Condition of the Kerch Strait ecosystem two years after the disaster of winter 2007: Preliminary results

Kovalyshyna, S., [1] *Yanko-Hombach, V.* [2, 3]*, Komorin, V.,* [4] *Matygin, A.,* [5] *Ukrainsky, V.* [6]*, Den'ga, Yu.,* [7] *and Likhodedova, O.G.* [8]

[1, 4-6] Ukrainian Scientific Centre of Ecology of the Sea, 89, Frantzuskii Blvd, 65009 Odessa, Ukraine, [1] *svetakovalish@rambler.ru*, [2] *vkomorin@mail.ru*, [3] *acm32alex@mail.ru*, [4] *popov50@mail.ru*, [5] *vladukr49@vail.ru*

[2] Scientific and Educational Center of Geoarchaeology, Marine and Environmental Geology, Dvorianskaia Str., Odessa I.I. Mechnikov National University, Odessa 65082, Ukraine,

[3] Avalon Institute of Applied Science, Winnipeg, MB R3E 1B4, Canada, *valyan@avalon-institute.org*

7 Department of Engineering Geology and Hydrogeology, I.I. Mechnikov Odessa National University, 2, Shampanskii Per., Odessa 65058, Ukraine, *log44@mail.ru*

Key words: monitoring, aliphatic and aromatic hydrocarbon, macrobenthos, meiobenthos

Introduction

Kerch Strait is situated between the Kerch Peninsula of Crimea and the Taman Peninsula of the Kuban; it joins the Black Sea and the Sea of Azov. Its length is 41 km; its width, 4–15 km; and its depth, 5–13 m. The strait is an important navigation route. Increasing ship transportation activities, with up to 40 vessels per day, provide for a high risk of vessel accidents in the strait, and this is compounded by the type of cargo being transported. This puts a heavy burden on marine ecosystems and increases ecological risks to biota.

On 11 November 2007, a severe storm in the Kerch Strait with winds up to 35 m/s and waves up to 5 m resulted in 13 vessels being sunk, stranded, or damaged. Among these vessels was the motor tanker Volgoneft-139 with 3463 t of residual oil on board; it was broken into two pieces and sank in its muddy anchorage. According to data provided by the Ukrainian Ministry of Transport, as of 20 November 2007, the total amount of the immediate spillage was 1300 t of heavy fuel oil, 2.3 t of oil lubricants, 25 t of marine diesel fuel oil, and 5.5 t of heating oil. Three other motor vessels, Volnorgorsk, Nahichevan, and Kovel (each one carrying about 2000 t of sulphur) also sank and drifted toward the coast of Ukraine (south of Tuzla Spit); however, they did not present any immediate large-scale environmental danger in terms of the sulphur. The water toxicity was not considered an immediate problem, as the potential spill will not lead to the presence of colloidal sulphur in suspension (Rasmussen et al., 2007).

Two years after disaster, the Ukrainian Scientific Centre of Ecology of the Sea (UkrSCES) was appointed by the Ukrainian Government to evaluate the ecosystem conditions in Kerch Strait in order to document possible consequences of the spill on biota.

This paper presents preliminary data on the condition of the ecosystem in Kerch Strait (Stations #33-73) two years after the disaster, with the main focus on the spatial distribution of petroleum (aliphatic and aromatic) hydrocarbons in the surface and bottom water, as well as sediments, and their possible influence on biota (exemplified by macro- and meiobenthos). The analytical treatment is still in progress, and we expect more results to come, enabling us to perform a multifactor statistical analysis that will be reported elsewhere.

Study area

The study area includes Kerch Strait (Fig. 1). This shallow strait possesses an unstratified water exchange between the two adjacent basins consisting of a surface current that flows from the Sea of Azov to the Black Sea at 1–2 m/sec and a lower current that flows in the opposite direction at a depth of about 5 m. The former carries about 33.4 km3/year of water from the Sea of Azov with a salinity of 11–13 ‰, and the latter carries about 49.8 km3/year of Black Sea water with an average salinity of 18‰ (Bondar, 2007).

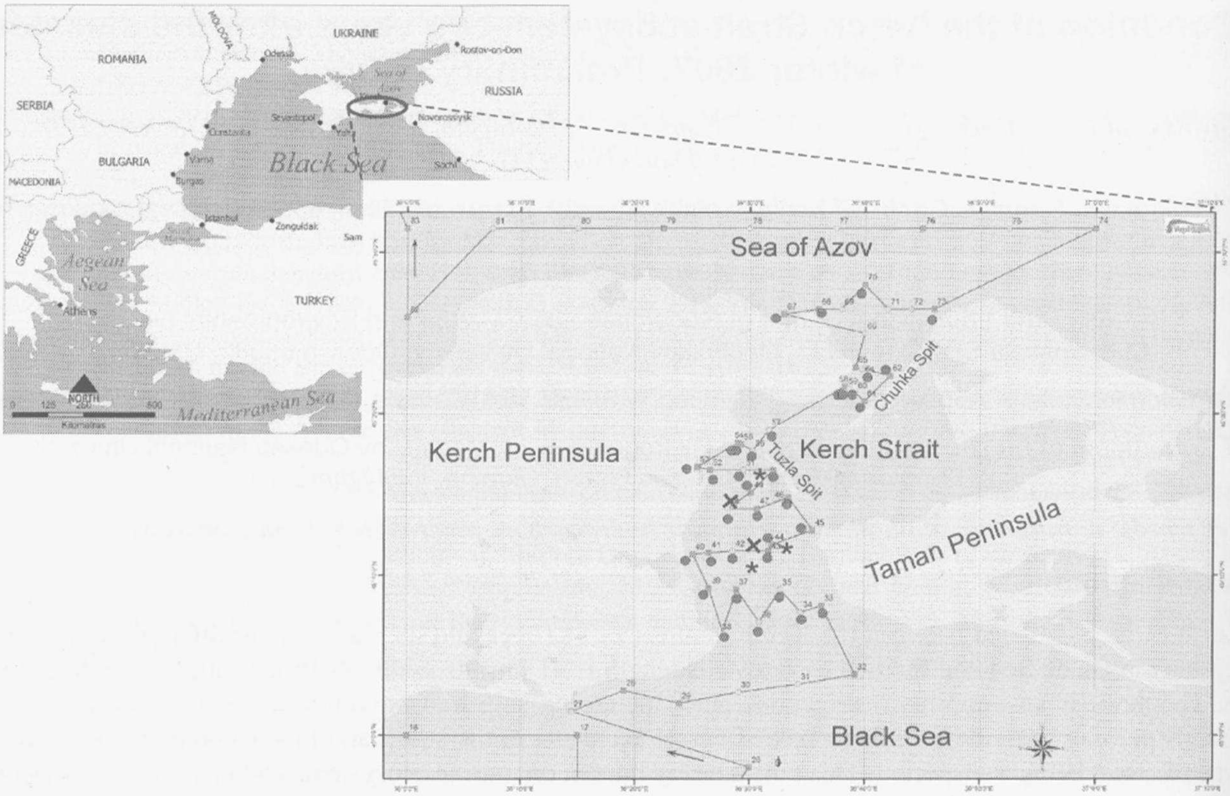

Figure 1. Sampling map of the 31th cruise carried out on R/V Vladimir Parshin in December 2009. Crosses identify the locations of the two parts of the sunken motor tanker Volgoneft-139; asterisks identify the locations of the sunken motor vessels Volnogorsk, Nahichevan, and Kovel (all under Russian Flag). Green squares = stations sampled for hydrological, hydrochemical, lithological, and geochemical analysis; yellow squares = stations sampled for hydrological parameters only; red circles = stations sampled for macro- and meiobenthos.

Material and methods

Twenty six stations at water depths of 3–14 m have been sampled in the Kerch Strait (Fig. 1). At all stations, the salinity, T°C, pH, and DO, were measured using a Neil Brown Instruments Systems (STD) with a General Oceanic rosette and Niskin bottles at several water layers. It also provided water samples for further analysis of BOD_5, nitrite-N, nitrate-N, ammonia-N, N_{total}, P_{org}, P_{min}, P_{total}, C_{org}, seston, as well as concentration of aliphatic and aromatic hydrocarbons, heavy metals, and pesticides, which were also measured in bottom sediments.

Sediment samples were obtained with a Petersen's bottom sampler (0.25 m^2) and subsampled from the uppermost 2 cm of the sediment column for grain-size, geochemical, and biological analyses. Grain-size study of the sediments was performed by wet sieving and pipette analysis as described in Rukhin (1969). Biological samples were obtained by thimble with an inlet hole of 12.5 cm, washed on the deck through 1 mm and 67 μm sieve, stored in 4 % formalin solution buffered with sea water, and stained in the laboratory with buffered Rose Bengal over 48 hours. Zoo- and phytoplankton were collected by Jedi trap but not discussed in this report.

Foraminifera and ostracoda were investigated using methods described in Yanko and Troitskaya (1987). Other macro- and meiobenthic organisms were investigated by standard methods (Standard ..., 1994). All Rose Bengal stained organisms were counted and expressed as number of specimens/m^2. For each group of organisms, a habitation density, biomass, and type of substrate were determined. For some groups, a simple diversity was calculated with identification of dominant species at each station and in the area.

Preliminary results and discussion

The concentration of DO in the upper water layer is ranged between 8.82-11.01 mg/l (avg 10 mg/l). Relative saturation of DO varies between 95.7 and 101.4% (avg 97.7 %). The highest concentration of DO was observed in the northern part of the strait in the area of cold Azov water. Concentration of DO in the bottom water layer did not exceed 100% ranging from 95.5 to 99.0 % with absolute concentration 9.1-10.6 mg/l.

BOD5 is ranged between 0.4 and 2.8 mg O2/l, and does not exceed the maximum rate of consuming 3 mg O2/l. However, BOD values that are so low always need to be interpreted carefully, because the systematic error of BOD measurements at these concentrations is rather high.

pH of the upper water layer varied between 8.13 and 8.5 while in the bottom water layer it did not exceed 8.43.

Concentration of nutrients (phosphorus and nitrogen) is characterized by dominance of their organic forms. In the upper layer concentration of phosphates was ranged between 3.9 and 31.0 μg/l while in the bottom layer it increased up 36 μg/l. An increase in concentration of phosphates in the upper layer was observed in the southward current of Azov water. Ratio Porg/Pmin in the upper and bottom layer was 1.7 and 2.0, respectively. Ptotal in the upper and bottom water layer varied between 14 and 56 μg/l (avg 39.5 μg/l) and between 21 and 108 μg/l (avg 47.2 μg/l), respectively.

Ratio Norg/Nmin in the upper and bottom water level varied between 34.5 and 36.0, respectively, pointing out on a high level of water eutrophication.

Concentration of nitrite-N was insignificant due to their character as intermediates in metabolic chains. Their average values in the surface and bottom layer were ~ 2.0 μg/l. The highest concentration of nitrite-N 6.9 μg/l was observed in the northern part of the strait in bottom water of the Sea of Azov.

Concentration of ammonia-N in the upper water layer was ranged varied between 1.0 and 14.1 μg/l (avg 5.3 μg/l. The highest concentration of ammonia-N 35.2 μg/l was also observed in the bottom layesr of the northern part of the strait.

An average concentration of nitrate-N varied between 6.8 and 7.0 μg/l. Their highest concentrations (23.3-24.3 μg/l) were observed in the coastal and central part of the strait in the area of Kumysh-Burun Cape.

Concentration of TKN (=Ntotal) ranged between 70 and 1070 μg/l (avg 550 μg/l). The highest concentrations of TKN (>900 μg/l) both in the upper and bottom layer were observed in the northern part of the strait and in the area of Kumysh-Burun Cape. High concentration of TKN (mainly organic form) is related to the current of Azov water. In the Sea of Azov its value reached 1260 μg/l.

All abovementioned environmental parameters are within their limits. However benthic biota (exemplified by macrobenthos) shows significant impoverishment compared to the year 2005 (Fig. 2).

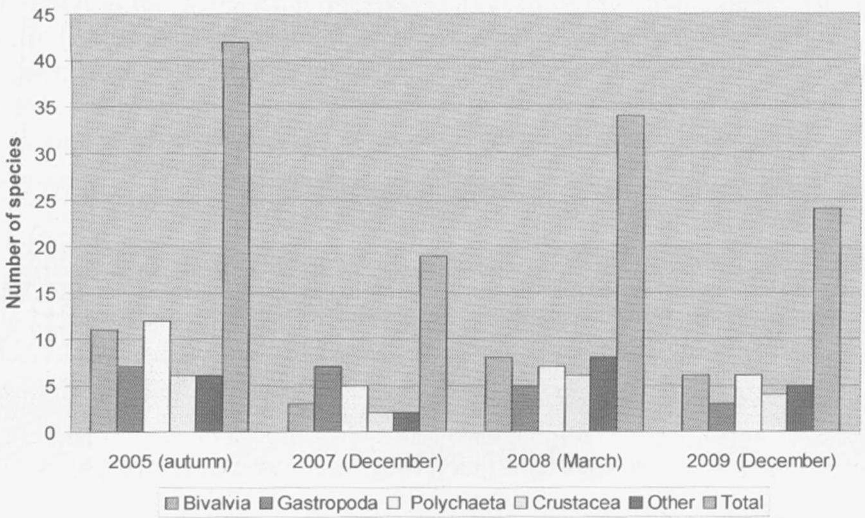

Figure 2. Dynamics of macrobenthos simple diversity before, during, and after the disaster of winter 2007

Meiobenthos are represented by twelve high taxa: Foraminifera, Nematoda, Harpacticoidea, Ostracoda, Kinorhyncha, Nemertina, Polychaeta, Oligochaeta, Bivalvia (juveniles), Gastropoda (juveniles), Cumacea, and Amphipoda (Fig. 3a). Nematoda and Foraminifera are dominant in term of number of individuals per m^2 (75 % of total meiobenthos, Fig. 3b) occuring at 96 % of all observed stations while polychaets prevail in trems of biomass (62 % of total meiobenthos, Fig. 3c).

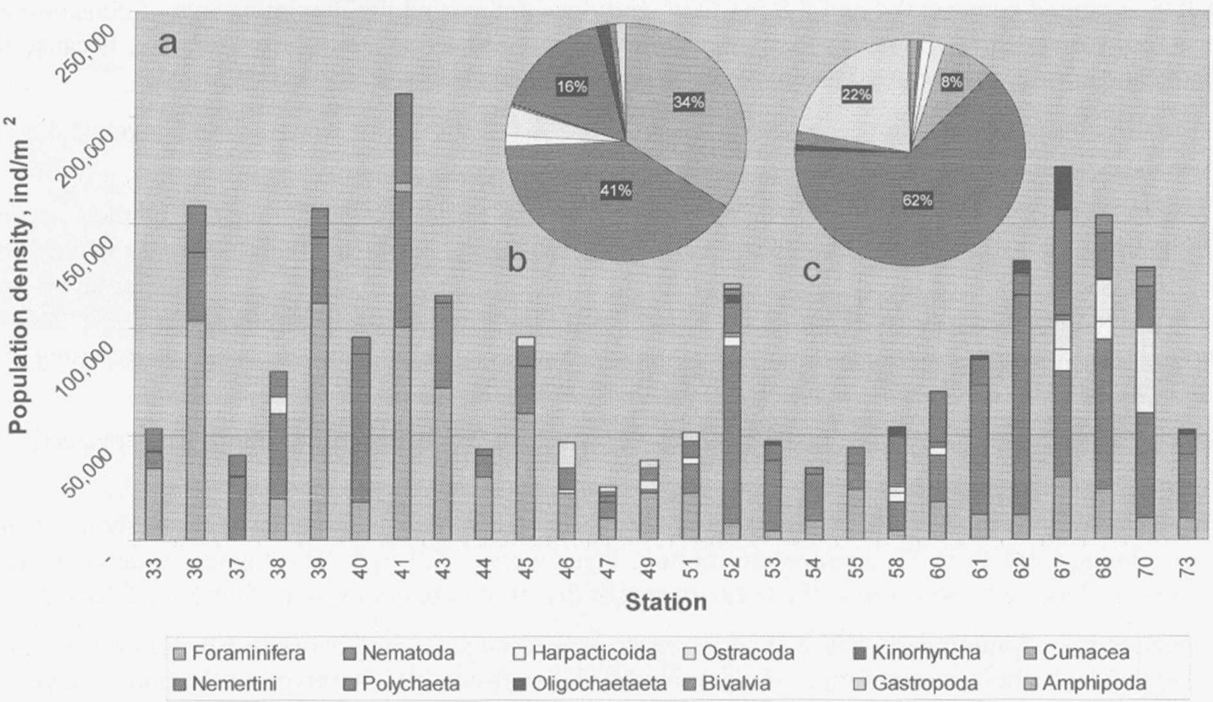

Figure 3. Density of high taxa of meiobenthos at each station (a); population percentages (b) and biomass persantages (c) of meiobenthos for the the whole study area in Kerch Strait in December 2009.

The bottom sediments contain a mixture of different fractions (Fig. 4) with Md varying between 0.008 and 2.8, and the coefficient of sorting ranging from 0.08 to 0.79, all this reflecting a high dynamic activity in the strait.

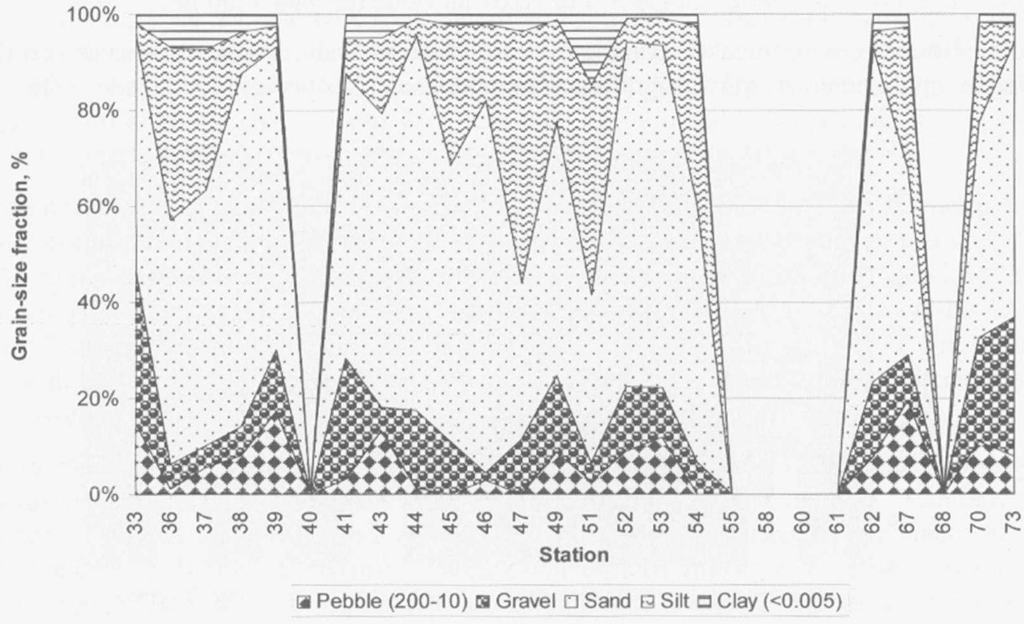

Figure 4. Distribution of grain-size fractions in the Kerch Strait. Please note that grain-size analysis for Stations 40, 55, 58, 60, and 68 is still in progress and will be reported elsewhere.

The concentration of both aliphatic and aromatic hydrocarbons in the water column is very low compared to that in the sediments (Fig. 5).

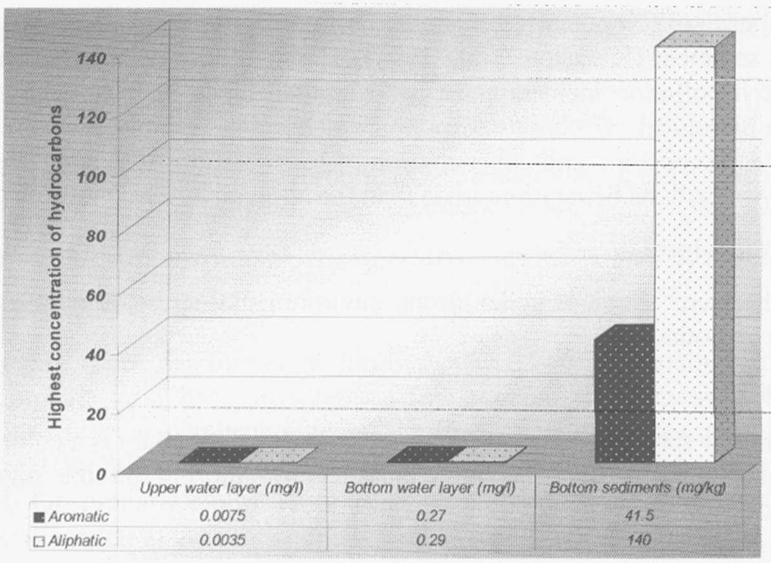

Figure 5. The highest concentration of aliphatic and aromatic hydrocarbons in the upper, bottom water layer and bottom sediments of Kerch Strait in December 2009.

The spatial distribution of both aliphatic and aromatic hydrocarbons in the water column (Fig. 6a,b; 7a,b) and its comparison with that in the sediments (Fig. 6c; 7c) show that they are largely accumulated in the sediments in close proximity to the sunken tanker.

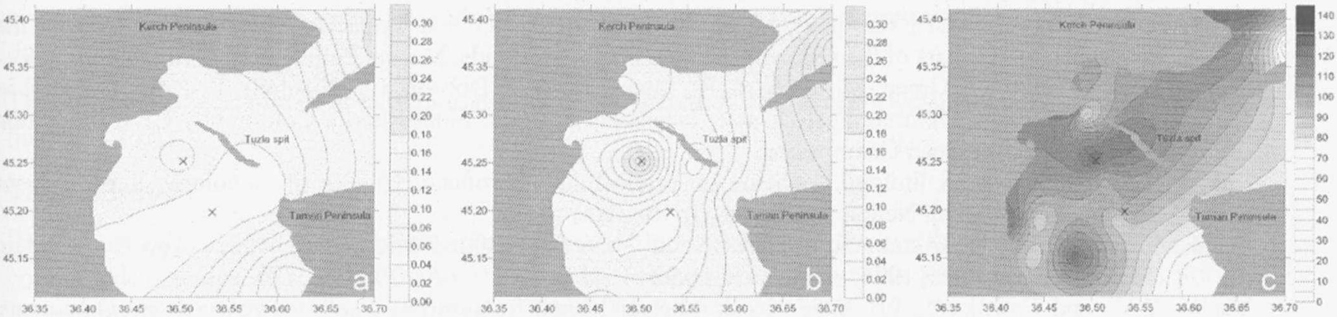

Figure 6. Spatial distribution of aliphatic hydrocarbons (mg/l) in upper (a), bottom (b) water layer, and sediments (c) in Kerch Strait. Crosses indicate location of two parts of sunken motor tanker Volgoneft-139.

Their low concentration in the water from one side is a result of high dynamic activity of water masses, from another side indicates their low solubility in sea water, and as so a long lasting effect on benthic ecosystem. This can be also seen from the fact that concentration of aliphatic hydrocarbons exceeds that of aromatic hydrocarbons in sediments about three times ndicating that original composition expected for crude oil did not change much also leading to long-term environmental consequences.

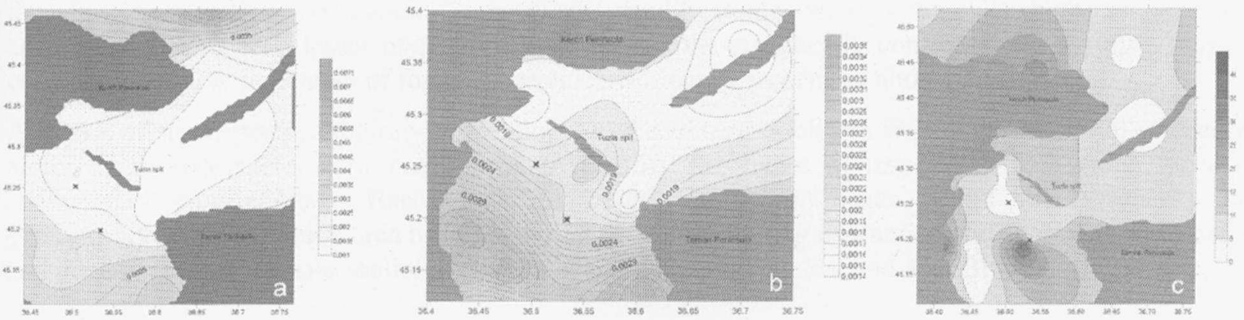

Figure 7. Spatial distribution of aromatic hydrocarbons (mg/l) in the upper (a) and bottom (b) water layers, and sediments (c) in the Kerch Strait. Crosses indicate the location of the two parts of the sunken motor tanker Volgoneft-139.

As environmental parameters of the water column are within their normal limits, we propose that petroleum hydrocarbons spilled from the sunken tanker are the main factor affecting benthic ecosystems.

Benthic community structure can clearly be altered by hydrocarbon concentrations higher than 50 ppm (=50 mg/kg) in the sediment (Kingston et al., 1995). The effects of a particular oil spill depend upon many factors, so each pollution incident must be examined in its own context (Gómez Gesteira and Dauvin, 2005). The biological effects of oil spills are determined mainly by the hydrodynamics at the site and the chemical composition and concentration of hydrocarbons that reach the shallow sediments, with the aromatic hydrocarbons being more toxic than the aliphatic ones (Dauvin, 2000).

Preliminary Conclusions

The ecosystem of the Kerch Strait is under strong environmental stress, although some recovery since December 2007 can be noticed.

Acknowledgements

We thank Dr. E. Konikov for providing us with grain-size data. This study is a contribution to the project 1/1190/22/2 "Performing state governmental ecological monitoring on the level of environmental pollution in the Kerch Strait after disaster of November 11-12, 2007".

References

Bondar, K. 2007. The Black Sea level variations and the river-sea interactions. Geo-Eco-Marina 13: 43–50.

Dauvin, J.C. 2000. The muddy fine sand Abra alba-Melinna palmata community of the Bay of Morlaix twenty years after the Amoco Cadiz oil spill. Marine Pollution Bulletin 40:528–536.

Gómez Gesteira, J.L., and Dauvin, J.-C. 2005. Impact of the Aegean Sea oil spill on the subtidal fine sand macrobenthic community of the Ares-Betanzos Ria (Northwest Spain). Marine Environmental Research 60:289–316.

Kingston, P.F., Dixon, I.M.T., Hamilton, S., and Moore, D.C. 1995. The impact of the Braer oil spill on the macrobenthic infauna of the sediments off the Shetland Islands. Marine Pollution Bulletin 30:445–459.

Rasmussen, C., Gerke, O., Greco, M., Richard, R., Sousa, J.-A.-C., Dobson, E., Nijenhuis, R. 2007. Oil Spill in the Kerch Strait, Ukraine, Post-Disaster Needs Assessment. Final Report. Community Civil Protection Mechanism, European Commission.

Rukhin, L.B. 1969. Osnovi litologii. Uchenie ob osadochnikh porodakh. [Basics of Lithology. Scence about Sedimentary Rocks]. Nedra, Leningrad. (In Russian)

Standard Methods for the Examination of Water and Wastewater 20th Edition. 1998. 10010 App By Standard Methods Committee, 1994, p.10.60 - p. 10.92

Yanko, V.V., and Troitskaya, T.S. 1987. Pozdnechetvertichnye foraminiferi Chernogo moria [Late Quaternary Foraminifera of the Black Sea]. Nauka, Moscow. (In Russian)