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One step from the deep ocean: Linking research and governance for the Tagus river estuary and the Lisbon canyon system – A conference report

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ABSTRACT

This report summarizes current threats to the Tagus estuary and adjacent ecosystems, presented in Lisbon in June 2021, and prioritizes actions to maintain or improve ecosystem services for a densely populated area close to the deep ocean.

1. Introduction

On June 22nd 2021, the Municipality of Lisbon and the Portuguese Ministry of the Sea promoted an expert conference to discuss the current state of the Tagus river estuary and adjacent oceanic areas and to promote future action. The Tagus river estuary shapes the Lisbon Metropolitan Area, bordering 11 water-facing municipalities across 320 km^2 (among the largest in Europe and critically positioned along the North-South bird migration corridor of the East Atlantic [1]). It communicates with the deep North Atlantic through the Tagus submarine prodelta and the Lisbon/Cascais/Setúbal canyon system (Fig. 1). This proximity allows interaction of water masses and biological communities between the estuary and the deep ocean and deserves scientific attention.

The conference integrated perspectives on current threats, after millennia of human occupation and decades of local efforts to improve environmental status and contributed towards an action plan to maintain or improve ecosystem services for this densely populated area, following an ecosystem stewardship framework [2].

2. Conference report

Morning sessions were dedicated to the estuary and afternoon ones to adjacent coastal and oceanic areas. Six experts from different disciplines and institutions with local research activity made short presentations in each session (Supplementary Table) and a science journalist moderated a panel discussion. Speakers provided overviews of local environmental conditions, persisting and emerging problems, likely solutions, constraints, and broader trends. The target audiences were mainly local and regional administration bodies, so technical jargon and methodological details were avoided. The pandemic limited presence, but over 200 people registered online and more than 2000 accessed the contents through social media (links in Supplementary Table legend).

Table 1 summarizes the main issues raised during the conference, organized in four topics: i) mechanical energy dissipation; ii) habitat and biodiversity degradation; iii) pollutants ́dispersion and iv) other ecosystem stressors. Drivers, influencing factors, ecosystem functions and services affected, and proposed solutions are listed for each group of problems. Influencing factors include both local signs of global trends (e.g., sea-level rise) and local contingencies (e.g., gas trapped in sediments of the Tagus prodelta). Ecosystem functions range from the estuary ́s role as a bird migration stopover to the canyon ́s potential importance as a conduit for the transfer of energy and matter (including pollutants) between the Tagus watershed and the homonymous adjacent abyssal plain.

3. Conference conclusions

Establishing an action-oriented framework for social-ecological stability under changing conditions requires judicious syntheses of existing understanding [2]. The conference brought together perspectives from distinct disciplines and biomes to identify main drivers of degradation, social-ecological traps to avoid or escape and opportunities for concerted action (Table 1).

For exogenous stressors, like extreme mechanical energy arriving at the coast, proposed action focuses on increased prevention or preparedness to minimize hazard exposure and vulnerability at the basin scale. For endogenous problems, like the public health concerns from the consumption of illegally marketed clams rich in heavy metals, integrated conservation and management action is proposed to restore ecosystem functions and services and to escape the social-ecological trap of mutually reinforcing habitat degradation and social marginalization. For the latter, the intermunicipal links within the Lisbon Metropolitan Area can leverage concertation based on polycentric arrangements without new layers of bureaucracy. Finally, functional links between the estuary and the canyon, like the export of carbon, contaminated sediments and non-indigenous and invasive species or the accumulation of litter in the canyon axis, offer an opportunity for knowledge creation, innovation and improved communication between administration and the public in a system linking urban centres and deep-sea ecosystems.

These proposals will be further shaped with administration to establish a roadmap for integrated action, including an “estuary rights”

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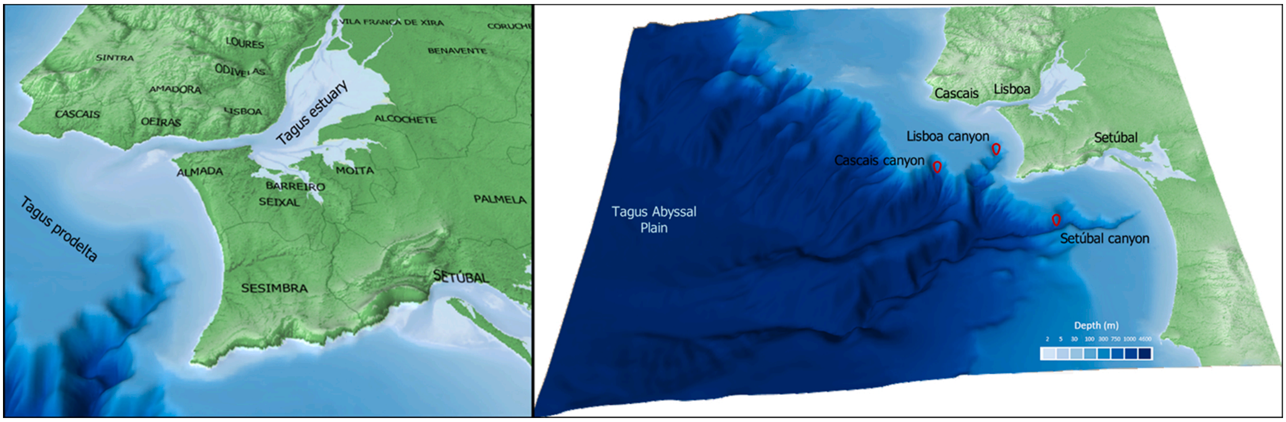

Fig. 1. Tagus estuary and municipalities of the Lisbon metropolitan area (left), adjacent coastal area and Lisbon canyon system bathymetry representation (right, colour scale in meters from hydrographic zero). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 1
Main challenges for the Tagus estuary, prodelta and Lisbon canyon system and proposed action course towards integrated ecosystem stewardship.

Drivers	Influencing factors	Ecosystem impacts	Course of action
Dissipation of mechanical energy Tsunamis Storms River flow Tides Waves	Seismicity of region Trapped gas in prodelta sediments Increasing storminess Sediment trapping and streamflow regulation by dams and weirs Dredging and reclamation Sea level rise	Landslides, including submersed landslides in areas with trapped gases Flooding of urban and agricultural margins Salinization of aquifers and agricultural soil Accretion of the navigation channel Coastal erosion, leading to beach nourishment	Develop multi-hazard observatory of operational monitoring and forecast Develop flood risk maps Improve morphological data acquisition with emphasis on LIDAR surveys Establish comprehensive reaction plans to extreme events at the basin scale Improve municipal reaction plans to locally disruptive events and future scenarios Integrate coastal protection measures, including beach nourishment, and adapt to decadal scenarios Articulate with metropolitan plan for adaptation to climate change and other management plans
Habitat and biodiversity degradation Intertidal saltmarshes, tidal flats and oyster reefs Seagrass and seaweed communities Migrating birds Fish spawners and juveniles Cetaceans	Biogeographic transition area Iberian agreement on the Tagus ecological flow Increasing frequency of droughts Increased dispersion of invasive halophytes Large unregulated fishery for invasive clam and unsustainable fishing practices Heavy ship traffic Increasing recreational use	Reduced carbon and sediment fixation, contaminant sequestration and wildlife habitat availability Reduced water filtration Disturbance of birds′stop-over habitat in migration corridor Collapse of local fishery resources Disruption of fish diadromy and amphihaline migration Perturbation of cetacean habitat in estuary and canyon Noisier terrestrial and aquatic soundscapes	Demonstrate utility of native halophytes to renaturalise urban estuary margins and remove invasive species using eco-friendly techniques Protect and restore saltmarshes and tidal flats to improve bioremediation Introduce buffer corridors for aquatic birds in agricultural land close to the estuary Designate protection areas for juvenile fish and spawners, restrict fishing activity in critical periods and promote more sustainable fishing methods Develop pilot management solutions for sustainable fisheries Support and articulate action with municipal river guards′initiatives Estimate local abundance and distribution of cetaceans to define carrying capacity for nature-tourist industry
Dispersion of pollutants Pharmaceuticals PAHs, PCBs Heavy metals Plastic, including microplastic Oil spills	Improving water quality Emergence of new pollutants Deficiencies in sewage treatment and in the network pipes De-industrialization and environmental inheritance	Bioaccumulation of pharmaceuticals, microplastics, emerging contaminants and metals Transfer along the food chain and into the human diet Remobilization of sediments and pollutants Export of polluted sediments and litter to the canyon head and accumulation in canyon axis	Improve monitoring (strategic design) Increase prevention and literacy Assess risk and benefit of seafood consumption Improve bioremediation and technological solutions for sewage treatment plants Improve tracing and sanitary control for bivalves from the Tagus estuary Reduce plastic use and increase its retention and recycling inland
Other ecosystem stressors Eutrophication Non-indigenous and invasive species (NIS) Jellyfish disequilibria (potential) Noise (potential)	Intensive agriculture Invasion of water hyacinth in tributaries Increasing introduction of NIS from ballast water and ship hull incrustation Seasonally large estuarine biomass and coastal export of local jellyfish Unregistered soundscapes and new international airport (decision pending)	Excess availability of nutrient loads Reduced light penetration and increased anoxia by proliferation of floating plants Introduction of predators and pathogens and increased competition Changes in native communities due to NIS Potential propagation of NIS to deep ocean through migrant vectors Disruption of provision and cultural services and potential ecosystem simplification by built-up of jellyfish biomass Potential disruption of behaviour and physiology due to noise pollution	Articulate with existing projects promoting ecosystem stewardship Promote trans/inter-disciplinarity Promote and protect saltmarshes to sequester excess nutrients Plan early intervention to prevent water hyacinth new colonies Promote shipping and aquaculture good practices that prevent NIS introduction Develop integrated port plans for treatment of ballast waters and early NIS detection Stimulate citizen science to monitor jellyfish and NIS Promote integrated estuarine soundscape monitoring

declaration and a proposal to study the environmental function of the Lisbon canyon system and its links with the estuary and the neighbouring abyssal plain.

CRediT authorship contribution statement

Yorgos Stratoudakis: Conceptualization, Methodology, Writing – original draft, Project administration. **José Lino Costa:** Conceptualization, Methodology, Writing – review & editing, Project administration. **André Fortunato:** Conceptualization, Methodology, Writing – review & editing, Project administration. **Filipe Porteiro:** Conceptualization, Methodology, Writing – review & editing, Project administration. **Inês Metelo:** Conceptualization, Methodology, Writing – review & editing, Project administration. **Miguel Bessa Pacheco:** Conceptualization, Methodology, Writing – review & editing, Project administration. **Maria José Costa:** Conceptualization, Writing – review & editing, Project administration. **Ivone Figueiredo:** Conceptualization, Writing – review & editing, Project administration. **Miguel Miranda:** Conceptualization, Writing – review & editing, Project administration. **José Sá Fernandes:** Conceptualization, Writing – review & editing, Project administration. All others – Methodology, Writing – review & editing.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2022.105224.

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