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A. S. AVERKIEV, P. P. CHERNYSHKOV

FISHERIES MANAGEMENT AND ASSESSMENT

Textbook

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Reviewers:
Dr. Rodin F.V. PhD in Geography, Pedchenko A.P. PhD in Geography, Vice-Director of the State Research Institute of Lake and River Fisheries (GosNIORKh)
Editor:
Dr. Lev Karlin, PhD in Physics and Mathematics

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1. REVIEW OF THE WORLD FISHERY DEVELOPMENT

1.1. Historical and geographical aspect of the fishery modern distribution. Scopes of world harvesting

Despite the ancient history of the fishery, technical progress resulted the in the multiple increase of global capturing of fish and non-fish products only in the XX century; previously, technical novelties were not applied in the fishery for a long time. However, the invention and the application of fishing gears and simplest water vehicles in ancient times contributed to the enlargement of fishery geography and emergence of the fishing industry. We will consider the brief history of industrial fishery development according to [1]. Already in the Ist century A.D., emperor Claudius expanded the deep-sea fishery from the coasts of the Mediterranean to the Atlantic littoral of Europe, the two littorals of the English Channel, and wanted to develop fishery in the Northern Sea. In the Medieval Age fishery developed as ships were improved; however, innovations in shipbuilding were used, first of all, in the navy and in the trade fleet.

The deep-sea fishery development in the Northern Rus began already in the IX century (according to the chronicles). Starting from the X century, Russian sailors fishing sea animals sailed from the White Sea to the Arctic Ocean, and carried out fishing near the shores of Greenland. Novgorodian "fishing gangs" constantly lived on in the White Sea, and got familiarized with the Murmansk Coast.

From the XIV to the XIX centuries fishing gears did not virtually change. It is true that ships constantly grew in number and became bigger in size. Expansion of ships dimensions considerably widened the area of fishing. Already in the XVI – XVII centuries, commercial fishery in European countries was performed in the Mediterranean Sea, on the substantial part of the water area of the Northern Atlantic, near the coasts of Jan Mayen Island, Spitzbergen and Medvezhy. The beginning of Portuguese and Spanish cod fishing near the shore of the Northern Atlantic is related to this period of time.

The invention of a steam engine did not perhaps influence fishing boats. Commercial fleet ships ploughed the seas, and sailing and rowing boats were fishing and hunting sea mammals as before. The substantial influence on the fishing development was made in the second half of the XIX century by the railroad transport. Just at the same period, a mechanical method of cotton fishnet emerged, which had an impact on fishing techniques and arrangement, as well as on the fishing ship building.

At the turn of the XX century, the world wolume of fish and other animals capture amounted to 7 mln. t, where up to 70 % of total yield was related to the re-gions of the Northern Atlantic. Commercial fishery in the modern understanding developed only in the countries of the Western Europe. Canadian and Ame-rican fishery was oriented only to near-coastal fishing, and Japanese fishery used sailing and rowing boats only. However, already in 1913, Japan had over 20 % of world fish catch.

In Russia, in the XIX century, fishery was concentrated in inland water reservoirs, which accounted for over 80 % of all catches in 1913. The main role in fishery in Russia was played by the Caspian basin, where 0.66 mln. t. of fish was caught in that year, or 63 % of the total catch of the country.

Fig. 1.1 shows the change of the world fish and non-fish products catch including aquaculture products and inland water reservoirs (curve 1- total catch). The second curve shows the increase of sea catch yield including sea aquaculture products. The first considerable leap in the commercial fishery development took place between the two world wars. Commercial ships tonnage increased, the areas of fishing widened. The Atlantic basin was familiar to the European countries, and the Pacific basin – to Japan, especially near the Russian shores. After the Second World War, the world fish catch experienced more than threefold increase. The most intensive growth was observed up to the 70s and constituted over 70 mln. t., including 86 % of fish, 8 % of invertebrates, 4 % of whales, 1 % of algae, and 1 % of other animals. This percentage remained in general the same until present except for the fact that whales catch has substantially decreased (almost forbidden on the international level), and the use of algae in the medicine and in foodstuffs has increased up to 8-9% of the total catch volume. On the whole, for the second half of the XX century the total capture of fish and of non-fish products increased by more than 7 times (fig. 1. 1). However, the sea captures reaching the value of about 100 mln. t by the end of the XX century still remains approximately on the same level within the last 15 years. That is, the growth of the total world catch is ensured at the expense of aquaculture products on inland and sea water reservoirs and at the expense of the mastering of the new kinds of non-fish products (algae, for instance).

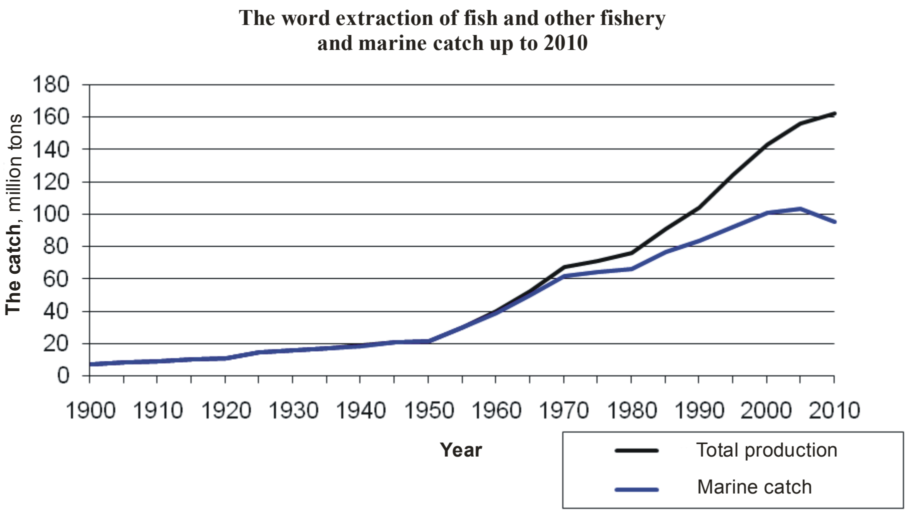

Figure 1.1. Alteration of World Catch Scope including Aquaculture Products and Inland Water Reservoirs (1), and Marine Catch (2) during the XX Century and at the Beginning of the XXI century.

The main stocks of fish, the locations of its spawning and reproduction, are concentrated in the coastal regions and in the waters nearby. Up to 90 % of fish is caught over the continental shelf occupying a little over 7 % of the seas and the oceans total area.

1.2. General description of fishery distribution in the World Ocean

The main regions of fishing are distributed in the World Ocean quite irregularly. Firstly, it concerns the ratio of intensity and volumes of fishing in the shelf and the deep water areas of the World Ocean. Recently, the share of deep water areas has increased, but it still remains relatively small (10 %), whereas within the continental shelf 90 % of fish and seafoods is caught.

Secondly, the ratio of fishing gradually changes in the three zones of the World Ocean – the Northern (northward from 30° north latitude), the Tropic (30° north latitude to 30° south latitude) and the Southern (southward from 30° south latitude). At the end of the 40s, the first one yielded 85 % of all catches, the second one – 13% and the southern one - 2%, whereas by the end of the XX this ratio constituted about 52:30:18. The signs are becoming clear that it is an evident shift of the world fishery towards north - south.

Thirdly, the distribution of the world catches between the oceans is still changing. The Atlantic Ocean, which was the main in the fishery during centuries, keeps now the second place leaving the priority for the Pacific Ocean (see Table 1.1).

Table 1.1

Catch in Different Oceans and in the Latitudinal Regions of the World Ocean according to FAO Data Represented in [2]

Years	*1990*		*1995*	
	mln.t	%	mln.t	%
Northern Atlantic	12,5	-	14	-
Central Atlantic	7,5	-	7	-
Southern Atlantic	4	-	4	-
Atlantic Ocean on the whole	24	29	25	27
Indian Ocean	6,5	8	8	9
Northern part of the Pacific Ocean	29		30	
Central part of the Pacific Ocean	9		11	
Southern part of the Pacific Ocean	15		18	
Pacific Ocean on the whole	53	63	59	64
Total	83,5		92	

The fourth, the ratio between the main regions of fishing is being changed in these oceans. In the World Ocean biologically high productive water areas and low productive water areas are clearly standing out. The first ones of them are located where photosynthesis occurs most actively and biomass is concentrated – food for nekton. With that, productivity is influenced upon by such factors as a geographic location, depths, nature of vertical and horizontal water masses motions, ichthyofauna composition, and its nutrition condition.

In the Atlantic Ocean, from time immemorial, the two high productive regions have been known – the *Northern-Eastern*, near the coasts of Europe, and the *Northern-Western*, near the coasts of America. The *Northern-Eastern region* just before the beginning of the 50s of the XX century gave the third of all world catches, but then the fishery was sharply reduced due to excess catches and to the "competitiveness" of the oil industry. Thus, the Northern Sea, previously very rich in fish, now supplies only 2.5 % of the world catch. Catches are also reduced in the *Northern-Western region*, where the USA and Canada mainly carry out fishery.

In the Pacific Ocean, there are three main fishing regions. The *Northern-Western region* near the coasts of Asia, where Russia, Japan, China, the Republic of Korea and the DPRK carry out fishery, which is now the greatest one not only in the Pacific, but in the world as well. It also stands out due to fish catch, and other seafoods catch – shellfish, crustaceans, and algae. The *Northern-Eastern region* near the coasts of Northern America is similar by the ratio of catches to the *Northern-Western region*, but by the scope of them it remains behind. Finally, one more fishing region - *South-Eastern* – is located near the coasts of Chile and Peru. The main fishing target here is the Peruvian anchovy.

These are five major fishery regions in the world. And apart from them, there are some other regions less ample. However, in the course of time they were all greatly exhausted. On the fish shoals of the Northern Atlantic the stocks of herring and cod have become poor, the same concerns Californian sardine near the shores of the Northern America, and Peruvian anchovy near the shores of Peru and Chile, cephalopods in the eastern part of the Central Atlantic (octopus, calamaries), and Alaskan royal crabs near the Aleutian Islands.
As mentioned above, the volumes of the world catch during the last decades have been increasing at the expense of aquaculture, the most contribution being ensured by breeding mainly fresh-water fish in China.

1.3. Fishery distribution by countries groups. Major fishery regions in the World Ocean

Lets consider in detail the fishery distribution in the regions of the World Ocean with indication of the countries, which carry out mainly fishing activities in these regions according to [1,2]. Fishery is concentrated historically in the northern latitudinal zone, which is conditioned by a variety of biological, economic and geographic factors. Firstly, this is the location of economically developed countries of Europe, America and Asia in the Northern hemisphere. Secondly, the rich raw material resources of the northern regions of the Pacific and of the Atlantic Oceans are conditioned by a variety of favorable abiotic factors, on the other hand. Currently, ~ 50 % of the worlds total catch, or over 80 % of the catch in the developed countries is carried out in the northern latitudinal zone of the World Ocean. Just at this place from the beginning of the XX century joint scientific and scientific-commercial studies were performed. The insignificant growth of catch in the tropical and the southern zones of the World Ocean is defined to a great extent by relatively small catches in the developing countries.

It is necessary to say that starting from the 50s of the XX century the statistics of catches and fishery distribution related to countries, to the regions of the World Ocean, and to the kinds of fishing targets is carried out by the Food and Agriculture Organization (FAO) under the UNO (United Nation Organization). To perform the statistics in a comfortable way in the World Ocean the international organization FAO UNO marks 17 statistical regions including each 7 ones in the Atlantic and the Pacific Oceans and the other 3 – in the Indian Ocean. The location of the statistical regions of the FAO in the World Ocean is presented in Fig. 1.2.

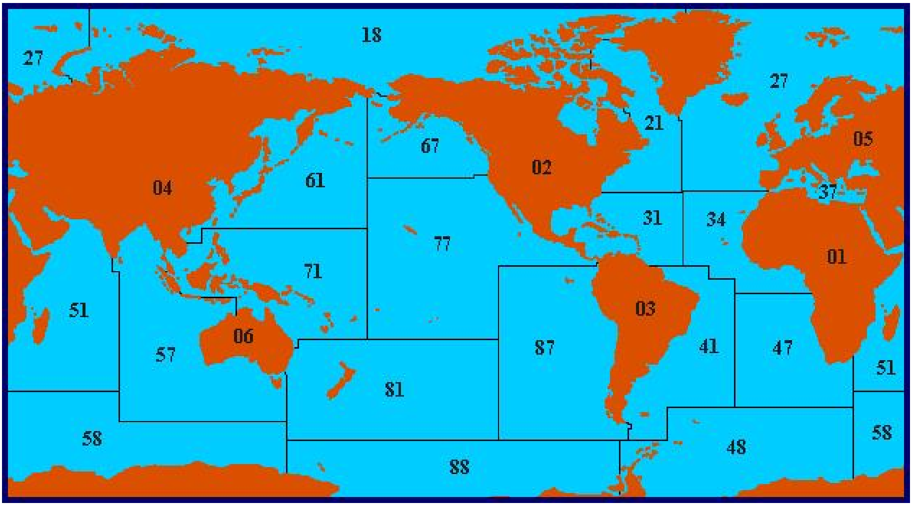

Figure 1.2. Fishing Regions of the World Ocean by FAO Classification

Each of the regions has its abbreviation and its number presented on Fig.1.2:

1. NEA – north-eastern part of the Atlantic Ocean (A. O.).
2. CEA – central eastern part of the A. O.
3. SEA – south-eastern part of the A. O.
4. NWA – north-western part of the A. O.
5. CWA – central western part of the A. O.
6. SWA – south-western part of the A. O.
7. APA – Antarctic part of the A. O.
8. NEPO – north-eastern part of the Pacific Ocean (P.O.).
9. CEPO – central eastern part of the P.O.
10. SEPO – south-eastern part of the P. O.

11. NWPO – north-western part of the P. O.
12. CWPO – central western part of the P. O.
13. SWPO – south-western part of the P. O.
14. APPO – Antarctic part of the P. O.
15. EIO – eastern part of the Indian Ocean (I.O.).
16. WIO – western part of the I. O.
17. APIO – Antarctic part of the I. O.

For instance, according to the data for 1992 [3] by the value of annual fish and invertebrates catch the statistic regions of the FAO were located as follows (Table 1.2).

Table 1.2

Annual Fish and Invertebrates Catch in 1992 as per [3]

Region	*Catch, mln.t*	*%*
NWPO	24,2	29,32
SEPO	13,9	16,8
NEA	11,1	13,4
CWPO	7,7	9,3
WIO	3,7	4,5
EIO	3,3	4,0
CEA	3,3	4,0
NEPO	3,1	3,7
NWA	2,6	3,2
SWA	2,1	2,5
CWA	1,7	2,1
SEA	1,5	1,8
CEPO	1,3	1,6
SWPO	1,1	1,3
APA	0,3	0,4
APPO	+	+
APIO	+	+
Total:	≈ 82,5	≈ 100,0

In brief lets present (as per [1]) the main commercial species harvested in the statistical regions of the World Ocean and the specific weight of catches of the countries fishing in these regions. The data are related to the 80s of the XX century, therefore, we will keep in mind that the situation in the global fishery was changing, but the main commercial species and the developed fishing countries remain the same ones in the traditional regions.

Thus, as per [3] in the 90s, after the long-term leadership of Japan and of the USSR, the first place was taken by China with its annual catch (in 1992) of over 15 mln. t. The second rank was taken by Japan (8.5 mln. t), the third – by Peru (6.8 mln. t), the fourth – by Chile (6.5 mln. t). Russia shared with the USA the fifth and the sixth places with an annual catch of 5.6 mln. t. The seventh rank was taken by India (4.2 mln. t), the eighth – by Indonesia (3.4 mln. t), the ninth – by Thailand (2.9 mln. t), and the tenth – by South Korea (2.7 mln. t). In the middle of 2000s, the countries-leaders in fishing were ranked as follows: China – 60.9 mln. t, Indonesia – 9.8 mln. t, India – 7.8 mln. t, Peru – 6.9 mln. t, Japan – 5.2 mln. t, Philippines – 5.1 mln. t, the USA – 4.7 mln. t, Chile – 4.6 mln. t, Vietnam – 4.5 mln. t, Russia – 3.9 mln. t. It is seen that the countries of Asia and of Latin America also predominate absolutely in the first and the second top ten ratings. As a result, according to some data, now 70% of the world total catch already falls on the developing countries.

As mentioned above, general the first priority of the sea products harvesting is related to the Pacific Ocean (>60 %), the second – the Atlantic Ocean (30 %) and the third one is related to the Indian Ocean (6 – 10 %). In the 80s, the common trend of the catch decrease began to show in all the oceans, the most substantial decrease falling on the Pacific Ocean. The species composition of catches is the most various in the Pacific; the most mass-volume harvested species herein are as follows: walleye pollack, mackerel, Pacific saury, tuna, red perch, Pacific salmon, and herring.

The north-western part of the Pacific Ocean (No.61). This part of the ocean takes up the predominant position in the global fishery and in the catch of non-finfish – crustaceans - products. The main countries fishing in this regions are as follows: Japan (55 %), China (20 %), Russia (10 %), South Korea (8 %), PDRK (6 %). 75 % of the total catch of Japan and 100% of the catch of China relating to this region. For Russia this value equals to 17 %.

The north–eastern part of the Pacific Ocean (No.67) is substantially behind in terms of catches compared to those in the north-western part, but it does not tangibly differ as for the composition. This region is operated by the following countries: Japan (52 %), Russia (32 %), the USA (10 %) and Canada (6 %).

The central-western part of the Pacific Ocean (No.71) is the main fishing region. For many developing Asian countries: Thailand (33 %), Philippines (24 %) and India (16 %). The fishery of Japan and Australia in this region does not exceed 3 %.

The eastern-central part of the Pacific Ocean (No.77) is the main fishing region for the developing countries of Latin America: Mexico (33 %), Ecuador

(20 %). But the first rank is taken by the USA (36 %), and Japan only 7 %.
The south-western part of the Pacific Ocean (No.81) is one of the rarely used regions of the global fishery. The total region of catch does not exceed 300 thousand t. The most common fish here is tuna (Japan, South Korea, and Russia). For the countries of this region – Australia and New Guinea – the fishery of shellfish and crustaceans has great significance.
The south-eastern part of the Pacific Ocean (No.87) was a leading region for the fishery until recently and now its catch does not exceed 15 % of the Pacific fishery. The main target of the fishery is Peruvian anchovy, as well as scad, in particular in 1970 the USSR harvested there up to 1.5 mln. t, and now the catch makes up zero. Tuna, shellfish and crustaceans are caught here. Over 88 % of the total catch in this region is related to Peru, and the rest – to Chile.
With the predominance of the fishery in the Northern part of the Atlantic Ocean compared to the Tropical and the Southern parts, fishery development in the Northern Atlantic progresses a little slower compared to the Tropical and the Southern Atlantic. The information is up-to-date for the 80s, but currently, delay or cessation of the catch growth is observed almost in all the main fishing regions.
One of the most important fishing regions in the Atlantic Ocean is the *North-Western part of the Atlantic Ocean* (No.21). Although this region is located at a significant distance from Europe, it is the main fishing region along with the North-Eastern part of the Atlantic Ocean for the European countries and Russia. In the total scope, the catch in the region less than 45% falls to the share of the following nearshore countries – the USA and Canada. About 54% falls on the European countries and Russia and about 1 % - on Japan. The main targets of fishing in this region are as follows: cods, flatfish, red perch and other dominant species. The growth of herring and mackerel is increased, and in the last years – of capelin. The initiative of catching some non-traditional species of fish and particularly of the crustaceans- haddocks, jelly-fish, - pertains to the former USSR.
The north-eastern part of the Atlantic Ocean (No. 27) includes the neighboring seas of the Arctic Ocean – the Barents Sea, the Norwegian Sea and the Greenland Sea. This region is one of the oldest and the most prime fishing regions of the World Ocean. The main targets of fishing in this region are as follows: red cods (cod itself dominates – up to 40 %), as well as herring. But in the 70 -80s, the catch of herring was sharply reduced. The Norwegian Sea was the main region of the herring fishery. Due to the excess catch, the herring fishery was limited, now it is being recovered. The fishery in the NEA is performed by all

European countries and Russia. Japan also performs fishing there a little. The first place is taken by Norway (30 %), Denmark (12 %), Russia (under 25 %) and Great Britain (10 – 12 %).

Fishery in the *Mediterranean and the Black Seas* (No.37) is carried out exclusively by the countries situated on the shore of these seas. The most catchable are sardines and anchovies. In addition, jelly-fish, scad, tuna and mackerel are also being caught. Shellfish and crustaceans also take up a place of no little significance in the total fishery (up to 15 %).

The West-central part of the Atlantic Ocean (No.1) is one of the smallest fishing regions of the World Ocean by the area it occupies. The species composition is extremely diverse – more than 100 various species. There are about 40 species of the tuna only. However, the main fishery yield is in this region is related to the herrings. The USA and the Caribbean countries are mainly fishing there, as well as Japan, Russia and South Korea.

The east-central part of the Atlantic Ocean (No.34); the water area washing against the African western littoral is the main fishing region. Herrings (sardines), as well as scad, mackerel, tuna and calamaries constitute up to 40 % of the harvesting. The peculiarity of this region is that to the share of the coastal countries falls 1/3 of catches, and 2/3 to the European and the Asian countries.

The south-western part of the Atlantic Ocean (No.41) is one of the regions of the global fishery richest in raw material resources, but it is rarely used. In the region of the Patagonian shelf adjacent to the littoral of Argentina, there are a lot of opportunities to develop fishery. In the 80-ies, over 60 % of catches in this region fell to the share of Brazil, the catches whereof contained predominantly sardines and crustaceans. Currently, the first place in the catch volume belongs to Argentina. Japan and other countries are also fishing there.

The south-eastern part of the Atlantic Ocean (No.7) is the important center of global fishery, so as the CEA. Cape hake (up to 40 %), sardines and anchovies (35 – 40 %) are the main targets of fishing. Besides, scad, mackerel, and tuna are being caught. The SAR takes the first rank (fishing for fabricating fish-flour). Russia takes up the second rank (hakes, mackerel).

Fishery in the Indian Ocean (No.51 and 57) is developed by the most slow rates compared to the other basins. It is connected with the geographic peculiarities: reefs, corals, shelves small by their area. Because of that the use of bottom trawls is very complicated. In the course of centuries, coastal waters were especially developed for fishery.

1.4. Assessment of potentially more productive fishery zones

The most productive fishery zones are the northern parts of the Atlantic and the Pacific Oceans, as well as the tropical part of the Pacific and the Indian Oceans. But the fishery resources every year is becoming more and more limited, commercial efforts per one unit of fishing is growing considerably, which is raising the price of products, the specific, bulk and dimensional range of fish is becoming worse. Hence new places and fishing methods, fishing in deep waters with a seine net, fishing on continent slopes and on the elevations of the oceanic bottom are being developed. The potential of these regions is evaluated as millions tons of seafoods.

As for the prospective of the global catch growth, they are considered limited according to the majority of calculations and forecasts. Although the evaluations of the opportunities to use the sea bioresources vary considerably (70 mln. to 200 mln. t), nevertheless the majority of specialists consider annual catches of 110-120 mln. t as the maximum allowed ones. And this is a level which is almost obtained. Comparatively limited self-reproduction ability of the World Ocean bioresources encourage looking for new approaches, which would ensure the supply of fish products to the global market. The main among them is the development of aquaculture.

It is more correct to identify the regularities and, essentially, the prospects to distribute the commercial productivity not according to data of total yield, but according to data of analysis for the absolute and the relative value of fish and invertebrates catch. On the modern level of knowledge the total of the optimally allowable catches of all fishing targets (hydrobionts) are considered as a potential catch. With that, FAO statistic materials and assessments generalized in accordance with the geographic division of the World Ocean adopted by FAO are mainly used. It must be kept in mind that in each of the regions, the main productivity accounts for the littoral and the frontal zones with limited water areas. That is why the attribution of the data of Table 1.3 to the entire area of the region is quite conventional and is acceptable for large-scale comparable evaluations only.

The greatest value of the potential catch falls on the middle and the high latitudes of the northern hemisphere. They are 10–12 times greater there than in the tropical latitudes of the Indian and the Pacific Oceans and 3–4 times greater

Table 1.3

Relative Potential Catch in the Oceans and in Fishing Regions (mln.t/km²)

	Fish	**Crustaceans**	**General**
Atlantic Ocean on the whole	0,41	0,14	0,56
NWA	1,02	0,33	1,35
NEA	0,74	0,1	0,84
CWA	0,44	0,07	0,51
CEA			0,40
Mediterranean and Black Seas			0,66
SWA			0,52
SEA			0,28
APA			0,81
Indian Ocean on the whole			0,17
WIO			0,15
EIO			0,11
ApIO			0,37
Pacific Ocean on the whole	0,35	0,05	0,40
NWPO			1,67
NEPO			0,63
CWPO			0,24
CEPO			0,08
SWPO			0,05
SEPO			1,03
ApPO			0,23

than in the tropical latitudes of the Atlantic Ocean. The economic productivity of the North-Western part of the Pacific Ocean with an area of more than 20 mln. km^2 is the highest - 1,67 t/km^2, that is, 3 – 4 times higher than the average value of potential catch for the Pacific and the Atlantic Ocean in total and 10 times higher than for the Indian Ocean.

It is rather difficult to evaluate the economic productivity of the Southern Ocean. The potential economic productivity of its waters for fish and nekton level in general is not significant, but on the level of megaplankton (krill, prmaraly) is not lower than in the most productive regions of the World Ocean. Considerable discrepancies in the potential productivity of the Antarctic part of the Atlantic, in comparison to the Antarctic parts of the Indian and of the Pacific Oceans potential productivity, are explained by the fact that in the Antarctic sector the great volumes of krill (0.2 to 1 mln. tons) were found and caught during 70-90s of the XX century, and in the Antarctic parts of the Pacific and of the Indian Oceans not more than 20-30 thousand tons were harvested.

1.5. Fishery indices in the changed international and legal conditions of 80-90s. Exclusive Economic Zones (EEZ). Fishery in EEZ

The two events of the 70-80s defined the state of the global oceanologic fishery for the last 20 years of the XX century. [4] The first one is the implementation of (within the 70-s by the majority of the coastal countries) a 200 mile Exclusive Economic Zone (EEZ) putting an end to the “era of free fishing”, i. e. free access to biological resources. The second one is the adoption in 1982 of the UNs Convention for the maritime law, which fixed the institution of regulating zones and defined the bases of the rules for managing the sea living resources, as well as the codes of behavior of the countries while using them. The objectives which defined these events were quite reasonable and honorable.

They were as follows:
1) Allow the coastal countries managing by themselves their own sea resources and the coastal zone in general.
2) Increase the economic efficiency of the use by the developing countries of their coastal waters.
3) Enhance the consumption of fish products by the developing countries at the expense of implementation of the two first objectives, insofar as in the developing countries the annual fish and seafood consumption constituted 2-6 kg/year, which is insufficient and constitutes not more than 20% of man s rate for this kind of nutrition according to the World Health Organizations data. For reference: fish and seafood consumption in Russia changed from 10-12 kg/year to 20 kg/year, and in Japan it constitutes 50-70 kg/year.

However, transition and adaptation to the new mode of fishing turned out to be much longer and painful, and the expected economic and social result was not obtained by many countries.

The global harvesting was growing in the 80s but the growth was slower than in the precedent decades, approximately by 2.5-2.8 % per year and reached 86 mln. t in 1989, then slowly increased having reached about 92 mln.t from the mid-90s. However, in this decade there were periods of recession; thus, for the first time the global catch decreased in 1990 compared to 1989.

The main growth was obtained chiefly at the expense of the 5 species of pelagic fish: pollack, Chilean scad, Peruvian anchovy, and Japanese and South-American sardine. These fishing targets constituted about 25 mln. t or approximately 30% of the global catch, which gave yield of 13 mln. t.
However, the total cost of these species of fish constituted only 6% of the total cost of fish feedstock.

Fishery development in the new conditions was passing differently in the various countries and the regions of the World Ocean. Let us first consider alterations in individual fishing regions.
The following calculation was carried out to assess economic reasons of various effects due to implementation of the EEZ for the developing and the developed countries on the basis of FAOs statistics. The total global harvesting and the cost of fishing targets caught in 1989 (Table 1.4) were calculated.
The obtained specific profits differed quite considerably depending on the value of commercial species, on the geographic situation of coastal countries and on the state of their economies. It is evident that whether the value of the EEZ implementation is positive or not, the role of the sea fertility cannot be evaluated by the consolidated figures of harvesting only. Specific contribution to the national economy of a coastal state is to be defined by an obtained profit in this field of business activities.

The cost of commercial targets is quite various, from 100 USD per ton of fish used for producing fish flour for the needs of agriculture, up to 10,000 USD for delicacies, for instance, for royal langoustes and lobsters. Nonetheless, FAOs specialists have defined the cost of 81 mln. t of the worldwide catch in 1989 in an amount of 69.7 billion USD. What are the expenses for harvesting such an amount of fishing targets? This is a difficult mission, insofar as payment for labor and its methods in the developed and in the developing countries differ greatly and fundamentally. In addition, loans and grants also make it difficult to carry out accounts, especially in the developing countries.

Nevertheless, FAO has a register of catching vessels with a tonnage of more than 100 gross freight tons (gft), their classification, fishing gears, and the cost of equipment on such vessels. The techniques offered by FAO allow giving a tentative estimation of: the cost of vessels, fuel consumption, and the cost of operating expenses and repair, the cost of fishing gears, manpower and provided capital, i.e. of the main expensive items.

Table 1.4

Global Harvesting in 1989 and Cost Parameters of First Pass (according to FAOs Data)

Fishing targets or groups of fishing targets		Harvesting (t)	Average cost of 1 t ($)	Total cost ($ mln.)
Salmons, Salmonidae		936	3500	3278
Flatfishes (sea flatfish, sole)		1193	2900	3459
Anacanthe	Atlantic cod	1783	1068	1904
	Pollock	6259	331	2074
	Esmarks cods	350	87	30
	Poutassou	663	66	44
	Anacanthe, haddock, hakes	3776	918	3467
Sand eels		1135	90	102
Red perches, capemouth, eels		4705	1890	8893
Capelin		898	100	90
Pacific scad		3655	90	329
Other species of scads, gray mullets		4548	720	3275
Herrings	Japanese sardine	5112	203	1038
	South-American sardine	4196	90	378
	Atlantic mehaden	357	101	36
	Coastal menhaden	583	90	53
	Japanese anchovy	313	200	63
	Anchoveta	5408	90	487
Perciformes	Other herrings, sardines	8630	200	1726
	Tuna	3985	1700	6775
	Japanese mackerel	1671	260	434
	Atlantic mackerel	626	270	169
	Other species of mackerel	1519	370	562
Sharks		684	750	513
Mixed species of fish		10 019	760	7615
Invertebrates	Crabs	1164	3600	4189
	Lobsters	202	11 270	2275
	Cave lobster	5	3350	15
	Shrimps	1841	4000	7370
	Other species of sea nvertebrates	35	3000	107
	Abalone	85	4960	423
	Oysters	80	3026	242
	Mussels	213	1260	269
	Scallops	529	2760	1461
	Clams	993	1025	1018
Cephalopods		2545	2100	5344
Other shellfish		216	950	205
Total		80 910		69 704

The cost of about 3 million fishing boats amounted to 2,320 billion USD in 1989 according to the incurred calculations.

The calculations made and the data of the Table 1.5 show that the main cost-based elements necessary for the procurement of the total global catch (and, accordingly, of the total fishing of a particular country!) almost completely absorb the obtained cost of this catch (or the cost of the "first pass"). And this is apart from the costs for salary, interests for credits and resources payment (quotas) in their own or in foreign EEZ. There is such an impression that the industry of fishing is unprofitable itself, and profit earning in this kind of business activities is possible only at the successive stages of fish products sales. This impression is correct, especially in the periods of fundamental changes in the structure of the industry or at the alteration of the international relations as in case of EEZ implementation.

To eliminate financial deficiency many countries fall back to grants. For the fishermen in the developed countries it became a normal practice, but most of the times grants offset deficiency only partially.

Thus, in most successful year of 1991, fishing activities of Japan (in the private and the state sectors) had a balance deficiency of $19 billion. To support the industry the government took responsibility to pay off the deficiency.

The fishermen of the EU countries also got substantial support. Thus, from 1983 to 1990, the EU increased the funding of the fishery of the countries from $80 mln. to $580 mln. per annum, with that, up to 20% of these sums were designed for building new ships and for updating the old ones. Besides, the government of each country in Europe supported fishery financially aside from this "pan-European" assistance.

In other non-EU countries, for example, in Norway the fishermen received financial benefits from the State, which amounted for about $150 mln. per annum in the late 80s.

In the 80s, the developed countries also worked out other kinds of promotion for fishery: limitation of seafoods import, implementation of special tariff rates, State support for export, prices monitoring system, State grants for fuel, provision of easy loans and credits. Of special note is such a kind of support as payment for the right to fishermens access to the productive EEZ of the other countries from the State budget (not from the very ship owners' funds) and "free" access to bioresources in their own EEZ.

Table 1.5

Cost-based Elements for Procurement of Total Fishing of 81 mln. t. obtained in 1989.

Cost-based elements	$ billion	% of cost of products made
Ships operation and repair	30,2	43
Procurement and fishing gears	18,5	26
Insurance, employers social benefits	7,2	10
Fuel	13,7	20
Sub-total without payment for workers	69,6	99
Payment for workers	22,6	32
Capital indemnity (basic funds depreciation, credits)	31,9	46
Total	124,1	177
Product sales income (Table 4)	70,0	
Deficiency	54,1	

Thus, in [4] the following conclusions the fishing industry related activities in the international legal conditions changed in the 80-ies are reasonably enunciated:

1) For normal operation of the national fishery, the State support of the industry by different methods is necessary, insofar as in general the extraction part of the industry requires grants, especially in cases of alterations in the international legal regulations or in the field conditions.
2) As a rule, in the definite fishery system financial losses in the course of the extraction of raw materials is compensated by additional profit during the sales of fish products. This instrument operates well in the developed countries, but the developing countries did not master this instrument (including Russia).
3) The developing countries increased their export in monetary terms in the 80s. But this growth was stipulated by the excess catch of valuable targets (lobsters, rock lobsters, valuable species of fish) and by the decrease of the catch of less valuable but numerous commercial species. Specifically the latter ones could be sold on the domestic market of these countries and improve the population feeding and the per capita fish products use. The developing countries did not get ready either for the high, constantly increasing, capital-output ratio of fishing activities.
4) The assigned mission to increase the average per capita fish consumption by the population of the developing countries was not achieved.

5) The issue of traditional fishing countries access to bioresources not used completely by the coastal countries is not settled. The issue of the license to use the bioresources reproduced in the EEZ of the coastal countries but forming fishing concentrations beyond them (for instance, pollack of the Okhotsk Sea) is not settled either. Neither is the harvesting of fish migrating over long distances (fish cross-border migration).

1.6. Main trends in the world fishery development and in the naval fishery policy of the leading coastal states

The maximum values of fish and non-fish objects capture in the World Ocean (without regard to inland water reservoirs and aquaculture products) were achieved in 1995 – 1997. The growth was ensured at the expense of the management of high-yielding generations of anchovy and of the other species near the Pacific littoral of South America; at the expense of the growth of codfishes catches (first of all, pollack) in the Okhotsk and in the Bering Seas; at the expense of the recovery of the reserves and due to the start of the Atlantic-Scandinavian herring catching in the Norwegian Sea and of the development of mariculture (the last term is related exclusively to fish breeding in sea ranches). The prospects and the trends of worldwide fishery development will be considered according to [5]. On the whole the experts stated that the achieved level of the global capture (about 95 - 100 mln. t) is that maximum limit which is acceptable when managing the traditional resources reclaimed by the fishery. The further steady management of these traditional resources will be defined by: 1) both natural factors and 2) good management of marine living resources from the side of responsible States and of international organizations, which includes the necessity to increase control over the number and the fishing activities of the high-sea fleet.

Together with the total use by the deep-sea fishery of traditional resources having a high user value and high prices on the world market, there is a variety of fish and crustaceans reserves which are not completely used by the fishery. It is stipulated by economic factors, i.e. by lower prices for these species and by the remoteness of their fishing regions from sales markets; it requires a specialized fleet and the special forms of their capture and processing organization. Scad, mackerel, sardine of remote regions of the Pacific Ocean, lantern fishes, krill, calamaries of open regions of the World Ocean, Pacific saury, billfish (Atlantic saury) and some others belong to such not completely used reserves. Implication of these resources in the conditions of market relations is possible only at a wide international cooperation and at an international financial organizations assistance, or at a creation of specialized transnational companies for performing fishing activities in the open parts of the World Ocean. It can insure an additional capture of about 20 – 25 mln. t.

The increasing demand for fish products and the escalating competitiveness for the traditional fish resources have stimulated mariculture development. Mariculture development creates an additional and the most steady feedstock base for the fishery of the coastal countries. Within the last 30 years the most successful countries in this direction are China, Norway, Japan, Chile, Thailand, India, and Indonesia. Thus, China, at the expense of mariculture (data are provided according to [5], i.e they are related to the end of the 90s), produces about 9 mln. t per annum, Norway – up to 600 thousand t of high-quality products. With that, Norway breeding salmonids in the sea waters has attained their market cost equal to the marine captures in total up to 2 mln. t. On the whole, the total amount of mariculture is increasing and has already reached (in marine regions excluding inland water reservoirs) 12 mln. t (1998 – 1999). The potential is estimated in 40 to 50 mln. t.

The important additional aspect of fish policy of the coastal countries is the reinforcement of the State management system for marine living resources in their national 200 mile economic zones (EEZ) and on the continental shelf. Such management means:

1. Control over *all* fishing operations.
2. Total use of their own EEZs resources by the *national* fishing fleet.

In this connection, extrusion of the foreign fleet out of the national zones has assumed a steady, irreversible character in the countries developed in fishing. The same trend is true for the countries of Africa, Latin America and Asia, although they dispose the resources they did not completely use.

On the basis of these trends of the worldwide fishery, the following three main directions are being formed [5] relating to the formation and the use of a feedstock base – the basis of the marine fishery.

1. Feedstock accelerated formation at the expense of the newest achievements in the biothechnics of breeding of the valuable objects of mariculture being in great demand. Norway and China are leaders in this regard.

2. Transition in managing the traditional marine bioresources in their own 200 mile zones and on the shelf from the intensive capture to their sparing, towards careful and controllable use on the basis of all available scientific data. The principle of the *careful approach* in unclear consequences from fishing activities, the State control over fishing boats operations and the State management of marine living resources is the basis of the fishing policy of the developed coastal countries. The USA, Canada, Iceland, and Australia follow this direction to the fullest extent.
3. Adherence to the traditional approach formed in the 40 – 60s of the XX century, when at the increase of any target in number and the intensity of its capture also increases and, accordingly, at its decrease in number, the intensity of its capture also decreases down to a complete cessation.

Examples: excess catch of Atlantic-Scandinavian herring in the 70s, the practical ban of its catch in the 80s and the recovery of fishing in the 90s of the XX century. Cod reserves decrease in the Barents Sea in the 90s, considerable limitation of its catch (TAC and national quotas) at the end of the 90s – at the beginning of the 2000s, slow recovery of the reserve and TAC increase and quotas in the last 3-4 years. Decrease of pallock reserves in the Okhotsk Sea within 1995 – 2000, appropriate decrease of catches and gradual growth of reserves in the last 5 years.
In accordance with this third direction, Japan, Chile, Peru, and Russia basically comply.

The greatest effect to supply the national marine fishery with a steady feedstock resource gives the *flexible, combined* use of *all three directions* by the coastal countries in their fishing policy. Such an approach is typical, if anything, for Norway and Iceland.

1.7. The status of the Russian fisheries industry

The Russian fisheries industry is the complex sector of the economy comprising a wide range of activities: from the forecasting of the feedstock base of the industry to the organization of fish products sales within the country and abroad. Before the 90s of the previous century, fishery was one the most dynamically developing industries of our countrys economy. By the value of fish catch, the USSR was the leader of the world fishery: more than 11 mln. t of fish and seafoods, of which 8.1 mln. t was attributed to the Russian Federation, and 2.9

mln. t – to the other union republics; about 28 % of the worldwide output of fresh, cooled and frozen fish and about 30 % of tinned fish were being produced.

Currently, the catch of sea biological targets has decreased by more than 50 % compared to 1991. Within this period the output of fish foods, at the significant worsening of its quality, has reduced by more than 21 %, of tinned foods – by 3.5 times, of fish meal – by more than 7 times, at the increase of export by more than 45 % and at the simultaneous increase of import by more than 3 times. Over 90% of export is attributed to fish products with a low processing phase. The number of workers in the fish industry has reduced by almost 33 %, efficiency has decreased by almost 2 times, and saleable production profitability has reduced by 9.5 times. About 33% of domestic consumption fish products are ensured at the expense of import the substantial part of which is actually the re-export of water and biologic resources. The per capita consumption of fish products has been reduced by fifty percent and constitutes 12.6 kg. Structural reforms could not ensure the efficient activity of production connected with the renewal of water bioresources; the fishing of which is defined by the highest profitability. Sturgeons are under the threat of elimination. The unsatisfactory technical equipment of the services carrying out the State control in the field of water bioresources protection does not allow effective standing against the poaching. Illegal fishery of the water biological resources exists on a vast scale in the exclusive economic zone of the Russian Federation, the level of which does not reduce, prevents the economic restoration of the industry. It derogates the business and political reputation of the Russian Federation globally and contradicts with the economic interests of the country. The process of ownership transition of the fisheries within the 90s was carried out at a quickened pace, therefore, to such important missions as the insurance of food supply security of the country and the fulfillment of social functions connected with the city-forming nature of the industry are not given due attention in the regions.

As a result of privatization, the structural reconstruction of the commercial enterprises of the industry has occurred, i.e. the fragmentation of industrial associations. The number of enterprises has increased by more than 4 times. Institutional transformations were also reflected in the alteration of organizational and legal forms of economic entities operating in the fisheries. The State currently is the owner of less than 5 % of enterprises. In such conditions, the absence of real organizational, legal and economic actuators from the side of

the State against the economic entities of the fisheries have resulted in the sharp reduction of their efficiency. The degree of business development and economic environment under formation has given an impulse for the sharp increase in the number of entrepreneurs without establishing a legal entity. The share of small enterprises in the total number has constituted over 74 %. The number of fish harvesting and processing enterprises increased within this period by 9 times, the number of water resources consumers – by 11 times, which exceeds the number of organizations in 1991 by 20 times.
Commercial fishery species and non-fish targets are a renewable resource and, nowadays, are one of the most eco-friendly, therefore all the countries want to possess as much reserves and quotas for fishing as possible.

Currently, the issues of quotas granting are regulated by international organizations. For instance, the TAC of the basic commercial species in the Barents Sea is annually approved at the session of the Joint Norwegian-Russian fisheries commission (JNRFC). Then a quota is to be defined, which is granted to the third countries, and the remaining part of the TAC is to be shared between Russia and Norway in equal proportion. After that, on the basis of the contracts concluded with the Federal Agency for Fisheries, fish harvesting enterprises are supplied with resources. Such a distribution is effective within 5 years.

As for the remote regions of the World Ocean, Russia is not always able to use the quotas granted. It is not economically advantageous for Russian companies to perform fishing activities in the Pacific Ocean or in Antarctic in existing conditions. It takes one month for fishing and a round trip takes not less than three months. In such conditions fish becomes “golden”. Therefore, given the factor of food supply of the country and the possibility to resume the presence in the remote regions of the World Ocean, it is necessary to review the issue on grants-in-aid for fish harvesting companies.

The question of foreigners status as the owners of Russian fishery companies is connected with the food supply security. There are already several cases in the Russian economic practice, when foreign companies acquired Russian fishing companies along with their fish harvesting resources (their part of quotas). In Norway, for example, no foreigner can hold more than 49% of the shares of a fish harvesting enterprise. Such restriction is also necessary to establish in Russia.

Two thirds of cash inflow to the fisheries industry of the RF in general is due to fish supplied for export. In the countries of Western Europe fish has never cost less than meat so fishery requires considerable expenses. In Soviet times, in department stores, frozen eviscerated cod cost 0.48 rubles per kilo, meat – 2 rubles. But with that for each kilo of cod fishing fleets got 2 rubles from the State, so there was a 4-fold allocating investment support. Such a ratio of prices cannot be the same as previously in the modern economic conditions. Today, the State has to make a decision on what we need the fisheries industry for: either for replenishing the budget or for feeding the population.

1.7.1. Material and technical resources of the Russian fishery industry

The key element of the material and technical basis of the Russian fisheries industry is the fleet. It ensures over 95% of the total catch. The ships produce over 92% of the of frozen products value, over 96% of fish meal and about 15% of tinned foods.

The high-sea fleet includes harvesting fleet and support fleet. The harvesting fleet includes catching vessels, processing bases and production refrigerators, transport-refrigerators and dry cargo vessels.
The support fleet unites research and training vessels, tankers and rescue boats, the dock vessels, etc.

In 2002 [6,7] there were about 2,500 catching units, 46 processing units, 366 transport refrigerator and over 700 units of the support fleet in the fisheries industry. Besides, over 5,500 units of small vessels of different types operated in the inland water reservoirs.

As of 2009, the fleet of the fishery industry included 2,400 vessels with a 55 kW (1h.p. – 0.73 kW) primary engine and with higher power [8]. But approximately *75%* of *domestic fish catching vessels are older than the limits of estimated useful life time.*

These data show that starting from the 90s substantial changes occurred in the composition of the fishing fleet. The funding allocations of the leading designing and engineering departments dealing with research and development were sharply reduced. According to different expert estimations, the number of such design departments decreased by 5-6 times, thus, fundamental and pilot studies nearly stopped, the mission of which was to ensure the brand new level of civil fishery production development.

Thus, by the beginning of the 2000s, the necessary scientific potential and the level of competence in the field of fishing shipbuilding was lost, conceptually new and economically efficient fishing boats were not built, individual scientific and technological achievements were not duly developed.

Changes in the number of and in the quality of the fishing fleet of Russia for 20 years are presented in Table 1.6 according to the data of [8]. At the insignificant decrease of the total number, the large fishing freezer trawlers of old design were discarded, the number of big ships was reduced almost twice. The number of processing vessels was reduced more than twice, when for processing vessels – by 3 times. The share of middle ships increased and that of small ships decreased a little. The replenishment of the fleet was carried out at the expense of small batches as per the designs of the 80s which were built on Russian shipyards or of the ships built abroad (only 2 to 3 dozens of ships).

Onshore production. Basic onshore factories ensure the output, the storage and the sales of fish products [6]. These are canning factories, smoking factories, cookeries, freezers, fish meal factory mother ships, refrigerating, and fish salting factories.
Despite the substantial physical excessive wear and the ageing of the onshore factories, in the opinion of the Rosrybolovstvo (in 2008, the State Committee for fishery was transformed into the Federal Agency for Fisheries – FAF), the RF fishery industry possesses a substantial potential. Though in fact, the onshore factories are in a deep crisis. Integrated control and support from the State are rather necessary.

The reforms in the industry impacted the general state of the port property. The retargeting of supplies of the products of Russian fishing organizations to the sea ports of foreign countries resulted in the decrease of cargo turnover numbers in fishing ports, and as a consequence– in the reduction of their profitability. Currently, the Russian fishing fleets ships integrated servicing is carried out by the harbor facilities which unite 16 terminals, 7 of which have deep-water berths able to handle large-tonnage vessels. The basic number of hydrotechnical constructions of the terminals was built in the 50 – 60s of the previous century and are considerably worn or are in emergency conditions. It

Table 1.6

Time History of the Russian Fishing Fleet Composition within the 1992-2009s.

Groups by fleet kinds and by ships dimensions	1992	Movement 1992-2009			2009	Dynamics of changes 1992-2009
		replenishment		discarding		
		total	including new building			
1.Harvesting fleet, incl.:	2807	1537	412	2277	2067	-26,36%
Large ships	33	14	7	22	25	-24,24%
Big ships	626	157	31	606	177	-71,73%
Middle ships	941	680	154	771	850	-9,67%
Small ships	447	237	37	345	339	-24,16%
Small size ships	760	449	183	533	676	-11,05%
2.Processing fleet incl.:	142	29	9	148	23	-83,80%
Factory ships	95	4	3	89	10	-89,47%
Refrigerated ship	47	25	6	59	13	-72,34%
3.Receiving-cargo fleet including:	463	235	45	429	269	-41,90%
Large capacity and medium capacity	198	155	26	256	97	-51,01%
Small capacity and inland navigation	265	80	19	173	172	-35,09%
4.Training, research vessels, fishery guard, marine and salvage vessels	90	55	26	85	60	-33,33%
Total:	3502	1856	492	2939	2419	-30,93%

does not allow increasing the traffic handling capacity of berths and the cargo turnover of terminals, ensuring the safe operation of berths and the application of handling equipment. For comparison, the number of fishing ports in China is 700, in Japan – 2,924, in Korea – 2,266.

The basic reasons of cargo turnover sharp collapse in the Sea fishing ports (SFP): 1. Reduction of hydrobionts general catch. 2. Growth of ship-made fish products export. 3. Reduction in number of RF port registered vessels. 4. Increase of customs duties and tax imposition for ports.

On the whole, the economic condition of ports is considered as difficult, about 50% of all ports are unprofitable. The total income from production activities does not cover expenses.

The simultaneous renewal of the fishing fleet and development of the production potential of the domestic shipbuilding industry in conditions of the market economy can be ensured only by the efficient implementation of a variety of measurements providing:

1. Renewal of the key assets of the fishing shipbuilding;
2. Increase of quality and reduction of ships design time;
3. Creating conditions for the large-scale renewal of the fishing fleet;
4. Development of scientific studies in the field of fishing vessels design and building;

Creating financial conditions acceptable for potential customers when building a fishing vessel.

2. FISHERY ORGANIZATION AND FISHERIES. FISHING BOATS AND GEARS

2.1. Fishery organization

In the domestic and the foreign fishery practice the two basic forms of fishery organization are admissible: an autonomous and an expeditionary one [9].

The autonomous form – harvesting vessels deliver raw fish, pre-processed products or ready-to-eat products directly to the shore. This form exists in some varieties:
a) The harvesting vessel operates at sea until the trawls are filled up, then it returns to the port for unloading and filling up the trawls (small and middle boats – in the coastal zone, the large ones – mainly out at sea, rarer in their own EEZ).
b) On board of a harvesting vessel with processing equipment catches are partly or totally processed into food products, then the trawls are filled and after that the vessel returns to the port. It is the most common technique of the autonomous fishing. Large and middle ships with equipment are able to carry it out.

The expeditionary form is a complex industrial engineering process, which unites the functions of fish harvesting, fish products manufacture, transfer to transport ships and floating factories, transportation to the port. There are also some options here. This form allows managing the remote regions of fishing and increasing the efficiency during the season. The options of the expeditionary organizational form are presented below:
a) Harvesting vessels + receiving-transport refrigerator (RTR). The RTRs are special vessels with voluminous holds coupled with freezing plants, pick-and-place machineries, and a high velocity.
b) Harvesting vessels + a floating factory
c) A floating factory + RTR + a floating factory + RTR

The variation of the expeditionary form is a detachment organization. It was widely used in the 70 – 80s, when huge organizations forwarded fishing fleets to the regions of mass fishery. The scheme of fishing detachment organization is as follows: a floating factory + RTR + some harvesting ships form a detachment, i.e. part of the fleet or the autonomous expedition has its own fishing tasks in a certain region, but it also has a possibility to cooperate with other detachments.

2.2. Fisheries

The international legal conditions and the real threat of the catch excess of individual species evoked the necessity to clearly analyze and to reveal the fisheries. Three kinds of fishery are distinguished [9].

1. Homogeneous or specialized fishery. It is defined by the usage of the certain gears for only one (mainly one, as there is always an additional catch) fishing target (species).
2. Heterogeneous fishery, whereby one and the same target species is caught using gears of different kinds and classes. For instance, in the North Atlantic haddock and cod are caught with trawls, longlines, and fishing rods, in the Far East salmon is caught with stationary and drift nets.
3. Mixed fishery, whereby different fishing gears are applied for small targets of catch. A ship (or several ships of one shipowner) catches cod, halibut, and haddock with longlines and with other fishing gears.

The heterogeneous and the mixed fisheries are evidently economically more profitable. Insofar as they allow maneuvering as fishing conditions change, but currently, the timely international legal restrictions often force to carry out the homogeneous fishery.

2.3. Specifications and types of fishing boats

Classification of fisheries ships upon their intended purpose:

1) Harvesting ships vary by catch type:

a) Trawler carries out the trawler catch, there are bottom trawls and pelagic ones;

b) Seine vessel – purse-seine fishing – purse-seine;

c) Longline vessel – longline fishing – longlines;

d) Drift vessels – drift fishing – drift nets. Currently, the drift fishing usage is substantially reduced, and is virtually banned by some countries.

1.1) Specialized harvesting vessels:

a) Seal-hunting vessels – fishing vessels;

b) Tuna boats – logline vessels, tuna boats - seiners;

c) Calamari catchers (vertical longlines, drift nets).

2) Transport vessels:

a) Receiving-transport refrigerator (RTR). RTR specific features are: heavy payload, a tonnage of up to 20 thousand tons, freezing plants and different operating temperatures, high velocity. Usually, RTRs also serve for furnishing ships at sea;

b) Dry cargo ships (they mainly provide supplies).

3) Fish processing vessels:

a) Floating factories: canning, fish processing, and whaling. These are equipped with processing and canning production, with all-purpose refrigerators, special fishing gears. They carry out the feedstock advanced processing, up to the canning.

b) Floating fishery plants. They carry out the feedstock advanced processing, up to the canning.

c) Refrigerator vessels. They receive raw fish at sea, freeze (without processing) and deliver it to transport-refrigerated vessels.

4) Support vessels: salvage, training, scientific and research, bunker ships, etc. Modern harvesting vessels usually have freezing plants and freezing chambers.

Classification of harvesting vessels by dimensions:

1) Small size vessels. Up to 20 m long, Ssv is an abbreviation, tonnage is from several tons to dozens of tons. For example, SsFTR stands for a small size fishing trawler- refrigerator.

2) Small vessels. 24-34 m vessels, S (M) is an abbreviation, a tonnage is up to 300 reg. t. Examples: SFTF (MPTM) stands for a small fishing trawler-freezer, SFTR (MPTP) stands for a small fishing trawler-refrigerator.

3) Middle vessels. 34 – 65 m long, M (C) (at the beginning of the index) is an abbreviation, a tonnage is 300 – 1,600 reg.t. Examples : MFT (CPT), MFTR (CPTP), MFTF (CPTM), FMT (ПСТ) .

4) Big vessels: 65 – 105 m long, B (Б) is an abbreviation , a tonnage is > 1,600 reg.t. Examples: BMRT (БМРТ), FTF (PTM) “Atlantic”, BST (БСТ) – a big seiner tuna catcher, ShFV (ЗРС) – a seal-hunting fishing vessel.

5) Large vessels, (super-trawlers). > 100 m long, …S (…C)(at the end of the index) is an abbreviation, a tonnage is > 3,000 reg.t. Examples: FTF-S (PTM-C) stands for a fishing trawler-freezer -super, FKTR-S (PKT-C) (a fishing-krill trawler-refrigerator- super).

Large vessels (supertrawlers) are usually all-purpose, i.e. they catch fish, process it, freeze it and deliver it.

An example:

The fishing trawler freezer-canning (supertrawler) type “Moonsund” built in the GDR (1986-1990). Its basic technical specifications (TS) are as follows:

115 m long, 2x3650 kW (2x3600 h. p.) main engine, speed is 15.1 knots, tonnage is ~ 9,000 t, temperature in the holds (up to -28 degrees), fishing gears – bottom and pelagic trawls, production: dressed and roundish frozen fish, fillet, tinned goods, fish meal, technical fat.

The fishing trawler freezer (supertrawler) type "Horizon", FTF-S (PTM-C) (project 1386). TS: tonnage is 8,000 t, 110.8m long, 2x2,575 kW main engine. Different depth trawls. Frozen production manufacture, conversion of wastes and additional catch milling, tinned goods manufacture, products storage.

2.4. Gears and fishing methods

Fishing gears. Classification of fishing gears after F.I. Baranov [9]:

1. Piercing and hook gears (longlines, rods, trolls – multihook rods or tracks) provide the opportunity to catch fish in trawler-free zones, on spaced fish concentrations. They are considered as more eco-friendly, than linemeshing and trawling gears.

With the help of Piercing and hook gears pelagic fish is caught: tuna, halibut, salmonids, sword-fish, cod, shark and others. There are also bottom longlines – cod, halibut and others.

2. Linemeshing gears – fish gets trapped in net-meshes. There are stationary nets, river nets and drift nets, i. e. "hung up" on bouys out of board the ship at sea. The defect is necessity to remove nets within a short period, or otherwise fish dies and decays. Drift nets have a dimension of up to several hundred meters long and up to two hundred meters high (deep), their installation and removal takes up to several hours. For efficient catch several gangs of nets are installed, therefore, so quick-time removal is often impossible.

Moving fish concentrations are to be caught – at sea: herrings, salmonids, scombrids, whitefishes and others – in rivers and lakes: carps.

3. Filtering-type fishing gears: throw nets in rivers and lakes; ring seines or purse seines – at sea; waterside traps. Drawback – season nature, great losses at excess catches.

Pelagic fish is caught, which forms reasonably thick concentrations: anchovy, capelin, Baltic herring, sardine, herring, mackerel, scad, tuna, and Black Sea anchovy.

4. Trawling fishing gears: net bad unfolding under action of special rigging and hauling by a vessel. There trawls, pelagic and different-deep trawls.

To be caught: codfishes, herrings, mackerels, scad, poutassou and many others.

5. Stationary fishing gears – traps of different types with a bait for crabs, rock lobsters and for other delicacy sea animals.
6. Self-activating traps – various traps of “local” designs.
In the commercial fishery of Russia (of the USSR) in the of the XX century, trawl fishing became predominant compared to fishery with other gears (Table 2.1). In the last decades, longline fishing is becoming predominant by virtue of its selectivity and ecologic nature (fish of a certain species and age is caught, longline installation and elevation takes few time and partly carried out when a ship is in motion).

Other fishing gears include mainly bulk fishing gears, basically stationary nets and throw nets.

The other classification in terms of fishing organization – *active and passive fishing gears.* The first ones are actuated by fishermen, ships or by industrial machines and they catch fish. The second ones are fishing gears where fish is trapped by itself without active forcing it.

The main characteristic of any fishing gear is the capability to catch fish or non-fish targets, or a catching efficiency. The catching efficiency is influenced by many factors. The *catching efficiency* is a qualitative characteristic which is attributed to different extent to all the fishing gears. For comparison it is necessary to express this qualitative notion in amount according to the catching efficiency of fishing gears. It is evident that it is possible, according to the catching efficiency, to reasonably efficiently compare only gears of one type. For example, for the trawl the quantitative index of catching efficiency is a catch attributed to the aperture area, or a catching power dependent on this

Table 2.1

Alteration of Relative Contribution of Catches in Russia (the USSR) Carried Out with Various Fishing Gears in % of Total Catch

Fishing kinds and gears	*1940*	*1950*	*1960*	*1970*	*1980*
Trawl fishing	15,6	19,2	34,0	63,7	72,5
Seine-net fishing	3,2	4,2	4,5	9,1	13,6
Drift fishing	6,2	5,1	17,0	1,5	0,2
Fishing with the use of new gears		0,1	5,8	6,0	4,1
Other fishing gears	75	71,4	38,7	19,7	9,6

area (accordingly, sometimes vertical and horizontal catching power is used dependent on the vertical or the horizontal dimension of the trawl).
For drift nets and purses the catching power is a catch attributes to the area of knotted fabric.

For longlines the catching power is a catch attributed to the total length of gang of the longlines (“mainline” length).

2.5. Fishing boat’s working time pattern

Evaluation of the merit of any fishing organization form, fleet or an individual ship operation planning, fishing profitability evaluation is based on the technical and economic parameters of the ship. One of the most important technical parameters is the working time pattern of a fishing boat [9].
Fishing boats working time pattern is the operational procedure of a vessel, its structure and time distribution by individual components.

We have *T* – all analyzed time, usually 1 calendar year, 12 months, 365 days.

$$T = top + tno \tag{2.1}$$

top – operating (this is time when a ship is used for its direct purpose based on all works and operations),
tno – non-operating (residence time for other agendas, for example, under repair) usually *top* constitutes 65-75% (up to 80%) of annual calendar time.
Furthermore:

$$top = ts + t \tag{2.2}$$

ts – off-port time, *tn* – in-port time

$$ts = tr + ttr + tl + tdt + tc \tag{2.3}$$

where *tr* – time taken for transfer to the fishing ground and back,
ttr – time taken for transfer to floating receiving and supplying ships,
tl – time taken for freight operations at bases and at sea,
tdt – dead time at bases and at sea,
tc – fishing time – properly productive time. In the RF, in the modern conditions *tc* constitutes averagely 40 – 50% of calendar time.

$$tc = t_1 + t_2 \qquad (2.4)$$

where tp – time taken for floating to the fishing ground and back,
t_1 – time taken for seeking fish in the fishing ground,
t_2 – fishing time.
t_1 – can reach 50%, it depends on the efficiency of reconnaissance and on the skills of the captain and oceanographer who ensures the fishery. Thus, t_2 – proper time of "clean" fishing constitutes ~ 20-40% of the calendar time.

3. ASSESSMENT OF WILD FISH STOCK AND QUANTITY. TOTAL ALLOWABLE CATCH (TAC)

3.1. Methods to define the quantity and the stock of fishing grounds

It is important to review some notions and definitions from ecology and commercial oceanology [3]:
Stock is the aggregation of commercial species biological units living in a certain region. There are single-specific and multi-specific kinds of stocks.
Population is the self-replicating aggregation of one species biological units possessing a common genofond and occupying a certain area.
Population (stock) condition is the integrated characteristic of the population (stock), which includes the appraisals of the most important parameters of the population (stock) and of their changes trends. The population (stock) parameters include the following: number, mortality rate, recruitment, etc.
Stock structure is the ratio of groups of biological units belonging to different species (for the multi-species stock) in the stock.
Population structure is the ratio of groups of biological units belonging to different age groups (for the single-species stock).
Number is the amount of the whole population (stock) or of its certain part in terms of species.
Total allowable catch (TAC) is the forecast value of the annual commercial withdrawal out of the stock unit calculated based on the biological features of this stock (productivity, population dynamics) and the purposes of its operation. TAC conforms to an optimal (in terms of selected regulation criteria) fishing intensity.
There are methods of absolute and relative estimation of the stock number and biomass [9].

Methods of absolute estimation

There are several ways of the direct and indirect definition of the stock number and biomass. As a rule, the absolute number of the commercial part of the stock and of young fish is estimated separately due to the methodologies divergence for full-grown and young fish.
1. The most familiar method is an *area method*. In this method a catch is attributed to a certain area of water reservoir, wherein the catch is carried out, or to the area, which is occupied by the fishing target. That is:

$$N = \frac{A}{a} \cdot \overline{n}, \qquad (3.1)$$

where, $\overline{n}$ - an average catch per trawling time unit (in terms of pieces); a – an area harvested by the trawl per trawling time unit; A – an area of survey region, or of this species range.

Development and stipulation of this method consists in the accounting of trawl catch efficiency:

$$N = \frac{A}{a} \cdot \overline{n} \cdot k_1 \cdot k_2, \qquad (3.2)$$

where, k_1 и k_2 – horizontal and vertical ratios of the trawl catch efficiency. The methods drawback is poor accuracy. However, with a great number of trawling and their occasional distribution in the water area, the method is successfully applicable for estimating the number.

2. Sometimes, the number is estimated not on the basis of a catch, but by way of the calculating the eggs laid.

$$N_S = \frac{n \cdot x}{\overline{n}}, \qquad (3.3)$$

where, N_s – the number of a spawning population (in pieces), n – the total of laid eggs; $\overline{n}$ - the average fertility of a female; x – the ratio of sexes in a spawning population. For example, if the number of males and females is equal to 1:1, then $x = 2$; if the females are more numerous (1:2), then $x = 3$.

With that:

$$n = \overline{n}_C \cdot \frac{V}{V_S}, \qquad (3.4)$$

where $\overline{n}_C$ – the average number of eggs in a catch (in pieces); V – the total volume of water reservoir space, wherein eggs are laid (in kmi); V_s – a catching volume (in kmi).

$$V_s = S_{тр} \cdot l; \quad l = t_{тр} \cdot W_{тр}, \qquad (3.5)$$

where $t_{тр}$ – trawling time; $W_{тр}$ – trawling velocity (km/hour); $S_{тр}$ – a trawl mouth area.

The method naturally has some drawbacks: eggs are irregularly distributed in the water column; eggs die during the process (from spawning to trawling); if trawling is carried out from different vessels and with different trawls, then it is necessary to take into account the divergences in the catching power of these trawls. However, the method also has a positive side: fish egg and larval shootings are carried out reasonably regularly at the same time for bulk commercial species, therefore, the results of estimations for different years (or periods of time) can be compared to each other.

3. One more method of absolute estimation of the number and of the biomass is a *marking method.* It consists of the creation of a pilot population with the assumption that marked fishes are uniformly distributed inside of the remaining shoal. Then the number is estimated by the following formula:

$$N = N_C \cdot \frac{n}{n_C}, \tag{3.6}$$

where N – the fish number (for example, of commercial size in reserve); N_C – the number of fish of the same size in a catch (pc); n – the number of marked fishes; n_C – the number of capture-mark fishes.

The methods drawbacks: 1) marked fishes may be distributed irregularly; 2) marked fishes survivability may be worse; 3) marks may be lost in the total mass of captured fish.

4. Sometimes the absolute number is defined by the *intensity of fish foods grazing*:

$$N = \frac{R}{r}, \tag{3.7}$$

where N – fish quantity; R – general food reserve of the water basin (in tons); r – ration consumed by one fish (in tons).

But the estimation of the general food reserve biomass is not less complicated than the estimation of the fish reserve amount. Therefore, the method is applicable for well studied local shoals and water areas.

Methods of relative estimation

1. The most wide-spread method is a method based on the *variability of catches depending on the variability of the shoal.* That is, the catch of a certain species is calculated by all the vessels and fishing gears within some years and it is assumed that the stock (number) of the species varies likewise. With that it is assumed that the ratio of commercial withdrawal is constant or

at least known. For instance, if the ratio is equal to 0.1, in other words it is possible to withdraw 10% of the species reserve.
This method shows the variability of the stock or the number, but the absolute number is virtually unknown. Hydrometeorological factors, changes of fishing techniques, etc, are not taken into account.
2. The other method is based on the *analysis of aged fish captures*. In other words, within several years a certain age group is tracked and, on the basis of the variability of this group in catches a conclusion to be made relating to all population or the species number and biomass variability.
The estimation of the number and the biomass of most bulk commercial species (Atlantic herring, Atlantic cod, the pollock of the Okhotsk and the Bering Seas, etc.) is carried out not only from the current date, but also annually (permanently) the estimations of the previous years are refined. For that, for example, in ICES (International Council for Exploration of the Seas) task forces for the appropriate species are established (for herring, pelagic fishes, cod and haddock). Annually (sometimes more often), the experts from the countries concerned (Norway, Iceland, Great Britain, the Netherlands, Denmark, Russia and others) come together. Apart from the stock figures acceptance, currently they estimate the TAC and the recruitment; they specify the figures of the reserves, the number of catches in the previous years. It is necessary to do this for developing methods of short-term and long-term forecasting of stocks conditions.

For example for Atlantic herring there are estimations of the stocks from 1903. The age structure of the stock is recovered year by year and, accordingly, the number of age groups, the weight indices for each year, the total biomass and the catch of individual countries and all countries in general.
Actually all of the methods in question were based on trawl survey. But within the 70 – 90s, other kinds of shootings based on the use of echo-sounders and sonar gears also were under development.

Currently, there are:

1) trawl survey;

2) acoustic survey;

3) trawl-acoustic survey. This way is the most efficient, insofar as the acoustic survey helps study virtually all the water area and all its concentrations. Trawl survey in the places of concentrations, preliminarily identified by acoustic survey, allows accurately defining the number and the structure of a

fishing concentration and extrapolating these data for the entire water area studied by the acoustic procedure;
4) underwater television survey;
5) direct divers survey. It is designed to a greater extent for observing and catching of rare numerically insignificant targets, for example, sea urchins, oysters, small scallops, etc.

3.2. Total allowable catch - the basis of naval biological resources rational use

TAC means the total allowable catch of a certain commercial fish species. TAC is developed for a prospect of 2-3-4 year and is annually specified by catchment-based institutes. TAC development and calculation is currently the most real mechanism of resources efficient management (but not a single one and not the most up-to-date).

The traditional approach to the TAC assessment is based on the simplest control strategy, i.e. on the annual withdrawal of some permanent share of the commercial stock out the stock as TAC, irrespective of its condition and value [10], in other words in this case the Фrec=*const*. Such an approach was formed in the middle 50s of the XX century, when the scopes of the commercial use of sea fish resources were significantly lesser than today. Originally the concept of the traditional approach was developed with regard to the unharmed, biologically steady stocks. However, within the last decades of the XX century, the situation in the world fishery was substantially changed: the overwhelming majority of commercial species populations is overfished or is in tension.
It is not difficult to show where the application of the traditional scheme of TAC estimation will translate into in case the broken stocks. In this case, it is necessary to introduce the notion of *a critical landmark* for the spawning biomass B_{lim}, beneath which the probability of weak-year class occurrence measurably grows up, i.e. the stock loses stability. Admitting the existence of the directly proportional dependency between the biomasses of the spawning and the commercial parts of the stock, lets review the TAC traditional estimation for the two levels of the stock: B_1 – a level conforming to successful, and B_2 – to the stock in tension.
Lets assume that the permanent level of fishing recommended for such a species stock is established in terms of the fishing loss coefficient Фreci and is equal to 30%.

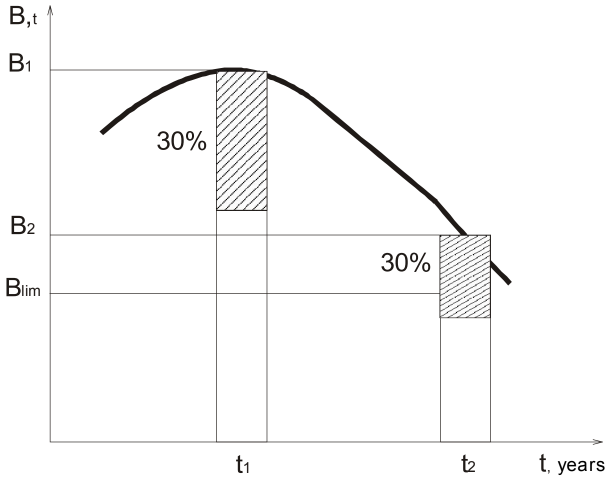

Figure 3.1. Biomass and fishing intensity for satisfactory and stressed stock conditions

In the first case (year t_1) TAC to the extent of 30% from the value of the fishing part of the stock will also reduce its spawning part on a pro-rata basis, which, however, does not descend to the critical level, and the stock will save its reproductive potential. In the second case (year t_2) the same share of the field withdrawal (30%) will result in the downfall of the parent stock biomass lower than the value B_{lim}. It will considerably decrease the reproductive capacity of the stock and will make it problematic to quickly restore it. It follows that the stocks management with the permanent and sufficient value of fishing intensity is applicable only when the stock is in good condition. If the stock is broken, such a mode worsens its condition yet more and can result in the continuous depression of the stock.

The all-pervading principle of TAC estimation can be expressed in terms of the simple formula as follows:

$$TAC_i = \Phi rec_i * FSB_i \quad (3.8)$$

where Φrec is a recommended value of fishing intensity; FSB – the biomass of the fishing part of the stock, i – year index of the fishing.

Depending on which terms the fishing intensity is expressed: in terms of the instantaneous coefficient of the fishing death rate F, the coefficient of fishing loss Φ or the fishing effort E – the various versions of the TAC estimation original-formula record are possible, the components of which remain a fishing intensity and the biomass of the fishing stock or a stock biomass [10] .

It is not so difficult to note that the estimation of the total allowable catch provides a solution of two independent missions: the forecast of a fishing biomass of the stock and the substantiation of a value of the recommended fishing effect on the stock. The forecast of the stocks value for the (i-th) year is carried out on the basis of the stocks dynamics analysis by the retrospective data and on the extrapolation of identified trends for an intended prospect. The estimation of the recommended fishing intensity is carried out based on the stocks production capabilities, the purposes and the strategy of its operation. In the world practice the purposes of operation of the most important stocks is defined in general terms by the management of the fishery industry or major companies, as well as by the administration of coastal regions. The task of forecasters consists in the formulation of the proposed objectives in biological terms, the elaboration of long-term strategies of implementation of these objectives and in an annual substantiation of the scopes of a total allowable catch (TAC) within the frames of fishing control strategies agreed with the industry.

The modern feedstock base comprises to a greater extent stressed or broken stocks, therefore when calculating TAC it is necessary to have regard to the techniques of a "circumspective approach." Besides, the forecast of the stocks condition and an estimation of the share of fishing withdrawal always contain uncertainty caused by mistakes in the initial data, gaps in models and calculations. Therefore, in many countries a principle of overcautious approach to fishery management is additionally implemented.

Thus, for example, at the 32 session of the NRFC in 2003, the new rules of decision making on the estimation of the value of cod and haddock TAC [11] were determined:
1) The stocks dynamics forecast for 3 years ahead at a coefficient of fishing death-rate F=0.4 is being fulfilled.
2) TAC is admitted equal to an average catch for 3 year forecasts.
3) The calculation is to be repeated next year. With that, TAC interannual alteration must not exceed 10% from the value of the previous year.
4) If SSB spawning stock decreases lower than the critical level (Bpa=SSBtg), the fishing withdrawal to be reduced in a linear fashion from 0.4 at SSBi=SSBtg to F=0 (or Φi=0) at a spawning stock almost equals to zero.

5) If the spawning stock in the current year or in one of 3 years of the forecast is lower than Bpa=SSBtg, TAC establishment is not limited by the rules of 10%, and may be reduced to the greater value.

3.3. "Circumspective approach" methodology while calculating the TAC of wild fish

The central part in the methodology of a "circumspective approach" concerns the estimation of environmental milestones and the optimal strategy of the stocks management [10]. The limiting and the purposeful milestones of the management are expressed in terms of the spawning-stock biomass (SSB) and of the instantaneous coefficient of the fishing death-rate (Φ). The non-perennial biologically allowable fishing withdrawal (Φ_{tg}) is to be calculated on the basis of the quantity analysis of the stocks reproductive capability, which is presented by functional dependencies connecting the stocks "surplus" products with fishing intensity in equilibrium conditions, and the number of the generation with the value of the parental stock. TAC estimation in the i–th year is carried out by the formulas:

$$TACi = \Phi reci * FSBi, \quad (3.9)$$

$$FSBi = a * SSBi, \quad (3.10)$$

i.e., as mentioned above, it is necessary to solve two problems: the forecast for the spawning-stock biomass (SSB) and the fishing-stock biomass (FSB) of the stock's parts and the estimation of recommended fishing intensity level in the year of the forecast (Φreci). Biomass forecasting is carried out by methods developed by VNIIRO basinal organizations for important fishing species in a pre-forecasting period.

Φreci is to be calculated according to the strategy of circumspective approach (Fig. 3.2) as follows:

$$\Phi reci = 0 \text{ at } SSBi < SSB_{lim}, \quad (3.11)$$

$$\Phi reci = \Phi tg(SSBi - SSB_{lim})/(SSBtg - SSB_{lim}) \text{ at } SSB_{lim} < SSBi < SSBtg, \quad (3.12)$$

$$\Phi reci = \Phi tg \text{at } SSBi > SSBtg, \quad (3.13)$$

where SSBlim is a limiting milestone;
SSBtg, Φtg purposeful management milestones.

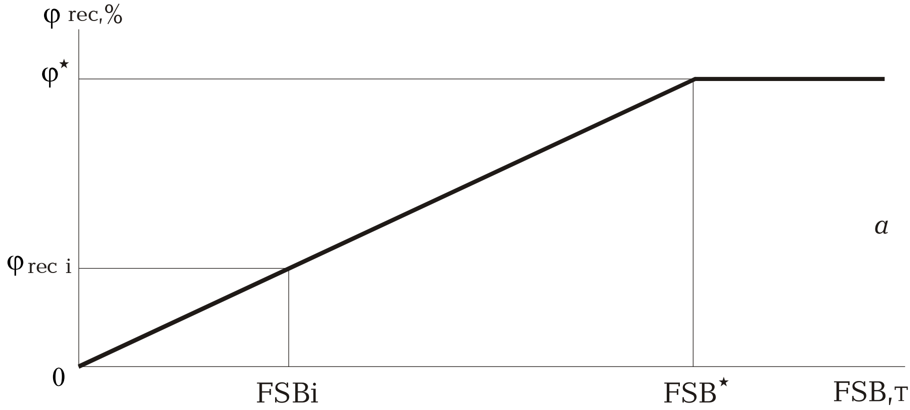

Figure 3. 2. Graphical Representation of Circumspective Approach Methodology

I.e. for TAC calculation, it is necessary to have the forecast of:
SSBi – spawning-stock biomass;
FSBi – fishing-stock biomass;
and to calculate Φreci fishing intensity recommended level.

The circumspective approach is virtually a legal rule, which in this case enforces to decrease the fishing intensity, if a species is in stress condition. The "overcautious approach" establishes an additional restriction for fishing withdrawal, if it is known that there are significant mistakes when estimating the stocks of a fishing species.
The simplest way of TAC calculation mentioned above is based on the "circumspective approach", when the level of fishing intensity (fishing withdrawal (Φ_{tg})) is reduced by the linear law at SSB_{lim}<SSBi< SSBtg.

The most flexible version is based on the hypothesis about the existence of logistic dependency between the fishing recommended intensity Φreci and the forecasting fishing-stock biomass SSBi (Fig. 3.3). Such a dependency can be presented as follows:

$$\Phi reci = \Phi tg/(1+ \Phi tg \exp(a*SSBi/ \Phi tg)).$$

To define a logistic function, it is necessary to compute the coefficient *a* typifying the rate of increase of the function (slope of the diagram of function). For this, it is enough to set the coordinates of bend points (Fig. 3.3), for example, as follows:

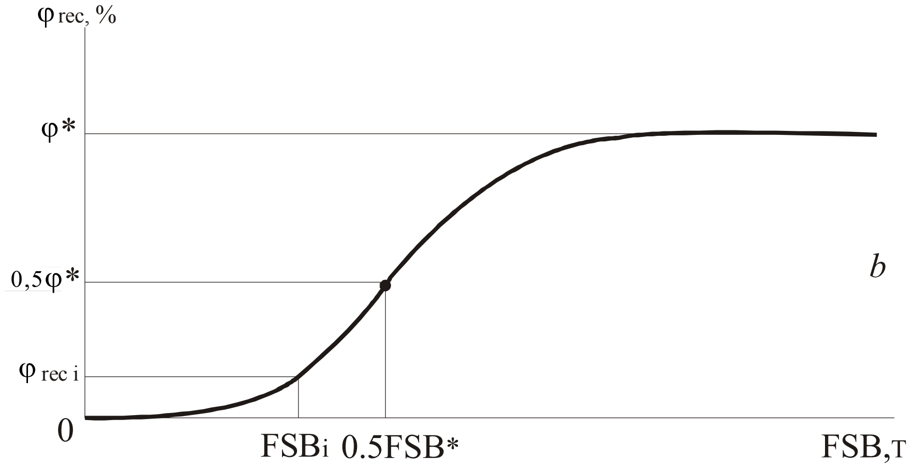

Figure 3.3. Diagram of Logistic Dependency between Recommended Fishing intensity Фreci and Forecasting Fishing-Stock Biomass FSBi

Фreci=0,5 Фtg; at SSBrec= 0,5 SSBtg.

In the zone of fishing recovery (0<SSBi< SSBtg) this version ensures more moderate fishing cycle in the field of the stocks small quantity (SSBi< 0,5 SSBtg) and TAC higher values at the approach of stock biomass to its average perennial value SSBtg.

3.4. TAC application to calculate an allowable fishing pressure

TAC value properly developed allows calculating an allowable fishing load (number of ships in the fishery) and the efficient use of the fishing fleet.
As an example, lets review a relatively long-standing time – the end of the 90s, when the cod stock in the Barents Sea was decreasing and it was necessary to take measures to save the stock and to control the catch. Thus, in 1999 the TAC for cod in the Barents Sea for all of the countries was fixed in a scope of 390-400 thousand tons. Therefore, as had been agreed within the frames of NRFC during the previous years, the Russian national quota for 1999 constituted ~ 1/2 TAC, i.e. not more than 200 thousand tons.
Note that in the fishery of cod in 1998, 200-220 vessels were involved, insofar as TAC and Russias quota had been substantially higher in the previous years than forecast for 1999. It was necessary to define the number of harvesting ships needed for spending a quota of 200 thousand tons:

1. It is known that the average annual efficiency of ships BMRT, FT (freezer trawler), FMT (averaged) constitutes – 0.5 t/hour.
2. Define a fishery effort, i. e. how much hours of trawling are necessary to "spend" a quota of 200 thousand t.

200 000/0.5=400,000 (an hour of trawling)

3. Define the number of the vessel-days of the fishery, if it is known that averagely for one day the trawling is carried out for 12.8 hours (trawling mode).

400 000/12,8= 31,250 (vessel-days of fishery)

4. Define the number of ships in the fishery (i.e. those involved in the fishery at sea), calculating based on the fact that out of 365 days a year, the fishery is carried out for 300 days.

400 000/300(days) = 105 (ships in fishery)

5. Define the necessary number of ships in the fishery (based on replenishments, passages, entries; it increases the number of ships by 30%)

105 + 0.3*105= 135 ships.

Thus, to spend a quota of 200 thousand tons of cod at the averaged parameters of ships efficiency and of trawling modes the fishery needs not more than 135 vessels. The remaining 80-90 vessels participating in the fishery in 1998 (and in the previous years) had to be redirected to other regions or targets.

3.5. Coastal fishery in the Russian seas

Currently, the coastal fishery in the developed countries is becoming an independent discipline of the fishing industry. The problems of the costal fishery and the coastal infrastructure connected with it including the servicing of fishing and transport vessels, the reception and the storage of raw fish and fish products, fish processing factories are undoubtedly included in the notion of the integrated management of the coastal zone [12].

Historically, the coastal fishery emerged first among the other industries of the fisheries. As far as harvesting vessels and fishing gears developed and improved its specific weight in the global fish harvesting was decreasing. In the second half of the XX century, the main place in the global fishery was taken up by the expeditionary or the autonomous fish and sea foods harvesting, which was carried out by large-tonnage vessels equipped with specialized and various fishing gears (fishing equipment). In the last decades of the XX centuries, the coastal fishery acquired an independent significance, its specific weight increased in the scope of the global fish procurement.

The reasons of the existence and the development of the coastal fishery are different in different countries. Thus, in *economically underdeveloped* countries having access to the sea, the coastal fishery is necessitous way to catch fish and sea foods by the local population at the absence of the modern fleet and of fishing gears. It is almost a single way to provide the significant part of the population with foods. Such is a situation in the countries of Polynesia and Oceania, some African and South-American countries.

In *economically developed* countries, which actively harvest sea bioresources (Norway, Spain, France, Japan, China, USA, Canada) the coastal fishery has always existed together with the fishery out at sea, and development and improvement of the both industries was in parallel and relatively uniformly. Currently, in these countries the coastal fishery is equipped with quite modern ships and fishing gears, often specially built for operation in the coastal zone. The developed infrastructure of ports and fish processing factories located in the coastal zone ashore complies with it. Thus, the coastal fishery is not only the additional source of bioresources for the developed countries, but also an opportunity to create new work vacancies, which is the most important mission in the integrated management of the coastal zone. Just in virtue of the last circumstance, in the developed countries the coastal fishery is given grants or other kinds of financial support from the State bodies.

In the *Russian Federation* (and previously in the USSR) the coastal fishery was not not focused on, although it has always existed. Small fishing teams, collective farms, cooperative societies or their associations conducted the coastal fishery of various commercial targets. For example, in the Baltic Sea they were catching thus Baltic herring, smelt, whitefishes and other migratory and semianadromous fishes. The coastal harvesting of many species of fish (cod, haddock and others) and of non-fish targets (shrimp, scallop, sea egg) in the Barents and in the White Seas is widespread. The fish harvesting in the estuaries of Arctic Oceans seas may be applied to the coastal fishery. The coastal fishery is widespread and traditionally exists in the far eastern seas of Russia. Individual indigenous ethnic groups in the littoral of the far eastern seas have been ensuring their existence based on the fishery in estuaries and in close foreshores, wherein they catch many species of valuable fish, mainly salmons, often fishery being one of their few sources of existence together with hunting and harvesting of forest products. The priority right of these ethnic groups to use bioresources of the coastal zone is fixed on a legal basis in the federal and the regional law of the RF.

Despite the coastal fishery is distributed throughout Russia, it was not emphasized up to the 90s of the XX century as a separate line in the budget of the fisheries in the USSR and Russia. It is necessary to note that on the level of regional authorities certain attention was paid to it. In the USSR and Russia, small-tonnage and small-size ships oriented for the coastal and coastwise fishery were being built in reasonably high amounts. Specialized fishing gears were also being designed and produced, which differed from fishing equipment meant for autonomous and expeditionary fishing in the remote parts of seas and oceans on large-tonnage fishing ships.

The situation changed in the 90s of the XX century, when the fishing industry of the RF substantially reduced fish and seafoods harvesting out in the World Ocean. It can be explained by several reasons. Firstly, *implementation of Exclusive Economic Zones (EEZ)* hindered the relations of Russia with other coastal States and restricted opportunities to fish in the EEZ of foreign States, as well as it made it difficult to repair ships and to service crews in the ports of coastal countries. Previously, the ships carrying out expeditionary catch in the parts of the World Oceans remote from Russia according to mutually advantageous agreements with coastal States were fishing on the shelf of these countries, carried out repairs and servicing of ships, crew shift in the ports of these countries, and fishing ships could waste no time during several seasons to return to Russian ports. It increased the economic efficiency of expeditionary fishing; and the specific weight of catches of the USSR and Russia out in the ocean and on the shelf of foreign States reached 70% of the total catch of the country.

Secondly, the *economic and political reorganization of the RF* resulted in the conversion of almost all (or most) fishing enterprises of the country into joint-stock companies, large companies being fragmentized, the number of large fishing vessels in a fleet being reduced to 10-20 units. Financially independent, numerous but small shipowners possessing some fishing ships cannot carry out expeditionary fishery in the remote regions of the World Ocean and, consequently, they are oriented for fishery in the seas of Russia and in the coastal zone.

Thirdly, *expenses for the crew* (salary, food, insurance, medical service) *and for ship operation* (fuel, oils, repair, technical servicing, etc.) in the RF reached or came up with the similar expenses of developed fishing industry countries. Previously in the 60-80s these expenses in the USSR had been substantially lower than the average global ones, insofar as prices for fish products and expenses for building, repairing and servicing ships had been controlled or directly fixed by the State. Currently, the profitability of fish and seafoods harvesting must be ensured only at the expense of fishing efficiency increase or non-productive time decrease, in particular, at the expense of the reduction of trips to fishing regions and dead-times.

It resulted in the fact that the majority of shipowners transferred fishing ships to the seas surrounding Russia. The load on the bioresources of these seas and, in particular, on the coastal zone substantially increased in the 90s. In the 1997-2000, the specific share of fishing of the RF in the open areas of the World Ocean reduced to 17-18%, and fishing in the proper EEZ (i.e. in the Russian seas) increased up to 68-70% and has been steadily kept on this level. It arouses concern of experts - ecologists, biologists, oceanographer – relating to the fact that the reserves of bioresources and of many commercial targets in the seas or Russia may be depleted or exhausted within 5-10 years.

The coastal zone of the Russian seas, as was mentioned above, is considerably elongated and rich in natural resources. However, the load on bioresources and reserves of commercial targets of the Russian seas is distributed very non-uniformly. Thus, the substantial amount of fishing operations is carried out on the Baltic and the Barents Seas in the European part and on the Japanese and the Okhotsk Seas on the Far East. Many bioresources of the coastal zone of Arctic Ocean seas and of the Bering Sea are used far not completely.

Therefore, the mission of the sustainable use of bioresources of the coastal zone is rather critical in the RF. With that, it is necessary to note that the coastal fishery remains an important item of income for many Russian regions providing the population with foods and work places. Consequently, the measures of the State and regional authorities must be directed not for prohibitions, but for development of this industry of the fisheries, for keeping its economic efficiency and, at the same time, for providing the steady state of natural resources reserves.

For example, lets review the coastal fishery in the Barents Sea. It is the most developed one in the RF and, therefore, there are rather representative economic and technical indices for this region.

3.6. Comparative operation efficiency of different class ships in the coastal fishery

Let s review an example of the annual budget of three types of vessels, which can carry out coastal fishing in the Barents Sea [12]. Just these three types of fishing vessels (Table 3.1) are most widely used in the Barents Sea for fishing the above targets both out at sea and in its coastal part. This is a Norwegian trawler (freezer) type “Sterkoder”; there are several modifications of this design, and the ships of such a type are used by Norwegian fishermen and are often acquired by foreign shipowners including Russian ones. By its performance this trawler is close to Russian large or supertrawlers, although it is significantly smaller in dimensions. The second widespread type of the fishing ship is a Russian middle fishing trawler freezer (MFTF). The third type in question is a Russian small fishing trawler of stern trawling with a freezer (SFTST). Currently, the presence of one freezer at least is a necessary condition of efficient fishing on any type of ships. Previously, in the designs of small trawlers, freezers were not provided for; however, after re-equipment on small ships, freezers are usually installed.

Supposing that the crews of these ships are in equal conditions, i.e. the average salary of 1 crewman during fishing is $1000 per month, costs for the insurance

Table 3.1

Basic Performance Data of Norwegian Trawler Type “Sterkoder”, and of Russian Middle Fishing Trawler-Freezer and of Small Fishing Trawler-Freezer

No.	*Performance*	*“Sterkoder”*	*MFRF*	*SFTF*
1	Total length (m)	62.1	53.65	27.5
2	Total tonnage (tons)	1560	≈900	280
3	Main engine power (h.p.)	3400	1320 (970)	580(425 kW
4	Speed (knots)	14	12	10
5	Fuel consumption (tons a day)	6	4	2.5
6	Capacity of freezing holds (m^3)	1140	230	80
7	Number of cabins (single,double)	2x15,1x7	2x12, 1x5	2x7, 1x2
8	Number of crewmen (men)	37	29	16
9	Freezing capacities (number of freezing roomsand their efficiency)	3x 12 t/day, 2x8 t/day	2 x 12 t/day	1x 12 t/day
10	Total output of freezing products (tons/day)	52	25	12
11	Total volume of freezing holds (tons)	880	160-180	50-60

and for medical equipment and for medicaments make up about $2 a day within the entire calendar year (Table 3.2). Fishing is carried out within 10 months. We will conceive that all three ships assume to carry out the coastal fishing of cod. Cod is a quoted species; therefore, we believe that the shipowners have acquired a quota in a scope of 1,000 tons for each ship by a price of $300 per ton. At the public sales, which were performed in terms of the test, a quota for cod costs $200 to $600 per ton. It is assumed that the shipowners use a loan. It is believed that 17% of income is the minimum, which is necessary to service a loan and to depreciate a particular ship according to the worldwide average standards. We will keep in mind that at the moment in the RF the majority of shipowners use old ships with a very small depreciation cost. Secondly, such costs are greater for large-tonnage ships than for small-tonnage ones. Supposing, nevertheless, such costs are the same and equal to 10% of income for all the selected types of ships. The shipowners pay equal taxes, which make up to 4% of revenue (income) and 33 % of profit.

The cost of the cod end product may reach $3,000 per ton, but based on the factor of conversion raw fish into finish fish products equal to 1.5, we accept the cost of 1 ton to be equal to $2,000. At the domestic market, shipowners sometimes also sell cod products at lower prices, but in this case cod fishing becomes unprofitable; so the financial support (grants) from processing factories concerned or from the State bodies is required.

Thus, the following conclusions about the efficiency of harvesting vessels in the coastal cod fishery can be made.

1. Use of Norwegian trawlers "Sterkoder" or Russian big fishing trawler-freezers (BFTF) is not profitable in such conditions. Such a conclusion is quite evident, insofar as for the efficient (profitable) operation of ships of such dimensions and efficiency a daily fish products output (production) in the scope of 7 tons and higher is necessary. In other words, for their efficient operation it is necessary to spend the quota or to fish unquoted targets in scopes of not less than 2,100-2,500 tons for 10-11 months of fishing. The coastal fishery can hardly provide to harvest such a scope of bioresources. Consequently, it is necessary to use large-tonnage highly-efficient ships for fishing in the open regions of the seas and of the oceans, beyond EEZ, and they can be only restrictedly used in the coastal zone.

2. Middle-tonnage ships can be used in the coastal zone, but a great raw-material base is also necessary for their efficient use. So, it is known from average

perennial data that the annual catch scope of MFTF type ships must constitute 1,800-2,000 tons for their profitable operation.

3. The most efficient is the use of small-tonnage ships in the coastal zone with a small crew, and equipped with freezing plants and holds sufficient for the raw-fish or frozen fish products storage within some days. With a freezing room unavailable, a small-tonnage ship will have to enter the port quite often

Table 3.2

Annual Operation (10 months of fishing) Budget of Norwegian Trawler Type "Sterkoder", and of Russian Middle Fishing Trawler-Freezer (MFTF) and of Small Fishing Trawler-Freezer (SFTF) with a Quota of 1,000 Tons of Cod in $ Thousands

No.	*Item of budget*	*"Sterkoder"*	*MFTF*	*SFTF*	*Comment*
1	Income from fish product sale	2000	2000	2000	
2	Costs for the crew: including	452.14	354.38	195.52	
2.1	Crew salary for 10 months	370	290	160	$1000 per month
2.2	Insurance and medical equipment	26.64	20.88	11.52	$2 per man-day x360 days
2.3	Dietary of the crew	55.5	43.5	24.0	$5 per man-day
3	Operation costs	782	570	412.25	
3.1	Fuel (10 months)	531	354	221,25	$295 per ton
3.2	Diesel oils etc	20	15	10	
3.3	Repair and technical servicing	50	30	20	
3.4	Handling operations	16	16	16	
3.5	Packing and wrapping materials	45	45	45	
3.6	Fishing equipment	60	50	40	
3.7	Administrative costs	60	60	60	
4	Profit (cl.1-cl.2-cl.3)	765.86	1075.62	1392.23	
5	Profit taxes (33%) and receipts tax (4%)	252.73	354.95	459.44	
7	Profit after tax payment	433.13	640.67	852.79	
8	Service of loan (10% from income – cl.1)	200	200	200	
9	Profit after loan payment	233.13	440.67	652.79	
10	Payment for quota	300	300	300	
11	Financial result	- 66.87	140.67	352.79	

(almost every day), which will reduce the efficiency of its use.
Besides, a developed network of transportation and fish processing enterprises must be available in the coastal zone ashore. It is especially important just when using small-tonnage ships, insofar as large ships being more autonomous (independent) can also deliver fish products to relatively remote ports. Unfortunately, currently on the littoral of the Kola Peninsula of the Barents Sea, the fish processing industry is declining, which prevents the modern domestic coastal fishery from developing.

4. ECONOMIC ASPECTS OF FISHERY SUPPLY. FISHING RENT. WATER BIOLOGICAL RESOURCES INVENTORY

4.1. Selection of criteria when planning the set and the arrangement of fishing boats in the fishery

The economic feasibility of fishing fleet selection by types of ships and its distribution in the fishery assumes solving two interrelated problems [13]:
- determining the optimal performance specifications of the ships;
- determining the type and the numerical composition of the fishing fleet.

The solution of the problem to define the fleets composition and structure must be carried out within a range of stages:
- The first stage defines the optimal performance specifications of the ships of a specific type ensuring the best resultant index of its operation in the specific region and while being in the fishery;
- The second stage builds the diagrams of each ships operation with the received performance specifications;
- The final stage, on the basis of the number of ships types received at the previous stages with the diagrams of their operation, forms the type composition of the fleet and its structure.

At each stage the most important task is to select one or several criteria [13]. The criterion must meet a range of requirements: 1) it must reflect the basic purpose of a designed project; 2) be obviously interpreted; 3) be the single-value calculated function of all scalable parameters; 4) meet the principle of the hierarchical pattern, i.e. not to contradict one another; 5) ensure the comparability of alternatives on the entire variety of scalable parameters.

In general, the basic economic indices such as reduced costs, profit, and profitability may be accepted as criteria. It is worthwhile to review the opportunity to use these criteria at the individual stage of the defined problem.
The values of the speed, of the self-dependence, of the catch per unit effort, and the fish output products range and the number vary in the course of justifying the selection of the ship s optimal performance specifications. The ships dimensions specific values, the crew strength, the construction estimate, the composition of industrial and process equipment will correspond to each value of scalable parameters.

For example, when comparing the 4 types of large-tonnage vessels (RTKS "N. Kovshova", BFTF "Pulkovo meridian", BFTF "Prometheus"), it turns out that the reduced costs greatly depend on the ships dimension, i.e. it is an unsuitable criterion at the first stage. The index "profit" weakly reacts to the change of the scope of capital investments and is also unsuitable, insofar as the ships of the same type (for example, BFTF) turn out to be in different profit classes. At the first stage, it is worthwhile to use "profitability" as a criterion to be defined as the ratio of the profit to capital investments:

$$G = \frac{П}{К}. \tag{4.1}$$

This criterion allows comparing and selecting the ships optimal performance specifications virtually on the entire scale of their variability. Its value allows easily defining a payback period, the acceptability of the ship selected based on the standard (or desirable) efficiency ratio. But it is possible that a task is fixed for building special vessels to reclaim the fishery of new raw material resources or the test fishery of any new targets even in case of the loss rate of their catch. In this case profitability cannot be directly used as a criterion, insofar as the negative value of profit will be in the numerator. Then, it is suggested to use the performance indicator as a criterion – "Э" expressing the ships output product cost ratio to the reduced costs for this ship; i.e.:

$$Э = \frac{P}{C + E_н K}, \tag{4.2}$$

where P – products cost (rub.), C – current costs (rub.), К – scope of capital investments (rub), E_H – the standard efficiency ratio of capital investments. This indicator is well agreed not only in amount with the indicators "profitability" and "net profit", but also reflects the cause-and-effect relations of these indicators. Thus, for ensuring benefit to society, the level of profitability must be higher than the standard efficiency factor:

$$G = \frac{P - C}{K} > E_н, \tag{4.3}$$

where G – a level of profitability.

Hence:

$$P - C > E_н \cdot K \rightarrow P > C + E_н K, \quad (4.4)$$

$$\frac{P}{C + E_н K} > 1. \quad (4.5)$$

In other words, for fulfilling provision (4.3) it is sufficient that the suggested efficiency indicator "Э" is more than 1.
Similarly it is possible to state that the efficiency indicator agrees with the indicator "net profit" which must be > 0:

$$П - E_H \cdot K > 0, \quad (4.6)$$

where П is profit which is defined as (П = P – C). Then

$$P - C - E_H K > 0 \rightarrow P > C + E_H K \rightarrow \frac{P}{C + E_H K} > 1 \quad (4.7)$$

Thus, this indicator – the ships output products cost per reduced cost unit – ensures the comparability of the alternatives and obviously reflects the efficiency of the ships operation.

At the indicator value =1, the standard payback period of capital investments is ensured, and if its value is >1, so the during operation a ship will have the efficiency level higher than it is provided by the standard capital investments payback ratio. If in formula (4.2) the indicator $1/T_H$ is put instead of E_H, where T_H is the ships standard service life, so that the indicator value <1, capital investments for the design and the construction of a ship will not be paid back within the standard period of its operation.

When carrying out the second stage – each ships operation diagram calculation – the resultant indices of each ships operation will be changed – the cost and the prime cost of output fish products, and, consequently, profit. It is fair, insofar as the implementation of the second stage virtually defines the distribution of ships over the fishing regions, and its efficiency ("felicity") defines the efficiency of the fishery, i.e. profitability, i.e.

$$П = P - C \rightarrow max. \quad (4.8)$$

Besides, it is just profit that is used for estimating the efficiency of the fleet s operation at the current planning.

It is necessary to remember here that on the whole as is shown in section 1, the extractive industries often turn out to be subsidized. Then, the value of a grant in such calculations may be put as the overvaluation P, i.e. the State buys products from the extractive organization at an overvalued price by compensating the current costs C and part of capital investments (reduced costs), thus stimulating the continuation of these organizations work.

When implementing the third stage – the selection of the fleets type composition and of the number of ships of each type, the following requirements for solving the problem are taken into account:
1. Scope and range of the products output by the fleet will be fixed prescriptively (in "market" conditions it is defined by the demand).
2. Scope of the catch is to be fixed in advance by the fishing regions and by the fishing targets (demand is to be planned based on the international law acts, quotas, and fishery licensing).
3. Capital investments for the fleet development should be minimal.
Consequently, the task of the third stage is to be formulated as follows: the substantiation of the fleets composition and structure ensuring the catch of the prescribed number of products in the mentioned consolidated range at the put restraints with minimal costs. This is a task for the sectorial planning or for the forward planning, and in many works on the forward planning it is pointed out that a criterion in the forward planning is "not that the profit maximization must be prescribed, but the costs minimization".

Thus, at the third stage the reduced costs to be minimized, i.e.:

$$C + E_H \cdot K \rightarrow min. \tag{4.9}$$

As at each stage for solving the problems of selecting the composition of the fishing fleet the inherent criterion is used [13], it is necessary to check their non-contradiction (principle of hierarchical pattern) and the compliance with all of the requirements formulated above.
1st stage – the maximum ratio of commercial output cost to reduced costs will be obtained at products cost maximum values and at a reduced costs minimum level (formula 4.5).

2nd stage - a profit maximum will be obtained virtually at the same conditions - a cost increase and a current costs minimization (formula 4.8).
3d stage - a reduced costs minimumт (formula 4.9) is obtained at a reduced costs minimum level.

Thus, the cost minimization is a basic necessary condition to obtain the extreme values of the three criteria. Although this result may seem trivial, nevertheless, the criteria offered for use at each stage are not contradictory (meet the principle of hierarchical patterns), are obvious and calculable. Consequently, they may be used when solving the problem of the optimal planning of the fishing fleets type composition for a long term.

Conclusions:
1. Problem of the forward planning of the fishing fleets type composition must be solved stage by stage.
2. As criteria at each stage it is recommended to use the following:
Stage 1 (selection of ships optimal performance specifications) - ratio of commercial commodity cost to reduced costs.
Stage 2 (ships operation diagrams calculations) - profit.
Stage 3 (planning of ships distribution and composition) - reduced costs.
3. Costs minimization is the necessary condition to obtain the extreme values of the three criteria.

4.2 Fishing rent – economically based mechanism of rates collection for water biological resources

Profit (interest on capital), payroll taxes and natural resource rent (the income, which is formed over equal costs of private capital and of labor calculated per the unit of fished feedstock materials) are related to the societys primary incomes. The primary incomes are interconnected as tax entities. The Russian government considers the issue of the gradual transfer of taxation on rental payment in the environmental management as the most important objectives of the economy.

The necessity of payment for the use of the sea bioresources in the Russian economy, as well as in other coastal countries, became evident even in the 80s of the XX century [14]. The methods of paying levies by the Russian fishermen were different. First, these were the levies of a certain interest from a ship owners income for the uniform fishery support and development fund irrespective of the fishing region and the target species. But after the Federal Agency (Committee) for Fishery had lost administrative levers and after the fleets had obtained the full financial independence, this mechanism finished to work. Afterwards, payment for quotas for catching certain species of hydrobionts was implemented, part of quotas for the most deficient species selling at public sales. However, this measure did not justify itself either, insofar as it fell as an intolerable burden upon some domestic fishermen and served as the basis for speculations for others.

Over the last two centuries, the economic theory has been confirming that the basic tax burden must fall on the natural resource rent in the extraction industries. The problem of rent taxation is actual for fishery, insofar as it is known that approximately three-quarter of expenses and of incomes in the fishery (out at sea or in inland water basins) are due to the conditions of fishing zones natural productivity predetermined by nature, the qualitative composition of the fish harvest, the location of fishing regions in relation to the sales markets 15]. Thus, in the fishery industry the rental income is due to the natural and the geographic factors, it is situated out of the zone of end products price formation and it is not a part of the price directly as a profit rate and production costs, although the market price for raw fish does include a natural resource rent value. Just rental payments directly make for studies and support of water bioresources replication, whereas labor and capital taxes are used by the federal and the regional authorities for the national goals.

Shipowners and fishing organizations in fisheries believe that the rental payments increase taxes. In reality, they decrease tax burdens on labor and capital and facilitate more fair distribution of bioresources between the users [16].
We will graphically show, as per [15], the spot of a differential fishing rent for productivity in the structure of the total fishing product (Fig. 4.1) in market prices.

On the Fig. 4.1 the following legend and notions are used.
OABT – total fishing product in market prices (volume of the catch multiplied by the ware price);
OCBT – total production price which consists of the costs for the fishery (material expenditures and salary in extreme worst conditions, wherein a rent is not formed) and the profit rate average in the industry;

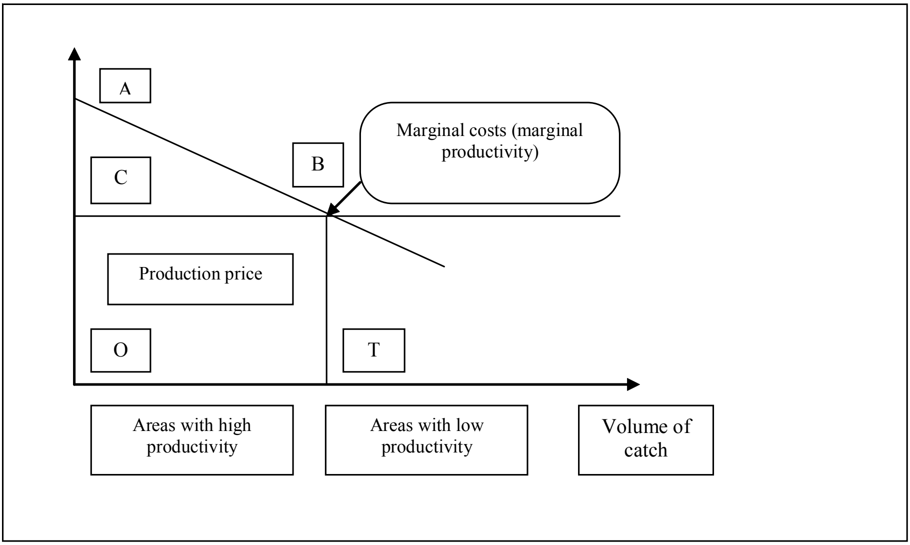

Figure 4.1. Differential Fishing Rent in the Structure of Total Fishing Product

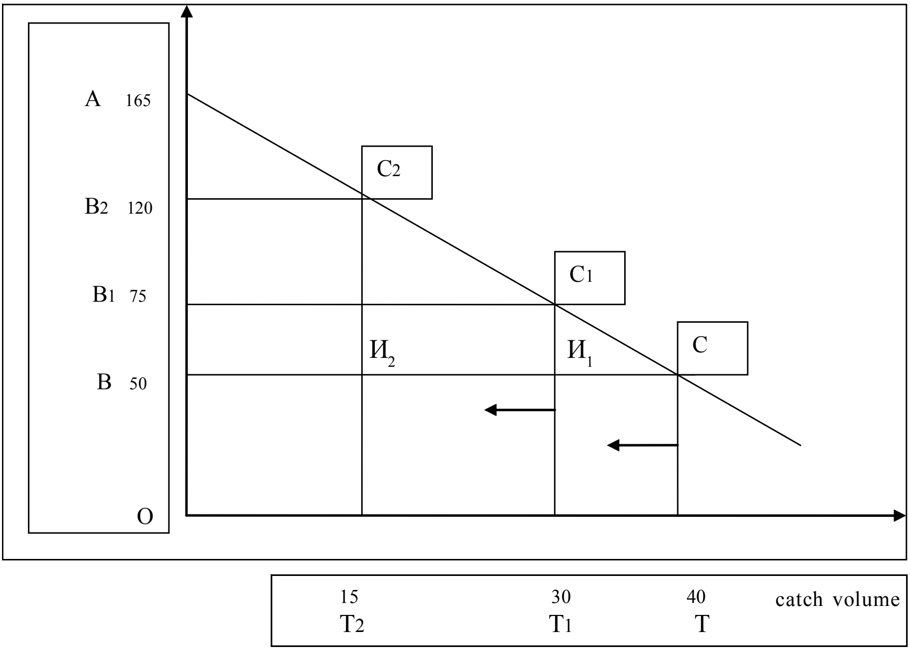

Figure 4.2 Influence of the Taxation Form on the States Fishery Incomes

ACB – a rent, which is located out of the field of production price formation, but it is part of the total fishing product in market prices.
Lets review the influence of the taxation form for the States fishery [15] incomes (labor and capital taxes plus a differential rent for productivity) in the different areas of a certain basin (Fig. 4.2).

Design values in the conventional units of the volumes of raw fish catch and prices at the change of the taxation structure are stated in Table 4.1. Production cost level (BC line) in three considered options remains the same, and the absolute cost value depends on a volume of catch.
1st option – the rental income is completely deducted, incomes from labor and capitals are not taxable;
2nd option – the States fiscal needs are executed at the expenses of wage and profit tax. It results in the fact that it becomes economically unviable to catch cheap fish in the regions of low productivity and the extreme fishing conditions displace to point C1. Concurrently with the wage tax increase labor payment reduces in the fishery, the number of fishermen decrease, fishing volumes go down, and the States absolute total income reduces. The situation worsens in ad-

Table 4.1

Design Values in Conventional Units of Volumes of Raw Fish Catch and Price at the Change of Taxation Structure

	1st option	*2nd option*	*3rd option*
Extreme conditions of bioresources fishing (whereby fishing becomes unprofitable)	point C on fig.4.2	point C_1 on fig.4.2	point C_2 on fig.4.2
Total fishing product in market prices (c.u.)	OACT area -4300	OAC_1T_1 area -3600	AC_2T_2 area -2138
Production costs (c.u.)	OBCT area -2000	$OBИ_1T_1$ area -1500	$OBИ_2T_2$ area -750
Labor and capital taxes (profit tax and charge on payroll) (c.u.)	-	$BB_1C_1И_1$ area -750	$BB_2C_2И_2$ area - 1050
Rental income (c.u.)	ABC area -2300	AB_1C_1 area -1350	AB_2C_2 area -338
States total income (labor and capital taxes + rental income)	2300	2100	1388

dition due to the existing practice of income concealment from the State, and due to tax increase the major part of the salary is paid using an illegal scheme, etc. 3rd option – despite the deterioration of the economic environment in the fishery, in the 2nd option the States fiscal needs remain the same. The government intensifies the taxation burden forcing fishermen to go away to the zones of even greater productivity (extreme fishing conditions displace to point C2).
Thus, it is shown in [15] that the increase of labor and capital tax rates (2nd and 3rd options) results in:
- the constriction of fishing zones, the increase of fishing loads on productive zones, and over exploitation and exhaustion of water bioresources,
- the loss by the State of a part of total tax amounts at the expense of the catch volume reduction, the increase of jobless fishermen; the growth of the fleets and equipment moral and physical depreciation;
- the increase of foreign currency targets catch volumes and the partial replacement of fair capital by criminal one in this connection;
- the decrease of sources of funding for raw material scientific surveys, the decrease of funds for the protection and reproduction of water bioresources.

The advantages of the 1 option are as follows:
- investment attractiveness of low productivity zones increases (including even T point to the right). In this zone the fishing rent is not deductible and after spending funds for the upgrading and the purchase of new fishing equipment (thus decreasing the existing level of production costs that is not taxable), ship owners will receive an income from capital invested to the fishery. Until that time, T point was a point of the worst conditions, wherein a fishing income was theoretically equal to zero (the so-called "transfer" earnings, after achieving the level of which, an entrepreneur takes away capital to another field of application);
- fishermens employment increases when expanding fishery regions.
Apart from the differential fishing rent for productivity, there is a fishing rent for a location.

Unequal economic conditions have been established in different regions of Russia concerning the access to seafoods [15, 16]. According to the statistic data about 75 per cent of the total seafoods catch is provided by the Far Easts seas, and potential domestic buyers are distant from the fishery regions by 7-10 thousand km. The necessity to transfer fish products for such distances results in the increase of retail prices by 2-3 times in the Central Part of Russia.

Due to the fact that the State keeps distant from such problems, raw fish is directed along the shortest and cheapest way to Japan, China, South Korea at the Far East and to Norway in the basin of the Barents Sea. In addition, these countries have created optimal conditions for Russian fishermen to accept products and to service ships.

Based on the theory of the space use and the manufacture arrangement, the State must undertake the function to solve the problem of seafood supplies within the country. The fishing rent value based on fishing region must be defined only within the boundaries of "a fishing zone (a fishing region) – a port of raw fish delivery".

Unlike the productivity rent, the region based fishing rent is simple to calculate. The rent value, at first approximation, is inversely related to a distance from a fishing region to a port of raw-fish delivery. To operate in the extremely distant regions of the World Ocean the State must put up with the "negative" values of the region based fishing rent and to implement differential reduced rates for fuel. Otherwise, the resources of the coastal and of the Exclusive Zone of Russia will be exhausted up to their complete annihilation. The accurate and obligatory collection of the fishing rent in other regions, as mentioned above, must ensure economic benefits for shipowners and the State, and the received funds must be forwarded for the studies of resources in the seas and in the oceans, for the development of the fishing industry, for upgrading the fishing and the scientific research fleet.

4.3. Special inventory of the water biological resources in Russia

The inventory of commercial fish and other water animals and plants of Russia represents a systematized code of documented data on the state, the spatial distribution, the fishing and the life environment of commercial species reserves in the waters under the jurisdiction of Russia [17].

The inventory was elaborated for the decision making informational support on the reasonable exploitation of the fishery resources at the federal level of management.

The inventorys structure and functions are defined by the peculiarities of the historically formed system of Russian fish resources monitoring [17]. The inventory contains the short biological descriptions and the color images of the 456 targets of the commercial and the sport fishery, the geomorphologic and the hydrologic characteristics of over 300 lakes, rivers and other water basins, as well as archived information annually replenished on biology, fishery and environmental conditions for more than 330 operated units of the stock. Biological and fishing data are classified by the species of commercial hydrobionts, by stock units, by water ponds and by statistical fishing, by the kinds of the fishery, and by fishing gear types and calendar years.

The Inventorys software package is executed as a geographic information system (GIS), which ensures the storage, handling and the analysis of cadastral information with regard to its geographical reference. Attribute-based information may be visualized by way of superimposition on digital maps and be represented as simpler screen forms (a text, Tables, diagrams).

Implementation of a state record-keeping, of a state monitoring and a state inventory of Russian water biological resources is a necessary condition of the sustainable domestic fish supply, which is determined not only by environment-oriented considerations, but also by the objectives of the country s food safety, which are not less important. Formed even in the 50s, the special commercial bioresources record-keeping and monitoring system allowing elaborating and making scientific-based, balanced decisions for managing the domestic raw fish stocks, successfully stood the test of time and proved its consistence despite the substantial changes taken place both in fishing organization and in the condition of the stocks themselves.

Necessity of a unified informational resource creation for more efficient management of the raw fish supply of the domestic fishery became evident in the middle 70s of the previous century [17]. Atlant-NIRO, VNIIPRH and VNIRO started solving that problem independently of each other. Within the first years, such works were conducted mainly due to the efforts of individual experts. However, by the middle 80s, the problem of the record-keeping and of the centralized information supply of decisions on protection and exploitation of living bioresources became national. On the basis of the law of the USSR “On the Protection and the Use of the Animal World” and of Decree of the Council of Ministers of the USSR dated April 28th, 1984, No. 373 “On the Procedure for Conducting Animals Registry and Their Use and the State Animal World Inventory”, the Ministry of Fisheries of the USSR made an order (No.334 dated June 27th, 1984) according to which the coordination of works for creating and conducting an inventory of commercial fish, water invertebrates and sea mammals (as the section of the State Inventory of the animal world of the

USSR) was imposed on VNIRO involving all of the fisheries institutes of union and republican subordination. By the beginning of the 90s within the frames of the cadastral subject, the experts of VNIRO, Atlant-NIRO, and VNIIPRH established two databases: the DB “Condition of Fish Resources” (statistical data on the catches in the inland water reservoirs and in the peripheral seas of the USSR) and the DB “Reproduction of Fish Stocks” (information on the work results of the fish farms). The ideology of the bio-economic fisheries inventory was developed; works on developing specialized application software programs for the quantitative analysis of cadastral information started. After the USSR had collapsed and due to the reorganization of the fisheries management that followed it, works on inventory establishment were suspended. But already in 1994, upon an initiative of Glavrybvodas administration they were resumed on the basis of a brand new concept, wherein not only the objectives and the peculiarities of the fish resources cadastral registry found their reflection, but also the modern achievements in the field of the information technology. The experience of VNIROs experts contributed to it to a large extent obtained by them when implementing the UN Environment Program (UNEP) “GIS the Black Sea and the federal programs: “All-inclusive Territorial Inventories of the Russian Natural Resources” (ATIRNR) and the “Unified State System of Environmental Monitoring of Russia (USSEMR).

After the publication of the Decree of the Russian government dated November 10th, 1996 No.1342 “About the Procedure for Conducting the State Registry, the State Inventory, and the State Monitoring of the Animal World”, works on the cadastral subject acquired new momentum, and by the end of 1999, the basic version of the sectorial inventory was completed and its test operation started. The decree of Russian Goskomrybolovstvo as of 25th, 1999 “About the Sectorial Inventory of Commercial Fish and of Other Water Animals and Plants of Russia” reasonably finalized that stage of sectorial inventory establishment. The decree assigned VNIRO as the parent organization of the industry responsible for elaborating and keeping an Inventory, as well as it approved the “Regulation on the Inventory”, the structure of the database, statistical forms and instructions for their filling up and established a procedure of cadastral information transfer.

In December 2000, the Inventorys DB was introduced into the State register of databases. The Inventorys “information sponsors” are the 14 fisheries institutes of different departmental subordination involving in elaboration of the

TAC consolidated forecast. As of the beginning of 2005, the Inventory accumulated information on 22 % of sea and 58 % of fresh water fishing targets in the waters of Russia.

According to the effective «Regulation on the Inventory", the latter is defined as a systematized consolidated code of information on the condition, the spatial distribution, the fishing and the life environment of commercial species stocks in the inland water basins and in the peripheral seas within the territorial waters, the continental shelf and the exclusive economic zone of the Russian Federation. The identification of water bioresources in the Inventory is carried out by the population characteristic. The so-called stock unit, which generally coincides with the notion "population", however, in individual cases may be interpreted as the spatially isolated part of the population keeping its basic features and having an independent commercial importance, was selected as a unit of the cadastral registration.

The internal structure and the general organization of the Inventory are defined by the peculiarities of the stocks as cadastral accounting items and by the specific nature of the fisheries in general:
· By the close dependency of the stocks condition from the environment and fishery;
· By the variability of the stocks in time (abundance dynamics) and in space (migrations, change in the area);
· By the inaccessibility of fish resources for direct observations and by the impossibility to track the stocks condition on a real-time basis;
· By the historically formed system of the domestic fishery raw fish supply management (watershed management) and by its most important structural part – by the monitoring of the fish resources condition and environment (the complex of expeditionary, field, and laboratory studies annually performed with a view to substantiate the forecasts of the total allowable catch (TAC)).

Due to the great variety of fishing targets inhabiting Russian waters, these targets were divided into 12 groups for the cadastral list – in accordance with the peculiarities of their ways of live and fishing: fish (except for salmons); salmons; sea mammals; crabs; shrimps; calamaries; octopuses; gastropods; bivalve mollusks; sea urchins; sea cucumbers; algae. The standard forms are worked out for each of these groups for collecting cadastral information, which include biological and commercial statistics, designed characteristics of the stocks and general information on the environment condition (Fig. 4.3)

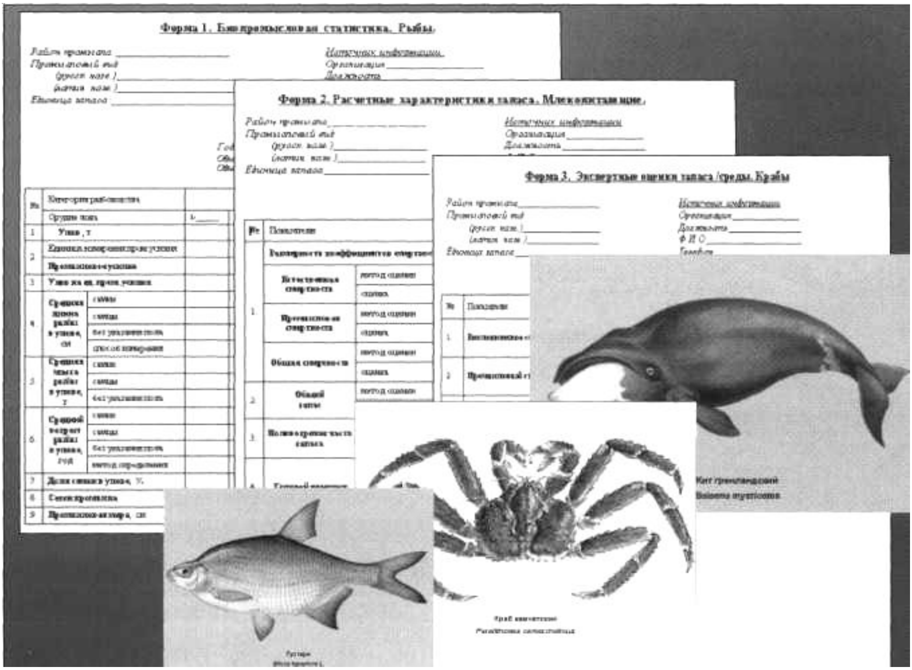

Figure 4.3. Statistical Forms Samples for Collecting Cadastral Information

The conditions for the cadastral data for each of the listed groups included two requirements: the list contained only the most important characteristics of the stock, fishing and environment, whose assessments are introduced into the annual biological substantiations of TAC forecasts; the selected indices altogether must contain information needed as a minimum for the users of the Inventory to have a sufficiently complete vision of the commercial stocks condition. It substantially simplifies the collection of cadastral information, insofar as the requirements to its composition do not exceed the requirements stated in the order of Goskomrybolovstvo of Russia dated September 19th, 2001 No.296 “About the Approval of the Procedure to Elaborate, Document and Submit the Material Justifying the Total Allowable Catches (TAC) of Water Biological Resources...”. Therefore, for each stock the completeness of statistic cadastral forms filling-up may serve as the indirect index of the TAC forecast feasibility: absence of spaces speaks for the fulfilment of the scope of studies minimally necessary to substantiate the TAC; numerous spaces in forms speak for the fact that the TAC substantiation is not demonstrative.

The functional capabilities of the Inventory are carried out with the help of the GIS packages GeoGraph, Microsoft Access and of specialized application software programs. The software consists of the 4 basic components: a relational database (DB), a cartographic DB, an atlas of the electronic images of commercial hydrobionts and an integrated database management system of (DDMS).

Table 4.2

Number of the Targets Included in the Sectorial Inventory

Stock units	*Number*	*Total, pc.*	*Covered by cadastral registration*	
			pc.	*%*
Sea waters	Fishes	464	121	26,1
	Invertebrates	207	35	16,9
	Sea mammals	39	3	7,75
	Algae	21	5	23,8
Fresh waters	Fish	246	166	67,5
	Invertebrates	41*	0	0
	Fresh-water mammals	1	0	0
	Algae	-	-	-

The relational DB contains codificators, reference books and archival files. Information included in the reference books (short descriptions of commercial species biology, certificates of fisheries waters) is revised quite rarely. Data annually updated are introduced in the archival files. The address section of files has a hierarchical structure, which includes the following coded fields: a calendar year, a fishing region, a fishing species, a stock unit, a fishing category and a fishing gear.

Such a codification of archival data substantially extends the capabilities of work with cadastral information. Codificators serve for the convenience to input information to the DB, to ensure the DB integrity, as well as to ensure compatibility with the other sectorial information systems, insofar as the majority of the Inventorys codificators were worked out based on the classification accepted in the industry of fishing targets, fishing gears, fisheries waters, statistical fishing regions, etc. In total, the Inventorys DB consists of 30 codifiers, 16 reference books and 36 archival files.

The cartographic DB includes the electronic map of Russia, scale M 1:1000000 (the Inventorys cartographic basis), and 11 auxiliary information layers (electronic maps of the administrative-territorial division of Russia, of statistical fishing regions, fisheries waters, fisheries ponds, climatic zones, a bathymetrical chart of peripheral seas, etc.), allowing carrying out some kinds of the spatial analysis of fishing.

The Inventory also contains an atlas of color electronic images of commercial hydrobionts living in the Russian waters. The images of 335 fish species, 55 mammal species, 65 invertebrate species and one species of algae are included in the atlas.

The DBMS ensures the operation of the entire software package including work with the relational and the cartographic databases under the common user interface.

In 2001, in pursuance of order of Goskomrybolovstvo of Russia dated October 25th, 1999, No.301, in parallel with the implementation of the Inventory works on the creation of its regional subsystems got started on the basis of the basin authority of fish stock protection and reproduction, and of the fishery regulation. With the participation of VNIROs experts, they developed and B-tested subsystems for Nizhneobrybvoda, Okhotskryba, Sev-zapryba, and prepared a technical task for the subsystem Murmanrybvoda. Regional subsystems support all the information and the software standards of the basic Inventory, but they have a switch-hook operation, which meet the additional requirements of local users.

The statements about the progress and the condition of works on the creation of a fishery Inventory were discussed again and again at VNIROs Academic Board, and were heard at international conferences. The concept and the practical implementation of the Inventory were rewarded by the diplomas of the three international exhibitions (2000, 2002 and 2004), and its creators were honored with the Golden Diploma of the International Forum for the problems of science, technology and education (2001).

The Inventory s upgrading planned in accordance with the “Regulation on the Federal Agency for Fishery” (cl. 5.4.3) will require the cardinal reconstruction of virtually all its structural and functional modules. The tasks fulfilled to transform the sectorial inventory into a State inventory took 5-7 years and included the following:

· establishment of a legal and regulatory frame for keeping the State Inventory of water bioresources (including the legislative recognition of the cadastral information access procedure);
· the Inventorys basic information and software standards to be brought into compliance with the standards of the existing State natural resources inventories;
· establishment of the complete archives of legally authentic cadastral data for all basic species of water bioresources within the last 10-15 years;
· elaboration of the software tools of topographic control over spatial cadastral information;
· establishment of the single network of the Inventorys regional subsystems.

One final comment is that all the efforts directed for implementation of the planned Inventorys update will be justified only in case if the Inventory becomes integral part of the nation-wide system of Russian water bioresources protection and sustainable use.

4.4. Value appraisal of the water biological resources

With the beginning of economic reforms in Russia and implementation of market mechanisms, the questions of the natural resources value appraisal, in particular, of the water bioresources one, switched from the field of theoretical studies to the field of implementation [18].

The natural resources value appraisal, i.e. the money term of their (natural resources) utility value, is part of the fundamental problem of the natural resource rent accounting and it suggests different methodological approaches depending on the nature of issues to solve.

The most critical and contradictory aspect of the value appraisal is the implementation of water bioresources availability for a price, which is provided for in the five federal laws, the laws “About the Continental Shelf of the Russian Federation” (1995) and “About the Environmental Protection” (2002) defining the purposive character of payments – the financial support of studies, of reproduction and of environmental and resources protection.

Within the frames of such ideology, VNIERH RC of Economy and Fisheries has elaborated a compensation mechanism of payment rate formation opening to the specific rates values. Such a mechanism must be implemented after the enactment of the special law "On the Fishery and the Water Bioresources Conservation".

Before the new law "On Fishery" a legal vacuum was filled with decree of the government of the Russian Federation dated December 27th, 2000, No.1010, in accordance with which public sales of water bioresources were put into practice.

Public sales put into practice considerably changed the ideology of the pay resources use, insofar as the very mechanism of public sales was adjusted first of all for the provision of funds inflow to the federal budget, the industry strategic development objectives accounting fading into insignificance. The industry was transformed into a sponsor of the budget. The amount of funds allocated by the budget for Goskomrybolovstvo of Russia made up RUR4.9 billion in 2003, whereas payments for resources – RUR12.8 billion, social expenditures – RUR3.7 billion. Thus, the amount of resource payments exceeded almost by 4 times the amount of funds allocated by the budget.

The complicated condition of the fisheries is determined by this fact to a large extent compared to the production sector on the whole and to the foods industry in particular. Over 50% of fisheries enterprises are unprofitable; the profit of enterprises is reducing. The profitability of the basic production decreased from 4.2% in 2001 to 2% in 2003.

After the II part of the Tax Code of the Russian Federation had been implemented, public sales for bulk fishing targets were cancelled and fixed payment rates for the bioresources use were introduced, the rates being fixed on a specific level although lower than auction prices, but considerably higher than the rates which should have been fixed based on the compensation approach to their formation. The interspecific ratio of rates in some cases was not justified and structured. As a result, the volume of some targets fishing sharply reduced and the budged suffered direct losses.

It is evident that for the fisheries work efficiency and competitiveness increase more finely adjusted mechanism of bioresources payment collection is needed with regard to their rent nature and to the industry sector strategy development.

The most important aspect of the water bioresources value appraisal is their appraisal as a part of the national wealth. The active integration of Russia into the worldwide economic system made it immediate problem to settle.
An intersectional task force for the problems of the national wealth elements appraisal under the scientific supervision of academician Lvov D.S. was founded for working out common methodological approaches and for coordinating works under the Scientific-Methodical Board of the State Statistics Committee of the Russian Federation; Federal State Unitary Enterprise (FSUE) VNIERH was represented by Mr. Borisov V.A.

The task force was assigned a mission to elaborate methodological grounds in compliance with the methodological grounds generally accepted worldwide, to take into consideration the specific nature of the water bioresources appraisal, and the difficulties to obtain necessary actual information.
In the most complete and accorded aspect, the questions of the national wealth appraisal were in the picture of the System of National Accounts (SNA), which, in substance, is the international standard of statistical data collection and book-keeping.

In accordance with the SNA philosophy the national wealth of the country is defined as the cost of economic assets in market prices being the property of the residents of this country as of any given date, by deducting their financial obligations (liabilities).

In the structure of economic assets provided for in the SNA, water biological resources are related to non-business assets which include the economic assets of natural origin, non-renewable and renewable by a natural way, i.e. being beyond direct control, responsibility and management from the side of institutional units.

In relation to the fisheries the water bioresources of the inland seas and of the Exclusive Economic Zone of Russia may be attributed to economic assets, with that, just that part by which the TAC is to be defined.

The estimation of assets and liabilities is carried out in current prices as of the date of a balance preparation. The prices directly formed on markets or calculated on the basis of market prices are the base for the value appraisal of assets and liabilities. With that, the prices directly formed on markets or calcu-

lated on the basis of market prices may be used.
The economic appraisal of water bioresources may be manifested itself as the resultant of the aggregated modules of indices:

$$Q = D - S, \quad (4.10)$$

where Q – an economic appraisal of water bioresources; D – a monetary appraisal of possible use of fish products from obtained resources; S – expenses for fishing the bioresources.

The key point of the specific computation algorithm of water bioresources cost was an approach to the calculation of individual specific value indicators for 1 t of the catch of certain species of water bioresources (SBR).

The SBR value indicator system included some basic modules of calculations: industry average prices for products out of 1 t of bioresources; expenses for the catch of bioresources by types of ships and basins; industry average expenses (calculations) by the species of bioresources.

The calculation of industry average prices for products out of 1 t of bioresources is carried out based on the structure, the technology-based output standards, and the specific weight of deliveries to domestic and foreign markets, actual wholesales prices for end products.

The basic standard costs for the catch of bioresources by the type of ships, of fishing gears and main basins were formed on the basis of "Rubolovstvo" informational system. With that, in the total expenses by the types of ships, the annual conditional-permanent expenses were detached by each type of ship and by basic elements taking into account the industry practices of the fleet operation and not depending on the volume of catch, and specific conditional-permanent expenses on a per 1 ton of water bioresources catch basis by each type of ships.

The calculation of industry average expenses per 1 t of catch by the species of water bioresources consists in the calculation the self-cost of a catch by the species of water bioresources. By each species of water bioresources those items are differentiated, which directly depend on the price of each species of bioresources (payment for labor and, accordingly, a unified social tax, payment

Table 4.3

Water Bioresources Estimation by Basins

Basin	TAC 2004, K ton	Monetary value of bioresources possible use, RUR mln.	Standard expenses for catch, RUR mln.	Economic estimation, RUR mln.
Far Eastern basin	3035,65	75326,91	59863,43	15463,47
Northern basin	135,89	2943,90	2145,3	798,6
Baltic Sea	6,35	127,4	106,17	212,3
Azov and Black Sea basin	65,19	972,07	810,06	162,01
Caspian Sea	123,31	2257,24	1753,37	503,86
Total	3366,40	81627,51	64678,33	16949,18

for resources according to part II of the Tax Code). The remaining items are accepted on the level of regulations for the anonymised ton of a catch.
The test economic estimation of water bioresources by the TAC 2004, based on the suggested technique, amounted for RUR16,949.2 mln.

The results of the economic estimation of water bioresources by basins are shown in the Table. The obtained result may be accepted as the value appraisal of water bioresources as material non-business assets for 2004. These calculations were accounted in the design of a law "On Fisheries and water biological resources conservation", 2004.

4.5. Economic efficiency evaluation of the commercial forecasting

Commercial forecasting is one of the control elements in the fishing industrial sector. It is used at the different levels and the degrees of the sector beginning from the work of the central state authority (Federal Agency in Russia) for the fishery and finishing by fishing enterprises and ships. To solve some problems it is important to know how advantageous to use a scientific fishing forecast, how its quality influences over the operation of an enterprise.

Different approaches are possible in forecast estimation. It is possible to estimate a forecast after defining its success rate, reliability, useful information, which it has, its economic efficiency. In particular, the TAC forecast is considered as justified if the difference from the actual catch is less than 25%.

Economic efficiency is one of the important criteria of forecast estimation. After defining it is possible, in particular, to evaluate quantitatively the activities of a collective body preparing a forecast.

An additional costs saving in the field of the fishing fleets operations obtained at the expense of the use of a scientific forecast at the elaboration and the implementation of fish harvest plans and fish products output is understood by the economic efficiency of a scientific fishing forecast which differs from a persistence forecast [19].

The scientific forecasts of the general catch, catches per unit of effort by ships types and by fishing regions are prepared on the basis of a biological and hydrological information analysis, of a historic catches analysis made by scientific organizations servicing the fisheries. In Russia, these are basin scientific centres (NIRO). They elaborate some types of forecasts: progressive ones (long-term and super long-term), annual and quarterly ones.
Each form of forecast has its certain fields of application. The annual forecast is most widely and fully used by fishing enterprises. The annual fishing forecast is necessary information when planning firstly the annual volume of harvesting fish, and secondly, the fleets distribution by fishing regions.

The efficient operation of the fishing fleet is dependent to a great extent on the distribution of ships in the fishing regions according to scientific recommendations. Sometimes, due to the underestimation of the scientific forecast (or to the insufficient accuracy of forecasts at previous years), the data on the catches of the previous year, which will be called a persistence forecast, are used as initial information.

When planning the distribution of the fleet, it is also necessary to take into account such factors as the availability of an intaking cargo fleet (ICF), sales opportunities, a product mix catch schedule, the expansion of economic zones by coastal countries, etc (Fig. 4.4). These factors, from the one hand, limit the use of a forecast (for example, a scad catch forecast is well held true, but this fish is not in demand, and the schedule of its catch is strongly constrained, and from the other hand, it underlines the necessity of the fishing forecasts use.

Whatsoever forecast we use – scientific or persistent – losses will always take place (Fig. 4.5). It is important to define in which case losses will be less.
At AtlantNIROs laboratory of economic researches [19] a model of

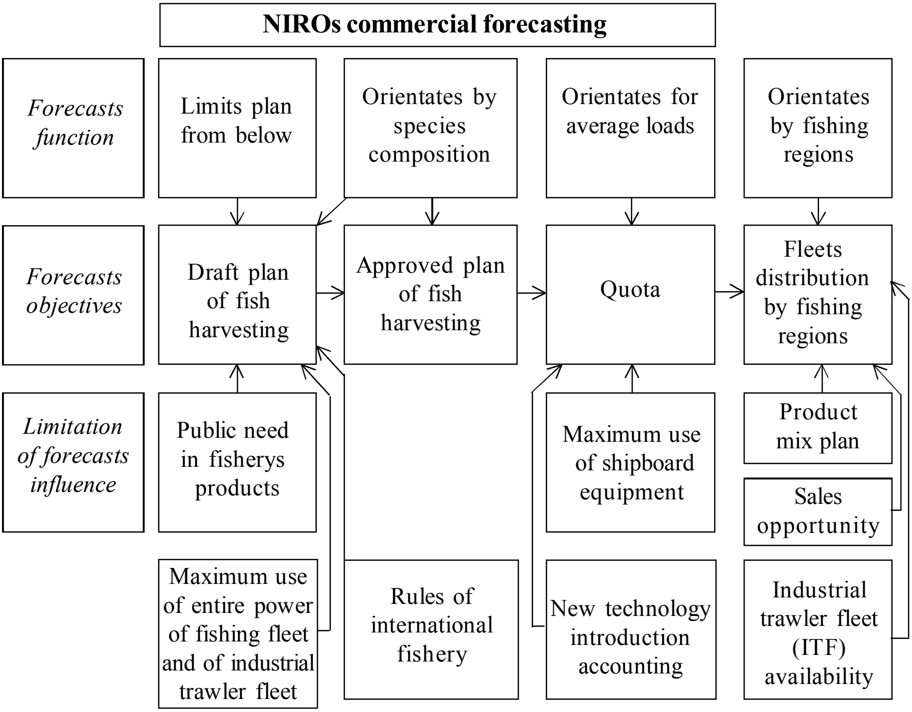

Figure 4.4. Functions and Objectives of the Fishing Fleet. Factors Limiting the Forecasts Influence

multiobjective planning was created for arranging the fleet in regions for the large association (formerly the Zapryba Authority), wherein the criteria of optimality is the obtainment of a profit maximum from the sales of end products or a gross margin normalized to a mass unit of an end product. A formula of profit calculation is offered at the different forms of fishing organization, wherein the profit *(П)* is a function from a catch *(U)*:

$$П = f(U). \tag{4.12}$$

To define efficiency, let us compare the profit values obtained at the two options of the fleets arrangement using a scientific and a persistent forecast. So that these options could be compared to each other, we will take the same catches per unit of effort by the types of ships and by the fishing regions (just for the year whose forecast is being evaluated).

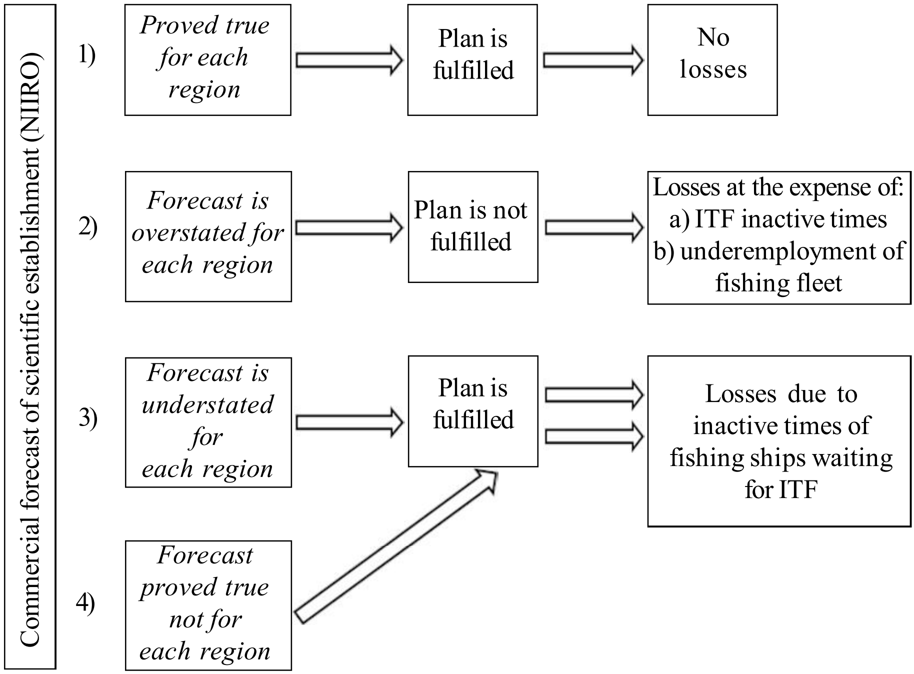

Figure 4.5. Results of Fishing Fleets Activities Depending on the Accuracy of the Forecast

Suppose X – a problem solution matrix, where X_{ij} – number of fishing ships of the i type, which must be located in the j region.

Actual catches per unit of effort in the fishing regions on conversion to one average tonnage vessel – C_{ij} (i=1,…m; j=1,…n).

Then the total catch, in case if the fleet is arranged in accordance with the scientific forecast at actual catches per unit of effort, will be equal to *Uн*, and the profit from the sales of end products will be equal to $П_н$.

The total catch, in case when the fleet is arranged in accordance with the persistent forecast at actual catches per unit of effort, will be equal to *Uин*, and the profit -to $П_{ин}$.

If $П_н > П_{ин}$, so the quality of the scientific forecast is higher than that of the persistent one, and the efficiency (Э) of the scientific forecast will be positive in this case: $Э = П_н - П_{ин.} > 0$.

Thus, the effect of the fishing forecasting for all the regions, wherein the fishing fleet operates, is defined. After defining separately the efficiency of the forecast for each fishing region, it is possible to clarify at the expense of which forecasts for regions the positive (or negative) effect is obtained.

4.6. Economic efficiency evaluation of the short-term commercial forecasting methods

NIR Standard Economic Efficiency Accounting Form [20]:

$$Э = C_б - C_о, \tag{4.13}$$

where $Э$ – economic efficiency
$C_б$ – expenses for reference (comparative base)
$C_о$ – reference expenses

There is not yet a standard practice of the appraisal of fishing region exploitation economic efficiency. 4 directions of its evaluation are emphasized [20]:

- by development costs,
- by effect from exploitation,
- by expenses and effect,
- by environment quality.

The most acceptable for the estimation of assurance practices including those of fishing forecasting, is a fishing region exploitation efficiency approach [20] for sufficiently long-term period (some years). In this case:

$$Э = \overline{C}_б - \overline{C}_0, \tag{4.14}$$

where $\overline{C}_б$ – average perennial expenses for fabricating fish products;
$\overline{C}_0$ – actual expenses for fabricating fish products in an estimated year, where $C = z*Q$

$$Э = (Z_p - Z_ф)Q_n^ф - Z_n, \tag{4.15}$$

where Z_p – design expenses per production unit fabrication;
$Z_ф$ – actual expenses per production unit fabrication;

$Q^{\phi}{}_{n}$ - actual catch for the period under review n;
Z_n - expenses for elaboration and implementation of forecast method.

For a short-term fishing forecasting, when the developed method is used many times (every day, every week, etc.) within a long period N and its use is supposed in the next fishing forecast, then it is possible to neglect expenses for its implementation:

$$Э = (Z_p - Z_{\phi})Q_n^{\phi} . \quad (4.16)$$

In such a way it is possible to evaluate the economic efficiency of the method application (implementation) right after the completion of the selected fishing period "n" using calculations according to the accounting forms.

When calculating the expenses for production unit fabrication it should be assumed that the expenses connected with the maintenance and the operation of the basic production assets must be equal for a reference (average) year (period) and for a year of the implementation of a new practice of fishing forecasting; the expenses only change, which are connected with the maintenance and the operation of the fleet within a period under review (a season, a year). The sequent fishing situation is the predictand of a short-term fishing forecast. The fishing situation is a population characteristic of environmental conditions defining the potential operation efficiency of the fishing fleet within a certain period (a decade, a month, a season). Thus, predicting a fishing situation, we forecast the potential opportunities of fishing in a region.

Forecasting information acquires real importance only when it is used for making administrative decisions which have direct impact on the fishing efficiency, for example, the transfer of a ship into another sub-region or the change of position to more efficient one; substitution of fishing gears at the vertical migrations of concentrations; selection of fishing gears in a certain day-time; termination of the output of one kind of products and the output of another one; call at a port to suspend operation and fuel refilling in a period of the probable worsening of a fishing situation.

V.N.Yakovlev, stating an oceanic fishery hydrometeorological support economic efficiency evaluation scheme, includes in it the module "decision selection" [20]. The formula (4.16) takes a shape as follows:

$$Э = k_n Q_n^{ф}(Z_p - Z_ф), \qquad (4.17)$$

where k_n – a coefficient taking into account the degree of fishing and hydrometeorological information use by the harvesting fleet.

To estimate the "decision selection", the captains of fishing vessels were offered to express their attitude towards obtainable forecasting information by a five-grade scale: from 1) – you always follow the recommendations of the fishery supervisor – 5 grad.; 2) – you use 80% of forecasting information based on your experience – 4 grad.; etc. up to 5) – you do not use the forecast – 1 grade. After calculating the average grade, it has been equal to 3.6, and calculating that 5 grades is $k_n = 1$, and 1 grade is $k_n = 0{,}2$ (the option of 0 grades is $k_n = 0$ is not discussed), we will receive about $k_n = 0{,}7$. That means that 70% of additional profit obtained by the fleet in this period from the decrease of the fish products self-cost may be rightfully assigned at the expense of the use of fishing forecasting new practice, and economic efficiency may be evaluated using the following formula:

$$Э = 0.7 Q_n^{ф}(Z_p - Z_ф), \qquad (4.18)$$

where Z_p – design expenses for the manufacture of a production unit in 1985.
$Z_ф$ – actual expenses for the manufacture of a production unit in 1986.
$Q^{ф}{}_n$ – an actual catch within March to June, 1986.

Conclusions:

1. The role of a short-term commercial forecasting is increasing, and the practice of a forecast economic efficiency appraisal is necessary.
2. The most real appraisal is that by an effect from the fishing region operations during the season.
3. Forecasting information attains real importance (i.e. brings economic effect) only then, when it is used while making administrative decisions having an impact on fishing efficiency.
4. One of the ways to take the “decision selection” into account is an introduction of utilization factor reckoning the degree of fishermens utilization of the forecasting method being evaluated.

This factor may be obtained by way of interviewing (testing) the captains of serviceable fishing vessels at the end of a period of service.

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CONTENTS

Aleksander Averkiev, Pavel Chernyshkov

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