ScienceDirect

Marine Policy

Volume 148, February 2023, 105461

Invasive blue crabs and small-scale fisheries in the Mediterranean sea: Local ecological knowledge, impacts and future management

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https://doi.org/10.1016/j.marpol.2022.105461

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Abstract

The recent expansion of the two invasive Portunidae blue crabs *Callinectes sapidus* and Portunus *segnis* has generated great concern in the western Mediterranean basin. Here, we collected perception from artisanal small-scale fishermen on the socio-economic issues associated with this invasion. Professional fishers from France, Italy, and Tunisia were interviewed to survey their perception on: (i) the potential drivers of spatial expansion of blue crabs, (ii) the impact on the small-scale fisheries, and (iii) the management measures expected. The main reported impacts were the damage of fishing nets (median = 4.3), followed by a consequent associated increase in work intensity (median = 3.6) and by physical injuries to fishers (median = 3.1). Fishermen reported to have caught less fish (median = 3.4) in presence of blue crabs, as well fish damaged by blue crabs' bite (median = 3.8) inducing a decrease in the quality and value of catches (median = 3.5). The negative effects induced a decrease on global revenues (median = 3.6) as well despite the negative

impacts of blue crabs on the fishery, the presence of these new species has been generally perceived as positive, being considered as a new revenue resource for some fishermen (median = 2.8). The majority of them (72 %) proposed fishing and marketing as main management measures. Despite the interested expressed for exploitation of this new resource, many questions emerged to promote and develop management strategies.

Introduction

Non-indigenous species (NIS) are one of the greatest biological issues of the 21st century [2], [35], [68], with their spread being facilitated by global climate change and anthropogenic pressures [59], [76], [79], [80]. Invasive species often cause strong ecological and economic impacts through habitat modification and biodiversity loss, with subsequent impacts on ecosystem functioning (e.g., trophic interactions; [30]). NIS often modify the provision of ecosystem services with consequential socio-economic losses for human activities (e.g., fisheries, industry, and tourism; [30], [86]).

The Mediterranean Sea has experienced a dramatic increase in non-native flora and fauna over the last few decades [90], [91]. The Mediterranean Sea is continually exposed to biological invasions and the current situation is exacerbated by several environmental factors (e.g. global change; [61]) and increasing human pressures (e.g. commercial shipping, aquaculture trade and the creation of corridors such as the Suez Canal; [65], [80]). The Mediterranean Sea is currently one of the most invaded marine areas in the world [21]. Current European Union (EU) policy for NIS management (Strategic Plan for Biodiversity (2011–2020), Target 9 of the Aichi Biodiversity Targets) states that, by 2020, (i) NIS should be identified and prioritized, and (ii) measures should be implemented to manage pathways of introduction and establishment in order to improve detection and early management in recipient regions [33]. But these objectives do not take into account the increasing number of introductions, their rapid geographic expansion, their ecological aspects as well as the difficulties in monitoring mass invasions [11], [64], which limits the implementation of effective adaptation and mitigation policies [28]. This is notably the case of two invasive Portunidae blue crabs, *Callinectes sapidus* (Rathbun, 1896) and *Portunus segnis* (Forskål, 1775). Respectively native to the Western American coast and Indo-Pacific Ocean, these blue crabs have both recently showed large expansion in the Mediterranean Sea [53], [82]. Both blue crabs are species of the same family (Portunidae), as well we know that they show the same ecology and behavior (aggressive and opportunistic behavior) [16], [39], [40], [51], [55], [57], [58] In the literature, the same trends are observed in both species on the impacts on biodiversity and artisanal fisheries [15], [16], [32], [44], [46], [56], [82]. The biological traits of these both Portunidae, such as early maturity, rapid growth rates, opportunist diet,

high reproductive rates, generalist habitat use, long-range larval dispersal, and effective physical and aggressive behavior [84] facilitate their invasive character and enhance the successful spread across regions [53], [82]. Despite local observations of competitive interactions with native species [32], [54] and impacts on the artisanal small-scale fisheries [44], the ecological and economic consequences of the invasion of these two blue crabs in the Mediterranean Sea are currently still only assumed [56], [85]. Moreover, there is currently a lack of harmonized, salient, and credible measures to control these species at both the European and global level.

Scientifically collected data showing the presence of NIS in the environment is crucial [69] but often rare, temporarily, and spatially limited. However, the inclusion of public and/or stakeholder perceptions of NIS is becoming increasingly common in scientific studies through well-tested approaches such as the Local Ecological Knowledge (LEK) [23], [38], [5], [60], [63], [79], [88]. Public opinion can be influenced by the perceived ecological benefits, financial costs, and ethical issues associated with proposed management actions and can strongly influence the outcomes and potential success of non-native species management attempts [13], [78], [81], [87]. As it is the case for blue crabs, public opinion is a very important component in making policy decisions about NIS to support management strategies for non-native species that can be ethically challenging, especially when it comes to removing species of commercial interest [10], [38].

Complete elimination of blue crabs is currently unrealistic and efforts are being directed toward understanding and controlling [56]. But, both blue crabs are considered a valuable seafood and supports an important fishery along the coasts of the Northern America for *C. sapidus* [83] and in many Asian countries for *P. segnis* [49]. Further, in the last decade, several studies have highlighted the high nutritional qualities of Mediterranean blue crab meat [48], [92] and artisanal small-scale fisheries of *C. sapidus* have developed in Turkey [4], in northern Greece [45], and in Tunisia [22].

One measure to control blue crab would be to commercially harvest them. Two options are possible: (1) commercial exploitation of blue crabs to reduce the numbers of these NIS, thus an exit option after and (2) considering the exotic species as a new resource to be integrated into the fishery activity. On the other hand, many undesirable effects can be observed: wild introduction in areas where the species was not present, the implementation of poorly selective fishing techniques that lead to significant by-catches, as well as cases where paradoxically the selective exploitation of the largest individuals has favored the dynamics of the species by decreasing intra-specific competition [71]. However, such management action involves a number of challenges, which may include a lack of management resources,

diverse points of view of stakeholders on the value of invasive species and the opposition to removal techniques as observed for lionfish [52]. As a main consequence, due to the highly level of risk due to the social components affecting ecological dynamics in managing NIS-related aspects of management at sea, gaining socio-ecological and economic understanding of how make effective management strategies is recognized as crucial in modern conservation science. In doing it, to accommodate the social (human related) component, the use of questionnaires distributed to well suited target groups (e.g. artisanal small-scale fishermen) may assist the research and management programs.

Here, we collate and synthesize information collected by Local Ecological Knowledge (LEK) approach targeting artisanal small-scale fishermen from France, Italy and Tunisia. Questions were asked to survey their perception on: (i) the causes and occurrences of blue crab proliferations in their countries chosen as blue crabs are there by now commonly harvested, (ii) the impact on the fishing activity, and (iii) on possible management measures that could be put in place. This study is the first study quantifying the socio-ecological and economic impact of the blue crab invasion on small-scale fisheries in the Mediterranean Sea.

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Materials and methods

This work is part of a cross-border multidisciplinary project (BLEU-ADAPT, Interreg Italy-Tunisia, 2020–2022) conceived to increase our understanding on the Portunidae blue crabs species (*C. sapidus* and *P. segnis*) invasion in the Mediterranean Sea, especially among Italy and Tunisia.

A questionnaires-based online survey (Google form format) was performed to identify the socio-economics impacts of blue crabs on the artisanal small-scale fisheries. The anonymous questionnaire was translated in…

Results

The invasion patchwork of the two species of blue crabs (*C. sapidus* and *P. segnis*) in the Mediterranean Sea is different among the 3 surveyed countries (Fig. 1A) as reported by plotting occurrence data from literature. Indeed, Italy was the first country to report the presence of these new species, respectively in 1949 for *C. sapidus* and in 1966 for *P. segnis*. Tunisia was the second country where both crabs rapidly spread, respectively since 2014 for *P. segnis* and since 2017 for *C. sapidus;* in …

Discussion

The impact of blue crabs was quantified in the eastern part of the Mediterranean Sea in 2020 only on the recreative fisheries [15]. The present study provided a recent additional data collection that allowed the analysis of the potential impacts exerted by the blue crabs on artisanal small-scale fishery in the Western Mediterranean Sea. LEK confirmed the value as a tool enabling the collection of crucial knowledge required to evaluate the distribution and socio-ecological impacts of invasive…

CRediT authorship contribution statement

Guillaume Marchessaux: Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Writing – original draft, Writing – review & editing, Conceptualization,Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Software, Writing – original draft, Writing – review & editing. **Maria Cristina Mangano:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Supervision, Writing – review…

Acknowledgements

We would like to thank all the French, Italian and Tunisian fishermen for the time and help they gave us to carry out this study. Many thanks to Nathalie Barré (CEN-Occitanie/Pôle-Relais Lagunes Méditerranéennes), Madeleine Freudenreich (IUCN France), Thomas Sérazin (CRPMEM Occitanie) and Iris Lang (Conservatoire d'Espaces Naturels d'Occitanie) for the diffusion of the questionnaires in France. We would like to thank the reviewers and the editor for their helpful comments and suggestions to…

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