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in Posyet Bay

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Growth rate and life span of *Stichopus japonicus* in Posyet Bay

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We have obtained data on the growth of *Stichopus japonicus* during experimental breeding of it in enclosures and during a study of changes in the weight composition of holothurians on the bottom of a body of water and on collectors with cultivated oysters. The life span of the sea-cucumber is also discussed.

Several papers have been devoted to the growth of *Stichopus japonicus* (Biryulina, Kozlov, 1971; Bregman, 1971a, 1971b). The data obtained by us on the growth of the young of this species have made it possible to correct some of the information presented in these papers.

Material and Method

The investigations were conducted in Minonosok and Novgorodskaya bays of Posyet Bay in the Sea of Japan from 1970 to 1981.

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The young of Stichopus japonicus were collected on special collectors made from the shells of the Yezo scallop, which were suspended in the water, or placed on the bottom or on a float of plastic tubes at a depth of 3-4 m. The growth of the sea cucumber was observed in enclosures consisting of a 40 x 40 cm wire frame covered with a grinding sieve with a 2-4 mm mesh. Not more than 10 sea-cucumbers were placed in each enclosure. The enclosures were suspended in the water on a horizontal cable extended across the bay. They were periodically cleared of encrusting organisms, and replaced when necessary. One enclosure with seven sea-cucumbers was kept in the water the longest (14 months), and not a single specimen died. The enclosures were examined every 1-2 months during the summer and autumn; they were not inspected during the winter and spring months. Sea-cucumbers collected from different biotopes and from these enclosures were dried with filter paper, and then weighed. Observations have shown that careful weighing and measurement have no negative effect on the behaviour and subsequent growth of the young.

Additional information about the growth of Stichopus japonicus juveniles was obtained during 1974-1981, while studying the encrusting organisms of the oysters cultivated in Novgorodskaya Bay. The larvae of the sea-cucumber settle quite well on the shells of oysters; the young do not leave them, as they feed on the biodeposits of the oysters. Because of this, the growth of Stichopus japonicus juveniles was traced throughout the growth cycle of the mollusks (22-25 months). There was no doubt that the sea-cucumbers

in a sample were of the same age, as the collectors had been set up in the water at the same time.

Results and Discussion

The periods of spawning and settling of Stichopus japonicus larvae are determined primarily by the temperature of the water. In 1971, it was 2-3^o lower (Centigrade scale) than in the same calendar period of the preceding year, and so the settling of the larvae began during the first ten-day period of August in 1970, and only during the third ten-day period of August in 1971. This affected the growth of the underyearlings (Table 1), the average body mass of which was lower in 1971, than during the same period in 1970. The observations on the settling of Stichopus japonicus larvae on oyster collectors in Novgorodskaya Bay have shown that it usually begins at the end of July--beginning of August, and ends toward the beginning of September. The density of the settled larvae varied extensively at different times; it amounted to 4-5 specimens/dm² of the collector surface in 1970, 1971, 1975, 1976 and 1979.

The high fluctuations (up to two orders of magnitude) in the body mass of sea-cucumbers from the youngest age groups (Table 1) were due to the prolonged period of larval settling. Because of this, the minimum values of the body mass of holothurians collected on the 2nd and 16th of September 1970 were similar, while their maximum values differed. (53)

Some of the Stichopus japonicus underyearlings taken from the collectors in the autumn of 1970 and several specimens from the bottom of the bay were placed in enclosures which were kept

in the water throughout the winter and spring up to the month of May. The average body mass of this group in May proved to be very small (429 mg). This indicates that the underyearlings of Stichopus japonicus grow very slowly during the winter. No significant difference has been noted in the growth rate of individuals living on different types of substrates and those developing in identical conditions. By the middle of August, i.e. a year after the settling of the larvae, the average body mass of the sea-cucumbers amounted to 708.0 mg (Table 2). One-year-old sea-cucumbers were found in July and August of 1970 on the collectors set out in 1969. The body mass of the majority of these specimens was also less than 1 g.

Table 1. Growth of underyearlings and juveniles of Stichopus japonicus on collectors

Date collected		Age (months)	Quantity	Body mass, g	
year	date			range	average
Minonosok Bay					
	15.VIII	0,5	150	0,00041—0,0403	0,0068
	2.IX	1,0	67	0,0023—0,0546	0,0105
1970	16.IX	1,5	272	0,0030—0,7000	0,0723
	16.X	2,5	73	0,0300—0,790	0,1830
	1—16.VIII	12	119	0,0160—2,670	0,3680
1971	4.X	1,2	176	0,0020—0,5800	0,0276
Novgorodskaya Bay					
	24.VII	12	11	0,150—3,00	0,70
1975	3.VIII	12,5	27	0,030—6,50	1,10
	4.IX	13,5	32	0,026—2,04	1,00
	4.IX	25	18	22,000—200,0	110,0
1976	10.IX	1,5	4	0,004—0,080	0,05
	25.V	22	28	— — —	1,25
1977	6.VII	11,5	1	— — —	0,50
	6.VII	23	4	— — —	12,5
1978	16.V	10	5	0,08—0,12	0,10
	16.V	22	3	3,00—5,20	4,23
1981	15.V	22	73	3,20—155,0	16,73

Table 2. Body mass of sea-cucumbers of different ages, collected from various substrates in Minonosok Bay (g)

Collected from:	1 year			2 years		
	quantity	range	average	quantity	range	average
Collectors	119	0.016-2.67	0.368	-	-	-
Enclosures	63	0.049-1.90	0.708	10	3.40-23.2	9.00
Raft	59	0.015-1.00	0.322	91	1.00-50.6	4.90
Bottom	16	0.030-1.75	0.509	8	2.40-8.7	3.90

After studying the structure of the sea-cucumbers collected in August 1971 from the float in the water and from under the rocks on the bottom of the bay, we were able to distinguish two size classes based on mass, and in the interval between these classes (0.8-1.0 g), we noted a marked decrease in numbers. These groups apparently corresponded to one- and two-year-olds (Table 2).

The correlation of our data with the information available on the growth rate of Stichopus japonicus has shown that the data of Bregman (1971a, 1971b), Biryulina and Kozlova (1971) coincide extremely well with our own data if the mass scale presented by these authors is adjusted one year to the right. Such congruence of data obtained by different researchers using different methods indicates that these data reflect a tendency that actually exists. The shift in the time scale is easy to explain, considering that the material for Biryulina and Kozlova was collected by divers from commercial stocks of the sea-cucumber, and so, naturally, the juveniles which keep away from the adults were not collected (as the authors themselves have noted). On the other hand, Bregman paid special attention to the collection of juveniles; however, the value given by him for the body mass of a year-old sea-cucumber

(35 g) is definitely overestimated as well. A comparison of his data with the information available on the growth rate of Stichopus japonicus off the coast of Japan (Okada, 1932; Fujimako, 1936-1937; Choe, 1963) is an indication of this. The growth rate given by these researchers for the sea-cucumber is significantly higher than the growth rate noted off the coast of Primor'ye (Maritime Territory). Nevertheless, the body mass of one-year-old holothurians as given by these authors is very high (from 0.9 to 15.5 g). (54)

According to our data (Tables 1 and 2), a one-year-old sea-cucumber under the most favourable conditions has a maximum body mass of not more than 3.0-6.5 g, but basically does not exceed 1 g. A body mass of 20-30 g can be acquired only by the age of 2. In the samples of sea-cucumbers taken from the valves of oysters cultivated in the water for a number of years, the values of body mass also lie within this range. For instance, the body mass of sea-cucumbers in Novgorodskaya Bay varied from 3.2 to 155 g during different years in 22-23-month-old specimens (average 12.2 g), and from 22 to 200 g (average 110 g) in 25-month-old specimens. In the colder Minonosok Bay, the body mass of two-year-olds varied from 1 to 50.6 g (average 5.2 g) (Table 1 and 2). Thus, Bregman's growth scale for Stichopus japonicus (1971a) should be adjusted at least one year to the right, while Biryulina and Kozlov's scale (1971) should be adjusted by two years. Consequently, the maximum life span of Stichopus japonicus will increase to 9-10 years. Thus, the growth of the sea-cucumber to sexual maturity is exponential, rather than parabolic.

The literature contains practically no data on the growth dynamics of the juveniles throughout the year. Our material has shown that the growth of the sea-cucumber is extremely irregular throughout the year. The most intensive growth of underyearlings, one-year-olds and two-year-olds is observed from the second half of August up to the first half of October (water temperature 23-12°C). On certain days in August and September, the daily average increase in body mass amounted to 84% in underyearlings, 12% in one-year-olds and 1.4% in two-year-olds. In June, July and October, this value amounted to 4-5% in underyearlings, and 1.0-1.5% in one-year-olds. The slowest growth in the sea-cucumber was observed at the end of autumn, in winter and in spring when the water temperature was below 12°C. During this period, the daily average growth in underyearlings and one-year-olds was equal to 0.6 and 0.5% respectively.

The growth rate of juveniles in enclosures was greatly influenced by their environment, specifically the depth at which the enclosures had been set up (Table 3). The greatest increase was

Table 3. Growth of juveniles of Stichopus japonicus at various depths in Minonosok Bay, 1971

Depth, m	Average body mass, g		Growth	
	17/VIII	3/X	g	%
2	0.784+0.50	3.930+2.7	3.146	401
4	0.699+0.65	1.306+1.0	0.707	101
6	0.811+0.56	1.481+1.1	0.670	83
8	0.724+0.46	1.817+1.4	1.093	153
10	0.647+0.43	1.062+0.7	0.415	66

observed at a small depth (about 2 m), and the lowest increase at the bottom (at a depth of 10 m). Since the surface layers of water in August and September are warmer than at the bottom, one can say that a higher water temperature is more conducive to the growth of young sea-cucumbers.

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