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PROGNOSIS FOR MUSSEL FARMING INFLUENCE ON THE ENVIRONMENT BASING ON THE MUSSEL ENERGY BUDGET

Abstract

Functional characteristics of experimental mussel farming are evaluated based on qualitative data for mussel energetic balance. Rates of excretion and substance consumption by mussels during their cultivation are defined. Peculiarities of marifarm impacts on the environment are discussed.

INTRODUCTION

Due to mussel mariculture farming organization at the Black Sea the task to prognose mussel mariculture influence on coastal ecosystem became actual.

Mussel impact on the environment is mainly caused by the consumption and release processes of suspended and dissolved organic matter. To quantify them is possible while studying energetic budget of individual mussels and of all mussels at the whole mariculture farming.

MATERIAL and METHODS

Researching was performed during 1983-1988 at the experimental mussel mariculture farm organized by the Institute of Biology of Southern Seas and located 40 km off Sevastopol. Technical characteristics for the farming is given in the present publication.

The growth and reproduction of mussels were studied by scientists of the foregoing Institute. The following parameters were used: linear accretion, analysis of gonad state and seasonal dynamics in the mussel's soft tissues (Ivanov et al., 1989). Oxygen consumption was assessed through equations suggested by V.D. Braiko and S.S. Derechkewich (1978). Organic matter content in a shell was defined by A.F. Kozintsev (1989).

Ration value was calculated as energy needed to rehabilitate all losses for body building, synthesis of shell organic substance, reproduction and respiration. Assimilation efficiency was taken as 75% (Ivanov et al., 1989).

In the given paper rough excretion rates of dissolved organic substances were used. They were determined by scientists experimenting with *Mytilus edulis* (Bayne et al., 1976; Golovkin et al., 1979; Kautsky and Wallentinus, 1980).

RESULTS and DISCUSSION

Periods of mussel culturing to commercial size (more than 49 mm) durated 18 months at the experimental mussel marifarm. Data on mussel growth, consumption and excretion are represented in Table 1. All values are given per one specimen. Mussel growth on collectors depended on many factors (Ivanov et al., 1989): seawater temperature, weight and age of a mollusc, genotype, feeding quantiative and qualitative content, mollusc physiology - a stage in reproductive cycle, dissolved oxygen concentration, mollusc place in a cluster, etc. Conditions for *Mytilus galloprovincialis* maximum growth (to 0.48 mm a day) are the following: water temperature 15-16°C; food concentration to 4-6 mg/l; juveniles - from spring generation; species phenetype - blackviolet specimens; water salinity 15-20%; oxygen saturation not less than 80%; mollusc gonads in state of rest.

Organic substance high content in shells is an essential argument to shell using as food supplements.

TABLE 1

GROWTH, CONSUMPTION AND SUBSTANCE EXCRETION BY MUSSELS CULTURING AT EXPERIMENTAL MARIFARMING

	1987									1988									
Watch period / months	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VII	IX	X
Length, mm	I	5	9.5	15	20	24	27.5	29.5	31.5	32.5	34	35.5	37	39.5	43	46	48	49	50
Wet weight, g	–	0.028	0.146	0.480	1.014	1.629	2.320	2.785	3.303	3.582	4.028	4.507	5.019	5.948	7.418	8.839	9.874	10.418	10.979
Body dry weight, g	–	0.00008	0.00040	0.01256	0.0258	0.0408	0.0574	0.0685	0.0807	0.0873	0.0978	0.1089	0.1209	0.1424	0.1762	0.2086	0.2322	0.2445	0.2572
Accretion, cal/d	–	0.0133	0.0533	2.0266	2.2117	2.4967	2.7683	1.8383	2.0450	1.0967	1.7432	1.8633	1.9867	3.5883	5.6316	5.4033	3.9333	2.0499	2.1133
Shell mass, g	–	0.0094	0.0498	0.1633	0.3452	0.5545	0.7900	0.9481	1.1245	1.2196	1.3715	1.5344	1.7087	2.0253	2.5255	3.0096	3.3617	3.5469	3.7382
Shell organic substance accretion, cal/d	–	0.0467	0.2033	0.5667	0.9167	1.0333	1.1833	0.7833	0.8883	0.4778	0.7500	0.8167	0.8833	1.5833	2.5000	2.3670	1.8000	0.9333	0.9500
Summerized accretion, cal/d	–	0.060	0.2566	2.5933	3.1284	3.5300	3.9520	2.6230	2.9333	1.5745	2.4933	2.8700	2.8700	5.1716	8.1160	7.7703	5.7330	2.9830	3.0633
Respiration, cal/d	–	0.322	1.201	3.311	5.237	7.006	7.461	8.593	9.811	10.449	11.444	17.948	19.539	22.343	18.321	19.774	21.169	21.875	24.907
Ration. cal/d	–	0.639	2.439	10.000	14.229	17.977	19.572	19.328	21.967	20.813	27.077	35.307	38.358	47.013	45.435	47.483	46.558	43.225	45.256
Faeces, cal/d	–	0.192	0.732	3.000	4.269	5.393	5.872	5.798	6.590	6.244	8.123	10.592	11.507	14.104	13.631	14.245	13.967	12.968	13.577
Ration, mg/d	–	0.133	0.508	2.083	2.964	3.745	4.078	4.027	4.576	4.336	5.641	7.356	7.991	9.794	9.466	9.892	9.700	9.005	9.428
Excretion NH_4 - N, mg/d	–	0.257	0.960	16.037	28.903	42.000	55.500	64.080	73.320	78.171	85.742	93.684	101.971	116.582	138.744	159.27	173.84	181.33	189.00
Dissolved organic substance excretion, mg/d	–	0.011	0.042	0.172	0.245	0.310	0.337	0.333	0.379	0.359	0.467	0.609	0.661	0.811	0.783	0.818	0.802	0.745	0.780
Excretion N_{org}, mg/d	–	0.00017	0.00063	0.0026	0.0037	0.0047	0.0051	0.0051	0.0057	0.0054	0.007	0.0092	0.0099	0.012	0.012	0.012	0.012	0.011	0.012
Excretion P_{org}, mg/d	–	0.00002	0.000084	0.00034	0.00049	0.00062	0.00067	0.00067	0.00076	0.00072	0.00093	0.0012	0.0013	0.0016	0.0016	0.0016	0.0016	0.0015	0.0016
Excretioni Si, mg/d	–	0.018	0.0067	0.028	0.039	0.050	0.054	0.053	0.061	0.057	0.075	0.097	0.106	0.130	0.125	0.131	0.128	0.119	0.125
Excretion PO_4-P, mg/d	–	0.0096	0.192	6.632	16.738	18.609	11.025	8.214	6.856	5.238	2.346	3.922	7.252	17.087	84.566	110.140	150.472	111.493	49.382

Mussel respiration rate also depended on its physiological state which was in association with year season. The highest level for blacksea mussel metabolism was revealed in spring at relatively high temperatures. That was linked with gametogenesis (Braiko and Derechkewich, 1978). The summer temperature increase was not followed with energy exchange enhancement. In contrast, the latter lessening was watched.

From ecological and geochemical viewpoints one of the most significant factors- indicators of mussel settlement functioning was water filtration and consumption of suspended organic substances. During the cultivation period mussel filtration rate increased from shares of a liter to 25 liters a day (Table 2).

Known that in the region where molluscs were cultivated, especially with their high density for example, to 270 kg oysters per sq.m (Mariojouls, 1987), and with limited water exchange (Sornin, 1981, 1986) there was high water enrichment in suspended and dissolved organic substances noted. The suspended substance sedimented forming biodeposition. This modified sediment properties and benthos content (Kraeuter, 1976; Tenore et al., 1982).

The aquatoria with experimental farm had intensive water exchange and rare mytiliculture due to which biodeposit accumulation was not noticed. Phytoplankton consumption rates by mussels were defined basing on the existing data showing phytoplankton concentration at an aquafarm and water filtration rates. The obtained values were compared with mollusc nutrient demands, that allowed to evaluate a phytoplankton role in mussel feeding (Table 2). The phytoplankton share in food made from 1.2 up to 96%. Consumption rate of organic substances by different-aged mussels changed from 4 to 300 mg/mo within different seasons, its excretion with faeces was 1.2-90 mg/mo (Table 2). For 18 months one cultured mussel consumed 3.19 g of dry organic substance and excreted 0.96 g.

Based on mussel energy budget date (Table 1) it was calculated that the farming of 100 t mussel capacity would consume 29 t of dry suspended organic substance and release with faeces 8.7 t during the cultivation process. At the end of the latter the consumption rate would reach 88.4 kg/d, excretions 26.5 kg/d. The given marifarm housed 1 ha so maximum density of sedimented faeces would be 2.6 g/m2/d of dry substance. At the end of the cultivation consumption rates of food with main chemical elements would average 35.3 kg C/d; 5.3 kg N/d; 0.33 kg P/d.

In the process of metabolism mussels released dissolved nitrogen and phosphor- containing organic and mineral compounds. Approximate number for dissolved substance release was: Norg till 0.109 kg/d; Porg - 0.015; Si - 1.193; NH4 - N - 1.72. If to calculate per volume of the filtered water by mussels the data will be: 0.522 mg Norg/l; 0.070 Porg/l; 5.695 Si/l; 8.21 mg NH4 - N/l.

The former experience regarding mussel mariculture farming showed the notable influence of mariculture on plankton and bottom biocenosis (Kraueter, 1926; Galkina, 1975, 1985; Golikov and Skarlato, 1979; Kautsky et al., 1980; Tenore et al., 1982; Kulakovsky et al., 1983; Sornin, 1986). More than 70% of dissolved organic substance excreted by mussels were compounds which molecular weights did not exceed 700 (Galkina, 1985) and therefore were relatively easy included into metabolism of planktonic community. Besides organic substances mussels released biogenic salts stimulating phytoplankton growth. Concentration and primary production of phytoplankton were one order higher in region with mariculture farming (Kulakovsky et al., 1983).

Biodeposit affected bottom habitats depended on substance sedimentation and mineralization rates. Benthos number increase was marked with moderate sedimentation. However known, that intensive sedimentation entailed anoxic conditions and sharp decrease in bottom population (Sornin, 1981, 1986). In aquatoria with limited water exchange and dense culture the water quality and mollusc growth rates decreased significantly even till mariculture ceased (Uyeno et al., 1980; Mariojoules et al., 1987).

Evidently, critical density of molluscs-filtrators in mariculture goals is expressed by the accumulation/loss balance of organic substance at the bottom, depending on local hydrological conditions. Therefore, density for mussel displacement is to be ascertained for each aquatorium.

The above mentioned value and feeding supply extent defines the potential of the chosen region to be the mariculture farm.

The foregoing testifies that complex of scientific research must be conducted prior to

TABLE 2
PHYTOPLANKTON ROLE IN FEEDING OF MUSSELS CULTIVATED AT EXPERIMENTAL MARIFARMING.
MOLLUSC SUMMERIZED CONSUMPTION AND EXCRETION OF FORMED ORGANIC SUBSTANCE, dry mass

	1987									1988									
Watch period	IV	V	VI	VII	VIII	IX	X	XI	XII	I	II	III	IV	V	VI	VII	VII	IX	X
Phytoplankton concentration, mg/l	0.110	0.140	0.040	0.030	0.015	0.014	0.020	0.020	0.004	0.006	0.030	0.080	0.150	0.014	0.020	0.030	0.013	0.020	0.188
Water filtration, l/d/egz	–	0.910	1.790	7.610	10.304	6.119	7.258	14.370	15.531	8.310	8.770	9.241	17.780	21.106	23.080	24.730	19.500	14.980	15.360
Needed feeding concentration, mg/l	–	0.146	0.284	0.274	0.288	0.612	0.562	0.280	0.295	0.522	0.643	0.796	0.449	0.464	0.410	0.400	0.497	0.601	0.614
Phytoplankton, % feeding	–	96	14.1	10.9	5.2	2.3	3.6	7.1	1.4	1.2	4.7	10.1	33.4	3.0	4.9	7.5	2.6	3.3	30.6
Consumped feeding, mg/mo	–	4.05	15.45	63.36	90.15	113.91	124.04	122.49	139.19	131.89	171.58	223.74	243.06	297.90	287.92	300.88	295.04	273.90	286.77
Organic substance in faeces, mg/mo	–	1.20	4.64	19.20	27.06	34.20	37.22	36.73	41.82	39.63	51.55	67.12	72.93	89.44	86.46	90.29	88.51	82.27	86.04

mussel marifarming organization to evaluate the potency of the chosen region and outline recommendations on how to optimize the cultivation process during exploitation of the farming place.

An ideal situation is based on the balance equations for water exchange and organic substance consumption-excretion ratio which would be to create a mariculture farm that will produce food and decrease eutrophying loadings to the sea.

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