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European Green Dimensions: Fundamental, Applied, and Industrial Aspects

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European Green Dimensions: Fundamental, Applied, and Industrial Aspects

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edited by
Olena Mitryasova
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FOREWORD

The imperative for a sustainable future has never been more pronounced. Across the globe, societies grapple with the intertwined challenges of environmental degradation, climate change, and the urgent need for a paradigm shift in our economic and social models. At the heart of Europe's ambitious response to these critical issues lies the European Green Deal, a comprehensive strategy aimed at making the continent climate-neutral by 2050. This landmark initiative transcends mere environmental policy; it represents a fundamental re-imagining of Europe's growth model, encompassing energy, industry, agriculture, and societal well-being.

It is within this dynamic and transformative context that this collective international monograph, «European Green Dimensions: Fundamental, Applied, and Industrial Aspects» takes its crucial place. This volume emerges as a timely and vital contribution to the growing body of literature dedicated to understanding, analyzing, and ultimately facilitating the transition towards a greener and more sustainable Europe. Its publication is made possible through the generous support of the Project «EUROPEAN GREEN DIMENSIONS» 101081525-JM EUGD-ERASMUS-JMO-2022-HEI-TCH-RSCH, a collaborative endeavor uniting the expertise and resources of Petro Mohyla Black Sea National University (Ukraine), the University of the West of England (United Kingdom), and the University of Presov (Slovakia). This transnational partnership underscores the inherent internationality of the green transition and the necessity of shared knowledge and collaborative efforts in addressing global environmental challenges.

The genesis of this monograph is deeply rooted in the recognition of Ukraine's pivotal position within the European landscape and the profound implications of the European Green Deal for its future development. As a nation aspiring towards closer integration with the European Union, Ukraine stands at a critical juncture. The opportunities presented by the Green Deal – from new economic pathways and technological advancements to enhanced environmental standards and improved quality of life – are immense. However, so too are the challenges associated with adapting to new regulatory frameworks, transforming existing industries, and embracing sustainable practices across all sectors of its economy and society.

This monograph seeks to provide a multifaceted exploration of the European Green Deal and its ramifications, with a particular focus on the opportunities and consequences for Ukraine. It delves into the fundamental principles underpinning the Green Deal, examines its key initiatives across various sectors, and proposes a potential roadmap for Ukraine's effective participation in this transformative agenda. By bringing together diverse perspectives from leading scholars, researchers, and practitioners across Europe, this volume offers a comprehensive and nuanced understanding of the complexities involved.

The scope of this monograph is intentionally broad, reflecting the all-encompassing nature of the European Green Deal itself. It navigates a range of critical themes that are central to achieving a sustainable future.

The monograph is devoted to topics: European Green Course: opportunities and consequences for Ukraine; European Green Course initiatives; Roadmap for Ukraine's participation in the European Green Course; Overcoming climate change in the framework of the European Green Course; Adaptation to the effects of climate change; Green business: new market opportunities and innovative products; Energy efficiency, renewable energy; Conservation of biodiversity as a condition for the sustainability of ecosystems; Water resources management: water quality, wastewater treatment; Protection of atmospheric air; Environmental control and monitoring systems; Industrial and household waste management.

Through the collective wisdom and diverse expertise of its contributors, this monograph aims to serve as a valuable resource for policymakers, researchers, businesses, educators, and all stakeholders interested in understanding and contributing to the European green transition, with a particular emphasis on Ukraine's journey within this transformative process. It is our sincere hope that the insights and analyses presented in these pages will contribute to informed decision-making, foster collaboration, and ultimately accelerate the realization of a sustainable and prosperous future for Europe and beyond.

The successful completion of this monograph is a testament to the dedication and collaborative spirit of all involved. We extend our sincere gratitude to the authors for their insightful contributions, the reviewers for their rigorous assessments, and the project team for their unwavering support. We are confident that «European Green Dimensions: Fundamental, Applied, and Industrial Aspects» will serve as a significant contribution to the ongoing dialogue on sustainable development and the crucial role of the European Green Deal in shaping our collective future.

Professor Olena Mitryasova

Professor Chad Staddon

DESTRUCTION OF THE ICHTHYOFAUNA OF THE SOUTHERN BUH

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ANNOTATION

The work is dedicated to solving the environmental problems of the Southern Buh River, which arose as a result of the construction and operation of hydroelectric power plants and the search for ways to restore and preserve the lost ichthyofauna.

It has been established that decades of economic exploitation of the water resources of the Southern Buh basin have had a devastating impact on the biodiversity of ichthyofauna. Many valuable species have been destroyed.

The beginning of the degradation of the Southern Bug was the massive construction of hydroelectric power plants, which turned out to be a grandiose static-destructive pollution. The Southern Buh turned into a cascade of stagnant reservoirs, which completely changed and worsened the conditions for the existence of ichthyofauna species and led to their further disappearance.

The construction of hydroelectric power plants had a strong structural and operational impact on the river ecosystem of the Southern Buh and led to the violation of fundamental ecological laws: the law of the minimum of Y. Liebig, according to which the relative effect of a single environmental factor will be the stronger, the more this factor, in comparison with other environmental factors, will approach its quantitative minimum; the law of tolerance of Shelford, according to which the presence or prosperity of a population of any organisms in a given location depends on a complex of environmental factors, to each of which there is a certain range of tolerance (endurance) in the organism; from the law of feedback of human - biosphere interaction, first formulated by P. Dansereau, according to which any change in the natural environment caused by human economic activity "returns" and has undesirable consequences that affect the economy, social life and health of people.

The processes of destruction of the Southern Buh, caused by enormous overregulation and significant pollution, continue, which negatively affects its inhabitants, in particular, new representatives of the ichthyofauna are being added to the category of endangered and missing.

Proposed that will help stop the process of final destruction of the Southern Buh, restore its water resources, and recreate the lost ichthyofauna.

Keywords: Southern Buh, hydroelectric power plant, ichthyofauna, sturgeon family, environmental protection measures.

INTRODUCTION

Why is the thousand-year-old Southern Buh sick and its glorious inhabitants dying? The answer is obvious. The Southern Buh suffers most from economic activity.

In the Southern Buh basin, there are 6,582 small rivers with a total length of about 20,000 km, 11 medium-sized rivers with a total length of over 1,600 km, and 1 large river, the Southern Buh.

Large-scale economic development of the Southern Buh River began in 1929 with the commissioning of the first hydroelectric power plant and reservoir near the town of Pevmoysk . Since then , dozens of small hydroelectric power plants with a capacity of up to 10 MW have been built and are operating on the Southern Buh River (Table 1). The energy potential of the Southern Buh River is 27,735 MW [1]. Currently, due to significant overregulation and a huge number of artificial reservoirs in the catchment basin, the actual generated capacity of all small hydroelectric power plants fluctuates within 25-40% of the planned values. The procedure for assessing the environmental impact of economic activities appeared almost 50 years after the start of construction of the first hydroelectric power plants.

METHODS AND EXPERIMENTAL PROCEDURES

If you approach the dam of the Sabarivska HPP, you can see that the Southern Bug River is all green and blooming. There is a smell of blooming water in the air. The locks are completely closed at the Sabarivska HPP, the water in the river is stagnant (Fig. 1 and 2). At the Sabarivska HPP, the required level is maintained so that Vinnytsia is not left without water. When water is released from ponds in the Khmelnytskyi region, its level in the Southern Bug rises by a couple of centimeters every day. When the Sabarivska reservoir is filled with water above the norm, it is released through the dam so that the water does not stagnate. Every month, the water is taken for analysis. The water is absolutely suitable for drinking and household needs, assures the management of the Southern Buh Water Resources and Development Department [2]. However, the management does not dare to demonstrate the suitability of the water for drinking.

Table 1 – Small hydroelectric power plants on the Southern Buh River.

No. n/n	SHPP	Power, kW	No. n/n	SHPP	Power, kW
1	Ladyzhynska (current)	7500	9	Berezivska (current)	300
2	Sabarivskaya (current)	1050	10	Savranskaya (active)	450
3	Bratslavskaya (active)	400	11	Gayvoronska (current)	5700
4	Hlybochanska (active)	6130	12	Sutyska (current)	1400
5	Chernyatskaya (current)	1400	13	Pervomayskaya	600
6	Sandratska (current)	640	14	Kostyantynivska	400
7	Novokostyantynivska (active)	525	15	Mygiyskaya (active)	600
8	Shchedrivskaya (current)	640		Total	27735

A characteristic feature of the Southern Buh basin, which distinguishes it from other large rivers, is its very high degree of regulation. 16 reservoirs with a capacity of 316 million m³ have been built on the bed of the Southern Bug River, which are used for the needs of hydropower, water supply and recreation. 170 reservoirs with a capacity of 578 million m³ have been created in the basin , with a total water surface area of almost 30 thousand ha, and over 10 thousand artificial reservoirs (ponds), with a total area of over 56.4 thousand ha, and a total volume of 644 million m³, which is practically equal to the runoff in a low-water year of 95% of the supply. There is not a single small river or stream in the Southern Bug basin that would not be dammed by several dams of fish farming ponds. This increases the volume of evaporation and the level of water pollution. Water from fish ponds is discharged only during fish catching. As a result, the areas of small river and stream basins are practically removed from the area of the Southern Buh basin [2,3].



Fig. 1. The Southern Buh “blooms and smells” near the dam of the Sabarivska SHPP in Vinnytsia [2].



Fig.2. Result of eutrophication of the reservoir.

Every year, ecologists note a decrease in the water level of the Southern Buh River. The phenomenon of shallowing is especially evident in the area of the village of Mygiya, Pervomaisky district, which is known for the famous Buh rapids. The constant dark green color of the river water (see Fig. 3) indicates significant eutrophication in the middle and lower reaches of the Southern Buh. In addition, the Southern Buh is silting up, there is less fresh water, its quality is deteriorating, and the banks are overgrown with reeds. According to the Southern Management of the Southern Buh Basin, reservoirs located upstream take water for sanitary releases and thereby dehydrate the Southern Buh [4].



Fig. 3. Rapids near the village of Mygiya, Pervomaysky district, Mykolaiv region.

Analysis of data from the Ministry of Community and Territorial Development of Ukraine (Table 2) shows that 3,738 settlements in Khmelnytskyi, Vinnytsia and Mykolaiv regions, where more than 1.6 million rural residents live, lack centralized wastewater treatment [5]. In the regional centers of Khmelnytskyi, Vinnytsia and Mykolaiv, sewage treatment plants cover only half of the urban population.

Table 2 – No centralized sewage system [5].

No. n/a	Administrative territories	Population		Number of n/a, total			There is no centralized sewage system.		
		Urban population	Rural population	cities	town	village s	cities	town	village s

1.	Vinnytsia	799.385	746.031	18	29	1456		10	1451
2.	Volynska	539 179	492.242	11	22	1054	2	4	1029
3.	Dnipropetrovsk	2668.744	507.904	20	46	1372	1	13	1343
4.	Donetsk	3754.349	377.459	40	72	128		34	114
5.	Zhytomyrska	716,457	491.755	12	43	1613		8	1596
6.	Transcarpathian	465.904	787 887	11	19	579		2	563
7.	Zaporizhzhia	1306.231	381.170	14	22	914		11	896
8.	Ivano-Frankivsk	606.764	761.333	15	24	765		13	756
9.	Kyivska	1105.383	675 661	26	30	1126		5	1068
10.	Kirovohradska	591.944	341.165	12	27	991	1	9	985
11.	Luhansk	1859.590	276.323	12	24	497		15	494
12.	Lvivska	1534.040	978.044	44	34	1850	5	17	1839
13.	Mykolaivska	768.022	351.840	9	17	885			866
14.	Odesa	1597.062	780 168	19	33	1124		19	1110
15.	Poltava	867 201	519.777	16	20	1810		3	1773
16.	Rivne	548.088	604.873	11	16	999		1	978
17.	Sumy	741.430	326.817	15	20	1458		8	1445
18.	Ternopil	473.727	564.968	18	17	1023	1	7	1017
19.	Kharkiv	2158.121	500 340	17	61	1673	1	22	1636
20.	Kherson	631.317	396 596	9	31	658		12	588
21.	Khmelnyskyi	720 752	533.950	13	24	1414		9	1402
22.	Cherkasy	678 682	513.455	16	15	824		10	810
23.	Chernivtsi	390.551	511.081	11	8	398	2	1	398
24.	Chernihiv	649.063	342.231	16	29	1465	1	15	1454
	Ukraine	30 735929	13 521035	406	683	26076	14	248	25611

Most regional departments of ecology and natural resources in their annual regional reports on the state of the environment shyly avoid information on the number and condition of sewage treatment plants. The unsatisfactory condition of outdated sewage treatment plants and the lack of storm sewers increases the anthropogenic load on the Southern Bug basin. As a result, natural aquatic ecosystems have been completely transformed into anthropogenic water bodies, which in the process of their evolution have turned out to be completely unsuitable for the existence of aboriginal sturgeon species of ichthyofauna.

The ichthyofauna of the Southern Buh includes 75 species of fish. The main species of fish are: bullhead, crucian carp, carp, roach, rudd, pike, perch, bream, flatfish, grass carp, silver carp, catfish, and pike perch. In the upper reaches The Southern Bug is inhabited by carp, bream, crucian carp, tench, roach, bream, rudd, chub, bream, roach, crucian carp, crucian carp, pike, perch, ruff, bream, loach, and bullhead. In the middle reaches, in addition to the above-mentioned fish, there are also bream, roach, pike perch, catfish, and burbot. In the lower reaches, the fish population is replenished with bream, which has been very rare recently. Some migratory and semi-migratory fish enter here from the Dnieper-Buh estuary and the Black Sea - beluga, sturgeon, stellate sturgeon, tyulka, herring, rudd, ram, shemaya, bream, roach, eel, pike perch and some others. However, they do not rise above the village of Oleksandrivny due to the presence of a dam [6].

The creation of reservoirs disrupts the centuries-old conditions of life and reproduction of ichthyofauna. The increase in the intensity of eutrophication in artificial reservoirs on rivers is evidence of a constant influx of untreated wastewater, which affects the change in the species and quantitative composition of ichthyofauna. The fact of a reduction in the number of species of ichthyofauna of the Southern Bug is obvious. First of all, species of ichthyofauna disappear, the existence of which becomes unbearable and impossible with the deterioration of hydrophysical, hydrochemical, hydrobiological and microbiological indicators of river water.

RESEARCH RESULTS AND DISCUSSION

The Southern Buh, along the Stopich, was considered one of the richest rivers in fish. Fishing was the most important branch of all the industries of the lower Cossacks and supplied them with the most used product for food and trade, and the Southern Bug River was considered one of the best places for fishing. In Buza, Inhul, and the estuaries, Cossacks caught sterlet (*Acipenser ruthenus*), stellate bream (*Acipenser stellatus*), Black Sea beluga (*Huso ponticus*), Russian sturgeon (*Acipenser gueldenstaedtii*), European catfish (*Silurus glanis*), common bream (*Abramis brama*), roach (a transitional form of *Rutilus rutilus*), and Black Sea flounder (*Platichthys flesus luscus*). But during the 20th century The Southern Bug was dammed by several dams, which practically crippled the river and turned it into a series of continuous reservoirs-sedimentation basins, which gradually become polluted and silted up, which creates unsuitable conditions for the life of representatives of the ichthyofauna [6]. Hydroelectric dams not only block the way for migrating fish to spawning grounds, but also affect the spawning grounds themselves (Fig. 4).

Migratory sturgeons, for example, lay their eggs in places of fast flow on a rocky or pebble bottom, to which they stick. Large reservoirs absorb most of such places, silt them up and make them useless as spawning grounds. When rivers are backed up, silting of the soil occurs, and spawning grounds under such conditions lose their significance. The path to the spawning grounds of migratory fish is often quite long and difficult. The spawning grounds of some species are located in the upper reaches of rivers, far from the estuary. The fish that go from the sea to the lakes to spawn include: sturgeons - beluga, sturgeon, stellate sturgeon; sterlet, sturgeon-thorn, Black Sea herring; some cyprinids, for example, bream or pike, etc.



Fig. 4. Negative consequences of the construction of small hydroelectric power plants.

Let's analyze which representatives of the ichthyofauna we have lost by creating unbearable conditions for their spawning and existence. Sturgeon – ancient family freshwater fish, What appeared 200-250 million years ago. According to paleontological studies, the human race appeared about 2.8 million years ago, and Homo sapiens, in general, is only 160 thousand years

old. However, the youngest species in the Earth's biosphere - *Homo sapiens*, in less than 100 years, managed to almost completely exterminate the sturgeon family, which was an ornament of the hydrosphere and which had practically no natural enemies, except for humans. The ethical question remains unanswered: "Why did the biological species *Homo sapiens* (*Homo sapiens*) decide that it has the right to decide which biological species are useful for the Earth's biosphere and which are not useful, which species should be preserved and which can be mercilessly destroyed, violating fundamental ecological laws."

The destroyed natural distribution areas of sturgeon fish are presented in (Fig. 5). The sturgeon family that lived in the rivers of Ukraine includes: beluga, Russian sturgeon, stellate sturgeon, sterlet and thorn sturgeon.

Beluga (*Huso huso*) is the largest freshwater fish on Earth (Fig. 6) and a valuable commercial fish. In Ukraine, this species was previously considered a separate subspecies - the Black Sea Beluga. The population of the beluga is very low, therefore the conservation status of the species is endangered [7-9]. Beluga is a migratory demersal-pelagic fish that lives permanently in the sea, and enters rivers to spawn. In the Black Sea basin, the beluga made spawning migrations to large rivers: the Danube (more than 2000 km from the mouth), the Dnieper, the Southern Bug, the Dniester and the Pioni. The life span of the beluga is up to 100 years. It reaches sexual maturity later than other sturgeon species: males at 12-14 years of age, females at 16-18 years of age. The interbreeding interval is 4-5 years.

Spawning migrations occur twice a year: in spring (second half of March - April, at a water temperature of 4–5°), and in autumn (September - November) - spawning in the spring of the following year. Males become sexually mature at the age of 12–14 years with a length of over 120 cm, females at 16–18 years with a length of over 150 cm. The greatest body length is over 5 m, weight 1000 kg (usually individuals up to 2.5 m and up to 200–300 kg are caught), life expectancy up to 100 years. Spawning from late April to early June at a water temperature of 8–17°C in deep places with a fast current and rocky or sandy-pebble soil. Fecundity 360 thousand - 7.7 million eggs. Caviar is bottom, sticky. After spawning, the adults, and later the juveniles, drop into the sea. The fry consumes crustaceans, worms, insect larvae, and fish fry; adults feed mainly on fish.



Fig. 5. Destroyed natural habitats of sturgeon fish.



Fig. 6. Beluga – the king fish. Completely destroyed in the Southern Buh River.

The main part of the Black Sea population of beluga goes to spawn in the Danube, Dnieper, Dniester and Southern Bug. In the first half of the 20th century, was a commercial fish almost on the entire sea coast. In the Dnieper, large individuals (up to 300 kg) were caught between the modern Dnieper and Zaporizhia, and extreme measures were noted in Kiev and higher: on the Desna, beluga reached the village of Vyshenki, and on the Sozh - to Gomel, where in the 1870s an individual weighing 295 kg was caught. In the Danube, in the past the species was quite common and rose to Serbia, and in the distant past it reached the city of Passau in eastern Bavaria. Along the Dniester, beluga spawning was noted near the city of Soroki in northern Moldova and above Mogilev-Podilskyi. Along the Southern Bug, beluga rose to Voznesensk (northern Mykolaiv region). In nature, beluga hybridizes with sterlet, stellate sturgeon, barbel and sturgeon [7-9]. The largest beluga ever caught is shown in (Fig. 7).



Fig. 7. The largest beluga ever caught weighed 1571 kg and reached 7.2 m long.

The disappearance of the beluga occurred as a result of changes in the hydrological, chemical, and biological regimes of water bodies caused by hydraulic engineering construction, water pollution, and overfishing. Beluga is found singly near the shores of the Crimean Peninsula, somewhat more often in the Danube and near its mouth. It has virtually disappeared in the lower reaches of the Dnieper, the Southern Bug, and the Dniester, as well as in the Northern Donets [8].

The construction of the hydroelectric power plant has negatively affected the entire family of Ukrainian sturgeons: Black Sea beluga, Russian sturgeon, stellate sturgeon, sterlet and sturgeon thorn.

The Russian sturgeon (*Acipenser gueldenstaedtii*) is a migratory bottom-dwelling fish that lives permanently in the sea and enters rivers to spawn (Fig. 8). The conservation status of the species is vulnerable [8, 9]. The Russian sturgeon is a valuable commercial fish, the number of which has been steadily declining over the past 25–30 years. It enters the Danube in small numbers, occasionally the Dnieper, occasionally the Dniester estuary, and practically does not enter the Southern Buh, Northern Donets, and the rivers of the Northern Azov Sea [8-11].

The Russian sturgeon has a long, spindle-shaped, thick body. The greatest length is over 2 m, weight over 100 kg, in catches there are individuals 1.3–1.6 m long and weighing about 30–40

kg; life expectancy is over 50 years. The upper third of the body is dark gray, brownish, often almost black, the sides are grayish, milky gray with a bluish cast, occasionally greenish, the belly is yellowish or milky white.

The disappearance of the Russian sturgeon is associated with changes in the hydrological, chemical, and biological regimes of water bodies caused by hydraulic engineering construction; water pollution, and overfishing [8].

The stellate sturgeon (*Acipenser stellatus*) is a migratory bottom fish that is common near the northern shores of the Sea of Azov, along the Crimean Peninsula, and in the northwestern part of the Black Sea (Fig. 9). The number of stellate sturgeons has been steadily declining since the end of the 20th century. It is very small in Ukraine and was the object of fishing for valuable black caviar. There are hybrids of stellate sturgeon with sturgeon, stellate sturgeon, and sterlet. Conservation status of the species: vulnerable [8, 9].

Now in small numbers it enters the Danube, occasionally singly into the Dnieper and Dniester estuaries, and practically does not enter the Dniester, Southern Bug, Dnieper, and rivers of the Northern Azov region.

The stellate sturgeon has an elongated, spindle-shaped body. The antennae are short, not fringed. The snout is xiphoid, long, its length is more than 60% of the head length. The greatest length is up to 220 cm, weight - up to 80 kg, usually individuals up to 150 cm long and weighing 25–30 kg are caught; life expectancy is about 30 years. The upper third of the body is dark, grayish-blue or almost black, the sides are whitish or silvery gray, the belly is yellowish or milky white.

The stellate sturgeon lives permanently in the sea, and enters rivers twice a year to reproduce: in the fall (from late September to late November) and in the spring (from March to late April - early May). The disappearance of the stellate sturgeon occurred as a result of changes in the hydrological, chemical, and biological regimes of water bodies caused by hydraulic engineering construction, water pollution, and overfishing [8].

Sterlet (*Acipenser ruthenus*) is a valuable commercial fish, the economic value of which has been lost due to its small number (Fig. 10). Conservation status of the species: endangered. Since the second half of the 20th century, its number and range have sharply decreased. In Ukraine, it was found in the main channel and in large tributaries of all large rivers. It has disappeared in the Northern Donets, Southern Buh and in most of the Dnieper and Dniester basins. It is now noted in the lower Danube and the Middle and Upper Dniester basins, and may be in the Dnieper Reservoir.

Sterlet has an elongated, spindle-shaped, low body. The lower lip is interrupted in the middle, the antennae are fringed. The greatest length is up to 1–1.2 m, weight up to 16 kg, usually fish up to 40–60 cm long and weighing 0.4–1 kg were caught in the traps, life expectancy is about 30 years. The upper part of the body is dark, grayish-brown, often with a greenish or bluish sheen, the sides are grayish, steel-silver, the belly is yellowish or milky-white.

The disappearance of sterlet occurred as a result of changes in the hydrological, chemical, and biological regimes of water bodies caused by hydraulic engineering construction, water pollution, and excessive fishing [8, 9].

Sturgeon Sturgeon (*Acipenser nudiiventris*) is a migratory bottom fish that lives in the sea and enters rivers to spawn (Fig. 11). Conservation status of the species: extinct. Sturgeon is a valuable object of fishing, in Ukraine it was found in the Black Sea off the coast of the Crimean Peninsula (Kara-Dag massif, Karkinitzskaya Bay) and in marine waters near the mouths of the Dnieper, Southern Bug, Dniester and Danube. In the first half of the 20th century. it was found singly, since the 1960s it has not been caught.



Fig. 8. Russian sturgeon.



Fig. 9. Sevryuga.



Fig. 10. Sterlet.



Rice. 11. Sturgeon thorn.

The sturgeon has a long, spindle-shaped, tall and massive body. The greatest length is over 2 m, the mass is over 40–70 kg (individuals weighing 8–10 kg were more common), and the lifespan is over 30 years. The upper third of the body is dark gray, sometimes almost black, with a dark blue or brown cast, the sides are light gray, the belly is milky or dirty white. Spawning occurs from late April to late May at a water temperature of 10–15°C, in sections of rivers with a fast flow and hard, pebble or sandy soil [8-10]. The disappearance of the sturgeon is due to changes in the hydrological, chemical, and biological regimes of water bodies caused by hydraulic engineering construction; water pollution and overfishing [8].

In the Red Book of Ukraine, representatives of the sturgeon species are listed as endangered or extinct [8]. The terms endangered or extinct are inaccurate and even cunning. Ukrainian sturgeons did not disappear on their own, since there are no natural reasons for their disappearance. Ukrainian sturgeons were destroyed as a result of a combination of man-made anthropogenic factors: the construction of hydroelectric power plants and countless artificial ponds on tributaries, the constant discharge of untreated wastewater and the creation of unsuitable conditions for the existence of sturgeon species. Current water quality indicators of the Southern Bug do not meet necessary indicators of water quality to ensure the normal functioning of the sturgeon family. The destruction of representatives of the sturgeon species in the Southern Bug was only the first stage of the extinction of the aboriginal ichthyofauna. The second stage of the destruction of the natural ichthyofauna is currently underway, associated with increased pollution of river water and a gradual deterioration of living conditions. Species for which living conditions have significantly deteriorated have become rare. On the verge of extinction are less demanding ichthyofauna species compared to sturgeon, which are presented in (Fig. 12-14).

Common bluegill (*Ballerus ballerus*) is a fish of the cyprinid family (Fig. 12) . Commercial fish. Length up to 30 cm (sometimes more), weight up to 1 kg (most often 200 - 300 g). The body of the bluegill is compressed laterally and more elongated in length than that of the bream. It is widespread in rivers and large lakes of the basins of the Baltic, Caspian, Black and Azov seas. Due to significant pollution of the Southern Bug, the bluegill is small in number [8-13].

Chekhonia (*Pelecus cultratus*) is a fish from the cyprinid family (Fig. 13). Commercial fish. The only species of the genus Chekhonia (*Pelecus*). Up to 35 cm long, weight - 300-400 g, sometimes more. Distributed in the basins of the Black and Azov Seas, as well as in the Caspian and Aral Seas and the waters of their basins. Chekhonia is very demanding on breeding conditions. It spawns in places with significant water flow speeds, in areas with a densely sodden bottom, for two to three days, depending on the water temperature. Due to significant pollution of water bodies - on the verge of extinction [8].

The bream, bream, also bream (*Rutilus frisii*) is a species of fish of the genus bream of the cyprinid family (Fig. 14). The species is listed in the Red Book of Ukraine [8]. In general, it is a large fish, the body length reaches 70 cm, and the weight is 6 kg. It has a slender, rolled, elongated body, covered with small scales. The bream is common in the basins of the Black and Azov Seas, as well as in the southern part of the Caspian Sea. The bream feeds in desalinated areas of the sea, and returns to rivers to spawn. The fish got its name because of its strong pharyngeal bones and powerful teeth, which can easily bite through large mollusk shells. In the recent past, it was common in many rivers of Ukraine, and in the lower reaches of the Southern Bug it was considered a commercial fish. Due to the regulation of river flows and pollution of their waters, the number of this species has significantly decreased, it has become a rare and at the same time a disappearing fish. Fish that constantly live in fresh waters, which cannot reach the mouths of rivers, where the food base is much richer, grow more slowly. There is a need for protection and even artificial breeding of the wrasse. Without this, it may disappear. One of the measures aimed at preserving the wrasse is a ban on its fishing [8- 10].

Introduction to the Far East ichthyofauna. Fish farming is of great importance in solving the food security of Ukraine. Thanks to the artificial introduction of representatives into reservoirs Far Eastern ichthyofauna: white amur (*Ctenopharyngodon idella*), amoupiian shrew (*Pseudorasbora parva*), white (*Hypophthalmichthys molitrix*) and variegated (*Aristichthys nobilis*) silver carp, acquired industrial meaning and actively are used in fish farming by growing them in polyculture with carp - a traditional fish farming facility.

Grass carp (*Ctenopharyngodon idella*) is a species of fish of the genus *Ctenopharyngodon* , family *Cyprinidae* (Fig. 15) . It is a large and fast fish, can reach a length of 1-2 meters, and weigh 33 kg or even more. Grass carp has an elongated body shape flattened on the sides, sharp teeth are designed for grinding vegetation. The fish has rather large scales, with a dark color. Grass carp usually lives in freshwater reservoirs of Asian rivers. Acclimatized in many countries of Asia, Europe, America, Africa. Grass carp is an industrial fish cultivated in pond farms, where breeding is completely artificial with the use of hormonal stimulation of maturation of mature fish, incubation of eggs in devices. It is used in canals as a natural land reclamation to combat overgrowth. Currently, fish are actively bred in freshwater reservoirs of Ukraine [8; 10].

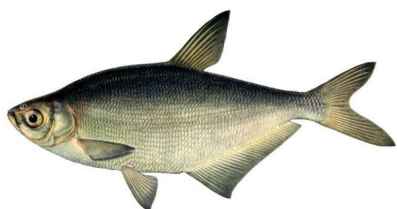


Fig. 12. Common bruise.



Fig. 13. Chekhonya.

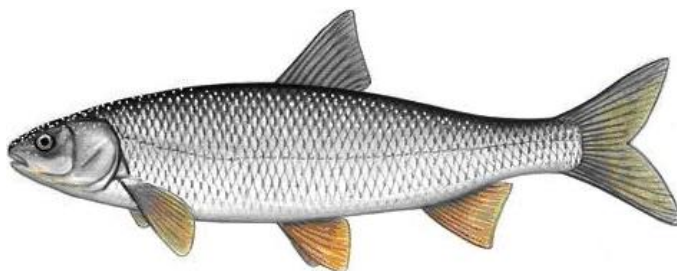


Fig. 14. Vyrozub, also vyrezub.

Amur roach (*Pseudorasbora parva*) is a species of fish of the genus *Pseudorasbora* , family *Cyprinidae* (Fig. 16). A small fish, similar to its peers of the grass carp. The roach has an elongated body, medium-sized scales. The body length reaches 5-9 cm, rarely 12 cm. The roach is a schooling fish that prefers calm, clean water bodies. It mainly inhabits rivers, lakes, bays and ponds. Non-fishery fish. In pond farms it is a mass waste fish. It is used in fishing as a live bait for catching predators [8-10].

Silver carp (*Hypophthalmichthys molitrix*) is a species of fish of the genus *Hypophthalmichthys* , family *Cyprinidae* (Fig. 17, 18). The body of the silver carp is quite high, moderately long, the head is wide. Silver carp is a large, schooling fish that can reach more than 1 m in length and a body weight of 40 kg. The fish lives in ponds with a weak current [8,10].



Fig. 15. White amur.



Fig. 16. Amur chebachok.

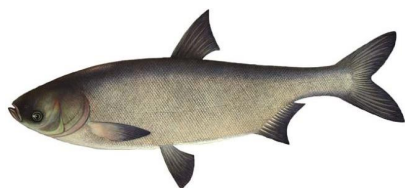


Fig. 17. White silver carp.



Fig. 18. Variegated silver carp.

Herbivorous grass carp and silver carp are introduced into reservoirs Southern Bug from goal increase their fish productivity, and Amur little girl imported accidentally (example) random full acclimatization). However, due to the constant significant increase in pollution of the water area, fish production is not increasing.

Migration of ichthyofauna occurs in order to find the most optimal conditions for existence, food base and spawning. For the vast majority of fish, hydroelectric dams pose a serious threat. If migration routes are artificially blocked by hydroelectric dams, the natural population completely dies.

Sturgeon, which are forced to make long upstream migrations to spawn, are at particular risk. In fact, almost 50% of fish die when passing through hydroelectric power plants. Fish die not only because they physically collide with turbine blades, but also because of the rapid decompression or pressure changes created by them. When passing through hydroelectric power plant turbines, fish are observed to suffer mechanical and biological damage, as well as abnormal behavior. Visual examinations of the body, as well as the results of autopsies of dead fish, revealed the following main types of injuries: bulging eyes, lacerations and cuts, damage to the body's integuments, gas bubbles in the muscles of the back, on the gills, fins and in blood vessels, hemorrhages in the eyes, in the bases of the fins, muscles, abdominal organs and in the brain, barotrauma of the swim bladder, rupture of the walls of the swim bladder, respiratory arrhythmia.

Some dead fish showed discoloration of the body, while others, on the contrary, had increased pigmentation. In most cases, the fish showed hemorrhages in the tissues and organs. The nature of the injuries largely depends on the size of the fish's body. In small fish, the swim bladder was most severely damaged, and in large ones, in addition, there was a violation of the body's integuments, muscle rupture, and a fracture of the spine. In dead fish, the following are observed: cut wounds, damage to the trunk, and the absence of body parts (Fig. 19).



Fig. 19. Photo of fatal injuries of dead fish that are forced to go to spawning through hydroelectric dams.

In Ukraine, to prevent fish from entering hydroelectric power plant turbines, barbaric electric fencing devices are used to scare away fish (Fig. 20). As a result, fish receive electrical injuries, the consequences of which have not yet been studied. The use of electric barrier devices is possible only after conducting additional studies of fish behavior in electric fields.

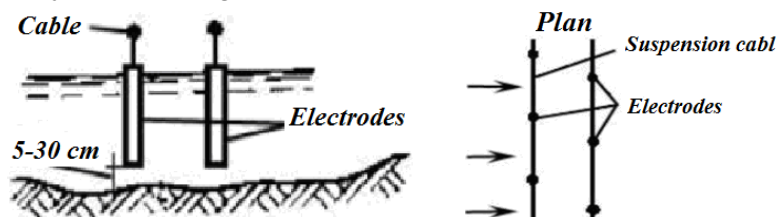


Fig. 20. Electric barrier devices.

Rivers are the only, comfortable, natural habitats for representatives of river ichthyofauna. Any change in the natural, hydrological regime of a river is necessarily reflected in the conditions of existence of the species that inhabit it. The transformation of rivers into a continuous cascade of reservoirs with a slowed-down flow leads to: an increase in the level of water pollution; changes in the temperature regime; an increase in the eutrophication process; silting of the riverbed; stopping migration routes, destruction of natural spawning grounds and food base for representatives of ichthyofauna.

Rising temperatures significantly affect the inhabitants of lakes and artificial reservoirs:

- up to 26°C - no harmful effects are observed;
- 26-30°C - inhibition of fish life;
- above 30°C - harmful effect on biocenoses;
- 34-36°C - fish and some species of other organisms die.

To cool the heat exchange equipment of Ladyzhynska TPP, river water is taken from the Ladyzhynska reservoir in the amount of 1.955 billion m³/year, of which 1.170 billion m³/year are repeatedly discharged into the reservoir. In addition, it should be noted that the river water intake by Ladyzhynska TPP for cooling needs is 5–6 times higher than the natural inflow of the Southern Bug River, and during low tide the corresponding imbalance increases to 16–18 times. In such a situation, the Ladyzhynska reservoir becomes an integral part of the single reversible circulation water supply system of Ladyzhynska TPP. Excessive use of water resources of the Ladyzhynska reservoir has led to the complete destruction of representatives of ichthyofauna (Fig. 21, 22).

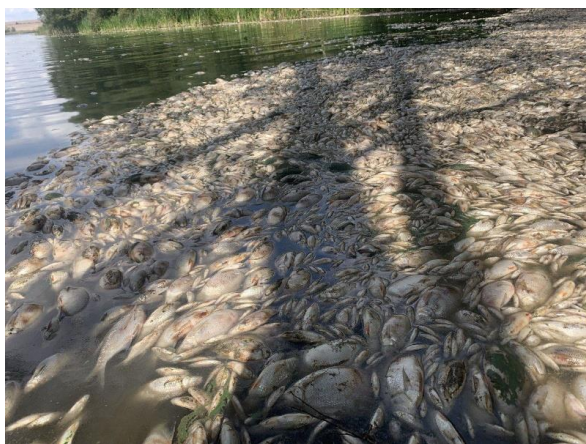


Fig. 21. Death of 45,750 representatives of the ichthyofauna of the Ladyzhyn Reservoir in September 2023.



Fig. 22. The discharge of a large amount of harmful substances into the Ladyzhyn Reservoir on October 4, 2023 led to the instant death of 3,000 Red Book sturgeons and belugas weighing over 9 tons.

The problem of fish migration was first addressed in 1909 by the Belgian scientist G. Denil, who proposed the design of a fish pass [1]. The baffles were arranged in such a way as to create a reverse flow at the walls and bottom, which in turn slows down the main flow. The fish pass in this case can be installed on a relatively steep slope, usually with a height to length ratio of 6/1, and maintain a maximum speed of less than 1.21 m/s. These models of fish passes are effectively used in places where there is little space [1; 14; 15].

To create normal conditions for the migration of representatives of ichthyofauna in developed countries, fish-friendly turbines and fish feeders are used at hydroelectric power plants (Fig. 23).

The general consequences of hydraulic engineering construction can be divided into the following types:

- 1) morphometric – change in the definition and length of coastlines, redistribution of depths, change in the surface area of the water mirror;
- 2) hydrophysical – increase and decrease in water content, redistribution of water flow in space and time, change in flow velocity, change in water exchange and temperature regime;
- 3) hydrochemical – change in total mineralization and ionic content, change in gas (oxygen) regime, increase in the content of organic and biological substances;
- 4) toxicoecological and radioecological: increased content of heavy metals, pesticides, radionuclides, increased biotest indices;
- 5) hydrobiological and bioproductive: changes in flora and fauna, including the reduction of rare, valuable and important economic species, the development of harmful species, the appearance of water blooms, overgrowth and waterlogging, deterioration of self-purification conditions.



John Day Hydroelectric Power Plant Fish Hopping on the Columbia River.



A small fish pass on the River Otter in the UK.



Washington state in the USA Fish pass with restored natural relief on the Rhine River in Germany.

Fig. 23. Fish-eating animals [1].

CONCLUSIONS

All the static and destructive changes in the Southern Buh and the rivers of Ukraine, carried out for the sake of obtaining "**cheap**" kilowatts of electricity, ultimately led to the destruction and loss of valuable natural species of ichthyofauna. During the construction of small hydroelectric power plants, no one thought about the environmental consequences, so a number of environmental mistakes were made that led to a catastrophic increase in the mortality of the ichthyofauna of the Southern Buh. The destroyed sturgeon ichthyofauna of the Southern Bug turned out to be a living bioindicator that demonstrated the complexity of environmental problems that arose as a result of hydraulic engineering construction and excessive economic use of water resources. Most of the fish that disappeared from the Southern Buh are migratory fish that lived in the Black Sea basin, and "passed" into the rivers to spawn. These are beluga, Russian sturgeon, stellate sturgeon, sterlet, sturgeon, blue sturgeon, Chekhonya, vyrozub, ramanya, etc. These fish almost ceased to exist in the Southern Buh and Dniester rivers due to the construction of hydroelectric dams, which prevented the fish from passing through to spawn.

The ecological mistakes made in nature management that led to the destruction of the Southern Buh sturgeon family must be corrected. Ecologists and environmentalists are obliged to create conditions for the restoration and revival of the destroyed ichthyofauna of the Southern Bug. To

restore the lost ichthyofauna of the Southern Buh and Ukrainian rivers, the following priority measures must be taken:

- 1) to carry out reconstruction and construction of new waste water treatment plants and to stop discharging wastewater without treatment;
- 2) to build fish passage channels and create conditions for the migration of migratory fish species through hydroelectric dams;
- 3) clear silted reservoirs and riverbeds, and establish spawning grounds for migratory fish species;
- 4) prohibit the use of electric barrier devices at hydroelectric power plants that cause electrical injuries to larvae and young fish;
- 5) replace conventional hydro turbines of hydroelectric power plants with fish-friendly turbines ;
- 6) conduct an inventory of infrastructure facilities in the sanitary protection zone of the water body and achieve compliance with the requirements of the Water Code of Ukraine;
- 7) increase the number of artificially grown fry of valuable fish species and stock clean reservoirs with fish.

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