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Summer school

SUSTAINABLE DEVELOPMENT OF YACHTING AND CRUISE INDUSTRY

Characteristics of fouling in ports as a hot spot for NIS: study case Port of Bar and marina Porto Montenegro

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- **Marine biodiversity** is the variety of life in the seas and oceans. It includes all animals, plants and microorganisms
- Environmental factors (**temperature, salinity, light, gases**) determine the development of different species
- The diversity of the living organisms is determinated by the environmental conditions, so it is believed that up to 4000 species, mostly sessile, can be identified in the fouling
- Port areas represent specific microhabitats that are under high anthropogenic influence
- They are primarily opportunistic species that quickly adapt to changes in the environment
- Harbor waters are considered hot spot locations for the introduced species

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- Introduced species are **non-indigenous species** (NIS) that do not naturally inhabit certain ecosystems or areas, but have entered them through intentional or unintentional introduction
- **Invasive species** are those types of NIS, that upon reaching another habitat and due to the lack of natural enemies, begin to reproduce uncontrollably and occupy available ecological niches
- How introduced species affect biodiversity? Their impact could be mainly negative (suppress of autochthonous species, competition for food, space, changes in food web)
- What are the pathways of introducing new species?
    - Waterways (Suez canal)
    - Maritime traffic (fouling on hull, ballast water, anchor)
    - Aquaculture

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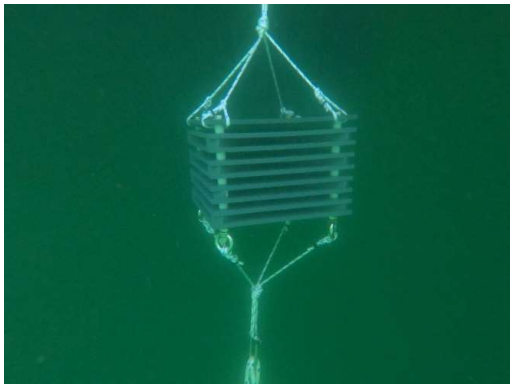
- For determination of the marine ecosystem quality in the port area, fouling analysis is mandatory
- Fouling is a particular biocenosis on an anthropogenic substrate that develops under the influence of environmental factors
- Biofouling is composed by plants and animals communities that are mostly attached to the substrate
- Study of fouling communities is mainly carried out by the method of autonomous diving and samling collection, although in recent times there are also other methods such as artificial substrates ARMS) which are immersed in the sea for a certain period of time
- Due to the high frequency of maritime traffic, we consider ports and marinas to be hot spots for the introduction of alien species



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Port of Bar-project BALMAS-IPA CBC

•The benthos analysis was done according to the modified CRIMP sampling protocol for benthos during spring and autumn

•Within the port area, at least three sampling points must be inspected (Figure 1). For each sampling site, three transects were selected to provide a series of vertical (hard bottom) and horizontal (probably sedimentary bottom) samples (Figure 2). The first transect should be located at least 10 m from the end of the dock, and the following transects at a distance of 10–15 m (Figure 2).

Figure 1. Positions in the port of Bar where sampling was done

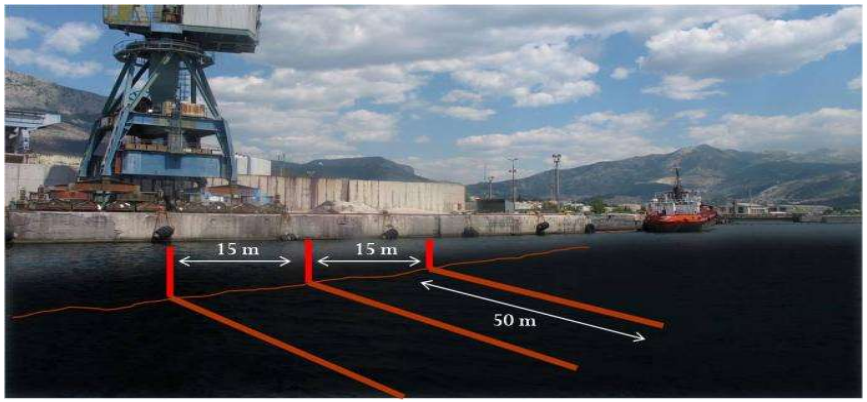

Figure 2. Three transects for each sampling site. Transects must be 10-15 m apart. They consist of a vertical hard part and a 50 m long horizontal part.

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•Vertical hard substrate:

• Three vertical plots of 0.10 m^2 (0.25 m x 0.4 m) must be collected on a vertical solid surface. One sampling plot for each depth (0.5 m, 3.0 m and 7.0 m) (Figure 3). The sampling depth distribution can be adjusted depending on the specific depth of the pier.

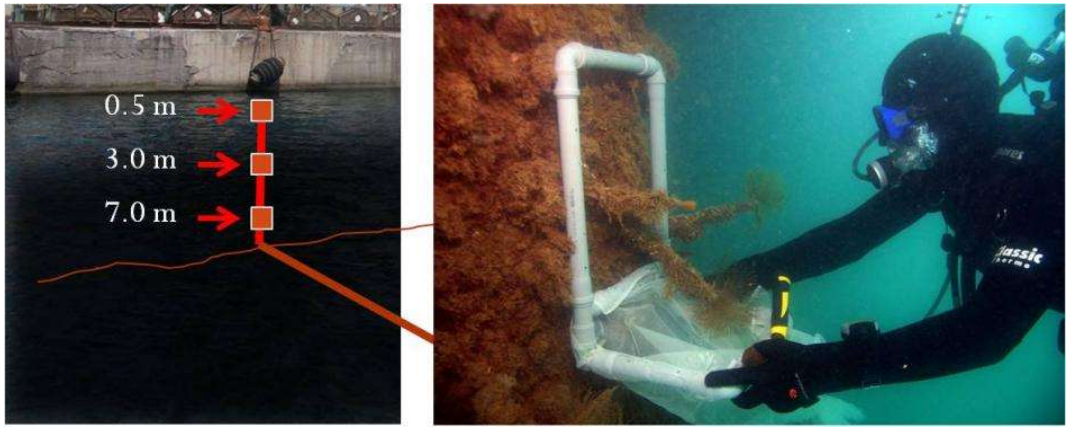

Figure 3. One sampling plot must be collected at each depth (0.5, 3 and 7 m) using a sampling rectangle (0.25 m x 0.4 m) with a mesh bag (1.0 mm mesh).

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Figure 4. Sampling on a sampling plot using a hammer and a sampling rectangle (0.25 m x 0.4 m) with a mesh bag (1.0 mm mesh).

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Results of the analysis

- At position P 1, the piles are located deep under the dock and therefore very little light reaches them, which is most likely the main reason why there is almost no algae on them.
- Among the collected algae, the most common is *Lithophilum* sp. , but *Peasonnelia rubra, Wrangelia penicillata, Dictiota dichotoma* and *Halopteris scoparia* were also recorded.
- Several other species (9) were found at position P2. This position is less affected than the previous one, and also has much more light reaching the sampling site. Because of this, a greater diversity of species has been recorded.

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- Among the animal organisms identified, representatives of all major invertebrate groups (Porifera, Cnidaria, Plathelmintes, Mollusca, Polichaeta, Crustacea, Bryozoa, Echinodermata and Tunicata) were present.
- A total of 102 species were identified, the most numerous of which were Polichaeta (37) and Mollusca (25)
- During both research seasons, more species were recorded at position P2 than at position P1, and the most diverse biodiversity was at depths of 0.5 and 3 m.
- In April, at position P2, we found a maximum of 24 species at a depth of 0.5 m, while the maximum in October was 17 species at a depth of 3 m.
- For the same period at position P1, the maximum was 15 species at a depth of 3 m, i.e. 14 species at a depth of 0.5 m. At the same position in October, the maximum number of registered species was 17 at 0.5 m depth and 16 at 3 m depth.



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- The number of species and their abundance largely depend on environmental conditions
- At a shallower depth, there are more favorable ecological conditions, so the number of species is usually higher
- The amount of light and temperature decreases with depth, so the living world is reduced and specific



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- Among the invertebrate species, introduced or non-idigenous species have also been recorded:
- Bivalvia *Arcuatula senhousia*
- Polychaetes *Hydroides dirampha and Palola valida*
- Bryozoa *Bugula neritina*
- Ascidia *Styela plicata*

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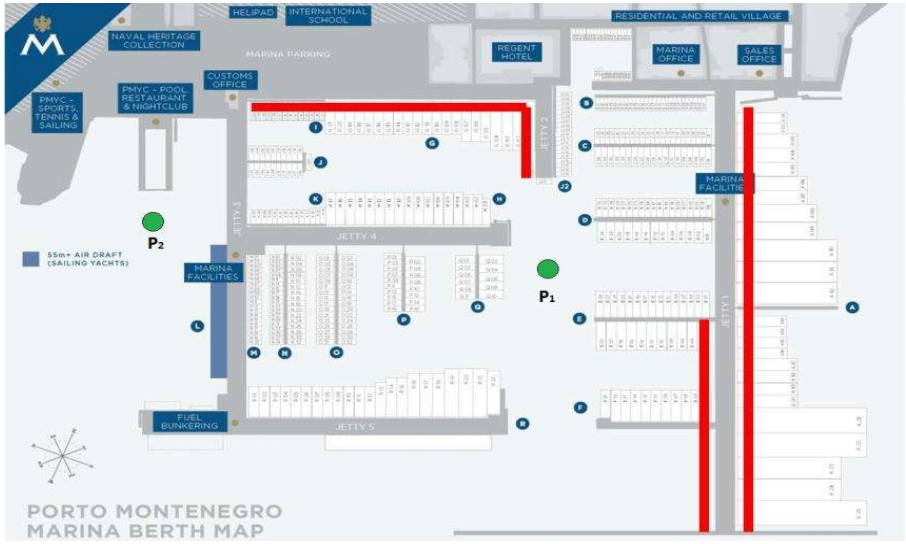
Marina Porto Montenegro-Tivat (monitoring program 2016-19)

•The research included the analysis of fouling and epifauna in a qualitative sense by the method of autonomous diving based on the principle of free choice of location

•The research was conducted according to seasonal dynamics (summer, autumn, winter, spring).



Positions where research of fouling was carried out (red line)

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Results of the analyses

•Seasonal analyzes of the collected material show variations in the number of species of certain groups of zoobenthos (graph 1).

•Analyzed by phyla, the number of species from the sponge group varied from 7 to 8 species, the number of species from the cnidaria group varied from 7 to 9 species, within the mollusk group the number of species varied from 21 to 22, within the annelids group the number was constant and amounted to 5 species, within the group of arthropods the abundance varied from 4 to 6 species, the number of bryozoa species was constant and amounted to 4, the abundance of echinoderm species ranged from 7 to 8 and the abundance of tunicate species varied from 11 to 13.

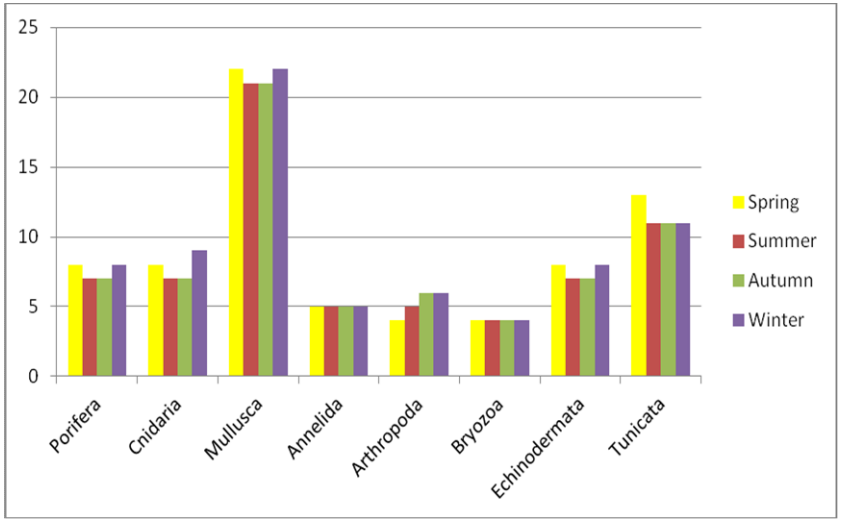

Figure 1. Number of species of the main invertebrate groups during the research period

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•These slight differences in the number of species are most likely of subjective origin.

•During the research, some species are noticed and some are not, which does not mean that they have not been in the same area before, or if they are mobile organisms, they are simply found in the locality at the time of the research.

•The dominance of filter feeding organisms was expected, which find a suitable substrate for anchoring on the docks of the marina and feed by filtering water with various dissolved and suspended particles.

•The dominant group of organisms were molluscs, of which the mussel (*Mytilus galloprovincialis* Lamarck, 1819) is by far the most important in terms of number and cover (Figure 1).

•*Bittium reticulatum* (da Costa, 1778), *Rocellaria dubia* (Pennant, 1777) and *Ostrea edulis* Linnaeus, 1758 were also very numerous from the mollusk group.

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•Ascidians are the next most important group in terms of number of organisms. Some species such *as Clavelina lepadiformis* (Müller, 1776) and *Ciona intestinalis* (Linnaeus, 1767) show seasonal dynamics, which is why they are more numerous in some periods of the year and less common in others.

• Monitoring of dock 1 showed that the number of certain species of tunicates (*Phallusia fumigata, Phallusia mammillata*) has decreased significantly.

•Most of the organisms found are filter feeders, so they purify the water to some extent, in that way they retain certain particles that are dissolved or suspended in the water

•Although organisms from the port must not be used for human consumption, they can indirectly reach bigger predators through the food web, i.e. fish that can be eat by humans. For this reason, it would be useful to analyze the content of some heavy metals, PCBs and PAHs in some of the sessile organisms in the harbor and compare them with the values in the same organisms from the unpolluted water area.

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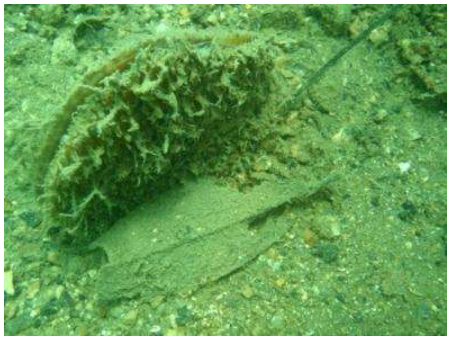
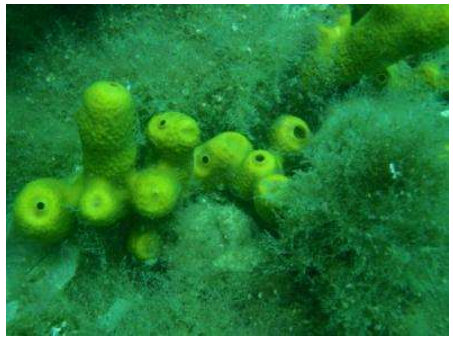
• Among the identified species there are those that are on the list of protected, threatened and those whose exploitation is limited according to national (Official Gazette of Montenegro No. 76/06) and international legislation (Barcelona Convention, 1976).

•These are sponges *Aplysina aerophoba, Spongia officinalis*, coral *Cladocora caespitosa*, bivalvia *Pinna nobilis*, sea urchin *Paracentrotus lividus*, sea cucumbers of the genus Holothuria.

•The number of these organisms increased during the research period so that we have an interesting situation of their reproduction and expansion of distribution in the harbor water area.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•In addition to the protected ones, the presence of alien, introduced species such as the sponge *Paraleucilla magna*, the clam *Pinctada imbricata radiata* and the ascidia *Styela plicata* was noted.

•The number of these species showed a seasonal dynamic, but considering that their reproduction and increase in the area of distribution has been confirmed, we can talk about their establishment in this locality

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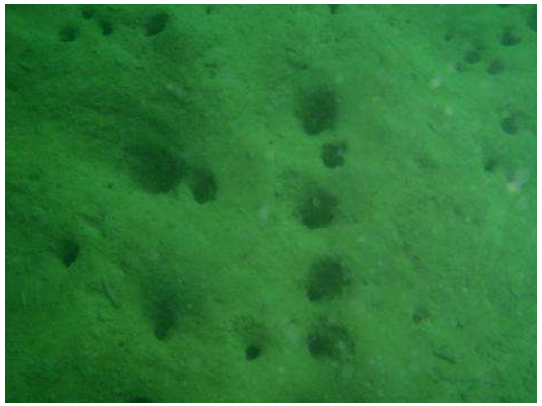
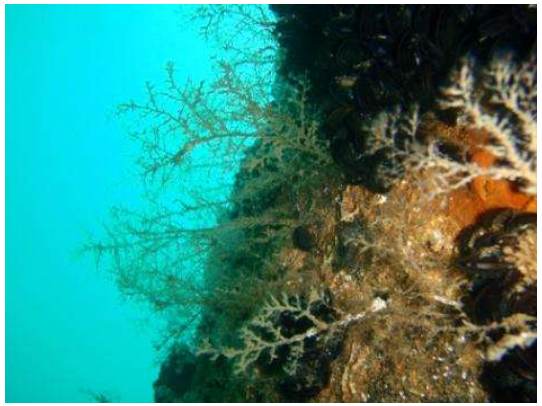
•Recommendations aimed at monitoring the condition and preservation of zoobenthic groups of organisms:

•to analyze the content of heavy metals, PCBs and PAHs in some of the sessile organisms in the harbor and compare them with the values in the same organisms from the unpolluted water area;

•monitor non-indigenous species and educate users about the problems of invasive species;

•rehabilitate the seabed (removal of solid waste).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Thank you for your attention!

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