QUANTITATIVE ASPECTS OF PERCIDS ECOLOGY: AN OVERVIEW OF RUSSIAN STUDIES.

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Introduction. Among percid fishes inhabiting inland water bodies of the former USSR three species are the most abundant and widespread – zander Sander lucioperca, European perch Perca fluviatilis, and ruffe Gymnocephalus cernuus. In Russian scientific publications one can find a great amount of data on their biology and life history. However, there is a surprising lack of studies directed to the data synthesis and interpretation from the general ecological positions. Such studies are needed for better understanding of how complex biological systems like populations and communities function. Below, I give a brief review of Russian key works in the field of percid populations dynamics and their role and place in freshwater ecosystems.

Percids population dynamics. Perhaps, the most comprehensive model of zander population dynamics among Russian studies is that developed by Kazansky & Koval (1980). It takes into account a variety of factors including environmental conditions, trophic interactions, and fishery operations. The model is intended for zander fishery optimization in Tzyrnansk Reservoir with an emphasis on predator-prey interactions between zander and blue bream, Abramis ballerus. The model uses energy units as a currency and traces the consumption of blue bream by zander via weight-at-age description of food requirements. It is assumed that zander are able to feed on other prey as well, among them sprat, gobies, yearlings of different fish species, and benthos, although their biomass is not subdivided into age-groups and given instead as lump quantities. Simulation experiments indicate that inter-annual fluctuations of the zander stock size are caused primarily by changes in recruitment abundance. The recruitment itself is shown to depend on water temperature and water level in May and on drainage area. Kazansky & Koval found out that the largest part of zander annual production (86%) is formed due to consumption of small non-commercial fishes, mainly sprat and gobies. Trophic interactions with other commercial fish species do not have a significant influence on the dynamics of zander population.

While studies on population dynamics of zander are motivated mainly by its commercial value, the interest in dynamics of perch populations stems from its ecological features. Among them two are of great importance. The first is perch ability to occupy different feeding niches consuming plankton, benthos, or being a predator. The second is its indifference to spawning substrate, which makes spawning highly efficient. As a result, perch can be found practically in all boreal water bodies, except anoxic lakes. In many small lakes perch form a single-species fish community, where different size classes function as its different elements.

In single-species perch communities an unusual age composition is sometimes observed – age-group 1+ is almost absent while the relative abundance of age-group 3+ is extremely high. Menshutkin & Zhanov (1964) have surmised that such a peculiar age distribution could not be stationary and designed a mathematical model that explains the phenomenon. It is based on data obtained in Lake Tuleny (Karelia) by direct counting of perch stock exterminated by applying chemical poison and assumes cannibalism to be a principal feedback mechanism in perch population dynamics. The population trajectory in the phase space is represented by stable limit cycle with the period about 6-8 years. Within the cycle the transition in age distribution occurs, from typical exponentially declining one at low population density to bimodal at high density and back again to exponential. Recruitment is shown to be dependent on planktonic food availability. The latter circumstance imparts great importance to the problem of fry mortality sources. Since there can be two of them (cannibalism and starvation), Menshutkin (1971) used another simulation model to examine their relative significance. The model is size-structured and is built on data from Lake Razdelnoye which is populated by perch only. It couples the dynamics of perch 0-group and zooplankton. The simulations demonstrate that at high density perch fry can deplete their food resource inducing their own mortality due to starvation. After the radical drop in numbers of perch 0-group, zooplankton population recovers. So, food availability appears to be the crucial factor of recruitment formation.

Population dynamics of ruffe attracts much lesser attention because of its low commercial value. Published studies deal mainly with particular aspects of ruffe life history such as growth, longevity, or feeding habits. Data on ruffe stock status or potential for commercial exploitation are limited by catch statistics or fragmentary information on some population parameters. A rare exclusion is the study by Ruszhin & Pavlova (1990) who attempted to use multivariable correlation and regression analyses for predicting percid catches in two water bodies. They assumed that, because of diversified relations within a fish community, the catch of the certain species can be predicted using information on other species catches, and found out that ruffe catches in Gulf of Finland positively correlate with lamprey catches while those in the Ladoga negatively correlate with bream catches. Abiotic factors affecting ruffe catches appear to be water temperature in May (for Lake Ladoga) and water discharges in May and June (for Gulf of Finland). The weak point of the study is a postulate of catch statistics to be an adequate reflection of stock size, which may not always be true.

Role of percid in aquatic communities and ecosystems succession and functioning. Attempts to comprehend the functions of percid on a systemic basis are not many in Russian scientific literature. Zhanov (1984) compared the fish species composition in 248 lakes in the Vologda Region (northwest-
ern Russia). He pointed out that the most frequent are lakes with single-species and five-species fish community. Moreover, among the latter ones the majority (66%) contains the same species, namely perch, pike, roach, burbot, and ruffe. Perch is highly adaptive species that can occupy any one of the three niches, feeding on plankton, benthos or fish. The regulatory role, which is executed by cannibalism in single-species perch communities, is transferred in five-species ones to pike and burbot. These predators have different seasonal cycle of activity and spawning substrate requirements, thus being well co-adapted. Roach, feeding primarily on detritus, periphyton and macrophytes, finds its own niche and avoids competition with other species. Finally, ruffe consumes a broad spectrum of benthic organisms and so is able to live in lakes with scarcely developed benthic fauna. The species mentioned form the dominant component of fish communities in boreal lakes. Broadening of species composition is related mainly with water bodies increase in area and in more intensive hydrodynamics. As a result, diverse biotopes emerge which might be inhabited by fishes with more narrow ecological preferences (Zhakov 1984).

Using these data as a starting point, Zhakov (1984) developed an age-structured simulation model of a community composed of 7 fish species (perch, pike, crucian carp, burbot, roach, bream, and ruffe). Different sets of the model parameters correspond to different trophic statuses of a lake. As the simulation results show, the succession process is accompanied by distinct changes in the community structure. When the lake becomes eutrophic, fish productivity increases approximately 1.5 times, mainly through the increase in roach and crucian carp biomass. At the later stages of the succession some species start to disappear from the community, first of them burbot and bream. In acidified environment what remains of the community is only perch and roach.

Complex nature of trophic relationships becomes even more evident when the impact of fishing is introduced into the model. For example, imposing strong fishing pressure on predators as a measure of fish productivity enhancement actually brings about an opposite result — the share of commercially valuable bream in the catches is diminished while the bulk of the catch (70%) turns out to be comprised by roach and perch.

One of the water bodies where system-oriented investigations seem to proceed fairly enough is Lake Syam (Karelia). Ecological processes in the lake have been monitored for 60 years by now, and the data collected have allowed to clarify many questions concerning the ecosystem succession, changes in aquatic community structure, and fisheries optimization. Recently, Kriksunov et al. (2001) designed a steady-state trophic model of the lake ecosystem using ECOPATH IV software. The model takes into account trophic relationships between 17 groups of organisms. One of the model outputs is a matrix of impact coefficients which are the measure of influence exerted by each trophic group on biomass of other groups (Fig. 1).

Figure 1. Percid fishes impact on the components of Lake Syam community.

The analysis shows that among percid fishes ruffe is the only species that influences negatively almost all other fishes. Predators (adult perch and zander) play an important role restraining the population growth of smelt, the species that invaded the lake in late 1960s and now forms about 60% of total fish biomass. That leads to their positive influence on the populations of whitefish and vendace, the most valuable species from the fisheries point of view. This conclusion corresponds well with the results obtained by Ladanov (1990) who constructed a matter flow model for the fish community of Lake Beloye (the Vologda Region). In his model the presence of predators (pike and zander) turns out to be a beneficial factor for the bream population due to suppression of its competitors for food, first of all ruffe.


