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Short communication

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Length–weight relationships of Baikal oilfish (Cottoidei: *Comephorus*)

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ABSTRACT. The paper presents the length-weight relationship (*LWR*) for *Comephorus dybowskii* Korotneff, 1904 ($W=6.63*SL^{3.59}$ ($R^2=0.99$)) and for *Comephorus baikalensis* (Pallas, 1776) ($W=7.13*SL^{3.14}$ ($R^2=0.98$)). The analysis is based on measurements of individuals caught in feeding season in 2022: *C. dybowskii* (401 samples) and *C. baikalensis* (189). The urgency of the research is determined by the necessity to obtain the *LWR* ratio to enhance the accuracy of resource studies using remote methods. Significant positive allometry of weight is shown for both fish species. It is assumed that the differences between *LWR* ratios in oilfish are a consequence of the adaptation of these species to a life in the pelagic zone.

Keywords: *Comephorus,* length, weight, length–weight relationships, LWR, adaptation, fisheries management, Lake Baikal

1. Introduction

Two species of the genus *Comephorus* inhabit Lake Baikal: small *Comephorus dybowskii* Korotneff, 1904 and big *Comephorus baikalensis* (Pallas, 1776) oilfish. They are the most numerous species of all the fish in the lake, *C. dybowski* being more numerous than *C. baicalensis* (Starikov, 1977). Abundance of *Comephorus dybowskii* varied from 22.2±4.2 to 41.2±4.8 and *Comephorus baikalensis* - from 7.1±1.4 to 10.8 bln. The biomass of these species reaches 3/4 of the biomass of all fish in Lake Baikal (about 200 thousand tons). (Starikov, 1977). They are dispersed throughout the water column down to a depth of 1642 m (Taliev, 1955; Koryakov, 1972; Mamontov et al., 2004). Both species inhabit open pelagic waters, and their visits into shallow waters of the lake (25 m and above) are short-term or accidental (Starikov, 1977). Oilfish do not form clusters that could ensure the profitability of their fishery, so their economic use is limited. Despite the fact that development of their stocks in modern conditions is not economically feasible, these fish are a major component of the Baikal ecosystem as the main consumers of zooplankton, on the one hand, and as a major component of the diet of the Baikal seal *Pusa sibirica* (Gmelin, 1788) and the Baikal omul *Coregonus migratorius* (Georgi, 1775), from the other hand (Gurova and Pastukhov, 1974; Volerman and Kontorin, 1983; Pastukhov, 1993).

Traditionally, oilfish are caught using gillnets, the Isaacs-Kidd trawl, and vertical trawl counting nets. Low accuracy of obtained values and complexity of sampling process on the lake water area of 31.5 thousand km² requires the development and application of alternative approaches and remote methods. At present, hydroacoustic methods of determining the stocks of the main commercial species *C. migratorius* in Lake Baikal take the form of a routine character (Melnik et al., 2009; Makarov et al., 2012). Algorithms for the analysis of sound-scattering layers (SSL) formed by accumulations of mesozooplankton and macroplankton (*Macrohectopus branickii* (Dybowsky, 1874)) are developed (Makarov et al., 2022). However, the use of these methods to study oilfish is difficult because of a number of features of the anatomy and ecology of these species: the absence of a swim bladder, their distribution to maximum depths, and the absence of dense aggregations that form the sound scattering layer. Besides the abovementioned peculiarities of oilfish, the possibility of carring out the resourse study on Lake Baikal with greater accuracy is an urgent task of hydroacoustics.

Modern submerged echolocation systems such as WBAT Simrad EK60 enable to record single objects with low reflectivity such as pelagic bubbleless fish and invertebrate animals (Falsone et al., 2022). Improvement and expansion of capabilities of echolocation systems both in open water and from the ice cover (Anoshko et al., 2019) as well as video and photorecording

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enables to study more effective the objects with low reflectivity. Studies using hydroacoustic technology allows to estimate with high accuracy the abundance and biomass of fish subject to the availability and use for calculations of the equation of dependence of the target force (*TS*) adapted to a particular species of fish (Anoshko et al., 2020). However, a significant contribution to the error of fish stock estimates can be made by determining the length-weight relationship (*LWR*). *LWR* is used when reconstructing fish weight from length data for further biomass estimation (Jiang et al., 2022; Dikou, 2022). The research was **aimed** to determine *LWR* for fish genus *Comephorus*.

2. Materials and methods

During the winter period (February-March 2022), fish were caught using gill nets from the ice cover of the lake from a depth of 300-400 m. In summer, the nets were drifting in the area of Listvennichny Bay (Fig. 1). Additionally, the material was sampled using the Isaacs-Kidd trawl from the board of the R/V G.Yu. Vereshchagin from a depth of 300-400 m in August 2022.

Analysis of basic data was performed on feeding individuals without regard to gender. The weight (*W*) of fish was measured with an accuracy of 0.001 g. The standard length (*SL*) of the fish was measured with an accuracy of 0.1 mm. In total, this study used the measurement data of 401 individuals *C. dybowskii* and 189 individuals *C. baikalensis*. The data were processed and analyzed using the statistical computing software R (R Core Team, 2020). *LWR* was investigated using the regression model of the allometric equation $W = aSL^b$ or $\log(W) = b * \log(SL) + \log(a)$, where *W* in grams and *SL* is in decimetres. Given that *W* is determined by the volume and density of the body, the coefficient of degree ***b*** should be close to 3 and can be interpreted as a coefficient of allometry. Deviations in the coefficient of degree ***b*** are due to changes in body proportions as the fish grow. At $b > 3$ a positive allometry of body weight is observed, at $b < 3$ – a negative one (Froese, 2006).

Coefficient ***a*** depends on the *SL* units of measurement of fish. The value is proportional to the weight of a fish of unit length in grams. *SL* in dm was used in the paper, due to which the coefficient ***a*** can be interpreted as the average weight of fish *W* 1 dm long. This dimension is preferred for the purposes of interpretation and comparison (Anoshko et al., 2022). In a comparative analysis, we took into account the dependence of the coefficient ***a*** on the value of ***b*** as: $a = \overline{W} / \overline{SL^b}$, or $\log(a) = \log(\overline{W}) - b \cdot \log(\overline{SL})$.

3. Results and discussion

The length range of the studied fish was 0.48-1.28 dm, weight was 0.5-15.0 g. for *C. dybowskii* and it was 0.54-1.97 dm, weight 0.9-70.0 g. for *C. baikalensis* (Fig. 2). As a result of the calculation of the regression model, the following relations are obtained: for *C. dybowskii* $W = 6.63 \times SL^{3.59}$ ($R^2 = 0.99$) and for *C. baikalensis* $W = 7.13 \times SL^{3.14}$ ($R^2 = 0.98$) (Table). Reliable positive weight allometry was obtained in both cases.

Coefficient ***b*** for *C. dybowskii* was much more than for *C. baikalensis*. These differences can be explained by anatomo-morphological features of these species adapted to inhabitat in the pelagic zone of the lake. Oilfish do not have a swim bladder, which performs a hydrostatic function in fish. Both species are characterized by large size of fins, primarily the pectoral fins and weak mineralization of the skeleton (Sideleva, 2003). The fins of oilfish contribute to the hovering of fish. Weakly mineralized skeleton is effective in reducing the actual weight. *C. baikalensis* in comparison with *C. dybowskii* reaches much larger sizes. Individuals of big oilfish that exceed the maximum size of small oilfish accumulate a large amount of lipids(up to 40%) not only in the perigastrium, but also in the muscle

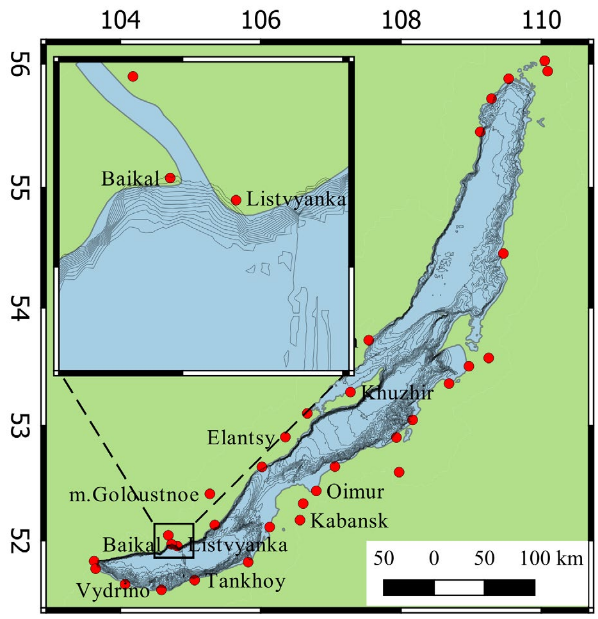

Fig.1. Study area in Lake Baikal.

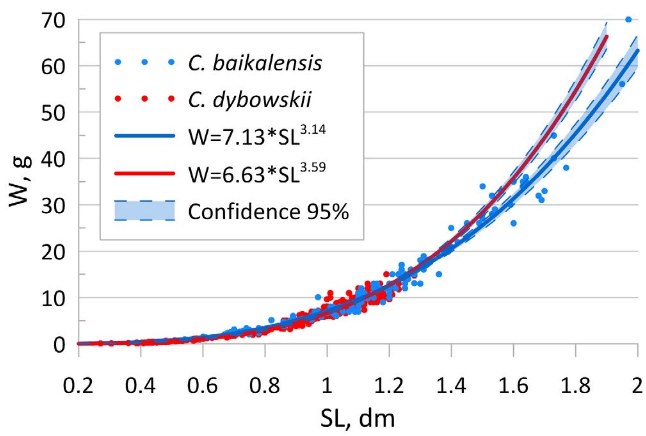

Fig.2. *LWR* of Baikal oilfish.

Table. Regression analysis results

	n	*SL*, dm (min-max)	*W*, g (min-max)	*a*	m_a	*b*	m_b	R^2
C. dybowskii	401	0.48-1.28	0.5-15.0	6.63	0.003	3.59	0.017	0.99
C. baikalensis	189	0.54-1.97	0.9-70.0	7.13	0.004	3.14	0.034	0.98

Note: n – number, m - standard error of regression coefficient.

tissues (up to 15%) (Kozlova and Khotimchenko, 2000; Gorshkov et al., 2016). The main function of lipids in the muscles of big oilfish is hydrostatic, so, it allows to reduce the actual weight of the fish. As an energy depot, cavity fat is used like in most other fish. Thus, less weight gain with a corresponding increase in length in *C. baikalensis* is probably a consequence of adaptation to the life in the pelagic zone at larger sizes of individuals.

4. Conclusions

Determination of *LWR* is an important part of resource studies and in the construction of balance models. Regression analysis of *LWR* allowed us to determine the dependence equations for *C. dybowskii* $W = 6.63 \times SL^{3.59}$ ($R^2 = 0.99$) and for *C. baikalensis* $W = 7.13 \times SL^{3.14}$ ($R^2 = 0.98$). Reliable positive allometry of weight is shown for the oilfish of Lake Baikal. The lower value of the coefficient ***b*** for *C. baikalensis* is probably a consequence of adaptation to the life in the pelagic zone of individuals of large size. Slight positive allometry $b = 3.1$ for *C. baikalensis* is close to the median value of $b = 3.03$ according to the metaanalysis of *LWR* (Froese, 2006), which is typical for pelagic fish. High value of $b = 3.7$ for *C. dybowskii* is not within the 90% range of metaanalysis values, which may be explained for the comparative analysis of *LWR* of endemic Cottoidei of Lake Baikal.

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Conflict of interest

The authors declare that they have no competing interest.

References

Anoshko P.N., Makarov M.M., Smolin I.N. et al. 2019. The results of the first hydroacoustic studies of the winter distribution of *Coregonus migratorius* in Lake Baikal. Limnology and Freshwater Biology 3: 232-235. DOI: 10.31951/2658-3518-2019-A-3-232

Anoshko P.N., Makarov M.M., Popov S.B. et al. 2020. Estimation of the coefficients of the equation of acoustic target strength based on the morphology of *Coregonus migratorius* (Georgi, 1775) swim bladder. Yug Rossii: Ekologiya, Razvitiye [South of Russia: Ecology, Development] 15: 89-98. DOI: 10.18470/1992-1098-2020-1-89-98 (in Russian)

Anoshko P.N., Makarov M.M., Ustarbekova D.A. et al. 2022. Length-weight relationships of Baikal omul *Coregonus migratorius* during the feeding season in the Selenga area, Russia. Yug Rossii: Ekologiya, Razvitiye [South of Russia: Ecology, Development] 17(1): 17-23. DOI: 10.18470/1992-1098-2022-1-17-23 (in Russian)

Dikou A. 2022. Weight–length relationship in fish populations reflects environmental regulation on growth. Hydrobiologia. DOI: 10.1007/s10750-022-05072-8 (in press)

Falsone F., Geraci M.L., Scannella D. et al. 2022. Length-weight relationships of 52 species from the South of Sicily (Central Mediterranean Sea). Fishes 7: 92. DOI: 10.3390/fishes7020092

Froese R. 2006. Cube law, condition factor and weight-length relationship: history, meta-analysis and recommendations. Journal of Applied Ichthyology 22: 241-253. DOI: 10.1111/j.1439-0426.2006.00805.x

Gorshkov A.G., Dzyuba E.V., Usolceva I.V. et al. 2016. Bio-indicators of persistent organic pollutants in Lake Baikal. 2. *Comephorus baicalensis* and *Comephorus dybowski*. Water: Chemistry and Ecology 3: 36-41.

Gurova L.A., Pastukhov V.D. 1974. Pitaniye i pishchevyye vzaimootnosheniya pelagicheskikh ryb i nerpy Baikala [Feeding and food relationships of fish and seal of Baikal]. Novosibirsk: Nauka. (in Russian)

Jiang C., Wang W., Wang M. et al. 2022. Length-weight relationships and other morphological traits of fishes in the Mangrove of Hainan, China. Fishes 7: 238. DOI: 10.3390/fishes7050238

Koryakov Ye.A. 1972. Pelagicheskiye bychkovyye Baikala [Pelagic cottoids in Lake Baikal]. Moscow: Nauka. (in Russian)

Kozlova T.A., Khotimchenko S.V. 2000. Lipids and fatty acids of two pelagic cottoid fishes (*Comephorus* spp.) endemic to Lake Baikal. Comparative Biochemistry and Physiology, Part B 126: 477-485. DOI: 10.1016/s0305-0491(00)00207-8

Makarov M.M., Degtev A.I., Kucher K.M. et al. 2012. Estimation of the abundance and biomass of the Baikalian omul by means of trawl–acoustic survey. Doklady Biological Sciences 447: 363-366. DOI: 10.1134/S0012496612060051

Makarov M.M., Zaydykov I.Yu., Tolstikova L.I. et al. 2022. Account of the population and distribution of macrohectopus in the Barguzinsky bay of Lake Baikal by the acoustic method. In: 5th International Conference “Resources, environment and regional sustainable development in Northeast Asia”, p. 26.

Mamontov A.M., Anoshko P.N., Sorokovikov A.V. et al. 2004. Dinamika prostranstvennogo raspredeleniya i razmernaya struktura golomyanok (Comephoridae) v pribrezhnoj pelagiali yuzhnogo Bajkala v zimnij period. Trudy Kafedry Zoologii Pozvonochnykh [Proceedings of the Department of Vertebrate Zoology] 2: 52-64. (in Russian)

Melnik N.G., Smirnova-Zalumi N.S., Smirnov V.V. et al. 2009. Gidroakusticheskiy uchet resursov baikal’skogo omulya [Hydroacoustic surveys of Baikal omul]. Novosibirsk: Nauka. (in Russian)

Pastukhov V.D. 1993. Nerpa Baikala: biologicheskie osnovy racional’nogo ispol’zovaniya i ohrany resursov [Baikal nerpa: biological basis for the rational use and protection of resources]. Novosibirsk: Nauka. (in Russian)

R Core Team. 2020. R: a Language and environment for statistical computing. R foundation for statistical computing, Vienna, Austria. URL: https://www.R-project.org/

Sideleva V.G. 2003. The endemic fishes of Lake Baikal. Leiden: Backhuys Publ.

Starikov G.V. 1977. Golomyanki Baikala [Golomyankas in Lake Baikal]. Novosibirsk: Nauka. (in Russian)

Taliev D.N. 1955. Bychki-podkamenshchiki Baikala (Cottoidei) [Cottoidei in Lake Baikal (Cottoidei)]. Moscow-Leningrad: USSR AS Publishers. (in Russian)

Volerman I.B., Kontorin V.V. 1983. Biologicheskiye soobshchestva ryb i nerpy Baikala [Biological communities of fish and seal in Baikal]. Novosibirsk: Nauka. (in Russian)