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Main aspects of pikepersh (*Sander lucioperca*) reproduction (a review)

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Abstract. Over the last 50 years, the concept of sustainable development has been introduced all across the world. It involves the transformation of all branches of the economy based on the "green economy". Fishery, which is based on the exploitation of natural resources and directly affects the ecological and food security of the country, is primarily subject to restructuring due to the need to achieve the goals of sustainable development. The latter means that the needs of the current generation must be fulfilled without creating obstacles for future generations. Accordingly, there is a problem of resource conservation in combination with the restoration of populations. Therefore, the preservation and sustainable development of humanity is possible only under the conditions of stable functioning and guaranteed reproduction of other components of the biosphere which can be considered as resources. Reproduction is one of the most important parts of fishery in general and aquaculture in particular. This is explained by the fact that the result of reproduction is the production of fish seeds. The latter can be aimed both at restoring natural populations and at the use in aquaculture farms. The actual reproduction process of aquatic organisms is carried out using different technologies. Their main difference is the degree of control over natural processes. In turn, it is largely determined by the degree of controllability of the selected methods. Thus, it can be stated that the highest level of controllability and technology of reproduction is achieved in the conditions of closed (recirculating) water supply system, while the lowest in the conditions of the arrangement of artificial spawning grounds in water bodies. Among the main technologies of fish reproduction, in addition to the two mentioned above, there are following: reproduction in cages, ponds, tanks, and combined. The last four are mainly used to work with one of the most valuable native fish species in Europe, the pikeperch (*Sander lucioperca* Linnaeus 1958). However, each technology includes pre-spawning work with brood fish regarding their preparation for reproduction, actual spawning campaign, and the subsequent incubation of the obtained eggs. All these links are formed on the basis of a combination of biological features of this species with existing environmental conditions as well as financial and organizational capabilities of certain farms. The main aspects of pikeperch reproduction include: the terms and conditions for reaching sexual maturity, the characteristics of the broodstock and reproduction conditions, working with brood fish, the actual selection and insemination of eggs, and the subsequent incubation of the embryos obtained in this way. The objective of this study was analytical review of the abovementioned technological processes of artificial reproduction of pikeperch based on information sources that highlight the results of scientific research.

Keywords: aquaculture; broodfish; reproduction; hormonal gonadotropic drugs; domestication; wild populations; spawning grounds; incubation of embryos.

Introduction

The main trend in development of the global economy is implementation of the principles of sustainable development in all sectors of the economy. One of the reasons for this is the need to prevent hunger and provide humanity with a complete protein, that is, one that contains all the amino acids necessary for humans. Therefore, since the 1980s, with the support of the United Nations, the concept of "green economy" has been developing in most countries of the world (Butlin, 1987). Fishery and aquaculture, which is gradually becoming its major part, are undergoing corresponding transformations. This is primarily due to the fact that they are able to ensure achievement of most of the goals of sustainable development. In particular, fish is a source of essential amino acids and contains the most useful fatty acids, as well as trace elements important for full functioning of the human body. Accordingly, resource-saving technologies are being developed in aquaculture and the most promising fish species or so-called valuable species are being identified for economic activity (Bienkiewicz, 2007; Ashe & Tveteras, 2022; Ashe et al., 2022). Rational propagation of valuable fish species relies on the aforementioned technologies and is characterized by a wide range of applicability. Thanks to it, it is possible to achieve and maintain both food and environmental security (Ashe & Tveteras, 2022; Bohnes et al., 2022). For example, regarding the first aspect, its use allows preserving the life of brood fish for their next use in spawning campaigns; carrying out selection and breeding business; reducing costs of cryopreservation of sexual products and the use of therapeutic and preventive drugs; increasing the quality of fish seeds, which allows obtaining more of them, and therefore lower cost; promoting the development of farm aquaculture, thereby creating new jobs and raising the standard of living of the population (Martins et al., 2010; Milardi et al., 2011; Mustamäki et al., 2014). As with another aspect, the introduction of rational reproduction of fish primarily contributes to: reducing pressure on natural (wild) populations; preservation of native ichthyocenoses; saving the resource base by minimizing its exploitation, including by reusing water and reducing production areas, by increasing stocking density (Hilge & Steffens, 1996; Kucharczyk, 2007; Dalsgaard et al., 2013). Rational reproduction combines several technologies, each being the most suitable for a certain purpose and conditions of economic activity. For example, in presence of significant areas of the water area, it is appropriate to use other technologies than in case of their absence (Alymov, 2003; Andriushchenko et al., 2003). Another example is the subsequent use of the fish stock obtained by reproduction - in aquaculture, or to restore the abundance of natural populations (Lappalainen et al., 2003; Kestemont, 2015; Kánainé et al., 2019). There are five species in the *Sander* genus (*Sander lucioperca*, *S. marinus*, *S. volgensis*, *S. vitreus*, *S. canadensis*), each defined as valuable in the global fishery (Dil & Teletchea, 2008; Movchan, 2011). First of all, this is explained by the high nutritional properties of their meat. For example, pikeperch (*Sander lucioperca*) has a lower calorie content (83 kcal/100 g) than carp (116 kcal/100 g) or trout (161 kcal/100 g), and a higher protein content compared with the other two fish species – 19.0 g/100 g against 17.6 and 18.5 g/100 g, respectively. This species is native to European countries and one of the most widespread in their fisheries (Lehtonen et al., 1996; Fontaine, 2008; Linfield & Rickards, 2008). Depending on existing socio-economic features of the development of a certain country and the level of technological support of fishery, pikeperch is grown in cages, ponds, recirculating aquaculture systems or by combining these technologies (Kozłowski et al., 2010; Fontaine et al., 2015; Franz et al., 2021). A common issue in fisheries of all countries is rational application of a certain technology of reproduction, as well as its improvement in order to increase efficiency (Jankowska et al., 2003; Hrynzhevskyi & Pekarskyi, 2004; Hrytsyniak et al., 2008). The objective of this study was to present an analytical review focused on the main points of the pikeperch breeding.

Time and conditions of reaching sexual maturity, peculiarities of spawning stock of pikeperch

The age when pikeperch reaches maturity largely depends on sex, diet, and nutrition, as well as the hydro-ecological conditions in which it develops (Frankiewicz, 1998; Heikinheimo et al., 2014; Ammar et al., 2015). For example, females mostly reach sexual maturity at the age of 3–4 years in aquaculture conditions, while it takes 4–6 years in natural (wild) populations. For males, this period is 2–3 years in aquaculture conditions, and 3–4 years in natural populations. More than 65% of individuals of both sexes of this species reach sexual maturity mostly at the age of 3 years in aquaculture conditions and 4 years in uncontrolled conditions. The minimum body length of first spawning males is about 30 cm, mostly 38–40 cm. Female pikepersh are 39 and 41–46 cm long, respectively (Antalfi, 1979; Andriushchenko et al., 2006; Khendek et al., 2018).

The spawning stock of pikeperch is characterized by the sex ratio of almost 1:1, after another, however, depending on the age group ratio, it may change insignificantly. In the spawning stock, the weight of females mostly ranges 1.5 to 4.0 kg, and that of males 0.8 to 2.0 kg, but smaller individuals can also be used in the work. In addition, during the spawning period, the sexual dimorphism typical for pikeperch is clearly seen: females are characterized by a much lighter color of scales on the body than males and also a more convex (hanging) abdomen (Lehtonen & Toivonen, 1987; Demska-Żakęś & Żakęś, 1995; Movchan, 2011).

Specificity of spawning grounds and duration of pikeperch spawning

Pikeperch spawning grounds can be located both at a distance from the shore, sometimes 3 and more meters deep, and near the shore – on nearshore vegetation (moss-covered tree roots, reeds, rushes). The ability to spawn on different substrates, including open areas of water bodies, allows it to be more tolerant to changes in water level than fish that reproduce only near shores. Accordingly, the amplitude of fluctuations in the relative abundance (the frequency of meetings of a certain species for a certain number of records) of its population is within 55–74%, which is significantly less than such of the blue bream (*Ballerus ballerus* Linnaeus, 1758) or pike (*Esox lucius* Linnaeus, 1758), and close to such values in common bream (*Abramis brama* Linnaeus, 1758) and roach (*Rutilus rutilus* Linnaeus, 1758). The semi-migratory form of pikeperch during the breeding season prefers floodplains, but in general it is also not demanding to the substrate and the location of the spawning grounds. The main requirements of this species to spawning sites are absence of a muddy bottom, high oxygen content and a small degree of overgrowth with aquatic vegetation. That is why the first means of increasing its abundace through reproduction in artificial and natural water bodies is the implementation of melioration measures (Poltavchuk, 1959; Movchan, 2011; Nagiec, 2011).

A bottom covered with small stones or coarse sand, where rigid water plants (reeds, rushes) grow singly, 1.5–2.0 m depth is optimal for pikepersh spawning. On such a substrate, males clear the surface layer of the bottom by digging up plant roots and thus building spawning nests. The latter are mostly characterized by 0.5 m diameter and 5 cm depth. There, females lay eggs. Male pikepersh fertilizes female and then guards the clutch placed in the spawning nest for about 7 days. During this period, it constantly moves its fins, thereby creating additional water circulation. Thus, the male pikepersh provides the oxygen regime necessary for the full development of embryos (Melnyk, 1966; Tretiak, 2008; Movchan, 2011).

The duration of pikepersh spawning depends on the time of onset and the length of the water temperature interval in the range of 8 to 15 ºC. The mass and most intensive pikepersh spawning is characterized by reaching the water temperature of 10 to 12 ºC. In the conditions of aquaculture in Ukraine, the spawning campaign with pikepersh is usually carried out from early April and can continue throughout May. In natural (wild) populations, the duration, intensity, and synchronicity of pikepersh spawning depends significantly on the weather. In particular, the colder and stronger the wind, the longer the spawning campaign becomes. Spawning actually usually occurs in April and early May (Bilyi, 1958; Andriushchenko et al., 2006; Movchan, 2011).

Thus, reproduction of pikeperch in natural or artificial water bodies is possible if the environmental conditions of these water bodies meet the following requirements: they do not have a muddy bottom, there is a developed food supply, there are areas free of higher aquatic vegetation, there is a weak flow rate, and hydrochemical parameters are within the limits defined in the Requirements for the Water of Farms DSTU 15.372-87 and Water of Aquaculture Enterprises. General Requirements and Norms of SOU - 05.01. 37-385:2006" (Hrynzhevskyi et al., 2001; Tretiak, 2008; Kononenko et al., 2016).

The basic processes of working with broodfish – catching, transportation, keeping

Broodstock caught in natural water bodies or grown in aquaculture, mainly in pond, can be used for pikeperch reproduction. In natural conditions, harvest of broodstock is carried out near wintering holes, on the routes of spawning migrations and directly in areas near spawning grounds. Brood fish can be caught using seines of various sizes (Fig. 1) (Bilyi, 1958; Tretiak, 2008; Kononenko et al., 2016).

Fig. 1. Harvest of brood pikeperch from a pond

Brood pikeperch are mostly caught twice a year – in the fall (October–November), before they are stocked for wintering and in the spring (March–April), usually at least 1 month before the start of spawning season (Andriushchenko et al., 2006; Kononenko et al., 2016). Reproduction works start when the average daily water temperature is about 8.5 ºC, when brood fish are caught and transported to spawning ponds or hatchery tanks, which are usually equipped with a closed water supply system (Teletchea et al., 2009; Zakęś & Demska-Zakęś, 2010; Martseniuk, 2014).

Transportation of brood pikeperch can last up to 120 minutes in 10–12 ºC warm water, but only if anti-stress substances are used. One of the most common anti-stress agents is a saline solution in the concentration of 5 g of $NaCl/dm^3$. However, the optimal duration of transportation of broodstock of this fish species is 60 minutes. Such a period of time allows for their movement at water temperatures ranging 8 to 15 ºC, but not broader. The shorter the time during which transportation is carried out, the higher stocking density can be used. For example, during short-term transportation, up to 60 kg of broodstock are sometimes loaded into a 1 m^3 container. It is best to use special boats, with holes in some parts for the flow of water, for transporting broodstock for the purpose of reproduction. In this way, the movement of a boat with live fish is ensured for considerable distances across the water area (Sachs, 1878; Pourhosein-Saramech et al., 2012; Németh et al., 2013). In the process of works with domesticated brood fish at farms, live fish are mostly transported using special, so-called "live fish", machines. The effectiveness of these vehicles when working with all age groups of pikeperch directly depends on the strict adherence to methodological norms and equipment, which can vary broadly (Fig. 2).

Fig. 2. A vehicle to transport live fish

In particular, it is possible to use both vehicles from the old transport fund, which is more than several decades old, and new ones. Modern vehicles are often equipped with installations for saturating water with oxygen, devices for temperature regulation of water, special anti-traumatic coating for walls, etc. The most common anti-traumatic materials are plastic film with bubbles or foam boards. Reducing injuries during transportation of pikeperch is very important, because the specific characteristics of this fish are oxyphilicity and low resistance to mycoses. In addition, stress is increased by traumatism, the risk of which is always high during transportation. In turn, the higher the level of stress in an individual, the worse its physiological and biochemical state, which directly affects the degree of efficiency of procedures with fish. That is why it is recommended to introduce additives with antioxidant properties into the diet of brood pikeperch, to use drugs with a sedative and anesthetic spectrum of action. A mandatory step when using any means of transportation of pikeperch under any conditions is a thorough antiseptic treatment of the equipment before and after moving the fish. It involves the use of a suitable preparation with antiseptic properties for the purpose of disinfecting the container in which fish are transported. After that, this container, before placing the fish in it, should be thoroughly washed to avoid possible intoxication (Hrytsyniak et al., 2008; Tretiak, 2008).

The pre-spawning keeping of pikeperch broodstock lasts for several days with fluctuations in the average daily water temperature from 8 to 10 ºC. It is mostly carried out in medium-sized rectangular or round plastic tanks. The main criterion when choosing a tank for working with brood pikeperch is the ease of their maintenance and minimizing the possibility of injury to the brood fish kept in them (Hokanson, 1977; Hermelink et al., 2011; Martseniuk, 2014).

During pre-spawning keeping, brood pikeperch should be sorted, at least by sex. These individuals should be kept in salt baths and fed with small live fish (in the case of using ponds) at the rate of 2.5–3.0% per day of the broodstock weight. In general, the effective maintanance of brood pikeperch is possible only when water is saturated with oxygen in the concentration of at least 5 mg/dm^3 (Wang et al., 2009; Frisk et al., 2012; Németh et al., 2013). Feeding of broodstock, which starts in fall, is extremely important, as it directly affects the timing of their sexual maturation and the quality of sexual products. In addition, a diet rich in animal protein helps to increase the fertility of pikeperch females. In general, in case of feeding broodstock exclusively with small fish, its total weight per day should be up to 6% of the pikeperch weight. If the diet of brood fish contains artificial feeds, the share of fish in it can be reduced to 2% of the pikeperch weight (Molnár et al., 2004; Schlumberger & Proteau, 2007; Martseniuk, 2014).

The main methods of increasing the effectiveness of pikeperch reproduction

The stocking density of brood fish in spawning ponds is 50 to 80 fish/ha. For the most part, in order to increase the efficiency of spawning, artificial nests are arranged in these same ponds, made of tree branches of mainly coniferous species or frames with gauze or kapron milling sieve (No. 18-20), installed in containers or boxes, at the rate of 15–20 m^2 of the pond area per 1–2 males and 1 female. Thus, it is possible to place 30 nests or frames and 30 females and 30 to 60 males in a 600 m^2 pond. However, if it is planned to leave egg clutches in the pond where spawning actually took place, then they are placed at the rate of 1 to 4 nests or frames with eggs per 1 ha. In case when nests or frames are planned to be transeferred, there are usually used ponds of less than 1 ha area. The number of nests was 10% higher than the number females and 10% more than males than needed. They are arranged at the distance of 3–5 m one to another. It is recommended that the body length of females used in spawning campaign is more than 40 cm (Poltavchuk, 1959; Melnyk, 1966; Tretiak et al., 2008).

In spawning tanks for pikeperch, artificial nests of artificial grass are also used, as well as wooden or metal frames with gauze or kapron mill sieve. First of all, this is due to the requirements for the use of all links of a tank system and the possibilities for water disinfection (Andriushchenko et al., 2006; Martseniuk, 2014; Kononenko et al., 2016).

In 1 m^3 spawning cages located in places protected from wind and waves at 1.5 m depth, 1 frame with gauze or kapron mill sieve is placed. It should be square in shape, 50 x 50 cm in size. Cages are mostly made from nets with a mesh size of 1 cm^2, cylindrical or cubic in shape (Demska-Żakęś & Żakęś, 2002; Salminen et al., 2013).

When choosing between kapron mill sieve and gauze, the main differences between them should be taken into account in each specific case. In particular, the disadvantages of the first material are that it is not environmentally friendly, since it decomposes for a long time and can harm the ecosystem of a natural water body. At the same time, the second material is organic, because gauze is made of cotton, and its advantages can be disadvantages in certain circumstances. For example, it is not resistant to cleaning and long-term use and easily decomposes, thereby worsening the ichthyopathological and hydrochemical state of water (Hrytsyniak et al., 2008; Tretiak, 2008).

Artificial spawning nests for pikeperch are placed on spawning grounds in natural and artificial water bodies, choosing areas with a hard, vegetation-free bottom. In natural water bodies and reservoirs, they begin to be placed when water temperature reaches about 6–7 ºC and continued to be installed until the end of spawning, at the rate of 1 nest for 1 female and 2 males. In spawning ponds for mostly one-time installation of nests, water temperature is expected to increase up to 8–10 ºC, and it should be 1 female and 1 or 2 males per 1 nest. Regardless of type of the water body, the nests should be round with the diameter of 50–100 cm, or square with the size of 50 x 50 or 70 x 70 cm. They are usually made of artificial grass or branches of willow or coniferous trees. The latter are mostly used in cases when the eggs laid on them are not planned to be transferred to a hatchery. This is due to the fact that brood pikeperch do not always choose artificial nests for spawning in ponds. In addition, the degree of spawning efficiency directly depends on the level of controllability of its conditions. That is why, during the spawning campaign using nests in ponds, they should be regularly inspected. Immediately after detection of laid eggs or 2 days after their fertilization, in the morning or in the evening, they are quickly transported to a hatchery or another pond, wrapped in a clean and damp cloth. Otherwise, the results of pikeperch spawning campaign could be evaluated only in July, when it is relatively easy to determine the productive and biological characteristics of young-of-the-year pikeperch during test catches (Hrynzhevskyi & Pekarskyi, 2004; Andriushchenko et al., 2006; Ljubobratović et al., 2017).

Before using artificial nests or frames with gauze or kapron mill sieve, they should be treated with a substance with antiseptic properties and a low toxic effect. The need to use such substances is due to the fact that representatives of more than 10 genera of various parasitic fungi can attack pikeperch eggs. At the same time, most of the substances widely used for this purpose 30 years ago are now recognized as potentially toxic or have not passed the state registration as appropriate agents (Andriushchenko et al., 2006; Németh et al., 2013; Polishuk & Simon, 2023).

The artificial method is used to reproduce pikeperch in fully controlled conditions. It involves the implementation of the entire cycle of artificial reproduction of fish in hatchery. For example, pre-spawning keeping of broodstock in tanks, where they are injected with hormonal gonadotropic (dehydrated pituitary glands of fish, Surfagon, "Vadilen", human chorionic gonadotropin, etc.) drugs in order to increase the effectiveness of maturation of sexual products. The calculation of the drug dose and the number of injections are determined depending on fish weight, maturity stage of its gonads, and water temperature (Křišťan et al., 2013). For example, injections of a pituitary preparation are the most common in Ukraine and are carried out once at the rate of at least 1.0–1.5 mg of dry matter per 1 kg of female weight and 0.5–1.0 mg of dry matter per 1 kg of male weight. At the same time, injections of human chorionic gonadotropin are the least common in Ukraine. They are given at the rate of 200–600 IU/kg. Injections are made into the anterior third of the body, into the back muscles located above the lateral line (Németh, 2009; Zarski et al., 2013; Polishchuk, 2022).

To obtain sperm, there are selected males that release it when slightly pressed on the abdomen. The sperm is placed into a dry and clean container, mostly using thin and flexible catheters. To obtain eggs, females are selected based on biopsy samples, which are also sampled using a catheter (Lahnsteiner & Mansour, 2004; Sarosiek et al., 2016; Schaefer et al., 2016).

Collected sperm and eggs are analyzed, including identifying the quality of brood fish. In sperm, the volume of ejaculate and the duration of sperm motility should be determined. Collected oocytes are examined for the position of the nucleus on glass slide under binocular microscope (Zarski et al., 2011). Eggs are taken from each female into a separate, clean vessel with smooth walls and bottom, usually plastic. If clots or blood appear in eggs during its draining, it should be immediately stopped. Using this method, eggs are inseminated in a semi-dry or dry way, using sperm from 2–3 males, at the rate of 1–2 mL of sperm per 100 g of eggs. Then, the fertilized eggs are deglutinized by washing in an aqueous solution of tannin in the concentration of 0.5–1.0 g/L of water for 2–5 min exposure or using an aqueous 0.5% protease solution for 2 min exposure. After that, incubation begins (Andriushchenko et al., 2006; Żarski et al., 2013; Polishchuk, 2022).

Reproduction of pikeperch in non-traditional periods (outside of the spawning season) takes place in tanks or trays in recirculaing aquaculture systems. Brood fish are stimulated by physiological and ecological methods: by changing 3 phases of temperatures (first lowering the water temperature from 20 to 8 ºC, then maintaining it at the level of 4 to 8 ºC and then raising it again from 8 to 12 ºC); increasing daylight from 8 to 14 hours; using hormonal stimulating drugs; using a special diet (Żakęś & Szczepkowski, 2004; Rónyai, 2007; Zakęś, 2007).

General principles of working with eggs and sperm

Pikeperch eggs, unlike other percids, are small. For example, about 1.5–2.2 million native eggs with the diameter of 0.5–1.1 mm and 1.0–1.5 million swollen eggs with the diameter of 0.9–1.6 mm are in 1 kg. Fertility of females mostly ranges 150 thousand to 1 million eggs. It directly depends on the fish age and size. In addition, early maturation in aquaculture often results in low industrial fecundity (the number of eggs produced by one female in one spawning campaign) in first-time breeding females. For example, according to the results of the first reproduction, the industrial fertility of a female with about 400 g average body weight can be more than 23 thousand eggs, which is a rather low value for pikeperch. During repeated reproduction, with an average weight of approximately 700 g, the industrial fertility increases to 78 thousand eggs on average. Therefore, it is best to use pikeperch females weighing over 1,000 g in a spawning campaign. Then, the fertility and fertilization levels are almost always high (Bilyi, 1958; Hrytsyniak et al., 2008; Martseniuk, 2014).

Pikeperch spermatozoa retain their mobility for about 78–187 seconds in fish weighing about 0.7–1.4 kg, i.e., they are able to fertilize eggs during this time. Usually, the volume of ejaculate in males is around 0.58–1.02 mL (Křišťan et al., 2014; Sarosiek et al., 2016; Schaefer et al., 2016).

Transportation of fertilized pikeperch eggs and their storage for 48 hours is possible if all the following conditions of collection and transportation are adhered to:

1) the procedures are carried out in the morning or evening hours, when the development of the embryos reaches the “eye” stage – when it is possible to see the eyes, or stage IV of development through the egg envelope, which usually occurs between 48 and 60 hours after fertilization, depending on the incubation temperature; any manipulations with eggs before this period of ontogenesis lead to a rapid increase in the mortality rate;

2) stable water temperature of 5–6 ºC is maintained, which is achieved gradually in order to avoid an additional increase in the stress level of nests due to sudden cooling, lining of nests or frames with gauze or kapron milling sieve, bags with ice;

3) nests or frames with gauze or kapron are wrapped with clean and moist gauze, folded in layers and covered from the sun and wind (Andriushchenko et al., 2006; Güralp et al., 2016; Kononenko et al., 2016).

In high-quality collected pikeperch eggs and sperm, the fertilization rate on average is up to 80% of the total number of all eggs obtained. The duration of the development of fertilized eggs or the incubation period directly depends on water temperature and varies widely. For example, the following correlation can be observed between water temperature (ºC) and the incubation period of fertilized pikeperch eggs (days): 20 – 3, 18 – 4.5, 16 – 5, 14 – 7, 12 – 9, 10 – 10, respectively (Bilyi; 1958; Melnyk, 1966; Güralp et al., 2017).

The highest degree of control over the incubation conditions of pikeperch eggs is attained by using special incubation devices – Amur, Weiss, VNDIPRG, Dnipro, and their home-made analogues. In each individual case, there are specifics of the most optimal use of a particular device according to a certain scheme. For example, it is best to install nests with fertilized eggs in a vertical position in the Amur apparatus. At the same time, it is most expedient to load the fertilized and separated eggs into the 8 L Weiss apparatus. Regardless of design of a device, preventive treatment of eggs placed in it with low-toxic antiseptic substances is mandatory. On the one hand, it is necessary to prevent diseases, primarily mycoses and protozoa, and on the other hand, to avoid intoxication of the embryos. Therefore, the most optimal time for sanitary and preventive treatments is the third day after fertilization (which usually corresponds to the stage of gastrulation). However, the resistance of fertilized eggs to mycoses directly depends on: the quality of brood fish; better flow rate of at least 0.2 m/s, stable water temperature within 12–15 ºC and optimal level (pH) of water (about 7); and number of live fertilized eggs in the apparatus. For example, presence of dead eggs increases the risk of mycoses, primarily saprolegniasis, which is caused by parasitic fungi such as *Saprolegnia* and *Achlya*. It is desirable to manually collect dead and affected eggs daily, after which short-term sanitary and preventive treatment should be carried out (Andriushchenko et al., 2006; Kononenko et al., 2016). The effectiveness of the latter significantly increases the disinfection of water supplied to incubation devices with pikeperch embryos using ultraviolet irradiation. For this, ultraviolet lamps (UV lamps) are mostly used at the stage of water preparation. Stability of the temperature regime directly affects the proportion of individuals with growth and development defects. For example, with a long-term decrease in water temperature during incubation beyond 8 ºC, the normal development of pikeperch embryos ceases irreversibly. Also, during the entire spawning campaign, it is necessary to carefully monitor that the concentrations of the following substances do not exceed the maximum allowable concentrations: ammonium nitrogen (NH_4) – 1 mgN/dm^3, ammonia (NH_3) – 0.05 mgN/dm^3, free carbon dioxide (CO_2) – 10 mg/dm^3 (Wuertz et al., 2013; Schram et al., 2014; Steinberg, 2018).

The hatching of prelarvae or free embryos from eggs completes the process of their incubation. The duration of hatching of pikeperch prelarvae is primarily determined by water temperature and the quality of fertilized eggs. In particular, under optimal conditions, hatching of free pikeperch embryos lasts for about 1.5–2.0 days. As the environmental conditions deteriorate, hatching of prelarvae starts to take longer. The percentage of free embryos released from fertilized eggs of high quality varies between 60–75%. In natural conditions (lakes, reservoirs, etc.), pikeperch reproduction usually occurs later than such of pike and perch. However, as a predator, it has earlier reproduction periods than most omnivorous and herbivorous European fish species, primarily caprynids. Therefore, its juveniles are provided with a food supply as they grow and develop, changing their diet from consuming zooplankton to larvae of other fish species, and later to fish fry (Antalfi, 1979; Blecha et al., 2016).

Under controlled conditions of pikeperch aquaculture, its prelarvae and larvae are counted visually, by individuals, or by the standard method (Andriushchenko et al., 2006; Kononenko et al., 2016).

The aim of reproduction of pikeperch is its subsequent effective cultivation, in which the most difficult stage is working with juveniles. During works, the main difficulties are raising the larvae and accustoming the fish to artificial feeds (Bódis et al., 2007; Martseniuk, 2014; Policar et al., 2019). It can be stated that as soon as from the young-of-the-years, the limiting factors regarding the cultivation of pikeperch in aquaculture have mostly been overcome, and the actual quality of young-of-the-years depends on the quality of brood fish as well as on success of a spawning campaign with them and the effectiveness of work on raising juveniles to viable stages.

Conclusions

Solving the problem of rational reproduction of aquatic biological resources contributes to the achievement of most of the goals outlined in the concept of "sustainable development". Among them, first of all, are overcoming poverty, good health and well-being, clean water and proper sanitation, decent work and economic growth, responsible consumption and production, mitigation of the consequences of climate change, and preservation of marine resources.

Pikeperch belongs to the most valuable species of European aquatic biological resources. During the last century, the technology of pikeperch breeding has been continuously improving, adapting to socio-economic and ecological-climatic changes. In particular, depending on specific conditions and goals of economic activity, breeding of pikeperch is carried out using artificial spawning grounds in various types of inland water bodies (primarily – lakes, rivers, reservoirs), as well as in cages, ponds, tanks, recirculating aquaculture systems (RAS) or using combined methods. All of the technological modifications listed above are designed to achieve an optimal balance between the natural biological features of the species (time and conditions of the onset of sexual maturity, the specificity of the broodstock, requirements for specific parameters of spawning grounds, duration of reproduction, actual spawning behavior, etc.) and the choice of effective ways of influencing them, in particular: installation of artificial nests from tree branches or artificial materials; stocking broodstock on them at the rate of 1 female for 1–2 males; special pre-spawning keeping, which involves changes in the diet and sanitary and preventive treatment; use of hormonal stimulants (preparations for the pituitary gland or chorionic gonadotropin, as well as their synthetic analogues – Surfagon, Vadilen, etc.); changes in temperature and light conditions. In this way, obtaining the largest number of eggs and sperm of the highest quality is achieved. After that, the eggs are fertilized and incubated, trying to achieve the highest levels of fertilization and embryo survival. The incubation process ends with the appearance of free embryos, which are the basis for fish seeds. The quality of the latter directly affects the cost of production and the degree of commercial fishery pressure on natural populations. In turn, it is determined both by the genetic structure of reproductive groups of brood pikeperch and by the degree of efficiency of the reproduction process.

Peculiarities of the technological support of pikeperch reproduction processes in aquaculture are largely determined by the specifics of the development of freshwater aquaculture in individual countries, primarily by availability of resources in the relevant water bodies and level of scientific and technical support of the activity.

In order to optimize the reproduction process of pikeperch, the most relevant scientific studies are currently characterized by: improvement of synthetic gonadotropic drugs for this fish species; development of effective methods of artificial reproduction under controlled conditions; increasing the productivity of brood fish and the quality of their eggs and sperm. At the same time, the priority tasks are to increase the survival rate of brood fish in the post-spawning period and to improve the transportation of fish used for breeding. This will allow reducing the stress of brood fish during manipulations with them and significantly increasing the efficiency of the pikeprch reproduction process. For this purpose, scientific studies are mostly carried out in the field of biologically active additives to the diet and creation of appropriate formulations of artificial feeds.

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