The release of juvenile fish as a compensatory measure to reduce the negative impact on the environment during the construction and operation of the multifunctional marine transshipment complex «Bronka»

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Abstract. This article discusses the release of juvenile fish as an effective compensatory measure to be applied at the multifunctional marine transshipment complex «Bronka». Losses of aquatic biological resources resulting from reduced zooplankton productivity were calculated, as well as temporary damage from dumping, and the cost of compensation measures of restoration. Finally, the study suggests suitable breeding species, along with its costs.

1 Introduction

The management of the reproduction of various fish species is of great importance in the conditions of partial or complete destruction of spawning grounds, places of concentration of young animals, feeding and wintering. There are two main areas of work to improve the reproduction of various types of fish: improving the natural conditions of reproduction and artificial breeding of fish at fish farms. Every year, interest in artificial fish farming ("aquaculture") is growing in different countries of the world, including Russia [1-6].

2 Method, results and discussion

The construction project of the Bronka port is carried out as part of the Concept for the development of promising areas of the Big Port of St. Petersburg. Port construction is planned to be implemented in 3 stages:
- Stage I (2013-2017) - construction of a container terminal and a rolling cargo terminal;
- Stage II (2019) - construction of a logistics centre;
- Stage III (2022) - construction of a container terminal.

To describe the ichthyofauna and biota components that ensure the reproduction of fish stocks, we used the results of fisheries monitoring of the eastern part of the Gulf of Finland, including the Neva Bay, for the period 1990 - 2013, as well as the data of the Eco-Express-Service LLC report, and other available literary sources.

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In the composition of the fish population of the Neva Bay, 39 species of fish and cyclostomes native to the Gulf of Finland were recorded. The core of ichthyofauna consists of species whose existence in this water area during the year exceeds 50% - Ruffe, Zander, perch, roach, bleak, bream and three-spined stickleback. A characteristic feature of the ichthyofauna of the Neva Bay is the predominance of the species that live in it for only part of the life cycle [1, 2, 7-9].

Many species enter the lip (bay) in a mature state, breed here, and their juveniles go to the eastern part of the Gulf of Finland or even to the central regions of the Baltic, where they wander and spend the winter. Upon reaching puberty, such fish return to the lip for spawning.

Table 1. Composition of fish species in the water area of port Bronka.

| Specie                      | Environmental group |
|-----------------------------|---------------------|
|                            | freshwater | Fleeting | marine |
| **COREGONINAE**             |            |          |        |
| vendace (European cisco)    | +          |          |        |
| **CYPRINIDAE**              |            |          |        |
| Roach                       | +          |          |        |
| White Bream                 | +          |          |        |
| Bream                       | +          |          |        |
| Common dace                 | +          |          |        |
| Ide                         | +          |          |        |
| Bleak                       | +          |          |        |
| **PERCIDAE**                |            |          |        |
| Common Ruffe                | +          |          |        |
| river perch                 | +          |          |        |
| Common zander               | +          |          |        |
| **GASTEROSTEIDAE**          |            |          |        |
| Three-spine stickleback     | +          |          |        |
| Nine-spine stickleback      | +          |          |        |

The period from the beginning of spawning to the end of the larval stage of the born generation's development is the most vulnerable when a violation of normal conditions of existence, especially an increase in turbidity of the water, has the most negative effect on the growth and development of fish.

The mass slope of young growth from the Neva Bay to adjacent areas begins in the second half of August. The state of fish stocks and, accordingly, the value of commercial catches are affected by both natural factors cyclically changing (duration of the growing season, salinity, forage base, etc.) and anthropogenic (pollution of the reservoir, hydraulic works, etc.).

The destruction of the coastal biotopes of the Neva Bay, where fish spawning occurs, is one of the main factors leading to a decrease in their reproduction.

In accordance with the current Methodology for calculating the amount of harm to aquatic biological resources (2011), the calculation of damage to the fauna from the construction of the approach channel and the deepening of the fairway during the formation of port Bronka was done according to the category - temporary damage.

Loss of aquatic biological resources from a decrease in the productivity of zooplankton is calculated according to the formula:

\[ N = B \times (1 + P/B) \times W \times K_d \times (K_d/100) \times d \times 10^{-3} \]  

(1)

where:

...
Loss of aquatic biological resources from the death of benthos is calculated according to the formula:

\[ N = B \times (1 + \frac{P}{B}) \times S \times K_E \times \left( \frac{K_3}{100} \right) \times d \times \Theta \times 10^{-3} \]  \hspace{1cm} (2)

where:
- \( N \) - loss (amount of harm) of aquatic biological resources, kg or t;
- \( B \) - the long-term average, for a given season (seasons, years), of the total biomass of fodder planktonic organisms, g/m³;
- \( P/B \) - coefficient conversion of the feed organisms' biomass into feed organisms' products (production coefficient);
- \( S \) - the area of the impact zone where the death of benthic food organisms is predicted, m²;
- \( K_E \) - coefficient efficiency of food used for growth (the proportion of food consumed by the body to form its body mass);
  \[ K_E = \frac{1}{K_2} (K_2 - \text{feed ratio}) \]
- \( K_3 \) - average coefficient (share) of the feed base's use for a given ecosystem (region) and season, %;
- \( d \) - the degree of impact, or the proportion of the dying organisms' number out of their total number, in this case, the ratio of the amount of biomass lost to the value of the original biomass, in fractions of a unit;
- \( 10^{-3} \) - conversion rate of grams into kilograms or kilograms into tons;
- \( \Theta \) - value of the increasing coefficient, taking into account the duration of the negative impact of the planned activity and restoration to the initial state of aquatic biological resources (abundance, biomass):

\[ \Theta = T + \sum K_B(t+i) \]  \hspace{1cm} (3)

where:
- \( \Theta \) - value of the increasing coefficient, in shares;
- \( T \) - an indicator of the continuity of the negative impact during which the restoration of aquatic biological resources and their food supply is impossible or does not occur, as a result of the destruction of the living conditions and the reproduction of aquatic biological resources (determined in fractions of a year taken as a unit, as the ratio of days/365);
∑K_{(i)} – the coefficient of the duration of lost aquatic biological resources' restoration, defined as \( K_{(i)} = 0.5i \). Wherein, the recovery period (i years) from the moment, the negative impact ceases: for planktonic food organisms is 1 year, for benthic food organisms - 3 years.

We calculated the temporary damage from dredging in the port, as well as from dumping of soil from the port water area to bottom dumps. The results are included in Table 2 and 3.

Table 2. Calculation of temporary damage.

| Loss                      | Temporary damage from dredging in the port / tons | from dumping of soil from the port water area to bottom dumps / tons | Total Tons of fish |
|---------------------------|--------------------------------------------------|---------------------------------------------------------------|-------------------|
| Zooplankton               | 0.651                                            | 2.411                                                         | 7.476             |
| Zoobenthos                | 1.185                                            | 3.229                                                         |                   |

The implementation of rehabilitation measures is planned in an amount equivalent to the consequences of the negative impact of the proposed activity.

As a restoration measure, artificial reproduction of aquatic biological resources is proposed to restore the disturbed state of their stocks, trout (Ladoga Palia) was chosen as the object of reproduction. The fish-biological indicators are taken as a basis. Atlantic salmon and brown trout yearlings are also proposed as an alternative.

Table 3. Calculation of compensation costs for restoration activities.

| Name of specie     | Number of yearlings | Estimated cost of compensation / rubles at the prices of 2019 |
|--------------------|---------------------|---------------------------------------------------------------|
| Ladoga Palia       | 12 565              | 3 744 370                                                     |
| Atlantic salmon    | 36526               | 11 870 950                                                    |
| brown trout        | 78531               | 16 682 820                                                    |

3 Conclusion

Based on the synthesis and analysis of materials and data, a temporary damage to ichthyofauna from dredging in the fairway is estimated at 7.476 tons of fish. To compensate, juvenile Palia in the amount of 12 565 yearlings should be released.

It should also be noted that the proposed compensation measure is aimed at compensating for the damage to the fauna and cannot compensate for the negative impacts on other components of coastal-marine biological communities, for example, on birds. The new scientific results obtained as a result of our studies are in good agreement with the data of various scientific studies that have been obtained by other scientists [10-11].

References

1. M. Andrianova, E. Bondarenko, E. Krotova, A. Chusov, *IEEE Workshop on Environmental, Energy and Structural Monitoring Systems, Proceedings* 6923291 198 (2014)
2. Kh. Il’ina, N. Gavrilova, E. Bondarenko, M. Andrianova, A. Chusov, *Magazine of Civil Engineering*, 76 241 (2017)
3. M. Daniel, A. Monteneblo et al. Water, Air, and Soil Pollution, 136 189 (2002)
4. A. Baker et al, Water Res., 38 2934 (2004)
5. R. Davydov, V. Antonov, D. Molodtsov, A. Cheremisin, V. Korablev, MATEC Web of Conference, 245 15002 (2018)
6. W. Liu, X. Li, et al, Environmental Pollution, 121 377 (2003)
7. N.S. Myazin, V.V. Davydov, V.V. Yushkova, T.I. Davydova, V.Yu. Rud, Journal of Physics: Conference Series, 917(4) 042017 (2017)
8. N.M. Grebenikova, N.S. Myazin, V.Yu. Rud, R.V. Davydov, Proceedings of the 2018 IEEE International Conference on Electrical Engineering and Photonics, EExPolytech 2018, 8564409 295-297 (2018)
9. N. Grebenikova, A. Korshunov, V. Rud, I. Savchenko, M. Marques, MATEC Web of Conference, 245 11006 (2018)
10. R. Davydov, M. Sokolov, W. Hogland, A. Glimushkin, A. Markaryan, MATEC Web of Conference, 245 11003 (2018)
11. J. Stenis, W. Hogland, M. Sokolov, V. Rud, R. Davydov, IOP Conference Series: Materials Science and Engineering, 497(1) 012061 (2019)