Acta Hydrobiol., **39** (1997), Suppl. 1, 31–34. Cracow, June 1998

Why should the development of predatory fish be promoted in dam reservoirs?

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(Received 26 September 1997)

The role of predatory fish in the ecosystems of lakes and dam reservoirs has been discussed in numerous publications concerning their function in controlling processes of excessive eutrophication. Less attention has been paid to the economic importance of predatory species although they provide valuable articles for the food market and play a important role in the biomanipulation process in water bodies. Since more and more dam reservoirs are constructed in Poland, their area exceeding 52,000 ha, the waters retained in them should be used not only for municipal and energy purposes but also for the culture of valuable species of predatory fish. Obviously, the occurrence of predators should not interfere with their basic role in protecting water quality by the control of excessively developing zooplanktivorous and benthivorous species.

The predatory fish species, which constitute the last link in the food chain of aquatic ecosystems, play a significant role in shaping the structure of plankton and bottom elements (phosphorus, nitrogen, and carbon) greatly exceeding direct activity such as the regeneration of mineral phosphorus, accumulation of this element in their biomass, or its sedimentation with faeces. Since in a reservoir the components of its bioceonosis which play a key role in the cycling of nutrients, i.e. zooplankton and benthos, are controlled by fish, several biotic and abiotic parameters of the ecosystem, such as the forms of phosphorus accessible to algae, and, in consequence, the biomass of phytoplankton, are indirectly affected by the ichthyofauna. With a slight pressure of fish the effectively filtrating large forms of the zooplankton dominating in reservoirs maintain the biomass of algae at a level below that predicted on models associating the spring concentration of phosphorus in the water with the summer biomass of phytoplankton. Large cladocerans, selectively eliminated by fish, consume larger particles and greater amounts of the phytoplankton. If the zooplankton subjected to the pressure of fish is dominated by small cladocerans, rotifers, and protozoans, it feeds only on a part of the phytoplankton occurring in the environment of sufficiently small cells and colonies, at the same time rapidly releasing nutrients contained in the food.

If planktivorous fish directly affect the structure of the phytoplankton, benthivorous ones directly increase the amount of phosphates in the water through the consumed bottom fauna. Nutrients accumulated in the benthos biomass are fairly rapidly released to the water in mineralized form after the unassimilable

fraction of food has passed the alimentary canal of the fish. Besides, the mixing of the surface sediment layer in their search of food brings about a release of phosphorus from the interstitial water and an increase in its turbidity, thereby favouring the development of cyanobacteria. Owing to the activity of the benthivorous fish, the load of phosphorus reaching the water from the sediment increases with their increasing density and may constitute one of its most important sources in the surface layer. It is also greatly augmented by herbivorous species, e.g. roach, which is the chief consumer of macrophytes containing large quantities of biogenic elements in their tissues.

Contrary to the noxious effect of Cyprinidae and perch in tap water reservoirs fish should be one of the instruments of water protection, piscivorous fish playing a very important role there. They are an essential factor limiting the excessive development of planktivorous and detritivorous species. It should be strongly stressed here that in every water body the fry of abundantly developing Cyprinidae and perch bring about enormous losses in the number of zooplankton, which is known to control the mass development of phytoplankton. The biomass of fry is usually smaller than that of adult fish in the reservoir, though the production of young fish, e.g. perch or Cyprinidae constitutes about 60–70% of the total production of the fish community in a given water body. Moreover, apart from planktivores, adult fish feed on the zooplankton to a much smaller degree than the young ones. Therefore, attempts should be made to bring about as drastic as possible limitation of the hatch of Cyprinidae and perch, the later species being frequently regarded as predatory. In fact, it feeds intensively on large filtrators which are its dominant food for a very long time of its life (7–8 years). Not until its length is 30–35 cm the perch pass to piscivorous feeding.

To sum up this short presentation of the activity of different fish species as regards their feeding behaviour which affects the quality of reservoir waters, it should be stressed that non-predatory fish are agents increasing the content of biogenic elements in the water. They intensify the rate of regeneration of nutrients from sediment and exert a strong pressure on the zooplankton. In contrast, great numbers of predatory fish which rapidly pass to the piscivorous way of feeding (pike, pikeperch, wells, and asp), and the reduced densities of Cyprinidae and perch fry, permit the balance to be maintained among the phytoplankton, zooplankton, zoobenthos, and fish, ensuring a flow of energy at the oligotrophic level. Thus, a pronounced decrease in the numbers of Cyprinidae and perch is a greatly desirable treatment in order that eutrophication of the water body may be prevented, and should be regarded as an efficient and fairly inexpensive reclamation measure.

The above-discussed role of fish in maintaining the biological balance of the environment indicates the important function of rational fish culture both in promoting the development of predatory fish and affecting the species composition and age structure of non-predatory ones, and lastly in the elimination of undesirable species. Actually, on account of its different bowl shape, every dam reservoir is in some respect handicapped in relation to natural lakes. The variation of water level and hence the absence of macrophytes in the littoral zone and the limited area of the littoral where the spawning and growth of fry take place, promote eurytopic species of great reproduction potential. In dam reservoirs these are planktivorous and benthivorous Cyprinidae and perch. In the aspect of the biomanipulation concept the role of planktivorous fish is obvious. It should be recalled here that larvae and juveniles of almost all the fish species feed on zooplankton, differentiation of the diet occurring in later stages of their life.

One very important question arises as to which predatory fish species should be preferred in accordance with the principles of the biomanipulation theory. Here the local conditions must be taken into consideration of which the most important are the temperature and degree of eutrophication of the water. Of Salmonidae family the Lake Wdzydze lake trout, *Salmo trutta* m. *lacustris* L. meets the requirements of the large piscivore which may play an important role in dam reservoirs. However, we know that the introductions of lake trout in the Solina, Przeczyce, and Besko Reservoirs were not very successful. A recent experiment with the introduction of the lake trout into the Klimkówka Reservoir on the River Ropa, and the project of stocking the Czorsztyn Reservoir with this species seem unsuccessful owing to the high degree of eutrophication of the River Dunajec and to the occurrence of pike in the reservoir. On the other hand, the predators acknowledged as most reliable in eliminating Cyprinidae species are pike, pikeperch, wells, and asp. Since in dam reservoirs the conditions of natural reproduction are sometimes less favourable owing to the fluctuating water level, the narrow littoral, and poaching, the numbers of the predators may if necessary be complemented with fry from artificial spawning.

Why these species? Pike, *Esox lucius* L. is a predator feeding in the littoral zone (Fig. 1). Because of the early spawning period (February–April), abundant hatch,

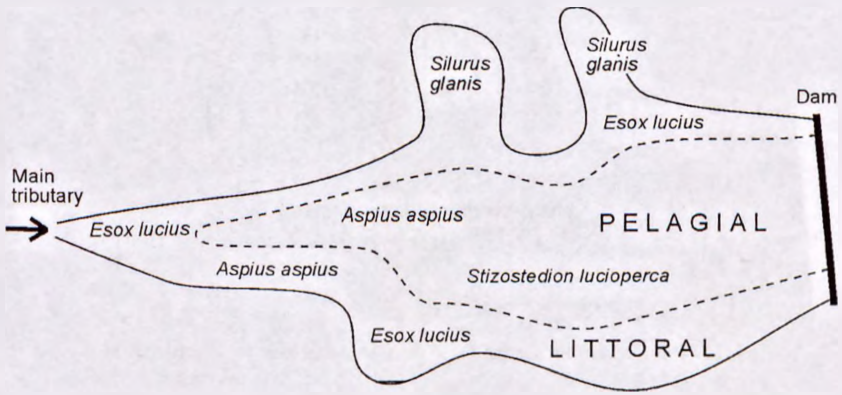

Fig. 1. Scheme of the distribution of particular predatory fish species in a dam reservoir.

and early passage to piscivory, it may considerably limit the numbers of hatch from the later spawning Cyprinidae, chiefly roach, common bream, and perch. The pikeperch, *Stizostedion lucioperca* (L.) feeds in open water, its prey being bleak, roach, ruff, gudgeon, white bream, and common bream. The spawning of pikeperch begins chiefly in May and June, therefore its role in controlling the numbers of even-aged hatch of Cyprinidae is not so significant as that of pike. Nevertheless, on account of its voracity and pressure on the populations of planktivorous fish and perch and also its low sensitivity to eutrophication, it is a valuable and much-desired species in reservoirs. The wels, *Silurus glanis* L. is the greatest predator of our inland waters. It feeds at dusk or at night, preying on fish of a size equal to 20% of its own body length. Its diet consists almost of fish, which constitute about 80% of its food ration. The asp, *Aspius aspius* (L.) is a predator of the Cyprinidae family. It is characterized by rapid growth and, like all Cyprinidae, by resistance to unfavourable effects of eutrophication. Therefore, it should be

recommended as an additional predator limiting the occurrence of non-predatory species. Currently, it occurs only in small numbers in dam reservoirs yet it may be regarded as a future predator of eutrophic waters.

The populations of predatory fish whose presumed function is the control of planktivorous and benthivorous fish, should be sufficiently numerous for the populations of prey to be affected to a significant degree, and composed of various species for at least two reasons: (1) the first is the necessary stability of the trophic level of predators ensuring a constant pressure on non-predatory fish irrespective of the effects of spawning, and (2) the second one is the complete utilization of ecological niches of the reservoir, i.e. all the day and night feeding on prey both near the banks and in the open water. Numerical dependencies between predatory and non-predatory fish species have been argued by some authors. Mastyński and Wajdowicz (1991) estimated a ratio of 25:75 (predatory:non-predatory species). Starmach (1988) suggests that the predatory species should constitute 30% of the population (Fig. 2). American scientists propose the most radical solutions by reducing the biomass of non-predatory fish to a few kg per ha, i.e. practically below

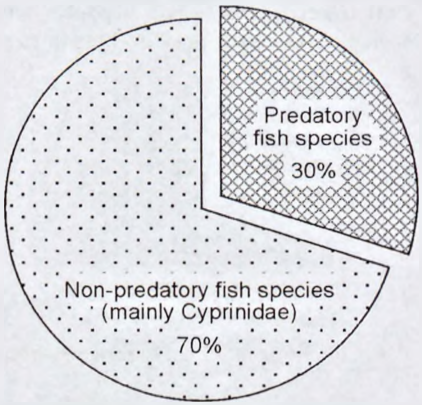

Fig. 2. Percentage of predatory fish species in the total ichthyofauna.

the value of the biomass of predators. It seems, however, that these calculations may be replaced by systematic analyses of commercial catches, the following information being taken into particular considerations: (1) species composition and weight of catches of the particular fish species; (2) growth rate of fish species which are significant from the natural and economic aspect; (3) age composition of currently caught species with the division into age groups of exploited fish and those whose exploitation has started.

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