POSSIBLE WAYS OF STABILIZATION OF THE COMMERCIAL RESOURCES OF THE SEA

IMPROVEMENT OF FISHERY REGULATION MEASURES

The key problem of supporting biodiversity is preserving the reproductive properties of marine animals populations . Taking into consideration a high artificial mortality of fish fauna, a more flexible system of temporal limitations for the fishery during the spawning season is needed. For instance, the introduction of the ban of fishery of cod spawning at the Norwegian coasts might strengthen the Barents Sea part of the population. Ban on the hunt for the white coat (belek) of the harp seal will produce an analogous effect.

In spite of the progress of the population models the scientists are confronted with large uncertainties in the estimations of the allowable catches (Maximum Allowable Catch). While previously the consequences of withdrawal of some sea species for other species normally were not considered at the estimation of the commercial species MAC, such an approach is unacceptable for the sustainable fishery model.

But none the less even current models of calculations and forecasting of the reserves have significant deficiencies. For instance, they do not consider the inter- specific interrelations in the ecosystems and the influence of the environmental conditions on the dynamics of abundance and biomass of exploited populations (Borisov 1998, Kochikov 1998). As the result the estimation of the reserves and, moreover MAC forecasting, precision and reliability of the developed recommendations do not often meet the requirements of the preserving of water bioresources and their rational exploitation. It should be pointed out that from the point of view of science the probability factor will remain the integral attribute of fishery oceanography forecasts. Much has been said about it at the International Congress in Bergen (Norway, June 1997) and at the first congress of ichthyologists of Russia in Astrakhan (September 1997). A stable usage of bioresources demands the transition to the ecosystematic principles of management. It is important to limit the fishery of the short-lived fish species, to apply a flexible system of temporal limitations for fishery during spawning, to introduce ecologically safe gears, etc.

SHIFT OF FISHERY TO THE NON-TRADITIONAL BIORESOURCES

Biological resources of the seas are very diverse but inefficiently utilized (**Fig.** 67). Some species, for instance, cod and haddock are subjected to a strong fishery pressure, while different species of flounder, polar shark, catfish, red fish, polar cod and other fish species and mollusks, as well as algae, are still exploited on the minor scale. The abundance of these species in the Barents Sea is rather significant, which implies that they may become objects of fishery.

ORGANISMS	BIOMASS, thousand tons
Macrophytes (algae) - laminarias - fucoids - all	 415 180 about 600
Euphasiides (sand hopper, polar krill)	40 000
Mussel	300
Scallop	1 000
Modiolus	200
Sea urchins (total number for all species)	2,000-3,000
Sea cucumber	350

Fig. 67. Total biomass of several algae and invertebrates species in the Barents Sea (by the data of Makarov V. N., Drobysheva S. S., Denisenko S. G., Gudimova E. N.)

LIMITATION OF THE MECHANICAL IMPACTS ON THE LIVING BENTHIC COMMUNITIES

Some commercial practices are known to produce a negative impact on benthic communities. Trawling of fish and invertebrates and dredging of shallow water navigation canals are regarded as the most important of them.

It would be hardly feasible to abandon practice of harvesting the mollusks with drags on the ships of the «Scalloper» type or to stop using bottom trawls on the Barents and the Baltic Sea cod, the Azov Sea gobies, the Black Sea flounder. But to continue the practice of «replowing» the sea bottom and hauling on board several tens of kilos to several tons of benthic organisms after each gear deployment means to undermine deliberately the forage basis of the commercial fish species.

It is quite evident, that the national shelf fishery should start using the new types of trawls to preserve bottom ecosystems. The experience of the Norwegians and the Japanese will be useful in this respect, as they deploy bottom friendly trawls and bottom long-lines.

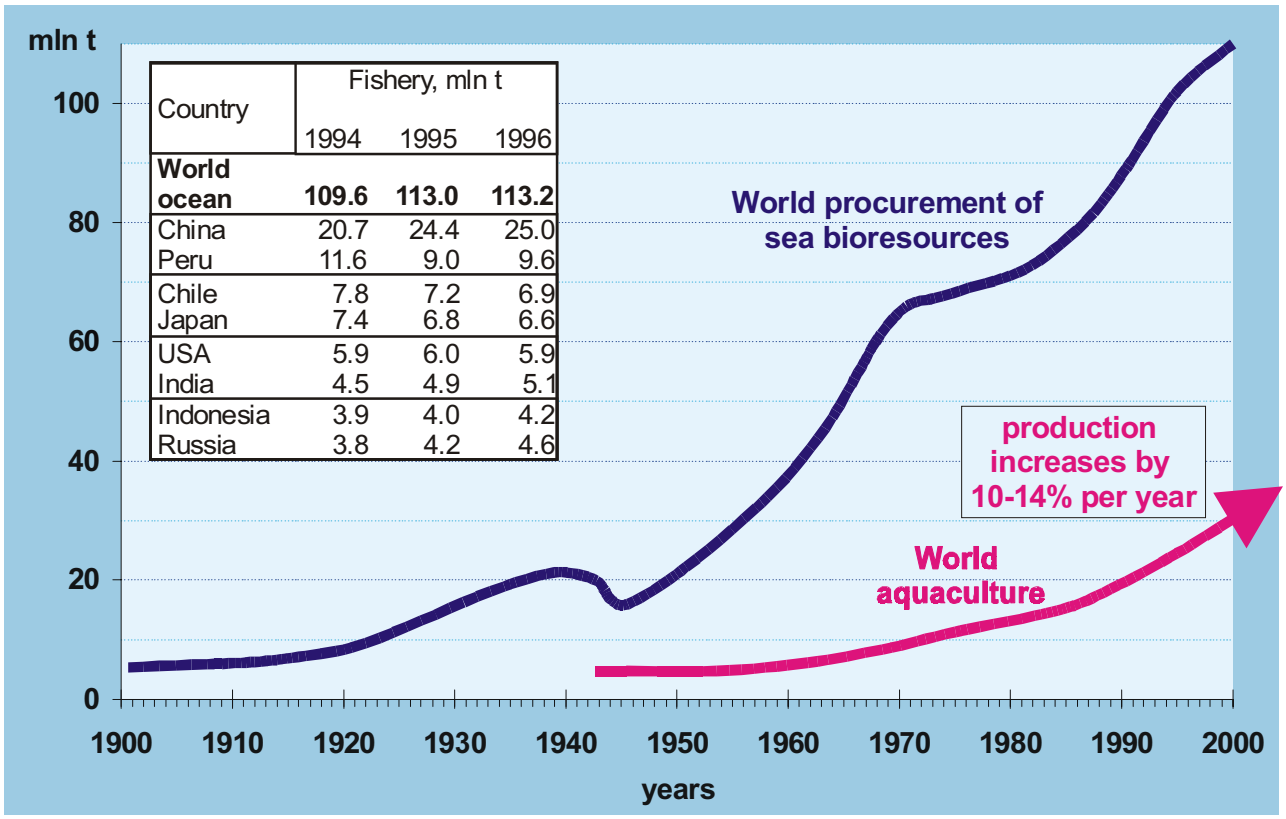
To minimize the negative consequences of dredging 2 ways of action can be adopted: (1) to introduce the full ban on works during the fishes brood period and (2) to select ecologically safe ground dumping sites.

ARTIFICIAL REARING (RESTORATION)

Different modes of aqua- and marine culture are well developed branch of the World Fishery. (**Fig.** 68). It is especially typical of the regions with a warm maritime climate. The production of world aqua-culture exceeds 25 mln tons. It includes rearing of fishes, (49.5%), algae (28%), mollusks (18.2%). The international experience in marine culture should not be followed blindly, of course.

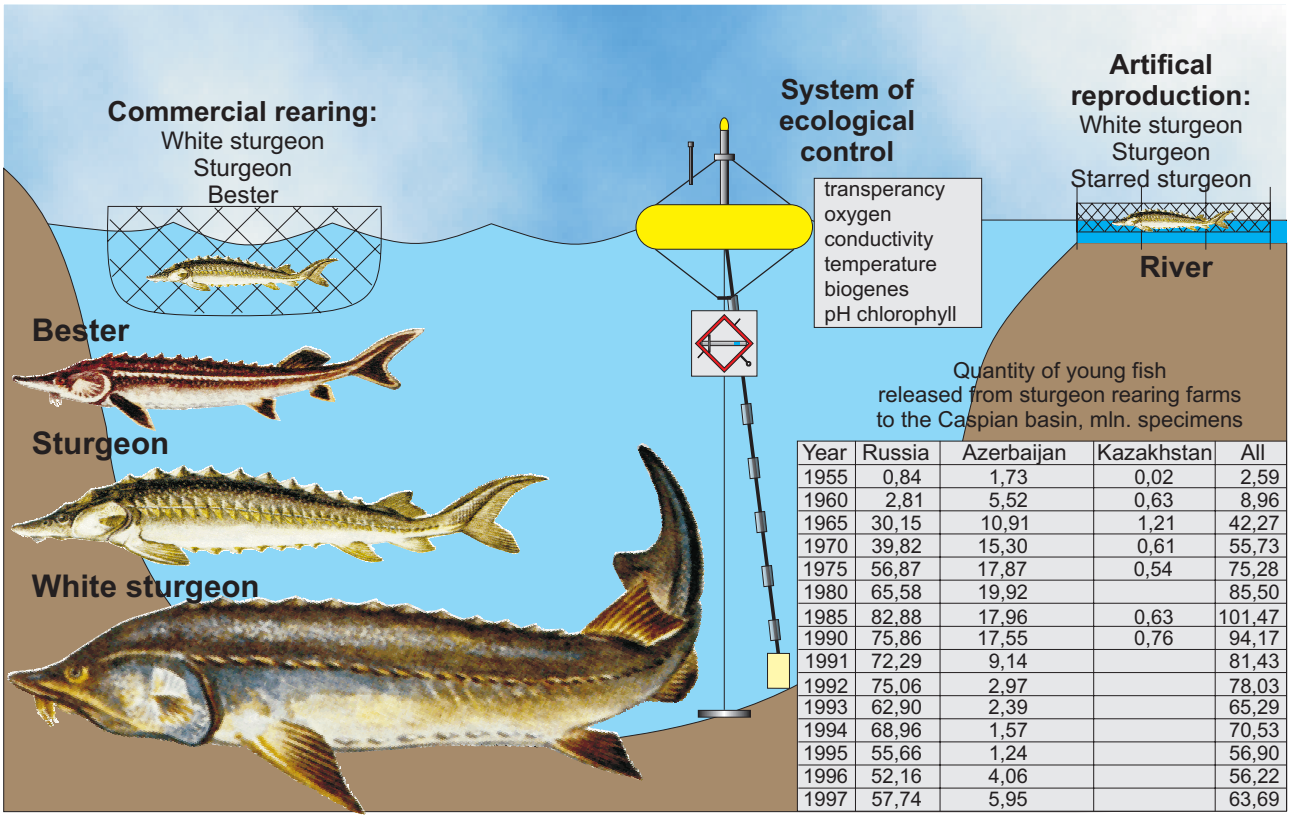
The achievements in the sphere of procurement of large amounts of viable planting material (eggs, larvae, young fish), rational diet, genetics, selection, development of the effective means of treatment of the diseases , technical innovations in the establishing of the marine and land constructions fostered the progress of marine culture(Dushkina and Esipova 1997).

In the present situation a sturgeon rearing farm is the most perspective direction of fishery especially for Russia (**Fig.** 69). Realization of reproduction measures, offered several times by the *Azov Fishery scientific-research institute*, will allow to increase the catch of only the sturgeon in the Azov Sea basin to 15,000 t (Gorbacheva and Rekov 1996). But the artificial rearing is not regarded as alternative to natural reproduction of the sturgeon. Owing to the species biological peculiarities the sturgeon is the easiest object of rearing and has been released in large amounts since the 1950s by fish farms on the Don and later the Kuban River.



Country	Fishery, mln t		
	1994	1995	1996
World ocean	**109.6**	**113.0**	**113.2**
China	20.7	24.4	25.0
Peru	11.6	9.0	9.6
Chile	7.8	7.2	6.9
Japan	7.4	6.8	6.6
USA	5.9	6.0	5.9
India	4.5	4.9	5.1
Indonesia	3.9	4.0	4.2
Russia	3.8	4.2	4.6

Fig. 68. Dynamics of the economic exploitation of hydrobioresources in seas and oceans



Quantity of young fish released from sturgeon rearing farms to the Caspian basin, mln. specimens

Year	Russia	Azerbaijan	Kazakhstan	All
1955	0,84	1,73	0,02	2,59
1960	2,81	5,52	0,63	8,96
1965	30,15	10,91	1,21	42,27
1970	39,82	15,30	0,61	55,73
1975	56,87	17,87	0,54	75,28
1980	65,58	19,92		85,50
1985	82,88	17,96	0,63	101,47
1990	75,86	17,55	0,76	94,17
1991	72,29	9,14		81,43
1992	75,06	2,97		78,03
1993	62,90	2,39		65,29
1994	68,96	1,57		70,53
1995	55,66	1,24		56,90
1996	52,16	4,06		56,22
1997	57,74	5,95		63,69

Fig. 69. Organization of sturgeon commercial rearing and increase of their reproduction rate in the Caspian Sea basin and in the Azov Sea and the Black Sea basins

Till the middle of 1980s, the catch of sturgeon reached practically maximum average annual catch of the 1930s – 1,000 t, and more than 90% of the catch were the fishes released from the fish farms. A the same time, recruitment of starred and white sturgeon was far from being sufficient (Makarov and Rekov 1997).

Marine culture in the Western Europe is concentrated in the gulfs and fjords (**Fig.** 70). Norway rears on the farms up to 0.4–0.5 mln t salmon. For some reason or other, efficiency of the artificial salmon rearing in the Murmansk region is still very low.

Marine culture development plans for Russia must be elaborated with regard of the ecosystem interrelations so as not to disturb their mechanisms. In such a case the efforts should be focused on restoration of the aboriginal fauna species. The scientific background of organizing of commercial species artificial rearing are to be based on the knowledge of the principles of functioning of all links of marine ecosystems and trophic chains (interrelations).

Most competitive branches of aquaculture should be primarily developed. Consequently investments should be made into sturgeons rearing (**Fig.** 69). The most substantial share of investments may be received as compensations, if oil and gas procurement on the Russian shelf will be as civilized as in the United Kingdom and Norway.

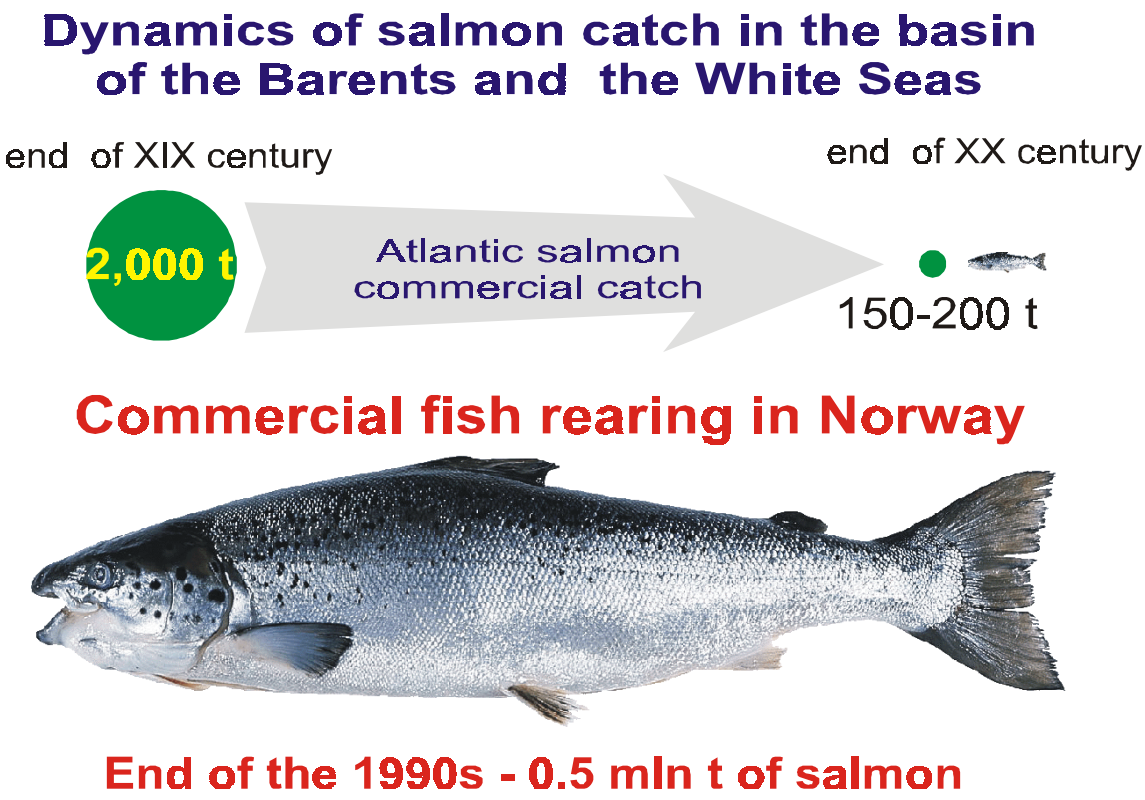


Fig. 70. Perspective development of fisheries

STATE SUPPORT OF FISHERY

Today the problems of stable development of fishery in the Russian seas are as acute as never before. In the new social and economic situation it is extremely hazardous to continue to carry out traditional extensive mode of fishing. A well balanced national strategy of fishery development, which takes into account possible extinction of the contemporary exploited resources, is needed. The main principles of this strategy might be as follows: ecosystematic, economic, infra-structural, administrative, psychological, juridical, professional, etc. These principles might be implemented provided all the sides are interested: authorities, fishermen, investors, scientists and consumers.

A series of measures should be implemented including the state support of fishery (subsidies), restoration of control over this branch of industry, broadening of the spectrum of the harvested resources, combining efforts of both the fundamental and applied science with special emphasis on studies of genetics, selection, adaptation of marine animals to the changing conditions of the environment.

Special attention should be paid to the compensating development of aquaculture. The Southern basins (the Azov Sea, the northern part of the Caspian Sea) might be re-profiled as «big cage» for the full cycle artificial rearing of the valuable fish species from fish eggs to fish of commercial value. Under the less favorable conditions (the Barents Sea) the artificial rearing of the young with a subsequent development of fishes in the natural environment is possible. Development of the sea farming should be supported by the state.

MEASURES FOR PRESERVING EQUILIBRIUM IN MARINE ECOSYSTEMS

The main strategy of the nature protection in the world is a progressive development and introduction of ecologically clean technologies into all the spheres of industry and human activities. This will result in radical reduction of the inflow of harmful substances into the estuaries and marine ecosystems. Large scale realization of this principle requires heavy investments which, nowadays, Russia could not afford. That is why only several realistic and practical ways are presented.

EXPERTISE OF THE ECONOMIC ACTIVITY AT SEA

All kinds of economic activity at sea affecting the life of ecosystems, including fishery, must undergo Environmental Impact Assessment (EIA) procedure. The EIA practice of the oil-gas complex on the shelf and ports construction may serve as the example.

RESTORATION OF THE SYSTEM OF THE STATE ECOLOGICAL MONITORING AT SEAS

At the moment, marine monitoring is practically non-existent. Biological and ecotoxicological monitoring is especially important as it gives the quantitative basis for decision making on the sustainable exploitation and sanation of natural ecosystems. That is why the restoration of the system of the state monitoring of marine environment and biota using remote sensing and autonomous buoy stations is of crucial. This is especially important in connection with the perspective of gas-oil extraction on the shelf (**Fig.** 71). Monitoring will allow to reduce the existing degree of uncertainty in ecosystem planning and decision making. The concept of the assimilation capacity developed by Academician Yu.A. Iisrael may become the basis for the objective quantitative estimations of the Maximum Allowable Coefficient of pollutants in different marine systems.

REGULATION OF THE RIVER WATERS RUN-OFF

In current ecological situation the state regulation of the regime and the volume of the river run-off in accordance with biological calendar is needed. This calendar must consider the seasonal life cycles of the marine flora and fauna in a certain sea basin. The specialists recommend to provide passage for the spawners into the upper part of the rivers in spring to increase effectiveness of natural reproduction and prevent large fluctuations of the water run-off through the hydro engineering constructions during mass migrations. It is also necessary to maintain water flow regime of the spawning grounds as close to natural as possible.

Specialists of the *Azov Fishery scientific-research institute* found out, that the river water run-off of no less than 35–36 km^3/year (including 17–18 km^3/ year spring run-off) is required to maintain the Azov Sea ecosystem at the present level. At the moment, this rich shallow water reservoir almost lost the capability of self purification and withstanding the excessive anthropogenic pressure. Such artificial measures to restore the Caspian Sea and the Azov Sea regime as, for instance, the transportation of the waters of the northern rivers or the dam construction across the Kerch Strait are unacceptable from the point of view of the modern science.

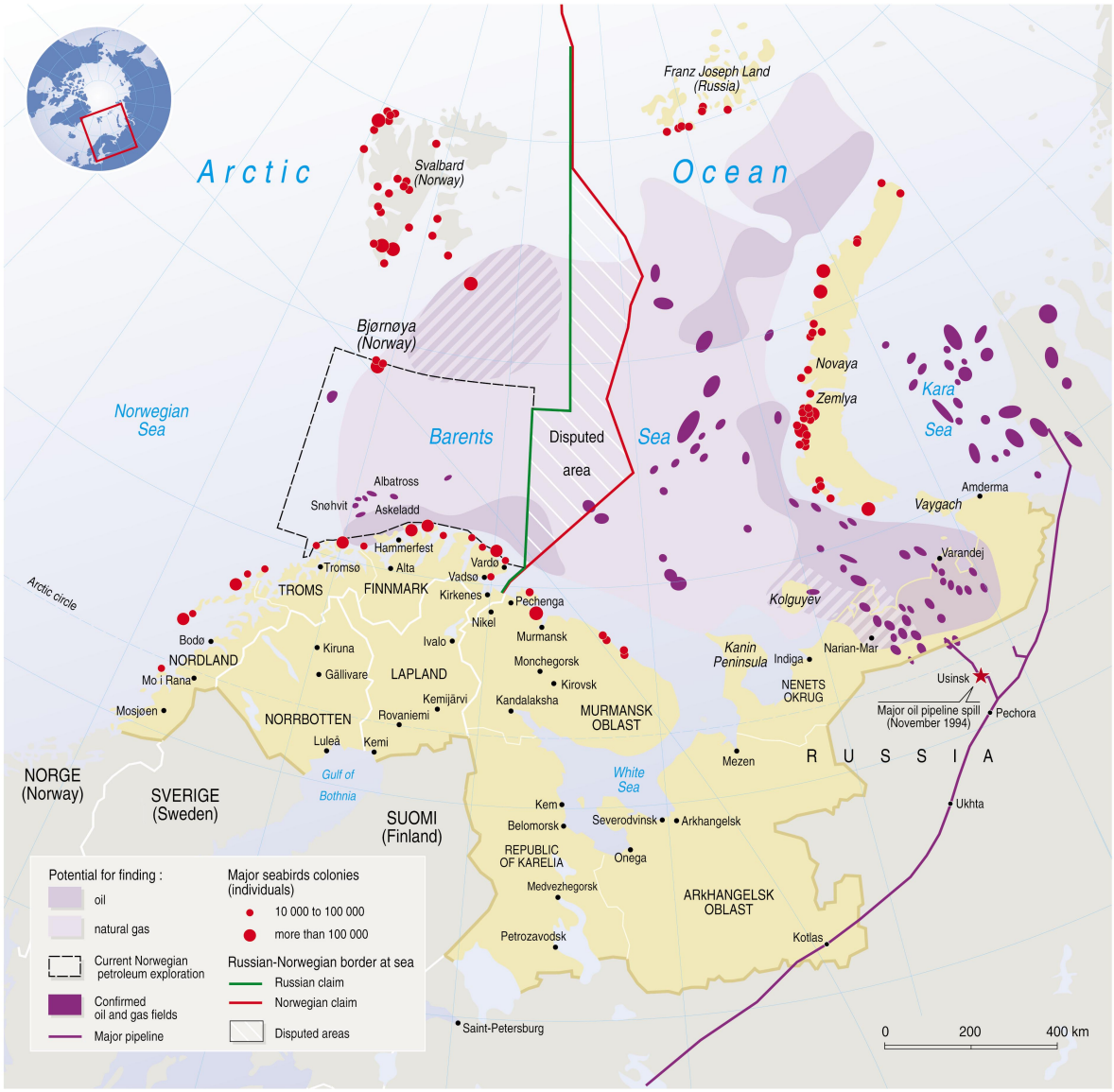


Fig. 71. Potential danger of oil and gas fields for the Barents Sea biota (Barents watch 1998)

It is evident that further development of the economy of the south of Russia is to be balanced considering the restoration of the unique ecosystem of the Azov Sea basin. A new international aspect of the problem caused by the disintegration of the USSR has to be considered, too

BIOLOGICAL AND MECHANICAL SANATION OF PORT AREAS AND APPROACH CANALS IN THE AZOV SEA, NORTH OF THE CASPIAN SEA AND THE GULF OF FINLAND

The examples of successful restoration of the degraded communities are numerous. The experience and the restoration technologies of the Great Lakes and the Chesapeake Bay in the USA, the Thames and the Rhine rivers in Europe should be utilized. For instance, artificial reefs which serve as the substrates for the bottom organisms-filters of contamination have been used in the West for quite a long time.

There is positive experience of development of water purification biotechnologies in the coastal zone in Russia (Shevchenko et al. 1987). Erected constructions are quite quickly inhabited by the thick water vegetation. Besides such animal periphyton as water mollusks and other filtrators frequently occur there. Positive reef reclamation will allow to improve significantly the water environment necessary for the support of a high biological and balneological status of the Azov Sea and the Baltic Sea.

Bottom sediments at the ports and the approach canals should undergo mechanical purification. As a rule, they comprise 50–80% of finely dispersed silt fractions contaminated with the oil hydrocarbons, heavy metals, polycyclic aromatic hydrocarbons, pesticides. The purification process should be carried out alongside regular bottom dredging works in the areas of drifts in the access canals. The volume of sediments annually transferred from the bottom of the Azov Sea (approximately 3.6 mln t) exceeds the Don River input of hard matter (1.2 mln t).

SANITARY AND TECHNOLOGICAL CONTROL AND ECOLOGICAL STANDARDIZATION

The problem of preventing unintentional biological and chemical contamination of water reservoirs is evident at the moment. It is connected with out-of-date technologies and non-compliance with ecological regulations in general.

Any modes of uncontrolled introduction of exotics should be stopped. It concerns, e.g. import of exotic species with ship ballast waters or in the course of introduction of new species of fish, crustaceans and mollusks. Improvement of epidemiological control over reproduction conditions of valuable fish species is of no less importance. Salmon, sturgeons, trout, carps fish farms are known to be periodically affected by mass outbursts of different diseases.

It is necessary to further develop ecotoxicological criteria and Maximum Allowable Coefficients values with regard of international experience. At the moment, these standards are practically undeveloped for different types of marine basins and climatic conditions. Both underestimation of the danger of chemical contamination and reconsidering of its impact are equally important.

It is understood, that in the closed shallow-water Azov Sea and the vast open basin of the Barents Sea the effect of the said processes will be quite different. Undifferentiated approach to the standardization of the anthropogenic pressure when implementing the marine commercial ecosystems protection measures might lead either to the discrediting of useful ideas and methods or countless economic losses.

INFLUENCE OF THE EXOTICS DANGEROUS FOR THE ABORIGINAL FAUNA

As it has been already noted, several hundreds species of the alien fauna penetrated into the European seas of Russia from different parts of the World ocean (**Fig.** 72). The exotics have penetrated by 2 ways: either intentionally or accidentally.

Generally, this evolutionary process proceeds in the marine ecosystems latently, so to say, unseen from outside. New exotics are being constantly discovered during marine biological expeditions of *MMBI, ZIS, IO RAS, PINRO, AzSRIF, IBSS, YugNIRO, AtlantNIRO, MSU, RSU*. Due to a high degree of adaptability they have acclimatized and now they reproduce and may threaten to the well-being of the aboriginal fauna.

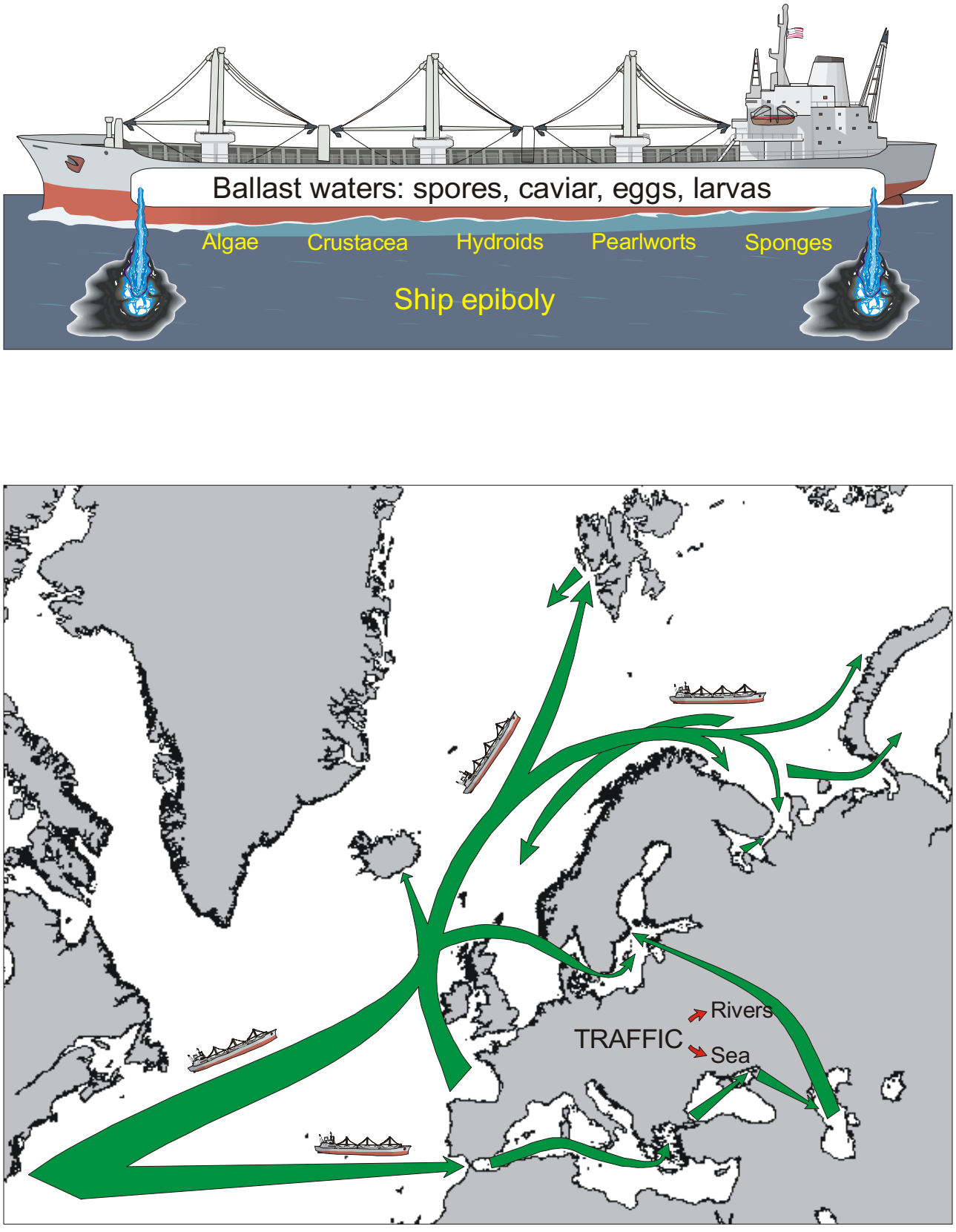


Fig. 72. Settling of the exotic fauna via transcontinental transportation by sea ships

However, a significant part of the exotic species actually upsets and, in some cases, suppresses the natural functioning of marine ecosystems. The humpback salmon introduced into the rivers of the Kola peninsula constantly ousts the Atlantic salmon from its spawning grounds. Almost half a million population of the Kamchatka crab in the coastal zone of the Barents Sea successfully competes with the aboriginal fauna for the same forage.

The Caspian crawfish *Cercopagis,* which settled down in the Gulf of Finland, spreads in the Baltic Sea and step by step occupies the niche of such valuable fish species as sprat and kilka (Avinsky 1997).

Gray mullet and stone moroco gradually supersede local valuable fish species in their natural ecological niches in the Azov Sea.

In the 1980–90s, the outburst of the abundance of comb jelly – the East American waters species (**Fig.** 73) – turned out to be quite a calamity for the Black Sea and the Azov Sea basin. During some years its biomass equaled 1 bln t in the Black Sea, that in the Azov Sea reached 20–32 mln t (Volovik et al. 1996, Zaitsev 1998). It should be noted for comparison's sake that the total biomass of the pelagic fish species – anchovy (European anchovy) and the common kilka – before the introduction of its main competitor for food was several million tons. For the subsequent years in future the forecast volume of formerly mass fish species is 7,500 t (Borisov 1998).

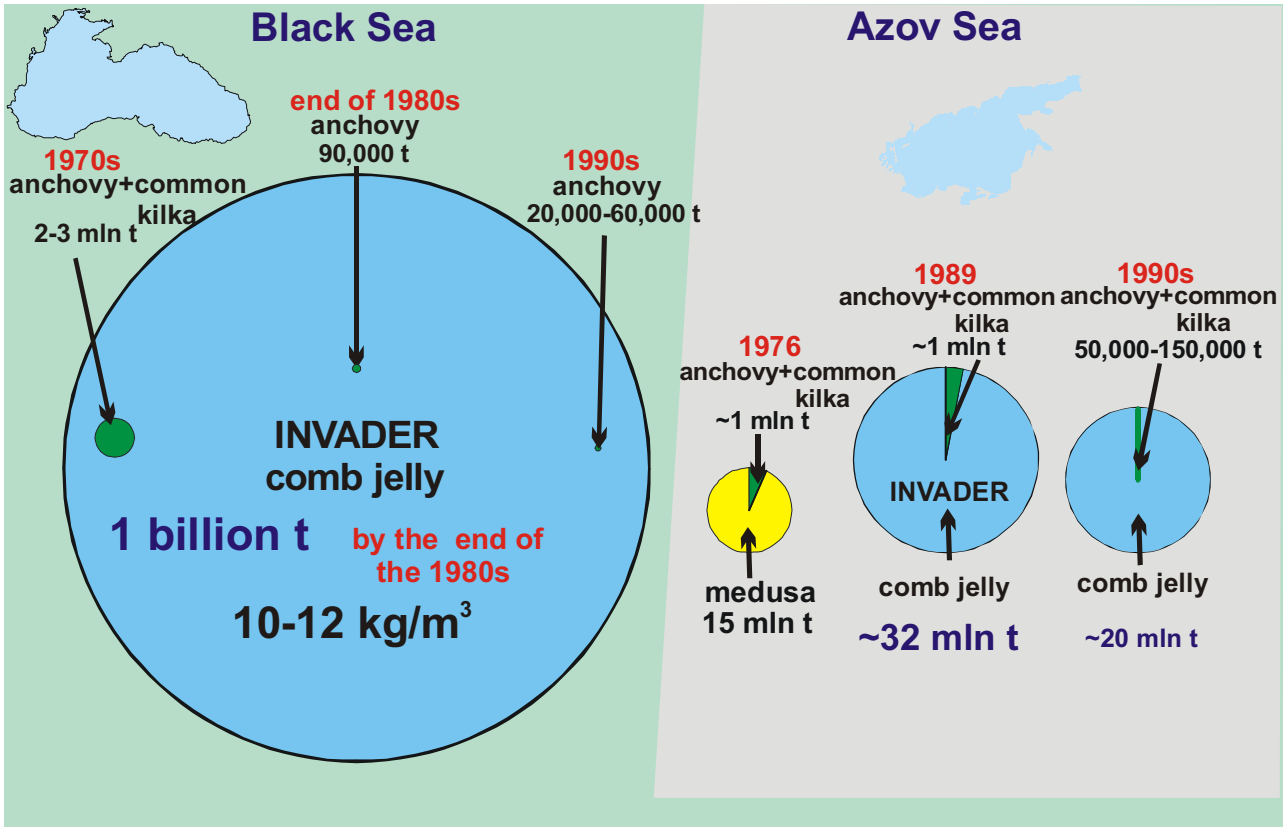


Fig. 73. Biomass ratio of the main competitors for food in the Azov Sea and the Black Sea (by the data of Vinogradov et al. 1989, Shushkina 1991, Volovik et al. 1998, Zaitsev et al.1998)

The growing concern about the future of the ecosystem in the Black Sea and the Azov Sea basin stimulates search for the new effective measures to withstand the impact of undesirable introducers. GESAMP working group elaborated guidelines and possible measures aiming at regulation of the comb jelly populations (GESAMP report 1995). Mechanical, chemical and biological means of control over *Mnemiopsis* abundance are discussed. Biological means seems preferable, as it suggests the introduction into the ecosystem of the basin the species feeding on jelly fishes. *Peprilis triacannthus*, fam. *Stromiatidae*, best matches criteria worked out for introduction. This fish species regulates the abundance of comb jelly in several regions in the North America (Harbison 1993), has good adaptability to the conditions of artificial rearing and high commercial value (Solodovnikov 1997). Such option as introduction of a predator comb jelly of the *Beroe* genus were also considered as they are known to eat out *Mnemiopsis* in other seas.

But taking into consideration all above mentioned, it is highly risky to use new introducers as the balance to *Mnemopsis*. Many specialists, and Yu.P.Zaitsev (1998) in particular, point out that in order to do so a series of measures aiming at restoration of the local fish species populations should be implemented. The efforts should evidently be focused on the restoration of the abundance of the Black Sea scad and mackerel capable to feed on *Mnemiopsis*.

Search for ecologically safe but effective measures of combating exotic species expansion is the most important challenge for natural sciences and fishery. Without solving this problem it will be impossible to maintain the natural reproduction and the artificial rearing of the local valuable fish species.