EMBLAS-II
Environmental Monitoring
in the Black Sea

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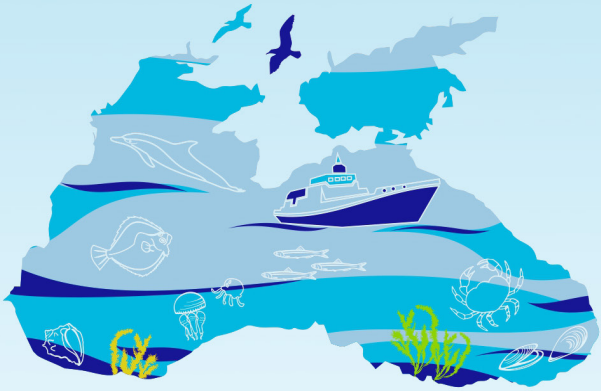

Joint Black Sea Surveys

12 FACTS ABOUT THE BLACK SEA

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ABOUT THE JOINT BLACK SEA SURVEYS

The surveys were carried out in Ukraine, Georgia, and Russian Federation in 2016, within the framework of **the EU/UNDP project "Improving Environmental Monitoring in the Black Sea" (EMBLAS-II).** The surveys consisted of the National Pilot Monitoring Studies (NPMS) conducted in the territorial waters of participating countries and Joint Open Sea Surveys (JOSS) in the deep water parts of the Black Sea. During the surveys, a large number of environmental parameters were measured in all compartments of the marine environment, including unique samples taken and analysed using novel monitoring methodologies. The surveys brought the first results on the assessment of the environmental status of the Black Sea according to the requirements of the EU Marine Strategy Framework Directive (MSFD). Read more at www.emblasproject.org.

Limitations: All the findings concern only 2016 and are important to be "cross-validated" by repeating the Black Sea surveys in August-September 2017. Repeating the campaign will verify and enhance the reliability of the results obtained so far.

1 THE BLACK SEA: HEALTHY OR SICK – HOW TO MAKE A DIAGNOSIS?

During the past 20 years, there were significant changes in approaches, how to assess the health of the Black Sea. Previously, if concentrations of the measured pollutants (metals, oil products etc.) were below the identified thresholds, it meant the sea is healthy. But with **adoption of the MSFD**, the key indicator of the health of the sea is **the health of its inhabitants, starting from microscopic algae up to fish and dolphins.** This approach requires a complex study and diagnosis in the style of 'genius Doctor House'. The MSFD includes 11 descriptors, covered by more than 60 indicators. The key goal for the EU Member States is **to achieve 'good environmental status' of the Black Sea** by 2020. For Ukraine and Georgia, the need to implement MSFD is included in **the relevant EU Association Agreements**, meaning that now these countries also should follow the approaches of the EU.

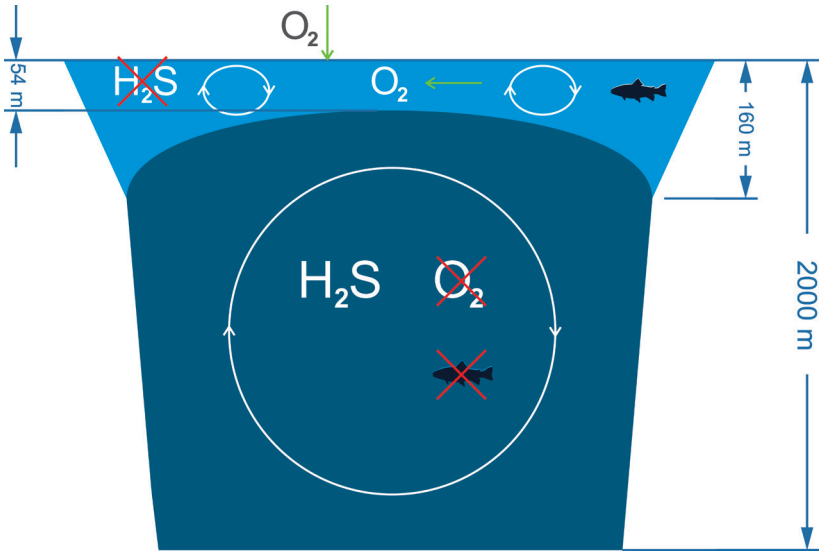
Joint Black Sea Surveys contributed significantly to the 'Initial Assessment', which is an essential part of the MSFD implementation of the present status of the marine waters, using the novel methodologies and equipment. Also, they supplied unique and relevant data for the Black Sea Integrated Monitoring and Assessment Programme (BSIMAP) agreed by all Black Sea countries under the umbrella of the Black Sea Commission (BSC).

What does it mean? Ensuring well-being of marine inhabitants is not only our obligation for the Black Sea, but also a part of the general process of the integration of Ukraine and Georgia to the European Union and fulfilling international agreements taken by all Black Sea countries at the level of the BSC.

2 THE OXYGEN LAYER IN THE BLACK SEA HAS DECREASED

The Black Sea has an oxygenated surface layer overlying a sulphide containing deep layer. This so-called anoxic zone is located at depths of more 90 - 160 m and covers about 87% of the volume of the sea. Over the **last 20 years a 20 - 25 meters rise of the hydrogen sulphide layer** has been observed. During the surveys, this tendency was confirmed.

Moreover, the thickness of the upper oxygenated surface layer is not the same all over the Sea. There are a number of currents flowing along the continental slope (Rim Current), western and eastern cyclonic gyres in the open sea. In centres of **the gyres the rising of lower level of oxygen layer up from earlier level (ca. 90 m) until 54 m was measured.** This was supported by finding many anaerobic bacteria in the samples at these depths.

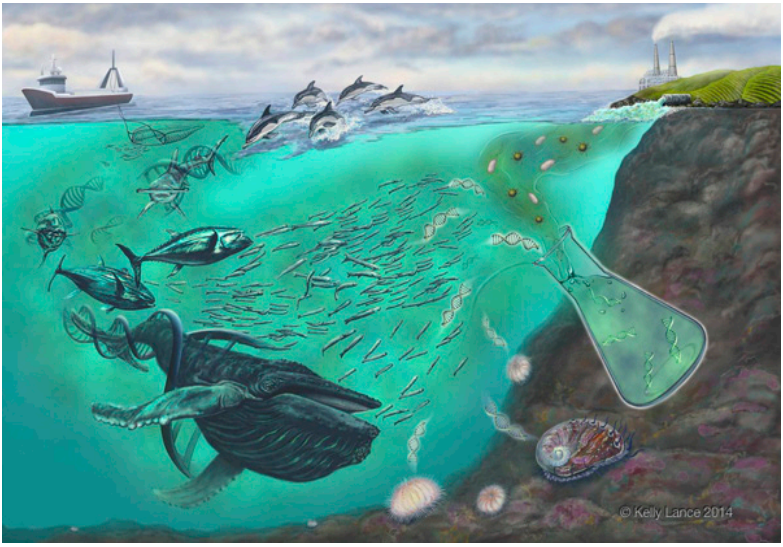


What does it mean? Most of the marine inhabitants as we know themsuch as underwater plants, fish. molluscs,dolphins etc. live in the upper oxygenated surface layer. If the layer decreases, it means that the living space for them is reduced. This dangerous change is considered to be related to the climate change and global warming. This should make society think once again how to mitigate the climate change.

3 NEW FOR THE BLACK SEA INTRIGUING MICROBIAL GROUPS WERE FOUND IN THE OXYGEN-FREE LAYER OF THE BLACK SEA AT 2 KM DEPTH

In the frame of the Joint Black Sea Surveys, samples were taken from the bottom of the Black Sea from more than 2 km depth. The results confirmed that there is actually a life in this hostile 'dead oxygen-free zone' of the Black Sea and quite diverse one, but mainly in terms of microbes. Such results were obtained with using a special metagenomics method, by analysing DNA of all microbes in the deep water and sediment samples. New unique information was obtained on large biodiversity of **archaea** and **bacteria** in the sea, which are represented only in very specific habitats in the other parts of the World Oceans such as e.g. geothermal underwater geysers, Norwegian closed fiords, etc.

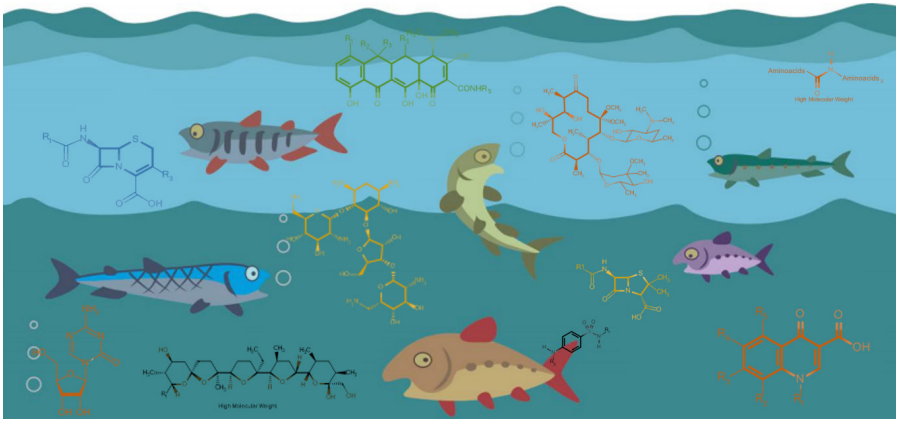
During the surveys **for the first time** unique microbes from *Lokiarchaeota phylum* group **were found in the Black Sea.** The group was discovered only in 2015 by researchers in Norway in underwater geothermal geysers in the Arctic Ocean and called after the Scandinavian shape-changing God – Loki. It is a kind of 'missing link' in the universal tree of life between prokaryotes (the ones which do not have nucleus) and eukaryotes (ones which have nucleus, as animals and plants do). In our sea, they are quite wide-spread inhabitants of bottom sediments in oxygen free zone.



What does it mean? It means that the oxygen-free zone of the Black Sea is not a 'dead desert' but more of a 'beautiful garden' reminding other planets without oxygen cover or like the Earth had been in the time of its youth – 2 - 3 billion years ago prior to the appearance of photosynthesising plants. Such kind of a 'live kit for study of astrobiology' or 'time machine' is a dream for any researcher. At the same time, oxygen-free zone appears to be an important component of the marine ecosystem, which ensures that organic pollutants deposited at the bottom of the sea are degraded by bacteria and thus **do not accumulate as a future 'chemical time bomb'.**

4 MAIN BLACK SEA SPECIFIC POLLUTANTS HAVE BEEN IDENTIFIED FOR THE FIRST TIME

During the Joint Black Sea Surveys, marine waters, sediments and biota (fish, mussels) were analysed for presence of more than 2100 substances to find out relevant **'Black Sea Specific Pollutants'.** The list contained pollutants included in the EU water legislation and substances considered important in the other European Seas including pharmaceuticals, personal care products, pesticides, biocides, flame retardants, industrial chemicals, their transformation products, etc. **Majority of these substances were investigated in Ukrainian and Georgian waters, and generally in the Black Sea, for the first time.** Fortunately, not all substances were present in the samples. Out of the investigated chemicals, **only 145 were detected** in at least one sample.



The results showed in the samples substances originating from **oil spills by ship traffic,** such as polyaromatic hydrocarbons whose measured concentrations were frequently exceeding the toxicity threshold values. The highest levels of the perfluorinated substance **PFOS,** which can accumulate in humans and marine inhabitants, were recorded at sampling stations affected by the Danube river. This compound, frequently used as water repellent in outdoor textiles and shoes or as a coating of paper cups/boxes (e.g. pizza), was present at high concentrations also during the Joint Danube Survey carried out in 2013. Other dangerous chemicals, toxic also for humans, such as **mercury** and **dioxins** were found in fish tissue samples well above their threshold limit values. High concentrations of **extremely toxic pesticides** (cypermethrin, heptachlor and heptachlor epoxide), were observed in the vicinity of the Georgian coast.

Among other compounds of potential concern for the Black Sea were **pesticides** such as **imidacloprid,** a systematic insecticide using for treatment of domestic pets to control fleas; **dinoterb,** an herbicide for controlling annual broad-leaved weeds post-emergence in cereals and corn; **metolachlor,** an herbicide used for grass and broadleaf weed control in corn; **lindane,** being applied as an agricultural insecticide and **fipronil,** a broad-use insecticide being toxic to fish and bees. Alarming concentrations of **pharmaceuticals adenosine** (antiarrhythmic agent) and **telmisartan** (treatment of essential hypertension) were observed in the sea water.

Toxicity threshold values were exceeded also for **industrial pollutants bisphenol A,** an endocrine disruptor which made it into a variety of common consumer goods, such as plastic bottles, sports equipment, CDs/DVDs etc.; **dibutyl phthalate,** which is a commonly used plasticizer and a suspected endocrine disruptor and **monobutyltin compounds,** which are used as a polyvinyl chloride (PVC) stabilizer. **Sun screen agent ethylhexylmethoxycinnamate** was found close to the Georgian coast at concentrations which may harm underwater fauna. **Organophosphorus compounds (OPCs), new generation flame retardants** being commonly used in products we meet at daily life such as textiles, furniture, computer plastics etc. were detected at each site. The sum of the concentrations of all OPCs was highest at the area close to the Danube estuary, however, the highest exceedances of the available limit values were observed at the Dniester region and in Georgian waters.

What does it mean? The good news is that now a Black Sea country does not need to spend money to search again for all the substances, but rather to concentrate and include into the monitoring programmes only those, which are found at significant concentrations and present a danger to living environment. The bad news is, that it is really complicated to find the exact source of pollution and to take the relevant action such as e.g., constructing new or improving obsolete waste water treatment plants 'to catch' most of the pollutants before they get into the sea, changing some industrial processes using more environmental friendly substances or legally banning the most toxic substances such as pesticides. But this is the task to be done in future while developing Programme of Measures for the Marine Strategy, which is an obligation of all Black Sea countries aspiring to enter the EU or complying with the BS SAP agreed at the level of the BSC.

5 TRACES OF THE HUMAN ACTIVITIES ARE FIXED ALL OVER THE BLACK SEA

In addition to analysis of the marine waters samples at several point locations, in order to get a picture of presence of pollutants along the entire area of the Black Sea, as the ship was moving water was continuously pumped on board and passing through a special device called 'passive sampler'. All pollutants present in the water got concentrated at the sorbents (kind of filters) in the device. These sorbents, containing 'chemical information' of several hundreds of km stretches of the Black Sea, were sent later on for an analysis in a specialised laboratory. Additionally, passive samplers were submerged in the Odessa bay and at the Zmeiniy island in Ukrainian waters for several weeks to trap pollutants present in the water at that time.

The sea water contained many chemicals, among them e.g.: **perfuorinated substances, which are frequently used as water repellents in e.g. waterproof textiles, shoes, water/grease-proof layers in paper cups, pizza boxes, etc.; pharmaceuticals** such as **paracetamol,** as well as the **mosquito repellent DEET.** Elevated concentrations of paracetamol were observed at the static sampling sites in the Ukraine`s territorial waters and higher levels of **caffeine** were found especially in the open sea areas. Also, quite some pesticides belonging to groups of herbicides, fungicides and insecticides were found to be present all around the investigated areas. The study targeted also **'old' (polybrominated diphenyl ethers) and 'new' flame retardants,** chemicals present in high amounts (tens of per cents of the total weight) in various products around as, such as textiles, plastics, furniture, etc.

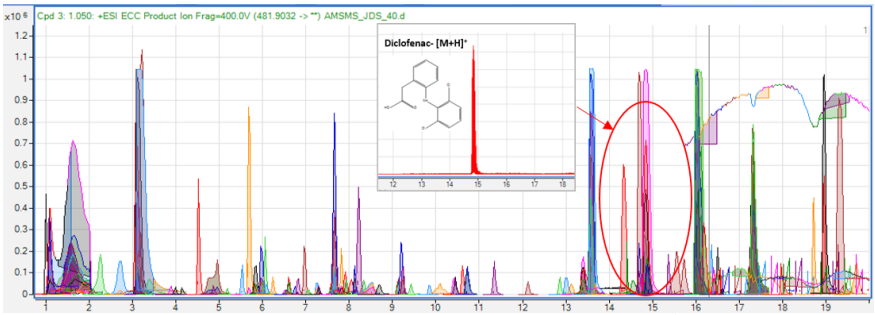
What does it mean? Our everyday behaviour, like taking pills against headache, wasteful use of single-use paper cups at a party with friends, spraying shoes with a water repellent not to get them wet, etc. have a direct impact on the status of the Black Sea even in its open deep-water parts. This means that with development of the industry and consumer goods, it is important to invest more in wastewater treatment facilities to catch all the pollutants. Otherwise our Black Sea can be in danger.

6 TIME CAPSULE FOR THE FUTURE SCIENTISTS: 'FINGERPRINTS' OF ALL IDENTIFIED AND UNKNOWN YET SUBSTANCES IN THE AQUATIC ENVIRONMENT ARE STORED FOR THE FIRST TIME IN THE WORLD

Each environmental sample contains typically several thousands of substances. About some of them we know nothing as of today, however, this can change in future with advance of the technology. In order to preserve the samples of e.g. fish, molluscs, sediments, soil, tree leaves etc.for the future, in some countries they get frozen at very low (ca. -80oC) temperatures and put into so-called 'Environmental Specimen Bank', so that later on scientists can analyse samples collected over several decades from the bank and get answers to questions about the long-term story behind the pollutants' influence on nature. Due to a physical limitations imposed by nature water samples cannot be stored this way.

But now a new easier way of preserving of the unknown substances has been developed, called **'Digital Sample Freezing Platform'**. For this, samples of water, sea bottom sediments and marine biota were analysed using the most modern equipment liquid chromatography-high resolution mass spectrometry. It is similar to **taking fingerprints** of all of the 2-3 thousand of substances which are typically present in each sample. Sometimes scientists do not know the name of the 'suspect' contaminant whose signal is recorded but they know it is there (exact mass unique for each chemical compound) and they have the fingerprint (mass spectrum). Imagine, that a toxic chemical is being produced in high amounts (thousands of tons per year) and released into environment without anyone knowing about it. Once our samples are 'digitally frozen' we can always have a look if this chemical was 'there' in 2016, 2018, 2020 etc. and see if the environmental policies banning its use were efficient to remove it from the environment. With this, scientists can reach the same goals as Environmental Specimen Banks, but without actual freezing.

Using the samples collected during Joint Black Sea surveys, such repository of 'digitally frozen' samples was initiated. The 'Black Sea dataset', which at present includes more than 17 thousands of fingerprints of unknown substances, is **the first one available globally.** The dataset is planned be enlarged in the next years by the national datasets from other European countries through NORMAN network (www.norman-network.net).

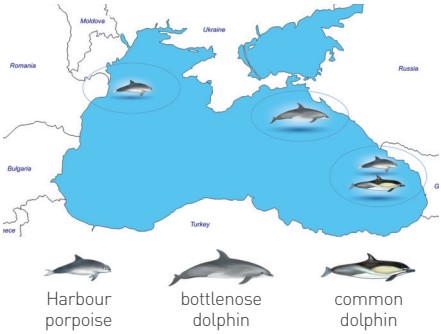


Finger print' of the pharmaceutical drug diclofenac, an anti-inflamatory painkiller (mass spectrum in the middle of the figure), which was found among hundreds of other substances present in the sea water sample (each peak represents individual substance).

What does it mean? First of all such a database allows future scientists to look back in time with more modern equipment and knowledge for those pollutants which are toxic to living environment and found everywhere. There is also a methodology how to turn an 'unknown' substance to 'known' using a combination of analytical know-how and globally available databases. Once we know the name of the compound, it is already possible to estimate whether it is toxic or not at the concentration levels found in the samples. But even without additional information, any of these thousands of unknown substances can already be put on the map and people can see **pollution patterns** – e.g. if the compound is everywhere (diffuse pollution) or just around one place – potential source of pollution, which can be then targeted by a localised programme of measures.

7 WHERE THE DOLPHINS PREFER TO STAY IN THE BLACK SEA IN SPRING: NEW DATA ON DIFFERENT DOLPHINS SPECIES DISTRIBUTION

There are three cetacean species in the Black Sea: the Black Sea harbour porpoise, the Black Sea common dolphin and the Black Sea bottlenose dolphin. All of them are considered endemic subspecies, i.e. existing only here, in this geographic region and are found nowhere else in the world. The Joint Black Sea Surveys identified the places of the dolphins' species concentrations. In spring in the northern-western region (near Ukrainian coast) significant **harbour porpoises** gathering was noticed near **the Danube Delta,** whereas **bottlenose dolphins** most often and during the all seasons were encountered in the coastal waters of the north-eastern part of the sea **(near the coast of the Russian Federation). Open waters of the south-eastern region and coastal waters near Georgia** were recognized as the **hotspot for both - common dolphins and harbour porpoises.** Normally dolphins stay in the group of the same dolphins sub-specie: common dolphins with common dolphins, harbour porpoises with harbour porpoises etc. Therefore it was a big surprise to detect **a joint group of the common dolphins and a juvenile harbour porpoise** in the offshore waters of the south-eastern part of the Black Sea. It seems that the story of Mowgli repeated successfully: a harbour porpoise seemed to be adopted by the common dolphins' family and it followed the behaviour of a common dolphin such as following the ship, which is not a common behaviour for the harbour porpoise. The survey confirmed the sad fact that **common dolphin do not form such big** gatherings of thousands or hundreds which were usual to observe in the first part of the last century.

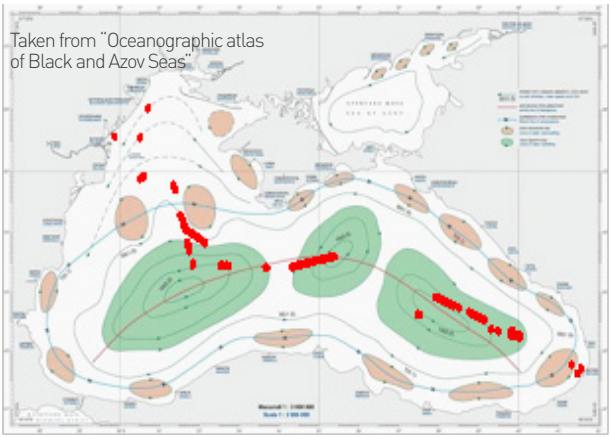


What does it mean? Having the new data on where the most dolphins are concentrated and when we can try to reduce the pressures on them, from e.g. noise pollution (which is really painful for them) by changing navigation routes or timing of underwater works.

8 LARGE CONCENTRATIONS OF THE FLOATING LITTER ARE FOUND IN THE MIDDLE OF THE BLACK SEA

Unfortunately, we are all getting used to seeing the marine litter at the beaches. But normally we imagine the middle of the sea far from the sea coast and settlements free from litter since it is far from the sources of pollution. It was unpleasant surprise during the surveys to find high concentrations of floating litter in the open sea.

The marine litter concentrations in the sea could be explained by the fact that currents in the Black Sea move the litter inside of the Sea. But there is a good side in it – if it is concentrated in the islands, probably it would be easier to take point actions to remove it. In general, marine litter is serious threat to marine inhabitants. Through natural degradation the floating litter tends to decompose into small particles called microlitter most of which consists of microplastics, which is often consumed with the food by marine inhabitants, which may initiate various adverse health effects.



Marine litter concentrations, fixed during the surveys and system of currents in the Black Sea

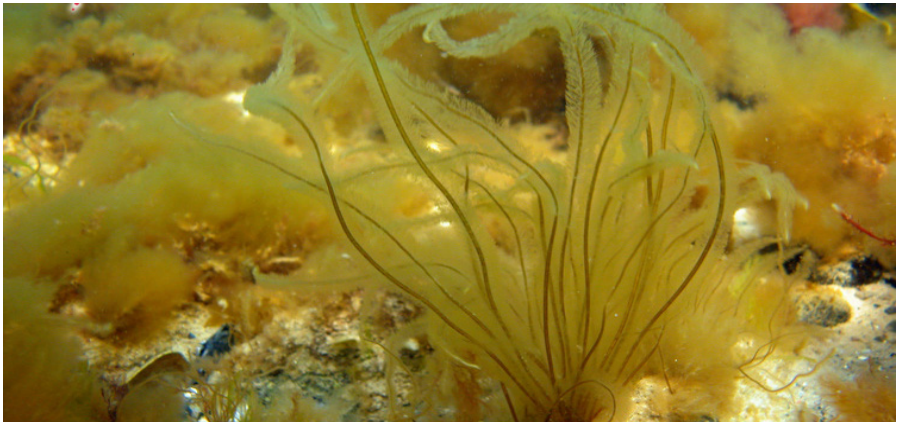
What does it mean? We should in the near future review our waste management behaviour. Plastic should be removed from the waste and recycled, otherwise we will need to invest hundreds of millions into first removing the "garbage islands" in the middle of the Sea.

9 THERE ARE SIGNS THAT INVASIVE SPECIES DECREASE THE PRESSURE ON "ABORIGINAL" SPECIES IN THE BLACK SEA

Invasive species: common minke whale, mnemiopsis and Aurelia aurita

At present, there are 365 alien species registered in the Black Sea starting with unicellular algae to common minke whale (Balaenoptera acutorostrata). The good news is that during the Joint Black Sea Surveys the number of invasive species registered was minimal. It gives some hope for the improvement of the state of the Black Sea. But at the same time the hope is fragile, because this should be confirmed through surveys in different seasons of the year. Hopefully, Joint Black Sea surveys in 2017 will confirm this finding. By the way, the survey confirmed the presence of the brown algae Halosiphon (Chorda) tomentosus (directly translated from Latin as "hairy string"). It is the only representative of Laminaria (Kelp) in the Black Sea and it was first registered in the Black Sea just recently in 2015 near the Dniester estuary.

What does it mean? The less invasive species and more aboriginal ones are in the ecosystem, the more sustainable and healthy it is. Let's hope that the danger of invasive species will not increase with the climate change.

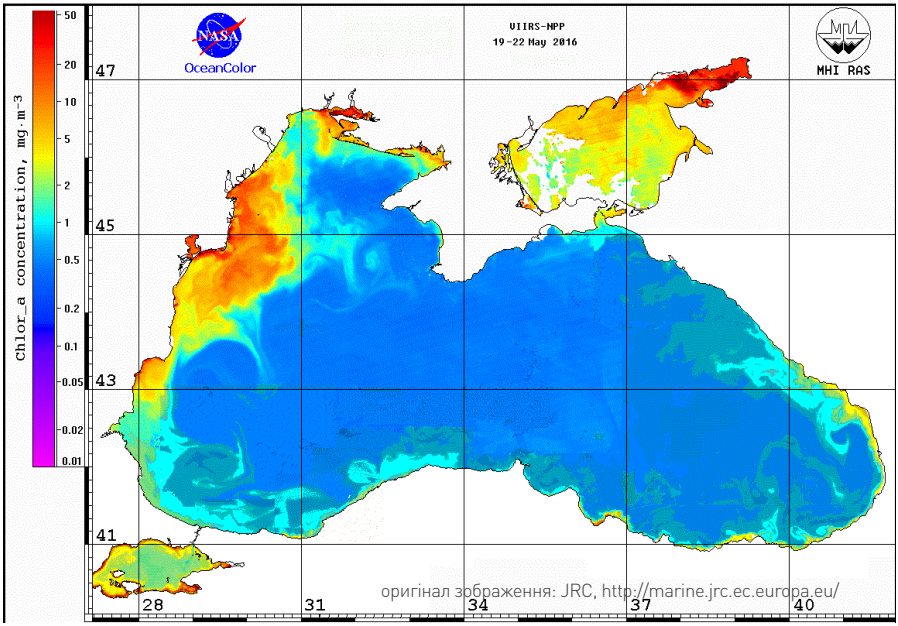


Halosiphon tomentosus – a new invasive specie from the family of Laminaria

10 SEA "BLOOMING" BECOMES MORE AND MORE LOCAL PHENOMENON FOR THE BLACK SEA

Often in summer people can observe "algal blooms" (mass development of phytoplankton) resulting in reduction of the oxygen in the water. This process – "eutrophication" is a response to increased levels of nutrients and it is almost always induced by the discharge of phosphate-containing detergents, fertilizers, or sewage, into an aquatic ecosystem.

The Joint Black Sea Surveys showed that **a general level of eutrophication of the Black Sea seems to be on decline.** The major part of the investigated areas were in good environmental status both in the surface and deep waters (the large part of the North-Western Shelf in



Satellite image of the concentration of the chlorophyll –a in the Black, Azov Seas and Sea of Marmara for 19-22 May, 2016

Ukraine, Georgian waters, Gelendzhik area at 5-miles transect, southern part of the Kerch Strait area). However, the situation is different in some other parts. The surface waters influenced by the Danube discharge in May 2016 strongly exceeded the limit threshold values due to the large diatom bloom. Also high concentrations of nutrients coming from the Azov Sea were observed in the Kerch Strait, however, not distributed further into the Black Sea.

What does it mean? Despite of a positive tendency in eutrophication reduction, the wastewater treatment in coastal cities and at the main rivers flowing into the Black Sea should be largely improved if we do not want to see "algal blooming" again.

11 UNIQUE RARE FISH AND BIOTA SPECIES ARE REGISTERED IN THE BLACK SEA.

During the Joint Black Sea Surveys a unique fish Black Sea Pelagic Pipefish (Syngnathus schmidti) was caught in the open sea. This specie is endemic for Black and Azov Sea. It looks like a greenish-brownish needle with length of up to 11 cm and huge eyes covering 80% of the head. This fish is still not studied to full extend.

Another unique fish found is Goldsinny wrasse (Ctenolabrus rupestris). This fish specie is very rare for the Black Sea and is included in the Red Book of Ukraine. It is banned for catching. It was found near Georgian coast. During national pilot monitoring surveys in Georgia, european flat oyster or edible oyster (Ostrea edulis) was found alive near Sarpi. Oyster belongs to endangered or already extinct mollusks of the Black Sea. It is very vulnerable to the increase of marine water turbidity due to massive development of the unicellular algae and other microscopic organisms. In Georgia it was a first finding of alive oyster in last 35 years! Historically it was always present in Georgia, it was even exported in the end of 19th century and beginning of 20th of century. After massive development of Rapana, the number of the oysters has significantly decreased.

Pelagic Pipefish

European flat oyster or edible oyster

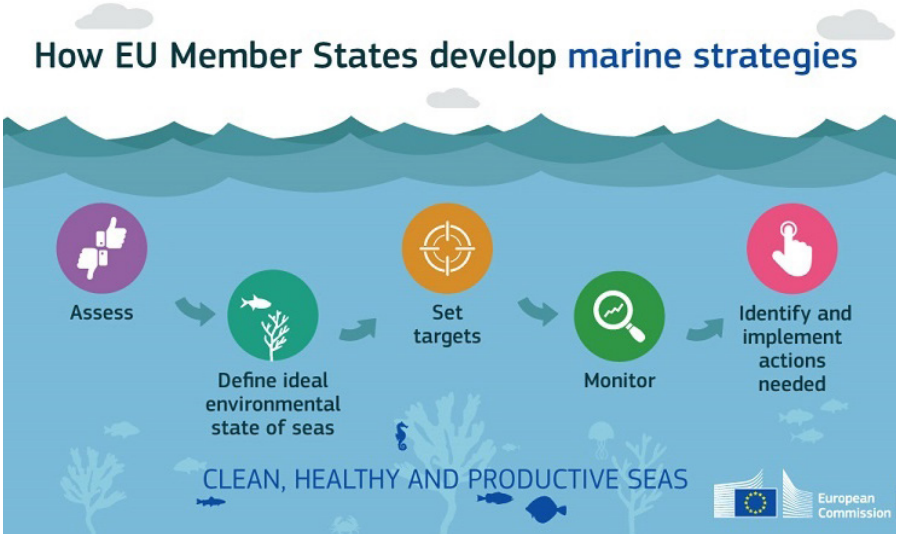
Goldsinny wrasse

What does it mean? The finding of the alive oyster is a good sign of the Black Sea rehabilitation. Finding rare species is always a good sign, meaning that they are still there and we do not lose them despite of the pollution and other pressures.

12 FURTHER ACTIONS: HOW TO USE ALL THE COLLECTED INFORMATION FOR THE BENEFIT OF THE MARINE INHABITANTS

The main goal of monitoring is to define the main problems and their solutions. E.g. in case of identification of priority substances in the water, the further actions should be to include them into regular monitoring in order to identify clearly their sources. Later, the Programme of Measures should be developed how to eliminate this pollution, which is threatening marine inhabitants.

In order to achieve good environmental status by 2020, each EU Member State is required to develop a strategy for its marine waters **(Marine Strategy).** Ukraine and Georgia also have started this process in the frame of implementation of the relevant Association agreements with the EU. In **Ukraine, development of a draft Marine Strategy has started already this year** under the leadership of the Ministry of Environment and Natural Resources of Ukraine. It will include updated monitoring programme of the marine waters following the requirements of the MSFD; new division of corresponding responsibilities among organizations, and what is the most important, a list of actions to be taken to improve the current status of the Black Sea will be prepared. So there is a strong hope that the life conditions of the marine inhabitants will improve as they are now in the focus of the relevant decision-makers. This will be a win-win situation for the Black Sea and humans around it – all of us who like the sea and use it for life, work or holidays and want to see it clean and healthy.



ABOUT THE PROJECT

The Joint Black Sea surveys were conducted within the framework of the project 'Improving Environmental Monitoring in the Black Sea" (EMBLAS II). The Project is co-financed by the European Union (EU) and United Nations Development Programme (UNDP). The Project implementation started on 1 April 2014 and will end on 31 May 2018. The overall objective of the project is to help improve the protection of the Black Sea environment. More information at http://emblasproject.org/.

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