Using the new SEICAT methodology to study the socio-economic impacts of the American blue crab *Callinectes sapidus* from Marchica lagoon, Morocco

[1]Mariam Oussellam, [2]Mohamed Selfati, [2]Najib El Ouamari, [1]Hocein Bazairi

[1] BioBio Research Center, BioEcoGen Laboratory, Faculty of Sciences, Mohammed V University in Rabat, Rabat, Morocco; [2] National Institute of Fisheries Research (INRH), Nador, Morocco. Correspondant author: M. Oussellam, mariam_oussellam@um5.ac.ma

Abstract. The majority of alien species are known to have socio-economic effects by impacting various components of human well-being (security, material and non-material assets, health, social, spiritual and cultural relations, freedom of choice and action). The evaluation of the impact of invasive species is one of the critical stages in setting priorities for policy and management actions, requiring assessment systems that allow comparison of impacts on different taxa, ecosystems and socio-economic contexts. Socio-Economic Impact Classification of Alien Taxa (SEICAT) is the methodology that can facilitate these comparisons. The essential feature of this approach is that it uses changes in people's activities as a common measure to assess impacts on well-being. Impacts are assigned to one of five levels, from Minimal concern to Massive, according to semi-quantitative scenarios that describe the severity of the impacts. The taxa are then ranked according to the highest level of deleterious impact that they have been recorded to cause on any constituent of human well-being. To demonstrate the usefulness of the system, we have classified the impacts of the American blue crab (*Callinectes sapidus*) in the Marchica lagoon, Morocco. These have shown a variety of impacts on human well-being, scoring the "Minor Impacts". The classification provides a consistent procedure for translating the wide range of measures and types of impacts by ranking the levels of socio-economic impact, allocating based on the best available evidence of proven deleterious effects, and being applicable to all taxa and a range of spatial scales. Surveys specifically tailored to capture the distinction between socioeconomic impact classes would strengthen our confidence in evaluations and to could better inform priority setting and decision-making.
Key Words: *C. sapidus*, invasive, Mediterranean, Nador.

Introduction. Invasive alien species are considered one of the most important causes for negative impacts on the environment, human health and socio-economics worldwide, once introduced into a new environment (Ojaveer et al 2015; Bellard et al 2016; Bradshaw et al 2016; Bacher et al 2018; Ogden et al 2019). Within their natural range of distribution, they live in balance with their biotope and populations are controlled by ecosystem interactions such as predation, parasitism and disease. Worryingly, the rates of introduction and settlement of alien species are increasing (Seebens et al 2017). At both national and international levels, these species have become one of the main threats, as they are spreading and multiplying rapidly due to the lack of natural predators and competitors (Piria et al 2021). Biological invasions bring diverse economic costs to society (Bonn 2005; Jackson 2015; Diagne et al 2020). Alien taxa in Europe are causing more socioeconomic impacts than ecological impacts, probably because the former are more readily perceived and immediately reported by concerned people (Vilà et al 2010).

The SEICAT methodology newly developed by Bacher et al (2018) represents the development of a tool specifically dealing with socio-economic impacts, known as SEICAT (Socio-Economic Impact Classification of Alien Taxa). The novel feature of SEICAT is that it analyses alien species impacts on human well-being, using the capability approach from welfare economics (Sen 1999; Robeyns 2005). Human well-being comprises the fundamental skills and conditions required for a dignified and fulfilling life, resumed by Narayan et al (2000) in four constituents, namely material and immaterial goods, security, health and good social relations, supported by freedom of choice and action. As alien species can alter the

environmental factors, economic setting and even the social context that determine the full range of potential human capabilities, they can affect human well-being through changes in one or more of its elements. The objective of SEICAT is not to balance the negative and positive impacts to determine the net value of introducing a foreign taxon, but rather to highlight the potential consequences. It provides a coherent approach for reflecting the wide range of impact types and measures into ranked levels of socio-economic impact, and is applicable to all taxa and at various spatial scales (Bacher et al 2018).

The American blue crab, *Callinectes sapidus*, presents a good example of biological invasion. Native to western Atlantic estuaries, it is found from southern Canada to northern Argentina, where it has been captured by professional fishermen for many years (Galil et al 2002). Blue crabs have been reported in the Mediterranean since 1898, probably introduced via ballast water (Holthuis & Gottlieb 1955). Later, it was reported in the Mediterranean sea at several locations (Galil et al 2002; Galil 2011). Recently, it has been reported as an invasive species in various areas of the western Mediterranean including the Moroccan, Algerian, Tunisian, and Italian coasts (Benabdi et al 2019; Piras et al 2019; Chartosia et al 2019), the Ebré lagoon and the Segura estuary in Spain (Castejón & Guerao 2013; González-Wangüemert & Pujol 2016) and the Corsica lagoon in France (Garrido et al 2018; Noël 2019). The first signaling of blue crab on the Moroccan coasts of the Mediterranean was from the Marchica lagoon, on 17 August 2017. Thereafter, systematic observations of this species were made at Marchica (Chartosia et al 2019). In 2019, the blue crab was observed in the valley mouths of Moulouya and Kert, located on the east side (at about 60 km) and west side (at about 25 km) of the Marchica lagoon, respectively, where it seems to gain more space in the western Moroccan Mediterranean (Taybi & Mabrouki 2020).

In 2020, the professional fishermen working on the Marchica lagoon made an important number of observations, like the impact these crabs will have on the quality of catches (shredding), the degradation of their nets and their interaction with other species. The present work proposes to make an initial assessment of the socio-economic impacts using the new SEICAT methodology, resulting from the interactions between blue crab and the main craft fishing professions in the Marchica lagoon.

Material and Method

Description of the study site. The Marchica lagoon (small sea in Spanish) of Nador has about 115 km² (Figure 1). The unique Moroccan Mediterranean facade is classified as the largest Moroccan lagoon and second largest North African lagoon. It is found between the latitudes 35°14'N and 35°05'N and between the longitudes 002°56'W and 002°44'W. This ecosystem is separated from the sea by a dune cord oriented NW-SE, which occupies a coastal strip of 25 km in length and 0.3 to 1.5 km in width. A high diversity of fauna and flora characterizes the lagoon. According to Zine (2003), there are 451 species of fauna in the lagoon. In addition to species and habitats of conservation interest in the Mediterranean, it contains about twenty species of benthic macroalgae, including some of great socio-economic interest, with ecological and environmental roles (Dakki et al 2003). Artisanal fishing is the main socio-economic activity in the Marchica lagoon, with approximately 390 boats, constituting 14% of the artisanal fleet in the entire Moroccan Mediterranean. It provides direct employment to 1200 people, representing about 11% of the total employment generated by artisanal fishing in the Moroccan Mediterranean (Institut National de Recherche Halieutique Centre Regional de Nador 1999; Najih et al 2015). The artisanal fleet is distributed over sixteen peripheral sites (Figure 1). It is classified as a Site of Biological and Ecological Interest (SIBE) since 1996, and as a Ramsar site for the conservation and protection of wetlands since 2005. This makes the quality and interest of this ecosystem recognized at international and national levels.

The blue crab Callinectes sapidus. In the Mediterranean Sea, the blue crab has first appeared in Egypt in 1898, just a few years after the opening of the Suez Canal. It is now present in 17 of the 23 countries bordering the Mediterranean (Benabdi et al 2019) (Figure 1). The blue crab can be identified by its bluish carapace, very wide, with nine orange serrations on either side of the carapace. The last serration is longer. This large crab can reach a width of 23 cm and a weight of more than 500 g. It has 8 bluish legs and 2 strong

claws. The latter are blue in males and red in females. The last leg ends in a flattened article, being used for swimming and burying in the sediment.

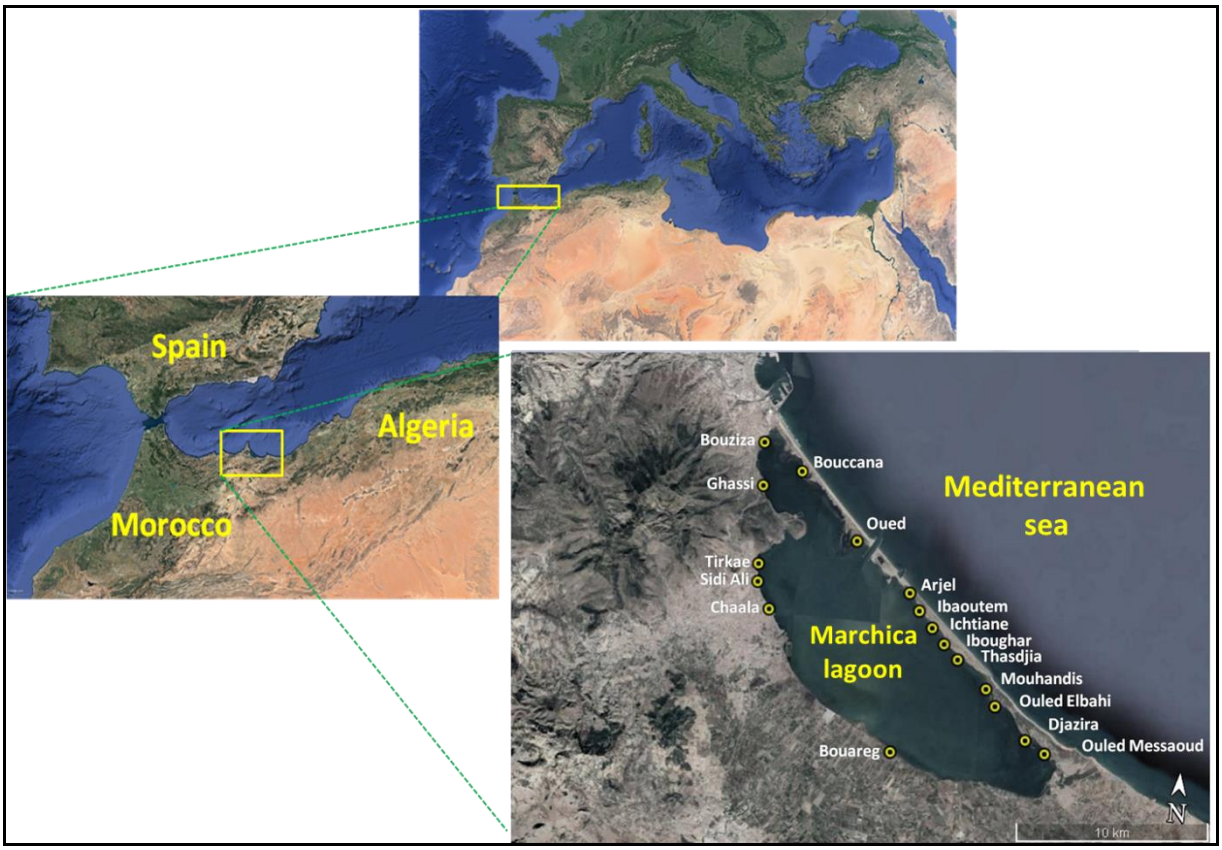

Figure 1. Marchica lagoon (Google Earth), Nador, Morocco.

The species lives in bays, lagoons and estuaries, on sandy or muddy substrate, commonly in shallow waters, frequenting the intertidal and infralittoral zone. It can be found up to 35 m depths. Eurythermal, it tolerates temperatures from 3 to 35°C and salinities between 2 and 48 g L^{-1} (García & Capote 2015). Nevertheless, females remain in highly saline waters in estuaries, especially during the egg-laying period. When the water temperature drops, during the cold season, blue crabs migrate to deeper waters. The blue crab can exit the water in wet weather and especially at night by clinging to various supports (Abbott 1967). They can also breath air (Powers 1977). The diet of *C. sapidus* is very diverse. It is a voracious omnivore, praying on small shellfish, crustaceans, fish and plants. The species can ingest high levels of algae (Rosas et al 1994). Below 15°C, it stops feeding and below 10°C it is completely inactive (Stoner et al 2010).

Sexual maturity is reached between 7 and 18 months, depending on location. Mating takes place in areas of low salinity, where males are present (Millikin & Williams 1984; Turner et al 2003). It is mainly carried out in summer, between a male and a recently moulted female (Churchill 1919). The male keeps the female between his legs for a pre-breeding walk of about a week. The female lays up to 2 million eggs, which are incubated for 2 weeks on its pteropod. Hatching takes place in water with a salinity different than that of mating (Millikin & Williams 1984). The larvae, marine and planktonic, are carried by marine currents. Larval development lasts 1 to 2 months, depending on water temperature and salinity, before giving rise to a coastal benthic megalope that metamorphoses in brackish water into a juvenile after 6 to 20 days.

As with most crustaceans, growth of blue crab occurs by successive moulting. Adult blue crab moult occurs on average 8.8 times per year for males and 7.6 times per year for females. Nevertheless, moulting remains dependent on several surrounding factors, notably temperature and food availability (Churchill 1919). An average growth rate of 120% per molt

was observed for an average molt duration of 16 days (Bilen & Yesilyurt 2014). The usual longevity does not exceed 3-4 years (Squires 1990).

Methodology. The evaluation of the magnitude of the socio-economic impacts of blue crab is based on the feedback from field observations and on about a 100 semi-structured interviews conducted with artisanal fishermen operating at different fishing sites bordering the Marchica lagoon and other fishermen from the other side of the dune cord precisely Bokana, Karia and Ras Elma. The categorization of the impacts using the SEICAT methodology is based on the grid proposed by Bacher et al (2018), allowing the species concerned (blue crab) to be placed on a scale of 5 levels ranging from minimal impact to massive impact (Table 1).

In addition to the socio-economic impact assessment, information on the abundance and spatial extent of crabs was collected during interviews and observations with fishermen. Samples of blue crab were recovered from the fishermen and were used for a preliminary analysis of the bio-ecology of the species. The length (L) and width (W) of the carapace were measured to the nearest mm. Individuals were weighed (live weight in grams) and sexed. The crabs showed obvious sexual dimorphism, immature females having a triangular-shaped abdomen, whereas mature females having a broader, semicircular-shaped abdomen. Males have an abdomen readily distinguishable from either female stage. They also present typical coloration differences between adult males and females (Cargo & Rabenold 1980).

Table 1

Description of the scale for classifying the socio-economic impacts of exotic taxa (SEICAT) according to observed changes (Bacher et al 2018)

	Massive (MV)	*Major (MR)*	*Moderate (MO)*	*Minor (MN)*	*Minimal (MC)*
SEICAT	Local disappearance of an activity, irreversible for at least a decade.	Disappearance of activity in part of the area colonized by the exotic taxon, irreversible for at least a decade.	Decrease in the importance of the activity, but the activity is still carried out (displacement of the activity towards regions devoid of the exotic taxon)	Difficulties in exercising the activity without a change in size.	No negative impact reported.

Results and Discussion. The investigations conducted on field showed that the blue crab had been previously caught by fishermen. They affirmed that the proliferation of the species was recent and that it had been spreading for a maximum of 5 years. In the present study, 104 specimens were identified, 77 males and 27 egg-bearing females (Figure 2).

Figure 2. Egg-bearing female *Callinectes sapidus*.

Specimens ranging from juveniles to adults were collected from the Marchica lagoon (Figure 3). On the other side of the dune cord, out of the Marchica lagoon, other investigations with fishermen confirmed the expansion of this species along the Moroccan Mediterranean coast.

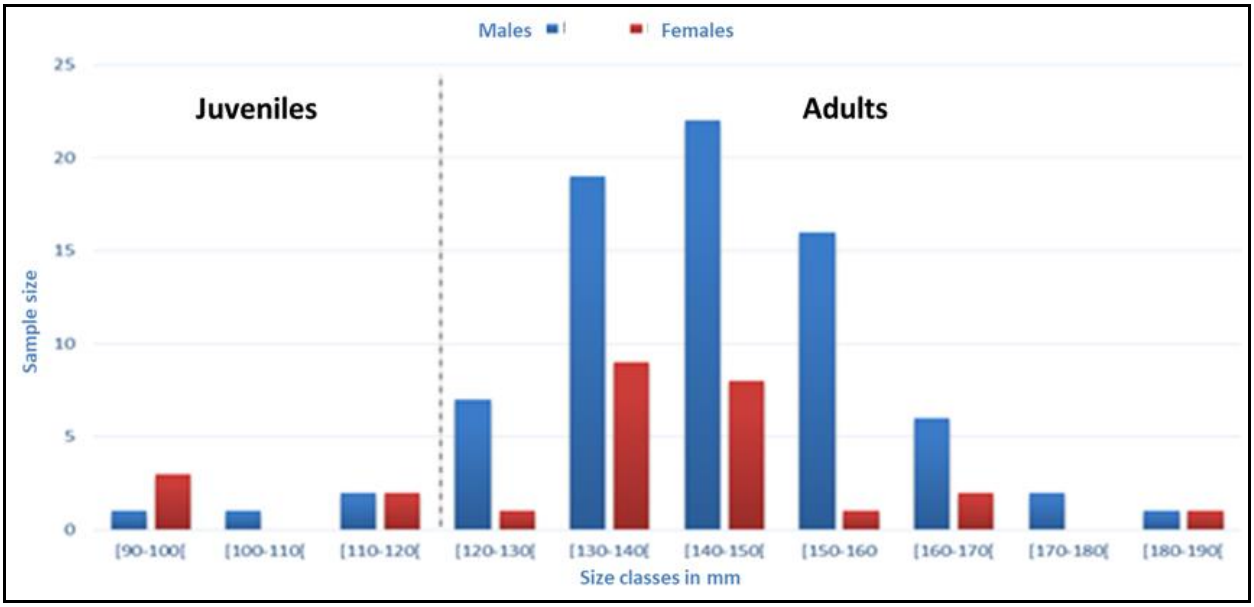

Figure 3. Size structure of blue crab caught in the Marchica lagoon, Morocco.

Overall, the carapace width for both sexes combined varied from a minimum of 90 mm to a maximum of 187 mm, with a mean value of 140.04±17.34 mm. The weight of the specimens varied between a minimum of 58.52 g and a maximum of 470.35 g, with an average value of 177.94±69.45 g. Biometric disparities between sexes were observed (Table 2).

Table 2

Biometric characteristics of blue crab in Marchica lagoon

		Length (mm)			*Width (mm)*			*Weight (g)*		
Sex	*n*	*Mean±SD*	*Min*	*Max*	*Mean±SD*	*Min*	*Max*	*Mean±SD*	*Min*	*Max*
Male	77	66.23±6.52	45	85	142.06±15.54	94	187	191.78±68.36	61.49	470.35
Female	27	60.66±7.17	45	75	134.29±20.96	90	185	138.45±57.13	58.52	274.73
Total	104	64.78±7.09	45	85	140.04±17.34	90	180	177.94±69.45	58.52	470.35

Results regarding the reduction of well being and changes in activity size are presented in Figure 4. 90% of the fishermen accused blue crab of having damaged their nets. The deterioration occurred mainly during the disentanglement of tangled crabs (Figure 5). Blue crabs also affected the well being of fishermen including safety and health, as affirmed by 80 and 60% of respondents, respectively (Figure 6). 70% of answers were about making higher efforts, while only 5% reported that these specimens are a source of income loss. There were no changes in the activity size.

According to the results of this study, using the new SEICAT methodology and based on direct interviews with fishermen, the analysis of impact intensity showed negative impacts of the American blue crab on fishing activity in the lagoon and was qualified as Minor.

According to fishermen, the first sightings were in 2015, being consistent with the first record of the species from the Marchica lagoon in early 2017 (Chartosia et al 2018). In addition, the presence of egg-bearing females argues for a self-sustaining population (Richardson et al 2000; Olenin et al 2011) in the lagoon. Other investigations with fishermen out of the Marchica lagoon, specifically on the other side of the dune cord, confirmed the expansion of this species along the Moroccan Mediterranean coast. Later in September 2020, Taybi & Mabrouki (2020) reported that many species were found at the mouths of the Kirt of Melouya, so it appears that the blue crab is in the process of spreading in new territories.

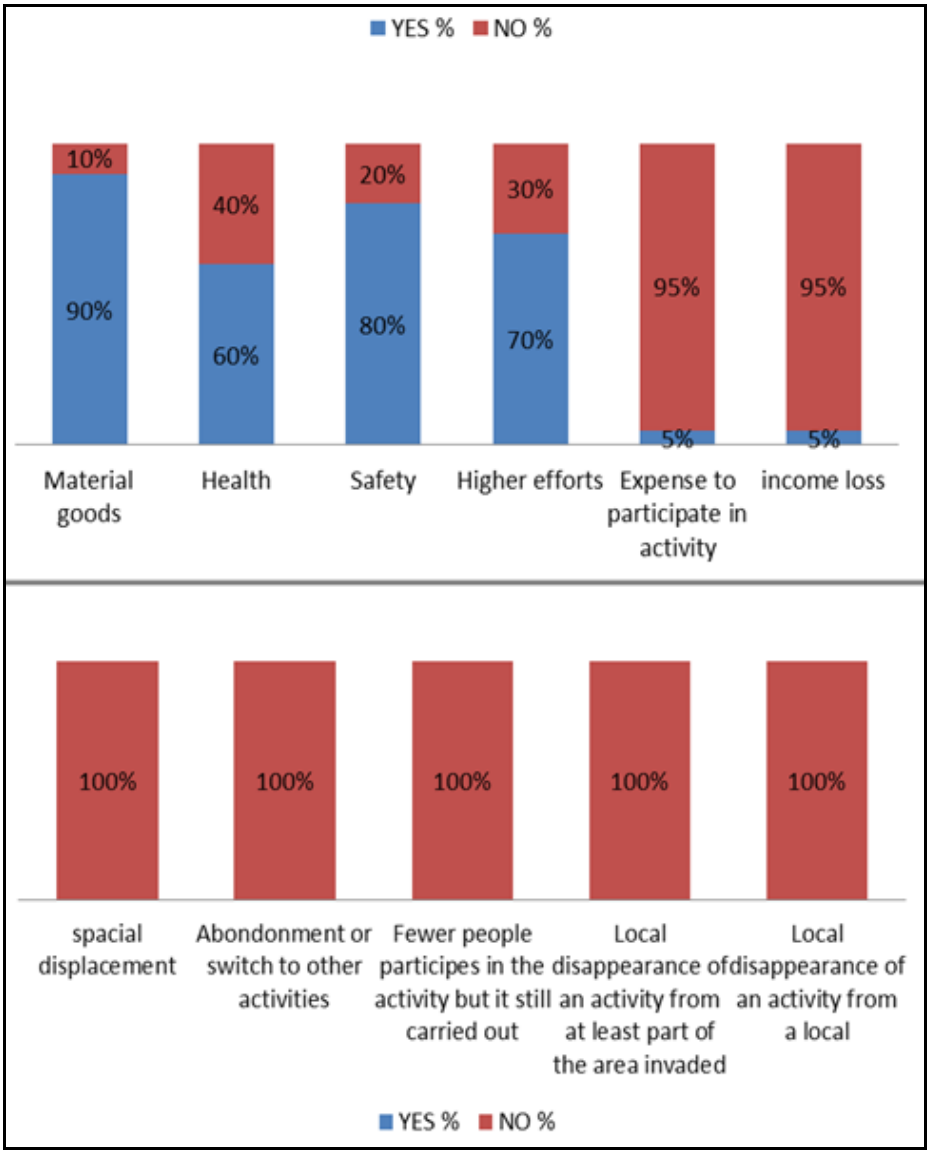

Figure 4. Reduction of well being (up); changes in activity size (down).

Figure 5. Crabs entangled in the net.

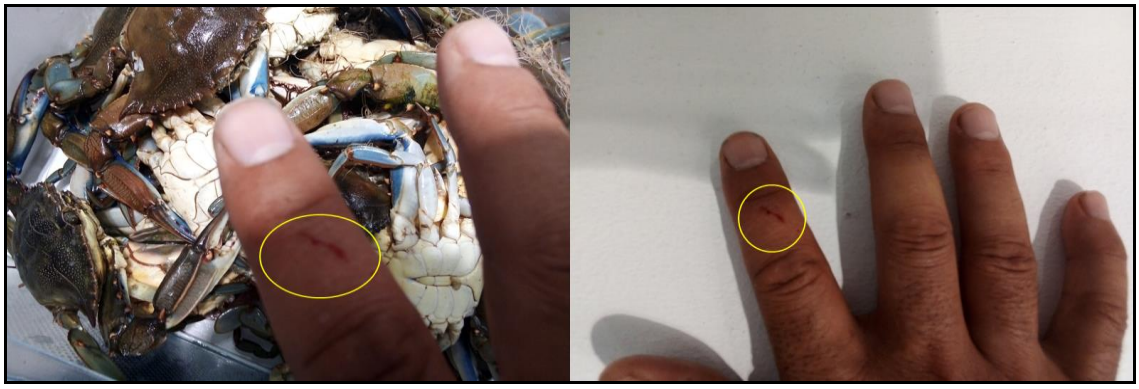

Figure 6. Example of injury caused by blue crab.

In summer 2020, the abundance indices of this species in the lagoon showed remarkable values. A daily average of 36 individuals per gillnets of about 100 m was recorded. The highest densities have been reported at the continental edge, particularly at the mouth of the Selouane valley, which is explained by the estuarine character of the species (Hines et al 2008). In view of the great abundance and frequency in the fishing nets from its first appearance, as well as the occurrence of juveniles and ovigerous females, the population of the blue crab *C. sapidus* can be considered as established (Beqiraj & Kashta 2010) in the Marchica lagoon and along the Mediterranean Moroccan coast.

The establishment of invasive species not only threatens the fauna and flora of the ecosystems in which they spread, but also affects the economic and social activities of the population, since the blue crab has emerged as a very aggressive species and has been listed as one of the 100 "most invasive" species in the Mediterranean, with an impact on both biodiversity and socio-economics (Streftaris & Zenetos 2006).

Fishermen accused the blue crab of having damaged their nets. The deterioration occurred mainly during the disentanglement of tangled crabs. It may also result from direct gnawing, as shown by the presence of pieces of net in the stomach contents of blue crab specimens. Moreover, in case of significant deterioration, the renewal of threads is necessary, and sometimes more practical than their repair. Concretely, the fishermen estimate that the lifespan of the trammel net has decreased by half (from 3 years to 18 months) according to 60% of the fishermen, and even by two thirds (from 3 years to 1 year). 5% of fishermen affirmed that the blue crab is often attacking the catches entangled in the fishing nets. This depredation causes alterations and serious injury to fish species of commercial interest, reducing or even cancelling their commercial value. These deteriorations, of both materials and caught fish, consequently cause more expenses. The attacks of the blue crab concern the fishermen themselves. All the respondents agreed on the aggressiveness of the species. Of these respondents, 60% had already been cut (Figure 6) during the removal of entangled individuals. As a precaution, the fishermen learned to club the individuals caught in the nets before handling them.

Thus, the major nuisances that were reported by the respondents with regard to the socio-economic impact are: deterioration of fishing nets, sanitary risk, alteration of the quality of the catches and having difficulties in exercising the activity. Otherwise, this reduction of well being did not cause changes in the activity size.

Recently, there have been only few studies on the socioeconomic impacts of alien species using the novelty SEICAT methodology. Among them, Galanidi et al (2018) assessed the socio-economic impacts of marine invasive fishes in the Mediterranean. The socioeconomic impacts of *Lagocephalus sceleratus* were also studied with SEICAT (Galanidi et al 2018), and recently, in 2020, Mohanty et al (2020) have evaluated the socioeconomic impacts of *Hoplobatrachus tigerinus* with SEICAT.

Conclusions. This study constitutes one of the first to evaluate and demonstrate the socio-economic impacts of the blue crab on the Mediterranean waters, one of the most aggressive alien species, in a systematic way, with the new SEICAT protocol, based on direct interviews

with local fishermen. The first signaling of the blue crab in the Moroccan Mediterranean was made on August 17, 2017. Recently, its presence was also reported in other regions, like at the mouths of the Moulouya and Kert, more than twenty kilometers on either side of the Marchica lagoon. This study reports it on the other side of the dune corde, along the Moroccan Mediterranean coast, specifically at Bokana and Karia. This invasive species is being monitored to study the dynamics of its population in the area, especially its spread, size structure, socio-economic impact, etc. The samples analyzed showed a size structure composed of juveniles and adults with sizes ranging from 90 mm to 187 mm, with a mean value of 140.04 mm. The presence of egg-bearing females (26% of the specimens observed) was noted, meaning that there is a self-sustaining population in the Marchica lagoon. The number of crabs in the lagoon continues to increase, and a daily average of 36 individuals per 100 m of gillnet being recorded during the first months of 2020.

The results of this study using the new SEICAT methodology and based on direct interviews with fishermen, showed negative impacts of the American blue crab on fishing activity in the lagoon, which are certainly worrying. They mainly result in a decrease in profitability due, on one hand, to the additional costs of repairing damaged nets, and on the other hand, to the loss of income from damaged catches. In addition to these impacts, there is the sanitary risk resulting from the aggressiveness of the species. All fishermen consider that the combined effect of the three previously listed nuisances causes difficulties in the exercise of the activity without any change in its size. So far, and referring to the grid proposed by the International Union for the Conservation of Nature (IUCN), the socio-economic impacts of blue crab on the artisanal fishing activity in the Marchica lagoon are qualified as minor.

Conflict of Interest. The authors declare that there is no conflict of interest.

References

Abbott W., 1967 Unusual climbing behavior by *Callinectes sapidus* Rathbun (Decapoda, Brachyura). Crustaceana 13(1):128-128.

Bacher S., Blackburn T., Essl F., Genovesi P., Heikkilä J., Jeschke J. M., Jones G., Keller R., Kenis M., Kueffer C., Martinou A. F., Nentwig W., Pergl J., Pyšek P., Rabitsch W., Richardson D. M., Roy H. E., Saul W. C., Scalera R., Vilà M., Wilson J. R. U., Kumschick S., 2018 Socio-economic impact classification of alien taxa (SEICAT). Methods in Ecology and Evolution 9(1):159-168.

Bellard C., Cassey P., Blackburn T. M., 2016 Alien species as a driver of recent extinctions. Biology Letters 12(2):e20150623, 4 p.

Benabdi M., Belmahi A. E., Grimes S., 2019 First record of the Atlantic blue crab *Callinectes sapidus* Rathbun, 1896 (Decapoda: Brachyura: Portunidae) in Algerian coastal waters (southwestern Mediterranean). BioInvasions Records 8(1):119-122.

Beqiraj S., Kashta L., 2010 The establishment of blue crab *Callinectes sapidus* Rathbun, 1896 in the Lagoon of Patok, Albania (south-east Adriatic Sea). Aquatic Invasions 5(2):219-221.

Bilen C. T., Yesilyurt I. N., 2014 Growth of blue crab, *Callinectes sapidus*, in the Yumurtalik Cove, Turkey: a molt process approach. Central European Journal of Biology 9(1):49-57.

Bonn I., 2005 Improving strategic thinking: a multilevel approach. Leadership and Organization Development Journal 26(5):336-354.

Bradshaw C. J. A., Leroy B., Bellard C., Roiz D., Albert C., Fournier A., Barbet-Massin M., Salles J. M., Simard F., Courchamp F., 2016 Massive yet grossly underestimated global costs of invasive insects. Nature Communications 7:e12986, 8 p.

Cargo D. G., Rabenold G. E., 1980 Observations on the asexual reproductive activities of the sessile stages of the sea nettle *Chrysaora quinquecirrha* (Scyphozoa). Estuaries 3(1):20-27.

Castejón D., Guerao G., 2013 A new record of the American blue crab, *Callinectes sapidus* Rathbun, 1896 (Decapoda: Brachyura: Portunidae), from the Mediterranean coast of the Iberian Peninsula. BioInvasions Records 2(2):141-143.

Chartosia N., Anastasiadis D., Bazairi H., Crocetta F., Deidun A., Despalatovic M., Di Martino V., Dimitriou N., Dragicevic B., Dulcic J., Durucan F., Hasbek D., Ketsilis-Rinis V., Kleitou P., Lipej L., Macali A., Marchini A., Ousselam M., Piraino S., Stancanelli B., Theodosiou M., Tiralongo F., Todorova V., Trkov D., Yapici S., 2018 New Mediterranean Biodiversity Records (July 2018). Mediterranean Marine Science 19(2):398-415.

Churchill E. P., 1919 Life history of the blue crab. Bulletin of United States Commission 36:93-128.

Dakki M., Fekhaoui M., El Fellah B., Belguenani H., Benhoussa A., 2003 [Diagnosis for the development of wetlands in northeastern Morocco: Sebkha Bou Areg (lagoon of Nador)]. MedWetCoast, Final Report, 56 p. [In French].

Diagne C., Leroy B., Gozlan R. E., Vaissière A. C., Assailly C., Nuninger L., Roiz D., Jourdain F., Jarić I., Courchamp F., 2020 InvaCost, a public database of the economic costs of biological invasions worldwide. Scientific Data 7:e277, 12 p.

Galanidi M., Zenetos A., Bacher S., 2018 Assessing the socio-economic impacts of priority marine invasive fishes in the Mediterranean with the newly proposed SEICAT methodology. Mediterranean Marine Science 19(1):107-123.

Galil B. S., 2011 The alien crustaceans in the Mediterranean Sea: an historical review. In: In the wrong place - alien marine crustaceans: distribution, biology and impacts. Galil B., Clark P., Carlton J. (eds), Invading Nature - Springer Series in Invasion Ecology, Springer, Dordrecht, pp. 377-401.

Galil B., Froglia C., Noel P., 2002 CIESM Atlas of exotic species in the Mediterranean. Vol. 2. Crustaceans: Decapods and stomatopods. CIESM The Mediterranean Science Commission, 192 p.

García Y. L. D., Capote A. J., 2015 List of marine crabs (Decapoda: Anomura and Brachyura) of shallow littoral of Santiago de Cuba, Cuba. Check List 11(2):1-22.

Garrido M., Noël P., Réseau A. C., 2018 [The endless expansion of *Callinectes sapidus* in Corsican lagoons]. Pôle-relais Lagunes méditerranéennes. Available at: https://pole-lagunes.org/linterminable-expansion-de-callinectes-sapidus-dans-les-lagunes-corses/print. [In French].

Gonzalez-Wanguemert M., Pujol J. A., 2016 First record of the Atlantic blue crab *Callinectes sapidus* (Crustacea: Brachyura: Portunidae) in the Segura river mouth (Spain, southwestern Mediterranean Sea). Turkish Journal of Zoology 40(4):615-619.

Hines A. H., Johnson E. G., Young A. C., Aguilar R., Kramer M. A., Goodison M., Zmora O., Zohar Y., 2008 Release strategies for estuarine species with complex migratory life cycles: stock enhancement of Chesapeake blue crabs (*Callinectes sapidus*). Reviews in Fisheries Science 16(1-3):175-185.

Holthuis L. B., Gottlieb L., 1955 The occurrence of the American blue crab, *Callinectes sapidus* Rathbun, in Israel waters. Bulletin of the Research Council of Israel 5(B):154-156.

Institut National de Recherche Halieutique Centre Regional de Nador, 1999 [Current situation of artisanal fishing in the Moroccan Mediterranean]. Working Paper, FAO, COPEMED, 29 p. [In French].

Jackson S. L., 2015 Research methods and statistics: A critical thinking approach. Cengage Learning, 510 p.

Millikin M. R., Williams A. B., 1984 Synopsis of biological data on the blue crab, *Callinectes sapidus* Rathbun. NOAA Technical Report NMFS, FAO Fisheries Synopsis, no. 138, 45 p.

Mohanty S. N., Ramya K. C., Rani S. S., Gupta D., Shankar K., Lakshmanaprabu S. K., Khanna A., 2020 An efficient lightweight integrated blockchain (ELIB) model for IoT security and privacy. Future Generation Computer Systems 102:1027-1037.

Najih M., Berday N., Lamrini A., Nachite D., Zahri Y., 2015 [Situation of small-scale fishing after the opening of the new channel in the lagoon of Nador]. Revue Marocaine des Sciences Agronomiques et Vétérinaires 3(1):19-30. [In French].

Narayan D., Chambers R., Shah M.K., Petesch P., 2000 Voices of the poor: Crying out for change. Oxford University Press for the World Bank, New York, 336 p.

Noël P., 2019 [DORIS blue crab network in the Mediterranean]. In: DORIS, Données d'Observations pour la reconnaissance et l'Identification de la faune et de la flore

Subaquatique. CNEBSFFESSM. Available at: http://doris.ffessm.fr/Forum/ReseauDORIS-crabe-bleu-en-Mediterranee. [In French].
Ojaveer H., Galil B. S., Campbell M. L., Carlton J. T., Canning-Clode J., Cook E. J., Davidson A. D., Hewitt C. L., Jelmert A., Marchini A., McKenzie C. H., Minchin D., Occhipinti-Ambrogi A., Olenin S., Ruiz G., 2015 Classification of non-indigenous species based on their impacts: considerations for application in marine management. PLoS Biology 13(4):e1002130, 13 p.
Ogden N. H., Wilson J. R. U., Richardson D. M., Hui C., Davies S. J. Kumschick S., Le Roux J. J., Maesey J., Saul W. C., Pulliam J. R. C., 2019 Emerging infectious diseases and biological invasions: a call for a One Health collaboration in science and management. Royal Society Open Science 6(3):181577, 15 p.
Olenin S., Elliott M., Bysveen I., Culverhouse P. F., Daunys D. Dubelaar B. J., Gollasch S., Goulletquer P., Jelmert A., Kantori Y., Mezeth K. B., Minchin D., Occhipinti-Ambrogi A., Olenina I., Kerkhove J. V., 2011 Recommendations on methods for the detection and control of biological pollution in marine coastal waters. Marine Pollution Bulletin 62(12):2598-2604.
Piria M., Stroil B. K., Giannetto D., Tarkan A. S., Gavrilović A., Špelić I., Radočaj T., Killi N., Filiz H., Uysal T. U., Aldemir C., Kamberi E., Hala E., Bakiu R., Kolitari J., Buda E., Bakiu S. D., Sadiku E., Bakrac A., Mujic E., Avdic S., Doumpas N., Giovos I., Dinoshi I., Usanovic L., Kalajdzic A., Pesic A., Cetkovic I., Markovic O., Milosevic D., Mrdak D., Sara G., Belmar M. B., Marchessaux G., Trajanovski S., Zdraveski K., 2021 An assessment of regulation, education practices and socio-economic perceptions of non-native aquatic species in the Balkans. Journal of Vertebrate Biology 70(4):21047, 12 p.
Piras P., Esposito G., Meloni D., 2019 On the occurrence of the blue crab *Callinectes sapidus* (Rathbun, 1896) in Sardinian coastal habitats (Italy): a present threat or a future resource for the regional fishery sector? BioInvasions Records 8(1):134-141.
Powers L. W., 1977 A catalogue and bibliography to the crabs (Brachyura) of the Gulf of Mexico. Port Aransas Marine Laboratory, University of Texas Marine Science Institute, 190 p.
Richardson D. M., Pyšek P., Rejmánek M., Barbour M. G., Panetta F. D., West C. J., 2000 Naturalization and invasion of alien plants: concepts and definitions. Diversity and Distributions 6(2):93-107.
Robeyns I., 2005 The capability approach: a theoretical survey. Journal of human Development 6(1):93-117.
Rosas C., Lazaro-Chavez E., Bückle-Ramirez F., 1994 Feeding habits and food niche segregation of *Callinectes sapidus*, *C. rathbunae*, and *C. similis* in a subtropical coastal lagoon of the Gulf of Mexico. Journal of Crustacean Biology 14(2):371-382.
Seebens H., Blackburn T. M., Dyer E. E., Genovesi P., Hulme P. E., Jesch J. M., Pagad S., Pyšek P., Winter M., Arianoutsou M., Bacher S., Blasius B., Brundu G., Capinha C., Celesti-Grapow L., Dawson W., Dullinger S., Fuentes N., Jäger H., Kartesz J., Kenis M., Kreft H., Kühn I., Lenzner B., Liebhold A., Mosena A., Moser D., Nishino M., Pearman D., Pergl J., Rabitsch W., Rojas-Sandoval J., Roques A., Rorke S., Rossinelli S., Roy H. E., Scalera R., Schindler S., Štajerová K., Tokarska-Guzik B., Kleunen V. M., Walker K., Weigelt P., Yamanaka T., Essl F., 2017 No saturation in the accumulation of alien species worldwide. Nature communications 8:14435, 9 p.
Sen A., 1999 Commodities and capabilities. OUP Catalogue, 102 p.
Squires H. J., 1990 Decapod Crustacea of the Atlantic coast of Canada. Canadian Bulletin of Fisheries and Aquatic Sciences 221:1-532.
Stoner A. W., Ottmar M. L., Haines S. A., 2010 Temperature and habitat complexity mediate cannibalism in red king crab: observations on activity, feeding, and prey defense mechanisms. Journal of Shellfish Research 29(4):1005-1012.
Streftaris N., Zenetos A., 2006 Alien marine species in the Mediterranean - the 100 "Worst Invasives" and their impact. Mediterranean Marine Science 7(1):87-118.
Taybi A. F., Mabrouki Y., 2020 The American blue crab *Callinectes sapidus* Rathbun, 1896 (Crustacea: Decapoda: Portunidae) is rapidly expanding through the Mediterranean coast of Morocco. Thalassas 36(2):1-5.

Turner H. V., Wolcott D. L., Wolcott T. G., Hines A. H., 2003 Post-mating behavior, intramolt growth, and onset of migration to Chesapeake Bay blue crabs, *Callinectes sapidus* Rathbun. Journal of Experimental Marine Biology and Ecology 295(1):107-130.
Vilà M., Basnou C., Pyšek P., Josefsson M., Genovesi P., Gollasch S., Nentwig W., Olenin S., Roques A., Roy D., Hulme P. E., DAISIE Partners, 2010 How well do we understand the impacts of alien species on ecosystem services? A pan-European, cross-taxa assessment. Frontiers in Ecology and the Environment 8(3):135-144.
Zine N., 2003 [Diagnostic de la Faune aquatique: Lagune de Nador]. Rapp. inédit, projet MedWetCoast-Maroc, PNUE/Secr. Etat Envir./Départ. Eaux & Forêts, Maroc, 57 p.

Received: 17 April 2021. Accepted: 19 July 2021. Published online: 13 November 2021.
Authors:
Mariam Oussellam, BioBio Research Center, BioEcoGen Laboratory, Faculty of Sciences, Mohammed V University in Rabat, 4 Avenue Ibn Battouta, B.P. 1014 RP, 10106 Rabat, Morocco, e-mail: mariam_oussellam@um5.ac.ma
Mohamed Selfati, National Institute of Fisheries Research (INRH), 13 Bd Zerktouni, BP 493, 62000 Nador, Morocco, e-mail: selfatimohamed@gmail.com
Najib El Ouamari, National Institute of Fisheries Research (INRH), 13 Bd Zerktouni, BP 493, 62000 Nador, Morocco, e-mail: azir46@hotmail.com
Hocein Bazairi, BioBio Research Center, BioEcoGen Laboratory, Faculty of Sciences, Mohammed V University in Rabat, 4 Avenue Ibn Battouta, B.P. 1014 RP, 10106 Rabat, Morocco, e-mail: hoceinbazairi@yahoo.fr

How to cite this article:
Oussellam M., Selfati M., El Ouamari N., Bazairi H., 2021 Using the new SEICAT methodology to study the socio-economic impacts of the American blue crab *Callinectes sapidus* from Marchica lagoon, Morocco. AACL Bioflux 14(6):3231-3241.