Nautical tourism ecological footprinting (NatEF) – experiences from east Adriatic in developing assessments

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Intensity of nautical tourism in Croatia is rapidly increasing. Most attractive and sensitive locations are under rapidly growing pressures threatening their ecological status. First analysis of nautical tourism environmental aspects were initiated 10 years ago focusing on emerging cruise tourism. Since then understanding of cause-effect matrix of environmental pressures and impacts is evolving and providing more detailed knowledge on nautical tourism ecological footprint. Furthermore, with marine NATURA 2000 network emerging in recent years, to complement existing nature parks, management challenges appeared from all aspects and the need for stakeholder cooperation and informed management is the priority. Although MPAs are conducting mitigation measures, the extent and complexity of related issues is such that wide partnerships are inevitable necessity.

Project presented here is taking place in scenic marine environment that is a NATURA site linking to the Krka National Park that annually attracts more then 1.000.000 visitors with continuous increase. Therefore the locations in question are under considerable visitation pressures from both nautical and land based tourism. Prime concern, therefore, from all interested stakeholders is to gain data, information, parameters and indicators that can enable informed decision-making.

Since basic information of number of vessel (per day/month/year/season) in the Krka River estuary is not available a preliminary "spot" counting was conducted concluding that: number of vessels passing in/out of the Estuary during nautical season may reach up to 1.500 per day - nearly 100.000 vessels during summer period.

A significant number of boats anchor in front of Skradin town that is frontier of the National Park Krka and sensitive estuary ecosystem. No reliable data is available on exact spatial and timing of boats' activities, making the risk of uncontrolled anthropogenic inputs even more worrisome. Additionally, the crowding and intensity of boat movement in the season increase the probability of various incidents and accidents with different scales of potential impacts.

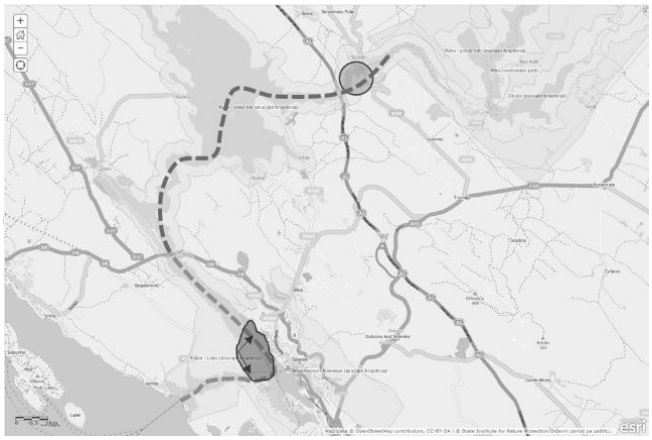

Figure1: Map of the "Krka Mouth" area (Code: # HR3000171). Dashed lines represent ranges of the two distinct protected areas: "Krka – lower part" (blue line) and "Channel – Harbor" (orange line). Marked red area represent investigated sites; arrows show two directions of video counting system. The pilot site is located in the Mediterranean part of Croatia, between towns of Skradin and Šibenik.

Located between the Skradinski Buk waterfalls through the Prokljan Lake to the St. Ante Channel, the estuary has a total length of 22 km.

Since 2014. research is conducted on the sources, distribution and behavior of ecotoxic metals in the Krka River estuary in cooperation with the colleagues from the Toulon University (France). Subsequently the irregularities were disclosed: during summer season concentrations of copper are up to 20 times higher compared to winter season! Sampling methodology and analyses of trace metals used here were:

- Two field scheme were surveyed: the first along the whole estuary transect, involving two contrasting periods of a year (winter and summer), covering 15 sites and the second, "high-resolution" mapping, within the Šibenik Bay (summer) covering 40 sites. Vertical profiles of main physico-chemical parameters (salinity, temperature, pH, and dissolved oxygen) were measured in-situ at each site by CTD multiprobe. Samples were collected using a trace metal clean horizontal water sampler (Wildco).
- Samples were filtered through 0.45 or 0.22 μm cellulose-nitrate membrane filters (Sartorius) and acidified with ultrapure concentrated HNO3 (TraceSelect Fluka) to pH < 2.
- Trace metal concentrations were determined by electrochemical techniques using Autolab (EcoChemie) potentiostats and three-electrode cell (663 VA Stand, Metrohm).

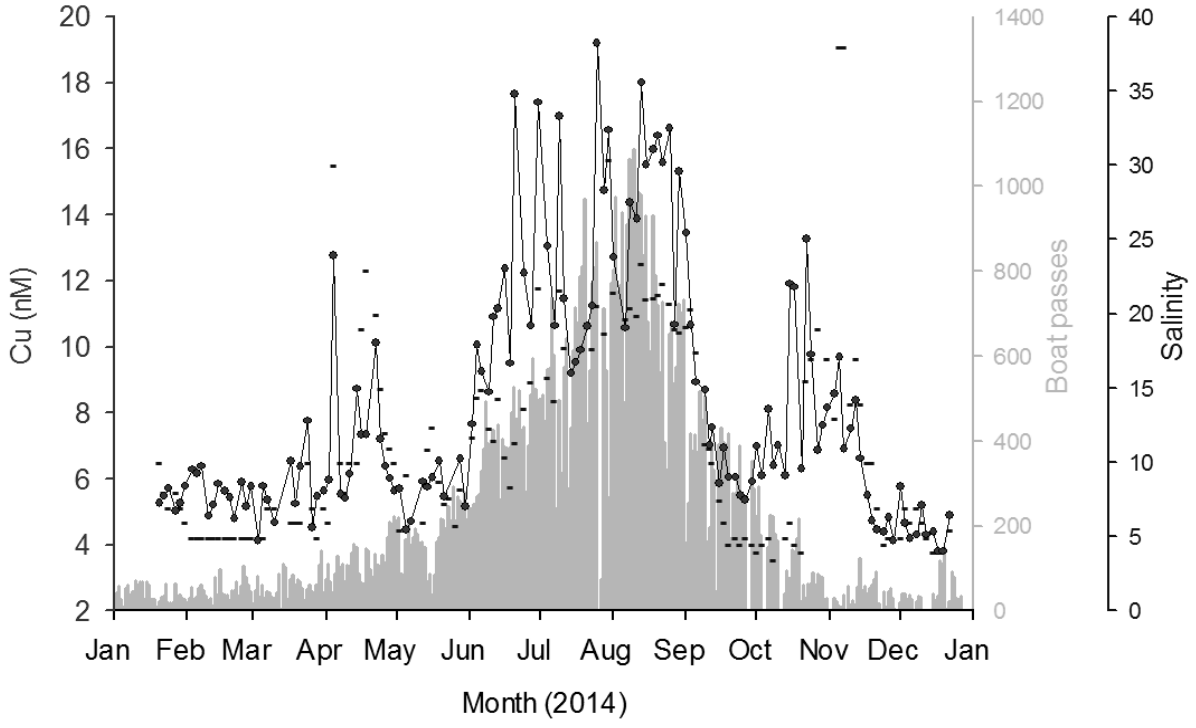

Figure 2. Daily values of salinity, passages of boats and Cu concentrations surveyed in 2014. in the Krka River estuary sites

The main source of increased copper concentration is anti-fouling paints used as biocide agent for nautical vessels. For particular environmental / chemical conditions, at this level elevated concentrations (~1.3 μg/L), copper is considered as potentially toxic and a matter of

concern regarding possible negative effects to different organisms (especially phytoplankton species) and entire ecosystem. In combination with temperature, high nutrient content, this could lead to the increased primary production, finally finishing with the eutrophication, which was already registred in parts of the MPA in question.
Since risk assessment model for antifouling was developed previously, the project is continuing in direction of further data gathering and analysis in order to disclose risk level and subsequently mitigation. Key issues here are heavy metal bio-magnification through food-chains in sea environments and biodiversity fragility. Because the Krka River Mouth area is fish and mussel farming area (5.000 tons per year) it is necessary to make effort to reduce possibly consequences to minimum.
Based on the up to date experiences, a group of researches decided to continue on evolving methodologies that would lead toward fuller understanding of Nautical tourism ecological footprinting: developing parameters and indicators based on both existing standards and evolving research. Along those lines the methodological approach for NatEF is as following:

1. Monitoring intensity, timeing and spatial distribution of maritime traffic by:
- video system for nautical vessels counting with automatic counting software;
- heat mapping of traffic through radar imaging and vessel finder system (through the ministry of maritime traffic).
2. Monitoring of copper content in surface water of the Krka Mouth: Off-shore sampling of surface water (every 2 to 15 days, depending on the season/site). Primary sample preparation (filtering, acidification) is conducted in laboratory or on-site. Further samples pre-treatments and handlings required for measurement is performed immediately before analysis. Analyses used high-quality instrumentations and methods: electrochemical and/or HR ICP-MS (High Resolution Inductively Coupled Plasma Mass Spectrometry).
3. Determination of correlation between copper distribution and number of boats in the estuary: data collected is analyzed through mathematical/statistical packages (Data Mining and Principal Component Analysis) and interrelations correlated within the measures: number of boats, copper concentrations, weather conditions, hydrological conditions, seasonal activities.
4. Expand footprinting analysis with other aspects: underwater noise, gray waters, black waters, bilge etc. Assessing best available methodologies for monitoring of named aspects.
5. Mitigation recommendations for MPAs - alternative methods, techniques and treatments that remove fouling with no heavy metal inputs into the environment.
Currently part of the named activities is being conducted as part of a MedPAN project ("NaTEF – Nautical Tourism Ecological Footprint in MPAs").

References

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