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A foreign settler: the anthropogenic displacement of sea cucumbers through fisheries discards

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Abstract

This study describes the presence of the royal cucumber *Parastichopus regalis* (Cuvier, 1817) in The Natural Park of Ria Formosa (NPRF), Portugal. A single individual was observed during a monitoring scuba dive at a depth of 3 m inside this shallow mesotidal lagoon. The most plausible explanation for this occurrence is attributed to the rejection by trawlers when returning to their home port from their fishing grounds. This marine species has a deeper distribution outside the lagoon and is commonly captured as by-catch and subsequently discarded. This study also alerts us to the growing presence of non-indigenous species and the emergent threat of new invasions, highlighting the need to adopt biosecurity measures, like good practices for fishers when dealing with discards to avoid new species introductions in this fragile coastal marine habitat.

Introduction

Sea cucumbers (holothurians) are pivotal species in marine ecosystems. In particular, deposit feeders have a critical ecological role in habitat structuring through bioturbation by recycling and redistributing nutrients (e.g., MacTavish *et al.*, 2012; Floren *et al.*, 2021). Holothurians worldwide are also subject to intense fishing and increasing demand, particularly for exportation to Asian countries (Purcell *et al.*, 2013; Azevedo e Silva *et al.*, 2021; Dereli and Aydın, 2021) and intensive harvest represents a severe ecological problem: the removal of key ecological functions from the ecosystems.

The holothurian *Parastichopus regalis* is a species with increasing commercial interest (Rámon *et al.*, 2010; Maggi and González-Wangüemert, 2015). It belongs to the Stichopodidae family and has a distribution that covers the NE-Atlantic and Mediterranean regions (e.g., Wirtz, 2009; Ramon *et al.*, 2010). Unlike other commercial species from the Atlantic coast (Azevedo e Silva *et al.*, 2021; Félix *et al.*, 2021), *P. regalis* is a deep-water sea cucumber with a bathymetric distribution that is more common in the range between 50 and 300 m depth (Rámon *et al.*, 2010). The Natural Park of Ria Formosa (NPRF), a shallow mesotidal lagoon on the southern Portuguese coast, is not part of the *P. regalis* distribution or habitat. The commercial species in this coastal system are *Holothuria arguinensis* and *H. mammata* (Marquet *et al.*, 2017). In some parts of the Mediterranean, *P. regalis* is a target species with recognised economic value (Maggi and González-Wangüemert, 2015) and is part of the trade market (Ramón *et al.*, 2022). However, otherwise, it is primarily discarded as by-catch by trawlers. This species has no commercial interest in Portugal and is commonly discarded, many of which are at, or near, the landing sites (Pedro M. Félix, personal observation). Furthermore, since 2021, all sea cucumber fisheries have been prohibited (National Decree number 38/2021). These discards have mainly been observed at the Sado estuary (Portugal). Despite this, no sea cucumbers occur in that transitional water body due to the unfit estuarine conditions for *P. regalis* or any coastal species (Félix *et al.*, 2021). The NPRF, on the other hand, has suitable environmental settings for the occurrence of detritivore sea cucumbers (Siegenthaler *et al.*, 2017) and could enable, at the very least, the survival of some non-autochthonous species.

Observation

In November 2023, while conducting an underwater visual census (UVC) survey in NPRF involving a triple 30 m × 2 m random transects in four seagrass meadows' sites (Figure 1), a single individual of *P. regalis* was detected and photographed (Figure 2) at a depth of 3 m with a water temperature of 19°C. The species was around 17 cm in size and without external physical lesions or apparent reduced physiological condition, presenting ambulacral activity and muscle contraction as a *stimulus* to manipulation (i.e., good fitness). This type of sampling has been conducted since 2022 on four occasions, with 16 UVC dives performed without any record of the species.

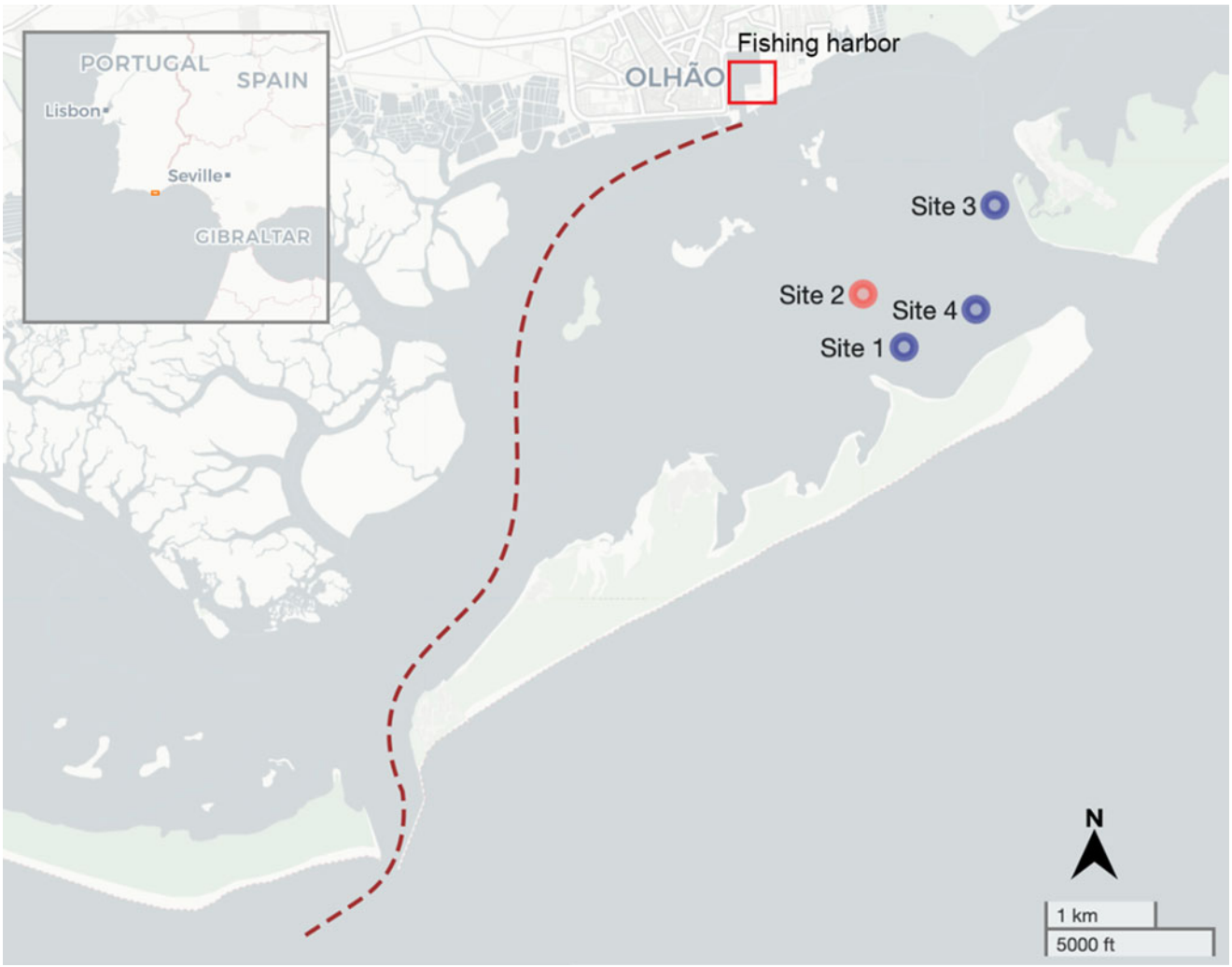

Figure 1. Location of studied sites (1–4) inside Ria Formosa Lagoon. The red circle (Site 2) is the location of the record of *Parastichopus regalis* detected in the present study. Also indicated is the route of the fishing vessels (dashed line) towards the landing site – Olhão fishing harbour (red square). The map was created in R (R Core Team, 2021) using the 'leaflet' package and the provider 'CartoDB positron'.

Figure 2. Photographs of *Parastichopus regalis* detected during the underwater visual census conducted in Ria Formosa Lagoon at 3 meters. Photographs taken by Nuno Castro.

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Discussion

The NPRF is a shallow mesotidal lagoon located on the south coast of Portugal. This valuable transition water body of regional, national, and international ecological importance is a site of Natura 2000 network (PTZPE0017), EU Birds Directive Special Protection Area and has been part RAMSAR wetland convention since 1980. This coastal lagoon is an important ecosystem with high biodiversity and serves as a nursery area for several species, including several commercial species (Erzini *et al.*, 2022). The lagoon has several seagrass meadows with associated species, including several endangered species, such as *Hippocampus guttulatus* and *H. hippocampus* (Caldwell and Vincent, 2012). It also has several associated leisure and economic activities, such as aquaculture, fishing, shellfish and polychaete harvesting (Oliveira *et al.*, 2013; Newton *et al.*, 2018; Cabral *et al.*, 2019).

Regarding fisheries, trawling, mainly targeting crustaceans, is heavily intensive in the south of Portugal due to the quantity and value of landings (Borges *et al.*, 2001; Monteiro *et al.*, 2001). Considering the distribution of trawling efforts in all regions of Portugal (Northwest, Midwest, Southwest, and South), the landing ports in the south are the most critical recipients, accounting for an average of 64.8% nationwide. According to a three-year survey carried out by Bueno-Pardo *et al.* (2017), the port of Olhão was the second most important in terms of landing, corresponding to a trawling effort of 13,212 h, on average *per* year, which corresponds to 23% on a national level. Regarding discards, trawl fisheries in this region are responsible for an overwhelming 70% of the total discarded catch (Monteiro *et al.*, 2001; Erzini *et al.*, 2002).

Globalisation has led to a significant increase in biological invasions, with an ever-growing number of species being introduced into regions that are far from their native range. Although most of these introductions have negligible impacts, some result in competition with local species, the growth of invasive populations, and a general decrease in native biodiversity (e.g., Brooks *et al.*, 2002; Clavero and García-Berthou, 2005; Burgess *et al.*, 2013; Cahill *et al.*, 2013). Consequently, it can incur significant economic costs through direct and indirect adverse impacts on ecosystem function and services (Diagne *et al.*, 2021). Many aquatic ecosystems have been seriously affected by non-indigenous species (NIS), which can displace native organisms (i.e., predation and competition), modify the genetic characteristics of the populations through hybridisation, and introduce exotic diseases (Bax *et al.*, 2003). The impacts caused by NIS may be irreversible, particularly in the marine environment, where NIS that becomes invasive can be very difficult to eradicate once they have established self-sustaining populations (e.g., Green *et al.*, 2012; Sempere-Valverde *et al.*, 2021).

To the best of our knowledge, this is the first record of *P. regalis* in NPRF, and its presence may have several possible explanations. The most plausible reason for this is the discard by fishers when returning to their home port. However, this is a common Atlantic Sea cucumber, a deep-sea species (50 and 300 m depth) (Rámon *et al.*, 2010) and is a common by-catch in trawlers, which are usually discarded during the selection process, not rarely at the landing sites (Borges, 2007). According to Tsagarakis *et al.* (2018), assessing the survival of discards in trawl fisheries in the Eastern Mediterranean Sea revealed that the survival rate of *P. regalis* after rejection was noticeably high, reaching almost 90% survival rate. This type of introduction vector is common worldwide and responsible for several species' introductions (Bailey *et al.*, 2020). Given the observations made in other estuaries and the testimonies of local fishers, the discard hypothesis is the most plausible one to explain the occurrence of this specimen of royal sea cucumber. Through human activities, the royal sea cucumber and other species often incoming from distant shores can carry a hidden menace – parasites (e.g., Chalkowski *et al.*, 2018; Whalen *et al.*, 2020). These hitchhiking parasites find new opportunities for transmission and infection in the novel ecosystems they encounter, whether by the introduction of NIS fish species hosting debilitating pathogens or the colonisation of invasive shellfish transporting microsporidian parasites (Graczyk *et al.*, 2004; White *et al.*, 2014; Moratal *et al.*, 2023). In this case, *P. regalis* is known to host the earlfish *Carapus acus*. The occurrence of this fish depends mainly on host availability and distribution from potential larval areas (González-Wangüemert *et al.*, 2014).

The study area has a growing abundance of NIS, particularly *Amanthia verticillata*, *Styela plicata*, and the Mediterranean native *Caulerpa prolifera* (personal observations by the authors during the present UVC). *Caulerpa prolifera* has been recently and rapidly expanding to gain space in deeper unvegetated soft bottoms and compete with the local seagrasses in the shallower areas (Parreira *et al.*, 2021). A further example of recently introduced NIS into the NPRF through maritime activities is the Atlantic blue crab (*Callinectes sapidus*), a Western Atlantic endemic species (Morais *et al.*, 2019). This growing number of NIS and associated species in NPRF requires monitoring since the introduction of NIS is a human-assisted global phenomenon with devastating effects on biodiversity, ecosystem services, and human well-being (Hulme, 2009; Sheets *et al.*, 2016; Vilà and Hulme, 2017). In addition, this study also highlights the need to incorporate biosecurity protocols in sensitive habitats. Prevention is the most effective method of avoiding or mitigating the impacts associated with unwanted NIS (e.g., Castro *et al.*, 2020, 2021). For example, the Ballast Water Management Convention (BWM Convention) is a biosecurity example adopted by the International Maritime Organization (IMO) to help avoid the spread of potentially harmful aquatic organisms and pathogens in ships' ballast water. Since September 2017, vessels must oversee their ballast water so that aquatic organisms and pathogens are eliminated or rendered harmless before being released into a new environment (IMO, 2020). Finally, implementing the best practice rules for discarding fisheries is a pressing issue for this sensitive region to avoid new introductions that might cause ecological and economic catastrophes.

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Competing interest. The authors declare no conflict of interest.

Ethical Standards. None.

Data Availability. No new data were created or analysed during this study. Data sharing is not applicable to this article.

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