



## Opinion Paper

# On the Atlantic blue crab (*Callinectes sapidus* Rathbun 1896) in southern European coastal waters: Time to turn a threat into a resource?



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## ABSTRACT

The blue crab *Callinectes sapidus* is native to the coastal waters of the western Atlantic Ocean, and along the US coasts the species supports an important fishery. The crab was introduced to Europe at the beginning of the 20th century. To date, the species is considered invasive and it has been extensively recorded in southern European waters (SEW), where it is starting to penetrate the shellfish market. Here, an integrated management strategy is proposed for the blue crab in SEW, including the Mediterranean and Black Sea and the eastern Atlantic coasts of the Iberian Peninsula. Taking as introductory examples two case studies represented by the red king crab *Paralithodes camtschaticus* and the green crab *Carcinus maenas*, a framework of key issues is reviewed, considering the double nature of the species as invaders and shellfish products. A SWOT analysis is eventually presented for *C. sapidus*, in order to perform a state-of-the-art synthesis of the proposed scenario, highlighting the potential opportunities as well as the weaknesses related with the limited knowledge of the ecological and economic impact of the species in invaded habitats. The review is concluded by an appraisal of the current trends in global and European crustacean fisheries. The ongoing expansion of *C. sapidus* might represent a useful management case study, where the need to control an invasive species and mitigate its ecological impact can be harmonized with the opportunity to value it as a fishery resource.

## 1. Introduction

Food webs of marine coastal habitats support crucial ecosystem services, and are currently experiencing a diversified spectrum of human pressures worldwide. Besides habitat loss and overfishing, the introduction of non-indigenous species is among the most pervasive stressors affecting coastal areas at every latitude, from polar to temperate and tropical regions (Molnar et al., 2008). In recent decades, the Mediterranean Sea and, in general, southern European waters (SEW hereafter) have experienced a dramatic increase in the frequency of introduction and rate of expansion of non-indigenous crustaceans (Nunes et al., 2014; Chainho et al., 2015). Several examples (e.g., see Katsanevakis et al., 2014 for a recent review) are available regarding the effects of some of these species on the delivery of goods and services (*sensu* Liqueste et al., 2013) in invaded ecosystems; in general, however, the ecological and economic impacts of crustaceans introduced in south

European coastal systems have scarcely been investigated.

An illustrative example of this knowledge void is provided by the Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 (Brachyura: Portunidae). Native to the western coasts of the Atlantic Ocean, this species inhabits estuaries, lagoons and other coastal habitats, is euryhaline and eurythermal, and is characterized by a high fecundity and aggressive behaviour (Millikin and Williams, 1984). In native habitats, *C. sapidus* has long been recognized as an important functional component of coastal benthic food webs (Baird and Ulanowicz, 1989; Hines, 2007). In addition, it supports important fisheries in Northern and Central America (Fig. 1A and B; FAO, 2014; see also Fogarty and Miller, 2004; Kennedy et al., 2007; Bunnell et al., 2010 for the U.S.A.), with a capture production estimated in 2013 only in the United States at 74,495 tons, corresponding with a commercial and recreational asset valued at approximately US\$185 million (NOAA, 2014).

The blue crab was introduced in northern Europe in 1900 through

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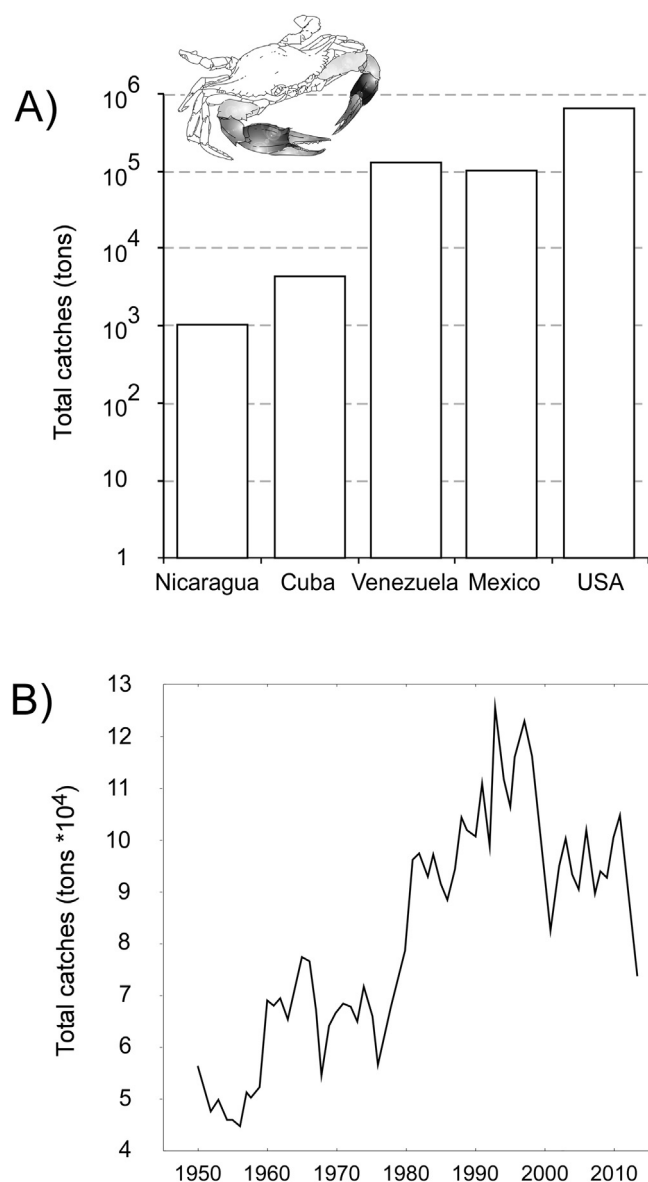


Fig. 1. Blue crab catch statistics in native areas: A) cumulative catches (in tons) of countries on the Western Atlantic in the decade 2003–2013; please note the logarithmic scale; B) temporal pattern of total catches in the same area in the period 1950–2013. Source: FAO (<http://www.fao.org/fishery/statistics/global-capture-production/en>, accessed 10/06/2016).

ballast waters; subsequently, its distribution range has progressively extended throughout the Mediterranean Sea and neighbouring waters (Nehring, 2011; Cilenti et al., 2015; González-Wangüemert and Pujol, 2016) and, to date, it is considered an Invasive Alien Species (IAS hereafter; Strefataris and Zenetos, 2006). Adverse interactions with other native crustacean species have been repeatedly suggested (Gennaio et al., 2006; Mancinelli et al., 2013a) and some negative effects on artisanal fishing activities have been episodically reported (Nehring, 2011); besides this scant information, the impact of the species on non-native coastal ecosystems is poorly known. No general capture regulations or managing strategies have been identified to date; in addition, the actual perception of fishermen and stakeholders of the impact of the species on human activities in coastal habitats has been virtually unexplored.

Here, the overarching scope is to outline an integrated management strategy of the blue crab in invaded habitats, highlighting its potential as a shellfish product in European markets for alimentary and non-alimentary purposes. The core of the study is an analysis of the

strengths, weaknesses, opportunities, and threats (SWOT) related with a commercial exploitation of the blue crab that may simultaneously translate in an effective strategy of control and mitigation of its impacts as an invasive species. Two case studies – the red king crab *Paralithodes camtschaticus* and the green crab *Carcinus maenas* – are used to identify a spectrum of key issues directly associated with an integrated management of invasive brachyurans as shellfish products. An analysis of current and future developments of crustacean fisheries at a global and European scale is also provided, indicating how a current ecological threat may, paradoxically, foster crab fisheries in SEW in the next decade.

## 2. The red king crab and the green crab: two illustrative case studies

In 2011, Brockerhoff and McLay (Brockerhoff and McLay, 2011) recorded 73 species of alien marine and brackish brachyurans worldwide; currently, the number is likely to be even higher as, in 2014, Klaoudatos and Kapiris (Klaoudatos and Kapiris, 2014) listed 40 species only in the Mediterranean Sea. Among others, here we focus on the red king crab *Paralithodes camtschaticus* Tilesius, 1815 and the green crab *Carcinus maenas* Linnaeus, 1758. Even though they differ in terms of biology, invasion history, native habitats, and ecological characteristics (Table A in the online information and references cited therein), they provide two highly illustrative examples of the general convergence of strategies implemented to integrate the management of a fishery resource with effective actions of control and mitigation of an invader and *vice versa*. In Table A, three key points are worth highlighting:

- 1) *P. camtschaticus* was deliberately introduced from native north-western Pacific waters with the explicit aim of developing a targeted fishery. The management and exploitation of established populations started almost immediately, and only afterwards their invasive nature was acknowledged. This recognition was based on information provided by a number of field and laboratory investigations, in turn motivated by a research plan funded by the Norwegian government, allowing a quantitative assessment of the ecological and economic impact of the species, and of its overall effects on the services delivered by invaded coastal habitats. Methodological approaches originally developed to manage the populations in Norwegian waters such as the identification of free-fishing zones, or three-S (size, season, sex) procedures of stock selection, are now acknowledged as effective tools of control and mitigation (Ojaveer et al., 2015);
- 2) *C. maenas* was unintentionally introduced in North America through ballast waters, and its invasive nature was recognized as early as 1998. A thorough assessment of the negative ecological and economic impacts on invaded coastal systems has been paralleled by various attempts at control and eradication, which have only been temporarily successful. Interestingly, the huge body of information collected on the ecology of green crab populations in invaded habitats constituted a potentially useful basis for starting a fishery. Indeed, some unsuccessful attempts have been made in the past decade in the USA to develop a hard-shell fishery; more recently, the Department of Fisheries and Oceans in Canada has begun experimenting with a commercial green crab fishery. The marketing features involved to make it an alimentary asset (e.g. break-even prices) are currently under evaluation (Poirier et al., 2016; St-Hilaire et al., 2016);
- 3) regardless of the species and the sequence of events characterizing its recognition by governments and stakeholders as an invader or a fishery resource, Table A emphasizes that any action of integrated management of a marine invasive crab must necessarily rely on i) detailed information on the occurrence and abundance of populations, ii) data on their connectivity, as well as on iii) robust estimations of the ecological and economic impacts on ecosystem

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