V. Mikhailov, R. Lisowsky, T. Gavrilova

Modern condition of pollution of the Black Sea ecosystem, some paths of reduction of its loads

The ecological condition of the Black Sea ecosystem can be estimated as critical. There are linked to many reasons, one of which is that the sea is influenced by the economic activities of 162 million, human beings from 16 countries. The vulnerability of the Black Sea is linked to insulation from World ocean and significance of various sources of pollution, in particular by inorganic nutrient substances, household sewage waters and agricultural discharges. Also a huge quantity of marine pollutants are linked to trade, military fleet and the marine extraction of petroleum. The Black Sea discharge basin is five times more than the sea itself and covers huge territories of coastal countries (Bulgaria, Romania, Russia, Turkey, Ukraine and other countries).

Thus now it is possible to outline in the priority order the main sources that influence on the ecosystem of the Black Sea.

The main pollutant of the Black Sea, still, is river run off, which annually for one year equals 296 km^3. The greatest run off is from the Danube river - 132 km^3/years, Dnieper - 54 km^3/years, Dnistr - 10 km^3/years and other rivers. With river waters annually 4-5 km^3 of sewage waters come to the Black Sea i.e. 4 % the total run off. They contain about 400 thousand tons of biogenic substances, 2 million tons of organic matter, 210 thousand tons of oil products, 20 thousand tons of detergents, 700 tons of fugitive phenols, 8 tons of hexachlorocyclohexane. The concentrations of nitrogen and phosphorus only in the Danube waters have increased for the last 10 years accordingly in 6 and 3 times, and in waters of Dnieper - in 2 and 6 times.

The irregular run off and irregular pollution of river waters shows, that from the territory of Ukraine to the Danube comes 0,8 km^3 of sewage waters, into Southern Bug - 1,8 km^3 . 80 % of the run off of Southern Bug to the Black Sea make sewage waters. Within the limits of Ukraine Dnieper receives 10,6 km^3 of sewage waters. The discharge of sewage waters into Dnistr makes 3,4 km^3. In this analysis the run off of the small rivers and rivers of Crimea are not taken into account.

In Fig. 1 the run off from the rivers Danube, Dnistr are shown. The analysis shows, that the maximal run off is by oil hydrocarbons. This is actual for the present time, since the Black Sea becomes a corridor of oil transportation's. For example, in 1995 the export to the Black Sea of petroleum was 54 million tons, and 140 tons annually of petroleum comes to the ecosystem. In 1999-2000 the export of petroleum will make 60 million tons.

The coastal zone of the Black Sea - is one of the most densely occupied regions - by virtue of the favorable climatic factors, that entails development of industry, agriculture etc., and it in turn increments the increase of uncontrollable pollution of waters of the Black Sea.

To the new factors of development of coastal regions that contribute the extension of scales of usage of natural resources and increase of the loads on the ecosystem it is possible to refer:

1. The extension of foreign economic relations, transmission gain of the role of ports;
2. Development of nonconventional for the coastal zone of the sea export-import of raw material;
3. Transmission gain of multifunctionality of marine coastal facilities (chemical industry, machinery engineering, etc.).

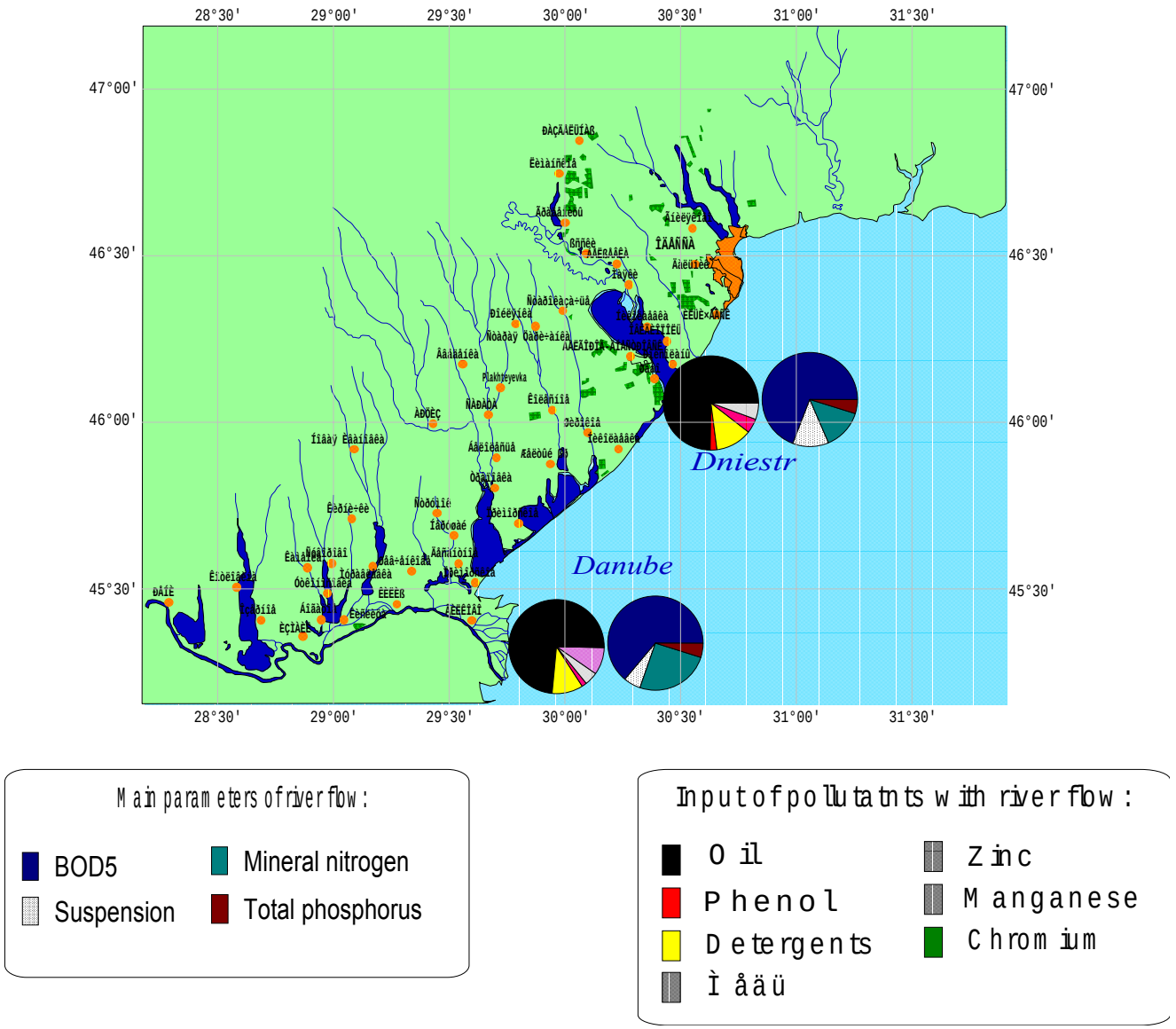


Figure 1. Sources of pollution-Rivers: Danube, Dniestr

For example, for 6 months of 1999 the gross ton-kilometre activity of ports in comparison with 1998 has increased by 17,7 %. The export component has increased by 22,3 % and by 11,0 % the import component. On 29,1 % the common gross ton-kilometre hauled of bulk cargoes, pyretic cargoes on 13,0 % have increased. This increases considerably the pollution of the aquatory of the Black Sea. In Fig. 2 the oil spills for the last 18 years in the Ukrainian part of the Black Sea are shown, which happened at the expense of various factors. Fig. 3 shows the quantity of oil spills for the last 10 years in the port of Odessa, and in other marine and estuary ports of Ukraine.

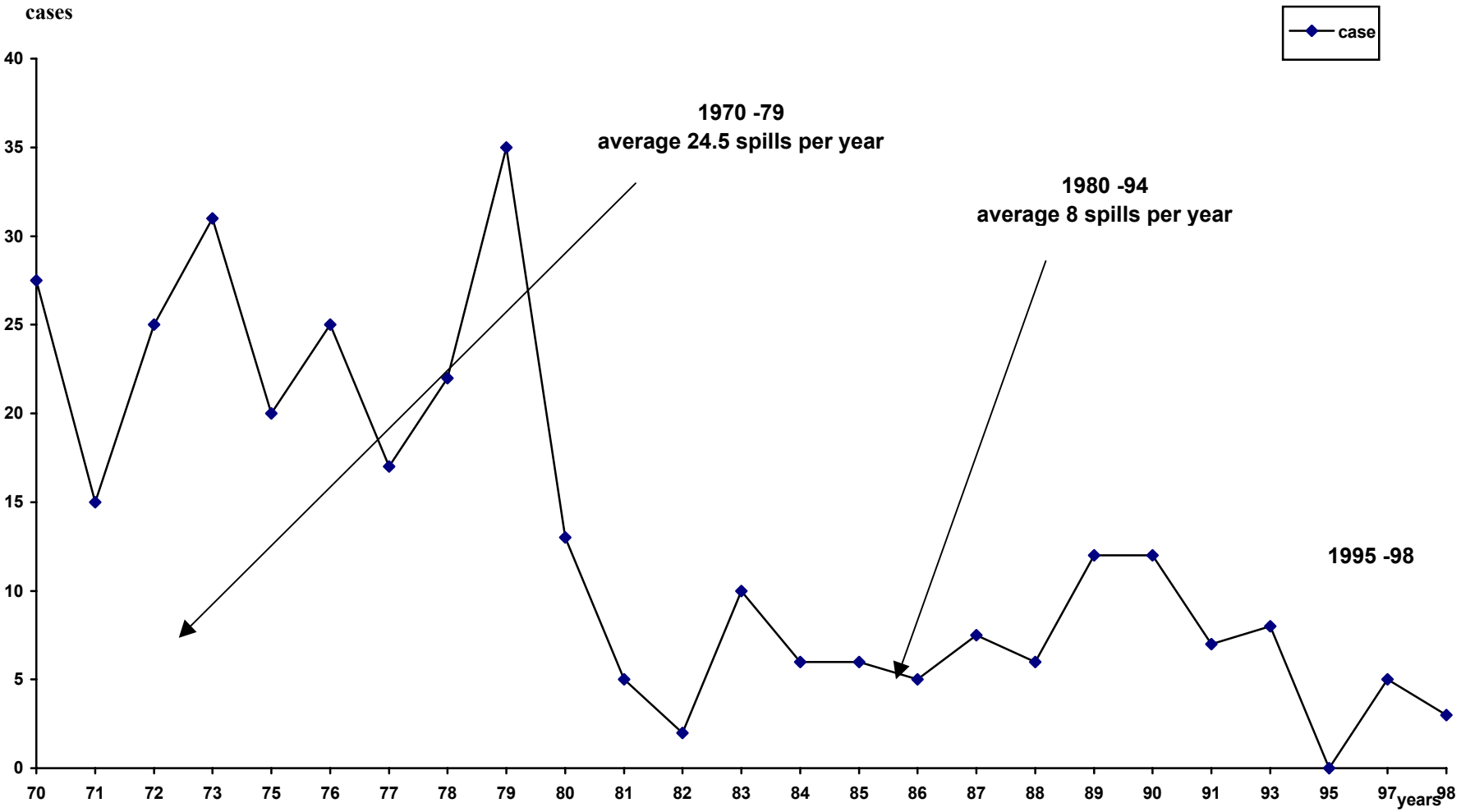


Figure 2. Annual quantity of large oil spills (more 800 m^3)

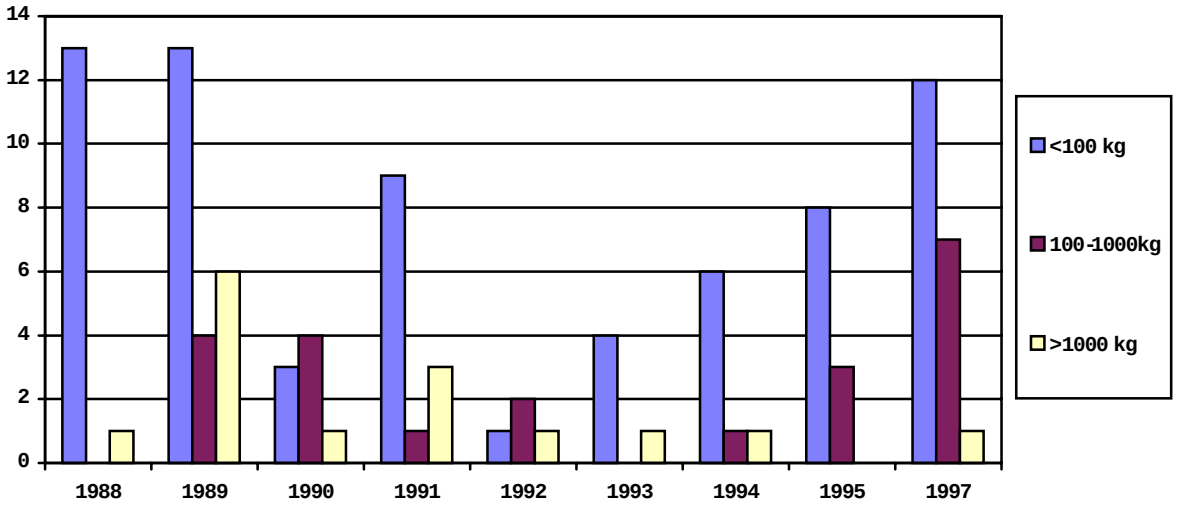


Figure 3. Quantity of oil spills in port Odessa

Information of oil spills in some Ukraine ports of 1995

Port	Quantity of oil spills			Oil operations, (bunker, thousand tons)	Corellation of spills with oil operations	
	Small 1 - 100 kg	Average 101 - 1000 kg	Large then 1000 kg		total quantity	large
Odessa	8	3	-	18381	0.0006	0
Illichevsk	2	-	0	535	0.004	0
Uzniya	4	-	-	82	0.048	0
Kerson	-	1	-	410	0.002	0
Sevastopol	2	1	-	362	0.008	0
Feodosia	-	1	-	2451	0.0004	0
Kerch	-	-	1	14	0.07	0.07

For the last year the value of oil products in bottom sediments of ports were not moderated.

Concentrations of oil products in marine bottom sediments of the ports of Ukraine 1997. UkrSCES

Concentration oil products	Port Odessa	Port Ust-Dunaysk	Port Illichevsk	Port Usnyia	Ports Kherson Nikolaev	Port Sevastopol
G/kg dry Ground	3,8	4,5	6,2	1,9	3,9	12,8

Besides port facilities the aquatory of the sea is polluted by sources that, directly discharge various substances to the sea. In Fig. 4 such sources are shown and the total annual amount of pollutants to the sea is given.

Considerable pollution of the surface of the Black Sea happens at the expense of atmosphere input. The coastal zone of the Black Sea is a breeze zone that gives the transfer of oil products to the aquatory first of all at the expense of transport vehicles, 60 % - of the pollution witch it gives. The mean value of the sea pollution through atmosphere reaches now up to 10 % of the total of all sources of pollution. The maximum pollution is located near the regions of Odessa, Sevastopol, and Kerch.

Works on the extraction of petroleum and gas from the sea bottom recently have begun actively, that increases the pollution of the Black Sea ecosystem. On the Ukrainian shelf of the Black Sea about 9 slits are developed and maintained.

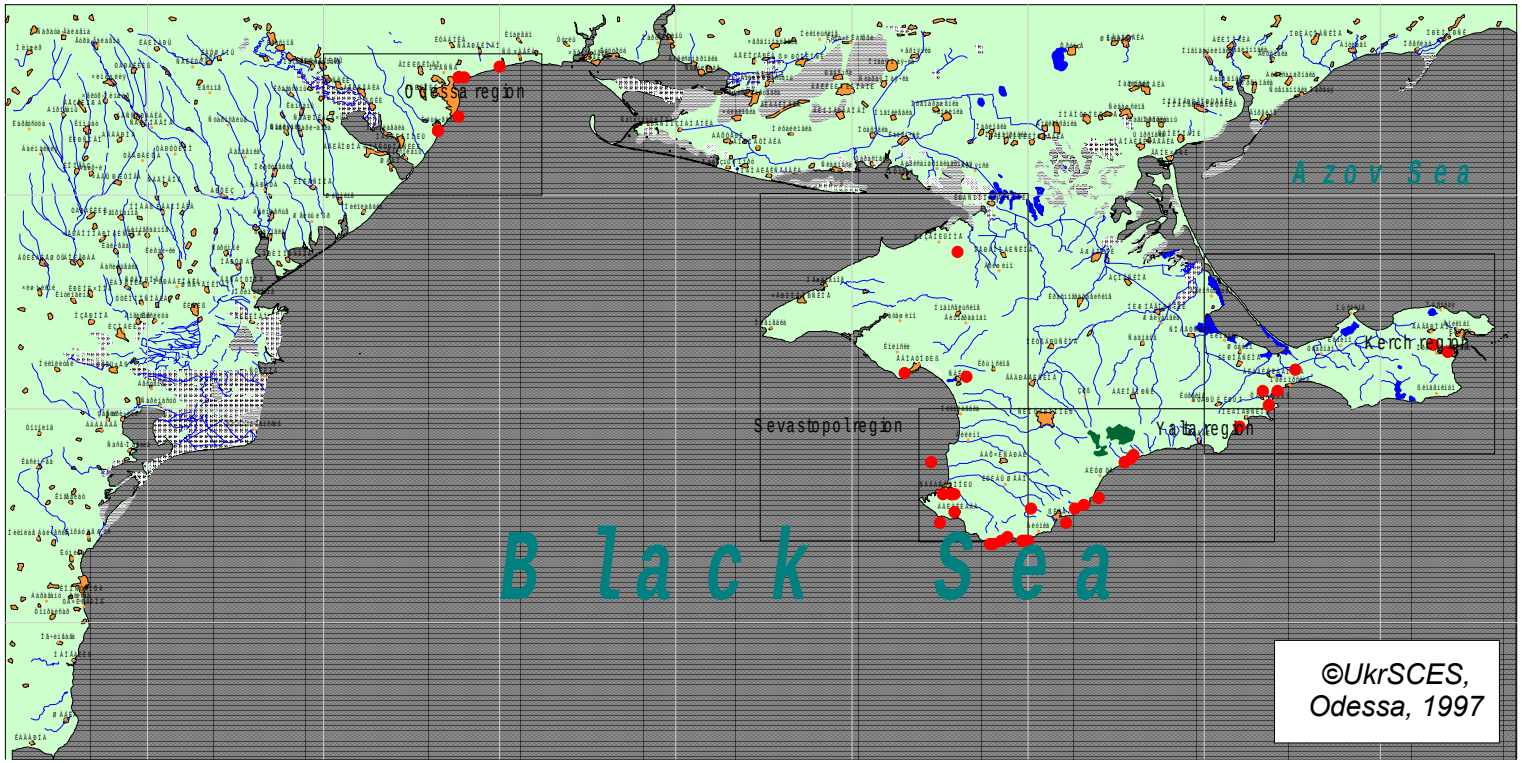
Now the Black Sea becomes a transport corridor of oil transport and products of its processing. It guesses construction of new offshore terminals in each country. For example the construction of big terminals is started in Turkey (port Samsun), Romania (port Constance), Bulgaria (port Burgas), Georgia (port Poti), Russia (port Novorossisk), Ukraine (port Usniya). All this will worsen the ecological situation on the whole aquatory of the Black Sea at expense of petroleum into the marine environment and surface atmosphere.

The term "petroleum" - has rather a fuzzy concept. For the purposes of natural use the definition of the International convention on pollution prevention from vessels Marpol - 73/78 is accepted, according to which this title is understood as crude oil, oil-fuel, oil precipitation, and oil residues. On the class perils, according to Marpol - 73/78, petroleum is a substance of average toxicity. The problem of oil pollution on the Black Sea coast has arisen in the second half of the fifties, and essentially increases now.

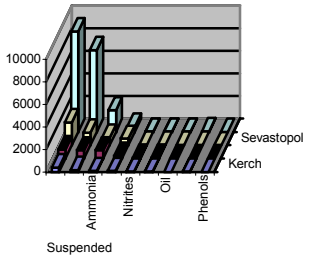
Monitoring that is conducted during the last 20 years on the pollution of the ecosystem of the Black Sea from that time has undergone significant changes. Three types of oil products are determined (oil slicks, tar balls, dissolved and dispersed oil).

In Fig. 5 the scheme of stations of the nation-wide service of observation and control is shown which was conducted by USSR. At the present time this system is not existing and each country depending on its economic possibilities began to conduct regional monitoring.

In Ukraine ecological monitoring is performed on III levels (Fig. 6).



Total annual input of pollution to Black Sea from LBS in recalculation to 100% observations



Region	Pollution substances								
	Sus-pended matter	BOD	Am-monia	Ni-trates	Nitrites	Iron	Oil	Surfac-tants	Phe-nols
Kerch	389.1	160.1	71.12	66.1	27	4.6	0.3	8.7	0
Yalta	802.9	717.9	724.4	230.2	58.4	58.4	2.6	5.9	0.1
Sevastopol	2045.7	1129.8	664.7	566.2	16.5	16.5	35.3	26.3	1.1
Odessa	8913.2	7273.4	1905.7	443.9	16.7	16.7	28.3	55.2	2.7

Figure 4. Scheme of location of land-based sources that discharge waste waters into the marine waters

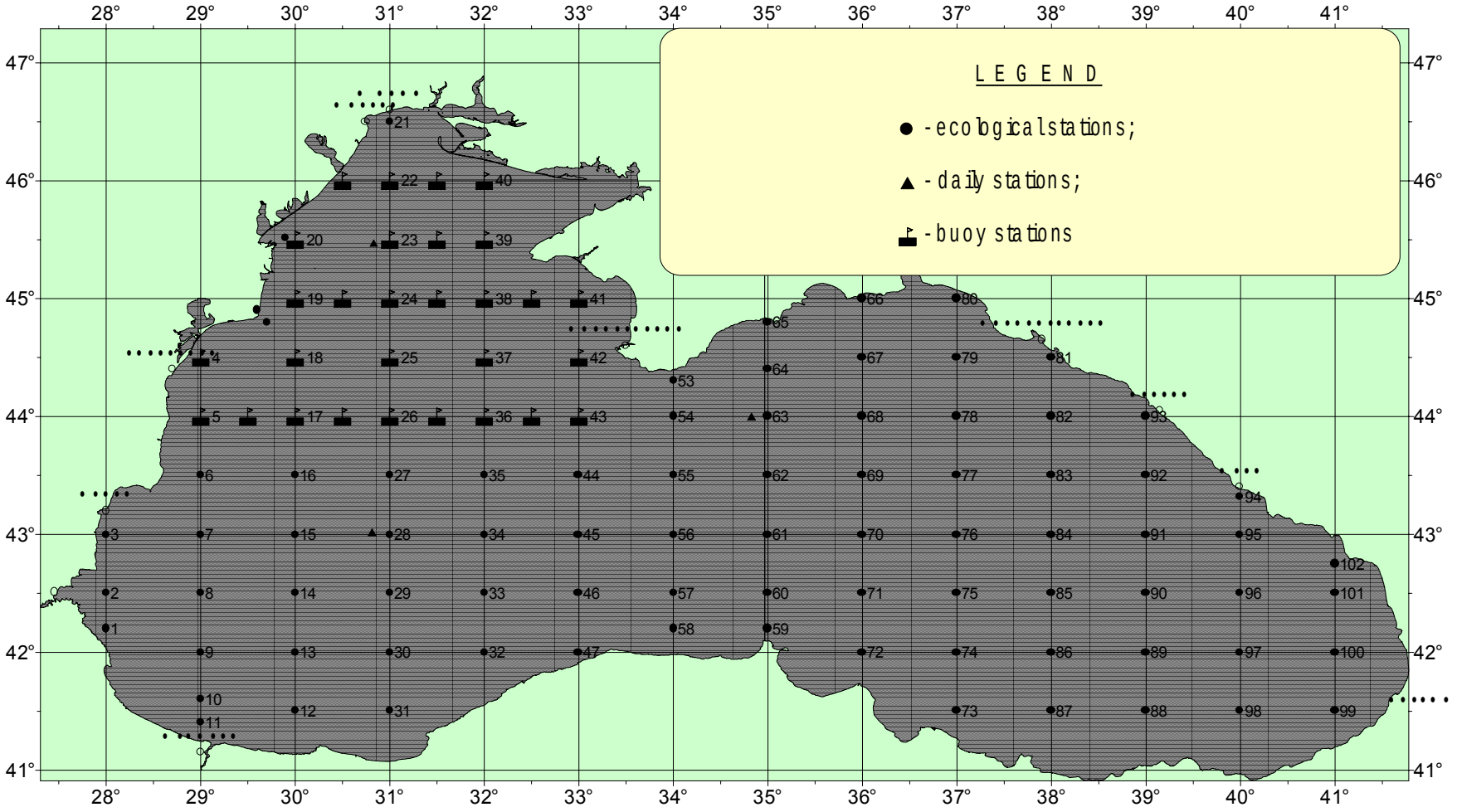
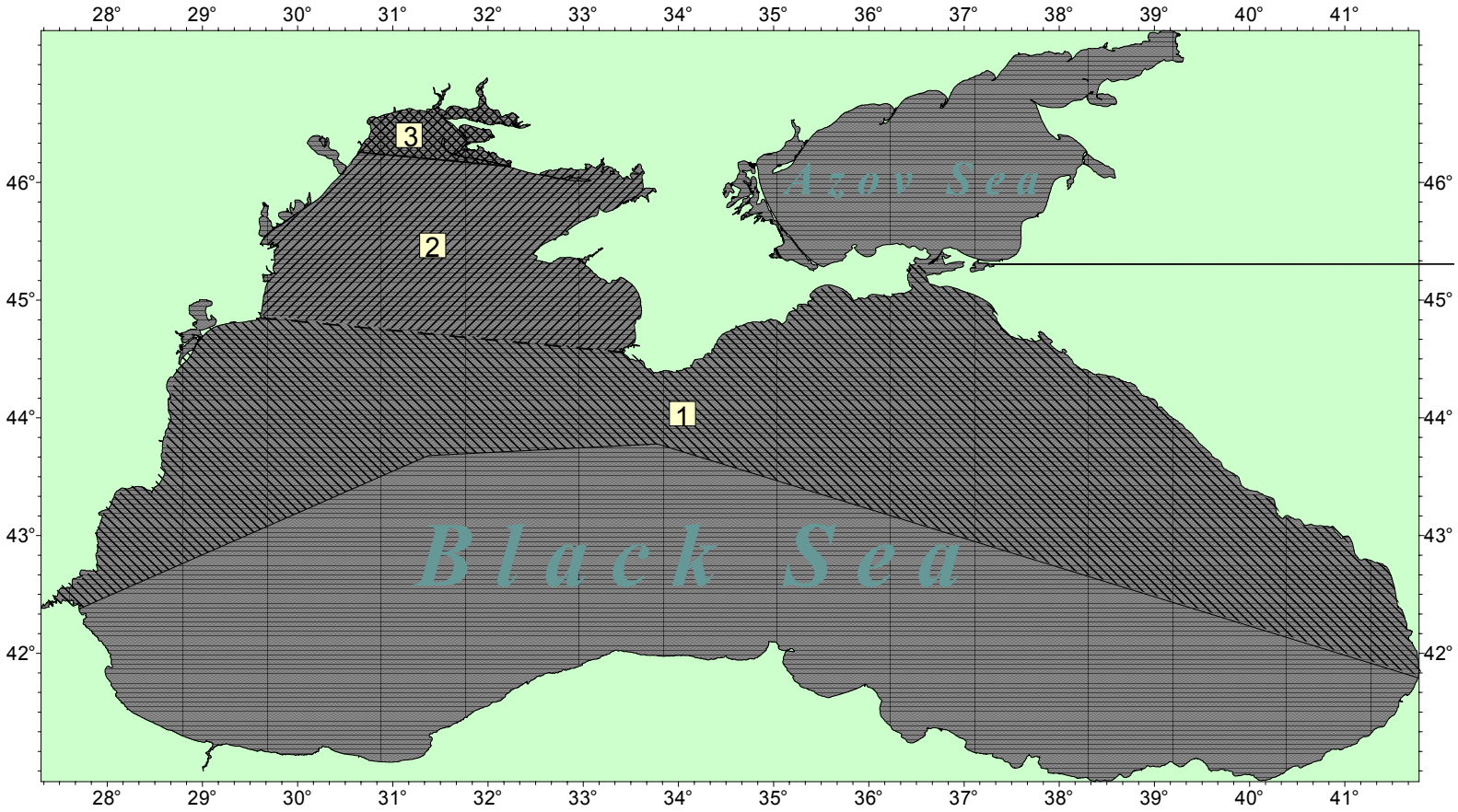


Figure 5. Scheme of ecological surveys in the Black Sea



Levels of monitoring:

1-Background

2-Regional

3-Local

Figure 6. Scheme of levels of monitoring in the Black Sea

On all levels of monitoring are investigated:

1) the main hydrochemical mode;
2) the hydrobiological parameters;
3) the main pollutants;
4) the hydrometeorological mode;
5) the radiochemical parameters in water bottom sediments, hydrobionts and surface atmosphere.

The first level is the monitoring of impact zones, i.e. most polluted aquatories. The researches are conducted every ten day's. The frequency of a choice of a grid of ecological servers is chosen with a particular discretization necessary for the registration of all local processes and sources of pollution, which happen and are with in this aquatory;

The problems of priority at this level are:

- microbial pollution;
- hydrological, synoptic etc. conditions on allocation and transference of numerous impurities;
- eutrophication;

This level of monitoring includes:

a) Inventory of land based sources (point, diffuse) with the complete chemical analysis;
b) Monitoring of beaches;
c) Monitoring of impact zones;
d) Development of water quality, bottom sediments, surface atmosphere standards.

The second level includes:

e) Monitoring of the shelf zone of the Black Sea.

The third level:

f) Background monitoring of the open part of the sea.

Carrying out monitoring guesses the investigations of the transfer and redistribution in the Black Sea ecosystem of the main pollutants. This is monitoring of the economic and opened parts of the sea. Transference and seasonal, annual variability in the allocation of the main pollutants trace the outcomes of this level of monitoring. We should note that till now in the Black Sea there is no legal sectioning into economic zones by the states. This circumstance aggravates the ecological condition of the Black Sea ecosystem, since any emergency situations beyond feature the 12-mile zone do not lay in the jurisdiction of the Black Sea countries, where there was an accident. Therefore application of penalty sanctions in these cases is not stipulated. Whereas, the oil slicks, under various synoptic conditions beyond the 12-mile zone can appear on the coast. The quantities of investigations are selected from this monitoring by the results of two levels of monitoring, including the on hydrochemistry and oceanography parameters. Thus the scientific - methodical basis of carrying out monitoring enables to spot the modern state and tendencies of variability in the distribution of hydrochemical parameters and pollutants, their climatic variability.

The results of three levels of monitoring enable:

a) To determine the modern condition, dynamics of variability and regions of unloading of pollutants, (first of all oil products);
b) To determine the strategy and acceptance of urgent measures on improvement of condition of the Black Sea ecosystem;
c) To develop uniform criteria and standards of quality of marine waters, bottom sediments;
d) To organize scientific management of the Black Sea ecosystem.

The modern state of pollution of coastal (recreational) zone of the Black Sea is characterized, by the last 15 years, as progressing anthropogenous pollution; practically many pollutants are stationary components of coastal marine waters. Here by we have petroleum, polyaromatic hydrocarbons, phenols, organic matters, heavy metals, chlororganic pesticides, polychlorbiphenyls, synthetic surfactants and biogenic substances (nitrogen, phosphorus, silicon).

The distribution of dissolved and emulsified oil products in marine waters for the last 15 years in the coastal zone varied insignificantly: from 1-10 MPC (0,05-0,5 mg/l). By annual concentration 0,07 mg/l. Some reduction of the average concentration of oil products recently in the coastal zone waters was not scheduled, that is a result of activation of the use of oil products in the Black Sea basin (Fig. 7). At the expense of drainage waters first of all to the Black Sea coastal zone enter oil products with concentrations more than 0,05 mg/l. For 1998 the beach zone of Odessa was polluted by 17286 thousand tonnes of drainage waters, i.e. 868 kgs of oil products.

In Fig. 8 the distribution of oil products in marine bottom sediments in various regions of the coastal zone of the Black Sea are shown. We should pay attention to the maximal pollution of bottom sediments that are registered in the region of the mouth of Danube.

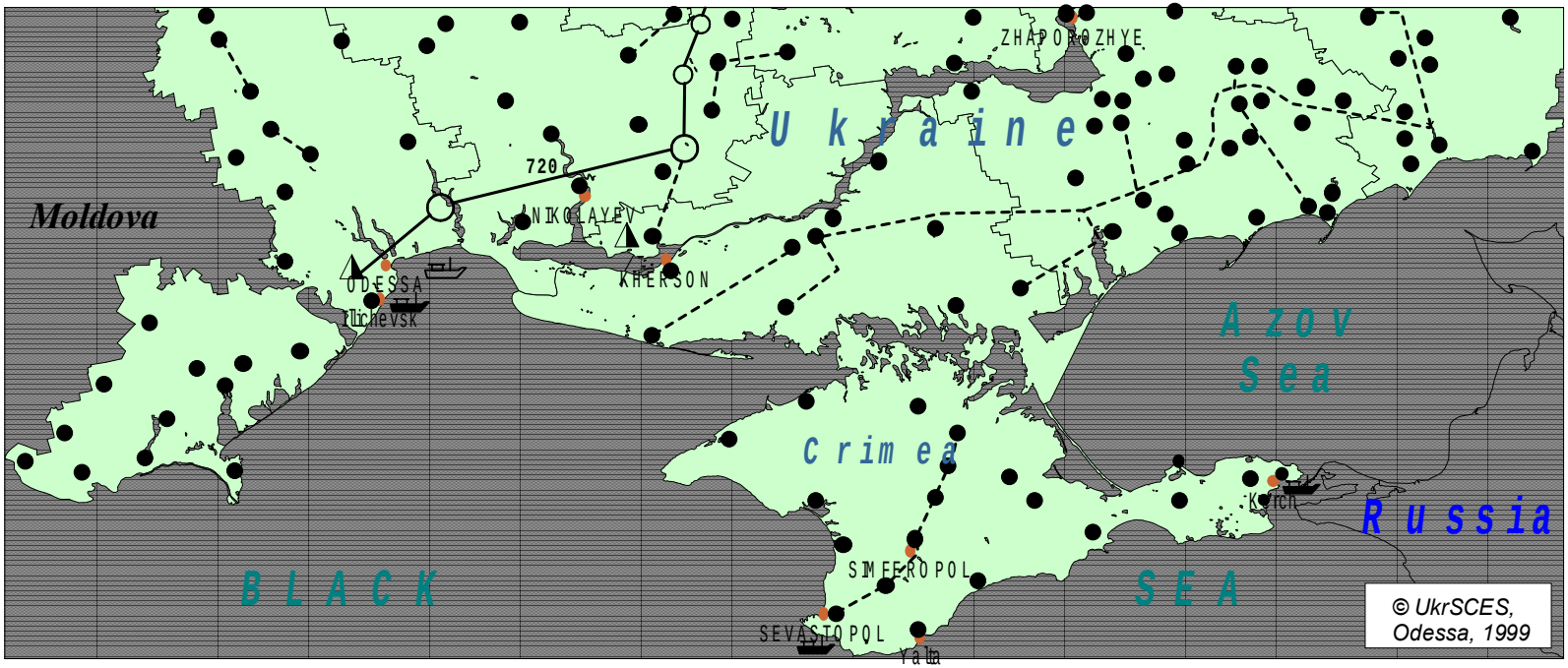
In the common ecological plan there is a considerable concentration of oil products in the coastal zone, that can be a trigger for secondary pollution of the Black Sea. The aliphatic hydrocarbons are concentrate in bottom sediments. In Fig. 9 the total quantity of individual aliphatic hydrocarbons in bottom sediments various locales are shown.

The most toxic part of oil products - polyaromatic hydrocarbons accumulating in coastal zone areas. In waters of the coastal zone concentrations of PAH vary from 0,2 μg/l up to 10 μg/l. And for the last 10 years a noticeable tendency of reduction of their concentration has not taken place. The annual concentration for coastal zone waters makes 1,1 μg/l. And the maximal concentration is dated for the Sevastopol region, where the navy of Ukraine and Russia is situated. In bottom sediments, oil products, are similar there is a considerable concentration of PAH. In Fig. 10 the distribution summary concentrations of PAH by regions and their individual composition is shown. Separately it is necessary to highlight the Crimean region. So, for example, in bottom sediments of ports of Crimea the contents of PAH are up to 5580 mg/KGs, whereas in ports of the Odessa region this value does not exceed 12 mg/KGs.

Thus, the coastal zone of the Black Sea tests considerable water pollution and especially of bottom sediments by the sum of oil products and their various individual components, such as PAH. The position will change in the worse direction by the new strategy of over loading petroleum in the Black Sea corridor. It, in turn, will bring behind itself an ecological disaster of the Black Sea ecosystem.

In the Black Sea shelf zone there was a redistribution of oil products depending on meteorological conditions, and the synoptic situation. Light oil products 10 m are determined on the harbor area in concentrations varying in limits from 0,00 - up to 0,20 mg/l in depths 0-10 m.

In the cover water mass of the shelf zone oil products are determined in quantities not exceeding 0,05 mg/l. The average concentration of them on surface shelf zone does not exceed 0,05 mg/l. In the water column from 10-50 m the weighted-mean concentration makes 0,01 mg/l.



LEGEND

- oil factoy
- oil storage
- oil pipelines with transite oil delivery
- product oil pipelines
- pumping stations
- the sample with reservoires
- 720 diameter of pipeline
- oil terminal "Odessa" existing
- oil terminal "Yuzhnyi" (under construction)

Fig 7. Locations of oil installations

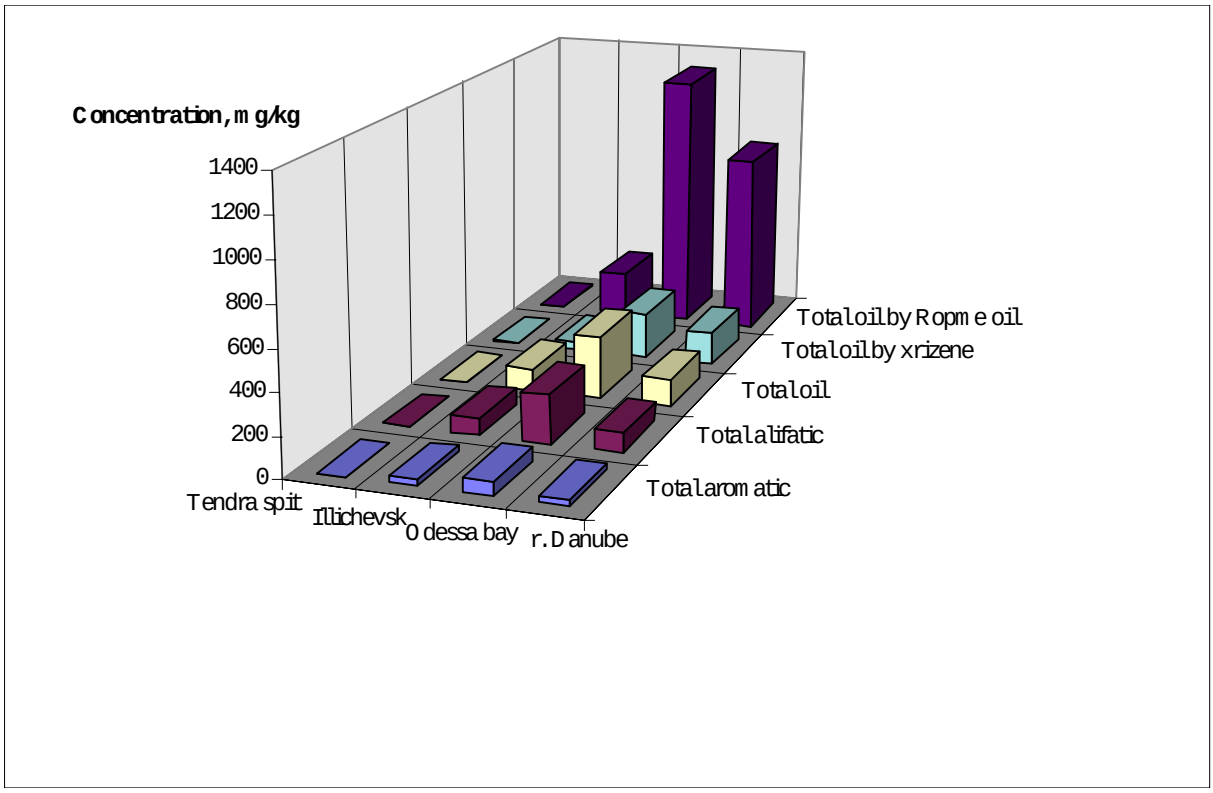
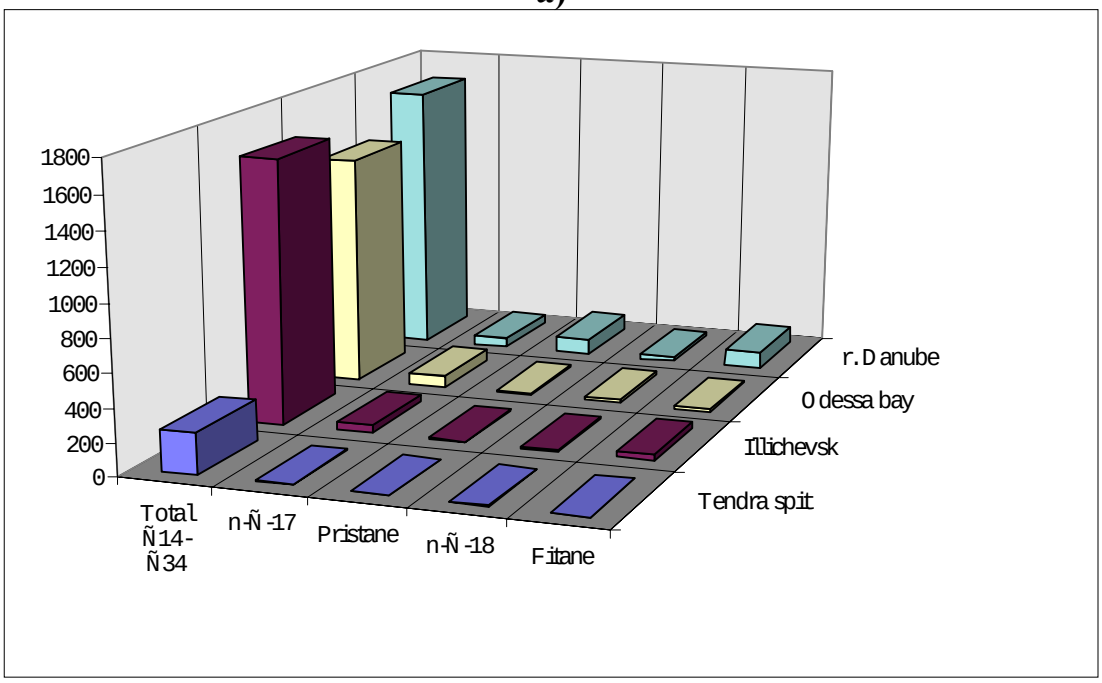
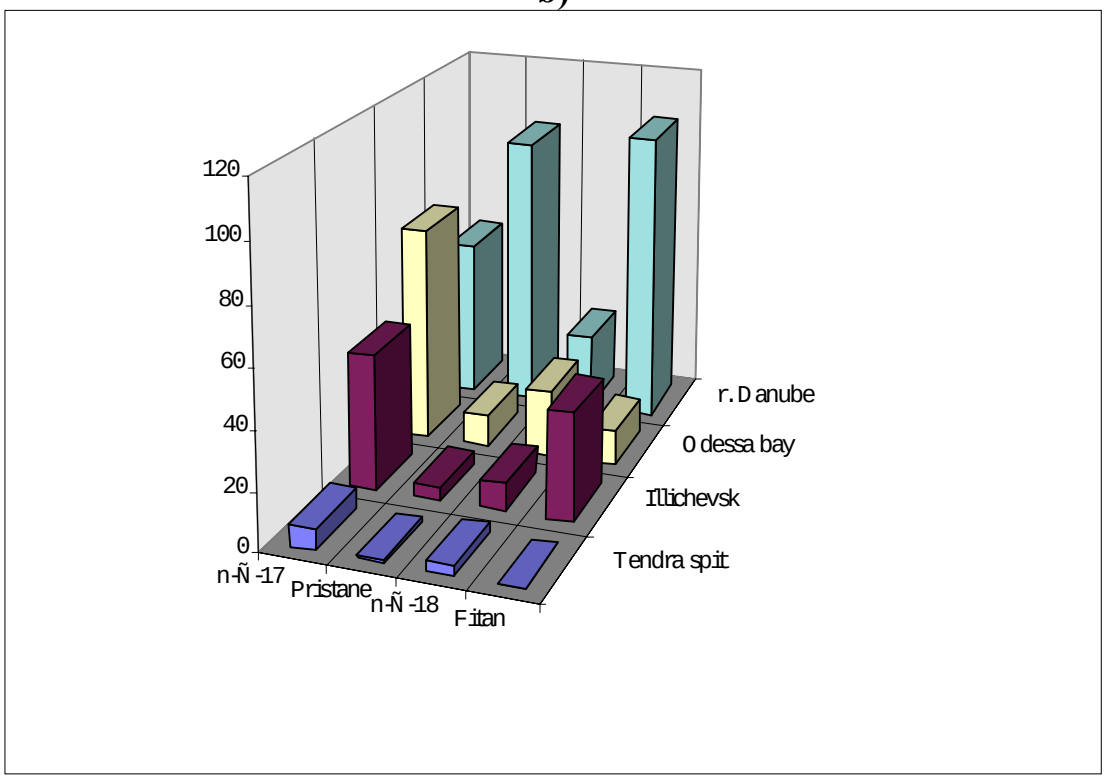


Figure 8. Oil in bottom sediments

a)



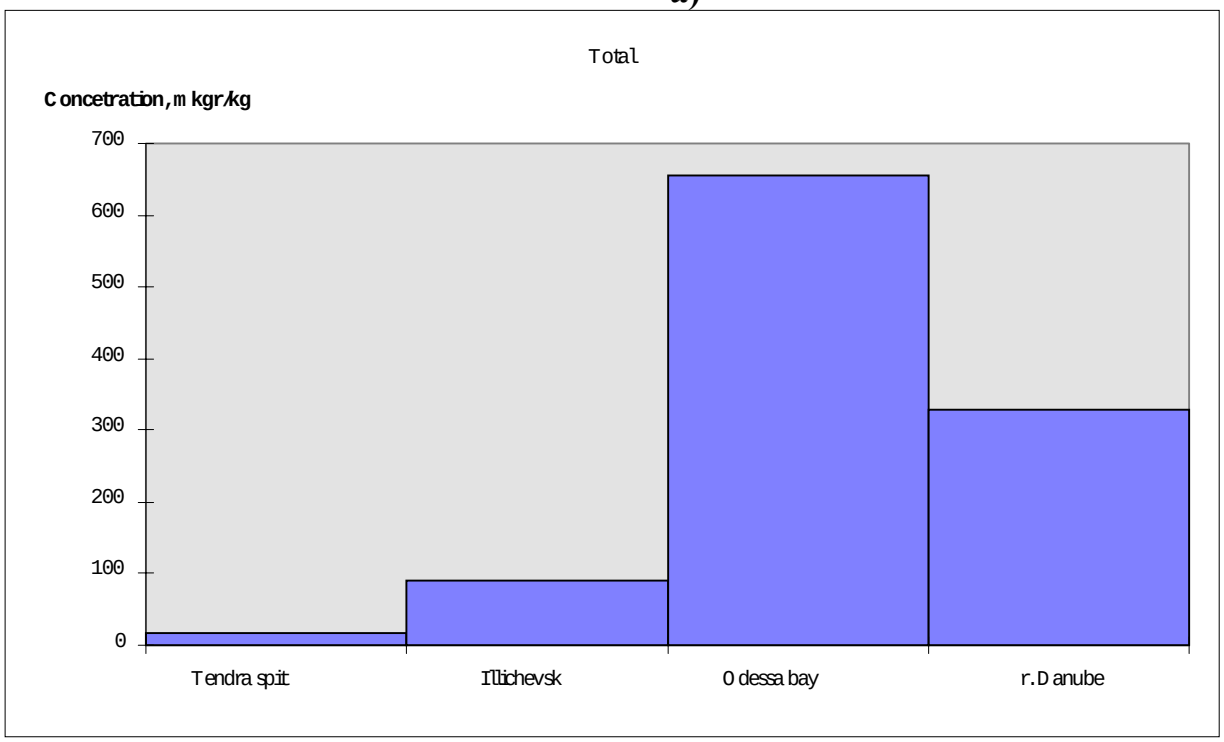
b)



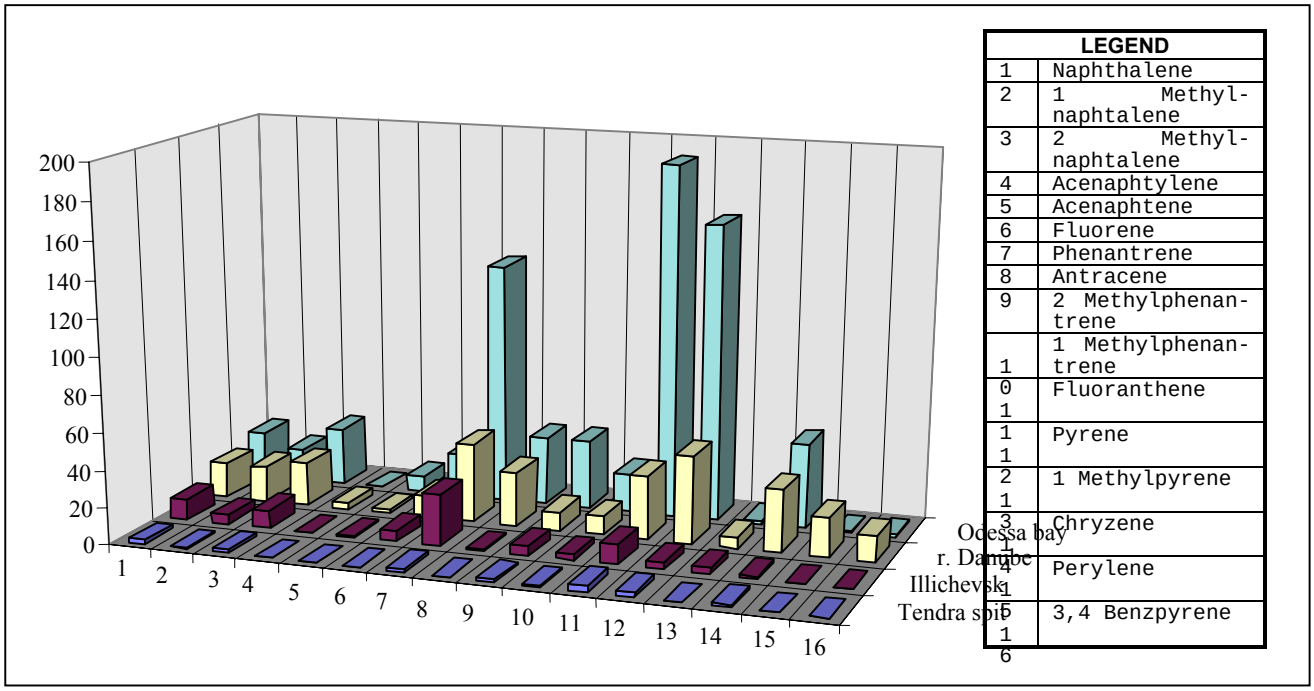
a) Total quantities by regions;
b) Individual.

Figure 9. Aliphatic oils (μg/kg) in marine bottom sediments

a)



b)



LEGEND	
1	Naphthalene
2	1 Methyl-naphtalene
3	2 Methyl-naphtalene
4	Acenaphtylene
5	Acenaphtene
6	Fluorene
7	Phenantrene
8	Antracene
9	2 Methylphenan-trene
1	1 Methylphenan-trene
0 1	Fluoranthene
1 1	Pyrene
2 1	1 Methylpyrene
3 1	Chryzene
4 1	Perylene
5 1 6	3,4 Benzpyrene

a) Total quantities by regions;
b) Individual.

Figure 10. Aromatic oils (μg/kg) in marine bottom sediments

There is a tendency of concentrating oil products in bottom sediments of the shelf zone. The values of oil products in bottom sediments do not exceed 1 gr/kg.

The aromatic component of oil products in shelf waters of the Black Sea does not exceed 2 μg/l on the surface and with depths are moderated up to 0,0 μ g/l. In bottom sediments the concentration of PAH do not exceed 3 mg/kgs. The annual average value of PAH for the shelf zone of the Black Sea makes 0,28 μg/l.

These results allow to conclude, that oil products in shelf regions of the Black Sea are within the limits of 1 PAC (permissible allowable concentration) (0,05 mg/l), that is the sufficient basis of a heavy ecological situation of the aquatory. In the open part of the Black Sea oil products are present in very small quantities only sometimes exceeding in the column 0-10 m - 0,05 mg/l, in many cases oil products in the column 0-10 m are not registered. The average annual value of oil products in the column 0-10 m makes 0,02 mg/l. For the last 5 years this value practically did not vary. The geographical distribution of oil products in the column of 0-10 m is varying only. In the water column up to 150 m practically oil products in the open part of the sea are not revealed determined. It is necessary to mark, that the considerable concentrations of oil products are registered on the surface of the seawater (layer not more than 1 mm), Fig. 11. This is connected with the physicochemical features of the microlayer. The effect of oil products on the main physicochemical mode of the surface here is most typical which considerably has varied for the last 10-15 years.

The 1992 data show, that the concentration of oil products vary from 0,00 - 0,54 mg/l. The maximal concentrations are dated for regions of major cities agglomerations of the Crimean and Odessa regions.

We can make conclusions such as:

1. The coastal zone of the Black Sea is considerably polluted, where the concentrations of oil products exceed PAC. The ecosystem is in a critical condition. Oil products considerably have changed the ecosystem of the coastal zone, first of all having destroyed the bioresources of the sea. The products of the sea in the coastal zone, and the Black Sea is only productive in the coastal zone because of the presence of H_2S, are already polluted by oil products, that taking them in food becomes dangerous to the mankind.
2. The increase of transportations and the construction of terminals can bring the ecosystem to non-reversible consequences.
3. The considerable pollution oil products of the sea shelf zone up to 0,05 mg/l results in regional changes of the ecosystem and will change the hydrochemical regime. First of all it will delete the stockpiles of phillophora, mussels and mollusks.
4. The presence of considerable concentrations of oil products on the surface of the sea can make global ecological changes in the bioefficiency and further can change the climate.

As oil (slicks) destroy caviar of many hydrobionts, and changes in physical properties of the surface, such as interfacial tension, viscosity etc., that can bring to changes of the energy exchange between the sea and atmosphere.