



TRACKING CHANGES IN FISH DIVERSITY IN THE SOUTH-EASTERN ADRIATIC SEA (ALBANIA) BASED ON LOCAL ECOLOGICAL KNOWLEDGE

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ABSTRACT

Evidence from the last two centuries has identified changes in the biodiversity of the Mediterranean basin triggered by the arrival of new species. Compared to the central and northern areas, the southern part of the Adriatic Sea, specifically the Albanian coast, has been less studied. The aim of this study is to evaluate the prevalence of new/non-native fish species on the north Albanian coast in order to provide the first data on their presence. Data collection was carried out from March to August 2019 using LEK (Local Ecological Knowledge) protocol in five different locations along the northern part of the Albanian coast. The research followed a predefined methodology previously successfully applied in different countries of the Mediterranean basin by using a semi-structured questionnaire. During this study, 9 new and non-native species were recognized by the fishers, while only 5 of them have shown an evident abundance increase based on their respective catches in recent years. Results suggest that some of the analyzed species, such as blue crab *Callinectes sapidus* and bluefish *Pomatomus saltatrix*, represent important members of the fish fauna in north Albania coastal waters (including the lagoons). Future studies regarding the assessment of their impact and management strategies are highly recommended.

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INTRODUCTION

The Mediterranean Sea has been considered as a system where a lot of ecological space is still available and the idea of having “vacant” niches has often been advanced to explain the success of non-native species in the marine region (Oliveiro and Taviani, 2003; Azzurro et al., 2014). Due to climate change, Mediterranean Sea ecosystems are undergoing the process of meridionalization, the northward expansion of native thermophilic species, and tropicalization, the introduction of (mainly tropical) alien species through the Suez Canal and the Strait of Gibraltar (Lejeune et al., 2010; Givan et al., 2017; Bianchi et al., 2013; Corrales et al., 2018).

Recently, the Mediterranean basin is considered to be a global hotspot for biological invasions from alien species, with nearly 1000 marine alien species among which more than 660 are considered as established (Bo et al., 2020). In the last decade, more than 90 fish species were added to this list, the majority of which have presumably entered either via the Suez Canal or are aquaria releases (Edelist et al., 2013; Zenetos and Galanidi, 2020).

In the Adriatic Sea, more than 20 non-indigenous fish species have been reported in the last two decades, 15 of which are Lessepsian migrants (Dulčić and Dragičević, 2011; Dulčić et al., 2020). Numerous species, previously either rare or completely absent, have recently become more common in the Adriatic Sea. However, although first records of the species are usually documented, subsequent species establishment or expansion is rarely reported (Dulčić et al., 2014). Most studies of alien species on marine ecosystems have focused on population-level questions, such as population establishment, spread, impacts, invasion control and spatial distributions (Azzurro et al., 2013). Despite local evidence, highlighting competitive interactions of some of these species with the native ones (Mancinelli et al., 2013) and impacts on small-scale fisheries (SSF) (Fuentes et al., 2019; Kampouris et al., 2019; Nehring, 2011; Perdikaris et al., 2016; Ventura et al., 2018), the ecological and economic consequences of this invasion have been poorly assessed and our understanding of the species distribution is largely limited to occasional observations (Mancinelli et al., 2017; Suaria et al., 2017).

Recently, several records of non-native fish species distribution have been documented in the Adriatic (Dulčić and Dragičević, 2011; Lipej et al., 2012; Pećarević et al., 2013; Dulčić et al., 2014), while on the Albanian coast only a few observations have been reported. In Albanian territorial waters, there is a lack of information related to the presence of non-native species (in terms of both first record and levels of abundance). Besides the notes on the distribution of blue crab *Callinectes sapidus* by several authors (Beqiraj & Kashta, 2010; Milori et al., 2013; Milori et al., 2017; Kamberi et al., 2020) and the first record of *Lagocephalus sceleratus* (Bakui and Durmishaj, 2019 in Koistenen et al., 2019), no other recent information has

been published. A few decades ago, *Hemiramphus far* (Forsskål 1775) and *Saurida undosquamis* (Richardson 1848) have been recorded in the Adriatic Sea near the Albanian coast (Collette and Parin, 1986; Rakaj, 1995), but there are no additional records to confirm their presence on the Albanian coast.

In this study, a participatory approach of data collection has been carried out in order to access “Local Ecological Knowledge” (LEK) of local fishers, which has recently emerged and is increasingly being used as an alternative information source on fish species occurrence and their distribution in the Mediterranean Sea (Azzurro et al., 2011; Boughedir, et al., 2015; Damalas et al., 2015; Azzurro and Bariche, 2017). LEK methodology is based on the information that professional and recreational fishers can provide about their local marine environment. To investigate the presence of the selected new and non-native fish species and their perceived abundance and trends, LEK of large-scale, small-scale and recreational fishers from five different locations in the northern part of the Albanian coast was accessed.

MATERIALS AND METHODS

Study areas

Interviews were conducted between March and August 2019 in five different areas in the northern part of the Albanian coast, namely Durres, Kune, Vain, Shengjin and Patok (Fig. 1).

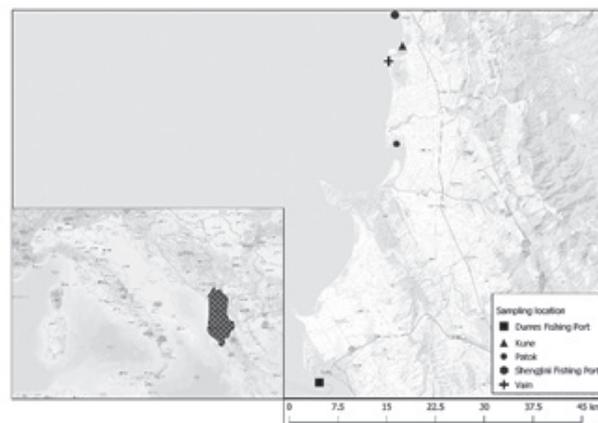


Fig. 1. Map of the study areas, represented by Durres, Kune, Vain, Shengjin and Patok; black circles indicate the fishing ports/shelters in the study areas

Interviews

Drawing on the methodology conceived within a pilot experience (Azzurro et al., 2011) and according to the procedure described by Garrabou et al. (2018), a semi-structured questionnaire to reconstruct changes in distribution and abundance of selected fish in the southern Adriatic Sea (Albanian coast) was used. This study focused on 18 fish and 1 crab species that have been

recently introduced or were characterized as distribution expanding species according to Azzurro (2008). The selected species presented to the fishers were as follows: *Balistes capriscus*, *Coryphaena hippurus*, *Fistularia commersoni*, *Lagocephalus sceleratus*, *Lichia amia*, *Pomatomus saltatrix*, *Sardinella aurita*, *Siganus rivulatus*, *Sparisoma cretense*, *Sphyrna viridensis*, *Trachinotus ovatus*, *Plotosus lineatus*, *Saurida udosquamis*, *Hemiramphus far*, *Pempheris rhombidea*, *Sargocentron rubrum*, *Stephanolepis diaspros* and *Callinectes sapidus*. Knowledgeable fishers with more than 10 years of experience were identified and chosen to complete the questionnaire. Successive individual face-to-face interviews were realized according to a standard protocol with all fishers. Respondents were asked to mention the species that increased in abundance or were perceived as “new” (i.e. never observed before) in their fishing areas. For each of these species, qualitative ranking of historically perceived abundances was expressed along a yearly timeline and according to six categories (0 = ABSENT; 1 = RARE [once in a year]; 2 = OCCASIONAL [sometimes in a fishing period]; 3 = COMMON [regularly in a fishing period]; 4 = ABUNDANT [regularly in a fishing period and abundant]; 5 = DOMINANT [always in a fishing period and with great abundances]). In order to facilitate the process of reconstructing historical abundances, line drawings on a preprinted diagramming table were used by the interviewer. Colored pictures of fish and fish identification manuals were used as visual aids for accurate species identification and for checking respondents’ knowledge of specific taxonomic characters, whenever needed. The duration of a single interview ranged between 15 and 60 min. For each target species, data (perceived abundance scores) obtained from fishers were combined and mean relative abundance was calculated for each year in order to build a graphical representation of the abundance trends as perceived by the fishers. Data elaboration and graphical presentations were prepared using R Studio.

Sample characteristics

A total of 83 fishers, with more than 10 years of experience, were interviewed within this period. Their age ranged from 25 to 66 years (mean ± SD: 50.4 ± 11.6) (Fig. 2).

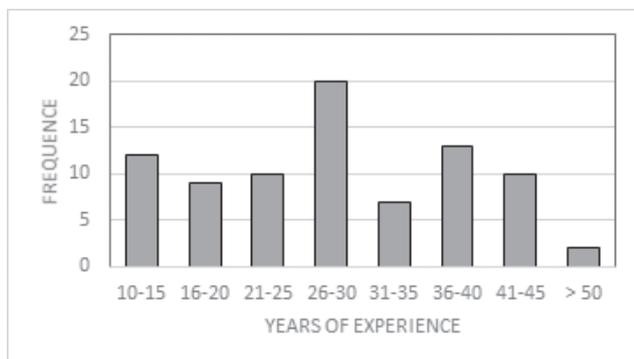


Fig. 2. Years of experience in the fishing sector of the respondent fishers from all 5 sampling areas

Their cumulative working experience accounted for a total of 2362 years of observation on the sea. Most of the interviewed fishers were working with polyvalent vessels, whereas trawling nets were the most commonly used fishing gear used by the large-scale and small-scale fishers (37%), followed by hooks and longlines (27%), gillnets (17%) and other fishing gears (19%) (Fig. 3). About 84% of the interviewed fishers were large- and small-scale (professional) fishers, while only 16% were represented by the recreational fishers (only one was a diver).

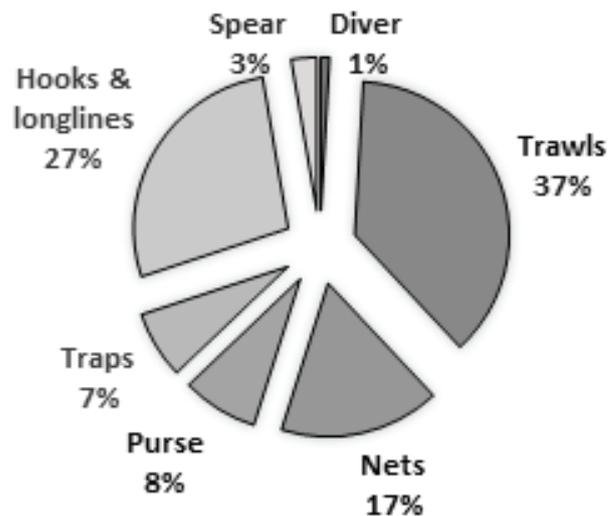


Fig. 3. Fishing gears used from the interviewed fishermen in all five areas in the northern part of the Albanian coast

RESULTS

Out of 19 species that were shown for identification, fishers positively identified 9 of them. In Table 1, a summary of data extracted from the Albanian fishers on investigated species is shown. The data indicate that, for the majority of species, the presence in the total catches has been increasing over the years. For two of them, silver-cheeked toadfish *Lagocephalus sceleratus* and marbled spinefoot *Siganus rivulatus*, a stable sporadic presence over the years is indicated. As for round sardinella *Sardinella aurita*, its presence was considered as fluctuating over the years. None of the species has shown a decrease of presence in the total catches since the first catch. Grey triggerfish *B. capriscus* Gmelin 1789 was familiar to 42 out of the 83 interviewed fishers. It appeared in Albanian fishers’ catches for the first time in 1978 in low levels, while its abundance started to increase around the year 1990 and has continued to increase moderately up to the present (Fig. 4). According to the information gathered from the fishers, this species does not show a high abundance in their catches, although a stable increase over the years has been indicated. This species is mostly fished by bottom trawling and trammel nets (Table 1).

Table 1. Overall summary on the occurrence of the selected species on the Albanian coast of the Adriatic Sea, along with the species, the year of the first capture of each species is indicated in the 3rd column, the 4th column indicates the abundance status of each species in the total catches from the first time it was captured until today where (I) indicates an increased presence in total catches, (S) indicates a stable presence in total catches, (F) indicates an fluctuating presence in total catches; the 5th column indicates the fishing gear used for the capture of each species

Nr.	Species	Common Name	First Capture (Year)	Status	Fishing Gears Used
1	<i>Balistes capriscus</i> Gmelin 1789	Grey triggerfish	1978	I	Trammel, Trawl
2	<i>Callinectes sapidus</i> Rathbun 1986	Blue crab	2000	I	Trammel
3	<i>Coryphaena hippurus</i> Linnaeus 1758	Dolphinfish	2002	I	Hooks, Trammel, Purse seine
4	<i>Lagocephalus sceleratus</i> (Gmelin 1789)	Silver-checked toadfish	2014	S	Trawl
5	<i>Pomatomus saltatrix</i> (Linnaeus 1766)	Blue fish	1995	I	Hooks, Stavnik, Trawl, Trammel
6	<i>Sardinella aurita</i> Valenciennes 1847	Round sardinella	1978	F	Purse seine, Pelagic trawl
7	<i>Siganus rivulatus</i> Forsskål & Niebuhr 1755	Marbled pinefoot	2010	S	Hooks
8	<i>Sphyrna viridensis</i> Cuvier 1829	Yellowmouth barracuda	2005	I	Driftnet, Purse seine
9	<i>Trachinotus ovatus</i> (Linnaeus 1758)	Pompano	2005	I	Longline, Divers

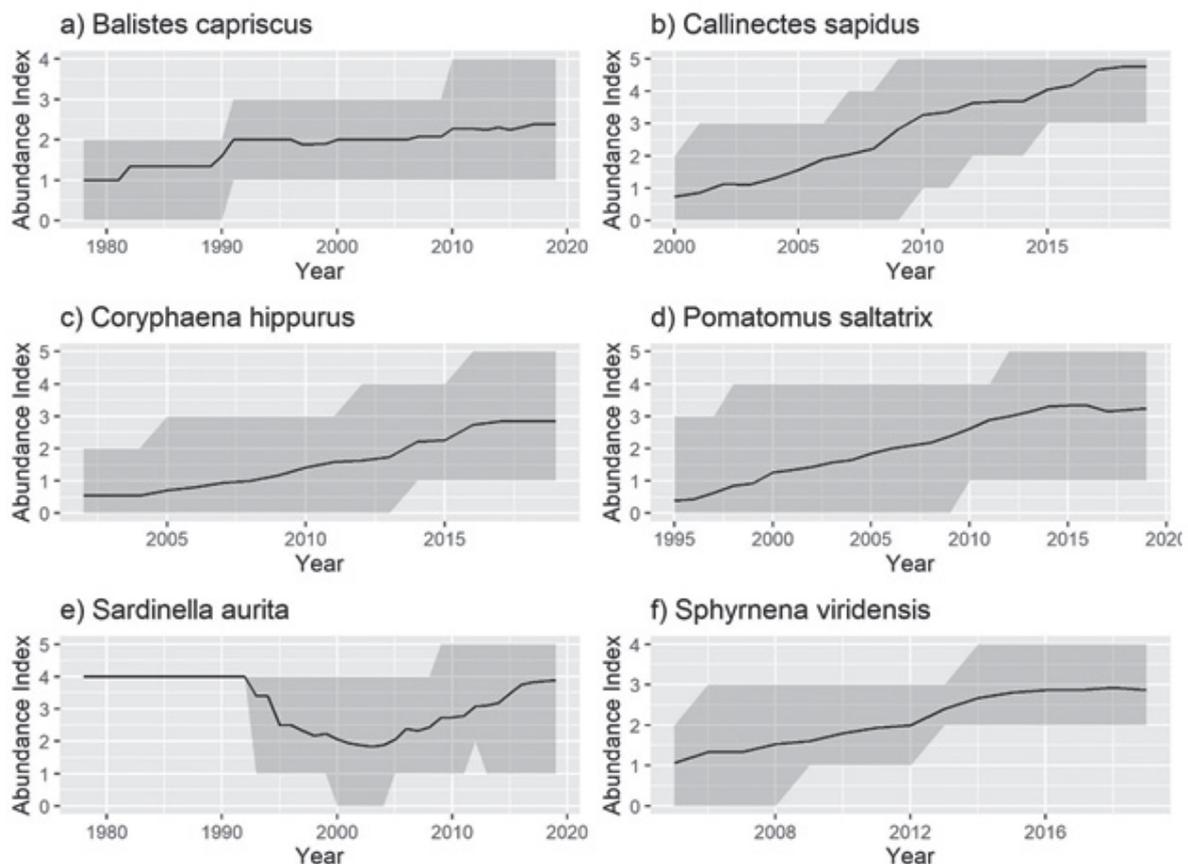


Fig. 4. Dynamics of the abundance of: a) *B. capriscus*, b) *C. sapidus*, c) *C. hippurus*, d) *P. saltatrix*, e) *S. aurita* and f) *S. viridensis*, according to fishers' perception. Trends of relative abundance index are shown on a scale from 0 - 5 as indicated by the protocol. Bold continuous line indicates the mean relative abundance index. The highlighted area indicates the minimum and maximum abundance in a continuous way for all the period since its first record.

According to the fishers, blue crab *Callinectes sapidus Rathbun 1986* appeared in Albanian waters in the year 2000 and it became abundant in a short time, mostly in lagoons and coastal areas. Although this species was familiar to all the fishers, just a few fished it regularly due to its low market price. This species has shown a constant increase in abundance since the year 2000, resulting in its highest levels from the year 2015 (Fig. 4). According to the personal communication with the fishers, during these years, the presence of blue crab in their catches has been observed to be considerably high.

Dolphinfish *Coryphaena hippurus Linnaeus 1758* was caught for the first time by the Albanian fishers in the year 2002 and ever since it has shown a gradual increase in its abundance. Recently this species is becoming much more frequent in Albanian territorial waters (Fig. 4). Of the interviewed fishers, 23 reported the abundant presence of this species mostly during the summer months. Dolphinfish is mostly caught by using hooks, though there are cases in which it is fished by purse seiners (mainly targeting sardines and anchovies) (Table 1).

During our interviews, only three fishers reported having caught silver-cheeked toadfish *Lagocephalus sceleratus (Gmelin 1789)*. Some of the Egyptian fishers who work in the Albanian fishery sector claimed that they have caught this species in the Levantine Sea, but not in the Adriatic Sea. Most of the fishers did not have any information related to the presence of the accumulation of the TTX in the body of these fish species. The first individual was caught in the year 2014, while the following catches were reported in the years 2017 and 2018 (Table 1).

Bluefish *Pomatomus saltatrix (Linnaeus 1766)* was familiar to 48 fishers; this species is recognized by the fishermen as one of the most aggressive fish species. The first record of *P. saltatrix* according to the fishers was in 1995, and since then its presence in catches has increased gradually over the years (Fig. 4). It is caught mostly using hooks and stavnik fish-traps (Table 1). Fishers identify this species as very aggressive, mainly responsible for damaging their catches represented by the fish entangled in the trammel nets and their fishing gears.

The first record of round sardinella *Sardinella aurita Valenciennes 1847* was in the year 1978, as recognized by some of the oldest interviewed fishers, at that time the abundance of the catches was high. Its abundance in the catches remained at high levels until the year 1990 when its abundance started to decrease until the year 2000, which was recognized as the year with the lowest level of catches. In the last 20 years even though its abundance has been increasing gradually, it is less targeted by fishers due to low market price (Fig. 4). Of the interviewed fishers, 29 recognized this species.

Marbled spinefoot *Siganus rivulatus Forsskål & Niebuhr 1755* is not very abundant in Albanian waters, though it has been caught several times by 15 of the interviewed

fishers who use hooks in shallow rocky bottoms (Table 1). According to fishermen, since the first time it was caught (in 2010), it has shown a stable presence over the years. Most of the fishers were informed about its venomous characteristics. The first catch of the yellowmouth barracuda *Sphyaena viridensis Cuvier 1829* was recorded in the year 2005. This species was familiar to 22 interviewed fishers who reported that its abundance had shown a gradual increase since the first catch, though it remained at relatively low levels. Currently, there is low interest in the consumption of this species. Most of the individuals were caught using driftnets and purse seines (Fig. 4, Table 1). Insufficient information was collected from the fishers also for pompano *Trachinotus ovatus (Linnaeus 1758)*; its first catch was reported in the year 2005 using longlines. Due to the low number of catches, there is no information related to the market value of this species. Only 7 fishers could recognize this species.

DISCUSSION

This study was developed with the aim to provide historical data on the presence and abundance of a selected number of non-native species on the Albanian coast (northern part) of the Adriatic Sea, as this area is less studied compared to other areas of the Adriatic. As a source of information, suggested by the protocol, local fishers from different locations were interviewed, given the fact that they are in contact with these species every day and sometimes they detect these changes earlier than the researchers or fisheries managers. The obtained results indicate the presence of 9 (out of 18 surveyed) species in the Adriatic Sea, which are represented by 8 fish and 1 crustacean. The majority were introduced in the recent 20 years. Collected data could provide information not only on their first records but also on the fluctuations in their abundance in different years, as well as information on the fishing gears used.

Among these species, six showed an increase in abundance since their first record (*B. capriscus*, *C. sapidus*, *C. hippurus*, *P. saltatrix*, *S. viridensis*, *T. ovatus*), while 2 species indicated a stable abundance over the years (*L. sceleratus* and *S. rivulatus*) and only one of them (*Sardinella aurita*) showed fluctuations in its presence in catches (Table 1).

The species that showed the greatest increase in abundance was blue crab *C. sapidus* (Fig. 4). Historical data from the fishers indicate its first appearance in catches in the year 2000. It is important to mention that the first scientific record on the Albanian coast was registered 10 years later, in 2010, which indicated an established population in the Patoku Lagoon (Beqiraj & Kashta, 2010). Over the years, they constantly increased their presence along the southern Adriatic coast. As it has also been referred by other authors in other countries, even in Albania, fishers claim huge damage in their nets from blue crab. Furthermore, they have observed that it

shows predatory behavior against native species (Galil et al., 2002; Onofri et al., 2008). Its impressive reproductive capacity and aggressive behavior make blue crab a serious pest due to its impact on the ecosystem and ecosystem services, and as such presents a challenging species in terms of its population control and management. Till now this species has not been of great interest to Albanian fishers, because of its low market price and low interest from processing companies.

The two species which appeared earlier on the Albanian coast are *B. capriscus* and *S. aurita* (Fig. 4). Both have been caught by Albanian fishers since 1978. Both species are common to the Mediterranean Sea and their presence has also been noted in other parts of the Adriatic (Jardas, 1983, 1996; Pallaoro, 1998; Dulčić and Soldo, 2005; Mustać and Sinovčić, 2012).

According to fishers' perception, the presence of *S. aurita* in fishery catches on the Albanian coast was quite high until 1990, while in 1992 they suddenly started to decrease heavily and this may be related to the democratic changes that happened during that time in Albania, and not to the species abundance itself (Fig. 4). Fishers who were previously oriented toward pelagic fishing, shifted their attention toward demersal resources. In the past, it was one of the most important species caught by the Albanian fishing vessels (Flloko A., 2004), but nowadays round sardinella is not of great interest to Albanian fishers because of its low market price and low interest from fish processing companies. Both these factors may explain the fluctuations of this species presence in the catches on the Albanian coast. Even though there is a long presence of round sardinella in the southern Adriatic, several studies show that there is an increase in its abundance and gradual northward expansion in the Mediterranean during the last decades, which seems to be related to the observed sea warming (Sabatés et al., 2006).

Special attention should be given to the distribution and abundance of grey triggerfish in the future. Previous evidence has shown that there is great geographical distribution of this species across the northern European coast, closely linked to climate change and oceanographic conditions. (Banon et al., 2002). Different articles refer to its presence as normal in the southern Adriatic, and our findings suggest that there is a stable increase in the presence of grey triggerfish on the Albanian coast, but it does not show very high abundances. Data related to the distribution of *B. capriscus* are good indicators of environmental changes related to warming in the marine environment (Perry et al., 2005; Azzurro, 2008).

The species distributed normally in the Mediterranean basin are represented by *P. saltatrix* and *C. hippurus*, which have both extended their distribution in the Adriatic Sea (Sbragaglia et al., 2020). According to the fishers, both species appeared on the Albanian coast in the last 25 years, bluefish in the year 1995 and dolphinfish in the year 2002 (Fig. 4). These species have shown similar abundance levels, both characterized by a constant increase over the

years and a stable situation in the last 4 years. Scientific data also support the presence of these species in the Adriatic Sea and its northern expansion may be a signal that they are not just seasonal visitors, as they had been considered before (Jardas, 1996). The latest findings suggest that both these species have already established populations in the Adriatic Sea (Dragičević et al., 2010; Dulčić et al., 2019).

Additional fish species that show an increase in the catches on the Albanian coast after their first catch are also *Sphyræna viridensis* and *Trachinotus ovatus*. Both species were fished for the first time in the year 2005, though *S. viridensis* has shown a greater increase in its abundance in comparison to the pompano *T. ovatus*. According to the historical evidence from the fishermen in the period 2012-2015, yellow mouth barracuda has shown the greatest increase in its abundance (Fig. 4). Further evidence in abundance, biology and behavior can offer a better understanding. As for pompano, even though the first evidence of its presence on the Albanian coast was registered 15 years ago by fishers and divers, since there is insufficient data available, it is early to give an opinion related to its abundance.

The latest fish species recorded on the Albanian coast are two Lessepsian migrants, *L. sceleratus* and *S. rivulatus*. Their distribution patterns may be the reason for their latest arrival and abundance on the Albanian coast. The first record of silver-cheeked toadfish *L. sceleratus* by Albanian fishermen occurred in 2014 in the southern part of Albania close to the Bay of Vlora, in the same area where the first scientific report on the presence of *L. sceleratus* on the Albanian coast was reported five years later (Bakiu & Durmishaj, 2019). As for marbled spinefoot *S. rivulatus*, the first record is done earlier compared to *L. sceleratus*, since the year 2010. Still, the collected data about its presence in the catches and observations of the fishermen are not enough to evaluate its abundance levels.

In the last years, the presence of these species, which were previously rare or missing on the Albanian coast, may be a consequence of the climatic and oceanographic conditions in the Adriatic Sea. The corresponding status needs to be evaluated on a continuous basis as an indicator of environmental changes (Dragičević et al., 2010, Dulčić et al., 2019). Further comprehensive studies need to be conducted in order to understand their impact on the Albanian marine ecosystem and the relative interactions toward the native marine organisms.

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PRAĆENJE PROMJENA RAZNOLIKOSTI RIBA U JUGOISTOČNOM JADRANU (ALBANIJA) NA TEMELJU LOKALNOG EKOLOŠKOG ZNANJA

SAŽETAK

Dokazi iz posljednja dva stoljeća identificirali su promjene u bioraznolikosti mediteranskog bazena izazvane dolaskom novih vrsta. U usporedbi sa središnjim i sjevernim područjima, južni dio Jadranskog mora, točnije albanska obala, manje je istražen. Cilj ovog istraživanja je procijeniti rasprostranjenost novih/alohtonih vrsta riba na priobalnom području sjeverne Albanije kako bi se dobili prvi podaci o njihovoj prisutnosti. Prikupljanje podataka provodilo se od ožujka do kolovoza 2019., koristeći LEK (*Local Ecological Knowledge*) protokol na pet različitim lokacija duž sjevernog dijela albanske obale. Istraživanje je slijedilo unaprijed definiranu metodologiju koja se prethodno uspješno primjenjivala u različitim zemljama mediteranskog bazena korištenjem polustrukturiranog upitnika. Tijekom ovog istraživanja ribari su zabilježili 9 novih alohtonih vrsta, dok je samo 5 vrsta pokazalo evidentno povećanje brojnosti na temelju ulova posljednjih godina. Rezultati sugeriraju da neke od analiziranih vrsta, kao što su plavi rak (*Callinectes sapidus*) i strijelka (*Pomatomus saltatrix*), predstavljaju važne članove ihtiofaune u obalnim vodama sjeverne Albanije (uključujući lagune). Preporučuju se buduće studije o procjeni njihova učinka i strategijama upravljanja.

Ključne riječi: Sredozemno more; alohtona riba; znanje ribara

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