LONG-TERM EUTROPHICATION IN A SEMI-ENCLOSED BAY (THE KAŠTELA BAY - ADRIATIC SEA) AND WATER QUALITY MONITORING

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Abstract

The enrichment by nutrients, (especially compound of nitrogen and phosphorous) and other contaminants, causing accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to balance the organisms present in water concerned. Growth rate changes lead to changes in species compositions in both planktonic and bentic assemblages. The Kastela Bay is particularly threatened by the organic matter and nutrients input causing an extreme phytoplankton bloom each summer. Monitoring the changes to the Bay's waterways is important, and the data that is collected can help scientists make determinations about water quality.

Introduction

All living things need water. In the Kastela Bay region, waterways support more than 3,000 species of plants and animals. Some plants and animals that currently live in the Bay haven't always been part of the Bay's balanced ecosystem. Healthy water contains a balanced amount of nutrients and normal fluctuations in salinity and temperature. It also has plenty of oxygen and little sediment so that underwater living resources can breathe or receive enough sunlight to grow. Monitoring the changes to the Bay's waterways is important, and the data that is collected can help scientists make determinations about water quality.

Study area

The Kaštela Bay is 14.8 km long, about 6 km wide and, on the average, 23 m deep. The eastern part of the Bay also receives large quantities of untreated municipal and industrial effluents. Water exchange and changes in the current field are mostly induced by local winds related to the passing of mid-latitude cyclones over the area. The Bay is particularly threatened by the organic matter and nutrients input causing an extreme phytoplankton bloom each summer.

Water Quality Factors:

Nutrients are essential for plants and animals, but too much can cause harmful effects.

- Sediments can cloud the water which can hinder the growth of aquatic plants.
- Water temperature affects when animals and plants feed, reproduce, and migrate.
- Salinity greatly determines where plants and animals live within the Bay.
- Dissolved oxygen is essential for animals living within the Bay.
- Chemical contaminants can affect the growth, survival and reproducibility of benthic organisms.
What is Nutrient Pollution

Nutrients, like nitrogen and phosphorus, occur naturally in water, soil and air. Nitrogen is essential to the production of plant and animal tissue. It is used primarily by plants and animals to synthesize protein. Nitrogen enters the ecosystem in several chemical forms and also occurs in other dissolved or particulate forms, such as tissues of living and dead organisms.

Phosphorus is another key nutrient in the Bay's ecosystem. Phosphorus occurs in dissolved organic and inorganic forms, often attached to particles of sediment. Phosphates, the inorganic form are preferred, but organisms will use other forms of phosphorus when phosphates are unavailable.

Although nutrients are essential to all plant life within the Bay, an excess of these same nutrients can be harmful. This is called "nutrient pollution". Excess amounts of phosphorus and nitrogen cause rapid growth of phytoplankton, creating dense populations, or blooms. In the Bay region, excess nutrients are supplied to the system through two sources: point and non-point sources.

**Point Source** - A source of pollution that can be attributed to a specific physical location; an identifiable, end of pipe "point". The vast majority of point source discharges for nutrients are from wastewater treatment plants, although some come from industries.

**Non-point Source** - A diffuse source of pollution that cannot be attributed to a clearly identifiable, specific physical location or a defined discharge channel. This includes the nutrients that runoff the ground from any land use - croplands, feedlots, lawns, parking lots, streets, forests, etc. - and enter waterways. It also includes nutrients that enter through air pollution, through the ground water, or from septic systems.

What is Sediment Pollution

Sediments are loose particles of clay, silt, sand and other substances that are suspended in the water and settle to the bottom of a water body. Sediments suspended in the water column blocks light needed for photosynthesis. When sediments sink to the bottom, they change the character of the Bay's floor. Sediment is significant in nutrient and toxic transport, deposition, and recycling: sediments adsorb (collect) nutrients and bind metals and organic compounds. Sediment deliveries to the Bay system are highly seasonal and unique to each tributary.

Why are sediments a problem in the Bay?

- Sediments can smother bottom-dwelling plants and animals, such as oysters and clams.
- Suspended sediments make the water cloudy so less light is available for underwater Bay grasses.
- Sediments can carry high concentrations of certain toxic materials that contaminate waterways.
- Sediments also carry nutrients, particularly phosphorus, which increase nutrient pollution in the Bay.
- Accumulation of sediments can fill in ports and waterways.

Water: Salinity, Temperature and Circulation

The distribution and stability of ecosystem, such as the Kastela Bay, depend on three important physical characteristics of the water: salinity, temperature and circulation. Each affects and is affected by the others. Together, salinity, temperature and circulation dictate the physical characteristics of water. The warmer, lighter freshwater flows seaward over a layer of saltier and denser water flowing upstream. The opposing movement of these two flows forms saltwater fronts or gradients that move up and down the Bay in response to the input of freshwater. These fronts are characterized by intensive mixing. A layer separating water of different densities, known as a pycnocline, is formed (Fig. 3.). This stratification varies within any season depending on rainfall. Stratification is maintained throughout summer due to the warming of surface waters. The change in temperature and salinity divides the Bay into saltier bottom water and lighter, The change in temperature and salinity divides the Bay fresher surface water.
blurry mixing layer, known as the pycnocline, divides the two. Strong winds can pile surface water against one shore of the Bay. To reestablish equilibrium, the bottom layer flows up into shallower water.

Figure 3. The change in temperature and salinity in the Bay

**Dissolved Oxygen Criteria.** Oxygen is required by most living organisms. It enters Bay waters from the atmosphere and as a byproduct of plankton and aquatic plant photosynthesis. Low oxygen (hypoxia) or no dissolved oxygen (anoxia) will stress or kill fish and other organisms. Surface water is at or near saturation all year, while deep bottom waters go from saturation to nearly zero. Fish and other aquatic life require levels of dissolved oxygen to survive. Seasonal algae blooms deplete dissolved oxygen, potentially rendering deep waters of the Bay uninhabitable to certain species. Bay dissolved oxygen levels should be those required by the aquatic communities inhabiting different parts of the Bay during different times of the year, fully reflective of natural conditions. The amount of oxygen needed in the Bay tidal waters depends on specific needs of the aquatic living resources, where they live, and during which time of the year they live there.

- **Healthy water** contains at least 5.0 mg/l of dissolved oxygen.
- **Hypoxia** occurs when water contains low levels of dissolved oxygen (2.0 mg/l - 5.0 mg/l).
- **Severe hypoxia** occurs when water contains very low levels of dissolved oxygen (0.2 mg/l - 2.0 mg/l).
- **Anoxia** occurs when water contains very little or no oxygen (0 mg/l - 0.2 mg/l).

**Toxics Pollution**

Another major stressor to the Kastela Bay is toxic chemicals. Toxic chemicals are the chemical contaminants that harm plants, animals, fish and humans. Chemical contaminants are not nutrients, and they do not affect the Bay system the same way nutrients do. Although many chemicals do not pose a threat, certain types and levels of chemicals found in water bodies can affect the reproduction, development and, ultimately, the survival of living resources.

Figure 4. One litre of used motor oil can polluted up to 2 million litres of water.

Toxicity of a chemical depends on many factors such as concentration, chemical and physical form, and persistence of the chemical. Some chemicals reach harmful levels when they accumulate in the sediment.
at the bottom of the Bay, in animal tissue, and in the water column. Chemical contaminants entering the Bay and its tidal rivers come from natural processes, such as the weathering of rock, and human activities, such as manufacturing and driving. Like nutrients, chemical contaminants enter the system from point and non-point sources.

Water Quality Monitoring

The water quality monitoring program in the Kastela Bay region, began in 1976 with some stations sampled once each month during the colder late fall and winter months and twice each month in the warmer months. "Special" cruises may be added to record unique weather events. The collecting organizations coordinate the sampling times of their respective stations, so that data for each sampling event, or "cruise", represents a synoptic picture of the Bay at that point in time. At each station, a hydrographic profile is made (including water temperature, salinity, and dissolved oxygen) at approximately 5 to 10 meter intervals. Water samples and sediments for chemical and biological analysis (e.g., nutrients, heavy metals and chlorophyll) are collected at the surface and bottom, and at two additional depths. Correlative data on sea state and climate are also collected.

In order to reduce chemical contamination, it is first necessary to identify where the chemicals are coming from. Loadings are estimates of the quantity of chemical contaminants that reach the Bay, from sources such as point sources discharging into the Bay or its rivers, urban runoff, atmospheric deposition, shipping and boating, and mine drainage. Releases are estimates of the quantity of chemical contaminants emitted to the Bay’s watershed that have the potential to reach the Bay.

The major pollution threats in the Kastela Bay region are excess nutrients, sediments, toxics or chemical contaminants, air pollution and landscape changes. Some nutrients, sediments and toxics occur naturally in the Bay system. However, the amount of nutrients, sediment and toxicants reaching predominantly by municipal and industrial discharges, i.e. agricultural and urban runoff. Nutrients from septic systems are increasing throughout the watershed as development spreads farther into the countryside, beyond the reach of sewer systems. Storm water runoff from urban and suburban areas is increasing as more land is developed.

The enrichment by nutrients, (especially compound of nitrogen and phosphorous) and other contaminants, causing accelerated growth of algae and higher forms of plant life to produce an undesirable disturbance to balance the organisms present in water concerned. Often the total biomass increases, such as, for example, the total amount of chlorophyll in the plankton. Growth rate changes lead to changes in species compositions in both planktonic and bentic assemblages.

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<thead>
<tr>
<th>Table 1. The following are monitored because they are key indicators of the Bay's health:</th>
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<td>PLANKTON</td>
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<td>BENTHOS</td>
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Some Ways to Prevent Nutrient Pollution

- Limit your fertilizer use and apply at appropriate times.
- Control runoff and soil erosion.
- Conserve water and energy.
- Start a compost pile and recycle yard waste.
- Plant trees.
- Maintain your septic system.
- Drive less
- Get involved!!!

Conclusion:

The long-term studies (from 1976 up to now) of chemical and biological parameters in the eastern Adriatic coast point to the fact that, during the past decade, an increase in the eutrophication level has persisted in some semi-enclosed areas, like Split area (Kastela Bay). For the past few years the waters of the Bay have shifted into the highest category of productivity ($500 \text{ mg C m}^{-2} \text{ y}^{-1}$) of the seawater. Our findings suggest that the biomass, in the terms of the overall amount of phytoplankton in some areas, does not change substantially, but the composition of biomass does. By causing unintentional shifts at the base of the food pyramid, we may have produced shifts at the top—shifts we still do not fully understand.

References:

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