FISHERIES INFORMATION PROJECT
SOUTH PACIFIC COMMISSION
PO BOX D5 - NOUMEA CEDEX
NEW CALEDONIA

BECHE-DE-MER

INFORMATION BULLETIN Number 3 — November 1991

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NOTE FROM THE CO-ORDINATOR

Since the last issue of the Bulletin many new members have joined the SIG. We welcome you and wish that you will contribute to the contents of the next issues by keeping the Group informed of the evolution and changes in the fishing and marketing activities in your country and the latest progress in research developments. Information will so become increasingly accessible, questions will arise and communication will improve.

In the previous issues some aspects of the tropical fisheries of Fiji, Tonga, Papua New Guinea have been presented. In this one recent trends in New Caledonia exploitation are analysed concerning the organisation of the fishery, the catches and the processing. The major point is a change of target species, which is now the black fish *Actinopyga miliaris*. This change has also been mentioned in Fiji. Did it occur in other countries? When?

Information from Fiji Fisheries Division indicates that some exporters chop the products into small pieces. This could be a way to go around a size limit and will hinder the establishment of statistics by species. It is worth drawing attention to this practice and asking if there are other observations elsewhere and try to quantify these chopped products.

Following the presentation in the last issue on the research conducted on the temperate *Stichopus californicus*, the dive fishery in the Washington State is analysed here. The measures taken to prevent overfishing could also be useful to manage the tropical fisheries.

In this issue, a summary of a Japanese handbook on *Stichopus japonicus* biology and propagation provides interesting data on its ecology, natural and artificial seed collection and culture experiments, including survival rates, food and growth rates. For the field studies reliable measures of live specimens are needed; a new technique of measurement is presented here which allows emptying the guts before weighing.

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
N E W S

Bohadschia argus

The dive fishery of sea-cucumbers in Washington State

by A. Bradbury[1] and C. Conand[2]
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The landings *of Parastichopus californicus* from a commercial dive fishery in Washington State have been recorded since 1971.

This fishery is particularly noteworthy as the five longitudinal muscles are stripped from the body wall, frozen and exported mainly to Asian markets (Taiwan). The body wall itself is also processed into beche-de-mer for export.

In a first review, Sloan (1985, 1986) states that 'the fishery is still characterized by incomplete market development which imparts instability and causes non stock-related fluctuations in landings'. Until 1987, there were no seasonal nor areal restrictions for the divers. The development of the fishery was assessed through mandatory log books filled in by divers holding a licence.

Following signs of overfishing, the Washington State Department of Fisheries divided state waters into four harvest areas - San Juan Islands (1), Strait of Juan de Fuca (2), Central Puget Sound (3) and South Puget Sound / Hood Canal (4). Seasons now rotate, so each area goes unfished for 3.5 years after a six-month harvest. A seasonal restriction has also been implemented, with a six month fishing season extending from May to October.

The closed period was based on the seasonal atrophy of the visceral organs as described by Fankboner and Cameron (1985). These rotating area closures give sea-cucumbers the chance to spawn at least once before being harvested. The recent progress in understanding the biology of this species (Cameron and Fankboner, 1989) has permitted a more scientific basis for the management of this fishery. Limited-entry legislation has also been approved in 1990 and the number of boats licensed is now declining.

The annual landings of the Washington sea cucumber fishery are shown in Figure 1 though these figures should be viewed with caution, due to unreporting. Landings stayed under 10 tons until 1977, then fluctuated for ten years at an intermediate level and not exceeding 200 tons. The figure shows a large increase in landings between 1988 and 1990, with the record catch, in 1989, of over 1,000 tons.

A summary of the production from the beche-de-mer fishery is given in Table 1. The value per kilogram has more than doubled during the last four years, making the fishery attractive for divers. Since 1983, the number of boats, fishing effort (dive

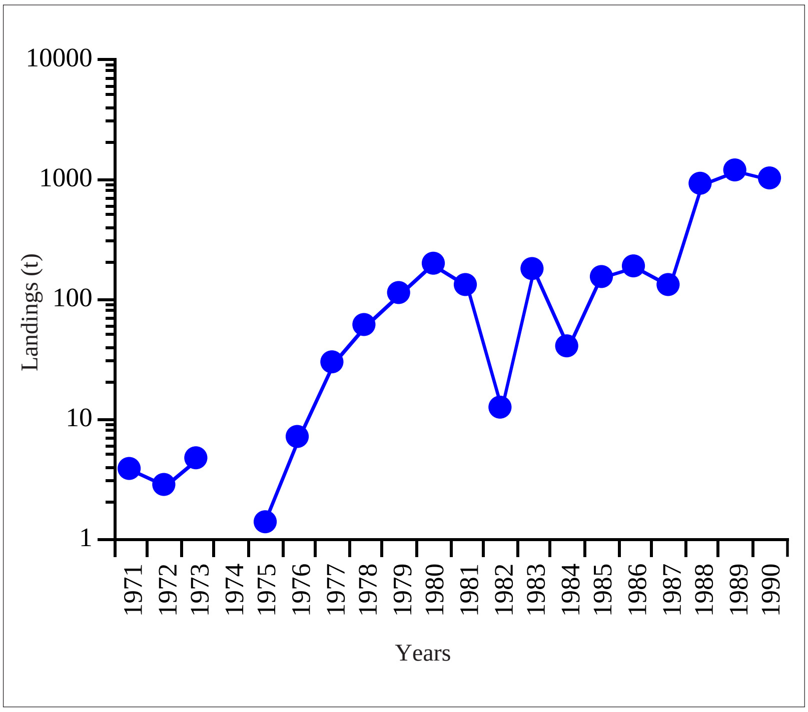

Figure 1. Evolution of *Parastichopus* landings from the Pacific coast of North America.

hours) and commercial buyers have all increased markedly. The CPUE, in number of sea cucumbers, although variable, is decreasing in the different districts forcing the divers to fish in deeper waters.

Among the different measures taken to prevent overfishing, the limited-entry legislation is probably the most important conservation strategy.

Table 1. Sea cucumber exploitation by divers in Washington State (U.S.A).

		Value(1)			District 1			District 2			District 3			District 4		
Year	Catch	Total	per kg	Number	Effort	CPUE (4)		Effort	CPUE (4)		Effort	CPUE (4)		Effort	CPUE (4)	
	(kg)	(US$ *10^6)	(US$)	boats (2)	(3)	n	kg	(3)	n	kg	(3)	n	kg	(3)	n	kg
1971	3,629															
1972	2,722															
1973	4,536															
1974	-															
1975	1,361															
1976	6,804															
1977	28,577															
1978	57,607															
1979	107,050															
1980	190,966															
1981	125,194															
1982	12,247															
1983	170,554			9				99	530		281	275				
1984	39,917			14	68	271		225	495		310	220		28	502	
1985	146,966			15	74	232		162	397		1,763	272		336	636	
1986	181,894			16	345	200		253	425		1,116	249		237	321	
1987(5)	127,008	0.89	0.7	25	837	248	69									
1988	871,366	1.07	1.23	78				6,492	381	106.1						
1989	1,146,701	1.87	1.63	125							11,437	239	66.7			
1990	992,794	1.75	1.76	79										5,833	264	73.5

(1) Estimated from the average price paid per bucket of slit, drained cucumber
(2) Number of boats making at least one landing
(3) Total dive hours
(4) Mean number (n) or weight (kg) per dive hour, from harvest logs
(5) Since 1987, area openings are rotating (districts 1 to 4).

In the meantime, assessments of the present resources and of the holothurian population after the fishing period, are being conducted by fishery biologists.

At present, the Washington dive fishery is probably the best documented and most carefully managed sea-cucumber fishery.

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Measurement of size in live sea cucumbers

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The need to devise a suitable and reliable measure of size in live sea cucumbers has been a consistent problem for researchers investigating the population ecology of this group. This was noted by Alex Bradbury (Washington State Department of Fisheries) in a recent issue of *Beche-de-mer Information Bulletin*. Any person faced with a sea cucumber deflating in one's hands will probably despair of ever getting a repeatable measure of size.

Measurement has usually been based on two variables — total length and total weight. However, there are problems with both these measures. Length is difficult to measure because of the morphology and elasticity of the body wall. Variation is also observed in total weight due to differences in the amount of food in the gut, seasonal changes in the size of the alimentary canal and respiratory tree (in some species of sea cucumber), and the quantity of water contained within the respiratory tree (Choe, 1963; Conand, 1981, 1989).

For research on the aspidochirote *Stichopus mollis*, a reliable measure of size was needed for calculation of gonad indices and size-frequency distributions. The method devised required that the animals be brought to the laboratory, but provided fairly reliable results. Although this method is described in a recent paper (Sewell, 1990), details of the methods are given here.

To get a reliable measure of size, the animals were placed in aquaria for 24 hours in order to clear the sediment from the alimentary canal. Each animal was put in a small mesh bag constructed from surplus onion sacks (mesh size 5 mm). The bags were approximately 20 x 20 cm square, just large enough to contain the animals. In the area studied, sexually mature *Stichopus mollis* were 13—24 centimetres in length. A large metal frame (a salvaged rectangular quadrat) was hung over a pool of running sea water (500 litres) as shown in Figure 1.

Then 'hangers' were constructed from two squeeze-type clothes pegs connected by string. The bag was closed by this hanger, and suspended from the metal frame so that the animal was totally immersed in the running sea water. Animals suspended in this fashion shed faeces to the bottom of the tank, and could not reconsume the sediments. After 24 hours, each animal was transferred to a small laboratory aquarium (15 l) of aerated sea water for 15 minutes. This allowed the animal to achieve a natural body form after being held in the mesh bags. Most animals started respiratory movements soon after entering the tank, and began moving tentacles after 5 —10 minutes.

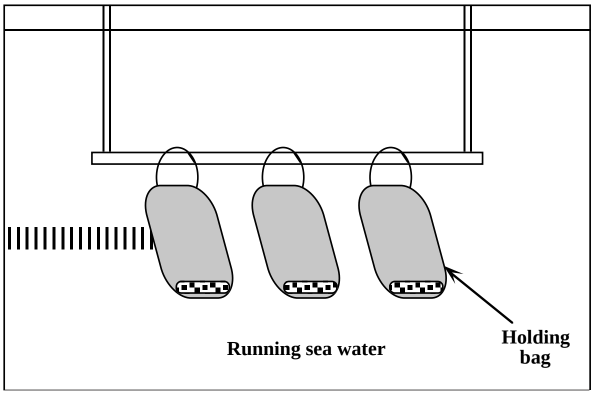

Figure 1. Side-view of aquarium showing position of holding bags. (Not to scale)

Two measures of size were made — total length and weight. Each sea cucumber was removed from the aquarium and its length measured dorsally from the anus to the centre of the tentactular crown with a dressmaker's tape to the nearest 0.5 cm. The animal was stimulated to expel the excess water remaining in the respiratory trees by gently squeezing the posterior half, and then quickly blotted dry and weighed.

To obtain an estimate of the errors associated with the total length and total weight measures used, ten sea cucumbers were measured ten times at 15-minute intervals. Details of the analysis and table of results are included in Sewell (1990). Raw data are included in Table 1.

The results showed that total length was not a very reliable measure of size (Sewell, 1990). Individual sea cucumbers varied up to 6 cm in length. In this study, however, there was no correlation between the size of animal measured in the field prior to collection (i.e. underwater), and the mean of the ten repeated measures in the laboratory. I, therefore, do not recommend the use of length to measure size.

Total weight appeared to be a reliable measure of size in *Stichopus mollis*, provided that sediments were removed from the gut and excess water squeezed from the respiratory trees. Analysis showed that a single measure had a reliability of approximately 95 per cent in estimating the mean

Table 1: Repeated measures analysis of total weight and total length in *Stichopus mollis*

Animal	Weight range (g)	Mean (g)	S.D. (g)	Length range (cm)	Mean (cm)	S.D. (cm)
1	178.1 - 205.0	189.4	8.3	17.5 - 20.5	18.5	1.0
2	178.2 - 206.1	198.3	8.8	17.0 - 21.5	19.4	1.3
3	138.6 - 156.9	145.6	6.1	16.5 - 19.5	17.9	0.9
4	146.4 - 159.0	154.7	6.2	14.5 - 20.0	16.9	1.9
5	173.6 - 194.4	183.9	7.1	16.0 - 22.0	18.1	1.9
6	183.2 - 193.1	188.1	3.4	18.0 - 19.5	18.9	0.5
7	103.8 - 115.6	107.1	3.4	12.5 - 17.0	14.8	1.4
8	148.6 - 166.1	156.8	5.7	16.0 - 19.5	18.1	0.9
9	154.7 - 163.8	158.7	3.1	15.5 - 19.0	17.7	1.1
10	175.9 - 203.7	191.6	7.5	18.5 - 20.0	19.4	0.5

of the ten measures (Sewell, 1990). A high correlation was also found between total weight and the drained weight used in the calculation of the gonad index (r=0.95, n=480), suggesting that total weight was a reasonably accurate and non-destructive measure of size in this species.

So in conclusion, a reasonable measure of weight could be obtained by the following protocol for *Stichopus mollis*

(i) Empty the alimentary canal in such a way that sea cucumbers cannot reconsume the sediments released as faeces;
(ii) Allow a relaxation period in the tank;
(iii) Squeeze excess water from the respiratory trees;
(iv) Blot quickly and weigh.

These methods were found to be suitable for calculation of gonad indices; however, if animals are to be reweighed for estimates of growth a number of measurements should be taken, and a mean calculated. The method described here reduces some of the variation, by at least ensuring that all the animals have empty guts before measurement.

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Recent trends in sea cucumbers exploitation in New Caledonia

by C. Conand[1] and C. Hoffschir[2]
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[2]O.R.S.T.O.M, Nouméa, Nouvelle Calédonie

The history of the sea cucumber fishery in New Caledonia has been traced back to the nineteenth century from various documents and statistics. The exports have shown wide fluctuations in connection with political and socio-economic events, as well as with the status of the biological resource (Conand, 1989, 1990).

Evolution of the exports

The most recent period of revival started in 1983, when a few New Caledonians of Chinese origin undertook to organise the fishing, processing and trade. As the catches in New Caledonia are all exported, the export statistics provide easily obtainable accurate data.

Table 1 shows the fluctuations in tonnage between 1983 and 1990. For this period, the mean annual export was 103 tons. Production was not constant but oscillated between years, giving peaks in landed volume during 1984, 1986, 1988 and 1990.

Table 1. Evolution of the recent beche-de-mer exports from New Caledonia

Year	1983	1984	1985	1986	1987	1988	1989	1990
Tonnage	15	150	89	180	77	135	55	126
exporters	2	4	7	6	4	3	3	4

The general tendency of the fishery appears to be towards a slow decline in the landed volume of beche-de-mer. The total value of the exports in 1990 was 156 million CFP, which corresponds to a mean price of 1,233 CFP per kg.

The number of companies exporting bêche-de-mer operating in New Caledonia (see Table 1) has also fluctuated. Although up to twelve different companies have occasionally exported beche-de-mer, only three of them share the major part of the market. Their respective importance has also fluctuated, as shown in Figure 1. The exports of the first company (1) fell to only 200 kg in 1990. The third one (3) increased and now holds the major share while another one (4) started in 1990 with an initial 20 per cent of exports.

The major markets for bêche-de-mer (Figure 1) were Hong Kong and Singapore. In 1987 and 1988, the tonnage exported to Singapore declined strongly and since 1989 Singapore has disappeared from the statistics. In 1989 and 1990, the exports were mostly destined for Hong Kong (with a further 3.7 tons to Taiwan in 1990).

Other sources of variability that caused production to fluctuate from year to year were the species targetted for collection, the locations selected for harvesting, and the organisation of the fishing and processing.

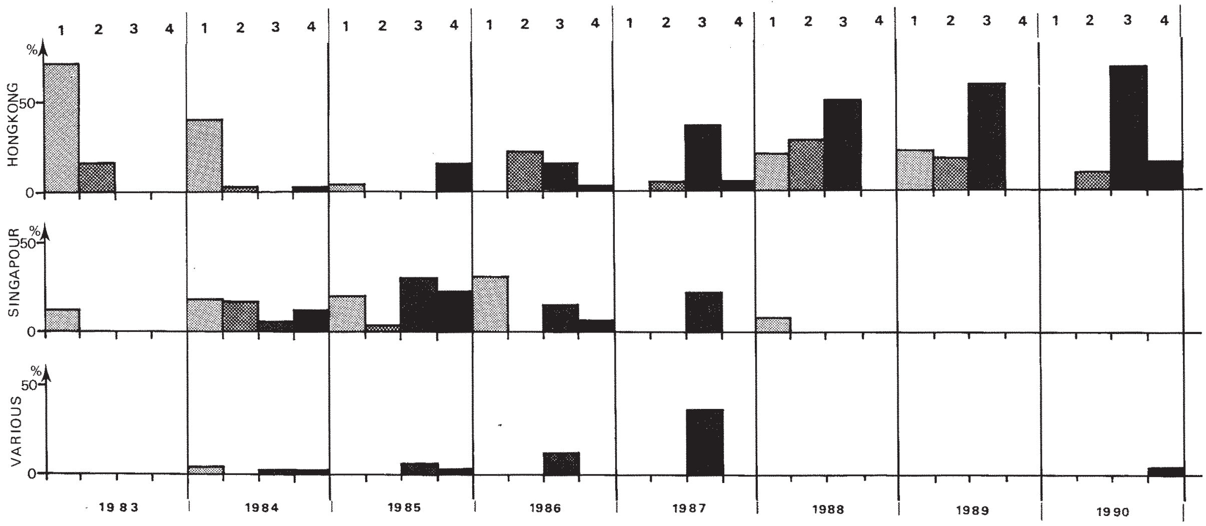

Figure 1: Exports of beche-de-mer by company and by destination, in percentage of the annual tonnage 1,2 & 3: main companies; 4: other companies

Organisation of the fishery and processing

There are now approximately one hundred fishermen involved in the sea cucumber fishery. Most of them are grouped by their respective tribes or in cooperatives located principally on the north-east coast. On the west coast, a few individual fishermen sell their captures to the processors or exporters.

Harvesting takes place at low tide on the reef-flat (Figure 2). Each fisherman collects the sea cucumbers in a restricted area, filling up his sacks, which are left on the fishing ground until high tide.

Changes in the composition of the species collected have occurred recently. Among the species of the first category (Conand, 1989), only *Holothuria scabra* (sandfish or **tavo** in New Caledonia) and *Holothuria scabra versicolor* (white sandfish or **mouton**) are still collected in some localities. They are traditionally processed, then sold to the exporter at prices according to their grade. For *H. scabra versicolor* grade A, which is the largest, the export price can reach around US$ 30 per kg. Meanwhile, more than 75 per cent of the production is from the blackfish, *Actinopyga miliaris*, which is a very common species found in dense populations on the reef-flats of the north-east coast. As it is processed the day after the harvest (Figure 3), the individuals have spontaneously eviscerated and the traditional stages of slitting and gutting are unnecessary, as is the smoke-drying. The export price for this species does not reach more than US$10 per kg.

The introduction of species and grade categories in the customs statistics is recommendedto improve the monitoring of this multispecies artisanal fishery.

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Photo: C. Hoffschir

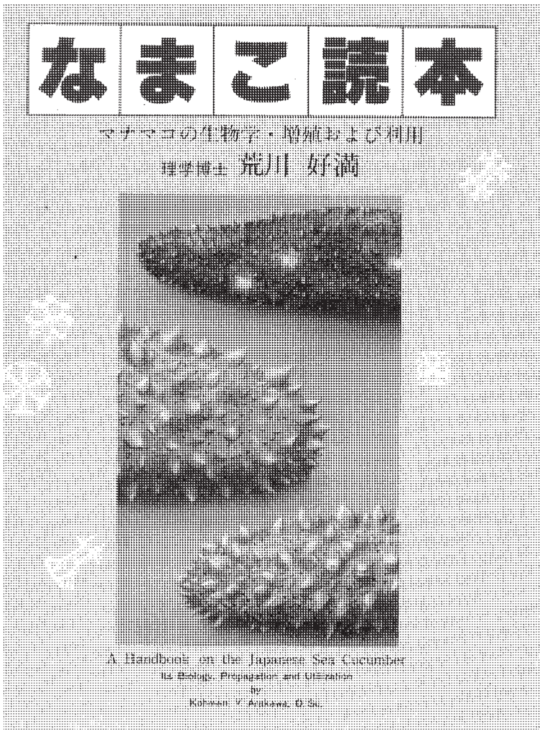
Figure 2. Harvesting in New Caledonia. The sacks full of sea-cucumbers are shipped

Photo: C. Hoffschir

Figure 3. Processing of blackfish at Arama

A Handbook on the Japanese Sea Cucumber - Its Biology, Propagation and Utilisation (K.Y. Arakawa, 1990)

translated by M. Izumi,
South Pacific Commission,
Noumea, New Caledonia



Introduction

This Japanese book was published in March 1990 and consists of the following four chapters.

Chapter 1 — Biology of the Japanese sea cucumber;
Chapter 2 — Propagation;
Chapter 3 — Utilisation;
Chapter 4 — Appendix.

It contains comprehensive information of the Japanese sea cucumber *Stichopus japonicus* (Selenka, 1967).

The book (ISBN4-89531-409-X) is available at a cost of Yen 1,650 (about US$12) from Midori-Shobo Publishers, 2-14-4 Ikebukuro, Toshima-ku, Tokyo 171, Japan.

A summary is given below of chapters 1,2 and 4, translated from Japanese to English.

1 Biology of the Japanese sea cucumber

1.1 Classification and distribution

The scientific name for the Japanese sea cucumber is *Stichopus japonicus* (Selenka, 1967) and the species has three colour morphs:

— Red sea cucumber (**Aka** in Japanese);
— Blue sea cucumber (**Ao**);
— Black sea cucumber (**Kuro**).

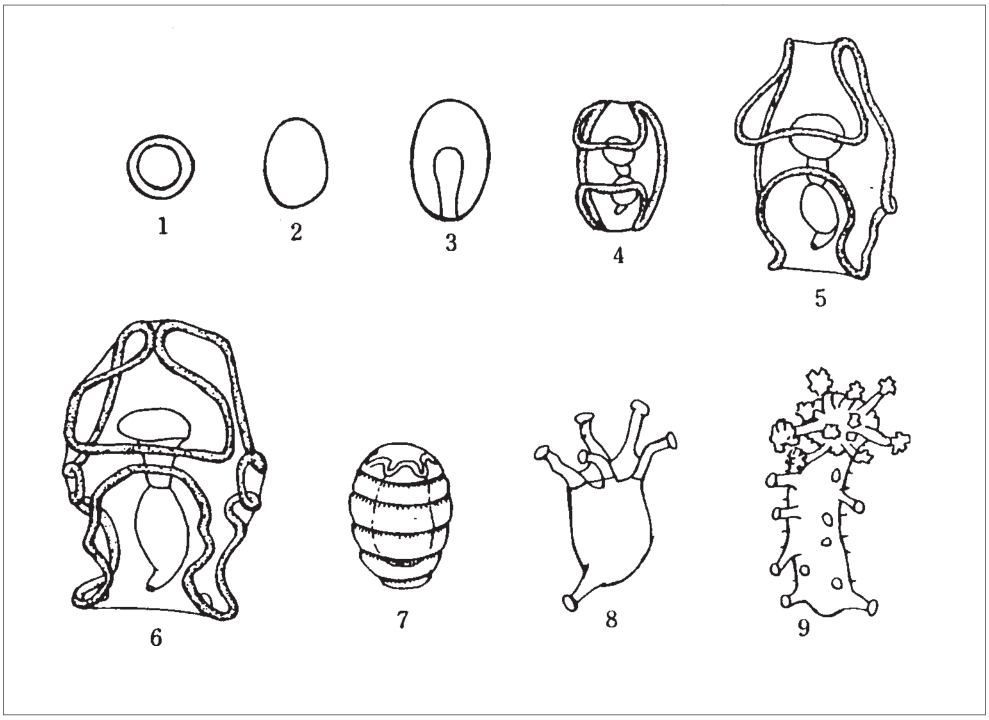
Aka and **Ao** are the most important morphs for commercial fishing. These colour morphs are distributed over a wide area of the north-eastern Pacific; from Sakhalin Island and Alsaka to Amami Island (Japan) and the east coast of China. The vertical distribution extends from the surface to 40 metres in depth.

1.2 Generation and early life history

The shape of the egg is ellipsoidal with a 156 µm ($1\mu = 10^{-6}$ m) major axis and 142 µm minor axis. The table opposite shows the larval stages after fertilisation at 24°C (water temperature).

Table 1. Larval stages after fertilisation

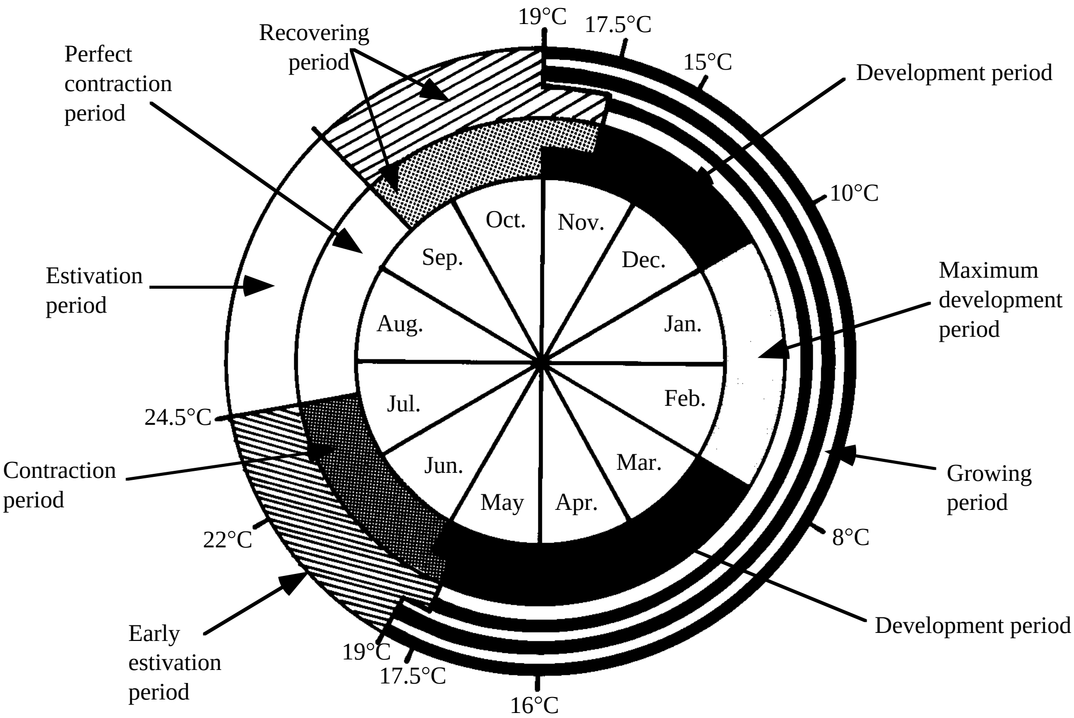
Time after fertilisation Day	Hrs	Min	Stage	Remarks
		0	fertilised egg	See figure 1 (1)
		25	releasing the 1st polar body	
		50	releasing the 2nd polar body	
	1	40	2 cells (1st cleavage)	See figure 1 (2)
	2	20	4 cells (2nd cleavage)	See figure 1 (3)
	3	0	8 cells (3rd cleavage)	
	14	0	blastula (200-210µ) rotatory motion	See figure 1 (4)
	22	0	gastrula (220µx170µ) floating on surface	See figure 1 (5)
	45	0	auricularia larvae (420µ) taking in monad	See figure 1 (6)
4	0	0	auricularia larvae (500µ) taking in monad	
6	0	0	auricularia larvae (620µ)	
8	0	0	auricularia larvae (700µ)	
10	0	0	auricularia larvae (750µ)	
12	0	0	doliolaria larvae (450µ) five ciliary rings	See figure 1 (7)
13	0	0	pentacula larvae (320µ) disappearance of ciliary rings appearance of five tentacles moving to benthic life taking in benthic diatom & detritus	See figure 1 (8)
22	0	0	juvenile (0.3 - 0.4 mm)	See figure 1 (9)



Different larval stages of *Stichopus japonicus*

1.3 Growth and life cycle

A diagram representing the annual life cycle is shown below. The outer part indicates activity of the sea cucumber and the inner part shows the status of the alimentary organ.

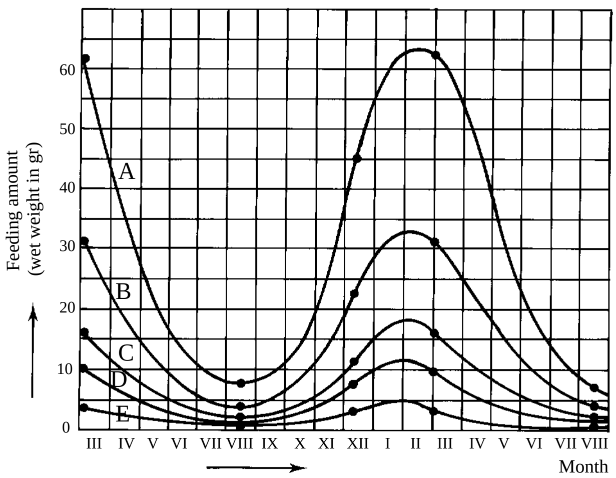


Somatic growth takes place in water temperatures less than 16—17°C and between the months of November and May. The table opposite gives a summary of the length and weight at ages 1 to 4 years.

Year	Body length (cm)	Weight(gr)	Eviscerated body weight (gr)
1	5.9	15.5	9
2	13.3	122.5	80
3	17.6	307.0	175
4	20.8	472.5	260

1.4 Feeding habits and digestion

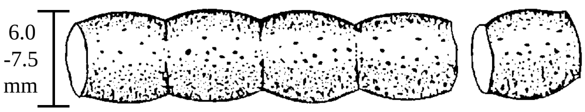
The monthly variation of feeding activity is shown in the following figure.



A: 200 g (test weight), B: 100 g, C: 50 g, D: 30 g, E: 10 g

During the auricularia stage and doliolaria larval stage, the diet consists of monads; in the pentacula stage, benthic diatoms and detritus form the major part of the diet. It was reported by fishermen that juveniles with a test weight of 2.0 to 2.5 grams fed on the excrement of bivalves. In the stomach of mature sea cucumbers, it was also reported that there were grains of sand, organic sediments and plankton including 60 species of diatomaceae, 14 species of protozoa, crustacea, fish roe, gastropod larvae and seaweed.

Digestion can take between 20 and 309 hours depending on environmental factors. 51—57 per cent of the total nitrogen content in the food is digested, with the remnainder discharged as excrement.

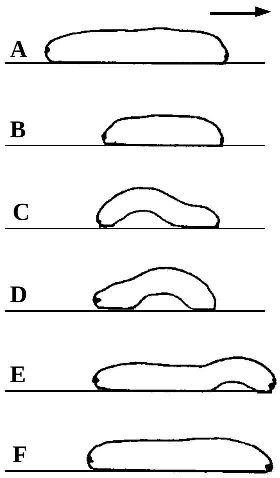


Scat of sea cucumber, 220mm in body length.

1.5 Movement

A sea cucumber uses its radial and circular muscles to expand and contract the inside of the body wall (see figure opposite)

— The front tube feet are lifted up from the ground when the body is contracted (A);
— The front part of body moves forward when the body is expanded (B);
— The front tube feet hold on to the ground (C);
— The rear part of the body is pulled forward when the body is contracted (D).



The following table shows the moving speed for ten bêche-de-mer specimens.

Specimen	Moving distance per hour (cm/hour)	Moving distance per day (m/day)
1	496.6	119.2
2	502.9	120.7
3	702.4	168.6
4	709.9	170.4
5	603.8	144.9
6	669.6	160.5
7	558.0	133.9
8	600.0	144.0
9	543.4	130.4
10	451.2	108.3
Average	583.7	140.1

1.6 Habitat and response to environmental variability

The larger sea cucumbers inhabit deeper water, while smaller-sized ones live in shallow water. This distribution pattern is related to the composition of bottom materials as sea mud in deeper water contains more organic carbon and organic nitrogen.

In general the best conditions for growth are when the range of water temperature is narrow. In Japan the period between spring and summer is marked by a rise in sea water temperatures. During this time, sea cucumbers move to deeper water to find suitable, stable water temperatures.

Sea cucumbers are rarely found in brackish water because these animals lack the ability to control the concentration of salts in the body fluids. The following tables show the response of the Japanese sea cucumbers to reduced salinities at different water temperature regimes.

Response to low salinity water between 2.4°C and 7.6°C.

Salinity (‰)	50% mortality (time in hours)		100% mortality (time in hours)	
	Ao	**Aka**	**Ao**	**Aka**
2.60	10.50	9.00	15.00	15.00
5.07	12.00	9.00	24.00	24.00
7.26	72.00	26.80	96.00	50.00
9.43	11.5 days	6.4 days	16.00	9 days
11.44	-	14 days	-	22 days
12.58	-	30 days	-	-

Response to low salinity water between 15.6°C and 21.7°C.

Salinity (‰)	50% mortality (time in hours)		100% mortality (time in hours)	
	Ao	**Aka**	**Ao**	**Aka**
1.73	11.50	12.00	18.00	18.00
3.43	11.50	12.00	18.00	18.00
4.99	17.00	17.00	24.00	24.00
6.72	27.00	30.00	67.00	39.00
8.33	51.00	34.00	67.00	67.00
9.94	*	156.00	-	-
11.00	**	***	-	-

* 33.5% died in 19.5 days
** 6.7% died in 19.5 days
*** 25.0% died in 19.5 days

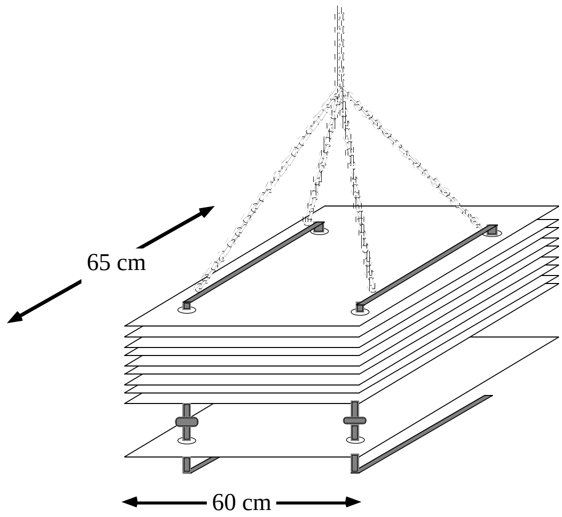
2 Propagation

2.1 Seed collection and rearing

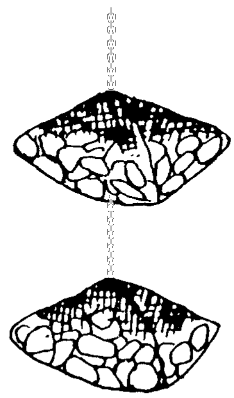
2.1.1 Natural seed collection and culture

Two types of seed collectors are shown in the figure opposite. The upper collector is a set of ten corrugated vinyl chloride or polycarbonated sheets, and the lower collector is a cage containing oyster shells.

The corrugated vinyl chloride and polycarbonated sheets have been found to be the best type of collector, although the cost is more than four times as much as that of cage collector.



Set of ten corrugated vinyl chloride or polycarbonated sheets



Cage containing oyster shells

2.1.2 Artificial seed collection and culture:

After capturing parent sea cucumbers in the spawning season, at least one week will be needed to condition the animals before feeding can be stopped and spawning induced. A combination of lower temperature and higher temperature treatments are effective for inducing spawning (see table next page).

Results of the induced spawning

	1983		1984		1985		1986	
Type of sea cucumber	**Ao**	**Aka**	**Ao**	**Aka**	**Ao**	**Aka**	**Ao**	**Aka**
Spawning period	30/5	17/5-5/6	14/5-26/6	14/5-26/6	24/4	27/3-25/5	22/4-3/6	6/5-3/6
Water temperature (°C)	20	18-22	17-19	17-23	15	11-20	15-19	17-19
Attempts to induce spawning	1	10	3	25	1	20	10	7
Spawning day	30/5	5/6	14/5-18/5	-	24/4	-	14/5-3/6	3/6
N° of eggs spawned (x 10,000)	400	400	1,500	-	800	-	800	200
N° of individuals	55	60	35	46	40	50	130	30
Weight range	60-390	200-750	95-315	55-295	140-470	250-550	95-265	240-630

The key points for the successful rearing of sea cucumbers are feeding, water exchange and cleaning. When the auricularia larva reaches 600 µ, it is necessary to change two thirds of the water every day.

Sea cucumber feed either comprises a single diatom species or mixture of *Chaetoceros gracilis, Isoschrysis galbana and Monochrysis lutheri* depending on the culturing condition. The following tables show the rearing results and feeding results of floating larva.

Results of the rearing experiments

	1983		1984	1985	1986		
Type of sea cucumber	**Ao**	**Aka**	**Ao**	**Aka**	**Ao**	**Ao**	**Aka**
Rearing period	31/5-10/6	17/5-5/6	14/5-26/6	14/5-26/6	24/4	22/4-3/6	6/5-3/6
Water temperature (°C)	20-21	20-22	17-20	16-19	17-19	21-22	21-22
Capacity of tanks (m^3)/ (N° used)	0.5 (1)	1 (3)	0.5 (1)	1 (4)	1 (14)	1 (6)	1 (2)
Number of larvae (x 10,000)	29	160	18	280	1,120	500	4/10
Survival number of body length 500µ (x 10,000)	27	70	17	252	900	210	0
Survival number of body length 700µ (x 10,000)	26	52	17	215	800	25	-
Number of doliolaria larvae (x10,000)	22	26	13.5	192	56	15	-
Survival rate of doliolaria (%)	75.9%	16.3%	75.0%	68.6%	5.0%	3.0%	-

Results of feeding experiments

N° of days after fertilisation	Body length (µ)	Feeding amount			Remarks
		Frozen diatoms (Cell/ml)	*Ch. gracilis* (l)	*Is.galbana* (l)	
0		-			
1	200	-	-		Hatching
2	350	-	-	-	
3	450	5,000		0.6	
4	480	8,000	2.0	0.5	
5	520	12,000	3.5	0.5	
6	560	15,000	7.5	-	
7	640	20,000	10.0	-	
8	720	22,000	11.0	-	
9	790	25,000	12.5	-	
10	850	10,000	5.0	-	Maximum body length
11					of auricularia
12	340	-			Doliolaria

Note: – Rearing water temperature: 18-20°C
– 700,000 animals in a tank water (1 m^3)
– Ch. gracilis: 2 million cells/ml; Is. galbana: 8 million cells/ml

For artificial seed collection, a corrugated vinyl chloride sheet or a polycarbonated sheet is most suitable. The auricularia larvae in the contraction period are transferred from a larvae rearing tank to a juvenile rearing tank for seed collection. On the corrugated sheet, it is necessary to propagate attached diatoms (1,000-3,000 cells per mm^2, single species is preferable) to spur the attached transformation. Then a further propagation of attached diatoms is controlled by decreasing the light intensity, and *Chaetoeros gracilis* or frozen diatoms are also added to the seed culture.

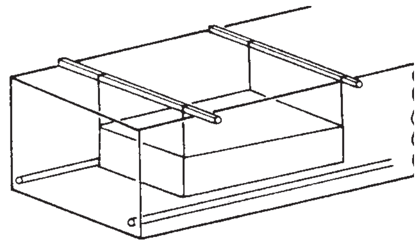
The best time to establish a seed collector is when the survival rate of doliolaria exceeds 70 per cent (see table on previous page). The corrugated sheets have to be set in the water parallel to the surface. During seed collecting, aeration of the water is critical, and an even distribution and insertion of larvae on the sheet must be made with care. Water is drawn off half day after the seed collector is established, and the drained effluent is strained through a net. The feed (*Chaetoeros gracilis*) is continuously provided during seed collecting. For two days after starting seed collection, the rate is 5,000 cells / cc as feed, 10,000 cells / cc by the third day and more cells day by day.

For juvenile rearing, special attention and care have to be paid to juveniles after transformation due to their smaller size (0.3-0.4 mm in body length), less motility and genearlly greater sensitivity. The feeding schedule is shown below.

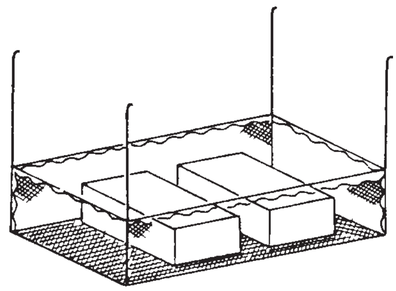
Juvenile rearing

Body length of juvenile (mm)	Feed
1	Ch. gracilis only
1–2	Ch. gracilis & frozen diatom
>2	Frozen diatom only
>10	Powdered-dried Eisenia bicyclis only

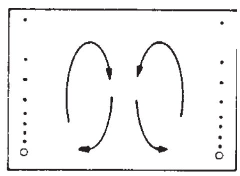
An initial feed (*Chaetoceros gracilis*) or frozen diatoms (*Melosira sp.*) of 1,200 litres (two million cells / cc) is necessary to produce 0.1 g of seed. Until 0.1 gram of seed has been produced, daily care has to be taken when feeding and moving the cage up and down for spreading feed and excrement. After 0.1 g of seed is produced, larger specimens are removed. Frozen diatoms are defrosted and mixed and sufficient aeration is necessary for even distribution in the tank. Thinned seeds (about 1,000-2,000) packed with sea water (6-7 litres) in a polyethylene bag are sent to the market. The figure opposite shows the juvenile rearing methods.



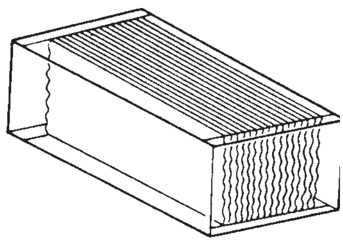
Hanging cage and 10 t concrete tank



Cage accommodated seed collector (lined by 1 mm meshed material)



Aeration and water movement



Seed collector (corrugated sheets and accommodated cage)

Juvenile rearing method

The following tables show the seed collection and juvenile survival rates, and the feeding results for juveniles (2 million individuals, 0.1 g each)

	1983		1984	1985	1986	
Type of sea cucumber	**Ao**	**Aka**	**Ao**	**Ao**	**Ao**	**Ao**
Number of doliolaria (x 10,000)	22	26	13.5	192	56	15
Juvenile (0.3-0.4mm) (x 10,000)	18	10	9	162	46	6
Juvenile (0.75mm) (x 10,000)	7	8.1	0.75	24	30.9	–
Juvenile (1.0mm) (x 10,000)	3.8	6.9	0.6	7	16	4
Juvenile (2.0 mm) (x 10,000)	2.3	4.4	0.5	4.5	9	3.2
Juvenile (4.0 mm) (x 10,000)	2.1	2.7	0.5	4.5	7.5	2.6
Seed collection rate	81.8%	38.5%	66.7%	84.4%	82.1%	40.0%

Note: Seed collection rates are the ratio between the number of juveniles (0.3-0.4mm) divided by the number of doliolaria

Number of rearing days	Body length of juveniles (cm)	Existing number of juveniles (million)	Feeding amount of Ch. gracilis diatoms (l)	Feeding amount frozen diatoms (l)	Feeding amount of powdered-dried E. bicyclis (g)
1	0.3 — 0.4	1.00	50		
			20		
			50		
			20		
5			70		
			30		
			90		
			50		
			90		
10	0.5 — 1	0.40	100		
			100		
			100		
			120		
			120	50	
15			120	50	
			50	70	
			20	70	
				100	
				120	
20	1 — 3			150	
		0.30		150	
				250	
				250	
				350	
25				350	
				400	
				400	
				500	
				500	
30	3 — 4	0.26		800	
				1,200	
				1,500	
				2,000	
				1,500	
35	4 — 6			3,000	
				500	
				3,600	
				1,000	
				3,600	
40	5 — 7			2,000	
				3,600	
				900	
				3,600	
				1,200	
45	6 — 8			4,500	
				900	
				4,500	
				1,200	
				4,500	
50	8 — 10			2,400	50
				4,500	
				2,400	50
				4,500	
				3,600	100
55	10 — 11			6,000	
				3,000	100
				6,000	
				5,000	200
				6,000	
60	13 — 14			8,000	200

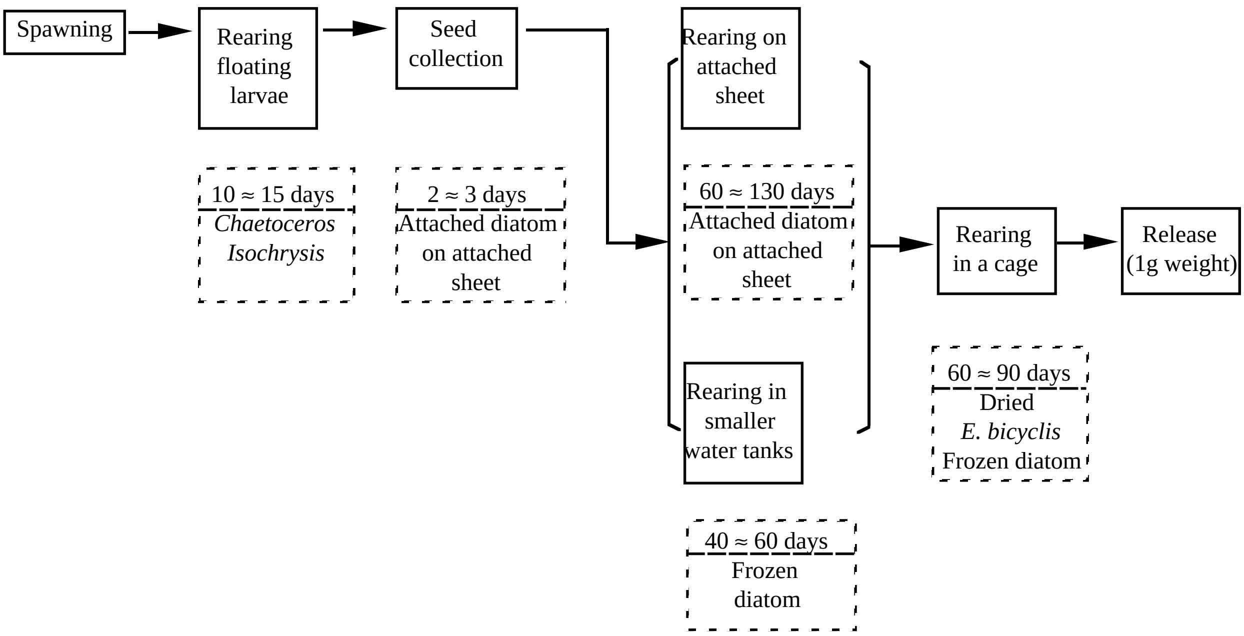
For intermediate culture, a plastic culture cage sealed by 1 mm meshed material is suspended (in the sea or in a tank). The cage should be suspended between sea surface and sea level. The intermediate culture schedule is shown in the opposite table.

The table below shows the results of the intermediate culture

Time	Feed	N° of seed	Weight of seed (g)	Size (mm)
Mid & late July	None	500 350	0.05 0.10	–
Early Sept.	dried *Eisenia bicyclis*	–	1.00	20
Late Oct.-early Nov.	–	250-300 (expected)	1.00	30-40

Experimented area	N° of individuals	N° of individuals after exp.	Survival rate (%)	Total weight (g)	Average weight (g/body)	Increased weight rate (%)
A-1	2,000	1,012	50.6	1,090	1.08	600
A-2	2,000	838	41.9	930	1.11	617
B-1	1,000	712	71.2	1,117	1.57	872
B-2	1,000	602	60.2	840	1.40	778
C-1	1,000	721	72.1	1,196	1.66	922
C-2	1,000	669	66.9	669	1.00	767
D-1	500	370	74.0	965	2.61	1,450
D-2	500	444	88.8	910	2.05	1,139
E-1	2,000	586	29.3	470	0.80	444
E-2	2,000	252	12.6	344	1.37	761
F-1	1,000	327	32.7	380	1.16	644
F-2	1,000	532	53.2	423	0.80	444
G-1	500	309	61.8	420	1.36	756
G-2	500	360	72.0	590	1.64	911
Total/Average	**16,000**	**7,734**	**48.3**	**10,344**	**1.34**	**743**

The following schematic figure shows a process of seed production



Chapter 4 (Appendix) will be published in the Beche-de-mer Information Bulletin #4

New references in SPC library

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

Dr. D.B. James sent us new references (listed below) to be added into the Fisheries Information Project's beche-de-mer bibliographic database. They will be held in the SPC library and will be available on request.

If there are documents that you feel should be added to the database, please send us a copy, or, if this is not possible, a photocopy of the cover page. Documents do not need to be formal publications — many of those held in the database are not — and we are keen to archive as much 'grey literature' (internal reports, correspondence, unpublished data, etc...) as possible.

Thanks in advance for your help.

References provided par Dr D.B. James

James, D.B. & Pearse J.S., 1969. Echinoderms from the Gulf of Suez and the Northern Red Sea. *J. Mar. biol. Ass. India*, 1969, **11** (1&2): 78-125.

James, D.B., 1985. Echinoderm fauna of the proposed National Marine Park in the Gulf of Mannar. *Proc. Symp. Endangered Marine Animals and Marine Parks*, 1985, **1**: 403-406.

James, D.B., 1986. Studies on Indian Echinoderms-13. *Phyrella fragilis* (Oshima) (Echinodermata: Phyllophoridae). A new record from the Indian ocean with notes on its habits. *J. Andaman Sci. Assoc*. 2(1): 37-38.

James, D.B., 1987. Prospects and problems of Beche-de-mer industry in Andaman and Nicobar Islands. *Proceedings of the Symposium on Management of Coastal Ecosystems and Oceanic Resources of the Andamans*. Central Agricultural Research Institute. pp 110-113.

James, D.B., 1989. Beche-de-mer — Its resources, fishery and industry. *Mar. Fish. Infor. Serv., T & E Ser.*, No **92**: 1989. 30 p.

Welcome to new members

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

The Beche-de-mer Special Interest Group is growing. Since last year, we have received additional completed questionnaires from the individuals below. The lists of members are available in the previous SPC Beche-de-mer Information Bulletins.

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

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Last news:

Recent results on the biology and ecology of sea cucumbers have recently been published by Balkema, Rotterdam, in the proceedings of the last Echinoderm Conferences under the references:
Echinoderm research. 1990. De Ridder et al. (eds), 343 p. and biology of Echinodermata. 1991. Yanagisawa et al. (eds), 590 p.
The next International Conference is to be held in France in 1993.