INTRODUCTION

Mussel culture is a well-established form of aquaculture in the USA.

Growth and population dynamics in mussels (Mytilus edulis L.) cultured in the White Sea

ARTICLE

Mytilus edulis L. cultured in the White Sea
Fig. 1. Map of the White Sea, showing the location of Chupa Inlet with the mussel culture area.

Spatfall and growth of young mussels takes place on substrata, which are suspended from rafts and can move vertically in the water. In autumn, before freezing-up, substrata are lowered 2 m to prevent freezing in the ice. In spring, after the ice floating, substrata are returned to the water surface.

In 1983 the first White Sea mussel culture farm was organized in Chupa Inlet near Cape Kartesh (66°20’N, 33°40’E) (near the White Sea Biological Station of the Zoological Institute) (Fig. 1). The average tidal current velocity in this area was 4 cm/s before the farm was established and 2–3 cm/s afterwards (Babkov and Kulakovski, 1988).

This article is devoted to the investigation of the growth of mussels in suspended culture in the White Sea as well as to the formation and development of mussel settlement on substrata of the mussel farm.

MATERIAL AND METHODS

The mussel culture farm occupied an area of about 100×100 m² and contained at the beginning 16 120 units of substrata which were nylon net bands 20 cm in width and 3 m in length. In autumn 1985 about 7000 substrata were transferred to the near-by harbour and the remainder, 9000 bands, were distributed over the released area. Mussel samples were collected in October–November annually from 1983 until 1988 at 9 stations within the farm. At each station, 10-cm sections of band were removed at depths of 0.5, 1.5 and 3.0 m. All mussels in the samples were measured to the nearest 0.1 mm. Mus-
sel number and biomass were obtained for each sample. Biomass and mean weight of mussels were estimated from the equation (Kulakowski and Sukhotin, 1986)

\[ W = 1.03 \times 10^{-4} L^{2.964} \]  

(1)

where \( W \) is live weight of mussels (g) and \( L \) is shell length (mm). Mortality coefficients were calculated from the formulae

\[ m = (\ln N_1 - \ln N_2) / (t_2 - t_1) \]  

(2)

where \( N_1 \) and \( N_2 \) are the mean numbers of mussels at time \( t_1 \) and \( t_2 \), respectively.

To study growth, mussels were collected from the mussel farm as mentioned, from separate bands from the nearest harbour (Kruglaya Harbour), and from dense subtidal (2-m depth) and tidal mussel populations in the vicinity. Growth was reconstructed by counting and measuring the winter rings formed on the shell when growth ceases. The data obtained were formalized using a linear modification of the Von Bertalanffy equation (Walford, 1946)

\[ L_t = L_\infty (1 - \exp^{-k(t-t_0)}) \]  

(3)

where \( L_t \) is shell length (mm) at time \( t \) (year), and \( L_\infty, k, t_0 \) are constants.

Seasonal changes in growth rate have been studied in caged mussels. Cages situated at a depth of 1.5 m contained 94 individually marked molluscs of different ages. After periodic measurements of the mussels during the year, a growth curve was reconstructed, taking into the consideration the average monthly water temperature (Babkov, 1982). The annual sum of day-degrees in the region of the mussel farm was 1932.2. To incorporate temperature in equation (3) instead of \( t \), accumulated values of corresponding sums of day-degrees were introduced (Usin, 1965)

\[ L_D = L_\infty (1 - \exp^{-k'(D-D_0)}) \]  

(4)

where \( k' = k / D_y, D_0 = D_y \times t_0, D_y \) is the annual sum of day-degrees, \( D \) is the sum of day-degrees since growth began, \( D_0, L_\infty, k' \) are constants. It has been accepted that \( L_\infty \) does not depend on temperature. A temperature of 0.9°C was taken as the lowest temperature when mussel growth stops.

Equations of growth in terms of weight were calculated using equations (3) and (1):

\[ W_t = W_\infty (1 - \exp^{-k(t-t_0)})^{2.964} \]  

(5)

where \( W_t \) is mussel weight (g) at time \( t \) (year), \( W_\infty, k, t_0 \) are constants, 2.964 is the regression coefficient from (1).
TABLE 1

The parameters of growth equations for the White Sea mussels in the investigated habitats

<table>
<thead>
<tr>
<th>Biotope</th>
<th>( L_\infty )</th>
<th>( W_\infty )</th>
<th>( k )</th>
<th>( t_0 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subtidal population</td>
<td>77.1</td>
<td>38.1</td>
<td>0.140</td>
<td>0.611</td>
</tr>
<tr>
<td>Intertidal population</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>low level</td>
<td>53.7</td>
<td>9.4</td>
<td>0.182</td>
<td>0.524</td>
</tr>
<tr>
<td>middle level</td>
<td>54.8</td>
<td>7.6</td>
<td>0.116</td>
<td>0.293</td>
</tr>
<tr>
<td>high level</td>
<td>33.4</td>
<td>3.7</td>
<td>0.205</td>
<td>0.397</td>
</tr>
<tr>
<td>Artificial substrata</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kruglaya Harbour</td>
<td>92.9</td>
<td>70.3</td>
<td>0.197</td>
<td>0.741</td>
</tr>
<tr>
<td>Mussel culture farm</td>
<td>144.0</td>
<td>257.2</td>
<td>0.089</td>
<td>0.758</td>
</tr>
</tbody>
</table>

Note: \( L_\infty \), \( W_\infty \), \( k \), \( t_0 \) are parameters of equations (1) and (4).

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**Fig. 2.** Length growth curves of mussels from different populations. 1, from the separate bands from Kruglaya Harbour \((n=72)\); 2, from the culture farm near Cape Kartesh \((n=27)\); 3, from the subtidal population \((n=42)\); 4, 5, 6, from low, middle and high levels of the tidal zone, respectively \((n=40\) for each case). Vertical bars: confidence limits at \( P < 0.05 \).
RESULTS

Growth of mussels
The parameters of the Von Bertalanffy equations, describing growth of mussels in the habitats studied, are given in Table 1. Graphics are shown in Fig. 2. The growth rate of mussels within the mussel culture farm appears to be lower than that of mussels from the separate bands in Kruglaya Harbour. This likely was caused by densities being too high in the farm during the first 2 years (eventually 7000 substrata were removed). On the whole, mussels in suspended culture grew considerably faster than those from the subtidal and the tidal populations (Fig. 2). The length of cultured mussels of the first year class was 1.4 and of the fifth year class was 1.7 times as much as the length of the subtidal individuals. Growth of mussels from the subtidal population was

Fig. 3. Length growth rate of the cultured mussels. A: 1, mean values (with s.e.) of 1, 2, 3 year age classes \((n=57)\); 2, mean values (with s.e.) of 4, 5, 6 year age classes \((n=37)\). B: sea water temperature during the experiment.
greater than that of mussels at all levels of the tidal zone, where the growth rate was lower in mussels inhabiting the upper levels.

In our experiments the growth rate of caged mussels was well correlated with seasonal changes of water temperature (Fig. 3). The maximal growth rate, 0.20–0.26 mm/day, was observed in younger mussels (1, 2, 3 year age classes) at the end of July and the beginning of August when water temperatures were +17 to +19°C. Older mussels (4, 5, 6 year class) had a growth rate in the same period of 0.04–0.08 mm/day. As water temperature decreased, the mussel growth rate also decreased to minimal values of about 0.001 mm/day when the area was covered with ice. During 6 months from November until April length increment of mussels was about 7% of the annual value. In the warmest months (July and August) it reached 45% of the annual value.

On the basis of the data on individual growth of mussels, linear growth of caged mussels of 2–7 year age classes was modelled. The Von Bertalanffy equation is

\[ L_t = 154.4(1 - \exp^{-0.990(t - 0.775)}) \]  

(6)

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**Fig. 4.** Total weight growth curves of mussels from different populations. 1, from the separate bands from Kruglaya Harbour; 2, from the culture farm near Cape Kartesh; 3, from the subtidal population; 4, 5, 6, from low, middle and high levels of the tidal zone, respectively.
This equation statistically does not differ from the equations of the cultured mussels (Table 1). This fact indicates that the growth conditions in net cages corresponded to the natural ones. After including temperature in equation (6) we get the following:

\[ L_D = 154.4 \left(1 - \exp\left(-0.0000467D - 0.070\right)\right) \]  

(7)

It was assumed that growth began on 30 August (the beginning of measurements).

Constants of mussel weight growth equations are given in Table 1. Growth

<table>
<thead>
<tr>
<th>Month year</th>
<th>Age (years)</th>
<th>Mean length (mm)</th>
<th>Mean density (ind/m)</th>
<th>Mean density %</th>
<th>Mean biomass (g/m)</th>
<th>Mean biomass %</th>
</tr>
</thead>
<tbody>
<tr>
<td>November 1983</td>
<td>0+</td>
<td>1.3(0.02)</td>
<td>85230(27780)</td>
<td>100</td>
<td>320(77)</td>
<td>100</td>
</tr>
<tr>
<td>October 1984</td>
<td>0+</td>
<td>1.5(0.02)</td>
<td>1380(350)</td>
<td>15</td>
<td>1(0.5)</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>1+</td>
<td>8.3(0.08)</td>
<td>6800(750)</td>
<td>85</td>
<td>2710(217)</td>
<td>100</td>
</tr>
<tr>
<td>November 1985</td>
<td>0+</td>
<td>2.2(0.08)</td>
<td>95(20)</td>
<td>2</td>
<td>0.2(0.1)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1+</td>
<td>6.6(0.13)</td>
<td>815(90)</td>
<td>18</td>
<td>55(11)</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>2+</td>
<td>17.4(0.06)</td>
<td>3490(227)</td>
<td>79</td>
<td>3320(486)</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>3+,4+</td>
<td>40.4(0.09)</td>
<td>45(10)</td>
<td>1</td>
<td>300(114)</td>
<td>8</td>
</tr>
<tr>
<td>October 1986</td>
<td>0+</td>
<td>1.6(0.06)</td>
<td>95(40)</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1+</td>
<td>3.5(0.37)</td>
<td>85(20)</td>
<td>3</td>
<td>0.7(0.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+</td>
<td>12.9(0.51)</td>
<td>115(30)</td>
<td>4</td>
<td>50(16)</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>3+</td>
<td>29.0(0.11)</td>
<td>2610(180)</td>
<td>88</td>
<td>9470(962)</td>
<td>93.5</td>
</tr>
<tr>
<td></td>
<td>4+,5+</td>
<td>46.0(0.99)</td>
<td>60(10)</td>
<td>2</td>
<td>595(105)</td>
<td>6</td>
</tr>
<tr>
<td>October 1987</td>
<td>0+</td>
<td>0.9(0.02)</td>
<td>6310(2050)</td>
<td>80</td>
<td>0.4(0.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1+</td>
<td>2.4(0.10)</td>
<td>220(70)</td>
<td>3</td>
<td>1(0.5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+</td>
<td>6.2(0.16)</td>
<td>70(20)</td>
<td>1</td>
<td>51(1.5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3+</td>
<td>12.6(0.50)</td>
<td>65(10)</td>
<td>1</td>
<td>40(7)</td>
<td>0.5</td>
</tr>
<tr>
<td></td>
<td>4+</td>
<td>39.9(0.89)</td>
<td>1090(100)</td>
<td>14</td>
<td>7505(620)</td>
<td>91.5</td>
</tr>
<tr>
<td></td>
<td>5+,6+</td>
<td>56.8(1.00)</td>
<td>40(10)</td>
<td>1</td>
<td>645(166)</td>
<td>8</td>
</tr>
<tr>
<td>November 1988</td>
<td>0+</td>
<td>1.3(0.02)</td>
<td>1939(360)</td>
<td>60</td>
<td>0.7(0.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1+</td>
<td>5.9(0.33)</td>
<td>320(90)</td>
<td>10</td>
<td>18(5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2+</td>
<td>15.6(0.55)</td>
<td>150(40)</td>
<td>5</td>
<td>78(25)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3+</td>
<td>25.1(1.12)</td>
<td>70(20)</td>
<td>2</td>
<td>120(26)</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>4+</td>
<td>39.9(0.72)</td>
<td>100(30)</td>
<td>3</td>
<td>586(196)</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>5+</td>
<td>54.0(0.30)</td>
<td>590(50)</td>
<td>19</td>
<td>7808(849)</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>6+,7+</td>
<td>59.5(3.41)</td>
<td>20(5)</td>
<td>1</td>
<td>337(109)</td>
<td>4</td>
</tr>
</tbody>
</table>

Note: the standard errors of mean values are given in brackets (number of samples n = 27).
curves are shown in Fig. 4. Weight growth curves have a sigmoid form and asymptotically approach $W_\infty$. Cultured mussels had a significantly higher growth rate than those from benthic populations. Five-year-old molluscs from the bands were 3.5 times heavier than the benthic mussels of the same age.

**Population dynamics and age/size structure**

Nylon net bands for spat collection were put into the sea in July 1983. In November of the same year, all young mussels settled on bands were divided into two main size groups, referred to as "slow growing" (SG) (mean length 1.2 mm) and "fast growing" (FG) (mean length 3.1 mm). These two groups were well distinguished in later years. Only in the 4th–5th year did the border between these groups become less distinct.

Mussel settlement on the already colonized substrata was rather insignificant. In 1984, 0-year mussels constituted 15% of the total mussel number. In 1985 and 1986 they accounted for only 2 and 3%, respectively (Table 2). In 1987 mass spat settlement on substrata occurred (about 81% of total number). In 1988 the 0-year class mussels also dominated in density. Variations in density of the main mussel generation (settled in 1983) are presented in Fig. 5.
Mortality was maximal in the first year after settlement. Thus, by the autumn of 1984 only 4% of the initial mussel number remained on the bands. After the second year the mussel density became two times lower. Further decreases in abundance was insignificant and during the fourth and the fifth years there was a noticeable drop in the number of main age class mussels (Table 2). Probably, the mass spat settlement in the fourth year was related to the decrease in the number of large mussels during the same year. The mortality coefficient \( m \) of the main generation mussels was not constant through the period of observation, but it changed significantly from year to year (Fig. 6). A maximal value \( m = 3.3 \) was observed in the first year. Then \( m \) decreased to 0.3 and in the fourth and fifth years it again increased to 0.6–0.8.

Changes in abundance of FG and SG mussels were different. At the age of 0+ and 1+ SG mussels predominated and accounted for 80 and 61% of the total age class number, respectively (Table 3). In the second year the correlation between the abundance of these two groups became reversed, that is
TABLE 3

Some characteristics of the main generation of mussels on the beds

<table>
<thead>
<tr>
<th>Date Age (year)</th>
<th>Group</th>
<th>Mean length (mm)</th>
<th>Mean density (ind/m)</th>
<th>Mean density (%)</th>
<th>Mean biomass (g/m²)</th>
<th>Mean biomass (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983 0+</td>
<td>SG</td>
<td>1.2(0.07)</td>
<td>148180(27030)</td>
<td>80</td>
<td>60(14)</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>FG</td>
<td>3.1(0.17)</td>
<td>37050(5160)</td>
<td>20</td>
<td>260(62)</td>
<td>81</td>
</tr>
<tr>
<td>1984 1+</td>
<td>SG</td>
<td>3.1(0.04)</td>
<td>4150(440)</td>
<td>61</td>
<td>85(15)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>FG</td>
<td>18.0(0.14)</td>
<td>2650(390)</td>
<td>39</td>
<td>2080(333)</td>
<td>96</td>
</tr>
<tr>
<td>1985 2+</td>
<td>SG</td>
<td>8.1(0.06)</td>
<td>1330(130)</td>
<td>38</td>
<td>100(18)</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>FG</td>
<td>23.1(0.10)</td>
<td>2160(130)</td>
<td>62</td>
<td>3220(481)</td>
<td>97</td>
</tr>
<tr>
<td>1986 3+</td>
<td>SG</td>
<td>12.7(0.19)</td>
<td>590(70)</td>
<td>23</td>
<td>225(69)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>FG</td>
<td>33.8(0.13)</td>
<td>2030(160)</td>
<td>77</td>
<td>9245(942)</td>
<td>98</td>
</tr>
<tr>
<td>1986 4+</td>
<td>SG</td>
<td>23.1(0.72)</td>
<td>320(80)</td>
<td>29</td>
<td>404(106)</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>FG</td>
<td>46.9(1.22)</td>
<td>770(60)</td>
<td>71</td>
<td>7103(611)</td>
<td>95</td>
</tr>
<tr>
<td>1987 5+</td>
<td>SG</td>
<td>35.8(0.75)</td>
<td>30(10)</td>
<td>5</td>
<td>128(52)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>FG</td>
<td>54.8(0.23)</td>
<td>570(50)</td>
<td>95</td>
<td>7707(832)</td>
<td>98</td>
</tr>
</tbody>
</table>

Note: the standard errors of mean values are given in brackets (number of samples n=27).

Fig. 7. Biomass of the main generation mussels. 1, FG mussels; 2, SG mussels.

the FG mussels began to dominate. The percentage of SG mussels continued to decline. This process became slower in the fourth year, and at the end of the fifth year on the substrata the SG group was only 5% of the total number of the main age class. Thus, mortality of mussels of the main generation occurred chiefly at the cost of SG mussels.
Biomass

Within 3 years on the substrata, mussel biomass increased from 0.3 up to 10.1 kg/m (Table 2). More than 90% of this value was produced by the main age class mussels. During the period of observation (except for the first autumn after spat settlement) the biomass of SG mussels did not exceed 5% of the total age class biomass (Table 3). In the fourth year the biomass decreased by 20% due to the loss of large mussels from the bands as mentioned above, which took place after the biomass reached more than 10 kg/m (Fig. 7).

DISCUSSION

The lower growth rate of littoral mussels compared with sublittoral ones is a well-known phenomenon (Savilov, 1953; Baird, 1966; Hosomi, 1966; Seed, 1969; and others). The intensification of mussel growth in suspended culture in the White Sea proves this regularity, noted in other regions (Reznichenko and Soldatova, 1976; Rodhouse et al., 1984; Fréchet and Bourget, 1985). It is considered that the reasons for enhanced growth in a pelagic habitat are the better food supply compared with the benthos, reduced disturbance by wave action and changes in the quality of food.

Our data are in good agreement with the statement that in boreal and arctic seas mussel growth rate depends mainly on water temperature due to the marked distinction between the summer and winter temperatures (Sadykhova, 1971; Theisen, 1973). The trophic factor there is not so important as it is in relatively warm waters (Page and Hubbard, 1987; Thompson and Nichols, 1988). The growth rate of mussels of all age classes showed a temporal decrease at the end of July. This could be accounted for by the depressing influence of a high temperature (surface water layer warmed up to +20°) and by partial spawning.

In order to reach 50 mm in length, White Sea mussels in suspended culture must grow for about four summer seasons i.e. to accumulate 8000–9000 day-degrees (depending on conditions within the mussel farm). The mussels grow for nearly the same period of time before reaching commercial size in North Norway (Wallace, 1980), and about 3 years in Canada (Thompson, 1984). In southern parts of the Mytilus edulis distribution range their growth rate is much higher (Perez and Roman, 1979; and others).

The growth in weight of the White Sea mussels has the same regularities as recorded for other bivalves. Inflection of the weight growth curves of the investigated mussels occurred at the age of 5–7.5 years and at a weight of about 28–34% of $W_\infty$. In freshwater bivalves, values of mollusc weight at the inflection point ($W_b$) of the growth curve were related to $W_\infty$ by the formula $W_b = 0.296 + W_\infty$ (Alimov, 1981), which is close to data obtained for the White Sea mussels.
The existence of two (or more) size groups within a single age class in mussels is a very common phenomenon. In the regions where mussel spawning occurs twice a year, spat settled during the year form two subgenerations – the autumn and the spring one – which differ in their life conditions (Ceccherelli and Rossi, 1984; Zlatanova, 1984; Konsulova, 1988). In those places where mussels spawn once a year, the appearance of various size groups in a single age class is of another nature. In Kandalaksha Bay, the White Sea, mussel spawning may be prolonged, i.e. it may last 1 month or even longer depending on the temperature conditions in a given year (Maximovitch, 1985). Thus, spat settlement may also be prolonged. Besides, secondary settlement is typical for mussels (Bayne, 1964). It may be supposed that the discrete structure of the mussel population on the bands is connected with the asynchrony of spat settlement. Mussels settled earlier are able to grow more before the winter comes, and, due to this, the next year they have advantages in intraspecific competition over the smaller mussels. Similar “stratification” was observed in other regions both in wild (Kautsky, 1982) and in cultured mussel populations (Theisen, 1968; Rodhouse et al., 1985).

The other reason for the existence of well defined size groups of mussels within one age class lies in genetic variation of the populations (Zhukovskaya et al., 1987; Balakirev, 1987). There are many papers in which the connection of mollusc growth rate with individual heterozygosity is stressed (Koehn and Gaffney, 1984; Diehl and Koehn, 1985; and others). However, special investigations are needed to prove genetic differences between FG and SG mussels on the bands in the White Sea.

Every year after the farm had been established, new settled mussels appeared on the bands. Moreover, mussels were observed on the bands which had drifted there on detached algae from the shore populations. The size and age of such mussels were considerably variable and could exceed those of the main generation. Mussels settled in 1983 prevented spat settlement in the following years, while during the fourth year there was a considerable loss of large mussels. In the same year, due to newly available habitat, a great number of young mussels settled on the substrata. A similar phenomenon was recorded in experimental mussel culture in the White Sea (Sukhotin, 1985). The presented data show that the investigated mussel population is characterized by a cyclical development which is observed for benthic mussel populations (Lukanin et al., 1986; Lukanin, 1989).

Changes in relative density of SG and FG mussels in favour of the latter demonstrate the differences in mortality rates in these two groups. Mortality coefficient \( m \) estimated for mussels in both groups (Fig. 6) for the whole period (except for the fourth year) was higher in SG mussels. Thus, the mortality of mussels of the main generation occurs mainly at the cost of SG mussels. The drop in mussel number in the fourth year concerned mainly the large mussels from the FG group (\( m \) in this period was higher in FG mussels). In
the fifth year almost all SG mussels were eliminated from the bands (Fig. 5).
We suppose that mortality of large mussels in the fourth year led to a consider-
able weakening of intraspecific competition on the substrata. Earlier SG mussels were situated near the band, covered on the outside by aggregations of large mussels. After the disappearance of some of these aggregations, small mussels gained a larger food supply and spatial freedom. Under these conditions the mussels showed a compensatory growth pattern. The largest mussels from the SG group became comparable in size with FG mussels. In many samples SG and FG groups became statistically indistinguishable. In this case the coefficient \( m \) of SG mussels, which sharply increased, did not reflect real mortality, but the transition of mussels to the other size group.

The increase in biomass of mussels of the main generation was well approxi-
mated by a parabolic equation

\[
B = 1.08t^2 - 0.903t + 0.763,
\]

where \( B \) is mussel biomass (kg/m) and \( t \) is time (years). A similar relation was characteristic of FG mussels. After the second year a considerable addition in biomass (4–8%) was contributed by mussels which were older than the main generation. The loss mentioned earlier occurred after the biomass reached more than 10 kg/m. Probably, heavy mussel aggregations simply dropped off due to their own weight, because the bands had no device preventing this.

A similar situation was observed in mussel aquaculture in western Sweden (Loo and Rosenberg, 1983). After the biomass had reached 8–8.5 kg/m it decreased by 15%. Mussel biomass after cultivation in the Irish Sea for 18 months before harvesting was about 5 kg/m (Rodhouse et al., 1985). \( M. galloprenicialis \) cultured in the Kerch Strait of the Black Sea reached a biomass of 10 kg/m for a cultivation period of 1.5 years (Zolotnitsky, 1987). A drop in biomass as a result of mortality of large molluscs was also recorded in natural mussel populations (Lukanin, 1989).

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