

ОСОБЛИВОСТІ МАРИКУЛЬТУРИ В СВІТІ І УКРАЇНІ: СТАН ТА ПЕРСПЕКТИВИ РОЗВИТКУ

FEATURES OF MARICULTURE IN THE WORLD AND IN UKRAINE: STATUS AND PROSPECTS OF DEVELOPMENT



Інна ІРТИЩЕВА,
доктор економічних наук, професор,
Національний університет
кораблебудування імені адмірала
Макарова, Миколаїв

Inna IRTYSHCHEVA,
Doctor of Economics, Professor,
Admiral Makarov National
University of Shipbuilding, Mykolaiv

Дарія АРЧИБІСОВА,
Національний університет
кораблебудування
імені адмірала Макарова,
Миколаїв

Daria ARCHYBISOVA,
Master students,
Admiral Makarov National University
of Shipbuilding, Mykolaiv



Ганна РИЖКОВА,
Національний університет
кораблебудування
імені адмірала Макарова, Миколаїв

Hanna RYZHKOVA,
Master students, Admiral Makarov National
University of Shipbuilding, Mykolaiv



Formulation of the problem. The limited capacity of reproduction of biological resources of the oceans force scientists to look for new approaches that would ensure the flow of fish products to the world market. The development of aquaculture is the main approach among them.

Aquaculture is the breeding and cultivation of fish, clams, crustaceans, echinoderms, seaweeds under controlled conditions. This cultivation represents economical and sometimes aesthetic (artificial pearls, aquarium fish) interest for people. In other words, the article is about appropriate artificial reproduction of fish and other seafood through their transport, acclimatization, underwater creation of «farms» and «plantation.» Water management is interpreted as a branch of economics that is intermediate between gathering management (gathering, hunting) and agricultural production. Range of environmental, economic and engineering sciences deals with aquaculture as a complex business area.

Experience of the most fishing countries shows that over the past 30 years sustainable development of fisheries is mainly related to the increased role of aquaculture - production, breeding and commodity cultivation of aquatic organisms. A new level of development of water resources, the transition to the formation of different directional productive ecosystems in water bodies like land agrocenoses suggest the transition from «hunting and gathering» to «agriculture and stockbreeding» in fisheries.

The premise of aquaculture development is the same – it's the inability to provide a growing population with food products using traditional extensive methods (eg, increasing the catch or the exploration of new fishing areas). A qualitative leap in increasing agri-

cultural production happened because of increasing its knowledge intensity, applications of related subjects and improvements of technical base. Similar processes occur in aquaculture and particularly in mariculture. Thus, the relevance of the outlined range of issues, the dynamism of contemporary food problems and the need for their management determined the choice of the research topic.

Analysis of recent publications and research. Problems of studying and solving global problems of humanity by means of aquaculture and mariculture were published in many researches and methodical developments of national and foreign scientists: O.M. Bagrov, V.I. Boreyko, P.P. Borzhevskyy, M.V. Hrynzhevskyy, J.P. Mamontov, V.O. Murin, S.A. Patina, M.S. Stasyshen, V.N. Turkulov, N.N. Yarkina. Problems of reproduction in artificial and industrial conditions of products were examined in publications of V.A. Budnychenko, M.V. Hrynzhevskyy, L.A. Dushkina, V.I. Petrashov. But mariculture development problems exist both in Ukraine and in the world, so there is a need to continue to study aquaculture reproduction in the artificial conditions.

The purpose of the article. To explore the history of mariculture, to analyze the peculiarities of development, economic benefit of mariculture in Ukraine and in the world, to outline the main problems and prospects of the development. To prove that mariculture in Ukraine is a perspective business and the economy of the future.

Presenting the main material. Seafood consumption in the world is increased every year. This is due not only to the increasing in population, but also with the popularization of information about useful items that were found in sea food (fish, mussels, seaweed). Also according to the report, in 2016 it

У статті розглядається питання відтворення живих організмів Світового океану за рахунок посилення ролі марикультури. Штучне відтворення біоресурсів моря має безліч переваг, насамперед збереження екосистем від вимирання та вирішення питання продовольчої кризи. Автори проаналізували господарську діяльність підприємств світу та України за видами продуктів марикультури, їх споживання та особливостями вирощування. Довели, що марикультура має потенціал для розвитку в Україні при змінах у законодавстві та залученні інвесторів.

The article deals with the the reproduction of living organisms of the oceans by increasing the role of mariculture. Artificial reproduction of biological resources of the sea has many advantages, primarily the ecosystems preservation from the extinction and resolving the issue of food crisis. The authors analyzed the economic activities of companies in Ukraine and the world by types of mariculture products, their consumption and growing features. They proved that mariculture had the potential for development in Ukraine with changes in legislation and attracting investors.

Table 1. **Forecast of production, consumption and trade in fisheries [1]**

	2016 (forecast), mln. tons	In % to 2015, mln. tons
Production	175,0	102,3
Fish	93,6	100,1
Aquaculture	81,4	105,0
Consumption	175,0	102,3
Rations	153,6	102,8
Other	21,4	99,1
Trade	59,9	100,0
Consumption per 1 person a year	20,6	101,7

is expected that world production of aquatic biological resources will be increased by 2.3% [1]. A slight increase (2.8%) is expected to the world demand for fish and fish products for consumption and food consumption growth of 1.7% per head (Table. 1).

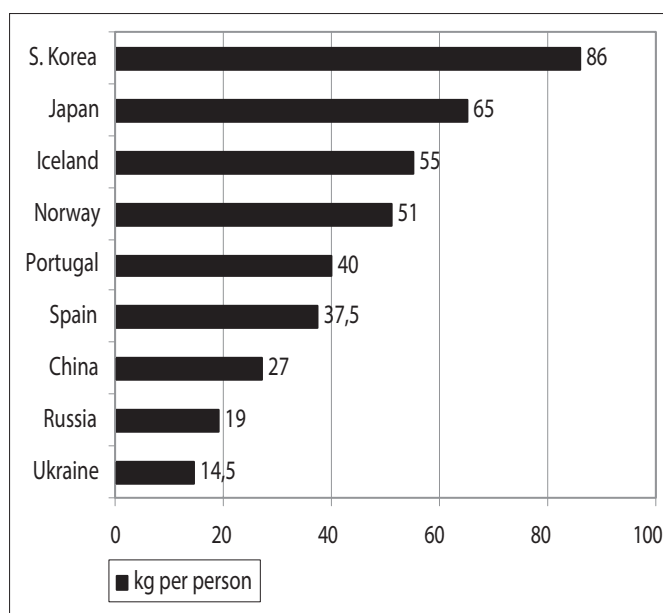
The main consumers of seafood are the Koreans, and it is consumed the least in Ukraine. This is shown at the diagram in Figure 1.

If the global dynamics of seafood consumption is increasing, in Ukraine this progress is less or absent despite extensive coastal territory. The waters of the Black Sea are constantly becoming poorer for fish and shellfish, and their extraction is controlled and quite limited. This is logical and correct in terms of preserving the ecosystem. On the other hand, imported sea products displace native ones. Therefore, it is quite cost-effective and efficient to place complexes for cultivation of mariculture in the southern territory of Ukraine.

Mariculture is the breeding and marketable cultivation of seaweed, invertebrates, fish under controlled conditions including relocation and acclimatization, biological reclamation, changing the parameters of environment to create favorable conditions for cultured organisms and so on. The productivity of this activity is very high. For example, it is possible to collect up to 300 tons of copper, 120 tons of seaweed or grow up to 3 tons of shrimp on one hectare of marine plantations. Such a yield of seafood breeding was known even before our era.

A Chinese named Fan Li is believed to be one of the parents of world aquaculture. In 599 BC he wrote the book about fish breeding. We know that fish ponds were already created in ancient China in 1120 BC, and later it became a branch of commodity production. In ancient Egypt, Mesopotamia, Greece and Rome fish farming was prevalent in freshwater ponds, and residents of the modern Pacific (Japan, China, Korea, Philippines, Indonesia) bred oysters, scallops, sea weed in the XVII century. In Europe and the US commodity mariculture began to develop at the end of the XIX century. Arcachon oyster farms appeared

Fig. 1. **Consumption of fish and seafood per head in the world for 2015. [1]**



then in the south of France. These places were famous for wild oysters from the time of Gallo-Roman era. In 1849 the first French emperor oyster farms were created there, and flat oyster (*Ostrea edulis*) were bred.

If in the XIX century Europeans were more interested in the wealth of food, then Japan thought about the beauty at that time. In 1888, a Japanese entrepreneur and scientist Kokiti Mykymoto created the world's first plantation of cultivation of pearls.

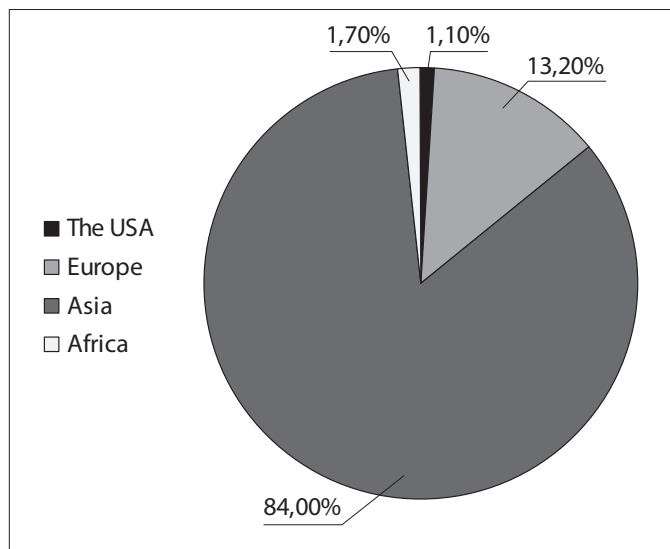
According to estimates of experts, only 1 m² of underwater lands can give 3.0-3.5 kg of fish on average, while complex for cattle gives 40-70 kg of meat on average per year from the same area of pasture that provides its feed. On the ocean shelf 1500 quintals of green mass per hectare, and only 10 quintals can be removed from the same land area. These figures are generalized, but they reflect the real benefits of using water resources. Appropriate economically seabed area of about 1,500 miles can produce 230 mln. tons of copper per year, which is more than three times higher than current global fishing. At the same time wealth of the oceans, the whole ecosystem (fish, plankton, mollusks, algae) remains unchanged, and products become more accessible for consumption.

Currently, the world production of mariculture is more than 6 mln. tons per year, 84% (5.4 mln. tons) of which are given by Asian countries, 13.2% (0.8 mln. tons) – by Europe, 1.7% (0.1 mln. tons) – by Africa and 1.1% (0.07 mln. tons) – by the USA (Figure 2).

Fig. 2. **Mussels and oysters**



Fig. 3. Distribution of world mariculture



For the species composition the world mariculture production is distributed as follows (mln. tons): fish – 37.1%, mollusks – 36.7%, seaweed – 25%, shellfish – less than 1%. Considering that shellfish and algae are mostly marine breeding objects, it can be assumed that mariculture production is about two-thirds of total aquaculture.

Many countries are paying serious attention to the development and further growth of aquaculture and particularly mariculture. Programs are developed and implemented, the issues of socio-economic plan, technical equipment, more professional production staff, sales of resulting product are provided. These programs are created in Norway, the US, Japan and others. Mariculture features in each of these regions are considered below.

The USA and Canada. Marine aquaculture in the United States supports commercial fisheries, restores habitat, monitors the threat of destruction of plant and animal species in the oceans and seas, and supports economic activity in coastal areas of the country.

Marine aquaculture production prevails and is about two-thirds of the cost. It consists of bivalves such as oysters, clams and mussels. Salmon and shrimps are the majority of others, but advances in tech-

nology and management methods increase the availability of other species to the American public.

Exports of fish and seafood of the USA focus on several key markets and in fiscal 2015 the five largest export destinations (European Union, China, Canada, Japan and South Korea) accounted for over 83% of total exports. While the total value of fish and seafood of the US exports grew more than 57 percent over the last decade, exports to China grew to 370 percent (Fig. 2).

Overview of Canadian Aquaculture is presented in Table 2.

According to the 2015 United Nation, with a share in world trade of 6%, the United States is the sixth-largest supplier of fish and seafood in the world market after China, Norway, Thailand, India and the EU.

Europe. In Western Europe mariculture specialization was established mainly on two groups of mollusks - oysters and mussels. At the same time in France and Germany cultivation of oysters dominated, and in Italy, Spain, the Netherlands cultivation of mussels dominated.

The three largest producers of aquaculture among EU member countries are Spain, United Kingdom and France, which together account for more than half (53%) of the total aquaculture production in the EU 2015.

Despite the large overall number of mariculture species (approximately 130 species of mollusks and fish are cultivated) each EU country is generally focused on production of several forms. For example, in Spain 72% of production is a Mediterranean mussel; the dorado, rainbow trout, sea bass and Europe turbot have 25%, the rest (3%) grow oysters. In the United Kingdom the fate of Atlantic salmon is 80%; mussels and rainbow trout have 20%. In France there are the largest volumes of growing oysters (38%), blue mussels (30%), rainbow trout (15%) and copper (7%).

In 2013 aquaculture production in Norway (1.25 million tons in live weight) was greater than the estimated value for all EU-28 (1.18 million tons in live weight). In contradistinction to the EU, aquaculture production of Norway was constantly expanding from 2000 to 2012. In 2013 Norway procured 1.17 million tons of Atlantic salmon with a value of 4.86 billion euros. 71 thousand tons of rainbow trout were sold for 290 million euros. More information about aquaculture production in EU is presented in Table 2.

Asia. Mariculture received the biggest development in Asia, especially in the coastal waters of the tropical and subtropical seas of the

Table 2. Aquaculture of Canadian provinces [2]

	Nfld	PEI	NS	NB	Que	Ont	BC	Canada
Finfish								
Salmon	-	-	6 824	17 184	0	0	54 971	78 979
Trout	-	-	-	-	1 143	4 000	44	6 698
Steelhead	-	-	0	0	0	0	790	790
Other	-	-	278	0	1	210	471	1 209
Total finfish	5 980	-	7 102	17 184	1 144	4 210	56 276	93 656
Shellfish								
Clams	0	0	299	0	0	0	1 327	1 626
Oysters	0	3 321	314	847	14	0	8 108	12 604
Mussels	3 260	20 269	970	-	373	0	592	25 464
Scallops	0	0	-	5	9	0	100	114
Other	0	0	58	41	20	0	0	119
Total shellfish	3 260	23 590	1 641	893	416	0	10 127	39 927
Total aquaculture	9 240	23 590	8 743	18 077	1 560	4 210	66 403	133 583
Re-stocking								
Total (incl. re-stocking)	9 240	23 590	8 743	18 077	1 560	4 210	66 403	133 583

Table 2 Aquaculture production in the EU (1000 Tons in live weight) [3]

	2000	2005	2010	2011	2012	2013
EU-28	1406	1276	1275	1246	1225	1183
Belgium	2	0	1	0	0	0
Bulgaria	4	3	8	7	7	11
Czech Republic	19	20	20	21	21	19
Denmark	44	39	32	32	34	32
Germany	66	45	41	39	27	25
Estonia	0	1	1	0	1	1
Ireland	51	60	46	44	36	34
Greece	95	106	121	111	109	114
Spain	309	221	254	274	267	226
France	267	245	203	194	205	200
Croatia	7	11	16	17	14	14
Italy	217	181	154	164	137	141
Cyprus	2	2	4	5	4	5
Latvia	0	1	1	1	1	1
Lithuania	2	2	3	2	3	4
Luxemburg	0	0	0	0	0	0
Hungary	13	14	14	16	15	14
Malta	2	5	7	4	7	9
Netherlands	75	71	67	44	46	47
Austria	3	2	2	3	3	3
Poland	36	38	37	26	33	33
Portugal	8	7	8	9	10	8
Romania	10	7	9	8	10	10
Slovenia	1	1	1	1	1	1
Slovakia	1	1	1	1	1	1
Finland	15	14	12	11	13	14
Sweden	5	6	11	13	14	13
United Kingdom	152	173	201	199	206	203
Iceland	4	8	5	5	7	7
Norway	491	661	1020	1145	1321	1248

Pacific and Indian Oceans that differ in the biggest productivity and diversity of species. China takes the first place among them by most measures. Japan is on the second place. The shallow coastal area (up to 20 m) there takes 30 thousand km², and about half of the area is already used for water management. In Japan oysters, pearls, marine fish and algae are grown. Advanced technologies are used in the local large and well-organized farms. Mariculture development took place in Southern Korea mostly in the same way. While small farms based on old traditional methods dominate in other countries of East, Southeast and South Asia, their contribution to the production of mariculture is also significant.

According to the World Bank report «Fish 2030: prospects for fisheries and aquaculture», China will account for 38% of world fish consumption by 2030. To meet these requirements, China increases its investment in mariculture. In addition, the demand for seafood from China, one of the largest seafood markets, has significantly increased, and its impact on world fish markets and trade has been increasing through the years. Fish consumption per head in China rose to 33.1 kg per year in 2015, which was an annual rate of 6% between 2000 and 2015 years, and it is projected to increase to 35.9 kg per year by 2020. Estimated food production will reach 160 million tons by 2030 [4]

Ukraine. All maritime waters of Ukraine are situated in favorable climatic features for cultivation and restoration of most expensive industrial aquatic organisms in national and foreign markets. List of objects of breeding and reproduction can be represented as follows: bivalves (scallops, mussels, oysters, anadary, spizula), echinoderms (sea urchins and sea cucumber), crustaceans (crabs, industrial, crabeaters, shrimps, chilim, mantis shrimp) and macrophytes. The most popular species for which technologies of breeding and reproduction are fulfilled, are sea scallop, Pacific mussel, oyster giant, grass shrimp, seaweed [1].

Unfortunately, in Ukraine mariculture is developing very slowly. The main reasons are the extremely complicated legal framework and bureaucratic obstacles and, of course, the problem of poaching. The development of mariculture in Ukraine should take place with a careful study of ecosystem relationships. The emphasis should be made on restoring of fauna native species. Fundamentals of artificial breeding of industry biota should be based on knowledge of the functioning of all elements of marine ecosystems.

An urgent task of Ukraine as a maritime state is to ensure optimal and sustainable functioning of marine economy, whose work is connected with the use of minerals, energy and biological resources.

Fig. 4. An example of scallops cultivation in China



Fig. 4. Coast of Kinburn Spit with mussels



The functioning of marine economy of Ukraine must be improved and based on the basis of the latest scientific advances in areas such as physical oceanography, hydrobiology, hydrochemistry, marine geology and geophysics, ecology and related basic technologies, ecological and economic approaches and integrated system management.

Expansion of marine research is the basis for resolving the problems of maritime economy, prerequisite and factor of formation of Ukraine as a maritime country. During the years 2007-2012 the National Academy of Sciences of Ukraine within the target complex research programs biological resources, hydrophysical, geological and geophysical studies carried out in the Black and Azov Seas. As a result of the draft program mariculture concept of sustainable development in the Black Sea was developed. It was based on environmental, social and economic aspects. The environmental aspect of mariculture is defined as an acceptable performance of designed marine farms which would not break the resource potential of the area. The social component includes training of specialists - sea farmers. Manuals have already been created and training programs have been designed for this. The economic assessment of typical copper-oyster farms has been also developed.

Today the industry requires support at the legislative level. To obtain continuous production and release the enterprise on self-sufficiency and self-financing a long time investment period (3-4 years) is required. During this period new plantations are placed. These plantations provide yield in the second, third and fourth technological cycles. The nature of mariculture production is very similar to agriculture. Leasing support and the ability to rent areas for plantations for quite a long period are necessary.

Mariculture in Ukraine is located in the initial stage of development. However, in 1955 Ochakiv fish-canning plant was organized (with a capacity of 8 thousand cans per day). In 1971 it was renamed as the Ochakiv Research mussel-oyster plant. Now the company is in decline [5].

To enhance the process of mariculture on the Black Sea coast of Ukraine documents governing the allocation of plots of land and water bodies in these activities should be developed and approved. It is also necessary to determine the procedure for its implementation, bringing into compliance with governmental requirements for of numerous regulatory challenges organizations. It should be taken into account that shellfish mariculture can be considered one of the priorities of the coastal areas in the conditions of the Black Sea coast. It does not just

contribute to the saturation of the national market of valuable seafood, but also promotes the development of small businesses and coastal communities, creation of job places, maintaining the quality of the water environment and biodiversity of reservoirs and thus preservation of its fishery and recreational value.

Conclusions. The prerequisites for the development of mariculture shellfish in the Black Sea are consistently growing demand for seafood and a strong scientific basis. Shellfish mariculture can be considered one of the priorities of the coastal areas in the conditions of the Black Sea coast. It does not just contribute to the saturation of the national market of valuable seafood, but also promotes the development of small businesses and coastal communities, creation of job places, maintaining the quality of the water environment and biodiversity of reservoirs and thus preservation of its fishery and recreational value.

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