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NOTE FROM THE EDITOR

This issue contains original contributions in various fields of sea cucumber biology and fishery. As in previous issues, they are arranged in three major sections: new information, correspondence and publications. The number and quality of your contributions show your interest and provide recent information that could be discussed in the next issue.

Articles on 'Spawning observations' (see p.11 and 12) provide helpful information on the reproductive biology of several species. We hope that the request for 'fission and regeneration observations' (p. 9) will provide interesting replies.

New fisheries in North-East Russia (p. 18) and Baja California (p.20) are presented here. The disquieting problem of the fishery in the Galapagos (see last issue, Apr. 1994) is discussed (pp. 21–23).

Several aquacultural experiments on sea cucumbers are being carried out. The results from the work done at ICLARM, Solomon Islands (p. 2) and in Hawaii (p. 25) show that it is possible to induce spawning and rear larvae, but there are still difficulties in obtaining settlement and growth of juveniles.

However some publications, particularly those of the Central Marine Fisheries Research Institute of Cochin (India), indicate that one species at least, *H. scabra*, can be grown to the juvenile stage and offers good prospects (p. 28).

Chantal Conand

Inside this issue

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

PIMRIS
Pacific Islands Marine Resources Information System

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

I N F O

Bohadschia argus

Spawning and early larval rearing of *Holothuria atra*

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Introduction

The Coastal Aquaculture Centre (CAC) of the International Center for Living Aquatic Resources Management (ICLARM) in Solomon Islands has started to assess the potential of enhancing populations of sea cucumbers associated with coral reefs (Anon, 1993). The first step in this process is to determine whether it is possible to produce juvenile sea cucumbers *en masse* at low cost. To this end, the CAC is holding broodstock of a variety of species for experiments on induction of spawning and larval rearing. Although the emphasis is on species of high commercial value, such as white teatfish (*Holothuria fuscogilva*), the locally abundant, low-value species, *Holothuria atra*, is also being maintained in captivity as an experimental animal.

This short note presents the results of an initial attempt to spawn *H. atra* in captivity using heat stress, and to rear the larvae using methods similar to those developed by the CAC for larvae of giant clams. These larval rearing methods centre on the use of large rearing tanks and 'off-the-shelf' diets, such as dried *Tetraselmis* algae and Frippak microcapsules. The rationale for using these methods in the first instance was that, if successful, they could be applied easily in developing countries. During this initial research on *H. atra* we experimented with a wide variety of rearing methods to generate observations on factors affecting the survival of cultured larvae. Several trends emerged which can be used to form useful hypotheses for testing in future research on this species.

Materials and methods

Induction of spawning

Adult *H. atra* were induced to spawn by using heat stress. Two tanks with holding capacities of 2500 l were supplied with flow-through seawater filtered to 25 µm. Water flow to one of the tanks was continual at an ambient temperature of 30° C. Flow in the second tank was held static until the temperature increased by 2 – 3° C above ambient. Adults were introduced into the tanks at 11h00 on 3 December 1993. Seven animals were placed in the static tank and six in the ambient tank. Blended gonads of *H. atra* were added to the static tank to stimulate spawning. Animals were transferred between the two tanks every 30 minutes until spawning occurred. Spawning females were placed in individual 50 l bins filled with UV-sterilised seawater filtered to 1 µm, and left to complete ovulation. A small quantity of sperm (~ 20 ml) was then added to each 50 l bin.

Larval rearing

The CAC has six 700 l larval rearing tanks and all were stocked with fertilised eggs at a density of 2.7eggs / ml. The tanks were supplied with UV-sterilised seawater filtered to 1 µm, and aeration. The antibiotic, *Streptomycin*, was added to each tank at a concentration of 10ppm. The water in each tank was changed completely every second day. This was done by draining the tanks and retaining the larvae in sieves of 80 µm. The antibiotic was added to the water as soon as tanks were refilled.

Until Day 20, water flow was kept static in two of the six tanks between the regular drainings. For two other tanks, 100 l was replaced daily by fresh seawater that had been filtered to 1 µm and sterilised by UV. In the remaining two tanks, 300 l of the rearing water was replaced each day. The number of larvae surviving in each tank was estimated every second day by counting the number of larvae in six 1 ml subsamples. These subsamples were taken from a well-stirred nally bin holding the larvae that had been sieved from the 700 l rearing tank during complete water changes.

Feeding of larvae

We also made a limited comparison of the suitability of different 'off-the-shelf' diets for larval *H. atra*.

Larvae in three of the 700 l tanks were fed 50 per cent *Tetraselmis* (T) and 50 per cent Frippak (F). Larvae in the other three tanks were fed 33 per cent T, 33 per cent F and 33 per cent Selco yeast (S). The three tanks used for each feeding treatment comprised one static tank, one with a daily exchange of 100 l and one with an exchange of 300 l each day. Both diets were given at a concentration of 40 000 cells / ml. After 10 days, it was evident that survival of larvae fed on the diet including the yeast was lower (see *Results* below), so this feeding regime was abandoned. The remaining larvae were then redistributed equally among the six tanks and fed on one of two diets. These diets were 50 % T:50% F fed at 40 000, and at 80 000 cells / ml. There were three replicate 700 l tanks for each treatment. The density of the 10-day-old larvae in this trial was 1.4 larvae / ml.

Once the larvae had reached the doliolaria stage at Day 20, they were again redistributed equally among the tanks so that a comparison could be made between the survival of older larvae fed on diets with and without diatoms. The diets used in this trial were 50% T:50% F at 40 000 cells / ml, and the same diet supplemented with 'wild' diatoms. The diatoms were obtained by soaking clear fibreglass plates measuring 24 x 200 cm in outdoor flow-through seawater tanks. After seven days the plates were removed and placed in larval tanks. Plates were replaced with others that had soaked for at least nine days each time the water was changed. When removing the plates from the larval rearing tanks, care was taken to rinse any larvae from the surface. The tanks containing the diatoms were moved outdoors on Day 21 to enhance the growth of the live algae. However, survival rates were very poor compared to the tanks kept indoors (see *Results* below) so the tanks were returned to the hatchery on Day 26.

Results

Induction of spawning

After two hours of exchanging animals between the static and ambient tanks, some of the *H.atra* in the ambient tank began to adopt typical spawning behaviour, i.e. they raised the anterior half of the body and swayed from side to side. Between 13h00 and 15h00 a total of five males (three from the ambient tank and two from the static tank) and four females (three from the ambient tank and one from the static tank) spawned.

Gametes were released from the genital papilla in strands of varying lengths. Gametes were negatively buoyant, sinking to the bottom of the tank or onto the animal itself. Eggs were pink and sperm were white. The release of gametes was moderately slow. Upon disturbance, gametes spilt from the strand into the water. The spawning period varied between individuals. Two of the male animals spawned continuously for more than an hour. Approximately 9.7×10^{6} eggs were fertilised.

Development of larvae

The unfertilised eggs had a mean size of 138.65 ± 1.6 SD µm (n = 10). After fertilisation, the embryonic and larval developmental pattern observed was similar to that described for other species of tropical sea cucumbers by Preston (1993). The development times to the 2-, 4-, 32- and 64-cell stages, and the blastula, auricularia and doliolaria stages, are given in Table 1.

Table 1: Developmental stages of *Holothuria atra* reared in captivity

Developmental stages	Time
2 – cell	1 – 2 hours
4 – cell	3 – 4 hours
32 – cell	5 hours
64 – cell	9 hours
Blastula	1 day
Auricularia (early)	2 days
Auricularia (late)	10 days
Doliolaria	20 days

The early auricularia stage had developed by Day 2 post-fertilisation. The mean size of these larvae was 431 ± 41.70 SD µm (n = 30). The late auricularia stage was observed at Day 10. The mean size of this stage was 402.13 ± 40.66 SD µm (n = 30), and not significantly different from the earlier stage (t = 4.02, df =28, P > 0.05). The late auricularia stage persisted until Day 19. Metamorphosis to the doliolaria stage began on Day 20 and there was complete metamorphosis of all surviving larvae to doliolaria on Day 23. The mean size of a doliolaria larva was 355.48 ± 56.86 SD µm. On Day 28, all larvae were still at doliolaria stage. By Day 30, all larvae had died.

Effects of partial water exchanges on survival

The patterns of survival for the different levels of water exchange were similar between Day 2 and Day 8 for both diets, and so data for each level of water exchange were pooled across the two diets for comparison. Until Day 8, survival in the tanks with a daily water exchange of 300 l was markedly lower than for the other treatments (Fig. 1a). This type of comparison was not possible for Day 10 because there was massive mortality of larvae in all three tanks fed with the T:F:S diet on that day (*see below*). Survival in the three tanks fed the T:F diet on Day 10 ranged from 44 per cent for the tank with a 300 l exchange to 72 per cent for the static tank.

Between Day 12 and Day 20 there was little variation in survival of larvae among the three levels of water exchange when data from the two diets were pooled (Fig. 1b). Rather, survival decreased sharply between Day 12 and Day 16 for all three treatments of water exchange (Fig. 1b).

Comparisons of survival between tanks with different water exchange were not possible for Day 18 and 20 because there was total loss of all larvae in most of the tanks fed on 80,000 cells / ml (*see below*).

Effects of diet on survival

The mean survival of larvae fed on 50%T:50%F and the diet containing yeast, was compared by pooling the data from the three tanks with different water exchange for each diet. Mean survival for both diets was more than 60 per cent until Day 8 (Fig. 2a). All larvae examined during this period had ingested *Tetraselmis*. On Day 10, however, there was a significant difference in survival between the two diets, with survival of larvae fed the diet containing yeast dropping to 10.1 per cent whereas survival of those fed 50%T:50%F remained at 59.7 per cent (Fig. 2a). The sharp decrease in survival of the larvae fed with the more complex diet may have been due to the difficulty of maintaining good water quality in the presence of yeast.

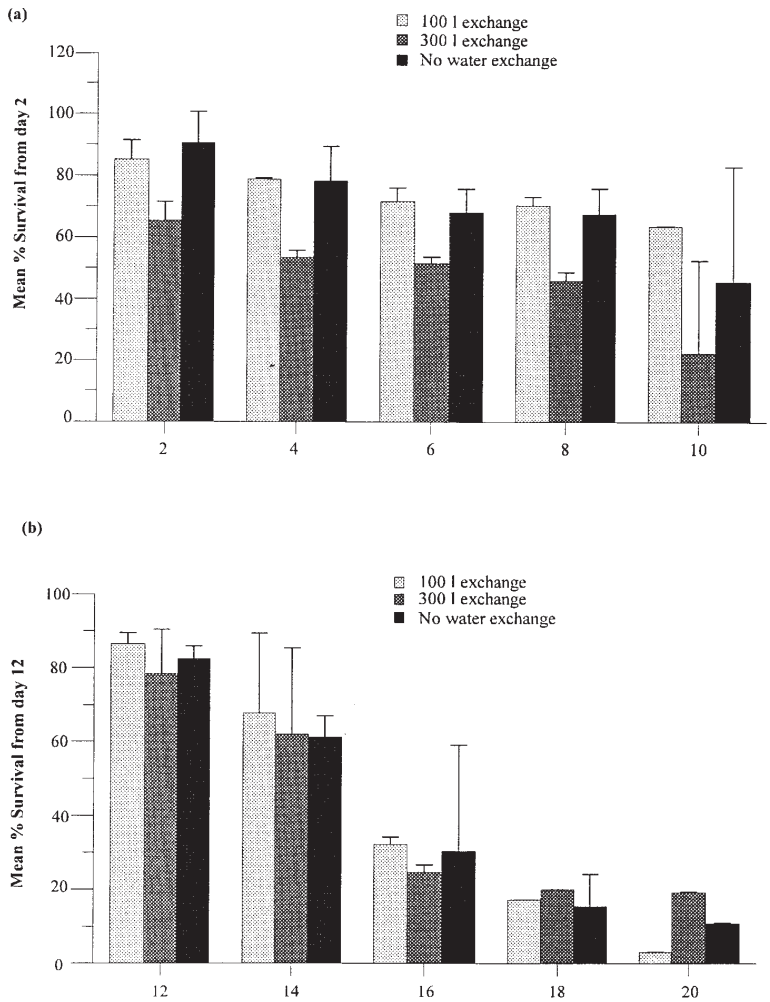

Figure 1. Mean (n = 2) survival of the larvae of *Holothuria atra* reared under three different levels of water exchange in 700 l tanks

a) Day 2 – Day 10; larvae stocked at 2.7 larvae / ml
b) Day 12 – Day 20; larvae stocked at 1.4 larvae / ml.
Note that data for each level of water exchange are pooled across two diets (*see text*). Error bars are standard deviations. Where no error bar is drawn, all larvae in one of the two tanks had died.

Survival of late-stage auricularia larvae fed on a diet of 50%T:50%F at 40 000 and 80 000 cells / ml declined markedly between Day 12 and Day 20, irrespective of the number of cells / ml (Fig. 2b). A significant difference in survival of larvae fed on the two diets occurred on Day 14, when survival was better for the 40 000 cell / ml treatment (Fig. 2b). From then on, survival in tanks fed with 80000 cells / ml was highly variable: it was greater than for the 40 000 cells / ml diet on Day 16 (Fig. 2b), but by Day 18 all larvae in two of the three tanks had died and by Day 20 all larvae in the remaining tank were also dead.

Survival of dololaria larvae fed on the diets with and without diatoms was very poor (Fig. 2c). On Day 22 survival was significantly better in the tanks kept indoors and fed the diet without diatoms. By Day 24, entire tanks of larvae fed on both diets had been lost and by Day 28 only 1.8 per cent of the 21-day old larvae stocked into this feeding trial were alive (Fig. 2c). All larvae were dead by Day 30.

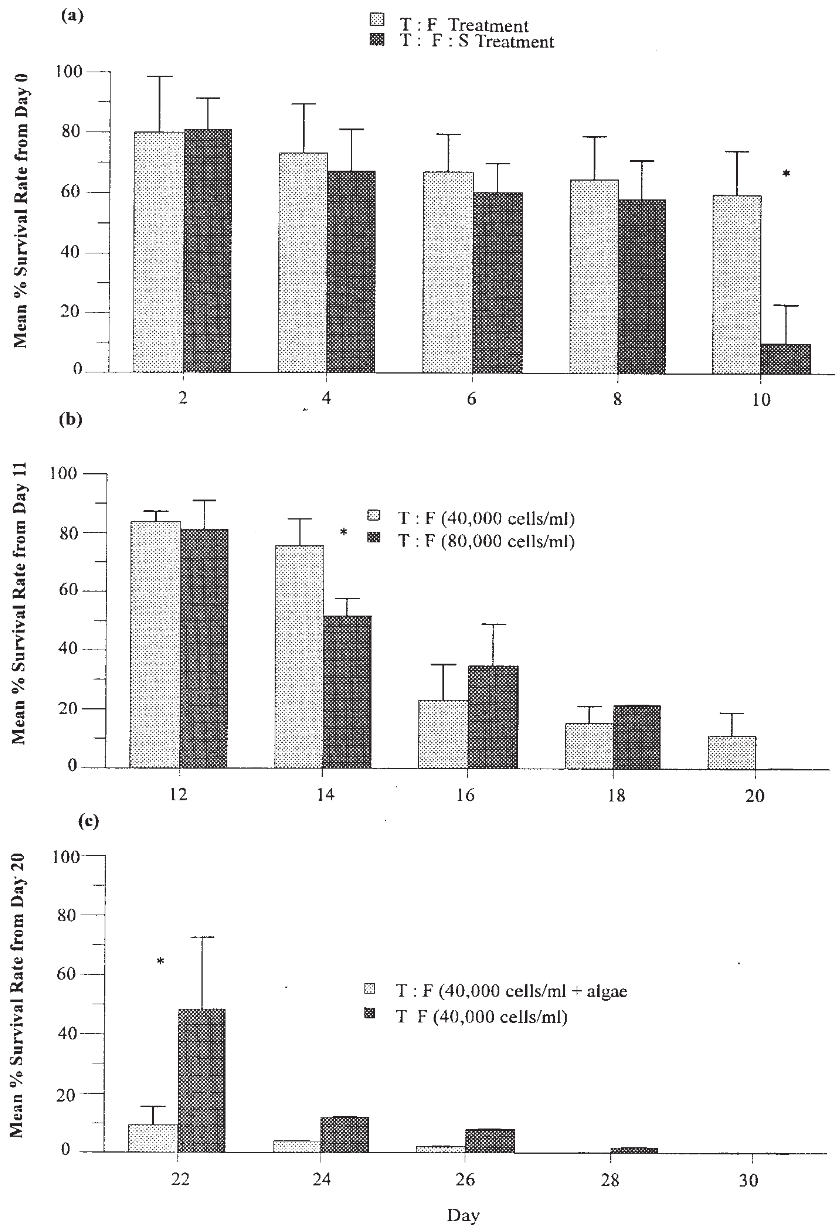

Figure 2 : Mean (n = 3) survival of the larvae of *Holothuria atra* during three feeding trials

The three trials involved larvae of different ages:

a) Day 2 – Day 10 auricularia larvae fed on dried algal and Frippak diets with and without Selco yeast (see text);
b) Day 12 – Day 20 auricularia larvae feed on dried algae and Frippak diets at 40 000 and 80 000 cells / ml; and
c) Day 22 – Day 30 larvae fed on dried algae and Frippak diets with and without diatoms. Asterisks indicate that the two means compared on that day were significantly different by t test (df = 4, $P < 0.05$).

Note that data for trials (a) and (b) were pooled across three tanks with different levels of water exchange. Error bars are standard deviations. Where no error bar is drawn, all larvae in two of the three tanks had died.

Discussion

Our initial attempt to spawn *H. atra* and rear their larvae demonstrated that spawning can be induced by a simple method of heat stress. James (1988) also sucessfully spawned *H. scabra* using this method. The period of the year when *H. atra* can be induced to spawn has not yet been determined, but in the case of Solomon Islands, it also includes November, because *H.atra* kept in captivity have been observed to shed gametes spontaneously in that month (Anon, 1994).

Fertilisation of the eggs was straightforward and the timing of development to the late auricularia stage was well within the range described for several other species of aspidochirate sea cucumbers (Preston, 1993). For example, it was slower than the 10 days taken by *H. scabra* (James et al., 1988), and the 15 days needed by *Actinopyga echinites* (Chen & Chian, 1990) to develop to the doliolaria stage, but considerably faster than the temperate species *Stichopus californicus*, which reaches the doliolaria stage after 65 days (Cameron & Fankboner, 1989).

Survival of the late auricularia larvae of *H. atra* under all our rearing protocols was relatively high for the first eight days, although it was reduced when large partial exchanges of water were made each day. This may have been because the antibiotics were diluted. The sharp increase in mortality on Day 10 in all tanks supplied with the diet containing yeast points to a deterioration in water quality caused by this dietary component.

The most likely explanation for the dramatic decrease in survival from Day 16 onwards is a deficiency in the diet. Larvae of other species of sea cucumbers have been reared successfully when fed on freshly cultured microalgae and diatoms (Preston, 1993; James et al., 1988; D. Sarver, pers. comm.). The reason for incorporating Frippak in the diet was to supplement the monospecific diet of dried *Tetraselmis*. We could not ascertain whether the larvae of *H. atra* ingested the Frippak microcapsules, so we do not know whether this source of nutrients was unavailable to them, or whether it was ingested but provided inadequate nutrition. Doubling the concentration of food between Day 10 and Day 20 did not improve survival. On the contrary, the mortality rate of larvae fed on the diet of 80 000 cells / ml was even faster than for those fed the diet of 40 000 cells / ml, suggesting that much of the food was not being eaten and that it had reduced water quality.

The addition of diatoms to the diet at Day 21 did not improve survival. In fact, total loss of larvae occurred sooner in the tanks supplied with wild diatoms. We cannot say whether this was due to the diatoms being contaminated by bacteria or to the increased risk of bacterial contamination, since the tanks with diatoms were kept outdoors.

Although the lack of more than six tanks limited our ability to design unconfounded experiments, our data suggest that survival of *H. atra* larvae will be improved by the use of static tanks and by diets that do not contain yeast. Above all, they show that the relatively simple methods that can be used for giant clam larvae may not be suitable for *H. atra*. On the basis of other research, larval sea cucumbers appear to need a variety of live algae.

Future experiments on larval rearing of *H. atra* and other species of sea cucumbers at the CAC will concentrate on comparing the effects of a wider variety of feeds on survival. These feeds will include some containing cultured live algae. All diets will be introduced at a range of times, starting at Day 2, to identify which diet and feeding regime maximises survival.

Acknowledgements

We thank Henry Rota for his help with the maintenance of larvae, and the Australia and Pacific Science Foundation for financial assistance.

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Asexual reproduction in *Holothuria atra* on a reef of Reunion Island in the Indian Ocean

by C. Boyer, S. Cailasson & K. Mairesse
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Holothuria atra is a sea cucumber species which is frequently encountered throughout the Indo-Pacific region. A population displaying fission characteristics was studied in one of the reefs of Reunion Island. Analysis of various studies on the external morphology and the internal anatomy of this back reef population contributed to the determination of parameters linked to the processes of fission and regeneration.

External morphology

An examination of the external morphology of each specimen observed in the field produced the following classification system:

– N: 'Normal' specimens which have a mouth and an anus and show no transverse constriction of their integument;

– F: Specimens in the process of fission which have a mouth and an anus and show transverse constriction of their integument;

– A: Anterior specimens which have a mouth but no anus;

– P: Posterior specimens which have an anus but no mouth;

– Ap: Anterior specimens which are regenerating their posterior portion;

– Pa: Posterior specimens which are regenerating their anterior portion.

Note that specimens in the process of regeneration can be identified, as the regenerated portion has an integument which is lighter in colour and smaller in diameter than the rest of the body.

Asexual reproduction in the overall population

Using the above classification, two characteristic parameters for asexual reproduction were determined: the rate of fission (F%) and the rate of regeneration (R%), based on sampling carried out during the six-month austral summer.

Overall, the process of asexual reproduction appeared to involve 20.2 per cent of the total surveyed population.

Rate of fission

As few specimens in the process of fission are generally available, the rate was calculated from the following formula: 100 x (A+P)/2T, with T being the total number of specimens. In La Réunion, this rate is 4.7 per cent on average, which corresponds to 9.5 per cent if the As and the Ps are considered as new specimens. Temporal variations in the rate were observed, as shown in Figure 1.

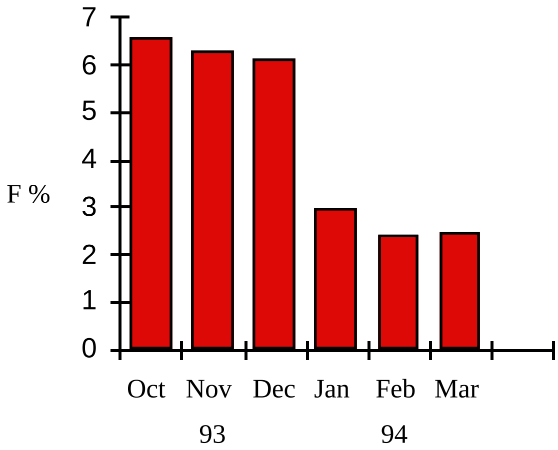


Figure 1: Temporal variations in the fission rate, F %

This rate seems to be relatively stable from October to December, then it decreases by 50 per cent between the months of December and January, after which it levels out again.

Having determined that division takes part in the anterior portion of the animal, at a point located at 45 per cent of the length of the specimen, and based on the weight distribution of recently divided specimens, it was determined that fission takes place in normal animals weighing between 9 g and 135 g.

Regeneration rate

This rate was obtained by using the following formula: 100 x (Ap+Pa)/T. The average value obtained, 10.6 per cent, indicates that the regeneration period is longer than the fission period.

The regeneration rate also varies over time. In fact, a decrease was noted from October to February, followed by a slight increase in March. Moreover, mortality in animals produced by asexual reproduction is greater in anterior specimens than in posterior specimens, which are more numerous.

A new parameter was considered during this study—the regenerated length. Contrary to what had been expected, given the location of the division, we noted that anterior specimens (Ap) regenerate to a shorter length than posterior ones (Pa). However, we have some reservations about this observation, since, above a certain regenerated length, the distinction between a normal specimen and an anterior specimen in the process of regeneration is less clear than it is for posterior specimens.

Asexual reproduction at the individual level

Some of the specimens surveyed (belonging to categories F, A, Ap, P and Pa) were harvested and dissected. Examination of the organs supplied additional information about fission and regeneration.

Description of fission

Sea cucumbers beginning fission hide and are contracted. They show constriction at one place on their integument which then develops into a ring. The integument stretches and then splits. At this stage, the digestive system is the only link between the two parts. In the end it also divides (sometimes pieces remain outside the body and are lost) and the anterior and posterior parts separate, but generally remain close to each other.

Dissection revealed where the split was located in relatio to the internal organs. Two possibilities are proposed as shown on Figure 2.

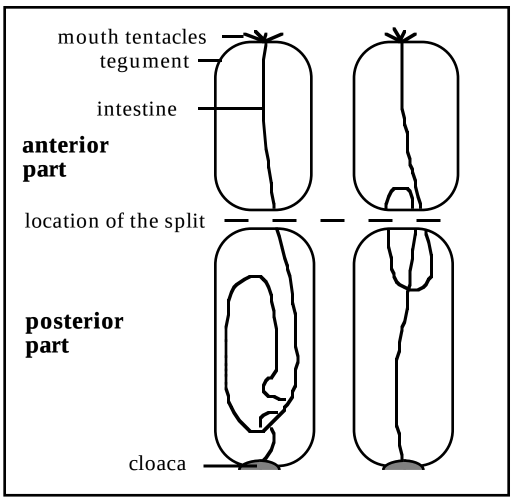


Figure 2 : Two fission possibilities

The difference in the layout of the digestive tube in the two cases is explained by the fact that the stretching forces which affect the animal disturb the arrangement of the organs.

Both external and internal signs of future fission were observed. The external signs are a point on the integument which is particularly contracted or a ringlike constriction of the body; internal signs are constrictions of the longitudinal muscular bands at the point of future fission. A few of the dissected subjects showed these characteristic signs, even though they had already undergone fission only a short time earlier.

Description of regeneration

After fission, the anterior part A has very few organs. The only ones remaining are the mouth area and its appendages, the gonads (if any), and part of the intestine. The intestine lengthens during the regeneration and recovers its initial appearance. The respiratory trees regenerate completely, as does the *rete mirabile*. Feeding recommences rather quickly, well before all the organs are completely regenerated.

In the posterior part P, generally most organs remain, except those of the anterior region. The left respiratory tree associated with the *rete mirabile* and attached to the digestive tract dissolves. Meanwhile, the length of the digestive tract measurably decreases, then regeneration restores it to its initial appearance. The right respiratory tree is also regenerated. The oral area is regenerated rather quickly, becoming functional even when it is very small and only has a dozen buccal tentacles.

Synopsis of organ regeneration

After fission, specimens in category A have to regenerate the intestine, the *rete mirabile*, the respiratory trees and the cloaca. Specimens in category P dissolve most of the remaining organs (intestine, *rete mirabile*, respiratory tree). They then regenerate them, probably through materials left over after dissolution. In both groups, the intestine, the left respiratory tree and the *rete mirabile* are regenerated.

Category verification

The various categories that we have defined according to their external morphology show some variability, related to the state of advancement of regeneration which affects the physiology of nutrition in particular. Thus category A includes all anterior specimens that have recently undergone fission or that are in the process of internal regeneration. The Ap category includes all anterior specimens that have begun regeneration of the integument; category P includes all posterior specimens that have recently undergone fission and have not regenerated any of their organs; and, finally, category Pa includes all posterior specimens that have regenerated the oral portion and begun regeneration of internal organs.

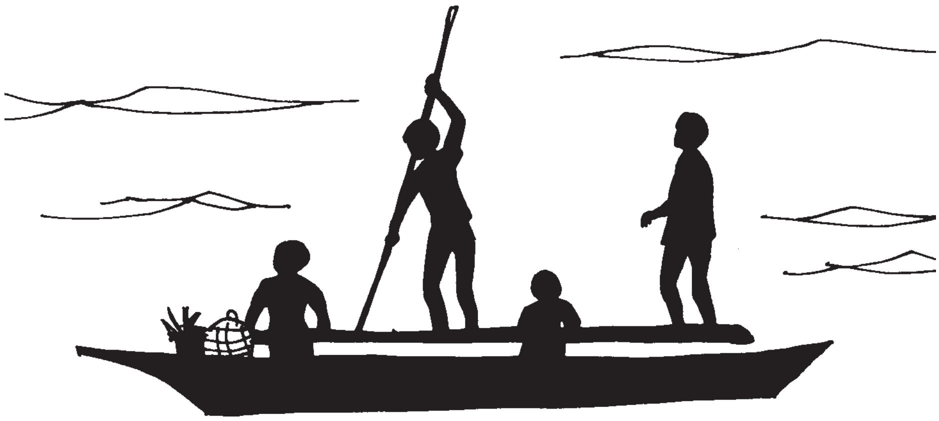
Sexual and asexual reproduction

The presence of gonads both in some subjects showing recent fission and in some that are in the process of regeneration suggests that sexual and asexual reproduction can occur in the same specimen.

Anatomical study has thrown light on the ways in which fission and regeneration take place in *Holothuria atra*. Study of regeneration and fission rates will be carried out over an entire year-long cycle for full understanding of these events. Finally, numerous other parameters, such as fission stimuli, energy requirements, etc. will have to be considered in order to understand the place of this strategy in population dynamics.

Acknowledgements

We thank Mrs C. Conand and the team at the Marine Ecology Laboratory who assisted us in carrying out this research.



Request for information on fission and regeneration of tropical holothurians

by Chantal Conand

Asexual reproduction by fissiparity and regeneration is displayed by some marine animals. It can occur in populations also reproducing sexually, but the evolutionary and ecological significances of this strategy are still a subject of debate (Ghiselin, 1987; Mladenov & Emson, 1988; Gouyon et al., 1993).

Although holothurians are noted for their ability to reproduce asexually by fission, there have been relatively few reviews on the subject and specific data are still very limited (Emson & Wilkie, 1980; Lawrence, 1987; Smiley et al., 1991; Mladenov & Burke, 1994). Approximately ten species, amongst Dendrochirotes and Aspidochirotes, have been reported, from field and laboratory observations, to reproduce asexually. Most of these observations are still anecdotal, and refer to very low fission rates in the field; they are therefore not significant at the population level.

Two tropical Aspidochirotes have attracted more attention: *Holothuria parvula*, in the Atlantic Ocean (Crozier, 1917; Deichmann, 1922; Emson & Mladenov, 1987) and *Holothuria atra* in the Indo-Pacific (Bonham & Held, 1963; Pearse, 1968; Doty, 1977; Harriot, 1982; Conand & De Ridder, 1990; Conand, 1993; Chao et al., 1993). As this species is widely distributed in the Indo-Pacific tropical region (Guille et al., 1986), it offers a good example of this particular life strategy .

The request for spawning informations (Byrne & Conand in BDMIB #4) has brought many new observations, some being the first for some species. If any reader has observed fission or more commonly regenerating individuals, please supply us with the following details:

1. Species, locality, habitat, date;
2. State of regeneration or fission;
3. Number of regenerating and not regenerating;
4. Variations in behaviour.

Please send the observations to C. Conand (see address on cover); they will be published in the next issue of this bulletin.

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Spawning observations

A request for information on spawning behaviour of tropical holothurians was published in Beche-de-mer Information Bulletin #4, For this issue we have received a list of observations (presented below) compiled by Dr Norman Reichenbach of the Oceanographic Society of Maldives.

Spawning observations of tropical holothurians from Male and Laamu Atoll, Republic of Maldives

Date:	5 June 1994
Time:	1500 h
Species:	*Holothuria nobilis*
Moon phase:	New + 26
Remarks:	1 male (1.62 kg total wt) spawned in holding tank after being collected that day along with 5 other *H. nobilis.*
Observers:	N. Reichenbach, Y. Nishar, A. Saeed

Date:	1 October 1994
Time:	1400 h
Species:	*Holothuria nobilis*
Moon phase:	New + 25
Remarks:	1 male (2.76 kg total wt) spawned in holding tank after being collected that day along with 2 other *H. nobilis*.
Observers:	S. Holloway, Y. Nishar, A. Saeed

Date:	16 October 1994
Time:	1300 h
Species:	*Holothuria nobilis*
Moon phase:	New + 11
Remarks:	1 male (1.12 kg total wt) spawned in holding tank after being collected that day along with 2 other *H. nobilis*.
Observers:	S. Holloway, Y. Nishar, A. Saeed

Date:	10 April 1994
Time:	1600 h
Species:	*Thelenota ananas*
Moon phase:	New – 1
Remarks:	2 males and 1 female spawned in holding tank after being collected that day along with 8 other *T. ananas*. Animals were collected at depths ranging from 10 to 33 m and with a surface water temperature of 30°C. One male spawned, and the second spawned about 20 minutes later. Then the female released eggs in two large bursts.
Observers:	N. Reichenbach, Y. Nishar, A. Amlah

Spawning of the sea cucumber *Cucumaria frondosa* in the St Lawrence Estuary, eastern Canada

by Jean-Francois Hamel & Annie Mercier
Québec, Canada

Jean-Francois Hamel (Société d'Exploration et de Valorisation de l'Environnement (SEVE), 90 Notre-Dame Est, Rimouski (Québec), Canada G5L 1Z6) and Annie Mercier (Département d'océanographie, Université du Québec à Rimouski, 310 allée des Ursulines, Rimouski (Québec), Canada G5L 3A1) present in the following article their work about the spawning of Cucumaria frondosa *in the Lower St Lawrence Estuary, eastern Canada.*

Abstract

Our work presents data on spawning of the commercial sea cucumber *Cucumaria frondosa* from the Lower St Lawrence Estuary, eastern Canada. The rapidly rising concentration of chlorophyll a in early spring 1992 and 1993 appeared as the spawning cue for male and female individuals during the large-scale monitoring. A closer look at the spawning cue on a scale of hours revealed that males spawned first, as the chlorophyll a concentration decreased and as the temperature increased rapidly, during the low tide at sun rise. Spawning in females occurred shortly thereafter and seemed to be triggered by the presence of sperm in the water column. Those results demonstrate that the correlation between spawning and environmental factors is often more complex than that suggested by large-scale monitoring.

Introduction

Cucumaria frondosa, the species chosen for this experiment, is a commonly occurring coastal, large sea cucumber, especially abundant on rocky bottoms along the eastern coast of Canada and the United States. Attaining densities greater than 5ind/m ^{2} (sometimes reaching 15 kg/m^2), this holothurian is well distributed in both shallow and deep waters.

A somewhat controversial subject, discussed in many studies on holothurians, is the potential trigger of natural spawnings. The temperature (Tanaka, 1958; Conand, 1993), the phytoplanktonic bloom (Cameron & Fankboner, 1986; Hamel et al., 1993), the light intensity (Conand, 1982; Cameron & Fankboner, 1986) and the salinity (Krishnaswamy & Krishnan, 1967) are the most frequent factors identified.

Spawning of *Cucumaria frondosa* has been noted to occur between April and May in Passamaquoddy Bay, New Brunswick (Lacalli, 1981); from February to May in Newfoundland (Coady, 1973); in March in the North Sea; in July farther in Arctic waters (Runnstrôm & Runnstrôm, 1919); and in late March and early April along the coast of Maine (Jordan, 1972). The phytoplanktonic bloom was suggested to be the spawning trigger, especially from the work of Coady (1973) and Jordan (1972).

All those studies deduced spawning or observed it during the course of a long-term sampling, from the occurrence of larvae in the field or following the histologic cycle of the gonad, but the large intervals between each sample allowed only an approximation of the spawning time and cue. In the present study, we carefully monitored the spawning period from beginning to end during two years, collecting samples at close intervals and making correlations with environmental conditions. A more precise observation of the spawning event was made underwater every hour, taking into account the fine-scale variations of the environmental conditions at the study site, in order to increase the resolution of the correlative data.

Materials and methods

Abundance of individuals ready to spawn and having spawned

Just before the spawning event, we determined the number of individuals likely to participate in the spawning in May 1991, 1992 and 1993 at Les Escoumins, eastern Canada (Fig. 1), using SCUBA. The observations were made on 3 samples of 180 – 200 individuals of both sexes, collected randomly at about 15 m depth (where the vast majority of animals were found). Each individual was dissected and the degree of maturity of its gonad determined by the proportion of mature gametes present in the whole gonad. The large tubules were those implicated in the spawning for the current year (Hamel et al., 1993 for *Psolus fabricii*, personal observation during preliminary experiments of this research). We considered that an individual was ready to spawn when the large tubules were fully distended at the maturity stage.

We took equivalent samples of sea cucumbers at the same study site, a few days after the spawning event, and determined the proportion of individuals having released their gametes for the total number of individuals collected at the site. We considered that an individual had spawned when the gonad contained no gonadal tubule at maturity but had an abundance of very small constricted tubules. Because the number of individuals collected at the study site represented a very little proportion of the whole population, the disturbance caused by our collecting effort was minimal.

Seasonal variations of environmental factors in relation to spawning (large-scale)

Samples of 30 sea cucumbers (males and females) were collected monthly or bimonthly to establish the time of spawning and the potential trigger. The chlorophyll a concentration was recorded weekly at the study site by collecting 3 water samples (8 l) at 15 m depth, during high tide.

We made the pigment determination in two subsamples of 50ml, by filtering them through Whatman GF / C filters, and immediately extracting with 90 per cent acetone for 24 h before evaluating the concentration by the spectrometric method of Yentsch and Menzel (1963).

The temperature at 15 m depth was recorded by 3 Peabody Ryan thermographs. Fresh water run-off data combined those of four rivers: Montmorency, Batiscan, Sainte-Anne and Chaudière, and were provided by Environment Canada (Climatologic Services).

Monitoring of the spawning events (fine-scale)

Gamete release was monitored using SCUBA in summer 1992. At the study site chosen for this experiment (Les Escoumins, St Lawrence Estuary, eastern Canada, see Fig. 1), the population of sea cucumbers attained its maximum density between 10 and 15 m depth, with an almost complete depletion at greater depths. Sea cucumbers were also poorly represented in shallower waters, as the sandy and muddy substrates at those depths discourage colonisation (unpublished data). The sea cucumber population was therefore localised and easier to study during spawning. This experiment was conducted with the help of a team of 24 divers, assisted by boat-skippers.

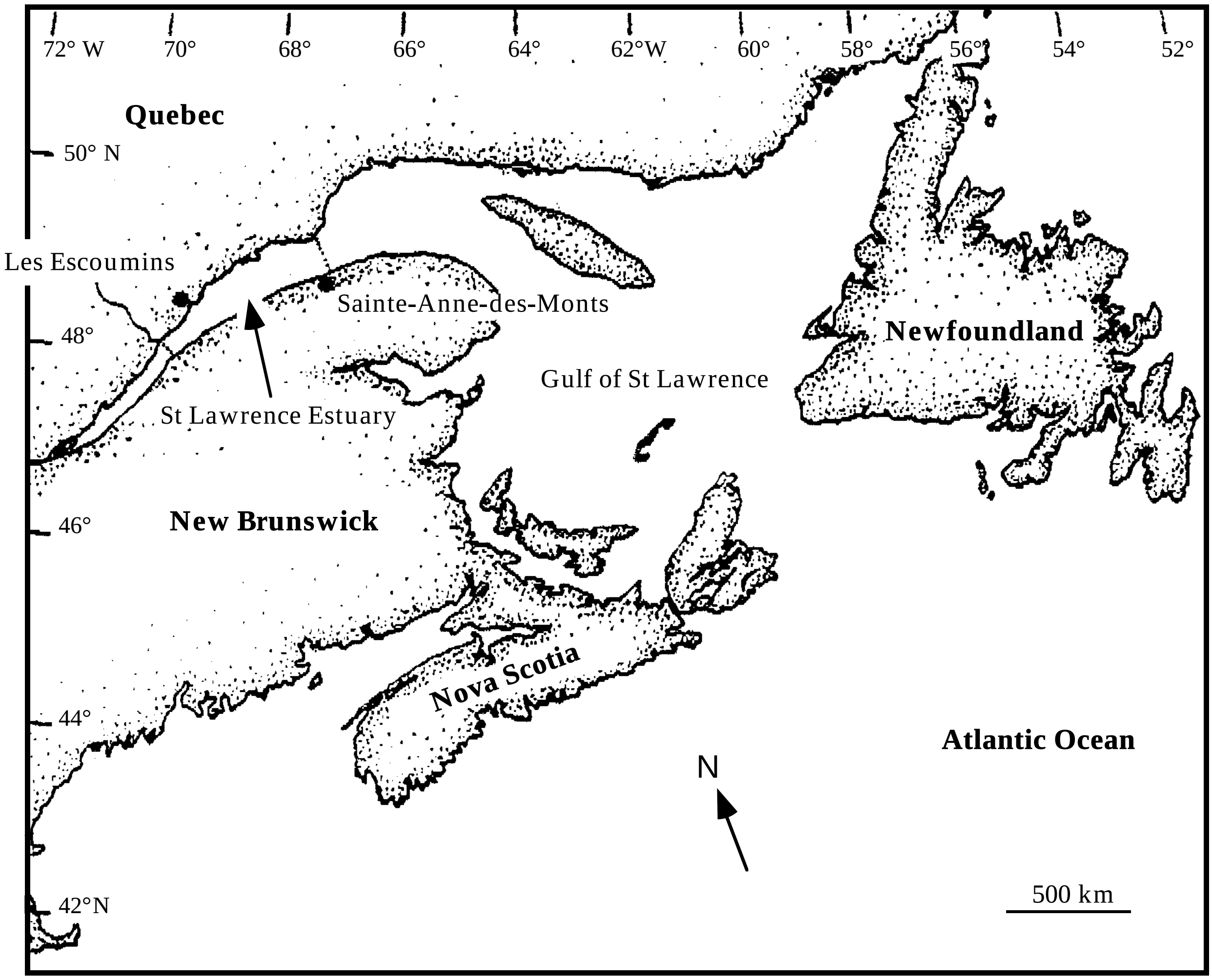


Figure 1. Map of eastern Canada, showing the study sites

After a few days of recognition dives, constant monitoring of the site was initiated in order to detect evidence of spawning events. Beginning on 16 June, alternating pairs of divers maintained a watch, day and night. During these dives, the following parameters were noted hourly: the velocity and direction of the current, with a torpedo currentometer; the direction of the flow in relation to the coast line, by addition of methylene blue to the water column between 10 and 15 m depth; the water temperature close to the sea cucumbers, using an electronic thermometer; the underwater visibility, using a Secchi disc to its total disappearance.

Water samples were also taken from a boat, for later evaluation of the chlorophyll a content. Light power supply was used at night to maintain underwater visibility. The tide level was established from the Canadian tide tables for this area (Canadian Hydrographic Service, Department of Fisheries and Ocean, Canada). Data on wind velocity and direction were obtained from Faune et Environnement Québec (Quebec Government).

At the first signs of spawning, closer monitoring and several types of data collection were initiated, with divers taking turns underwater by groups of up to 10 divers for 50 h until the end of spawning. Each diver spent a maximum of 35 minutes diving at intervals of 3 – 4 h or more. Most of the measures were taken above 10 m (only a few divers needed to descend to 15 m). Routinely, during each dive, we noted the proportion of males and females spawning, between 10 and 15 m depth, along a 100m long transect parallel to the coastline.

The results are presented for males and females as the proportion of spawning individuals (number ind / m^2) in a sample of 350 sea cucumbers observed every hour.

Results

Large-scale environmental fluctuations in relation to spawning

In early summer 1993 (June), the temperature oscillated regularly around 7°C and a few higher peaks between 8° and 10.5°C were observed. This period also corresponded to the spawning time observed between mid-May and mid-June 1993.

Chlorophyll a concentrations at the beginning of the experiment (May 1992) fluctuated around 0.5 and 1 mg / m^3. A strong increase in chlorophyll a occurred in mid-June 1992, with a peak attaining 6mg / m ^{3}, indicating an important phytoplanktonic biomass. Spawning occurred abruptly at this time. This high production persisted until August, although the pigment concentrations were not constant and sometimes fluctuated from the highest values (7 mg / m^3) to less than 1 – 2.2 mg / m^3.

Fine-scale environmental fluctuations in relation to spawning

Male spawning began early on 17 June at 0500 h (Fig. 2). At that time, only a few isolated males released their gametes in the water. Seven hours later, the proportion of spawning individuals had increased to attain 5 per cent of the 300 observations made. However, the male spawning only became generalised in the entire population around 1400 h, when more than 65 per cent of males were spawning. The highest number of spawning individuals was recorded at 1500 h, comprising 83 per cent of males.

Female spawning began at 1400 h, with numerous isolated individuals starting to release oocytes. When the first isolated female spawnings were recorded, they always occurred in proximity to a spawning male (less than 5 m). Following a drop in the male spawnings to less than 32 per cent of males (at 1700 h), maximum female spawning (87 per cent of the population) was observed. Around 1800 h, less than 12 per cent of females were still releasing gametes (Fig. 2). A small proportion of male and female individuals continued to spawn until 0700 h the next morning (18 June). No spawning individual was observed in the following 10 h of diving at the study site.

The data on tidal oscillation at the study site (Fig. 2) indicated that the first isolated spawnings of male and female individuals occurred during the lower slack tide. Spawning was initiated in both sexes when the current was minimum (0.5 to 1.5 cm / s). At that time, the underwater visibility was maximum, attaining around 4.7 m, associated with a net decrease in the concentration of chlorophyll a (Fig. 2).

The male spawning began at sunrise (0500 h), as the water temperature increased rapidly, passing from 3° to 7°C in less than 2 h. Female spawning also occurred as the visibility increased rapidly to attain 3.6 m, and the temperature increased rapidly, passing from 3° to 6°C in 2.5 h. The chlorophyll a was at its minimum (around 2.5 mg / m^3).

The maximum number of male individuals spawning (7 h after the first isolated one) occurred at the next slack tide, when again the concentration of chlorophyll a was minimum. However, the time of greatest abundance of female individuals spawning coincided with the beginning of the flood

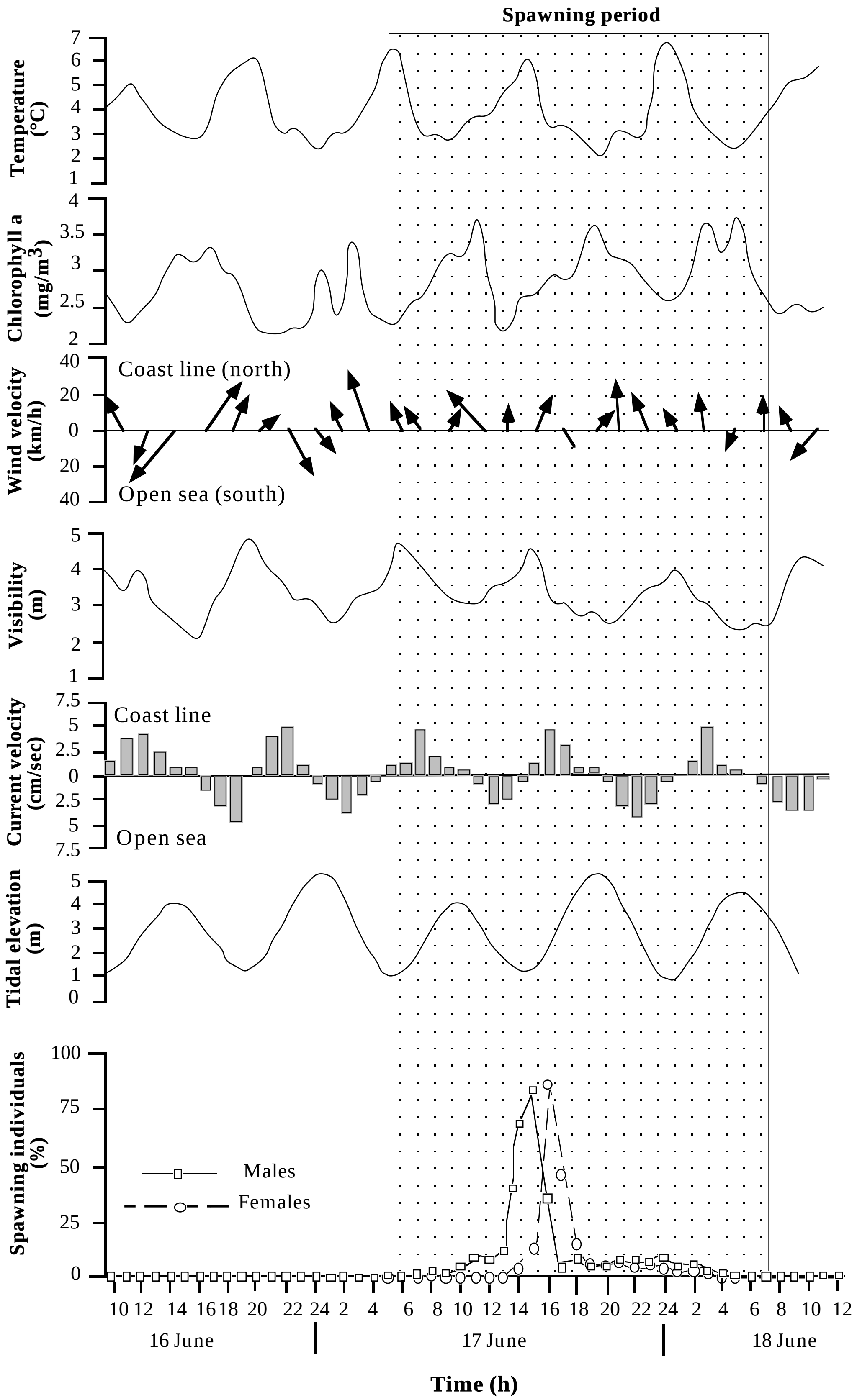


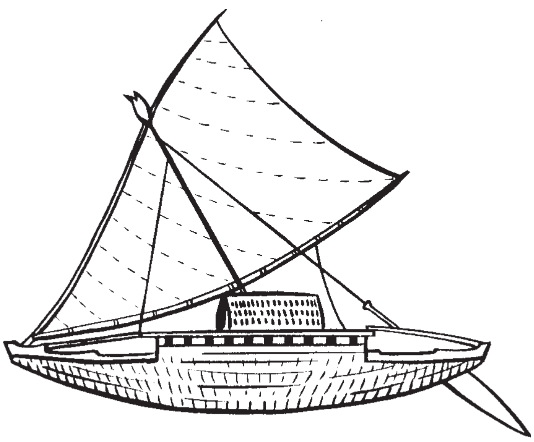
Figure 2. *Cucumaria frondosa*. Evolution of water temperature, chlorophyll a concentration, wind velocity, underwater visibility, direction and velocity of the current and tide level recorded every hour at Les Escoumins

The proportion of spawning males and females based on 300 observations every hour is also indicated. All measurements were recorded between 16 and 18 June 1992.

tide, when the current increased (passing from 0.5 to >4 cm/s) and both underwater visibility and water temperature decreased rapidly. During the spawning event of both sexes the wind blew relatively constantly, mainly in the north-north-west direction towards the coast at 5 – 35 km/h (Fig. 2).

Proportion of individuals implicated in spawning events

In summer 1991, 1992 and 1993 the proportions of males and females ready to spawn and those implicated in spawning were roughly the same. A maximum of 85 per cent of males and 84 per cent of females collected were ready to spawn a few days before the spawning event. A few days after the spawning event, our data indicated that the vast majority of individuals had spawned, since less than 14 per cent (considering males and females together) still possessed gonadal tubules at maturity.



Discussion

For many species of echinoderms, spawning events extend over a long period, but the reproductive season may be shortened when the environmental conditions are only favourable for a short time (Giese & Kanatani, 1987; Chia & Walker, 1991; Pearse & Cameron, 1991).

We observed in the St Lawrence Estuary that more than 80 per cent of the individuals ready to spawn had done so just after the massive spawning event recorded in the field (within a one-week period), suggesting that the conditions for an extended breeding season were not found in the St Lawrence Estuary. In contrast, Jordan (1972) and Coady (1973) indicated that the breeding season of *Cucumaria frondosa* was spread over a month in Newfoundland and along the coast of Maine.

The short duration of the phytoplanktonic bloom and the restrained warm season may in part explain the difference from these other locations where *C. frondosa* was studied. Varying lengths of spawning periods in relation to latitudes are very common among marine invertebrates and have been observed in other echinoderms (Giese & Kanatani, 1987).

The spawning periods reported for the numerous locations where *Cucumaria frondosa* was studied also showed a great variability. Occurring in July in the highest latitudes, spawning was noted in March and April in more southern locations. In the St Lawrence Estuary, the spawning of *C. frondosa* occurred in mid-June, when the stratification of the water column was well established, with a defined warmer surface layer.

Those conditions appeared as the fresh-water run-off dropped drastically. At that time, the primary production also increased, as the day-length progressively reached about 15 h/day. Highly variable at that time of the year, the temperature fluctuated over more than 7^{o}C every day and does not seem to be the factor that stimulated *C. frondosa* to spawn (Fig. 2). The fact that days had gradually been growing longer well before the spawning, and continued to do so, minimises the likehood of a relationship between daylength and spawning event.

However, the male and female spawnings in 1992 and 1993 coincided with a drastic increase in primary production, as demonstrated by the significant increase of chlorophyll a. Simultaneously, individuals were found to have a higher content of phytoplanktonic cells in the digestive tract (unpublished data), strongly suggesting that the phytoplankton initiated spawning in *Cucumaria frondosa*. Starr et al. (1990, 1992, 1993) also demonstrated this with the sea urchin *Strongylocentrotus droebachiensis* and Hamel et al. (1993) suggested it for the sea cucumber *Psolus fabricii* at the same study site. For *C. frondosa,* Jordan (1972) and Coady (1973), also suggested that phytoplankton may induce spawning.

Moreover, the distinctive breeding seasons found in July for the Arctic (Runnstrôm & Runnstrôm, 1919); in mid-June for our research; in May–June for Newfoundland (Coady, 1973) and in April–May along the coast of New England (Jordan, 1972) again suggest that the primary production plays an important role in the initiation of spawning. The phytoplanktonic bloom occurs sooner in lower latitudes than in higher ones such as the Arctic waters.

Nonetheless, a closer look at the fine-scale spawning of *Cucumaria frondosa* informed us that the spawning correlation with environmental conditions was not as simple as suggested by the previous data (Fig. 2). In fact, male C. *frondosa* spawned first, a piece of information that was not revealed by the large-scale correlations. This phenomenon was also observed in other sea cucumbers by McEuen (1988).

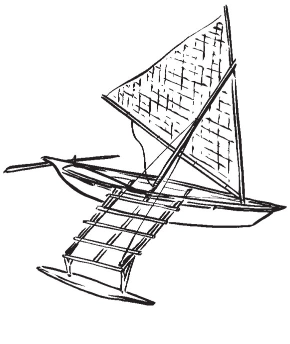
The female spawning began much later in *C. frondosa* (Fig. 2). More precisely, the male spawning initiated at first in a few isolated individuals coincided with low tide, minimum current, a drop in chlorophyll a concentration and a drastic increase in temperature as the sun rose (Fig. 2).

After those isolated individuals, spawning became epidemic, spreading away from the first individuals to spawn. This suggests that the environmental cue perceived by the males was not similarly effective for all members of the population. It strongly suggests that the spawning became epidemic in males following the direct effect of the sperm or pheromones issued from spawning individuals, as previously proposed by Pearse et al. (1991).

The female spawning also began with a few isolated females. Moreover the delay between male and female spawnings suggests that the female spawnings were stimulated by the sperm and not directly by the environmental factors.

Epidemic spawning, in which individuals take their cues from others, may play a role in the synchronicity of the phenomenon in entire populations. Sperm has been experimentally demonstrated to stimulate spawning in a few species, such as the green sea urchin *Strongylocentrotus droebachiensis* (Starr et al., 1992), the sea star *Leptasterias polaris* (Hamel & Mercier, 1995) and was also suggested by Young et al. (1992) for the bathyal sea urchin *Stylocidaris lineata*.

However, what is the cue for the spawning of the first few isolated individuals? Despite the apparent correlation with phytoplankton demonstrated in the large-scale correlative experiment, laboratory experiments with ripe female and male *C. frondosa* (Hamel & Mercier, unpublished data) demonstrated that no spawning success was obtained by stimulation of the phytoplankton species found at the study site during the spawning period.



The spawnings seem to be triggered by a progressive increment of the temperature and a drastic change of the light intensity. These conditions closely resemble those found at sunrise, when *C. frondosa* began to spawn in the field. A closer look at the fine-scale fluctuations of the environmental factors showed that, if the spawning cue came from phytoplankton in many species, in *C. frondosa* the correlation was not very convincing or was more complex than suggested by the large-scale experiment (Fig. 2). It seems to demonstrate the synergetic effect of numerous factors, such as tidal height, inter-individual communication (via sperm or pheromone), current, temperature, time of the day and phytoplanktonic biomass.

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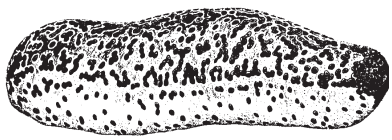


Japanese sea cucumber *Cucumaria japonica* in the far eastern seas of Russia

by V. Levin,
Kamchatka Research Institute
of Fishery and Oceanography, Russia

Most commercially harvestable species of sea cucumbers belong to the order Aspidochirotida and are basically distributed in the tropics.

The only two representatives of the order Dendrochirotida occur far to the north. One of them is the Japanese cucumaria, *Cucumaria japonica,* which is distributed in the far eastern seas of Russia.

The Japanese cucumaria (called 'kinko' in Japanese) is a fairly large sea cucumber (Fig. 1). Its body length is up to 20 cm, the live weight is up to 1.5 kg (average 0.5 kg), and the weight of the body wall is 20 per cent of the total weight. The body is roundish, smooth, with 5 rows of tube feet. Its colour is grayish purple, but in some regions pure white specimens can be found.

The sea cucumber can be found at depths of 5 to 300m and in temperatures ranging from –1.8 ° to 18.0°C. The young specimens prefer to inhabit kelp beds and shallow-water habitats warmed thoroughly in summer time. The adults prefer to inhabit sites off the open coast with rocky or muddy substrate. The cucumaria are distributed randomly on the bottom, but sometimes congregate in aggregations of up to several hundreds. The highest registered density of the animals is 40 ind / m^2.

The cucumaria is usually almost immobile. Accordingly to data surveys the aggregations of sea cucumbers move to shallow sites where the sea becomes warmer. For instance, potential harvestable congregations are known to appear off the West Kamchatka coast in the middle of May. They feed on seston that settles on their treelike branched tentacles.

The cucumaria is gonochoric (separated sexes). It can produce up to 300,000 eggs; they are green, very large (500 µm), have the ability to float and go up to the surface during spawning. Embryonic and larval development is observed in the upper water-layer and is probably short, but has been little studied. The spawning seems to occur twice a year, in April–June and September–October.

The Japanese cucumaria is distributed in the northern part of Japan, along the continental coasts of the Sea of Ochotsk and Sea of Japan, off the Kuril Islands and the Kamchatka Peninsula, and in the Bering Sea at least to Northern Kamchatka in Russia (its distribution further to the north is not known).

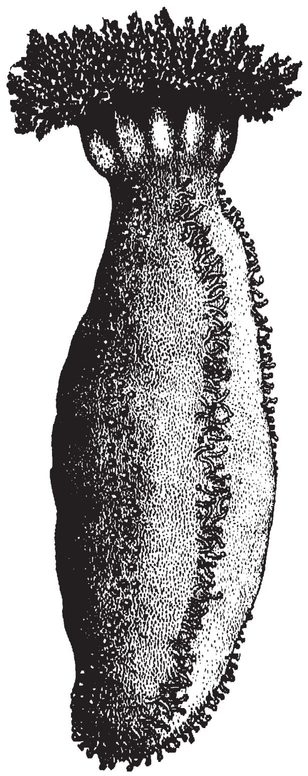


Figure 1:
***Cucumaria japonica*,**
the Japanese sea cucumber

The resources of this species are fairly significant. The predicted possible catches in the main fisheries zones for 1994 were: Sea of Japan: 2,300 t; Kuril Islands: 2,000 t; Sea of Ochotsk: 11,800 t. Presently these stocks are very little exploited and the real total catch appears to be no more than several hundred tons. It is difficult to present precise catch data since the cucumaria is targeted by small-scale fisheries and most of the catch is utilised and processed on the spot.

The fishing method traditionally used to catch the cucumaria is trawling, so while harvesting it is important to take into account the profile of the bottom. It is fairly often harvested in localities characterised not by high density of sea cucumbers, but by a suitable bottom-profile for trawling. Fishermen use the same standard bottom trawls that are used to catch flounders and other bottom fishes.

The Japanese cucumaria is rarely used as the dry product—trepang. The Japanese consume it raw. In Russia all harvested cucumaria is boiled, sliced in small pieces and sold in local shops as a salad with the addition of the seaweed *Laminaria japonica* (‘sea cabbage’) and various spices. The second way of preparing cucumaria is to can them, sometimes mixed with kelp.

In the Orient the cucumaria, like other species of sea cucumber, is reputed to be both a delicacy and a valuable product for pharmacology. The research data obtained by Vladivostok scientists have shown that this opinion is fairly well-grounded. The cucumaria, like other species of sea cucumbers, contains triterpene glycosides that have marked biological effects (Kalinin, V. I., V. S. Levin & V. A. Stonic, 1994). These effects are similar to those of the legendary herb zhen-shen. These chemicals—obtained from the solution left after boiling the cucumarias, since glycosides are soluble in water—are used in Russia for the production of medicines (for domestic animals) and as an additive in toothpastes, creams, etc.

The use of Japanese cucumaria in Russia has a great potential. Undoubtedly, unlike some of the most valuable species of sea cucumber that are said to be over-exploited, the exploitation of the Japanese sea cucumber *Apostichopus japonicus*—of which the present legal total catch in Russia is only 50t—can be expected to grow gradually.

References

Kalinin, V. I., V. S. Levin & V. A. Stonic (1994). The chemical morphology: triterpene glycosides of sea cucumbers (Holothurioidea, Echinodermata). Vladivostok: Dalnauka Press. 284 p.

Management options of the commercial dive fisheries for sea cucumbers in Baja California, Mexico

by Lily R.S. Castro
National Institute of Fisheries, P.O. Box 1306
Ensenada, B.C. Mexico 22800

Isostichopus fuscus and *Parastichopus parvimensis* have been commercially fished in Baja California (BC) for ten and six years respectively. Processors sell these whole, gutted and dried, boiled, semifrozen and as raw fresh muscle. These products are all exported to the United States and later re-exported to Asia. For both coasts, landings averaged 1000 t from 1988 to 1994 (fresh total weight); the highest catch, in 1991, was almost 2000 t.

Until now, sea cucumber fishing has been virtually unrestricted; divers could take animals 365 days a year from any area as long as they held a permit.

In 1992 and 1993 there was a noted drop in diver's catch per unit of effort (CPUE) and total catch, related to the 'explosion' of fishing effort (more permits and bigger fleet size). In the light of decreasing catches and CPUE and increasing harvest depths, it appeared that the resource had been overfished and this has prompted intensive management. Closed season, size limits, underwater population surveys and catch monitoring all play a role in maintaining the resource.

In February 1994, regulations were adopted to restrict the harvest season to the period from 1October to 30 April. This seasonal closure for five months was designed to permit reproduction. Different size limits were proposed for each species. They consisted of length limits (26 – 23 cm and 24 – 21 cm) and weight limits (550 – 400 g and 350 – 200g) for whole and gutted-and-drained sea cucumbers respectively.

Recommendations for catch and CPUE levels are : total catch under 1000 t per year (harvest season) with a fleet size of 50 boats and 14 permits.

These regulations have still not been enforced, but in May 1994 the National Institute of Ecology declared *I fuscus* to have the status 'in danger of extinction' along the Mexican Pacific coast, which means a ban on the fishing of this species in the entire area.

Future changes will be made to the regulations in the light of additional information from our studies.

Developments in California sea cucumber landings

by Kristine Barsky & Dave Ono
California, USA

Kristine Barsky and Dave Ono from Associate Marine Biologists (74763.1265@compuserve.com, California Dept. of Fish and Game, 530 East Montecito Street, Room 104, Santa Barbara, California 93103) write about the situation of the sea cucumber fishery in California.

The sea cucumber fishery began in California near Los Angeles around 1978. The catch is composed of the warty sea cucumber (*Parastichopus parvimensis)* and the California or giant red sea cucumber (*P. californicus*).

Warty sea cucumbers inhabit the ocean bottom from the intertidal zone out to 27 m, and range from Monterey Bay to Baja California. This species is uncommon north of Point Conception.

Giant red sea cucumbers inhabit the subtidal zone out to 90 m, and range from the eastern Gulf of Alaska to Baja California.

Warty sea cucumbers migrate annually between their shallow- and deep-water depth limits. Fishermen claim that giant red sea cucumbers make similar large-scale movements over varying depth ranges, but this has not been verified by research.

The warty cucumber is harvested by hand by commercial divers, primarily in southern California (south of Point Conception). The California sea cucumber is taken primarily with trawl net gear, also in southern California.

The catch averaged under 45 t annually until 1982, when a trawl fishery developed near Santa Barbara. During the next 10 years, annual landings increased gradually. In 1991, an influx of trawlers, predominantly out of the port of Los Angeles, greatly expanded the fishery.

Catches from 1984 to 1992 were as follows:

Year	Catch (t)
1984	21.0
1985	26.6
1986	35.1
1987	48.5
1988	71.6
1989	72.0
1990	66.3
1991	261.9
1992	263.0

Since the 1992–93 fishing season (1 April to 31 March), the fishery has had restricted limited entry. To qualify for a sea cucumber permit a fisherman must have landed 50 lb of sea cucumber between 1 January 1988 and 30 June 1991. There were 86 permit-holders in 1993.

In 1993, 293 t of sea cucumber were landed in California. The catch was mainly composed of 12 t of warty sea cucumber and 279 t of California or giant red sea cucumber.

Most sea cucumbers were landed at the ports of Los Angeles and Santa Barbara. The main fishing grounds for *P. californicus* were the Santa Catalina Channel and the Santa Barbara Channel, at depths of 30 to 90 fathoms. *P. parvimensis* was harvested as far south as San Diego, but most of the catch was taken from waters off the northern Channel Islands.

Cucumber landings for the first nine months of 1994 were 259 t. The average price for warty sea cucumbers was $0.66 / lb; it ranged from $0.30 to $0.90 / lb; the average price for California sea cucumbers was $0.62 / lb; it ranged from $0.20 to $0.70 / lb.

However, divers are frequently paid a higher price per pound for the cucumbers they harvest. The warty variety is supposed to have a thicker, meatier body wall, which could result in a higher price for the diver.

Most of the sea cucumbers landed are dried and exported to Hong Kong and Taiwan. A small portion of the harvest is sold in the United States.

Problems of the Galapagos sea cucumber fishery

Communicated by C. Conand

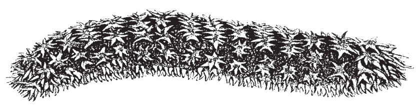
Background information

Based on information and correspondence from G. Coppois, Charles Darwin Foundation

Ninety-five per cent of the Galapagos Islands Territory is a national park, with the remaining five per cent occupied by ‘Ecuadorean settlers’. Unemployment on the mainland has caused many Ecuadoreans to move to this region over the last decade. The Marine Resources Reserve was created in 1986.

Traditional subsistence fishing in the Galapagos Islands is relatively undeveloped and there has never been any traditional fishing of sea cucumbers. Sea cucumber fishing appeared after the decline of the rock lobster fishery which was prohibited at the end of the 1980s. This venture was brought in from abroad and is controlled by entrepreneurs on the mainland. Local fishermen quickly turned to this type of fishing and currently account for 100 out of the 250 people involved. Processing camps have been set up on land in national park areas, leading to clearing of the land, fires, etc.

In 1992, a decree from the President of the Republic of Ecuador prohibited the harvesting of sea cucumbers, but social tensions have been very high (summer, 1994) and it has been very hard for the authorities to enforce this decree. In September 1994, an attempt was made to regulate the conflict through trial authorisation of ‘artisanal’ fishing in park waters, but this experiment does not take into consideration long-term conservation efforts. Negotiations are currently in progress. The Darwin Foundation, the Darwin Research Station and the National Park are continuing their efforts so that the Galapagos Islands, which have been declared a ‘World Heritage’ site by the United Nations, will safeguard their ecological resources for future generations.



Fishermen threaten Galapagos

by Richard Stone (source: SCIENCE, vol. 267, 3 February 1995)

Early in the afternoon on 3 January, several fishermen armed with clubs and machetes took researchers and their families hostage at Darwin Research Station, a small laboratory on Santa Cruz in the Galapagos. The pepineros—who fish for sea cucumber, or pepinos, that lie in beds off the Ecuadoran coast—said they were desperate.

The Government of Ecuador had just prohibited them from fishing off the Galapagos, in response to protests from scientists and tour operators who claimed the pepineros were harming one of the world’s most fragile, and famous, ecosystems. Carmen Angermeyer, a resident of Santa Cruz, the main Galapagos island, recalls that Ecuadoran TV broadcast a chilling interview with a man in a mask, who ‘said if they did not get what they wanted, blood would flow’.

Bloodletting, at least from humans, was avoided when troops arrived to free the hostages and remove the pepineros from the area. But sea cucumber beds are dangerously overfished, scientists say. And several Galapagos tortoises and sea lions were reported killed or mutilated prior to the occupation, according to Macarena Green, a biologist based in Quito, Ecuador, whose account of the events was forwarded to scientists over the Internet last week.

Many researchers reading the dispatch now worry that the flotilla of fishermen anchored off the islands may have introduced mainland rats and other species to some Galapagos islands, endangering the unique species that flourish there. ‘Galapagos is facing an ecological crisis’, warns Matt James, the Sonoma State University marine paleontologist who posted Green’s distress signal.

The troubles began early last year, when biologists began finding slaughtered tortoises, some ‘hung from trees’. Green told *Science* locals blamed the pepineros, who, Green says, were trying to force the Government to allow them to harvest the rich sea cucumber beds of the Galapagos, most of which is a national park.

The sea cucumbers, sushi delicacies, fetch a nice price upon export. The Government bowed to the demands, opening Galapagos waters to harvesting on 15 October for a three-month trial period. It set total catch limit at 550,000 sea cucumbers, but ‘no effective controls and enforcement were ever applied’, claims Johannah Barry, an official of the Charles Darwin Foundation Inc., which raises funds for Darwin Station. The Foundation estimates the pepineros took at least six million sea cucumbers in just two months.

The Ecuadoran press began airing concerns about overharvesting and as public criticism mounted, the Government halted the sea cucumber season on 15 December, a month early, say Green and other scientists who work in the Galapagos.

According to the Darwin Foundation, which got its reports from stations personnel, three weeks later several armed pepineros stormed the park service office and the research station; Ecuador sent troops and Government officials to negotiate, and initially agreed to reopen the waters to fishing; the pepineros released their hostages and left.

But under pressure from environmental activists and from its own Ministry of Information and Tourism, which feared the loss of tourist dollars, the Government reversed its decision on 12 January and said it would prohibit sea cucumber harvesting until October 1995.

All is quiet on the Galapagos at the moment. But researchers were worried that the government was considering opening a four-month lobster season on 1 February.

San Francisco State University biologist Robert Bowman, a long-time Galapagos researcher, argues that such an action would effectively declare open season on sea cucumber again because, he says, the lobster fishers could just as easily take sea cucumbers.

Ecuador’s National Fisheries Institute, with the Darwin Foundation, is currently undertaking a survey of the beds. The Fisheries Institute favours lifting the harvesting ban, at least for local fishermen. But any final decision on fishing rights rests with the Office of Ecuador President Sixto Duran Ballen, who will balance the economics of fishing against tourism and the well-being of flora and fauna.

Update on the illegal fishing activities in the Galapagos Islands, 24 March 1995

by J. R. Green

In mid-February 1995 a check was made by me personally of a previously established sea cucumber processing camp, situated in the mangroves at the northern end of the beach of a visitor site known as Punta Tortuga, on the western coast of Isabela Island. A 50 gallon drum, for cooking the cucumbers had been set up and dead mangrove wood lay chopped and strewn around the drum for firewood. There was no sign of anyone around the camp, but some of the mangroves appeared freshly cut.

On Monday 13 March I returned to the site to find brand new 'cooking' equipment. A rectangular steel tub, approximately 8 feet long, 2 feet wide and 2 feet deep had been set up alongside the drum. Judging by the piles of ash under the tub, this equipment had already been used several times. More mangroves had been cut around the clearing and along the beach. The area was strewn with plastic rubbish and introduced tomato seedlings were growing around the edges of the clearing (presumably the area used by the cucumber fishermen as a bathroom!)

What this 'camp' clearly indicates is that:

1. Quantities of sea cucumbers are continuously being harvested and processed, despite the ban on this form of 'fishing'.

2. New species are being introduced into this almost pristine environment.

3. This small stand of mangroves which represents one of the most important habitats for the extremely rare and endemic mangrove finch, *Camarhynchus heliobates*, is being destroyed.

Galapagos Action Alert

J. E. Barry from the Charles Darwin Foundation, comments on the recent events in the Galapagos as follows:

1. The events of 3–6 January are worrisome. They are symptomatic of the collision of certain interest groups, biodiversity conservation and resource use, and the lack of definitive implementation of management and authority. In taking strong action, Ecuador has demonstrated its willingness to establish a framework for conservation decision-making that may well stand as a model for the rest of the world.

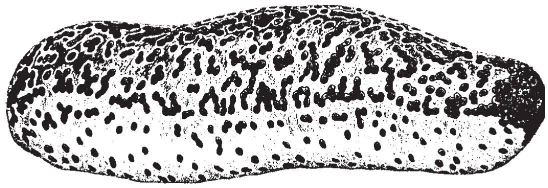
2. The evaluation of the 'experimental' sea cucumber fishery is critical and must be done with the utmost rigour. It will be extremely important to include information on sea cucumber biology and ecology, and experience gained from sea cucumber fisheries from all over the world as to their sustainability, efficacy, real costs and benefits, and ecological, social, economic and cultural impacts. The experience in Galapagos should be compared with information throughout the world in order to project appropriate scenarios for Galapagos (both for the sea cucumbers and the entire marine environment) if the fishery were to be allowed to resume. The evaluation will be conducted by the National Fisheries Institute in Ecuador and the fisheries authorities have invited the Charles Darwin Foundation to participate. The CDF will be collaborating. In this matter, anyone who could offer their own technical expertise in gathering data, interpreting data, or providing other information to assist the evaluation team would be most welcome.

Editor's note:

A letter asking for international concern is circulating on 'eternet' and anyone interested in the problems of beche-de-mer fishing in Galapagos, is invited to contact J. E. Barry at the following address: Charles Darwin Foundation, Isla Santa Cruz, Galapagos, Ecuador.

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

CORRESPONDENCE



Can we use colour for sex-determination of the white teatfish?

Christian Ramofafia, Scientist Assistant at ICLARM (Coastal Aquaculture Centre, P.O. Box 438, Honiara, Solomon Islands) sent a letter to Chantal Conand to ask her about one possible way to determine sex of the white teatfish.

'...You might have gathered from Alex Holland that ICLARM Coastal Aquaculture Centre launched a sea cucumber project in 1993. Since then, work has been ongoing in the following areas: (i) growth of juvenile surfredfish in captivity, (ii) spawning and larval rearing and (iii) gonad study of white teatfish.

The gonad study of white teatfish was started 4 months ago. 20 individuals are collected monthly. The Gonad Index was calculated and gonads are classified into macroscopic maturity stages using your methods. I have observed that gonad colour varies among individuals, some being blue or grey while others were white. Unfortunately these gonads were still in stages I or II, so the sex could not be determined. Can you please advise me whether sex can be determined on the basis of colour?

In 1993, we attempted to spawn white teatfish in captivity. We observed that female gametes were greyish in colour while male gametes were white. I am tempted to conclude that the individuals whose gonads were blue or grey must be female and those with white gonads must be males.

I would be most grateful if you could help clarify these ideas.'

Reply by Chantal Conand

'...I respond to your question: in stages I and II, colour is not used for sex determination; microscopical observation is necessary. Even in the later stages it is always necessary to confirm the macroscopical observations by microscopical ones.'

New positions at Northern Reefs Seafoods Pty. Ltd.

Mr J. D. Sheahan , one of the new directors of Northern Reefs Seafoods Pty. Ltd. (ACN No. 063 701 628; 537 Malvern Road; TOORAK VIC 3142; Tel: 823 1456; Fax: 823 1496) writes to Chantal Conand about new positions in his company.

'...We wish to advise you that Mr John Rosenhain has resigned as director of RTS Trading Pty. Ltd. as referred to in your Magazine issue No. 6.

We advise that the new directors of the Company are G.D. Sheahan and E.J. Trahair, at the same address.

We are the largest beche-de-mer exporters in Australia working mainly in Northern Territory waters. We further advise that our beche-de-mer operation is conducted through the company Northern Reef Seafoods Pty. Ltd. by the above mentioned directors.'

Update on the work at the Royal Hawaiian Sea Farms

Dale Sarver Research Director at the Royal Hawaiian Sea Farms, (Inc., P.O. Box 3167 Kailua-Kona, Hawaii 967450) sent a letter to Chantal Conand to tell her about his work on *Stichopus horrens*.

'...I am writing to update you on the work we have been doing here in Kona. We are about six months into our two-year project to develop nursery and growout techniques for Stichopus horrens *and another yet unidentified species.*

The larval rearing methods are now relatively consistent and we can obtain many thousands of settled juveniles of S. horrens *using only small rearing vessels in the laboratory. During the last run we successfully scaled up to 30 l tanks, and will try out some 350 l designs in June.*

There have been mixed results with the nursery systems so far, with low survival rates to one month. Once they make it past the first two-week transitional period, however, survival is very good and growth is fast. We are planning to try a stock enhancement trial this summer, stocking newly settled juveniles into a traditional Hawaiian fish pond. I think if we can harvest all or most of the present population from the small pond, we can monitor the cohort of stocked animals.

We had good luck with the other species too. This Stichopus / Thelenota *is found in water over 30 m, but is not common. I wrote to you earlier about this species and how we observed male spawning in one of our tanks. Recently I saw natural spawning in the wild. There was a single male reared up and releasing sperm. This was at a depth of 47 m, at 1600 h on the day after full moon. There were a few others of this species in the general area, but none closer than 20 m away, and none of the others were spawning. I observed the same thing in the same spot this month at full moon too. I frequent this diving spot and have not noted spawning at any other time. It seems pretty obvious they have a lunar spawning cycle.*

Just after observing the first male spawning, we brought several into the lab and tried to induce spawning. Heavy spawning occurred during the night. We applied the same larval rearing methods we use for S. horrens, *and we successfully settled several hundred juveniles. The larvae of the two species are essentially identical, although the cues for settling are different. They are now about a week old and seem to be doing well.*

In the next couple of weeks I will preserve some specimen samples and send them to you. Hopefully you can get a name for me. Incidently, I gave some of these cucumbers to people who normally eat S. horrens. *They prepared them in the typical Japanese pickled fashion, and raved about how good they were. This species may have more commercial potential than the one presently eaten.*

Intensive aquaculture for sea cucumbers may or may not prove financially feasible, but I am confident rearing large numbers of juveniles in hatcheries could form the basis for extensive reef culture or stock enhancement, if there is reasonable resource management in place. I will keep you informed on our progress.'

Sea cucumbers in Madagascar

Olivier Behra, Manager of BIODEV (Biodiversity and Development, Lot YX 18 Andrefandrova Antananarivo, Madagascar; Phone or Fax (2) 286 51) wrote a letter to Chantal Conand about the possible over-exploitation of sea cucumbers in Madagascar.

'...We work in the areas of conservation and sustainable development in Madagascar. For this reason, recently several questions about Echinodermata have been sent to us. We would like to get your comments on sea cucumbers.

Sea cucumbers have been subjected to significant levels of exploitation and in certain areas, fishermen can only find them at depths from 12 to 15 m. Is it possible that they could still be found at depths which are inaccessible *to fishermen, or is it likely that certain species, or at least certain populations, are actually threatened?*

Is sea cucumber farming possible? Either off-site until metamorphosis or possibly in a protected bay by simply providing nutritional supplements? Or in any other form?'

Reply from Chantal Conand

'...I have just received a letter about sea cucumbers from the Head of your programme and would like to provide some information concerning a subject which merits study in Madagascar given the current lack of information available and the ***probable world-wide over-exploitation*** *of this resource.*

On the question: 'Does exploitation have any negative impact?':

Sea cucumbers are a fragile fisheries resource which requires a sensible management which does not exist in most of the producing countries. At the very least, statistics about fishing, processing and/or exportation should be collected. This would allow an initial approach to be made to the problem. It does not seem possible to give an opinion about overfishing without such data. The fact that fishermen are diving deeper than before is an indication of the overexploitation of certain populations. It is also necessary to know which species are involved, because there are about 10 species that have commercial value and the biology of each one is different. Overfishing of detritivore species can also have an effect on the functioning of the ecosystem, but we still lack data on this subject.

'Aquaculture?':

This has not yet been technically mastered. Individual growth is probably slow, a factor which does not favour productivity. Well-controlled growth experiments could prove useful. Such programmes are currently being carried out in some laboratories.'

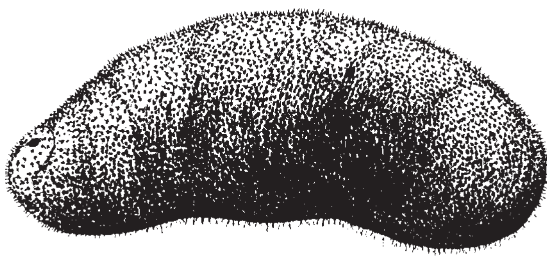
Erratum

Beche-de-mer Information Bulletin #6, p. 20

On the page 20 of the article by S. Uticke, the biomass should read: 'The overall abundance for *H. atra* was 10.7 / 100 m^2 (biomass 1280 g) and for *S. chloronotus* was 9.0 / 100m^2 (biomass 1410 g).

S. Uticke informs that he is now preparing a Ph.D. at the Australian Institute of marine Studies, PMB 3, Townsville, Queensland 4180, Australia. His e-mail is S.UTICKE@aims.gov.au.

He is studying the role of holothurians in nutrient cycles of near-shore reefs.



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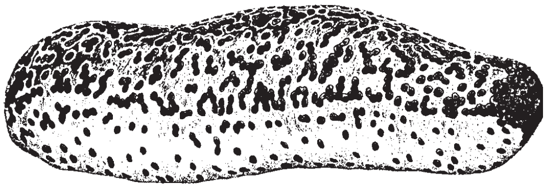
Abstracts, Publications Workshops and Meetings



Recent publications on echinoderms

SPC handbook No.#18
Sea cucumbers and beche-de-mer of the tropical Pacific

Published and edited by the South Pacific Commission, this is a revised version of *Beche-de-mer of the South Pacific Islands*, 1974 and *Beche-de-mer of the tropical Pacific*, 1979. A colour poster showing the various species of beche-de-mer found in the Pacific (live and processed) has also been produced.

Nearshore marine resources of the South Pacific

Wright, A. and L. Hill (eds.). Institute of Pacific Studies, Suva; Forum Fisheries Agency, Honiara; International Centre for Ocean Development, Canada. 1993.

This book is a product of the Forum Fisheries Agency which has 16 Pacific Island member-countries. It presents the works of 19 authors renowned in the field of fisheries. One of the authors, Garry Preston, gives on 36 pages (pp. 371 – 407) a detailed review on the biology and the fisheries of the South Pacific holothurians, largely based on the results obtained by C.Conand while she was working at ORSTOM (New Caledonia).

Echinoderms through time

Edited by
Bruno David, Université de Bourgogne, Dijon, France
Alain Guille & Jean-Pierre Féral, Observatoire Océanologique, Banyuls / Mer, France
Michel Roux, Université de Reims, France

In: A.A.Balkema / Rotterdam / Brookfield / 1994. Proceedings of the Eighth International Echinoderm Conference, Dijon, France, 6 – 10 September 1993.

Some years ago, the International Echinoderm Conferences reached full maturity and echinoderms are now considered to be a biological and geological model that supports research studies of great importance. The extent of their contribution to various fields of research is shown by the scope of presentations at the international conferences. These proceedings contain either complete papers or abstracts of all the presentations made and posters displayed at the Eighth International Echinoderm Conference, Dijon, September 1993. Contents: General; Extinct classes; Crinoids; Asteroids; Ophiuroids; Holothuroids; Echinoids. 90 5410 5143, October 1994, 992 p.

The section on holothuroids (73 pages) includes:

Ahearn C. Family Psolidae: New distribution records from the Antarctic. p. 503.

Castro, R. L. S. The fishery of the sea cucumbers *Isostichopus fuscus* and *Parastichopus parvimensis* in Baja California, Mexico. p. 504.

Foster, G. G. & A. N. Hodgson. The distribution and reproduction of three sympatric species of intertidal holothurians from South Africa. p.505.

Gebruk, A. V. Two main stages in the evolution of the deep-sea fauna of elasipodid holothurians. p.507.

Hamel, J. F. & G. Desrosiers. Larval fixation and small scale migration of the sea cucmber *Cucumaria frondosa.* p. 515.

Haude, R. Fossil holothurians: constructional morphology of the sea cucumber, and the origin of the calcareous ring. p. 517.

Klinger, T. S., C. R. Johnson & J. Bell. Sediment utilisation, feeding-niche breadth, and feeding-niche overlap of Aspidochirota (Echinodermata; Holothuroidea) at Heron Island, Great Barrier Reef. p. 523.

Massin, C. Calcareous deposit variations in holothurians illustrated by Antarctic dendrochirotes (Echinodermata). p. 529.

McClintock, J. B., M. Slattery, B. Gaschen & J. Heine. Reproductive mode and population characteristics of the Antarctic sea cucumber *Cucumaria ferrari.* p. 530.

Moore, H. M. & D. Roberts. Feeding strategies in abyssal holothurians. p.531.

O'Loughlin, P. M. Brood-protecting and fissiparous cucumariids (Echinodermata: Holothuroidea). p.539.

O'Loughlin, P. M., T. M. Bards & T. D. O'Hara. A preliminary analysis of diversity and distribution of Holothurioidea from Prydz Bay and the MacRobertson Shelf, eastern Antarctica. p. 549.

Sewell, M. A. Mortality of pentactulae during intraovarian brooding in the apodid sea cucumber *Leptosynapta clarki.* p. 557.

Thandar, A. S. A new species of the holothuroid genus *Phyllophorus* from South Africa. p. 558.

Thandar, A. S. Character divergence and cladistic relationships of the southern African genera and subgenera of the family Holothuriidae. p.559.

Tuwo, A. & C. Conand. Fécondité de trois holothuries tempérées à développement pélagique. p. 561.

Uthicke, S. Distribution patterns and growth of two reef flat holothurians, *Holothuria atra* and *Stichopus chloronotus.* p. 569.

CMFRI special publication number 57:
Hatchery techniques and culture of the sea-cucumber Holothuria scabra

by D. B. James, A. D. Gandhi, N. Palaniswamy & J. X. Rodrigo
Central Marine Fisheries Research Institute, Indian Council of Agricultural Research, Dr Salim Ali road, Post Box No. 1603, Tatapuram P.O., Ernakulam, Cochin 682 014, India

Preface by P. S. B. R. James, Director of CMFRI:

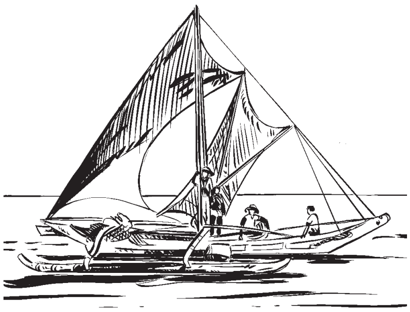
Hatcheries of sea-cucumbers have been established in China and Japan and more recently in Korea and Russia. At all these places only seed of *Stichopus japonicus* is produced. After the seed has been retained for two or three months, it is sea-ranched, since it is expensive to maintain in the hatcheries for long periods.

In India the beche-de-mer industry is a very ancient one. Until recently, the whole fishery was supported, by a single species, *Holothuria scabra.* As a result of this, the natural populations dwindled alarmingly. In order to enrich the natural populations, a research project on the hatchery and culture of sea cucumbers was started by the Central Marine Fisheries Research Institute (CMFRI) at Tuticorin Research Centre in 1987. Break-through was achieved in 1988 in inducing *Holothuria scabra* to spawn in the laboratory for the first time by thermal stimulation. Since then, several spawnings have taken place and seeds have been produced. In 1992 the Marine Products Export Development Authority, Cochin approved a research project worth six lakhs of rupees for three years on intensive seed production and sea-ranching of sea cucumbers. This has given further impetus to the work.

This Special Publication is a practical guide for seed production in the hatchery and culture of *Holothuria scabra*, which is the most valuable species processed in India at present. It is well illustrated with colour photographs. We hope this special issue in the 'Transfer of Technology' series will be of interest to those who are involved in the beche-de-mer industry.

The efforts of the team headed by Dr. D. B. James in the production of seeds in the hatchery and also in the preparation of this publication is highly appreciated and I congratulate them for this achievement. I also thank Dr. K. Rengarajan for editing the publication and getting it printed in time.

The contents of this publication are:



Proceedings of the national workshop on beche-de-mer, February 1994, CMFRI, Bulletin 46

K. Rengarajan & D. B. James (eds.), Central Marine Fisheries Research Institute, Indian Council of Agricultural Research, Post Box No. 1603, Tatapuram, P.O. Ernakulam, Cochin 682 014, India

This publication contains the following technical papers:

James, P. S. B. R. & D. B. James. Management of the beche-de-mer industry in India. p.17.

James, P. S. B. R. & D. B. James. Conservation and management of sea cucumber resources of India. p. 23.

James, D. B. Holothurian resources from India and their exploitation. p.27.

Alagaraja, K. Assessment of sea cucumber resources of India. p. 32.

James, D. B. Zoogeography and systematics of holothurians used for beche-de-mer in India. p.34.

James D. B. Ecology of commercially important holothurians of India. p. 37.

Baskar, B. K. Some observations on the biology of the holothurian *Holothuria (Metriatyla) scabra* Jaeger. p. 39.

Mary Bai, M. Studies on regeneration in the holothurian *Holothuria (Metriatyla) scabra* Jaeger. p. 44.

Nagabhushanam, R., B. Ashok Kumar & R. Sarojini. Toxicity evaluation of the holothurian *Holothuria (Mertensiothuria) leucospilota* (Brandt), the effect of toxin on the prawn *Caridina rajadhari*. p.51.

Jayasree, V. & P. V. Bhavanarayana. Reproduction in *Holothuria (Mertensiothuria) leucospilota* (Brandt) from Anjuna, Goa. p. 57.

James, D. B. A review of the hatchery and culture practices in Japan and China with special reference to possibilities of culturing holothurians in India. p. 63.

James, D. B., M. E. Rajapandian, C. P. Gopinathan & B. K. Baskar. Breakthrough in induced breeding and rearing of the larvae and juveniles of *Holothuria (Metriatyla) scabra* Jaeger at Tuticorin. p. 66.

James, D. B. Improved methods of processing holothurians for beche-de-mer. p. 71.

Nair, M. R., T. S. G. Iyer & K. Gopakumar. Processing and quality requirements of beche-de-mer. p.76.

Sachithananthan, K. A small-scale unit to process sand-fish *Holothuria (Metriatyla) scabra*. p. 79.

Gurumani, O. N. & S. Krishnamurthy. Some aspects of processing and quality control of beche-de-mer for export. p. 81.

James, D. B.& B. K. Baskar. Present status of the beche-de-mer industry in the Palk Bay and the Gulf of Mannar. p. 85.

Sakthivel, M. & P. K. Swamy. International trade in sea cucumber. p. 91.

Radhakrishan, N. The role of fisherwomen in the beche-de-mer industry. p. 99.

James, D. B. & M. Ali Manikfan. Some remarks on the present status of beche-de-mer industry of Maldives and its lesson for the Lakshadweep. p. 101.

Sachithananthan, K. Beche-de-mer trade : global perspectives. p. 106.

Ambrose Fernando, S. Problems facing the fishermen of the beche-de-mer industry. p. 110.

Livingston, P. Prospects for establishing a beche-de-mer industry in Lakshadweep. p. 112.

Abstracts

A conservative application of a surplus production model to the sea cucumber fishery in Southeast Alaska

by Douglas A. Woodby,[1] Gordon H. Kruse[2] & Robert C. Larson[3]
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[1]Douglas, [2]Juneau, and [3]Petersburg, Alaska

In : Management of exploited fish. Alaska Sea Grant 1993. *Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations*, Alaska Sea Grant College Program, AK-SG-93-02, 1993. pp. 191 – 202.

We developed a conservative application of a surplus production model to estimate the potential annual yield for sea cucumbers, *Parastichopus californicus*. This application was motivated by a lack of information on the population biology of sea cucumbers and is conservative in at least three ways: quota reductions are made to account for potential errors in the model; only a portion of the entire population size is estimated; and the population size estimate used to set a harvest quota is at the lower boundary of the confidence interval. The maximum annual yield is estimated to be 6.4 per cent of the population surveyed. We have initiated an assessment programme to evaluate the ability of the stocks to sustain harvests as prescribed by the model. We determined that it is important to reduce sample variance from location effects; this allows detection of changes in population density that are the same size as the commercial harvests. It may also be important to consider seasonal migrations in survey design.

A review of recent development in the world sea cucumber fisheries

by Chantal Conand & Maria Byrne

In: *Marine Fisheries Review*, 1993, 55 (4)

Sea cucumbers (Holothuridae and Stichopodidae) have been harvested commercially for at least 1,000 years. The world fisheries for sea cucumbers, however, are not well documented and in general are poorly managed. Depending upon the species exploited, there are two processing procedures for the sea cucumber product. Some species are eaten raw, while most commercial species are processed into a dry product called beche-de-mer or 'trepang'. This dry product is exported to a central market such as Hong Kong and then re-exported to the consumers.

In this review, recent statistics on the world sea cucumber fisheries, collected from different services, are detailed for each major fishing area. Case studies for each fishing area are also presented. Recent major changes in the Indo-Pacific fishery include the participation of new producer countries, the shift in the species being exploited, and an increase in the Chinese market. The expansion of the largely monospecific temperate North Pacific fisheries is also described.

Statistics from Hong Kong, Singapore, Taiwan, and the Food and Agriculture Organization provide valuable information on the producer and importer countries. Particular attention is paid to the reciprocal trade of beche-de-mer between Hong Kong and Singapore. An evaluation of world sea cucumber landings and beche-de-mer production is presented. Recent developments include an expansion of the Hong Kong market due to increased demand by China, the importance of Indonesia as a major world producer and an increase in the fisheries of tropical Pacific nations. This increase is best documented for New Caledonia and Fiji. Ways to improve the access and the reliability of statistics for the sea cucumber fishery are discussed, as is the potential for management of artisanal fisheries.

The three following abstracts were published in: Proceedings of the Seventh International Coral Reef Symposium. *Guam. 1992. Vol.2*

Feeding behaviour of two tropical holothurians *Holothuria (Metriatyla) scabra* (Jäger 1833) and *H.(Halodeima) atra* (Jäger 1833), from Okinawa, Japan

by Winfried L. Wiedmeyer
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Digestive contents of *Holothuria scabra* and *H. atra* (n = 476 ind. each) were analysed on Okinawa, southern Japan from field surveys covering 24-hour periods. Specimens were collected at separate locations during the spawning and post-spawning seasons of 1991.

H. scabra fed during the night when burrowed. Small, medium and large individuals of both species had distinct feeding modes based on digestive speed, daily and seasonal feeding cycles, particle size and chemical selectivity. *H. scabra* and *H. atra* showed different feeding strategies and behaviour which were specific for seasons and habitats. *H. scabra* reworked more sediment than *H. atra*. But with respect to thickness of the sediment layers at the survey areas, the effect of reworking of *H. atra* at areas of underlying hard substrates is considered more significant.

The amount (dry weight) of daily reworked sediment, as a percentage of the drained body weight of the individuals, was 31.0 per cent and 23.4 per cent in *H. scabra* and 46.5 per cent and 45.2 per cent in *H. atra* for spawning and post-spawning seasons respectively. Daily assimilated organic matter (carbon / dry weight) as a percentage of the drained body weight of the individuals was 0.29 per cent and 0.23 per cent in *H. scabra* and 0.18 per cent and 0.13 per cent in *H. atra* for spawning and post-spawning seasons respectively. Assimilated organic matter per unit weight decreased with increasing body weight in both species, with the exception of the reproducing individuals during the spawning seasons. Assimilation efficiency for organic matter was 75 per cent higher in *H. scabra* than in *H. atra.*

Effects of typhoon-generated waves on windward and leeward assemblages of holothuroids

by A. M. Kerr
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In the western Pacific, where typhoons are frequent, storm-associated waves were suspected of influencing the distributions of shallow-water holothuroids. I sampled holothuroids on a windward and leeward reef on Guam before and after Typhoon Russ. *Holothuria atra* and *Actinopyga echinites*, which live on open, unsheltered substrata, and diurnally cryptic species were greatly reduced (66.1%, 59.6% and 55.6% respectively) on the outer reef flat of the windward site. On the windward inner reef *Actinopyga echinites* and cryptic species also decreased (47.2% and 14.3%). No species decreased on the leeward outer and inner reefs. Rheophilic taxa along the reef margins at both sites were also unaffected by the typhoon. These data, the frequency of typhoons in the region (1 every 3.5 years on average) and the hypothesised longevity of many species (5 – 15 yrs) suggest that cyclonic storms may be important in structuring populations of holothuroids, particularly exposed, epibenthic forms, on windward reefs in the western Pacific.

Internal micro-tag identification systems for teleosts, holothurians and decapods

By R. M. Buckley[1] and M. C. Gomez-Buckley[2]
[1] Washington Department of Fisheries, 115 GAB AX-11 Olympia, WA 98502, USA
[2] University of Las Palmas, Fac. Cien. del Mar, 35017 Las Palmas de Gran Canaria, Spain

Successful extrinsic identification of organisms in ecological studies enables validation of biocenosis assumptions, estimation of population parameters, and assessment of migrations at relevant spatial and temporal scales. The magnetic, binary-coded wire tag (CWT), alpha/numeric-coded visible implant (VI) tag and fluorescent polymer (FP) tag, are bio-compatible internal micro-tags that (1) allow individual or batch recognition, (2) have low rates of loss (3) do not invalidate biological normality, and (4) enable practical long-term recovery of information. Retention of CWT in juveniles of five temperate reef and three subtropical nearshore fishes was 95 – 100 per cent up to 365 d; retention of VI tags in seven species was 0–85 per cent up to 365d. Retention of FP tags in juveniles of two temperate reef fishes was 94 per cent at 70 d. Pilot study retention of FP tags in one sea cucumber and two shrimp species was 100 per cent up to 50 d. FP tags in juvenile *Sebastes* sp. have been recovered *in situ* during visual transects using ultra-violet dive lights.

Role of the detritivorous macrobenthos in coastal ecosystems: study of the holothuroid *Holothuria tubulosa*, common species of the *Posidonia* Mediterranean seagrass beds.

Ph. D. thesis presented by Pierre Coulon at the Université Libre de Bruxelles (October 1994, in French). Laboratoire de Biologie Marine, CP160/15, 50 av. F.D. Roosevelt, 1050 Bruxelles, Belgium.

The comprehension of the 'detritus food chain' functioning in marine ecosystems is very often limited to its microbial aspect, neglecting the potential role of detritus-feeding macro-organisms. The lack of basic information (population dynamics, feeding behaviour, nutrition processes, growth) about the biology of detritus feeders—even the most conspicuous species—is one of the reasons they are generally not considered in general schemes of marine ecosystems.

The biology of the deposit-feeding holothuroid *Holothuria tubulosa*, one of the most common species in the Mediterranean, has been investigated at both the population and the organism level.

The population studied inhabits a continuous *Posidonia oceanica* seagrass meadow off Ischia Island (Gulf of Naples, Italy). The mean size of *H. tubulosa* collected in the meadow increased regularly with sampling depth (1.85, 4.88 and 11.36 g body-wall dry weight at 5, 20 and 33 m depth, respectively).

The size-frequency histograms established monthly at the 3 depths considered are always unimodal and do not permit recognition of any peak of recruits. However, annual fluctuations of population density suggest that a significant fraction of the holothuroid population is renewed each year. Actually, 50 per cent, 25 per cent and 5 per cent of the *H.tubulosa* collected at 5, 20 and 33 m depths respectively during the sexual-maturity season do not develop a visible gonad and are thus supposed to be newly recruited juveniles.

These juveniles are not biometrically different from the older, sexually mature individuals of corresponding depths. This emphasises the fact that individual size is not a good indicator of holothuroid age. Furthermore, it suggests that *H.tubulosa* may grow at a fast pace until they reach a critical size, depending on local, depth-related, environmental constraints.

Energy income (gut absorption) and outcomes (respiration, gonadic production and nitrogenous excretion) were measured, in winter and in summer, on *H.tubulosa* individuals living in the shallow (5m), intermediary (20 m) and deep meadow (33m).

The energy available for somatic production was subsequently calculated to equilibrate the energy balance. The daily potential growth of an individual of a given size at a given depth may then be estimated after transformation of energy to biomass (1 g body-wall dry weight = 10.16 kj).

The results obtained show that *H.tubulosa* potential growth is very low or nil during winter but can be very fast in summer. A theoretical growth curve was calculated for a juvenile *H.tubulosa* of 0.19 g dw (the smallest individual ever collected) recruited in the shallow meadow and migrating toward the deep meadow border during its first year of life (the year has been arbitrarily divided into six months' 'winter' and six months' 'summer') (see Figure 1).

The curve shows that our 'theoretical juvenile' could reach 11.57 g body-wall dw after 11 months of post-metamorphic growth. That large size (equivalent to 230 g total fresh weight) is remarquably similar to the mean size of large individuals living at the deep meadow border (11.36g dw).

However, it should be emphazised that our calculation does not figure the actual growth of *H. tubulosa* individuals in the *Posidonia* meadow, but only the maximal potential growth of migrating juveniles.

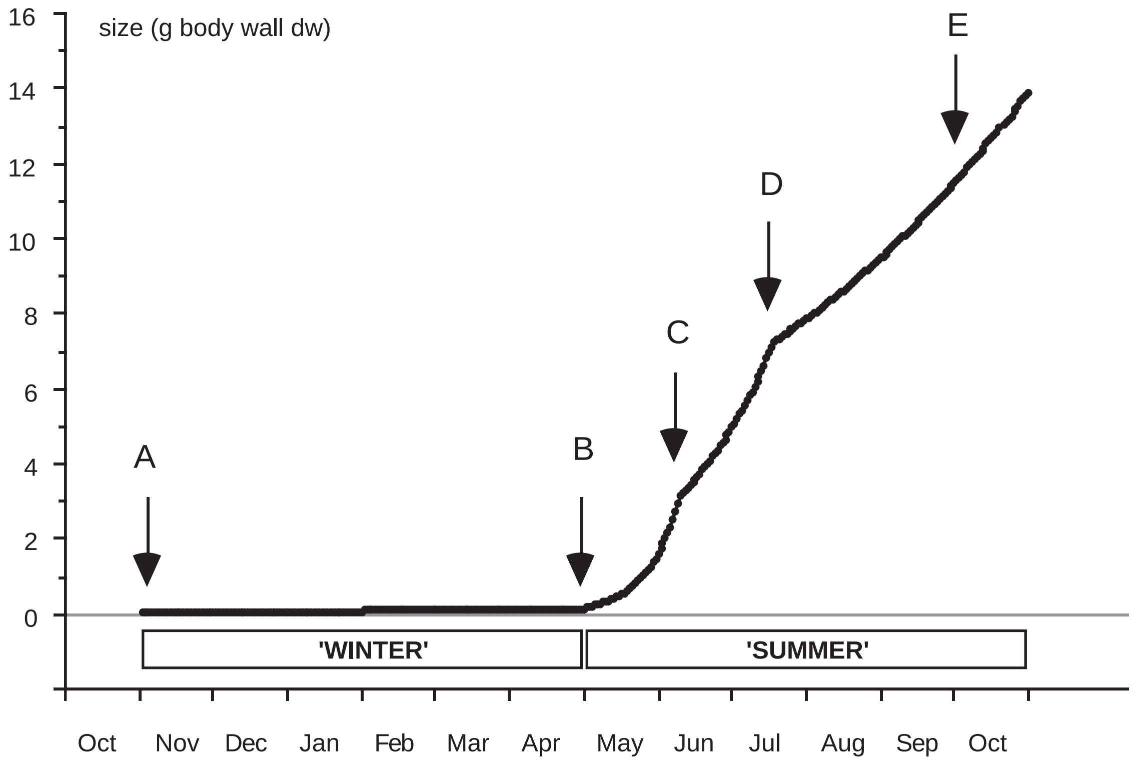

Figure 1. Theoretical growth curve of *H. tubulosa* during its first year of life

A–B : Slow growth period in the shallow meadow (winter)
B–C : Fast growth period in the shallow meadow (summer)
C–D : Fast growth period in the intermediary meadow (summer)
D–E : Fast growth period in the deep meadow (summer)
E : The mean size of *H. tubulosa* of the deep meadow is reached

Biology of small juveniles of the tropical holothurian *Actinopyga echinites*: growth, mortality and habitat preferences

by W. L. Wiedemeyer

In: *Marine Biology* (1994) 120: 81 – 93

Several morphological, physiological and ecological experiments on the general biology of small juveniles (drained body weight = 0.09 to 17.34 g) of *Actinopyga echinites* (Jäger 1833) (Echinodermata, Holothuroidea) were conducted between August 1991 and July 1992 at Bise reef flat, Okinawa, southern Japan. Supplementary experiments were carried out at the laboratory. The experiments were designed with a view to potential stock enhancement projects of *A. echinites* and other commercially exploited tropical sea cucumbers of the coral reef zone. During the enclosure experiments, the average percentage of drained body weight to fresh body weight of the juveniles was 48.3 per cent. The specimens displayed a growth rate of 1500 per cent during the 11-month period. Their drained body weight increased from 0.87 to 12.82 g.

The juveniles' internal and skeletal morphology differed considerably from the morphology of adult *A. echinites*. Two new types of skeletal spicules were discovered. Individual growth of all spicule types monitored differed notably, and shrinkage was observed for the two newly discovered types. Relative frequency of the spicule types within the skeletons changed with increasing body weights of the individuals.

The juveniles of *A. echinites* displayed a strong habitat preference for plate-like substrate types such as eroded limestone or dead coral plates. Skeletons of *Acropora* spp. were accepted at a much lower rate. Weight-frequency distributions of the specimens on varying substrate types and between various times of the day showed significant differences. Cryptic behaviour of the juveniles was observed at all times of the day.

Natural mortality of the holothurians, excluding predation and minor dislodgement effects, was low, at 0.6 per cent per month. When predation effects were introduced to the experiments, mortality reached a rate of 0.3 per cent per month. The average percentage of predation effects within the natural mortality total was 76.8 per cent.

Juvenile *A. echinites* exhibited a maximum short-distance migration speed of 9 cm / h. This was two orders of magnitude slower than the speed observed in adults (900 cm / h) when differences in total body length were taken into consideration. The holothurians had two activity peaks during the four-hour periods monitored, around sunrise and sunset.

Reproduction and growth of *Holothuria atra* (Echinodermata: Holothuroidea) at two contrasting sites in southern Taiwan

by S. M. Chao, C. P. Chen & P. S. Alexander

In: *Marine Biology* (1994) 119: 565 – 570

Reproductive periods and growth of two populations of *Holothuria atra* Jäger distinctly different in body size at two sites of southern Taiwan were determined. Individuals examined in the present study were collected between March 1990 and February 1992. At Nanwan (21°57' N, 120 ° 45' E), large individuals (351 to 1400 g wet wt) spawned from June to September. At Wanlitung (22° N, 120° 42' E) a small proportion of frequently dividing individuals (<190 g wet wt) had mature gonads in May, June and September, but histological examination revealed no sign of spawning. Sexual recruits, defined as small individuals <5 g wet wt without sign of regeneration, were not found at either site during this 2-year study.

After the peak of fission at Wanlitung, 40 per cent of the population showed signs of external regeneration. At Nanwan, small individuals transferred from Wanlitung grew from 6 g (n = 6) to 166 ± 8g within 8 months and from 48 ± 4 g (n = 50) to 324 ± 16 g within 1 year, with a 6.8-fold biomass increase in 1 year. At Wanlitung, the monthly average body weight of *H. atra* was between 33 and 62 g, apparently due to frequent fission, and the biomass increased only 2.9 fold in 1 year. In southern Taiwan, sexual reproduction of *H. atra* occurs in large individuals. Asexual reproduction in small individuals is the chief mechanism for population maintenance and increase, but it may decrease sexual reproductive potential.

Association of the commensal scaleworm *Gastrolepidia clavigera* (Polychatea: Polynoidae) with holothurians (Holothurioidea: Holothuriidae, Stichopodidae) near the coast of South Vietnam

by Temir A. Britayev & Elena A. Zamishliak
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The Indo-West Pacific commensal scaleworm *Gastrolepidia clavigera* (Schmarda, 1861) is here recorded for the first time from the shallow waters of Vietnam (Nha Trang city). It is associated with the sea cucumbers *Stichopus chloronotus* (Brandt), *S. variegatus* (Semper), *Holothuria atra* (Jäger), *H. leucospilota* (Brandt) and *Actinopyga echinites* (Jäger). The last two species are reported as hosts for the first time. The worms were usually attached to the host surface near the oral or cloacal openings and their coloration was in close accordance with that of the hosts. Swollen white tips of dorsal cirri and head appendages of worms associated with *H. atra* mimic its sand-grain-covered papillae.

Commensal worms show two main types of trauma: large traumas of the posterior body end, probably caused by predators, and small ones (damage of parapodia, dorsal cirri and head appendages), probably a result of intraspecific aggressive interactions. Each host harboured 1–3 worms. About half of the infested hosts (51.4%) harboured a pair of worms, one male and one female. The frequency of occurrence of *G. clavigera* on hosts varied from 31.9 per cent on *A. echinites* to 80.0 per cent on *S. variegatus*. Infested sea cucumbers were larger than non-infested ones.

A positive correlation between size of males and females from every pair was found; a correlation between size of holothurian hosts and size of their commensals was not observed. The relationship between *G. clavigera* and its hosts is evaluated as commensalism.

Shallow-water holothuroids (Echinodermata) of Kosrae, Eastern Caroline Islands

by Alexander M. Kerr

In: *Pacific Science* (1994), vol. 48, no. 2: 161 – 174

Line transects and qualitative surveys were used to determine species composition and abundance distributions of holothuroids on the fringing coral reefs of Kosrae, Federated States of Micronesia. On the reef flats, in a total sample area of 2982 m^2, 9,383 holothuroids, comprising 13 species, were recorded. An additional 13 species were recorded off the transects between depths of 0 and 30 m. Species richness varied considerably between sites and physiographic zones and was significantly correlated with reef-flat width. *Holothuria (Halodeima) atra* (Jäger) was the most abundant species recorded, composing 92.1 per cent of the holothuroids on the transects. Other species were considerably less abundant: *H. (Playperona) difficilis* (Semper), *H. (Thymiosycia) hilla* (Försskal), *Afrocucumis africana* (Semper), and *Actinopyga mauritiana* (Quoy & Gaimard) made up 6.1, 0.8, 0.3 and 0.2 per cent of the enumerated taxa, respectively. Each of the other species composed ≤0.1 per cent of the fauna. Kosrae had very low densities of most commercially valuable holothuroids; only two marketable species, *Actinopyga mauritiana* and *H.(Metriatyla) scabra* (Jäger) were found there in relative abundance. Twenty-eight species of holothuroids are now reported from Kosrae.

Application of menthol as an anesthetizer for body size measuring of sea-cucumber juveniles

by Hiroyuki Hatanaka & Kenichi Tanimura

In: *Suisanzoshoku* 1994 – H6: 221 – 225

It is difficult to obtain stable body length values of the sea cucumber *Stichopus japonicus*. Menthol was applied as an anaesthetiser to keep the body shape of sea cucumbers in stable condition during size measurement. Basic menthol solution was made by mixing 0.5 g of menthol in 1 l of seawater.

A series of menthol solutions (100. 80. 60. 40%) was prepared by diluting the basic solution with sea water. The body length of the organisms placed in the anaesthetic solution was measured at ten-second intervals, until the length became stable.

All the anaesthetised sea cucumber juveniles came back to their natural shapes—not expanding or contracting—without any mortality for many months. Based on the changing pattern of body length in an anaesthetiser and recovery, the 80 per cent menthol solution gives the best anesthetic conditions for measuring the body length of sea-cucumber juveniles.

Distribution of Japanese common sea cucumber *Stichopus japonicus* in Saroma Lagoon

by Seiji Goshima, Yoshihiro Fujiyoshi, Nahomu Ide, Ruth U. Gamboa & Shigeru Nakao

In: *Suisanzoshoku*, 1994 – H6: 261 – 266

The distribution pattern of the Japanese common sea cucumber *Stichopus japonicus* was studied to obtain essential information for fishery management in Saroma Lagoon, where fishing of the sea cucumber has been prohibited since 1989 because of depleting resources. Distribution of the sea cucumber was surveyed by dredge and diving at various locations within the lagoon. The sea cucumbers were distributed mainly on oyster *(Crassostrea gigas)* reefs located at depths of 8–10m, while almost no sea cucumber was found in flat mud, muddy sand or sand bottoms. The reefs composed of dead oyster shells have a mean diameter of 16 m and mean height of 2m. Many other megabenthos organisms, such as sea urchins, starfishes, tunicates and mussels, were commonly distributed on the reefs, making up a peculiar benthos community. These results suggest a strong correlation between sea cucumbers and oyster reefs. The possible interactions between them are discussed from the viewpoint of suitable environmental conditions and food supply.

Several inducers initiated settlement and metamorphosis of Doliolaria larvae of sea cucumber *Stichopus japonicus*

by Shiro Ito, Itsuro Kawahar, Izumi Aoto & Kazutsugu Hirayama

In: *Suisanzoshoku*, 1994 – H6: 299 – 306

Settlement and metamorphosis of planktonic larvae of the sea cucumber *Stichopus japonicus* at the Doliolaria stage was induced by culturing them with several kinds of inducers. The inducing effects of these were examined by counting the number of individuals which metamorphosed to juveniles after being transferred to the petri dishes containing different kinds of inducers. Inducing effect was observed with several kinds of brown algae (*Sargassum patens, Sargassum ringgolianum, Hizikia fusiformis, Myagropsis myagoides, Colpomenia sinuosa)* but their effects were extremely low compared to that of attaching diatoms.

An attaching diatom community propagating on the 'Nami-ita' plate showed high inducing effect if diatoms collected from the natural coast area were used as the starting material. Natural diatoms with higher density showed higher inducing effect. However, diatoms showed no effect if a single species, such as *Achnanthes biceps*, *Navicula ramosissima* or *Nitzschia* sp., which had been isolated and cultured under artificial conditions, was used as the starting material. To exhibit the inducing effect, contact between Doliolaria larvae and an inducer such as attaching diatoms is necessary.

K^+ did not show any inducing effect on the sea cucumber larvae in spite of its effect on sea urchin larvae. The 'Nami-ita' plate for settlement of the larvae should be set vertically, not horizontally, so that the juveniles can scatter uniformly over the plate.

Larval stage of sea cucumber *Stichopus japonicus* suitable for inducement to settlement and metamorphosis

by Shiro Ito, Itsuro Kawahara & Kazutsugu Hirayama

In: *Suisanzoshoku*, 1994 – H6: 287 – 297

Optimal water temperature and salinity for settlement and metamorphosis of the larvae of two types (green and red) of the sea cucumber *Stichopus japonicus* were investigated on an experimental scale. From the developmental stages of post-Auricularia and Doliolaria, metamorphosis was induced and the larvae settled by transferring them to petri dishes having diatoms attached at the bottom.

The low levels of temperature and salinity at which complete metamorphosis can take place without any influence from environmental factors were lower for the Doliolaria stage than for the post-Auricularia stage in both types of sea cucumber. The proportion of individuals metamorphosed completely into juveniles was higher at the Doliolaria stage than at the post-Auricularia stage. These results suggest that the process of settlement and metamorphosis in the larvae was induced after they had grown up to the Doliolaria stage through the post-Auricularia stage. The exact opportunity for inducing Doliolaria larvae to metamorphose can be detected as the growth stage when the length of planktonic larvae reduced to about 500 µm after they had initially grown to a maximum length of about 900 µm.

These experiments successfully achieved seedling production of sea cucumber from the culture of planktonic larvae in the order of 105 individuals.

Histochemical detection on the ontogenic development of digestive enzymes in the intestine of a juvenile sea cucumber *Stichopus japonicus*

by Motohiro Shimizu, Ikuko Mikami & Kazuhiro Takahashi

In: *Bulletin of the Faculty of Fisheries* 1994, 45 (1): 1 – 8. Hokkaido University

Activities of digestive enzymes such as peptidase and lipase were histochemically detected in intestines of adult and cultured juvenile sea cucumbers *Stichopus japonicus*, in the determination of ontogenic development of the digestive activity for proteins and lipids. The intestines of specimens larger than 0.008 g body weight were dividable into three parts (anterior, mid- and posterior intestines), while those of specimens smaller than 0.004 g body weight were undifferentiated, having a thin layer of flattened epithelial cells. Although adult specimens had well-developed villi in all intestines, young specimens showed some variations among the three intestines in villus-development; villi of the anterior and mid-intestines developed somewhat earlier than that of the posterior intestine.

Peptidase activity was conspicuous in the digestive epithelium throughout all intestines in specimens larger than 0.9 g body weight, but there were some variations among the three intestines in specimens smaller than about 0.2 g body weight; the activity developed earlier in the anterior intestine than in other intestines. However even in flattened digestive epithelia of specimens smaller than 0.004 g body weight, the peptidase activity was confirmed to exist. Lipase activity was observed to be intense in the anterior and mid-intestines in all specimens examined, but it developed somewhat later in the posterior intestine.

The results obtained in the course of the present study suggest that small juvenile *S. japonicus* already have the digestive enzymes for proteins and lipids, and that their activities advance as the villus formation progresses.

Stiffness changes of holothurian dermis induced by mechanical vibration

by Rie Shibayama, Takakazu Kobayashi, Hiroaki Wada, Hiroko Ushitani, Jun Inoue, Toshimitsu Kawakami & Haruo Sugi
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In: *Zoological Science* 1994, 11: 511 – 515.

The effect of mechnical vibration on the stiffness of catch connective tissue in the dermis of a sea cucumber *Stichopus japonicus* was studied using the dermis strip preparation held between a force transducer and a vibrator. During the application of vibration (peak-to-peak amplitude, 2– 10%; 2 – 20 Hz), the stiffness of fresh, stiffened preparations increased by 40 – 200 per cent, and then stayed constant or slowly decreased. After the stiffness reached a maximum, pause of vibration (5 – 20 min) had no effect on the steady level of stiffness, except that the stiffness initially showed a higher value on re-application of vibration. The stiffness of non-fresh, softened preparations showed a much more marked transient increase during the period of vibration. Electrical stimulation either increased or decreased the stiffness by 10 – 20 per cent in some preparations examined. The vibration-induced stiffness changes were not affected appreciably by Ca^{2+}-free, high-Ca^{2+} (100 mM) and high-K^{+} (100 mM) solutions, acetylcholine (10^{-3} M), and low temperatures (1° – 2°C). These results are discussed in connection with nervous control of the dermis stiffness.

Reproductive cycle of the tropical holothurian *Holothuria leucospilota* in Nha Trang Bay (Southern Vietnam)

by Nguyen Viet Nam & T. A. Britayev
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In: *Biologiya morya*, Vladivostok, 1992, No. 5 – 6: 70 – 77.

The reproductive cycle of a shallow-water tropical holothurian *Holothuria leucospilota* (Brandt) was investigated. The material was collected monthly in Nha Trang Bay from June 1982 to May 1984. Analysis of the seasonal changes in gonad state was conducted, using wax sections of gonads, and the dynamics of the gonadal index were studied. No evidence of hermaphroditism was recorded. The average male / female ratio was about 0.87, however, this characteristic varied significantly depending on the season and the site of sampling. It was found that *H. leucospilota* spawns twice a year: in spring (February–March) and in summer (June–August). The spring spawning is rather short and synchronised, while the summer one is more prolonged. However, the relative number of individuals participating in summer spawning is higher. The average diameter of prespawning oocytes is 112.8 µm, that of released oocytes is up to 144 µm. Asexual reproduction was not observed. The characteristics of the reproductive strategy of *H. leucospilota* are compared with those of some other tropical species of the same genus.

Holothurian resources in the sea of South Vietnam

by Dao Tan Ho, Institute of Oceanology, Nha Trang

from the Symposium of Marine Science in Vietnam (3rd), Hanoï, 1991: 112 –118.

So far 53 species of holothurians have been found in the sea of South Vietnam. In the coastal region of Phu Yen-Khanh Hoa provinces, holothurians were the dominant animals of the benthic community. They consisted mainly of species of commercial value such as: *Actinopyga echinites*, *A. mauritiana*, *Holothuria scabra*, *Microthele nobilis*. Holothurians are also abundant in Phu Quoc Island.

Echinoderm conferences

The **8th International Echinoderm Conference** was held at Dijon, France, (September 1993)—see Information Bulletin #6 (April 1994). The proceedings are now published and available : A.A. Balkema, P.O. Box 1675, Rotterdam, Netherlands. Price: Hfl.230 / USD135.

The **International Workshop on Biotic and Abiotic Interactions during Larval and Adult Stages of Marine Benthic Invertebrates** was held at Villefranche-sur-mer, France, 19 – 24 Sep. 94.

The three main themes were:

– role of reproduction on the life cycle;
– biotic and abiotic factors regulating the life cycle;
– the effect of interactions in structuring a community.

The presentations and the discussions were largely focused on echinoderms.

The contributions will be published in the journal *Oceanologica Acta*.

The **4th European Echinoderms Colloquium** will be held in London, 9 – 12 April 1995, at the Natural History Museum. For information contact A. Smith, Department of Paleontology, Cromwell Road, London SW7 5BD, UK.

The **9th International Echinoderm Conference** will be held in San Francisco, in 1996. For information contact Dr R. Mooi, Department of Invertebrate Zoology, California Academy of Sciences, Golden Gate Park, CA 94118–4599 San Francisco.

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