ISSN: 0001-5113 AADRAY	ACTA ADRIAT., 63 (1): 109 - 122, 2022	ORIGINAL SCIENTIFIC PAPER

New species of fish and crustaceans in Montenegrin waters (South Adriatic Sea)

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The structure and composition of Mediterranean biodiversity has changed significantly. So far, in Montenegrin coastal waters, nine new non-native species have been recorded: Tylosurus acus imperialis, Caranx crysos, Siganus luridus, Fistularia commersonii, Stephanolepis diaspros, Sphoeroides pachygaster, Lagocephalus sceleratus, Callinectes sapidus *and* Farfantepanaeus aztecus. Allochthonous *species are starting to compete for food and space and leading to habitat degradation, socio-economic impacts and can hybridise with the native species. Natural factors and human activities have enabled the arrival of non-native species into the Adriatic Sea. Four of the species are Lessepsian immigrants, which arrived via the Suez Canal, but five others were introduced from the Atlantic Ocean, through the Strait of Gibraltar. Analysis using the Marine Fish Invasiveness Screening Kit (MFISK), Aquatic Invasiveness Screening Kit (AS-ISK) and Receiver operating characteristic (ROC) showed a calibration threshold of 22.5 for MFISK, a BRA (Basic Risk Assessment) score of 34 and a CCA (Climate Change Assessment) score of 46. A measure of the accuracy of the calibration analysis is the area under the ROC curve (AUC). Two species were characterised as non-invasive:* Tylosurus acus imperialis *and* Caranx crysos, *but five others were characterised as invasive and covered by the categories from moderate to high-risk.*

Key words: Non-native species; Montenegro; Risk Assessment

INTRODUCTION

The Adriatic Sea belongs to the Mediterranean Sea in terms of its genesis, ecological characteristics and its flora and fauna. According to its temperature characteristics, it can be classed as a moderately warm sea. The importance of its biodiversity is in the stability and sustainability of its natural systems. According to the last census, there were 664 species of fish recorded in the Mediterranean (557 Osteichthyes, 86 Chondrichtyes and three species of Agnatha) which are sorted into 156 families (QUIGRAND & TOMASINI, 2000), but it is now considered that there are 716 species (GOLANI, *et al*., 2002). In the Adriatic Sea, currently 407 fish species and subspecies have been recorded (JARDAS, 1985). Meanwhile, that number has grown to 449, which is about 66% of the total species and subspecies of the Mediterranean Sea (DULČIĆ & DRAGIČEVIĆ, 2011). During the last few decades biological invasions have been taking place. In the Mediterranean Sea, an expansion of 986 alien species belonging to various taxa (fish, molluscs, foraminifera and macrophytes) has been recorded: 775 species were reported in the eastern part, 249 in the central part and 308 species in the western part of the Mediterranean Sea (ZENETOS *et al*., 2012). Of those alien species, 102 were fish species and 35 were crustaceans (ZENETOS *et al*., 2005). In Greece, more than 270 new aquatic organisms were recorded, of which 42 were marine fish (ZENETOS *et al*., 2009).

In the Croatian part of the Adriatic Sea, 24 new non-native species have been found, of which 13 are Lessepsian migrants that arrived from the Red Sea via the Suez Canal (DULČIĆ & DRAGIČEVIĆ, 2011). In Montenegro, there are seven new, non-native species of fish, of which four were listed on the Black List of Mediterranean Invasive Species: *Fistularia commersonii*, *Lagocephalus sceleratus*, *Siganus luridus* and *Stephanolepis diaspros* (OTERO *et al*., 2013).

In the majority of European seas, the marine ecosystems are susceptible to socio-economic impacts, too (STREFTARIS & ZENETOS, 2006). During the last few years, new species from the Mediterranean have been entering the Adriatic Sea continuously, originally arriving via the Suez Canal and the Strait of Gibraltar (Fig. 1). Lessepsian immigrants that come from the Red Sea, whose salinity is greater than that of the Mediterranean, have become a structural part of Mediterranean ecosystem and are threatening many local and endemic species (GOLANI, 1998). Introductions from the Atlantic Ocean through the Strait of Gibraltar are also well known, but their incidence is lower compared to the Lessepsian ones. In addition, they have been more prominent during the last few years because of climate change, which is the reason for invasions of a large number of allochthonous species from tropical seas into northern, temperate seas. Significant vectors that increase the introduction of new species into the Mediterranean Sea recipient area are ballast waters and aquaculture activities. In the south Adriatic (Montenegro), nine allochthonous species have been found, seven of them being fish and two being decapod crustaceans. They were caught in fishing nets in the Montenegrin coastal sea area. It is considered that this number of species will continue to grow over time. The first step in biodiversity protection is to obtain data about the impact of alien species on the composition

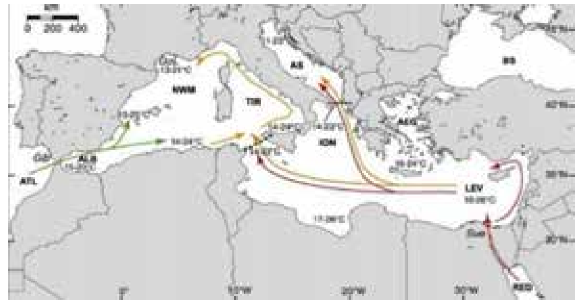

Fig. 1. Geographical diagram of Mediterranean with the directions of the spread of allochthonous species labelled: ALB – Alboran Sea, NWM – North-West Mediterranean, TIR – Tyrrhenian Sea, ION – Ionian Sea, AS – Adriatic Sea, AEG – Aegean Sea, LEV – Levantine Sea; and the seas that are around: ATL – Atlantic Ocean, BS – Black Sea, RED – Red Sea. The listed temperature ranges correspond to the average seasonal surface temperature values. The arrows show the directions of species immigrations with their origins: orange – autochthonous Mediterranean species, green – Atlantic immigrants, red – Lessepsian migrants (Lejeusne et al. 2009)

of communities in the ecosystems where they have been introduced. Risk assessment of alien species is the first important step in biodiversity protection because of the need to develop appropriate measures of prevention, control and management of these species.

MATERIAL AND METHODS

Nine new non-native species of fish and crustaceans that were recorded in the Adriatic Sea along the Montenegrin coast were assessed: *Tylosurus acus imperialis*, *Caranx crysos*, *Siganus luridus*, *Fistularia commersonii*, *Sphoeroides pachygaster*, *Callinectes sapidus*, *Farfantepanaeus aztecus* (JOKSIMOVIC *et al*., 2015), *Stephanolepis diaspros* (DULČIĆ & PALLAORO, 2003) and *Lagocephalus sceleratus* (DULČIĆ *et al*., 2014). The Aquatic Invasiveness Screening Kit (AS-ISK) (COPP *et al*., 2016) and Marine Fish Invasiveness Screening Kit (MFISK) (LAWSON *et al*., 2013) were applied as the risk-assessment tools for non-native species of various kinds of aquatic organisms and specifically of fish in marine ecosystems, respectively, on the basis of the features of their biogeography, history, biology and ecology. Those screening kits consist of 49 questions, with an additional six ones used for risk assessment with expected climate-change events particularly in mind. After all the questions are answered, a score is obtained, based on which the assessment should be carried out. The higher the score, the higher the probability that the invasive effect of the species will be more obvious (SIMONOVIĆ *et al*., 2013). Receiver operating characteristic (ROC) analysis was used to assess the predictive ability of FISK to discriminate between invasive and non-invasive species. To this end, species were classified a priori as either invasive or non-invasive based on the information available from the Invasive Species Specialist Group Database (http://www.issg.org/) and from FishBase (http://www.fishbase.org). Statistically, a ROC curve is a graph of sensitivity vs. 1 – specificity (or alternatively, sensitivity vs. specificity), where in the present context the sensitivity and specificity are the proportions of invasive and non-invasive fish species, respectively, that are correctly identified by the FISK tool as such. A measure of the accuracy of the calibration analysis is the area under the ROC curve (AUC). If the AUC is equal to 1.0 (i.e. the ROC "curve" consists of two straight lines, one vertical from (0.0) to (0.1) and the other horizontal from (0.1) to (1.1), then the test is 100% accurate, because both the sensitivity and specificity are 1.0 and there are no false positives (i.e. non-invasive species categorised as invasive) and no false negatives (i.e. invasive species categorised as non-invasive). Conversely, if the AUC is equal to 0.5 (i.e. the ROC "curve" is a diagonal line from (0.0) to (1.1), then the test is 0% accurate, as it cannot discriminate between true positives (i.e. actual invasive species) and true negatives (i.e. actual non-invasive species). Typically, the AUC will range between 0.5 and 1.0, and the closer the AUC is to 1.0 the better the ability of FISK to differentiate between invasive and non-invasive species (ALMEIDA *et al*., 2013).

RESULTS

Based on the MFISK scores, and the BRA and CCA scores of the AS-ISK screening kit, of the nine non-native species recorded on the Montenegrin coast, only two species of fish were characterised as non-invasive. All the species were classified into three categories: Invasive/Least Concern (Inv/LC), Invasive/Not Evaluated (Inv/NE) and Non-Invasive/Least Concern (Non Inv/LC). *Siganus luridus, Stephanolepis diaspros*, *Sphoeroides pachygaster* and *Lagocephalus sceleratus* were classified into the category Inv/LC. Only the species *F. commersonii* was in the category Inv/NE, while *T. acus imperialis* and *C. crysos* were placed in the category Non Inv/LC. Two species of crustaceans – *C. sapidus* and *F. aztecus* – were not processed through the MFISK program but were classified into the category Inv/NE in AS-ISK due to the high scores they achieved (Table 1). On the basis of the values of the scores we obtained, ranging from 16 to 26 further assessment and ROC analyses were worked out. The area under the ROC curve for MFISK was

*Table 1. Risk assessment for nine species of fish and crustaceans using MFISK and AS-ISK screening tools for alien marine fish and crayfish species in the Adriatic Sea of Montenegro. *For every species, conservation status (from www.iucn.org) and that of invasiveness (from www.issg.org and from FishBase www.fishbase.org) are given together with the scores obtaine.*

Name of the species	English name/local-language vernacular name	Invasiveness	Status of vulnerability	BRA score	CCA score	MFISK score
Siganus luridus	Dusky spinefoot/ Tamna mramornica	Invasive	Least concern	30.5	42.5	19
Tylosurus acus imperialis	Agujon needlefish/ Veličanstvena iglica	Non-invasive	Least concern	28.5	40.5	21
Lagocephalus sceleratus	Silver-cheeked toadfish/ Srebrnotačkasta napuhača	Invasive	Least concern	32.5	44.5	26
Fistularia commersonii	Bluespotted cornetfish/ Plavotačkasta trumpetača	Invasive	Not Evaluated	34.5	46.5	24
Caranx crysos	Blue runner/ Plavi trkač	Non-invasive	Least concern	33.5	45.5	16
Stephanolepis diaspros	Reticulatedleatherjacket/ Afrički kostorog	Invasive	Least concern	28.5	40.5	24
Sphoeroides pachygaster	Blunthead puffer/ Četverozupka	Invasive	Least concern	40.5	52.5	25
Callinectes sapidus	Blue crab/ Plavi rak	Invasive	Not Evaluated	43.5	55.5	
Farfantepanaeus aztecus	Brown shrimp/Braon škamp	Invasive	Not Evaluated	39.5	51.5	

0.9167 (Fig. 2) which shows that it can distinguish invasive from non-invasive species. The FISK threshold of 22.5 was used to distinguish between "medium-risk" (i.e. with scores within the interval [1, 22.5]) and "high-risk sensu lato" (s.l.: [22.5, 54]) species, into "moderately high-risk" [22.5, 25], "high-risk" [25, 30], or "very high-risk" [30, 54], and with "low-risk" species having a score within the interval [−11, 1] (BRITTON, CUCHEROUSSET, DAVIES, GODARD & COPP, 2010). Of the nine fish species assessed, *S. luridus*, *T. acus imperial*is and *C. crysos* were classed as medium-risk, *F. commersonii* and *S. diaspros* as moderately high-risk and *S.*

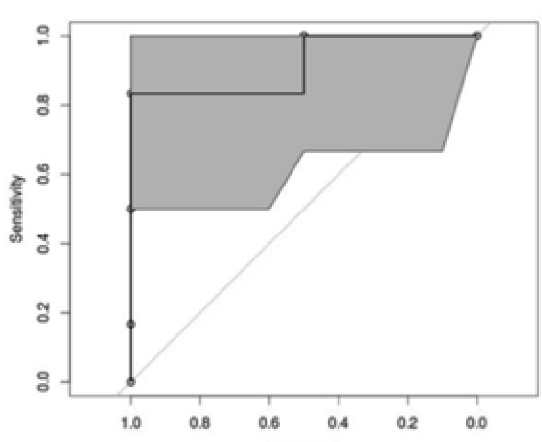

Fig 2. Receiver operating characteristic (ROC) analysis for seven species of fish by the MFISK program

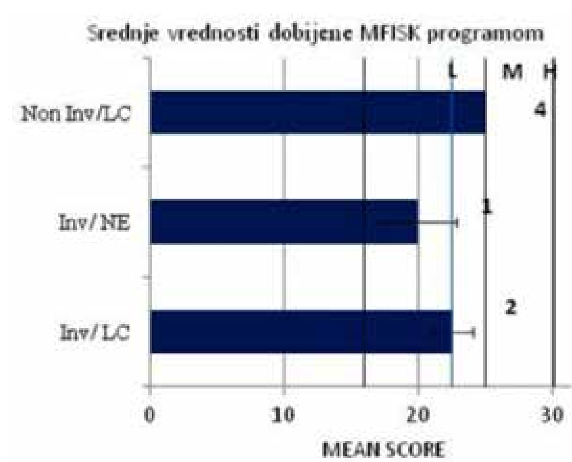

Fig. 3. The mean MFISK scores for seven non-native marine fish species according to their a priori invasiveness and conservation status.

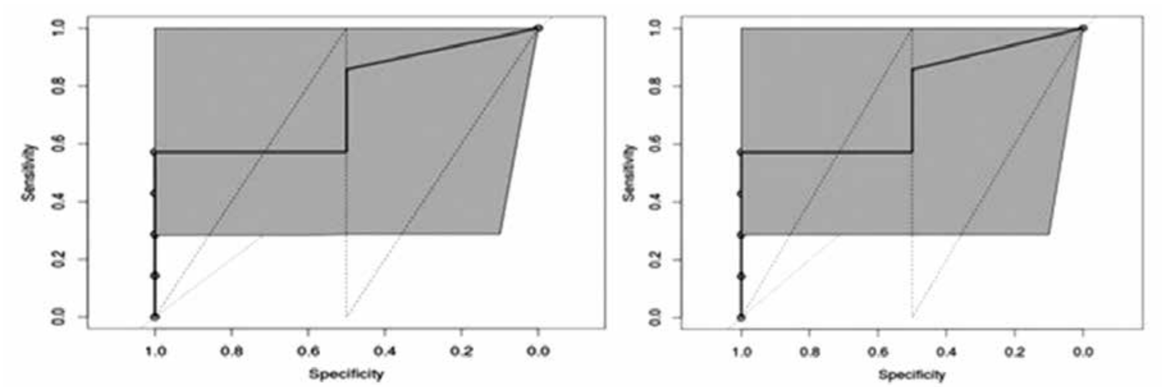

Fig. 4. Receiver operating characteristic (ROC) curves for BRA scores (left) and BRA + CCA scores (right) of AS- ISK risk screening tool used for seven species of fish and two species of crustaceans found in the Adriatic Sea along the Montenegrin coast.

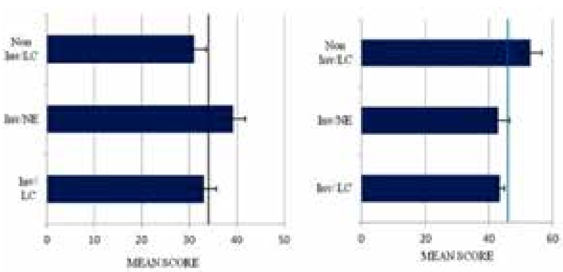

Fig. 5. Mean BRA (left) and BRA+ CCA (right) of the AS-ISK screening tool for seven non-native marine fish species according to their a priori invasiveness and conservation status.

pachygaster and *L. scelertus* were classified in the high-risk category. The mean value obtained from the MFISK results for the category Inv/LC was 22.5 ± 1.554 SD, for the category Inv/NE it was 20 ± 2.848 SD, while for the category Non Inv/LC the mean value was 25 ± 0.0 SD (Fig. 3). The results of AS-ISK BRA scores were in the interval from 28.5 to 43.5 while those of the BRA + CCA scores were in the interval between 40.5 and 55.5. ROC analysis showed the AUC value for the BRA and CCA scores of 0.75, i.e. the screening tool easily distinguishes between invasive and non-invasive species. The threshold value for the BRA scores was 34, and for the BRA + CCA scores it was 46 (Fig. 4). The mean value of the BRA scores for the category Inv/LC was 33 ± 2.629 SD; for the category Inv/NE it was 39.16 ± 2.603 SD; while for the category Non Inv/LC the mean value of the BRA scores was 31 ± 2.5 SD. The mean value of the BRA + CCA scores for the category Inv/LC was 43.5 ± 1.290 SD; for the category Inv/NE it was 43 ± 3.480 SD; while for the category Non Inv/LC the mean value of the BRA + CCA scores was 53.16 ± 3.480 SD (Fig. 5)

DISCUSSION

During the last few years, risk assessment has been often used as a tool for supporting decisions in policies to manage allochthonous species (VERBRUGGE *et al*., 2012). The biodiversity of the Mediterranean Sea has changed during the past 200 years due to the continuous and frequent introduction of alien species (ZENETOS *et al*., 2012), where the phenomenon of biological invasion has been particularly expressed (COLL *et al*., 2010). However, in the central Mediterranean Sea, only few Lessepsian immigrants have established stable populations (TIRALONGO *et al*., 2020). In Montenegrin marine waters, nine new species have been introduced so far. It is considered that the number of introduced species will grow drastically in the future and these species' rapid expansion in the risk assessment area is supported by similar climate conditions, as revealed by permanent new findings by certain individuals. However, it is too early to conclude about their establishment, or naturalisation, in the southern Adriatic Sea of Montenegro, as well as on their impact on the recipient marine ecosystems. The results gathered using both screening tools are similar and in agreement, which is convincing evidence that they can both be used in the same risk assessment area.

Tylosurus acus imperialis (Agujon needlefish) is a species that is native to the eastern Atlantic Ocean. There are two more species of the genus Tylosurus: *Tylosurus choram* (Red Sea houndfish) (Rüppell, 1837) and *Tylosurus crocodilus* (hound needlefish) in the Mediterranean Sea (FROESE & PAULY, 2014) *Tylosurus acus imperialis* has been recorded in Turkey (TÜRKER ÇAKIR, & ZENGIN, 2013), Lebanon and Israel (FROESE & PAULY, 2014), in Tunis (CHÂARI *et al.*, 2013), Italy, Greece (AKYOL & KARA, 2011) and Croatia (PEĆAREVIĆ *et al.*,2013). In Montenegro, *T. acus imperialis* was recorded in 2011 near the island of Sv. Nikola, near the city of Budva, and three years later near Cape Platamuni (JOKSIMOVIĆ *et al.*, 2015). In the last few years, this epipelagic fish has been caught more and more frequently along the Montenegrin coast, usually at shallow depths near the sea surface.

Caranx crysos (Blue runner) is a species common to the whole Mediterranean (FISCHER *et al.*, 1987). It is very common in the eastern and southern areas, but it is also occasionally found in the northern and western parts (TIRALONGO *et al.*, 2020). As the consequence of meridionalization, *C. crysos* is extending its boundaries of dispersal into northern areas. It was recorded in Israel (PSOMADAKIS *et al.*, 2011), Egypt (ASSEM, 2000) and in Libya, where this fish has been caught in nets in the Bay of Sirt (SHAKMAN & KINZELBACH, 2007). In the southern part of the Tyrrhenian Sea and in the port of Palermo, species have been caught in nets, as well as near aquaculture cages (PSOMADAKIS *et al.*, 2011). They have been found in Turkey (BILECENOGLU *et al.*, 2002) and along the shores of the Aegean Sea (BRADAI *et al.*, 2004). In Greece, they have come up to the coast of the Peloponnese (PSOMADAKIS et al., 2011). Naturally, they inhabit the Atlantic Ocean and the Mediterranean Sea, being common only in the latter's southern parts. In the Adriatic Sea, they were caught in 2008 in the northern parts, four individuals were recorded in the area of Ulcinj in March 2013 (DULČIĆ *et al.*, 2014a), and one individual was recorded in the Boka Kotorska Bay in December of that same year. During the past few years, they have been frequently caught in nets and with hooks (DULČIĆ *et al.*, 2014b).

Fig. 6. Fistularia commersonii caught along the Montenegrin coast

Siganus luridus (Dusky spinefoot) inhabits the western part of the Indian Ocean and in the Mediterranean Sea (DANIEL *et al.*, 2009), where this species has been recorded in the area of Israel (BEN-TUVIA, 1964), Libya (SHAKMAN *et al.*, 2008), Tunisia (KTARI-CHAKROUN & BOUALAl, 1971), Greece (PANCUCCI-PAPADOPOULOU *et al.*, 2005) and Sicily (AZZURRO & ANDALORO, 2004; TIRALONGO *et al.*, 2019). *Siganus luridus* can be considered an exotic species that has established its population in the Mediterranean Sea, so it represents a common species in the eastern part. This species is a Lessepsian migrant which came to the Adriatic Sea from the Red Sea through the Suez Canal (BEN-TUVIA, 1985). Fish of this species were caught in nets in 2014 in the village of Bigova, Montenegro (DJUROVIĆ, *et al.*, 2014). Since then, they have been caught several more times in Montenegrin waters.

Fistularia commersonii (Bluespotted cornetfish) is one more species new to the Adriatic Sea (Fig. 6). Its native dispersal area is the Indian and Pacific Oceans, including the western coasts of Central and South America. It has arrived to the Mediterranean Sea through the Suez Canal. For the first time *F. commersonii* has been recorded near Israel (GOLANI, 2000), but it is spreading very fast along the Mediterranean Sea (TIRALONGO *et al.*, 2019). The species is one of the best colonisers and it is on the list of the 100 most invasive species (STREFTARIS & ZENETOS, 2006). First Adriatic records of this species

Fig. 7. Lagocephalus sceleratus *caught along the Montenegrin coast*

consider two specimens caught on 7 November, and 15 December, 2006 in trammel nets off the coastal waters of Tricase Porto (southwestern Adriatic, Italy) and Sveti Andrija (southeastern Adriatic, Croatia), respectively (DULČIĆ *et al*., 2008). The first records for Montenegro were from February and November 2008, near the city of Tivat in the Boka Kotorska Bay. The third recording was made in December 2013, when an individual was caught by speargun near Budva (JOKSIMOVIĆ *et al*., 2015).

Lagocephalus sceleratus (Silver-cheeked toadfish) is one of the most dangerous tropical invasive species that has entered the Mediterranean Sea (STREFTARIS & ZENETOS, 2006) through the Suez Canal. Its native dispersal areas are the Indian Ocean, Pacific Ocean and Red Sea (GIORDANO *et al*., 2012). Its first recording was in 2003, in Gokova Bay in south-eastern part of the Aegean Sea in Turkey (AKYOL *et al*., 2005). During the following year, the species was recorded in Antalya Bay, and then in November of that same year in Israel, where two cases of poisoning from its toxins were recorded (GOLANI & LEVY, 2005). They experienced rapid expansion in the Mediterranean. In the Adriatic Sea, they were recorded near Dubrovnik (Croatia) and on the Jakljan Island in 2012 (ŠPREM *et al*., 2014). In Montenegro, three individuals have been caught along the coast so far (MAČIĆ *et al*., 2014), (Fig. 7).

Stephanolepis diaspros (Reticulated leatherjacket) is native to the western part of the Indian

Fig. 8. Sphoeroides pachygaster *caught along the Montenegrin coast*

Ocean, Red Sea and Persian Gulf. It came to the Mediterranean Sea through the Suez Canal and has been recorded in the eastern (GOLANI, 1996; KATSANEVAKIS, & TSIAMIS, 2009) and central parts (DEIDUN *et al*, 2015). The first recording of this species was in Palestine (POR, 2012). *Stephanolepis diaspros* has established a sustainable population in Turkish waters (SANGUN *et al*., 2007). In the area of the eastern Mediterranean Sea they are numerous, while in the Adriatic Sea they have been recorded only once, in August 2002, near the city of Ulcinj in Montenegro (DULČIĆ & DRAGIČEVIĆ, 2011).

Sphoeroides pachygaster (Blunthead puffer) is a species that inhabits tropical and moderate seas. It is native to the Atlantic Ocean (northwestern and south-eastern parts), the eastern and western parts of the Indian Ocean, Black Sea and Mediterranean Sea (www.IUCN.com). The Adriatic Sea is the northernmost boundary of dispersal of *S. pachygaster*, where it was recorded for the first time on 5 January 2008, when it was caught in a trammel net near the city of Budva at a depth of 80 metres (JOKSIMOVIĆ *et al*., 2009), (Fig. 8).

Farfantepenaeus aztecus (Brown shrimp) is another allochthonous species of decapod crustacean that was accidentally introduced into the Mediterranean Sea, as well as into the Adriatic Sea. Only two species from this family *Parapenaeus longirostris* and *Penaeus kerathurus*, have been found along the Montenegrin coast of the Adriatic Sea. *Farfantepenaeus aztecus* was recorded for the first time on 19 September 2013, when it was caught in a net at a depth of between 20 and 25 metres. The vector of

Fig. 9. Farfantepaeneus azttecus *caught along the Montenegrin coast*

introduction was ballast waters (MARKOVIĆ *et al.*,2014), (Fig. 9).

The first occurrence of *Callinectes sapidus* (Blue crab) in Europe was along the coast of France (BOUVIER, 1901). *Callinectes sapidus* is a species of crab native to the waters of the western Atlantic Ocean and the Gulf of Mexico. Recently, it has spread along the Mediterranean Sea and the western coast of the Black Sea (MANCINELLI *et al.*, 2017). It was first recorded in the Adriatic Sea in December 2013. Two male specimens were found on the sandy seafloor within Tivat Bay (JOKSIMOVIĆ *et al.*, 2015). During the past years, a large number of these crabs have been present in Boka Kotorska Bay (MAČIC *et al.*, 2014), as well as outside of it.

The invasive potential of these species in the future, their behaviour and adaptation to climate changes are being estimated according to the results gathered from the MFISK and AS-ISK screening kits. In the next 50 years, it is expected that the air temperature will rise by 2ºC, which implies a change in the temperature of marine ecosystems, which will enable the spread of the existing species and the introduction of new ones (BRITTON *et al.*, 2010). Both screening kits show that the newcomers pose a moderate-to-high risk and can easily adapt to changes in the biotic and abiotic factors of the habitat. They are threatening the native species, including some plants that are endangered and protected by law. *Posidonia oceanica* and algae from the genus *Cystoseira* have been recorded in the stomach contents of *S. luridus* (STERGIOU, 1988). Several species of these plants and algae are listed on the National List of Threatened Species of the Republic of Montenegro (OFFICIAL GAZETTE OF MONTENEGRO, 76/2006). *Lagocephalus sceleratus* is a species with an MFISK score of 26, which puts it in the category of a high risk of invasiveness, as well as *S. pachygaster*, which has an MFISK score of 25 and much higher BRA and BRA + CCA scores from the AS-ISK screening tool. There is a high risk of a fast expansion of these two species in the future and a disturbance of the natural balance in the recipient ecosystem can be expected, as they probably have no natural enemies in the Adriatic Sea. *Lagocephalus sceleratus* is a species that is having a negative impact on commercial species in fisheries, as well as on local fishermen whose nets and catches they are damaging. In some parts of the Mediterranean Sea, a reduction in cuttlefish (S*eppia officinalis*) stocks has been connected to the appearance of *L. sceleratus* (KALOGIROU *et al.*, 2010). Also, *L. sceleratus* has a neurotoxin which could have a negative impact on human health. *C. crysos* is the species with the lowest MFISK score of 16. In contrast to the low values of AS-ISK (BRA and BRA + CCA) scores for this species, it has established a self-sustaining population in Montenegro. *Caranx crysos* should currently be considered as exotic but not invasive. Regardless of it being caught more and more frequently and local fishermen claiming it is becoming commercially important in the fish market, no decrease in the stock of any other commercially important marketing fish species was noticed in combination, nor were there any negative consequences for fishermen related to their welfare, at all.

As for crustaceans, *C. sapidus* had higher BRA and BRA + CCA scores compared to *F. aztecus*, which shows that this is a species with a higher risk of invasiveness. This can be explained by their great fecundity (2 to 6 million eggs per female, better adaptation abilities, such as that of phenotype plasticity in some characteristics (e.g. changing colour when a predator attacks it), and versatility in its utilisation of a variety of habitats (DAVIS *et al.*, 2005). Recently, *C. sapidus* has not reduced its population, but has been found to be spreading in short time intervals into more and more localities along the Montenegrin coast.

Monitoring of the current structure of communities is necessary, in order to get a detailed picture about the current state of the biodiversity and to prevent its degradation. The removing of alien species from the ecosystem is very difficult, but their early discovery is strongly needed, because only then can urgent actions for controlling their expansion and for their removal be efficiently applied as the only effective measures in the battle against them. There are different ways that they are being introduced into the ecosystems. Some of them are facilitated by various human activities (e.g. construction of the Suez Canal, climate changes). Global warming facilitates their spreading and increases their invasiveness potential. Many Tetraodontiformes pufferfish are Lessepsian migrants that entered the Mediterranean Sea because of the warming of the sea. It seems that the way to control some alien fish species can be their commercialisation and by placing them in fish markets. *Callinectes sapidus* and *Caranx crysos* are species that have a commercial value and with the establishment of a local market and prices, local commercial fishermen might be stimulated to catch those species in a targeted way. That might lead to a reduction of their populations and slow down their spreading to new territories. At the same time, there will be an improvement for local fishermen in the economy and the fishing effort for native species would likely be reduced. MEHTA *et al*. (2007) showed that with an increase of resources for the detection of invasive species, the chances of detecting them early while their populations are still small increase, as do the opportunities for better preservation of the native ecosystems and better control of alien invasive species. Such an approach is urgently needed for the Adriatic Sea, as well as for the whole Mediterranean Sea, as those areas that are highly affected by invasive species.

According to GALIL (2007), the Mediterranean Sea has more than 500 invasive species, so it is necessary to establish efficient protocols for preventing further loss of biodiversity due to the negative effects of intentional or unintentional introductions of invasive species. One average wooden sailboat from 1750 was estimated to carry 120 marine organisms and 30 additional ones in the dry ballast and on the anchor chain (CARLTON, 2001). BAX *et al*., 2003 quoted that today just one input vector, that of ballast waters, has been resolved and the fact that it is controlled at some point may lead us to the conclusion that the whole problem has been resolved. Actually, almost nothing is being done to reduce the impact of a large number of other vectors which are responsible for the worldwide dispersal of some of the most harmful invasive species. ÇINAR *et al*., 2014 stated that our current knowledge about the effects of marine invasive species on ecosystem services and biodiversity is mostly narrative, as it is based on poor quantitative proofs. In such circumstances, semi-quantitative invasiveness screening tools, such as MFISK and AS-ISK, have a high predictive value concerning the successful acclimatisation and naturalisation of alien species and the effects they might have in their new recipient areas.

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Received: 14 May 2021
Accepted: 20 April 2022

Nove vrste riba i rakova u Crnogorskim vodama (južni Jadran)

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SAŽETAK

Struktura i sastav bioraznolikosti Sredozemlja značajno su se promijenili. Do sada je u crnogorskom primorju zabilježeno devet novih ne-nativnih vrsta: *Tylosurus acus imperialis*, *Caranx crysos*, *Siganus luridus*, *Fistularia commersonii*, *Stephanolepis diaspros*, *Sphoeroides pachygaster*, *Lagocephalus sceleratus*, *Callinectes sapidus* i *Farfantepanaeus aztecus*. Alohtone vrste počinju se natjecati za hranu i prostor i dovode do degradacije staništa, socio-ekonomskih učinaka i mogu hibridizirati s autohtonim vrstama. Prirodni čimbenici i ljudske aktivnosti omogućili su dolazak ne-nativnih vrsta u Jadransko more. Četiri vrste su lesepsijski imigranti, koji su stigli preko Sueskog kanala, ali pet drugih uneseno je iz Atlantskog oceana, kroz Gibraltarski tjesnac. Analiza korištenjem programa MFISK (Marine Fish Invasiveness Screening Kit), AS-ISK (Aquatic Invasiveness Screening Kit) i ROC (Receiver operating characteristic) pokazala je prag kalibracije od 22,5 za MFISK, BRA (Basic Risk Assessment)) rezultat od 34 i CCA (Climate Change Assessment) ocjenu od 46. Mjera točnosti kalibracijske analize je površina ispod ROC krivulje (AUC). Dvije vrste okarakterizirane su kao neinvazivne: *Tylosurus acus imperialis* i *Caranx crysos*, no pet drugih okarakterizirano je kao invazivno i obuhvaćeno kategorijama od umjerenog do visokog rizika.

Ključne riječi: alohtone vrste; Crna Gora; procjena rizika