Chapter 8. Description of biological communities and their experienced impact

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8.1. Microorganisms in the water and sediments

UA: IBSS. December 2007 and August–September 2009. **Water.** In December 2007, abundance of planktonic microorganisms (heterotrophic bacteria, picophytoplankton) and the virus-like particles presence in the Kerch Strait surface waters were investigated at 12 stations, i.e., immediately after the oil spill happened. To trace possible residual impact of the Kerch accident, at 20 stations located in the Kerch Strait and the Black and Azov Seas adjacent waters studies were carried out in August 2009.

In December 2007, the heterotrophic bacteria density was recorded in the range of 2.1–4.4 mln cells. ml^{-1} and it was substantially higher the levels previously registered for the region (e. g., up to 1.4 mln cells. ml^{-1} in the 1990s summers), and even exceeding the Sevastopol Bay (highly polluted waters) levels, (Chepurnova E.A., 1993, Mukhanov *et al.,* 2003). Abundance of phytoplankton and photoautotrophic picoplankton (9700–23 100 cells. ml^{-1} equal to the cyanobacterial numbers upper limit for the Western and North-Western Black Sea) remained within their typical levels for the area, therefore high bacteria concentrations observed could have been related to increase in the allochthonous organic matter inflow. The virus-like particles (VLP) plankton abundance (investigations carried out at the Black and Azov Seas for the first time) ranged from 6×10^7 cells. ml^{-1} to 10^8 cells. ml^{-1} that was typical for highly polluted marine coastal waters.

In August 2009, numbers of heterotrophic bacteria were registered with density of 3.4–14.8 mln cells. ml^{-1} (average ±95 % CI: $7.6\pm1.5\times10^6$ cells. ml^{-1}) and of picophytoplankton — as 3200–93 900 cells. ml^{-1} (average: $19.7\pm10.6\times10^3$ cells. ml^{-1}), and their spatial distributions were recorded uneven. High presence of heterotrophic microorganisms was registered in the Kerch Strait Northern section, while the low presence, mainly detected in the central section, well coincided with the hydrochemical parameters distribution (Chapter 5). Bacteria's increased abundance in August 2009 was well related to the high water temperatures.

Summarizing the results obtained in 2007 and 2009, it must be noted that abundance, composition and spatial distribution of the pelagic microbial community in the Kerch Strait reflected the presence of highly polluted waters right after the Kerch accident. However, in 2009 the studied bacteriological parameters were controlled by natural factors such as the Kerch Strait water temperature gradient, the Black and Azov Seas water-mass exchanges, trophic processes, etc., and they were hardly related to the post-disaster effects.

UA: IBSS. December 2007 and March 2008. Bottom sediments. Worldwide, there are 28 classes of bacteria (over 100 species), 30 species of fungi and 12 species of yeasts that are capable of decomposing (oxidizing) petroleum hydrocarbons (PHs), (Ivanov V. P., Sokolsky A. F., 2000). They belong to genus *Pseudomonas, Achromobacter, Mycobacterium, Flavobacterium, Corynebacterium, Micrococcus, Bacillus, Vibrio, Actinomyces, Proactinomyces, Streptomyces*, etc. The hydrocarbon oxidizing bacteria presence in common microbial and saprophytic populations ranges from 0.1 % to 10 % in clean waters and from 35 % to 80 % in the areas of chronically polluted coastal waters. Respectively during oil spills, the PHs oxidizing bacteria abundance could be higher than that of the saprophytic microflora (Tsyban A. V., Simonov A. I., 1979).

After the Kerch Strait accident, the microorganisms sediments abundance was carefully studied on 12–18 December 2007 and in March 2008 (13 stations, the *Experiment* RV, Fig. 6.2.9a). Total abundance of heterotrophic microorganisms (1,\500 to 950 000 cells per gram of wet soil) was two times higher than of the PHs-oxidizing species. However, the latter were discovered present in all the bottom sediment samples, and in March 2008 their density was recorded increased by 1–2 order of magnitude compared to the data obtained in December 2007. Bottom sediments collected from the waterway area and by the coast contained oil-decomposing bacteria present in maximal densities. Besides, numbers of those bacteria inhabiting conditionally clean water area sediments (for instance, the Black Sea areas located far from the oil pollution sources) were hundred times lower (0.4 cells per gram) than in the Kerch Strait areas.

RU: AzNIIRKH. November–December 2007. Bottom sediments and the water. Right after the Kerch Strait accident**,** abundance of petroleum oxidizing microorganisms in the waters was changing from 0 cells. ml^{-1} (in the bottom sediments at certain stations) to up to 10^6 cells. ml^{-1}. Bacteria's abundance was at the maximum at the water surface averaging 3×10^4 cells. ml^{-1} along the whole Kerch Strait basin. Down from the surface, the abundance kept substantially reducing to reach 50–100 cells. ml^{-1}. Abundance of petroleum oxidizing bacteria was registered at the highest maximum of 10^5–10^6 cells. ml^{-1} in the water surface layer of the Tuzla Spit and at the Taman village traverse of the Taman Bay vicinity. In the Kerch Strait Southern section, as well as in the Chushka Spit vicinity bacteria's abundance was substantially lower (Fig. 8.1a). Stations located in the Tuzla Spit vicinity (its Northern section) and the Taman Bay central section registered the maximal petroleum oxidizing bacteria abundance (Fig. 8.1b). Their concentration was found substantially lower in the bottom sediments of the Kerch Strait Southern section and in the Chushka Spit vicinity (Korpakova I.G., Agapov S.A., 2008).

In the Azov Sea, the total petroleum oxidizing bacteria abundance in water kept changing in the range of 0–1000 cells. ml^{-1} to average 100 cells. ml^{-1} at the surface, and around 5 cells. ml^{-1} — at the 5 m depth and near the bottom. The highest petroleum decomposing microorganisms presence (200–330 cells. ml^{-1}) in the water surface layer was witnessed at the stations located in the Southern, Eastern and South-Eastern Azov Sea sections to include the Temruk Bay (Table 8.1a, Fig. 8.1a). In the bottom sediments their concentration ranged within 10–1000 cells. g^{-1} averaging 100 cells. g^{-1}. The highest petroleum decomposing bacteria abundance was registered in the Kerch Strait bordering section of the Southern Azov Sea area to sustain 1000 cells. g^{-1} (Fig. 8.1 b) in the bottom sediments of majority of stations.

In the Black Sea waters, the petroleum oxidizing bacteria density was comparable with their Azov Sea abundance though substantially lower than in the Kerch Strait. In the pre-strait area, the density did not exceed 100 cells. ml^{-1}, while in the bottom sediments it averaged 250 cells. g^{-1} fluctuating within the range of 100–1000 cells. g^{-1} (Fig. 8.1b). A higher presence of these bacteria was considered typical for the water basin stretching from the Iron Horn Cape till the Blagoveschenskaya village.

Therefore, bacteria density was detected on decline down from the surface to the bottom layers in all water areas under investigation. Out of all areas of research, bacteria's maximal abundance in water was registered in the Tuzla Spit vicinity in the Kerch Strait, i. e., in the Taman Bay central part. There, as well, abundance of petroleum decomposing bacteria in the bottom sediments was recorded the maximal for the whole region under investigation.

A relatively high abundance of petroleum decomposing bacteria recorded at certain Kerch Strait stations (at the 10^4–10^6 cells. g^{-1} levels) evidenced the ongoing microbiological processes of petroleum-origin organic substances transformation in the water

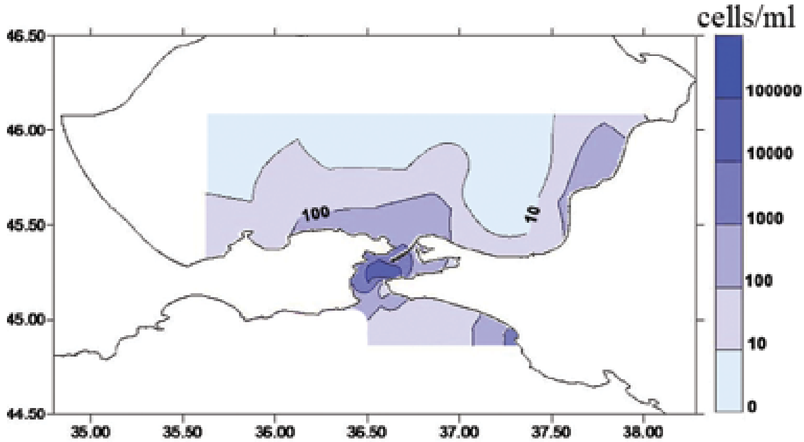

Fig. 8.1a. Abundance of petroleum oxidizing bacteria in the Kerch Strait water at surface with the Azov and Black Sea adjacent water basins, November-December 2007 (Korpakova I. G., Agapov S. A., 2008).

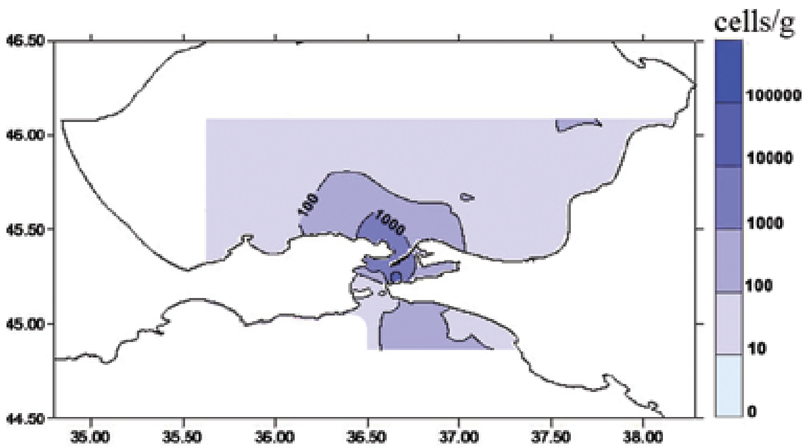

Fig.8.1b. Abundance of petroleum oxidizing bacteria in the Kerch Strait bottom sediments with the Azov and Black Sea adjacent water basins, November–December 2007 (Korpakova I. G., Agapov S. A., 2008).

surface layer. Still in general and due to low temperatures, the total petroleum decomposing bacteria presence kept remaining relatively low in the water of all investigated sections right after the Kerch accident.

Table 8.1a. Abundance of petroleum decomposing bacteria in the water and bottom sediments of investigated areas in November-December 2007 (Korpakova I. G., Agapov S. A., 2008).

Place of sampling	Horizon	Abundance of petroleum oxidizing bacteria	
		water (cells. ml^{-1})	bottom sediments (cells. g^{-1})
Azov Sea			
Eastern Azov Sea area to include the Temruk Bay	surface	(0–1000)/200	10–100 60
	5 m	(0–10)/4	
	near bottom	(0–10)/3	
Central Azov Sea area	surface	(0–100)/20	10–100 60
	5 m	(0–10)/2	
	near bottom	(0–10)/2	

Southern Azov Sea section	surface	(100–1000)/330	100–1000 400
	5 m	10	
	near bottom	10	
Western sea area	surface	10	10
Kerch Strait			
Chushka Spit vicinity (its Southern end)	surface	1000	1,000
	near bottom	0	
Tuzla Spit vicinity	surface	(10 000–1 000 000)/37 000	1000–10 000 4000
	near bottom	(100–1000)/400	
Northern Tuzla Spit side, the Taman Bay area till the Taman village	surface	(10–100 000)/66 700	100–100 000 34 000
	near bottom	(10–100)/40	
Southern Kerch Strait section	surface	(1000–10 000)/6400	10–1000 300
	5 m	(10–100)/70	
	near bottom	(0–100)/30	
Black Sea			
pre-Strait area	surface	100	100
	10 m	(0–10)/5	
	near bottom	(0–10)/5	
Open-sea area (sea stations)	surface	(10–100)/30	100–1000 330
	10 m	(0–10)/3	
	20 m	0	
	near bottom	0	
Abrau village vicinity	surface	1000	100
	10 m	1000	
	20 m	10	
	near bottom	0	

8.2. Phytoplankton

UA: IBSS. October-December 2007 and August 2009. Prior to and after the Kerch Strait accident, the main parameters of phytoplankton were registered as follows:

Period	Density (mln. cells·m^{-3})	Biomass (mg·m^{-3})	Number of species	Dominating group
October 2007	47.27–244.59	315.85–1797	46	Diatoms (26 species)
December 2007	65.6–8684	83.23–2240.22	39	Diatoms (16 species)
August 2009	96–638	162.21–9887.55	50	Diatoms (26 species)

In October 2007, diatoms predominated at all stations. Their presence in the total abundance and biomass was exceeding 96 % (mainly elongated large diatoms). Cyanobacteria were second in abundance (8.9 %) with domination of *Lingbya limnetica.* Dinoflagellates accounted for 2.89 % and were second by presence in biomass.

By December, the dinoflagellates presence was registered increased in total biomass while that of Diatoms, Cyanophyceae and Chrysophyceae had slightly decreased, and Cyanophyceae had significantly raised their contribution to abundance. Among cyanobacteria, the representatives of genus *Oscillatoria* were dominant both in abundance and biomass. Their total abundance ranged from 29 % to 93 % followed by that of diatoms (centric forms such as *Coscinodiscus, Skeletonema costatum*) and flagellates. Large diatoms dominated in biomass over the entire area (from 67 % to 99 %).

In August 2009, Bacillariophycea species were mainly recorded represented by *Pseudosolenia calcar-avis* and *Proboscia alata*, and 12 species of dinoflagellates and six of cyanobacteria were present as well. Out of all dinoflagellate species, the maximal abundance was registered of *Prorocentrum micans* (316.6 mln. cells m^{-3}). Near the Tuzla Spit, phytoplankton biomass was determined critically high evidencing a poor water quality.

Comparison between the phytoplankton community condition status prior to and after the Kerch Strait accident has revealed insignificant differences. Variability of the algae abundance and biomass or the species composition would be rather attributed to high level of eutrophication present in the Strait than to the oil pollution.

8.3. Zooplankton

UA: IBSS. December 2007 and August-September 2009. Mesozooplankton samples (ten samples in winter and 30 in summer) were collected by means of vertical hauls of the Juday net with the mouth diameter of 36 cm and 140 μ mesh size.

In December 2007, right after the accident, groups dominant in the mesozooplankton community were *Cirripedia* larvae (49 %) and copepods (41 % of total abundance), (Zagorodnyaya Yu. A., 2009), which was traditional for the area. Presence of dead plankton organisms was high reaching 11.7 % on the average and varying from 2 % to 34 %, while their maximal numbers were detected not far from the oil spill site that might have contributed to the zooplankton mortality increase. However, rapid changes in water temperature and salinity, to follow the storm that occurred during the accident and after, could have also become a factor to cause increase in mortality.

In August 2009, the highest by abundance groups recorded were cladocerans (37 %) and copepods (32 %) followed by the pelagic larvae of benthic invertebrates (27 %). Among the copepods, two species of Acartia genus — *Acartia clausi* and *Acartia tonsa* — were dominant accounting for 86 % of total abundance, and were followed by other species typical for the Black Sea, i. e., *Centropages ponticus* (13 %). Acartia genus is known for being very tolerant to changes in environment conditions (like salinity and temperature), and in the Kerch Strait shallow coastal waters those organisms play an important role in the community structure. Among the cladocerans, *Pleopis polyphemoides* was often found present. From the plankton other groups, three species of *Ctenophora*, chaetognathes and larvae of benthic animals were observed.

In September 2009, the structure of the mesozooplankton community was not recognized as significantly changed in the Kerch Strait. Abundance of the *Paracalanus parvus* copepod was recorded slightly increased, while that of *Acartia* — decreased. Both total abundance and biomass were registered at the slightly lower levels than the long-term annual averages.

In 2009, mesozooplankton mortality was found significantly lower, as compared to December 2007, and it varied between 1 % to 7 % evidencing a better condition status of the mesozooplankton community. No residual influence of the Kerch Strait accident was detected.

8.4. Macrozoobenthos

UA: IBSS. December 2007, March 2008 and August 2009. In the course of observations conducted on 12–18 December, when onboard of the *Experiment* RV, 24 stations were surveyed in the Kerch Strait Ukrainian section from the Azov to the Black Sea, 55 species were detected to include 24 shellfish species, 7 crustaceans, 15 polychaetes worms, and other taxonomic groups representatives, i. e., nemertean, oligochaetes, ascidians, flatworms, etc. The shares of taxonomic groups present, in particular predominance of molluscs and polychaetes worms, is considered typical/classical for the coastal waters of the investigate areas. The species number per station varied from 5 to 26. At the same time, presence of seven species (*Hydrobia acuta, Myti-*

laster lineatus, Heteromastus filiformis, Nephtys hombergii, Nephtys cirrisa longicornis, Anadara inequivalvis, Bittium reticulatum) and *Olygochaeta* was registered exceeding 50 %, while 26 species were detected at one-two stations only. The richest species variety was discovered eastwards from the Tuzla Island and the poorest — at the entrance to the Azov Sea, i. e., in the areas impacted by the November 2007 oil spill. In the area under observation, three major habitats with a 30 % similarity between them were identified through the Bray-Curtis cluster analysis (Fig. 8.4a). Habitat A (the dominant species was *Mytilaster lineatus)* covered the area at the Kerch Strait exit to the Azov Sea. Habitat B (the dominant species was *Chamelea gallina)* covered the area at the exit to the Black Sea. Habitat C with two Sub-habitats C1 and C2 covered the Kerch Strait total area. *Hydrobia acuta* (small gastropod) was typical for that habitat. Species composition of the Sub-habitat C2 was most diverse that had been possibly predetermined by the near-bottom layers salinity change.

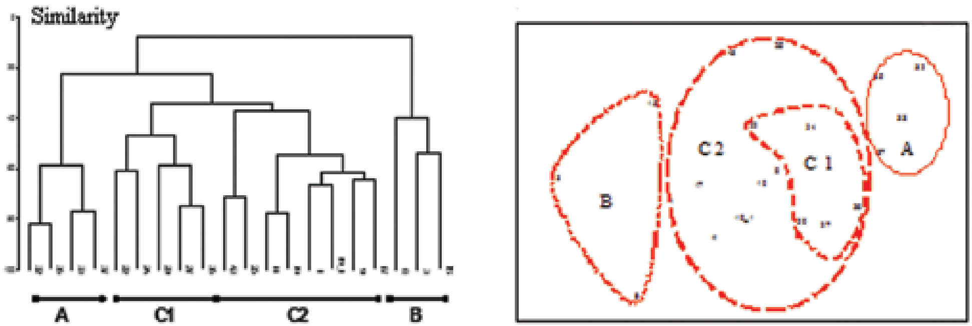

Fig. 8.4a. The Cluster and MDS (Multidimensional Scaling) analysis of benthic communities similarities detected at the Kerch Strait stations in December 2007.

In December 2007, macrozoobenthos abundance and biomass varied significantly from station to station, especially in the Kerch Strait central section. The maximal biomasses were within the range of 432.4–535.6 g/m^2 due to the presence of mature *Anadara inequivalvis*, the *Mytilaster lineatus* individuals and young *Rapana venosa.* At the same time, the macrozoobenthos biomass did not exceed 10 g/m^2 at half of the stations. Abundance varied from 300 to 132 037 individuals per square meter. High density of small *Hydrobia acuta* gastropod (1900–21 370 ind/m^2) and young *Mytilaster lineatus* (440–127 825 ind/m^2) was detected at the Kerch Strait exit to the Azov Sea.

In March 2008, 27 stations were observed and 46 species were detected to include 20 mollusc species, 10 crustaceans and 12 polychaete worms. Compared to December 2007, frequency of occurrence of *Nephtys longicornis, Anadara inequivalvis, Bittium reticulatum* decreased by up to 10–30 %. However, the *Melinna palmata* frequency of occurrence exceeded 50 %. All along the Kerch Strait, diversity indicators for March 2008 were recorded lower than for December 2007, while — at the same time — distribution of major species remained without a serious change. However, macrozoobenthos abundance and biomass had decreased significantly at the entrance to the Azov Sea, as compared to December, mainly due to *Anadara inequivalvis, Hydrobia acuta* and *Mytilaster lineatus* decrease in abundance and biomass. Also, *Microdeutopus gryllotalpa* discovered in December at half of the stations was not detected in March 2008.

In 2007–2008, molluscs predominated in macrozoobenthos abundance and biomass at most of the stations observed. According to the feeding type, mostly present were the detritophagues.

Through controlling the area further on, macrozoobenthos was studied at 20 stations in August 2009. General variability of qualitative and quantitative parameters, including the groups systematic presence, hardly differed substantially from the levels observed in 2007–2008. In total, 46 species were detected, including 20 mollusc species, 9 crustaceans, 11 polychaete worms as well as other taxonomic groups representatives, i. e., Nemertina, Oligochaeta, ascidians, flatworms, etc. The number of species detected per station varied from 3 to 14. At one station, 22 species were recorded. The richest biodiversity was observed in the Kerch Strait central section. Only three species (*Hydrobia acuta, Mytilaster lineatus* and *Nephtys hombergii*) had higher than 50 % occurrence, while seven other had it at 25 %.

Unlike of 2007–2008 winter and spring periods, in summer 2009 two major habitats with 30 % similarity were determined through the Bray-Curtis cluster analysis. Habitat A, where *Mytilaster lineatus* and *Hydrobia acuta* were the dominant species, covered the area close to the Azov Sea strait entrance jointly with the Kerch Strait Northern section. Habitat B, with the *Chamelea gallina* and *Melinna palmata* dominant species, covered the area at the Black Sea strait entrance jointly with the Kerch Strait Southern section up to the Tuzla Island.

Macrozoobenthos abundance and biomass varied significantly in August 2009, as it had been previously observed as well. Low abundance and biomass were recorded in the Black Sea adjacent Strait area. Biomass of up to 100 g/m^2 was detected in the Kerch Strait central section due to *Ch. gallina, Anadara inequivalvis* and young *Rapana venosa* presence. *Ch. gallina* belongs to the oil-sensitive group of species. Therefore, increase in its abundance and biomass could be taken for an indicator of low oil content presence in the bottom sediments in that part of the Strait. The macrobenthos maximal biomass reaching up to 1000 g/m^2 was observed at the Azov Sea Strait exit. Abundance varied from 300 to 60 000 ind/m^2 being the highest in the Kerch Strait Northern section. High densities of small *Hydrobia acuta* gastropods (up to 30 000 ind/m^2) and young *Mytilaster lineatus* (up to 40 000 ind/m^2) were detected at the Azov Sea strait exit. In general, macrozoobenthos abundance and biomass were increasing from the Black Sea towards the Azov Sea, while the species diversity was decreasing.

The 2007–2009, the macrozoobenthos studies results have confirmed that the Kerch Strait macrozoobenthic community structure was typical for the areas once stressed by anthropogenic activities, however, no significant evidence of experienced impact of the Kerch Strait accident was found. Quantitative and qualitative parameters of the bottom communities detected at the depths from 5 m to 20 m and recorded in the period from December 2007 (shortly after the accident) till August 2009, appeared to be similar to those registered before the accident. As is well known, the Kerch Strait oil spill largely went onto the shore. Reports were circulated about increased crustacean mortality and that numerous dead shellfish and seawalls were found ashore (Matishov G. G., 2008). However, both phenomena could have been equally produced by the high waves instead of resulting from oil contamination.

No doubt, any pollution deterioration of the Kerch Strait bottom sediments could further negatively impact the bottom communities condition status, as well as the Kerch

Strait ecosystem self-purification capacity, since the filter-feeding species abundance has gone down and the general diversity presence currently stands low, while the habitats are quite unstable. The mentioned conclusion has been well supported by several studies conducted in the Kerch Strait in 2008–2009 and to be presented further on.

RU: Institute of Geography. August 2008: The Ukrainian coastal waters bottom sediments condition status. On 13–25 August 2008, the Russian Academy of Sciences Institute of Geography, IG RAS organized the Kerch Strait visual diving survey and collected some bottom sediments samples in order to assess pollution levels. The stations location scheme (Fig. 8.4b) was built in line with results of the Kerch Strait oil spill expansion mathematical modeling simulated for a six-day period of 11–16 November 2007 (Ovsienko S. N. *et al,.* 2008) and results of the Kerch Strait aerial survey (Fig. 8.4c) conducted at the same time (Matishov G. G., 2008). The idea behind was to check whether the oil was still present in the areas identified as impacted and where, if at all, it could have settled down.

Fig. 8.4b. Scheme of the bottom sediments visual diving survey and sample collecting conducted in the Kerch Strait on 13–25 August 2008.

Distance between the stations varied from 1 km to 2 km. To carry out the bottom visual survey, 41 scuba-divings were performed. No oil spots were discovered anywhere, even at the Tuzla Island and the Taman Bay entrance.

Satisfactory was found condition status of the *Rapana venosa* population inhabiting the areas in vicinity of the Tuzla Island Eastern coast. This evidenced that benthic communities, investigated at the Kerch Strait impacted locations, had not been badly damaged as a result of the accident.

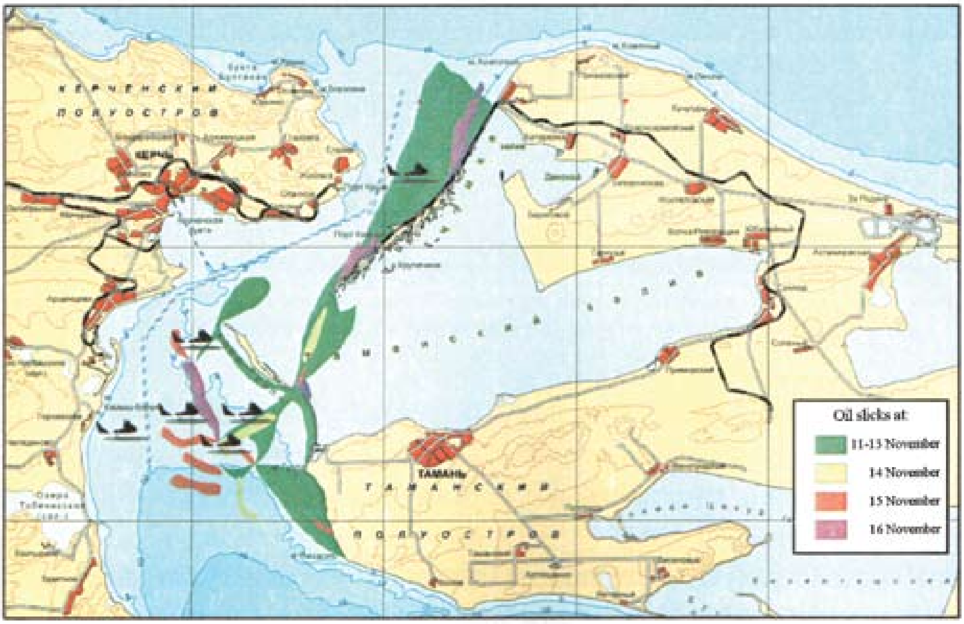

Fig. 8.4c. Scheme of oil expansion resulting from the 11 November 2007 oil spill accident in line with results of the Kerch Strait aerial survey conducted on 11–16 November 2007 (Matishov G. G., 2008). Periods: in green — 11–13 November, in yellow — 14 November, in red — 15 November and in pink — 16 November.

Photo. Intact *Rapana venosa* collected from the bottom by the Tuzla Island Southern and Eastern coasts in August 2008.

RU: AzNIIRKH, 2008.

Rapana venosa. Since 1995, the AzNIIRKH scientists have been engaged with monitoring research into the status assessment of mollusc populations inhabiting the North-Eastern Black Sea. According to the multiannual data, the Kerch Strait fishing area has always had a high Rapana population bioproductivity. The area is populated by different age groups of Rapana to include the 9^+ and 10^+ age groups. According to averaged multiannual data, the share of commercial size species (70 mm) exceeds 40 % of population, while its distribution density averages 2–3 ind/m^2. Taking into consideration *Rapana's* bottom-based way of living, it was expected that settling down of huge volumes of fuel-oil and sulphur left from the November 2007 accidents would negatively affect this gastropod population and stock. To determine the accidents impact on the *Rapana* communities condition status, in August-September 2008 relevant data were collected in the Kerch Strait and Black Sea coastal zone (Russian coastline). Sampling was carried out at 100 stations located at the depth from 1 to 20–25 meters. The expedition thoroughly inspected the Tuzla and Chushka Spits costal zones since Rapana population there had increased in numbers in 2006–2007 and large volumes of fuel-oil were washed ashore in November 2007 in the vicinity of those spits in particular.

Based on the data collected, in 2008 certain changes in molluscs distribution density, as well as in its size-and-mass and age structure were determined within the limits of potential long-term fluctuations though. Thus, *Rapana* was found present along the whole Russian Black Sea coastline from Adler to the Panagia Cape, as well as in the Kerch Strait waters at the depth from 2.5 m to 20 m. The *Rapana* distribution density broadly varied depending upon the area of investigation and it most often sustained 0.01–0.5 ind/m^2. In 2008, *Rapana*'s high abundance concentrations (exceeding 15 ind/m^2) were detected less often than during the previous years of investigation.

In the course of a more detailed analysis of *Rapana venosa* community presence in the Kerch Strait it was revealed that by the inner side of the Tuzla Spit young individuals could spread with density of 0.1–0.5 ind/m^2 at the depth of 0.5–5 m, while by its outer side and outwards of the Chushka Spit — at the depth of 20 m. Concentrations of 20–30 ind/m^2 density were detected at the middle-belts sites where the species mass and abundance were reaching their highest levels. Still, in 2008 no Rapanas were found in the Taman Bay proper.

Assessment of the *Rapana* population structure failed to reveal any substantial changes both in the species age and its gender composition. Still, it is worth noting that the share of the elder-group and larger-size (exceeding 10 cm) species had gone down, though unsubstantially in comparison with previous investigations. The 2008 analysis of this gastropod physiological and biochemical condition status did not reveal either any substantial change.

Thus, analysis of materials collected showed that the *Rapana* population distribution, abundance and structure in the Kerch Strait area had not been negatively impacted by the Kerch accident substantially, or the effect of the pollutants discharged into the Strait waters in November 2007 was hardly distinguishable from the existing chronic pollution influence and changes predetermined by the unstable environment conditions naturally present in the Strait.

Pontogammarus. *Pontogammarus* is the sole relict crustacean species present all along the Azov Sea coastline. It proves to be a reliable indicator of the water basin ecosystem wellbeing. While a typical filter-feeder, in coastal habitats *Pontogammarus* has a vital role to play in the substance and energy transformation processes. Its intense development seriously affects the coastal zone self-purification ability which is anthropogenic impact prone. Due to this, the *Pontogammarus* population condition status served as a reliable indicator in the assessments of the aftereffects of the November 2007 accident.

Assessment of the *Pontogammarus* population distribution, density and biomass was carried out in June-July 2008 at the Azov Sea coastal zone located close to the Kerch accident area, i.e., the Chushka Spit, Ahilleon Cape, Ilyich village, Za Rodinu village and in the vicinity of the Golubitskaya stanitsa. According to accumulated data, no substantial change in the *Pontogammarus* population qualitative and quantitative condition status was revealed. Thus, in the Ilyich village and Chushka Spit coastal zone, the worst oil pollution affected area, *Pontogammarus* population density and biomass, juveniles share and eggs number per female species were recorded the highest for the last three years of investigations, while still revealing a slight decrease (less than 11%) of female species abundance in samples (Table 8.4a).

Table 8.4a. Characteristics of *Pontogammarus* population present in the Kerch Strait and adjacent Azov Sea areas in 2005–2008 (Korpakova I. G., Agapov S. A., 2008).

Year	Density, ind/m²	Biomass, g/m²	Juveniles, %	Females, %	Females with eggs, %	Number of eggs per one female
Golubitskaya station						
2005	15421	391.0	25.8	61.3	8.0	5
2006	11712	250.4	7.5	59.7	2.0	9
2007	53373	353.3	79.9	17.0	17.0	12
Averaged 2005–2007	26835	331.6	37.3	46.0	9.0	9
2008	54906	483.4	73.5	49.4	4.9	13
Za Rodinu village						
2005	18466	328.7	40.8	55.8	7.0	7
2006	27200	607.6	2.2	54.1	–	–
2007	45350	254.7	74.0	6.0	6.0	12
Averaged 2005–2007	30339	397.0	39.0	38.6	4.0	6
2008	21700	199.5	63.5	36.3	5.0	7
Ahilleon Cape						
2005	650	14.6	15.4	45.5	–	–
2007	7200	75.3	48.6	5.4	5.4	10
Averaged 2005–2007	3925	44.9	32.0	25.4	3.0	5
2008	1700	22.0	41.2	50.0	10.0	11
Ilyich village						
2005	600	18.1	–	61.7	13.0	3
2006	1700	46.3	4.4	81.0	–	–
2007	25650	33.4	96.6	20.0	20.0	12
Averaged 2005–2007	9317	32.6	33.7	54.2	11.0	5
2008	29900	296.7	53.5	48.2	6.1	10

Pontogammarus communities revealed similar distribution patterns at all investigated sandy bottoms (e. g. nearby the Golubitskaya stanitsa). Yet, by the Za Rodinu village and the Ahilleon Cape, lower *Pontogammarus* population density and biomass were registered, while juveniles share and average eggs number per female individual were exceeding their annual averages. Still, the range of changes remained within the annual fluctuation limits for ecologically relatively safe years. It is worth mentioning that in the process of visual inspection of sampling sites and the adjacent coastline no residue left from the oil-spill pollution was detected.

Assessment of *Pontogammarus* stock in the areas of investigation is presented in Table 8.4b.

Table 8.4b. The *Pontogammarus* averaged stock (tons) at the sampling stations investigated in 2005–2008 (Korpakova I. G., Agapov S. A., 2008).

Station	2005	2006	2007	2005–2007 average	2008
Ahilleon Cape	2.4	–	12.5	5.0	3.7
Za Rodinu village	51.1	94.4	39.6	62.0	31.0
Ilyich village	0.8	2.0	1.5	1.4	13.2
Golubitskaya station	52.1	33.3	47.1	44.2	64.4

Therefore, the *Pontogammarus* population condition analysis carried out in the area directly affected by the autumn 2007 oil pollution has failed to reveal any substantial change in the population structure and abundance. Minor fluctuations in this *Amphipoda* abundance kept remaining within the limits of multi-year changes typical for the mentioned species. Analysis of the materials provided gave grounds to assess the consequences of the 11 November 2007 shipwreck as of low impact for the *Amphipoda* reproduction and stock conditions in the Russian section of the Kerch Strait and Azov Sea coastal zone.

UA: MKARTS-UkrSCES, 2009. In 2009, the Kerch branch of the Marine Coordination Rescue Center of the Ukrainian State Specialized Rescue Services on Water Bodies jointly with UkrSCES (MKARTS-UkrSCES) conducted a survey through diving inspections of the Kerch Strait and the Black and Azov Seas adjacent waters (Fig. 5.2.5.2b). The area surveyed totaled 35 613 m^2, while the main results accomplished were the bottom's surface miscellaneous photo/video materials obtained and the benthic flora and fauna samples collected to check the level of biota contamination with oil. No oil pollution present was identified at the investigated bottom areas in the course of conducted visual observation.

The individuals alive and eggs of *Rapana venosa*, *Nassarius reticulate,* the *Diogenes pugilator* hermit crab, crab-helmets traces, polychaeta holes, the tube houses most probably belonging to *Ampelisca diadema*, fragments of the *Xantho paressa* eelgrass and *Pilumnus hirtellus* crabs, and empty shells of Anadara — all that was observed at silt-sand bottoms in the Ukrainian coastal waters at the Kerch Strait entrance to the Black Sea. Silt sand covered with shells of mollusc and polychaeta holes, and the spread around dwellings of mobile hermit crabs were found at the *Volgoneft-139* tanker shipwreck site as well. At the ferry location in the Kerch Strait Northern section between the Crimean and Caucasian harbors, silt soil was detected covered with numerous empty shells partially greened by cyanobacteria. The *Actinia equina,* balanus, and many *Rapana venosa* specimens were found (Photo below). Large molluscs (Mia, Anadara) were not observed alive, though their shells were found present. At several stations located at the exit to the Azov Sea, nereids and small crabs were discovered.

In 2009, detected presence of crabs, hermit-crabs and mole-crabs, that used to be numerous in 1960s and almost disappeared later, evidenced the benthic fauna certain recovery in comparison with its condition status in the 1980s. However, an elevated level of organics present in the water revealed an unstable trend toward the Kerch Strait area ecosystem improvement as a whole.

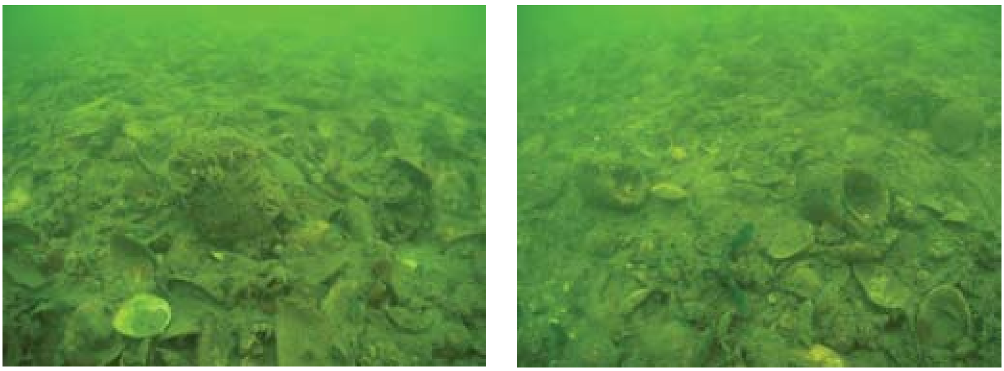

Photo: The Kerch Strait Northern narrowness bottom in 2009.

8.5 Phytobenthos

Investigations on the type of phytobenthos present in marine environment are crucially important when identifying the fate of oil hydrocarbons heavy fraction after oil spills. Products of seaweeds or macroalgae destruction contribute to hydrocarbons accumulation in the bottom sediments or on the coast.

According to the multi-year data, within the biocenoses of the researched area (the Kerch Strait, Tuzla and Chushka Spits, and the Taman and Dinsky Bays), all phytobenthos communities reside at the depth of up to 4.5 m (in the bays) and up to 20 m (by the spits) and have both poly- and mono-dominating composition. Communities have mosaic formation resulting primarily from difference in soils and due to the curved bottom surface in the places of the riffs coming out to the surface.

Seagrasses. At sand and slimy soils in the Kerch Strait, *Zostera marina* seagrass (eelgrass) presents the communities' base by forming 'bushes' with relatively high biomass. Assistant species may be fennel-leaved pondweed, *Lophosiphonia (Rhodophyta)*, hornweed and water milfoil. Annually, the higher plants biomass reaches values in the range of 0.5–5.0 kg/m^2 excluding the root mass (Korpakova I. G., Agapov S. A., 2008).

During the period of 23 July — 14 August 2008, in the Kerch Strait works were carried out through assistance of the several Russian agencies personnel and facilities to lift and transport to the Port of Caucasus the *Volgoneft-139* tanker's sunken bow part. As is well known, the Kerch Strait bottom there is densely covered with *Zostera marina* grass (eelgrass). Young *Zostera* is dominant in communities residing at the depth from 0.3 m to 0.8–1.2 m. At the depth starting from 0.5 m it forms mixed associations and its share in the benthic flora total biomass is around 40 %, while down from 1.5–1.8 m it accounts for 90 %. *Zostera*'s dead leaves usually form small floating 'islands' on the water surface. While towed after recovery, the *Volgoneft-139* bow part apparently released into the water the heavy fuel oil leftovers. This oil, having stuck to the dead floating plants around, was in a while transported to the Kerch Strait Southern section by the water currents and stranded further on onto the Kerch Peninsula coast nearby the Zavetnoe village. The same days, 150 bags of sea grass polluted with small oil particles were collected there (Fashchuk D. Ya., 2009).

The Taman Bay is the only place at the Russian Black Sea coast where the *Zostera marina* eelgrass forms a wide meadow to make a highly important structural component of the bay ecosystem, while being the organic matter major producer. The Taman and Dinsky Bays main ecosystem types (Fig. 2b) in terms of macrophytes distribution were described by Simakova U. V. (pers. comm.), (Fig. 8.5a) according to results of two SIO RAS expeditions carried out in February–March 2008 and July 2008.

In 2008, eelgrass was also detected in the Kerch Strait waves-protected silt areas jointly with living there different types of macroalgae, mollusc, crustaceans and fish. No pressure on plant formation and reductions in the higher-water-plants biomass as compared with the average multi-year data were registered in 2008.

Signs of a disease known as the «wasting disease» were detected at the Taman Bay during the February 2008 expedition. This disease is caused by the *Labyrinthula zosterae,* Porter and Muehlstein saprotrophic myxomycete. Normally, this myxomycete is present in old leaves and activates at the initial stages of the plants dying parts decomposition (Den Hartog, 1996). However, destruction of young leaves up to their full disappearance could take place also, when the eelgrass physiological state is de-

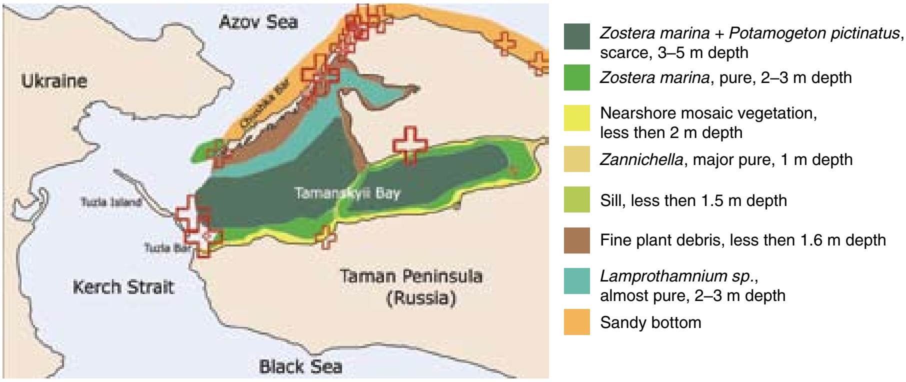

Fig. 8.5a. The bottom ecosystem scheme and the spring visual observation scheme of the storm drains pollution (graded, marked by crosses).

teriorated. Signs of the mentioned disease found in the sea grass would imply that under a stronger pollution effect the disease could spread as well to potentially result in the Kerch Strait «meadows» full disappearance. However, no considerable increase in percentage of the eelgrass leaves infected by *Labyrinthula* was detected during the summer survey. Vice versa, it is worth noting that in 2008, as compared with previous investigations, the eelgrass development area slightly expanded to the sandy and slow-flow sections of the shallow shelf waters. Thus, the Tuzla Spit (from the Taman Bay side) and the Verblud Cape sandy shelf areas were found densely populated by *Zostera*. The newly emerged formation had a biomass ranging from 0.5 to 2.5 kg/m^2, while from the Kerch Strait side it varied between 0.01 and 0.3 kg/m^2.

Macroalgae. Macroalgae are not diverse in the Kerch Strait, only two families are usually found, since the loose bottom sediments of the Strait provide poor conditions for algae development. Macroalgae proliferate in the Kerch Strait shallow coastal waters mainly (more stable bottoms). The *Ectocarpus* and *Cladophora* opportunistic filamentous macrophytes that grow well in polluted environments are present. Fragmentations of the multiannual brown algae *Cystoseira (Phaeophyceae)* grow in the places of the riffs coming out to the surface (the Panagia Riff, the Verblud Cape).

In August 2008, macrophyte biomass varied from 0.35 to 4.7 кg/m^2, while reaching from 0.8 to 6.5 kg/m^2 at certain sections. According to the data collected, macrophytes spatial distribution in 2008 experienced no substantial changes as compared with the previous years of investigation (Korpakova I. G., Agapov S. A., 2008).

8.6. Ichthyoplankton

Fish reproduction is a sensitive and informative indicator of the water environment condition status. Many fish species escape from polluted areas, and especially their breeding stocks avoid polluted water basins during spawning periods. The fishes ‘know’ that during the embryo and larvae development period the species do not have yet the fully-developed homeostasis system (usually acquired at later stages) and may be vulnerable to harmful impacts of polluted environment.

UA: IBSS. November–December 2007

Studies on ichthyoplankton were conducted at eight Kerch Strait stations on 28–29 November 2007 and at ten stations — on 16 December 2007. An inverted Bogorov-

Rass net with the mouth opening of 0.5 m^2 and mesh size of 500 micron was used to collect ichthyoplankton applying the total vertical (from the bottom to the surface) and horizontal surface catches regime.

The first ichthyoplankton survey was carried out 16 days after the Kerch Strait oil spill occurred. Eggs of sprat (*Sprattus sprattus phalericus* — 74%) and shore rockling (*Gaidropsarus mediterraneus*), and sprat and sand lance larvae (*Gymnammodytes cicerellus*) were found present in the water column. However, despite of the favorable temperature conditions, ichthyoplankton abundance was low. No eggs and only two larvae were found in the horizontal surface catches. In vertical catches, the eggs average number was 6.6 ind/m^2, larvae — 0.3 ind/m^2. More than 75% of sampled pelagic eggs appeared dead. All dead eggs were detected to have developed abnormalities (bubble formation, compression and deformation of the yolk, lack of pigment in embryos at the later development stages, etc.). High proportion of dead eggs with abnormalities at the last stages of development as well as low numbers of recorded larvae evidenced the presence of unfavorable for their survival conditions two weeks after the oil spill.

Ten vertical and two horizontal surface catches were carried out in the Kerch Strait on 16 December. The sea water temperature was optimal for spawning of the winter-spawning fish species. However, neither eggs, nor larvae were found in ichthyoplankton samples. Therefore, no spawning had occurred.

RU: AzNIIRKH. 2008

Table 8.6a. Average numbers of fish (ind/net) at the early development stages in the Black Sea Kerch-Taman area (Korpakova I.G., Agapov S.A., 2008).

Species	2005		2006		2007		2008	
	eggs	larvae	eggs	larvae	eggs	larvae	eggs	larvae
Sprat			0.1					
Whiting	1.1	0.3	0.3	0.1	1.0		2.1	
Dogfish	0.6			0.02		0.01		
Turbot	0.7		0.7		5.0		0.7	
Anchovy	622.8	4.6	392.1	4.3	427.2	2.3	180.2	0.2
Flathead mullet	0.01	0.02	0.1					
Golden grey mullet		0.01			0.1			
So-iuy mullet	0.3		0.3		0.3		0.3	
Thinlip Mullet	63.4		49.0	2.2	22.0		56.0	0.5
Horse mackerel	52.7	0.8	51.9	3.8	4.6	0.7	6.7	0.1
Brown meagre	3.2	0.02	0.5				0.3	
Comber	0.1							
Wrasse						0.4		0.04
Goldsinny-wrasse	0.2		1.4		0.1		1.1	
Sea bream	29.4	0.02	19.6	12.9	2.9		7.6	
Sand sole				0.04				
Cuskeel			0.2					
Black scorpionfish			0.2		0.4		0.2	
Stargazer	1.7				0.1			
Common dragonet			0.1					
Blenny		5.2		18.5		4.3		6.0
Pipefish				0.01		0.1		0.04
Caucasian goby		0.1		0.04		0.03		
Black goby		0.02		0.3				

AzNIIRKH research on condition status of ichthyoplankton was carried out in November 2007 and in 2008 in order to assess the Kerch Strait accident aftereffects and the adjacent water areas levels of pollution by oil products and sulphur (Korpakova I. G., Agapov S. A., 2008).

Traditionally, in the Kerch Strait proper ichthyoplankton abundance remains the lowest in comparison with the Black and Azov Seas due to constant changes in currents direction resulting in sharp fluctuations of water temperature and salinity. In 2008, a broader variety of fish species was witnessed in the pre-strait area from the Black Sea side, while from the Azov Sea side a lesser variety of fish species at the early development stages was recorded (Tab. 8.6a).

In general, complex research into the ichthyoplankton condition status in 2008, as well as comparison with data obtained in 2005–2007 (prior to the oil-spill disaster), has made it possible to conclude that the 2007 Kerch accident — after all clean-up activities — as a whole, produced no long-lasting impact on fish reproduction in the Azov and Black Sea areas adjacent to the catastrophe site.

8.7. Ichthyofauna (Fishes)

UA: IBSS. The 2006–2009 monitoring. November-December 2007

The Black and Azov Seas waters adjacent to the Kerch Strait are shallow and have no permanent currents; still their circulation is affected by the winds and temperature/salinity gradients. In the narrow-spaced Kerch Strait with adjacent waters, migratory fish forms large shoals thus creating favorable conditions for the fisheries. Anchovy and herring, whose migratory routes go through the Kerch Strait, are overfished, as well as the gobies, goatfishes, mullets, flounders, sturgeons, rays, sprats, sand smelts, garfish and some others. The Kerch Strait adjacent waters are one of the main commercial areas of the Black Sea. Also, it is a major spawning area for different fish species. Within the period of 1986–2007, fish eggs and larvae belonging to 29 species from 22 families were registered in the shelf area between the Kerch Strait and Feodosiya in the Crimea.

In the period of 26 November — 2 December 2007, the Kerch Strait ichthyofauna studies were carried out through using the pound and gill nets. For comparison was used the 2006–2010 monitoring data collected at the Azov Sea along the Kerch Peninsula coast to include the Cazantip Cape (Cazantip Nature Reserve) and the Cazantip and Arabatskaya Bays.

Traditionally, the Azov Sea ichthyofauna has the lowest species diversity compared to the other Mediterranean basin seas. According to different sources, 114–150 species and subspecies of fish are present in the Azov Sea. The genesis, taxonomy and ecological structure of the ichthiofauna there are most heterogeneous due to the rather harsh environment conditions and the sea turbulent geological history. The Azov Sea used to be one of the world most productive regions just 50 years ago and an annual fish catch there used to range from 73 to 82 kg/ha.

Presently, the ichthyofauna of the Cazantip and Arabatskaya Bays consists of 59 fish species belonging to 24 families. The *Cyprinidae* and *Gobiidae* family are most diverse, followed by *Clupeidae* family. The families *Percidae* and *Mugilidae* are each represented by 4 species.

Marine species make up 46% of the whole ichthyofauna. The pelagic species abundance is mostly formed by the thermophilic and marine species, such as the Azov and

Pontic Sea anchovy (*Engraulis encrasicolus maeoticus*, *E. e.ponticus*) and the Black Sea large sand smelt (*Atherina pontica*). In smaller quantities, the Black Sea horse mackerel (*Trachurus ponticus*), the Black Sea garfish (*Belone euxini*), occasionally golden grey mullet (*Liza aurata*), flathead mullet (*Mugil cephalus*) and rarely bluefish (*Pomatomus saltatrix*) could be detected.

The most common demersal species are red mullet (*Mullus barbatus ponticus*) and Common stingray (*Dasyatis pastinaca*). Species of families *Blenniidae* and *Syngnathidae* are well represented in the coastal zone, while species of family *Labridae* occur only occasionally.

The marine boreal species sub-group includes six species and subspecies: the Azov Sea turbot (*Psetta torosa*), the Black Sea flounder (*Platichthys flesus)*, three-spined stickleback (*Gasterosteus aculeatus*), the Black Sea whiting (*Merlangius euxinus*), So-iuy mullet (*Liza haematocheila*) and the relatively rare Black Sea turbot (*Psetta maeotica*).

The brackish-water fishes form a special group of the Azov Sea fauna (11 species and sub-species) originating from the Pliocene Pontic Sea-lake. The Pelagic Azov Sea sprat (*Clupeonella cultriventris cultriventris*) is most popular among the sub-species. Within this group, *Gobiidae* family are most diverse, consisting of nine species with the round goby (*Neogobius melanostomus*) among them which is most frequently present and accounts for the highest recorded numbers in catches. Occasionally, the Azov Perkarina (*Percarina maeotica*) could be detected in small quantities.

Eight species of migratory fish (mostly anadromous, which migrate from the sea to spawn in the rivers) are present in the Azov Sea. Among these, members of the family *Acipenseridae* are most valuable from commercial point of view, though almost all migratory fish has commercial importance. The catadromous European eel (*Anguilla anguilla*) is also present. Overfishing and negative anthropogenic impact have currently resulted in the catastrophic migratory fish populations decline. This primarily concerns the migratory shads (genus Alosa), the Azov shemaya (*Alburnus mento)*, the vimba bream (*Vimba vimba) and* three sturgeon species (*Acipenser gueldenstaedtii*, *Acipenser stellatus* and *Huso huso*) as well.

The group of semi-migratory fish consists of seven species, mainly from the Cyprinidae family: bream (*Abramis brama*), common carp (*Cyprinus carpio*), Prussian carp (*Carassius gibelio*), ziege (*Pelecus cultratus*), saber fish (*Rutilus rutilus heckeli*), wells catfish (*Silurus glanis*) and pike-perch (*Stizostedion lucioperca*). Recent investigations have shown that the latter species (pike-perch) inhabits the Kerch Strait front area sporadically only.

Freshwater fishes may be in small numbers detected in catches mostly during the river discharges increase. They belong to the families Cyprinidae (rudd, grass carp, carp), Percidae (European perch, Don ruffe) and Esocidae (Northern pike).

No serious changes were witnessed in the structure of the coastal fish communities inhabiting the adjacent (to the Kerch Strait) Azov Sea waters that could be directly linked to the Kerch oil spill accident.

RU: AzNIIRKH. January–December 2008

There were different programs conducted by AzNIIRKH in 2008 to produce materials for the biological communities condition status assessment within the Kerch Strait, and the Azov and Black Seas adjacent areas after the Kerch accident (Tab. 8.7a), (Korpakova I. G., Agapov S. A., 2008).

Table 8.7a. AzNIIRKH programs of research in the Kerch Strait and the Azov and Black Seas to study the impact of the Kerch accident on the living resources status in 2008.

Area of investigation	Works program title	Period of works
Azov Sea	Trawl survey for demersal fish stock assessment. Daily stations to study fish feeding.	July–August, September–October
	Trawl survey for so-iuy mullet and other fish species stock assessment.	February–April, November–December
	Condition status evaluation of semi-migratory fish species.	April–June
	Lampara, ichthyoplankton and zooplankton surveys.	June, August
	Evaluation of goby stock and its distribution in the coastal zone.	August–November
	Complex oceanographic survey and implementation of state monitoring program to assess anthropogenic pollution of the water and bottom sediments.	April–October
	Investigations into the so-iuy mullet population wintering grounds, distribution and condition status	January–April, October–December
	Investigations into the *Pontogammarus* population condition status and evaluation of its stock.	June–August
	Fishes stocks quantitative and qualitative characteristics, and evaluation of the bioresources commercial usage.	January–December
Kerch Strait	Migrations time clarification and yield evaluation, as well as investigations into the marine and migratory fish condition status in the Kerch Strait to include the Taman and Dinsky Bays.	January–December
Black and Azov Seas	The macrophyte and *Rapana* stocks assessment.	June–October
Black Sea	Control over migratory anchovy and its wintering concentrations.	January–April, October–December
	Control over the Sea fish reserves and evaluation of its reproduction efficiency.	May–June, August–September
	Control over scad migratory and wintering concentrations, its stock assessment.	January–February, November–December
	Complex oceanographic survey and implementation of state monitoring program to assess anthropogenic pollution of water and bottom sediments.	May–September
	Fishes stocks quantitative and qualitative characteristics, and evaluation of the bioresources commercial usage.	January–December
	Sea fish stock and distribution assessment in the Kerch–Taman shelf area within the Russian territorial waters and economic zone to include the Anapa bank.	March–September

Morphological, physiological, histological and toxicological analyses have been conducted for 12 commercial species. Age, length, and weight of up to 67 000 individuals were determined. Stomach content and fatness of 4415 specimens were analyzed. Major results per species are presented further below.

Dogfish. In the Kerch Strait proper, the very rare picked dogfish is mostly caught as by-catch in trawls and purse seines during the fishing season.

To scientifically define the population dynamics of dogfish, special trawlings have been carried out in 2005–2008 in the Black Sea Kerch-Taman areas adjacent to the Kerch Strait. The dogfish average catches (kg) per tug (1 trawling hour) of standard sprat trawl of up to 46 m depth are presented in Table 8.7b. As seen from the Table, in the pre-Kerch Strait area abundant concentrations of picked dogfish have been observed in 2005–2008.

Table 8.7b. Distribution of Dogfish in the Black Sea (shelf section adjacent to the Kerch Strait) in May–June 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Depth, m	Catch (kg) per 1 hour trawling							
	2005		2006		2007		2008	
	average	range	average	range	average	range	average	range
21–30	14.8	0–156.3	28.6	0–305.0	62.9	0–234.0	23.9	0–80.5
31–40	0.3	0–5.5	3.8	0–34.1	0	–	36.1	0–155.0
41–46	0	–	2.8	0–44.6	–	–	0	–
Total	5.3	0–156.3	9.7	0–305.0	34.9	0–234.0	28.0	0–155.0

Thornback ray (***Raja clavata* L.**). Thornback ray is a bottom-dwelling species belonging to the boreal and arctic zoogeographic complex. Adults are predators. *R. clavata* dwells in shelf and upper slope waters from the coastal line to about 100 m depth. In the course of the conducted in May–September 2008 two trawl surveys, Thornback ray was continuously detected at depths ranging from 21 m to 46 m (Table 8.7c). The oldest age groups were the most numerous, while juveniles were recorded in small numbers (1.3%). In recent years, Thornback ray concentration in the Kerch pre-strait area shows an increasing tendency (data 2005–2008).

Table 8.7c. Distribution of Thornback ray in the Black Sea (shelf section adjacent to the Kerch Strait) in May–June 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Depth, m	Catch (kg) per 1 hour trawling							
	2005		2006		2007		2008	
	average	range	average	range	average	range	average	range
21–30	0.43	0–4.20	3.46	0–28.90	2.10	0–10.50	6.30	0–10.80
31–40	0.44	0–4.74	0.83	0–6.00	5.80	0–17.20	11.10	0–43.40
41–46	0	–	0.76	0–6.36	–	–	0	–
Total	0.35	0–4.74	1.46	0–28.90	3.74	0–17.20	8.17	0–43.40

Common stingray (***Dasyatis pastinaca* L.**). Common stingray is a bottom-dwelling species that can be found from the shore to a depth of 10–20 m. During cold year periods it goes down from the surface to up to 90 m depth, takes lengthy migrations along the Black Sea coast. In summer, the species migrates to the Azov Sea through the Kerch Strait for overwintering and feeding on gobies.

Common stingray and Thornback ray are relatively large predators (Table 8.7d).

Table 8.7d. Average length and average weight of Thornback ray and Common stingray in 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Year	Thornback ray		Common stingray	
	Length (cm)	Weight (kg)	Length (cm)	Weight (kg)
2005	–	–	–	–
2006	44.5	4.3	–	–
2007	45.5	4.1	33.0	2.8
2008	43.3	4.4	37.3	3.3

Sprat ***(Sprattus sprattus phalericus*** **Risso).** The Black Sea Sprat is a typical Black Sea fish. It could be detected in rather large quantities in the Kerch Strait during the cold year period only (Tab. 8.7e). It is distributed over the whole Black Sea, but its maximum abundance is registered in the northwestern region. In spring, schools migrate to coastal waters for feeding. In the summer, sprat stays under the seasonal thermocline forming dense aggregations near the bottom during the day and in the upper mixed layer during the night.

Table 8.7e. Distribution of Sprat in the Black Sea (shelf section adjacent to the Kerch Strait) in May–June 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Depth, m	Catch (kg) per 1 hour trawling							
	2005		2006		2007		2008	
	average	range	average	range	average	range	average	range
21–30	702	95–1980	573	67–1170	145	50–370	425	0–1133
31–40	867	70–2150	789	234–3645	482	263–839	374	196–500
41–46	524	200–1330	965	198–1870	–	–	555	–
Total	741	70–2150	773	67–3645	295	50–839	410	0–1133

During the last decade a clear tendency of sprat stock reduction in the Black Sea Russian territorial area was recorded. Apparently, the trend is triggered by climatic changes and reconstruction of the Black Sea foodweb. However, since 2008 sprat stock stabilization has been noticed, with growth in certain sea areas registered. One of these areas is the section of the Black Sea Kerch-Taman area adjacent to the Kerch Strait.

Whiting *(Merlangius merlangus euxinus* Nordmann*)*. In the Black Sea, whiting is one of the most abundant demersal species (Table 8.7f). Like turbot, it does not undertake distant migrations, and spawns mainly in the cold season all across the basin. Whiting produces pelagic juveniles, which inhabit the upper 10 m water layer for one year. The adult whiting lives in cold waters (6–10ºC) and forms dense concentrations at depths up to 150 m (most often at 60–120 m depth).

Table 8.7f. Distribution of Whiting in the Black Sea (shelf section adjacent to the Kerch Strait) in May–June 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Depth, m	Catch (kg) per 1 hour trawling							
	2005		2006		2007		2008	
	average	range	average	range	average	range	average	range
21–30	8.1	0.1–67.0	6.7	0–30.0	0.5	0–2.6	1.3	0–6.5
31–40	24.9	1.6–110.0	11.4	1.7–33.0	9.9	3.1–14.3	22.2	15.0–28.0
41–46	10.7	0.4–30.0	17.4	2.0–51.0	–	–	45.0	–
Total	16.2	0.1–110.0	11.5	0–51.0	4.7	0–14.3	15.4	0–28.0

During the last decade, whiting has experienced a trend of stock reduction. In 2008, certain whiting stock increase on the Black Sea shelf and in the Kerch-Taman area adjacent to the Kerch Strait, has been recorded.

Turbot (***Psetta maeotica maeotica*** **Pallas**). In all Black Sea countries, turbot is one of the most valuable fish species. Turbot does not undertake distant transboundary migrations. Local migrations for spawning, feeding and wintering occur between the coast and the offshore areas.The data collected in 2005-2008 have shown an increasing trend for the turbot stock in the shelf section under investigation (Table 8.7g).

Table 8.7g. Distribution of Turbot in the Black Sea (shelf section adjacent to the Kerch Strait) in May–June 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Depth, m	Catch (kg) per 1 hour trawling							
	2005		2006		2007		2008	
	average	range	average	range	average	range	average	range
21–30	0.8	0–9.5	2.7	0–8.5	4.5	0–11.7	1.2	0–5.8
31–40	0.9	0–7.1	6.2	0–32.0	2.5	1.5–4.8	15.6	0–48.4
41–46	2.1	0–8.0	6.2	0.7–17.9	–	–	5.4	–
Total	1.1	0–9.5	5.3	0–32.0	3.7	0–11.7	8.7	0–48.4

Horse mackerel (*Trachurus mediterraneus ponticus* Aleev). The Black Sea horse mackerel is a subspecies of the Mediterranean horse mackerel *Trachurus mediterraneus*. It is a migratory species distributed all over the Black Sea. During spring, it migrates to the north for reproduction and feeding. In the summer, it is found mainly in shelf waters above the seasonal thermocline. During autumn it migrates towards the wintering grounds along the Anatolian and Caucasian coasts. It is a warm-water pelagic species with a wide range of abundance in the investigated areas (Tab. 8.7h). In the investigated areas, the stock of horse mackerel was particularly high in 2008.

Table 8.7h. Distribution of Horse mackerel in the Black Sea (shelf section adjacent to the Kerch Strait) in May–June 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Depth, m	Catch (kg) per 1 hour trawling							
	2005		2006		2007		2008	
	average	range	average	range	average	range	average	range
21–30	0.235	0–1.900	–	–	0.005	0–0.023	63.0	9.0–97.2
31–40	0.001	0–0.012	–	–	0	–	2.90	0–8.9
41–46	0.005	0–0.050	–	–	–	–	0	–
Total	0.084	0–1.900	–	–	0.003	0–0.023	27.70	0–97.2

Red Mullet (*Mullus barbatus ponticus Essipov*). The red mullet is a species inhabiting sandy and muddy bottoms. Its habitat extends from the shallow littoral zone (especially of juveniles) down to 300 m, but it is more common in depths between 20 and 50 m. The total abundance of mullets entering for fattening the Azov Sea fluctuated from 450 thousands (2005) to 28 mln individuals (2006) reaching 5.2 mln individuals in 2007. The North-Caucasian mullet stock has a clear two-year periodicity in production of abundant offspring.

The Azov-Black Sea bluefish. Among the six species of mullets from the *Mugilidae* family inhabiting the Black and Azov Seas, three species (*Liza aurata* (golden mullet), *Mugil cephalus* and *Liza saliens*) and one acclimatized species *Mugil so-iuy* (*Liza haematocheilus*) are of commercial value. Mullets are distributed all over the coastal waters and in the estuaries adjacent to the Black and Azov Seas. Their migration routes run along the whole coast and via the Kerch Strait (to the Sea of Azov and back). Wintering migrations of mullets are most intensive in November. Wintering of warm-loving aboriginal mullets takes place in the narrow coastal zone and in bays at less than 25 m depth. Spawning migrations of aboriginal mullets from feeding grounds to the Black Sea take place in late August-September. The most abundant stock occurs in the northern Black Sea in the waters of the Russian Federation and Ukraine. The main fishery area is the Kerch-Taman area, data on catches in 2005-2007 are presented in Table 8.7i.

Table 8.7i. Abundance (th.ind) and biomass (tons) by age class of *Liza aurata* in commercial catches (Kerch-Taman area) in 2005–2007 (Korpakova I.G., Agapov S.A., 2008).

Age	2 (2+)		3 (3+)		4 (4+)		5 (5+)		6 (6+)		Total	
Year	th. ind.	tons	th. ind.	tons	th. ind.	tons	th. ind.	tons	th. ind.	tons	th. ind.	tons
2005	25.6	5.3	126.6	42.8	23.3	11.1	6.0	4.2	0.4	0.3	181.9	63.7
%	14.1	8.3	69.6	67.2	12.8	17.4	3.3	6.6	0.2	0.5	100	100
2006	44.7	8.9	78.1	22.7	102.5	40.3	52.1	24.7	18.6	9.6	296.0	106.2
%	15.1	8.4	26.4	21.2	34.6	37.9	17.6	23.3	6.3	9.2	100	100
2007	3.6	0.8	37.1	9.6	39.8	14.0	4.2	1.8	–	–	84.7	26.2
%	4.2	3.1	43.8	36.6	47.0	53.4	5.0	6.9	–	–	100	100

Prior to the Kerch accident, the distribution of golden mullet has been studied in the Sea of Azov (Fig. 8.7a), most dense accumulations have been found in the south-west areas of the Sea.

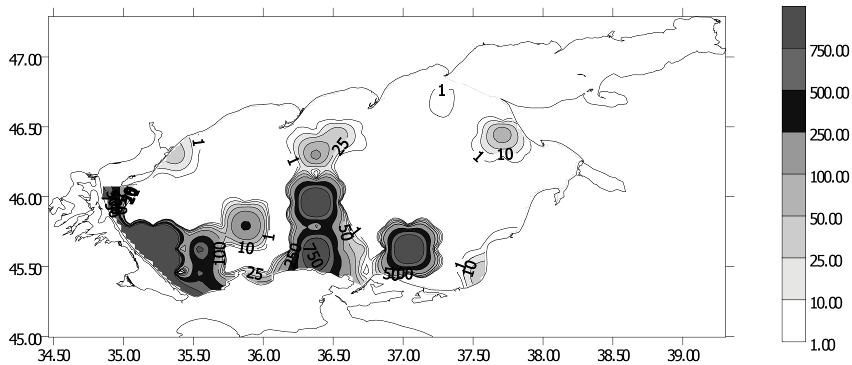

Fig 8.7a. Distribution of 1 year-old golden mullet (th.ind/km²) in October 2007 in the Sea of Azov (after Korpakova I.G., Agapov S.A., 2008).

In 2008, two-year-old specimens were the most abundant age group (96.3%) in the golden mullet population. Their length and weight ranged from 13.5 cm to 18.5 cm. (average 15.7 cm) and from 26 g to 76 g (average 42 g), respectively (Table 8.7j). The maximal catches (kg) per 1 hour trawling in the end of May 2008 varied in the range of 4.9–5.3 kg. These catches were at the levels registered in previous years.

Table 8.7j. Average length (cm) and weight (g) by age class of Golden mullet in May 2008 in the Kerch-Taman area (after Korpakova I.G., Agapov S.A., 2008).

Fishing gear		Age, years					Gender, %	
		2+	3+	4+	5+	6+	male	female
Bag nets, 16 mm cell mesh	L, cm	15.7	23.3	–	–	–	0	18.5
	M, g	42	144	–	–	–		
Set nets, 45–50 mm cell mesh	L, cm	–	23.1	28.5	34.6	38.7	6.8	93.2
	M, g	–	144	357	498	767		

In 2008, the Azov-Black Sea bluefish migrations in the Kerch Strait area remained traditional, and the bluefish Taman Bay presence and catches per tug stood at the levels registered prior to the Kerch Strait catastrophe, according to the carried out research results.

Goby (Gobiidae). The Sea of Azov is inhabited by 15 Gobiid species, all of them are demersal species permanently inhabiting the Kerch Strait, and the Taman and Dinsky Bays. Five species are subject to intensive commercial fishery.

In previous times (1950s and 1960s), the catches of gobies varied widely between 50 tons and 90 th.tons. Later on (1980s and 1990s), the gobies catches decreased to 1 th. tons. The stock of gobies has decreased due to salinity increase of up to 11.5–12.5‰, anoxic situations and spawning sites silting in the 1970s and 1980s, and experienced in the 1950s–1960s heavy overfishing. Up till the 20th century end, goby stocks remained depressed, yet started recovering during the last years. In 2007, the Russian and Ukrainian goby catches stood at 7 th.tons. In 2008 gobies distribution, migration and concentration in the Kerch Strait area remained typical and at the previous several years level.

So-iuy mullet (***Liza haematocheilus*** Temminch *et* Schlegel). So-iuy mullet is a relatively new species for the Azov-Black Sea area. Its self-reproducing population emerged in the Azov Sea in the end of the 1980s and the Kerch Strait has become its prime migration area (its wintering goes on in the Black Sea and reproduction — on the Don River). In the recent years, the Azov so-iuy mullet abundance and stock went up from 5 mln ind. undividuals in 1996 to 30 mln ind. in 2005, currently remaining at a reasonably stable high level.

Due to the dramatic decrease in abundance of indigenous migratory and semi-migratory commercial fish species, the So-iuy mullet became a valuable commercial target species for fisheries. In 1997–2007, catches of so-iuy mullet in the Azov Sea waters varied within 3.5–12.3 tonnes.

The Azov-Black Sea migratory herring (*Alosa immaculata* Bennett). Specimen older than eight years have not found in the catches of 2005–2008. In 2005–2007, the herring abundance varied in the range of 292.6 to 707.5 thousand individuals in the waters adjacent to the Kerch Strait. Herring's total abundance and commercial stock increased in 2008. In summer 2008, herring abundance in the pre-strait area stood at 1658.3 th.ind. (Table 8.7k). No negative impact of the Kerch accident on the herring population and hence on fishing effort has been found.

Table 8.7k. Abundance (th.ind) of So-iuy mullet and herring in the Sea of Azov (adjacent to the Kerch Strait) in 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Years	2005	2006	2007	2008
So-iuy mullet	11 858	2561	3560	6244
%	25.23	21.45	40.81	48.48
Herring	707	878	292	1658
%	8.1	16.6	2.4	13.8

No negative impact of the Kerch accident on the so-iuy mullet and herring has been observed.

Anchovy. The Azov anchovy moves to the Kerch Strait and the Sea of Azov for fattening and spawning in spring and returns to the Black Sea coasts for wintering. There are two fishing seasons in the Kerch Strait: the first takes place in October–November where fish such as anchovies migrate from the Azov to the Black Sea; the second is in March–April where fish go from the Black Sea to Azov Sea.

Ukrainian fleet caught 4600 tons of anchovy during November, including 2800 tons after the Kerch Strait accident, having fully exhausted its annual national quota. As of 16 March 2008, the Azov anchovy catches stood at around 5.1 th.tons (34% of national quota). This fishing commercial indicator appeared to be the highest for the last decade.

Thus, anchovy stock during and after the Kerch oil spill accident revealed a good population condition status (Tables 8.7l and 8.7m). Anchovy recruitment in 2008 has been found low, however, this was rather related to low mesozooplankton abundance (food limitation). No negative impact of the accident on anchovy has been recorded.

Table 8.7l. Biomass (th.tons) and density (kg/km^2) of anchovy in the Sea of Azov during spawning migrations in 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Year	Biomass, thousand tons				Density (kg/km^2)			
	pre-Kerch Strait	Azov Sea proper	Taganrog Bay	Total stock	pre-Kerch Strait	Azov Sea proper	Taganrog Bay	Total stock
2005	1.93 (7.4)	23.07 (89.1)	0.90 (3.5)	25.90	1600	750	280	740
2006	1.34 (5.1)	23.85 (90.3)	1.21 (4.6)	26.40	1120	750	430	760
2007	2.11 (3.8)	52.39 (94.7)	0.80 (1.5)	55.30	1760	1700	880	1590
2008	5.47 (7.3)	68.64 (91.5)	0.89 (1.2)	75.00	4560	2230	320	2470

Note: The share (%) of area biomass from the stock subtotal is given in brackets.

Table 8.7m. Biomass (th.tons) and density (kg/km^2) of anchovy in the Sea of Azov during feeding migrations in 2005–2008 (after Korpakova I.G., Agapov S.A., 2008).

Year	Biomass, thousand tons				Density (kg/km^2)			
	pre-Kerch Strait	Azov Sea proper	Taganrog Bay	Total stock	pre-Kerch Strait	Azov Sea proper	Taganrog Bay	Total stock
2005	8.40 (15.7)	37.40 (70.0)	760 (14.3)	53.40	7000	1220	1690	1460
2006	0.90 (1.5)	59.86 (97.5)	0.64 (1.0)	61.40	750	1940	130	1670
2007	0.86 (1.1)	73.39 (94.7)	3.31 (4.2)	78.10	720	2400	680	2120
2008	0.19 (0.1)	162.71 (93.0)	12.10 (6.9)	175.00	160	5200	2330	4700

Note: The share (%) of area biomass from the stock subtotal is given in brackets.

8.8. Parasitology

UA: IBSS. 2006–2009. According to parasitological studies conducted, massive death of the girodaktilyus type parasites was registered to occur on the skin of fish caught in the Kerch Strait right after the accident. It is well known that mucus covering the fish skin may serve as nutrition source for monogeneans, while being a good sorbent. Therefore, the parasites death may be well attributed to petroleum hydrocarbons absorption by the fish skin mucus. The monogeneans species composition and presence on the whiting skin recorded later in May 2008 did not reveal any change in their condition status observed in May 2007 prior to the Kerch Strait accident. It was obvious that ectoparasites population had quickly recovered to its baseline state.

8.9. Mass mortality of fish due to oxygen defficiency

UA: IBSS. July 2007. During the last decades, fish mass mortality from oxygen deficiency has become a common phenomenon at the Azov Sea. Large amounts of nutrients stem to the sea as a result of different anthropogenic activities. Correspondingly, the Azov Sea has turned into a highly-eutrophicated area. During summers, when the water is stratified and well warmed at the surface, chances for hypoxic and anoxic situations to develop increase highly. Fish mass mortality due to oxygen deficiency was registered in 27 July — 1 August 2007 by the IBSS expedition carried out in the Cazantip Cape and Arabatskaya Bay coastal waters.

The day of 27 July 2007 was characterized by calm weather. In the narrow coastal zone, the surface water temperature was exceeding 30°C. Salinity varied from 10.66% at the surface to up to 10.95% at the bottom. Associated with phytoplankton active development, oxygen saturation in the surface water layers ranged from 129% to 171%, whereas in the bottom layers it was registered as 6% only at certain locations. In parallel, bacterioplankton total abundance was witnessed very high to average 6.46±2.21 mln cells/ml. The maximal presence of bacteria (more than 8 mln cells/ml) was detected by the Cazantip Cape Eastern shore, whereas their density in the Northern section was minimal (about 4 mln cells/ml). Bacteria cells were mainly represented by the 0.113–0.268 μm^3 biovolume cocci. Phytoplankton abundance had a 1.5–35.8 mln cells/m^3 and the biomass stood at 4.5–104.5 g/m^3. Toxic microalgae were identified as the dominant species at the most stations.

Five tons of the Azov sprat (*Clupeonella cultriventris cultriventris*) were found stranded onto the Azov Sea Tatar Bight shore on July 28. The species is pelagic and its mortality was not related to the oxygen deficiency. High concentrations of toxic *Cyanophyceae* algae, such as *Anabaena knipowitschii* and *Aphanizomenon flos-aquae,* could have been the cause of the fishes death. Blue and green algae were visibly forming colored bands on the surface of the studied area. On top of that, the *Prorocentrum*

Photo. Fish mass mortality resulting from oxygen depletion in the Azov Sea, registered on 29 July 2007 at the Cazantip Cape (above, by *Eugeniya Karpova*) and another cases here (below, from http://novosti-n.mk.ua, http://www.rostov-fishcom.ru).

micans and *Prorocentrum cordatum* (*Dinosphyceae)* species, both known as potentially harmful, were found dominating in the phytoplankton biomass, while forming red tides (discoloration of water). Howeever, the benthic fishes mortality observed in parallel derived from presence of hypoxia in the bottom layers of the studied areas.

In the morning of 29 July 2007, mass stranding of gobies, inactive and easily caught by hands, was observed at the Cazantip Cape and in the Arabatskaya Bay. Over the next four days, their mass mortality area had increased in size and spread along the Cazantip Cape entire coastal zone reaching certain spots at the Arabatskaya and Cazantip Bays. Four species of goby were discovered, with the round goby (*Neogobius melanostomus*) dominating presence of 40.2 % followed by the knout goby (*Mesogobius batrachocephalus*) — of 29.6 %, the monkey goby (*Neogobius fluviatilis*) — of 19.0 % and the mushroom goby (*Neogobius eurycephalus*) — of 11.2 %. The Black Sea large sand smelt (*Atherina boyeri pontica*) and shrimps were detected occasionally. The dead fish individuals were found everywhere: washed ashore, lying at the bottom and floating on the surface. In average, 190 dead goby individuals were found in 100 m^2 area of bottom and surface waters. The dead fish patches ranged from 10 m to 40 m (25 m in average) at the bottom and from 50 m to 150 m on the surface. According to observations, the dead fish belt stretched for at least 10 km. It was difficult to calculate the commercial goby species total loss, since dead fish was distributed unevenly. By very rough estimations, the dead gobies mass off the Cazantip Cape coast ranged from 75 to 115 tons. No fish eggs or larvae were recorded.

In 2008–2009, no oxygen deficiencies have been recorded, as well as mass mortality of fish has not taken place in the Kerch Strait area.

8.10. Cetaceans

The Kerch Strait cetacean fauna is limited to the Black Sea subspecies of the bottlenose dolphin (*Tursiops truncatus ponticus*) and harbour porpoise (*Phocoena phocoena relicta*). Bottlenose dolphins form local aggregations of 80–130 individuals that leave the Kerch Strait area for the Black Sea in winter. Harbour porpoises (about 3000 individuals) take annual migrations, leaving the Azov Sea through the Kerch Strait in autumn and returning back in spring. These movements concur with seasonal migrations of anchovy, one of the preys preferred both by the porpoises and the dolphins (Birkun A., Krivokhizhin S., 2008).

It is very likely that the Kerch Strait marine mammals were directly impacted by the Kerch accident to lesser extent than other species (e. g., sea birds). No mass cetacean strandings (i. e., mass mortality), nor live animals ashore were observed during and after the Kerch Strait catastrophe. For instance, along the Kerch Strait Ukrainian coast, during ten days in the period of 11–20 November no cetacean stranding was recorded. At the Russian coast, on 13 November two dead animals (a bottlenose dolphin and probably small harbour porpoise) were found by a clean-up team on the Chushka Spit. However, both bodies where not examined and could have been washed ashore prior to the catastrophe or could have resulted from the experienced heavy storm. Cetacean stranding is not rare in that area, and is mostly produced by the fishing gear bycatch, which is not related to such factors as local pollution. Therefore, there is no clear evidence of cetaceans mortality resulting from the Kerch Strait oil spill during the disaster or afterward.

Conclusions

Based on results of investigations conducted in 2007–2008 after the Kerch Strait accident and on their comparison with the Kerch Strait background and baseline data/information, the following conclusions were drawn regarding the Kerch Strait oil spill impact on the biota. The accident severely damaged bird populations in the region, as it was described in Chapter 6.3. However, the Kerch Strait water and bottom communities got insignificantly disturbed, and the experienced impacts were not large in space and were unimportant by duration. Certain changes were registered at different trophic levels: bacteria, algae, ichthyoplankton, zooplankton, macrozoobenthos, and fish ectoparasites, but their causal relationship with the November 2007 oil spill accident was hardly established. The oil-spill effect was rather traceable for zoo-, ichthyoplankton and ectoparasites only. All the registered changes lasted for no longer than six months. By 2009, the Kerch Strait ecosystem was showing no status differences compared to the period prior to the accident. The latter could be well explained by prompt removal of the fuel oil residues produced both by the devastating storm itself and left from the clean-up operations at the coast.

Nevertheless, the Kerch Strait and its adjacent waters have to be classified as the area of chronic and substantial pollution produced by large and numerous anthropogenic pressures present in the area since many decades.