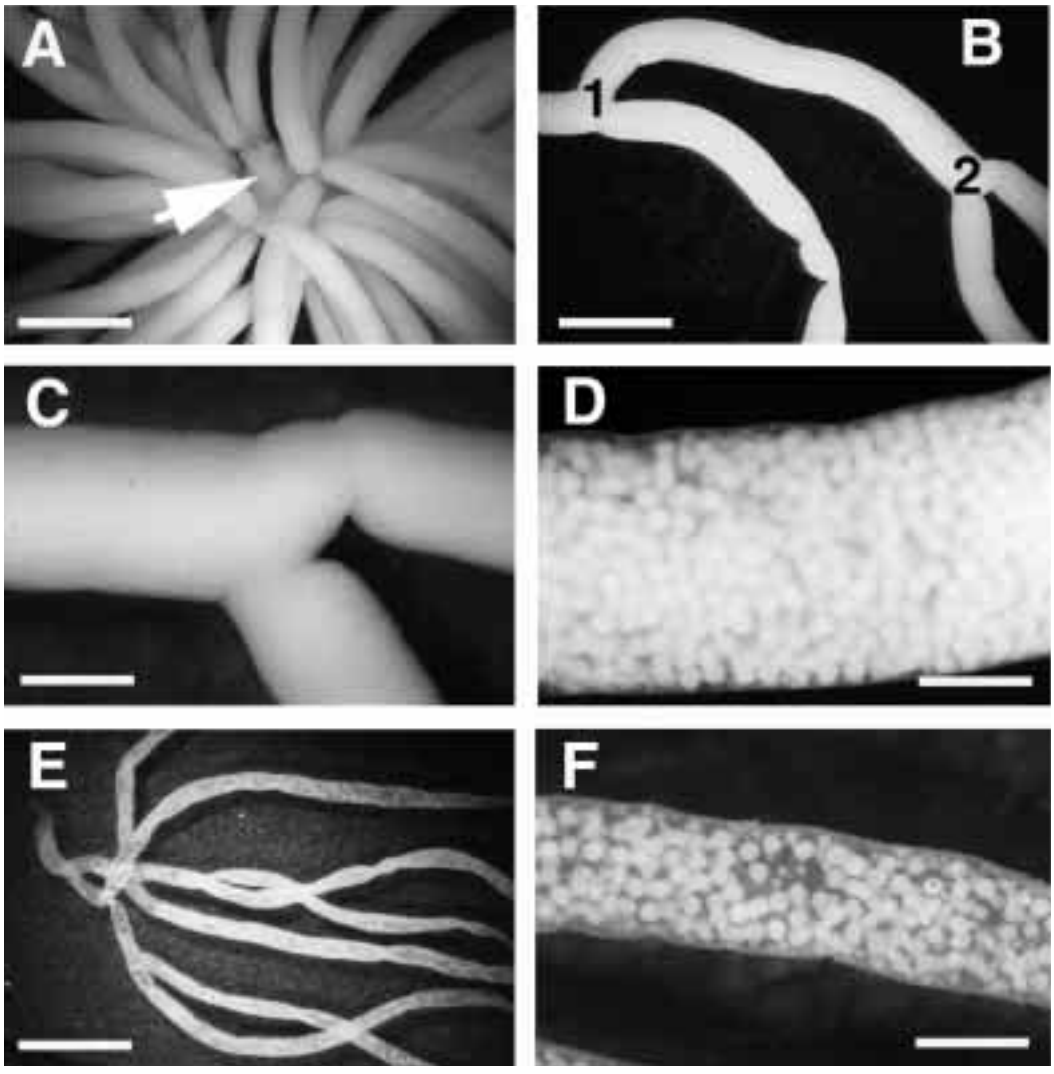

Figure 1. Gonad morphology in tropical apidochirotid holothurians.

A. *A. mauritiana.* Mature ovary consisted of a single tuft of tubules arising from a gonad basis (arrowed). Note the radial attachment of tubules around the gonad basis.
B. Tubule bifurcation (1 and 2) resulting in branches that were of variable lengths.
C. Bifurcated tubule in *A. mauritiana* illustrating uniform gametogenic development within branches.
D. A ripe ovary tubule in *H. fuscogilva* packed with mature oocytes seen through the transparent tubule wall.
E. Spent tubules in *A. mauritiana.* Note the reduced size of tubules.
F. A portion of the spent tubule in E magnified to show relict oocytes that were loosely arranged.
Scale bars in A, B, E = 300 µm; in C = 90µm; in D = 53 µm; in F = 50 µm.

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Preliminary sandfish growth trials in tanks, ponds and pens in Vietnam

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Abstract

Variable amounts of water and ingested substrate held inside the bodies of sandfish may interfere with growth trial data based on weight. On average there is a weight loss of about 4% on drying for 15 minutes, and weight changes of a similar order associated with uptake or loss of sand over 2–3 days. However, individual short-term weight fluctuations are often several times larger.

Sandfish that were kept in bare tanks were fed shrimp pellets or were unfed. All lost weight, the fed animals more rapidly. In tanks with sand, live weights were maintained. There was little difference between the effects of diets based on chick feed or on wheat flour mixed with shrimp pellets, *Gracillaria* seaweed or sea grass. A wide range of finely-ground vegetable materials were eaten and defecated, apparently unchanged.

In ponds, sandfish grew at about 1–3 g / animal / day. Two attempts to look at different densities and different substrates were cut short by major mortalities associated with heavy rain and stratification. There was some indication of a negative density effect and slight advantage of sand over hard or muddy substrates.

Seabed pens built by divers proved useful for holding small numbers of sandfish. Survival was generally very good while growth rates (0–1 g / animal / day) appeared to depend on location as well as density. It should be possible to enclose quite large areas in this way if suitable secure sites can be found.

Introduction

Sea cucumbers of the species *Holothuria scabra,* or sandfish, have received attention as promising candidates for aquaculture and / or stock enhancement (Battaglene and Bell 1999). They are found in shallow inshore waters over a wide range of the tropics and subtropics, and can be used to prepare a high value dried export product. They are, consequently, often over-fished (Conand 1998). There have been a number of studies on the maturity cycle of animals in the natural environment (Ong Che and Gomez 1985; Conand 1993; Tuwo 1999) and methods for stimulating spawning of ripe adults have been described (James 1996; Battaglene 1999; Ramofafia pers. comm.). It appears to be relatively easy, at least in small numbers, to rear the larvae to settlement and beyond.

However, there has been surprisingly little published regarding the growth rates that may be expected from sandfish in culture or nature.

This information is, of course, essential when considering the viability of possible schemes for commercial grow-out or stock enhancement. It is also likely to be of importance in places where stocks of big sandfish are depleted and collected animals may have to be grown to a larger size before they can be used for broodstock.

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This collaborative Sea Cucumber Rearing Project between the Ministry of Fisheries, Vietnam and ICLARM began at the Research Institute for Aquaculture number 3 (RIA3), Nha Trang in June 2000. Locally collected sandfish usually weighed 200g or less. Although they sometimes contained motile sperm or developed oocytes, these small animals proved difficult to spawn when subjected to the usual stimulation techniques; slow or fast temperature changes, drying, water jetting, dried algae, macerated gonad, etc. They were, therefore, stocked in ponds or pens to grow and ripen.

At monthly intervals, or less, groups of sandfish were removed from their pond or pen for spawning attempts. Most of these were returned to the same containers after spawning trials. In addition several groups of small tank experiments were conducted. Results of the first 10 months of work are shown below. Each trial is described briefly, results are summarised or tabulated and problems or conclusions discussed.

Tank trials

Weight changes due to sand and water

Sea cucumbers are notoriously difficult to weigh consistently (and to tag). This was a first attempt to quantify three kinds of weight changes that sandfish undergo. When left out of the water for some minutes they eject some of the water held in the body cavity. When moved between containers with or without substrate they ingest or excrete sand, which is held in the gut. And over a few weeks, somatic growth or weight loss may also occur. It is this last weight change that growth trials need to measure, in isolation from the first two sources of variation. This is particularly important if short growth periods are being used.

Fifteen sandfish, which could be individually distinguished by differences in weight and colour, were used in this trial. They ranged in weight from 60–500g and were selected from a tank where they had been held without sand for 3 days. They were taken out of water and weighed 3 times; immediately, and after 2 drying periods of 15 and 30 minutes in shade. They were then transferred to a shaded outdoor concrete tank containing about 10 cm sand where they were not fed. On the following 3 days they were again weighed immediately after taking out of the water, and after 2 drying periods.

The fifteen sandfish were left unfed in the tank with sand for a total of 30 days, then weighed (after 20 minutes drying) and put into a small bare (fibreglass) tank under partial shade. They were weighed again (shade dried) after 1, 2, 5, 7 and 11 days without feeding in the tank without sand. After 1, 2 and 5 days the excreted sand was collected and weighed (damp). There was some confusion in recording the first day's weighings (14/10). The next 3 data sets were consistent, in that individual sandfish always decreased in weight over the drying periods.

Sandfish expelled water at varying rates, some immediately on being picked up, others after a few minutes. Average individual weight drop due to water released in the first 15 minutes was 4.0%. Over the next 15 minutes there was a further 1.9% average individual weight loss. Overall there was only about 1.2% increase in total weight over 3 days on sand. Over the next 26 days unfed (density 440 g/m^2) there was an average weight loss of 0.48 g/animal/day.

One day after transfer to the bare fibreglass tank 370 g of sand (damp weight) was collected, amounting to 10.8% of the total weight of the animals on transfer. A similar amount of water must have been retained, since the average individual weight loss (after the usual drying period) was only 0.3%. However this average figure hides large and unexplained differences, from individuals that lost about 12%, to those that gained over 20%.

On the following day only 60g of sand was collected (1.75% of total transfer weight), but overall average individual weight loss on that day was 4.2%. The total weight loss over the first 2 days was 5.8% of the total weight stocked in the fibreglass tank. The tank was not siphoned again until day 5, when a further 50 g of sand (1.46%) was collected. However, salinity dropped to 20 ppt due to heavy rain. There was a weight gain, presumably due to water uptake, of nearly 21%. This was later lost, although the salinity remained low. Over the last 9 days unfed in the tank without sand (at a density of 1800 g/m^2), there was an average weight loss of 0.62 g/animal/day.

Sandfish took in or released water somewhat unpredictably. Stress seemed often to lead to large weight increases due to water retention. Weight measurements should, therefore, be made as far as possible when environmental conditions have been stable. Animals should be shade dried for at least 15 minutes before weighing.

The sand contents of adult animal guts amounted to about 14% of the total weight, but the uptake or loss of this sand is accompanied by weight changes of only about 1.2–5.8%. It is apparently balanced in part by the amount of water retained somewhere in the body, even after shade drying.

Table 1. **Weight changes due to water expelled by sandfish when dried for short periods**

Date	14/10/00			15/10/00			16/10/00			18/10/00		
Days with sand				1			2			3		
Days without sand	3											
Dried (minutes)		11-18	31-35		14	27		16	31		15	30
Total weight (g)	3600	3640	3570	3805	3650	3563	3835	3627	3554	3831	3716	3610
Av. weight (g)	240	243	238	254	243.3	238	256	241.8	237	255	248	240.7
Av. % weight change		2.2	-2.6		-4.3	-2.0		-5.0	-1.4		-2.6	-2.3

Table 2. **Weight changes when sandfish were moved to a tank without sand**

Date	13/11/00	14/11/00	15/11/00	18/11/00	20/11/00	24/11/00
Days with sand	30					
Days without sand		1	2	5	7	11
Salinity (ppt)	~30	~30	~30	20	~25	18
Dried (min)	20	20	20	20	30	22
Total weight	3421	3346	3222	3879	3263	3138
Av. weight (g)	228.1	223.1	214.8	258.6	217.5	209.2
Av. individual wt. change (%)	-5.6	-0.3	-4.2	20.9	-15.4	-5.7
Sand weight (g)		370	60	50		

In the trials described below, when animals without sand were stocked on a sand substrate the initial weight was increased by 3.5% (mean figure of the above range) in the calculation of growth. (This of course led to a decrease in the calculated growth rate.) Data to which this correction factor has been applied are shown below in italics.

Effect of shrimp feed on sandfish in bare tanks

Recently-collected sandfish were held in fibreglass or concrete tanks for one week and then divided into 6 matched groups of 12 animals, weighed and stocked in bare concrete tanks (120 cm diameter, 60 cm water depth, outdoors under partial shade). Animals averaged 157 g at the start of the experiment, and mean stock density over the course of the trial was 1390 g/m^2.

Three tanks were fed every second day with 10 g/tank of Betagro 503 (50% protein juvenile shrimp food), while the other three were left unfed. All tanks were cleaned every second day and underwent similar partial water changes (about 50%) before any feeding took place. All animals were weighed on 3 subsequent occasions over 33 days.

The small feed granules became soft but remained visible on the tank floors. There was no sign that the food was consumed, apart from a possible slight increase in the small amounts of faeces produced. Average weights in fed tanks dropped from 157 g to 97 g (mean density 1300 g/m^2) while in unfed tanks they fell from 158 g to 113 g (mean density 1400 g/m^2). Weight loss rates were markedly higher in fed tanks (1.81 g/animal/day) than in unfed tanks (1.38 g/animal/day), with $0.1>P>0.05$ (2-tailed t-test).

This is clearly not an effective way to grow sandfish. Despite very low feeding rates (average 0.3%/day dry food:live biomass), this feed, designed for a largely carnivorous species, appeared to have a negative effect. Also, although no sandfish died, by the end of the trial eleven from the fed and eight from the unfed tanks had become sick, with skin lesions that exuded white mucus.

Effect of four different diets on sandfish in tanks with sand

Four matched groups of ten sandfish from a tank without sand were weighed (after 20 minutes drying in shade) on 9 November 2000. They were stocked in 250 flat-bottomed fibreglass tanks (80 cm diameter x 50 cm depth) with fine white sand to a depth of about 5 cm.

On alternate days partial water changes were made and tanks were fed 10 g of one of four moist pelleted diets scattered (as small soft particles) over the sand surface. In general, waste food and faeces were left in the tanks. On only three occasions the sand was stirred, water swirled and waste materials were siphoned out from the centre of the vortex.

The diets used were:

1) Ground baby chick feed (18% protein), mixed with water and red food colouring, pelleted, stored frozen;
2) Prawn feed Betagro 503 (50% protein) mixed with an equal weight of wheat flour, ground up, and mixed with water and purple food colouring, pelleted, stored frozen;
3) Three parts nearly dry *Gracillaria verrucosa* mixed with two parts wheat flour, minced and mixed with water with blue food colouring, made into dough, stored frozen;
4) One part seagrass leaves, blended and partly drained, mixed with two parts wheat flour and green food colouring into stiff dough, stored frozen.

Tanks were kept outdoors under partial shade until 24 November. They were then moved indoors until the end of the trial, due to heavy rains. There was no feed given for the last 2 weeks, from 5–19 December.

The initial weights have been increased by 3.5% to correct for the absence of sand in the animals at the beginning of the trial. Results are shown in Figure 1. Overall there was little difference between diets 1, 2 and 4. Animals in all tanks lost weight during the first week of December, but regained it during the next 2 weeks, despite being indoors and unfed for that period.

The fact there was no overall weight loss, despite the high average stocking density (2580 g/m^2), may partly be due to the presence of sand, in contrast with the results of trial 2. However in trial 1 sandfish that were unfed in a tank with sand at considerably lower density lost some weight.

This un-replicated trial can only serve as a pointer for more rigorous work. However it seems that not much reliance can be placed on this type of tank trial, where weight changes are tracked over a short period. For sandfish, unpredictable short-term fluctuations tend to overwhelm any underlying effects that different treatments may have.

Feeding observations

In the course of numerous attempts to stimulate spawning, groups of sandfish were held in a bare fibreglass tank for several days at high density (typically over 4 kg/m^2). Among other things, chopped and blended mixed seaweed was tried as a spawning stimulant and left overnight in the tank. It was seen to be the main constituent of faeces the following day, apparently undigested. However seaweed that was chopped by hand without blending was not defecated in noticeable amounts. Subsequently, a number of other potential food materials were tried. These included commercial animal feeds, seaweeds, seagrass and terrestrial vegetables.

Typical sandfish faeces are of 'string of pearl' appearance. The binder or membrane that holds them together is apparently concentrated in the outer layer. Once this is opened there is little cohesion, and the contents can easily be dispersed and examined.

Feed materials given to sandfish without sand in their guts comprised the main faecal content within 8–12 hours. Usually the particle sizes and colour appeared unchanged, so that faeces from green algae or cabbage leaves were bright green, while those from carrot or pumpkin were orange.

Faecal colour is an indicator of food transit time, at least under these somewhat unnatural conditions. It would be of interest to know how much is being digested and assimilated. Perhaps this could lead to the development of practical sandfish feeds based on agricultural products or food processing wastes.

Pond trials

Ponds (and pens) were used to hold sandfish and grow them until they could be spawned. The frequent movement of stock to and from ponds is not ideal for growth trials, however, all such transfers were recorded. Weighing conditions were standardised as much as possible, and weighing was performed before any stressful event such as transportation, and after shade drying for at least 15 minutes. In calculations of growth rates, 3.5% was added to weights of those sandfish that had been held for some days in tanks without sand. (Numbers where this correction has been applied are shown in italics.) Average growth or biomass increases were determined and the number of animal growth days contributing to them was summed. Biomass increase per animal stocked or mean daily growth rates was calculated.

Growth in shrimp ponds with a sand substrate

Two ponds situated beside Cam Ranh Bay, about one and a half-hours drive south from RIA3, were rented from a farmer who was growing shrimp, groupers and babylon snails. He undertook the management of the ponds when used for sandfish experiments.

Pond 1, of 250 m^2, had recently been emptied after a crop of carnivorous babylon snails (*Babylonia areolata*) and appeared highly eutrophic at the start,

with heavy phytoplankton growth and partly-anaerobic floor. Initially no food was given, but later a small amount of shrimp food was fed daily, amounting in total to 20 kg over the whole period. Water changes were tidal only.

After weighing on 12 September, animals were stored for about an hour in baskets standing in the pond. They became very inflated with water, increasing in weight by perhaps as much as 50%. They were rapidly counted out between ponds 1

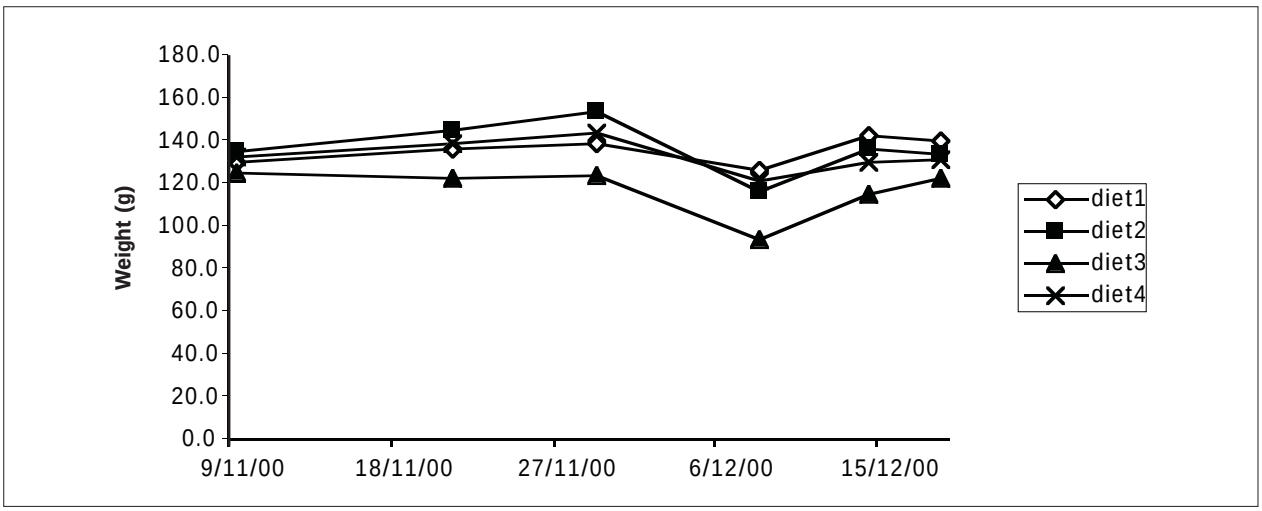

Figure 1. **Average sandfish weights with four different diets**

Table 3. **Materials eaten and excreted by sandfish that were kept in a bare tank (+ indicates that the supplied material is the main faecal component, judged by colour and form)**

Material	Result
Chopped and blended green filamentous seaweed (*Enteromorpha* sp.)	+
Chopped and blended red or brown seaweeds (*Sargassum* sp. and others)	+
Chopped mixed seaweeds	-
Shrimp juvenile (Betagro 503) granules	-
Dough from chopped and blended seagrass leaves with wheat flour 1:2 (diet 4, trial 2)	-
Chopped and blended Chinese cabbage leaves	+
Chopped and blended carrot	+
Chopped and blended pumpkin	+
Chopped and blended grass	probable +

Table 4. **Weights of sandfish moved in and out of 250 m² sandy pond**

	Put in	Put in	Put in	Weighed	Took out	Put in	Emptied
Date	17/07/00	20/07/00	26/07/00	09/08/00	09/08/00	09/08/00	12/09/00
Number	18	93	89	165	7	100	256
Average (g)	*147.8*	*123.8*	*140.0*	152.1	298.6	*134.6*	260.9
Av. growth/animal/day (g)				1.08			3.35

Number put in	300
Number taken out	263
Survival %	88
Approx. density (g/m²)	170
Biomass gain/animal/day (g)	2.11

and adjacent pond 2 (370m²). There was a further weighing, on 2 October when some additional sandfish were also put into pond 2.

On 11 October, after 4 days of heavy rain, there was a problem with the animals in these ponds. In pond 1 the salinity had reached 4 ppt at the surface and 11–17 ppt at the floor, and all sandfish were dead. In pond 2 the salinity was 8 ppt at the surface and 20–30 ppt at pond floor level, and 31% had died.

While 20 days is a rather short period, the results from the two ponds are consistent with each other and with the growth rate in the first period. Until the heavy rain, survival and growth were good despite dense phytoplankton growth, high temperatures and limited water exchanges. Harvesting (by touch, using hands and feet) was made easier by the sandy nature of the pond floor.

Sandfish normally survive salinity levels of around 2 ppt, but it is possible that minimum values during the days of heavy rain were lower than those measured on 11 October. Due to stratification, temperatures below the halocline may have risen and oxygen levels dropped. It is likely that a combination of these factors killed the animals.

Growth of sandfish in pens inside a pond, on 3 substrates at 3 densities

At Van Ninh, about 80 minutes north of RIA3, is a large shrimp farming area. For this experiment a recently-harvested shrimp pond (6000 m²) was rented. The substrate was mainly broken coral with some sand. Part of the pond was subdivided into 12 pens using fine mesh walls. The bottoms of the mesh walls were buried, pegged down and then covered with small bunds rising 10–20 cm above the surrounding pond floor.

This created nine 100 m² experimental pens plus three holding pens of 200 m² each. Soft mud was removed from six of the experimental pens (and also from the holding pens and from the rest of the pond area outside the pens). Sand (50 kg / m²) was spread on the floor of three of the cleaned 100 m² pens.

Thus, the nine experimental pens were of three substrate types, soft (unmodified after harvesting the shrimp), hard (produced by scraping away soft mud) and sand (added after removing mud).

The nine 100 m² pens were stocked at three densities (with 20, 40 and 80 sandfish per pen) on 27 September 2000. The main area of the pond was stocked with babylon snails and fed using dead fish. Water changes were tidal, and no aeration was installed. All sandfish were found to be dead (and decayed) on 12 October after 4 days of heavy rains. The salinity on the surface was 12 ppt, while at the bottom it was 35 ppt and the temperature about 34ºC (measured on an overcast day). It is likely that stratification leading to low oxygen and high temperatures in the bottom water layer was the cause of death, rather than low salinity.

A water pump and paddlewheel aerator / circulator were installed and more sandfish collected. The nine experimental pens were subdivided into 40 m² and 60 m² sections, to allow the experiment to be run using smaller numbers (since it was difficult to obtain large numbers of sandfish in the wet season). On 20 December when the pond salinity had reached 25 ppt (after weeks below or near 20 ppt) the experiment was re-started in the nine 40 m² pens. They were stocked at three densities, using groups of 30, 16 or 10 animals per pen.

The contents of the pens were collected by touch and weighed three more times before an unseasonal period of heavy rain at the end of March. Although a paddlewheel was available it had been

Table 5. **Weight increase of sandfish in 250m² pond**

	Put in	Weighed
Date	12/09/00	02/10/00
Number	120	117
Average weight (g)	260.9	316.3
Average density (g/m²)		137
Average growth/animal/day (g)		2.77

Table 6. **Weight changes of sandfish in 370m² pond**

	Put in	Weighed	Put in	Removed
Date	12/09/00	02/10/00	02/10/00	11/10/00
Number	136	132	37	119
Average weight (g)	260.9	324.8	177.8	266.3
Average density (g/m²)		106		
Average growth/animal/day (g)		3.20		-2.93

partly dismantled and was not used for several days. Stratification again developed, accompanied by hot, foul conditions near the pond floor, with plenty of decaying pond weed. Circulation was not improved by the small internal bunds, and the poor quality of 'new' water in the supply channel, which served a large number of other ponds. Once again, there were very large-scale mortalities, bringing the trial to a premature end.

The interim sampling appeared to be fairly complete, but no final check could be made. Due to the apparent early drops in numbers of the high-stocked pens 1 and 6, and the premature collapse of the whole trial, densities over about 200 g / m^2 were not reached. There were also anomalous counts in 3 and 9. What remains are some indications (not significant using 2-way ANOVA) of higher daily growth rates at low density and on sand.

Table 7. **Weights of sandfish in nine 40m^2 pens inside a pond, with 3 substrates and 3 stocking rates**

Substrate	**1** Mud				**2** Hard				**3** Sand			
Date (2000–2001)	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03
Number	30	12	13	15	16	11	15	13	10	8	10	11
Average (g)	160.5	180.4	239.5	292.4	176.1	208.2	253.7	286.0	168.4	215.4	267.9	308.9
Daily growth (g)		0.83	2.19	1.71		1.34	1.69	1.04		1.96	1.95	1.32

Substrate	**4** Mud				**5** Hard				**6** Sand			
Date (2000–2001)	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03
Number	16	11	12	15	10	9	9	9	30	17	16	21
Average (g)	173.6	217.1	257.7	279.5	163.9	205.7	264.4	321.1	171.0	216.0	264.5	314.3
Daily growth (g)		1.81	1.50	0.70		1.74	2.18	1.83		1.87	1.80	1.61

Substrate	**7** Mud				**8** Hard				**9** Sand			
Date (2000–2001)	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03	20/12	13/01	9/02	12/03
Number	10	6	10	10	30	15	26	24	16	20	11	12
Average (g)	160.7	165.2	277.0	312.2	168.4	196.5	244.0	255.2	166.8	246.4	283.0	310.3
Daily growth (g)		0.19	4.14	1.14		1.17	1.76	0.36		3.32	1.36	0.88

Table 8. **Mean stock densities and overall growth rates**

Pen	**1 (mud)**	**2 (hard)**	**3 (sand)**	**4 (mud)**	**5 (hard)**	**6 (sand)**	**7 (mud)**	**8 (hard)**	**9 (sand)**
Mean observed density (g/m^2)	90.5	78.9	59.3	77.8	54.8	122.7	53.1	127.9	90.2
Overall growth rate (g/day)	1.61	1.34	1.71	1.29	1.92	1.75	1.85	1.06	1.75

Table 9. **Pooled mean densities and growth rates**

Density	113.7g/m^2 (high) 1.47g/day	82.4g/m^2 (medium) 1.46g/day	55.7g/m^2 (low) 1.83g/day
Substrate	mud 1.58g/day	hard 1.44g/day	sand 1.74g/day

Problems encountered in pond management

It is clear that pond location and vigilant pond management are of great importance. Salinity levels of around 20 ppt are tolerated, and even lower salinity levels are not apparently in themselves quickly lethal. However, fresh or brackish water floats on the surface of more saline water. The lower layer becomes hot and anoxic, particularly if there is a lot of rotting feed or weed lying on the pond floor. It is not yet known whether paddlewheels, rapidly deployed, can prevent this situation from developing, or whether blowers, airlifts or other systems of vertical mixing need to be used. Low-salinity surface water can be spilled out at low tide but it is more difficult to effect changes to the water layer in contact with the pond floor, which is where the sandfish live. If the pond is allowed to remain too shallow in the interim period until the tide comes back in, solar heating can be even more rapid. Pumped or tidal replacement water may also be of high temperature, poor quality or low salinity, depending on the pond location.

Pen trials

Initially it was planned to build pens in water shallow enough for construction and maintenance to be done without diving. However, it was hard to find shallow areas of suitable substrate and salinity that are protected against waves and human interference. At locations where lobster or fish cage farming takes place, environmental conditions around the year are better known, and farmers guard against theft by living near or above their cages. Moreover many of the small fishing boats run hookah compressors from their diesel engines, and the fishermen and cage farmers are experienced in underwater work. Pens were, therefore, constructed in two such areas.

Pen trials in a fertile inshore area

Duong De is a fishing village in the same bay as RIA3, about 3 km to the north. There are some lobster culture cages with small huts standing above them, in water with a depth of 3–4 m. Lobster juveniles are collected directly in front of the village and babylon snail pen trials have also been carried out.

There appears to be considerable anthropogenic fertilisation, as well as streams draining the partly-cultivated surrounding hills. Inshore there is some *Sargassum* seaweed, and seawards, a submerged reef offers partial protection. This seemed a most convenient location for about 9 months of the year. However, it is considered too exposed to the open sea for lobster culture during the wet season.

The first 2 pens were constructed here at about 3 m depth (low tide), with emergent netting walls (25 mm stretched mesh), supported inside a framework of bamboo poles. They were without net floors (unlike lobster or babylon pens) to allow the sandfish access to the substrate, mainly sand with some silt. The foot of the netting was buried to a depth of about 20 cm and was pegged down with 40–60 cm bamboo pegs at 75 cm intervals. A row of sandbags was laid around the inside of the net on top of the pegs. Both pens were removed from Duong De at the end of September 2000.

Pen 1 enclosed a seabed area of 6 m x 6 m. It was stocked three times with animals that had been used in spawning stimulation attempts, and was therefore empty of sand. The overall stocking density was high most of the time, although when pen 2 was ready some animals were transferred out of pen 1. Survival was excellent but average weights dropped slightly after adjusting for sand uptake. This was probably due to the high numbers of sandfish, exceeding the natural food production of the small area enclosed (Table 10).

Pen 2 enclosed an adjacent area of 6 m x 11 m of seabed. It was stocked with animals thinned from pen 1 and later twice with new purchases of sandfish. Animals were removed for spawning attempts and then returned, along with a few additional new animals. Survival was again good and there was also some growth with the lower stocking density (Table 11).

Growth of sandfish at an island pen site

Tri Nguyen is a small island (also called Hon Mieu) about 20 minutes boat ride (3 km) from the port of Nha Trang. The site used is a southeast facing pebble beach fringed with seagrass beds and some corals. There appears to be little freshwater influence even during the wet season. From a depth of about 2 m at low water the substrate is mainly sand. Only the staff of a small beach restaurant and recently-constructed babylon hatchery live nearby. There are some year-round fish cages on a raft, and sea-bed Babylon culture cages.

The sandfish pens were constructed at about 4 m depth (low water), in the form of regular 12-sided figures of 40 m^2. They were made from the pen 1 netting previously used at Duong De. After cleaning and repairing this was cut in half longitudinally, making two loops of 43 m circumference and 1.7 m height. For each pen 12 posts were sunk into the sandy ground around a circle of 7.2 m diameter.

Pen 1 initially used 3-m long wooden stakes, which were pile-driven in from a fishing boat. Pen 2 used

Table 10. Growth of sandfish in inshore pen 1

	Put in	Put in	Took out	Put in	Took out	Emptied
Date	24/07/00	28/07/00	07/08/00	12/08/00	21/09/00	25/09/00
Number	50	65	60	61	15	98
Average (g)	*223.1*	*243.8*	243.8	*198.7*	263.3	204.2

Number put in	176
Number taken out	173
Survival %	98
Approx. density (g/m²)	530
Biomass gain/animal/day (g)	-0.08

Table 11. Growth of sandfish in inshore pen 2

	Put in	Put in	Put in	Took out	Put back	Took out	Emptied
Date	07/08/00	01/09/00	07/09/00	07/09/00	11/09/00	21/09/00	25/09/00
Number	60	104	112	44	70	33	238
Average (g)	243.8	*178.0*	*149.9*	450.5	*335.5*	380.9	239.9

Number put in	302
Number taken out	271
Survival %	90
Approx. density (g/m²)	390
Biomass gain/animal/day (g)	1.56

34 mm galvanised steel water pipes 2 m in length, hammered in by divers. The netting was tied to the posts at 3 or 4 points up to a height of about a metre from the ground. A drawstring through the top of the netting was tightened, pulling the upper half of the netting in towards the centre. (Due to this inward-curved shape the pens also had some fish-trapping effect.) The foot of the net was buried, held down with bamboo pegs and weighted with a row of sacks of stones around the inside edge.

The pens were stocked mainly with sandfish collected from the wild. However, 35 animals from pen 1 were used in a spawning attempt (of which 5 were injected with KCl solution to force evisceration) for a few days. Animals are still being held for future spawning attempts.

Some wooden posts collapsed in May 2001 due to severe worm damage, and were replaced by 1.5-m lengths of 27 mm galvanised steel water pipe. Waves or current caused some damage, tearing the netting at points of attachment to the posts of both types.

Survival was quite good, especially in pen 1, although growth was disappointing, perhaps due to the lower productivity of this area. Wave action, which is sometimes quite strong even at 4-m depth, may have a negative effect on feeding behaviour, or increase energy needs (see Tables 12 and 13 on next page).

Pen walls can probably be made much lower than 1 m and still retain sandfish effectively. This will reduce both cost and stresses on the structure. As long as theft is not a problem, large low pens can probably be built wherever suitable environmental conditions are found. By going to greater water depths the influence of low salinity runoff and waves can be reduced. However, this will increase the dependence on diving with compressed air.

Conclusions

Tank growth trials need to be carefully conducted over quite long periods to smooth out fluctuations due to sand and water content changes. Using wild-caught sandfish in small tanks means that stocking densities are likely to be high. Unless effective diets become available, animals are more likely to lose than gain weight in tanks. A supply of juveniles or very small adults will probably be required if meaningful controlled tank-based experiments are to be carried out.

Table 12. **Growth of sandfish in island pen 1**

	Put in	Put in	Took out	Replaced	Weighed	Weighed
Date	03/11/00	09/11/00	30/01/01	05/02/01	23/03/01	07/05/01
Number	25	25	35	35	45	45
Average weight (g)	*250.6*	*207.1*	270.4	*238.8*	273.7	267.6
Average growth/animal/day (g)			0.49		0.07	-0.11

Survival (%)	90
Approx. av. density (g/m²)	275
Overall growth/animal/day (g)	0.21

Table 13. **Growth of sandfish in island pen 2**

	Put in	Weighed	Weighed	Weighed
Date	09/11/00	30/01/01	23/03/01	07/05/01
Number	50	36	37	38
Average weight (g)	203.3	277.4	263.4	286.4
Average growth/animal/day (g)		0.90	-0.27	0.51

Survival (%)	76
Approx. av. density (g/m²)	255
Overall growth/animal/day (g)	0.46

Growth of around 2 g/animal/day appears to be possible in ponds throughout much of the tropical year on a range of substrates, although sand may be best. Mortalities have mainly been due to heavy rain. This can cause hot anoxic conditions to develop below the halocline, leading to total loss of stocks. The problem often shows itself in the first period of fine weather after the rain. If it can be avoided, by aeration or stirring, and perhaps by changing bottom as well as top water, then sandfish appear to tolerate quite a wide range of water conditions.

They can live in water with salinity levels around 20 ppt for weeks and will probably survive shorter periods at lower salinity. High, midday water temperatures in shallow or partly-drained ponds, do not appear to cause problems.

Pens have also proved quite effective for holding and growing sandfish. Where local fishermen or aquaculturists work underwater using hookah equipment, the additional difficulty of deeper sites may be offset by more stable conditions and security advantages.

In ponds and pens most, growth rates fall in the range 1–3 g/animal/day. Figure 2 indicates an inverse relation between density and growth, although this has yet not been tested at high densities in ponds due to shortage of animals. Site effects in pens need to be studied further.

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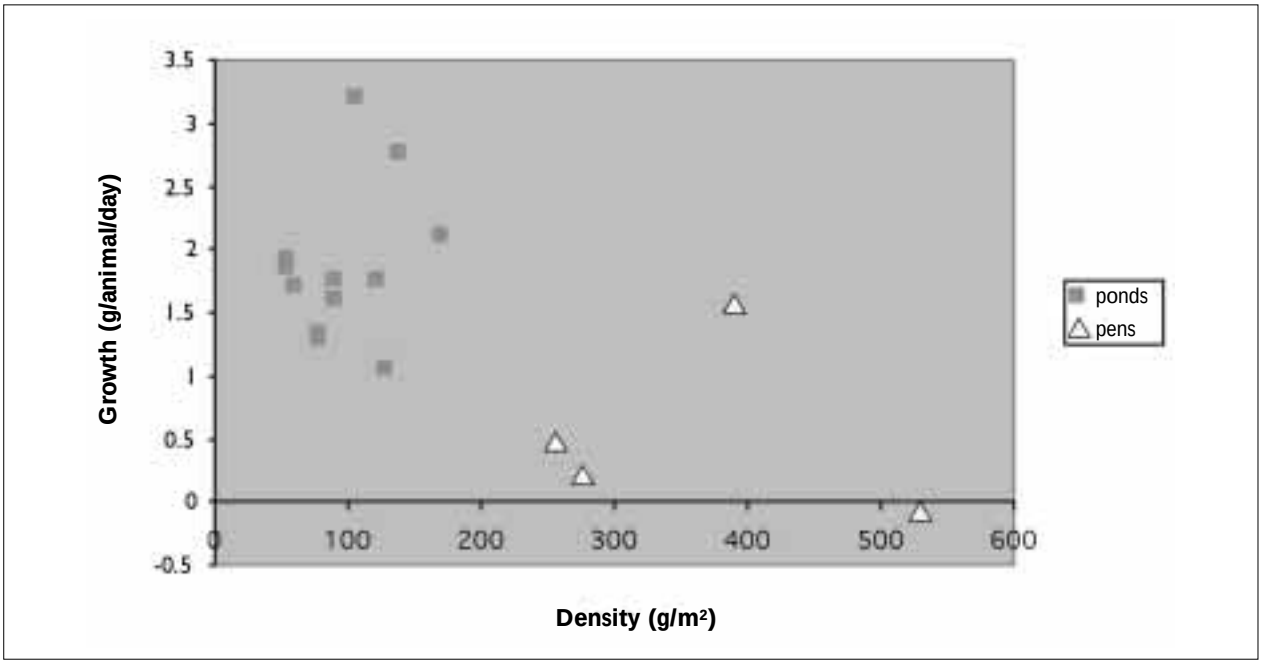

Figure 2. Density and growth of sandfish in ponds and pens

The new Marshall Islands Science Station inaugurates a sea cucumber aquaculture research programme

Jean-François Hamel[1,2] and Annie Mercier[1,2]

Iokwe!

The College of the Marshall Islands (CMI) initiated construction of a multi-disciplinary research station in January 2001, marking the embryonic phase of their research programme in aquaculture and stock enhancement. Like many Indo-Pacific nations, the Marshall Islands has been dealing with foreign interests in the exploitation of their holothurian resources and there is imminent danger of local over-exploitation of the most valuable species. Among them, *Thelenota ananas* and *Holothuria nobilis*, which are easily harvested from shallow coastal waters. The new research program will consequently encompass holothurian aquaculture and restocking studies, as well as similar work on other marine creatures of commercial and ecological value. Additionally, the new facilities will foster marine science education and the development of a training and demonstration centre to promote awareness of marine resources preservation and management in the local communities.

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2. Jean-François Hamel and Annie Mercier are currently in charge of developing the new MISS while working as Aquaculture Research Scientists at the College of the Marshall Islands.

Initial funding for the project has been provided by the United States Department of Agriculture under the College of Micronesia Land Grant program and by the Marshall Islands Marine Resources Authority.

The new Marshall Island Science Station (MISS) is located in Arrak, about 35 kilometres west of Majuro Atoll's airport — and 50 kilometres from its commercial centre.

Despite its modest size, the station promises to be very functional. The aquaculture facilities already include outdoor concrete tanks for keeping the brood stock and growing the juveniles, concrete tables fit for smaller experimental designs, a nursery with PVC tanks and an algae room. All tanks can be provided with running seawater in a flow through system or maintained in a close-circulatory fashion, using a series of mechanical, biological and UV filters. Air is also distributed throughout the set up. The adjoining wet and dry labs give access to technical and scientific material such as microscopes, cameras, aquariums, an autoclave and a laminar flow bench.

Aside from the hatchery, outdoor tanks and laboratories, the 10 acres of land harbour lodging facilities, a kitchen/cafeteria, and offices equipped with computers and Internet access. The station will soon host installations for agricultural research as well.

The Marshall Islands are almost entirely composed of atoll formations, often so narrow that the road is the only barrier between the lagoon and the open ocean. The majority of the islands have an average elevation of 30 cm. In fact, land represents less than 0.1% of the country's total surface area, and is scattered across nearly 2 000 000 km^2 of ocean. With such figures, the importance of ocean studies and marine resources management becomes obvious. The population of about 60 000 depends chiefly on the sea for their economic development as well as for their survival. Restocking, stock enhancement, sustainable fisheries and coral reef preservation are key issues that the nation needs to address very seriously.

This is why the CMI has undertaken to educate the young generation, train the local entrepreneurs and lead them in the new millennium with a fresh way of dealing with their surrounding ocean. We are glad to be a part of this venture and can only hope that the new research station will receive a growing number of scientists and marine life enthusiasts. Hopefully, the program will encourage young and aspiring Marshall Islanders to become marine biologists and resource-conservation scientists. As for the sea cucumber project, it is scheduled to be fully operational in August 2001.

Kommol tata!

Sea cucumbers: farming, production and development of value added products

Andrew Morgan[1]

In May 2000 the New Zealand government, through the Foundation for Research Science and Technology Top Achiever Doctoral Scholarship scheme, awarded funding to investigate the farming, production and development of value-added sea cucumber products.

The aim of this project is to provide an integrated approach to the study of the life history of the sea cucumber *Stichopus mollis* and its application to industry. One of the primary objectives is to develop hatchery techniques to produce enough larvae and juveniles to study characteristics of this animal's life history in the larval period, post settlement and pre-recruitment period. These are areas that are well developed in theory but little understood in practice and limited to very few publications.

The next major objective is to ascertain the role of habitat and its relationship with distribution and abundance. Apart from research on the association of tropical reef habitats with sea cucumbers, little information exists on the demographics of temperate species. The idea is to create a habitat landscape to model the distribution and abundance of *S. mollis*.

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Few publications exist on *in situ* growth of natural populations of sea cucumbers, and these are mostly about tropical species. The objective is to quantify growth parameters from size frequency distributions through time. Estimates of growth and mortality rates (using a deterministic model) will assist in further understanding of the life history of this animal and echinoderms in general.

A life table could be constructed for this animal, provided enough information can be gained from hatchery and *in situ* research.

Project status

Spawning

Preliminary spawning trials in the second half of last summer, January to February 2000, have been positive. Collected broodstock were induced to spawn in small numbers up to one month in captivity. Further, animals spawned naturally in the holding tanks during this period. From November 2000 to February 2001 animals were induced to spawn in a number of trials and larvae reared to late stages of development. The spawning season was interrupted by unusual weather patterns and animals often spawned non-viable gametes. More extensive trials and analysis of spawning behaviour will be conducted in the coming summer. A biopsy of gonad will be used to try and correlate reproductive behaviour and gonad state with readiness to spawn.

Hatchery production of larvae and seed

The hatchery building was refurbished to accommodate this project. Hatching and larval rearing tanks have been set up; an algae culture unit is in place; and a paddle stirrer is being put together to use in replicated experiments to study larval developmental plasticity in response to food availability.

Polyculture

The nutritional value of marine farm effluent as a source of food for the sea cucumber *S. mollis* is being ascertained. Consumption and assimilation of protein and organic matter in polyculture with paua, mussels and sea urchins is being compared to *in situ* populations.

Growth in situ

A population is being monitored *in situ* for 12 to 18 months to determine growth parameters for this animal. Size frequency data is being used to create a deterministic model of growth and mortality rates over time.

Distribution and abundance

The nature of this animal's habitat is being quantified by surveying different reef types using transects and quadrats. This information will be used to create a model for habitat landscape and the corresponding variation in abundance of *S. mollis*.

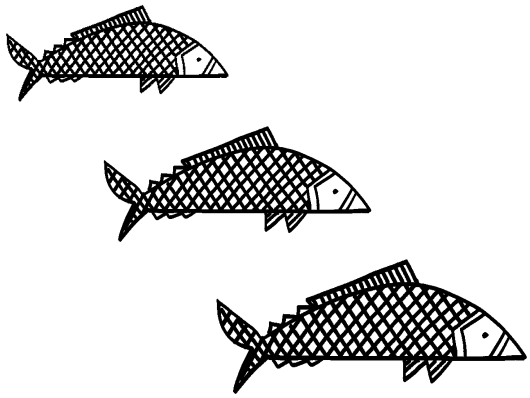
This project will be designed and implemented to develop and refine technologies for farming the sea cucumber *Stichopus mollis*. The project will benefit the sea cucumber industry in the South Pacific in four ways:

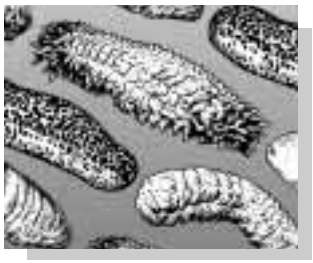
1) developing techniques to harvest the gut of wild caught adults of the sea cucumber *S. mollis* in a non-destructive, renewable manner;

2) developing hatchery techniques to produce large numbers of juveniles;

3) developing value added products from the gut and body wall. A market exists for exporting the whole animal soaked in brine or dried. Further, there is a market for pharmacologically active substances, namely anti-inflammatory compounds extracted from the animal and encapsulated and sold as a food supplement; and

4) initiating pilot scale commercial production of sea cucumbers to supply the industry as an alternative to harvesting wild populations.





market news
beche-de-mer

Papua New Guinea export prices of beche-de-mer

Source: *Fishing Line*, The monthly newsletter of the National Fisheries Authority. Issue No. 1, April-May 2001

Type	Grade	Price/kg US$	Market
Sandfish	A	45.0	Singapore, Hong Kong, Malaysia
Sandfish	B	38.0	Singapore, Hong Kong, Malaysia
Sandfish	C	25.0	Singapore, Hong Kong, Malaysia
White teatfish	A	30.0	Singapore, Hong Kong, Malaysia
White teatfish	B	22.0	Singapore, Hong Kong, Malaysia
White teatfish	C	18.0	Singapore, Hong Kong, Malaysia
Black teatfish	A	25.0	Singapore, Hong Kong, Malaysia
Black teatfish	B	17.0	Singapore, Hong Kong, Malaysia
Stonefish	A	15.0	Singapore, Hong Kong, Malaysia
Prickly redfish		15.0	Singapore, Hong Kong, Malaysia
Greenfish		17.0	Singapore, Hong Kong, Malaysia
Brown sandfish		7.0	Singapore, Hong Kong, Malaysia
Chalkfish		4.0	Singapore, Hong Kong, Malaysia
Snakefish		4.0	Singapore, Hong Kong, Malaysia
Lollyfish	B	3.0	Singapore, Hong Kong, Malaysia
Lollyfish	A	4.0	Singapore, Hong Kong, Malaysia
Tigerfish		8.5	Singapore, Hong Kong, Malaysia
Curryfish		14.0	Singapore, Hong Kong, Malaysia
Amberfish		5.0	Singapore, Hong Kong, Malaysia
Flowerfish		4.0	Singapore, Hong Kong, Malaysia
Greenfish		15.0	Singapore, Hong Kong, Malaysia
Elephant trunk		4.0	Singapore, Hong Kong, Malaysia

Beche-de-mer prices on the Asian markets (January–July 2001)

Species	Size	Grade	Indicative price in US$/kg (C&F) – 2001												Market area	Origin
			16/01	2/02	16/02	2/03	16/03	2/04	16/04	16/05	5/06	18/06	2/07	16/07		
White teatfish (skin-on)	3–5 pc/kg	A	33.0	33.0	30.0	30.0	30.0	30.0	28.0	28.0	25.0	25.0	25.0	25.0	SE Asian ports	South Pacific
		B	23.0	23.0	20.0	20.0	20.0	20.0	20.0	20.0	18.0	18.0	18.0	18.0	SE Asian ports	South Pacific
Prickly Redfish *(Thelenota ananas)*	6-15 pc/kg		15.0	15.0	18.0	18.0	18.0	18.0	13.0	13.0	12.0	12.0	12.0	12.0	SE Asian ports	South Pacific
Black teatfish	3-5 pc/kg	A	28.0	28.0	23.0	21.0	21.0	21.0	20.0	20.0	18.0	18.0	18.0	18.0	SE Asian ports	Australia
		B	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	15.0	15.0	15.0	15.0	SE Asian ports	Australia
Sandfish		A							33.0	33.0	33.0	33.0	33.0	33.0	Singapore	Indonesia
	10-30 pc/kg		55.0	55.0	58.0	58.0	58.0	58.0	63.0	63.0	58.0	58.0	58.0	58.0	Singapore	Australia
	15-40 pc/kg		35.0	35.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	Singapore	South Pacific
Greenfish *(Stichopus chloronotus)*	50-120 pc/kg			13.0	13.0	13.0	13.0	13.0	13.0	13.0	10.0	10.0	10.0	10.0	Singapore	South Pacific
Lollyfish	30-160 pc/kg		4.0	4.0	3.0	3.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	Singapore	South Pacific
Stonefish			19.0	19.0	18.0	18.0	18.0	18.0	18.0	15.0	15.0	15.0	15.0	15.0	Singapore	South Pacific
Surf redfish *(Actinopyga mauritiana)*	15-35 pc/kg		15.0	15.0	15.0	15.0	15.0	15.0	12.0	12.0	12.0	12.0	12.0	12.0	Singapore	South Pacific
Tigerfish	25-55 pc/kg		3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	Singapore	South Pacific
Brown sandfish *(Boadschia marmorata)*	25-110 pc/kg		3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5	Singapore	South Pacific
Curryfish *(Stichopus variegatus)*	30-50 pc/kg		17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	Singapore	South Pacific
	70-120 pc/kg		8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	Singapore	South Pacific
Elephant trunkfish	3-8 pc/kg		2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	Singapore	South Pacific

Source: *INFOFOSH Trade News*

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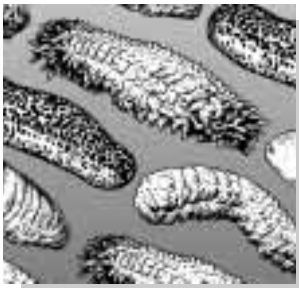

abstracts, publications, workshops & meetings

beche-de-mer

Abstracts • 9th International Congress on Invertebrate Reproduction & Development • Grahamstown - South Africa - 15–20 July 2001

Oral presentation

Sexual and asexual reproduction and consequences on population genetics of the holothurian *Stichopus chloronotus* (Echinodermata): a comparison between La Reunion (Indian Ocean) and Australia (Pacific Ocean)

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Stichopus chloronotus (Brandt, 1835) is one among ten aspidochirotid holothurian species known to reproduce both sexually and asexually by transverse fission. Data, which were lacking on the sexual cycle of this species in La Reunion are presented here and information available on sexual and asexual reproduction in this species is summarised. Sexual reproduction on Reunion Island shows a distinct seasonality with a main spawning period in the warm season. The spawning period on the Great Barrier Reef appears to be exactly at the same time as in Reunion Island. Some intriguing deviations from unity in sex-ratio, usually biased towards more male individuals, have been observed in both geographic regions. New data on the asexual reproduction of this species in La Reunion confirm the high rates of fission. The peak of asexual reproduction in both the Indian and Pacific Ocean was observed in winter. Thus, asexual reproduction in this species occurs outside the season for sexual reproduction. The rate of asexual reproduction appears to vary between sample locations. However, results of population genetic studies on *S. chloronotus* (Uthicke et al. 1999, Uthicke et al. in press) indicated that in most populations investigated a maximum of about 60% of all individuals may be derived sexually. Cluster analyses on genetic distances between populations grouped populations within oceans together, with the exception of one sample from a nearshore reef of the GBR which loosely clusters with the samples from Reunion Island. Although genetic differences between the 2 regions exist, these are relatively small regarding the large geographic distance. We conclude that asexual reproduction in *S. chloronotus* is important to maintain local population sizes, but that larval exchange between populations mediated by sexual reproduction is important for colonisation of new areas and to provide connectivity between populations. It is now possible to present the first synthesis on these phenomena for a holothurian species.

Poster papers

In vivo observation of ovulation and further oocyte maturation in spawning holothurians

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To our knowledge, the present study is the first to examine the transformation of oocytes along the gonoduct, in vivo, from the first signs of spawning until gamete release in marine invertebrates. The well-defined spawning posture and the gonoduct morphology of holothurians favoured the study of female *Holothuria leucospilota* and *H. scabra* for this purpose. Fertilization assays of gametes sampled in the different sections

of the gonoduct during spawning were repeated for up to 10 h after collection. Mature oocytes inside the gonad were arrested in the prophase-1 stage of meiosis. The contraction of the gonadal muscle bands, following the onset of spawning behaviour, coincided with the detachment of oocytes from the follicular cells. These oocytes did not show the germinal vesicle migration and break down (GVBD) and were not maturationally competent. About 20 min later, the oocytes were propelled through the gonadal opening in groups of 5 or 8 and were stored in the first section of the gonoduct, which swelled to ca. 7–15 times its initial diameter within 25–35 min. Over 95% of the oocytes inside the bulge had started germinal vesicle migration or completed GVBD, but could not be fertilized. About 45 to 55 min after the onset of spawning behaviour, the oocytes were squeezed in a continuous flow through the narrow and slightly twisty second section of the gonoduct. Oocytes sampled during this transit were still not maturationally competent. Oocytes in the last section of the gonoduct were at the metaphase of the first meiotic division in both species and were fertilizable. Gamete release occurred ca. 70 to 85 min after the first signs of spawning in *H. leucospilota* and *H. scabra*, respectively. Oocytes were generally expelled in one powerful spout after having spent 25–30 min in the last section of the gonoduct. This study shows that holothurian oocytes undergo important transformations throughout their progression toward the gonopore and that final maturational competency is acquired during passage through the constricted middle section of the gonoduct.

Reactions of the sea cucumber *Apostichopus japonicus* (Echinodermata: Holothuroidea) larvae to sharp desalination of surface water

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Sharp salinity decreases in the superficial layer of seawater occur after rainfall in Vostok Bay (Sea of Japan). *Apostichopus japonicus* larvae at the blastula and gastrula stages are distributed at the surface, later developmental stages (dipleurula, auricularia and doliolaria) migrate to deeper layers. Under laboratory conditions larvae behaviour and their vertical distribution depending on the desalination in the superficial layer were investigated at 22–23º C. To dilute the seawater surface layer (to form a density gradient), diluted seawater was slowly poured in a cylindrical aquarium with 32 ppt seawater (50–cm water column). Larvae had been introduced into the control and experimental vessels prior to the addition of the dilute layer. They accumulated in the layer with salinity, which caused osmotic shock in the larvae. The larvae became motionless, their bodies enlarged due to hydration. Blastulas and gastrulas concentrated in the water layer at 20.0–20.5 ppt. Eventually they adapted, but still could not leave this horizon. Control larvae reached the transitional stage between gastrula and dipleurula were evenly distributed throughout water column. The experimental larvae at the same stage lost their locomotor activity in 20.0–20.5 ppt water layer. The larvae locomotor activity was then recovered. In 4 h all the larvae attained the dipleurula stage and left the diluted horizon. Auriculariae were less resistant to desalination than more early larvae and died at 20.0 ppt. Both control and experimental late auriculariae and doliolariae did not rise to the surface but when the salinity there was decreased to 18.0–20.0, the larvae migrated down to 32 ppt water. Thus, mechanisms of adaptation and behavior allow *A. japonicus* larvae at certain development stages to survive and to avoid the unfavorable effects of desalination in the surface layer.

Reproductive cycle of the sea cucumber *Isostichopus badionotus* (Echinodermata) from Baía da Ilha Grande, Rio de Janeiro, Brazil

Renata Pires Nogueira Lima, Camila Freire Barcellos*, Carlos Renato Rezende Ventura** and Lúcia Siqueira Campos-Creasey**

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Isostichopus badionotus (Selenka, 1867) is a common sea cucumber found in Rio de Janeiro, especially its southern coast at Baía da Ilha Grande. This species is sold in restaurants in Rio de Janeiro, being consumed by certain sectors of the Oriental and European communities. The continuous exploitation of *I. badionotus* may represent a danger to its population. The objective of this study is to provide information on the reproductive cycle of this species since little is known about its life history in this region. Animals have been collected on

a monthly basis. Their organ indices have been calculated on the basis of the relationship between organ and body total wet weights. The gonads have been prepared for histology. Oocyte-size frequency and diameter of the gonadal tubules have been calculated, and gametogenesis described here. The water temperature has an increase of 5 to 10°C from winter through to spring and summer (maximum temperature in February = 31°C). The gonad index was found highest in late spring (October, November mean = 2.11 ± 1.99; n = 17) and the summer months (in January, February; mean = 2.43 ± 1.16; n = 21). Spawning was observed in January when the water temperature was high (30°C). The results from this work will aid a project for management, larval development, and stock replacement of *I. badionotus* in the region.

Coelomic fluid as a mediator of spawning induction in tropical holothurians

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Holothurians are among the most commercially valuable echinoderms for which successful spawning induction under laboratory conditions is still difficult to obtain on a dependable basis. The present study demonstrates that the transfer of coelomic fluid can be used as a reliable tool to increase spawning success in mature individuals. Fluid collected in the coelomic cavity of holothurians that had been in the typical spawning posture, without shedding gametes, for ca. 20 min triggered spawning in 71 to 100% of conspecifics. The individuals responded to the injection of a 2–3-ml aliquot by displaying the spawning posture within 30–62 min and by massive gamete broadcast 57–78 min later. The results varied according to the time of collection during the spawning activity of the donor and the amount of liquid injected. The active substance is not sex specific since positive responses were observed in individuals of the same or opposite sex as the coelomic fluid donor. The fluid of a spawner was also active when spread in the surrounding seawater; it induced the typical posture in 54 ± 6% of mature individuals and subsequent gamete release in 25 ± 7% of them less than 85 min later. Coelomic fluid collected from immature or non-spawning individuals did not induce spawning. Although most experiments were performed on *Bohadschia argus*, similar results were obtained with *B. marmorata*, *Holothuria leucospilota* and *H. atra.* Inter specific trials were also successful, inferring that the chemical involved is not species-specific. Nonetheless, coelomic fluid from spawning asteroids and echinoids did not induce spawning behaviour or gamete release in holothurians. The results showed that holothurian coelomic fluid acts as a carrier of inductive substances during spawning. Its efficiency even when diluted in seawater could partly explain the epidemic and synchronous spawning observed in some holothurian populations.

Reproductive aspects of *Athyonidium chilensis* (Semper, 1860) (Echinodermata : Holothuroidea) in the IV Region of Chile

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Athyonidium chilensis (Semper, 1986) is the largest sea cucumber species in Chile and has great commercial importance. This infaunal species is found from Perú to Chiloé (Chile). No information is available on reproduction or the reproductive cycle of this species. The aims of this work were to study the reproductive cycle and recruitment of *A. chilensis* in the IV Region of Chile (30º05' S; 71º26' W). Adults were collected monthly from June 1999 to June 2000. Wet and dry mass of animals and gonads and the diameter of ten gonadal tubules were estimated. Histological analyses of the gonads were made to determine their degree of maturity (egg's diameter, germinative layer's thick and acinus area with sperm). We conclude that *A. chilensis* is reproductive all year long, thus it is possible to obtain mature and spawned animals at any time. Juveniles (< 2 mm) of *A. chilensis* were only found at the bottom of crevices in intertidal pools, with high densities of adults present in December 1999. Juveniles were also observed in boulder pools and beaches with a high abundance of adults.
(Financial support: DGICT, Universidad Católica del Norte)

Oral presentation at the Meeting of the Australian Coral Reef Society, Magnetic Island, 7–8 July 2001.

Population genetics of the fissiparous holothurians *Stichopus chloronotus* and *Holothuria atra* (Aspidochirotida) on the Great Barrier Reef, the Torres Strait and La Reunion

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2. Centre for Marine and Coastal Studies University of New South Wales Sydney, NSW 2052;
3. ECOMAR Université de La Réunion, 97715 Saint Denis, France

Population genetic structure was studied in 8 populations of the fissiparous holothurian species *Stichopus chloronotus* and *Holothuria atra* on the Great Barrier Reef (GBR) and the Torres Strait (Western Pacific), and La Réunion (Western Indian Ocean). Allozyme electrophoretic surveys of 5 *S. chloronotus* and 6 *H. atra* loci were conducted to compare patterns of asexual reproduction and to investigate connectivity between regions. Deviations from genotype frequencies expected under Hardy Weinberg equilibrium were observed in all populations. The maximum contribution of sexual reproduction (calculated as the maximum number of sexually produced individuals: sample size = $N^*:N^i$) was similar for all *S. chloronotus* (58–64%) and *H. atra* (76–92%) populations, with the exception of nearshore reefs of the GBR which showed distinctly higher contributions of asexual reproduction. Genetic variability was strongly reduced in *S. chloronotus* populations at La Réunion. FST values calculated from clonal genotypes were not significantly different from zero, suggesting high gene flow between the regions. However, UPGMA cluster analyses roughly clustered populations by region. Thus, although some restrictions in geneflow between the western Pacific and western Indian Ocean may exist, those differences are distinctly less than those reported in previous studies on echinoderms over similar geographic scales. Despite the importance of asexual reproduction for the maintenance of local population size, this study confirmed that the potential for widespread dispersal mediated by sexually produced larvae is large.

Oral presentation and abstract from: Proceedings of the 2001 meeting of the Australian Marine Sciences Association and the New Zealand Marine Science Society (3–6 July, Townsville)

Management of harvest fisheries: Population genetic analyses suggest different management strategies for two commercially important holothurian species. Changes in the Marine Environment

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2. Centre for Marine and Coastal Studies, The University of New South Wales, Sydney, NSW 2052

The fishery for the two most valuable bêche-de-mer species (black teatfish: *Holothuria nobilis*; sandfish: *H. scabra*) has recently collapsed along the tropical east coast of Australia due to over fishing. We investigated genetic structures of populations of these species to assist future management of these stocks on the Great Barrier Reef (GBR). Allozyme analyses of 7 polymorphic loci in populations of *H. nobilis*, sampled up to 1300 km apart, detected no restrictions to gene flow (FST values were not significantly different from 0, and the maximum Nei's unbiased genetic distance was 0.003). Sequence analysis of a mitochondrial gene of more than 300 animals detected no population subdivision. In contrast, allozyme analyses on populations of *H. scabra* showed distinct population differentiation (average FST: 0.088, and Nei's unbiased genetic between regions ranging from 0.020–0.063). Cluster analyses identified three distinct groups of populations representing samples from the three regions, Hervey Bay, Upstart Bay and Torres Strait. These results suggest different management strategies are required for the two species. The high gene flow in *H. nobilis* suggests recruits can be received from a wide geographical area and stocks could be managed on a regional scale. The detection of separate genetic stocks of *H. scabra* implies more limited recruitment from within regions that may reduce recovery of overfished areas. These may need to be managed as separate stocks and local refugia may need to be provided. Continued monitoring will be required to determine the population dynamics and spatial extent of the recovery in each species.

Note from the Editor:

Considering the importance of the sandfish Holothuria scabra *all around the Indo-Pacific, a joint project was undertaken a year ago to produce an extensive and complete review of the species. The document, which summarises and discusses roughly 370 references related to* H. scabra *is due to appear in Volume 41 of Advances in Marine Biology (2001). See title and abstract below*

The sea cucumber *Holothuria scabra* (Holothuroidea: Echinodermata): its biology and exploitation as beche-de-mer

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One of the most intensively studied holothurians, *Holothuria scabra,* has been discussed in the literature since 1833. The species is important for several reasons: 1) it is abundant and widely distributed in several shallow soft-bottom habitats throughout the Indo-Pacific; 2) it has a high commercial value on the Asian markets, where it is mainly sold as beche-de-mer; and 3) it is the only tropical holothurian species that can currently be mass-produced in hatcheries. Research on *H. scabra* continues and because of commercial exploitation, wild stocks are declining. This review compiles data from 14 theses and 349 technical reports and scientific papers pertaining to the biology, ecology, aquaculture and fisheries of *H. scabra.* Although several references are likely to have been missed by our investigation, we present the most complete reference list to date, including obscure material published by local institutions and / or in foreign languages. The main goal of this project was to summarise and critically discuss the abundant literature on this species, making it more readily accessible to all those wishing to conduct fundamental research, or aquaculture and stock enhancement programs, on *H. scabra* across its entire geographic range.

Other abstracts from diverse publications

Holothurian Exploitation in the Philippines: Continuities and discontinuities

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Adapted from: TROPICS Vol. 10(4):591–607, March 2001

In this paper I discuss variations in holothurian resource exploitation in the Philippines. I also discuss specifically trepang fishing especially on Mangsee Island, southern Palawan Province, where people fish in the Spratly Islands. Holothurian has been a major export product from Southeast Asia to China for over three hundred years. Many scholars working in Southeast Asian maritime societies have noted the dynamic human networks involved in pursuing dried sea products such as trepang or shark fins. However, few scholars have dealt with the actual materials of the trade. This paper establishes that 22 species of holothurian are traded in the Philippines at present, and that the price of the most expensive is some 80 times greater than that of the least expensive. Moreover, in recent years, lower quality trepang has been acquiring more commercial value. Holothurian is not just an exclusive expensive foodstuff as mentioned in historical records. It is also becoming part of the every day diet. The less expensive trepang species are consumed more than ever before in the Philippines and elsewhere. One of the most important aspects of the Philippine trade is that the country exports a huge volume of trepang of lower commercial value. There is a vast difference between the industry in the past and the industry of the present and we have to pay careful attention to the continuity and discontinuity in the industry.

Effect of beche-de-mer fishing on densities and size structure of *Holothuria nobilis* (Echinodermata: Holothuroidea) populations on the Great Barrier Reef

S. Uthicke and J.A.H. Benzie

Source: Coral Reefs (2000) 19:271–276

Decreasing catch rates for *Holothuria nobilis* (black teatfish) on the Great Barrier Reef (GBR) prompted management agencies to close the fishery for this species in October 1999. At the same time, we surveyed densities and size structure of *H. nobilis* populations in the main area fished on the GBR. Densities of *H. nobilis* on four reefs protected from fishing (approximately 20 ind. ha-l) were about four times higher than those on16 reefs open to fishing (approximately 5 ind. ha-1). Each of the four other reefs was divided into an area protected from fishing and an open area. On the largest of these reefs (ca. 28 km long), densities of *H. nobilis* were nearly five times higher in the protected area compared to the area open to fishing. On three smaller reefs (< 11 km long), however, densities were not significantly different between the open and protected area, and were similar to that on reefs completely open to fishing. The average weight of individuals was significantly reduced on fished reefs (1,763 g) compared to closed reefs (2,200 g). Thus, beche-demer fishing led to a strong reduction of density and biomass of *H. nobilis*. The division of smaller reefs into open and closed zones appears not to provide sufficient protection, but reefs that are completely closed to fishing appear to provide some degree of protection. There were some indications that proximity to tourist attractions may enhance the effect of protection.

A search for the digestive enzymes in gut fluid of *Holothuria scabra* Jaeger, 1833 (Echinodermata: Holothuridea)

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Source: Proceedings of Jaffna Science Association, vol. 8, no. 1, 2000

A monthly survey of sampling on *Holothuria scabra* in Jaffna lagoon, Sri Lanka, from June 1998 to June 1999 was made to evaluate the digestive enzymes in its gut fluid. The gut fluid collected from eviscerated alimentary canal contained enzymes to hydrolyze starch, casein and oil. The mean volumes of fluid in fore gut and mid gut were 1.2 (± 0.638) ml and 6.0 (±0.233) ml, respectively. The mean PH value of mid gut fluid was 6.1 (± 0.24). The mean carbohydrase, protease and lipase activities, in one millimetre of mid gut fluid were 35.11 (± 12.41) U, 12.32 (± 3.41) U and 3.59 (± 0.61) x 10-3 U, respectively. The mean amount of reducing sugars, free amino acid and peptides and free fatty acids were 0.54 (± 0.20) g/l, 0.07 (± 0.03) g/l and 48.12 (± 10.0) g/l, respectively. The results showed that this animal seems to have higher carbohydrase activity than protease and lipase activities, even though it is a sediment feeder's animal. When the activities of the digestive enzymes in gut fluid were studied in different periods of a year, the activities were least in the month of April. But in April gonadal development of *Holothuria scabra* is maximum. The observation suggests that the organism contains least digestive enzymes during its reproductive period.

Reproductive biology of the commercial sea cucumber *Holothuria fuscogilva* in the Solomon Islands

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Source: Marine Biology (2000), 136:1045–1056

Reproduction of *Holothuria fuscogilva* (Selenka 1867) in the Solomon Islands was investigated over a 4 year period (1994 to 1998) by macroscopic and microscopic examination of the gonad tubules, the gonad index (GI) method, histological examination of gametogenesis, and spawning-induction trials. The gonad consisted of numerous tubules that dominated the coelom of gravid specimens. New tubules appeared in March, and grew in size and extent of branching until they reached their maximum size and maturity in August. Spawning occurred from August to October, with the majority of gametes released during

October, although it was only partial in many individuals. After spawning, the tubules wrinkled and resorbed into the gonad basis. A five-stage gonad maturity scale based on the macroscopic appearance of the gonad tubules corresponded with discrete stages of gametogenesis identified by histology. Gametogenesis was initiated in mid-March, with oogenesis and spermatogenesis occurring in parallel, followed by the growing stage (May to July), which was marked by active gamete development. Successful induction of spawning during the breeding period corroborated the GI and histological data. The uniform growth of gonad tubules indicated that *H. fuscogilva* in the Solomon Islands does not conform to the progressive tubule recruitment model described for other holothurians. An important application of this study is that the appearance of gonad tubules, removed by biopsy, can be used to determine the gonad condition of wild adults or captive broodstock.

Early closure of Milne Bay Province beche-de-mer fishery

Source: *Fishing Line*, issue no. 1, April–May 2001, The monthly newsletter of the National Fisheries Authority, Papua New Guinea

The National Fisheries Authority (NFA) will close the Milne Bay Province beche-de-mer fishery on 8 June 2001 to ensure that the total allowable catch of 140 metric tonnes as set out in the Milne Bay Province Beche-de-mer Fishery Management Plan is not exceeded.

NFA Fisheries Manager, Mr Philip Polon, revealed that the catch of beche-de-mer in Milne Bay to the end of April totalled 110 tonnes. This indicated an average harvest of 27.5 tonnes per month, which also indicates that the total allowable catch will be exceeded by early June this year.

He said NFA is closing the fishery so that the stock of beche-de-mer in Milne Bay Province has time to regenerate, and undersized fish have time to grow. "This means that when the season opens next year there should again be a good harvest," Mr Polon said.

He said on 8 June 2001, the taking, storing and buying of beche-de-mer products should stop immediately and anyone found buying or collecting beche-de-mer after this date is operating illegally and is liable to be charged.

Mr Polon said exporters are required to declare all holding stocks of beche-de-mer products on their premises by 15 June. All stocks must be exported by 30 June.

He added that a new National Management Plan for the beche-de-mer fishery is being developed by NFA. This will come into force later this year and will replace the Milne Bay Province Management Plan. The beche-de-mer fishery will reopen on 31 January 2002 under the new National Management Plan. NFA anticipates reviewing all beche-de-mer licenses following the release of the new plan.

A glimpse into some sea cucumbers in Panay, Philippines

M.B. Surtida and R.Y. Buendia

Adapted from: SEAFDEC Asian Aquaculture vol XXII, no. 3, May–June 2000

Except for coastal dwellers, most Filipinos do not know what sea cucumbers (beche-de-mer, trepang) are or what they look like. Most Filipinos have dined on them at some time, but were probably not aware of it. Its popular name *balat* is known only to traders and gatherers. This article attempts to give an idea of what sea cucumbers are, what they look like, processed, and perhaps cultured. The culture aspect has been gathered from other countries because the Philippines does not culture it.

Sea cucumbers are animals that belong to the families Holothuridae and Stichopodidae. They have worldwide distribution and are found in large numbers in the Indo-west Pacific region. They can reach a maximum length of 40 cm and, when alive, weigh 500 g. Sea cucumbers prefer sandy-muddy substratum, and are often buried with their posterior end always above the surface of the mud. Sea cucumbers prefer slightly less saline areas; and smaller varieties are found near the shore. As they grow, they migrate to deeper water for breeding, which takes place twice a year.

Sea cucumbers have been considered as a delicacy for the past thousand years especially in Asia. In some countries, its industry is considered ancient, mainly originating from China.

Despite its history, little scientific data have been collected. Perhaps scientific studies in some countries have not been considered important because wild catch was plentiful and threats to its supply never occurred.

Today, widespread trading occurs in Hong Kong and Singapore, the two major export centres of sea cucumber in the world. Dried sea cucumbers are processed and re-exported to the USA, Canada, Europe, Taiwan, Republic of Korea, China, Australia, Malaysia, Thailand and elsewhere. In 1996, Philippine exports of sea cucumbers were P 125 million. Total exports in 1958 were 5 tonnes, jumping to 1389 tons in 1996.

But the Asian economic crisis in 1997 has drastically affected the catering business and the demand for sea cucumbers has decreased. This may be good, as this decrease will remove pressure on sea cucumber resources, which are in danger of depletion in many producing countries.

Illegal beche-de-mer fishing in the Seychelles - Indian Ocean

Source: *Le Quotidien* (La Réunion). 11 May 2001

Several tonnes of sea cucumbers were discovered on a Malagasy fishing boat in the Seychelles' exclusive economic zone. After being boarded by the coast guard, the vessel and its 110 seamen are currently docked in Port Victoria. The *Modell* is the first vessel from a country in this region to be investigated for illegal fishing in this 115 island archipelago.

The Malagasy vessel and its crew of 110 seamen were boarded on 23 April 2001 by the Seychelles coast guard off the coast of the Amirante Islands. The island group's sea patrol seized several metric tonnes of sea cucumbers on board. According to the Seychelles weekly *Regard*, the crew of the *Modell*, a fishing vessel registered in Mahajanga (Madagascar), was arrested near Farquhar Island, one of the Amirantes.

Most of the crewmen are suspected of having been hired as divers to harvest nothing but sea cucumbers, a highly-prized food item in Southeast Asian countries. The rest of the crew would mainly have worked on cleaning and salting the cucumbers destined for export.

The *Modell* is a mother-ship transporting eight smaller boats, which the divers use to gain easier access to fishing sites. There are relatively large numbers of sea cucumbers along the northern Malagasy coast and in the shoals of the Seychelles, at depths from 20 to 60 meters. Over the past few years, Malagasy resources have declined considerably due to intensive fishing, which explains why pirate boats are attracted to the waters of the Seychelles.

After being escorted to the Seychelles, the *Modell* is now docked in Port Victoria, where it is under investigation. According to one crew member, the boat never worked in the archipelago's waters. After sustaining damage, it simply drifted into waters off the Amirantes, at the southern end of the Seychelles' EEZ.

The Seychelles' weekly *Regard* pointed out that the Attorney General's Office was supposed to make a decision very soon on the legal pursuits it intended to give to this matter. A justifiable haste, considering the living conditions of the 110 seamen detained. In spite of working conditions well below international standards – many sleep of sacks of salt in the ship's holds – the divers' and workers' health has proven surprisingly good. Seychelles representatives of the Red Cross and Apostleship of the Sea have visited the ship and are currently trying to find funding to provide clothing and basic necessities to the 110 seamen. "However, it would be better for the ordinary seamen to be repatriated while legal proceedings continue," added the *Regard*. "Even so, sending the seamen back would be a problem financially, given the large number of them."

Should sanctions be taken against the *Modell*, Seychelles authorities will have no problem getting to the owner. Not only was he on board, but he also was the ship's captain. These sanctions could take the form of seizure of the boat and its cargo and a heavy fine.

According to the *Regard*, this is the first time that a vessel from a south-west Indian Ocean country suspected of illegal fishing has been intercepted in the waters of the Seychelles.

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MEETINGS

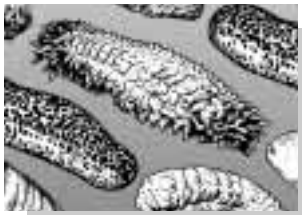
6th European Conference on Echinoderms

The conference was held from 03 to 07 September 2001 in Banyuls, France. For more information, visit the website:
http://www.obs-banyuls.fr/web/departs/feral/biolpop/6thECE/6th%20ECE_accueil.htm

4th North American Echinoderm Conference

The 4th North American Echinoderm Conference (NAEC) was held from 22–26 August 2001 at the University of Maine's Darling Marine Center in Walpole, Maine. This four-day conference was a great opportunity for echinoderm biologists from a broad array of fields to exchange their recent research findings in a stunning location. The event featured keynote addresses by Drs. John Pearse, Paul Tyler, Craig Young and John Dearborn as well as sessions of oral and poster presentations.

For more information: http://server.dmc.maine.edu/html/NAEC.html



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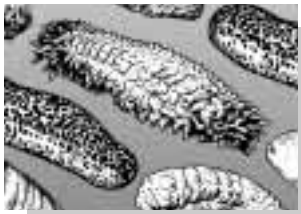
3 May 2001

We are a group of seven people working on a project about the sea cucumber market in China. As you can imagine many of the papers we have on hand have your name on. I found Bulletin number 14 on the web and I have to say I was fascinated to see how well this information is organised — it's not that often that happens — so congratulations. It's very important to keep the information really valuable for everyone — even a student in Iceland can find it!

The reason I am contacting you is to ask for a little help if possible. One species of sea cucumber, *Cucumaria frondosa*, is found in Iceland's coastal waters. No real research has been made on this species, and it is not fished for at present. Some experiments have been done though, and the conclusion was that the Icelandic type wasn't valuable enough to warrant further research. But, when considering the very short time used for these experiments, one may question the results. I am trying to find out the value of *Cucumaria frondosa* on the world market. I can find price information on sandfish, redfish, greenfish, etc., but nothing on *Cucumaria frondosa*.

I have found some information about *Cucumaria frondosa* in Quebec, Canada, but I am not certain if they are still conducting research or if they are actually exporting it; and if they are exporting it, under what class. We really need this information for our report, and of course we are very much interested in any other information you might be able to share with us. For example, if you know what countries, if any, are exporting this type of sea cucumber.

Thanks in advance for any information you can share.
Signy Sig



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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