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Investigating Consumer Attitudes and Market Trading of Edible Marine Invasive Alien Species in the Greek Seafood Market

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Abstract: Marine invasive alien species (IAS) are spreading in the Mediterranean Sea, altering species composition and reshaping marine ecosystems. The study explores consumer attitudes towards the consumption of marine invasive alien species (IAS), particularly lionfish and Atlantic blue crab, in the Greek seafood market. These species are considered a threat to marine biodiversity but are also being considered for commercial seafood to mitigate their ecological impact. Through surveys of consumers and seafood retailers, the research finds that while Greek consumers show a positive attitude towards consuming these species, they often lack awareness of their ecological impact. Retailers see potential in promoting these invasive species, with freshness, hygiene, and poison concerns being the most important factors for consumers when purchasing seafood. In general, there is a need for better public education regarding the ecological and health impacts of IAS consumption. Factors that could increase consumption include recommendations from seafood retailers, promotion by TV cooking shows, and quality certifications. The study suggests that aligning consumer education with conservation goals could help control the spread of IAS while supporting local fisheries.

Keywords: consumer perceptions; seafood retailers; eating habits; Greece; Mediterranean

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1. Introduction

Professional fishers usually complain about structurally low prices and strict sales conditions in the seafood market [1]. On the other hand, the increasing population and rising per capita consumption of seafood have led to a boom in the global demand for seafood in recent decades [2]. The valorization of fisheries products is one of the main activities promoted by Axis 4 of the European Fisheries Fund, which is a tool to support the sustainable development of fisheries [2]. The economic pressure on professional fishers, especially after the renewed energy crisis and COVID-19 pandemic, has increased the sector's vulnerability to external factors [3,4]. However, one of the reasons for the stagnation of the sales prices of fishery products is that the fishers and shellfish traders are not adjusted to consumer preferences. These have changed significantly in recent years due to the increasing urbanization of lifestyle and the increasing disconnection of consumers from primary production [5,6].

Furthermore, the economic crisis experienced in Greece over the past 10 years has affected seafood consumption because consumers lowered their overall consumption of seafood [7]. The price of the major categories of fish species has generally been increasing

throughout the crisis, albeit demand has been redirected towards lower-priced seafood [8]. In this context, the knowledge of consumers' preferences could act as a catalyst to improve distribution conditions for marine captured fish and promote new products in the Greek seafood market [7,9], which benefits the rational organization of the corresponding distribution networks. This could be encouraging, especially given that Greeks consume less seafood products than the EU 28 average (17th out of 28) [10].

Increasing the supply of new marine species will add value and assist professional fishers in recovering some of the product value that is typically lost further down the chain. The entrance of new fishery products in the seafood market has become particularly important in recent years due to the increase of invasive alien species (IAS) in the Mediterranean Sea. In this area, about a thousand such marine species are recorded [11], while a quarter of them have been reported in the Greek seas [12]. Certain species of them, such as puffers (*Lagocephalus* spp.), are toxic, containing harmful substances in their flesh (tetrodotoxin). These substances render the fish inedible and cause health problems in humans when consumed [13], which in some cases could be fatal. IAS also cause significant damage to fishing gear [14], making it impossible for fisheries to operate uninterrupted in areas where they are established. To combat IAS, the European Union (and the United Nations) has published directives, legislation, and initiatives in this area [15]. In addition, scientists have proposed the consumption of edible IAS as one of the measures to combat their spread. In 2019, the campaign "Pick the Alien" was developed in Greece. This is an initiative of the environmental organization iSea and the support of the Cyclades Preservation Fund, Blue Marine Foundation, Ionian Environment Foundation, and Argolic Environment Foundation that, with the help of experienced chefs, seeks to promote the consumption of edible IAS while informing and raising awareness among citizens about IAS in Greek seas. Gastronomy events have also been held around Greece to promote IAS as seafood.

Even though there is a lack of statistics related to the consumption of IAS products in Europe, numerous studies on this issue provide useful insights into the challenges and potential solutions related to the management of marine IAS, including the concept of controlling them through consumption. For instance, [16] examines the impact of IAS on ecosystem services, focusing on marine environments across Europe, and [17] discusses how man-made marinas can serve as hotspots for IAS, exploring methods for their eradication. The possibility of controlling IAS, focusing on blue crab, through consumption has also been investigated [18], as has the economic impact of aquatic invasive species, including marine environments [19]. Furthermore, the role of chefs in promoting the consumption of IAS as a method of control has also been studied [20]. A recent study in Greece [21] confirmed the favorable attitude of Greek consumers toward the consumption of IAS and supported the significance of further establishing a market that may improve fisheries sustainability through the consumption of IAS species.

In the above context, the food environment, which guarantees food availability and access, affects consumer decisions [22,23]. Thus, the present study focuses on identifying consumer preferences regarding the potential purchase and consumption of edible IAS, in particular, lionfish *Pterois miles* (Bennett, 1828) for residents of Heraklion and Rhodes, and blue crab *Callinectes sapidus* Rathbun, 1896 for residents of Thessaloniki and Xanthi (Figure 1), and investigate the views of seafood product traders on the potential marketing perspectives of the above-mentioned species. These species exhibit a market price ranged from EUR 7/kg to EUR 18/kg, depending on size, in the local markets of Rhodes and Heraclium, making them a considerable income for the professionals derived from a limited ecological footprint fishery—that of small-scale fisheries [24]. Both species have been considered as the most successful IAS in marine ecosystems threatening local biodiversity [25,26] and have been thoroughly studied in terms of their biology, migrations, and risk to the marine ecosystem and native species (e.g., [25,26]), albeit there is a lack of study examining the acceptability of their consumption by consumers.

Figure 1. Map of sampling areas.

The present study intends to promote the intensification of the consumption of two IAS that have a major negative influence on the aquatic ecosystem and its resources [22,23]. The results of this survey will be used to draw conclusions on how awareness campaigns about the ecological impact of IAS influence consumer willingness to purchase and consume these species. Also, the present study will improve market viability by identifying the potential barriers for seafood retailers in promoting invasive species like lionfish and blue crab, and how these can be overcome. Especially important will also be the sustainability impact of this study, given that IAS consumption could benefit both the environment and local fisheries, as well as the policy measures that the Greek government could implement to foster a sustainable market for these species. Joint actions will allow the comparison of working methods and experiences and the exchange of best practices for developing connections with the different stakeholders in the subsequent stages of the product chain [27].

2. Materials and Methods

2.1. Survey Design

Two semi-structured questionnaires were prepared, one for identifying consumer preferences on edible IAS, particularly lionfish and blue crab (Appendix A), and one for investigating the views of seafood retailers (Appendix B). Both questionnaires were designed and developed based on past studies of the Greek consumer's attitude to the seafood market [22,28,29]. The questionnaire on IAS was promoted in person and online, in two areas where the two studied species are frequently caught and traded, namely Heraklion and Rhodes for lionfish, and Thessaloniki and Xanthi for blue crab (Figure 1). Each of the above-mentioned areas was selected due to their abundance in the corresponding species and the great consumer capacity due to tourists and population density, which has already created and established a market for the specific IAS at a local scale, especially in the larger urban cities like Thessaloniki and Heraklion.

The time required to complete both questionnaires was four months (November 2022–February 2023). Participants were timed, and their responses to the questions were taken into consideration. Once the appropriate adjustments have been made, specific questionnaires were prepared using Google's survey management software (Google Forms). The questionnaires were promoted to the participants both in person and through social media, specifically through the Facebook platform. One big advantage of web-based surveys is that the survey administrator can continue to distribute invitations to the survey

among the panel until the predetermined quota is reached [30]. The questionnaire method was the most appropriate method for this research as it allowed the information to be shared and obtained quickly. During the process of completing the questionnaire, the participants were asked to answer with great sincerity and not arbitrarily, emphasizing at the same time the anonymity of the questionnaires and the fact that their answers would not be evaluated as correct or incorrect.

Following marketing literature on consumer behavior [31] and in view of the exploratory nature of this study, interviews were conducted with experts in seafood marketing employing judgment sampling (the nonprobability sampling method, where the sample is based on a judgment/criterion) [32]. It should also be noted that subjects participating in qualitative research are not necessarily chosen randomly [33]. The qualitative research findings were important for the construction of the survey questionnaire. In light of the above objectives, a structured questionnaire was prepared specifically for this purpose, based on the qualitative research findings. Regarding the structure of the questionnaire for the consumers (Appendix A), this starts with the question, "Are you the one buying fish for your family?" and in the case of positive answers, the survey continued. The questionnaire consisted of three sections related to consumers' fish consumption habits and perceptions of non-native species and their potential purchase in Greece (Appendix A). Section A was related to demographic characteristics such as gender, age, marital status, and education level. Section B concerned questions on general fish consumption, such as frequency, quantity, and point of purchase. Section C focuses on questions related to the perception and the purchase and consumption of edible marine IAS in Greece and the prospects for consumption of IAS in the future. This section of the questionnaire investigates, with dichotomous questions (YES or NO), whether consumers know what IAS and, in particular, lionfish or Atlantic blue crab are, whether the species have negative impacts on human health, the marine environment and native species and whether they believe that the consumption of IAS may pose a risk to their health. Particular attention was given to the factors that consumers consider important for the purchase of IAS (lionfish or Atlantic blue crab), such as size, freshness, sanitary conditions of the fishmonger and its staff, packaging, price, origin of the product and whether it is poisonous (see annex). For this purpose, a multi-item question was used in which respondents were asked to rate each of the above factors according to their importance, using a three-point Likert scale (1 = unimportant, 2 = important, and 3 = very important).

The questionnaire for the marine traders of fisheries products (Appendix B) consisted of 22 questions relating to the species and type of seafood products traded, spatial and temporal coverage of the seafood products' trade and consumption, and the economic issues of the seafood trade.

2.2. Data Analysis

The sample is representative of the population, at least in proportion to the gender, age, and place of residents. According to [34], in the 2021 population census survey, the gender ratio was approximately 1:1 (49.0% male, 51.0% female), the average age of the resident population of Greece was 41.9 years, while the proportion of residents living in urban and rural areas was 76.6% and 24.3%, respectively [34]. Fisher's exact test [35] was performed to determine the relationship of demographic factors with the answers referring to both the general consumption of fish and the potential consumption of marine IAS. All the analyses were carried out using the statistical package IBM SPSS Statistics 27.0.1.0 [36].

3. Results

3.1. Demographic Characteristics and Fish Consumption Habits

In total, 180 people participated in the survey to investigate the acceptance of lionfish and blue crab consumption, with the participation rate per region ranging from 17.2% for Rhodes to 38.3% for Thessaloniki, with Xanthi and Heraklion participating almost equally from 22.8% and 21.7%, respectively. More young people aged 18–25 from Heraklion partici-

pated in the survey, while in other regions, the largest percentage concerned participants aged 26–45, in Thessaloniki, aged over 65 in Xanthi, while in Rhodes participants aged 26–45 and 46–65 participated with a similar percentage (32.3%). The educational level of the participants was mainly high school graduates in Heraklion and Rhodes (43.6% and 38.7%, respectively) and bachelor's and master's degree holders in Rhodes and Xanthi (45.2% and 43.9%, respectively). Regarding marital status, 2/3 of the participants from Heraklion were single (66.7%), while the largest percentage from the other regions were married (>45.2%).

3.2. Perceptions on Purchase and Consumption of Lionfish and Blue Crab Consumption

More than half of the survey participants had knowledge of both IAS and lionfish (Figure 2). This knowledge differed between regions and gender, with participants from Heraklion and women not having a significant (Fisher's exact test: $p < 0.05$) large percentage knowledge of lionfish. The prospect of future lionfish consumption was positive for the following cases (Figure 2): (a) it is a delicacy in other countries (58.6%), (b) the fish-monger recommends it (57.1%), (c) it is promoted by a cooking show (61.4%), (c) if it was on a restaurant menu (50.5%), and (d) it promotes the protection of the marine environment and native species (55.7%). In contrast, most participants were negative toward lionfish consumption when the species was cheaper than the endemic species (70%). In addition, more than 70.0% of the participants were unaware of whether lionfish have negative effects on human health or the marine environment and whether lionfish consumption may threaten their health (Figure 2).

With respect to blue crab, slightly more than half of the participants were aware that blue crab is an IAS (Figure 2). This percentage varies between Thessaloniki and Xanthi, as in Thessaloniki, 63.8% of participants were aware that the blue crab is an IAS, while in Xanthi 61.0% were not. Most participants (>83.6%) were not aware whether blue crab has adverse effects on human health or the marine environment and whether its consumption may pose a health risk (Figure 2). These tensions did not differ between participants from Thessaloniki and Xanthi. Participants' statements on the prospect of future blue crab consumption showed that the highest percentage (Figure 1) would consume it if it were food in other countries (70.0%), they would buy it if it was recommended by their fish-monger (61.8%), they would buy it if it was a delicacy in a cooking show (52.7%), as well as if they saw it on a restaurant menu (57.3%). On the contrary, they would not buy it if they found it cheaper than the traditional species (56.4%). Almost 3/5 of the survey participants (62.7%) stated that they would consume blue crab if they knew that this action promotes the protection of the marine environment and native species (Figure 2). It should be noted that the above percentages do not differ significantly (Fisher's exact test: $p > 0.05$) between participants from Thessaloniki and Xanthi.

3.3. Quality Criteria on Blue Crab/Lionfish Consumption

The overwhelming majority of participants from both regions stated that a very important factor for the purchase of lionfish (Figure 3) was freshness (>86.8%), the hygienic conditions of the fishmonger and its staff (>64.5%), and whether the IAS was poisonous (>87.1%). The participants overwhelmingly stated that the factors of packaging, price, and origin of the fish were important or very important, while the size of the fish was an unimportant factor for more than 1/3 of the participants (Figure 3). Most participants stated that a very important factor for the purchase of blue crab (Figure 1) was, in descending order of importance, freshness (86.8%), the hygienic conditions of the fishmonger and its staff (85.3%), whether the IAS is poisonous (77.9%), the price (51.5%) and the origin of the fish (48.5%). In contrast, most survey participants rated packaging and size as simply important factors (47.1% and 45.6%, respectively). It is worth noting that the above percentages do not differ significantly (Fisher's exact test: $p < 0.05$) between the research participants from Thessaloniki and Xanthi.

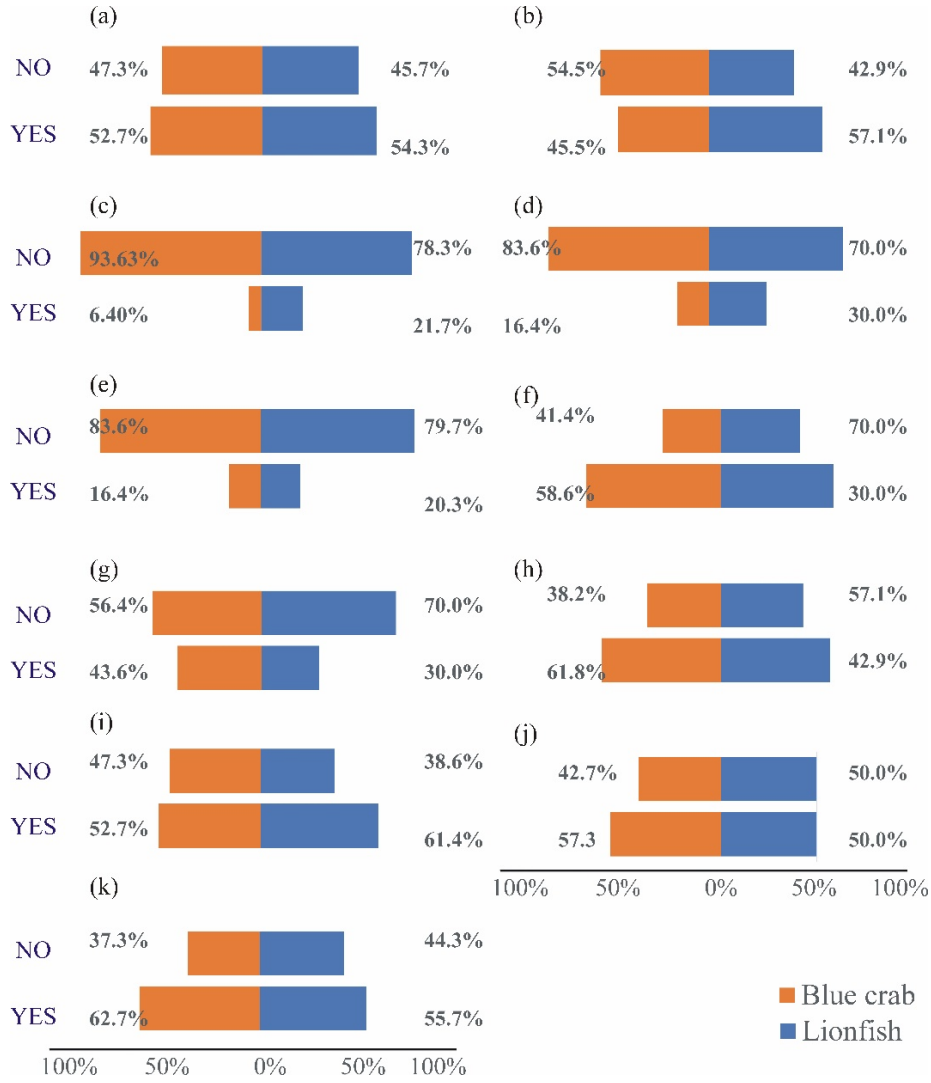

Figure 2. Perceptions of the participants on invasive alien species, blue crab and lionfish. (**a**) "Knowledge of IAS", (**b**) "Knowledge of lionfish/blue crab", (**c**) "Knowledge on negative effects of lionfish/blue crab on human health", (**d**) "Knowledge on negative effects of lionfish/blue crab on the marine environment", (**e**) "Are lionfish/blue crab a threat on health", (**f**) "If lionfish/blue crab are a delicacy, would you try them", (**g**) "Purchase of lionfish/blue crab in case they are found cheaper than endemic", (**h**) "Purchase of lionfish/blue crab in case they are suggested by fishmonger", (**i**) "Consume of lionfish/blue crab in case they are cooked at a cooking show", (**j**) "Consume of lionfish/blue crab in case they are found in a restaurant menu", and (**k**) "Consume of lionfish/blue crab in case that protects the marine environment and native species".

The analysis of consumers' perceptions and preferences for IAS in relation to socio-demographic characteristics revealed that (Fisher's exact test ($p < 0.05$)): (a) postgraduates or doctoral candidates were more likely to report knowledge of IAS, while younger consumers (18–25 years) were less aware, (b) married individuals were more informed about the negative health impacts of IAS consumption, while students and the younger age group responded negatively more often, (c) older consumers showed more awareness of the negative effects of IAS on the marine environment, (d) men and unmarried consumers were less likely to see health risks from consuming IAS products, (e) males were more likely than females to purchase alien species products, especially if they were priced lower or recommended by a fishmonger, (f) married consumers prioritized freshness when selecting IAS products, and females emphasized the origin of the products, and (g) married

consumers and those aged 46–65 were more likely to be influenced by media reports on fish health.

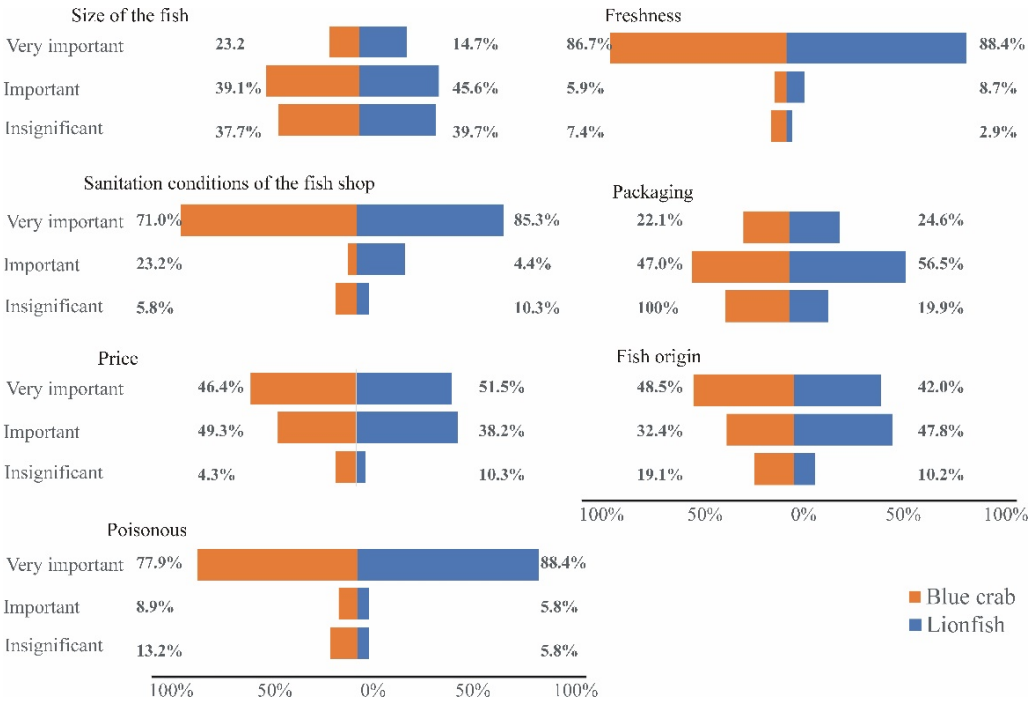

Figure 3. Criteria considered very important when buying IAS.

With respect to quality controls, more than 60% of participants would like, when purchasing lionfish, to carry a quality control certificate or a distinct quality mark, a trend that did not differ significantly (Fisher's exact test: $p < 0.05$) by region. Similarly, most participants (>97.4%) never experienced any health problem from eating fish, a trend independent (Fisher's exact test: $p < 0.05$) of the region (Figure 2). In contrast, most participants from Rhodes preferred to purchase processed lionfish from local cooperatives rather than from Heraklion (60% vs. 25.6%, respectively). More than 2/3 of the participants (67.3%) would like, if buying blue crab, to carry a quality control certificate or some distinct quality mark, while 60.0% of the participants would not buy processed blue crab from local cooperatives (Figure 4). Also, most participants (95.6%) never experienced any health problems from eating fish (Figure 4). It is worth noting that the above percentages do not differ significantly (Fisher's exact test: $p < 0.05$) between the research participants from Thessaloniki and Xanthi.

3.4. IAS Trading

A total of 26 questionnaires were completed by Greek seafood retailers, mostly distributed in Northern Greece (40%), while 1/3 were in Southern Greece, and the remaining were operating throughout the Greek territory and in Mediterranean countries. The average period of involvement of the companies in fishery products trading was 28.6 years (standard deviation = 18.8 years), and the type of business in about 1/3 (36.0%) of the companies surveyed was wholesale, while 24.0% were trading businesses, 20.0% were fish markets and 12% as itinerants. A small proportion were fishers (4.0%). Almost two-thirds of the retailers (62.5%) had up to 9 employees, while 16.7% had more than 50 employees, with a maximum number of 250 employees. Most of the trade companies (76.9%) did not trade IAS, such as blue crabs, lionfish, spinefoots, etc. The majority of the retailers (63.6%) were not willing to supply and distribute IAS, whereas, for the remaining 36.4% of the retailers that were positive in the trade of IAS, more than half (55.6%) were interested in the marketing of blue crab, followed by those that intend to trade lionfish (16.7%), or big

fin reef squid (11.2%) and the remaining units IAS such as spinefoots and bluespotted cornetfish, as well as salmon (5.5% each).

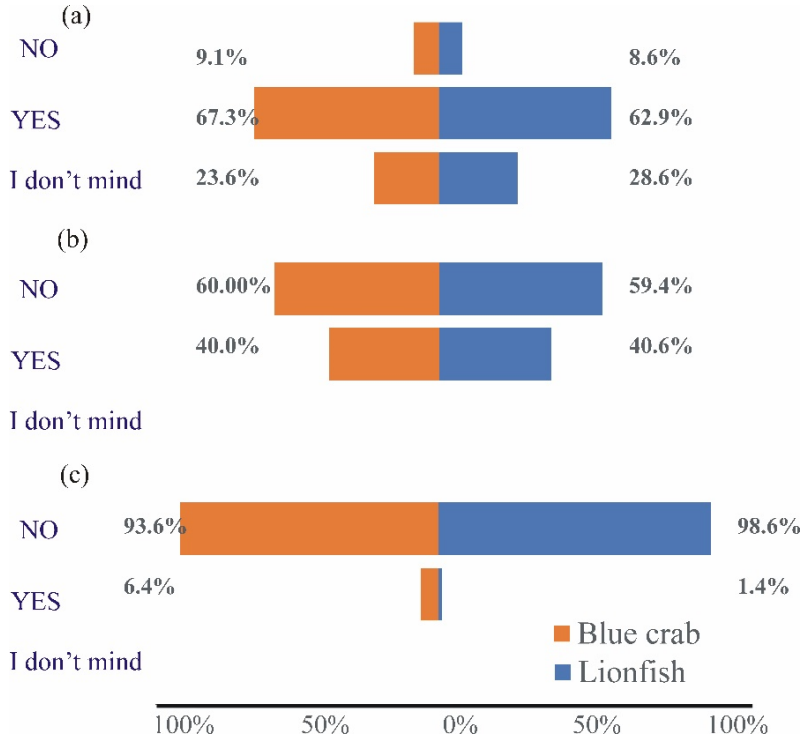

Figure 4. Criteria considered very important when buying IAS. (**a**) Would you like the Atlantic blue crabs/lionfish purchased to have a quality control certificate or quality mark? (**b**) Would you buy processed products of Atlantic blue crab/lionfish from local associations? (**c**) Have you ever had any health issues from the consumption fish?

The IAS most frequently supplied or traded by companies were mainly blue crabs (76.9%), followed by molluscs (cuttlefish and squid) *Sepioteuthis lessonana* (23.1%). Lionfish is a species that is supplied and traded very rarely (76.9%), like other IAS, such as spinefoots and bluespotted cornetfish. The time of the year during which the blue crab has the highest consumption, according to the majority of those surveyed (53.8%), is Lent, followed by summer (30.8%). For the remaining IAS, there is no specific time for higher consumption. Regarding the price of the aforementioned species compared to the prices of other common fish and seafood, according to 46.1% of the seafood retailers, it is the same, while 30.8% of them stated that the average price is lower and 23.1% that it is higher than the price of other species.

According to a large percentage of seafood retailers (69.2%), the consumers were not aware of IAS. Most seafood retailers (76.9%) stated that they did not recommend IAS to customers and that no company approached them to supply them with IAS for further processing or trading. Regarding the existing demand for processed fishery products, the highest percentage of seafood retailers (79.0%) stated that, as they did not get supplied with IAS, they do not have a picture of demand or consumption. A small percentage (7.6%) stated that if there was demand, they would be interested, while for lionfish and spinefoots there is interest in exporting them to Cyprus.

More than half of seafood retailers (58.3%) stated that there has been no change in the trend of consumption patterns in the last 5–10 years for the consumption of marine IAS. The remaining 41.7% who observe a change in consumption patterns stated that it is mainly attributed to new healthy eating standards, lack of fish and tasting of new species, awareness raising, and purchase costs, as increased consumption of low-cost species is observed. Regarding the ways they propose to promote the consumption of IAS, the

seafood retailers stated mainly advertising (45%) and, in smaller percentages, free testing, processing, and promotion through retail stores.

4. Discussion

The present study provided valuable insights into how Greek consumers perceived the consumption of invasive alien species (IAS), specifically lionfish and blue crab. In recent years, the spatial distribution of IAS and their mass occurrence in the catches of commercial fishers, especially in coastal fisheries, has led fisheries researchers to seek to change both the fishing strategies of commercial fishers and the consumption patterns of humans to reduce the burden of these organisms on the marine food chain [37]. At the same time, the entry of new species into the fishery product markets for consumption is forcing consumers to seek increasingly effective measures to ensure the hygiene and quality of the goods they consume [22,29].

The methods used to understand consumers' attitudes towards their potential preference for consuming IAS, focusing on Atlantic blue crab and lionfish, i.e., face-to-face interviews and advertising via social media, have lowered the bias that can be created when only online surveys are used. Low-cost data collection is an important advantage of using social media for similar surveys compared to traditional social research methods (face-to-face interviews, telephone interviews, etc.). However, limitations occur when online surveys are the only source of data, as the results can be biased towards higher educated and young participants who are the most frequent users of such platforms. Other research studies have also documented these limitations [38].

The present study revealed a mixed level of awareness among Greek consumers regarding IAS, with more than half of the respondents knowing about IAS in general and specific species like lionfish and blue crab. However, knowledge about their potential negative impacts on health and the environment remains limited. Many consumers (over 70%) were unaware of the health risks associated with IAS consumption. Gender, age, and educational background influence awareness levels. For instance, older individuals (over 65 years) and those with lower educational levels exhibited less knowledge about IAS, especially regarding environmental impacts. The latter is consistent with seafood consumption in the European Union [1,7], where the youngest generation is more susceptible to seafood products, especially as a trade-off for the protection of the marine environment and native species. The idea that consuming IAS could help protect marine environments and native species resonates with environmentally conscious consumers, particularly youngers (18–25 years). Aligning IAS marketing with sustainability campaigns could thus drive increased consumption among eco-conscious consumers. These consumers were more likely to adopt IAS in their diets if they are aware of the environmental benefits.

Consumers in Greece were generally open to trying IAS like lionfish and blue crab, especially when these species were recommended by trusted retailers, featured in cooking shows, or linked to environmental sustainability. Positive factors that can motivate consumers to try IAS could be whether IAS species are promoted as delicacies in other countries (58.6% of respondents showed interest in lionfish consumption) and recommended by retailers (57.1%) and cooking show promotions (61.4%). Furthermore, consumers will consume them if theywere carried a quality control certificate or a special quality seal. It is useful to emphasize that in the above cases, younger age groups (18–25 years) showed a positive attitude, which underlines the targeting of consumer information to specific age groups. The media had a significant impact in normalizing IAS consumption, making strategic marketing a major channel for increasing demand. According to the results of this study, media and cooking programs exhibited significant influence on how consumers behave. When IAS are featured in cooking shows or recommended by trusted seafood retailers, consumers are more inclined to try them [21]. This perspective gives professional fishers greater control over the entire commercial cycle of their products and allows them to move from an opportunistic approach to a planning mindset with solid economic evi-

dence [22]. This highlights the potential of strategic marketing campaigns to normalize the consumption of IAS [7].

The majority of the retailers were hesitant to engage in IAS trading or distribution. Retailers also revealed that there is resistance to IAS consumption when these species are perceived as cheaper than traditional local fish. In this context, around 70% of consumers stated they would be less likely to consume IAS if they were priced lower than local species, associating price with lower quality. A significant challenge in promoting IAS was the lack of consumer knowledge and awareness, which limits demand and sales. Even though most seafood retailers stated that they do not supply the market with IAS, they were nevertheless positive that if there is a demand, they would certainly be interested in processing these species. Therefore, a retailer's endorsement of IAS could significantly increase consumer adoption. In other similar studies on the promotion of seafood products, their inclusion in restaurant menus seems to encourage consumers to try them, while the promotion on relevant cooking TV shows would contribute positively to this direction [18,21]. Events had already been held in various regions of Greece to inform the public about IAS in Greek seas, while efforts have been made to familiarize consumers with IAS and seafood.

A significant percentage of retailers (41.7%) observed a trend of changing consumption patterns, possibly due to new healthy eating habits, the lack of traditional fish species, and the experimentation of new species, information, as well as purchasing costs, where there was high consumption of low-cost species. Expanding the list of consumable species also means broadening the customer base for the consumption of new fishery products, such as IAS. New technologies, especially the widespread availability of the internet, offered new perspectives for the distribution of fisheries products. This type of distribution has the same disadvantages as direct sales, namely the need to offer a wide variety and enough to meet demand [7]. An important tool for the promotion of IAS is the ever-growing online (web) and telephone market, which includes marketing and logistics services (logistics) that allow professionals in the sector to sell recently to restaurants and consumers [1]. In this context, there was agreement with the views of the seafood retailers responsible for the distribution of seafood products, who, to promote the consumption of edible IAS, propose mainly advertising (45%) and, to a lesser extent, free tastings, processing, and promotion by retail outlets.

Awareness campaigns and safety assurances (e.g., quality control certificates) were critical to overcoming the current gaps in knowledge and concerns about health risks. The food industry is generally more interested in safety than environmental issues [39], whereas [40] concludes that consumers strongly support environmental sustainability in seafood markets. Also, the positive associations found between "concern for the environment" and "frequency of consumption" (more than 2.5 kg per purchase) indicated that consumers are positive about seafood supply chains that are perceived as sustainable and environmentally friendly. This optimistic message pointed to a new era of consumption patterns. The more consumers care about the marine environment, the more likely they are to consume seafood products [41]. This indicates the importance of promoting sustainability in the supply chain. Maintaining sustainable local fisheries by promoting the protection of the marine environment and native species can also maximize the added value generated locally. Seafood market companies recognize that the concept of "sustainability" is becoming a key driver in consumers' choices and creating confidence among the parties involved (professionals and consumers) [42].

Greek consumers placed significant importance on the freshness and hygienic conditions of the seafood they purchased. For both lionfish and blue crab, freshness (86.8%) and sanitation (64.5% for lionfish and 85.3% for blue crab) were top priorities. Consumers were also concerned about whether these species are poisonous (87.1% for lionfish and 77.9% for blue crab), indicating that safety was a major consideration. Other criteria like packaging and origin of the fish were considered less important than factors like price and quality, but still influenced purchasing decisions. In the present study, the application of multivariate analysis showed that married and highly educated consumers who frequently buy more

than 2.5 kg of fish tended to pay close attention to the above factors. This tendency of consumers has been observed both in surveys on the purchase of fish and shellfish on the high seas [22] and on non-native species in general [43] at the national level [29], where freshness and, to a lesser extent, the sanitary conditions of the fish shop, but also the origin of the fish were the main criteria for consumers' choice of fish. The positive attitude of consumers in this survey towards fish quality certification and other quality issues was an important directional indicator and a useful tool in efforts to address structural problems in the production and marketing of fisheries products. These policies created the impression among consumers that IAS are healthy foods with high nutritional value that are also controlled and certified.

The implications of this study covered a broad spectrum of thematic areas, including environmental policy, consumer behavior, economic benefits for fisheries, and marketing strategies. Promoting IAS consumption can be an innovative method to manage invasive species and protect marine habitats from an environmental standpoint. In terms of the economy, IAS openned up new markets for nearby businesses and fishers. A comprehensive marketing effort and consumer education were essential for raising awareness and building confidence in the sustainability and safety of IAS goods. By implementing cohesive policies, promoting campaigns, and raising public awareness, IAS had the potential to contribute significantly to sustainable seafood consumption in Greece and other regions worldwide.

The overarching theme of the present study was aligning consumer preferences with environmental goals. Consumer preferences indicated the need to introduce sophisticated forms of marketing in the sector, with integrated plans for promoting and marketing seafood products. By promoting the consumption of IAS through education, certifications, media visibility, and collaboration, they mitigated the ecological threat while creating new market opportunities. Policymakers implemented incentives such as subsidies or tax breaks for fishers and retailers who trade in IAS, encouraging the capture and sale of these species. Seafood retailers expanded seafood products and presented them as premium, eco-friendly products. This could be promoted through cooking shows, tastings, and social media to drive demand and consumer interest.

In this context, gastronomy events were held in parallel with the present study for the purposes of the promotion of IAS marketing all around Greece. The participants were informed about IAS, with emphasis on the most common alien species in Greece, including the species of this study, and tasted dishes with basic ingredients and IAS, providing feedback for the chance of introducing them in their diet (Figure 5). The majority of the event attendees, who were either mostly familiar with the presence of IAS or had never tasted it before, were astonished by the taste once they tried it and were willing to include it in their regular diet. This was more apparent, particularly with lionfish, due to its similarity with scorpionfish and spinefoots, due to their low price and easy and quick traditional recipes.

Figure 5. Gastronomic events were organised for the promotion of alien species consumption throughout Greece.

5. Conclusions

The present study helps in understanding how consumer awareness, retailer initiatives, and policy efforts be aligned to promote the consumption of invasive species for environmental and economic benefits. Consumers were generally unfamiliar with the ecological impact of IAS and were reluctant due to concerns about food safety, freshness, and quality. Most consumers were unaware of the potential health risks posed by consuming invasive species and were skeptical about cheaper seafood options, associating low prices with poor quality. The promotion of these species through culinary TV shows, recommendations from seafood retailers, and the presence of quality certifications were identified as key drivers that could increase consumer willingness to purchase IAS. The potential market for these species offered an opportunity to mitigate their ecological impact while supporting local fisheries. However, consumer ignorance regarding the negative environmental effects of IAS and their impact on health presented a barrier that needs addressing through public awareness and targeted marketing strategies. Additionally, while a significant portion of seafood traders were currently not involved in the distribution of IAS, there was interest in these species if consumer demand can be cultivated. This indicated a promising market potential if the right conditions, such as quality control and effective promotional efforts, were established. The findings emphasized the need for integrated marketing strategies that included consumer education and promotion to enhance the marketability of IAS as a sustainable seafood option. By aligning consumer preferences with conservation goals, the Greek seafood market can play a crucial role in controlling the spread of invasive species and promoting sustainable consumption patterns.

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Institutional Review Board Statement: The Ethics Committee of the University of Patras Review Board approved through its decision No. 16738/27-08-2024 that the research protocol followed in the present study does not need examination by the committee of the University.

Informed Consent Statement: The questionnaires used/filled for the purposes of the study were all anonymous and did not contain any information that could lead to the identification of the respondent.

Data Availability Statement: Data supporting the reported results of the study can be provided upon request to the last author.

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Appendix A. Questionnaire for "Atlantic Blue Crab/Lionfish Consumption"

The present study was initiated as part of the Pick the Alien project to understand the consumption patterns of Atlantic blue crabs (Callinectes sapidus)/lionfish (Pterois miles). The questionnaire was anonymous and did not contain any information that could lead to the identification of the respondent.

The project is implemented by iSea, with the collaboration of the University of Patras and the University of Plymouth, and the support and collaboration of the Blue Marine Foundation, the Ionian Environment Foundation, the Argolic Environment Foundation, and the Cyclades Preservation Fund.

1. How often do you buy and consume fish in your family?

Every day	
Every week	
Once per month	
Once per three months	
In exceptional occasions	

2. Do you buy yourself the fish for your family?

Always	
Often	
Rarely	

3. Where do you usually buy fish for your home?

Traditional fish shop	
Public market	
Central fish market	
Hyper market	
Auction market	
Itinerant fishmongers	
Other	

4. How much fish do you usually buy and consume for one meal for your family?

1.0 kg	
1.5–2.0 kg	
2.5 kg and more	

5. Do you always prefer buying from the same "supplier"?

YES	
NO	

6. If YES, what is the reason?

Trust	
Good service	
Other	

7. Do you gut clean the fish your own?

YES	
NO	

8. Do you know what alien species are?

YES	
NO	

9. Do you know blue crab/lionfish?

YES	
NO	

10. Do you know if blue crab/lionfish have negative impact in human health?

YES	
NO	

11. Do you know if blue crab/lionfish have negative impact in the marine ecosystem?

YES	
NO	

12. Do you think that the consumption of blue crab/lionfish may pose a risk to your health?

YES	
NO	

13. If you were told that blue crab/lionfish are a delicacy in other countries, would you try them?

YES	
NO	

14. If you found blue crab/lionfish at your fishmonger, cheaper than the classic species consumed, would you buy them?

YES	
NO	

15. If your fishmonger recommended blue crab/lionfish, would you buy them?

YES	
NO	

16. If you saw blue crab/lionfish being cooked on a cooking show, would you be more inclined to buy/eat them yourself?

YES	
NO	

17. If you saw blue crab/lionfish on a restaurant menu, would you try them?

YES	
NO	

18. Would you eat blue crab/lionfish if you were told that its consumption is protecting the marine environment and native species?

YES	
NO	

19. How important is each of the following factors to you if you were to buy blue crab/lionfish?

Factor	Very important	Important	Insignificant
Size of the fish			
Freshness			
Sanitation conditions of the fish shop and its staff			
Packaging			
Price			
Fish origin			
Poisonous			
Known species			

20. Would you like the blue crab/lionfish purchased to have a quality control certificate or quality mark?

YES	
NO	
I don't mind	

21. Would you buy processed products of blue crab/lionfish from local associations?

YES	
NO	

22. Have you ever had any health issues from the consumption of fish?

YES	
NO	

Gender:				
Male [1] ☐		Female [2] ☐		
Age:				
<18 [1] ☐	18–25 [2] ☐	26–45 [3] ☐	46–65 [4] ☐	>66 [5] ☐
Education level:				
Haven't finished elementary school		[1] ☐	University student	[5] ☐
Elementary Diploma		[2] ☐	Bachelor	[6] ☐
Junior high school Diploma		[3] ☐	Master/PhD	[7] ☐
High school Diploma		[4] ☐		[8] ☐
Your family status:				
Unmarried [1] ☐		Married [2] ☐	Divorced [3] ☐	

Appendix B. Questionnaire for "Marine Alien Species Trade"

The present study was initiated as part of the "Pick the Alien" project to understand the consumption patterns of blue crabs (*Callinectes sapidus*)/lionfish (*Pterois miles*). The questionnaire was anonymous and did not contain any information that could lead to the identification of the respondent.

The project is implemented by iSea, with the collaboration of the University of Patras and the University of Plymouth, and the support and collaboration of the Blue Marine

Foundation, the Ionian Environment Foundation, the Argolic Environment Foundation, and the Cyclades Preservation Fund.

1. In which 3 regions were you sent your products?
    a. Region 1:. . .. .
    b. Region 2:. . .. .
    c. Region 3:. . .. .
2. What are the main seafood products you are supplying/trade?
3. Do you trade species of alien species such as Atlantic blue crab, lionfish, spinefoots,etc.?
    a. Yes
    b. No
4. If you answered Yes in question no. 3, which of the following do you supply/trade (multiple choice, number in order of frequency with 1 being the most frequent and 8 being the least frequent)?
    a. Lionfish (Pterois miles)
    b. Blue crab (Callinectes sapidus)
    c. African swimming blue crab (Portunus segnis)
    d. Spinefoots (Siganus luridus & Siganus rivulatus)
    e. Trumpetfish (Fistularia commersonii)
    f. Red sea goatfish (Parupeneus forsskali)
    g. Bigfin reef squid (Sepioteuthis lessoniana)
    h. Redcoat fish (Sargocentron rubrum)
5. The price of edible alien species compared to the prices of other traditional fish species is on average (One answer):
    a. Lower
    b. Equal
    c. Higher
6. In which period of the year is the consumption of lionfish higher?
    a. Lent (Easter fasting)
    b. Summer
    c. Christmas
    d. All seasons
    e. Other
    f. None
7. In which period of the year is the consumption of Atlantic blue crab higher?
    a. Lent (Easter fasting)
    b. Summer
    c. Christmas
    d. All seasons
    e. Other
    f. None
8. In which period of the year is the consumption of spinefoots higher?
    a. Lent (Easter fasting)
    b. Summer
    c. Christmas
    d. All seasons
    e. Other
    f. None
9. Does the consumer know the species of alien species?
    a. Yes
    b. No

10. Do you suggest alien species to your customer?
    a. Yes
    b. No
11. Have you been contacted by companies that would like to process or trade alien species products and would like you to supply them?
    a. Yes
    b. No
12. If you answered No in question no 3: Would you be interested to supply/trade edible alien species?
    a. Yes
    b. No
13. If you are interested, which of the following species would you be interested?
    a. Species:. . . . . Process/Trade, Region:. . . . . .
    b. Species:. . . . . Process/Trade, Region:. . . . . .
    c. Species:. . . . . Process/Trade, Region:. . . . . .
    d. Species:. . . . . Process/Trade, Region:. . . . . .
14. Has there been a consumer trend change over the last 5–10 years in the consumption of marine edible alien species?
    a. Yes
    b. No
15. If yes, why do you believe there is this change?
16. Which 3 measures would you suggest to promote the consumption of edible alien species?
    a. Measure 1:. . . . . .
    b. Measure 2:. . . . . .
    c. Measure 3:. . . . . .
17. Are there any processing methods (salted, smoked etc.) that would help to promote edible alien species?
    a. Species:. . . . . Processing method:. . . . . .
    b. Species:. . . . . Processing method:. . . . . .
    c. Species:. . . . . Processing method:. . . . . .
    d. Species:. . . . . Processing method:. . . . . .
18. How many years have you been in seafood products trading?
19. Type of business
    a. Fisher
    b. Retailer
    c. Fishmonger
    d. Itinerant
    e. Supermarket—Hypermarket
    f. Food store
    g. Wholesale
    h. Restaurant
    i. Tavern
    j. Other
20. In which municipality is your business based?
21. Number of employees?
    a. Full time. . . . . .
    b. Part time. . . . . .

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