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

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Introduction

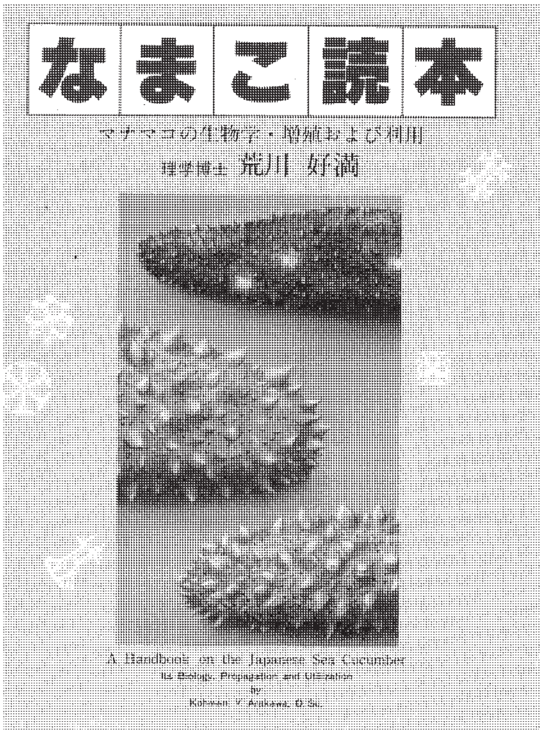
This Japanese book was published in March 1990 and consists of the following four chapters.

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**).

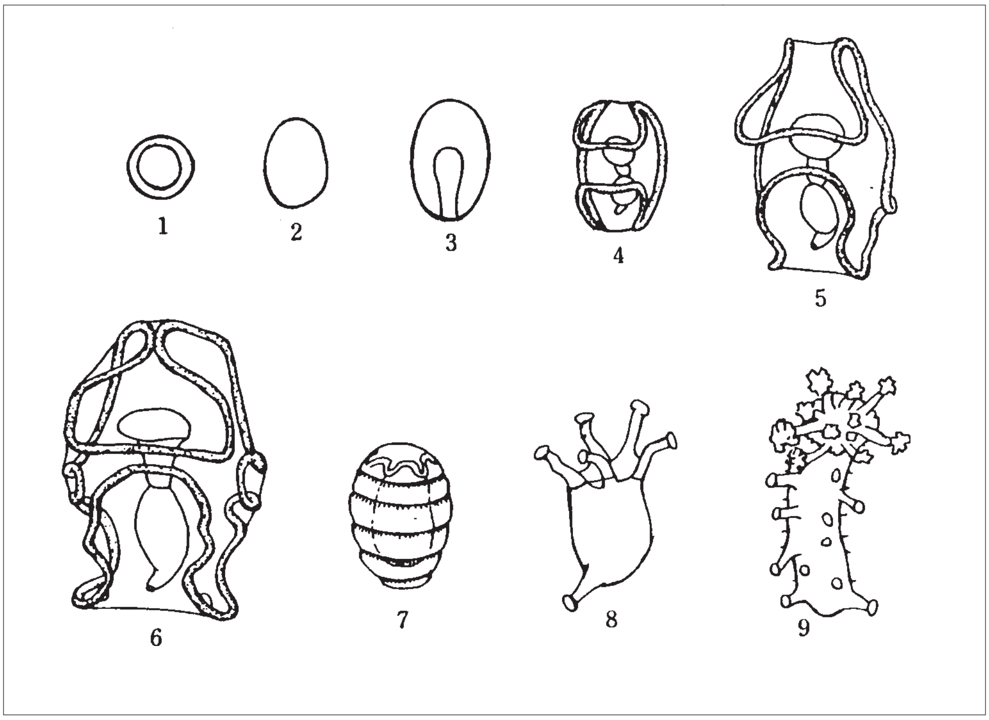
Aka and **Ao** are the most important morphs for commercial fishing. These colour morphs are distributed over a wide area of the north-eastern Pacific; from Sakhalin Island and Alsaka to Amami Island (Japan) and the east coast of China. The vertical distribution extends from the surface to 40 metres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

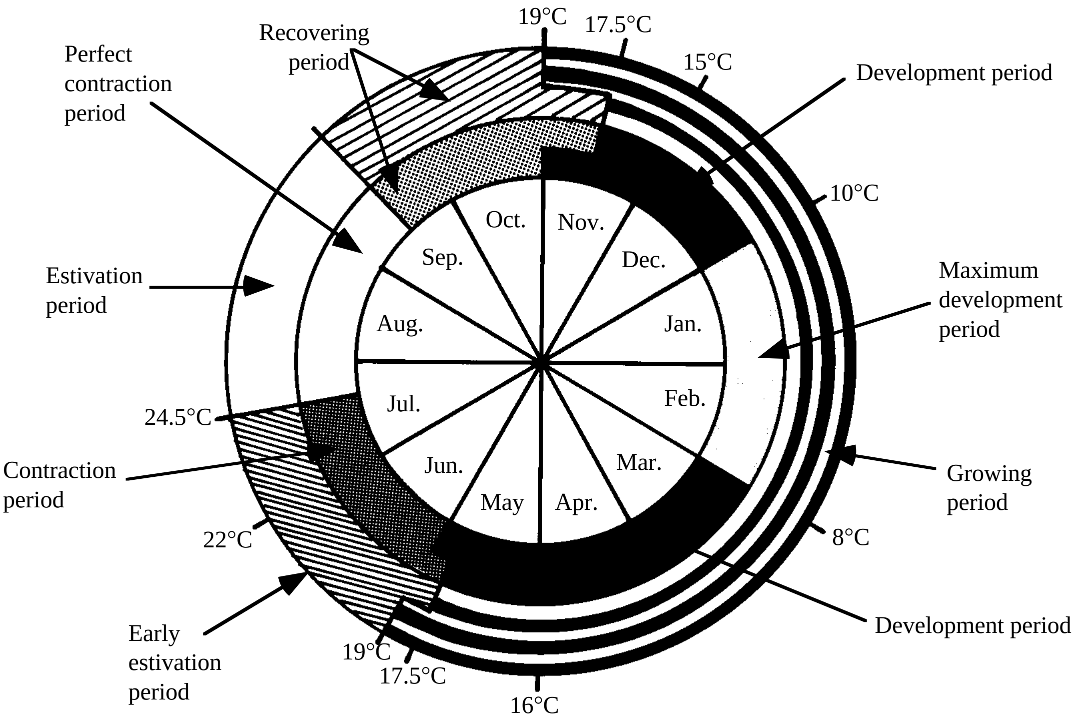
Time after fertilisation Day	Hrs	Min	Stage	Remarks
		0	fertilised egg	See figure 1 (1)
		25	releasing the 1st polar body	
		50	releasing the 2nd polar body	
	1	40	2 cells (1st cleavage)	See figure 1 (2)
	2	20	4 cells (2nd cleavage)	See figure 1 (3)
	3	0	8 cells (3rd cleavage)	
	14	0	blastula (200-210µ) 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.

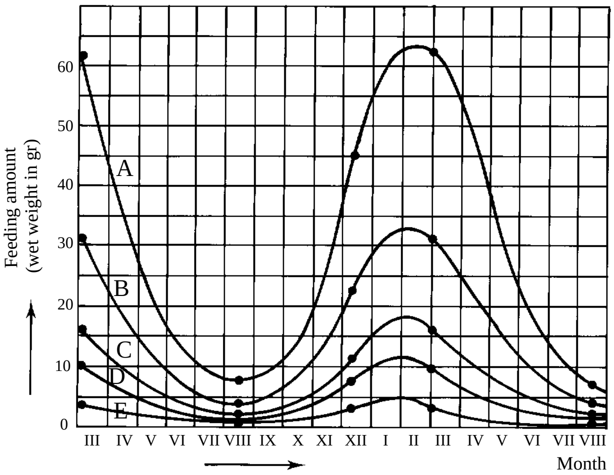


Somatic growth takes place in water temperatures less than 16—17°C and between the months of November and May. The table opposite gives a summary of the length and weight at ages 1 to 4 years.

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

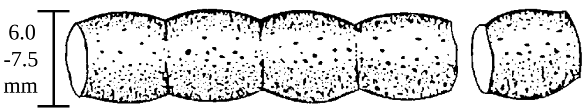
The monthly variation of feeding activity is shown in the following figure.



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.

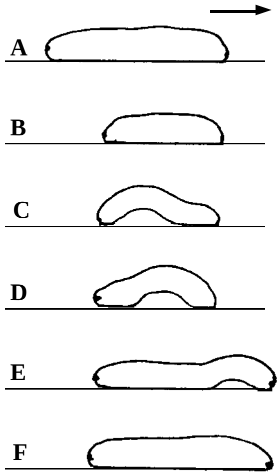


Scat of sea cucumber, 220mm in body length.

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

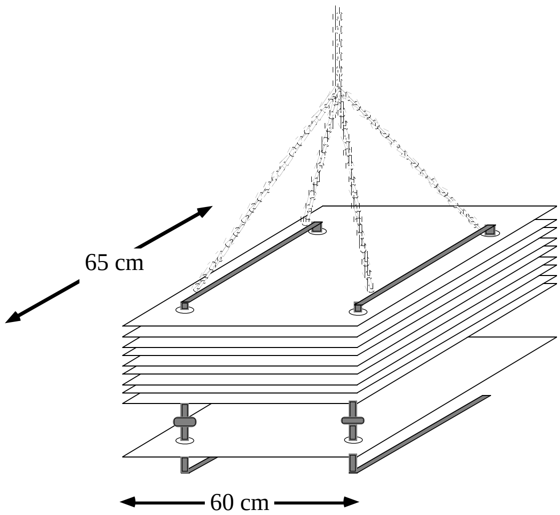
2 Propagation

2.1 Seed collection and rearing

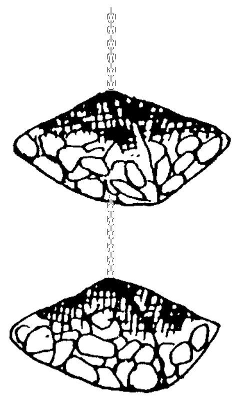
2.1.1 Natural seed collection and culture

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.

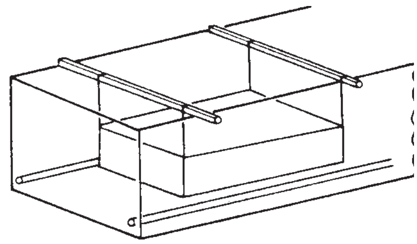
The best time to establish a seed collector is when the survival rate of doliolaria exceeds 70 per cent (see table on previous page). The corrugated sheets have to be set in the water parallel to the surface. During seed collecting, aeration of the water is critical, and an even distribution and insertion 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.

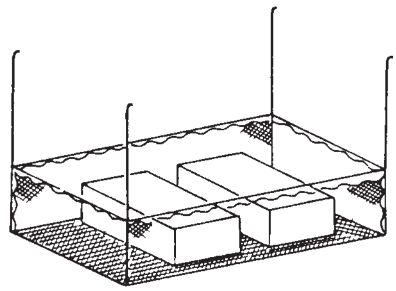
Juvenile rearing

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

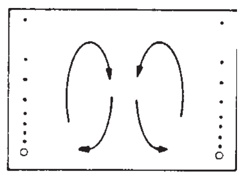
An initial feed (*Chaetoceros gracilis*) or frozen diatoms (*Melosira sp.*) of 1,200 litres (two million cells / cc) is necessary to produce 0.1 g of seed. Until 0.1 gram of seed has been produced, daily care has to be taken when feeding and moving the cage up and down for spreading feed and excrement. 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.



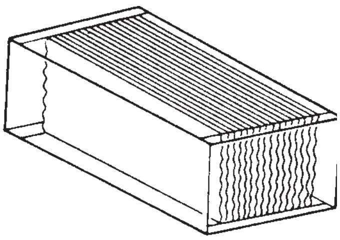
Hanging cage and 10 t concrete tank



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

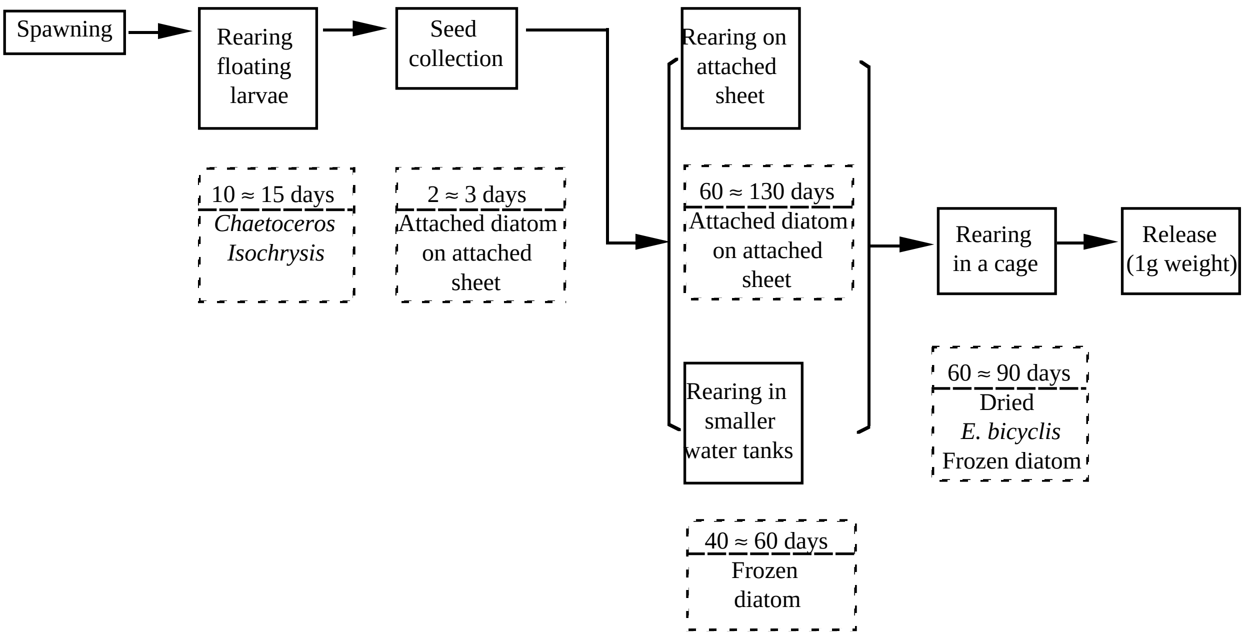
For intermediate culture, a plastic culture cage sealed by 1 mm meshed material is suspended (in the sea or in a tank). The cage should be suspended between sea surface and sea level. The intermediate culture schedule is shown in the opposite table.

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